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SPEED CONTROL FOR ROTARY MOTORS

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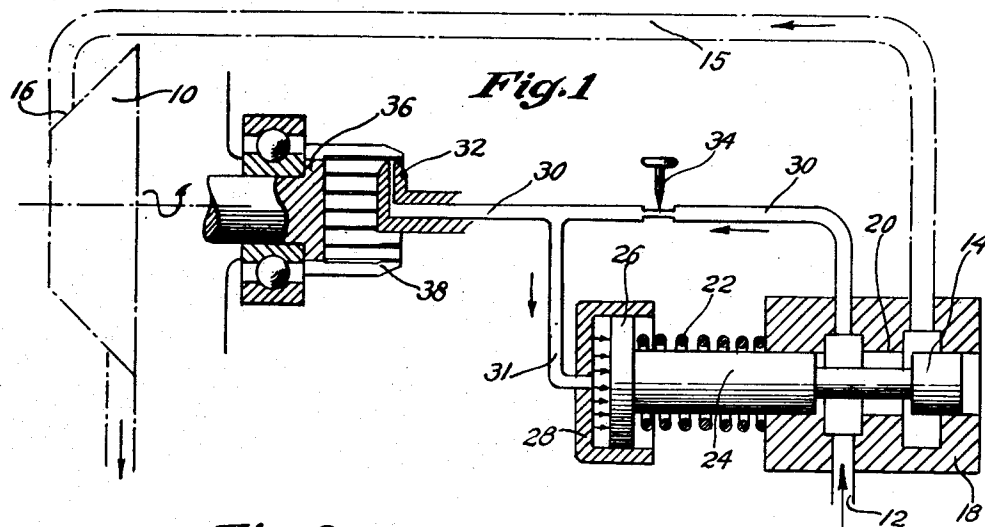


Fig. 2

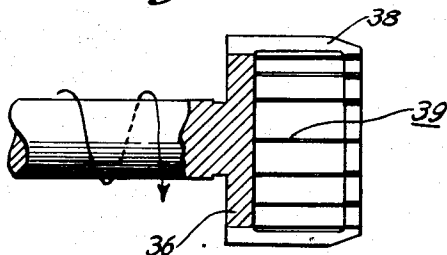
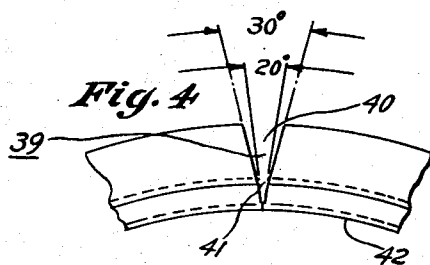
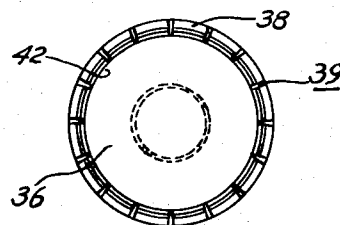


Fig. 3



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SPEED CONTROL FOR ROTARY MOTORS

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This invention relates to a speed control for rotary motors, particularly to means for controlling the rotation of a high speed, elastic fluid turbine.

A primary object of the invention is to provide a simple speed controlling device particularly for the purpose of actuating a fluid admission valve to variable open positions to control the amount of motive fluid admitted to the motor or turbine intake.

Another object of importance of the invention is to provide fluid pressure means to move the fluid admission valve in one direction, the fluid applied to actuate the valve being supplied from the motive fluid for the turbine, the pressure of the fluid acting against the valve being varied by controlling the escape of fluid from a jet or orifice in the conduit connecting the motive fluid to the actuating means for the fluid admitting valve.

A feature of the invention that is important is that the escape of the motive fluid from the jet is varied by flexure, due to centrifugal force, of parts of a member closely adjacent the jet and rotated at high speed by the motor.

Another feature of the invention that is important is that the centrifugally flexed members comprise cantilevers or extensions, forming parts of a hollow cylindrical member, the free ends of the extensions being disposed adjacent the jet orifice and so disposed that with increased speed of rotation of the motor and greater flexure, fluid will escape from the jet more easily and reduce the pressure of fluid acting to force the fluid admission valve for the motor in a direction to reduce the amount of motive fluid admitted to the motor.

And finally, it is an object of the invention to provide a novel method of forming the centrifugally flexed portions of the member rotated by the motor or turbine adjacent the jet orifice to vary the pressure of the fluid permitted to escape from the orifice.

With the above and other objects in view, my invention may include the features of construction and operation set forth in the following specification and illustrated in the accompanying drawing.

In the accompanying drawing annexed hereto and forming a part of this specification, I have shown my invention embodied in the controlling of a piston operated throttle valve for controlling the admission of motive fluid to a turbine to maintain constant, but adjustable, rates of rotation of the turbine; it will be understood, how-

ever, that the invention can be otherwise embodied and that the drawing is not to be construed as defining or limiting the scope of the invention, the claims appended to this specification being relied upon for that purpose.

In the drawing:

Fig. 1 is a schematic view of a turbine showing a cross-sectional view of a fluid admitting valve and its control mechanism;

Fig. 2 is a side elevation of a member of the control device rotated in timed relation to the turbine;

Fig. 3 is a front elevation of the member shown in Fig. 2; and

Fig. 4 is an enlarged view of a part of the member shown in Figs. 2 and 3, showing in detail the form of the slots in the extended and flexing portion of the member.

In the above mentioned drawing, I have shown but one embodiment of the invention which is now deemed preferable, but it is to be understood that changes and modifications may be made within the scope of the appended claims without departing from the spirit of the invention.

Briefly, and in its preferred aspect, the invention may include the following principal parts: first, a fluid admitting valve movable axially within a suitable valve casing to vary the supply of motive fluid admitted to a motor or turbine; second, a piston preferably formed on the valve and movable within a cylinder with movements of said valve; third, a spring normally forcing said valve and piston in one direction; fourth, conduits for supplying fluid to said valve and for supplying fluid from said valve to said turbine intake; fifth, a conduit in the control system for supplying pressure to said cylinder to actuate the piston and valve against the pressure of the spring; sixth, means to restrict the flow of fluid in the control system; seventh, a jet formed in said fluid control system; and eighth, a member rotating in timed relation to the turbine and having slightly flexible portions movable toward and away from the jet orifice to vary the pressure of fluid escaping from the orifice and control the rotative speed of the turbine.

Referring more in detail to the figures of the drawing, there is shown a turbine or other form of rotary motor 10 operated by fluid under pressure. The motor or turbine 10 is supplied with motive fluid from any suitable source 12, the fluid passing through a throttle or other form of valve 14 and from the valve through conduit

15 directly to the turbine intake 16. The valve 14 is movable axially within a casing 18 to vary the opening of its supply port 20 and control the amount of fluid admitted to conduit 15 and to the turbine 10. The valve 14 is normally pressed by a helical spring 22, wrapped about a portion of the valve extension 24, in a direction to close the port 20 admitting motive fluid to the turbine so that a pressure acting to move the valve 14 in a direction to close the admission port 20 is at all times existent.

To move the valve 14 in a direction to open the admission port 20 to increase the amount of motive fluid supplied to the turbine, a piston 26 is mounted on, or forms part of the valve 14. This piston 26 operates within a short cylinder 28 to which motive fluid may be admitted at one end to force the piston 26 and valve 14 in a direction to open port 20 against the pressure of the spring 22.

Rotated at high speed by the turbine, by any desired means not shown, is the cylindrical member 36 which as shown in Figs. 2 and 3, is slotted to form a plurality of closely and equally spaced projections 38. Each of the sections 38 between the slots 39 cut into the cylindrical surface of the member is elongated sufficiently to be flexed slightly by centrifugal action at high rotative speeds. Different speeds will flex the extensions 38, varying small amounts and will, therefore, vary the space between the jet orifice 32 and the surfaces of the projections 38. Varying the area of the escape from the jet 32 will inversely vary the pressure exerted against the piston 26.

To admit fluid at variable pressures to the cylinder 28 and force the piston 26 to actuate the valve 14 to variable, intermediate fluid supplying positions, the following means are provided.

The total control can be divided into three systems; (1) the control circuit represented by the conduit 30, the side branch 31, a needle valve 34 and a jet 32, (2) the speed sensitive element 36 with its cantilevers 38 and (3) a pressure sensitive system comprising the piston 26, spring 22 and valve 14.

The control circuit carries a flow of fluid through conduit 30 from the supply pressure at 12 and discharges through the jet 32 into atmosphere or other low ambient pressure. The jet 32 is partially blocked by the cover of the cantilever 38 and forms a restriction to the flow. A second restriction is interposed at the manually adjustable valve 34. The pressure in the conduit 39 intermediate the two restrictions 32 and 34 can be made to assume any value between the supply pressure at 12 and the ambient pressure at 32, depending solely upon the ratio of the effective areas of the two restrictions 32 and 34. This intermediate pressure, hereafter called the signal pressure, is transmitted through the branch 31 and acts upon the piston 26.

It is evident that when this signal pressure becomes great enough, the piston 26 will overcome the reaction of the spring 22, open the valve 14 and position its degree of opening in accordance with the rate of the spring 22. By a proper choice of piston area and spring rate, it is possible to move the valve 14 from closed to full open with a small change of signal pressure. If the spring 22 is given a suitable preloading, the level of the signal pressure can be raised to any desired value. For instance, a spring load can be chosen such that valve 14 will crack open when the signal pressure is 60 p. s. i., and a rate selected such that the opening of valve 14 will

be complete when the signal pressure is 63 p. s. i.

It is to be noted then, that the pressure sensitive system 26—22—14 can be designed for a relatively constant signal pressure, small variations of which can progressively operate it through its entire function.

The control circuit 30—31—34—32 can provide this signal pressure by proper proportion of the restrictions 32 and 34. This ratio is fixed once the proportions of the system 26—22—14 are defined, but the actual areas of the restrictions 32—34 can be of any reasonable value provided only that they have this ratio to one another.

If the restriction at 32 is given a definite area by lifting the cantilever 38 a small distance away from the jet 32, the valve 34 must also be given a definite area in order to produce the designed signal pressure in branch 31 and on the piston 26. Conversely, if the area of valve 34 is given any arbitrary value, the cantilever 38 must be sprung to the correct distance away from the jet 32 in order for the signal pressure to reach the design level and actuate the valve 14.

It will be now evident that when the restriction 34 is held at a constant value, movement of the cantilever 38 away from the jet 32 will progressively reduce the signal pressure from a value higher than the design level, to the design level, and then below the design level.

In the operation of the turbine, the centrifugal force of the rotating speed sensitive element 36 lifts the cantilevers 38 to the point where the signal pressure lowers to the design level, the valve 14 throttles and maintains essentially constant speed.

If a load is now imposed upon the turbine, its speed will drop slightly, lower the cantilevers 38, increase the resistance of the restriction at 32, build up the signal pressure on the piston 26 and open the valve 14 to the degree necessary to supply the required amount of motive fluid to the turbine to handle the extra power demand.

Conversely, if load is removed from the turbine, its speed will increase slightly, raise the cantilevers 38, decrease the restriction at 32, reduce the signal pressure, and the spring 22 will throttle the valve 14.

It will be apparent also that the preset governed speed is dependent only upon the setting of the valve 34. If this is opened to a large area, the area of the restriction at 32 must also be proportionately large, in order that the signal pressure be at the design level. A large area at 32 is obtained when the cantilevers 38 are sprung well away from the jet 32, which corresponds to high rotational speed and high centrifugal force. Likewise, a small area setting of valve 34 requires a small area at restriction 32 which is conditioned by low speed and low centrifugal force.

The preset area of the valve 34 thus is a measure of the governed speed of rotation and it may be equipped with a dial and pointer calibrated in terms of governed speed. One of the advantages of this method of governing this is the fact that the speed control need not be directly attached to the speed sensitive member and may be placed as convenience demands.

A feature of the method, not easily apparent, is that the sensitivity of governing, i. e., the percent regulation, is uniform regardless of preset speed. The pressure sensitive system 26—22—14 largely controls the percent regulation by virtue of the designed rate of the spring 22. Because it is pressure controlled, it cannot of itself be influenced by speed level. However, it must be

demonstrated that the signal pressure transmitted to it from the speed sensitive element 36 is not influenced by speed level. It has been determined by experiment and supported by mathematical analysis that a given percent change in rotational speed, at whatever practical level, produces a constant differential change in the signal pressure. Because the throttle valve 14 is moved from closed to open by this differential change, it is obvious that the percent regulation is independent of preset speed.

This constancy of regulation will be destroyed and an appreciable loss in overall sensitivity suffered if the tips of the cantilevers 38 do not present a substantially unbroken cover to the jet 32. A coarse separating slot having a width of 5 percent of the cantilever width is definitely detrimental. When it is realized that the diameter of the member 36 must be about $\frac{5}{8}$ " to withstand the extraordinary centrifugal forces of 60,000 R. P. M., it will be recognized that the machining of slots from .001 to .002 wide is quite difficult.

The following successful method may be used. The longitudinal angular slots 39 are first milled with a cutter whose sides have a rather wide acute angle as shown at 40. This cutter removes the bulk of the stock and will not maintain a sharp point. However, it is sunk deeply enough to cut through and separate the recessed portion represented by the dotted line at 41. The slots 39 are again milled with a cutter having a narrow acute angle as shown at 41. The delicate point of the cutter can be maintained because the amount of stock to be removed is very small. The depth of cut does not quite reach the diameter 42, so all the cantilevers are still tied together at the outboard end. The piece is next heat-treated and tempered to develop the high tensile strength needed at the base of the cantilevers. As a final operation, the diameter 42 is ground to remove the tie, the grinding intercepting the root of all slots, leaving each cantilever 38 free and independent but presenting a substantially unbroken cover to the jet 32.

In a mechanical speed sensitive device, such as the ordinary flyweight governor connected to its throttle or servomechanism by linkages, the sensitivity which may be employed is always limited to some extent by the friction of its moving joints and the unavoidable backlash between elements. The difficulty from these sources is magnified many fold at high speeds, where the centrifugal forces may be of the order of 20,000 or 30,000 G's. The virtue of the speed sensitive device in the form shown at 36 lies in the fact that it can be constructed without joints, can move freely to governing position without friction, and needs no biasing spring other than that inherent in the beam of the cantilevers 38. Hence, it can be used with high sensitivity at speeds for which it is impossible to construct a mechanical type, and at speeds where this is possible, exhibits in general a higher degree of sensitivity for an equal degree of stability. The pressure sensitive device 26—22—14 can be constructed without backlash and its friction of movement can be made very small as compared with the motive force from the piston 26. Hence, it exhibits a very small hysteresis loop. In combination with the essentially

non-existent hysteresis of the speed sensitive element 36, it is possible to use high rates of servo-amplification. As an example, the combination can be designed so that the throttle 14 can be moved throughout its range with movements of the cantilevers 38 as little as .0001 inch.

The type of governing shown in the drawing and described above exhibits a small positive speed droop with increasing load.

Because the displacement of the piston 26 at a much magnified scale follows the displacement of the cantilevers 38 directly, it is possible to arrange other types of governing to be driven by the piston, such as the isochronous, and that with a negative speed characteristic.

What I claim is:

1. A speed control for rotary motors comprising in combination, a fluid admitting valve, a member rotating with said motor having integral axially extended flexible portions, the radial flexing of said portions varying with the motor speed, a conduit, means to admit a limited amount of fluid therethrough to a jet orifice adjacent and within said flexible portions, whereby escape of fluid from said conduit and resulting pressure therein varies with the flexing of said portions, and means to vary the position of said valve by said variations of pressure.

2. A speed control for rotary motors comprising in combination, a fluid admitting valve, a cylindrical member rotating with said motor having a circular series of integral flexible cantilever portions, the radial flexing of said portions varying with the motor speed, a conduit, means to admit a limited amount of fluid therethrough to a jet orifice within said cylindrical member and adjacent said flexible portions, whereby escape of fluid from said orifice and resulting pressure within the conduit varies with the flexing of said flexible portions, and means to vary the position of said valve by said variations of pressure.

3. A speed control for rotary motors comprising in combination, a fluid admitting valve, a member rotating with said motor, integral flexible cantilever portions extending parallelly to each other, the radial flexing of said portions varying with the motor speed, a conduit, means to admit a limited amount of fluid therethrough to a jet orifice adjacent the ends of said flexible portions and within said member, whereby the escape of fluid from said conduit and resulting pressure therein varies with the flexing of said flexible portions, and means to vary the position of said valve by said variations of pressure.

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