Feb. 9, 1932. E. H. HORSTMAN 1,844,659

ROTOR VENT

Filed Sept. 15, 1930

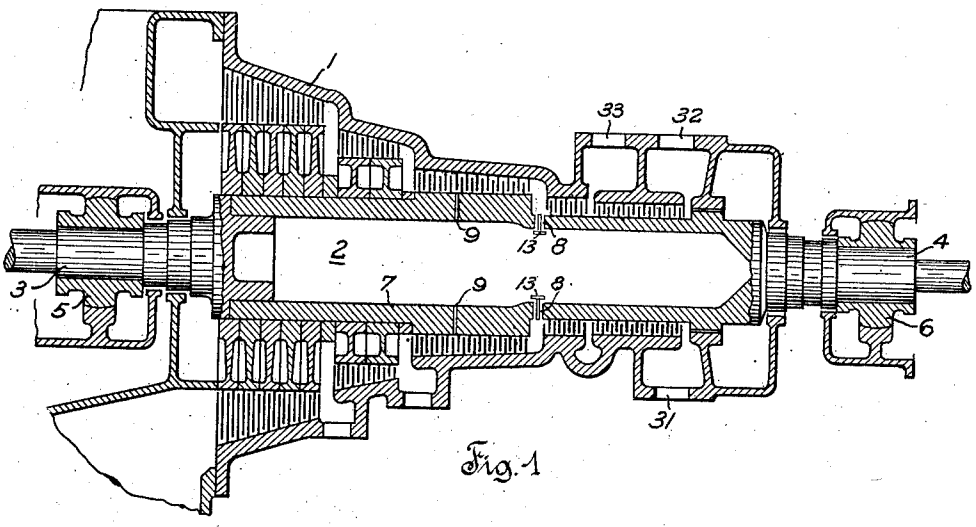


Fig. 1

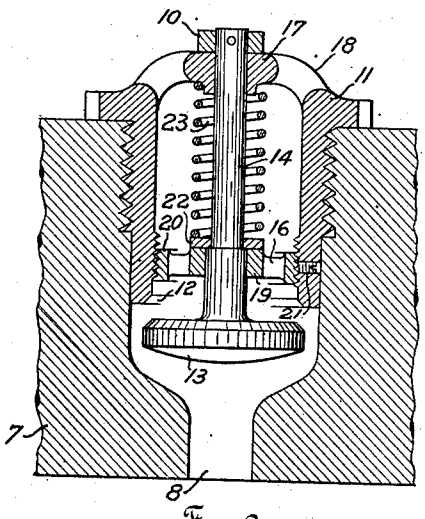


Fig. 2

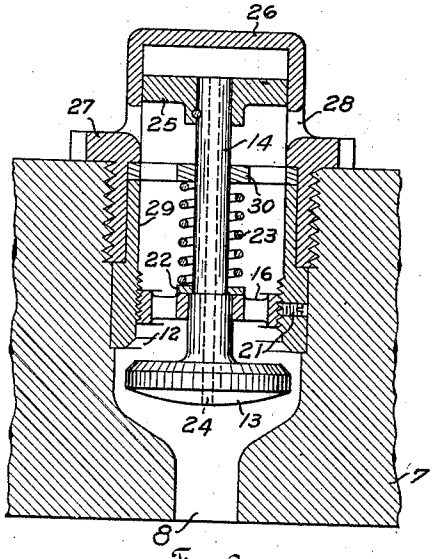


Fig. 3

Inventor

E. H. Horstman

by A. J. DeWein

Attorney

Patented Feb. 9, 1932 1,844,659

UNITED STATES PATENT OFFICE

ELMER H. HORSTMAN, OF WEST ALLIS, WISCONSIN, ASSIGNOR TO ALLIS-CHALMERS MANUFACTURING COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF DELAWARE

ROTOR VENT

Application filed September 15, 1930. Serial No. 481,867.

This invention relates to elastic-fluid turbines and more particularly to improvements in rotor structures for machines of this type.

In the operation of turbine engines operated by heated elastic-fluid, such as steam, difficulties have been encountered in that the rotor became distorted due to uneven cooling during a shut-down period, and as a result thereof severe vibration developed during the subsequent starting period even when a considerable length of time was allowed to permit the rotor to become uniformly heated. In order to overcome these difficulties it has been suggested previously to provide a hollow, drum like rotor with inlet and outlet vent holes through which a part of the steam admitted to the turbine housing was allowed to circulate through the interior of the rotor in order to effect a more rapid and uniform heating of the rotor by applying the hot fluid to its inside surface as well as to its outside surface. Experience in operating some large steam turbine units which were provided with such rotor vents has shown that the rotor could be uniformly heated and brought up to speed in a comparatively short time without objectionable vibration but that severe vibration of an unstable nature developed after loading when the pressure difference between the inlet and outlet vent holes of the rotor tended to cause too great a steam flow through the rotor.

It is an object of the present invention to provide a self-closing rotor vent whereby such undesirable flow of heating medium through the interior of the turbine rotor is prevented.

Another object of the invention is to provide a self-closing rotor vent which is simple and compact in structure and efficient in operation.

These and other objects and advantages of the present invention will be apparent from the following description. A clear conception of an embodiment of the invention and of the operation of a device constructed in accordance therewith, may be had by referring to the drawings accompanying and forming a part of this specification, in which like reference characters designate the same or similar parts in the several views.

Fig. 1 is a longitudinal vertical section through a steam turbine having a hollow rotor drum provided with inlet and outlet vent holes, the general arrangement of self-closing valves for the inlet vent holes being indicated schematically in this figure.

Fig. 2 is a detail view showing in an enlarged scale a self-closing valve for a rotor vent hole.

Fig. 3 is a view similar to Fig. 2 showing a modified construction of a self-closing valve for a rotor vent hole.

The numeral 1 indicates the housing of a multi-stage steam turbine, and 2 indicates, generally, the rotor of this turbine. At its ends the rotor 2 has journals 3 and 4 which are supported by suitable bearings 5 and 6 in conventional manner. The main body of the rotor is formed by a hollow drum 7 which carries the moving blades, the latter being mounted as usual partly on the drum itself and partly on supporting disks associated with the drum. Inlet vent holes 8 and outlet vent holes 9 are provided in the drum 7 to allow part of the steam which is admitted to the housing 1 to circulate through the interior of the drum 7. The inlet vent holes are here shown as being located between the second and the third group of stages while the outlet vent holes connect the interior of the rotor with a zone approximately in the middle of the third group of stages. It will readily be seen that the steam leaving the second group of stages has a higher pressure than the steam in the zone of the outlet vent holes and that, therefore, part of the steam discharged from the second group of stages may enter the interior of the rotor through the inlet vent holes and leave the interior of the rotor through the outlet vent holes. Such circulation of steam through the interior of the rotor will cause the rotor to warm up uniformly and in a relatively short time, but it is not desirable to allow such steam circulation while the turbine is under load, and this for the following reason. During the starting period the pressure difference between the inlet and outlet vent holes is rela-

tively low compared with full load conditions and, in order to warm the rotor up quickly, a relatively large area of the inlet and outlet vent holes is required to cause a sufficiently vivid circulation of steam. If these relatively large openings were kept open while the turbine is under load the increased pressure difference between the inlet and outlet vent holes would tend to cause too great a steam flow through the interior of the rotor, which might result in an unsatisfactory operation of the turbine. Fig. 1 of the drawings shows schematically how the inlet vent holes may be equipped with valves which close automatically under the influence of the centrifugal forces to which they are subject when the turbine has reached its full speed. In detail, these valves may be constructed as shown in Fig. 2. The wall of the drum 7 is provided with counter-sunk inlet vent holes 8 each of which has a threaded portion adjacent the outer surface of the rotor. Screwed into the threaded portion of each hole 8 is a valve seat 11 having a seating surface 12 which faces the interior of the rotor.

A valve disk 13 is adapted to engage the seating surface 12, a valve stem 14 being associated with the valve disk and guided in an outer and an inner bearing. The outer bearing is formed integral with the valve seat 11 and has a hub portion 17 which is supported by arms 18. The inner bearing is formed by a perforated plate 16 having a hub portion 19 and a rim portion 20. The rim portion 20 is threaded on its circumference and screwed into a threaded portion of the valve seat 11, a suitable set screw 21 being provided to lock the bearing plate 16 in a certain position. The valve stem 14 has a shoulder on which a washer 22 is seated, and a coil spring 23 surrounding the valve stem 14 exerts pressure against the washer 22, tending to hold the valve in its open position as shown. A collar 10 is fastened on the outer end of the valve stem and limits the travel of the valve disk 13.

Under certain conditions the valves may fail to keep the inlet vent holes closed while the turbine is operating at full speed. This may happen when the pressure difference between the inlet and outlet vent holes becomes excessive, for instance when the turbine is overloaded, and in this case the steam pressure acting upon the valves would overcome the centrifugal forces which tend to keep them closed, so that the valves would open and admit steam to the interior of the rotor while the turbine is under load. This disadvantage may be overcome by using a construction as shown in Fig. 3. The valve stem 14 is here provided with a longitudinal drill 24, and associated with the outer end of the valve stem is a balancing piston 25 which is slidable in a balancing cylinder 26. This balancing cylinder has an extension 27 which is integral therewith and screwed into the rotor body, suitable openings 28 being provided to allow the admission of steam to the interior of the rotor. A bushing 29 and a perforated plate 30 are retained by the cylinder extension 27, and the valve stem 14 is guided by the plate 30 and a bearing plate 16 in a similar manner as described in connection with Fig. 2. A coil spring 23 engaging the plate 30 and pressing against a washer 22 on the valve stem 14 tends to keep the valve open. The tension of the spring 23 and the valve lift may be adjusted by loosening the set screw 21 and screwing the bearing plate 16 up or down.

The diameter of the balancing piston 25 is approximately equal to the diameter of the valve disc 13, and it will be seen that steam entering through the openings 28 will act upon the balancing piston 25 and the upper surface of the valve disc 13 in opposite directions. As the surfaces of the balancing piston and of the valve disc, which are exposed to the pressure of that steam, are substantially equal, the valve disc will have no tendency to move under the action of that steam pressure in one direction or the other, and its movement will be controlled by the centrifugal forces developed during rotation of the rotor, and by the pressure of the spring 23 counteracting said centrifugal forces. Any steam leaking past the piston 25 into the upper space of the balancing cylinder 26 is prevented from accumulating in that space, by the longitudinal bore 24 of the valve stem. This bore further prevents the creation of a vacuum in the balancing cylinder if the piston 25 moves downwardly to open the valve. It should be noted that if the valve is closed, the bore 24 and the interior space of the rotor establish a communication between the upper space of the balancing cylinder and the outlet vent holes 9 (Fig. 1), and that these vent holes, therefore, should be placed in a zone of sufficiently low pressure in order to avoid undesirable pressure in the upper space of the balancing cylinder.

In operation, steam is admitted to the turbine housing 1 through the opening 31 and passes through the several stages of the turbine in the usual manner. The openings 32 and 33 are provided for the conveyance of steam from the entrance zone directly to the second group of stages as this is usual in steam turbine design. During the starting period the centrifugal forces acting upon the valve disks 13 and their associated parts are—at least in the beginning—not sufficient to overcome the forces exerted by the springs 23, and the valves are, therefore, kept open and steam discharged from the second group of stages is allowed to enter the interior of the rotor. As the angular velocity of the rotor increases the open area of the inlet vent holes steadily decreases, and at a certain speed

which is preferably slightly below the normal operating speed the valves are entirely closed. In this position they will remain, independently of the steam pressure in the turbine housing and independently of the pressure difference between the inlet and outlet vent holes, if the valves are balanced, as this is shown by way of example in Fig. 3 of the drawings.

It should be understood that it is not intended to limit the invention to the exact details of construction herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In an elastic-fluid turbine, a housing, a hollow rotor within said housing having apertures connecting the interior space of said rotor with zones of high and low pressure, respectively, within said housing, and speed responsive means associated with said rotor, whereby the pressure difference effective between said apertures is permitted to cause circulation of operating fluid through the interior of said rotor as long as the turbine speed is below a predetermined value but whereby such circulation is prevented while the turbine is operating at normal speed.

2. In an elastic fluid turbine, a housing, a hollow rotor having inlet and outlet vent holes connecting the interior space of said rotor with zones of high and low pressure, respectively, within said housing, and speed responsive means adapted to close said inlet vent holes when said rotor has reached a predetermined angular velocity.

3. In an elastic-fluid turbine, a housing, a rotor within said housing comprising a hollow drum portion having inlet and outlet vent holes connecting the interior space of said drum portion with zones of high and low pressure, respectively, within said housing, and means adapted to prevent circulation of operating fluid through the interior space of said drum portion, said means comprising a plurality of closure members each associated with one of said vent holes, supporting elements for said closure members permitting radial movement thereof with respect to said drum portion, and a spring member associated with each of said closure members, said spring member having a tendency to hold its respective closure member in an open position but being adapted to yield to centrifugal forces acting upon said closure member at a predetermined angular velocity of said rotor, so that the respective vent hole is kept closed as long as said rotor has an angular velocity in excess of a predetermined value.

4. In an elastic-fluid turbine, a housing, a rotor within said housing comprising a hollow drum portion having inlet and outlet vent holes connecting the interior space of said drum portion with zones of high and low pressure, respectively, within said housing, and means adapted to prevent circulation of operating fluid through the interior space of said drum portion, said means comprising a plurality of valve seat members each fitted to one of said vent holes and providing a valve seat surface facing the interior of said drum portion, a valve disk including a stem, associated with each of said valve seat members, and resilient means adapted to hold said valve disks lifted from their respective valve seat surfaces but allowing them to engage said surfaces under the influence of centrifugal forces acting upon said valve disks when said rotor has reached a predetermined angular velocity.

5. A turbine rotor having in combination, a hollow drum portion provided with a plurality of vent holes and, associated with each of said vent holes, a valve seat member providing a seat surface facing the interior of said drum portion, a valve disk including a stem disposed to extend radially from said drum portion, a balancing piston associated with said valve stem, a balancing cylinder enclosing said balancing piston, associated with said drum portion, and resilient means adapted to hold said valve disk lifted from said valve seat surface but allowing it to engage said surface under the influence of centrifugal forces acting upon said valve disk when the rotor has reached a predetermined angular velocity.

6. A turbine rotor having in combination, a hollow drum portion provided with a plurality of vent holes and, associated with each of said vent holes, a valve seat member providing a seat surface facing the interior of said drum portion, a valve disk including a stem disposed to extend radially from said drum portion, a balancing piston associated with said valve stem, a balancing cylinder associated with said drum portion and enclosing said balancing piston, the interior of said cylinder communicating with the interior of said drum portion through a bore in said valve stem, and resilient means adapted to hold said valve disk lifted from said valve seat surface but allowing it to engage said surface under the influence of centrifugal forces acting upon said valve disk when the rotor has reached a predetermined angular velocity.

In testimony whereof, the signature of the inventor is affixed hereto.

ELMER H. HORSTMAN.