

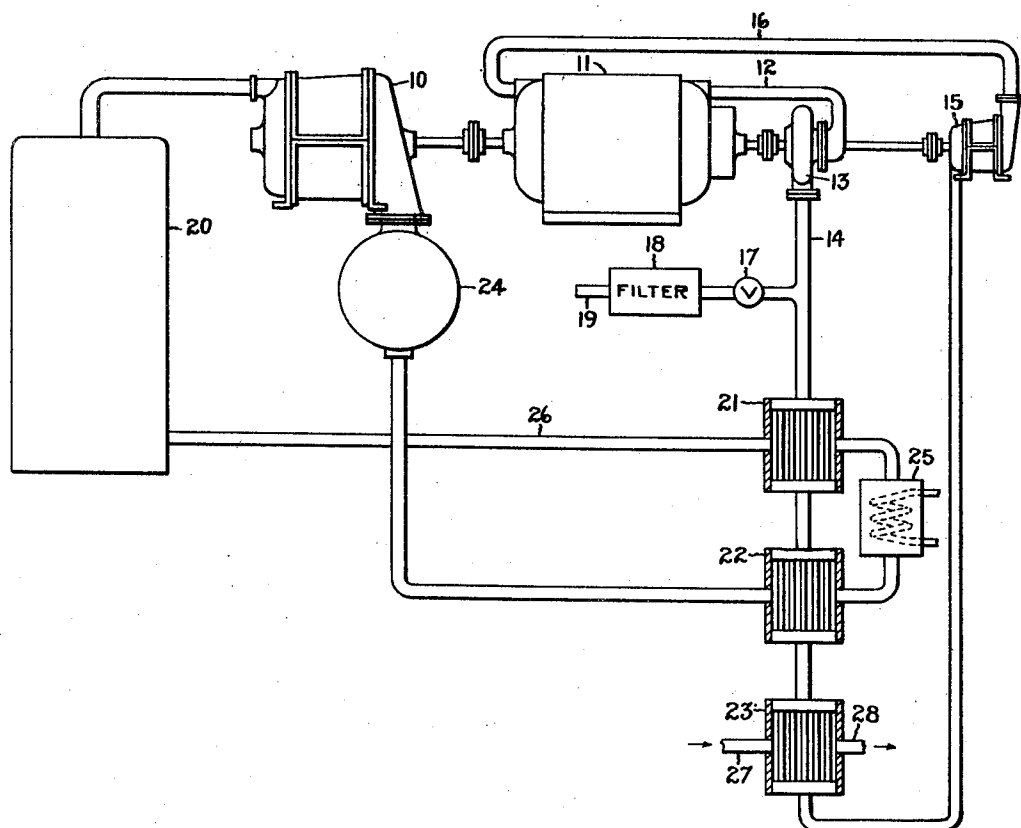
Dec. 13, 1949

K. R. HOPKIRK

2,491,314

TURBOGENERATOR COOLING SYSTEM

Filed May 11, 1948



Inventor:
Kenneth R. Hopkirk,
by *Cravell & Mark*
His Attorney.

UNITED STATES PATENT OFFICE

2,491,314

TURBOGENERATOR COOLING SYSTEM

Kenneth R. Hopkirk, Rugby, England, assignor to
General Electric Company, a corporation of
New York

Application May 11, 1948, Serial No. 26,252
In Great Britain October 14, 1946

3 Claims. (Cl. 290—2)

1

This invention relates to arrangements for cooling electric generators.

It is an object of the present invention to provide means whereby the cooling gas for a generator (and particularly a generator driven by a steam turbine) may be maintained at a low temperature level without material increase in overall energy consumption by the unit such as would be required to achieve the same result by conventional refrigerating methods.

It is a further object of the present invention to provide, for a turbogenerator having an external circuit for cooling its ventilating medium, means whereby heat from the ventilating medium may be transferred to the condensate from the turbine and thereby returned to the system in the form of preheated boiler feed water or steam.

Broadly the means employed in the embodiment herein illustrated and described comprises a turbine generator having an external cooling system employing a rotary compressor and an expanding auxiliary turbine mounted on the same shaft with each other and with a driving means, such as the main steam turbine-driven generator, and heat exchangers interposed in the cooling medium circuit between the compressor and the auxiliary turbine, with some of said heat exchangers interposed in the circulating fluid system between the main turbine exhaust and the boiler which is used to supply steam to the main turbine. Other aspects of the invention will appear from consideration of the following description taken in connection with the accompanying drawing in which I have diagrammatically shown an arrangement suitably embodying the invention.

In the drawing, I have shown a steam turbine 10 which is mechanically coupled so as to drive a turbine generator 11. Generator 11 is of a conventional type adapted to force ventilating medium by means (such as impellers—not shown) through itself and out of the generator through an external cooling system and then back to the machine. The ventilating medium may be hydrogen or air and for purposes of description is assumed to be air. An outlet conduit 12 from the generator conducts the air to the intake of a compressor 13 which, by suitable coupling, is being driven by the main turbine 10. The compressor draws air from the generator and discharges it through a conduit 14 across a series of air coolers 21, 22 and 23 and then to the inlet of an auxiliary turbine 15 which is mechanically coupled to the compressor and to the main generator and main turbine shaft. The air expands through the auxiliary turbine 15 and thereby balances some of the

2

work done by the compressor 13. Cooled air from turbine 15 is returned to the cooling medium inlet of the alternator through the conduit 16, which may contain de-icing equipment (not shown).

It is desirable to have the compressor 13 output at approximately atmospheric pressure and this feature may be supplied (when the ventilating medium is air) as shown by a T connection from conduit 14 through valve 17 and filter 18 to atmosphere at the end of conduit 19. When the equipment is started up air is exhausted through this connection until the outlet from the compressor is at atmospheric pressure. When the equipment is shut down, air from outside is drawn in through the filter to the system so that the entire system pressure will be atmospheric.

Turbine 10 is supplied from a boiler 20 and exhausts into a conventional condenser 24. The cooler 21 for the generator ventilating air from the turbine 13 uses condensate (from condenser 24) which has already passed through the first stage of feed water heating as represented by the feed water heater 25. That is, the first cooler for the ventilating medium acts as the last heater for the feed water returning to the boiler 20 through a conduit 26. Cooler 22, which is the heat exchanger for the second stage of ventilating medium cooling, uses condensate direct from the condenser 24 before it enters the feed water heater 25. Cooler 23, which forms the last stage of ventilating medium cooling before expansion in the auxiliary turbine, uses circulating water which may come from a city main through the conduit 27 and be discharged as to a sewer through a conduit 28.

In operation the cooling gas after having ventilated the generator passes to the inlet of the compressor in which it is compressed adiabatically so that its temperature is raised to a suitable value, and then it passes through the gas coolers in which its heat is transferred to the boiler feed water, although as shown an extra cooler unit may be supplied from a circulating water system to take care of vacuum failures or other factors causing abnormal temperature rise. After leaving the last cooler, the gas passes through the auxiliary turbine 15 in which its pressure and temperature is substantially reduced at the same time that it imparts energy to help drive the compressor. Since the pressure at the outlet of the compressor unit 13 is or may be maintained at atmospheric pressure, the pressure and consequent density of the gas in the generator are considerably less than atmosphere so that the windage loss due to rotation is reduced.

While I have shown the compressor 13, as well as auxiliary turbine 15, directly coupled to the turbine and generator shaft, this is not an essential feature of my invention, and the compressor may be driven by any convenient means.

Inasmuch as part of the energy required for compressing the cooling gas after it leaves the generator is directly recovered in the auxiliary turbine and part is returned to the feed water (the remainder being used in the normal way for forcing the gas through the generator ducting and coolers), it is apparent that a very efficient system is provided so that more power may be generated by the generator and a greater quantity of steam supplied to the turbine. The extra power thus made available compensates in large measure for the extra demand of power required to drive the compressor unit.

There is thus provided a device of the character described capable of meeting the objects hereinabove set forth.

While I have illustrated and described a particular embodiment of my invention, modifications thereof will occur to those skilled in the art and I desire it to be understood, therefore, that my invention is not to be limited to the particular arrangement described and I intend in the appended claims to cover all modifications which do not depart from the spirit and scope of my invention.

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

1. In combination with a steam boiler feeding a main turbine driving an electrical generator, a compressor, means including a pipe for conducting gaseous cooling medium from said generator to said compressor adapted to compress said medium thereby raising its temperature, means including an exhaust to atmosphere for selectively stabilizing said medium exhausted from said compressor at atmospheric pressure, a cooler, means connecting the exhaust of said compressor to said cooler, means adapted to conduct condensate fluid from the exhaust of said main turbine to said cooler and through said cooler to said boiler to cause a heat transfer from said compressed cooling medium to said condensate, an auxiliary turbine mechanically connected to said compressor, means adapted to conduct cooling medium from said cooler to the input of said auxiliary turbine, and means including a pipe for re-introducing said cooling medium into said generator from the exhaust of said auxiliary turbine.

2. A cooling system for ventilating medium of a turbine-driven electric generator comprising a conduit to and a conduit from said generator, a compressor having its intake connected to said conduit from said generator, a series of heat exchangers connected to the output of said compressor, a filtered connection to atmosphere interposed between the output of said compressor and the input to said heat exchangers for estab-

lishing atmospheric pressure in that portion of said system, an auxiliary turbine having its intake connected to the output from said heat exchangers and its exhaust connected to said conduit to said generator, means including a mechanical connection with said auxiliary turbine for driving said compressor, a main turbine for driving said generator, a boiler for supplying steam to said main turbine, and means including pipes for directing condensate from said main turbine through at least one of said heat exchangers to said boiler, whereby the heat energy of said ventilating medium may be recovered in part in raising the boiler feed water temperature and in part in mechanical power developed in said auxiliary turbine used to supply part of the power required to drive said compressor.

3. A cooling system for ventilating medium of a turbine-driven electric generator comprising a conduit to and a conduit from said generator, a compressor having its intake connected to said conduit from said generator, a series of heat exchangers connected to the output of said compressor, a filtered connection to atmosphere interposed between the output of said compressor and the input to said heat exchangers for establishing atmospheric pressure in that portion of said system, an auxiliary turbine having its intake connected to the output from said heat exchangers and its exhaust connected to said conduit to said generator, means including a mechanical connection with said auxiliary turbine for driving said compressor, a main turbine for driving said generator, a boiler for supplying steam to said main turbine, and means including pipes for directing condensate from said main turbine through a plurality of said heat exchangers to said boiler, with the first of said plurality with respect to the passage of ventilating medium therethrough constituting the last of said plurality with respect to the passage of condensate therethrough, whereby the heat energy of said ventilating medium may be recovered in part in raising the boiler feed water temperature and in part in mechanical power developed in said auxiliary turbine used to supply part of the power required to drive said compressor.

KENNETH R. HOPKIRK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
798,156	Bidwell	Aug. 29, 1905
1,440,000	Bonine	Dec. 26, 1922
1,741,605	Baumann	Dec. 31, 1929
1,906,370	Darrow	May 2, 1933
1,938,077	Lysholm	Dec. 5, 1933