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AIR CONDITIONING SYSTEM EMPLOYING A HYGROSCOPIC MEDIUM

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FIG. 1

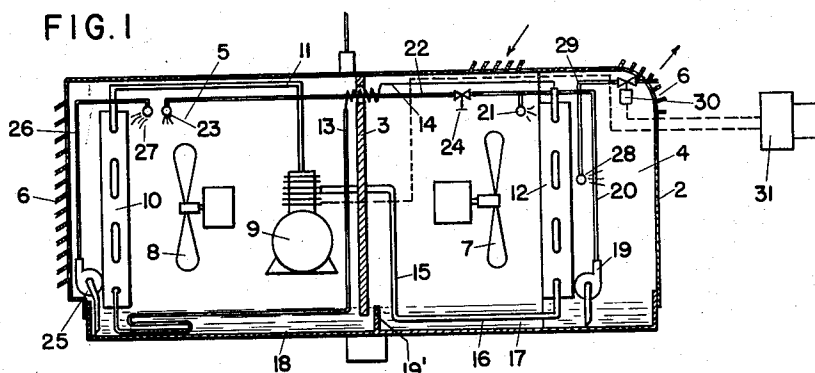


FIG. 3

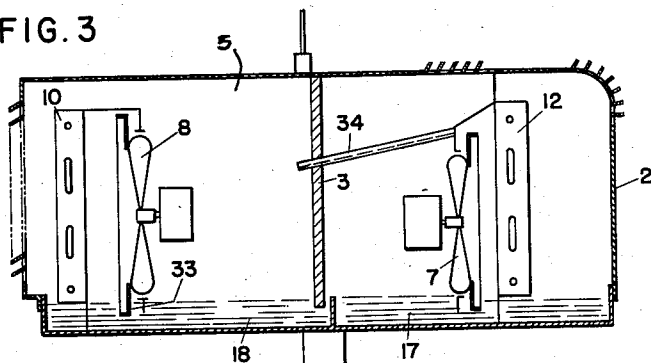


FIG. 4

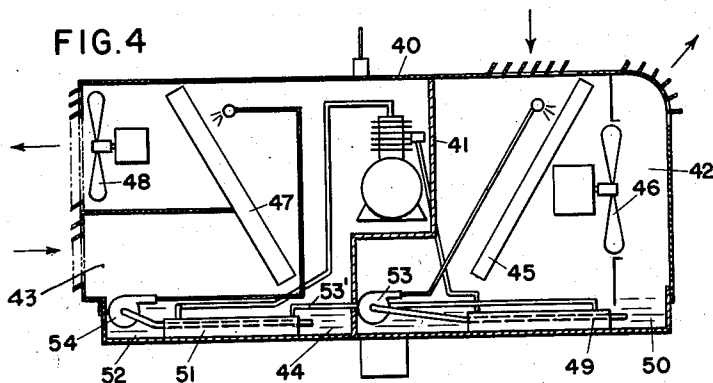
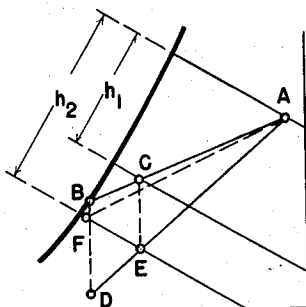


FIG. 2



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## UNITED STATES PATENT OFFICE

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AIR CONDITIONING SYSTEM EMPLOYING  
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This invention relates to air conditioning units and more particularly to the introduction of a hygroscopic medium in an air conditioning unit to achieve greater capacity, to effect a substantial reduction in initial cost of the unit, and to provide lower relative humidity.

The chief object of the present invention is to provide an economical air conditioning unit for conditioning air to provide a lower relative humidity which permits substantial reductions in operating costs.

A further object is to provide an air conditioning unit for conditioning air to provide a lower relative humidity in which the size of the compressor employed in the unit is reduced in comparison with units heretofore known to achieve a great reduction in initial and operating costs.

A further object is to provide an air conditioning unit in which hygroscopic medium is employed to provide greater flexibility as to arrangement of components of the unit, and to effect a great reduction in initial and operating costs of the unit. Other objects of the invention will be readily perceived from the following description.

This invention relates to an air conditioning system which comprises in combination a first air passage containing the evaporator of a refrigerating system, a second air passage containing the condenser of the refrigerating system and fans to direct streams of air to be cooled or heated respectively through the air passages. Means are provided in the first passage to distribute a hygroscopic medium over the evaporator in the path of the first air stream to remove moisture therefrom. At least a portion of the hygroscopic medium carrying removed moisture is transferred to the second passage and distributed over the condenser in heat exchange relation with the second air stream, thus removing moisture from the hygroscopic medium to concentrate the same. The concentrated hygroscopic medium is then returned to the first passage and is again distributed over the evaporator in the path of the first air stream to remove moisture therefrom.

The attached drawings illustrate a preferred embodiment of my invention in which:

Figure 1 is a diagrammatic view of an air conditioning unit embodying the present invention;

Figure 2 is a skeleton psychrometric chart illustrating the principle of operation of the invention;

Figure 3 is a fragmentary view illustrating a

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modification of the mechanism for distributing hygroscopic material in the path of the air streams passing through the unit; and

Figure 4 is a diagrammatic view illustrating a modification of the invention.

Referring to the drawings, there is disclosed in Figure 1 an air conditioning unit including a casing 2 separated by a partition 3 into two air passages 4 and 5. The usual louvre openings 6 are provided in each passage 4 and 5 to permit air to be directed through casing 2. A fan 7 is provided in passage 4 to draw air therethrough and to discharge such air into the area being conditioned. A fan 8 is provided in air passage 5 to draw air therein and to discharge the air from the casing 2.

A refrigeration system is provided to cool the air drawn through passage 4. The refrigeration system includes the compressor 9 preferably disposed in passage 5, and connected to condenser 10 placed in passage 5 by discharge line 11. Condenser 10 is connected to evaporator 12 placed in passage 4 by liquid line 13. A capillary tube 14 for example is placed in line 13 to regulate the quantity of refrigerant passing to evaporator 12. Evaporator 12 is connected to compressor 9 by suction line 15.

A sump 16 preferably is formed in the lower portion of casing 2. Sump 16 preferably is divided into two portions, 17 and 18, portion 17 being placed in passage 4 while portion 18 is placed in passage 5. A weir 19 is placed in sump 16 to regulate the flow of medium from portion 18 to portion 17. Hygroscopic material such as tri-ethylene glycol is contained in sump 16. It will be understood, of course, other hygroscopic materials may be employed in the present invention; for example, water solutions or brines of the chlorides or bromides of various inorganic elements such as lithium chloride, lithium bromide and calcium chloride may be employed. A pump 19 circulates medium from portion 17 through line 20 to nozzles 21 which sprays the medium over the surface of evaporator 12, the medium flowing down such surface and returning to portion 17 of sump 16. Preferably, a bypass line 22 is connected to line 20 to direct some portion of medium to passage 5, such medium being sprayed through nozzle 23 over the surfaces of condenser 10 or if desired, permitting the medium to flow into the sump portion 18. A valve 24 may be placed in line 22 to permit the amount of medium directed to passage 5 to be regulated.

A pump 25 withdraws medium from sump por-

tion 16 and distributes such medium over the surface of condenser 10 through line 25 and nozzles 27, the medium after passage over the surfaces of condenser 10 returning to sump portion 18. As the level in sump portion 18 rises, some portion of concentrated medium therein overflows the weir 19' to raise the level of medium in sump portion 17. Preferably, the concentrated medium and diluted medium are placed in heat exchange relation by directing the diluted medium through a coil (not shown) placed in the sump or by directing line 22 through sump 18. Liquid line 13 may pass through sump portion 18 in heat exchange relation with medium in such portion of the sump.

Considering the operation of the device, fan 7 directs air to be treated through evaporator 12. Pump 19 withdraws hygroscopic medium from sump portion 17 and sprays the medium through nozzles 21 on the surfaces of evaporator 12, in heat exchange relation with air passing there-through. Spraying the medium over the evaporator surface increases the cooling capacity of the evaporator because a lower equilibrium vapor pressure is established by the medium, thereby removing more moisture from the air than would occur without the use of the medium. A small quantity of the medium is directed through by-pass 22 to passage 5 for reconcentration. Pump 25 sprays medium for pump portion 18 over the surfaces of condenser 10, thereby raising the equilibrium vapor pressure of the medium above the prevailing outside air dew point causing the water to be evaporated into the air stream for discharge outside of the enclosure in which the unit is placed, the concentrated medium returning to the sump portion 18. The concentrated medium continuously flows over weir 19' to sump portion 17 in an amount corresponding to that bled off through by-pass 22. Air directed through passage 4 is cooled and dehumidified while the heat so transferred to the refrigerant and to the hygroscopic medium is removed in passage 5 since the stream of air directed through condenser 10 condenses refrigerant therein and removes moisture from the hygroscopic medium sprayed on the surfaces of the condenser.

The unit as described above possesses considerably more capacity than a conventional refrigeration cycle including the same compressor, condenser, and evaporator. The air distributed from the unit through passage 4 is at a reduced temperature and at a very low dew point. Under some circumstances, it may not be desirable to utilize such a large amount of dehumidifying capacity. In such circumstances, the dehumidifying capacity can be converted to sensible cooling capacity by the addition of moisture to the air stream leaving passage 4. If desired, an atomizing spray nozzle 28 is placed in the path of air leaving the evaporator, nozzle 28 being connected by line 29 to a suitable source of supply.

For purposes of control of the addition of water to the leaving air stream the solenoid valve 30 may be placed in line 29, solenoid valve 30 being controlled by means of a thermostat 31. Thermostat 31 may be a common two step type control responsive to a drop in temperature of the room in which the unit is placed. Upon a predetermined drop in room temperature, the solenoid valve is closed to reduce the sensible cooling capacity of the unit while increasing the dehumidifying effect which is a desirable operating condition under reduced loads and prevents a

rise of room relative humidity on partial load operation. A further drop in room temperature may actuate the thermostat 31 to discontinue operation of compressor 9. While I have disclosed a two step on and off type of control, it will be understood that in larger systems a modulating type of control may be employed.

In Figure 2, I have illustrated on a skeleton psychrometric chart the principle of operation of the air conditioning unit described above. Referring to Figure 2, assuming a conventional refrigeration system operating with an evaporator surface temperature B upon air to be treated at condition A, air may leave the unit at condition C. The total heat removal would correspond to the enthalpy difference  $h_1$ . When a hygroscopic medium is sprayed over the evaporator with the same air quantity and the same surface temperature, the equilibrium condition will be at a lower lever D. For example, assuming 77% tri-ethylene glycol employed as the hygroscopic medium, this equilibrium condition will be at a dew point 18° lower than the surface temperature B and at the same dry bulb temperature. The air will then leave the unit at condition E. The total amount of cooling is represented by the enthalpy difference  $h_2$ .

If it is desired to have greater sensible cooling capacity in place of dehumidifying capacity, moisture is evaporated in the air stream to cause adiabatic cooling from, for example, condition E to condition F. This represents substantially the same sensible heat factor in the room as a conventional system but results in a greatly increased cooling capacity as represented by the line AF as compared to the line AC.

It will be appreciated that with a given compressor it is impossible to maintain the same surface temperature after the medium is sprayed on the evaporator. However, when medium is sprayed over the evaporator the compressor capacity and the evaporator capacity balance off at a dew point at a higher refrigerant temperature with an increase in capacity of the evaporator. The usual objection to designing to a high refrigerant temperature is not present because the dehumidifying capacity obtained from the medium more than offsets the loss of dehumidification resulting from the increase in refrigerant temperature.

While I have described sump 16 as extending beneath the condenser and the evaporator of the refrigeration system, it will be appreciated separate sumps may be provided together with means to return concentrated solution to passage 4 and to supply diluted medium to passage 5 for concentration.

In Figure 3, I have illustrated a modification of my invention in which pumps 19 and 25 are eliminated. In this case slingers 33 may be employed to distribute medium over the surfaces of evaporator 12 and condenser 10. A gutter 34 may be provided to pass a desired portion of diluted medium to passage 5. Heat exchangers, as described above, may be provided if desired.

In Figure 4, there is illustrated a modified self-contained air conditioning unit which comprises a casing 40 separated by a partition 41 into air passages 42 and 43. A sump 44 is provided adjacent the bottom of casing 40. Sump 44 may be similar to sump 16 as described above. A filter or air washing member 45 is placed in passage 42, air being drawn through such passage and discharged into the area being treated by fan 46. A second air washing member 47 is placed in pas-

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sage 43, air being drawn through such passage by fan 48. The usual refrigeration system as described above may be employed. In this case, the evaporator 49 is a double pipe interchanger placed in sump portion 50 in heat exchange relation with hygroscopic medium therein. The condenser 51 may also be a double pipe interchanger and is placed in sump portion 52 in heat exchange relation with hygroscopic medium therein. A pump 53 withdraws medium from sump portion 50 and sprays the same over filter 45 in heat exchange relation with air passing through passage 42. Pump 53 also forwards some portion of such medium to passage 43 for reconcentration as shown at 53'. A second pump 54 sprays medium to be concentrated over member 47. The concentrated medium returns to sump portion 50 by any suitable means. The medium is cooled by evaporator 49 and is sprayed over the surfaces of filter 45 by pump 53. Air to be treated is directed through filter 45 in heat exchange relation with the cooled medium sprayed thereon, thus cooling and removing moisture from the air being treated. The medium is reconcentrated in passage 43 because it is heated by condenser 51 and an equilibrium dew point obtained which is higher than the outside air dew point, thus the outside air passing through member 47 carries off the moisture removed at member 45 reconcentrating the medium.

The modified unit illustrated in Figure 4 as well as the unit shown in Figure 1 provides a substantial reduction in cost because of less heat transfer surface and provides effectively greater capacity for the same suction pressure because the solution gives an equilibrium dew point perhaps 10° lower than would be obtained on straight air cooling. Another advantage of such unit resides in the fact that the filter is self-cleaning since it is used for wetted surface as well as air cleaning. Greater flexibility as to arrangement of components in the casing is permitted since no problem exists as to levels or water disposal.

The present invention provides an air conditioning unit of improved design and more economical manufacture. The present unit permits smaller heat exchange surfaces and a smaller size of compressor to be employed than is customary in air conditioning units of conventional design. The present invention permits smaller units of similar capacity to be provided and permits similar size units of greater capacity to be employed. The present invention provides a substantial reduction in cost and permits increased flexibility with regard to arrangement of components of this system.

While I have described a preferred embodiment of my invention, it will be understood my invention is not so limited since it may be otherwise embodied within the scope of the following claims.

I claim:

1. In an air conditioning unit, the combination of a first air passage, a second air passage, a refrigeration system including a first heat exchange member in the first passage and a second heat exchange member in the second passage, means for directing a stream of air through the first passage, means for directing a second stream of air through the second passage, means to place a hygroscopic medium in heat exchange relation with the first member and in heat exchange relation with the first air stream to remove mois-

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ture therefrom, means for supplying at least a portion of the diluted hygroscopic medium to the second passage, means in the second passage to place the diluted hygroscopic medium in heat exchange relation with the second member and in heat exchange relation with the second air stream to transfer moisture thereto thereby concentrating the medium, and means for returning concentrated medium to the first passage, and means to evaporate moisture in the air stream leaving the first heat exchange member.

2. An air conditioning unit according to claim 1 in which a thermostat is provided responsive to a change in area temperature to actuate the evaporating means.

3. In an air conditioning unit, the combination of a first air passage, a second air passage, a sump containing hygroscopic medium, hygroscopic medium in one portion of the sump being concentrated to a greater degree than hygroscopic medium in a second portion of the sump, a filtering member in the first air passage, a distributing member in the second air passage, means for directing an air stream through the first passage, means for directing a second air stream through the second passage, a refrigeration system including a first heat exchange member in the first sump portion and a second heat exchange member in the second sump portion in heat exchange relation with medium therein, means for distributing cooled hygroscopic medium over the filtering member in the path of the first air stream to cool the air and to remove moisture therefrom, means for supplying diluted medium to the second passage in heat exchange relation with the second heat exchange member to heat the medium, means for distributing heated diluted medium over said distributing member in the path of the second air stream to concentrate the medium, and means for supplying concentrated medium from the second portion of the sump to the first passage.

4. A method of air conditioning in which the steps consist in cooling a stream of air to be conditioned while simultaneously placing a hygroscopic medium in the path of the stream to remove moisture therefrom, bleeding a portion of the hygroscopic medium into the path of a second air stream, concentrating the medium by passing it through a heat exchanger placed in the path of the second air stream, and returning the concentrated medium to the path of the first air stream, and spraying moisture in the first air stream after its passage in heat exchange relation with the hygroscopic medium to reduce the dry bulb temperature of the first air stream.

5. In an air conditioning unit, the combination of a casing, a partition in the casing cooperating therewith to form a first passage and a second passage, means to direct a stream of air through the first passage, means to direct a stream of air through the second passage, a refrigeration system in the casing including an evaporator in the first passage in the path of air directed therethrough and a condenser in the second passage in the path of air directed therethrough, means to distribute a hygroscopic medium over the evaporator in the path of air to be conditioned to remove moisture therefrom, means for supplying at least a portion of the diluted medium to the second passage, said concentrated medium and diluted medium being placed in heat exchange relation, means to distribute the diluted medium over the condenser in the path of the second air stream to remove moisture there-

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from, a sump in the bottom of said casing, and means in said sump to regulate flow of concentrated medium from the second passage to the first passage.

6. In an air conditioning system, the combination of a first air passage, means to direct air to be conditioned through the passage, a second air passage, means to direct air through the second passage, a refrigerating system including an evaporator placed in the path of the air directed through the first passage, and a condenser for condensing refrigerant placed in the second passage, means to supply hygroscopic medium to the evaporator, a distribution member to distribute the hygroscopic medium over the evaporator in the path of the first air stream to remove moisture therefrom, a line connecting said supply means to the distribution member, a bypass connecting said line to the first air passage to bleed a desired quantity of hygroscopic medium to the

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second passage, means for distributing some portion of said hygroscopic medium over the condenser in the path of the second air stream to transfer moisture to the second air stream thereby concentrating the medium, and means for returning concentrated hygroscopic medium to the first passage, said hygroscopic medium supplied to the second passage being placed in heat exchange relation with hygroscopic medium returning to the first passage.

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