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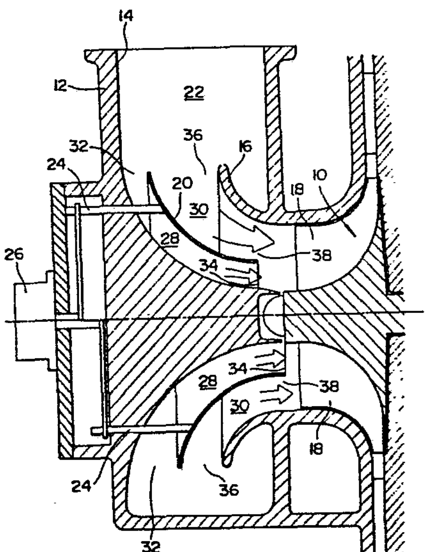
(54) **Turbo compressor having a surge suppressing arrangement.**

(57) An annular vane (20) having a truncated hyperboloid configuration is disposed in a portion of a turbo compressor induction passage (22) having a similar curvature. The vane (20) defines inner and an outer sub-passages (28,30) the cross sectional area of the inlets (32,36) of which may be varied by moving the vane axially with respect to the compressor wheel while the outlets (34,38) of the two passages remain substantially unchanged. As the surge limit is approached the vane is moved away from the compressor wheel to increase the flow passing through the outer passage (30) while reducing that which passes through the inner one (28). The resulting increased flow velocity through the outer sub-passage (30) reduces the angle of incidence of the air impinging on the compressor wheel blades (18) suppressing the surge tendency.

FIG. 4



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TURBO COMPRESSOR HAVING A SURGE SUPPRESSING ARRANGEMENT

DESCRIPTION

The present invention relates generally to a compressor and more specifically to a turbo compressor for a gas turbine or the like equipped with a surge suppressing arrangement.

In order to suppress or lower the surge limit of a turbo compressor it is known to swirl the inducted air flow upstream of the turbo compressor wheel when the induction volume falls to a level at which surging is apt to occur. This serves to reduce the angle of incidence of the incomming flow of air on the blades of the compressor wheel suppressing the surge limit.

A known arrangement utilized for controllably swirling the incomming flow of air upstream of the turbo compressor wheel 1 is shown in Figs. 1 and 2. This arrangement takes the form of a series of equidistantly spaced vanes 2 disposed radially about the axis of rotation of the turbo compressor 1. Each of the vanes 2 is pivotally mounted on a shaft 3 provided at one end with a connection link or lever 4. A ring member 5 is operatively connected to each of the links 4 and so that upon rotation of same each of the vanes 2 undergoes the same degree of deflection from its home or neutral position. However, when this arrangement is applied to the type of gas turbine illustrated in Figs. 1 and 2, viz., a gas turbine having an induction port asymmetrical with respect to the axis of rotation of the turbo compressor wheel wherein the port lies in an essentially flat plane which is spaced from and non-intersecting with the turbo compressor wheel axis, the flow path from the "asymmetrical" induction port to the guide vanes closest thereto is shorter than to those successively spaced therefrom. Further, due to the configuration of the induction port the angle of entry of the flows between the vanes tends to vary along with the generation of a flow velocity differential between adjacent vanes. These flow velocity differentials between the vanes tends to induce the situation wherein the flow velocity on one side of a vane is different from that on the other, whereupon a pressure differential occurs at the trailing edge of the vane which in turn produces turbulent or eddy flow downstream thereof. This turbulent flow creates a vibration which under given operational conditions tends to maximize or resonate to the degree of damaging the blades 6 of the compressor. Moreover, the differing angles of entry of the flows between the vanes induce the situation wherein the angle of incidence of the air on the blades of the compressor is not uniform and accordingly deviates across the face of the compressor wheel from the desired value for any given low induction mode of operation.

Hence, this type of swirl generating arrangement has been limited to use in compressors having a"symmetrical" induction port such as shown in Fig. 3. However, even in this case the arrangement has still suffered from the drawback of being overly complex. Viz., the swirl arrangement includes a plurality of radially disposed adjustable vanes each of which is connected to a control ring through a linkage, whereby the production, assembly and disposition of same in the extremely confined environment of the compressor housing, are time consuming and expensive.

The invention features an annular vane having a truncated hyperboloid configuration which is disposed in a portion of a turbo compressor induction passage having a similar curvature. The vane defines inner and an outer sub-passages the cross sectional area of the inlets of which may be varied by moving the vane axially with respect to the compressor wheel while the cross sectional area of the outlets of the two passages remain substantially unchanged.

As the surge limit is approached the vane is moved away from the compressor wheel to increase the flow passing through the outer sub-passage while reducing that which passes through the inner one. The resulting increased flow velocity through the outer sub-passage reduces the angle of incidence of the air emitted therefrom impinging on the outer peripheral region of the compressor wheel blades, suppressing the surge tendency, while the lower velocity flow emitted from the inner sub-passage impinges on the root portion of the compressor blades. Although the latter flow has relatively little kinetic energy its site of impingement renders its low energy nature of little consequence and does not tend to induce stalling or the like.

Further, the cross section of each of the sub-passages smoothly reduces in the direction of flow which compresses and accelerates each of the flows to promote laminar flow and prevent any tendency to "peel off" the walls of their respective passages.

The features and advantages of the arrangement of the present invention will become more clearly appreciated from the following description taken in conjuction with the accompanying drawings in which

Fig. 1 is a sectional view of a centrifugal type compressor having an "asymmetrical" induction port which is equipped with a prior art swirl generating arrangement;

Fig. 2 is a sectional view taken along the section line II-II of Fig. 1;

Fig. 3 is sectional view of a centrifugal type gas turbine having a "symmetrical" induction port which is equipped with a prior art swirling device;

Fig. 4 is a sectional view of a preferred embodiment of the present invention as applied to a centrifugal type compressor having an "asymmetrical" induction port by way of example; and

Fig. 5 is a vector diagram showing the effect of the present invention.

Turning now to the drawings and in particular Fig. 4 a preferred embodiment of the present invention is shown. In this arrangement a turbo compressor wheel 10 is operatively disposed in a turbo compressor induction housing 12 of the type having an asymmetical induction port 14 (viz., a port having a mouth which lies on an essentially flat plane spaced from and non-intersecting with the axis of rotation of the compressor wheel 10).

The induction housing 12 is further formed with a bell or trumpet shaped member 16 for smoothing and promoting laminar fluid flow toward the blades of the compressor wheel.

A surge suppressing guide vane 20 is disposed within the induction passage 22 of the induction housing. This vane has a truncated hyperboloid configuration which has a curvature approximately the same as the bell or trumpet shaped member 16 and is disposed coaxially about the axis of rotation of the compressor wheel.

Rods 24 or other suitable linkage members interconnect the surge supressing vane 20 to an actuator 26 adapted to move the vane axially with respect to the compressor wheel in response to the normal surge limit of the compressor being approached.

This arrangement under normal operation of the compressor is positioned as shown in Fig. 4 below the compressor wheel axis. In this "normal" position, the vane 20 cooperates with the trumpet shaped member 16 to define two sub-passages 28, 30 within the induction passage 22. Each of the passages has an annular inlet and an annular outlet.

With this arrangement, upon the induction volume falling to a level where surging is apt to occur, the vane 20 is moved axially away from the compressor wheel

10 as shown in Fig. 4 (above the compressor wheel axis). Due to the movement of the vane within the induction passage the cross sectional area of the inlet 32 of the inner sub-passage 28 decreases while the cross sectional area of the outlet 34 thereof, remains essentially the same and on the other hand the cross sectional area of the inlet 36 of the outer sub-passage 30 hand increases while the cross sectional area of the outlet 38 thereof also remains almost unchanged. This causes a restriction of the flow passing through the inner sub-passage 28 while allowing an increased flow through the outer sub-passage 30. The flow velocity through the outer sub-passage 30 is accordingly increased as compared with the same induction volume with the vane in its "normal" position while the flow through the inner passage is accordingly decreased. Thus, the flow velocity of the air impinging on the compressor wheel blades 18 at the outer peripheral portions thereof, is increased which reduces the angle of incidence between the air flow and the blades and suppresses the tendency for the compressor to surge.

The flow of air emitted from the inner sub-passage 28 has a velocity lower than that emitted from sub-passage 30 but impinges on the root portion of the blades 18 at a location wherein the blades tend to curve both radially and outwardly and which, as such, is not apt to impair the operation of the compressor (viz., inducing a stall or the like).

As the curvature of the vane 20 is essentially the same as that of the induction passage defined within the bell shaped member 16, and the cross-sectional area of each of the inner and outer passages 28, 30 tends to decrease in the direction of flow, the flows passing through each of the passages are gradually compressed and accelerated which prevents same from "peeling off" the walls of the respective passages. This of course promotes laminar flow and reduces the tendency for eddy flow to occur in either of the two flows emitted from two sub-passages.

The actuator 26 may be rendered responsive to a suitable control signal from a controller or the like depending on the control system employed to control the compressor and/or associated gas turbine be it hydraulic, electric or pneumatic. In the case that the controller is pneumatic it may be responsive to a pressure signal originating on the discharge side of the compressor. This pressure signal may be directly fed to the actuator if desired in which case a damper may be combined with the actuator to offset any hunting tendency apt to occur.

Fig. 5 shows in vector form, the relationship between the flow velocity of the fluid in the induction passage, the peripheral velocity of the wheel and the relative velocity of the gases entering to the compressor wheel. Thus, in this diagram VPS denotes the peripheral velocity of the turbine wheel, IS the induction velocity in a region close to the outer periphery of the bladed compressor wheel and RIS the relative induction velocity of the air entering the peripheral region of the compressor wheel. In this figure, the broken lines indicate the surge limit of the compressor without the provision or use of the present invention while the solid line shows the extended limit via the use of the invention. As shown by the solid line in this figure, when the surge supressing arrangement of the present invention is put into use, RIS increases while the angle of incidence on the blades 18 of the compressor wheel decreases. Accordingly surging is suppressed.

Thus in summary, the present invention provides a very simple arrangement which neither tends to produce turbulent flow nor be usable with only given types of turbo compressor induction housings and which takes the form of a truncated hyperboloid guide vane movably disposed in the induction passage upstream of and coaxial with the bladed compressor wheel. Movement of the vane away from the compressor wheel accelerates the flow of air impinging on the outer peripheral region of the compressor blades while slowing that impinging on the root portion thereof.

CLAIMS

1. A turbo compressor having a compressor wheel disposed in an induction housing having induction port, c h a r a c t e r i z e d by

an annular vane (20) movably disposed within said induction housing (12) so as to define first and second coaxial annular cross section flow passages (28,30); and

an actuator (26) operatively connected to said vane (20) for moving said vane (20) in a given axial direction with respect to said compressor wheel (10) for restricting the flow through the second outer passage (30);

said actuator (26) being responsive to the induction volume of the compressor approaching a level whereat surging is apt to occur, to move said vane (20) in said given direction.

2. A turbo compressor as claimed in claim 1, c h a r a c t e r i z e d in that

said annular vane (20) has an essentially truncted hyperboloid configuration having a curvature similar to that portion of said induction passage (22) in which it is disposed, and

wherein said first and second coaxial annular cross section passages (28,30) have configurations wherein the cross section thereof gradually decreases from the inlets (32,36) thereof to the outlets (34,38) thereof.

3. A turbo compressor as claimed in claim 1, c h a r a c t e r i z e d in that

said actuator (26) is responsive to a pressure signal originating of the discharge of said compressor wheel (10).

FIG.2 (PRIOR ART)

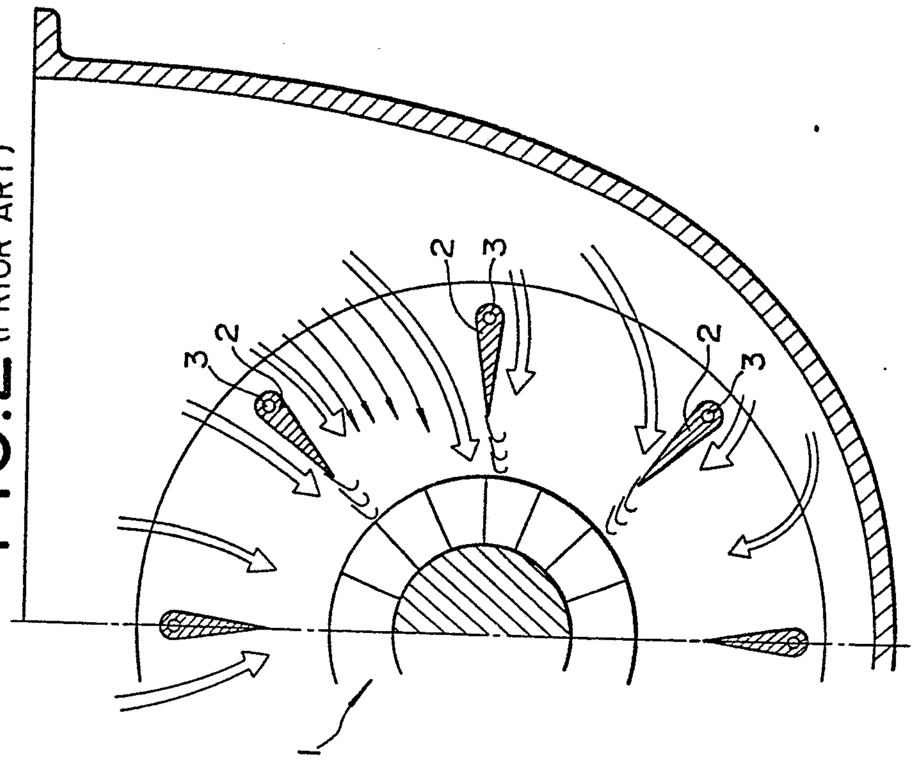
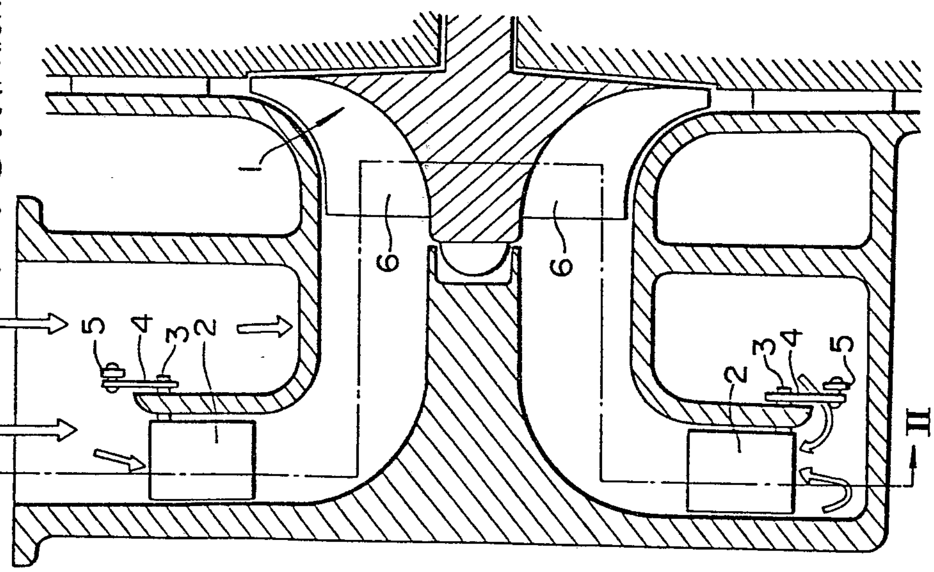


FIG.1 (PRIOR ART)



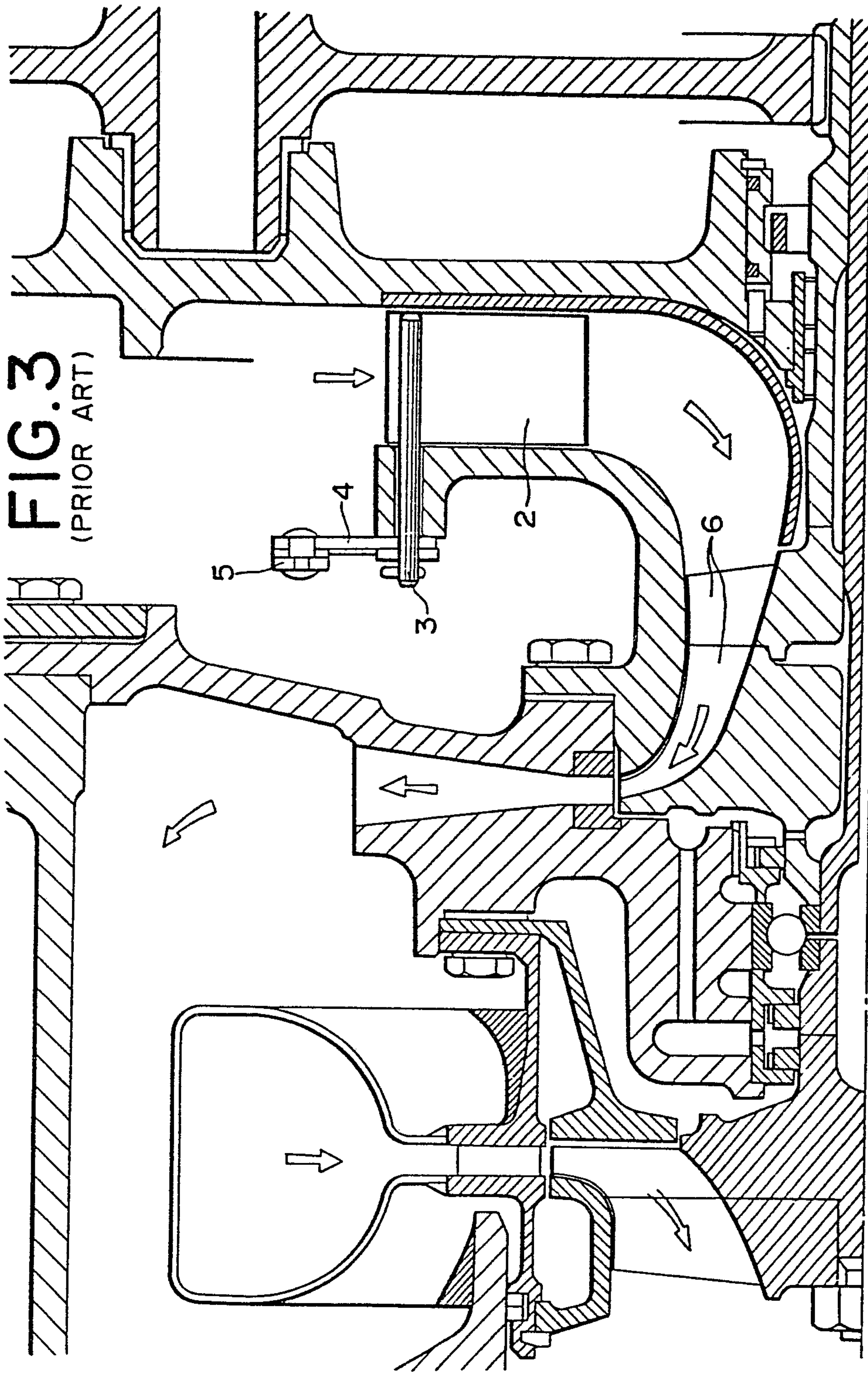


FIG.3
(PRIOR ART)

FIG. 4

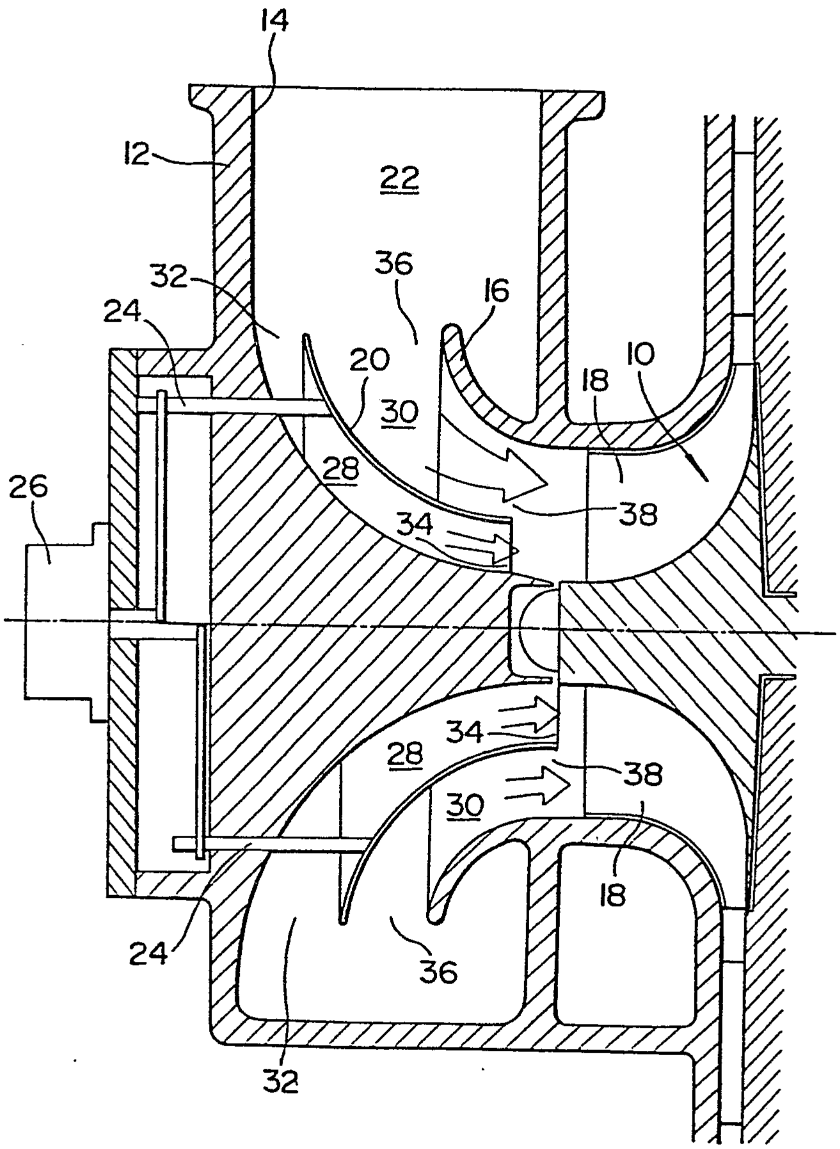
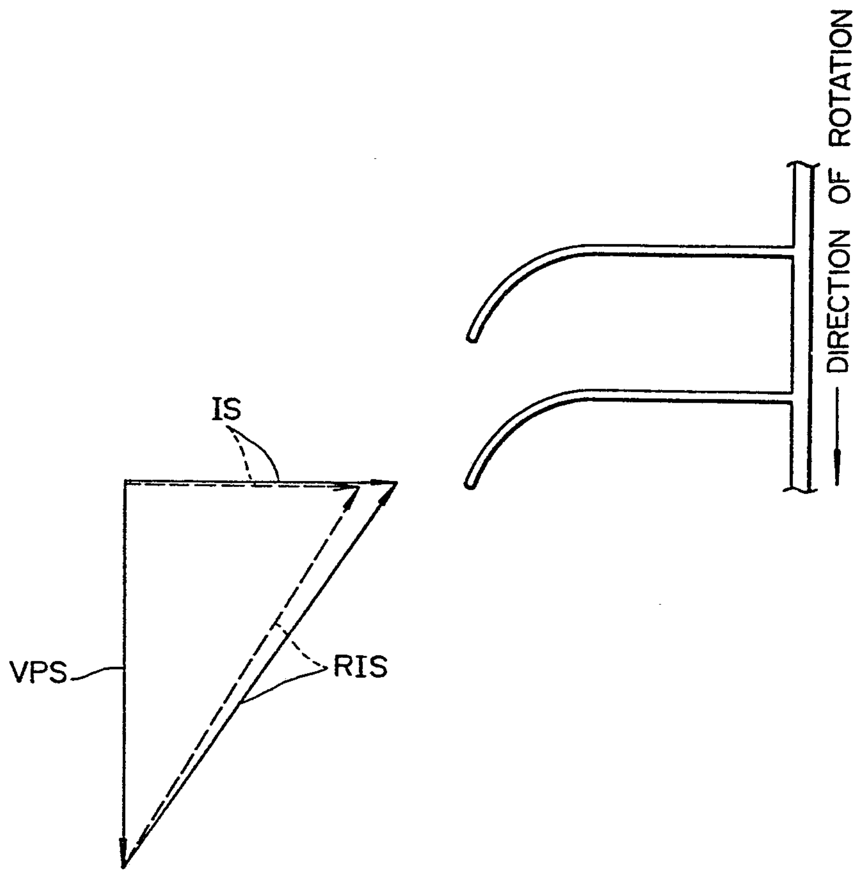


FIG. 5



European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 81 10 5752

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - C - 526 494 (SIEMENS-SCHUCKERT-WERKE A.G.) * Whole document * --	1
	US - A - 2 169 232 (FLANDERS) * Column 2, lines 19-58; figures 3,4,5 * --	1,2
	CH - A - 120 888 (ESCHER WYSS) * Whole document * --	1,3
	US - A - 3 918 828 (KUMM) * Column 1, lines 64-68; column 3, line 5 - column 6, line 32; figures 1,3 * -----	1

CLASSIFICATION OF THE APPLICATION (Int Cl.3)
F 04 D 27/02
29/46

TECHNICAL FIELDS SEARCHED (Int. Cl 3)
F 04 D

CATEGORY OF CITED DOCUMENTS
- X: particularly relevant
- A: technological background
- O: non-written disclosure
- P: intermediate document
- T: theory or principle underlying the invention
- E: conflicting application
- D: document cited in the application
- L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27-10-1981	WENZEL