May 19, 1959 E. WIEDEMANN 2,887,593

TURBO-GENERATOR WITH GAS COOLING IN CLOSED CYCLE

Filed Sept. 13, 1956

Fig. 1.

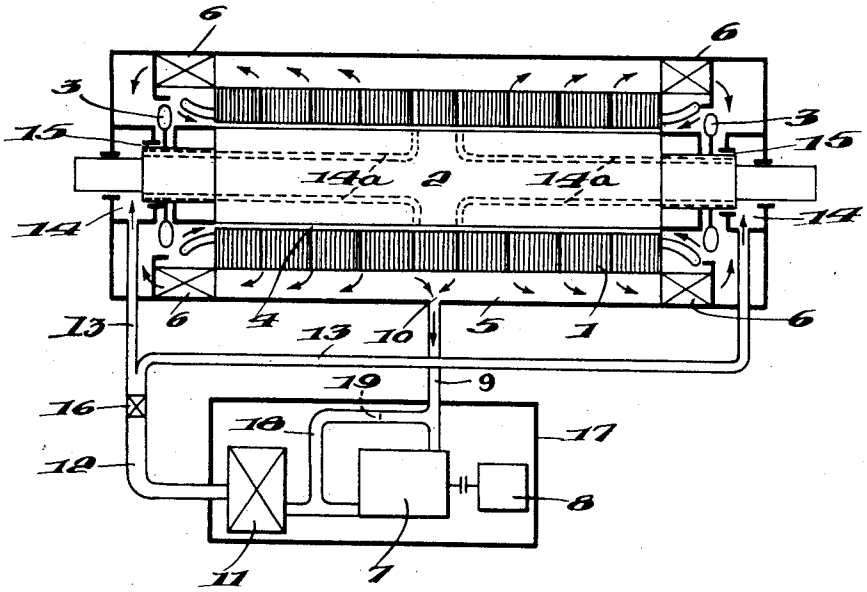
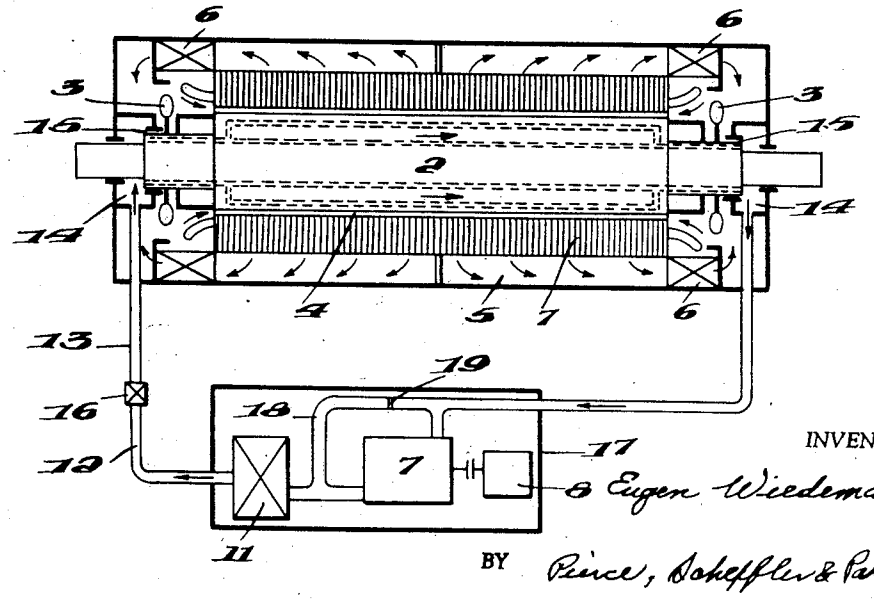


Fig. 2.



INVENTOR

Eugen Wiedemann,

BY Pierce, Scheffler & Parker

his ATTORNEYS

United States Patent Office 2,887,593 Patented May 19, 1959

2,887,593

TURBO-GENERATOR WITH GAS COOLING IN CLOSED CYCLE

Eügen Wiedemann, Hasel, Spreitenbach, Switzerland, assignor to Aktiengesellschaft Brown, Boveri & Cie, Baden, Switzerland, a joint-stock company

Application September 13, 1956, Serial No. 609,693

Claims priority, application Germany September 21, 1955

5 Claims. (Cl. 310—58)

This invention relates to gas-cooled turbo-generators.

Turbo-generators with gas cooling in closed cycle conventionally are provided with gas currents for the cooling of the rotor and of the stator, which gas currents are forced at various speeds through the turbo-generator in order to provide for a higher velocity of flow of the cooling gas for the cooling of the rotor than that required for the stator. There are also known installations wherein both of these gas currents are produced by a common ventilator or compressor, mounted on the generator shaft; as well as those wherein, for production of both gas currents, there are provided one or more special ventilators on the generator shaft.

In all of these installations it is, in general, necessary to use multiple-stage fans or compressors for production of high velocity of cooling gas flow. These installations are attended with the disadvantage that they enlarge the total length of the apparatus, particularly if hydrogen is used as cooling gas, since due to its slight specific weight a comparatively large number of compressor stages is required to achieve an adequate pressure.

According to the present invention, this disadvantage is eliminated in that in turbo-generators with gas cooling in closed cycle and separate gas circulating devices for the stator and rotor cooling, there is provided a gas circulating apparatus for the cooling gas flow through the rotor, disposed outside of the turbo-generator. For re-cooling of the gas flow actuated by the gas circulating apparatus there is provided a special cooler which is, suitably, disposed outside of the turbo-generator. In the latter installation, the coolers provided in known way inside the turbo-generator can be dimensioned comparatively small since, in principle, they should need to lead away only the heat losses of the stator.

It is, of course, desirable to maintain turbo-generators —in particular those of large dimensions—at constant temperature, independently of the load thereon, in order to avoid as much as possible relative shifting between copper conductor and iron due to the different expansions of both substances. Here it also is necessary to adapt the velocity of flow of the cooling gas in the rotor to the respective current load of the rotor. This possibility is not offered by the above-mentioned known installations; however, it can be achieved in a simple way in my novel installation of a special cooling gas circulating apparatus disposed outside of the generator, whereof the gas flow actuated thereby is made regulatable.

In the following the invention will be explained in detail by way of an illustrative example, and with reference to the appended drawing, wherein:

Fig. 1 diagrammatically represents a practical embodiment of a turbo-generator-cooling system, illustrative of principles of the invention; and

Fig. 2 diagrammatically represents another embodiment of the invention.

In the drawing, a stator of a turbo-generator is designated at **1**, while the rotor of said generator is indicated at **2**. For the cooling of the stator, fans **3**, **3**, are provided at both ends of the rotor shaft, which fans produce in known way currents of cooling gas flowing through the air gap **4** of the engine and through radial slots in the stator, and finally through the space between stator and casing **5**; said gas currents are cooled in coolers **6** adjacent the ends of stator **1**. For the actuation of the gas flow cooling principally the rotor, there is provided a cooling gas circulating apparatus **7** which may, in particular, include a compressor of arbitrary construction, driven by a motor **8**, or, under certain circumstances, also by direct or indirect coupling with the generator shaft. Gas is drawn off from the apparatus by a pipe line **9** through one or more apertures **10** in the casing **5**, preferably approximately in the center of the latter, and is forced through the cooler **11** after an increase in pressure in the gas circulating apparatus **7**, effecting the required velocity of cooling gas flow. Said gas arrives from the gas circulating-cooling assembly through the pipe lines **12**, **13** into annular spaces **14**, **14** around the shaft, disposed at both ends of the rotor shaft, wherefrom it flows through axial ducts **14*a***, **14*a*** in the rotor **2** to the apertures of these ducts communicating with the air gap **4** to reach the suction apertures **10** through radial cooling slots in the stator.

The annular spaces **14**, **14** are sealed against the remaining internal space of the turbo-generator by labyrinth packings **15**, **15** so that the cooling gas current provided for the cooling of the rotor can be mixed with the remaining gas, present in the internal space only when the same has passed through the rotor.

In order to be able to modify the velocity at which this cooling gas current passes through the rotor, independently of the velocity of the gas circulation, an adjustable choking device **16** is provided in the pipe line **12**. Instead of changing the velocity of flow of this gas stream by a choking device, the same result can also be effected by a modification of the speed of the cooling gas circulating apparatus or of the engine driving the latter. It is possible to apply both means simultaneously.

If the cooling gas, preferably hydrogen, in the generator is subjected to a comparatively high pressure, for example 3 atm., the gas circulating apparatus needs to produce only a comparatively small increase in pressure, for example an increase in pressure from 3 to 3.1 atm., in order to provide the required velocity of flow in the rotor.

In order to apply the shaft packings of the cooling gas circulating apparatus only for this difference in pressure it is possible, according to a further construction of the invention, to enclose the cooling gas circulating apparatus together with its driving means in a gas-tight casing **17** wherein preferably almost the same pressure prevails as in the generator casing, so that leakage losses of the compressor or its shaft packings can practically be eliminated. To avoid leakage losses in the cooler, this latter can also be, and preferably is, enclosed in the gas-tight casing **17**.

According to an additional construction of the invention, the suction side and the pressure side of the gas circulating apparatus can be combined by way of a bypass line **18** provided with a latchable damper means **19** which is locked in the normal operation and opens automatically when the feed pressure ceases, e.g., when the cooling gas circulating apparatus is out of operation. In this way a certain flow is still maintained, if the gas circulating apparatus is out of service, by means of the inherent pressure of the rotor through the open damper means **19** and the rotor ducts.

Independently thereof, an additional connection between the suction side and the pressure side of the gas circulating apparatus can be provided by means of a high-pressure relief valve to prevent undesirably high

values of the pressure on the pressure side of the gas circulating apparatus when the gas flow is choked by the throttle device **16**.

The actuation of the throttle device **16** and/or of the shifting device for the speed of the cooling gas circulating apparatus can be regulated—according to a further development of the invention—by appropriate regulating devices of known type in inter-relation to a magnitude effected by the load of the generator. The load current or the exciting current of the generator or the temperature of the rotor can, for example, be used as such a magnitude.

The invention is not limited to the specific embodiment depicted. There are, e.g., feasible modifications in the sequence of gas circulator **7**—cooler **11**—and throttle device **16**. Under some circumstances, it may be expedient to dispose the cooler for the rotor losses on or in the generator.

In the constructional example described above and illustrated in the drawing an arrangement is shown wherein the cooling system for the rotor is not completely separate from the cooling system for the stator in that the two systems join in the middle of the machine. It is to be understood, however, that the present invention is not restricted to such intermingling of the two cooling gas streams but rather that the invention includes the embodiment according to which both cooling systems are completely separate. In the case of completely separate cooling systems for the rotor and stator, the stator system is separated from the rotor system and the cooling gas for the rotor enters at one end of the rotor and passes through the axial rotor ducts to the other end of the rotor, without there being any communication in the centre of the machine between the rotor and stator cooling systems. An example of such separate cooling systems is shown in Fig. 2 where the same elements as in Fig. 1 are designated by the same numbers.

I claim:

1. In a turbo-generator having a casing, a stator within and spaced from said casing, and a rotor rotatably mounted within said stator by a rotor shaft; a common gas cooling system for cooling said rotor and stator comprising a cooling gas circulating apparatus positioned outside said turbo-generator casing, said circulating apparatus having a pressure outlet and a suction inlet, said stator having a plurality of radial cooling slots therein longitudinally spaced along the length thereof, said rotor having at each end cooling ducts extending axially through the rotor toward the center thereof and opening radially outwardly at the central portion of said rotor, said casing having annular chambers at each end of the rotor in communication with the rotor axial ducts, first conduit means connecting the pressure outlet of said cooling gas circulating apparatus with said annular chambers and second conduit means connecting the suction inlet of said circulating apparatus with an opening in the central portion of said casing opposite the central radial openings in said rotor whereby cooling gas is circulated from said circulating apparatus outlet to the annular chambers, through the axial cooling ducts in said rotor and radially outwardly from the central portion thereof through at least some of the stator radial cooling slots for return to said gas circulating apparatus through said second conduit means, and fan means mounted at each end of the rotor shaft within said casing for circulating a portion of the cooling gas from the central portion of the space intermediate the stator and the casing adjacent the casing outlet in separate streams toward the ends of the stator, through the air gap between the rotor and the stator, and radially outwardly through the radial cooling slots in the stator.

2. Apparatus as defined in claim 1 and further including means for regulating the cooling gas flow produced by said cooling gas circulating apparatus.

3. Apparatus as defined in claim 2 wherein said cooling gas is enclosed in a gas-tight casing and includes a gas cooling device and a driving motor.

4. Apparatus as defined in claim 1 and further including auxiliary cooling means in said turbo-generator casing for cooling the portion of the gas recirculated by the fan means.

5. Apparatus as defined in claim 1 wherein the ends of the rotor shaft are journalled in the casing annular chambers and further including labyrinth packing means cooperating with the rotor shaft ends for sealing the spaces within the annular chambers from the interior of the turbo-generator casing.

References Cited in the file of this patent

UNITED STATES PATENTS

1,030,556	Williamson	June 25, 1912
1,522,333	Schroeder	Jan. 6, 1925
1,816,489	Kuyser	July 28, 1931
2,451,219	Holmgren	Oct. 12, 1948
2,663,808	Rosenberg	Dec. 22, 1953
2,707,244	Kilgore	Apr. 26, 1955

FOREIGN PATENTS

896,086	Germany	Nov. 9, 1953