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SURGE CONTROL MECHANISM FOR TURBOMCHINERY

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2 Sheets-Sheet 1

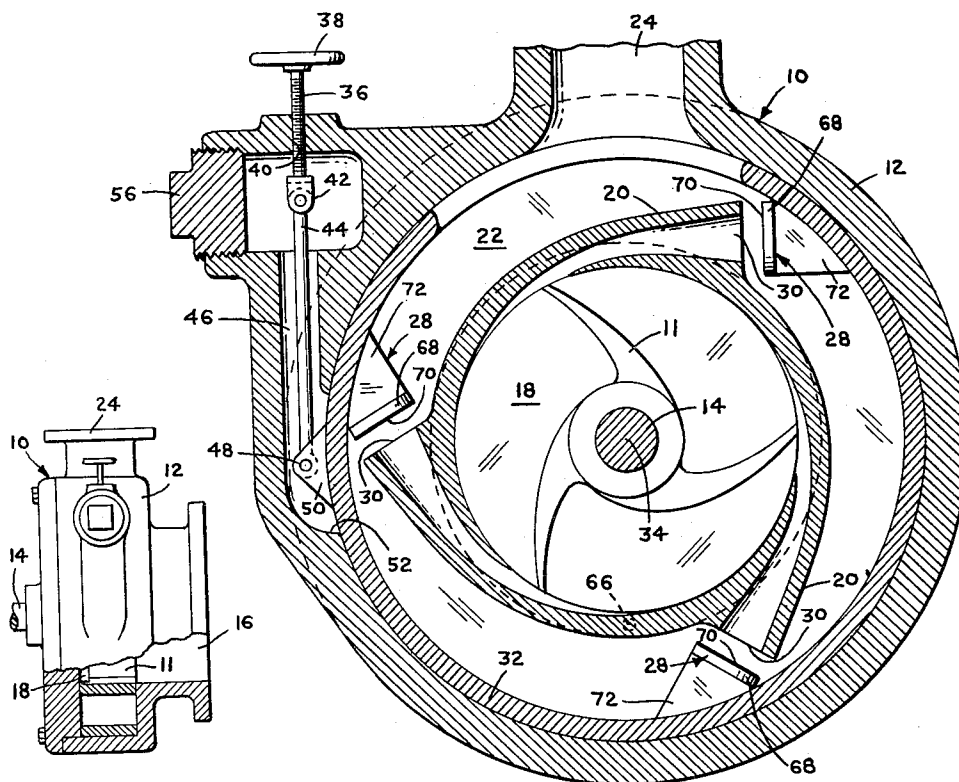


FIG. 1

FIG. 2

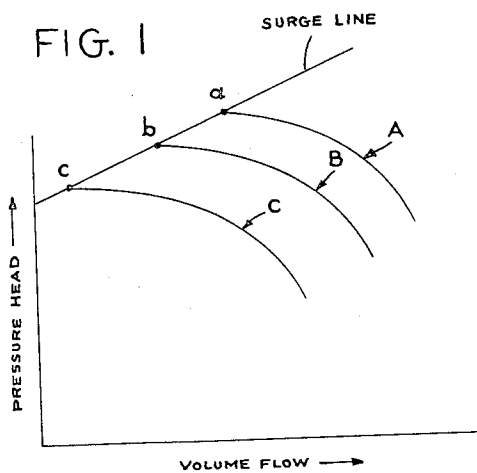


FIG. 8

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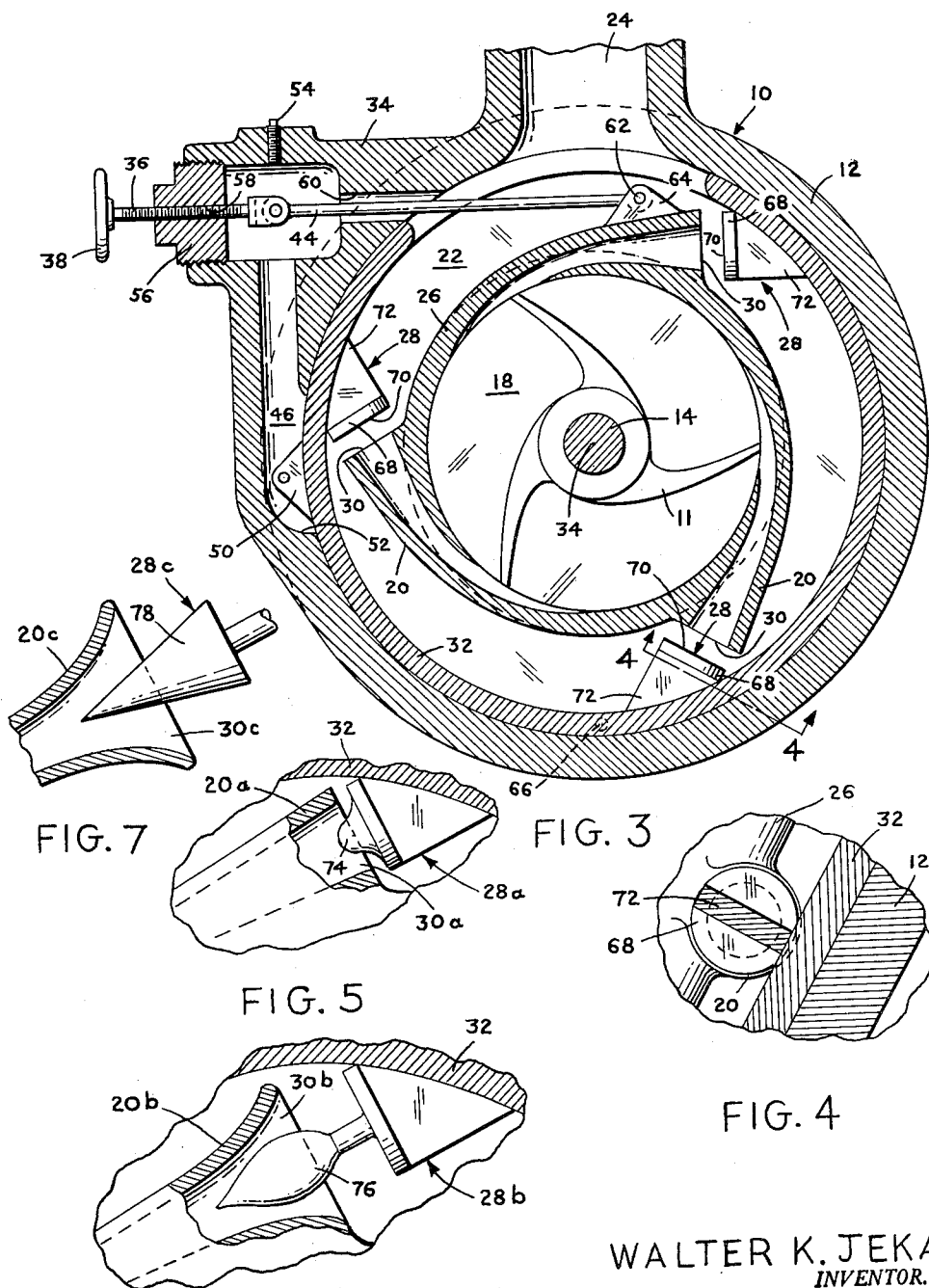
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SURGE CONTROL MECHANISM FOR TURBOMACHINERY

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This invention relates generally to turbomachinery. More particularly the invention relates to a surge control mechanism for turbomachinery.

Various devices have been tried in the turbomachinery of the prior art to control surge; some of which are as follows:

(1) Turnable guide vanes at the inlet or the outlet of the turbomachine,

(2) Throttling the flow at the inlet of the turbomachinery,

(3) Throttling the flow at the inlet of the discharge diffuser of the turbomachine.

However, such devices while partially eliminating surge have created such additional problems as cavitation of the impeller vanes, and the lowering of the turbomachine's efficiency and capacity.

It is the object of the present invention to provide a novel surge control mechanism to prevent surge, which is the pulsating noisy phenomena, without substantially affecting the capacity of the turbomachine and also avoid the other disadvantages of the prior art.

In accordance with the present invention a turbomachine is provided which comprises a casing having an inlet and an outlet therein and a volute adjacent to the outlet, a rotary shaft in the casing is connected to a source of power, an impeller is mounted on the shaft, there is a plurality of discharge diffusers disposed in the volute. Control body means are disposed at the outlet end of each of the diffusers in spaced relationship thereto to change the flow characteristics of the fluid flowing in the turbomachine.

One of the objects of this invention is to provide an improved efficiency over a wide range of flow.

Another object of this invention is to prevent stalling of the flow in the diffusers.

Still another object of this invention is to equalize the flow at the discharge end of the diffusers.

With these and other objects in view as may appear from the accompanying specification the invention consists of various features of construction and a combination of parts which will be first described in connection with the accompanying drawings showing a surge control mechanism of a preferred form and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

FIGURE 1 is an elevation partly in section of a turbomachine in which the present invention is embodied.

FIGURE 2 is a partial section perpendicular to the axis of the turbomachine showing one form of the novel control bodies of the surge control mechanism at the outlet of the diffusers.

FIGURE 3 is a partial section perpendicular to the axis of the turbomachine showing a modified rotational arrangement.

FIGURE 4 is a section taken in the direction of line 4-4 of FIGURE 3.

FIGURE 5 is a fragmentary view partly in section showing another form of control body.

FIGURE 6 is a fragmentary view partly in section showing another form of control body.

FIGURE 7 is a fragmentary sectional view of another form of control body.

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FIGURE 8 is a pressure volume diagram representing the flow at a constant r.p.m.

Referring more particularly to the drawings, FIGURE 1 shows a turbomachine 10 in which the novel surge control mechanism is used.

The turbomachine could be, for example, any type of pump or compressor having a driven impeller 11 in a casing 12 and mounted on a shaft 14, the shaft 14 being connected to a suitable source of power (not shown).

The operation of turbomachinery is well known in the art and will therefore only be briefly related. The fluid to be energized enters the inlet 16 and passes to the energizing chamber 18 where the impeller 11 energizes the fluid and discharges the fluid through diffuser 20 into volute 22 and out through outlet 24.

Mounted in the volute 22 as illustrated in FIGURE 2 is an annular inner ring 26 provided with a plurality of diffusers 20. Control bodies 28 are positioned adjacent the discharge end 30 of each of the diffusers 20 and connected to an annular outer ring 32 which is adapted to rotate about the axis 34 of the turbomachine 10, thus changing the spatial relationship between the control body 28 and the discharge end 30 of the diffuser 20.

The use of rotatable annular rings is well known in the art and it is understood that the spatial relationship between the control body 28 and the discharge end 30 of the diffuser 20 can be changed by rotation of either the outer ring 32 or the inner ring 26 as indicated in FIGURES 2 and 3 respectively.

Casing 12 has an integrally formed member 34 therein which as shown in FIGURE 2 is adapted to house a threaded member 36 with a turnable handle 38 outwardly of the casing 12. The threaded member 36 passes through tapped hole 40 and is pivotally connected as at 42 to a rod 44 which extends into the channel 46. The other end of the rod is pivotally connected as at 48 to a triangular piece 50 mounted on the outer ring 32 and passing through the opening 52 of the casing 12. By turning the handle 38 the outer ring 32 can be rotated as desired thus selectively positioning control body 28 relative diffuser end 30, for example, to open or throttled or highly throttled positions.

In order to rotate the inner ring 26 instead of the outer ring 32 plug 54 is placed in the hole 40. Plug 56 is threadedly bored as at 58 in alignment with a bore 60 in the casing 12 with threaded member 36 and rod 44 extended therethrough, the end of the rod 44 being pivotally connected as at 62 to piece 64 mounted on the inner ring 26. Once again by turning the handle 38 the inner ring 26 can be rotated as desired to selectively position control body 28 with respect to diffuser end 30.

Depending on whether inner ring 26 or outer ring 32 is to be rotated a pin 66 is disposed between the casing 12 and the ring not being rotated to prevent unwanted movement of that ring.

Control body 28 as shown in FIGURES 2, 3 and 4 is provided with a main body having a flat face 70 and a web member 72 which is connected to the outer ring 32. However, when the inner ring 26 is to be rotated web member 72 can be connected directly to the casing 12 on removal of the outer ring 32 if so desired.

The flat face 70 of the main body 68 is substantially perpendicular to the diffuser or discharge end 30 of the diffuser 20 to minimize the angular displacement caused by rotation of either the outer ring 32 or the inner ring 26. The flat face 70 is substantially perpendicular to diffuser end 30 at the closed position.

For certain applications it is desirable to use an extension tip on the control body 28. The specific size and shape of the extension tip will be mostly determined by the size and shape of the diffuser and the flow characteristics desired to be obtained.

Accordingly, in FIGURES 5, 6 and 7 a few examples of extension tips and diffusers are shown but they are by no means exhaustive and it is understood that any size and shape of extension tip and diffuser can be used and that such use is not limited to any particular coacting diffuser or extension tip but that they may be interchanged in any desired manner or combination without departing from the scope of the present invention.

FIGURE 5 shows control body 28a with a convex contoured extension tip 74 disposed adjacent the discharge end 30a of diffuser 20a. The purpose and operation of this extension tip will be described hereinafter.

FIGURE 6 shows control body 28b with a tear drop extension tip 76 disposed in the discharge end 30b of bell-mouthed diffuser 20b. The purpose and operation of this extension tip will be described hereinafter.

FIGURE 7 shows control body 28c with a conic contoured extension tip 78 disposed in the discharge end 30c of bell-mouthed diffuser 20c. The purpose and operation of this extension tip will be described hereinafter.

While control bodies having flat faces and extension tips in the shape of a convex contour, tear drop, conic contour are illustrated, it is understood that these control bodies may be interchangeably used in the various diffusers shown or others not shown and further that their shape and size may be widely modified and combined within this invention. For example, a needle point can be combined with the convex contoured extension tip or the flat faced body could have recesses therein, etc.

Operation

The operation of the surge control mechanism illustrated in FIGURES 2 and 3 is as follows:

The control body 28 is positioned adjacent the outlet of the diffuser in the open position which means it is far enough away from diffuser 20 so as to have substantially no effect on the fluid being discharged from diffuser 20.

Ordinarily, if the volume drops below a certain value surge will occur. In order to prevent this occurrence the handle 38 is rotated to adjust the control body 28 closer to the discharge end 30 of the diffuser 20 so as to throttle the flow and thus prevent stalling. What takes place is that the control body 28 acts to restrict or diminish the effective cross-sectional area at the discharge end 30 of the diffuser 20 or in other words the flow is throttled by the nozzle-like action of the control body 28 thus causing the fluid to accelerate and increase its velocity to cause a corresponding slight decrease in the pressure and thereby also to equalize or smooth out the flow. Consequently surge is prevented.

The amount the control bodies 28 are moved, toward or away from the discharge end 30 of the diffusers 20, will depend on the operative capacity of the turbomachine, of which there are an infinite number of possibilities. However, for the sake of clarity only three Q—H lines are shown in the diagram of FIGURE 8, namely lines A, B and C which Q—H lines occur, for one reason or another during the operation of turbomachine 10, at a constant r.p.m. It is understood that there is a different set of Q—H lines for each constant speed.

The point on the surge line to the left of which surge will occur for lines A, B and C is indicated as a, b and c, respectively. Point a corresponds to the open position of the control bodies and no throttling of flow leaving the discharge end of the diffusers takes place. Point b is a throttled position and point c is a highly throttled position at which the control bodies 28 will be adjustably rotated close and very close, respectively, to the discharge end 30 of the diffusers 20, thus moving the point at which surge will occur leftwardly in the area of decreased volume while only slightly lowering the effective head.

Turning now to FIGURES 5, 6 and 7 the same opera-

tive effects are present namely that of modifying the cross-sectional area of the diffusers 20a, 20b and 20c by selectively positioning the respective extension tips 74, 76 and 78 therein to obtain the desired flow characteristics. The reason for varying the size and shape of either or both the diffuser and control bodies is to obtain a more subtle and refined control over the flow characteristics of the fluid being energized in the turbomachine 10. In certain applications of this invention it may be desirable to interchangeably use the component control bodies and/or diffusers illustrated herein or others not shown.

More specifically, FIGURE 5 shows a convex contoured extension tip 74 when moved into the discharge end 30a of diffuser 20a, which tip 74 when moved into the discharge end 30a will act to successively decrease the cross-sectional area of the flow pass of diffuser 20a so as to throttle the flow as described hereinbefore under FIGURES 2 and 3.

FIGURES 6 and 7 show extension tip 76 and 78 disposed in bell-mouth diffuser 20b and 20c, respectively. When extension tips 76 and 78 are moved into the discharge end 30b and 30c respectively, they will cause cross-sectional area of the flow path of the diffusers 20b and 20c to be initially successively decreased and then gradually increased with the rate of increase of the flow pass being greater for the tear drop extension tip 76. Thus the flow in the diffuser will be once again throttled, only in these instances it will be allowed to be diffused immediately thereafter.

As to which type of either controlled body or diffuser is used will depend in each instance on the particular flow curve desired. Some general considerations which must be taken into consideration are as follows: the type turbomachine, the range of operative pressure head and capacity of turbomachine and the coefficient of friction in the turbomachine.

From that described hereinbefore it is apparent that for any shape diffuser the desired flow characteristics can be obtained by the use of a suitable control body adjustably disposed adjacent the diffuser. Accordingly, by changing the cross-sectional area of the diffuser I am able to vary the flow characteristics therein, for example, we may accelerate the flow, decelerate the flow, increase the velocity, decrease the velocity, keep the velocity unchanged or any desired combination of these. Furthermore, the changes in flow characteristics can be made without substantially reducing the capacity of the turbomachine.

It will be understood that this invention is not to be limited to the specific construction or arrangement of parts shown but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. A turbomachine comprising:

- (a) a casing having a rotatable shaft disposed therein,
- (b) an impeller mounted on said shaft,
- (c) an inlet means in said casing to communicate fluid to said impeller,
- (d) a volute in said casing,
- (e) said volute communicating with an outlet means in said casing,
- (f) an inner annular ring having a plurality of diffusers circumferentially spaced thereon disposed in said volute adjacent the discharge tip of said impeller to receive fluid being discharged from said impeller,
- (g) an outer annular ring disposed in said volute remote from the discharge tip of said impeller,
- (h) a plurality of control bodies connected to said annular ring and extending inwardly therefrom,
- (i) said control bodies having a leading edge thereof in spaced relationship with the outlet end of each of said diffusers and adapted to move substantially along the axis of said diffusers,
- (j) said inner ring and said outer ring to rotate about the axis of said impeller relative each other whereby said control body is moved correspondingly thereby

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changing the fluid flow characteristics of the fluid by changing the cross-sectional area of the flow pass of the diffuser to inhibit stalling over a wide range of flow to prevent surge.

2. The combination claimed in claim 1 wherein:

means disposed in said casing and adapted to change the spaced relationship between each of said control bodies and the corresponding outlet end of said diffusers whereby the flow characteristics of the fluid in said turbomachine can be changed to prevent surge over a wide range of flow.

3. The combination claimed in claim 1 wherein:

(a) each of said control bodies has a projecting tip formed on the leading edge thereof extending into the outlet end of said diffuser to change the cross-sectional area of the flow path of the diffuser to inhibit stalling of the flow and thus prevent surge.

4. The combination claimed in claim 1 wherein:

(a) each of said control body means has a projecting tip formed on the leading edge thereof and extending toward the outlet end of said diffuser,

(b) said tip disposed into the outlet end of said diffuser whereby the cross-section of the flow path of the diffuser will be reduced thus causing a nozzle effect in the fluid being discharged to prevent surge.

5. The combination claimed in claim 1 wherein each of said control bodies of a corresponding form to that of said diffusers and to be selectively positioned adjacent the discharge end of said diffusers to change the cross-

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sectional area of flow path of said diffuser to prevent stalling of the flow therefrom.

6. The combination claimed in claim 1 wherein each of said control bodies is shaped to successively decrease and gradually increase the cross-sectional area of the flow path of said diffuser whereby the flow therein will be throttled to prevent surge initiated from stalling and separation of the flow in the diffuser and thereafter diffuse to convert velocity energy to pressure energy in the area of non-surfing.

7. The combination claimed in claim 1 wherein each of said control bodies is shaped to successively decrease the cross-sectional area of the flow path of said diffuser thereby the flow therein will be throttled to prevent surge initiated from stalling and separation of the flow in the diffuser.

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