April 7, 1964 H. J. TENNISWOOD 3,127,930

HEAT PUMP FOR COOLING OR HEATING AIR

Filed May 27, 1959 2 Sheets-Sheet 1

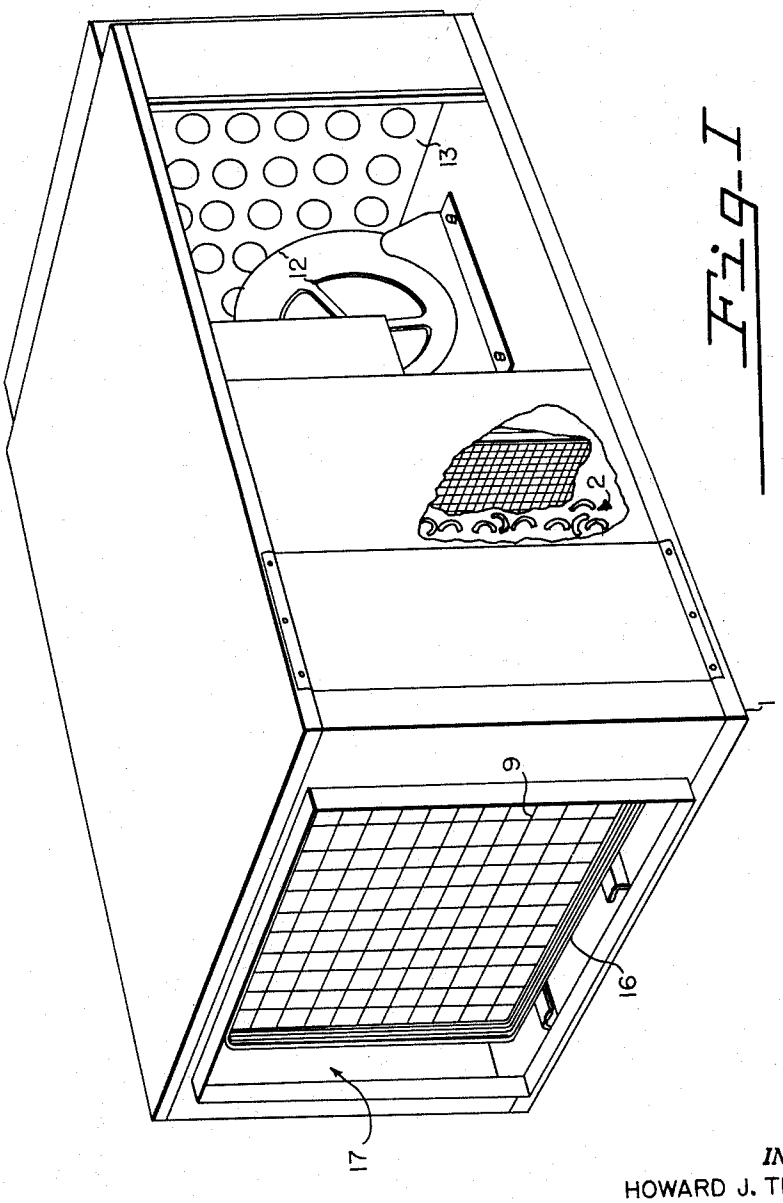


Fig. 1

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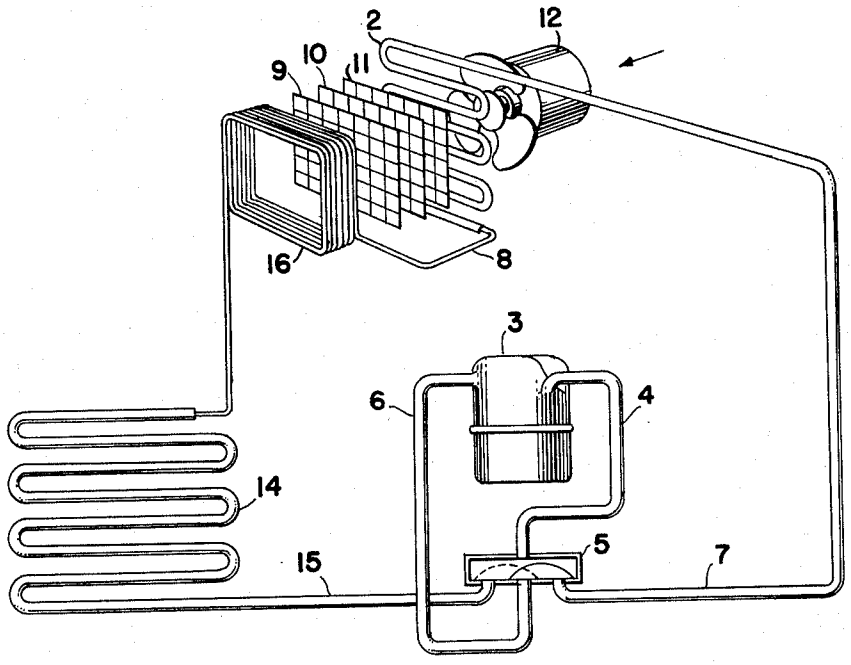


Fig. II

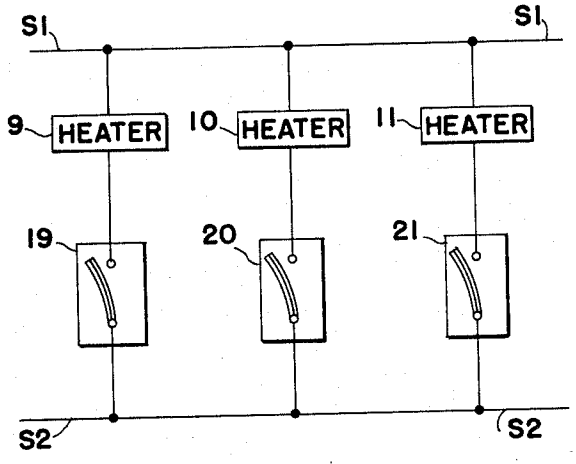


Fig. III

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United States Patent Office 3,127,930 Patented Apr. 7, 1964

3,127,930

HEAT PUMP FOR COOLING OR HEATING AIR

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Filed May 27, 1959, Ser. No. 816,148
4 Claims. (Cl. 165—29)

This invention relates to heat pumps of the type which is capable of taking heat from the interior of a building and dissipating the heat outside during warm weather, and which can be adjusted to be capable of taking heat from the outside air and supplying the heat to the air inside the building during cold weather. A heat pump of this type comprises: a compressor which compresses a refrigerant in the gaseous phase (thereby raising the temperature of the refrigerant); a coil located inside the building; a coil located outside the building; a capillary tube connecting the coils to each other; and piping incorporating a valve which can be set to connect the discharge side of the compressor either to the inside coil or to the outside coil and simultaneously to connect the suction side of the compressor to the other coil.

The components of a heat pump can be so proportioned as to operate with good efficiency either to cool the interior of a building or to heat the interior of the building, but it is desirable that the rate at which refrigerant passes through the capillary tube from the inside coil to the outside coil while the apparatus is being used to heat the interior of the building be lower than the rate at which the refrigerant passes through the tube from the outside coil to the inside coil while apparatus is being used to cool the interior of the building. Moreover, it is desirable that the rate at which the refrigerant passes through the capillary tube to the outside coil decrease as the outside temperature falls.

The desirability of passing refrigerant through the capillary tube at a comparatively fast rate while the apparatus is being used for cooling a building interior, and at a comparatively slow rate while the apparatus is being used for heating a building interior results from the fact that while the apparatus is being used for cooling a building interior the refrigerant passes through the capillary tube into the coil that is located inside the building where evaporation takes place comparatively rapidly, whereas when the apparatus is being used for heating a building interior the refrigerant passes through the capillary tube to the coil located in cold air outside the building where evaporation is low.

It is known that flow of refrigerant through a capillary tube can be retarded by heating the capillary tube and accelerated by cooling the capillary tube, and the prior art discloses apparatus in which the capillary tube is placed in juxtaposition to a pipe through which cold refrigerant is pumped out of the inside coil while the interior of the building is being cooled and through which hot refrigerant is pumped into the inside coil when the apparatus is being used to heat the interior of the building (e.g. U.S. Patent No. 2,750,762 issued June 19, 1956). The temperature of the capillary tube in the apparatus described in the above mentioned United States patent is either high or low depending upon whether the inside coil is being used to heat or to cool, but in the above mentioned patent there is no provision for gradation of rate of flow of refrigerant to compensate for variation of atmospheric temperatures.

It is an object of the instant invention to provide a heat pump of the type described briefly above in which, when the pump is being used to heat the interior of a building, the flow of refrigerant into the outside coil is increased automatically when the outside temperature rises and is decreased automatically when the outside temperature falls.

Another object is to provide a heat pump of the type described above in which the flow of refrigerant through the capillary tube to the outside coil is retarded as the outside temperature falls and accelerated as the outside temperature rises.

Another object is to provide a heat pump of the type described in which the flow of refrigerant through the capillary tube into the outside coil is accelerated or retrogressively retarded by lowering the temperature of the capillary tube as requirements for heat supplied by the pump become less or progressively increasing the temperature of the capillary tube as requirements for heat supplied by the pump become greater.

Other objects and numerous advantages of the invention will appear upon perusal of the following description illustrated by the accompanying drawings wherein:

FIG. I is a view in perspective with parts broken away of the inside section of the heat pump incorporating the instant invention;

FIG. II is a schematic diagram showing the relationship of cooperating elements of a heat pump embodying the instant invention; and

FIG. III is a schematic diagram of a simple thermostatic control circuit.

These drawings and the description that follows illustrate and describe a preferred embodiment of the instant invention but it is to be understood that they are not to impose limitations upon its scope. For convenience in merchandising, transportation and installation, the heat pump is divisible into an inside section and an outside section each with its own housing. The outside section is not illustrated in the drawings. The inside and outside sections should be installed reasonably close to each other.

The operative elements which are enclosed in the housing **1** of the inside section consist of an inside coil **2**, a hot gas pipe **4** leading from the compressor **3** to a four-way or reversing valve **5**, a suction pipe **6** leading from the reversing valve to the compressor **3**, an inside coil conduit **7** connecting the inside coil **2** to the four-way valve **5**, a folded length of capillary tubing **8** connected to the inside coil **2**, a series of electric heaters **9**, **10** and **11** and a motor-operated fan **12** which blows room air over the inside coil **2**, the electric heaters **9**, **10** and **11** and folds of the capillary tubing **8**. The heaters **9**, **10** and **11** may be located within the housing **1** behind the fan **12** or, more advantageously, they may be located in between the coiled capillary tube **16** and the inside coil **2** as shown in FIGS. I and II.

The room air may enter the housing **1** through a filter **13**. The housing **1** also may contain wiring and controls such as thermostats, though some temperature sensitive elements of thermostatic controls may be located outside.

As is illustrated schematically in FIG. II the capillary tubing **8** connects the inside coil **2** with an outside coil **14** which is located in the outside section of the heat pump. The outside coil **14** is connected by means of an outside coil conduit **15** to the four-way or reversing valve **5**.

Assume that the reversing valve **5** indicated in FIG. II is set so that hot compressed refrigerant in the gaseous phase flows from the compressor **3** through the hot gas pipe **4**, the reversing valve **5** and the inside coil conduit **7** into the inside coil **2** where it is cooled by imparting heat to the air that is blown over the inside coil **2** by the fan **12**. Thus the interior of the building is heated and the refrigerant is cooled under pressure in the inside coil to a temperature and pressure at which the refrigerant

condenses to a liquid that is forced into and through the capillary tubing 8.

The capillary tubing 8 acts as a restricter. The refrigerant is expanded into the outside coil 14 and the refrigerant vaporizes, absorbing heat of vaporization through the outside coil 14 from the outside air as the refrigerant itself falls to a temperature below that of the outside air. The refrigerant carrying the heat that it has thus absorbed flows from the outside coil 14 through the outside coil conduit 15, the four-way or reversing valve 5 and the suction pipe 6 back to the compressor 3.

When the heat pump is used for cooling the interior of a building the direction of the flow of refrigerant from the four-way or reversing valve 5 is opposite to the direction of flow as just described, i.e., the refrigerant in the hot gas phase goes through the outside coil conduit 15 into the outside coil 14 where it is cooled by dissipation of its heat into the outside atmosphere and reduced to a temperature at which it condenses to a liquid that is forced through the capillary tubing 8 into the inside coil 2 where it evaporates and absorbs heat from the air blown over the inside coil by the fan 12 thus cooling the interior of the building.

In warm weather while the heat pump is being used for cooling, evaporation takes place in the inside coil. The temperature surrounding it is much higher than the temperature that surrounds the outside coil in cold weather when the heat pump is being used to heat the interior of the building. In cold weather the outside temperature to which the outside coil 14 is subjected is so low as to retard evaporation so that if liquid refrigerant is injected from the capillary tubing 8 into the outside coil 14 during cold weather it may not evaporate completely before the refrigerant returns through the outside coil conduit 15, the four-way valve 5 and the suction pipe 6 to the compressor 3. The valving, the piping and the compressing mechanism all are engineered to operate most effectively upon refrigerant in the gaseous phase and the presence of refrigerant in the liquid phase interferes with the proper functioning of the apparatus.

In order that the rate at which liquid refrigerant is supplied to the outside coil 14 may increase and decrease as the rate of evaporation of refrigerant in the outside coil 14 increases and decreases with the variations in temperature to which the outside coil 14 is subjected, the capillary tubing 8 is heated, according to this invention, as the outside temperature falls or rises and/or the requirements for heating the interior of the building increase or decrease.

It is known that the rate of flow of refrigerant through a capillary tube decreases when the tube is heated sufficiently to cause the formations of bubbles of refrigerant vapor within the capillary tube or to cause refrigerant to vaporize as it approaches the exit end of the capillary tube and thus encounters lower pressure conditions. This invention provides means by which the temperature of the capillary tube is raised progressively as the outside atmospheric temperature falls by so locating a major length of the capillary tubing as to be subjected to suitable concentration of heat being employed to raise the temperature of the interior of the building. Since the heat so employed varies in intensity roughly inversely as the outside temperature varies, the rate at which the capillary tubing supplies refrigerant to the outside coil increases when the outside atmospheric temperature rises and decreases when the outside atmospheric temperature falls.

As shown in FIGS. I and II, folds 16 of the capillary tubing 8 surround a discharge opening 17 of the housing 1 through which opening passes air that has been blown over the inside coil 2 by the fan 12 and has thus become heated. Other arrangements of the capillary tubing 16 may be utilized as long as the tubing 16 is placed where it may be responsive to the heated or cooled air being supplied to the interior of the building. The compressor motor and the fan motor start and are controlled by a motor control thermostat so that the motors start whenever more heat is required and stop when less heat is required. Since more heat is required whenever outside temperatures fall the heat that the capillary tubing folds 16 receive from the air that is blown over them from the inside coil 2 is increased when the outside temperature falls.

In the preferred form of heat pump described in this specification and illustrated in the accompanying drawings supplemental electric heaters 9, 10 and 11 are employed to provide additional heat whenever the heating requirements are extraordinarily great. By employing such supplemental electric heaters the necessity of providing a heat pump of sufficient capacity to take care of occasional extreme requirements is obviated.

In the preferred form of invention disclosed herein the electric heaters are so located that supplemental heat supplied by them acts in good concentration to heat the capillary tubing and thus retard the refrigerant flow to supply less and less refrigerant to the outside coil 14 when the coil 14 is subjected to proportionately low temperatures. Supplemental heaters such as are indicated diagrammatically in FIG. II are well-known; therefore they are not described or illustrated in detail herein. Thermostatic controls for switching current into and out of such supplemental electric heaters also are well-known and are commercially available. A separate thermostatic control can, if desired, be employed for each supplemental heater or the heaters may be provided with any preferred controlling mechanism to switch them on successively or modulate their operating currents. A simple thermostatic control circuit for the three supplemental heaters 9, 10, and 11 is shown in FIG. III. Each of the supplemental heaters 9, 10, and 11 (shown in block diagram form) are connected in series with the separate thermostatic controls 19, 20 and 21, respectively, between the power supply leads S1 and S2. The thermostatic controls 19, 20, and 21 are represented symbolically since they are readily commercially available. The thermostatic controls may be set to energize their respective associated supplemental heating elements at predetermined temperatures. For example, the thermostatic control 19 may be set to close when the temperature goes down to a first predetermined value. If the subsequent energization of the supplemental heater 9 is not sufficient to maintain the room temperature above the first predetermined temperature, the room temperature will go down to a second predetermined temperature, at which time the thermostatic element 20 will energize its respective associated heater 10. A further plurality of stages of supplemental heaters may be similarly connected.

The invention, a preferred form of which is hereinabove described, is intended to encompass all modifications within the spirit and scope of the disclosed teachings.

I claim:

1. In a heat pump, in combination, an inside coil capable of functioning either as an evaporator for refrigerant or as a condenser for refrigerant, a motor-operated compressor, a four-way reversing valve, a hot gas pipe connecting said compressor to said four-way reversing valve, a suction pipe connecting said four-way reversing valve to said compressor, an outside coil conduit connecting said four-way reversing valve to said inside coil, a fan arranged to blow a blast of air over said inside coil, a series of auxiliary electric heating means so located as to supply supplemental heat to such blast of air, thermostatic means to progressively activate said electric heating means in accordance with heat requirements exceeding the heat supplied by said inside coil, an outside coil capable of functioning either as an evaporator for refrigerant or as a condenser for refrigerant, said four-way reversing valve being settable either to direct hot compressed refrigerant in gaseous phase through said inside coil conduit and thereby cause said inside coil to func-

tion as a condenser, and hence act as a heater, or to withdraw vaporized refrigerant through said inside coil conduit and thereby cause said inside coil to function as an evaporator, and hence act as a cooler, and a length of capillary tubing connecting said inside coil to said outside coil, a portion of said capillary tubing being in folds located to receive heat in high concentration from said inside coil and from said auxiliary heating means, whereby said capillary tube is conditioned to conduct refrigerant at rates which decrease when said outside temperature falls, and increase when outside temperature rises.

2. In a heat pump system, in combination; a pair of coils, one of said coils to be disposed inside a compartment to be heated or cooled, the other of said coils to be disposed outside of said compartment; means for circulating refrigerant through said coils; restriction means connected to conduct refrigerant between said coils; and means for directing a current of air in heat exchange relationship with said inside coils; said restriction means being disposed in thermal relationship with said current

of air after said air current has been in heat exchange relationship with said inside coil.

3. A heat pump system as defined in claim 2 in which supplemental heating means are disposed in thermal relationship with said current of air prior to passage of said air current in thermal relationship with said restriction means.

4. A heat pump system as defined in claim 3 in which said supplemental heating means comprises a plurality of sections adapted to be sequentially actuated in response to predetermined temperatures in said compartment.

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