July 7, 1964 R. BALDUR 3,140,074

FLUID MACHINES

Filed Nov. 29, 1963 4 Sheets-Sheet 1

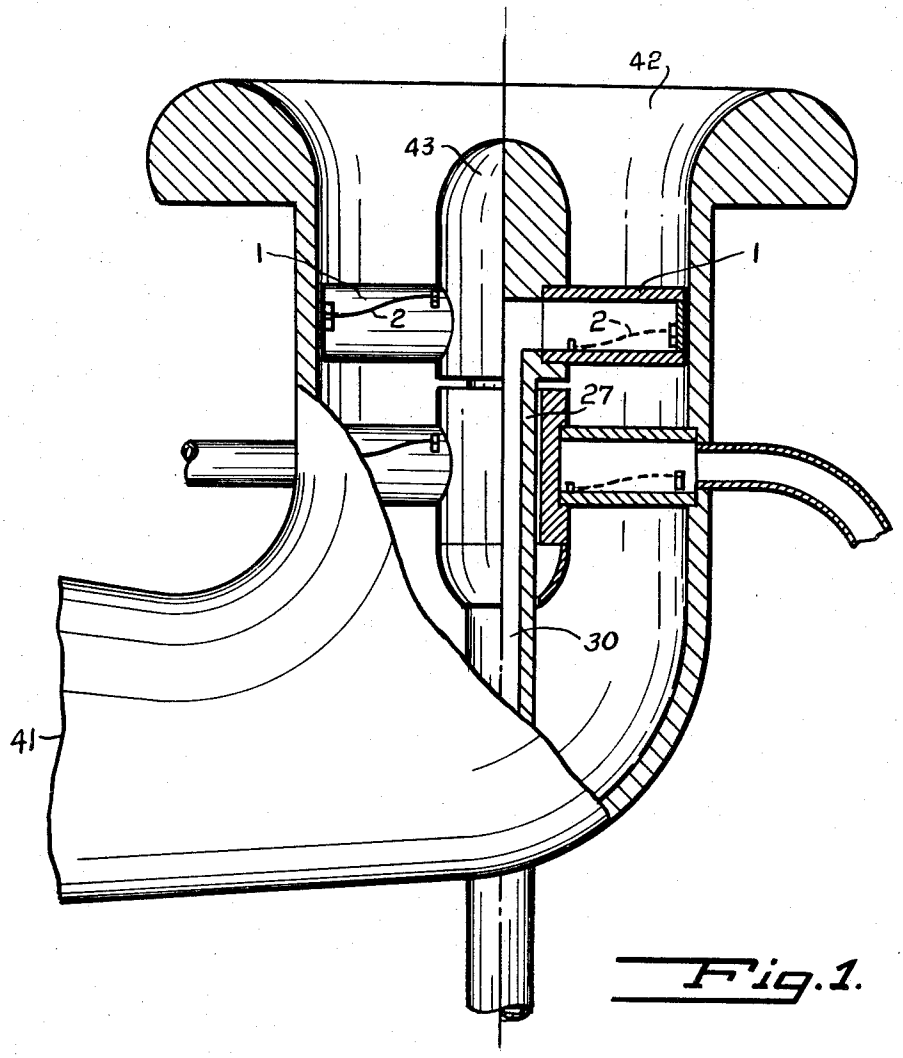

Fig. 1.

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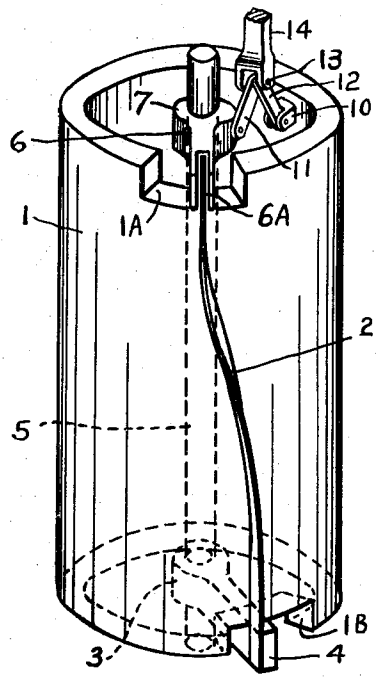

Fig. 2.

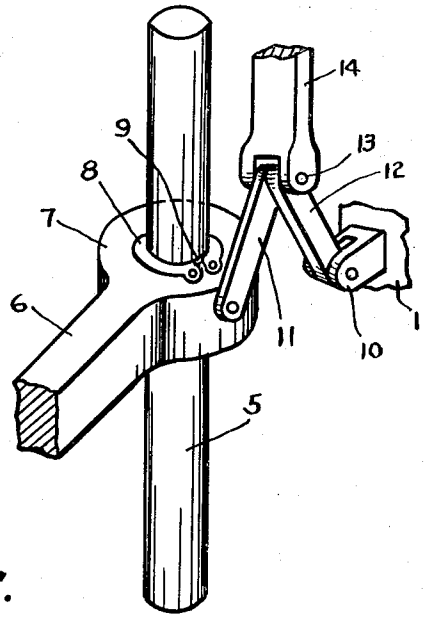

Fig. 3.

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FLUID MACHINES

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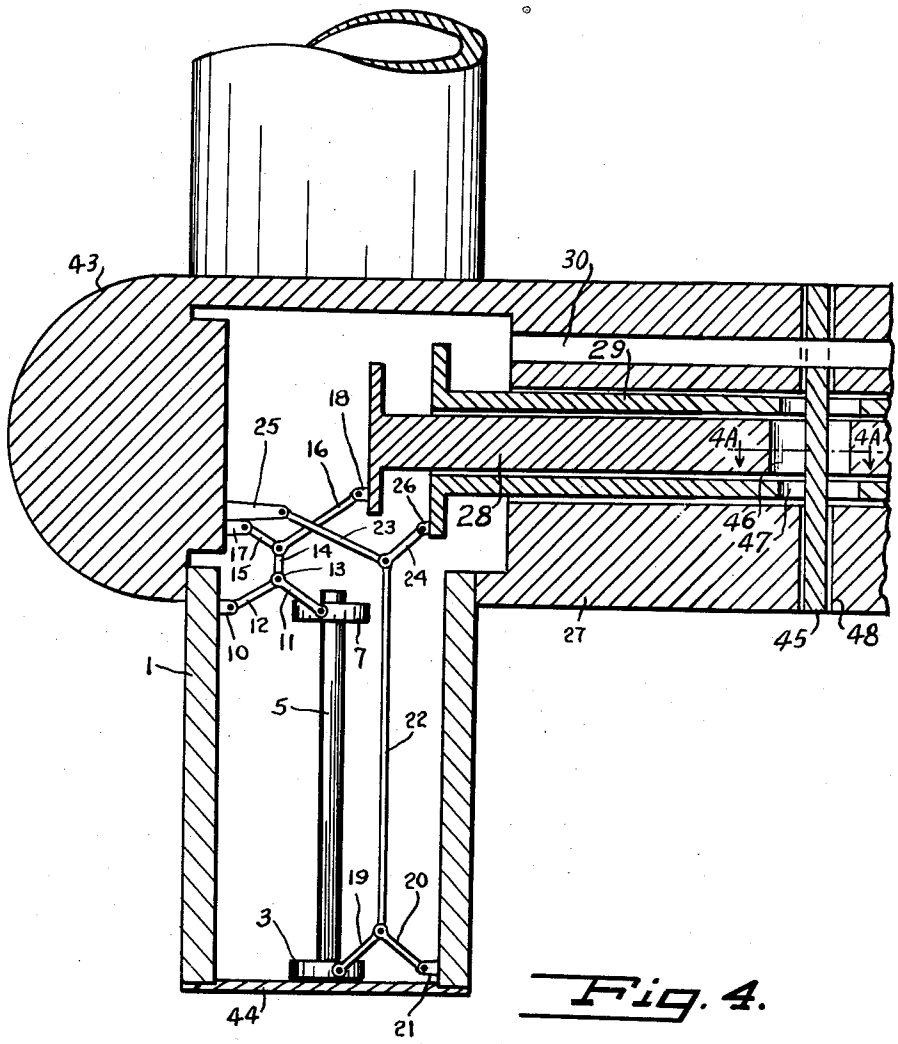

Fig. 4.

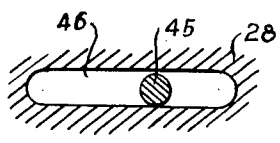

Fig. 4A

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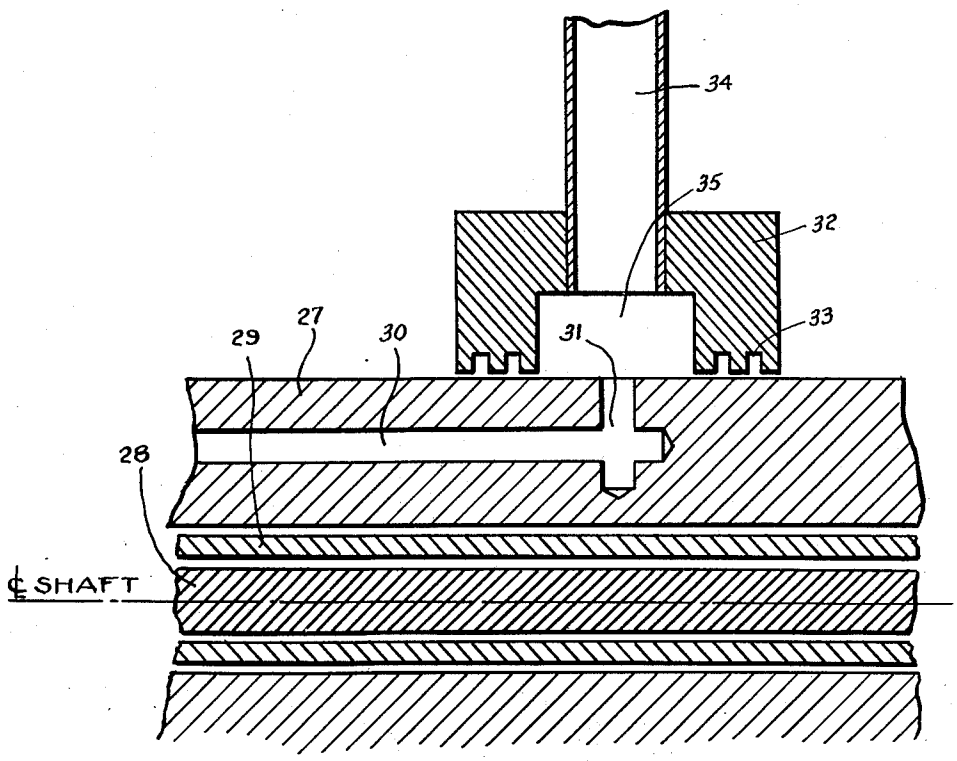

Fig. 5.

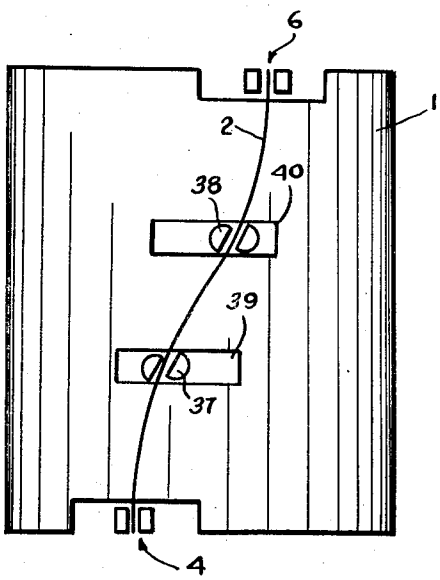

Fig. 6.

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United States Patent Office

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FLUID MACHINES

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Filed Nov. 29, 1962, Ser. No. 240,866
19 Claims. (Cl. 253—142)

This invention relates to improvements in fluid machines and has particular reference to the provision of new and improved vane means for fluid machines.

Conventional fluid machines such as fans, pumps, turbines and the like include stationary and rotating blade elements which cooperate to effect interchange of energy between a stream of fluid and a rotating shaft. It is customary to design such machines to satisfy a design point specification, while accepting somewhat lower performance at other operating conditions. Sometimes, means are provided to improve the off-design point efficiency by making the pitch of the rotating and stationary vanes variable, as, for example, Kaplan turbines.

Furthermore, many fluid machines require, in addition to the lift-producing blade elements, vanes which are required for structural purposes only. These vanes are designed for minimum interference with the fluid flow and, therefore, usually take the form of airfoils. Due to the changing conditions of operation, however, these vanes can only have the correct geometry at design-point, and contribute to loss of efficiency at all other points in the operating spectrum.

In fluid machines which are required to operate over a wide range of conditions, neither rotating nor stationary vanes of conventional design can satisfy the complete range of modes of flow. This is particularly true of reversible hydraulic pump turbines in which case the same machine may be required to operate as a pump or as a turbine, with flow in either direction. Implicit in this requirement is complete interchangeability of leading and trailing edges of the vanes; there are also conflicting requirements as to camber and twist for the different regimes of operation.

It is an object of the present invention to provide new and improved vane means for use with a fluid machine which vane means are adjustable to meet the requirements of the fluid machine over a wide range of operating conditions.

Another object of the invention is to provide new and improved vane means of the type set forth which operate with a high degree of efficiency over this wide range of operating conditions.

Another object of the invention is to provide new and improved vane means of the type set forth which combine this efficiency in operation with economy of construction.

Other objects and advantages will be apparent from the foregoing description taken in connection with the accompanying drawings. It is understood that changes may be made in the details of construction and arrangement of parts shown and described as the preferred form of the invention has been given by way of illustration only.

Referring to the drawings:

FIG. 1 is a sectional elevation of a fluid machine, in the plane of the mainshaft axis, incorporating the constructed invention;

FIG. 2 is an external view of a blade element with flap according to the invention;

FIG. 3 is a perspective view of one form of the blade element adjusting mechanism;

FIG. 4 is a sectional view of another form of blade element adjusting mechanism;

FIG. 4A is a sectional view taken on line A—A of FIG. 4, looking in the direction of the arrows;

FIG. 5 is a fragmentary sectional view showing the fluid passage through the blade element adjusting mechanism of the form shown in FIG. 4; and

FIG. 6 is a schematic view of a modified form of the invention.

Referring more particularly to FIG. 1 of the drawings, such illustrates generally a portion of a fluid machine having an inlet 42, an outlet or discharge 41, and an impeller hub 43, in combination with a physical embodiment of the present invention. It will be understood that said fluid machine could equally well be constructed with the inlet 42 and the discharge or outlet 41 in reversed relation and that the functions of the openings comprising said discharge 41 and said inlet 42 depend upon the designed function of the particular configuration of fluid machine to which the present invention is applied.

Referring more particularly to the other drawings wherein similar reference characters designate corresponding parts throughout the several views, the vane means shown in FIG. 2 comprise a hollow, porous cylinder 1 having cutout portions of a predetermined size at its opposite open ends, a shaft 5 passing through said cylinder 1 and a radial arm 6 including a hub portion 7 and a forked free end 6a, which hub 7 is journalled upon said shaft 5 adjacent one end of the cylinder 1 such that the free end of said radial arm 6 extends externally from said cylinder 1 through one of said cutout portions of said cylinder 1 and the movement of said arm is limited by said cutout. A second radial arm 4 including a free end and a hub portion 3 is also provided, said hub 3 being journalled upon shaft 5 adjacent the open end of said cylinder 1 opposite to that adjacent to which said radial arm 6 is positioned. The free end of said radial arm 4 extends externally from the cylinder 1 through one of said cutout portions located in said cylinder 1 such that movement of said arm 4 is limited by said cutout.

A thin flexible flap 2 is positioned externally to said cylinder 1 by means of the forked free end of said radial arm 7 and the free end of said radial arm 4.

The present invention includes the provision of means whereby the hub 3 of said radial arm 4 and the hub 7 of said radial arm 6 may be independently rotated through limited angles upon the vane-shaft 5.

FIG. 3 illustrates one form of such means applied to said hub 7. It is understood that selection of hub 7 is for purposes of example only and that the means shown in FIG. 3 are applied to the hub 3 in the same manner in which they are shown applied to said hub 7.

It will, further, be understood that FIGS. 2 and 3 have been drawn as shown for illustrative purposes; and that, in actual practice of the invention, a flat circular plate such as is shown as 44 in FIG. 4 or similar means which includes a centrally located hole for rigidly positioning the shaft 5 in axial and radial alignment may be fitted into the open end of the cylinder 1.

The means shown in FIG. 3 comprise the grooves 9 in said shaft 5, one of said grooves 9 being in said shaft 5 on each side of said hub 7 immediately adjacent to said hub 7 and the snap rings or the like 8 positioned in said grooves 9. The provision of these snap rings 8 in the grooves 9 restrain the hub 7 from axial displacement relative to the shaft 5.

A lug or similar connecting member 10 is affixed to the inner wall of the cylinder 1 adjacent to the hub 7 and a toggle mechanism is operably connected to both lug 10 and hub 7.

Said toggle mechanism comprises the link 11 connected to said hub 7, the link 12 connected to said lug 10, connecting member 14 located at the free ends of said links 11 and 12 and having a forked end, and the

pivot pin 13 common to both links 11 and 12 and carried by said connecting member 14 in its forked end.

Through this mechanism, axial displacement of said connecting rod 14 results in angular displacement of said hub 7 about the axis of shaft 5.

A similar means is provided for adjusting the hub 3 with the ranges of the two means being set so that they do not interfere with the operation of each other.

When the means of FIG. 3 for independently adjusting the hubs 3 and 7 of the radial arms 4 and 6 respectively are applied to the stationary parts of a fluid machine, no further elements are required. However, when said means are applied to the rotary elements of a fluid machine, a further means must be employed so that the angular displacements of the hubs 3 and 7 may be effected by stationary controls. An example showing one form of these additional means is shown in FIG. 4.

The means shown in FIG. 4 comprise the lug or similar connection means 10 attached to the inner side of the cylinder 1 adjacent one of the open ends of said cylinder 1 and the lug or similar connection means 21 attached to the inner side of said cylinder 1 adjacent the end of said cylinder 1 opposite to that of said lug 10. The lugs or similar connection means 17 and 25 are attached to the main rotor shaft 27.

The inner and outer operating or control rods 28 and 29, respectively, are located within said main rotor shaft 27, said control rod 29 being hollow and including therein, in a concentric manner wtihin its bore, the control rod 28. Said control rods 28 and 29 rotate in unison with said main rotor shaft 27. However, said control rods 28 and 29 may be axially displaced independently of each other and independently of the main rotor shaft 27. Said control shafts 28 and 29 and shaft 27 are enabled to rotate in unison, yet be capable of axial displacement independently of each other, as said shaft 27 includes an opening or hole 48 into which pin 45 is rigidly secured and said control shafts 28 and 29 are provided with axially elongated slots 46 and 47, respectively, through which slots said pin 45 is slideably fitted. Said main rotor shaft 27 includes, in addition to said control rods 28 and 29, the opening or passage 30 for the passage of boundary layer control fluid.

The control rods 28 and 29 are connected at their ends by means of yokes or the like to the lugs or similar connection means 18 and 26 respectively.

Said lug 18 serves to connect said control rod 28 to the hub 7 of radial arm 6 through the means shown in FIG. 3 such that axial movement of said control rod 28 causes angular displacement of said hub 7.

Likewise, said lug 26 serves to connect said control rod 29 to the hub 3 of radial arm 4 through the similar linkages 19, 20, 23 and 24 and connecting rod 22 such that axial movement of said control rod 29 causes angular displacement of said hub 3.

More specifically, as has been previously described with regard to the hub 7, the hub 3 is free to rotate about the rigidly positioned shaft 5 within the limits dictated by the axial movement of shafts 28 and 29 and by the cutouts 1*a* and 1*b* in the cylinder 1.

Thus, both control rod 28 and control rod 29 are provided with means whereby they may be axially displaced independent of each other and of the main rotor shaft 27. Through this independent displacement of said control rods 28 and 29, the hubs 7 and 3 respectively may be actuated independently of each other. Therefore, as the radial arms 6 and 4 of which said hubs 7 and 3 respectively are elements act to hold the flexible flap 2, this independent movement of the hubs 7 and 3 results in adjustment of said flexible flap 2. In this manner, said flexible flap 2 may be adjusted as necessary in the operation of the fluid machine.

In FIG. 5 of the drawings, a method is illustrated for connecting the opening 30 in the main rotor shaft 27 through a stationary duct 34 to a pump or similar source

of supply such that boundary layer control may be provided for the blades of the fluid machine which are comprised of the cylinders 1. The arrangement illustrated comprises the opening or passage 30, a duct 31 connected to said passage 30 for fluid flow, a stationary annular member 32 surrounding the main rotor shaft 27 and including a plenum chamber 35, said chamber 35 being sealed by the labyrinth 33, and the stationary duct 34, said stationary duct 34 being connected at one end to said chamber 35 and at the other end to a pump for providing boundary layer control for the blades of the fluid machine.

Through the means illustrated in FIGS. 2 through 5 methods have been disclosed for adjusting the position of the flexible flap 2 adjacent to the ends of the cylinder 1. The position of said flap 2 at intermediate points between its ends may be controlled either through the natural configuration of said flap 2 or by the means shown schematically in FIG. 6.

In the arrangement shown in FIG. 6, the cylinder 1 is provided with grooves 39 and 40 in its periphery intermediate its two opposite open ends. In the illustrated embodiment said grooves 39 and 40 are shown as being two in number. However, the number of said grooves is not material to the present invention as more or less than two grooves may be preferable in a specific embodiment of the invention.

Two guide means 37 and 38 are slidably mounted in said grooves 39 and 40 respectively. Said guide means 37 and 38 may be attached to radial arm members similar to the radial arms 4 and 6 and may be coupled to actuating mechanisms through connecting rods similar to the connecting rods 14 and 22 shown in FIG. 4. Such an arrangement would, however, require four concentric operating rods instead of the two operating rods 28 and 29 shown in FIG. 4.

Said guide means 37 and 38 are suitably connected to the flexible flap 2.

Thus, in this manner, the position of said flap 2 intermediate of its ends may be controlled.

From the foregoing, it will be seen that I have provided new and improved means for obtaining all of the objects and advantages of the invention.

I claim:

1. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft and having free ends, the free ends of said radial arm means being external to said cylinder, and an adjustable flap member external to said cylinder and positioned by the free ends of said radial arm means.

2. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through said cylinders, radial arm means mounted upon said vane-shaft and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by the free ends of said radial arm means, limiting means for limiting the movement of said radial arm means, and means for adjusting said adjustable flap member.

3. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and

means for adjusting said adjustable flap member, said adjusting means comprising means for independently adjusting said radial arm means about said vane-shaft.

4. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means adjacent the open ends of said cylinder and having free ends, said radial arm means including a hub and a free end, said hub of said radial arm means being journaled upon said vane-shaft and said free end of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by means of said free end of said radial arm means, means for limiting the movement of said arm means, and means for adjusting said adjustable flap member.

5. In a fluid machine, a mainshaft, a hub attached to said main shaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, said cylinder having shoulder portions adjacent its opposite open ends for limiting the movement of said radial arm means, and means for adjusting said adjustable flap member, said adjusting means comprising means for independently adjusting each of said radial arm means about said vane-shaft.

6. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, said cylinder having cutaway portions adjacent its opposite open ends for limiting the movement of said radial arm means, and means for adjusting said adjustable flap member, said adjusting means comprising means for independently adjusting each of said radial arm means about said vane-shaft.

7. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said adjusting means comprising linkage and control means.

8. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said adjusting means comprising toggle means.

9. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, said cylinder having shoulder portions adjacent its opposite open ends for limiting the movement of said radial arm means, and means for adjusting said adjustable flap member, said adjusting means comprising linkage and control means.

10. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, said cylinder having cutaway portions adjacent its opposite open ends for limiting the movement of said radial arm means, and means for adjusting said adjustable flap member, said adjusting means comprising toggle means.

11. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said adjusting means including concentric control shafts operably associated with said mainshaft such that said control shafts rotate in unison with said mainshaft and are axially adjustable independently of said mainshaft and of each other and linkage means connecting said control shafts to said radial arm means.

12. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said adjusting means including concentric control shafts operably associated with said mainshaft such that said control shafts rotate in unison with said mainshaft and are axially adjustable independently of said mainshaft and of each other and linkage means connecting said control shafts to said radial arm means and passage means within said mainshaft for permitting the passage of fluid.

13. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylin-

der, and means for adjusting said adjustable flap member, said adjusting means including control means located in said mainshaft and operably associated therewith, said control means comprising a first control rod and a second control rod concentrically located in said first control rod, said first and second control rods being capable of being adjusted independent of said shaft and of each other, and linkage means for connecting said control means to said radial arm means.

14. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said adjusting means including control means slidably associated with said mainshaft such that said control means rotate in unison with said mainshaft, said control means being axially adjustable independently of said mainshaft and of each other, and linkage means for connecting said control means to said radial arm means, and passage means within said mainshaft for permitting the passage of fluid, a stationary duct connected to said passage means, and a fluid source or sink connected to said stationary duct such that said stationary duct serves to connect said passage means and said fluid source or sink.

15. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said means comprising guide means intermediate of the ends of said adjustable flap member, said adjusting means comprising means for independently adjusting each of said radial arm means about said vane-shaft.

16. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said means comprising guide means in said cylinder intermediate of the ends of said adjustable flap, said adjusting means comprising means for independently adjusting each of said radial arm means about said vane-shaft.

17. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said means comprising said cylinder being provided with grooves intermediate the ends of said cylinder, guide means positioned in said grooves, and means for controlling the operation of said guide means, said adjusting means comprising means for independently adjusting each of said radial arm means about said vane-shaft.

18. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of the cylinder, and means for adjusting said adjustable flap member, said means comprising said cylinder being provided with grooves intermediate the ends of said cylinder, second radial arms positioned in said grooves, guide means attached to said second radial arms, and means for controlling the operation of said guide means, said adjusting means comprising means for independently adjusting each of said radial arm means about said vane-shaft.

19. In a fluid machine, a mainshaft, a hub attached to said mainshaft, a plurality of vanes attached to said hub, each of said vanes including a hollow, porous cylinder, a vane-shaft passing axially through each of said cylinders, radial arm means mounted upon said vane-shaft adjacent the open ends of said cylinder and having free ends, the free ends of said radial arm means being external to said cylinder, an adjustable flap member external to said cylinder and positioned by said free ends of said radial arm means, stop means for limiting the movement of said radial arm means adjacent the ends of said cylinder, said adjustable flap member being shaped to provide desired flow control, and adjusting means comprising means for independently adjusting each of said radial arm means about said vane-shaft.

No references cited.