United States Patent

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[54] **AXIAL FLOW FAN WHEEL**
10 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **416/157**
[51] **Int. Cl.** **B63h 3/02**
[50] **Field of Search** 416/157, 156

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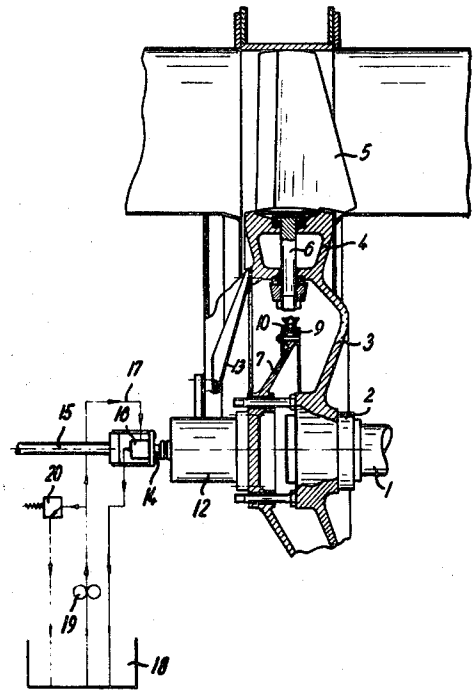
ABSTRACT: An axial flow fan wheel with adjustable blades controlled by a hydraulic-driving system comprising a working piston and a cylinder disposed coaxially within the wheel one of them being axially displaceable for adjusting the blades.

The system is supplied with hydraulic fluid with a constant pressure through an adjustment cylinder-piston system coaxially connected with the displaceable part of the driving system.

The working piston has a passage throttling the fluid flow.

The sum of the pressure drop through the piston and the drop in the adjustment cylinder-piston system equals the total pressure.

Displacing the adjustment piston relative to the adjustment cylinder disturbs the state of equilibrium. The working piston moves relative to the cylinder and reestablishes the equilibrium state in another position.



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SHEET 1 OF 7

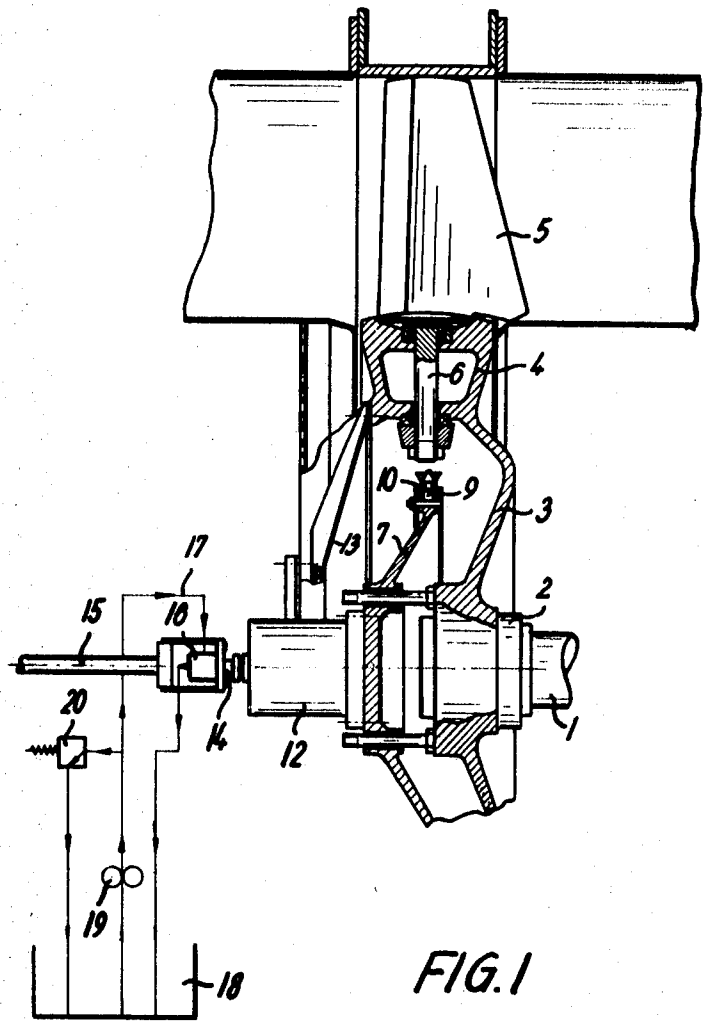


FIG. 1

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ATTORNEYS

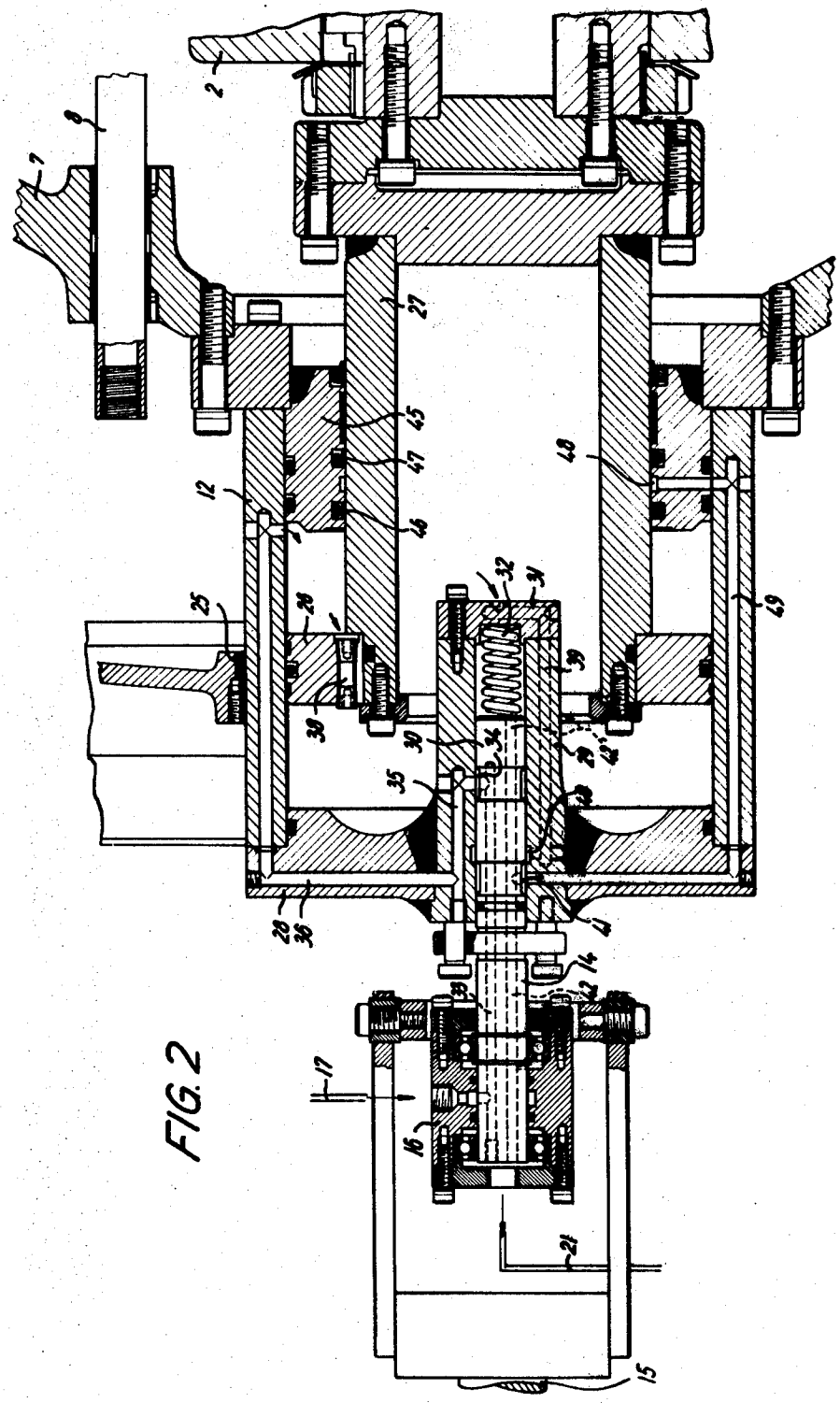

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FIG. 2

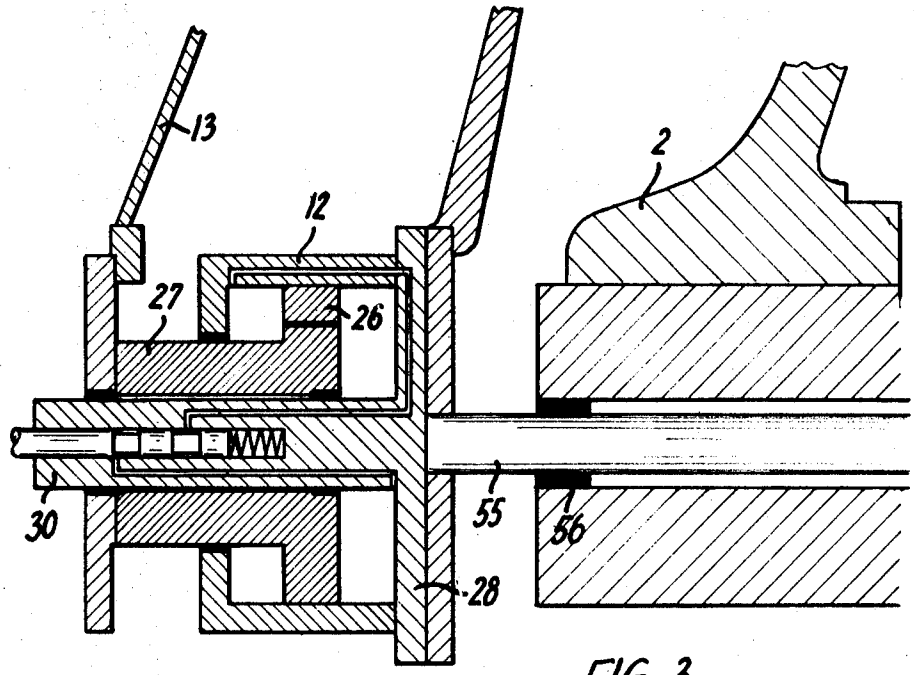


FIG. 3

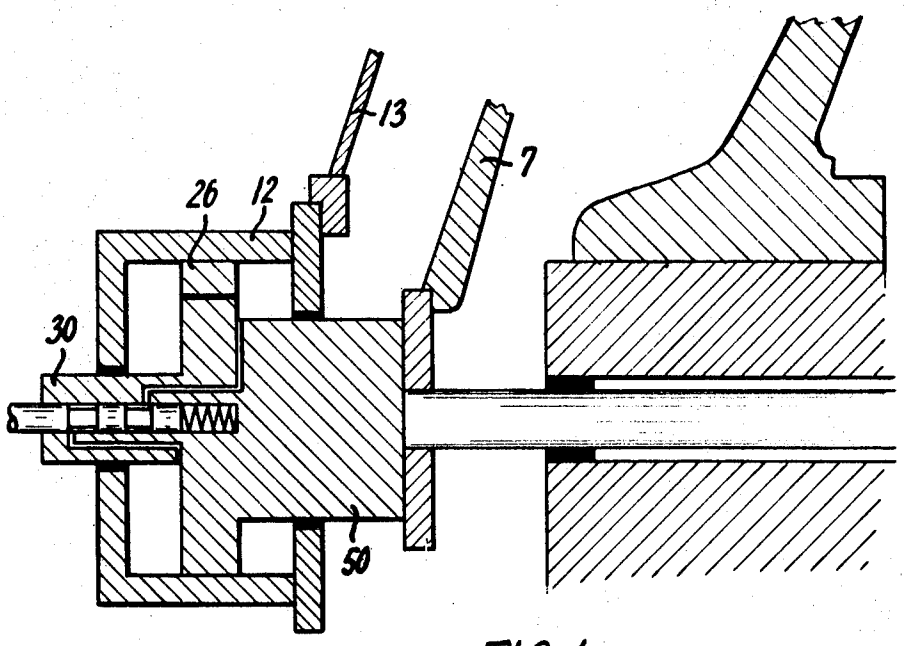


FIG. 4

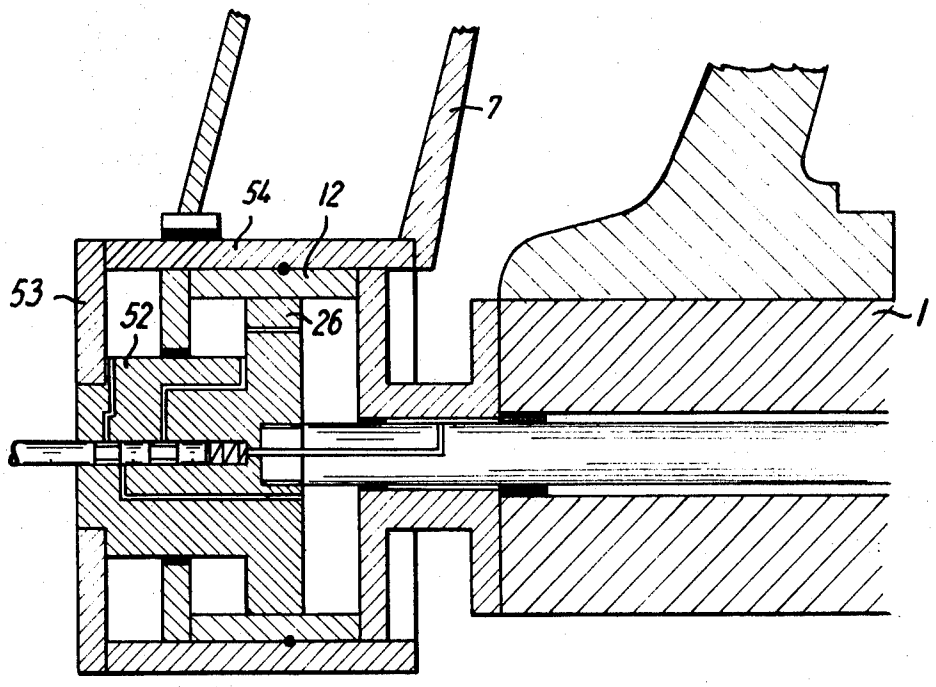


FIG. 5

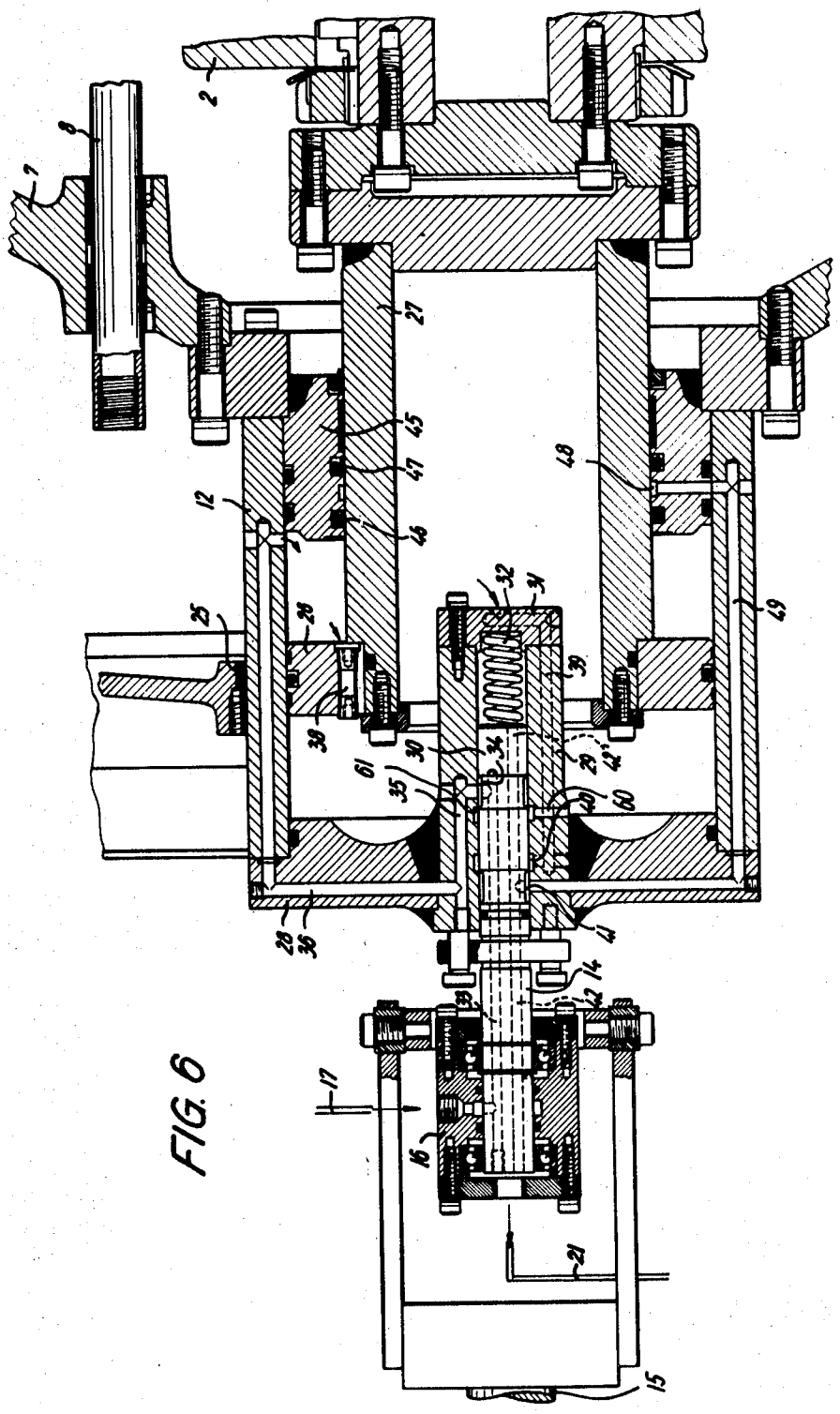


FIG. 6

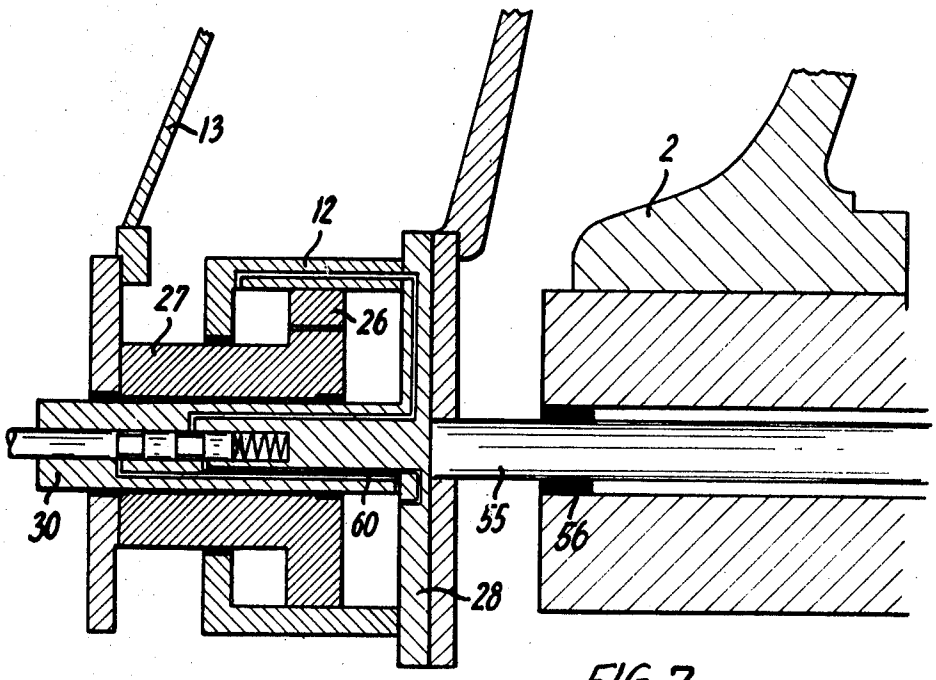


FIG. 7

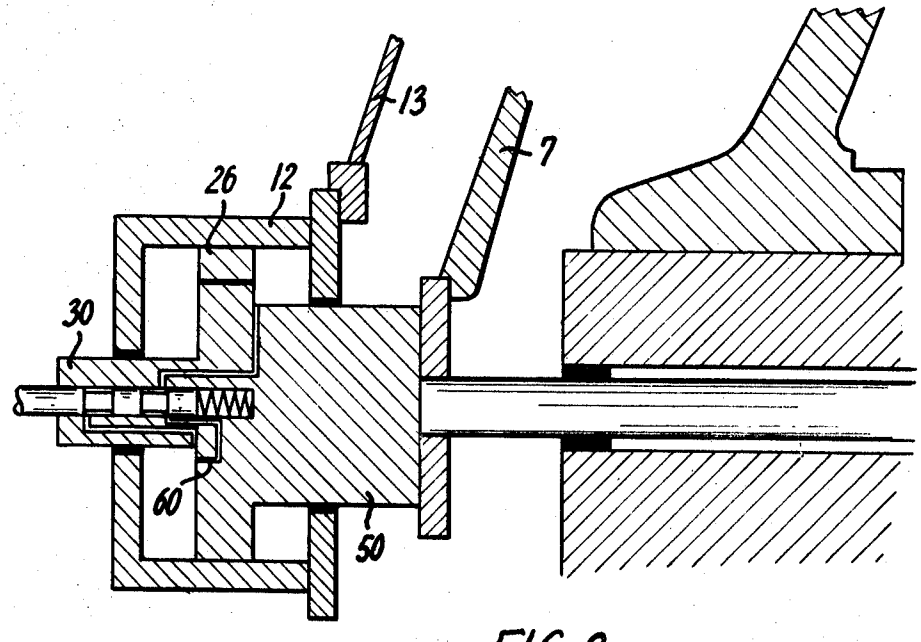


FIG. 8

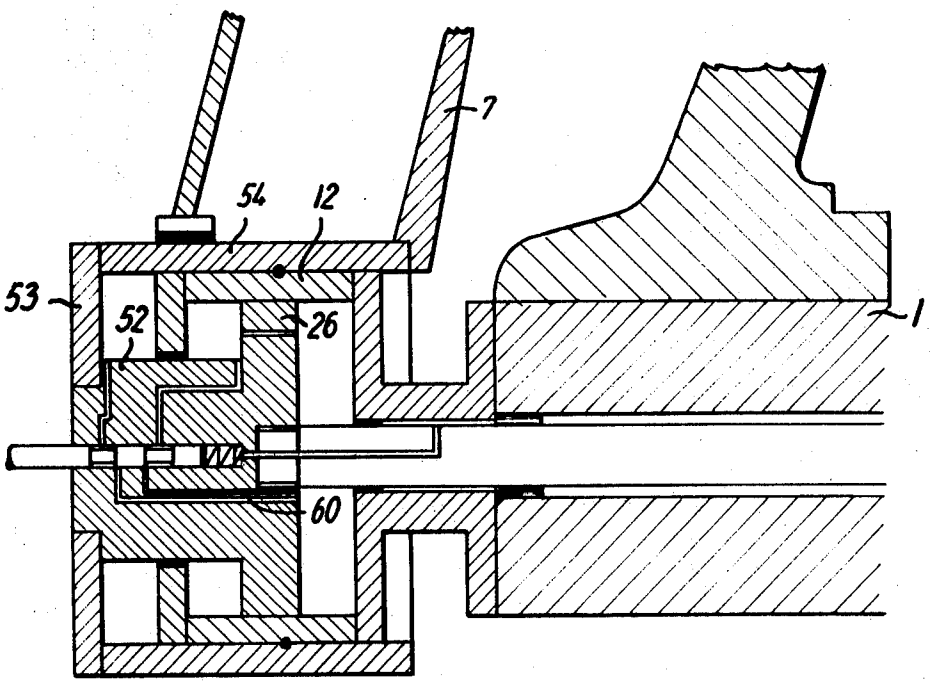


FIG. 9

AXIAL FLOW FAN WHEEL

This invention relates to an axial flow fan wheel with a hydraulic adjustment system for the adjustment of its vanes, which vanes are pivotably supported by radial axes in the hub ring of the wheel and which are adjustable to a desired angular position by means of an adjustment member which is rotating together with the wheel and is hydraulically adjustable in the axial direction of the wheel.

In the known fan wheels of the kind dealt with, the adjustment takes place in that, as soon as a change in the adjustment is to be effected, hydraulic fluid is supplied to the one or the other side of a working piston, which by this means is displaced in its cylinder. The regulation takes place with the aid of a control valve having the shape of an adjustment piston mounted in a cylinder which, by means of a plurality of grooves may be opened or closed for the supply and removal of fluid to the one or the other side of the working piston. The adjustment cylinder is connected with the working cylinder in such a way that the passages for the hydraulic fluid are closed when the working piston has assumed the desired position.

When the vanes of the fan wheel are adjusted to a desired angular position, the hydraulic fluid in the working cylinder is thus stationary and the pressures on the two sides of the piston are equilibrated. Only during the adjustment process proper, a supply or a removal of the hydraulic fluid does take place, so that there is only a slight replacement of the fluid which is generally subjected to considerable heating. As thus no possibility for cooling the liquid exists, a deleterious transformation of same occurs comparatively quickly, which has as a result that it has to be changed frequently and, at the same time, there exists a certain danger of corrosion.

The various grooves in the adjustment piston and the corresponding apertures in the associated cylinder have to be constructed with extreme precision, particularly with a view to their mutual spacing for their function to be satisfactory.

Moreover, great demands are made as regards the sealing between the working piston and its cylinder, because a seepage of the hydraulic fluid from the one side to the other of the piston will entail an unstable adjustment.

Hydraulic adjustment systems are known, in which these disadvantages are obviated to a significant degree. In these, the hydraulic fluid flows constantly from the one side to the other of the working piston, in that the fluid continuously, under constant pressure, is supplied to the one side of the piston, and the passage from the one side to the other takes place under throttling, so that a pressure drop results, whereupon the hydraulic fluid is led out from the other side of the piston through a throttle arrangement, by which means the pressure is reduced to zero. The throttling between the two sides of the piston and in the said throttling arrangement is adjusted in such a way that the pressures on the two sides of the piston are inverse proportional to the area of the piston on the two sides when the mechanism is in the equilibrium state, so that the total pressure is the same on each of the two sides of the piston.

This known adjustment mechanism has, however, so far only been employed in connection with stationary devices and the known construction cannot be used for the adjustment of vanes in a rotating fan wheel.

This is, however, rendered possible with the fan wheel according to the invention, in that a hydraulic-working piston is in rigid connection with the drive shaft of the fan wheel and, in a manner known per se, is constructed with different effective areas for its two sides and with a communicating channel between the two sides of the piston for equilibrating the pressure on these two sides by throttling of the continuously flowing fluid of the hydraulic adjustment system, and by a working cylinder for this piston being displaceably mounted in relation to the piston and rigidly connected with the adjustment member of the vanes, in addition to which an adjustment cylinder is disposed coaxially with the working cylinder in

rigid connection with same and which comprises a displaceable adjustment piston which, in a known manner, serves for the adjustable throttling of the liquid flowing through for adjusting the working cylinder to a desired position corresponding to a desired vane adjustment, in addition to which a rotor seal casing mounted displaceably but not pivotably outside the adjustment cylinder is pivotably, but not displaceably, supported on an extension of the adjustment piston extending outside the adjustment cylinder, which rotor seal casing has connecting branches leading to mutually fluid-sealed, delimited areas of the inside of the rotor seal casing, in which areas terminate a fluid inlet channel and a fluid outlet channel in the adjustment piston and its extension.

A construction is obtained hereby, which not merely remedies the disadvantages dealt with above in the known construction to a very great extent, but which also in a constructional respect is considerably simpler and easier to manufacture.

The two sides of the working piston can be designated, respectively, as the high-pressure side, i.e. the side which is in direct communication with the fluid inlet channel in the adjustment piston, and the low-pressure side which, in the state of balance communicates with the discharging channel since by means of the adjustment piston a throttling is brought about which has such a relation to the throttling in the communicating channel between the two sides of the piston that the pressures on the two sides are inversely proportional to the effective areas of the two sides.

By means of an adjustment of the adjustment piston to the one side, a full opening of the connection between the low-pressure side and the discharging channel takes place, whereby a reduction in the volume of the fluid on the low-pressure side and an increase in the volume of the fluid on the high pressure side is brought about, while by means of adjusting the adjustment piston in the opposite direction, a full closing of the said connection takes place and thereby a reduction in the volume of the fluid on the high-pressure side and an increase in the volume of the fluid on the low-pressure side.

There is constantly free access for the fluid to the high-pressure side, and as by means of the first adjustment free discharge is given to the fluid from the low-pressure side, the movement of the working piston in relation to the working cylinder is going to take place at a rather considerable speed.

By means of the opposite adjustment, the discharge from the low-pressure side is closed completely so that the increase in the volume of the fluid on this side only takes place by means of fluid being supplied through the communicating channel between the two sides of the piston. On account of the throttling, this flow of fluid takes place relatively slowly and considerably more slowly then the flow in the state of balance because the difference in pressure on the two sides is reduced as a consequence of closing the discharge from the low-pressure side and consequently, the adjustment movement in this direction is considerably slower than in the first direction.

In an embodiment of the invention, this disadvantage is being remedied in that in the adjustment cylinder there is a passage controlled by means of the movement of the adjustment piston, which passage runs from the fluid inlet channel to the working cylinder on the side of the working piston where its largest effective area is located, which passage is fully open by adjusting the adjustment piston to increase the volume of the fluid on the said side of the working piston, but closed by the reduction of this volume.

By means of the second one of the two adjustment movements mentioned, in which this passage is closed, the function is quite like in the embodiment described above. By means of the opposite adjustment movement, in which the said passage from the outlet channel is, however, open, the fluid from the inlet channel is going to flow in direct on to the low-pressure side of the piston, in addition to which, at the same time, fluid from the high-pressure side flows in the backward direction through the part of the inlet channel connected thereto and into the space at the low-pressure side.

A considerably increased adjustment velocity is obtained thereby and by suitable dimensioning of the passage, no difficulty arises in obtaining a specific desired adjustment velocity, e.g. the same adjustment velocity as by means of the adjustment in the first direction.

In certain cases it is of advantage that the passage is slightly open in the state of balance. By this means, it is possible to employ a stronger throttling in the communicating channel in the piston and thereby obtain a faster increase in the volume of the fluid on the high-pressure side of the piston when, by means of the adjustment piston, provision is made for the discharge from the low-pressure side without any substantial reduction in the total amount of fluid circulating during the equilibrium state which, inter alia, is of importance for the cooling.

In other cases it may, however, be advantageous for the passage to be completely closed in the equilibrating position and only to have a beginning opening at a position of the adjustment piston at a short distance from the equilibrating position, as a smaller hysteresis is obtained. The increase in the velocity occurs only when the adjustment exceeds a certain low value, but in the case of small adjustments, the velocity is, on the other hand, only of little importance.

In the following, the invention is explained in greater detail with reference to the drawing, in which

FIG. 1 shows diagrammatically an embodiment of an axial flow fan wheel according to the invention and

FIGS. 2–5 four different embodiments of the regulating mechanism of the wheel.

FIGS. 6–9 show four different modified embodiments of a regulating mechanism for an axial flow fan wheel according to the invention.

FIG. 1 shows a part of the drive shaft 1 of the fan wheel on which the hub 2 of the wheel is fitted with hub plate 3 and hub ring 4. In the hub ring 4, the vanes 5 of the wheel are pivotably supported each with a pin 6.

An adjustment disc 7 is displaceably mounted in the axial direction of the wheel on pins 8, which are secured in the hub 2. By displacement of the disc 7, a simultaneous adjustment of all vanes takes place in a known manner, since each shaft pin 6 is connected with an eccentric adjustment pin 9 which engages with a guiding track 10 in the circumference of the disc 7.

12 designates a working cylinder for a hydraulic adjustment mechanism, which serves to adjust the adjustment disc 7 and which will be described in greater detail in connection with FIGS. 2–5.

The wheel is provided with a cover plate 13, through which the working cylinder 12 in the embodiment shown juts out a little.

The operation of the hydraulic adjustment mechanism is effected by means of an adjustment spindle 14, which can be displaced in the axial direction with the aid of an adjustment rod 15, which is connected to the adjustment spindle 14 by means of a rotor seal 16, in which the adjustment spindle is pivotally, but undisplaceably, supported.

The hydraulic fluid is supplied via the rotor seal 16, to which, via a conduit 17, a pump 19 is connected, which pumps the fluid from a tank 18. In the pump 19, the conduit 17 is connected with a bypass valve 20, which ensures that the pressure does not exceed a maximum value and from which excess fluid runs back to the tank 18. The discharge of fluid from the hydraulic regulating mechanism does likewise take place via the rotor seal 16, in that a conduit 21 is connected to same, which leads back to the tank.

In the embodiment shown in FIG. 2, the working cylinder 12 is rigidly connected with the adjustment disc 7. Said disc rotates together with the wheel, but is displaceable in relation to the shaft 1 and the hub of the wheel and the parts connected thereto. In the duct between the cover plate 13 there is a bearing 25.

In the working cylinder 12 a working piston 26 is fitted, which is secured on a piston rod in the form of a piece of tube 27, which is rigidly connected with the shaft 1 concentrically with same. The piston 26 thus rotates, just like the cylinder, together with the shaft 1, but is immovable in relation to same.

In the bottom piece 28 of the cylinder 12, an adjustment cylinder 29 is concentrically secured, which extends into the cylinder 12 and partly also into the piece of tube 27.

In the adjustment cylinder 29, an adjustment piston 30 is fitted, the above-mentioned adjustment spindle 14 of which extends outside the cylinder 29.

Between the bottom piece 31 and the piston 30 of the cylinder 29, a coil spring 32 is inserted, which produces a bias against the inward movement of the inward movement of the adjustment piston 30.

The fluid which is supplied to the rotor seal 16 via the conduit 17, is conducted through a channel 33 in the adjustment spindle 14 to a groove 34 in the adjustment piston 30. This groove 34 is situated outside the mouth of a channel 35 in the adjustment cylinder 29, to which channel 35 a channel 36 is connected, which, via the bottom piece 28 and the wall of the cylinder 12, leads to the inside of the cylinder on the side of the working piston 26 which turns towards the shaft 1. From this side of the working piston there is connection to the opposite side through a nozzle 38 inserted in a bore in the piston 26.

The other side of the space of the working cylinder 12 communicates with a groove 40 in the wall of the adjustment cylinder via a channel 39 in the adjustment cylinder 29 and its bottom piece 31. This groove 40 partly overlaps a groove 41 in the adjustment piston 30, which groove 41 communicates with a channel 42 which, through the adjustment spindle 14, leads out into the rotor seal 16 and there communicates with the conduit 21.

The grooves 40 and 41 are mounted relative to each other in such a way that the passage between them is constituted by a relatively narrow slit, so that a throttling of the fluid occurs during its passage from one of these grooves to the other. Likewise, a throttling takes place in the nozzle 38, and thus a pressure drop results partly in the said slit and partly in the nozzle, and since this pressure drop is of such a magnitude that the pressure drop in the other parts of the system may be considered as negligible, this means that the total of the two pressure drops has to be equivalent to the excess pressure by means of which the liquid is supplied via the conduit 17.

The pressure on the two sides of the working cylinder 26 does, therefore, depend on the ratio between the pressure drop in the nozzle and the pressure drop in the said slit.

The force acting on each of the two sides of the piston 26 is equivalent to the product of the pressure and piston area on the side in question. The two forces are equally great when the ratio between the areas is equivalent to the inverse ratio between the pressures. When this happens to be the case, no movement of the piston takes place in relation to the cylinder, i.e. the cylinder does not move in relation to the wheel.

This state corresponds to a quite specific throttling in the said slit, that is to say, a quite specific position of the adjustment piston 30 in relation to the adjustment cylinder 29.

Starting at this state a displacement of the adjustment piston 30 somewhat toward the left, in such a way that the slit between the grooves 40 and 41 becomes smaller, will result in an increase in the pressure drop through the slit. This means that the pressure on the left side of the working cylinder 26 is increased, so that same is displaced toward the left in relation to the working cylinder 12. As the working piston is stationary, this means that the working cylinder 12 is displaced toward the left.

By this means, a corresponding movement of the adjustment disc 7 takes place simultaneously, as it is rigidly connected with the working cylinder 12, and consequently, an adjustment of the vanes 5 takes place.

The adjustment cylinder 29, which is rigidly connected with the bottom piece 28 of the working cylinder 12, moves in a like manner to the left, however, so that the slit between the grooves 40 and 41 is progressively increased, with the result

that the pressure on the left side of the piston decreases, and when the adjustment cylinder **29** has again assumed the same position in relation to the adjustment piston **30** as prior to the adjustment of same having been effected, the stationary state is reestablished.

If the adjustment piston **30** is displaced a little to the right, the slit between the grooves **40** and **41** is increased, that is to say, the pressure drop is diminished, so that the pressure on the left side of the working piston becomes smaller, whereby the working piston is forced to the left in relation to the working cylinder **12**, i.e. that the working cylinder **12** moves to the right and by means of the adjustment disc **7**, effects an adjustment of the vanes **5** in the opposite direction.

In this case, too, the stationary state is being reestablished as a consequence of the adjustment cylinder **29** moving to the right together with the working cylinder **12**.

The groove **34** has to possess such a width that same, in every possible adjustment of the adjustment piston **30**, has a full opening towards the channel **40**, since the variable throttling must only take place in the slit between the grooves **40** and **41**.

The channel **42** in the adjustment spindle **14** is extended outwards through the adjustment piston **30** to its opposite end in order to form a drain for such fluid as possibly seeps through between the adjustment cylinder **39** and the adjustment piston **30** and which collects in the space between the piston **30** and the bottom piece **31**.

The toppiece **45** of the working piston **12** is sealed against the piston rod or the piece of tube **27** by means of two gasket rings **46** and **47**, between which a drain **48** is fitted, by means of which fluid, which may possibly seep through, can be collected and led back to the groove **41** via a channel **49**.

FIGS. **3–5** show three modified embodiments substantially more diagrammatically.

In the embodiment according to FIG. **3**, the movement of the adjustment disc **7** likewise takes place by the movement of the working cylinder **12**, while the piston **26** is rigidly connected with the shaft **1** and the hub **2**. In this case, the parts are, however, placed the other way around, in that the connection between the working piston **26** and the shaft **1** occurs indirectly, by the piston rod or the piece of tube **27** being rigidly connected with the cover **13**. The adjustment cylinder **30** has, therefore, to extend right through the piece of tube **27** in order to be connected with the bottom piece **28** of the working cylinder **12**.

The embodiment shown in FIG. **4** differs from the ones shown in FIGS. **2** and **3** in that the working piston **26** is rigidly connected with the adjustment disc **7** via its piston rod **50**, while the working cylinder **12** is rigidly connected with the cover plate **13**. Consequently, the adjustment cylinder **30** is rigidly connected with the working piston **26**.

The embodiment shown in FIG. **5** has, just like the one shown in FIG. **4**, a displaceable working piston and an immovable working cylinder, but in this case, the working cylinder **12** is secured directly to the shaft **1**. The working piston **26** is, with its piston rod **52**, connected with a flange **53**, which is fixed to a cylinder piece **54**, which surrounds the working cylinder **12** and which is rigidly connected with the adjustment disc **7**.

In this embodiment, the piston rod **52** does, at the same time, constitute the adjustment cylinder, in which the adjustment piston **30** is fitted.

In the embodiments shown in FIGS. **3**, **4** and **5**, the movable part is connected with a rod **55**, which is controlled in a bushing **56** in a bore in the shaft **1** and may lead to one or several adjustment discs corresponding to the adjustment disc **7** and controlling part of one or several further vane sets, when the blower is constructed as a two or multiple step blower. A corresponding rod may also be employed in connection with the embodiment shown in FIG. **2**, as this control rod may then be connected with the adjustment cylinder **30** or its bottom piece **31**.

FIG. **6** corresponds to FIG. **2** and the same reference designations have been used as in same, but with the difference that in the wall of the cylinder **29** a passage **60** has been provided connecting the space of the working cylinder **12** with a groove **61** in the end wall of the adjustment cylinder immediately at the side of the groove **34** in the adjustment piston **30** in the state of balance, so that the passage **60** is closed in this position and is likewise closed during a movement of the adjustment piston **30** inwardly in the adjustment cylinder **29**, in which, via the grooves **40** and **41**, there is opened completely for the discharge from the space of the working cylinder **12** to the discharge channel **42**, while there is fully open between the groove **61** and the groove **34** and the inlet channel **35** when the adjustment piston **30** is displaced in the opposite direction in the adjustment cylinder **29**.

In the first of these adjustment movements, in which the passage **60** is closed, the state is quite the same as in the corresponding adjustment movement in the construction described in connection with FIG. **1**, since the pressure drops on the left side of the working piston **26**, so that the working cylinder **12** is pushed to the right, while the fluid on the left side of the working piston **26** is quickly forced out through the discharge channel.

By means of the reverse movement of the adjustment piston **30**, the discharge from the left side of the working piston **26** is closed, whereupon the pressure on this side rises so that the working cylinder **12** is moved to the left. This necessitates a reduction of the quantity of fluid on the right side of the working piston **28** and that the quantity of fluid on the right side in increased correspondingly, which, in the construction shown in FIG. **1**, can only take place by the fluid flowing through the nozzle **38**, which is only possible to take place very slowly, especially because the closing of the connection between the two grooves **40** and **41** results in substantially the same pressure occurring on both sides of the working piston **26**.

In the construction shown in FIG. **6**, however, during this movement the passage **60** is opened, which connects the space of the cylinder on the left side of the piston **26** with the channel **35**, so that the space at that side of the piston can be supplied with the requisite quantity of fluid. At the same time, the space on the right side of the working piston can be quickly emptied of a corresponding quantity of liquid, because this space, via the channel **36**, communicates with the channel **35** thereby, via the passage **60**, with the left side of the working piston **26**. It is thus possible, without any difficulty, to obtain the same adjustment velocity by means of the two reverse adjustments.

In the embodiment shown in FIG. **6**, the passage **60** is completely closed in the equilibrium state, but it is also possible to dispose the groove **61** in such a manner that there remains a narrow passage between same and the groove **34** on the adjustment piston **30** in the equilibrium state. By this means, an increased adjustment velocity is obtained, since the fluid which, in the equilibrium state, flows from the left side of the working piston **26** through the gap between the grooves **40** and **41**, now comes to this space by two routes, that is to say, on the one hand, via the nozzle **38** and, on the other hand, via the gap between the grooves **34** and **61**, so that in order to obtain the correct pressure balance it will be necessary to throttle harder in the nozzle **38**. This results in that the space on the right side of the gap, by means of the adjustment in which the working cylinder is to be moved to the right, can be filled more rapidly with the quantity of fluid required, because the flow away from this space via the nozzle **38** becomes less.

Even though in the embodiment dealt with last, lower hysteresis is produced than in the known constructions, it is possible, however, if one forgoes this increase in velocity, to obtain a substantially lower hysteresis, viz by the groove **61** being disposed in such a way that the connection between same and the groove **34** is only opened after the adjustment piston **30** has been moved a short distance from the equilibrating position towards the left. Thereby, the passage **60** will, it is true, not become effective during very small adjustment

movements, but so long as it is only a question of small adjustment movements, the adjustment velocity is of minor importance.

FIGS. 7, 8 and 9 correspond entirely to FIGS. 3, 4 and 5, only with the difference that in these figures it is shown how the passage 60 is to be placed in each individual case.

Moreover, the effect is quite like that described in connection with FIGS. 1–5, with the addition of the effect of the passage 60, as described above in connection with FIG. 6.

What is claimed is:

1. An axial flow fan wheel comprising a drive shaft, a hub secured on said drive shaft, a hub ring rigidly connected with said hub, adjustable vanes journaled with radial axis on said hub ring, a hydraulic adjustment system for the adjustment of said vanes during the rotation of said wheel, said adjustment system comprising an adjustment member displaceable in the axial direction relative to said hub ring and connected with said hub ring for the rotation thereof together with said wheel, a first hydraulic-working member and a second hydraulic-working member, one of said first working member and said second working member being a working cylinder the other of said first and second working members being a working piston displaceably disposed relative to said working cylinder within same, said first hydraulic-working member being rigidly connected with said drive shaft, said working piston having different effective areas on its two opposite sides and a communicating channel interconnecting said opposite sides for equilibrating the pressure on said opposite sides, said second hydraulic-working member being rigidly connected with said adjustment member, an adjustment cylinder disposed coaxially with said second hydraulic working member rigidly connected therewith, an adjustment piston displaceably disposed in the adjustment cylinder, a rotor seal casing mounted displaceably but unrotatably relative to said adjustment cylinder and rotatably but nondisplaceably supported on an extension of said adjustment piston, said rotor seal casing being provided with connecting branches leading to separate areas inside said rotor seal casing, said areas being fluid sealed against each other, a fluid inlet channel and a fluid outlet channel being provided in said adjustment piston and said extension thereof, extending from one and the other said areas respectively, said inlet channel communicating with the space of said working cylinder at that of said sides of said working piston having the smaller area, said outlet channel communicating with the space at the other side of said working piston through adjustable throttling means, said means being constituted by said adjustment piston and said adjustment cylinder, one of said connecting branches being connected with means for the supply of hydraulic fluid at a constant pressure to said inlet channel, said communicating channel in said working piston having a flow resistance of such value relative to the flow resistance of said throttling means that in a state of equilibrium the proportion of the pressure drop over said throttling means to the total pressure equals the proportion of said different effective areas on both sides of said working piston.

2. An axial flow fan wheel as claimed in claim 1 in which said first hydraulic-working member constitutes said working piston and said second hydraulic element constitutes said working cylinder.

3. An axial flow fan wheel as claimed in claim 1 wherein said first hydraulic-working member constitutes said working cylinder and said second hydraulic member constitutes said working piston.

4. An axial flow fan wheel as claimed in claim 2, wherein said wheel is provided with a cover plate rigidly connected with said hub ring, said working piston being provided with a piston rod rigidly connected with said cover plate and projecting into the space between said cover plate and said drive shaft.

5. An axial flow fan wheel as claimed in claim 2, wherein said working piston is provided with a hollow piston rod, said adjustment cylinder being fitted displaceably within said hollow piston rod projecting therefrom at both ends, said working cylinder being provided with a bottom piece, said drive shaft having a central bore, said bottom piece being connected with a shaft, which is displaceable supported in said bore.

6. An axial flow fan wheel as claimed in claim 2, wherein said working piston is of an annular shape and secured on a piece of tube, said piece of tube being secured to said drive shaft as an extension of same, said adjustment cylinder extending into said working cylinder, the external diameter of said adjustment cylinder being less than the internal diameter of said piece of tube.

7. An axial flow fan wheel as claimed in claim 1, wherein the external diameter of said working piston is approximately twice as large as the external diameter of said piece of tube.

8. An axial flow fan wheel as claimed in claim 1 wherein a passage is provided in said adjustment cylinder leading from said fluid inlet channel in said adjustment piston to said working cylinder at the side of same having the larger effective area, said passage being controllable by means of said adjustment piston, said passage being fully open in positions of said adjustment piston relative to said adjustment cylinder corresponding to an increase of the space in said working cylinder at the side of said working piston having the larger effective area, and said passage being closed in positions corresponding a decrease of said space.

9. An axial flow fan wheel as claimed in claim 8 wherein said passage is slightly open in the equilibrium state.

10. An axial flow fan wheel as claimed in claim 8 wherein said passage is completely closed in the equilibrium state and in positions of said adjustment piston relative to said adjustment cylinder within a short interval extending from the equilibrium state in direction of an increase of said space.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,603,698 Dated September 7, 1971

Inventor(s) Carl Erling Jensen

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Priority November 22, 1968, May 8, 1969
DENMARK
5733/68 and 2528/69

Signed and sealed this 11th day of April 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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