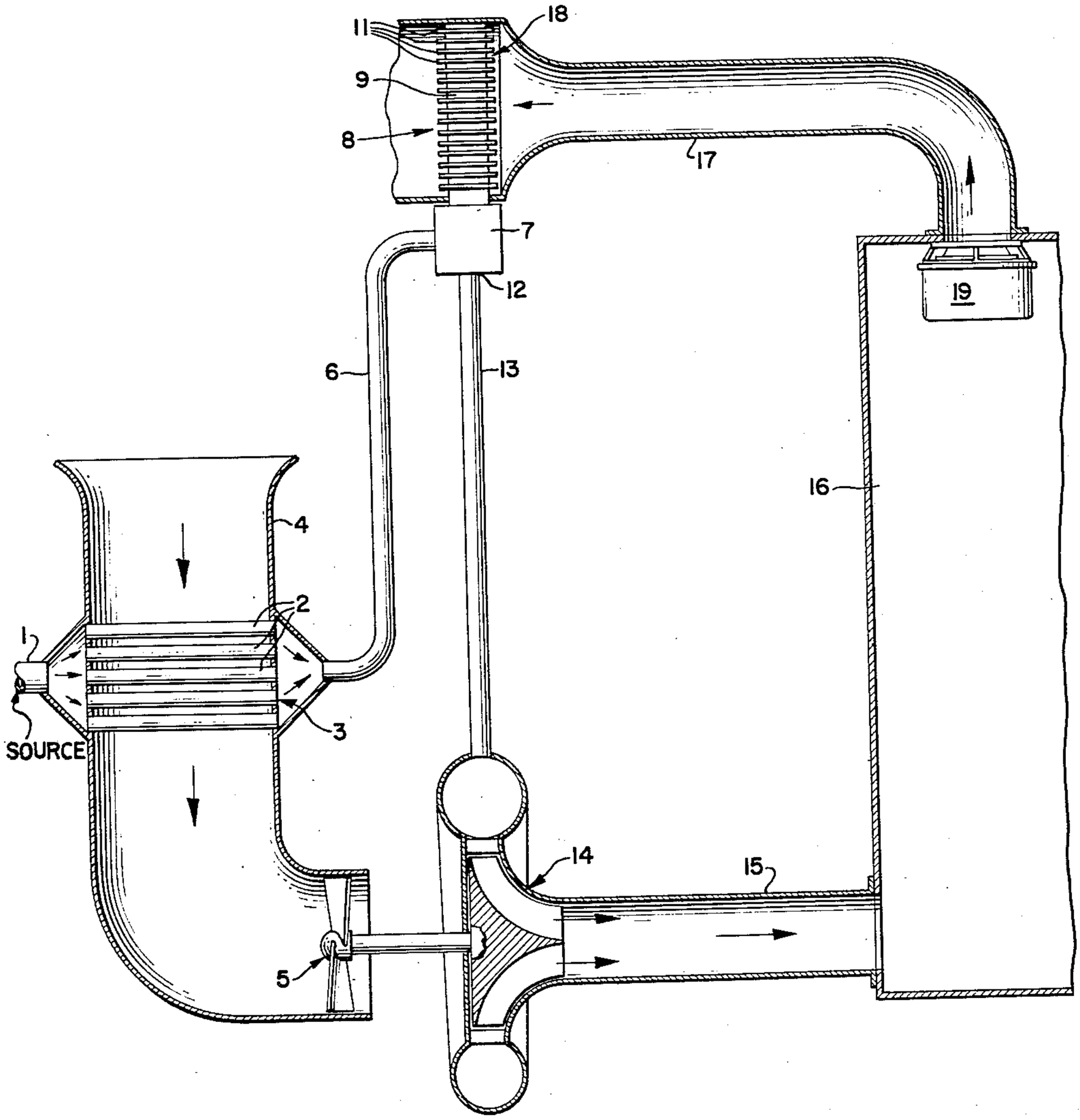
Sept. 20, 1960 J. L. BARTLETT, JR 2,952,981

REGENERATIVE AIR CYCLE REFRIGERATION

Filed May 25, 1959



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United States Patent Office

2,952,981

Patented Sept. 20, 1960

2,952,981

REGENERATIVE AIR CYCLE REFRIGERATION

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Filed May 25, 1959, Ser. No. 815,425

6 Claims. (Cl. 62—5)

This invention relates to a regenerative air cycle refrigeration system utilizing a vortex tube as one stage of the system and employing as coolant for the hot tube of the vortex tube, the exhaust air from an enclosure being cooled.

In the operation of the system according to this invention, the heated and pressurized air from the pressure source is first cooled in a heat exchanger in which the cooling air is passed therethrough by the action of a fan or similar compression means driven by an expansion turbine. From the first heat exchanger, the compressed air is fed into a vortex tube having a cold outlet from whence the compressed air passes into an expansion turbine which drives the fan for the cooling air of the first heat exchange stage. The cooled air exhausting from the expansion turbine is fed into an enclosure or chamber which is maintained also at an over-pressure which may be determined by the setting of an exhaust valve. This still relatively cool air exhausting from the enclosure is passed in heat exchange relation with the hot tube of the vortex tube and thence to exhaust. It is contemplated that within the scope of the invention, gases other than air may be employed in the system and in such case, the gas after performing its cooling function at the vortex tube, will be fed to the entrance port of the compressor source, so that a closed system will result with no loss of the operating gas.

It is therefore an object of the invention to provide an expansion cooling system utilizing a vortex tube as a stage of the system in which air or gas exhausting from a cooled enclosure is passed over the hot tube portion of the vortex tube in heat exchange relation to effect cooling of the hot gases therein.

Another object of the invention is to provide an expansion cooling system in accordance with the preceding object in which the heated and compressed air fed to the vortex tube inlet is first cooled in a heat exchanger stage; and

It is a further object of the invention to provide an expansion cooling system in accordance with the preceding objects with the first heat exchanger stage cooled by a fluid whose flow is induced by a fan or other compressor driven by an expansion turbine forming a third stage of the system and fed from the cold outlet of the vortex tube.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawing illustrating certain preferred embodiments in which:

The figure represents the duct from the compressor source at **1** with the compressed heated gas fed through heat exchange tubes **2** of a heat exchanger indicated generally at **3** and having a cooling duct **4** in which the tubes **2** are disposed and also having therein a fan **5** which induces flow of ambient air or other fluid coolant through the cooling duct of the heat exchanger. The exit of the heat exchanger is connected by a duct **6** to the inlet

chamber **7** of a vortex tube **8** having a hot tube portion **9** provided with cooling fins **11**. The vortex tube **8** has a cold outlet **12** connected by duct **13** to an expansion turbine **14** which is mechanically coupled to drive the fan **5**. The exhaust from the turbine **14** is connected through a duct **15** to an enclosure **16** whose interior is to be cooled and in which an over-pressure is to be established. Exhaust from the chamber **16** is passed through a duct **17** to a heat exchanger **18** in which is disposed the hot tube portion **9** of the vortex tube **8**. Flow of air or gas from the interior of the enclosure **16** through the duct **17** is controlled by means of a regulating valve **19** which may be made responsive to either or both the pressure and temperature within the chamber **16**, so as to effect the regulation thereof by varying the exhaust in accordance with requirements and the quantity, temperature, and pressure of the air or gas fed into the enclosure **16** through the duct **15**.

It is thus seen that flow of exhaust air or gas from the enclosure **16** will vary in quantity with the pressure and temperature of the air supplied from the source compressor, while the quantity and temperature of the air within the hot tube portion **9** of the vortex tube **8** will likewise vary with the pressure and temperature of the source air, so that the amount of cooling effected in the heat exchanger **18** will thus vary with the heat load requirements. Thus, not only is utilization made of the still cool exhaust air or gas from the chamber **16** to effect a regenerative heat exchange stage in the vortex tube, but also this coolant effect automatically increases and decreases with increase and decrease in the heat dissipation requirements of the hot tube portion **9** of the vortex tube **8** so that the system operates with desirable economy and efficiency.

The terms air and gas have been used herein interchangeably and when used in this specification and when used in the following claims, the terms are intended to be synonymous and to include not only air or gas, but also any combination of gases which it may be desirable to use in the system.

While a preferred embodiment of the invention has been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation consistent with the prior art.

What is claimed is:

1. An expansion cooling system for cooling an enclosure comprising a source of pressurized gas, a vortex tube for cooling said gas having an inlet, a hot tube and a cold outlet, means connecting said source to the inlet of said vortex tube, expansion means for further cooling said gas, means connecting the cold outlet of the vortex tube to the inlet of said expansion means, means connecting the outlet of said expansion means to said enclosure, an outlet for said enclosure, and means for passing the gas exhausting through said enclosure outlet into heat exchange relation with the hot tube of the vortex tube.

2. An expansion cooling system for cooling an enclosure comprising a source of pressurized gas, a vortex tube for cooling said gas having an inlet, a hot tube and a cold outlet, means connecting said source to the inlet of the vortex tube, an expansion turbine for further cooling said gas, means loading said expansion turbine, means connecting the cold outlet of said vortex tube to the inlet of the expansion turbine, means connecting the outlet of the expansion turbine to the enclosure, an outlet for said enclosure, and means for passing the gas exhausting through said enclosure outlet into heat exchange relation with the hot tube of the vortex tube.

3. An expansion cooling system for cooling an en-

closure comprising a source of pressurized gas, a first heat exchanger for lowering the temperature of said gas, means for inducing flow of coolant through said heat exchanger, a vortex tube having an inlet, a hot tube and a cold outlet, means connecting the outlet of said heat exchanger to the inlet of the vortex tube, expansion means for further cooling said gas, means connecting the cold outlet of the vortex tube to the inlet of the expansion means, means connecting the outlet of the expansion means to the enclosure, an outlet from said enclosure, and means for passing gas exhausting through said enclosure outlet into heat exchange relation with the hot tube of the vortex tube.

4. An expansion cooling system for cooling an enclosure comprising a source of pressurized gas, a first heat exchanger for lowering the temperature of said gas, means for inducing flow of coolant through said heat exchanger, a vortex tube having an inlet, a hot tube and a cold outlet, means connecting the outlet of said heat exchanger to the inlet of the vortex tube, expansion means for further cooling said gas, means connecting the cold outlet of said vortex tube to the inlet of said expansion means, means connecting the outlet of the expansion means to the enclosure, a regulating outlet valve for said enclosure, and means for passing gas exhausting through said outlet valve into heat exchange relation with the hot tube of the vortex tube.

5. An expansion cooling system for cooling an enclosure comprising a source of pressurized gas, a first heat exchanger for lowering the temperature of said gas, means for inducing flow of coolant through said heat

exchanger, a vortex tube having an inlet, a hot tube and a cold outlet, means connecting the outlet of said heat exchanger to the inlet of the vortex tube, an expansion turbine driving said coolant flow inducing means, means connecting the cold outlet of said vortex tube to the inlet of the expansion turbine, means connecting the outlet of the expansion turbine to the enclosure, a regulating outlet valve for said enclosure responsive to the value of pressure therein, and means for passing the gas exhausting through said outlet valve into heat exchange relation with the hot tube of the vortex tube.

6. An expansion cooling system for cooling an enclosure comprising a source of pressurized gas, a first heat exchanger for lowering the temperature of said gas, means for inducing flow of coolant through said heat exchanger, a vortex tube having an inlet, a hot tube and a cold outlet, means connecting the outlet of said heat exchanger to the inlet of the vortex tube, an expansion turbine driving said coolant flow inducing means, means connecting the cold outlet of said vortex tube to the inlet of the expansion turbine, means connecting the outlet of the expansion turbine to the enclosure, a regulating outlet valve for said enclosure responsive to the value of temperature therein, and means for passing the gas exhausting through said outlet valve into heat exchange relation with the hot tube of the vortex tube.

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