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MULTISTAGE HIGH PRESSURE ELASTIC FLUID TURBINE

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Fig. 1.

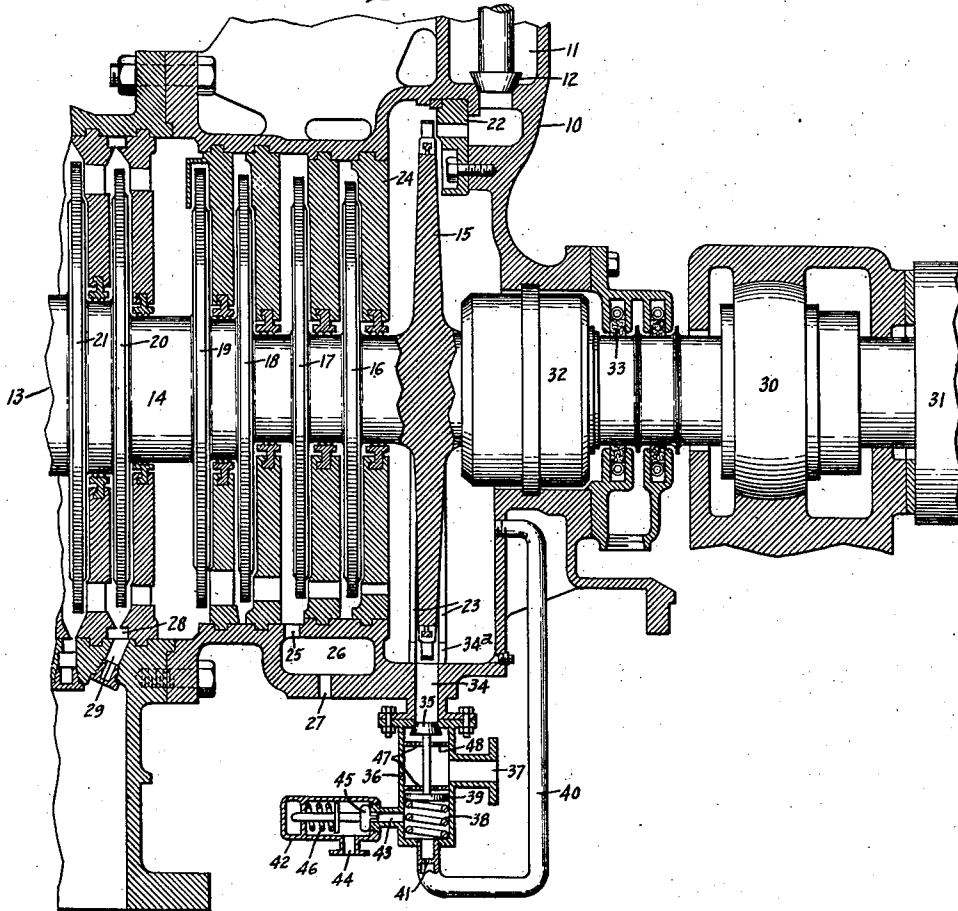
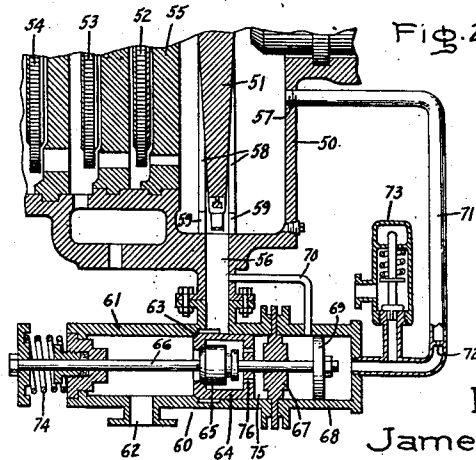


Fig. 2



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MULTISTAGE HIGH PRESSURE ELASTIC
FLUID TURBINE

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Application November 10, 1943, Serial No. 509,646

11 Claims. (Cl. 253—76)

The present invention relates to multi-stage high pressure elastic fluid turbines of the type disclosed in the copending application of Francis H. Van Nest, Serial No. 509,692, filed on the same date and assigned to the same assignee as the present application. High pressure turbines arranged to receive elastic fluid directly from a boiler or elastic fluid generator are often subject to liquid slugs such as water slugs when operated with steam. These liquid slugs may be due to the peculiar design and operation of the elastic fluid generator or boiler means for supplying elastic fluid to the turbine and due to the fact that many installations, such as marine installations, do not permit of the provision of special liquid vapor separators connected between the boiler and the turbine. Liquid slugs when permitted to pass through all turbine stages create a considerable momentary thrust load, requiring the provision of special thrust bearings. In addition, the liquid produces a severe counter torque on the turbine rotor which causes a sudden drop in speed and may impair the operation of the turbine.

The object of my invention is to provide an improved construction and arrangement of turbines whereby water slugs are removed from the high pressure turbine stages, preferably the first turbine stage, and the danger of excessive thrust loads is materially reduced.

For a consideration of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto in connection with the accompanying drawing.

In the accompanying drawing Fig. 1 illustrates a turbine arrangement embodying my invention, and Fig. 2 is a modification according to my invention.

The turbine arrangement of Fig. 1 comprises a casing 10 having an inlet chest 11 with a control valve 12 for controlling the flow of fluid from an elastic fluid generator to the turbine. A rotor 13, disposed in the casing, includes a shaft 14 with a plurality of bucket wheels 15, 16, 17, 18, 19, 20, 21 secured to it. The turbine is of the partial admission type, elastic fluid being conducted to the first stage bucket wheel 15 by means of a nozzle plate 22 extending over an arc of the bucket wheel 15. The remaining arc of the bucket wheel 15 is covered by shields 23 on the inlet and outlet sides of the wheel to reduce windage loss during operation. The nozzle plate 22 is supported on the casing. Elastic fluid is directed to the succeeding bucket wheels by

means of diaphragms 24 supported on the turbine casing. The opening 25 leads to a chamber 26 from which steam or like fluid may be extracted through an outlet 27 for external use. The diaphragms adjacent the bucket wheel 20 have outer rings with adjacent surfaces forming a circumferentially extending groove 28 with a drain 29 in the bottom for receiving and discharging water or like liquid formed during operation and discharged from the bucket wheel 20. The rotor is supported by journal bearing means 30 and thrust bearing means 31. Packings 32 and 33 are provided to seal the rotor shaft to the casing 10 in order to reduce leakage of fluid from the turbine along the turbine shaft.

The inlet end of the turbine casing has an opening 34 in the bottom of the first stage casing for receiving and discharging water or like liquid conducted from the first stage of the turbine through cut away portions 34a of the shield 23. The discharge of the water or like liquid is controlled by means of a valve member 35 disposed in a cylindrical casing 36 with a drain 37 and biased towards its seat by means of a compression spring 38 engaging a piston 39 attached to the lower end of the stem of the valve 35. The lower end of the casing forms a pressure chamber connected by a pipe 40 to the turbine casing, preferably at a point radially inward from the outlet 34 near the turbine shaft, that is, the diametrical center of the turbine casing near the inlet end thereof. The pipe 40 includes a flow limiting means in the form of a restriction 41. A spring biased relief valve 42 is associated with the casing 36 and has an inlet 43 connected to the lower end of the casing 36 and a drain 44. The valve member 45 of the relief valve is normally held closed by means of a spring 46.

The mechanism responds to either of two transient pressure conditions which are known to occur in the first stage shell of the turbine when water or like liquid passes through the first stage nozzle. For example, when relatively cold water enters a turbine the static pressure in the first stage shell decreases rapidly. This probably is due to the sudden reduction in steam flow into the stage, as well as the condensing of steam in the stage produced by the cold water. At the same time that the static pressure drops a pronounced difference in pressure occurs between the center and the outer periphery of the casing. It has been well established that this difference in pressure is caused by the centrifugal action of liquid rotated by the turbine wheel. When such a pressure condition exists, the pressure act-

ing on the lower side of the piston 39 is sufficiently lower than that acting on valve 35 to effect its opening and the consequent draining of the liquid from the turbine casing through passages 34 and 37.

The other condition of operation occurs, for example, when the turbine receives relatively hot liquid while operating with light steam flows. Under such conditions no appreciable difference in pressure exists between the center and periphery of the casing, but the static pressure in the stage quickly rises to a value considerably above the maximum which can occur while operating on dry steam. The relief valve 45 which is set to open at a pressure slightly above the maximum operating steam pressure prevents the pressure on the lower side of piston 39 from reaching the pressure occurring in the turbine stage, thus the pressure exerted against valve 35 is sufficiently above that exerted on the lower side of piston 39 to effect opening of valve 35 which drains liquid from the stage of the turbine. The stem of the valve 35 is guided by means of webs 47 having openings 48. Upon the discharge of liquid through the valve 35 and the drain 37 the valve is relieved of the peripheral pressure created by the liquid and subsequently closed by action of the spring 38.

The arrangement of Fig. 2 comprises a turbine casing 50 corresponding to the casing 10 of Fig. 1 and a rotor with a plurality of bucket wheels 51, 52, 53, 54, corresponding to the bucket wheels 15, 16, 17 of Fig. 1 and diaphragms 55 associated with the bucket wheels 51, 52, 53, 54 and corresponding to the diaphragms 24 of Fig. 1. The turbine casing 50 has a peripheral outlet opening 56 in the bottom and an axial opening 57 radially inward from the opening 56 near the diametrical center of the casing inlet end. Shields 58 are provided on opposite sides of the first stage bucket wheel 51 corresponding to the shields 23 of Fig. 1 to reduce windage losses. Portions of the shields 58 near the opening 56 are cut away to form openings 59 through which liquid may pass to the peripheral outlet 56.

The discharge of liquid such as water slugs through the peripheral outlet 56 is controlled by means including a valve 60. The valve 60 has a casing 61 flanged to the outlet 56 of the turbine casing and forming a drain 62. The casing 60 has a seat 63 for a main cylindrical valve member 64 which in turn forms a seat for a pilot or auxiliary valve member 65 attached to a stem 66. The right-hand end of the valve casing 61 is closed by a cover or bottom 67 which also forms part of a differential pressure responsive device comprising a cylindrical casing 68 flanged to the cover 67 and including a piston 69 attached to an extension of the valve stem 66. The left-hand portion of the casing 68 is connected by a pipe 70 to the peripheral outlet 56 and the right-hand end of the casing 68 is connected through a pipe 71 to the axial outlet 57 of the turbine casing. The pipe 71 has a restriction or orifice 72 corresponding to the orifice 41 of Fig. 1. A spring loaded relief valve 73 corresponding to the relief valve 42 in Fig. 1 is connected to the pipe 71 at a point between the orifice 72 and the cylinder 68. The pilot valve stem 66 is biased towards the left, that is towards valve closing position, by means of a spring 74. In addition, the valve is biased towards closing position by the differential pressure exerted on the pilot valve 65. The outlet side of the pilot valve 65 is subject to the pressure in the discharge opening 62 while the inlet

side of the pilot valve 65 is subject to the pressure in the peripheral outlet 56. This pressure is communicated to the inlet side of the pilot valve through the clearance formed between the main valve member 64 and the cylinder 61, a space 75 between the cover 67 and the main valve member 64, and openings 76 in the right-hand part of the main valve member.

During normal operation when there are no water slugs in the turbine the axial pressure at the opening 57 is substantially the same as the peripheral pressure in the opening 56 so that the pressures on opposite sides of the piston 69 balance each other and the pilot valve and main valve members are held closed by action of the spring 74 and the forces due to the differential pressures on the inlet and outlet sides of the valve members. If a slug of liquid such as water is conducted to the first turbine stage at a temperature substantially below saturation temperature, the water by centrifugal action forms a ring in the turbine casing. With this condition the peripheral pressure in the outlet 56 will be greater than the axial pressure through the outlet 57. Hence, a greater force will be created on the left-hand side of the piston 69 than on the right-hand side thereof whereby the piston 69 is moved towards the right, causing opening of the pilot valve 65. This in turn will relieve the pressure in the space 75 and upon further movement of the pilot valve cause opening of the main valve member 64, thus permitting the discharge of liquid from the peripheral outlet 56 through the drain 62 of the valve casing. The discharge of liquid from the turbine casing reduces the peripheral pressure and thus permits the piston 69 to return to its normal position by action of the spring 74, resulting in closing movement of the valve.

As in the case described in connection with Fig. 1, the operation is different when the liquid slugs are such as to produce no differential pressure but an abnormally high static pressure in the turbine casing. In that case the peripheral pressure in the first turbine stage does not rise at a rate much greater than that of the axial pressure at the axial outlet 57. In order to effect valve opening under such circumstances the relief valve 73 is provided which functions similarly to the relief valve 42. The relief valve 73 is set for a certain pressure above normal operating pressure in the first turbine stage. If this pressure is exceeded the relief valve 73 opens, thus reducing the pressure on the right-hand side of the piston 69 relative to the pressure on the left-hand side thereof, resulting in movement of the piston 69 towards the right and opening movement of the movable valve members 65, 64.

Thus, with my invention I have accomplished an improved construction and arrangement of elastic fluid turbines subject to liquid slugs in the high pressure turbine stage or stages during operation. These liquid slugs according to my invention are removed from the high pressure turbine stages, preferably the first turbine stage, by means including a valve and a mechanism for operating the valve, which mechanism is responsive to the difference between the peripheral and axial pressures or the radial pressure rise near the peripheral outlet of the turbine and also responsive to a predetermined pressure above the normal operating pressure in the first turbine stage. The elements of this mechanism responsive to the difference between the peripheral and axial pressures in the first turbine stage effect positive opening of the valve as long as the liquid

slugs are of such a nature as to produce a difference in pressure between the center and periphery of the casing while the elements of the mechanism including a relief valve responsive to a certain axial pressure in the turbine, effect operation of the mechanism in case the liquid slugs are such as to produce only an abnormally high static pressure in the turbine casing.

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

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

1. Multi-stage elastic fluid turbine having a casing with an inlet and an exhaust end for elastic fluid and being subject to liquid slugs carried along with the elastic fluid, the casing having a peripheral opening near the first stage for discharging liquid therefrom, and means including a spring-biased valve subject to the peripheral pressure in the turbine for automatically controlling the discharge of liquid through the opening.

2. Multi-stage high pressure elastic fluid turbine comprising a casing with an inlet and an exhaust end for elastic fluid and a peripheral outlet near the inlet for discharging liquid slugs conducted through the inlet together with elastic fluid conducted thereto, a valve controlling the flow through the peripheral outlet, means normally biasing the valve towards closing position, and means responsive to differential pressure between the peripheral outlet and a point near the diametrical center of the turbine for actuating the valve.

3. Multi-stage high pressure elastic fluid turbine comprising a casing having an inlet and an exhaust end for elastic fluid and a peripheral outlet near the inlet end of the turbine for discharging liquid slugs carried into the turbine together with elastic fluid conducted thereto, and means for controlling the flow of liquid through said outlet comprising a pressure differential responsive device including an element subject on one side to the peripheral pressure in the outlet and a conduit connecting the other side of the element to the inlet end of the turbine casing at a point near the diametrical center thereof.

4. Multi-stage high pressure elastic fluid turbine comprising a casing having an inlet and an exhaust end for elastic fluid and a peripheral outlet near the inlet end of the turbine for discharging water slugs carried into the turbine together with elastic fluid conducted thereto, and means for controlling the flow of liquid through said outlet comprising a pressure differential responsive device including an element subject on one side to the peripheral pressure in the outlet and a conduit connecting the other side of the element to the inlet end of the turbine casing at a point near the diametrical center thereof, said conduit including a pressure reducing means and a relief valve beyond the pressure reducing means as regards the flow of fluid through the conduit.

5. Multi-stage high pressure elastic fluid turbine having a casing with an inlet and an exhaust end for elastic fluid and a peripheral outlet near the inlet end of the casing for discharging liquid slugs entering the casing together with elastic fluid conducted thereto, means for controlling the flow through said outlet comprising

a valve having a casing flanged to the turbine casing and having an inlet communicating with the peripheral outlet and a drain, a movable valve member engaging a seat in the valve casing and facing the peripheral outlet, means biasing said valve towards closing position comprising a piston connected to the valve and forming with the casing a pressure chamber, a spring in said chamber engaging the piston, a conduit connecting the pressure chamber to the inlet end of the turbine casing at a point radially inward from the peripheral outlet.

6. Multi-stage high pressure elastic fluid turbine having a casing with an inlet and an exhaust end for elastic fluid and a peripheral outlet near the inlet end of the casing for discharging liquid slugs carried into the casing together with elastic fluid supplied thereto, means for controlling the flow through said outlet comprising a valve having a casing flanged to the turbine casing and having an inlet communicating with the peripheral outlet and a drain, a movable valve member engaging a seat in the valve casing and facing the peripheral outlet, means biasing said valve towards closing position comprising a piston connected to the valve and forming with the casing a pressure chamber, a spring in said chamber engaging the piston, a conduit connecting the pressure chamber to the inlet end of the turbine casing at a point radially inward from the peripheral outlet, and spring biased relief valve means connected to said conduit and set to open at a certain pressure in the turbine casing above the normal operating pressure.

7. Multi-stage high pressure elastic fluid turbine comprising a casing having an inlet and an exhaust end for elastic fluid and a peripheral outlet in the bottom of the turbine casing near the inlet end thereof for discharging liquid slugs conducted to the turbine together with elastic fluid supplied thereto, means for controlling the flow of liquid slugs through the peripheral outlet comprising a valve having a main valve member and a pilot valve member, means biasing the valve member towards closing position, and means connected to the pilot valve member to open the valve in response to certain pressure conditions in the turbine casing.

8. Multi-stage high pressure elastic fluid turbine comprising a casing having an inlet and an exhaust end for elastic fluid and a peripheral outlet in the bottom of the turbine casing near the inlet end thereof for discharging liquid slugs conducted to the turbine together with elastic fluid supplied thereto, means for controlling the flow of liquid slugs through the peripheral outlet comprising a valve having a main valve member and a pilot valve member normally closing the outlet, means biasing the valve members towards closing position, and means for operating the valve members comprising a differential pressure responsive device connected to the pilot valve and having pressure chambers connected respectively to the peripheral outlet and to a point in the turbine casing near the diametrical center thereof.

9. Multi-stage high pressure turbine comprising a casing having an inlet and an exhaust end for elastic fluid and a peripheral outlet in the bottom near the inlet end of the casing for discharging liquid slugs conducted to the turbine together with elastic fluid supplied thereto, means for controlling the flow of liquid through the peripheral outlet comprising a valve having

a casing flanged to the outlet, a main valve member and a pilot valve member in the valve casing, means normally biasing the valve members into closing position, and means for automatically opening the valve members in response to a pre-determined difference in pressure between the peripheral outlet and a point in the inlet end of the casing near the diametrical center thereof.

10. Multi-stage high pressure turbine comprising a casing having an inlet and an exhaust end for elastic fluid and a peripheral outlet in the bottom near the inlet end of the casing for discharging liquid slugs conducted to the turbine together with elastic fluid supplied thereto, means for controlling the flow of fluid through the peripheral outlet comprising a valve having a casing flanged to the outlet, a main valve member and a pilot valve member in the valve casing, means normally biasing the valve members into closing position, and means for automatically opening the valve members in response to a pre-determined radial pressure drop near the peripheral outlet in the inlet end of the turbine casing, said last named means comprising a casing having a piston connected to the pilot valve and forming two pressure chambers on opposite sides of the piston, a pipe connecting one of the chambers to the peripheral outlet and a conduit connecting the other chamber to the inlet end of the turbine casing at a point radially inward from the peripheral outlet.

11. Multi-stage high pressure turbine comprising a casing having an inlet and an exhaust end for elastic fluid and a peripheral outlet in the bottom near the inlet end of the casing for discharging liquid slugs conducted to the turbine together with elastic fluid supplied thereto, means for controlling the flow of fluid through the peripheral outlet comprising a valve having a casing flanged to the outlet, a main valve member and a pilot valve member in the valve casing, means normally biasing the valve members into closing position, and means for automatically opening the valve members in response to a pre-determined difference in pressure between the peripheral outlet and a point in the inlet end of the casing radially inward from the outlet, said last named means comprising a cylindrical casing having a piston connected to the pilot valve and forming two pressure chambers on opposite sides of the piston, a pipe connecting one of the chambers to the peripheral outlet and a conduit connecting the other chamber to the inlet end of the turbine casing at a point radially inward from the peripheral outlet, said last named conduit including a pressure reducing means and a spring biased pressure relief valve connected to the conduit between the pressure reducing means and the respective pressure chamber.

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