

June 12, 1962

J. HÄNNY
EXPANSION TURBINE AND TURBOCOMPRESSOR CONNECTED
THEREWITH IN A COLD PRODUCING PLANT
Filed June 2, 1958

3,038,318

Fig. 1.

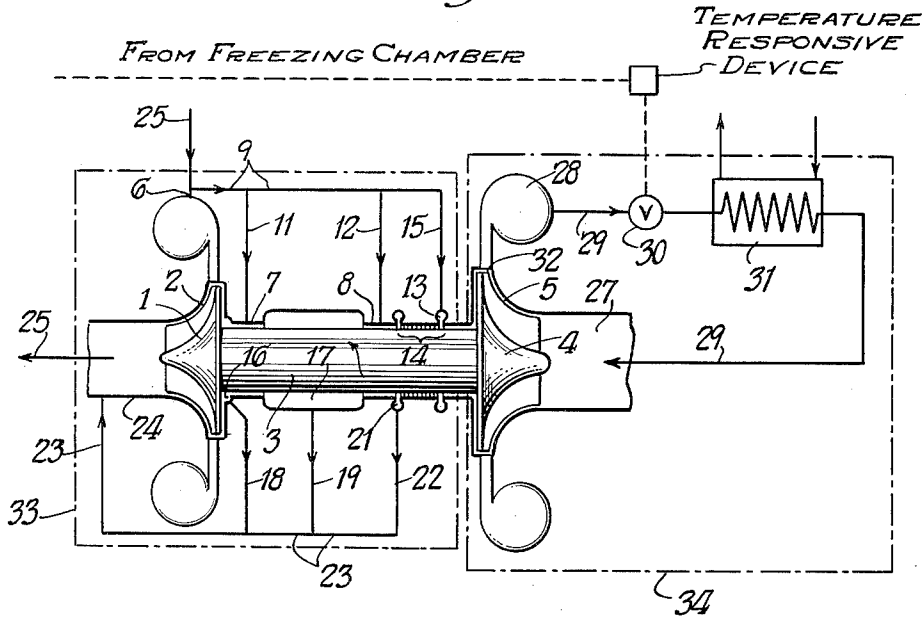
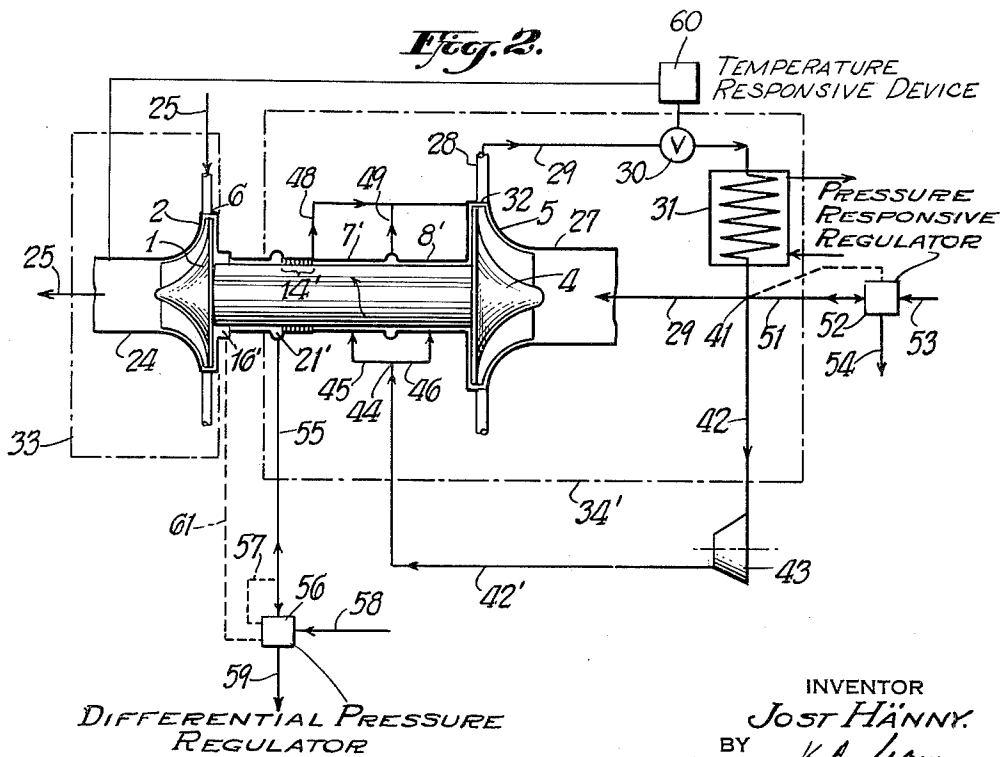


Fig. 2.



INVENTOR
JOST HÄNNY
BY
K. A. Mayr
ATTORNEY

1

3,038,318

**EXPANSION TURBINE AND TURBOCOMPRESSOR
CONNECTED THEREWITH IN A COLD PRODUC-
ING PLANT**

Jost Hänni, Winterthur, Switzerland, assignor to Sulzer
Freres, S.A., Winterthur, Switzerland, a corporation
of Switzerland

Filed June 2, 1958, Ser. No. 739,385

Claims priority, application Switzerland June 7, 1957
6 Claims. (Cl. 62—192)

The present invention relates to the arrangement of an expansion turbine for cooling a gaseous fluid in a refrigerating plant and of a compressor driven by the turbine.

In conventional arrangements of a turbine driving a compressor, for example, in a plant as shown in Patent No. 2,721,456, the compressor draws air from the atmosphere which is eventually returned to the atmosphere.

In the system according to the invention the compressor is interposed in a closed circuit which also contains a cooler and a throttling device arranged in series with the cooler. This closed circuit is separate from and provided in addition to the cycle of which the turbine forms a part and the compressor serves exclusively as a brake for controlling the speed, the expansion in, and the cooling effect of the turbine. In the system according to the invention the compressor circuit can be operated under superpressure, i.e., in supercharged condition so that more gas can pass through the compressor than in the conventional arrangements. The work of the compressor is therefore greater. If the pressure of the compressor circuit is substantially the same as the pressure within the turbine, the interiors of the turbine and of the compressor can be separated by a simple seal, for example, a labyrinth packing.

In a preferred embodiment of the invention the gas flowing through the turbine is chemically the same as the gas flowing in the compressor circuit. In this case gas, for example, a refrigerating agent which may leak from the compressor circuit into the turbine cannot do any harm in the turbine circuit. The pressure in the compressor circuit will automatically be the same as the pressure in the turbine circuit, if sufficient connections are provided and unless special provisions are made to separate the two circuits.

In an embodiment of the invention a bearing for a shaft which is common to the turbine rotor and to the compressor rotor is lubricated by gas from the compressor circuit which gas is returned to the compressor circuit after passing through the bearing. The rotor shaft is preferably surrounded by an annular chamber between the bearing and a labyrinth packing and by an annular chamber between the turbine and the labyrinth packing, a pressure equalizing channel being connected with one of the chambers for supplying and withdrawing the gas to and from the chamber. In this way the pressure in the annular chamber can be made equal to the pressure prevailing in the turbine by admitting or relieving gas depending whether the pressure in the turbine is lower or higher than that in the annular chamber. Flow of gas from the compressor circuit to the turbine circuit can, in any case, be prevented so that the compressor circuit may be operated at a normal temperature of, for example, approximately +20° C. whereas the temperature in the turbine may be approximately -90° C.

The pressure equalizing channel is preferably provided with a conventional automatic control apparatus which is responsive to the difference of the pressures in the interior of the turbine and in the annular chamber which is adjacent to the labyrinth packing.

2

In another embodiment of the invention the bearing of a shaft which is common to the turbine rotor and to the compressor rotor is lubricated by gas which is taken from the turbine cycle and which is returned to the turbine cycle after passage through the bearing. Preferably a gas flow connection is provided through a labyrinth packing on the common shaft between the turbine inlet and the compressor outlet. The labyrinth packing may be connected, for example, at the end which is facing the compressor with the inlet of the turbine so that the compressor circuit will assume the pressure at the turbine inlet. In this case a maximum amount of gas circulates in the compressor circuit. There is also a maximum amount of heat energy removed and a maximum expansion cooling obtained in the turbine, if no special means for increasing the pressure in the compressor circuit are provided. The end of the labyrinth packing which is distant of the compressor is preferably connected with the outlet of the turbine.

In an embodiment of the invention the flow area of the throttling device in the compressor circuit is adjustable. In this case the speed of the turbine, the optimum efficiency and the cooling effect of the expansion can be controlled exclusively by changing the flow area of the throttle device. If desired, the automatic control of the flow area of the throttle device may be effected in response to an operating condition of the refrigerating plant of which the expansion turbine forms a part. Such an operating condition may be, for example, the temperature which must be maintained in a cooling chamber of the refrigerating plant which temperature is sensed by a thermostat used in the conventional manner for controlling the flow area of the throttle device.

The novel features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, and additional objects and advantages thereof will best be understood from the following description of embodiments thereof when read in connection with the accompanying drawing in which:

FIG. 1 is a diagrammatic layout of an arrangement of an expansion turbine driving a turbocompressor according to the invention.

FIG. 2 is a diagrammatic illustration of a modified plant according to the invention.

Referring more particularly to the drawing, numeral 1 designates the rotor of an expansion turbine 2 which rotor is fast on a shaft 3. Also fast on the shaft 3 is a rotor 4 of a blower 5. The pressure at the turbine inlet 6 may be 13 atmospheres absolute and the temperature at the turbine inlet may be -90° C. The inlet 6 of the turbine is connected for gas flow with two gas lubricated bearings 7 and 8 by means of conduits 9, 11 and 12. The turbine inlet 6 is also connected by a pipe 15 with the end 13 of a labyrinth packing 14 which end faces the compressor 5. Bearing gas is accumulated in annular chambers 16 and 17 which are connected through conduits 18, 19 and 23 with the outlet 24 of the turbine 2 where the pressure of the gas is approximately 10 atmospheres absolute and the temperature -110° C. An annular chamber 21 at the end of the labyrinth packing 14 which end is distant from the compressor 5 is connected by means of a conduit 22 with the conduit 23, i.e., is also connected with the outlet of the turbine 2. The expansion turbine forms part of a refrigeration plant having a gas circuit generally indicated by an arrow 25. Refrigeration plants of this type are known, as evidenced by Patent No. 2,721,456 in which an expansion turbine is used in lieu of a throttle valve. The refrigeration plant, per se, is not part of the present invention and is therefore not illustrated. The gas in the cooling

circuit of the refrigeration plant may be hydrogen or helium.

The compressor 5 having an inlet 27 and an outlet 28 is interposed in a separate closed circuit 29 in which the same gas circulates as in the circuit 25. A throttle device 30 having an adjustable flow area is interposed in the circuit 29 in which a cooler 31 is arranged downstream of the throttle device 30. The cooler 31 is cooled, for example, by water and removes the energy transferred from the turbine to the compressor and from the latter in the form of heat to the gas, for example, hydrogen, by compression from, for example, 12 atmospheres absolute to 13 atmospheres absolute. The gas is cooled in the cooler 31, for example, from +20° C. to +12° C. The cooled gas is returned to the inlet of the compressor. By adjusting the flow area of the device 30 the output and the speed, for example, 150,000 r.p.m., of the turbine and the cooling effect of the expansion turbine can be regulated. If desired, the flow area of the device 30 may be controlled automatically, for example, in response to an operating condition of the plant of which the turbine 2 forms a part, for example, in response to the temperature of a freezing chamber which is cooled by the cold resulting from the expansion of a gas in the turbine 2. A thermostat may be provided for this purpose which is connected in the conventional manner with the device 30.

There is the same relatively great pressure, for example, 13 atmospheres absolute at the circumference 32 of the rotor 4 of the blower 5 as at the inlet 6 of the turbine because the inlet pressure of the turbine is transmitted to the circumference 32 of the compressor rotor through the conduits 9, 15 and to the annular chamber 13 as well as through the clearance around the shaft 3 and between the compressor rotor and its casing. Therefore, particularly great gas masses are circulated through the circuit 29 so that the brake effect of the compressor and of the circuit 29 on the turbine is particularly great.

Whereas the turbine 2 and the bearings 7 and 8 as well as the labyrinth packing 14 which parts are within a space defined by a dash-dot line 33 in FIG. 1 are at the low operating temperature, for example, -90° C. of the refrigerating plant, the blower 5 and the circuit 29 including the throttle 30 and the cooler 31 which parts are within the space diagrammatically indicated by a dash-dot line 34 in FIG. 1 operate at normal temperature, for example, at +20° C.

In the embodiment of the invention illustrated in FIG. 2 bearings 7' and 8' as well as a labyrinth packing 14' are within an area defined by dash-dot line 34' in FIG. 2. The compressor circuit 29 contains the same gas as the turbine circuit 25. A conduit 42 is branched off at 41 from the compressor circuit 29 for taking gas from the compressor circuit and compressing it in a compressor 43 and conducting it through a pipe 42' to a point 44 from which it is conducted through conduits 45 and 46 into the bearings 7' and 8'. The gas which has passed through the bearings 7' and 8' is returned through conduits 48 and 49 to the outlet 32 of the compressor 5.

A pipe 51 is connected at 41 with the circuit conduit 29, a pressure regulating means 52 including a valve being interposed in the pipe 51 for admitting gas from a supply pipe 53 to the circuit or for relieving gas from the circuit through a relief pipe 54. The regulator 52 maintains the pressure in the circuit at 41 and consequently at the inlet of the compressor 5. The pressure desired at 41 and at the blower inlet is obtained by proper setting of the regulator 52. In this way the density of gas circulating in the compressor or brake circuit and the brake effect on the turbine 2 can be controlled.

A pipe 55 is connected with an annular chamber 21' at the end of the labyrinth packing 14' which faces the turbine 2. By supplying gas to or relieving gas from the chamber 21', through the pipe 55 the pressure in the chamber may be increased or decreased to maintain a desired pressure in the annular chambers 21' and 16',

the latter being adjacent the turbine rotor, and to prevent flow of gas from the chamber 21' towards or from the turbine. The pipe 55 is supplied with gas from a supply pipe 53 and is relieved of gas through a relief pipe 59. This supply and relief is accomplished by a regulating device 56 including a valve which device is responsive to the pressure difference in the chambers 21' and 16' with which it is connected by pulse conduits 57 and 61, respectively. The device 56 is conventional and may, for example, include a piston or diaphragm one side of which is exposed to the pressure in the chamber 21' and the other side of which is exposed to the pressure in the chamber 16' and whose movements are used for actuating a valve connecting the conduit 55 either with the supply conduit 53 or with the relief conduit 59. The device 53 to 59 and 61 can be used for preventing flow of warm gas through the chamber 16' from the packing 14 or from the conduit 53 into the cold turbine.

If the pressure of the compressor circuit is greater than that of the turbine circuit, a certain amount of gas must be sacrificed by relieving it from the compressor circuit through the bearings 7', 8', the labyrinth packing 14' and the chamber 21', through the pipes 55 and 59. The loss is the smaller the tighter the packing 14'. The lost gas is replaced by gas admitted to the compressor circuit through the supply pipe 53 and the regulator 52.

If it is desired to maintain a lower pressure in the braking or compressor circuit than in the chambers 16' and 21', the amount of gas flowing through the packing 14' and the conduit 49 must be replaced from the supply pipe 58 through the regulator 56 and the pipe 55 and must be relieved through the pipe 51 and the regulator 52 and blown out through the pipe 54.

The throttling device 30 has an adjustable flow area and may be automatically controlled by a conventional device 60 which is responsive to the temperature of the gas leaving the turbine 2 and passing through duct means 24.

In a modified arrangement according to the invention the compressor circuit contains a gas which is different from the gas of the turbine circuit. In plants according to FIG. 2 in which the temperature of the bearings is normal, liquid-lubricated bearings may be used instead of gas-lubricated bearings for supporting the shaft 3.

I claim:

1. In combination with a cold producing plant having an operating fluid and an expansion turbine for expanding and thereby cooling said operating fluid, a gas circuit separated from the cold producing plant and the operating fluid thereof, a compressor interposed in said gas circuit and connected to said turbine to be driven thereby and forming a brake for controlling the speed and the expansion in and the cooling effect of said turbine, a throttling device interposed in said gas circuit for controlling the power consumption and the brake effect of said compressor, and a gas cooler interposed in said gas circuit in series relation with said throttling device for cooling the gas in said gas circuit.

2. In the combination defined in claim 1 a shaft common to and interconnecting said turbine and said compressor, a bearing for said shaft, conduit means connected to said gas circuit for tapping gas therefrom and returning the tapped gas to said gas circuit, said bearing being interposed in said conduit means for lubrication by the gas of said gas circuit, a labyrinth packing on said shaft between said bearing and said turbine, an annular chamber surrounding said shaft and interposed between said labyrinth packing and said turbine, and pressure controlling means connected to said annular chamber for maintaining a predetermined pressure therein which is slightly lower than the pressure in said turbine for preventing passage of relatively warm gas from said gas circuit into said turbine.

3. In the combination defined in claim 1, a shaft common to and interconnecting said turbine and said compressor, a bearing for said shaft, a labyrinth packing on

5

said shaft between said bearing and said turbine, an annular chamber surrounding said shaft and interposed between said labyrinth packing and said turbine, pressure responsive means connected to said turbine and to said chamber and responsive to the difference of the pressures in said turbine and in said annular chamber, and valve means connected to and actuated by said responsive means for supplying gas to and relieving gas from said annular chamber for preventing flow of relatively warm gas from said gas circuit into said turbine.

4. In the combination defined in claim 1, including a gas supply and relieve pipe connected to said gas circuit for supplying gas to said circuit and for relieving gas from said circuit, and a control means connected to said supply and relieve pipe for controlling the supply to and relieve of gas from said circuit to maintain a desired pressure in said circuit.

5. In the combination according to claim 4, a device responsive to the pressure in said gas circuit and connected to said control means for actuating the latter.

6. In the combination defined in claim 1 and wherein

6

said throttling device has an adjustable flow area, actuating means being connected to said throttling device for actuating said throttling device, duct means being connected to and receiving expanded gas from said turbine, and means being connected to and being responsive to the temperature of the gas in said duct means and being connected to said actuating means for adjusting the flow area of said throttling device to maintain the temperature of the gas leaving said turbine.

References Cited in the file of this patent

UNITED STATES PATENTS

1,979,525	Baumann	Nov. 6, 1934
2,049,343	Warren	July 28, 1936
2,367,223	Larrecq	Jan. 16, 1945
2,721,456	Whitney	Oct. 25, 1955
2,721,728	Higgins	Oct. 25, 1955
2,729,073	Nielsen	Jan. 3, 1956
2,760,832	Bidwell	Aug. 28, 1956