Sept. 13, 1938. C. F. KETTERING 2,130,092

REFRIGERATING APPARATUS

Original Filed Dec. 30, 1931 2 Sheets-Sheet 1

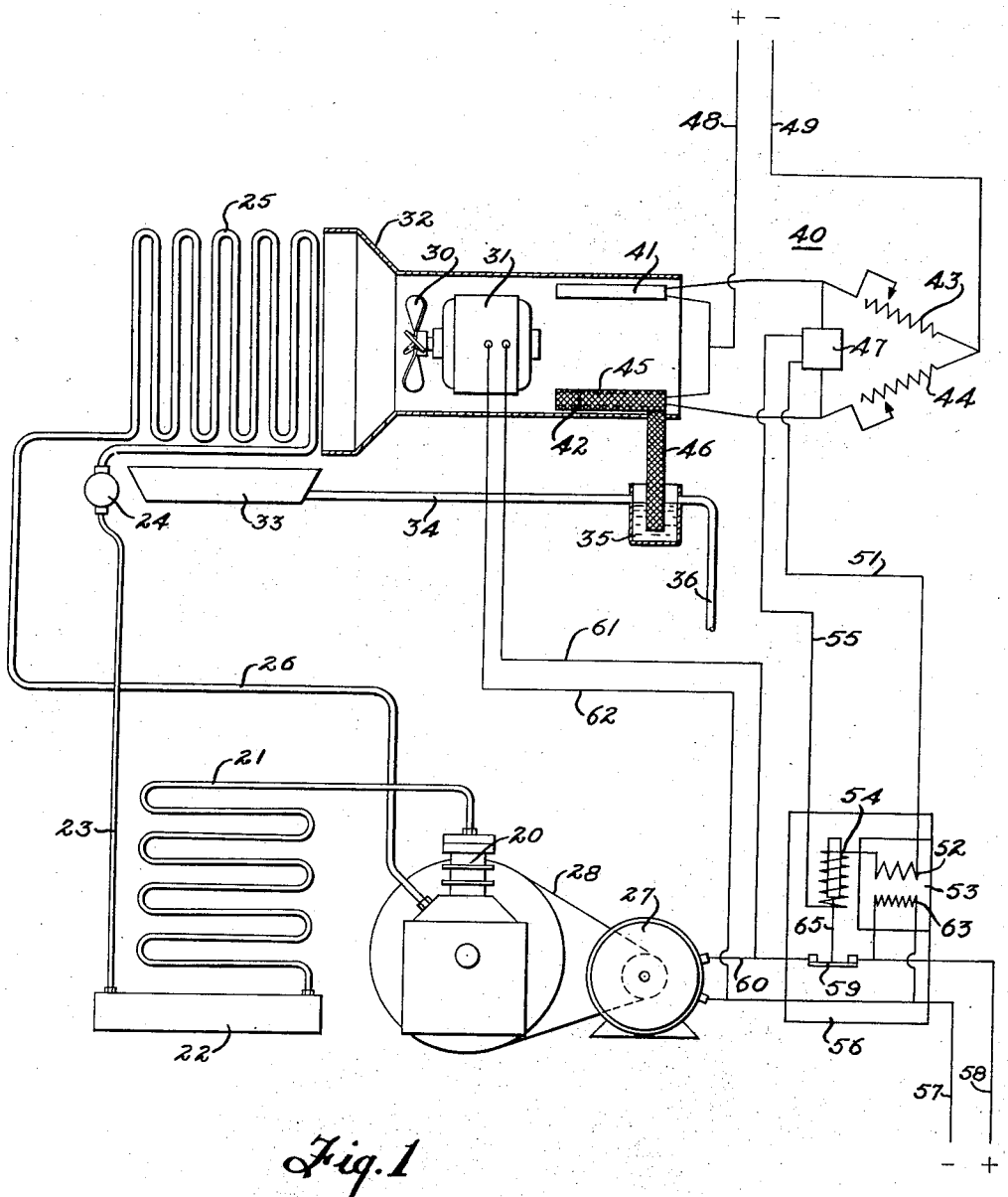

Fig. 1

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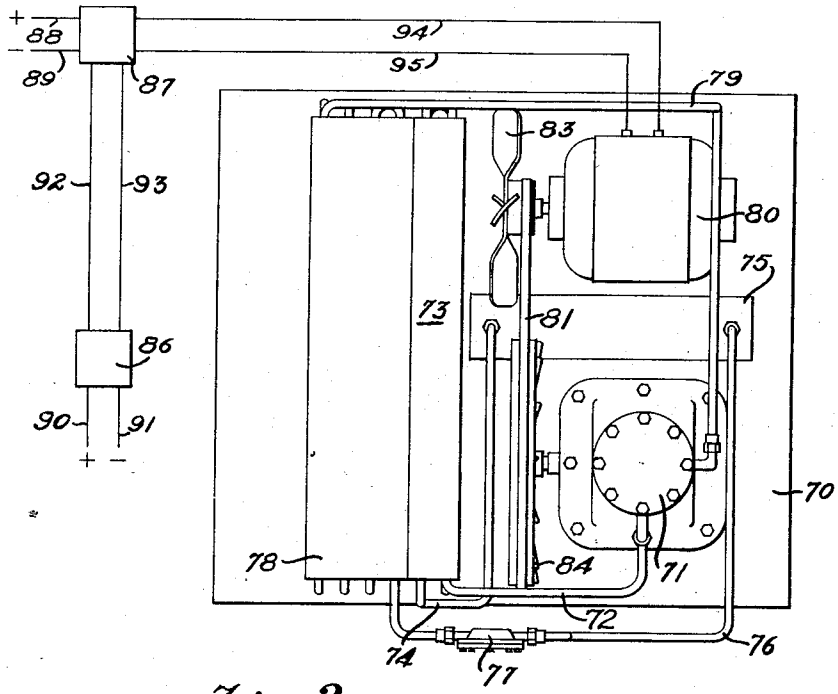

Fig. 2

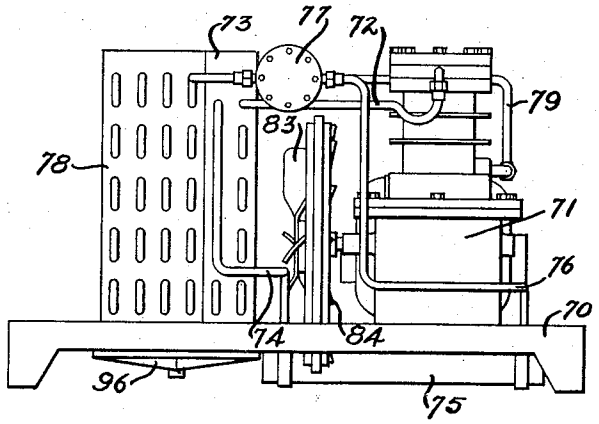

Fig. 3

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REFRIGERATING APPARATUS

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Renewed April 28, 1937

6 Claims. (Cl. 62—140)

This invention relates to refrigerating apparatus and more particularly to automatically controlled air conditioning apparatus.

The popularity of automatically controlled air conditioning has increased rapidly in recent years and the use of apparatus therefor in new and different situations has increased rapidly. The growth of this new industry has been retarded by the relatively high cost of such apparatus. The growth of the industry has also been retarded by the lack of a simplified portable and highly efficient air conditioning apparatus for lowering the relative humidity particularly in damp places and drying rooms.

Consequently the objects of my invention include the provision of an improved, simplified, portable, and highly efficient air conditioning apparatus having a simple automatic control mechanism which can be manufactured and sold at a low cost.

A more specific object of my invention is to provide an improved electrical humidity control mechanism for dehumidifying apparatus employing a Wheatstone bridge circuit and wet and dry bulb resistance thermometers in the arms of the bridge circuit.

Another object of my invention is to provide a refrigerating apparatus for lowering the relative humidity of the room in which apparatus the air after being cooled and dehumidified by the evaporator is passed directly over the air cooled condenser and compressor for cooling the compressed refrigerant to a greater degree, making the apparatus more efficient, and also lowering the relative humidity of the air in the room by the heat which is removed from the condenser and the compressor by the circulating air.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a diagrammatic view of an air conditioning apparatus of the compression type together with my improved humidity control apparatus;

Fig. 2 is a plan view of my improved portable, dehumidifying apparatus including the humidity control apparatus; and

Fig. 3 is an elevational view of my improved portable dehumidifying apparatus.

In Fig. 1 I have shown for the purpose of illustrating my invention an air conditioning apparatus of the compression type including a compressor 20 for compressing the refrigerant and for forwarding the compressed refrigerant to a condenser 21 where the refrigerant is condensed and collected in the receiver 22. From the receiver 22 the refrigerant is forwarded through supply conduit 23 to an expansion valve 24 which controls the flow of refrigerant into the evaporator 25. The refrigerant evaporates under reduced pressure in the evaporator 25 and is returned to the compressor through the return conduit 26. The compressor 20 is driven by a suitable electric motor 27 through pulley and belt means 28. The evaporator 25 is preferably positioned within the room to be conditioned or in communication with the room or place to be conditioned.

The refrigerant liquefying apparatus, comprising a compressor, a motor for driving the compressor, and a condenser may be placed in the room to be conditioned or it may be placed outside of the room to be conditioned and connected to the evaporator through the supply and return conduits 23 and 26. For the purpose of increasing the amount of air passing over the heat transfer surfaces of the evaporator 25 a fan 30 driven by an electric motor 31 provided within a duct 32 is employed for blowing a stream of air over the evaporator 25. The evaporator 25 cools the air, and if desired will dehumidify the air by cooling the air below its dew point, causing moisture to collect upon the evaporator 25 and to run down the surfaces of the evaporator 25 and collect in the catch pan 33, from which the condensed moisture will pass through a conduit 34 to a cup 35, which is kept supplied with water thereby, and from which point the excess is conducted to drain through the conduit 36.

An improved electrical control apparatus is provided for controlling the operation of this air conditioning apparatus. This control apparatus is applicable to any form of apparatus which changes the amount of humidity in air or any other gas. In this electrical control apparatus there is provided a Wheatstone bridge circuit generally designated by the reference character 40 having a dry electrical resistance thermometer 41, preferably non-inductively wound, in one of the arms of the bridge circuit, a wet resistance thermometer 42 in another arm of the bridge circuit, and adjustable resistances 43 and 44 in the other arms of the bridge circuit. The wet resistance thermometer 42 as well as the adjustable resistances 43 and 44 are also preferably non-inductively wound so that alternating current, if desired, may be used for energizing the Wheat-

stone bridge circuit. The bridge circuit is supplied with electric current by the electric conductors 48 and 49 which are connected to both ends of the bridge circuit, the conductor 48 being connected between the wet and dry resistance thermometers 42 and 41 while the conductor 49 is connected between the adjustable resistances 43 and 44. These electric conductors 48 and 49 may be supplied with direct current or with alternating current of a suitable voltage. If desired, alternating current supplied from a transformer connected to the main circuit or any suitable source of alternating current may be used for supplying the current necessary for the use of the Wheatstone bridge circuit.

The wet resistance thermometer 42 is provided with a stockinet 45 covering its surface and a wick 46 which dips into the water within the cup 35 and supplies moisture to the stockinet 45. Both the wet resistance thermometer 42 and the dry resistance thermometer 41 are placed within the duct means 32 so that the air which is drawn through the duct by the fan 30 is drawn over the surfaces of these two thermometers before it is blown over the surfaces of the evaporator 25. The dry resistance thermometer 41 will therefore be responsive to the dry bulb thermometer temperature of the air in the place to be conditioned and the wet resistance thermometer 42, by reason of the evaporation of moisture in the stockinet caused by the air passing thereover, will be responsive to the wet bulb temperature of the air in the room or place conditioned. A normally closed relay 47 is connected to the sides of the Wheatstone bridge circuit between the dry resistance thermometer 41 and the adjustable resistance 43 on one side and between the wet resistance thermometer 42 and the adjustable resistance 44 on the other side.

It is often desirable to operate the apparatus so as to maintain the proper relative humidity at different temperatures. This desired relative humidity will depend upon the particular purpose for which the air is to be conditioned. For drying purposes the main object is to obtain as low a humidity as possible if rapid drying is desired. In textile mills the humidity must be carefully controlled for proper spinning, weaving and winding. For comfort it is desirable that the relative humidity should be lower at higher temperatures. My improved control mechanism can provide a control having any character desired.

If it is desired that the relay should close and the apparatus begin to operate when the relative humidity reaches approximately 100%, the wet and dry resistance thermometers may be made of substantially the same kind of wire and the resistances 43 and 44 are adjusted to be substantially equal. With the bridge circuit arranged in such a manner when the humidity reaches approximately 100%, the temperature of the dry resistance thermometer 41 and the wet resistance thermometer 42 will be substantially the same since very little evaporation will take place from the stockinet. Under these conditions the current flowing through the relay 47 will be at a minimum and the relay contacts will be permitted to move to closed circuit position.

If it is desired to maintain a certain wet bulb depression of temperature throughout the range of temperatures the resistances 43 and 44 may be adjusted to make the current flowing through the relay 47 at a minimum permitting the relay to close when the minimum wet bulb depression has been reached. Under these conditions the resistance 44 will be adjusted to have a lower value than the resistance 43. From the table compiled below it will be seen that a constant wet bulb depression does not give a constant relative humidity.

Percent relative humidity

D. B. temperature	5° F. depression	10° F. depression	15° F. depression
°F.	*Percent*	*Percent*	*Percent*
65	75	53	33
70	78	56	37
75	79	59	41
80	80	62	44
85	81	64	47
90	83	66	50
95	83	67	53

If it is desired to have a constant relative humidity the dry resistance thermometer 41 and the wet resistance thermometer 42 are made of different materials so that the electrical resistance of the resistance thermometers 42 increases more rapidly with increase in temperature than with electrical resistance of the dry resistance thermometer 41. For example, such an effect can be obtained by using copper wire in the wet resistance thermometer 42 and German silver wire in the dry resistance thermometer 41, since the resistance of copper per ohm per degree centigrade at 20° centigrade increases .0041 ohm while under the same conditions the resistance of German silver increases only .00036 ohm. This method can also be employed to obtain a lower relative humidity at higher temperature and a higher relative humidity at lower temperatures by properly selecting the materials used in the thermometers. This condition of relative humidity is much more desirable for personal comfort. If desired, however, instead of using such a means for compensating for variations in temperature, the relay 47 may be adjusted or provided with a temperature compensating bulb for varying the operation of the relay according to the temperature.

The relay 47 is employed to open and close the relay circuit comprising the conductor 51, the secondary winding 52 of the transformer 53, the relay coil 54 and the electric conductor 55. The relay, generally designated by the reference character 65, as well as the transformer 53 are all situated within an enclosed switch housing 56. The opening and closing of the relay circuit by the relay 47 causes the relay 65 to open and close the main supply circuit of the apparatus comprising the electrical conductors 57 and 58. The fan motor 31 and the compressor motor 27 are supplied with electric current through the electric conductors 57 and 58 from the power lines. The electric conductor 58 is connected to the relay switch 59, operated by the relay coil 54 and the relay 65, which switch connects at suitable times the electric conductor 58 with the electric motor 27 through the electric conductor 60 as well as the electric fan motor 31 through the electric conductor 61. The electric conductor 62 completes the electric circuit of the fan motor 31. The transformer 53 is provided with a primary winding 63 which is supplied with current from the electric conductor 58. When the relay 47 is closed, the relay 65 closes causing the electric motors 27 and 31 to drive a compressor 20 and fan 30 respectively thus causing the air conditioning apparatus to operate. When the relay 47 opens, the relay 65 will open and stop the opera-

tion of the apparatus. In this way the air conditioning apparatus will be intermittently operated to maintain the desired humidity.

In damp places and in drying rooms it is usually desired to dehumidify the air without any reference to the temperature of the air. Indeed, in many cases it is desirable that the temperature of the air be increased. For this purpose I have provided a unitary portable air conditioning apparatus controlled by my improved electrical humidity control apparatus for effectively dehumidifying the air within the place desired. Referring to Figs. 2 and 3 I have shown a portable dehumidifying apparatus mounted on a platform 70 including an air-cooled compressor 71 mounted thereon for compressing the refrigerant and for forwarding the compressed refrigerant through the conduit 72 to an air-cooled fin-type condenser 73 where the refrigerant is condensed and forwarded through the conduit 74 to a receiver 75 where this liquefied refrigerant is collected. From the receiver 75 the liquid refrigerant is forwarded through the supply conduit 76 to an expansion valve 77 which controls the flow of liquid refrigerant to the finned evaporator 78 which is situated directly aside of the condenser 73. The condenser and evaporator 73 and 78 are provided with a hood over the top portion. The refrigerant in the evaporator evaporates under reduced pressure and is returned to the compressor through the return conduit 79. All of the above mentioned apparatus is mounted on the platform 70. An electric motor 80, also supported on the platform, is provided for driving the compressor through pulley and belt means 81.

The motor 80 and the compressor 71 are both provided with means for drawing air first through the evaporator and then through the condenser 73 and then over the motor 80 and the compressor 71. For this purpose the motor pulley adjacent the condenser 73 is provided with fan 83 and the combined pulley and flywheel of the compressor 71 is provided with fan blades 84 for drawing air first through the evaporator 78, then through the condenser 73, and finally directing the air over the motor 80 and the compressor 71. In this way the air is first cooled below its dew point in the evaporator which removes moisture from the air, and then the air passes directly into the condenser 73 which transmits the excess heat of the compressed refrigerant to the air thus condensing the refrigerant and warming the air, and finally the air is discharged over the motor and compressor which also give up heat to the air further warming the air. By warming the air with the condenser, compressor and motor the relative humidity is greatly reduced. The system operates highly efficiently since the condenser 73 is cooled by the relative cold air coming from the evaporator 78.

The apparatus is preferably controlled by the improved electrical control apparatus shown in Fig. 1 and has the Wheatstone bridge circuit including the wet and dry resistance thermometers and the relay provided within an enclosure 86 having louvers therein for allowing the air to pass over the wet and dry resistance thermometers on its way to the evaporator 78. This enclosure containing the bridge circuit is preferably placed in the path of the air moving to the evaporator 78. It, however, may be placed in any portion of the room desired, but preferably it should be placed where it will be responsive to the true relative humidity of the room. The primary relay as well as the transformer for the secondary relay circuit are enclosed in the box 87. The electric current for the motor 80 is supplied through the electric conductors 88 and 89. The electric current is supplied to the Wheatstone bridge control circuit through the conductors 90 and 91. The electric conductors 92 and 93 connect the primary relay housed within the box 87 and the secondary relay which is housed within the enclosure 86. The electric conductors 94 and 95 conduct electric current from the box 87 to the electric motor 80.

With this type of dehumidifying apparatus the maximum drying effect is obtained, as well as the maximum efficiency. This is accomplished by reason of the fact that the air cooled by the evaporator is employed for cooling the condenser, the compressor and the electric motor which raise the temperature of the air without increasing its humidity content. The moisture condensed by the evaporator 78 is collected in a catch pan 96 from which it is removed by means of a drain pipe or other convenient means. My improved control apparatus so controls its operation of the electric motor 80 so as to prevent the humidity from rising above the permissible maximum.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. A unitary portable refrigerant dehumidifying apparatus to be placed in a room to be dehumidified including common supporting means for said apparatus, a refrigerant liquefying apparatus mounted upon said supporting means, said refrigerant liquefying apparatus including a condenser having a plurality of air passages therethrough discharging directly into the room, evaporating means also having a plurality of air passages therethrough discharging directly into the air passages in the condenser and being mounted on said supporting means, said evaporating means being located aside of and connected to the condenser, and fan means for circulating air from the room to be dehumidified first through the air passages in said evaporating means to cool the air below its dew point for removing water vapor therefrom and then through the air passages in the condenser to warm the air to lower its relative humidity and to cool and condense the refrigerant passing through the condenser and finally discharging the dehumidified air into the room to lower the relative humidity of the air therein.

2. A unitary portable refrigerant dehumidifying apparatus to be placed in a room to be dehumidified including a common supporting means for said apparatus, a refrigerant liquefying apparatus mounted upon said supporting means, said refrigerant liquefying apparatus including a motor, a compressor driven by said motor, a condenser having a plurality of air passages therein discharging directly onto the motor and compressor, said condenser being connected to said compressor, evaporating means operatively connected to said condenser and evaporator, said evaporating means being supported on said supporting means at the side of said condenser, said evaporating means having a plurality of air passages therethrough discharging directly into the air passage in the condenser, and fan means for circulating air from the room to be dehumidified first over the evaporator to cool the air below its dew point for removing water vapor therefrom and then

over the condenser, compressor, and motor to warm the air to lower its relative humidity and to cool and condense the refrigerant passing through the condenser and finally discharging the dehumidified air into the room to lower the relative humidity of the air therein.

3. A unitary portable dehumidifying apparatus having a common supporting means, a refrigerant evaporating means and a refrigerant condensing means mounted upon said supporting means, means mounted upon the supporting means for drawing evaporated refrigerant from the evaporating means and discharging it into the condensing means, said evaporating means being provided with means for conducting air to the condensing means, and means for circulating air from the space to be dehumidified first in heat exchange relation with the evaporating means, then directly in heat exchange relation with the condensing means, and then returning the air to the space to be dehumidified.

4. A unitary portable dehumidifying apparatus having a common supporting means, a refrigerant evaporating means and a refrigerant condensing means mounted side by side upon the supporting means, a refrigerant compressing means connected to the condensing and evaporating means and mounted upon the supporting means at the side of the condensing means, and fan means located between the compressing and condensing means for circulating air to be dehumidified first in heat exchange relation with the evaporating means and then in heat exchange relation with the condensing means.

5. A unitary portable dehumidifying apparatus having a common supporting means, a refrigerant evaporating means and a refrigerant condensing means mounted side by side upon the supporting means, a refrigerant compressing means connected to the condensing and evaporating means and mounted upon the supporting means at the side of the condensing and evaporating means, and means for circulating air to be dehumidified first in heat exchange relation with the evaporating means and then in heat exchange relation with the condensing means.

6. In combination, a compressor, condenser and evaporator in refrigerant flow relationship, and fan means carried by the compressor shaft, said fan being disposed between the compressor and evaporator whereby said fan circulates air over the compressor and evaporator in series.

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