May 24, 1960 H. KLEMT 2,937,499

LIQUID RING GASEOUS FLUID DISPLACING DEVICE

Filed Aug. 14, 1956 3 Sheets-Sheet 1

Fig. 1.

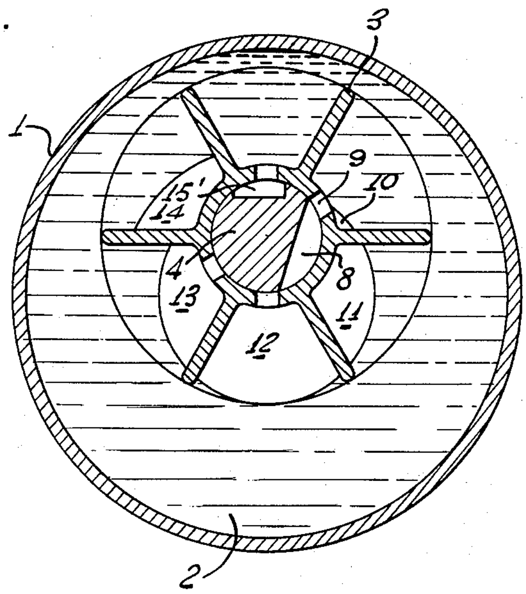
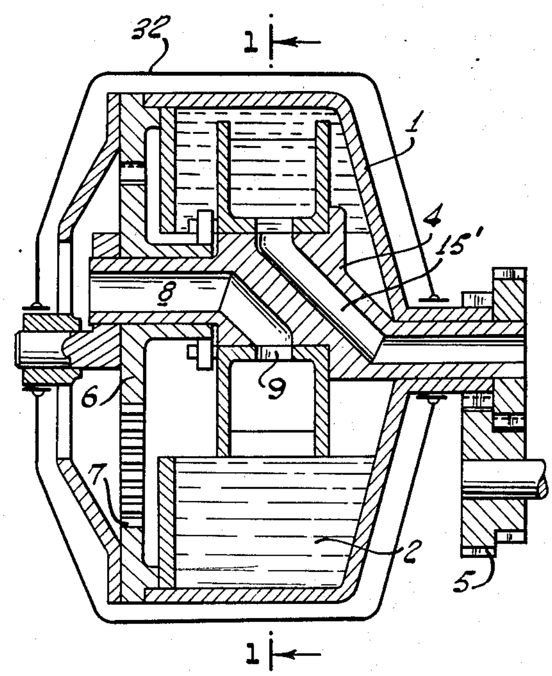


Fig. 2.



INVENTOR
HERMANN KLEMT

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LIQUID RING GASEOUS FLUID DISPLACING DEVICE

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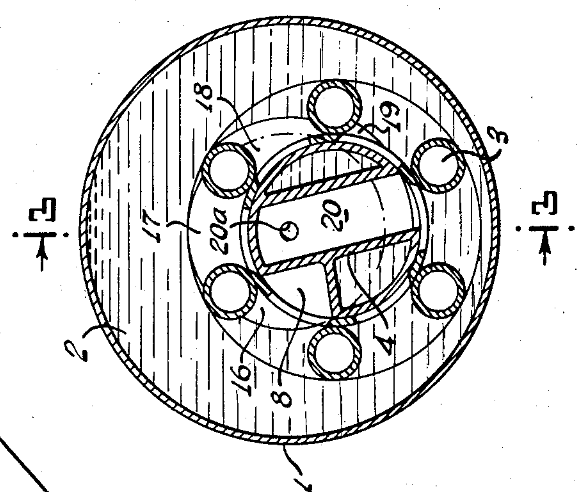

Fig. 4

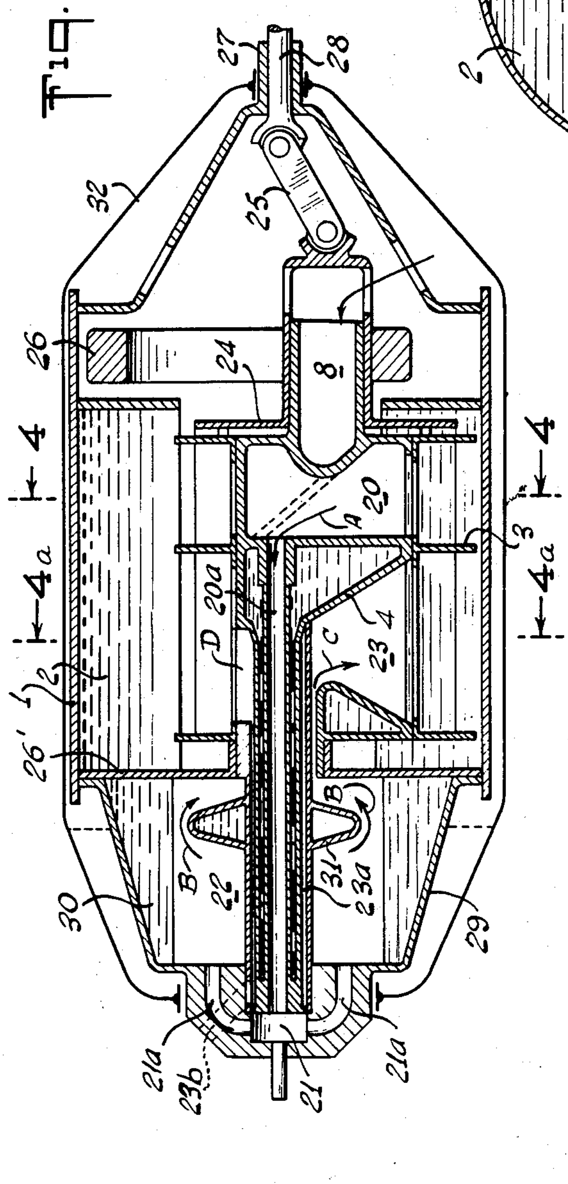

Fig. 3

INVENTOR
HERMANN KLEMT

May 24, 1960 H. KLEMT 2,937,499

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Fig. 4a.

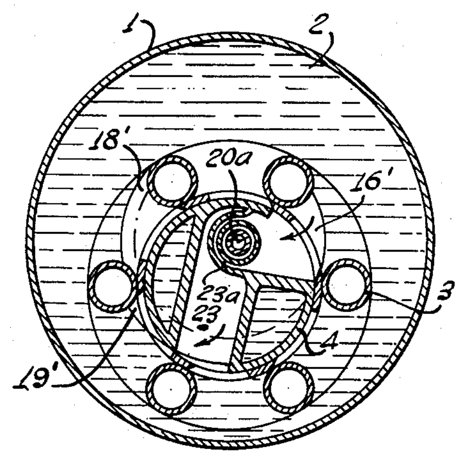
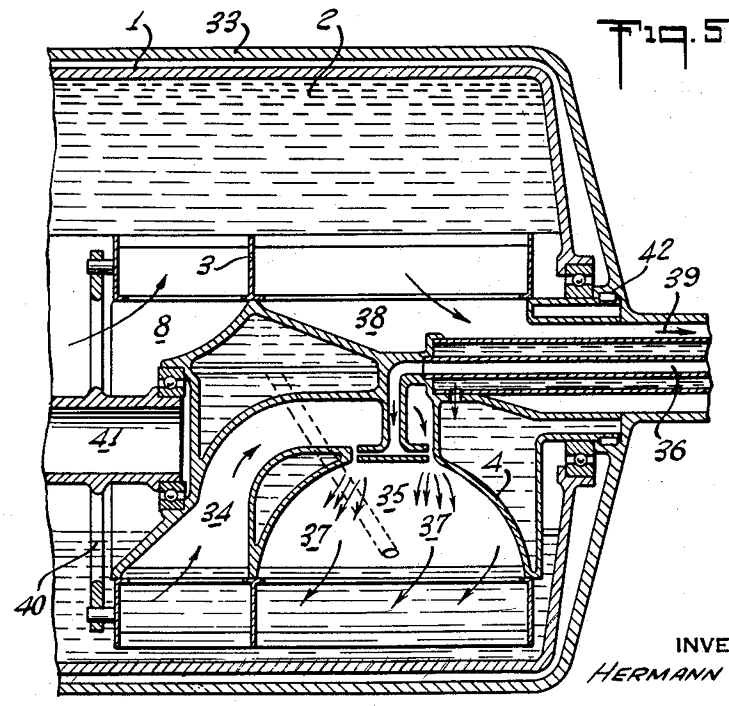


Fig. 5.



INVENTOR
HERMANN KLEMT

United States Patent Office

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LIQUID RING GASEOUS FLUID DISPLACING DEVICE

Hermann Klemt, Berlin-Pankow, Germany, assignor to Institut fuer Schienenfahrzeuge, Berlin-Adlershof, Germany

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Claims priority, application Germany Mar. 9, 1956

12 Claims. (Cl. 60—39.61)

The present invention relates to liquid ring gaseous fluid displacing devices for use as pumps, both air and vacuum pumps, evacuators, pneumatic motors, blowers, etc., more particularly to devices of this type which utilize a girating liquid fluid ring cooperating with a bladed bucket or impeller wheel excentrically mounted with respect to said ring, to provide pockets of compression and expansion bounded by the blades of said wheel and the liquid surface, whereby such a device may be used as a gaseous fluid displacing means in a pump, evacuator or the like machine.

For the purpose of the following description the term pump is therefore to be construed in its broader sense and meaning to include all related and equivalent uses or applications, that is, as a compressor, evacuator etc., in accordance with the general spirit and scope of the invention.

Liquid ring displacing devices have already become known which comprise a stationary circular casing and a driven impeller wheel excentrically mounted therein to cause a liquid fluid, such as water, within said casing to rotate and to set up a girating liquid ring or annulus by the action of centrifugal force. Due to the excentric mounting of the impeller wheel relative to the casing, there are produced condensing and expanding air pockets between the blades of the impeller enabling the use of such a device as a pump or evacuator by the provision of suitable intake and outlet openings or ducts advantageously arranged inside the arbor or shaft of the impeller wheel. Since in devices of this type the water or other operating liquid is subject to a girating movement, the resulting centrifugal liquid ring or water column will be referred in the following as a "hydrodrome" for the purpose of this specification.

Such ordinary hydrodrome displacers are able to operate only at relatively low pressures, since the hydrodynamic or circulation losses which increase with the third power of the speed of rotation very soon equal the thermodynamic (compression) energy of the machine which latter increases approximately in proportion only with the speed of rotation, whereby the efficiency of the machine decreases rapidly before the liquid ring has attained a sufficient centrifugal "hardness" required for the attainment of higher input-output compression ratios.

Furthermore, such hydrodrome displacers have the disadvantage of an excentric liquid level relative to the casing, that is, the liquid level is distorted towards the pressure side in the case of an impeller wheel having straight blades, while the liquid level is distorted in the trailing direction in case of impeller blades curved in the usual leading or forward direction, as may be observed by means of a flashlight stroboscope through a transparent casing wall section. Besides, with hydrodrome displacers of this type, strong turbulence effects occur at the surface of the liquid ring on account of the relatively low centrifugal force, whereby the liquid level deteriorates into a violent spray as may be directly observed through a transparent casing wall. This greatly reduces the efficiency and performance of the device.

It has already been proposed to reduce the above disadvantages by rotatably mounting the casing to allow the same to freewheel and to be taken along by the girating liquid ring, as soon as the circulation (kinetic) energy exceeds the bearing friction of the casing. This expedient has, however, not been successful since no liquid ring is available at starting and auxiliary means have to be provided for the starting of the machine. Moreover, the power output of such a machine having a freewheeling casing is not appreciably higher than the output of the ordinary hydrodrome displacer having a stationary casing. In any case, the blade immersion and deflection losses in the liquid when using the conventional type of impeller wheel exceed the liquid circulation energy, so that the freewheeling hydrodrome permits of hardly any higher speed of rotation, and in turn, greater compression ratios, as compared with the ordinary hydrodrome displacer having a stationary casing.

An important object of the present invention is, therefore, to overcome the above and related difficulties and drawbacks of conventional hydrodrome displacers and to generally improve their performance and efficiency.

Among the more specific objects of the invention is to increase the compression or input-output pressure differential by stabilizing the liquid circulation and removing the liquid level distortion.

Yet another object of the invention is to increase the hardness of the liquid ring to improve the sharpness or definition of the liquid level and, in turn, the performance and efficiency of the device as a gaseous liquid displacing means.

The above objects and novel results of the invention are achieved essentially by rotatably mounting the impeller wheel upon a shaft, such as a crank pin, which in turn rotates concentrically inside the liquid ring, whereby the casing containing the liquid may be either freewheeling or may itself be driven at the same or at a different speed as the impeller shaft. This makes it possible, in order to produce a high centrifugal force and consequent increased hardness of the liquid ring, to increase the speed of rotation of the casing considerably and independently of the speed of the impeller which on the basis of hydrodrome considerations cannot be increased in the same proportion. As a practical example, assuming a conventional hydrodrome displacer to have an upper limit speed of its impeller wheel of say 1000 revolutions/min. due to the rapidly increasing liquid circulation losses, whereby to result in a maximum pressure of say one atmosphere above normal, the speed of rotation and, in turn, the pressure in the case of the invention using a rotating impeller shaft may be increased manifold, say to 3000 revolutions/min. of the impeller shaft and to 4000 revolutions/min. of the casing. In this case, the maximum pressure obtainable will be increased to about 16 atmospheres above normal.

At the same time the efficiency of the device increases, as the pressure changes in proportion to the square of the speed of rotation, thus resulting in a manifold power output compared with prior devices having a stationary impeller shaft, whereas the centrifugal hardness of the water remains uneffected by the pressure and the hydrodynamic losses also remain the same as a result of the same impeller speed. The speed of rotation and, in turn, the pressure, of a machine of this type is, therefore, no longer limited by hydrodynamic considerations and may be increased to the limit of strength of the casing material. Auxiliary starting means are still required in the case of a freewheeling of the casing, wherefore a further advantage of a driven casing as described in detail hereafter.

Furthermore, the rotation of a freewheeling casing by the liquid ring results in large liquid circulation losses and, in turn, a distortion of the liquid level. While this distortion decreases with increasing hardness of the liquid ring, the drag of the casing being taken along by the liquid increases as the speed of rotation is increased. As a result, there remains a residual distortion of the liquid level in a freewheeling type displacer of this type, as well as a slight turbulence effect at the liquid surface. However, even in a freewheeling type displacer according to the invention, the rotating impeller shaft provides a simple and efficient means to increase the hardness of the liquid ring, to an extent that the centrifugal weight of the liquid at the liquid level considerably exceeds the terrestrial gravity (several kg./cm. compared with 0.001 kg./cm.). In such a device, the centrifugal force inceases with increasing radius towards the periphery of the casing and the successive pressures add cumulatively.

Essentially, therefore, the invention involves the separation of the functions of setting up and maintaining a liquid ring by centrifugal forces by the rotating casing, on the one hand, and the formation of compression and expansion air pockets by the impeller wheel, on the other hand. By the separate rotation of the casing, any desired degree of "hardness" of the liquid ring may be achieved without interference with the function of the impeller wheel and being limited only by the strength of the materials used. As a result, the performance and efficiency of the device as a compressor, evacuator, etc. may be increased considerably.

According to an improved feature of the invention, as pointed out hereinabove, in particular in an effort to afford easy starting and to increase the efficiency of the device, the casing containing the liquid medium is rotated or driven forcibly relative to the rotating impeller shaft. Another advantage of a driven casing over both the stationary and the freewheeling casing is the fact that the speed of rotation of the casing may be so related and/or adjusted relative to the impeller speed that the impeller revolves within the liquid ring in the manner of a planet or pinion gear revolving upon the teeth of an internal ring gear, whereby there will be no relative liquid movement between the casing and the girating liquid. As a result, such a driven casing presents a possibility when used with suitably shaped impeller blades, to produce a hard liquid ring and undistorted liquid level concentric to the gyrating axis of the device. The device then assumes the character of a gyroscope which is advantageously elastically mounted about a vertical shaft or axis.

In a device of this type, the impeller, due to the excentric position of the impeller shaft relative to the casing axis, is subject to the effect of the centrifugal force, which results in increased bearing friction and, in turn, in wear and tear as well as a decrease of the efficiency of the device.

Still a further object of the invention is, therefore, to provide an improved design and construction, whereby the impeller floats upon the liquid ring, its optimum specific weight required being advantageously determined by the aid of a momentum chart and under consideration of the fact that one part of the impeller is within the liquid while another part is outside the liquid and, furthermore, that one part is on one side and the other part is on the other side of the casing. Synthetic materials which have an adequate specific weight are suitable only for impellers for relatively low pressures on account of their insufficient heat resistance. For the attainment of higher pressures, the impeller consists advantageously of a number of hollow metal tubes, such as steel tubes or the like, acting as blades or buckets, as will be further described hereafter.

The invention is especially suitable for use in combined compressor-evacuator machines, such as internal combustion engines, gas turbines and the like. In the realization of any high capacity high-pressure direct-pressure closed process, it is necessary to convert substantial amounts of compressed exhaust gases into compressed fresh air. This can be achieved simply and efficiently by means of a device according to the invention by subdividing a single impeller wheel into two or more axial sections, one of which sections serves as a compressor while the other is operated as an expander or evacuator, in the manner more clearly described hereafter. In such a machine, the combustion chamber may advantageously be in the form of a further water ring also produced by the rotating casing of the device, this being of special importance where ashes and other foreign matter must be separated from the combustion gases by centrifugal force. The efficiency and performance of such a machine are further improved by the cooling of the impeller wheel during each revolution while being immersed or passing through the water or other cooling liquid ring.

The invention, as to its further objects and novel aspects, will be better understood from the following detailed description of a few practical embodiments thereof taken with reference to the accompanying drawings, forming part of this specification and wherein:

Fig. 1 is a cross-sectional view, taken on line **1—1** of Fig. 2, of a basic construction of a gaseous fluid displacing device embodying the principles of the invention;

Fig. 2 is a longitudinal sectional view of the device according to Fig. 1;

Fig. 3 is a longitudinal section, taken on line **3—3** of Fig. 4, through a modified compressor-evacuator combination according to the invention embodied in an internal combustion engine;

Figs. 4 and 4*a* are cross-sectional views taken on lines **4—4** and *4a—4a* of Fig. 3, respectively; and

Fig. 5 is a sectional view of an alternative construction of an internal combustion engine according to Figs. 3 and 4 embodying a modified compressor-evacuator according to the invention.

Like reference numerals identify like parts in the different views of the drawings.

Referring more particularly to Figs. 1 and 2 of the drawings, the circular casing **1** supports a water or equivalent liquid ring **2**. The bucket or impeller wheel **3** is excentrically supported within the casing **1** upon a shaft or crank pin **4**. A pair of gears **5** serve to drive the casing, on the one hand, and the crank **4**, on the other hand, at different relative speeds, according to the example illustrated. On account of this speed differential between the casing **1** and the crank **4**, the gear **6** secured to the crank pin revolves upon the internal gear **7** secured to the casing **1**. As a result, the impeller wheel **3** revolves in like manner within the water ring **2**, whereby, with the impeller assumed to rotate in clockwise direction, air will be drawn in through the intake duct or channel **8** within the crank pin or shaft **4**, and via the slot **9** in the hub of the wheel **3** into the condensing pocket **10** enclosed by the impeller blades and liquid ring **2**. In similar manner, air is sucked into the pockets **11** and **12**. This intake air is compressed in the pockets **13** and **14** and forced out through the pocket **15** into the output duct **15'** within the impeller shaft from where it may be conveyed to a consumer or utilization device. The stationary housing or support of the machine is schematically indicated in the drawing by the single line **32**.

Assuming, for instance, as a result of the design of gears **5**, that the crank **4** rotates in clockwise direction at a speed of 3000 revolutions/min. and that the casing rotates in the same direction at 4000 revolutions/min., the casing with its ring gear **7** leads the crank **4** and gear **6** by 1000 revolutions/min., whereby the gear **6** revolves upon the internal gear **7**, thereby taking along the impeller **3**. The latter, in turn, is forced to rotate about the crank pin **4** at a speed of 1500 revolutions/min., the latter representing the actual operating or pumping speed. The total speed of the impeller is, therefore, equal to

4500 revolutions/min., on the basis of the transmission ratio between the gears 6 and 7, as shown in the drawing.

The afore-described operation relates to the function of the machine as a compressor. In this case, the gear 5 is driven by a suitable prime mover, whereby air or any other gas is drawn in at 8 and delivered as compressed air at 15'. The operation as a vacuum pump is similar with this difference, however, that the pressure in the intake channel 8 is below atmospheric, while normal atmospheric pressure exists in the output or delivery channel 15'.

On the other hand, during the operation of the machine as an expander or evacuator, compressed air is forced into the channel or duct 15', thus driving the impeller in anticlockwise direction by allowing the air to expand in the pockets 13 and 14 and by discharging it by way of pockets 8, 10, 11 and 12. In this case, the machine operates as a pneumatic motor or prime mover delivering rotary mechanical power to the gear 5. As pointed out, in place of air, the machine may be used with equal advantage for the compression or evacuation of any other gas, vapor or gaseous fluid medium.

It will be understood, of course, that for maximum efficiency of operation of the machine as described, frictional effects must be minimized to the greatest possible extent. In order to appreciate the importance of this factor, the following example might be considered. Assuming that the eccentricity of the crank 4 is 10 cm., then at a rotational speed of the crank of 3,000 r.p.m., the ratio of the centrifugal force of the impeller wheel 3 to the weight thereof is in the order of 1,000:1. Thus, an impeller wheel weighing 10 kg. would, at 3,000 r.p.m., exert a bearing pressure or force of 10,000 kg. on the crank 4, which would lead to excessively great friction losses and rapid destruction of the bearing arrangement. It is for this reason that, in accordance with the present invention, the impeller wheel is constructed so as to have a predetermined specific gravity which will enable it to effectively float on the water or liquid ring 2, whereby substantially no bearing forces are exerted on the crank pin 4. As indicated hereinabove, proper specific gravity characteristics may be imparted to the impeller by making the same from any suitable synthetic plastic material capable of withstanding the operating stresses to which the impeller will be subjected during operation of the machine.

Figs. 3, 4 and 4*a* of the drawings illustrate a combined compressor-evacuator according to the invention embodied in an internal combustion engine or turbine designed for use with pulverized coal, crude oil or equivalent operating fuel. The gyrating casing 1 again supports the water ring 2 within which revolves a dual section impeller 3. The latter, in order to withstand the high temperature of the combustion gases, is composed of a number of steel tubes acting as blades or buckets and being mounted upon a sheet metal hub rotatably supported by the crank pin 4. The tubes 3 are hollow, as best shown in Figs. 4 and 4*a*, and are so dimensioned that the overall volume of the impeller wheel is such as to ensure that the latter has the desired specific gravity and is capable of floating on the liquid ring, the tubes being made of metal only to provide greater strength and to permit operation of the machine at greater speeds than would be possible with plastic material blades. This construction further differs from that shown in Figs. 1 and 2, in that the crank pin 4 supporting the impeller 3 is driven at the same speed as the casing by directly connecting it to the latter via a wall or partition 26' and in that the impeller 3 is driven separately through a universal angular-shaft coupling 25.

In operation, if the impeller 3 rotates in clockwise direction, air is sucked into the compressor section of the machine by way of the air intake duct 8, passed to pockets 16 and 17 of the first axial impeller section,

compressed in the pockets 18 and 19 of said first impeller section and forced into space 20 within the impeller shaft, as best shown in Figs. 3 and 4. From there, the compressed air passes through a central duct 20*a*, as indicated by the arrow A in the drawing, into the mixing chamber 21, where it is combined with a suitable fuel, such as pulverized coal, crude oil or the like. The combustible mixture flows through ducts 21*a* and is ignited and burned within the combustion chamber or space 22, the resulting combustion gases being centrifuged while passing between an auxiliary water ring 30 enclosing said chamber and a water-filled guide member 31, as indicated by the arrow B, to remove ashes, water, etc. which are expelled into or absorbed by the water. The clean combustion gases are then passed into the evacuator section of the machine, as indicated by the arrow C, and are expanded in the crank pin space 23 and subsequently thereto in the pockets or chambers 19', 18', 17' and 16' of the second axial section of the impeller wheel 3, as best shown in Fig. 4*a*. The impeller is so constructed, as can be readily seen from a comparison of Figs. 4 and 4*a*, that the chambers or spaces 20 and 23 are oppositely inclined relative to the plane or axis of symmetry of the impeller and are mirror images of one another, the same holding true for the pockets 16 to 19 and 16' to 19'. This may best be visualized by holding Figs. 4 and 4*a* in face to face relationship. The expanded gases flow, as indicated by the arrow D, from the chamber or pocket 16' into a duct 23*a* concentric with the duct 20*a*, it being understood that this relationship of the ducts is not critical since they could be semi-circular or sector-shaped in cross-section. From the duct 23*a*, the expanded gases pass into the atmosphere through a duct 23*b* (Fig. 3).

As pointed out, for the purpose of starting the machine the impeller 3 is connected to the drive or output shaft 28 through an angular-shaft coupling 25 and coupling disc 24, while the casing is driven directly by the hub 27 of the shaft 28. The crank pin 4 is directly secured to a spacing wall 26' within the casing separating the two water rings 2 and 30. During operation, i.e., once the combustion in chamber 22 is initiated, the starter drive means is deactuated and the impeller drives the output shaft 28 which delivers mechanical power for driving a vehicle, electric generator or the like. A rotating metal ring 26 within the casing serves to compensate the centrifugal force on the excentrically mounted coupling disc 24 in the embodiment shown.

In Figs. 3 and 4, the crank pin and casing, in contrast to Fig. 1, rotate at the same speed, whereby the water in the ring is acted upon in such a manner as to result in a rotating hydrodrome with the water circulation maintained in laminar flow condition by a sufficiently high rotating speed, or in other words, resulting in a water ring of high hardness.

Maximum performance and efficiency are obtained by the use of a twin casing compressor-evacuator, as shown in Fig. 5. In the latter, the inner casing 1 supports the water ring 2 and contains the dual section impeller wheel 3 similar to the preceding embodiment, while the crank pin 4 is driven through 42 by a further outer casing 33. The casing 1 and impeller 3 are each driven at a different speed, such as by means of a multiple gear 5 (see Fig. 2) driving the hub of the casing 1 and the angle shaft 25, the impeller being coupled to angular shaft 25 in the manner as shown in Fig. 3. The driving gears, which are not shown in Fig. 5, are advantageously arranged near the output side to enable an easy mounting and removal of the impeller from the opposite side of the machine.

A further improvement of the Fig. 5 construction consists in the arrangement of the combustion chamber inside the crank pin 4. The air is first drawn in via duct 8 and compressed in the pockets or chambers 16, 17, 18 and 19 of the first impeller section and is thus forced via chamber 34 in the crank pin into the combustion chamber 35. Secured to the body of the crank pin 4 is a water cooled fuel intake pipe 36 from which the fuel is injected into the chamber 35 by means of an atomizing disc or the like. The fuel burns by auto-ignition with the air introduced from the space 34 in the form of a ring or shower flame 37. The exhaust gases after expansion in the pockets 19', 18', 17' and 16' of the second impeller section enter the chamber 38 in the crank pin, and thereafter leave the impeller at 39 and pass into the outside atmosphere. Item 40 is the coupling disc for the impeller wheel corresponding to item 24 of Fig. 3, while numeral 41 represents the shaft of the coupling disc which is connected via angle shaft 25 to the output or drive shaft of the machine. Item 42 may be an expansion ring indicating the mounting of the crank pin 4 upon the casing 33.

A machine of the type described is especially suitable for producing high power rotary mechanical energy, such as required for traction motors, locomotives, as a prime mover for power plants and many other uses.

In the foregoing the invention has been described with reference to a specific illustrative device. It will be evident, however, from the foregoing, that numerous variations and modifications, as well as the substitution of equivalent elements and parts for those shown and disclosed herein for illustration, may be made without departing from the broader scope and spirit of the invention as set forth in the appended claims. The specification and drawings are accordingly to be regarded in an illustrative rather than in a restrictive sense.

I claim:

1. In a fluid-displacing apparatus of the combined compression and expansion type and including a rotatable casing containing a body of liquid arranged to be formed by centrifugal force upon rotation of said casing into a liquid ring, a rotatable eccentric shaft extending into said casing, and impeller means carried by said shaft within said casing for rotation relative to said shaft and said casing; said impeller means comprising an impeller wheel divided into a plurality of axially aligned, contiguous, interconnected sections each having a plurality of circumferentially spaced blades defining therebetween and in conjunction with the innermost surface of said liquid ring, when the same is formed within said casing, a plurality of coaxial sets of circumferentially spaced pockets, the specific gravity of said impeller wheel being predetermined to ensure that said wheel effectively floats on said liquid ring, and said shaft being provided with a plurality of passageway means arranged, respectively, to communicate with the spaces between said blades of the corresponding one of said impeller wheel sections, whereby upon rotation of said impeller wheel and casing, fluid is first drawn into the pockets formed by said liquid ring and said blades of the first one of said impeller wheel sections so as to be subjected to a first pressure change, and finally, after having flowed through said passageway means, enters the pockets formed by said liquid ring and said blades of the last one of said impeller wheel sections so as to be subjected to a final pressure change reverse to said first pressure change.

2. In a fluid-displacing apparatus according to claim 1; said impeller wheel being made of a synthetic plastic material having the desired specific gravity characteristics.

3. In a fluid-displacing apparatus according to claim 1; each of said blades of said impeller wheel comprising a hollow tube of metal having its longitudinal axis extending substantially parallel to the axis of rotation of said impeller wheel, the volume conditions of said tubes being such as to impart to said impeller wheel the desired specific gravity.

4. In a fluid-displacing apparatus of the combined compression and expansion type and including a rotatable casing containing a body of liquid arranged to be formed by centrifugal force upon rotation of said casing into a liquid ring, a rotatable eccentric shaft extending into said casing, and impeller means carried by said shaft within said casing for rotation relative to said shaft and said casing; said impeller means comprising a dual axial section impeller wheel having a plurality of circumferentially spaced blades defining therebetween and in conjunction with the innermost surface of said liquid ring two coaxial sets of circumferentially spaced pockets, said impeller wheel being constructed to have a specific gravity rendering it capable of floating on said liquid ring, said shaft being provided in its interior with two passageways each of which communicates at one end with the spaces between said blades of the corresponding one of said impeller wheel sections upon rotation of said impeller wheel, each of said passageways at its other end being in communication with a common space portion within said casing, whereby upon rotation of said impeller wheel and casing, fluid is first drawn into the pockets formed by said liquid ring and the first impeller wheel section blades and subjected to a first pressure change, is then fed via one of said passageways to said common space portion, and is then fed via the other of said passageways to the pockets formed by said liquid ring and the second impeller wheel section blades and subjected to a second pressure change reverse to said first pressure change.

5. In a fluid-displacing apparatus of the combined compression and expansion type and including a rotatable casing enclosing a combustion chamber and a body of liquid arranged to be formed by centrifugal force upon rotation of said casing into a hard liquid ring, a rotatable eccentric shaft extending into said casing, and impeller means carried by said shaft within said casing for rotation relative to said shaft and said casing; said impeller means comprising a dual axial section impeller wheel having a plurality of circumferentially spaced blades defining therebetween and in conjunction with the innermost surface of said liquid ring two coaxial sets of circumferentially spaced pockets, said shaft being provided in its interior with two passageways arranged, respectively, to communicate at one end with the spaces between said blades of the corresponding one of said impeller wheel sections upon rotation of said impeller wheel, and at the other end with said combustion chamber, whereby upon rotation of said impeller wheel and casing, fluid is first drawn into the pockets formed by said liquid ring and the first impeller wheel section blades for compression, then fed via one of said passageways to said combustion chamber for contributing to a forced-draft firing process, and then fed as a combustion gas mixture from said combustion chamber via the other of said passageways to the pockets formed by said liquid ring and the second impeller wheel section blades for expansion and exhaustion from the apparatus.

6. In a fluid-displacing apparatus according to claim 5; said impeller wheel being constructed to have a predetermined specific gravity rendering it capable of floating on said liquid ring, to thereby minimize frictional losses resulting from rotation of said wheel about said shaft.

7. In a fluid-displacing apparatus according to claim 5; said combustion chamber being disposed interiorly of said shaft.

8. In a fluid-displacing apparatus according to claim 6; an additional rotatable casing surrounding and spaced from said first-named casing and drivingly connected to said shaft.

9. In a fluid-displacing apparatus according to claim 5; said casing comprising first and second portions affixed to and isolated from one another, said body of liquid and said impeller wheel being located within the confines of said first portion of said casing, said second portion

of said casing defining said combustion chamber and containing a further body of liquid arranged to be formed into a liquid ring surrounding said combustion chamber upon rotation of said casing.

10. In a fluid-displacing apparatus according to claim 5; each of said blades of said impeller wheel comprising a hollow tube made of highly heat-resistant metal and having its longitudinal axis extending substantially parallel to the axis of rotation of said impeller wheel.

11. In a fluid-displacing apparatus according to claim 5; said one end of said one passageway being constituted by a first recess provided in the interior of said shaft, said other end of said other passageway being constituted by a second recess provided in the interior of said shaft and disposed symmetrically with respect to said first recess.

12. In a fluid-displacing apparatus according to claim 5; said one end of said one passageway being constituted by a recess provided in the interior of said shaft, said shaft being further provided with another recess arranged to communicate with said pockets of said second impeller wheel section upon rotation of said impeller wheel, for receiving the expanded gases from said last-named pockets and conducting said gases to the exhaust of the apparatus.

References Cited in the file of this patent

UNITED STATES PATENTS

1,668,532	Stewart	May 1, 1928
1,831,336	Abbott	Nov. 10, 1931
2,201,575	Corneil	May 21, 1940

FOREIGN PATENTS

495,979	Germany	Apr. 12, 1930