Sept. 7, 1948. L. F. MOODY 2,449,002

APPARATUS FOR REGULATING CENTRIFUGAL MACHINES

Filed Aug. 30, 1946 3 Sheets-Sheet 1

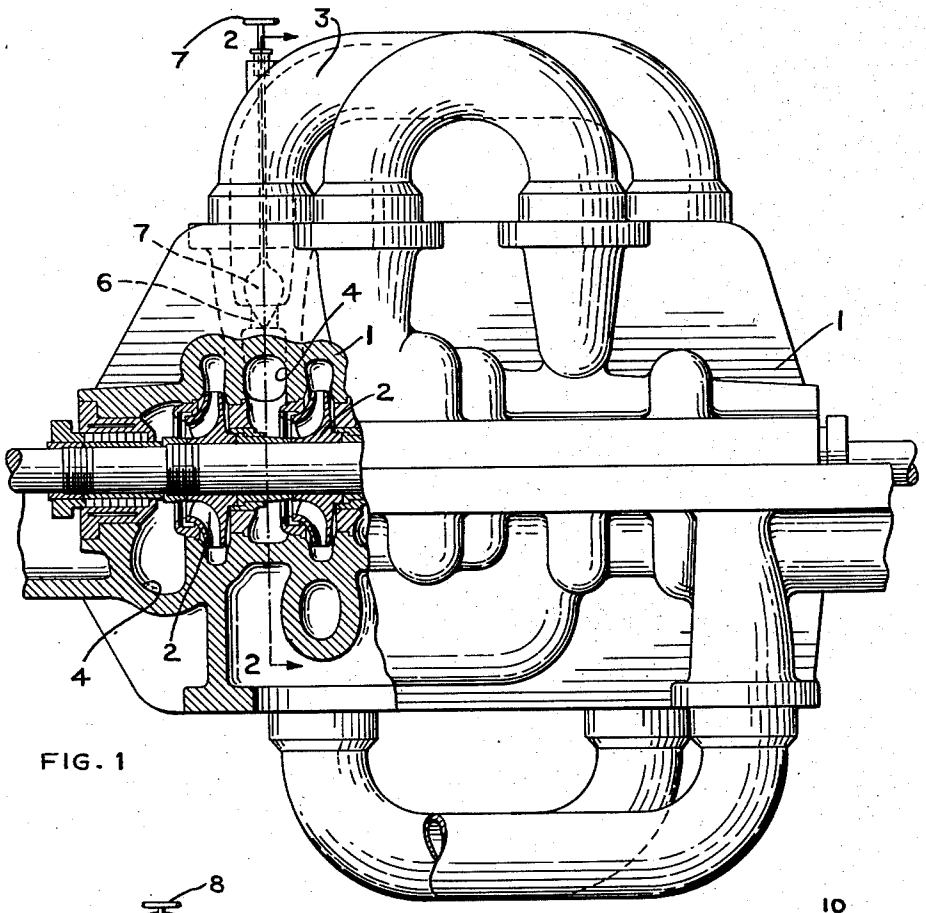


FIG. 1

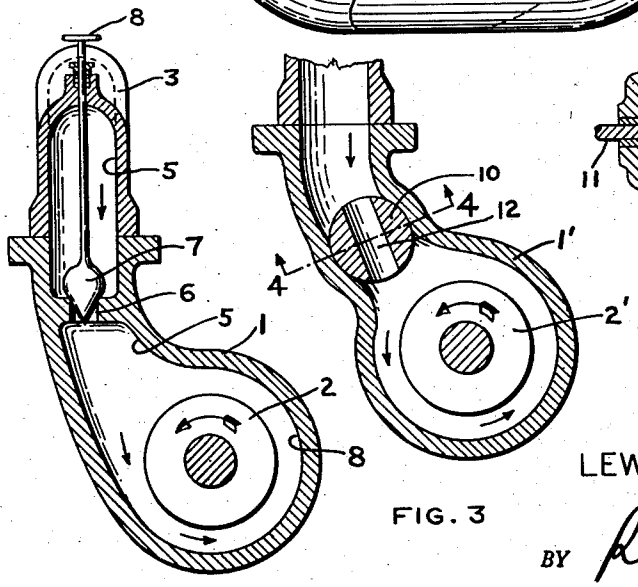


FIG. 2

FIG. 3

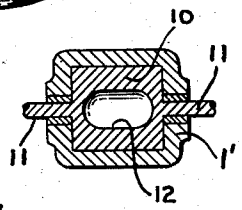


FIG. 4

LEWIS F. MOODY
INVENTOR.

BY Robert Meyer
Attorney

Sept. 7, 1948. L. F. MOODY 2,449,002

APPARATUS FOR REGULATING CENTRIFUGAL MACHINES

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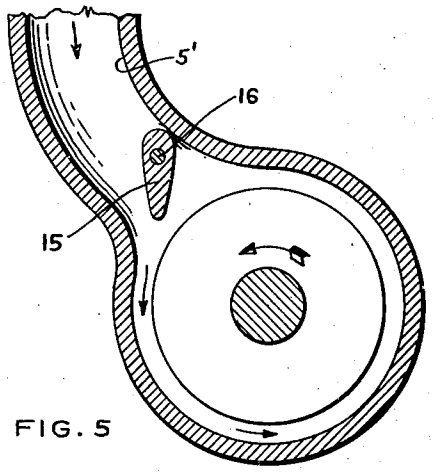


FIG. 5

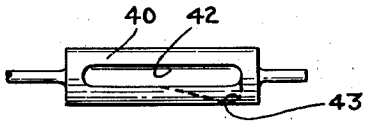


FIG. 15

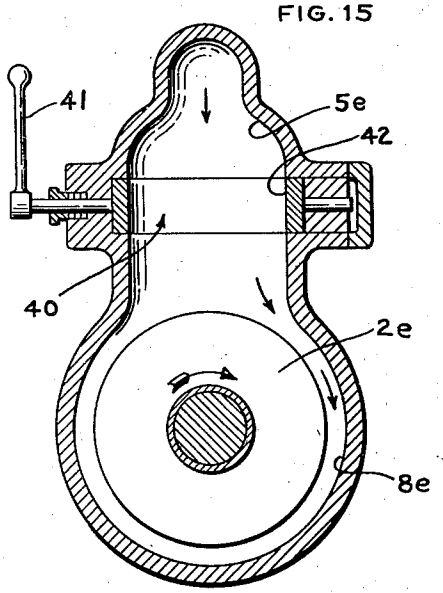


FIG. 13

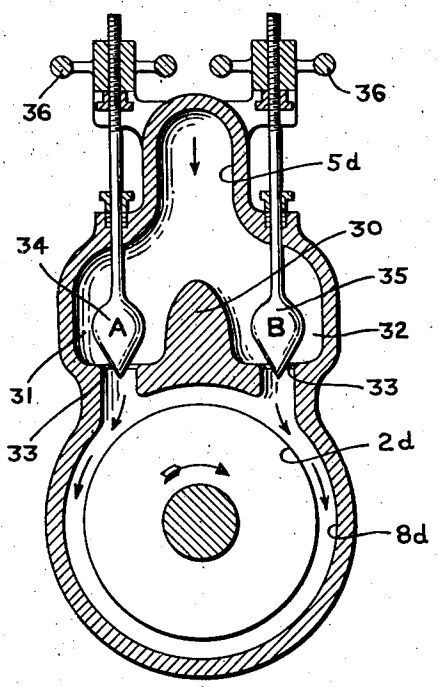


FIG. 12

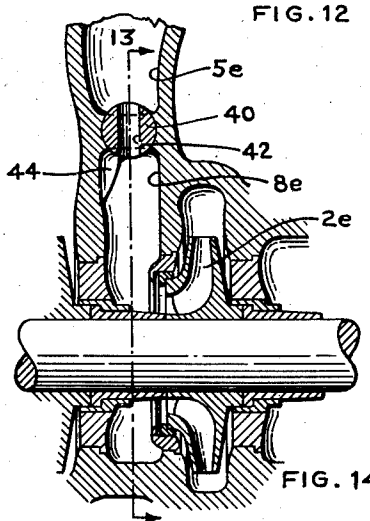


FIG. 14

LEWIS F. MOODY
INVENTOR.

BY Robert Meyer
Attorney

Sept. 7, 1948. L. F. MOODY 2,449,002

APPARATUS FOR REGULATING CENTRIFUGAL MACHINES

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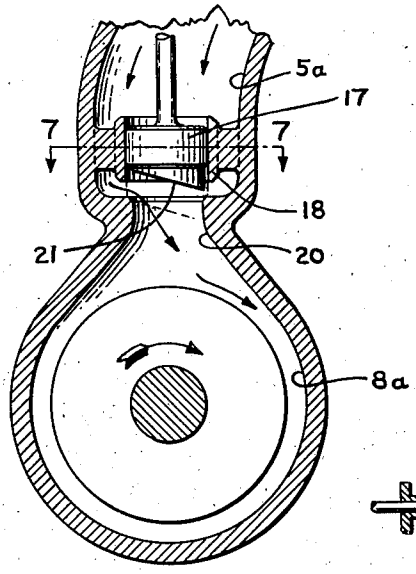


FIG. 6

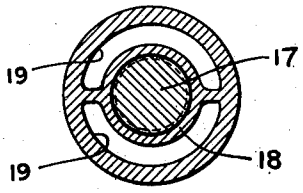


FIG. 7

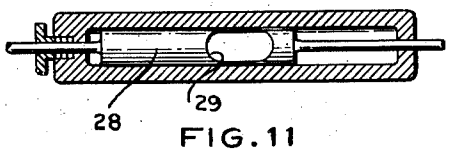


FIG. 11

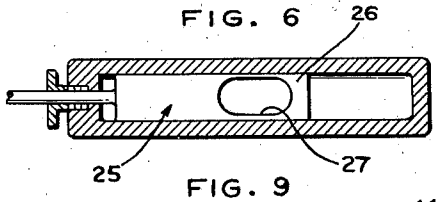


FIG. 9

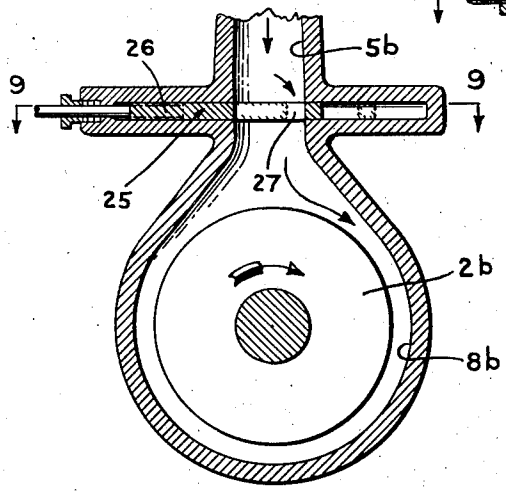


FIG. 8

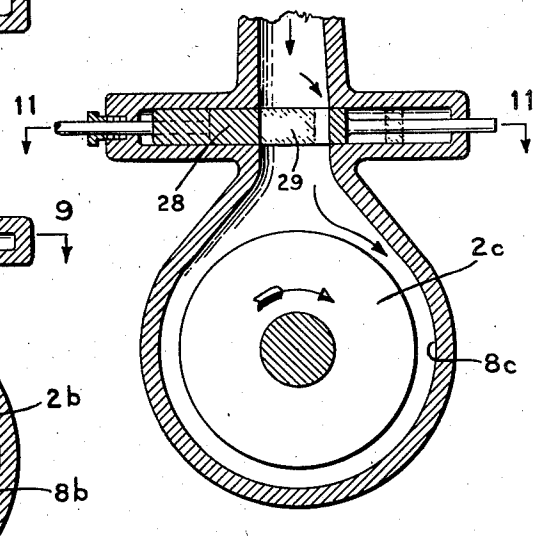


FIG. 10

LEWIS F. MOODY
INVENTOR.

BY Robert Meyer
attorney

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2,449,002

APPARATUS FOR REGULATING CENTRIFUGAL MACHINES

Lewis F. Moody, Princeton, N. J.

Application August 30, 1946, Serial No. 693,995

1 Claim. (Cl. 103—97)

1

This invention relates to centrifugal machines such as pumps or compressors and more specifically to a method and construction of such machines for regulating the head and capacity of the machines.

It is an object of the present invention to effect the desired regulation of head and capacity of a multi-stage centrifugal pump or compressor in a comparatively simple and inexpensive manner with a minimum waste of power and without impairing the mechanical reliability of the machine.

The present invention effects the desired control or regulation of the head and capacity of a multi-stage centrifugal machine such as a pump or compressor by throttling the flow of fluid to the suction of one or more of the stages of the machine, and at the same time redirecting the flow into the suction chamber.

More specifically the present invention comprises the provision of one or more throttle valves in an inter-stage suction passage of a multi-stage machine, which when fully open permit full unimpeded normal flow of fluid through the suction passage and into the inlet of the impeller without material prerotation in the entering flow, and which when partially closed to throttle down the quantity flow of fluid to the impeller will shift the direction or distribution of flow of fluid into the inlet space of the impeller. This is accomplished by directing the incoming flow transversely with respect to the axis of the impeller, or by laterally shifting the center of flow, so as to produce unsymmetrical flow of the fluid and thereby set up prerotation in the entering fluid flow in the same direction as the impeller rotation. With progressive closure of the valve or valves the one-sided effect of the entering fluid flow is increased and its velocity is increased producing a vortex of continually increasing velocity towards its center and reduced quantity due to the unsymmetrical throttling action of the valve or throttle. The effect of such prerotation is to reduce the torque required to drive the impeller by utilizing the velocity head produced by the valve throttling and thereby reduce the power required for operating the pump.

In the drawings:

Figure 1 is a view partly in section and partly in elevation of a multi-stage machine embodying the present invention.

Figure 2 is a cross-section taken on the line 2—2 of Figure 1.

Figure 3 is a fragmentary cross-section of a

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centrifugal machine showing a modified form of the throttling valve.

Figure 4 is a cross-section taken on the line 4—4 of Figure 3.

Figure 5 is a fragmentary cross-section of a centrifugal machine showing a still further modified form of the valve.

Figure 6 is a fragmentary cross-section through a centrifugal machine illustrating a further modified structure of the throttling valve.

Figure 7 is a cross-section on the line 7—7 of Figure 6.

Figure 8 is a fragmentary cross-section through a centrifugal machine illustrating a further type of throttling valve.

Figure 9 is a cross-section taken on the line 9—9 of Figure 8.

Figure 10 is a fragmentary section through a centrifugal machine showing a combined rotary and slidable throttling valve structure.

Figure 11 is a cross-section taken on the line 11—11 of Figure 10.

Figure 12 is a cross-section through a centrifugal machine having a divided inlet passage and showing a plurality of throttling valves associated therewith.

Figure 13 is a vertical section through a centrifugal machine having a single inlet to the impeller thereof and illustrating a rotary type of throttling valve, and further taken on the line 13—13 of Figure 14.

Figure 14 is a fragmentary longitudinal section through the form of centrifugal machine shown in Figure 13.

Figure 15 is a detail view of the valve employed in the construction of machine shown in Figure 13, and 14.

Referring more particularly to the drawings a multi-stage centrifugal pump embodying the invention is shown in Figure 1 of the drawings; however it is to be understood that the invention may be applied to any type of multi-stage centrifugal pump, compressor, or other analogous machine without departing from the spirit of the present invention.

The centrifugal pump shown in Figures 1 and 2 of the drawings comprises a casing 1 which has a plurality of stage chambers therein in which are rotatably mounted stage impellers 2. The casing 1 is provided with a stage passage indicated at 3 which conveys the fluid pumped from the discharge of one stage to the suction of the succeeding stage through the stage inlet passage 4.

The present invention comprehends the regulation of the head and capacity of the pump by

unsymmetrically throttling the inlet flow to one or more of the stage impellers of the pump or machine, preferably a stage or stages subsequent to the first or inlet stage of the machine.

In Figures 1 and 2 of the drawings the inlet passage 5 to the controlled stage has a valve seat 6 formed therein with which a bulb or needle type valve 7 co-operates. The valve 7 is adjusted by means of a hand wheel 8. The passage 5 beyond the valve 7 opens into the suction chamber 8 formed in the casing 1. The suction chamber 8 is formed as a space of revolution of somewhat larger radius than the impeller eye to accentuate the vortex flow provided by adjustment of the valve 7.

When the valve 7 is fully opened the fluid flows normally to the impeller 2 without any appreciable prerotation in the entering flow, but when the valve 7 is partly closed it will increase the velocity along the enclosing wall of the suction chamber so as to produce increasing tangential velocity components about the pump axis set up in the entering flow of fluid in the same direction as the rotation of the impeller 2. With progressive closure of the valve 7 the one-sided effect of the admission is increased, and its velocity is increased, producing a vortex of continually increasing velocity towards its center and reduced quantity due to the throttling action of the valve 7. The effect of the prerotation of the fluid is to reduce the torque required to drive the impeller by utilizing the velocity head produced by the valve throttling, instead of throwing away such velocity head as is usual with the throttling of the pump discharge for the purpose of controlling its capacity. When pumping liquids the inter-stage throttling control is preferably to be applied to one or more of the later or final stages of the centrifugal machine rather than in the first stage or in the entire machine, so as to avoid cavitation. The valve 7 is in series with the impeller acting on the entire flow of fluid through the machine.

Instead of the needle type of valve shown in Figures 1 and 2 of the drawings a rotary valve 10 as shown in Figures 3 and 4 of the drawings may be embodied. The rotary valve 10 is shown as rotatably supported by suitable trunnions 11 carried by the casing 1. The valve 10 has a diametrically extending passageway 12 therein which controls the flow of fluid to the impeller 2', and by varying the degree or proportionate part of the opening 12 which is opened to the inlet passage the flow of fluid to the impeller 2' may be throttled or controlled. It will be noted that the valve 10 is arranged so that as it throttles the flow of fluid to the impeller 2' it will direct the inflow of fluid transversely with respect to the pump axis so as to produce unsymmetrical and whirling flow as described in connection with the needle valve shown in Figures 1 and 2.

In Figure 5 a further modified form of the valve mechanism is shown and this form embodies a pivoted valve of the butterfly type shown at 15. The pivot point of the pivot 16 of the valve 15 is placed in the center of the inlet passage 5' and the body of the valve 15 is streamlined, tapering to substantially a thin edge at its discharge end. Adjustment of the valve 15 to throttle the incoming fluid flow will direct such flow in the same manner as referred to in connection with the forms shown in Figures 1 to 4 inclusive.

Figures 6 and 7 of the drawings illustrate a modification of the structure controlling the head and capacity of centrifugal machine wherein a sliding piston valve 17 is slidably supported in a valve cylinder 18. The valve cylinder 18 is positioned in the inlet passage converging into the inlet passage 20. The inner flow control end 21 of the valve 15 inclines diagonally from one edge to the other so that when the valve 17 is shifted it will first throttle and finally cut off the flow of fluid through the passage at the right of the valve cylinder 18 while permitting a greater fluid flow through the passage to the left of the valve cylinder, and thus causing an unsymmetrical flow of fluid entering the suction chamber 8a of the centrifugal machine as set forth in connection with the description of the previous drawings. When the valve 17 has reached the bottom of its stroke it seats against the chamfered seating surface shown and completely cuts off the flow of fluid.

Figures 8 and 9 of the drawings show a horizontal slide valve 25 for throttling and directing the flow of fluid to the impeller 2b within the suction chamber 8b. The valve 25 comprises a slidable plate 26 having elongated opening 27 formed therein. In this form the plate 25 is moved laterally across the inlet passage 5b serving both to throttle the fluid flow and at the same time shifting the center of flow to one side of the passage 5b to provide the unsymmetrical flow, and vortex-forming prerotation desired for regulating the capacity of the pump. In Figures 10 and 11 of the drawings the sliding valve structure 25 is replaced by a sliding cylindrical plug valve 28 provided with an elongated orifice 29 by means of which valve the flow to the inlet chamber 8c and impeller 2c is controlled or throttled and directed laterally to provide the unsymmetrical fluid flow to the impeller 2c.

In Figure 12 of the drawings the intake passage 5d is shown as divided by divider 30 into branches 31 and 32 which enter the suction chamber 8d at opposite sides of the axis of rotation of the impeller 2d forming dual inlets to the suction chamber. Each of the branches 31 and 32 has a valve seat 33 therein which co-operates with valves 34 and 35 to control the flow through the branch passages. The valves 34 and 35 are adjusted manually by suitable wheels 36.

When both the valves 34 and 35 are opened as shown in Figure 12 of the drawings a symmetrical normal flow into the suction chamber 8d will be provided thus providing normal operation and avoiding prerotation in the fluid entering the suction or inlet chamber 8d. By first closing one of the valves, for instance the valve 34, all of the flow of the fluid entering the impeller 2d is shifted to the branch 32 past the valve 35 which will cause the fluid to enter the suction chamber 8d in such manner as to produce unsymmetrical flow and thereby set up prerotation in the entering fluid flow. As the valve 35 is progressively closed for further throttling the inlet of fluid to the inlet chamber 8d, the velocity of the entering fluid flow is increased thereby increasing the prerotation of the entering fluid and producing a vortex of continually increasing velocity and reduced quantity as the valve 35 is closed, until such time as the valve 35 is completely closed when all flow to the inlet of the impeller 2d will be shut off.

Figures 13 to 15 inclusive of the drawings show a modification of the manner of control of the head and capacity of a multi-stage machine. In these figures the inlet passage 5e is constructed and arranged so that the flow of the entering fluid is normally distributed symmetrically to

the impeller 2e. A rotary valve 40 which may be manually rotated by a suitable operating handle 41 extends across the inlet passage 5e and is provided with an elongated opening 42 the position of which controls the quantity of flow and consequently the throttling of the flow of fluid into the suction space 8c of the impeller 2e. The valve 40 has an offset port 43 formed therein, offset laterally from the elongated port 42 at one end of the valve. This offset port 43 co-operates with the opening 42 in the valve so that when the elongated relatively narrow port 42 has been partially closed by rotating the valve 40, the offset portion 43 will still admit fluid to the chamber 8e giving a one sided admission of said fluid and co-operating with the offset passage 44 to provide prerotation and unsymmetrical flow to the incoming fluid. By continuing the rotation of the valve the flow through the valve may be cut off after the offset port 43 is closed and thus provide complete closure.

When the principle of this invention is applied to blowers or compressors handling gaseous fluids, the unsymmetrical throttling means may be applied to a single-stage machine or to the first or suction stage of a multi-stage machine. When however it is applied to pumps handling water or other liquids in which cavitation may occur, the throttling means must usually be restricted to the second stage or subsequent stages, so that the unthrottled first stage will provide sufficient pressure in the throttled suction passage to avoid cavitation.

It will be understood that the invention is not

to be limited to the specific constructions or arrangements of parts shown, but that they may be widely modified within the invention defined by the claim.

What is claimed is:

In a multi-stage centrifugal pump for handling liquids subject to cavitation, the combination of a housing, a plurality of rotary stage impellers in said housing, said housing having suction and discharge passages connecting in fluid communication the discharge of the individual stages with the suction of the other stages, said housing having a first suction passage for the first stage impeller, said suction passages except the first having needle valve seats therein, said seats being disposed so that fluid flowing therethrough is tangential to the impeller, needle valves cooperating with the seats to vary the effective cross section thereof, and means outside of the housing and connected to the valves for regulating the movements of the valves.

LEWIS F. MOODY.

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The following references are of record in the file of this patent:

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