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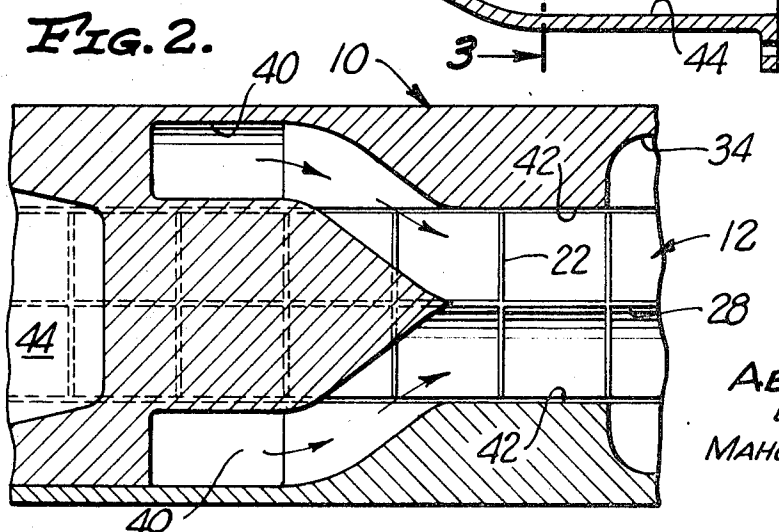
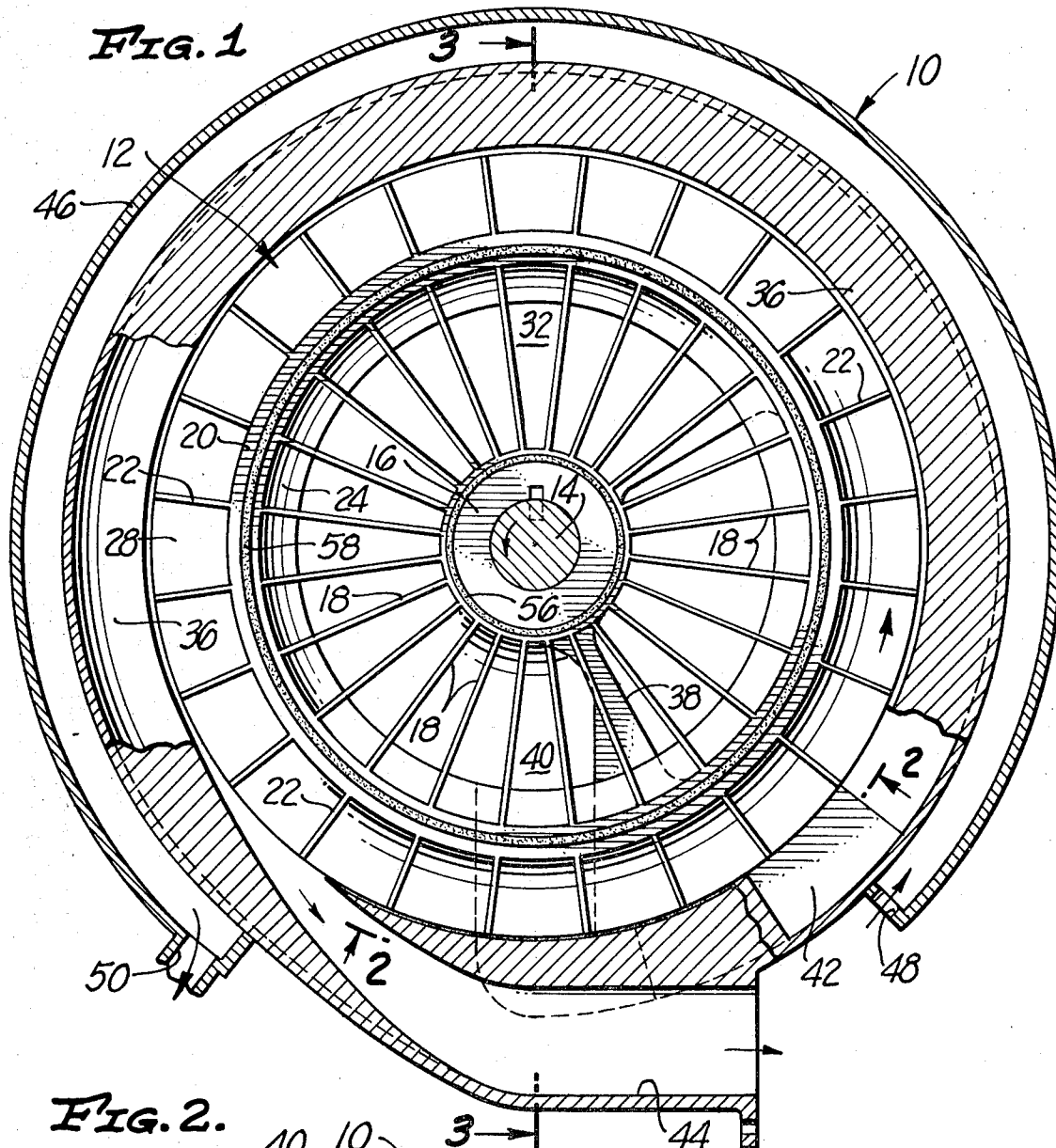
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3,560,104

TWO-STAGE, VORTEX-TYPE CENTRIFUGAL COMPRESSOR OR PUMP

Filed Feb. 28, 1969

2 Sheets-Sheet 1



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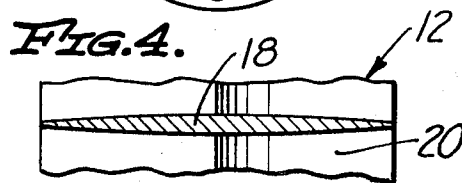
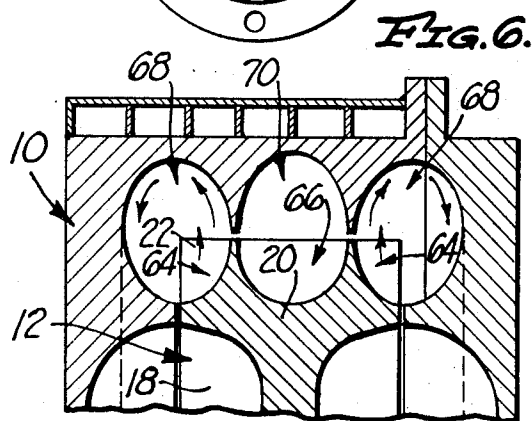
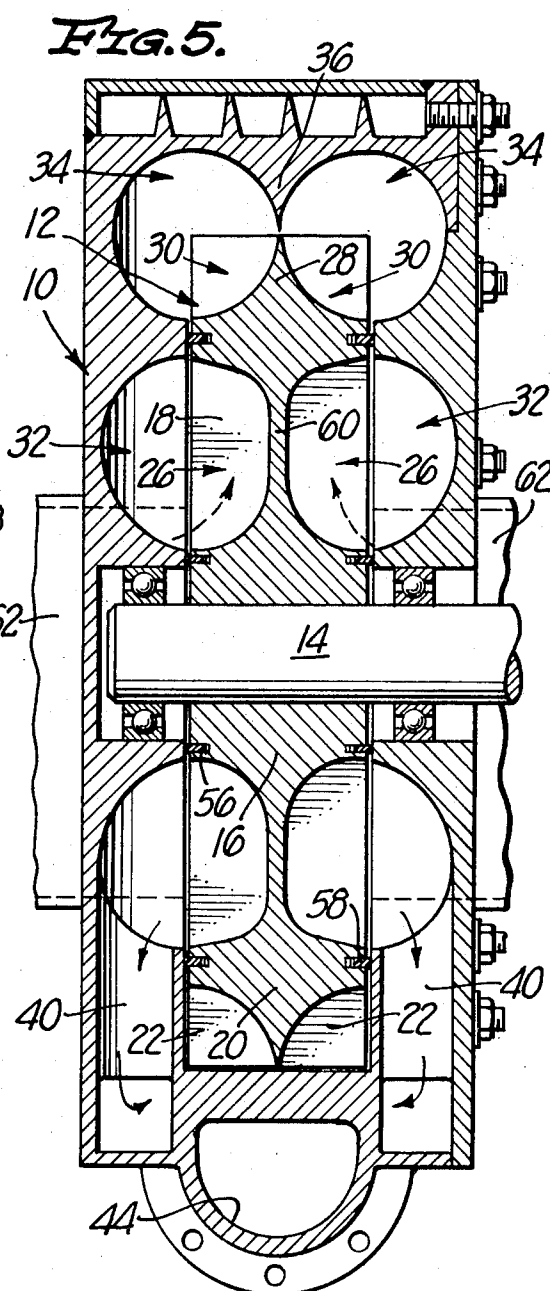
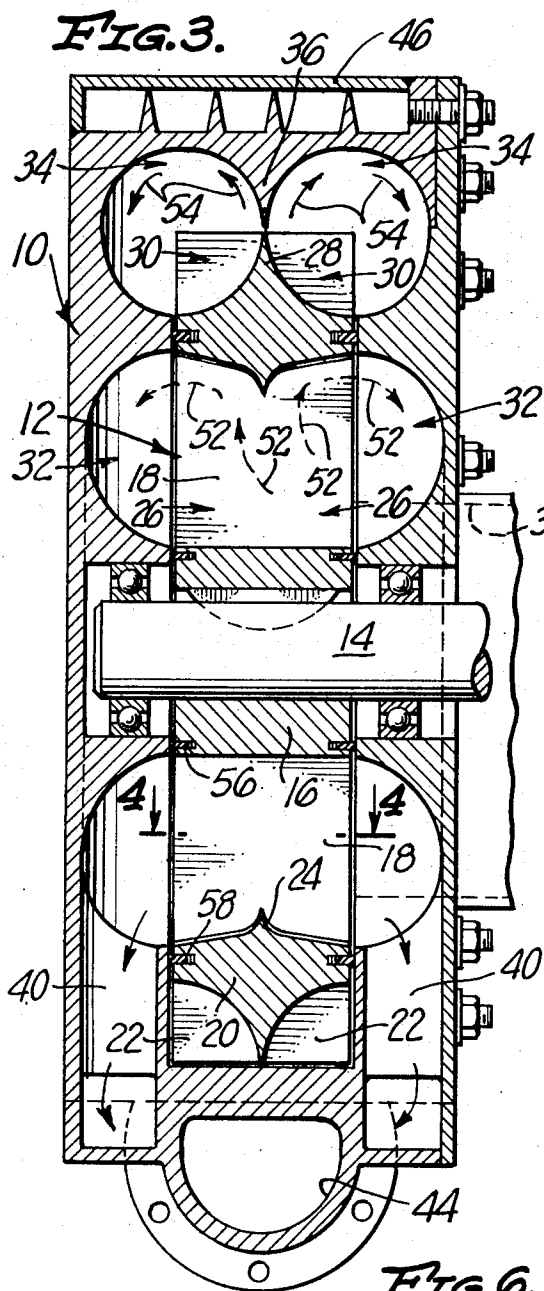
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TWO-STAGE, VORTEX-TYPE CENTRIFUGAL COMPRESSOR OR PUMP

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17 Claims

ABSTRACT OF THE DISCLOSURE

A rotor is enclosed by a housing rotatable preferably about a horizontally extending central axis, the rotor having a central first stage spindle and an annular second stage spindle spaced outwardly therefrom with first stage blades between the spindles and second stage blades projecting radially outwardly from the second stage spindle. Radially separated annular fluid cavities, preferably substantially totally arcuate in radial cross sections, are formed in the housing axially adjacent each side of the rotor axially aligned with and opening into the rotor fluid cavities formed between the first and second stage rotor blades. The second stage spindle is formed arcuately inwardly along the first stage rotor blades either partially or totally dividing the first stage rotor fluid cavities into axially adjacent parts, each part with its associated housing fluid cavity forming a combined cavity part approaching circular in radial cross section. The second stage spindle is similarly formed arcuately outwardly along the second stage blades and preferably to radially adjacent similar inward projections of the housing to provide two or three axially adjacent, combined rotor and housing second stage fluid cavities, each approaching circular in radial cross section. A fluid inlet is formed through the housing from one or both sides of the rotor into the housing first stage cavities, axially aligned fluid communications in the housing at the sides of the rotor between the first and second stage housing cavities, and a fluid outlet upwardly through the housing from all of the second stage housing cavities, the fluid inlets and outlets preferably being in the lower portion of the housing. Where necessary, a cooling fluid channel may be formed around the housing outwardly of the second stage fluid cavities and radially aligned with all of said cavities.

BACKGROUND OF THE INVENTION

This invention relates to a two-stage, vortex-type centrifugal device usable as a compressor or pump and with fluids in either the gaseous or liquid state depending on the service application desired. More particularly, this invention relates to such a centrifugal device wherein two stages are provided radially aligned, making use of the same rotor, each stage having at least two axially adjacent combined rotor and housing fluid cavity parts, all approaching circular in cross section for maximum efficiency of fluid flow. Furthermore, the foregoing improved fluid cavity shapes combined with particularly positioned and formed fluid inlets, communications between stages and outlets provide the centrifugal device of the present invention with greatly improved efficiency over similar prior devices and capable of handling far greater fluid volumes and pressures than has heretofore been possible.

Various prior forms of centrifugal devices of the general character herein involved have previously been provided, certain of which have been of two-stage form. In the prior formation of two-stage centrifugal compressors or pumps, however, it has been the usual practice to merely position two single stage devices axially aligned or side by side. In other words, the fluid outlet of the first stage

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is merely directed into the fluid inlet of the second stage so that the fluid flow is subjected to the second compression or pumping.

Various difficulties have been encountered with these prior axially aligned, two-stage centrifugal compressors and pumps, one of the major difficulties being an extremely low efficiency as a result of combinations of fluid flow turbulence, cavitation and various fluid frictional losses. Not only have these devices been improperly designed for the maximum elimination of turbulence within each stage, but also the fluid communication between the two stages has required relatively complex passages with which it is virtually impossible to eliminate turbulence and high friction losses. In addition, if increased fluid flow is desired with a given form of compressor or pump, it is only possible to provide such increased flow by increasing the size of the compressor or pump since only a single fluid inlet may be provided at the open side of the first stage, the other side of such first stage being blocked by the second stage.

Still further, in the prior centrifugal compressors or pumps, whether of the single or double stage formation, the fluid inlets and outlets have been located at the upper portions thereof, which, under various conditions, increases the tendency toward objectionable cavitation. As the fluid enters, it is moved downwardly by the rotor blades and this downward movement is aided by the fluid weight, but when the fluid reaches the lower portion of the compressor or pump, it must then move upwardly in the latter part of the rotational movement in order to finally reach the fluid outlet. During this upward movement of the fluid, the pressure thereof has increased which, combined with frictional drag and the now opposing fluid weight can cause the fluid to increase lag relative to rotational movement of the rotor, thereby resulting in a hindrance in fluid flow and a decrease in efficiency.

An even additional problem of the prior constructions has been the particular formations of the rotor and housing fluid cavities through which the fluid must flow with a minimum of turbulence and within which such fluid is compressed. Such fluid cavities have heretofore included obstructing ledges and other projections located so as to greatly disturb the smooth flow of fluid therein during the rotor rotation, again increasing frictional losses, disturbing the smooth flow of fluid and decreasing the efficiency. As an overall result of all of the foregoing problems and deficiencies, the efficiencies of the prior centrifugal compressors or pumps has seldom been more than 45 to 50% and there has been a long-felt want and need to increase such efficiency.

There have been certain attempts to decrease the problems involved and increase the efficiency, most attempts being centered about the particular blade formation of the rotors. Despite relatively complex blade formations, however, it has been impossible to increase the efficiencies even minimal amounts. Thus, despite various prior attempts, the low efficiency rate has still persisted prior to the improvements of the present invention.

OBJECTS AND SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide a two-stage, vortex-type centrifugal device usable as a compressor or pump wherein the two stages thereof are provided radially stacked in the same single rotor and with only a relatively minimal rotor increased size. The relative close proximity of the two stages permits the use of short fluid passages of maximum simplicity in configuration between the stages so as to maintain maximum smoothness of flow and minimum tendency toward turbulence. At the same time, due to the second stage merely

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being radially outwardly from the first stage, the first stage is left completely unobstructed from the opposite rotor sides so that where increased flow is desired, fluid inlets from both sides may be used, such not being possible with the prior constructions.

It is a further object of this invention to provide a centrifugal device of the foregoing type wherein the fluid cavity formation and low speed of the first stage virtually eliminates problems of cavitation in both the first and second stages. During movement of the fluid in the device during the first half of revolution and particularly in the second stage, the fluid is moved upwardly with a uniform vortex motion having sufficient momentum to overcome the force of gravity. In the second half of revolution, the fluid is moving downwardly with constant uniform vortex motion so as to be again unaffected by gravity, thereby providing an overall uniform fluid with complete vortex motion and without damaging turbulence.

It is also an object of this invention to provide a centrifugal device of the foregoing type wherein fluid frictional losses are greatly reduced by improved fluid cavity contouring and shaping directed toward increased smooth uniform fluid flow and undisturbed vortex motion within the fluid cavities reducing turbulence losses to a minimum. The first stage fluid cavities in the rotor are smoothly and arcuately divided into axially adjacent equal parts, each part communicating axially with a conforming housing fluid cavity, the combined rotor and housing cavity parts preferably approaching circular in radial cross section. The second stage combined rotor and housing cavity parts are similarly formed, either as double or triple cavity parts, the prime difference being that the second stage combined cavity parts are preferably defined by closely adjacent annular rotor and housing projections. The resulting increased smoothness of flow and minimal turbulence greatly improve the overall efficiency of the device.

It is still an additional object of the present invention to provide a centrifugal device of the foregoing character which is of maximum versatility and is adapted for relatively simple changes to meet varying conditions and requirements encountered in both centrifugal compressors and pumps.

Merely as an example, where increased fluid volume is desired, the previously discussed dual fluid inlet from opposite sides of the rotor into the first stage thereof may be provided, and such may be augmented by increasing the cross sectional areas of the overall second stage cavities. As another example, when increased suction characteristics are required, the first stage housing cavity exit may be partially blocked to prevent direct free flow from the first to second stage, thereby retarding flow and increasing such characteristics. Thus, the centrifugal device of the present invention may be adapted for virtually any requirement while still maintaining the basic improvements herein discussed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view of an embodiment of the centrifugal device of the present invention taken through the housing thereof axially spaced from one side of the rotor and with parts thereof broken away to show certain details of construction;

FIG. 2 is a fragmentary, circumferential sectional view looking in the direction of the arrows 2—2 in FIG. 1;

FIG. 3 is a fragmentary, vertical sectional view looking in the direction of the arrows 3—3 in FIG. 1;

FIG. 4 is an enlarged, fragmentary, horizontal sectional view looking in the direction of the arrows 4—4 in FIG. 3;

FIG. 5 is a view similar to FIG. 3 but of a slightly modified form of centrifugal device; and

FIG. 6 is a fragmentary, vertical sectional view of still a further modified form of centrifugal device.

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DESCRIPTION OF THE BEST EMBODIMENTS CONTEMPLATED

Referring to FIGS. 1 through 4, the centrifugal device shown therein and incorporating certain of the principles of the present invention includes a housing generally indicated at 10 enclosing a rotor generally indicated at 12, the housing and rotor assembly preferably being positioned with the rotor central axis extending horizontally. Further, the housing 10 and rotor 12 may be formed of usual materials and by conventional manufacturing methods all within the knowledge of those skilled in the art and dependent on the particular application requirements of the construction. Also, as is true of many centrifugal devices of this character, the centrifugal devices of the present invention may be adapted for use as either compressors or pumps, and the working fluids may be gaseous or liquid with only the usual slight modifications required.

More particularly to the mounting and construction of the rotor 12, a central driven shaft 14 rotatably mounts the rotor in the housing 10 and is telescoped by a rotor central first stage spindle 16 keyed to the shaft. The central first stage spindle 16, in turn, mounts a series of circumferentially spaced, radially extending rotor first stage blades 18 projecting outwardly and having the outer extremities thereof secured to a radially outwardly surrounding, annular rotor second stage spindle 20. A series of circumferentially spaced, radially outwardly extending rotor second stage blades 22 are secured to the second stage spindle 20, the second stage blades preferably being radially aligned with the first stage blades and all of said blades preferably extending axially parallel to the central axis of the rotor 12.

As best seen in FIG. 3, the rotor second stage spindle 20 is formed axially midway thereof with a circumferentially extending, radially inwardly projecting first stage rotor cavity divider 24 blending oppositely axially arcuately into the remainder of the second stage spindle axially toward opposite sides of the rotor 12, said divider extending circumferentially totally between the rotor first stage blades 18. As shown in FIG. 3, in this first embodiment form of the centrifugal device of the present invention, the first stage rotor cavity divider only projects radially partially into the first stage rotor cavities formed circumferentially between the first stage blades 18, but for fluid flow purposes effectively divides the rotor first stage cavities into axially adjacent and axially equal rotor first stage cavity parts 26. The consequence of such rotor first stage cavity division by the rotor cavity divider 24 as it affects fluid flow within said cavity will be hereinafter discussed more in detail.

Still as shown in FIG. 3 the second stage spindle 20 is formed radially outwardly with a circumferential, oppositely axially arcuate, second stage rotor cavity divider 28, axially centrally thereof and preferably totally circumferentially between the second stage blades 22. The second stage rotor cavity divider 28 preferably extends radially outwardly totally of the second stage blades 22 terminating radially outwardly co-extensive with such second stage blades. Furthermore, the second stage rotor cavity divider 28 is oppositely axially arcuate preferably totally to the axial extremities of the second stage blades 22 or the side extremities of the second stage spindle 20 and the rotor 12, whereby rotor second stage cavities formed circumferentially between the second stage blades 22 are divided into axially adjacent and equal rotor second stage cavity parts 30.

The housing 10 axially adjacent and radially aligned with the rotor first stage cavity parts 26 is formed with axially opposite, annular fluid cavities constituting housing first stage cavity parts 32. The housing first stage cavity parts 32 at the opposite sides of the rotor 12 are preferably totally arcuate in radial cross section as shown in FIG. 3 and preferably extend radially co-extensive with the rotor first stage cavity parts 26. Thus, each of the

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housing first stage cavity parts 32 with its axially adjacent rotor first stage cavity parts 26 forms for fluid flow purposes a combined housing and rotor first stage cavity part at each half of the rotor 12 and as circumferentially interrupted by the first stage blades 18 which approaches circular in radial cross section, that is, in a radial plane extending axially parallel to and through the main axis of the rotor 12.

Similar housing second stage cavity parts 34 are formed in the housing axially adjacent the rotor second stage cavity parts 30 with the exception that the housing second stage cavity parts preferably extend totally axially adjacent and totally radially outwardly adjacent the rotor second stage cavity parts as provided by the radially inwardly projecting, circumferential second stage housing cavity divider 36. Thus, the housing second stage cavity parts 34 are annular and are preferably arcuate throughout the same radial cross sections thereof as shown in FIG. 3, and with the rotor second stage cavity parts 30 form combined housing and rotor second stage cavity parts which are axially adjacent and substantially equal. Also, in the radial plane parallel to and extending through the main axis of the rotor 12, the combined housing and rotor second stage cavity parts approach circular in radial cross section.

The cross sectional shapes of the rotor first stage blades 18 are illustrated in FIG. 4, the same being relatively axially flat with only a slight decreasing thickness from the midpoints outwardly to sharpened edges in order to reduce drag relative to the fluid being circulated. The rotor second stage blades 22 may be of similar cross section with the important point being that neither the first stage blades 18 nor the second stage blades 22 are required to be of complex shapes, but rather of the simple shapes shown.

Referring to FIGS. 1 and 3, a single fluid inlet 38 is formed axially through the housing 10 into one of the housing first stage cavity parts 32. Important to the principles of the present invention, the single fluid inlet 38, as shown in FIG. 1, although extending partially vertically above the horizontal main axis of the rotor 12, has the major portion thereof vertically below this rotor horizontal central axis so that the major portion thereof is positioned opening axially into the one housing first stage cavity part 32 at the lower portion of the rotor 12.

Circumferentially separated from but adjacent and axially aligned with the lowermost portion of the rotor 12, the housing 10 is formed with axially opposite and axially aligned fluid passages 40 as shown in FIGS. 1, 2 and 3 extending generally radially between each of the housing first stage cavity parts 32 and the respective housing second stage cavity part 34 at that side of the rotor 12. As shown in FIG. 2, these fluid passages 40 are of equal axial cross section and uniform in such cross section extending axially angularly into the rotor second stage cavity parts 30 from the opposite sides of the rotor 12. Furthermore, the fluid passages 40 are of substantially the same radial cross sectional areas as the housing second stage cavity parts 34 into which these fluid passages empty forming a preferably unrestricted inlet throat 42 into the housing second stage cavity parts as shown in FIG. 2.

A generally circumferentially extending, angularly radially outwardly projecting fluid outlet 44 is formed from the combined rotor second stage cavity parts 30 and housing second stage cavity parts 34 within the housing 10 as shown in FIGS. 1 and 3. This fluid outlet 44 communicates with the combined rotor second stage cavity parts 30 and housing second stage cavity parts 34 spaced slightly circumferentially from the location of the fluid passages 40 and at the opposite circumferential sides thereof from the fluid inlet 38 and opens outwardly of the housing 10 partially nested axially between the fluid passages 40. As partially shown in FIG. 2, as the fluid outlet 44 projects angularly outwardly away from the combined second stage cavity parts, it reduces in axial width while simul-

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taneously increasing in radial dimensions so that the cross sectional area thereof remains substantially constant so as to provide an unrestricted fluid outlet.

If conditions require, depending on the use of the centrifugal device of the present invention, a cooling fluid jacket 46 may be formed on the housing 10 circumferentially surrounding the major portion of said housing spaced radially outwardly from the combined rotor second stage cavity parts 30 and housing second stage cavity parts 34 as shown in FIGS. 1 and 3, said cooling fluid jacket preferably extending axially totally across these combined rotor and housing cavity parts. The provision of the cooling fluid jacket 46 would be most usual when the centrifugal device of the present invention is used as a compressor and such cooling fluid jacket may be provided with the usual cooling fluid inlet 48 and cooling fluid outlet 50. Also, if desirable, the cooling fluid outlet may be directed into the main fluid outlet 44 if mixing with the outlet fluids is desired in the usual manner, for instance, where the centrifugal device is being used as a compressor to compress air for an air-fuel mixture and the cooling fluid within the cooling jacket 46 is fuel, all well known to those skilled in the art.

In use of the first embodiment form of the centrifugal device of the present invention as described, the rotor 12 is driven through the shaft 14 in the counterclockwise direction as shown in FIG. 1 and the mainstream of fluid enters the fluid inlet 38 into the rotor first stage cavity parts 26 as indicated by the direction arrows 52 in FIG. 3. The rotation of the rotor 12 moving the rotor first stage blades 18 causes the fluid to move radially outwardly within the rotor by centrifugal force at both axial sides of the first stage rotor cavity divider 24. As also shown by the direction arrows 52 in FIG. 3, this centrifugal movement of the fluid combined with the described arcuate formations of the rotor first stage cavity parts 26 and their axially adjacent housing first stage cavity parts 32 sets up oppositely circularly rotating fluid movements in the opposite axial directions from the midpoint of the rotor 12, axially outwardly from the rotor first stage cavity parts into the housing first stage cavity parts and circularly radially inwardly and back into the rotor first stage cavity parts at each of the opposite sides of the rotor.

Keeping in mind that the fluid within the rotor first stage cavity parts 26 is being circumferentially driven by the moving rotor first stage blades 18 and the fact that the housing 10 is stationary, the circular movement of the fluid within the housing first stage cavity parts 32 will tend to lag the fluid within the rotor first stage cavity parts resulting in a complex circumferentially lengthened somewhat spiral fluid movement. This complex fluid movement is known as vortex movement and is well known to those skilled in the art. Furthermore, this vortex fluid movement imparts circumferential movement to the fluid and begins to build pressure therein.

The fluid within the combined rotor and housing first stage cavity parts 26 and 32 moved circumferentially by the driven rotor 12 ultimately reaches the fluid passages 40 and the major portion thereof passes radially outwardly and downwardly through the fluid passages, smoothly through the second stage inlet throat 42 and ultimately circumferentially into the combined rotor and housing second stage cavity parts 30 and 34. Due to the vortex movement of the fluid within the first stage and the axially angular inwardly converging connection of the fluid passages 40 into the second stage, the fluid takes on the same vortex movement within the combined rotor and housing second stage cavity parts 30 and 34, that is, oppositely axially circular in radial cross section as indicated by the directional arrows 54 in FIG. 3. The fluid is forced circumferentially about the second stage in this vortex movement building up the pressure therein desired to ultimately reach the fluid outlet 44 and the major portion thereof passing outwardly through said fluid outlet and outwardly of the centrifugal device.

According to certain improvements of the present invention, due to the fact that the first stage is at less radius and, therefore, of less peripheral speed than the outer second stage, fluid entering the first stage does not receive a large velocity increase nor consequent pressure drop, thus minimizing usual dangers of cavitation. Furthermore, as velocity is increased, particularly in the second stage, the smooth vortex flow has been set up as previously described. Thus these features, particularly combined with the other features of the present construction, virtually eliminate the dangers of cavitation in the improved device.

The radial stacking of the two stages of the centrifugal device minimizes losses therein by providing the fluid passages 40 between the stages of minimum length as opposed to the axially adjacent stages of the two-stage centrifugal devices of the prior constructions. Fluid leakage between the two stages of the present invention is easily prevented despite the rotation of the rotor 12 relative to the housing 10 by the use of conventional seals between the rotor and housing of any usual form, for instance, slidable rotor seals 56 and 58 between the rotor first and second stage spindles 16 and 20 bearing axially against the housing 10. Also, as hereinbefore pointed out, where the centrifugal device of the present invention is used as a compressor, the cooling fluid jacket 46 may be provided and cooling fluids circulated therethrough such as water or other liquids or gases.

Various usual and well known modifications may be made to the centrifugal device shown in FIGS. 1 through 4 as specific requirements dictate, all of which are well known to those skilled in the art and need not be illustrated herein. For instance, the particular form of centrifugal device shown in FIGS. 1 through 4 would normally be for higher fluid flow conditions and high compression. Where higher suction is required with slightly reduced flow, various usual obstructions may be placed in or associated with the fluid passages 40 between stages and the fluid outlet 44 from the second stage requiring circuitous movement of the fluid to slightly restrict the flow thereof and cause a greater pressure build-up within the centrifugal device.

A modified form of the centrifugal device of the present invention is shown in FIG. 5 and operates in most respects substantially identical to the first embodiment form previously described. The FIG. 5 modified form, however, includes a first stage rotor cavity divider 60 extending radially the entire radial distance between the rotor first and second stage spindles 16 and 20, totally separating the axially adjacent rotor first stage cavity parts 26. Also, this modified form of FIG. 5 includes dual, axially opposite fluid inlets 62 in the housing 10 communicating into the housing first stage cavity parts 32.

The dual fluid inlets 62 permit a freer and higher volume of fluid flow into the centrifugal device while the complete separation of the rotor first stage cavity parts 26 eliminate any fluid mixing, friction and turbulence axially midway of the rotor 12 providing more perfect vortex fluid flow within the axially adjacent combined rotor and housing first stage cavity parts 26 and 32. Otherwise, the operation of the centrifugal device is the same and the advantages thereof are the same, with this added advantage.

The form of centrifugal device shown in FIG. 6 is still further slightly modified from that of FIG. 5 in that the rotor 12 is formed with three separate rotor second stage cavity parts, axially separated and opposed side cavity parts 64 and a central cavity part 66, with corresponding housing cavity parts, side cavity parts 68 and a central cavity part 70. This modification merely provides increased volume in the second stage of the centrifugal device and otherwise the centrifugal device operates in the same manner and with the same advantages.

Thus, according to the principles of the present invention, a two-stage, vortex-type centrifugal device usable as a compressor or pump is provided having far increased

efficiency over similar prior centrifugal devices, the present centrifugal device accomplishing efficiencies in the order of 60% to 75% whereas the prior devices operate at efficiencies in the order of 45% to 50%. At the same time, a centrifugal device is herein provided which is highly versatile and is readily adaptable to many modifications and changes necessary in order to meet varying desired operating conditions and service requirements.

I claim:

1. In a two-stage, vortex-type centrifugal device usable as a compressor or pump, the combination of: a housing; a rotor in said housing rotatable about a central axis and including, a central first stage spindle, a plurality of circumferentially spaced first stage blades secured extending generally radially outwardly from said first stage spindle and forming first stage rotor fluid cavities circumferentially therebetween, an annular second stage spindle secured surrounding outer extremities of said first stage blades radially outwardly closing said first stage rotor fluid cavities, a plurality of circumferentially spaced second stage blades secured extending generally radially outwardly from said second stage spindle and forming second stage rotor fluid cavities circumferentially therebetween; first stage rotor cavity divider means on said second stage spindle extending circumferentially between said first stage blades and projecting radially inwardly at least partially into said first stage rotor fluid cavities separating each of said cavities into two substantially equal axially adjacent cavity parts; an annular first stage housing fluid cavity formed in said housing axially adjacent each side of said rotor and opening axially into axially adjacent of said cavity parts of said first stage rotor, said first stage housing and rotor fluid cavities forming axially adjacent combined first stage fluid cavity parts; second stage rotor cavity divider means on said second stage spindle extending circumferentially between said second stage blades and projecting radially outwardly at least partially into said second stage rotor fluid cavities separating each of said cavities into substantially equal axially adjacent cavity parts; an annular second stage housing fluid cavity formed in said housing axially adjacent each side of said rotor and opening axially into axially adjacent of said cavity parts of said second stage rotor, said second stage housing and rotor fluid cavities forming at least two axially adjacent combined second stage fluid cavity parts, each of said second stage housing fluid cavities being separated from said first stage housing fluid cavities at that side of said rotor by portions of said housing axially adjacent portions of said second stage spindle; a fluid inlet formed axially through said housing communicating with at least one of said first stage housing fluid cavities; a fluid passage formed in said housing generally radially between each of said first stage housing fluid cavities and said second stage housing fluid cavity at that side of said rotor, said fluid passages at said rotor sides being generally axially aligned; and a fluid outlet formed in said housing communicating between all of said combined second stage fluid cavity parts and outward of said housing.

2. A centrifugal device as defined in claim 1 in which said fluid inlet is one of two fluid inlets formed generally axially through said housing with one being at each of said sides of said rotor and communicating with said first stage housing fluid cavity at that rotor side.

3. A centrifugal device as defined in claim 1 in which said fluid inlet is one of two fluid inlets formed generally axially through said housing with one being at each of said sides of said rotor and communicating with said first stage housing fluid cavity at that rotor side; and in which said first stage rotor cavity divider means extend totally radially between said first and second stage spindles completely axially separating said first stage rotor fluid cavity parts.

4. A centrifugal device as defined in claim 1 in which said second stage rotor cavity divider means project radially outwardly to radially adjacent portions of said housing substantially completely axially separating said second stage rotor fluid cavity parts.

5. A centrifugal device as defined in claim 1 in which said second stage rotor cavity divider means project radially outwardly into said second stage rotor fluid cavities substantially axially midway of said cavities separating each of said cavities into two substantially equal axially adjacent cavity parts.

6. A centrifugal device as defined in claim 1 in which said fluid inlet is one of two fluid inlets formed generally axially through said housing with one being at each of said sides of said rotor and communicating with said first stage housing fluid cavity at that rotor side; in which said first stage rotor cavity divider means extend totally radially between said first and second stage spindles completely axially separating said first stage rotor fluid cavity parts; and in which said second stage rotor cavity divider means project radially outwardly to radially adjacent portions of said housing substantially completely axially separating said second stage rotor fluid cavity parts.

7. A centrifugal device as defined in claim 1 in which cooling fluid passage means is formed in said housing extending circumferentially a major portion therearound spaced radially outwardly from and at least in radial alignment with each of said combined second stage fluid cavity parts.

8. A centrifugal device as defined in claim 1 in which said fluid inlet is one of two fluid inlets formed generally axially through said housing with one being at each of said sides of said rotor and communicating with said first stage housing fluid cavity at that rotor side; in which said first stage rotor cavity divider means extend totally radially between said first and second stage spindles completely axially separating said first stage rotor fluid cavity parts; in which said second stage rotor cavity divider means project radially outwardly to radially adjacent portions of said housing substantially completely axially separating said second stage rotor fluid cavity parts; and in which said second stage rotor cavity divider means project radially outwardly into said second stage rotor fluid cavities substantially axially midway of said cavities separating each of said cavities into two substantially equal axially adjacent cavity parts.

9. A centrifugal device as defined in claim 1 in which said rotor is positioned with said central axis thereof extending generally horizontal; in which said fluid inlet is formed in said housing with a major portion thereof below said rotor horizontal axis; and in which said fluid outlet is formed in said housing totally below said rotor horizontal axis.

10. A centrifugal device as defined in claim 1 in which said rotor is positioned with said central axis thereof extending generally horizontal; in which said fluid inlet is formed in said housing with a major portion thereof below said rotor horizontal axis; in which said fluid outlet is formed in said housing totally below said rotor horizontal axis; and in which said inlet is one of two fluid inlets formed generally axially through said housing with one being at each of said sides of said rotor and communicating with said first stage housing fluid cavity at that rotor side.

11. A centrifugal device as defined in claim 1 in which said rotor is positioned with said central axis thereof extending generally horizontal; in which said fluid inlet is formed in said housing with a major portion thereof below said rotor horizontal axis; in which said fluid outlet is formed in said housing totally below said rotor horizontal axis; in which said fluid inlet is one of two fluid inlets formed generally axially through said housing with one being at each of said sides of said rotor and communicating with said first stage housing fluid cavity at that rotor side; in which said first stage rotor cavity

divider means extend totally radially between said first and second stage spindles completely axially separating said first stage rotor fluid cavity parts; and in which said second stage rotor cavity divider means project radially outwardly to radially adjacent portions of said housing substantially completely axially separating said second stage rotor fluid cavity parts.

12. In a two-stage, vortex-type centrifugal device usable as a compressor or pump, the combination of: a housing; a rotor in said housing rotatable about a central axis and including, a central first stage spindle, a plurality of circumferentially spaced first stage blades secured extending generally radially outwardly from said first stage spindle and forming first stage rotor fluid cavities circumferentially therebetween, an annular second stage spindle secured surrounding outer extremities of said first stage blades radially outwardly closing said first stage rotor fluid cavities, a plurality of circumferentially spaced second stage blades secured extending generally radially outwardly from said second stage spindle and forming second stage rotor fluid cavities circumferentially therebetween; first stage rotor cavity divider means on said second stage spindle extending circumferentially between said first stage blades and projecting radially inwardly at least partially into said first stage rotor fluid cavities separating each of said cavities into two substantially equal axially adjacent cavity parts; an annular first stage housing fluid cavity formed in said housing axially adjacent each side of said rotor and opening axially into axially adjacent of said cavity parts of said first stage rotor fluid cavities from axially opposite sides of said rotor, said first stage housing and rotor fluid cavities forming axially adjacent combined first stage fluid cavity parts; second stage rotor cavity divider means on said second stage spindle extending circumferentially between said second stage blades and projecting radially outwardly at least partially into said second stage rotor fluid cavities separating each of said cavities into axially adjacent cavity parts; an annular second stage housing fluid cavity formed in said housing axially adjacent each side of said rotor and opening axially into axially adjacent of said cavity parts of said second stage rotor fluid cavities from axially opposite sides of said rotor, said second stage housing and rotor fluid cavities forming axially adjacent combined second stage fluid cavity parts; said first and second stage rotor cavity divider means in a radial plane parallel and intersecting said rotor central axis being formed facing the respective of said combined first and second stage fluid cavity parts with arcuate surfaces blending smoothly into axially adjacent surfaces of said combined cavity parts, said first and second stage housing fluid cavities in said radial plane being formed with substantially continuous arcuate surfaces, said divider means arcuate surfaces and said housing fluid cavity arcuate surfaces cooperating providing said combined first and second stage fluid cavity parts each with major portions thereof formed by said arcuate surfaces; a fluid inlet formed axially through said housing into communication with at least one of said first stage housing fluid cavities; a fluid passage formed in said housing generally radially between each of said first stage housing fluid cavities and said second stage housing fluid cavity at that rotor side, said fluid passages being generally axially aligned; and a fluid outlet through said housing communicating between each of said second stage housing fluid cavities and outwardly of said housing.

13. A centrifugal device as defined in claim 12 in which said fluid inlet is one of two fluid inlets extending oppositely axially through said housing toward opposite of said rotor sides and into communication with said first stage housing fluid cavity at that of said rotor sides.

14. A centrifugal device as defined in claim 12 in which said fluid inlet is one of two fluid inlets extending oppositely axially through said housing toward opposite

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of said rotor sides and into communication with said first stage housing fluid cavity at that of said rotor sides; and in which said first stage rotor cavity divider means extends radially totally between said first and second stage spindles blending smoothly arcuately into each of said spindles and totally axially separating said first stage rotor fluid cavity parts.

15. A centrifugal device as defined in claim 12 in which said second stage rotor cavity divider means projects radially outwardly to radially adjacent corresponding radially inward projection means of said housing totally axially separating said combined second stage fluid cavity parts.

16. A centrifugal device as defined in claim 12 in which said second stage rotor cavity divider means is located substantially axially midway of said rotor dividing said second stage rotor fluid cavities into two substantially equal axially adjacent cavity parts, said second stage rotor cavity divider means projecting radially outwardly to radially adjacent a corresponding inward radial projection of said housing totally separating said cavity parts of each of said combined second stage fluid cavity parts, said housing projection being formed with said arcuate surfaces blending smoothly into other surfaces of said combined second stage fluid cavity parts.

17. A centrifugal device as defined in claim 12 in which said second stage rotor cavity divider means is located substantially axially midway of said rotor dividing said second stage rotor fluid cavities into two substantially equal axially adjacent cavity parts, said second stage rotor cavity divider means projecting radially out-

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wardly to radially adjacent a corresponding inward radial projection of said housing totally separating said cavity parts of each of said combined second stage fluid cavity parts, said housing projection being formed with said arcuate surfaces blending smoothly into other surfaces of said combined second stage fluid cavity parts; and in which cooling fluid passages are formed in said housing extending circumferentially and spaced radially outwardly from each of said combined second stage fluid cavity parts.

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