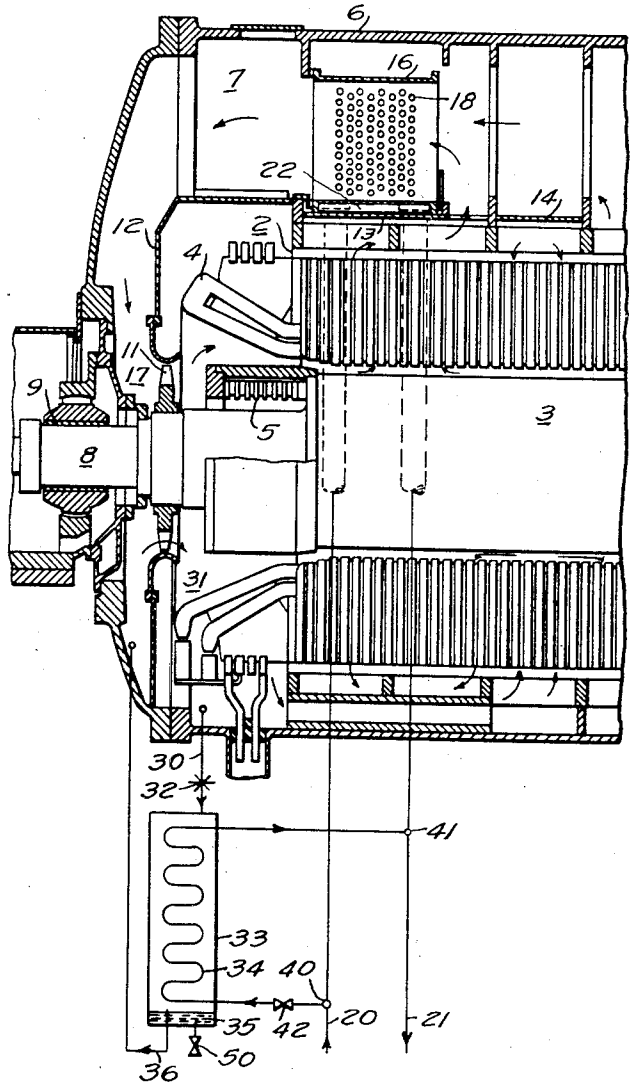
March 20, 1945. C. C. STERRETT 2,372,135

DRIER FOR GAS-COOLING SYSTEMS

Filed Oct. 30, 1942



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Patented Mar. 20, 1945 2,372,135

UNITED STATES PATENT OFFICE

2,372,135

DRIER FOR GAS-COOLING SYSTEMS

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Application October 30, 1942, Serial No. 463,987

4 Claims. (Cl. 171—252)

My invention relates to novel means for preventing unwanted condensation of moisture in a recirculating gas-system having cooling-means therein, and it has particular relation to the cooling of turbo-generators, or other electrical energy-translating devices, having insulated electric windings which are susceptible to damage upon long-continued exposure to moisture.

Heretofore, gas-cooled turbine-generators, and other electric machines, have been cooled by being enclosed in a substantially gas-tight housing, with means for recirculating the gas contained within the housing, and causing the recirculated gas to pass over cooling tubes or coils in which a cooling liquid is circulated. The recirculated gas may be hydrogen, or carbon dioxide, or air, or any other gaseous medium. The gas, when first introduced into the generator-housing, may have a certain moisture-content, or humidity, or degree of saturation as to moisture-content, and whether it originally had this moisture-content or not, the ventilating-system is subject to leakage, not only at the shaft-seals, but also at other points, so that moisture-laden air is apt to infiltrate into the closed gaseous system within the housing during the operation of the machine. Since the cooling coils reduce the temperature of this moisture-laden gas in the machine, a point will obviously be reached at which the moisture-content at the reduced temperature will exceed the saturation-point of the gas at said temperature, causing precipitation or condensation of moisture, resulting in the formation of water which may either flow onto the windings, or be carried onto the windings by the high velocity of the moving gas, resulting ultimately in damage to the electrical insulation which protects the winding.

Heretofore, it has been customary to equip such machines with a gas-drier, and a common form of such a drier has been a chamber filled with activated alumina, which was connected in an auxiliary recirculating path, usually connected across the generator-fan, so that gas was normally circulated through the drier whenever the machine was running. This type of drier had the disadvantage, however, not only of being somewhat costly, but also requiring quite considerable supervision, and rather frequent periods of shut-down, during which the drier had to be disconnected from service, and put through a special heating-process for re-activating the alumina, requiring hours of time and attention on the part of the station-attendant.

The principal object of my present invention is to provide a gas-drier for the above-mentioned service, which is continuous in its operation, inexpensive in its first installation-cost and in its maintenance, and operable without any supervision, either without any supervision at all, or without any supervision over and above that which prudence dictates should be given to the gas-cooled generator, regardless the nature of the drier.

With the foregoing and other objects in view, my invention consists in the apparatus, parts, combinations, systems and methods hereinafter described and claimed, and illustrated in the accompanying drawing, the single figure of which is a somewhat diagrammatic longitudinal sectional view illustrating the principles of embodiment of my invention in a preferred form of embodiment.

I have illustrated my invention in connection with a hydrogen-cooled turbine-generator, only the collector-end half of which is illustrated, it being understood that the turbine-end is, or may be, essentially similar, so far as the essential features of my present invention are concerned. The generator is provided with a stator 2 and a rotor 3, having insulated electrical windings 4 and 5, respectively, which are liable to damage if long subjected to an excessive amount of moisture. The entire generator is enclosed in a substantially gas-tight housing 6, which is filled with a gaseous medium 7 which may be hydrogen, carbon dioxide, air, or other gaseous medium, although the particular machine which was shown was intended to be utilized with hydrogen as the cooling gas, and with carbon-dioxide as the scavenging gas for displacing the air before admitting the hydrogen. The rotor 3 is provided with a shaft 8 which is journaled in bearings 9 which are subject to small continual infiltrations of moisture-laden air from outside of the machine.

The hydrogen 7, which fills the chamber provided by the housing 6, is recirculated by means of a fan 11 which is carried by the shaft 8 at each end of the rotor 3, and a system of baffles 12, 13, 14 and the like are provided for directing the hydrogen into and over the stator 2 and rotor 3, and the windings 4 and 5 carried thereby, in any known or desired manner, for the purpose of cooling the same. After passing through or over the electrical parts of the machine, the hydrogen is then caused to flow through or over a cooler 16, and hence back to the low-pressure side 17 of the fan 11, some of the gas-flow paths being indicated by the arrows.

The cooler 16 is the main cooler of the machine,

and is of considerable size, usually two coolers being provided, one at each end of the machine, or else a plurality of coolers are provided, extending longitudinally of the machine. These coolers 16 consist of pipes or coils 18, through which water is circulated, the water being admitted through an intake-pipe 20, and discharged through an outlet-pipe 21.

As previously explained, and as is well known, unless the moisture-content of the recirculated gas is reduced by artificial means, the gas is likely to be chilled below its dew point, in passing through the cooler 16, so that water has to be collected in a tray 22 underneath the cooler, and it sometimes may overflow into other parts of the machine, besides being mechanically entrained and carried along, in the form of liquid droplets, by reason of the high velocity of movement of the recirculating gas which is utilized to cool the machine.

My invention relates to a special means for drying the recirculated cooling-gas 7, so that it will not give up any substantial amount of water, or any water at all, in passing through the main cooler 16, or in passing over, or in heat-exchanging relation to, the cooling-coils 18, which constitute the cooler-proper. My invention is based upon the discovery that the temperature-gradient which necessarily exists between the water in the cooling-coils 18 and the recirculated gas which passes thereover is sufficient to provide a practically-operating means whereby the gas can be prevented from reaching its saturation-point, or dew point, in passing over or through this main cooler 16—18. In practical machines, this temperature-gradient is of the order of 7° F.

In accordance with my invention, I draw off a small percentage of the recirculated gas, as by means of a pipe 30, which is connected on the high-pressure side 31 of the fan 11, and I supply this relatively small percentage of the recirculated gas, through a gas-flow control-orifice 32, to an auxiliary cooler 33, which contains water-circulating cooling-coils 34, and which has a water-sump or reservoir 35 in which water or other condensate may be collected. This auxiliary cooler 33 is in an auxiliary recirculated-gas path which is completed by means of an outlet gas-pipe 36, extending from above the water-sump 35 in the cooler 33, to a point on the low-pressure side 17 of the fan 11 within the generator-housing 6. The cooling-coils 34 in the auxiliary cooler 33 are cooled with water which is obtained from the same water-supply system 20—21 as the main coolers 16, as by means of the pipe-connections 40 and 41, respectively, the rate of water-flow in the auxiliary cooler being controlled by means of a suitable valve 42.

In accordance with my invention, I cause the small amount of gas which circulates in the auxiliary circulating path 30—33—36 to flow at such a restricted velocity, as controlled by the gas-flow control-orifice 32, that only a small temperature-gradient, such as a gradient of, say, 1° F., exists between the gas as it leaves the auxiliary cooler 33 and the inlet-water which enters the water-pipes or coils 34 of the auxiliary cooler. Since the auxiliary cooler is cooled by the same water-supply which is utilized for the main coolers 16, the auxiliary cooler is at least as cool as the main cooler, and since the temperature-gradient between the water and the gas is much lower in the auxiliary cooler, it follows that the portion of the recirculated gas which is passed through the auxiliary cooler 33 is reduced to a lower temperature than is produced at any other point in the entire gas-circulating system.

In the illustrated case, the gas-leaving the auxiliary cooler 33 is 6° cooler than the gas leaving the main cooler 16, which is another way of saying that, when the gas leaves the auxiliary cooler 33, through the pipe 36, and mixes with the low-pressure gas in the space 17 of the main machine, it mixes with a relatively large quantity of gas which is 6° warmer than itself. If the gas is at its saturation-point at its coldest temperature, where any excess water-vapor, over and above the amount which can be carried in vapor form, has been precipitated or condensed out of the gas, in the auxiliary cooler 33, a 6° rise in gas-temperature is enough to produce a relative humidity of about 80% in the gas, which is well below the saturation-point, giving a sufficient margin of safety to assure that objectionable condensation of water-vapor is not obtained in the main portion of the chamber enclosed by the generator-housing 6. This process need not be carried on at a rapid rate, but by continuing slowly and constantly, it holds down the moisture-content of the gas in the generator-chamber, so that its humidity, as it leaves the main cooler 16, is of the order of 80%, or other value which is considerably lower than the saturation-point.

Since only a relatively small quantity of gas is cooled in the auxiliary cooler 33, this cooler may be relatively small in size, so that its cost and space-requirements are insifinigcant, as compared with those of the main cooler 16.

The condensate-receiving sump or reservoir 35 of the auxiliary cooler 33 is provided with a suitable drain-valve 50, which may be of either an automatic type or a manual type. So far, I have preferred to utilize a manually operated drain-valve 50, which is opened once a day, to remove the water which has been condensed during the day, and to serve as a very valuable check in regard to the amount of leakage into the supposedly gas-tight housing 6, because any increase in this leakage will immediately show up in an increased amount of water collected for that day.

From the foregoing description, it will be understood that I have provided a thoroughly reliable means for drying the recirculated gas in an electrical energy-translating device having insulated windings, or, in fact, in any other chamber utilizing a recirculated, conditioned gas. By the simple expedient of reducing the temperature of the gas to the lowest temperature which it will have anywhere in the system, and causing this lowest temperature to occur at a selected point located essentially out of the main portion of the chamber, where the condensed water or condensate from any other vapor will be harmless, I have provided a simple, reliable, and continuously operative means, whereby it is assured that the gas, at every other point in the system, will have a humidity which is safely below the saturation-point. By the expedient of utilizing the same cooling-fluid to cool both of the coolers, coupled with the expedient of causing the gas to flow more slowly past the auxiliary cooler, I have provided a means for automatically insuring that the temperature-gradient between the gas and the cooling-fluid for the coolers is lower, in the auxiliary cooler, than in the main cooler, thus insuring a lower temperature for the gas as it leaves the auxiliary cooler. By withdrawing only a relatively small proportion of the recirculated gas, and passing it, in a slow, steady stream, past

the auxiliary cooler, and keeping up this process continuously, I am enabled to dry or condition all of the gas in the entire gas-system or enclosure, and to maintain it at a substantially uniform, predetermined humidity which is well below the moisture-condensing point, everywhere except at the auxiliary cooler where the condensate is readily and harmlessly collected, and I accomplish this with an auxiliary cooler which is so small that its cost is relatively negligible, and with a gas-velocity in the auxiliary cooler which is so low that the condensed water is not borne back into the main portion of the chamber by the gas-flow.

While I have described my invention, and illustrated it in a single illustrative form of embodiment, with a somewhat simplified and diagrammatic showing, it will be obvious that many minor changes in arrangement and detail may be made, within the skill of those skilled in the art, without departing from the essential spirit of my invention. I desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language.

I claim as my invention:

1. The combination, with a chamber in which a conditioned gaseous medium is to be recirculated; of means for maintaining a main recirculating-gas path for the main portion of the recirculated gas of said chamber; a large-sized main gas-cooler located in heat-exchanging relation with respect to a portion of said main recirculating-gas path; means for maintaining an auxiliary recirculating-gas path for only a small portion of the recirculated gas of said chamber; a small-sized auxiliary gas-cooler located in heat-exchanging relation with respect to a portion of said auxiliary recirculating-gas path at a point essentially out of said main recirculating-gas path; a substantially common cooling-medium for cooling both of said coolers, so that the auxiliary cooler is at least as cool as the main cooler; and means for causing the velocity of the gaseous medium which passes in heat-exchanging relation to the auxiliary cooler to be lower than that which passes in heat-exchanging relation to the main cooler, whereby there is a lower temperature-gradient between the cooled gaseous medium and the cooling medium in the region of the auxiliary cooler than in the region of the main cooler.

2. The combination, with a chamber in which a conditioned gaseous medium is to be recirculated; of main-duct means for providing a main recirculating-gas path for the main portion of the recirculated gas of said chamber; fan-means for maintaining gas-flow in said main-duct path; a large-sized main gas-cooler located in heat-exchanging relation with respect to a portion of said main recirculating-gas path; auxiliary-duct means for withdrawing a relatively small portion of the recirculated gaseous medium from one point in said main recirculating-gas path and returning it at another point at a lower gas-pressure in said main recirculating-gas path, thereby providing an auxiliary recirculating-gas path; a small-sized auxiliary gas-cooler located in heat-exchanging relation with respect to a portion of said auxiliary recirculating-gas path at a point essentially out of said main recirculating-gas path; a substantially common cooling medium for cooling both of said coolers, so that the auxiliary cooler is at least as cool as the main cooler; and means for causing the velocity of the gaseous medium which passes in heat-exchanging relation to the auxiliary cooler to be lower than that which passes in heat-exchanging relation to the main cooler, whereby the recirculated gaseous medium reaches its lowest temperature, of anywhere in the entire system, in the vicinity of said auxiliary cooler, said lowest temperature being above the freezing-point of the principal condensed vapor obtained from said recirculating gaseous medium; a condensate-receiving receptacle in said auxiliary recirculating-gas path for receiving the condensate produced by said auxiliary cooler; and draining-means for said receptacle.

3. A cooled electrical energy-translating device having insulated electric windings susceptible to damage upon long-continued exposure to moisture, an approximately gas-tight housing for said energy-translating device, a filling of a gaseous medium in said housing under conditions in which said gaseous medium may carry water-vapor in suspension therein, main-duct means for providing a main recirculating-gas path for the main portion of the gaseous medium within said housing, fan-means within said housing for mantaining a continuous recirculation of said gaseous medium around said main recirculating-gas path while said electrical energy-translating device is in operation, a main gas-cooler located in heat-exchanging relation with respect to a portion of said main recirculating-gas path within said housing in a place where moisture-condensation from said recirculated gaseous medium is undesirable, auxiliary-duct means for withdrawing a relatively small portion of the recirculated gaseous medium from said main recirculating-gas path and returning it to said main recirculating-gas path, thereby providing an auxiliary recirculating-gas path, and a gas-drying means in said auxiliary recirculating-gas path at a point essentially out of the main portion of said housing, said gas-drying means comprising a relatively small-sized auxiliary gas-cooler located in heat-exchanging relation with respect to a portion of said auxiliary recirculating-gas path, a substantially common cooling-medium for cooling both of said coolers, so that the auxiliary cooler is at least as cool as the main cooler, and means for causing the velocity of the gaseous medium which passes in heat-exchanging relation to the auxiliary cooler to be lower than that which passes in heat-exchanging relation to the main cooler, whereby there is a lower temperature-gradient between the cooled gaseous medium and the cooling medium in the region of the auxiliary cooler than in the region of the main cooler.

4. A cooled electrical energy-translating device having insulated electric windings susceptible to damage upon long-continued exposure to moisture, an approximately gas-tight housing for said energy-translating device, a filling of a gaseous medium in said housing under conditions in which said gaseous medium may carry water-vapor in suspension therein, main-duct means for providing a main recirculating-gas path for the main portion of the gaseous medium within said housing, fan-means within said housing for maintaing a continuous recirculation of said gaseous medium around said main recirculating-gas path while said electrical energy-translating device is in operation, a main gas-cooler located in heat-exchanging relation with respect to a portion of said main recirculating-gas path within said housing in a place where moisture-condensation from said recirculated gaseous medium is undesirable, auxiliary-duct means for withdrawing

a relatively small portion of the recirculated gaseous medium from a point on the high-pressure side of the fan-means in said main recirculating-gas path and returning it at a point on the low-pressure side of the fan-means in said main recirculating-gas path, thereby providing an auxiliary recirculating-gas path, a relatively small-sized auxiliary gas-cooler located in heat-exchanging relation with respect to a portion of said auxiliary recirculating-gas path at a point essentially out of the main portion of said housing, a substantially common cooling-medium for cooling both of said coolers, so that the auxiliary cooler is at least as cool as the main cooler, means for causing the velocity of the gaseous medium which passes in heat-exchanging relation to the auxiliary cooler to be lower than that which passes in heat-exchanging relation to the main cooler, whereby the recirculated gaseous medium reaches its lowest temperature, of anywhere in the entire system, in the vicinity of said auxiliary cooler, said lowest temperature being above the freezing-point of the condensed water obtained from said recirculating gaseous medium, a condensate-receiving receptacle in a recirculating-gas path for receiving the condensate produced by said auxiliary cooler, and draining-means for said receptacle.

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