Feb. 7, 1933. E. BROWN 1,896,508

METHOD AND APPARATUS FOR THE PREHEATING AND MAINTAINING AT OPERATING TEMPERATURE THE CYLINDERS OF STEAM OR GAS TURBINES

Filed Nov. 24, 1928 2 Sheets-Sheet 1

Fig. 1

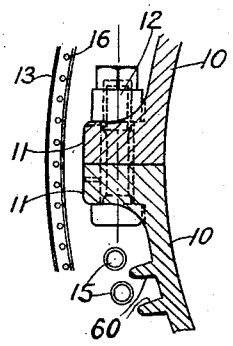


Fig. 7

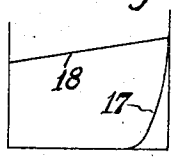


Fig. 2

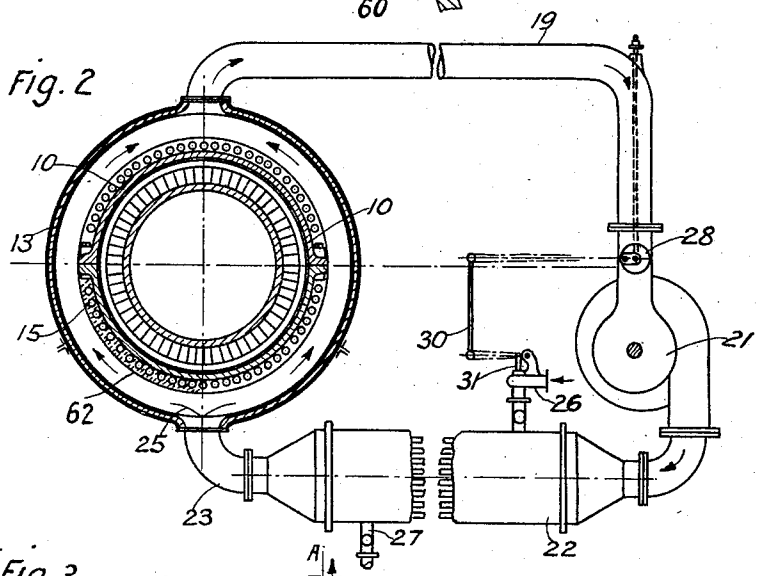
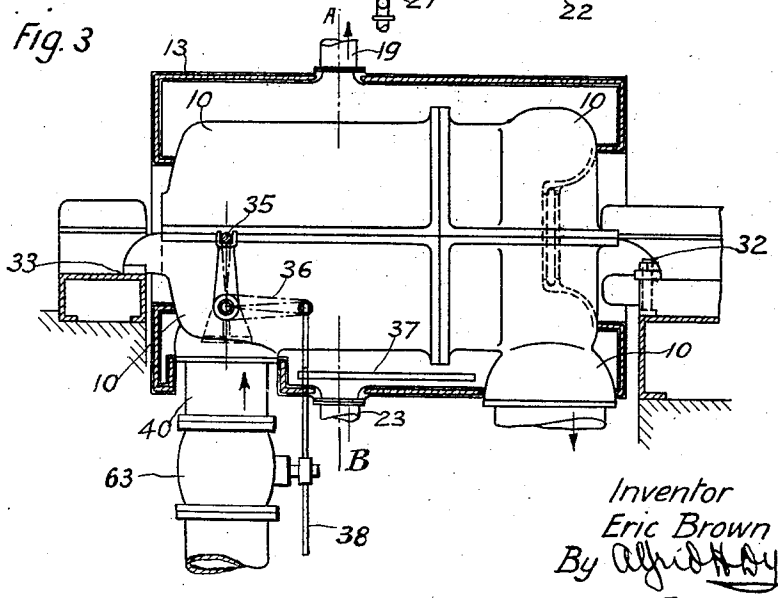


Fig. 3



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Fig. 4.

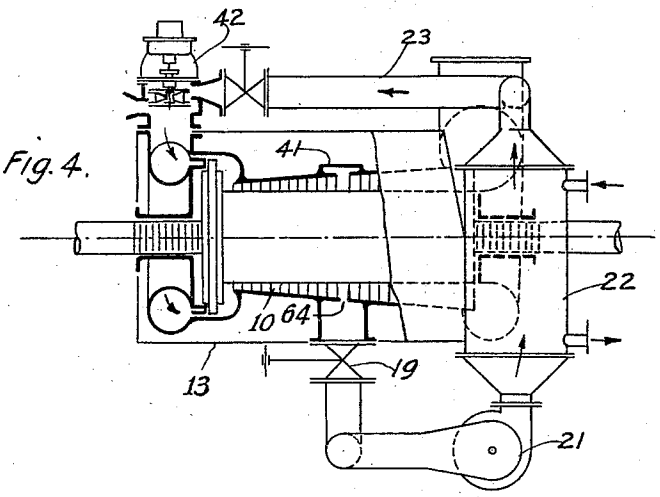


Fig. 5

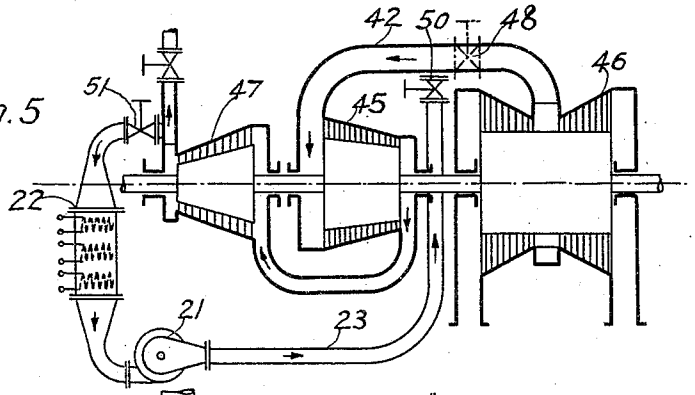
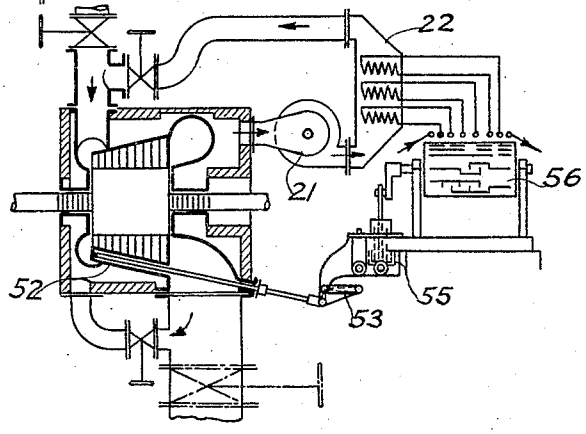


Fig. 6



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR THE PREHEATING AND MAINTAINING AT OPERATING TEMPERATURE THE CYLINDERS OF STEAM OR GAS TURBINES

Application filed November 24, 1928, Serial No. 321,749, and in Germany November 26, 1927.

This invention relates to steam turbines and especially to means for enabling such turbines to be put into operation in a shorter time than hitherto possible.

It is well known that the various sections of steam and gas turbines do not heat and cool uniformly when being put into and out of operation and that during such periods of unequal heating and cooling, the cylinders and shafts are subjected to objectionable stresses with resulting distortion. If, therefore, a turbine is placed into operation during the periods of such stresses and distortions, the turbine will be subjected to excessive vibration with consequent damage unless structural allowances, such as excessive running clearances, are made. Otherwise, the turbine must be preheated at a very slow rate to approximately the operating temperature which may require several hours for large turbines and for turbines operating at particularly high temperatures or at high pressures.

Moreover, the admission of steam at the rate, or in the amount, necessary for the operation of the turbine will, in consequence of the high heat transfer due to condensation on the contact surfaces, create heat stresses in the several portions of the turbine which may greatly exceed the elastic limits of the materials used, and may produce permanent distortion with resulting cracked casings and other parts, stretched flange bolts and leakage at the various joints between the several portions.

The method hitherto used for preheating, and maintaining in a hot state, of the various sections of the turbine to be protected against the dangers of distortion and stressing beyond the elastic limit when rapidly placed in operation, by providing a continuous flow of steam therethrough or thereabout, is inadequate as preparation for rapid placing in operation, as, in spite of the costly expenditure of steam, the degree of heating attained and maintained is limited by the temperature of saturation or condensation corresponding to the low pressure of the steam flowing through the sections to be heated.

The disadvantages and difficulties above set forth in starting a turbine are overcome by the present invention, of which it is an object to maintain a turbine in heated condition for the purpose of facilitating starting thereof without the expenditure of large quantities of heat.

A further object of the invention is to maintain a turbine in a heated condition by heating from the interior or from the exterior thereof or by a combination of heating from both the interior and exterior thereof.

A further object of the invention is to maintain the surfaces of the turbine to be brought in contact with the operating medium at a temperature substantially equal to or higher than that corresponding to the temperature of condensation of said medium.

Another object of the invention is to supply heat for maintaining a turbine in a heated condition, between the casing and the lagging thereof.

A further object of the invention is to provide a combination of steam and electric heating means which may be used separately or in combination for maintaining a turbine in a heated condition to facilitate quick starting thereof.

Another object of the invention is to provide means for securing different temperature zones during the maintenance of a turbine in a heated condition which zones are similar to those occurring during operation.

Other objects and advantages will be apparent to those skilled in the art from the following description in connection with the drawings accompanying and forming part of this specification.

In the drawings:

Fig. 1 is a partial sectional view of the casing wall of a turbine incased in lagging;

Fig. 2 is a cross-sectional view of a turbine embodying the invention, taken approximately on a central line;

Fig. 3 is a view showing a turbine in elevation and the lagging thereon in section;

Fig. 4 is a view partially in section and partially in elevation of a turbine showing one embodiment of the invention;

Fig. 5 is a cross-sectional view of a multicylinder turbine embodying the invention;

Fig. 6 is a cross-sectional view of a turbine showing one means for automatically controlling the source of heat supplied to the turbine; and

Fig. 7 is a diagram indicating the heat gradient in the structure.

In the drawings, the several figures are arranged to illustrate a plurality of embodiments of the invention in such a manner as will enable ready comprehension by those skilled in the art.

Referring to the drawings by characters of reference, 10 indicates a casing of a turbine cylinder which comprises a plurality of removable sections to facilitate manufacture, assembly and inspection of the various portions of the device enclosed therein. The casing portions 10 have flanges 11 formed integral therewith to provide for the aligning and joining of the several casing portions by means including bolts 12 passing through the flanges 11. Conductance of heat to the bolts may be increased by providing the flanges with passageways as shown. The turbine is shown as entirely surrounded by a lagging 13 formed of materials having a low co-efficient of heat conductivity and comprising an inner and an outer shell separated by insulating material. Any other suitable arrangement may, however, be employed.

The lagging 13 is spaced from the turbine casing 10 to provide an intervening space in which a plurality of heating coils or pipes 15 are located and which are preferably arranged closely adjacent the turbine casing. The rate of heat conduction to the several portions of the turbine casing may be increased by providing the casing with fins or projections as at 60 which will increase the surface areas of the turbine in contact with the heating means.

An electric heating coil 16 is shown as secured near the interior surface of the lagging 13. It will be apparent that the spacing of the turns of the steam heating coil 15 and the electric heating coil 16 may be increased or decreased to provide for different heating zones adjacent the different portions of the turbine casing. The heating coil 16 will be supplied from a suitable source of electric current controlled by any of the usual suitable means. Instead of spacing the lagging 13 from the turbine, the casing 10 of the turbine may be coated with a material of low heat conductivity as of 62 applied directly thereto and, when so applied, the heating coils 15 may be imbedded therein, preferably closely adjacent the turbine casing. When the electric heating coil 16 is employed, it will, preferably, be imbedded in the surface of the lagging as shown in Fig. 1 and in contacting or closely adjacent relation to the turbine casing.

The thermal action produced by maintaining the turbine in a heated condition will be readily understood by reference to lines 17 and 18 of Fig. 7, indicating the heat gradient in the structure. Considering the contacting surfaces of the flanges 11 as one of two coordinate axes and a line perpendicular to the flange surfaces as the other, the line 17 represents the heat gradient or the rate of heat conduction when a turbine is started from rest without being maintained in a heated condition. Line 18 represents the heat gradient when a turbine is started in a heated condition. The steepness of line 17 is caused by high heat conduction due to condensation of steam on the casing. As soon as a condition of thermal equilibrium is reached, the heat gradient conforms to line 18, and a comparison of the lines shows that all danger of creating heat stresses is eliminated by maintaining the turbine in heated condition.

In addition to the heat supplied by the heating coils 15 and 16, the space between the casing 10 of the turbine and the lagging 13 may be supplied with heated gases circulated therethrough. When such addition is made, a tubular conductor 19 is connected with the lagging 13 in a suitable gas-tight manner. The conductor 19 is in communication with a fan 21 which is joined to a heat exchanger 22 which is connected, in a suitable manner, to an inlet through the lagging 13 into the space between the lagging and the turbine casing 10. The fan 21 exhausts the space within the lagging 13 thereby forcing a circulation of fluid through the heat exchanger 22 and through the space within the lagging 13 surrounding the turbine. A heating medium is supplied to the heat exchanger through an inlet 26, from a suitable source which may, for instance, be high pressure steam. If electric heating is utilized, the several heating elements may be connected in any of the known circuits for obtaining the desired temperature differences. After passing through the heat exchanger, the heating medium is discharged therefrom through an outlet 27. During the preheating period or while the operating temperature is being maintained, the turbine rotor should be turned, preferably slowly, by any suitable device to secure even heating of the several portions of the structure.

The quantity of heat required for proper maintenance of the turbine in heated condition may be regulated, either manually, in response to the indications of thermometric devices located in different parts of the device, or automatically by means of thermostatic devices. For example, a thermostat 28 may be placed in the conductor 19 immediately ahead of the fluid inlet to the fan 21, and the thermostat may be connected, by a system of levers 30, to a throttling valve 31, which permits the temperature of the heating fluid passing through the space between the lagging and the turbine casing to be au-

tomatically controlled by control of the amount of heating fluid passing through the heat exchanger 22.

Fig. 3 shows an embodiment of the invention in which expansion of the turbine casing 10 is utilized to provide means for interrupting the flow of heating medium from the heat exchanger 22 to the space within the lagging 13. In this embodiment, the turbine casing is fixedly attached to the base plate or foot at 32 and, as the casing is heated, expansion of the elements thereof will take place in direct ratio to the amount of heat supplied. One end of the turbine being fixed at 32, it is necessary that the turbine expand in a direction away from the point of attachment 32 and the lug 33, resting upon a foundation or base member at one end of the turbine, opposite to the fixed point of attachment 32, permits expansion in that direction. In this way the heat supplied is directly dependent on the temperature of the casing which serves as a thermostat.

A pin 35 extending outwardly from the turbine casing portions 10 into the space between the turbine casing and the lagging 13 and connected by the system of levers 36 with a valve member 37 arranged to vary the size of the opening through the lagging for the tubular connection 23 to the heat exchanger 22, provides for variation in the quantity of heating fluids surrounding the turbine casing. Any suitable means such as 38 may be connected to an extension of the lever system 36 to open and close the circuit to the heating element 16. It will be seen, therefore, that the expansion of the turbine under the influence of heat, may be utilized to govern the amount of heat to be supplied thereto.

The lever system 36 may also be connected with a valve 63 in the steam inlet 40, whereby a suitable amount of steam may be allowed to circulate throughout the interior of the turbine casing, thereby assisting in maintaining the same in a properly heated condition.

One means for accomplishing partial admission of steam to the interior of the turbine to assist in maintaining the turbine at operating temperature is illustrated in Fig. 4, wherein the turbine casing 10 is provided with an annular passageway 41 within the lagged space, which passageway encloses ports 64 spaced about the periphery of the turbine so that steam introduced into the interior of the turbine casing may pass therefrom into the space enclosed by the lagging 13. A fan 21 which exhausts the heating medium from the interior of the turbine casing through the ports in the annular passageway 41, may be utilized to force the heating medium through the exchanger 22 and discharge the same therefrom into the tube 23 from which it again passes through the turbine. In addition to heating the turbine, the tube 23 may be so connected with the main steam supply valve 42 as to maintain the valve 42 in a heated condition and thus further facilitate rapid starting of the turbine.

The invention may also be applied to a multi-cylinder turbine as is shown in Fig. 5. The heat exchanger may also be an electrical device which is supplied from a suitable source of energy rather than the steam heated heating exchanger above described.

When the invention is applied to a multi-cylinder turbine the discharge tube 23 may be connected to the conduit 42 joining the intermediate and low pressure cylinders 45 and 46 respectively and to a high pressure cylinder 47 connected with the exhaust end of the intermediate cylinder 45, whereby the heating medium is permitted to flow through the high pressure cylinder 47 from which it is returned through the heat exchanger 22, and the cycle is repeated. It will be understood that the auxiliary heating circuit is provided with valves 48, 50 and 51, by means of which the same may be entirely disconnected from the turbine, or which will permit variation in the direction of flow of the heating medium so that the low pressure cylinder 46 may be cut off from the heating circuit and may be maintained under a vacuum to further facilitate starting of the turbine. Any desired temperature and velocity of gases may be obtained by adjustment of the valves and the speed of the fan.

Automatic regulation of the heat supplied to the heat exchanger may be obtained by enclosing a thermostatic member 52 within the walls of the turbine casing which member may, preferably, be of such character that the heating thereof will produce longitudinal expansion and thus control the action of a relay 55 through the medium of the connected lever system 53 which relay in turn controls a device 56 to regulate the admission of heating fluid to the heat exchanger 22. It will be apparent that the heat exchanger may be supplied with steam from any suitable source or that the same may be equipped with an electric heating element such as is shown in Figs. 5 and 6.

It has been found that the invention may be so satisfactorily applied to turbine installations that the same may be utilized as a reserve power machine capable of instantaneous operation on demand, rather than requiring a period of several hours for an imperfect preheating operation before being capable of operation.

It should be clearly understood that the invention has nothing in common with the well-known drying of turbines and the accompanying condensers, but deals with means for quickly starting a turbine from rest. The temperature ranges for the two operations are entirely different and are brought about by different means. In the invention, the heating fluid is of such temperature that the

turbine structure is preheated to and maintained at approximately the operating temperature thereof, whereas, in the usual drying operation, the temperature of the drying fluid is merely sufficiently high to cause evaporation of any condensate contacting therewith.

Although I have shown only a few embodiments of my invention, it will be clear to persons skilled in the art that various modifications may be made therein without departing from the spirit thereof or from the scope of the appended claims.

What I claim is:

1. In an elastic-fluid turbine system comprising a turbine having a casing, means for preventing stresses and distortions in said turbine comprising an inclosure of low heat conductivity forming a chamber about the casing, a heat exchanger in communication with the chamber, means for circulating a heating medium through the said heat exchanger, means for controlling the supply of heating medium by the external surface temperature of the turbine, and means for circulating a fluid heated by said heat exchanger through the chamber surrounding said turbine, to maintain the turbine during periods of non-operation at a temperature substantially equal to or higher than the temperature of condensation of the operating medium.

2. In an elastic-fluid turbine system comprising a turbine having a casing, means for preventing distortions and vibration in said turbine comprising a heat insulating inclosing member forming a heat retaining chamber surrounding the casing, a heat exchanger means in communication with the chamber, means for supplying a heating medium to said heat exchanger, a fan in communication with said heat exchanger and with the chamber for circulating a fluid to be heated therethrough, and means for controlling the rate of supply of said heating medium by the temperature of the circulated fluid, to maintain the turbine during periods of nonoperation at a temperature substantially equal to or higher than the temperature of condensation of the operating medium.

3. In an elastic-fluid turbine system, means for preventing stresses and distortions in a turbine during non-operating periods thereof including an enclosure of low heat conductivity forming a chamber about the turbine, a heat exchanger in communication with the chamber, means for circulating a heating medium through said heat exchanger, means for controlling the supply of heating medium in response to the external surface temperature of the turbine, and means for circulating a fluid heated by said heat exchanger through the chamber about said turbine.

4. In an elastic-fluid turbine system, means for preventing stresses in the turbine structure comprising a heat insulated enclosing member forming a heat retaining chamber surrounding the turbine, a heat exchanger means in communication with the chamber, means for supplying a heating medium to said heat exchanger, a fan in communication with said heat exchanger and with the chamber about said turbine for circulating a heating fluid therethrough, and means for controlling the rate of supply of said heating medium in response to the temperature of the circulated fluid.

5. In the art of operation of steam turbine apparatus wherein it is required that said apparatus be placed from a state of non-operation into a state of operation substantially instantaneously, and that the state of operation into which said apparatus is placed substantially instantaneously be at any degree of load for which said apparatus is designed; the method for such purpose which comprises maintaining the temperatures throughout the high-pressure end of the turbine structure at least substantially as high, during the non-operating state, as the temperatures of condensation of the full-load working steam, and in such manner that the temperature gradients in the turbine structure, formed in the substantially instantaneous transition from the non-operating state to the full-load operating state, are maintained within the range of substantially instantaneous temperature change to which the materials of the turbine structure can be subjected and still remain within the range of permissible strain below their elastic limits.

In testimony whereof I have hereunto subscribed my name this 27th day of October A. D. 1928.

ERIC BROWN.