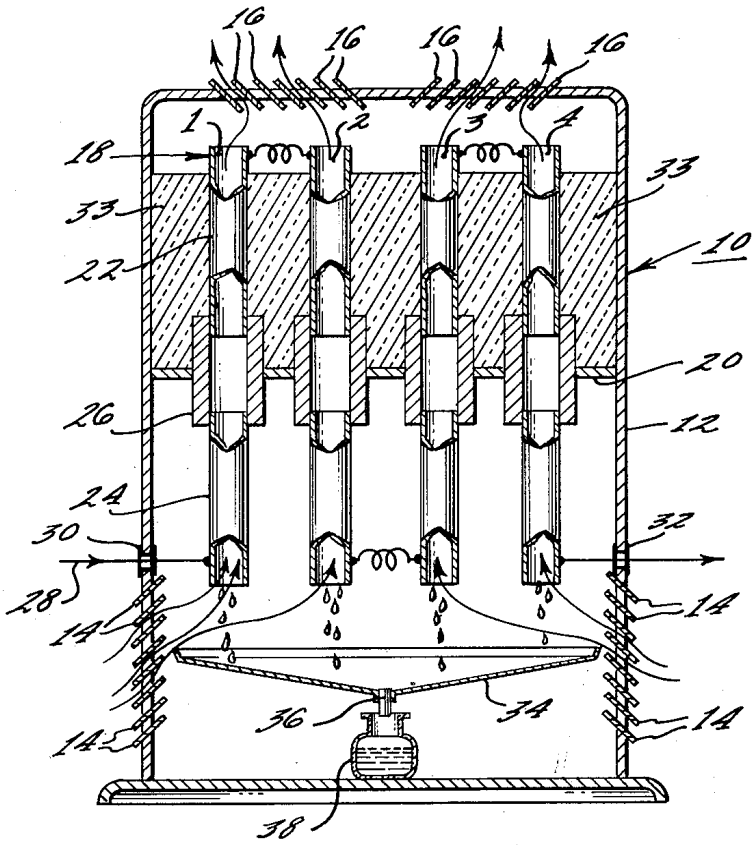
Jan. 29, 1957 N. E. LINDENBLAD 2,779,172

THERMO-ELECTRIC DEHUMIDIFIER

Filed Sept. 28, 1954



INVENTOR.
Nils E. Lindenblad
BY
Morrish Robbins
ATTORNEY.

United States Patent Office 2,779,172 Patented Jan. 29, 1957

2,779,172

THERMO-ELECTRIC DEHUMIDIFIER

Nils E. Lindenblad, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application September 28, 1954, Serial No. 458,836

10 Claims. (Cl. 62—140)

This invention relates to apparatus for removing water vapor from air, and more particularly to compact dehumidifiers that operate silently.

In order to extract moisture from the surrounding atmosphere, a flow of ambient air is propelled through a water vapor condensing apparatus. If a mechanical fan is used to propel this air, it must be in direct communication with the surrounding atmosphere. Any noise generated by the fan is, therefore, transmitted to the surrounding atmosphere. This noise may be troublesome when the dehumidifier is used in an inhabited compartment. This invention provides a compact dehumidifier that can be comfortably utilized in an inhabited compartment.

An object of this invention is to provide a dehumidifier that operates relatively silently.

Another object is to provide a relatively silent air propelling device for a dehumidifier.

A further object is to provide a silent dehumidifier that that operates without moving parts.

In accordance with this invention, a vertical column or columns of air are provided within a casing. The casing has air inlets in its lower portion and air outlets in its upper portion. Means are provided for heating the upper portions of these air columns, and means are provided for cooling the lower portion of these columns. The heated air is expanded and forced upward from these columns by the heavier ambient air. As the air flows through the lower cold portions of these columns, it is cooled below the dew point; and water vapor is condensed and extracted therefrom. Provision of a number of columns provides more heat exchange area and, therefore, more dehumidifying effect.

The heating in the upper portions of the columns must exceed the cooling of the lower portions in order to cause the air to expand and rise within the column. If the heat rejecting section of a heat pump is disposed in heat exchange relationship with the upper portion of the column, and its heat absorbing section is disposed in heat exchange relationship with the lower portion of the column; more heat will be added to the air within the column than is absorbed. This is true no matter what known refrigeration cycle is utilized—whether compression cycle, absorption cycle or thermoelectric cycle. The heat rejected includes the work performed to operate the cycle. It is, therefore, greater than the heat absorbed by an amount equal to this cycle work. This excess of heat assures a positive expansion of the air to produce a steady chimney effect.

In accordance with these teachings, therefore, a compact dehumidifier may be constructed combining these columns with a heat pump unit. An extremely quiet unit may be built using a thermoelectric heat pump. A heat pump of the absorption type provides a silent unit, but it may be bulkier and must include a troublesome sealed refrigerant system. A compression type heat pump is not so quiet, and it also must include a sealed refrigerant system. The thermoelectric embodiment, therefore, may

be preferable for a compact dehumidifier for use in inhabited rooms.

Other objects and advantages of the present invention will become apparent to one skilled in the art from a reading of the following description in conjunction with the accompanying drawing the single figure of which is a cross-sectional view in elevation of an embodiment of the present invention.

This dehumidifier **10** is constructed within a casing **12** which may be formed, for example, of sheet steel. Air inlet means which may be, for example, a series of louvers **14** are provided in the lower portion of the casing. Air outlet means which may be, for example, louvers **16** are provided in the upper portion of the casing. An array of tubes or chimneys **18** is vertically supported within the casing. Vertical air columns are, therefore, provided within these tubes. These tubes are supported by a horizontal partition **20**. In this cross-sectional view, four of these tubes are shown. There are, therefore, four holes in the horizontal partition **20** to receive and hold these tubes. Any other convenient supporting means for vertical tubes may be provided instead of the partition.

Heat pump means is provided for heating the upper portions of these tubes and for cooling the lower portions of these tubes. Heat is pumped from the lower portions to the upper portions by the heat pump. Any of the well known types of heat pumps may be utilized such as the compression type, the absorption type or the thermoelectric type. In this illustrative embodiment, the thermoelectric type heat pump is utilized. It has the advantage of being compact, silent and free of gaseous refrigerant under pressure.

In all of these heat pump cycles, the heat given off from the heat rejecting side of the pump includes the work energy expended in pumping heat from the heat absorbing side of the pump to the heat rejecting side of the pump. More heat is, therefore, given off than is absorbed. This phenomenon provides heat for the movement of air without the use of a mechanical fan.

A flow of gas through a chimney is produced by the difference in weight between the column of hot gas in the chimney and a column of equal height of outside air. The gas or air within the chimney is at a higher temperature than the outside air and is lighter in weight. Since all of the known refrigeration cycles inherently liberate more heat than they absorb, liberation of heat to the air column is consistently achieved.

In order to operate as a dehumidifier, the air, on entering the tubes, is chilled below its dew point. It then passes up through the tube by virtue of the chimney effect after a portion of the moisture within has been condensed. Before passing out of the top of the chimney or tube, it is heated to slightly above ambient temperature by the heat rejecting side of the heat pump. It then passes out of the louvers **16** provided in the upper portion of the dehumidifier casing.

This illustrative dehumidifier utilizes the thermoelectric effect. The tubes **18** are made in three portions. The upper and lower portions or extremities **22** and **24**, respectively, are made of a heat and electricity conducting material. They may be made, for example, of copper tubing. The center or intermediate portion **26** of the tubes is made of materials having dissimilar thermoelectric properties. When these intermediate portions are thermoelectrically coupled, they provide hot and cold junctions. The intermediate portion of one of these tubes may be made, for example, of bismuth; and the intermediate portion of another of these tubes may be made of antimony. When an electric current is passed through a circuit which thermoelectrically couples an element of bismuth with an element of antimony, a cold

and hot junction is formed in accordance with the well known Peltier effect.

Tube **1** has an element of bismuth as its intermediate portion. Tube **2** has an element of antimony as its intermediate portion. Tube 3 has an element of bismuth as its intermediate portion, and tube 4 has an element of antimony as its intermediate portion. These elements may be intermediate portions of the tubes as shown, or they may be merely electrically joined or connected to the walls of these tubes.

A convenient means of connecting these thermoelectric elements to provide hot junctions at the upper portions of tubes or chimneys and cold junctions at the lower portions of the tubes or chimneys is to connect them in a series circuit. An electrical conductor **28** passes through the wall of the casing **12**, through an insulated bushing **30**. The bushing may be, for example, rubber, while the electrical conductor may be the ordinary copper wire with rubber waterproof insulation. The upper portion of tube **1** is connected to tube **2**, and the upper portion of tube **3** to the upper portion of the tube **4**. The lower portions of tubes **2** and **3** are also connected. This forms a series electrical circuit which passes up through tube **1**, down through tube **2**, up through tube **3**, down through tube **4** and out of the casing through the rubber bushing **32**. This provides cold junctions at the lower portions of the tubes and hot junctions at the upper portions of the tubes. Any other circuit providing the same arrangement of hot and cold junctions may be utilized.

A barrier of heat insulating material **33** (for example, asbestos) is interspersed between the upper portions of the tubes. It acts in conjunction with partition **20** to cause the air to flow upward within the tubes instead of around them. It also prevents the heat provided by the hot junctions from dissipating outwardly from the tubes. It helps, therefore, to concentrate the heat on the air within the tubes. This assists in expanding and causing the air to rise in an upward direction.

When a direct current is passed through this series circuit, the lower portions of the tubes adjacent the cold junctions become cold. They are cooled below the dew point of the ambient air or surrounding atmosphere. A portion of the water vapor in this air is, therefore, condensed. This water drips down from the lower portions of the tubes. A collecting means which may, for example, be a pan **34** is placed in the lower portion of the casing below the cold portions of the tubes. The bottom of this pan is sloped towards a drain pipe **36**. A receptacle **38** is provided under this drain pipe to catch the condensate.

As current is passed through the circuit, the overall heating effect within each of the tubes or chimneys acts to cause air to be displaced from the tube by the heavier air in the surrounding atmosphere. This air rises through the openings **16** in the casing. As the air passes through the lower portions of the tubes, it is cooled below its dew point and water is liberated therefrom. The dryer air passes upward through the tubes and through the upper portions of the tubes where it is heated to slightly above the ambient temperature. The decrease in weight caused by the liberation of water vapor from the air also assists in heightening the chimney effect.

Other refrigeration cycles may be used for heating the upper portions of these tubes and for cooling the lower portions of these tubes, as previously discussed. The illustrated embodiment, however, provides a highly convenient arrangement for a dehumidifier to be used in an inhabited compartment. It is well adapted for this type of service because it is completely silent, includes no refrigerant under pressure and requires a minimum of maintenance and service work.

What is claimed is:

1. A dehumidifier comprising means providing a substantially vertical column of air, means disposed in heat exchange relationship with the lower portion of said column for cooling said air below its dew point to liberate moisture therefrom, means spaced from said lower portion of said column and disposed in heat exchange relationship with the upper portion of said column for heating said upper portion of said column to provide in cooperation with the surrounding atmosphere a rising column of air, and said heat providing means providing an excess of heat over the heat absorbed by the cooling means to expand the air in said column.

2. A dehumidifier comprising means providing a substantially vertical column of air, a heat pump including a heat absorbing section and a heat rejecting section, said heat absorbing section being disposed in heat exchange relationship with the lower portion of said column for cooling said air below its dew point to liberate moisture therefrom, said heat rejecting section being disposed in heat exchange relationship with the upper portion of said column for heating said upper portion of said column to provide in cooperation with the surrounding atmosphere a rising column of air, and said heat rejecting section inherently providing an excess of heat over the heat absorbed by said heat absorbing section to expand the air in said column.

3. A dehumidifier comprising conduit means providing at least one substantially vertical column of air, a thermoelectric heat pump including cold junctions and hot junctions, said cold junctions being disposed in heat exchange relationship with the lower portions of said column for cooling said air below its dew point to liberate moisture therefrom, said hot junctions being disposed in heat exchange relationship with the upper portion of said column for heating said columns to provide in cooperation with the surrounding atmosphere a rising column of air, and said hot junctions inherently providing an excess of heat over the heat absorbed by said cold junctions to expand the air in said column.

4. A dehumidifier comprising a structure having air inlets and air outlets, an array of substantially vertical chimneys disposed within said structure, said chimneys including upper and lower portions of heat and electricity conducting material, said chimneys including intermediate portions of materials having dissimilar thermoelectric properties providing hot and cold junctions when thermoelectrically coupled, means connecting said chimneys in a circuit to thermoelectrically couple said intermediate portions, said upper portions of said chimneys being disposed adjacent hot junctions and said lower portions being disposed adjacent cold junctions, and means for passing an electric current through said chimneys to induce a flow of air in an upward direction from said inlets to said outlets through said chimneys and to cool the air adjacent said lower portions of said chimneys below its dew point.

5. A dehumidifier comprising a casing having air inlets in its lower portion and air outlets in its upper portion, an array of chimneys substantially vertically disposed within said casing, said chimneys including upper and lower portions of heat and electricity conducting material, said chimneys including intermediate portions of material having dissimilar thermoelectric properties to provide hot and cold junctions when thermoelectrically coupled, said chimneys being connected in an electrical circuit, said upper portions of said chimneys being disposed adjacent hot junctions and said lower portions of said chimneys being disposed adjacent cold junctions, means for passing an electric current through said chimneys to induce a flow of air in an upward direction from said inlets to said outlets through said chimneys and to cool the air adjacent said lower portions of said chimneys below its dew point, and means disposed below said chimneys for collecting condensate extracted from said air by said cooling.

6. A dehumidifier comprising elements which provide hot and cold junctions when thermoelectrically coupled,

an array of heat and electricity conductors, said elements being connected to said conductors, said conductors being connected in a circuit which thermoelectrically couples said elements to provide cold junctions and hot junctions, conduit means for providing a column of air longitudinally disposed adjacent said conductors, the portions of said conductors adjacent said cold junctions providing air condensing means for extracting moisture from said air, the portions of said conductors adjacent said hot junctions providing air expanding means for providing a current of rising air, and said conductors being substantially vertically disposed with said air condensing portions disposed below said air expanding portions to induce said column of air to flow in a substantially upward direction and permit said air condensing portions to continuously extract moisture therefrom.

7. A dehumidifier comprising elements which provide hot and cold junctions when thermoelectrically coupled, an array of heat and electricity conducting tubes, said elements being connected to said tubes, said tubes being connected in a circuit which thermoelectrically couples said elements to provide cold junctions and hot junctions, the portions of said tubes adjacent said cold junctions providing air condensing means for extracting moisture from said air, the portions of said tubes adjacent said hot junctions providing air expanding means for providing a current of rising air within said tubes, and said tubes being substantially vertically disposed with said air condensing portions disposed below said air expanding portions to induce said current of air to flow in a substantially upward direction and permit said air condensing portions to continuously extract moisture therefrom.

8. The combination comprising the invention set forth in claim 7 in combination with a barrier of heat insulating material disposed between the portions of said tubes adjacent said hot junctions for concentrating the heat produced by said hot junctions on the air within said tubes.

9. A dehumidifier comprising a casing, elements within said casing which provide hot and cold junctions when thermoelectrically coupled, a substantially parallel array of heat and electricity conducting tubes disposed within said casing, said casing having an air inlet disposed adjacent one end of said tubes and an air outlet disposed adjacent the other end of said tubes, said elements being connected to said tubes at intermediate portions thereof, the ends of said tubes being connected in a circuit which thermoelectrically couples said elements to provide cold junctions and hot junctions, the portions of said tubes adjacent said cold junctions providing air condensing means for extracting moisture from said air, the portions of said tubes adjacent said hot junctions providing air expanding means for providing a current of rising air, said tubes being substantially vertically disposed within said casing with said air condensing portions disposed below said air expanding portions to induce said column of air to flow in a substantially upward direction to permit said air condensing portions to continuously extract moisture therefrom, and a pan disposed within said casing below said air condensing portions to collect said moisture.

10. A dehumidifier comprising a casing having air inlet means in its lower portion and air outlet means in its upper portion, an array of tubes substantially vertically disposed within said casing, said tubes being comprised of electricity and heat conducting material at the extremities thereof and of materials having dissimilar thermoelectric properties in intermediate portions thereof, means electrically connecting said extremities of said tubes in a manner to provide cold junctions to cool the lower portions of said tubes below the dew point of the ambient air and hot junctions to heat the upper portions of said tubes, means for passing an electric current through said tubes to cause air in said hot portions of said tubes to rise and flow through said outlet means thereby inducing a flow of air through said inlet means into the cold portions of said tubes, and collecting means disposed below the cold portions of said tubes for collecting condensate extracted thereby from said induced flow of air.

References Cited in the file of this patent

UNITED STATES PATENTS

413,136	Dewey	Oct. 15, 1889
1,193,467	Mills	Aug. 1, 1916
2,369,511	Winkler	Feb. 13, 1945
2,685,608	Justi	Aug. 3, 1954