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GAS DESICCATION APPARATUS

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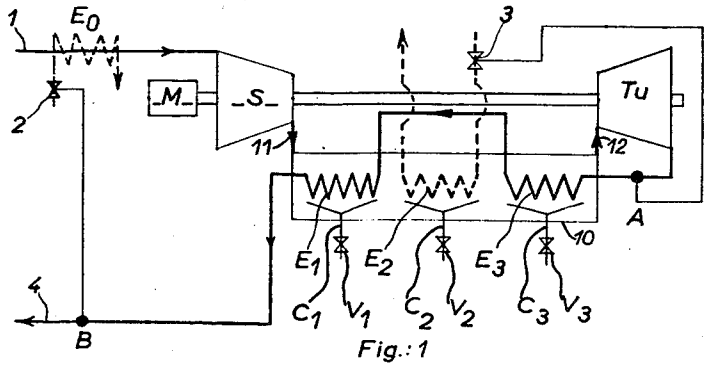

Fig.: 1

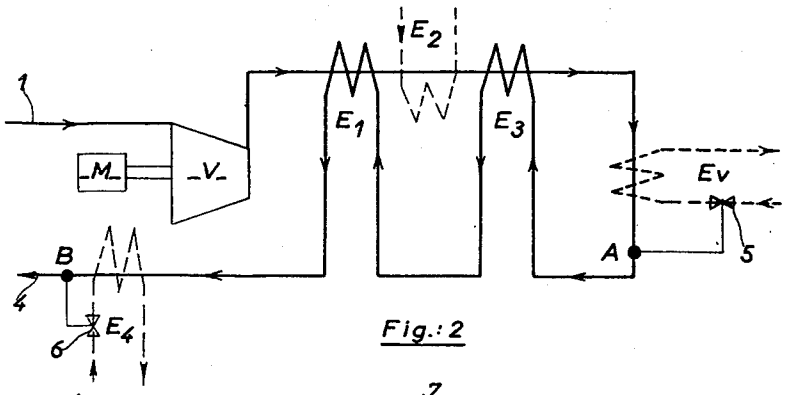

Fig.: 2

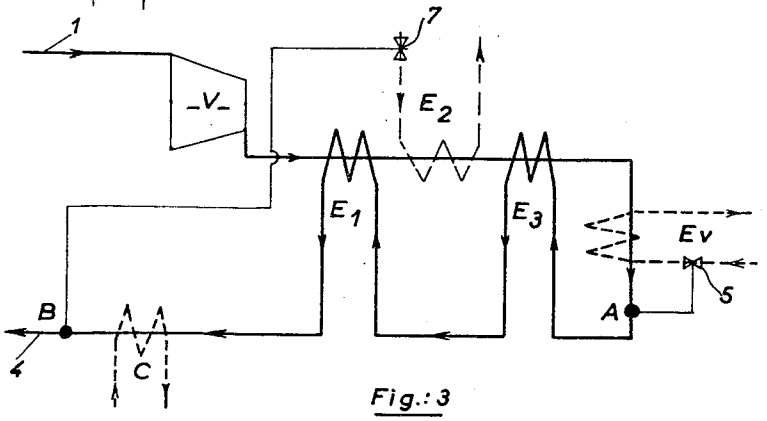

Fig.: 3

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GAS DESICCATION APPARATUS

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This invention is concerned with drying a "wet" gas and adjusting the degree of residual "wetness" of the dried gas, by means of heat exchangers through which flows a fluid available in sufficient quantity at a temperature below that of the gas in question, notable examples of such a fluid being water or air.

The invention consists essentially in inserting, into the paths of the conduits conveying the wet gas to be dried, a plurality of heat exchangers acting as cold points, the water and other liquids of which said gas is to be rid condensing along the walls thereof.

A number of these heat exchangers have flowing through them a readily available fluid, such as water or the surrounding air, and are arranged at a point along the gas path where the temperature of the gas exceeds that of said fluid to a sufficient extent. One such exchanger is of the adjustable flow type and serves to check the temperature of the gas on exit from the desiccation apparatus.

Other exchangers are traversed twice by the gas and are associated to a cooling system which cools the gas in between these two routings. Such exchangers are preferably combined with an exchanger of the first type, which they flank. The cooling system can operate both on the temperature and the local pressure of the gas to be dried.

In all cases, the quantity of condensed liquid is adjusted by controlling the temperature of the gas at the coldest point along its path. This quantity therefore depends primarily on the temperature differential between said point and the ambient fluid utilized (air or water), although it also depends on the efficiency of the heat exchangers used.

Several alternative embodiments will be described hereinbelow by way of example but not of limitation, such embodiments differing essentially in the type of cooling system utilized. The latter could consist for instance of the combination of a blower driven by a motor and a gas turbine positioned further downstream; alternatively, it could consist of the evaporator and the condenser of a cooling plant of known design, or of its evaporator alone. In both these latter arrangements a fan is employed to circulate the gas.

The description which follows with reference to the accompanying drawings, which are filed by way of example and not of limitation, will give a clear understanding of the various features of the invention and of the art of carrying them into practice, all such disposition as emerge either from the description or the drawings naturally falling within the scope of this invention.

Referring to the drawing filed herewith:

FIGURE 1 is a block diagram of a dessication apparatus according to the invention, comprising a shaft which is driven by a motor and supports a blower and a turbine which serve as cooling means;

FIGURE 2 is an alternative block diagram, comprising the evaporator of a cooling plant; and

FIGURE 3 is yet another alternative block diagram, in which both the evaporator and the condenser of said cooling plant are utilized.

Referring first to FIGURE 1, there is shown thereon

a desiccation plant according to the invention, shown in highly diagrammatic form.

The gas to be dried is first conveyed through a conduit 1 into a heat exchanger E_0, which it traverses. Said exchanger has flowing through it a fluid readily available in sufficient quantity (water or ambient air for instance) and incorporates a valve 2 for adjusting the flow of said fluid.

The gas cooled in exchanger E_0 then passes through a blower S which is driven by a motor M and by a turbine T*u* located further downstream. On passing through blower S, said gas is compressed and heated.

Along its path between blower S and turbine T*u*, the gas passes through the clusters of several heat exchangers: an exchanger E_2 through which circulates an ambient fluid and which is equipped with a valve 3 for adjusting the flow thereof, and preferably also (for considerations of thermal efficiency well known per se) two further exchangers E_1 and E_3 which flank exchanger E_2 and are traversed by the cooled gas expanded in turbine T*u*. A casing 10 encloses the heat exchangers and an inlet 11 is connected between the blower and the casing, and an outlet 12 is connected between the casing and the turbine T*u*.

A temperature detector disposed at the turbine exit end, namely at a point A which is the coldest along the gas path, is connected to the mechanism which operates the valve 3 equipping exchanger E_2, while a second temperature detector disposed at the exit end of the desiccation device, namely at a point B, is likewise connected to the valve 2 equipping exchanger E_0. The gas issues from the device as at 4 and the direction which it follows through the various exchangers is preferably as indicated on the drawing.

When the plant is in operation, the gas to be desiccated, the temperature of which is assumed to be higher than the ambient temperature, is heated polytropically as it passes through blower S, which increases the effectiveness of the exchanger E_2 traversed by an ambient-temperature fluid. Condensation takes place over the cold walls of the exchangers and is collected through moisture collectors such as C_1, C_2, C_3 having valve or bleed means, such as V_1, V_2, V_3, and possibly utilized. Beyond point A, the gas is definitively heated and it will be appreciated that its residual "wetness" as it emerges from the apparatus at 4 will in fact depend upon its temperature at A, which temperature—and hence also the residual wetness of the gas—is rendered constant by thermostat means actuating valve 3. Regulation of the final temperature acts upon the flow rate of the fluid passing through exchanger E_0, which exchanger can possibly operate without condensation. Such an exchanger can be disposed with advantage upstream of the blower, the functional characteristics of which can be accordingly diminished.

Such a plant is consequently noteworthy by the moderate temperature gradients it implies, by the use of an ambient fluid to produce quasi-natural condensation by cold-wall physical effects and by the fact that it lends itself to continuous closed-circuit operation with any convenient gas.

The use of an ambient fluid sets a condensation temperature level within the system and thus limits the amount of "wetness" requiring to be condensed by a cooling system as such.

This invention would consequently seem to be particularly well adapted to the drying of foods and natural products, when it would be feasible to recover the condensates (which are usually perfumed and subsequently utilizable); the invention should also be well suited for the precise air-conditioning of premises such as telephone exchanges and foodstuff storage warehouses.

A first alternative embodiment is illustrated sche-

matically in FIGURE 2. It comprises (in the direction of travel of the gas through the conduit 1–4 conveying it) a blower V driven by a motor M, and a plurality of heat exchangers.

An exchanger Ev, through which circulates the fluid of a cooling plant (of which it constitutes the evaporator), brings the gas to its lowest temperature. The flow of cooling fluid through said evaporator is adjusted by a valve 5 operated by thermostat means sensitive to the gas temperature at A on exit from Ev.

Upstream from said evaporator are disposed an exchanger E_2 traversed by an ambient fluid and, preferably, two exchangers E_1 and E_3 flanking E_2 and traversed by the gas cooled in evaporator Ev. Condensation takes place over the relatively cold walls of exchangers E_1 through E_3 and of evaporator Ev.

If desired, an exchanger E_4 can be disposed at the exit end of the desiccation apparatus whereby to adjust the final temperature of the gas at B. Exchanger E_4 would be traversed by a conveniently available fluid and would incorporate a thermostat valve 6.

It would be appreciated that in this case the residual wetness of the gas is adjusted by evaporator Ev on the basis of the temperature at the coldest point A, and also that the final temperature of the gas at B is adjusted by exchanger E_4, which exchanger can be traversed by an ambient-temperature fluid provided that the scale of the temperatures allows of such a disposition.

When this is the case, it is possible to reduce the mechanical power required by the desiccation apparatus, as well as the number of moving parts used, but on the other hand it is necessary to employ a complete cooling plant.

In the likewise schematically illustrated second embodiment of FIGURE 3, said cooling plant is utilized not only for drawing off calories for condensation purposes (by means of its evaporator Ev, the output of which is adjustable in terms of the temperature at A) but also for returning calories to the dried gas at B (by means of its condenser C). In point of fact, condenser C replaces the exchanger E_4 of FIGURE 2, and the final temperature adjustment at B can be effected in this case by incorporating the corresponding thermostat valve 7 on exchanger E_2, which is traversed by a readily available fluid at preferably ambient temperature.

It is of course to be understood that this invention is by no means limited to the specific embodiments hereinbefore described, but that its scope also covers all such embodiments as can be devised by the application of equivalent technical means; in particular, it is applicable to the desiccation of a gas at any given temperature, insofar as a convenient fluid at lower temperature is available in sufficient quantity; the invention is also applicable to the extraction of condensable products.

What is claimed is:

1. An apparatus for desiccating or dehumidfying a wet gas, comprising

(*a*) a cooling device for cooling the gas;

(*b*) feed means for feeding the gas under pressure to the cooling device;

(*c*) means for discharging the gas outgoing from the cooling device;

(*d*) exchanger means for placing the gas incoming to the cooler device in heat exchange relation with the gas outgoing therefrom and including first and second exchanger devices arranged in series in the path of said incoming gas and in the path of said outgoing gas;

(*e*) a third exchanger device for placing the said incoming gas in heat exchange relation with a cooling agent which is available in substantial quantity at a temperature below the temperature of the wet gas, the third exchanger being arranged in series between the first and second exchangers in the path of said incoming gas, and

(*f*) means for discharging condensed moisture from the exchanger devices.

2. An apparatus as claimed in claim 1, comprising means for controlling the temperature of the gas leaving the cooling device to adjust the amount of condensed moisture.

3. An apparatus as claimed in claim 1, comprising means for adjusting the temperature of the gas which is discharged from the apparatus.

4. An apparatus as claimed in claim 1, wherein the cooling device consists of an expansion device for the gas.

5. An apparatus as claimed in claim 4, comprising means for controlling the flow rate of the cooling agent which is delivered to the third heat exchanger in response to the temperature of the gas leaving the expansion device so as to adjust the amount of condensed moisture.

6. An apparatus as claimed in claim 4, wherein the feed means and expansion device comprise a blower device for compressing the gas and a turbine device for expanding the same, the turbine device cooperating with a motor to drive the blower device; a fourth exchanger device arranged in the path of the wet gas incoming to the blower device for placing said wet gas in heat exchange relation with a cooling agent which is available in substantial quantity, and means for controlling the flow rate of said cooling agent which is delivered to said fourth exchanger device, in response to the temperature of the gas leaving the apparatus, to adjust said temperature.

7. An apparatus as claimed in claim 1, wherein the cooling device comprises an evaporator of a cooling plant, which is fed with cooling fluid, and means for placing said cooling fluid in heat exchange relation with the gas in the evaporator; comprising means for reheating the gas in the path thereof downstream of the said exchanger devices.

8. An apparatus as claimed in claim 7, wherein the reheating means comprises a fourth exchanger device for placing the gas in heat exchange relation with a reheating fluid which is available in substantial quantity at the ambient temperature; means for controlling the flow rate of the cooling fluid which is fed to the evaporator, in response to the temperature of the gas leaving said evaporator, to adjust the amount of condensed moisture, and means for controlling the flow rate of the reheat fluid which is fed to the fourth exchanger, in response to the temperature of the gas leaving the apparatus to adjust said temperature of the gas.

9. An apparatus as claimed in claim 7, wherein the reheating means comprises the condenser of the cooling plant; means for controlling the flow rate of the cooling fluid which is fed to the evaporator, in response to the temperature of the gas leaving said evaporator, to adjust the amount of condensed moisture, and means for controlling the flow rate of the cooling agent which is delivered to the third heat exchanger, in response to the temperature of the gas leaving the apparatus, to adjust said temperature of the gas.

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