March 7, 1944. D. H. REEVES 2,343,581

REFRIGERATING APPARATUS

Filed Jan. 28, 1939 3 Sheets-Sheet 1

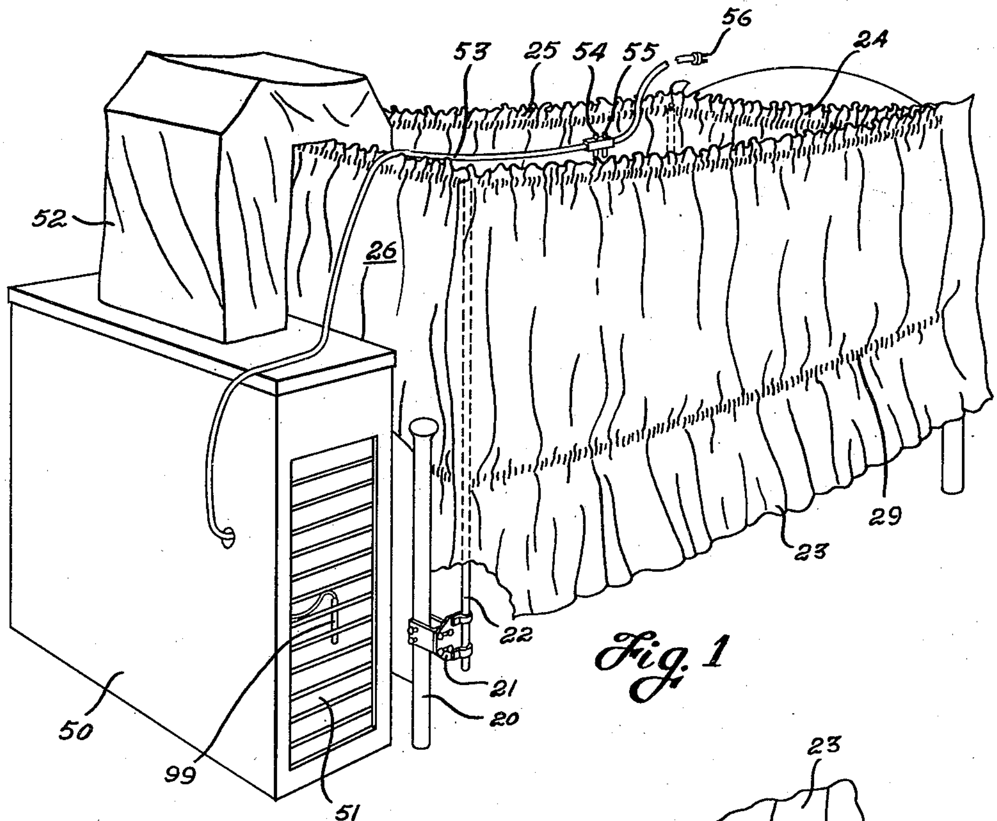

Fig. 1

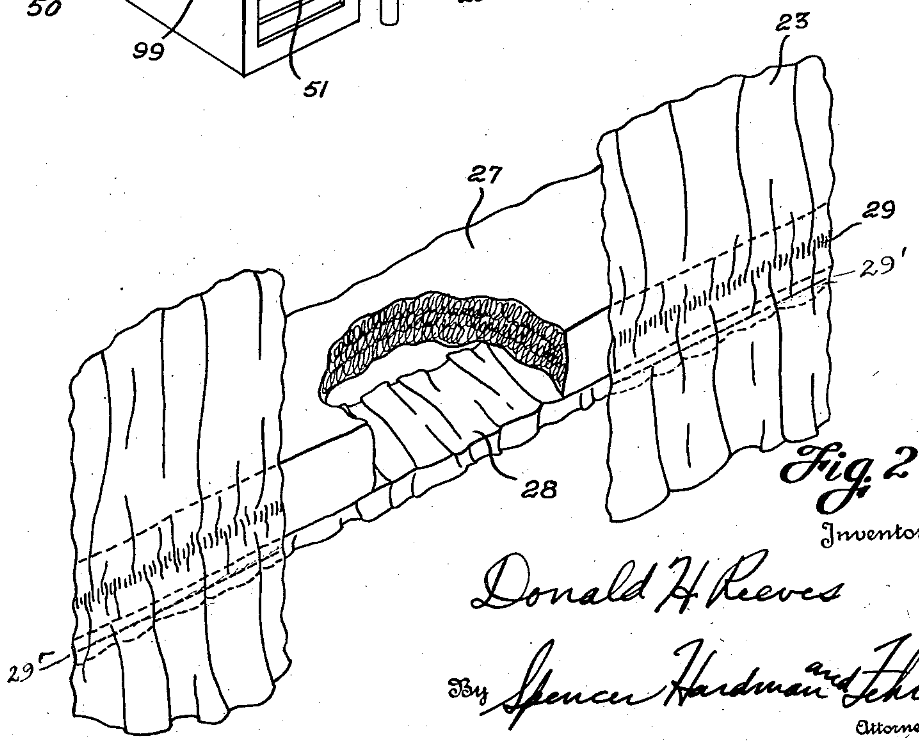

Fig. 2

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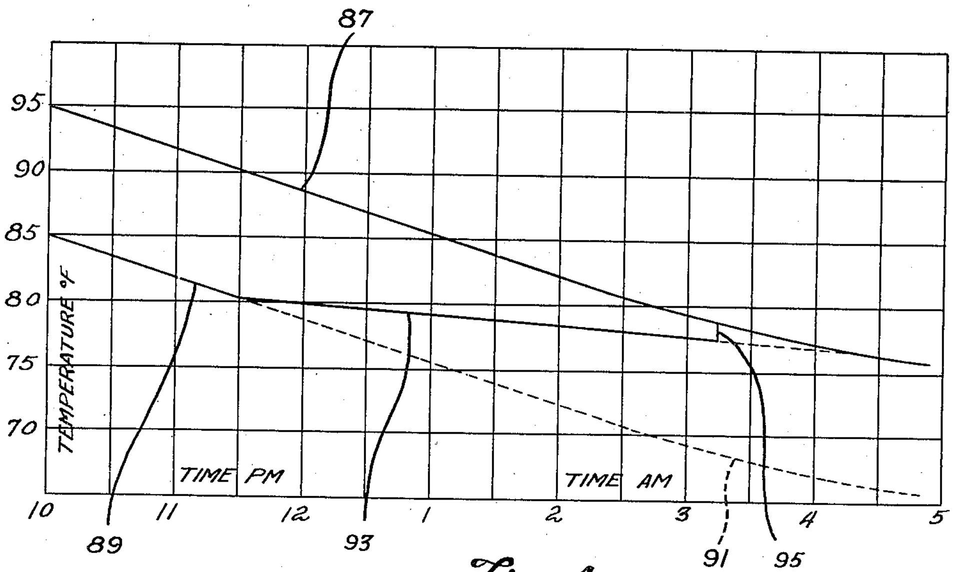

Fig. 4

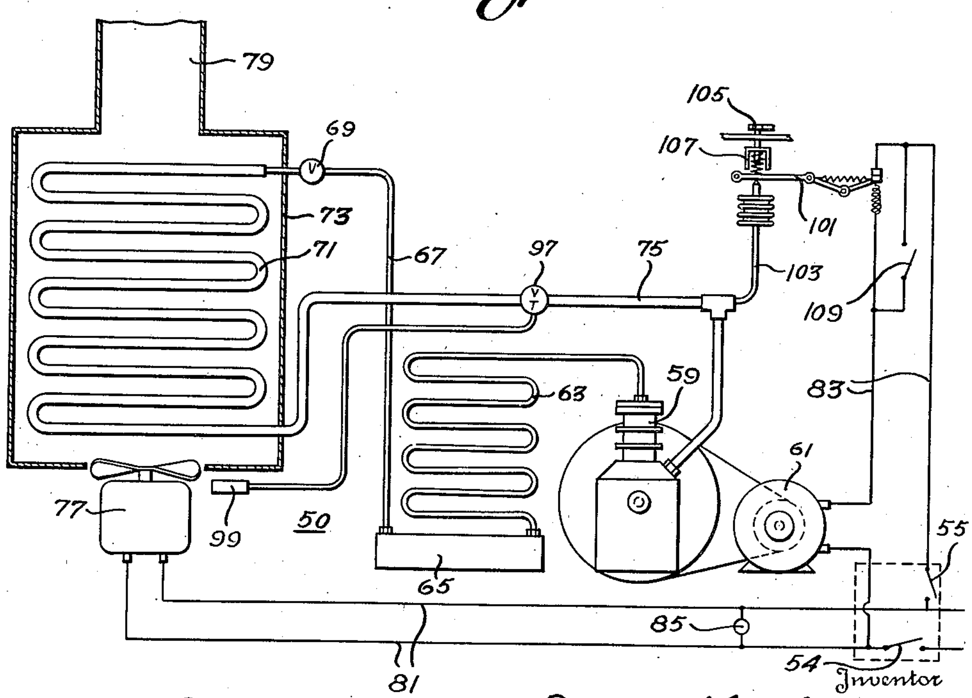

Fig. 3

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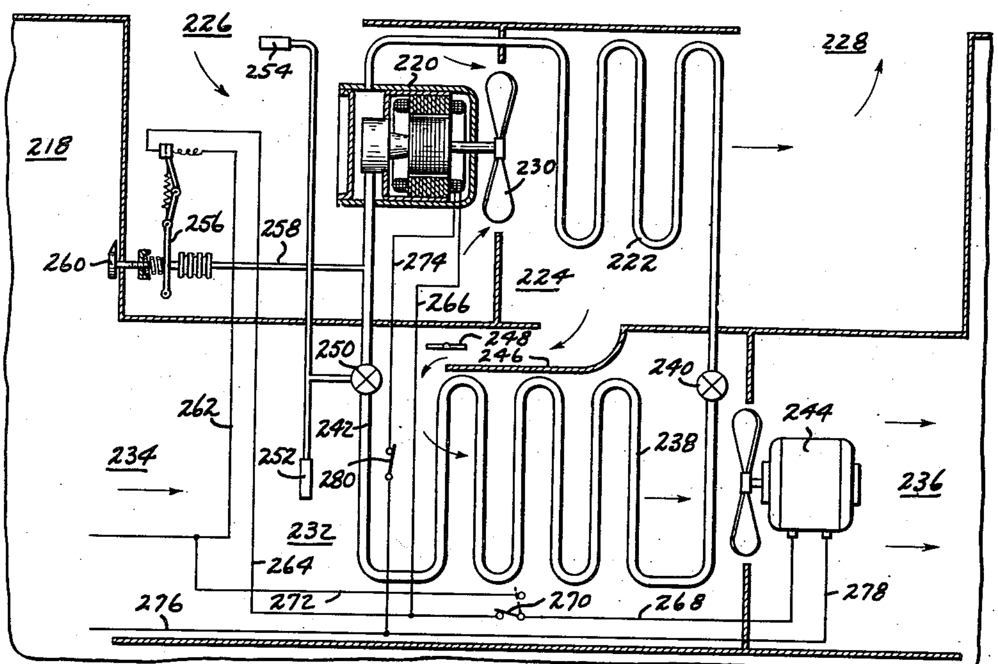

Fig. 5

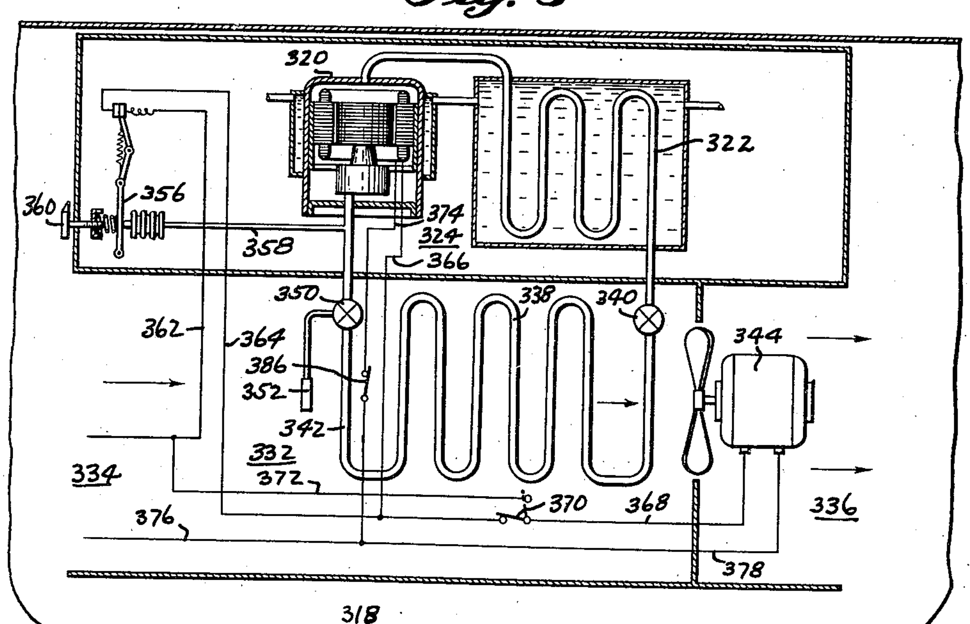

Fig. 6

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Patented Mar. 7, 1944

2,343,581

UNITED STATES PATENT OFFICE

2,343,581

REFRIGERATING APPARATUS

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Application January 28, 1939, Serial No. 253,399

3 Claims. (Cl. 62—129)

This application is a continuation in part of my copending application Serial No. 745,433, filed September 25, 1934.

This invention relates to refrigerating apparatus and more particularly to the control of air cooling means where quiet operation is essential.

Where air cooling means is used for cooling sleeping rooms and bed coolers extremely quiet operation is essential since one of the primary purposes of employing air cooling means in sleeping rooms and bed coolers is to make conditions more favorable for sleeping. Ordinarily air cooling units are controlled by a thermostat which controls the starting and stopping of the compressor unit of the air cooling means. This entails noises which are sufficiently loud to be objectionable where very quiet conditions of the room or enclosure are desired, such as bed-rooms, bed-coolers and some other special applications. Noise is not only caused by the snap acting operation of the switch but is also due to the starting of the compressor motor and to fluid noises in the system which occur generally during the starting and immediately after the stopping of the operation of the system. In general a relatively constant noise, such as the hum of the motor during operation of the system would not be objectionable and ordinarily would be little noticed. When such a noise becomes intermittent it becomes very noticeable. Another somewhat less objectionable feature of such a form of control is that the intermittent cooling provided is often noticeable and creates drafts.

It is therefore an object of my invention to provide an air cooling means with a control which is quiet and which insures quiet operation of the entire system.

It is another object of my invention to provide desirable psychrometric conditions without fluctuations and particularly by providing gradual changes in the refrigerating effect in the air cooling means according to a desired psychrometric condition.

It is another object of my invention to provide an air cooling means with a suction line valve which is controlled wholly or partially in response to psychrometric conditions outside the enclosure cooled by the air cooling means.

It is still a further object of my invention to provide a control for an air cooling means which gradually reduces the refrigerating effect and then when no further refrigeration is required, the operation of the entire system is stopped.

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 perspective view of a bed-cooling apparatus showing one form of my invention;

Fig. 2 is an enlarged perspective view of a portion of the curtain structure of the bed enclosure shown in Fig. 1;

Fig. 3 is a diagrammatic view of the portable air cooling means shown in Fig. 1;

Fig. 4 is a graph showing the relation between the temperature within the bed and the external or room temperature for a typical night;

Fig. 5 is a diagrammatic view of one form of air cooling means for a room provided with another form of control embodying my invention; and

Fig. 6 is a diagrammatic view of another form of air cooling means for cooling a room provided with a control similar to the control provided for the bed-cooling means.

The bed-cooling device herein described consists essentially of a portable cabinet containing an entire refrigerating system in which air is circulated over the surfaces of the evaporator and discharged through a fabric duct means into an enclosure formed of curtains extending around the sides of an ordinary bed, which curtains are supported by removable posts fastened to the bed at the corners. The temperature within the curtain enclosure is controlled by throttling the suction line of the refrigerating system so that the amount of refrigerant circulated is gradually reduced and thereby the amount of cooling gradually reduced after the external or room temperature falls below a predetermined minimum temperature. In addition, an additional control is provided which stops the operation of the refrigerating system when refrigeration is no longer required. The throttling of the suction line is not controlled by the temperature of the air within the bed enclosure but is controlled by the temperature of the air in the room outside of the bed enclosure.

The air cooling means shown in Fig. 5 for cooling the room consists essentially of a refrigerating system in which the air from the room together with a small amount of outside air is drawn through the evaporating means and returned to the room. The refrigerating system is provided with a throttling suction line valve which is operated partially in response to the temperature of the air drawn from the room and partially according to the temperature of the air outside the room. A low pressure switch is connected to the suction line between the suction line valve and the compressor inlet so as to stop the operation of the entire refrigerating system when the pressure in that portion of the suction line becomes so low that substantially no refrigeration is being performed.

In Fig. 6 there is shown diagrammatically a portable air cooling means for cooling a room which is generally like the air cooling means of Fig. 5 but the compressor and condenser are water-cooled and no provision is made for the admission of outside air into the air cooling means. Air from the room is drawn through the evaporating means and the refrigerating effect of the evaporating means on the air is controlled by throttling the suction line valve which is responsive to the temperature of the room air which is flowing to the evaporating means. A low pressure switch responsive to the pressure within the suction line between the throttling valve and the compressor inlet is provided for stopping the operation of the entire system when the pressure within that portion of the suction line becomes so low that substantially no refrigeration is being provided.

Referring now to the drawings, and more particularly to Fig. 1, there is shown an ordinary bed designated by the reference character **20**, which is provided with adjustable clamps **21**, one for each corner post of the bed. These clamps have posts **22** extending upwardly for supporting the four separate curtains **23**, **24**, **25** and **26**, each of which is provided with elastic and stretched between the posts on a side of the bed.

Referring now more particularly to Fig. 2 which shows the curtain **23**, it will be seen that the curtain **23** extends both upwardly and downwardly from the mattress **27** which is supported upon the springs of the bed. Sewed to the upwardly and downwardly extending portions of the fabric curtain structure **23** is a transversely extending portion **28** which extends laterally from the vertical curtain structure in between the mattress and the springs below the mattress so as to provide a seal between the curtains and the mattress. The lower elastic **29** extends from post to post along the side edge of the mattress and also tends to hold the vertical curtain portion tightly against the edge of the mattress in order to further prevent air leakage in the downward direction. The side curtain of the bed may be lowered when it is desired to enter or leave the bed and the most convenient way is to merely push down the side curtains stretching the top elastic until a portion of the top of the curtain is pushed down to the mattress.

At the foot of the bed, as shown in Fig. 1, there is provided a portable refrigerating unit **50** which draws the air from the room through the grilled opening **51** in one end of the cabinet, cools the air and then discharges the air through the collapsible fabric duct means **52** mounted on the top of the unit and the fabric duct means discharges the air into the curtained enclosure. The cool air by gravity falls to the bottom of the curtained enclosure and remains there until it is warmed up and rises by convection out of the curtained enclosure. In this way, the bed is cooled. Extending from the portable refrigerating unit **50** into the bed is a multiple electric cable or conductor **53** which extends into the curtained enclosure and is provided with switch means containing the switches **54** and **55**, one of which is employed for shutting off the refrigerating apparatus and the other of which not only shuts off the refrigerating system but also is employed for shutting off the fan for circulating the air and discharging the air into the curtained enclosure. This multiple electric cable **53** is also provided with a standard electrical plug **56** for connecting the portable refrigerating unit with a source of power.

Referring now more particularly to Fig. 3, there is shown a refrigerating system contained within the portable refrigerating unit **50**. This refrigerating system comprises a refrigerant liquefying unit including a compressor **59** driven by the electric motor **61** for compressing the refrigerant and for forwarding the compressed refrigerant to the condenser **63** where the compressed refrigerant is liquefied and collected in a receiver **65**. From the receiver **65**, the liquid refrigerant is forwarded through a supply conduit **67** under the control of a suitable expansion valve **69**. The expansion valve **69** controls the flow of liquid refrigerant into the evaporating means **71** which is located within an evaporating chamber **73** within the portable refrigerating unit. The liquid refrigerant evaporates within the evaporating means **71** and is returned to the compressor through the return conduit **75**.

In order to supply cooled air to the fabric curtained enclosure, an electric motor driven fan **77** is provided which draws air from the room through the grille **51** and discharges the air over the surfaces of the evaporating means from which it flows through the conduit **79** to the curtained enclosure. The electric motor-driven fan **77** is connected to an electric circuit **81**, while the electric compressor driving motor **61** is connected to an electric circuit **83**. These two circuits are connected in parallel to a source of power.

In parallel with the electric fan motor **77** is an electric signal light **85** preferably red or amber in color which indicates that the fan motor is in operation. It is advisable to provide some sort of indication to indicate the operation of the fan because the fan operates so quietly that whoever is using or taking care of the apparatus may be unaware that the fan has not been shut off after further operation is not desirable. The switch **55** which may be operated from the bed is placed in series with the electric circuit **83** and the electric motor **61** so that the compressor may be stopped by opening the switch. The switch **54** is placed in series with both of the electric circuits **81** and **83** so that the operation of both the electric fan motor and electric compressor motor is stopped by opening this switch.

Referring now more particularly to the graph shown in Fig. 4, the upper curved line shown in the graph beginning with the temperature 95° F. and designated by the reference character **87** shows a typical fall in room temperature during a hot summer night. The line beneath designated by the reference character **89** illustrates the bed temperature provided by applicant's apparatus. In cooling a bed, it is desirable to use the maximum capacity of the cooling system when the room temperature is very warm, but is not desirable to cool the bed below a temperature of about 78° F. to 80° F. The apparatus herein shown is capable of producing a drop in temperature of about 10° F. throughout the range shown in the graph. Thus, when the bed temperature is above 80° F., it is desirable to use all of the capacity of the refrigerating system. However, to do this throughout the entire night, where the room temperature falls below 80° F.

during the latter part of the night would cause the bed to become uncomfortably cool by providing a bed temperature below 70° F.

This would be decidedly objectionable and for this reason, applicant's apparatus is provided with a means for reducing the capacity of the refrigerating system when the room temperature approaches 80° F. and to entirely stop the operation of the refrigerating system when the room temperature approaches 77° F. In the graph shown in Fig. 4, the line designated by the reference character 91 illustrates the temperature which would be produced by the cooling system if permitted to operate at full capacity during the entire night. The heavy line designated by the reference character 93 shows the temperature provided during the throttling of the refrigerating system, while the short vertical line designated by the reference character 95 shows the effect of shutting off the refrigerating system after which the temperature in the interior of the bed follows the room temperature.

As mentioned before, it is desirable to avoid cycling of the refrigerating system as much as possible, because this tends to disturb the occupant of the bed. In order to reduce the capacity of the system without cycling, I provide a throttling valve 97 in the return conduit 75 which is operated by the volatile liquid pressure in the thermostatic bulb 99 so that the valve is opened when the temperature is high but when the room temperature is reduced nearly to 90° F., the throttling valve begins to close and continues to close after the temperature is lowered, and when the room temperature reaches about 77° F., the throttling valve is entirely closed. With this system it is possible to raise the temperature of the air discharged into the enclosure while the room temperature is lowered.

In order to prevent the waste of operation of the refrigerating system when the system operates at an extremely low capacity, I provide a snap acting switch means 101 provided with a bellows connected by the tubing 103 to the portion of the return conduit between the throttling valve 97 and the compressor 59. This snap acting switch 101 is provided with a temperature regulating means 105 for varying the pressure at which the switch opens and which is also provided with a cage 107 for forcibly moving the switch 101 to open position. The switch 101 and the throttling valve and its control may be combined into one unit in which case the switch is controlled by the position of the valve rather than by the suction pressure. This switch 101 is connected in series with the electric circuit 83 and the compressor motor 61 so that when a predetermined low pressure is reached in that portion of the suction or return conduit 75, the switch will open to stop the operation of the compressor motor and compressor. However, if it is desired not to stop the operation of the compressor, a switch 109 which is provided in a shunt around the snap acting switch 101 may be closed to short circuit the switch 101 and thus prevent the stopping of the motor compressor unit.

Referring now to Fig. 5 there is shown an air cooling means for cooling a room 218 in which quietness is essential, such as a bed-room. In this air cooling means there is provided a motor-compressor unit 220 for compressing the refrigerant and for forwarding the compressed refrigerant to an air cooled condenser 222 where the compressed refrigerant is liquefied. The motor-compressor unit and the condenser are located within the duct 224 having its entrance portion 226 and its exit portion 228 opening into the air outside the room. The motor-compressor unit 220 is provided with a fan 230 for drawing air from the outside into the entrance portion 226 of the duct 224 and circulating the air over the surfaces of the condenser 222 after which the air is discharged through the outlet 228.

At the side of the duct 224 is a duct 232 having its entrance portion 234 and its exit portion 236 connecting directly with the room 218 to be cooled. The refrigerant evaporating means 238 is located within this duct 232 and is connected by a liquid supply conduit provided with an automatic expansion valve 240 through which the liquid refrigerant from the condenser 222 is supplied to the evaporator 238. The evaporating means 238 is connected by the suction line 242 with the compressor inlet of the motor-compressor unit 220. An electric motor-driven fan 244 is provided for drawing air from the room 218 through the entrance 234 and through the duct 232 so that it flows into heat exchange relation with the evaporating means 238 and then is discharged through the outlet 236. In order to supply a small amount of fresh air to the room 218 a duct 246 is provided which leads from the outside air duct 224 to the room air duct 232 adjacent to the portion of the evaporating means 238 nearest the entrance of the duct 232. This duct 246 is provided with a damper 248 in order to regulate the amount of outside air which is drawn into the duct 232.

As mentioned before where such an air cooling means is used for cooling bed-rooms and other installations it is essential that it be very quiet. To start and stop the refrigerating system according to the temperature or other psychrometric condition of the air would cause considerable noise not only from the snap acting mechanism of the switch but also because of fluid noises within the refrigerating system, which accompany starting and stopping. Also the starting of the compressor-motor as well as the operation of the compressor usually makes some noise and if this noise is intermittent it is objectionable to many users. Also the intermittent operation of the system causes intermittent discharge of cold air from the outlet 236 which is also objected to by many.

In order to avoid these objections I have provided a throttling valve 250 in the suction line 242 so that when the room temperature reaches a desired minimum the valve 250 will gradually throttle the evaporated refrigerant issuing from the evaporating means 238, in order to reduce the refrigerating effect by reducing the amount of refrigerant circulated which in turn raises the evaporating pressure and temperature. This throttling valve 250 is closed in accordance with temperatures of the thermostatic bulb 252 and 254. These bulbs are connected to the operating diaphragm of the valve 250 by capillary tubing.

Preferably these bulbs are filled with an adsorbent such as activated charcoal and the bulbs, the connecting tubing and the diaphragm chamber are charged with a suitable gas such as carbon dioxide which is adsorbed and evolved from the activated charcoal in accordance with the changing temperature conditions. Instead of activated charcoal, activated silica may be employed. Preferably the bulb 252 is charged with a considerably greater amount of adsorbent substantially in proportion to the amount of inside and outside air which is drawn through the duct 232. In this way the closing of the valve 250 is primarily in accordance with the temperature of the bulb 252 but is also controlled to a lesser extent by the temperature of the outside air as reflected by the bulb 254. Since it has been found desirable to modify the conditions within the room according to outside temperatures I find this dual bulb arrangement quite satisfactory for this purpose. The bulb 254 may also serve to anticipate changes in the temperature of the outdoor air which in turn will gradually change the cooling requirements of the air within.

When the temperature within the room to be cooled becomes so low that the valve 250 is practically closed it is desirable to provide some means to stop the operation of the refrigerating system in order to save unnecessary operating expense. Such a single shut-down of the system ordinarily will not annoy, since under such conditions the system will remain shut down for several hours or more. When the system is used for a bed-room, the system is usually shut off under these conditions after the person occupying the bed-room is sleeping soundly.

In order to stop the operation of the refrigerating system I provide a low pressure control switch 256, shown diagrammatically, having its bellows connected by capillary tubing 258 to the portion of the suction conduit between the valve 250 and the compressor inlet of the motor-compressor unit 220. This low pressure switch is provided with a manual adjustment 260 by which the pressure at which the system is stopped may be adjusted, if desired. This low pressure switch is connected in series with the electrical conductors 262 and 264. The conductor 264 in turn connects to a conductor 266 connected to the motor-compressor unit and a conductor 268 connected to the motor-driven fan 244.

The conductor 268 is provided with a two-way switch 270, shown diagrammatically, through which the motor-driven fan 244 may be caused to cycle according to the operation of the low pressure switch 256 or it may be connected to a shunt 272 around the low pressure switch 276 so that the electric motor-driven fan 244 may operate continuously. The motor-compressor unit 220 is also connected by the conductor 274 and the conductor 276 to the other source of electric current supply and the motor-driven fan 244 is connected by the conductor 270 to the conductor 276. The conductor 274 is provided with a switch 280 for stopping the operation of the motor-compressor unit 220 whenever desired without disturbing the operation of the motor-driven fan 244. By the manual adjustment 260 the refrigerating system may be stopped under most any desired condition of load upon the system. Instead of controlling the suction line valve 250 according to temperature conditions, this valve may be controlled in accordance with effective temperature conditions, or humidity conditions, or any other psychrometric condition.

In Fig. 6 there is shown another air cooling means for a room 318 requiring considerable quiet such as a bed-room. This air cooling means differs from that shown in Fig. 5 in that it has no provision for the admission of fresh air from the outside and has no outside compensation for its suction line valve. The system includes a water-cooled motor-compressor unit 320 which compresses the evaporated refrigerant and forwards the compressed refrigerant to a water-cooled condenser 322 which is located in a closed compressor compartment 324. The compressed refrigerant is liquefied in a condenser 322 and forwarded under the control of the automatic expansion valve or a restrictor 340 to a refrigerant evaporating means 338 which is located within the duct 332 of the air cooling means. This evaporating means 338 is connected by a suction conduit means 342 to the inlet of the motor-compressor unit 320. A motor-driven fan 344 is provided for drawing air into the entrance 334 of the duct 332 and for discharging the air back into the room 318 through the outlet 336.

In order to provide a system of control which will be satisfactory for a quiet room I provide a suction line control valve 350 in the suction conduit 342. This suction line control valve 350 throttles the flow of evaporated refrigerant through the suction conduit 342 in accordance with the temperature of the thermostat bulb 352, which is located in the air stream of the duct 332 before the air reaches the evaporator 338. This bulb 352 may be filled with activated charcoal or activated silica and the bulb, the connecting capillary tubing and the operating diaphragm chamber of the valve may be charged with a suitable gas which is adsorbed and evolved from the adsorbent such as carbon dioxide. However, instead of charcoal bulb control system the bulb 352 and the tubing and diaphragm chamber may be completely filled with a liquid. The bulb 352 may be provided with a wetted sock so that it is responsive to wet bulb conditions.

As in the system shown in Figs. 3 and 5, the system shown in Fig. 6 is provided with a low pressure switch 356 having its bellows connected by a capillary tubing 358 to the portion of the suction conduit 342 between the valve 350 and the compressor inlet of the motor-compressor unit 320. This low pressure switch 356 is provided with a manual adjustment 360 by which the pressure at which the system is stopped may be regulated at will. This low pressure switch 356 is connected in a series with electrical conductors 362 and 364. The conductor 364 connects to the motor-compressor unit through the conductor 366 and to the motor-driven fan through the conductor 368 which is provided with a two-way switch 370. This switch 370 is adapted to connect the conductor 368 in series with the low pressure switch 356 by connecting with the conductor 364, or the conductor 368 may be connected directly to the source of power by the shunt 372 which shunts the low pressure switch 356 and permits the continuous operation of the motor-driven fan 344 regardless of the operation of the motor-compressor unit 320. The motor-compressor unit 320 is connected to the other supply conductor by the conductors 374 and 376 while the motor-driven fan 344 is connected to the conductor 376 by the conductor 378. The operation of the motor-compressor unit 320 may be stopped by the opening of the switch 386 which is provided in the conductor 374.

Thus by providing a system of control for air cooling means which includes a suction line throttling valve and a low pressure switch I have provided a control which makes possible more quiet and less disturbing noise conditions so that air cooling means will be more satisfactory for bed-rooms, bed-coolers and other applications requiring quietness. This form of control also provides more constant room conditions and in that way another source of disturbance is overcome. I have also provided a control by which the system may be controlled wholly or partially according to the temperature or psychrometric conditions outside the enclosure to be cooled. The suction line valve may be controlled by wet bulb or dry bulb temperature conditions, by humidity conditions or any other form of psychrometric conditions.

While the form of embodiment of the invention as herein described, 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. Apparatus for providing for human comfort comprising in combination with an enclosure to be cooled, means for circulating fresh air into said enclosure, a volatile refrigerant evaporator for cooling said air, a suction line connected to said evaporator, a valve in said suction line for throttling the flow of refrigerant therethrough to regulate the quantity of refrigeration produced in said evaporator, and means for reducing the temperature differential between the air inside and outside of said enclosure as the temperature outside of the enclosure decreases consisting of a thermostat responsive to the temperature of the fresh air before it is cooled for throttling the said suction valve to reduce the amount of refrigeration produced in said evaporator.

2. In combination with an enclosure to be conditioned, refrigerant evaporating means for cooling air, means for flowing air substantially all of which is taken from the atmosphere without said enclosure into heat exchange relation with said evaporating means and discharging the air into said enclosure, said enclosure having air outlet means whereby a corresponding amount of air is discharged therefrom into the atmosphere without said enclosure, refrigerant compressing and condensing means for supplying liquid refrigerant to and for withdrawing evaporated refrigerant from said evaporating means, a suction conduit connecting the evaporator outlet and the compressor inlet, a throttling valve in said suction conduit, control means for said valve responsive to the temperature of the air taken from the atmosphere, said valve and said control means being so constructed and arranged that the temperature differential between the air within said enclosure and without said enclosure decreases as the temperature without said enclosure decreases.

3. In combination with a sleeping enclosure arranged within a room, refrigerant evaporating means for cooling air for said enclosure, means for flowing air substantially all of which is taken from the room into heat exchange relation with said evaporating means and discharging the air into said enclosure, said enclosure having air outlet means whereby a corresponding amount of air is discharged therefrom into the room, refrigerant compressing and condensing means for supplying liquid refrigerant to and for withdrawing evaporated refrigerant from said evaporating means, a suction conduit connecting the evaporator outlet and the compressor inlet, a throttling valve in said suction conduit, control means for said valve, said valve and said control means being so constructed and arranged that the temperature differential between the air within said enclosure and in said room decreases as the temperature in said room decreases.

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