(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 191 007**
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 86850029.9

(51) Int. Cl.[4]: F 24 F 3/14

(22) Date of filing: 31.01.86

(30) Priority: 08.02.85 SE 8500584

(43) Date of publication of application:
13.08.86 Bulletin 86/33

(84) Designated Contracting States:
BE DE FR GB IT NL

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(54) **Method and device for gas conditioning.**

(57) Method and device for conditioning a gas such as air, wherein the gas is cooled by means of a cooling circuit for dehydration of the gas by evaporation of a refrigerant in the evaporator (16) of the cooling circuit. The gas is conducted also through a treatment zone in a regenerative exchanger apparatus, in which moisture is delivered to a moisture absorbing drying agent. The cooling circuit comprises in addition to the evaporator (16) a compressor (26) and a condenser (24). The cooling circuit is regulated as to its effect so that the greatest cooling and dehydration effect is obtained without any formation of ice on the evaporator taking place.

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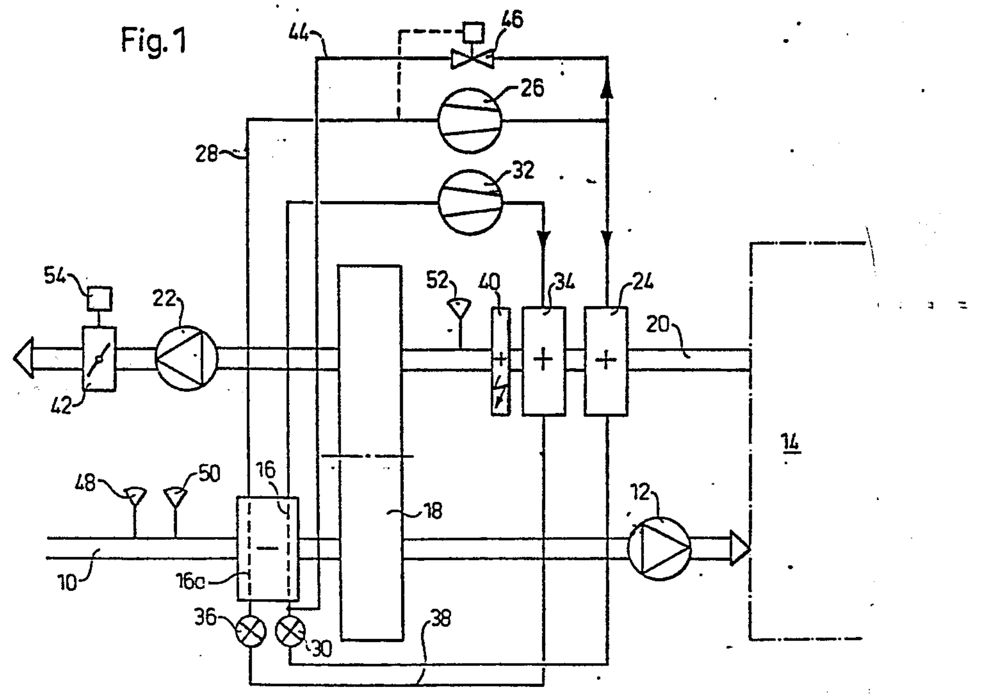
Fig. 1



Method and device for gas conditioning.

The present invention relates to a method for conditioning, especially dehydration, of a gas, such as air. The invention also relates to a device carrying out the method.

In the drying of a gas such as air under extremely moist conditions, for example in a highly moist climate within great intervals of temperature during day and night or the year, generally cooling dehydrators are employed, within which the air to be dehydrated is conducted over the evaporator in a cooling circuit for cooling of the gas and therewith precipitation of the moisture at the evaporator. With this method large quantities of moisture can be removed, whereas it is difficult to achieve a dehydration of the gas down to really low moisture contents. Another problem inherent to such devices is the risk of formation of ice on the evaporator under conditions of operation with highly moist air.

Another method for dehydration of gas, wherein the problem of formation of ice is avoided, consists in using a regenerative moisture exchange apparatus with a moisture absorbing drying medium which dehydrates the gas to a very low water content. However, in operation under the above operative conditions and/or with large quantities of gas a regenerative exchanger becomes more expensive than a cooling dehydrator having the same capacity.

The main object of the invention is to provide a method and a device for conditioning a gas as described in the introductory part wherein the mentioned inconveniences inherent to the known methods and devices for dehydration of a gas are eliminated to a great extent.

This object is attained by combining, according to the invention, a cooling dehydrator with a regenerative exchanger apparatus in such a manner that the air which shall be dehydrated firstly is conducted over the evaporator of the cooling circuit before it reaches the treating zone of the regenerative exchanger apparatus, and that the effect of the cooling circuit is adjusted so as to avoid a formation of ice on the evaporator. The other charachterizing features are evident from the subsequent claims.

The invention will be described nearer in the following in connection with the embodiments which are shown in the accompanying drawings. Figure 1 shows a diagrammatic view of a plant according to the invention of carrying out the novel method. Figure 2 shows a view similar to Figure 1 of a changed embodiment of the plant.

In the following it is assumed that the gas which is to be treated according to the invention is air to be dehydrated and that the regenerating gas also is air, even if the invention is not limited thereto.

In the plant diagrammatically shown in Figure 1, outdoor air denoted with the arrow 10 is blown by means of a fan 12 into a room 14 after that the air has been dehydrated by means of an evaporator unit 16 and a regenerative exchanger apparatus 18. The evaporator unit 16, which will be described nearer more below, achieves by cooling of the air a first dehydration of the air, from which the main part of the water content is removed, whereas the regenerative exchanger apparatus dries the air finally to the desired state. In the shown embodiment the exchanger apparatus is constituted by a rotor containing a moisture absorbing drying mass of a material which in itself is absorbing and/or impregnated with a hygroscopic substance.

By means of non-shown partition walls and sealings of a kind usual in this field of technique, the moisture exchanger rotor 18 is subdivided into a drying zone through which the outdoor air 10 streams, as mentioned above, and a regenerating zone, within which the regenerating air which is indicated at the arrow 20, is brought to flow by means of a fan 22. Most suitably the regenerating air is taken from the room 14, as in the shown embodiment,

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even if, of course, other possibilites are conceivable. The regenerating air 20 is supplied upon preheating to the regenerating zone of the rotor 18, in which the moisture taken up by the rotor is removed. In the actual embodiment according to Figure 1 the proportion between the drying zone and the regenerating zone is 1:1, i.e. each of the zones covers approximately one half of the rotor surface.

In order to cool the outdoor air 10 ahead of the drying zone of the exchanger 18, there is provided, according to the invention, a cooling dehydrator in the shape of a heat pump circuit, over the evaporator 16 of which the outdoor air passes ahead of the exchanger 18. In that connection a preheating also of the regenerating air is effected prior to the entrance into the regenerating zone of the exchanger 18 by means of the condenser 24 of the heat pump circuit. The circuit comprises also a compressor 26 and a conduit system 28 which connects the components contained therein. The heat pump circuit or system contains also other elements necessary of the operation thereof such as throttle valve 30 and other details of the kind usual in this technique for the opeartion.

The described plant works as follows: The air entering at 10 is cooled and dehydrated on one hand in the evaporator 16, on the other in the moisture exchanger 18, as has been described above, whereafter it is supplied to the room 14. At very warm weather conditions, for example at 40°C, and with the highest moisture in the outdoor air, the plant works with its full capacity, i.e. the heat pump circuit is in opearation with full capacity.

According to the invention, the arrangement is such, that the cooling dehydrator or evaporator 16 is operated with the highest possible capacity without any formation of ice taking place. This is achieved thereby that the cooling circuit is controlled as to its capacity in such a manner that when a risk of formation of ice on the evaporator 16 is present, a portion of the refrigerant gas coming from the compressor 26 - instead of being conducted to the condenser 24 and there becoming condensed - is conducted via a branch conduit 44 to a point in the heat pump circuit 28 behind the throttle valve 30 in the evaporator 16 and there is mixed with the vaporized refrigerant gas. In this way the refrigerating capacity in the evaporator 16 is reduced in relation to the temperature of the entering outdoor air. The adjustment to a lower level is effected by reducing the suction pressure in the heat pump circuit from the compressor 26 when the temperature in the outdoor air and therewith in the evaporator 16 falls, and this pressure fall operates a capacity controlling valve 46 inserted in the branch conduit 44 so as to cause it to open and to by-pass a portion of the warm gas from the compressor 26. Disposed in the outdoor conduit 10 are furthermore ahead of the evaporator 16 temperature feelers 48 and 50 which sense the temperature in the outdoor air and are connected to the control system of the heat pump circuit.

In order to increase the possibilities of control and to afford a more regular control curve and a greater cooling capacity, there may be provided a further heat pump circuit which comprises a compressor 32, a condenser 34, a throttle valve 36 and a conduit system 38, which connects the mentioned units with an evaporator circuit 16a. The two heat pump circuits are separated from one another and affect also two separate evaporator circuits 16, 16a, as is shown diagrammatically in Figure 1. The evaporators may be built to form a unit by means of common flanges of the so-called inter-twin-type.

In the conduit (the arrow 20) for the regenerating air, there is provided also behind the condensers 24, 34 and ahead of the regenerative exchanger 18 a heating battery 40, for example an electrically driven unit for additional preheating of the regenerating air, if this is required, as will be described more below. Disposed behind the exchanger 18 and the fan 22 is a throttle valve 42 in the shape of a damper or the like for additional adjustment of the flow of the air.

When the heat pump circuit which is connected to the compressor 26 has been adjusted down as much as possible and there is still a continued risk of formation of ice on the evaporator 16, 16a, the second heat pump circuit from the compressor 32 will shut off completely depending on the temperature recorded by the feelers 48, 50. In this case the downwards adjusted first heat pump circuit from the compressor 26 will - if so is possible - increase its capacity in order to be adjusted downwards again if the temperature of the air falls. In order to obtain a so regular adjustment curve as possible without large jumps in the capacity it is suitable that that heat pump circuit which is controlled has a compressor with higher effect than that circuit which only is switched on or off, which may be accomplished by utilizing different compressors or different refrigerants or a combination thereof. Then the evaporator or that circuit in the combined evaporator 16, 16a which belongs to the heat pump circuit with the highest capacity or effect and which therewith has the largest cooling capacity, shall be located last, viewed in the direction of flow of the outdoor air. In the same manner the condenser 24 in this heat pump circuit with the highest capacity, which condenser 24 has low condenser capacity and the largest heat supply, be situated first in the direction of flow of the regenerating air towards the regenerating zone of the exchanger apparatus 18, as is shown in Figure 1 of the drawing.

On the regeneration side, there is heated, as described earlier, the regenerating air coming from the room 14 by the condensers of the heat pump circuits, namely at first the condenser 24 and thereafter the condenser 34, as just mentioned. A temperature feeler 52 manoevres the flap 42 positioned behind the exchanger 18 and the fan 22 over a flap motor 54 in such a manner that the temperature of the regenerating gas is kept constant. If the heat effect from the condensers 24, 34 in some control cases should be insufficient for the required heating of the regenerating gas and therewith for regeneration of the rotor material of the exchanger 18 even when the flap 42 has been adjusted down, the additional heating battery 40 is switched on in order to provide necessary additional heat.

It is evident that the described construction of the plant affords a regulation of the capacity over a very large range by the subdivision of the cool drying circuit into two steps in combination with the regenerative moisture exchanger apparatus.

In the modified embodiment shown in Figure 2 those details which are common with the plant in Figure 1, have been denoted with the same reference numerals.

In this embodiment the evaporator circuits to the two cooling circuits from the compressors 26, 32 are divided into two separate units 116 and 116a, said units being separated in such a manner that the evaporator 116a is situated behind the rotor 18 in the outdoor air channel 10, seen in the direction of flow of the air. Thus, the evaporator 116a belongs to the cooling circuit which either is switched on and then works with full effect, or is shut off because of risk for formation of ice. The plant according to Figure 1 is suited for conditions of operation with less moist air but somewhat colder climate as described in connection with Figure 1 and where the first evaporator circuit 16a often is shut off because of the risk of formation of ice. Under such conditions of operation the evaporator can suitably, as is shown at 116a, be transferred to a position behind the rotor viewed in the direction of flow for the outdoor air, in which position the air is dryer and warmer, because it has passed both the cooling circuit to the evaporator 116 and the rotor 18. According to an alternative, the evaporator 116a may be transferred to the position 116b indicated by dashed lines, i.e. behind the rotor 18 in the channel for the outlet air. In these cases the evaporators 116a or 116b, respectively, will through the condenser 34 supply heat to the regenerating air in the regenerating air stream 20.

It is also possible to have several of the named evaporators (116, 116a, 116b) attached to the same cooling circuit.

Otherwise, the embodiment according to the Figure

2 works in the same manner as has been described in connection with Figure 1.

It is obvious that the shown embodiments are examples only for the realization of the invention and that this can be changed and varied within the scope of the subsequent claims.

CLAIMS

1. A method for conditioning, especially dehydration, of a gas such as air, c h a r a c t e r i z e d in that the gas is cooled by means of a cooling circuit for dehydration of the gas by evaporation of a refrigerant in the cooling circuit in combination with that the gas is conducted through a treating zone in a regenerative exchanger apparatus for delivery of moisture to a moisture absorbing drying agent in the exchanger apparatus, the effect of the cooling circuit hereunder being adjusted so that the maximum of cooling and therewith of dehydration is obtained without formation of ice on the evaporation.

2. A method according to claim 1, c h a r a c t e r - i z e d by operating a second cooling circuit connected in parallel with said first cooling circuit with full effect or shutting off the same depending on the risk of formation of ice.

3. A method according to claim 2, c h a r a c t e r - i z e d in that the cooling circuits have different effects and that the adjusted cooling circuit has the highest effect.

4. A method according to any of the claims 1 through 3, c h a r a c t e r i z e d in that the effect adjustment is performed by by-passing a part of the flow of refrigerant past the condenser in that cooling circuit which is adjusted.

5. A method according to any of the claims 1 through 4, c h a r a c t e r i z e d in that the drying agent is regenerated by means of air which is heated with heat produced by condensation of the refrigerant in the cooling circuit or cooling circuits, the temperature of the regenerating air being kept constant by increasing or throttling the quantity of regenerating air.

6. A device for carrying out the method according to any of the claims 1 through 5 for dehydration of a gas such as air, c h a r a c t e r i z e d by a cooling circuit for dehydration of the gas by evaporation in an evaporator (16) connected to a compressor (26) and a condenser (24),

a regenerative exchanger apparatus (18) located behind the evaporator (16) in the direction of flow of the gas and containing a moisture absorbing drying agent, a conduit system (28) which connects the evaporator (16), the compressor (26) and the condenser (24) and within which a refrigerant circulates, which refrigerant via a throttling valve (30) is evaporated in the evaporator (16), a branch conduit (44) which conducts refrigerant gas from the compressor (26) to a point in the refrigerant circuit (28) behind the throttle valve (30) and a capacity controlling valve (46) inserted into the branch conduit (44) and governing the flow of refrigerant gas in the branch conduit (44).

7. A device according to the claim 6, c h a r a c t e r i z e d by a further cooling circuit comprising a compressor (32), a condenser (34), a throttling valve (36) and a conduit system (38) which connects the said units with an evaporator circuit (16a) which is arranged ahead of the evaporator (16) in the first-mentioned cooling circuit viewed in the direction of flow of the outdoor air, and a control device, by means of which the further cooling circuit is either totally connected on or totally disconnected.

8. A device according to the claims 6 or 7, c h a r a c t e r i z e d in that the condensers (24, 34) of the cooling circuit or circuits are arranged in a regeneration circuit (20) for heating of regeneration air, with which the drying agent of the exchanger apparatus (18) is regenerated, the condenser (24) belonging to the first-mentioned cooling circuit, which is regulated as to its capacity, is arranged as the first, viewed in the direction of flow of the regeneration air to the exchanger apparatus (18).

9. A device according to claim 8, c h a r a c t e r i z e d by a flap (42) arranged in the regeneration circuit (20) behind the exchanger apparatus (42) and manoevered by a temperature feeler (52) in the regeneration circuit (20) so as to keep the temperature in said circuit constant.

10. A device according to the claims 6 and 8, c h a - r a c t e r i z e d by a further cooling circuit comprising a compressor (32), a condenser (34), a throttle valve (36) and a conduit system (38) which connects said units with an evaporator (116a) arranged behind the exchanger apparatus (18) in the direction of flow of the outdoor air and/or an evaporator (116b) arranged in the regeneration circuit (20) ehind the exchanger apparatus (18).

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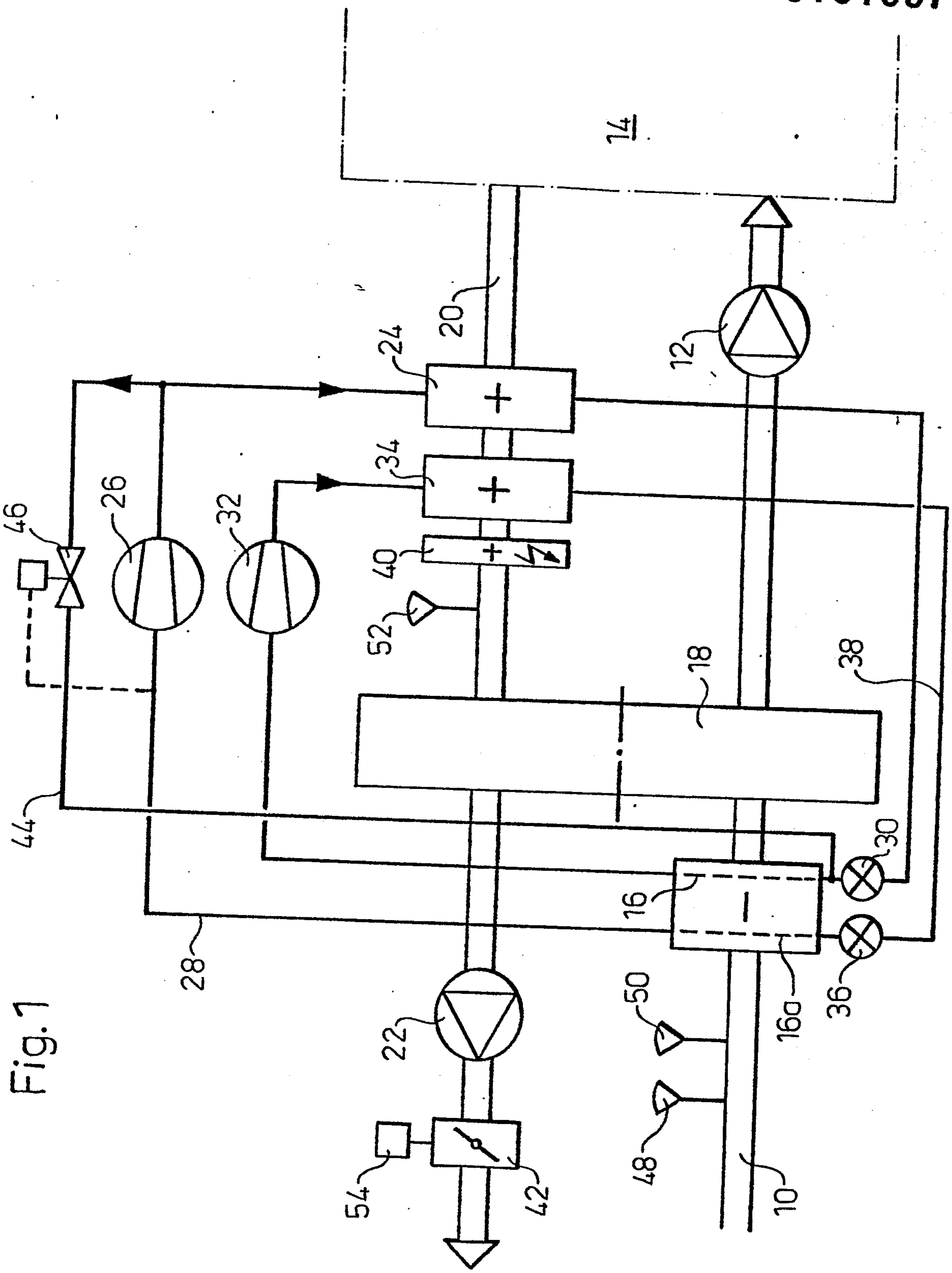

Fig. 1

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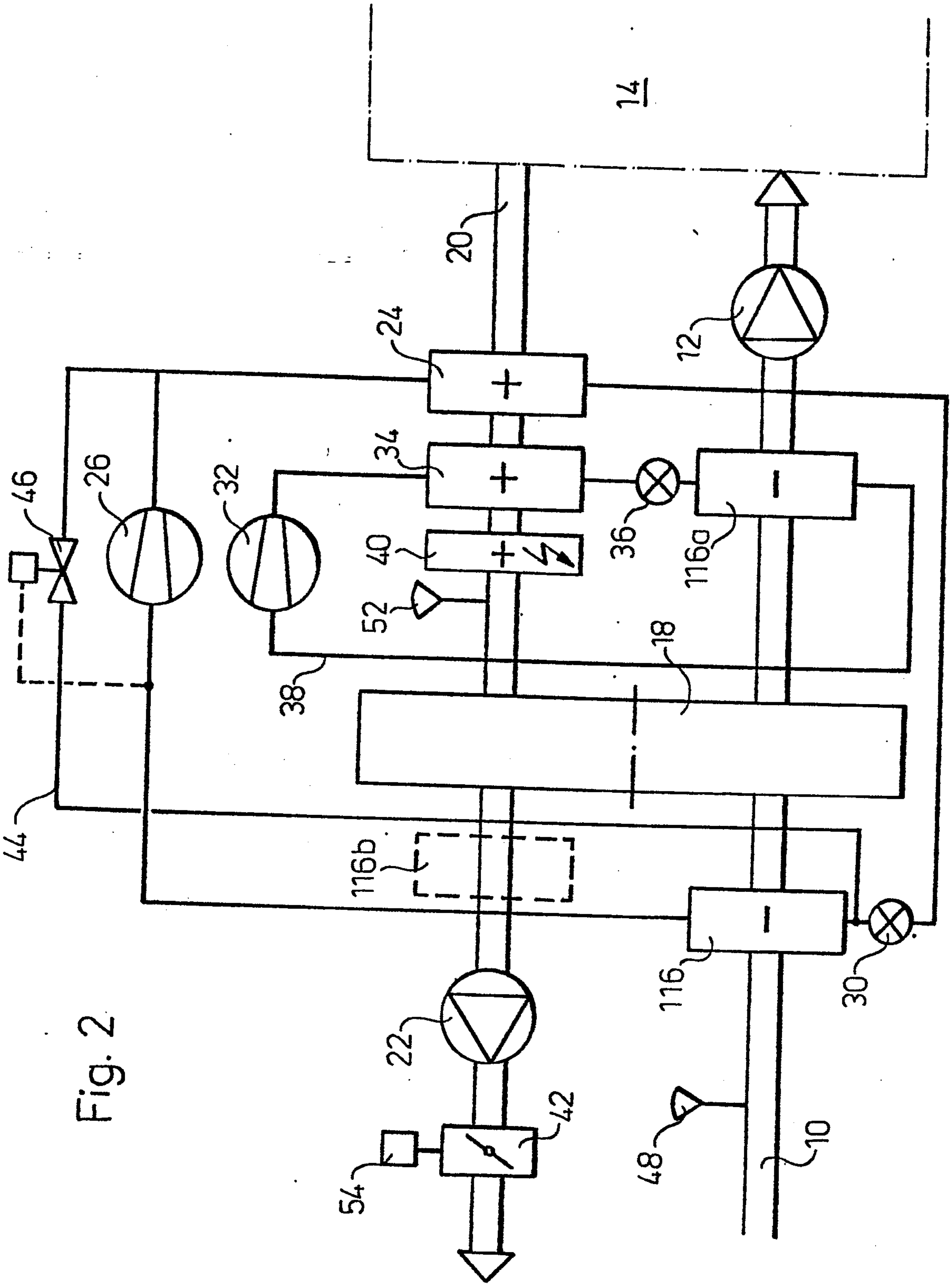

Fig. 2