

Nov. 3, 1959

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2,911,189

FLUID MACHINE

Filed July 20, 1953

4 Sheets-Sheet 1

FIG. 1

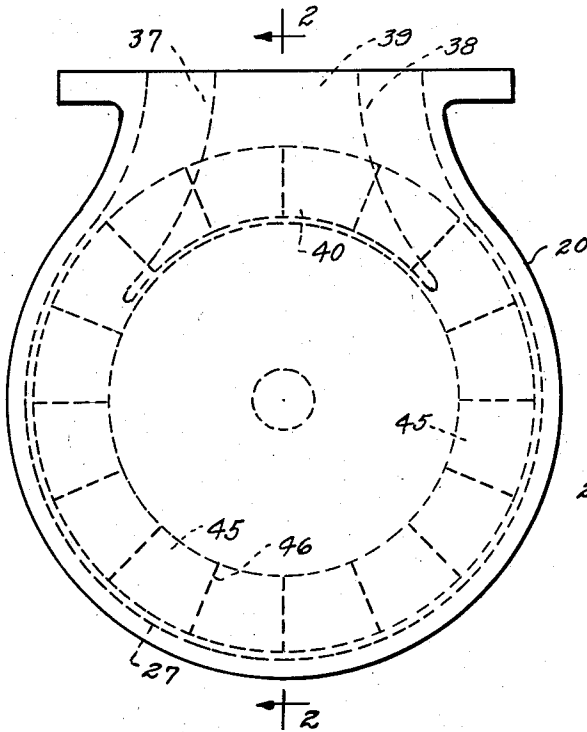


FIG. 2

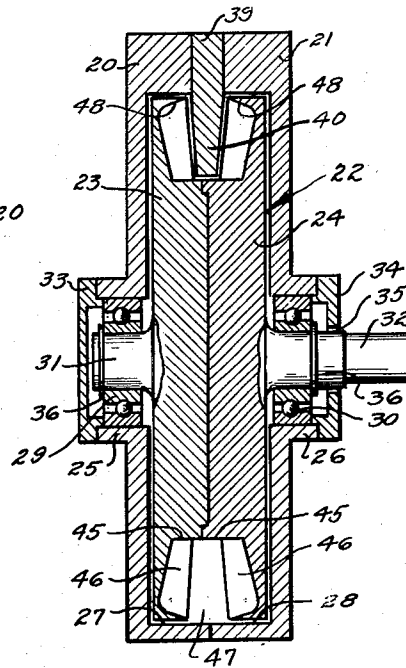


FIG. 3

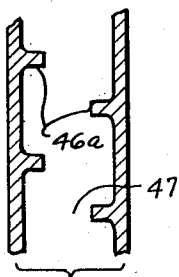


FIG. 4

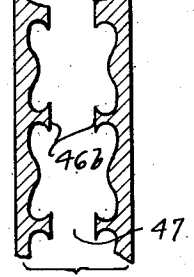


FIG. 5

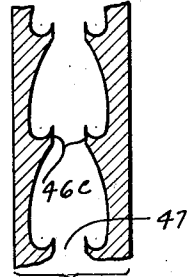
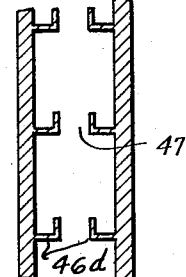


FIG. 6



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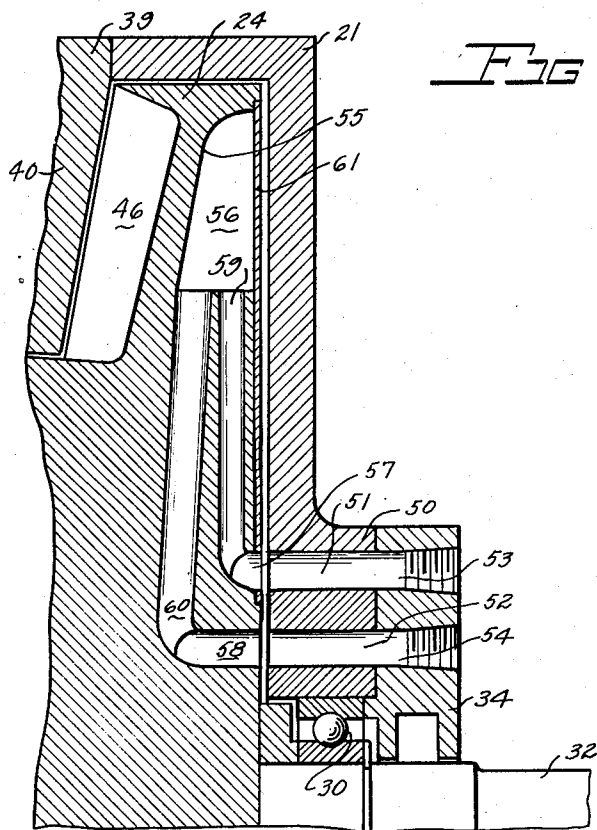


FIG. 7

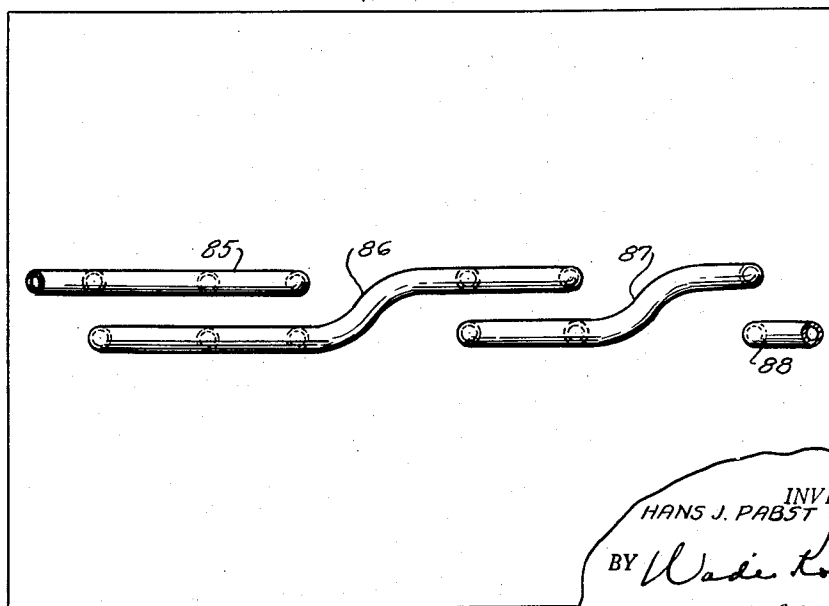


FIG. 9

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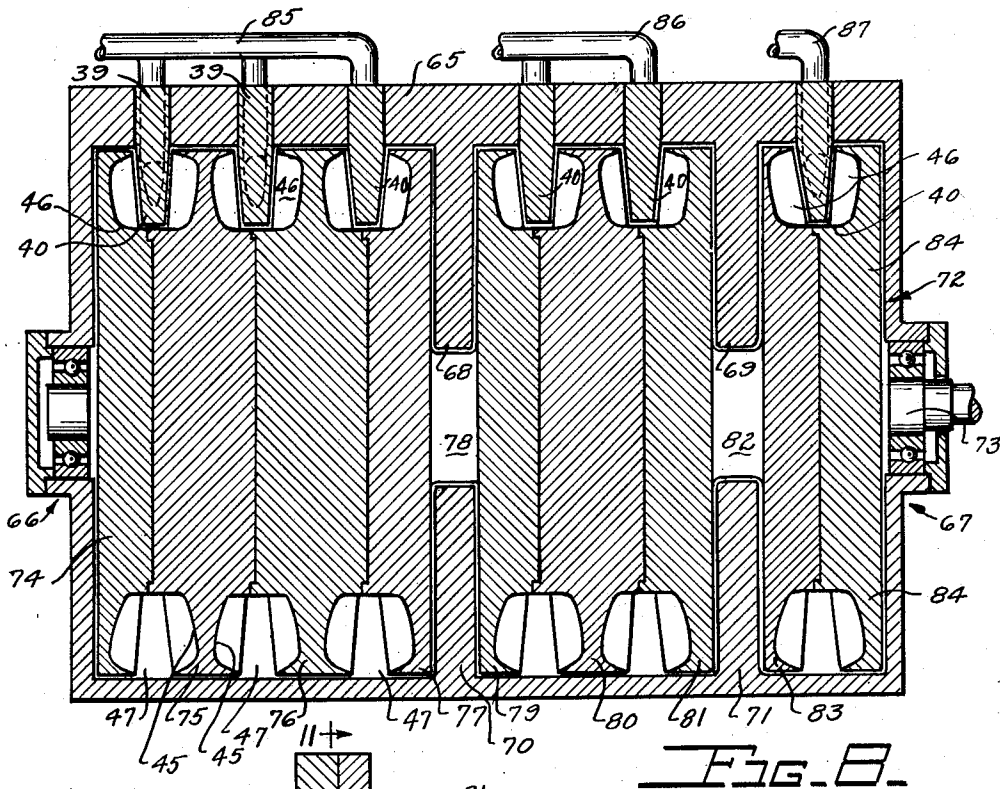


FIG. 8.

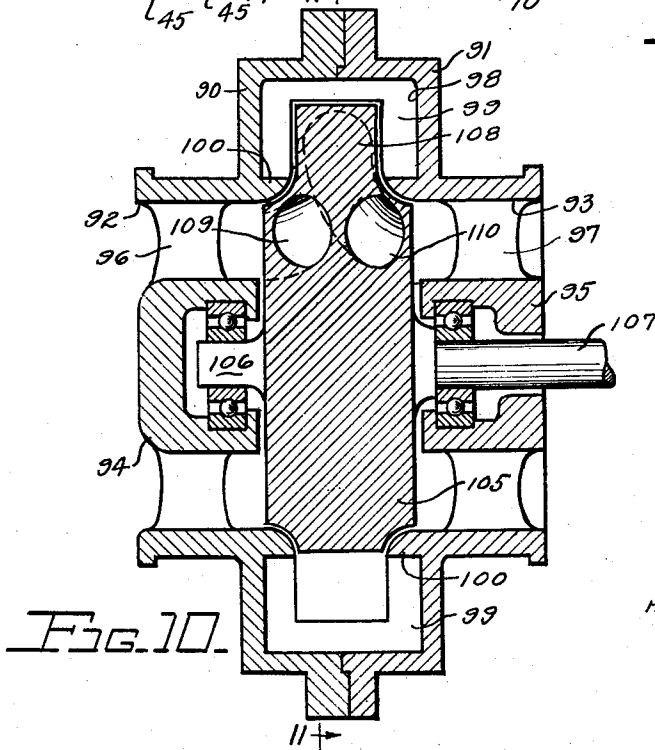


FIG. 10.

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2,911,189

FLUID MACHINE

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3 Claims. (Cl. 253—91)

(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to fluid machines and more particularly to fluid machines of the type capable of being operated as a pump, a compressor, or a turbine characterized in the utilization of high pressure coefficients and low values of volume flow per second resulting in extremely low values of specific revolutions per minute making such machines very useful for small applications.

In the present invention only two primary parts are used, a stator housing and a rotor in the housing. Between the periphery of the rotor and the housing is a ring channel or annular passage which is blocked over a short portion of its circular extent by a baffle extension on one of the two primary elements. Inlet and outlet ports enter, one each, on opposite sides of the baffle extension. The primary element not having the baffle extension thereon has vanes or buckets thereon facing inwardly in the ring channel and in close relation to the baffle extension whereby fluid passing from the inlet to the outlet will cause rotation of the rotor in the case of a fluid motor or turbine, or in the case of a pump or compressor the fluid will be drawn in through the inlet port and forced out through the outlet port. The vanes or buckets are shaped as high resistance nozzles to offer the greatest resistance to fluid flow whereby the rotor speed will very nearly approach that of the fluid flow. These vanes or buckets may be designed to offer resistance to fluid flow in either direction so that the same machine may be operated as a motor or a compressor, or perform both functions at the same installation. The rotor and housing may be cooled where the fluid machine is to operate under heat conditions. The inner surfaces of the primary elements may also have a ceramic coating placed thereon to protect metal portions exposed to hot fluids. The two primary elements may be made in plural arrangements to provide a plurality of stages, where desirable. It is therefore a general object of this invention to provide a highly efficient fluid motor or turbine, pump or compressor by increasing the effectiveness in the vanes or buckets to resist fluid flow thereover and so positioning the vanes, the inlet, the outlet, and the baffle extension between the inlet and outlet to produce rotor speeds corresponding to the velocity of the fluid flow from inlet to outlet.

These and other objects, advantages, features, and uses will become more apparent as the description proceeds when taken in consideration of the drawings, in which:

Fig. 1 is a side elevational view of the fluid machine with dotted lines indicating some of the internal structure;

Fig. 2 is a longitudinal cross-sectional view of the machine taken along the line 2—2 of Fig. 1;

Fig. 3 is a cutaway cross-sectional view of one type of vane or bucket structure;

Fig. 4 is a cutaway cross-sectional view of another type of vane or bucket structure;

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Fig. 5 is a cutaway cross-sectional view of still another type of vane or bucket structure;

Fig. 6 is a cutaway cross-sectional view of a further modification of vane or bucket structure;

Fig. 7 is a partial cross-sectional view of a cooling construction of the rotor assembly;

Fig. 8 is a cross-sectional view of the fluid machine in several stages;

Fig. 9 is a top plan view of the multi-stage fluid machine of Fig. 8 showing the intake and outlet manifolding;

Fig. 10 is a longitudinal cross-sectional view of a modification of the fluid machine with some structural parts shown in dashed lines;

Fig. 11 is a cross-sectional view of the housing of Fig. 10 taken along the lines 3—3 with the rotor therein shown in elevation; and

Fig. 12 is a longitudinal cross-sectional view of a two-stage fluid machine following the modification structural design of Figs. 10 and 11.

Referring more particularly to Figs. 1 and 2, there is shown a construction of the fluid machine of this invention in its simplest form. A stator housing consisting of two similar companion halves 20 and 21 houses a rotor 22 made of two disk members 23 and 24. The external appearance of the housing 20 may be of any desirable configuration but is preferably circular to conserve material. The housing has concentric journal flanged end openings 25 and 26. Each companion half housing has a cylindrical bore 27 and 28 which are aligned to provide a cylindrical chamber in which the rotor 22 is free to rotate. In each journal flange opening 25 and 26 is a frictionless type bearing 29 and 30, respectively, of well known construction which supports in the inner race respectively a shaft extension 31 on the rotor disk member 23 and a shaft extension 32 on the rotor disk member 24. A bearing retainer and cap 33 is detachably fixed to the journal flange 25 as by screw threads, cap screws, or the like, while a bearing retainer 34 on the other journal flange 26 has a concentric opening 35 therein to allow the shaft extension 32 to pass to the exterior of the housing 21. The shaft extension 32 may be used as an input or output shaft, depending on whether the device is to be used as a pump or motor in a manner later to be described. The bearings 29 and 30 may each be held in position on the shaft extensions by snap rings 36 as is well known in the art. The housing 20—21 has two ports 37 and 38 substantially radially entering the cylindrical chamber 27—28, the two ports being separated by a wall 39 that extends inwardly past the wall of the cylindrical chamber 27—28 to form a baffle extension 40. The wall 39 and baffle extension 40 may be made integral with one of the companion housing members but is preferably a separate part with means to be assembled by the portion 39 on one of the companion housing members. As may best be realized in the drawing, the wall 39 becomes progressively wider with graceful curves as it progresses toward the center of the housing and the baffle extension 40 also becomes progressively thinner for reasons presently to be explained.

The rotor 22, as before stated, is made preferably of two disk members 23 and 24 to expedite machining operations which members may be joined in any well known manner as by screws, bolts, or the like. Near the outer periphery of each rotor disk member is an annular channel 45 on the inner face thereof with radial vanes or buckets 46 equidistantly spaced therearound. The vanes 46 extend outwardly only partially across the annular channel 45 with the outer edge thereof slightly inclined from a true normal through the axis of the rotor which, in the assembled form of the rotor 22, provides an open peripheral ring channel 47 interrupted only by the baffle

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projection 40 of the housing. As best seen in Fig. 2, the inclined edges of the vanes 46 match the tapered faces of the baffle projection 40, the rotor and housing parts being constructed with close tolerances between the relatively moving parts. The baffle projection 40 should extend a sufficient circumferential distance in the ring channel 47 to lie across at least two vanes of both disk members 23 and 24 to prevent an open by-pass, as will later be better understood.

Referring to Figs. 3 to 6, inclusive, there is shown cross-sections of several vane constructions. Figs. 3 and 4 show vane constructions that enable the fluid machine to be used as either a motor or turbine or as a pump or compressor since the housing and rotor design is substantially symmetrical. The vanes 46a and 46b may be positioned in alignment across the ring channel 47 as shown in Fig. 4 or staggered as shown in Fig. 3. For the vane constructions shown in Figs. 4, 5 and 6 it is preferable to position the vanes in alignment across the ring channel 47. It is particularly preferable for the vane constructions shown in Figs. 5 and 6 to be used since these vanes are designed for the greatest mutual blade interference to fluid flow in only one direction. While the spacing and distances of the vanes are not particularly critical, it has been found that the ratio of the distance between the vanes in the same disk member to the average distance between the vanes across the ring channel 47 should amount to about 1.5 plus or minus 25% and that the ratio of the height of each vane to the distance between vanes in the same disk member should be about 0.35 plus or minus 25% for producing the best type nozzle between the opposite vanes providing resistance to flow around the ring channel 47. The vanes 46c of Fig. 5 or 46d of Fig. 6 provide good resistance to flow through the ring channel 47 but the vane structure shown in Fig. 5 is preferred. It has been found that in the structure shown in Fig. 5 the best results are obtained when the toe of the vane is sharp and the slope immediately progressing from the heel of the vane to the toe of the next adjacent vane is about 60 degrees, plus or minus 15 degrees, from a line normal to the rotor faces. Thus, high resistance nozzles are formed between opposed vanes.

Assuming for the purpose of example that the vane types 46a or 46b are used, either port 37 or 38 could be used for the inlet or the outlet and either rotative direction of the rotor 22 can be obtained in the operation of the fluid machine either as a motor or as a pump or compressor. As a motor, fluid under pressure is introduced into one of the ports 37 or 38 which will flow out of the other port carrying the rotor around in the same direction. Power may be taken from the shaft 32. A considerable pressure differential will exist between the inlet port and the outlet port which will result in a slight spilling of the fluid around the rotor within the housing which will cause some objectionable friction and gap losses which can be reduced proportional to the clearance tolerances of machining and thereby rendered negligible. The fluid normally by-passing the baffle projection 40 by remaining in the spaces or pockets between the vanes causes some friction and gap losses but these losses are negligible in relation to the high efficiency of the whole device. It is of importance to note that the peripheral lip 48 of each rotor member at the outer ends of the vanes 46 helps to reduce peripheral friction and gap losses to a minimum.

If the vane design of 46c or 46d is used, for example with the upstanding points or portions pointing clockwise as seen in Fig. 1, fluid under pressure would be introduced into the port 37 to provide a fluid motor in which the rotor 22 would be rotated counterclockwise. Used as a pump or compressor, the shaft 32 would be driven clockwise (as seen in Fig. 1) which would cause fluid to be drawn in the port 38 and forced out the port 37.

Where the fluid machine is to be used as a turbine

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utilizing hot fluids to drive the rotor, a cooling construction as shown in Fig. 7 may be made to cool the rotor and vanes. The companion housing 21 is provided with a thickened portion 50 near the bearing flanged opening 26 through which passes two passages 51 and 52. The cap 34 extends over these passages and has corresponding passages 53 and 54 with internal threads therein for connection to conduits (not shown). On the back face of the rotor disk 24 is an annular channel 55 near the periphery with a plurality of radially extending blades 56 equidistantly spaced about the channel. Also in the outer wall of the rotor disk 24 are two concentric annular channels 57 and 58 that exactly match in radial distance the passages 51 and 52, respectively. The channel 57 is in fluid communication with the annular channel 55 at the outermost portion thereof by a plurality of passages 59 while the channel 58 is in fluid communication with the innermost portion of the channel 55 through a plurality of passages 60. The open face of the channel 55 is covered by an annular plate 61, the plate 61 being detachably fixed to the disk member 24 in any well known manner. Coolant introduced into the passage 54 will pass through the passages 52, 58, and 60 into the annular channel 55 between all the blades 56 and out through the passages 59, 57, 51, and 53. The centrifugal action of the blades 56 will draw the coolant into the channel 55 and the thermo-siphoning action resulting from the fluid being heated will cause the coolant to "rise" toward the center of rotation and out as described above. While the construction of cooling illustrated in Fig. 7 may be used, other equally efficient well known cooling means may be used, as a centrifugal air fan means.

Where hot fluids are used, it may be more desirable to coat the annular channel, vanes, and rotor with ceramic material than to provide a separate cooling system, or both ceramic coating and a cooling system may be used.

The fluid machine is readily adapted to be produced in stages as shown in Figs. 8 and 9. The housing 65 has the usual rotor bearings 66 and 67 at opposite ends thereof as well as bearings 68 and 69 concentrically arranged in wall divisions 70 and 71 of the housing 65. A rotor assembly, generally referred to by the reference character 72, is journaled in the bearings 66, 68, 69, and 67 with a shaft 73 extending out of the housing 65. The particular manner of assembly is not shown but the housing 65 may be made in two longitudinal half sections and assembled together over the rotor assembly in a manner well known in the art. As may be seen in Fig. 8, the rotor assembly is constructed of several disk parts to produce the several stages. The first stage consists of rotor disk parts 74, 75, 76, and 77 in which 74 is similar to the disk member 23 of Fig. 1. The disk members 75 and 76 have annular channels 45 in opposite peripheral faces thereof and the disk 77 has an annular channel 45 in only the inner face thereof so that in the assembled condition three ring channels 47 are formed. Also like that of Fig. 1 a wall 39 with a baffle extension 40 extends into each ring channel 47. These three units of ring channels and baffle extensions within the left end wall and the wall division 70 provides the first stage.

The disk member 77 has a journal extension 78 connecting another disk member 79 providing the first member of the first unit in the second stage. A disk member 80, corresponding to the member 75 and 76, lies between the disk member 79 and a disk member 81, the latter disk member being similar to the element 77-79 by having a journal 82 and a disk member 83. The disk members 79, 80, and 81 provide a second stage of two units there being the annular channels on opposite sides of the two baffle extensions 40.

The third and last stage is a single unit having the disk member 83 fixed to a disk member 84 on which is fixed the shaft 73. The baffle extension 40 is positioned between the vaned annular channels 45 as before. An inlet manifold 85 is connected in parallel to the inlets (for

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example in explaining the device as a fluid motor) of all three units in the first stage. The outlets of all three units in the first stage are connected in parallel which are fluidly connected through a manifold 86 to the inlets in parallel of the two units in the second stage. The two outlets of the second stage are connected in parallel to the inlet of the third stage by the manifold 87 and the outlet of the third stage is through the conduit 88. While the present illustration is of three stages, any number of stages may be provided; however, in order to obtain high efficiencies with such multi-stage arrangements, it has been found that the number of units or ring channels for each stage should decrease from stage to stage in accordance with the increasing density of the fluid. Also, multi-stage machines are necessary for higher pressure ratios. A pressure ratio of approximately 2:1 represents the limiting pressure ratio for a single stage but these pressure ratios may be 5:1 in a multi-stage machine.

The multi-stage fluid machine just described can be produced with the vane or bucket construction as shown in Figs. 3 to 6 to provide a pump or compressor, or a motor or turbine. It is believed that the operation of the multi-stage fluid machine is clear from the description of operation of the single stage machine of Figs. 1 and 2 and further description of operation will therefore not be given.

Referring now more particularly to Figs. 10, 11 and 12 there is shown cross-sectional views of a single stage fluid machine in Figs. 10 and 11, and a cross-sectional view of a multi-stage fluid machine in Fig. 12, all three figures representing two modifications of the fluid machine of Figs. 1 to 9. In the modification of Figures 10 and 11 the housing is made in companion sections 90 and 91. Each section has a large central opening 92 and 93, respectively, and in each opening is a bearing cup 94 and 95, respectively, supported by spider means 96 and 97. In the portion of the composite housing 90-91 between the openings is an annular channel 98 or cylinder inner chamber enclosed by an outer peripheral cylindrical wall and flat end walls forming the sides of the chamber with vanes or buckets 99 equidistantly spaced on the walls around this annular channel. The ends of the vanes 99 are closed by an overhanging lip 100 extending from each companion housing into the annular channel. The companion sections of the housing are held together in any suitable and well known manner.

The rotor 105 has a journal shaft extension 106 in the bearing cup 94 and an opposite, aligned shaft 107 extending out through the bearing cup 95. The rotor 105 is of a diameter that the periphery thereof extends to, but not into, the annular channel 98 except for an extended baffle portion 108 which just clears the outer edges of all the vanes 99 with a tolerance consistent with machining operations. The rotor 105 has one fluid passage 109 connecting the circular area about the cup 96 with the annular channel 98 on one side of the extended baffle portion 108 and it has another passage 110 fluidly connecting the circular area about the cup 97 and the annular channel 98 on the other side of the extended portion 108. Used as a pump or a compressor the rotor, as viewed in Fig. 11, will be driven by shaft 107 in a counterclockwise direction causing fluid to be drawn in through passage 109 and forced out through passage 110. The openings 92 and 93 are readily adapted to be connected to conduit means where desirable or feasible. The rotor 105 is balanced dynamically, the passages 109 and 110 being of a size to offset the added weight of the extended portion 108. Used as a motor or turbine, the fluid under pressure would be introduced through the passage 110 and exhausted through the passage 109 causing rotor rotation in a clockwise direction whereby power may be taken from shaft 107.

As shown in Fig. 12 this modification can be produced in a plurality of stages by doubling, tripling, etc., the housing divisions 115 which has wall divisions 116 separating the annular channels 98 and extension portions.

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The rotor is modified to the extent that separate rotor portions are produced corresponding in number to the annular channels and may be made integral or in separate pieces as machining operations or costs dictate. It is necessary, however, that a passage 117, corresponding to passage 110 in Fig. 11, connects the annular channel 98 of the second stage on the same side of the baffle projection as the passage 109 in the first stage. The passage 110 fluidly connects the annular channel 98 in the last stage to the circular opening 93 as in Fig. 10 wherein like reference characters represent like elements and features. As may be seen in Fig. 12 the second stage is smaller than the first stage to make allowance for the increasing density of the fluid. The vanes or buckets 99 used in the single stage machine of Fig. 10 are used in the multi-stage machine and the multi-stage machine may be driven through shaft 107 to provide a pump or compressor, or driven by fluid to provide a motor or turbine in the same manner as the machine of Fig. 10.

While many modifications and changes may be made in the various constructional details and features to produce the same results, it is to be understood that the drawings and description merely set out illustrations of the invention and I desire to be limited only in the spirit and scope of my invention as set out by the appended claims.

I claim:

1. In a machine of the fluid drag type, a casing having a cylindrical outer wall and parallel spaced side walls defining a cylindrical cavity, a rotor including a shaft rotatably journaled in said casing, a hub on said rotor positioned in said cavity and leaving a cylindrical annular chamber extending radially outward therefrom, a circumferential equally spaced row of vanes extending laterally into said annular chamber from each of the side walls thereof, the corresponding vanes in each row being in register with the vanes in the other row and inclined at an angle from the plane of the corresponding sidewall, said vane rows having at least portions thereof laterally spaced apart to leave an annular vane free channel therebetween, a sector shaped baffle on said rotor blocking off a portion of said annular channel, a fluid port in each of the radial end faces of said baffle, means connected to one of said ports for admitting fluid under pressure into said annular channel and means connected to the other of said ports for discharging fluid from said annular channel, the inclination of said vanes being such as to offer a high resistance to the flow of fluid from the inlet port to said discharge port.

2. In a machine of the fluid drag type, a housing element and a rotor element rotatably journaled in said housing element, a hub on said rotor element, said hub and said housing element defining an annular chamber extending radially outward from said rotor hub, two rows of circumferentially equally spaced vanes mounted on one of said elements, the corresponding vanes in each row being in register with the vanes in the other row and the two rows of vanes having at least portions thereof laterally spaced to form a vane free channel therebetween, the vanes in each of said rows being shaped to form pockets therebetween which create a high resistance to fluid flow in one direction in said vane free channel therebetween by mutually redirecting the fluid entering the pockets in a direction opposite the direction of flow in the channel, a fluid blocking baffle on the other of said elements and completely interrupting flow continuity in said vane free channel, said baffle having a passage formed therein for admitting fluid into said vane free channel on one side thereof and said baffle having an exhaust passage therein for exhaust of fluid on the opposite side thereof, the high resistance to flow of fluid in said vane free channel causing relative rotation between said housing element and said rotor element.

3. In a machine of the fluid drag type, a casing having a cylindrical outer wall and parallel spaced side walls

defining a cylindrical cavity, a rotor including a shaft rotatably journaled in said casing, a hub on said rotor positioned in said cavity and leaving a cylindrical annular chamber extending radially outward therefrom, sets of vanes rimming the side walls and outer wall of said annular chamber, the vanes in each set being equally circumferentially spaced and the corresponding vanes in each set being in register and equally inclined in the same direction, the outer edges of said vanes bounding a central annular vane free channel in said annular chamber, a sector shaped baffle on said rotor blocking off a portion of said annular channel, a port in each of the radial end faces of said baffle and communicating with said annular chamber, a pair of passages formed in said baffle each respectively connected to one of said ports in the baffle end face and terminating at its other end in a port formed in one of the end faces of the rotor hub, separate fluid channels in said casing in respective continuous communication with one of said last named ports, means

for admitting fluid to one of said fluid channels and for discharging fluid from the other of said channels.

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