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METHOD OF AIR CONDITIONING

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1

This invention relates to improvements in methods of air conditioning, and has for its object to increase the capacity of standard refrigeration systems without materially adding to their operating costs.

In the standard refrigeration system used for cooling air, for instance, as is well known, the refrigerant in low pressure gaseous form, of any standard and known type, is first compressed by a standard compressor to a gas of high pressure. This compression of the gas generates heat. The high pressure gas then passes to the condenser, where it is condensed, or changed to liquid form through the use of a cooling medium, which is frequently cold water, and some times air, and in the condensation process the high pressure gas loses heat and the cooling medium gains heat. The heat thus acquired by the cooling medium is normally wasted. The high pressure saturation refrigerant then usually passes to a receiver or storage tank, from which it is released through an expansion or regulating valve to an evaporating coil, where the liquid refrigerant changes back to a gas of low pressure. In this process the refrigerant drops rapidly in temperature and there is an exchange of heat between the refrigerant and a cooling medium, which may be brine, which in turn is recirculated about the area being refrigerated. Or the exchange of heat may be between the refrigerant in the evaporating coil across which air is passed to be cooled, or it may be the substance being refrigerated itself which loses heat to the refrigerant. The gas is then again compressed as before and the cycle is repeated.

Heretofore, the only practical way of materially increasing the capacity of such a standard refrigeration system has involved increasing the physical facilities, as by duplicating the existing plant or by replacing it with one of greater capacity. This of necessity has involved increasing the operating costs, or doubling them, if the plant is duplicated. I have discovered, however, that the capacity of the standard refrigeration system may be greatly increased or even doubled, without materially increasing the operating costs, by combining with it a fluid sorbent system (such as triethylene glycol, or lithium chloride) for dehumidifying the air, and regenerating the sorbent, by using the liquid sorbent, after passing through the dehumidifier, as the cooling or condensing medium for the refrigerant. At the same time, the sorbent, which has thus gained heat in the condensing process, can be used for preheating the air stream in the sorbent regeneration

2

system for regenerating or restoring the sorbent by extracting from it the moisture previously absorbed from the air in the dehumidification process. The air stream in the fluid sorbent regeneration system is normally separately heated from an outside or additional heat source. The heat thus normally thrown away on the refrigeration side is thus utilized for preheating the air stream in the sorbent regeneration cycle, and as the heat normally thrown away on the refrigeration side usually equals that required for sorbent regeneration (per ton of accomplishment) great savings in operating costs can be achieved. Thus for any desired refrigeration tonnage, by thus combining the standard refrigeration system with a fluid sorbent regeneration system, the refrigerating capacity can be doubled, without appreciably increasing the operating costs, in either power or water consumption. When the fluid sorbent regeneration system also includes the use of a diffusing tower, as described in my copending patent application Serial No. 63,358, filed December 3, 1948, now abandoned, where the warm high vapor pressure air is passed through the diffusing tower and equalization of the vapor pressure to that of the surrounding atmosphere is effected, with consequent loss of water vapor without appreciable loss of heat, additional savings in operating costs can be achieved.

In the drawings:

The figure is a diagrammatic showing of my invention, in which a standard refrigeration system is combined with a fluid sorbent regeneration system.

As shown in the drawings, A represents the standard refrigeration system or cycle, and B represents the sorbent regeneration system or cycle. In the refrigeration system of standard form the compressor unit is indicated at 10, where the low pressure saturated gas of a refrigerant, of any well known type such as "Freon" 11 or 12 (which chemically is dichloro-difluoro-methane, CCl_2F_2) is compressed to a high pressure saturated gas, and in the process heat is generated. A condenser unit is indicated at 12, and again is of standard type, where the high pressure saturated gas of a superheated temperature is cooled and condensed to a high pressure saturated liquid. The usual cooling medium is, of course, cold water and occasionally air, which is passed through a heat exchanger, whereby the heat of the high pressure saturated gas is removed and carried away by the cooling medium. The heat thus acquired by the cooling medium in the condensing process is normally wasted. A novel fea-

ture of the present invention, however, is that the dilute liquid sorbent from the dehumidifying unit 20 in the sorbent regeneration system B is used as the cooling or condensing medium in the condenser 12 of the refrigeration system A. The high pressure saturated liquid refrigerant then passes to the receiver or tank 14, where it is retained until it passes through the expansion valve 15. In passing through the expansion valve 15 the high pressure liquid refrigerant passes to the evaporator or cooler 16 and expands to a low pressure gas. During this change of state heat is required, and as well known, the heat is drawn from the substances to be cooled, which may be of any nature, and where the evaporator or cooler 16 is located at a distance from the substance to be cooled, brine, ammonia, cold water or other suitable cooling medium is first cooled in the evaporator 16 and then pumped to the cooling chamber as in central refrigeration plants.

As previously stated, the sorbent regeneration system B is connected to the refrigeration system A through utilizing the dilute liquid sorbent from the dehumidifier 20 as the cooling medium in the condenser 12 of the refrigeration system A. The sorbent regeneration system B may be of any standard type, but for greatest efficiency the form shown in the drawings at B is preferred. It will be understood that the warm moist air passes through the dehumidifier 20 which takes out most of the moisture and removes latent heat or heat of the moisture from the air. The warm dry air may then be passed through a cooling coil 22 which receives cooling medium through the pipe 17 from the evaporator or cooler 16 and which cooling medium is then returned to the cooler 16 through the pipe 19. Passing the warm dry air through the cooling coil 22 removes a portion of the sensible heat content of that air. The cool dry air then passes into the controlled zone. By thus combining the sorbent regeneration system B with the refrigeration system A, the latent heat removal is accomplished in great part by the use of heat formerly wasted.

The sorbent regeneration system B first conducts the concentrated liquid sorbent, of any standard or suitable type, such as triethylene glycol, lithium chloride and the like, to the dehumidifier 20 through the conduit 18. As is well known an air stream is forced through the dehumidifier 20 by a fan (not shown), where it passes through a spray or cascade of the concentrated sorbent which absorbs moisture from the air stream, thus dehumidifying it. As previously stated, liquid sorbent thus diluted is conducted through the condenser 12 of the refrigeration system A, where it acts as the cooling medium for the refrigerant in the condenser 12. In the process the dilute liquid sorbent acquires considerable heat, and it is then conducted to the pre-heat exchanger 24 in the air stream 26 of the closed sorbent regeneration system B. The dilute liquid sorbent there gives up its heat to the air stream and thus preheats the latter for subsequent use. The sorbent may be further cooled in the sorbent cooler 28, which is cooled by any suitable cooling medium, chilled water or the like, or from the cooling medium of the evaporator or cooler 16 of the refrigeration cycle A. The sorbent cooler 28, however, may be omitted entirely if the sorbent is sufficiently cooled without it, and the cooled dilute sorbent then passes to the spray nozzle 30, where the sorbent is regenerated and the moisture extracted from it by passing the heated air stream from conduit 26

through the spray of the dilute sorbent. The regenerated and concentrated sorbent then passes again through pipe 18 back to the dehumidifier 20. The heated moisture containing air after passing through the spray 30 may then be wasted to atmosphere where its heat is entirely lost. But I prefer to conduct it through conduit 32 to the diffusing tower 34 having porous, permeable or pervious walls 35. The side walls 35 of the diffusion tower are made of a porous, permeable or pervious material, relatively densely packed but having fine interstices therethrough which permits the moisture content in the air, in vapor or gaseous form and of relatively high vapor pressure to escape through the walls 35, until the vapor pressure within the diffusion tower 34 equalizes with that of the air surrounding the tower 34. The interstices or passages through the walls 35 are so small that they offer frictional resistance to the passage of air therethrough both from the inside out and from the inside in. The walls 35 thus in effect act as a filter in permitting the high pressure water vapor to escape, but retaining the relatively low pressure heated air therein. The filtered walls 24 may be made of any suitable material, which is preferably rustless, and will not absorb or soak up moisture, such as spun glass, or fine metal wire wool such as stainless steel, copper or brass. The sorbent regeneration system B, with its diffusing tower 34 is more fully described in my co-pending application Serial No. 63,358, filed December, 3, 1948. By conducting the heated and moisture containing air through my diffusion tower 34, at least fifty percent of the heat therein normally lost if exhausted to atmosphere, can be saved by the method and apparatus embodying my sorbent regeneration system B and disclosed in my above mentioned patent application. The air stream with a large portion of its moisture content removed is then re-circulated through the closed sorbent regeneration system B by means of the circulating fan 36, where the air is again passed through the preheat exchanger 24, to repeat the sorbent regeneration cycle. It will thus be seen that by utilizing the warmed dilute liquid sorbent after passing through the condenser 12 of the refrigeration system A, to preheat the air in the closed sorbent regeneration system B, no separate or additional heat source is necessary for preheating the air, as is required in a standard sorbent regeneration system.

It will thus be seen that by combining a standard refrigeration system with a liquid sorbent regeneration system the capacity of a standard refrigeration system, the refrigerating capacity can be doubled, without materially increasing the operating costs, either in power or water consumption.

I claim:

1. The process of air conditioning which combines cooling and dehumidifying the air in a controlled area which consists in combining a refrigeration system for cooling the air wherein a refrigerant in gas form is compressed to high pressure, and then condensed to liquid form, with a liquid sorbent regeneration system for dehumidifying the air, and using the dilute liquid sorbent from the dehumidifier of the controlled air stream in the liquid sorbent regeneration system as the cooling medium for condensing the refrigerant in the refrigeration system, and using the dilute liquid sorbent as heated in condensing the refrigerant in the refrigeration system for preheating the air stream used in regenerating

5

the liquid sorbent in the liquid sorbent regeneration system.

2. The process of air conditioning which combines cooling and dehumidifying the air in a controlled area which consists in combining a refrigeration system for cooling the air wherein a refrigerant in gas form is compressed to high pressure, and then condensed to liquid form, with a liquid sorbent regeneration system for dehumidifying the air, and using the dilute liquid sorbent from the dehumidifier of the controlled air stream in the liquid sorbent regeneration system as the cooling medium for condensing the refrigerant in the refrigeration system, using the dilute liquid sorbent as heated in condensing the refrigerant in the refrigeration system for preheating the air stream used in regenerating the liquid sorbent in the liquid sorbent regeneration system, and regenerating the dilute liquid sorbent by passing said preheated air stream through it.

3. The process of air conditioning which combines cooling and dehumidifying the air in a controlled area which consists in combining a refrigeration system for cooling the air wherein a refrigerant in gas form is compressed to high pressure, and then condensed to liquid form, with a liquid sorbent regeneration system for dehu-

6

midifying the air, and using the dilute liquid sorbent from the dehumidifier of the controlled air stream in the liquid sorbent regeneration system as the cooling medium for condensing the refrigerant in the refrigeration system, using the dilute liquid sorbent as heated in condensing the refrigerant in the refrigeration system for preheating the air stream used in regenerating the liquid sorbent in the liquid sorbent regeneration system, and regenerating the dilute liquid sorbent by passing said preheated air stream through it, and conducting the heated air stream through an equalizer chamber exposed on its outer surface to normal atmospheric pressure and having porous walls permeable to the passage of high pressure water vapor in said preheated air stream, but resistant to the passage of air therethrough.

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