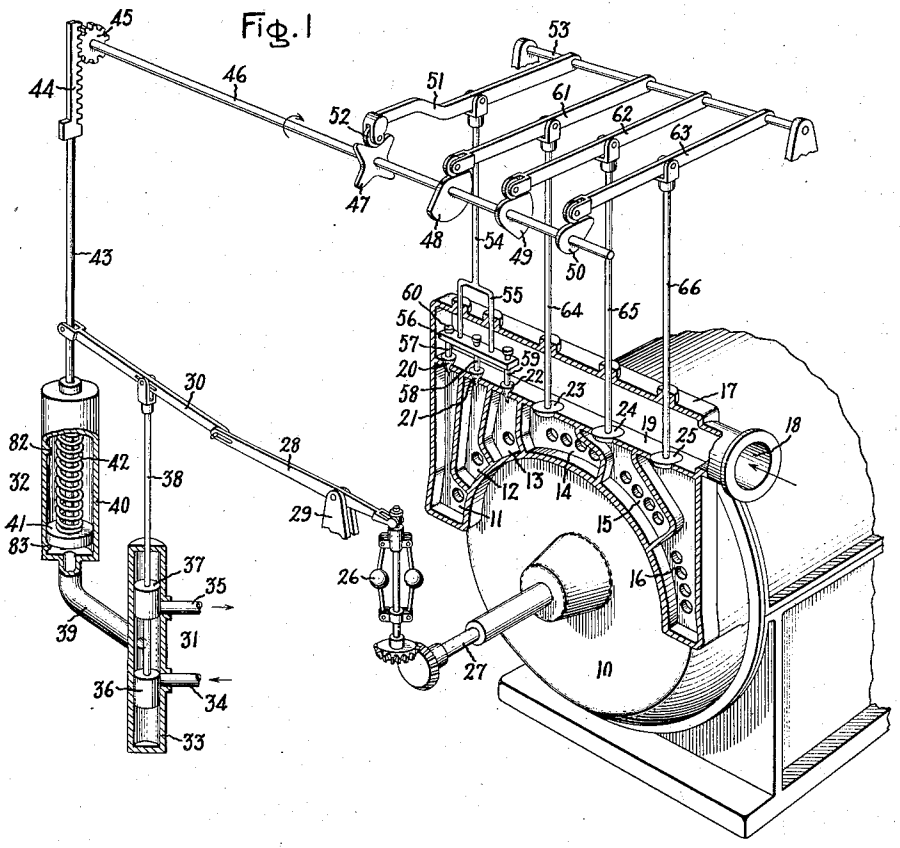
April 9, 1935. E. D. DICKINSON ET AL 1,997,456

ELASTIC FLUID TURBINE

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Fig. 1



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Fig. 3.

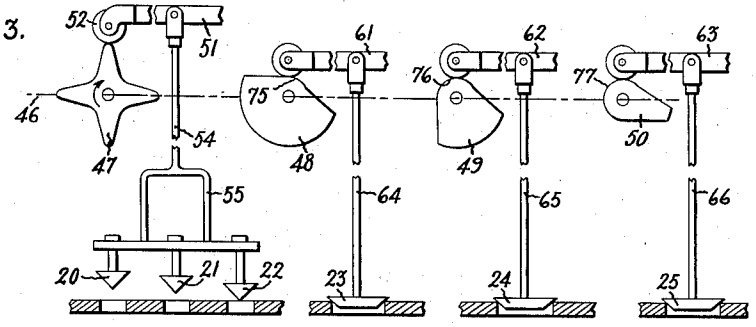


Fig. 4.

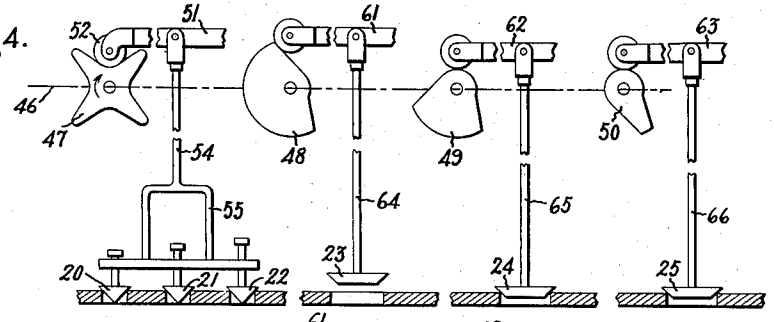


Fig. 5.

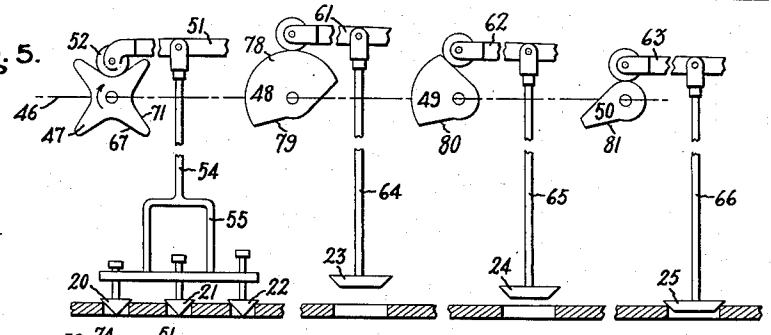
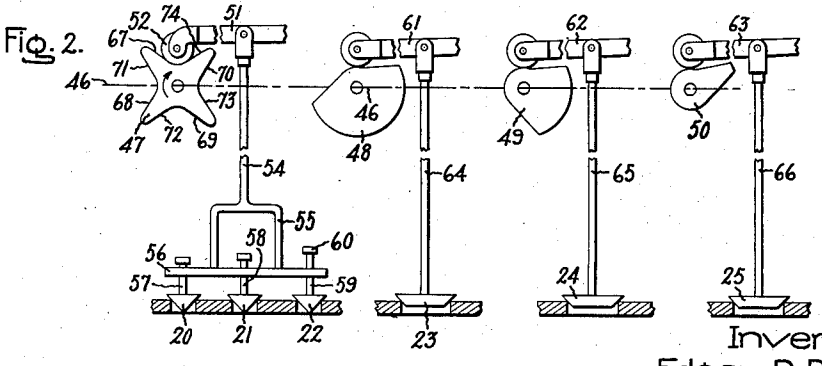


Fig. 2.



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ELASTIC FLUID TURBINE

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Application April 12, 1934, Serial No. 720,238

6 Claims. (Cl. 253—59)

The present invention relates to elastic fluid turbines comprising a bucket wheel and means for directing and controlling the flow of elastic fluid to said bucket wheel. This means usually comprises a nozzle or nozzles and a single or a plurality of throttle valves. The control of the flow of elastic fluid to the turbine by means of a throttle valve or valves causes a loss of energy which reaches a maximum when the throttling is accomplished by a single valve. This loss is considerably reduced by the provision of a plurality of valves for controlling the flow to a plurality of groups of nozzles and the loss reaches a minimum in case a control valve is provided for each nozzle. The last arrangement, however, is in most cases prohibitive in view of the great manufacturing cost. The customary arrangement resorted to therefore comprises a plurality of groups of nozzles and a throttle valve for each group. Each group may have the same number of nozzles or a different number of nozzles.

The object of our invention is to provide an improved construction and arrangement of the kind of turbines above specified whereby with comparatively few groups of nozzles and a separate valve for each group substantially the same control effect is obtained as with an arrangement in which the flow of elastic fluid to each nozzle is controlled by a special throttle valve.

For a consideration of what we believe to be novel and our invention, attention is directed to the following description and the claims appended thereto in connection with the accompanying drawings which form a part of our specification.

In the drawings, Fig. 1 is a perspective view partly broken away of an arrangement embodying our invention and Figs. 2 to 5 inclusive are exploded views of a part of Fig. 1 under different operating conditions.

The arrangement comprises an elastic fluid turbine 10 having a plurality of nozzles for directing the flow of elastic fluid in to a bucket wheel, not shown. In the present instance we have indicated six such groups of nozzles 11, 12, 13, 14, 15, and 16. The first three groups comprise only one nozzle each, whereas the last three groups 14, 15, and 16, have four nozzles each, that is, a number greater by one than the total number of nozzles of the first three groups, or from a general viewpoint, if the number of nozzles of each of the first or primary groups is "n" and the number of such groups is "m" we provide the second or secondary groups of nozzles with a number of nozzles equal to $(n \times m)+1$.

Elastic fluid is conducted to the nozzles through a chest 17 having an inlet 18 connected to a source of elastic fluid, not shown. The chest has a bottom 19 with a plurality of openings for conducting elastic fluid from the chest to the groups of nozzles. Valves 20, 21, 22, 23, 24, and 25 are provided for controlling the flow of elastic fluid from the chest to the groups of nozzles. The valves are controlled by a mechanism, in the present instance indicated as a speed governing mechanism, whereby the valves are moved in response to speed or load changes of the turbine. The arrangement according to our invention is such that the valves 20, 21, and 22 are consecutively opened and closed while the other valves 23, 24, and 25 are opened. During the opening of any of the valves 23, 24, and 25, which may be termed secondary valves, the valves 20, 21 and 22, which may be termed primary valves, are consecutively closed. The primary valves 20, 21, and 22 are consecutively opened intermediate the consecutive opening of two secondary valves. Thus, the primary valves 20, 21, and 22 for directing the flow to the primary groups or individual nozzles 11, 12, and 13, serve to subdivide the large groups 14, 15, and 16, thereby effecting gradual, substantially uniform change in flow during valve opening travel and small loss in efficiency by throttling of elastic fluid.

More specifically, the mechanism shown in the drawing comprises a speed governor 26 driven from the turbine shaft 27 and connected to the right-hand end of a lever 28 having a fulcrum 29. The left-hand end of lever 28 is connected to a floating lever or follow-up lever 30 having an intermediate point connected to a pilot valve or control member 31 and its left-hand end pivoted to a hydraulic motor 32 controlled by the pilot valve. The latter comprises a cylinder 33 having an inlet conduit 34 for receiving actuating fluid such as oil and a drain conduit 35. The connections to these conduits are normally covered by valve heads 36 and 37 respectively secured to a stem 38, which latter is connected to the intermediate point of the floating lever 30. A conduit 39 is connected between the pilot valve and the hydraulic motor 32. The latter includes a cylinder 40 having a piston 41 movable therein and biased in a downward direction by a spring 42. The piston 41 is fastened to a stem 43 pivoted to the left-hand end of floating lever 30 and having an upper portion connected to a rack rod 44. The latter meshes with a pinion 45 secured to a cam shaft 46.

The arrangement so far described is well

known. During operation, an increase in load effecting a decrease in speed causes the fly balls of the governor to move inwardly, thereby effecting upward movement of the right-hand end of the fulcrumed lever 28 and downward movement of the pilot valve stem 38. The lower valve head 36 thereby uncovers its port connection to conduit 34 and permits actuating fluid being supplied through the pilot valve and the conduit 39 into the cylinder 40 of the hydraulic motor. The actuating fluid causes upward movement of the piston 41 against the biasing force of the spring 42 and through the rack rod 44 and the pinion 45 effects turning of the cam shaft 46 in the direction of the arrow indicated. This movement effects, by a mechanism which will be described hereinafter, opening of the valve means and an increased flow of elastic fluid to the turbine. Upward movement of the stem 43 also causes upward movement of the left-hand end of the floating lever 30, effecting upward movement of the pilot valve stem 38, which latter thereby is restored to its original position in which the pilot valve heads 36 and 37 cover their ports. This is a usual follow-up arrangement.

The six turbine control valves are moved by means including four cams 47, 48, 49, and 50 secured to the cam shaft 46. Movement of the cam 47 is transmitted to the primary valves 20, 21, and 22 through a lever 51 having one end provided with a roller 52 engaging the cam 47 and another end pivoted to a fixed rod 53. An intermediate point of the lever 51 is pivoted to a rod or stem 54 which has a forked end 55 connected to a bar 56. Each valve 20, 21, and 22 has a stem 57, 58, and 59 respectively, slidably projecting through a bore in the bar. These stems are of different lengths and their upper ends are provided with abutments 60 whereby the valves 20, 21, and 22 are consecutively removed from their seats as the bar 56 is moved upward. Similarly, movement of the cams 48, 49, and 50 is transmitted to the secondary valves 23, 24, and 25 respectively through levers 61, 62, and 63, each of which has one end provided with a roller engaging the cams and the other end pivoted to said rod 53. An intermediate point of the levers 61, 62, and 63 is connected to stems 64, 65, and 66 respectively of the secondary valves 23, 24, and 25.

The operation of the mechanism will be more clearly understood from a consideration of Figs. 2 to 5 inclusive, showing an exploded view of the valves and the cams at different operating conditions of the turbine. The position shown in Fig. 2 corresponds to that of Fig. 1 in which all valves are closed. Let us first consider the operation of the primary cam 47 and the primary valves 20, 21, and 22 during a complete revolution of the cam 47. The cam has four valve opening surfaces 67, 68, 69, and 70 and four valve closing surfaces 71, 72, 73, and 74, assuming the cam is turned in one direction only. To simplify the arrangement the cam has been shown as a symmetrical star cam. If this cam is turned one-eighth of a revolution in clockwise direction, the cam opening surface 67 moves the roller 52 upward into the position shown in Fig. 3. In this position all three valves 20, 21, and 22 are opened. Due to the different lengths of the valve stems these valves open consecutively as pointed out above, that is, after one twenty-fourth of a revolution, valve 20 would be opened, after two twenty-fourths of a revolution, valve 21 would be opened, and after three twenty-fourths or one-eighth of a revolution, valve 22 would be opened. The valves 20, 21, and 22 are now in the position indicated in Fig. 3. If the cam 47 is further turned another eighth of a complete revolution, the roller 52 travels along the cam closing surface 71, whereby the valves 22, 21, and 20 are consecutively closed in the order mentioned, reaching the position indicated in Fig. 4. If the cam 47 then is rotated another eighth of a revolution, the valves are again opened and after a further eighth of a revolution, the valves are again closed, reaching the position indicated in Fig. 5. Thus Fig. 5 represents the position reached after one-half of a revolution of the cam shaft. Whereas, I have provided a single primary cam 47 for the primary valves 20, 21, and 22, each of these valves may be controlled by a separate cam.

The relation between the operation of the primary valves and the primary cams and that of the secondary valves and the secondary cams is as follows: While the cam shaft is rotated the first eighth of a revolution, the rollers on levers 61, 62, and 63 travel on the "closed idling" surfaces 75, 76, and 77 of the secondary valve cams 48, 49, and 50 respectively, the secondary valves remaining closed (Fig. 3). During a further one-eighth of a revolution of the cam shaft, the roller engaging the cam 48 travels along the cam opening surface of said cam, that is, the cam opening surface forces the roller upward, effecting opening of the secondary valve 23. During this period of time the primary valves have been closed, the other secondary valves 24 and 25 remaining closed (Fig. 4).

Thus, whereas in the position of Fig. 3 elastic fluid is supplied through three nozzles only, in that of Fig. 4 elastic fluid is supplied through four nozzles to the first bucket wheel of the turbine. After another eighth of a revolution, the primary valves are again consecutively opened, effecting steam supply through seven nozzles, and after a further eighth, that is, after one-half of a revolution, the primary valves are closed and the secondary valve 24 is opened. Elastic fluid then is supplied through eight nozzles to the turbine (Fig. 5). During this last period the roller for the secondary valve 23 engages the "idling opening" surface 78 of the cam 48.

After three-fourths of a complete revolution the third secondary valve 25 is opened, elastic fluid being conducted to the turbine through the three secondary valves 23, 24, and 25 to the groups of nozzles 14, 15, and 16. After another eighth of a revolution, that is, after seven-eighths of a complete revolution, the primary valves are opened and elastic fluid is supplied through all fifteen nozzles provided in the present arrangement.

From the above it will be readily understood that with our regulating arrangement, which in the present instance includes six valves and fifteen nozzles, the same effect is obtained as with an arrangement in which fifteen valves, that is, one valve for each nozzle, is provided. This results in a considerable reduction of losses due to throttling and in a more uniform change of flow during the opening travel of the valves.

If the cam shaft 46 were turned more than seven-eighths of a revolution, the rollers would engage cam closing surfaces 79, 80, and 81 which would permit closing of all of the valves during about one-eighth of a revolution of the cam shaft. In our preferred arrangement we provide means for limiting the angular movement of the cams, in the present instance indicated as a stop 82 in

the hydraulic cylinder 40. This prevents closing of the turbine valves by limiting the angular movement of the cam shaft 46 and the cams. Another stop 83 provided near the bottom of the cylinder 40 limits the downward movement of the piston 41.

Closing movement of the turbine valves to reduce the flow of elastic fluid during descreasing load and increasing speed is effected through the hydraulic motor 40 and the pilot valve 31 by turning the cam shaft in opposite direction. When this occurs the cam surfaces, which formerly caused opening of the valves, now effect closing thereof and the operation of the different cams and the valves, in particular the relation between the operation of the primary cams and valves and that of the secondary cams and valves, is very similar to that described above with regard to increasing load demand on the turbine.

Having described the method of operation of our invention, together with the apparatus which we now consider to represent the best embodiment thereof, we desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. In an elastic fluid turbine, a plurality of individual nozzles and groups of nozzles for directing elastic fluid to a bucket wheel, means for controlling the flow of elastic fluid to the nozzles comprising primary valves for separately controlling the flow to several individual nozzles and at least one secondary valve for simultaneously controlling the flow of fluid to a group of several nozzles, and means including cams for first consecutively gradually opening the primary valves, then gradually opening the secondary valve and simultaneously consecutively closing all of the primary valves, and finally gradually reopening the primary valves when the secondary valve is fully opened to obtain substantially the same control effect as may be obtained with a separate valve for each nozzle.

2. In an elastic fluid turbine, a plurality of individual nozzles and a plurality of groups of nozzles for directing fluid to a bucket wheel, a primary valve for controlling the flow of fluid to each of said individual nozzles, and a secondary valve for controlling the flow to each of said groups, means including cams for controlling the valves effecting consecutive gradual closing of the primary valves while a secondary valve is being opened and consecutive gradual opening of the primary valves after a secondary valve has been moved into full opening position for obtaining a substantially uniform change of flow during load increase on the turbine.

3. In an elastic fluid turbine, a plurality of individual nozzles and a plurality of groups comprising a number of nozzles greater by one than the total of the individual nozzles, primary valve means for separately controlling the flow of fluid to each of said individual nozzles, secondary valve means for separately controlling the flow of fluid to each of said groups, and means for operating both valve means to effect during load increase consecutive gradual opening of the secondary valve means and during the opening of each secondary valve means consecutive gradual closing of the primary valve means and intermediate the opening of two secondary valve means consecutive gradual opening of the primary valve means to obtain a straight line flow characteristic of the turbine.

4. In an elastic fluid turbine, a plurality of individual nozzles and a plurality of groups comprising a number of nozzles greater by one than the total of the individual nozzles, primary valve means for separately controlling the flow of fluid to each of said individual nozzles, secondary valve means for separately controlling the flow of fluid to each of said groups, and a governing mechanism including a cam shaft with a cam for operating the primary valve means and a plurality of cams for operating the secondary valve means to effect during a certain load increase first opening of the primary valve means, then opening of a secondary valve means and simultaneously closing of the primary valve means, and with said secondary valve means in fully opened position consecutive opening of the primary valve means.

5. In an elastic fluid turbine, a plurality of individual nozzles and groups of nozzles for directing elastic fluid to a bucket wheel, a chest having an inlet for receiving elastic fluid, a bottom in the chest having a plurality of openings each connected to an individual nozzle and a plurality of larger openings connected to separate groups of a number of nozzles greater by one than the total of individual nozzles, a primary valve for each of the first mentioned openings, a secondary valve for each of the larger openings, a speed governing mechanism including a speed governor driven by the turbine and a cam shaft operated in response to speed changes, cam means on the shaft for consecutively gradually opening the secondary valves during speed drop, and other cam means on the shaft for consecutively gradually closing the primary valve means during the opening of each secondary valve means, said last named cam means effecting consecutive gradual opening of the primary valve means prior to the opening of each secondary valve means to obtain a straight line flow characteristic of the turbine.

6. In an elastic fluid turbine, a plurality of individual nozzles and a plurality of groups comprising a number of nozzles greater by one than the total of the individual nozzles, primary valve means for separately controlling the flow of fluid to each of said individual nozzles, secondary valve means for separately controlling the flow of fluid to each of said groups, and means for operating both valve means to effect during load increase consecutive gradual opening of the secondary valve means and during the opening of each secondary valve means consecutive gradual closing of the primary valve means and intermediate the opening of two secondary valve means consecutive gradual opening of the primary valve means to obtain a straight line flow characteristic of the turbine, the means for operating the primary valve means including a cam having a plurality of cam opening and closing surfaces for causing a plurality of consecutive opening and closing movements of the primary valve means during the consecutive opening of the secondary valve means.

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