United States Patent

[11] **3,547,186**

[72] Inventor **William L. McGrath**
Syracuse, N.Y.

[21] Appl. No. **800,524**
[22] Filed **Feb. 19, 1969**
[45] Patented **Dec. 15, 1970**

[73] Assignee **Carrier Corporation**
Syracuse, N.Y.
a corporation of Delaware

[54] **HEATING AND COOLING SYSTEM**
7 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **165/22,** 165/29, 165/50, 165/62
[51] **Int. Cl.** **F24f 3/00**
[50] **Field of Search** 165/28, 29, 50, 62, 122

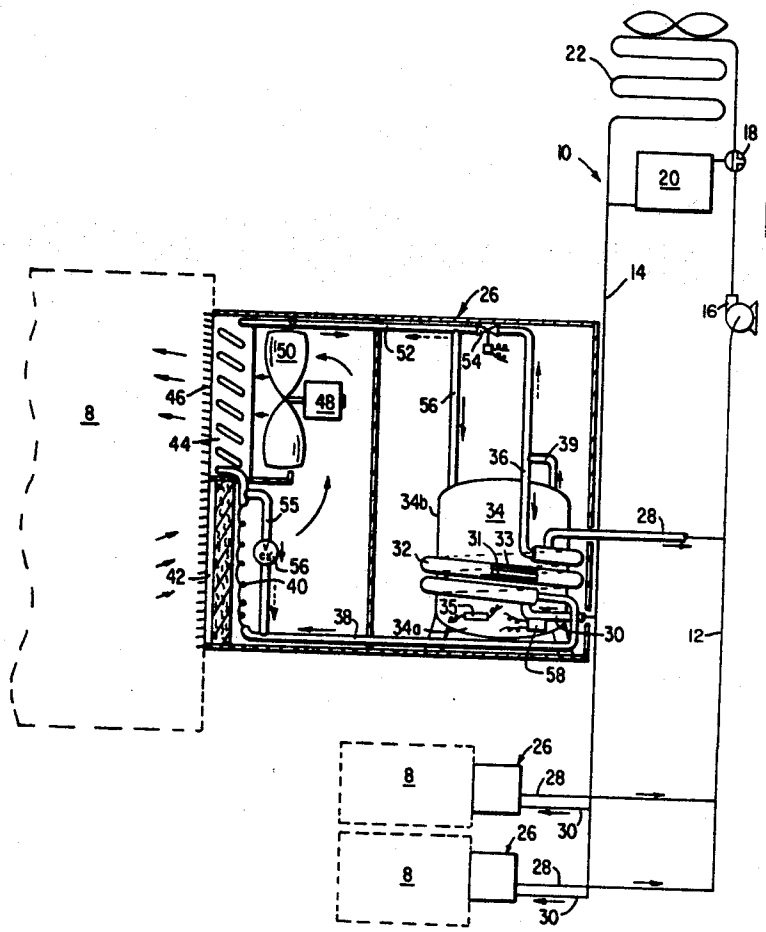
[56] **References Cited**

UNITED STATES PATENTS

2,260,887	10/1941	Dasher	165/62
2,715,514	8/1955	Stair	165/50
2,756,970	7/1956	Hermann	165/22
3,472,313	10/1969	Milgram et al.	165/22

Primary Examiner—Charles Sukal
Attorneys—Harry G. Martin, Jr. and J. Raymond Curtin

ABSTRACT: A heating and cooling system for controlling the temperature of air circulating within a plurality of separate areas located within a common enclosure to provide comfort conditioning to occupants of the areas comprising a plurality of independently operable self-contained air-conditioning units including a refrigeration system comprising a motor-driven compressor, a first heat exchanger, a second heat exchanger, and expansion means, the air-conditioning unit alternatively operable to either heat or cool the area being served. Further included in the heating and cooling system are means to heat or cool a circulating heat exchange medium before it is supplied to the first heat exchanger. The temperature of the heat exchange medium is regulated so a unit may provide either heating or cooling, depending upon the desires of a person in the area being served by the unit. During the heating cycle and at all times when the temperature of the heat exchange medium exceeds a predetermined point, the compressor will be inoperable and the heat necessary to warm the air circulating in the area is transferred directly to the refrigerant for rejection to the air.



PATENTED DEC 15 1970

3,547,186

FIG. 2

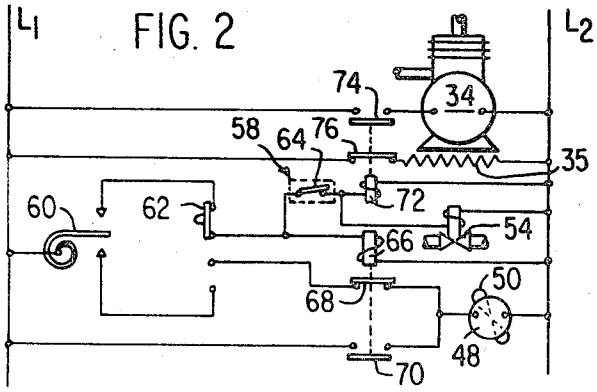


FIG. 1

INVENTOR.
WILLIAM L. MC GRATH.
BY J. Raymond Curtis
ATTORNEY.

HEATING AND COOLING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates primarily to a heating and cooling system for use where it is desired to condition simultaneously a plurality of areas such as apartments in apartment buildings and offices in commercial buildings. More particularly, this invention relates to such systems utilizing self-contained air-conditioning units operable so that the occupant of each area may obtain either heating or cooling during that time of the year when the requirement may change within a 24-hour period.

There are many air-conditioning systems that can be installed to alternatively heat or cool a plurality of areas. However, many of these systems are unable to provide heating and cooling simultaneously without relatively expensive equipment. The inability to provide simultaneous heating and cooling is a serious drawback, especially during the intermediate seasons of spring and fall. At these times, an occupant of an individual area may desire heating while another occupant of a different area may wish to cool that area. Since the overall system can only provide heating or cooling, one of the aforementioned persons will be unable to obtain the conditioning effect desired for his area.

Those systems that do provide means for simultaneous heating and cooling often are extremely costly to install and operate. Additional components, such as costly and complex four-way valves for reversing refrigerant flow are typically included in a self-contained refrigeration unit installed to serve one of the areas. Additionally, the refrigeration compressor must be in operation in order to obtain heating, thus expending much electrical energy and causing accelerated wear of the compressor.

The object of the present invention is to alleviate the problems discussed hereinabove by providing a heating and cooling system that can supply heat to the air circulating in one area while reducing the temperature of air circulating within a second area to provide a cooling effect within that area. In addition, the system disclosed does not involve the use of an inordinate number of components to obtain the benefit desired. Simple, comparatively inexpensive mechanisms are provided whereby an individual occupant may easily select the conditioning effect desired. Furthermore, the novel system disclosed will be able to raise the temperature within a plurality of areas in a relatively short period of time as is desirable.

SUMMARY OF THE INVENTION

The present invention pertains to an air-conditioning system which utilizes a separate circulating water circuit wherein the water is heated or cooled to a desired temperature and the subsequent delivery of the water to a plurality of self-contained refrigeration units, each of the units operating to control the condition of the air within a separate area. The heating and cooling system disclosed will be particularly useful in apartment buildings and commercial office buildings.

The temperature of a heat exchange medium such as water, to be supplied to each of the refrigeration units may be regulated so that either heating or cooling of the areas being served by the entire system may be simultaneously accomplished when conditions so require; the operation of an individual unit being completely independent of the operation of any other unit.

It has been found that by heating the water to a temperature of from 140° F. to 160° F., it is possible to vaporize a refrigerant present in the individual units so that the area being served by the unit will be heated without the compressor of the unit being required to operate. The heating of the air is accomplished by providing a path of flow for the vaporized refrigerant to the second heat exchanger over which room air is routed. Thus, it is apparent that operating costs of the heating and cooling system will be substantially reduced since the compressor will be inoperable when the area is being warmed, thereby requiring less energy to operate the self-contained reverse-cycle refrigeration units.

The cooling of the areas will be obtained by having the self-contained refrigeration units, operate under the basic refrigeration cycle. When it is desired to cool all the areas being served, the heat exchange medium will be supplied at a temperature of from 70° F. to 90° F.

Especially during the spring and fall seasons, it will be desirable to simultaneously provide either heating or cooling. Accordingly, a third operating cycle is required. At such times, the water will be supplied at a temperature of from 110° F. to 125° F. The water may either be used as a heat sink for cooling purposes or as a heat source for heating purposes when supplied within the above temperature range. Since the heat exchange medium will be used for both heating and cooling purposes, the heating or cooling of the water prior to delivery to the units will be reduced, since heat is being extracted from, and added to the heat exchange medium by the operation of each of the self-contained refrigeration units. It is possible that no regulation of the temperature of the water will be required since an exact heat balance may be created by the operation of the entire system. However, since this is highly unlikely, the heat exchange medium will be either heated or cooled so that the 110° F. to 125° F. temperature range will be obtained as desired.

At a temperature in excess of 125° F. the heat exchange medium can no longer be used as a heat sink. Therefore, to prevent possible injury to the compressor, means are associated therewith to prevent the compressor from operating, even though the area being conditioned requires cooling, if the temperature of the water exceeds 125°.

A further advantageous feature of the novel system disclosed herein is that means are provided between the high-pressure side and low-pressure side of the compressor so that when the operation of the compressor terminates as when a requirement for cooling is satisfied, such means will automatically operate to sufficiently reduce the pressure differential between the discharge and suction sides. The substantial elimination of the pressure differential is greatly desired, since the compressor will not therefore be required to start against a high load. By forcing the compressor to start against a high load, a high initial torque would be required. This usually produces concomitant problems such as larger installed wiring and electric supply costs, increased size of components to handle the high initial torque, and the possibilities of the compressor motor windings deteriorating due to the high torque otherwise required.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates schematically a type of air-conditioning system to which the present invention applies; and

FIG. 2 illustrates schematically a wiring diagram serving as a preferred form of control of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the novel heating and cooling system is represented schematically by FIG. 1 of the drawing. As shown, the system is designed to regulate the temperature of air circulating within a plurality of separate areas forming an enclosure.

Each of the areas 8 being served by the system will have a self-contained air conditioning unit 26. All of the units 26 are connected in parallel with a source of heat exchange medium such as water, which is heated or cooled prior to being supplied to each of the units 26 through a central circulating system 10. The circulating system is regulated on either a heating cycle, a cooling cycle or an intermediate cycle through regulation of the temperature of the fluid flowing within the circulating system. Each of the cycles of operation is distinguished by the temperature of the fluid flowing to the units.

The central circulating system 10 includes pump means 16 which direct the water through the system 10. The water is initially circulated via conduit 12 and three-way valve 18 to either heating means 20 or cooling means 22. Depending upon

various conditions such as the season of the year, the outdoor temperature, and the temperature of the water being circulated, either heating means **20** will be used to heat the water to a predetermined temperature or cooling means **22** will be utilized to cool the water to a predetermined temperature. Regulation of the apparatus being used to obtain the desired water temperature may be accomplished automatically by any of various well-known means. With the three-way valve positioned as shown, the water is circulated through cooling means **22**, shown as an evaporative cooler or conventional water tower, wherein heat is extracted from the water by evaporating a small portion thereof. Other apparatus known to the art may be employed to cool the circulating water.

The water is thenceforth directed via conduit **14** and supply lines **30** to a first heat exchanger **32** of the units **26**. Heat exchanger **32** is shown as being of the tube-in-tube variety. The circulating water flows in the annular space between the inner tube **31** and the outer tube **33** of the heat exchanger **32**. Flowing through inner tube **31**, in a counterflow direction to the water is the refrigerant contained in the units **26**. As will be more fully explained hereinafter, the refrigerant flowing within tube **31** will either reject heat to or absorb heat from the water flowing over the outer surface of inner tube **31** in heat exchange relation therewith. Other types of heat exchangers known to the art, such as a surface heat exchanger, may be employed in lieu of the tube-in-tube type. The water thereafter returns to the central circulating system via conduits **28**.

Additionally, the self-contained air-conditioning units **26** include a refrigerant compressor **34**, expansion means **40**, a second heat exchanger **44**, a solenoid valve **54** disposed between the compressor **34** and the second heat exchanger **44**, and a fan **50** to route room air over the heat exchanger **44**. Although expansion means **40** is shown as being a capillary tube, other expansion devices such as thermostatic expansion valves known to the art may be used.

Connecting the first heat exchanger **32** and the expansion means **40** is conduit **38**. Connecting the second heat exchanger **44** to the suction side of the compressor **34** are conduits **52** and **56**. Conduit **36** links the discharge line **39** of the compressor **34** to the first heat exchanger **32**.

COOLING CYCLE OPERATION

At certain times of the year, especially during the summer season, all of the areas within the enclosure will require cooling. When such is the case, the water will be cooled in the evaporative cooler **22** or other suitable cooling means so that it will be supplied to the first heat exchangers **32** at a temperature range from 70°—90° via the circulating system **10** previously described.

Again referring to FIG. **1**, the flow of the refrigerant during the cooling cycle is represented by the solid arrows. Vaporous refrigerant discharged from the compressor **34** through line **39** and conduit **36** is passed to the first heat exchanger **32**. Normally open solenoid valve **54** which closes simultaneously with the energization of the compressor **34** in response to the cooling requirements of the area sensed by thermostat **60**, in a manner to be described more fully hereinafter, separates conduit **36** from conduits **52** and **56**, thereby enabling the vaporous refrigerant to flow to the first heat exchanger **32** as desired.

The high-pressure, high-temperature vaporous refrigerant is passed in heat transfer relation with the relatively cold water, the refrigerant thereby being condensed as a result thereof. The flow of the refrigerant and the water through tube-in-tube heat exchanger **32** has been previously described.

The condensed refrigerant then flows through conduit **38** and expansion means **40** to the second heat exchanger **44**. The refrigerant flowing through heat exchanger **44** is vaporized by having relatively warm area or room air circulated in heat transfer relation therewith by fan **50**. The room air is drawn through opening **42** disposed in a housing serving as an enclosure for the air conditioning unit and after flowing over heat exchanger **44**, is delivered to the area being served, via grille **46**. The refrigerant, having been vaporized in heat exchanger **44**, is returned to the compressor **34** via conduits **52** and **56**. Thus, it is apparent during the cooling cycle, units **26** are operating in accordance with the basic refrigeration cycle.

HEATING CYCLE OPERATION

In direct contrast to operating all the units **26** on their cooling cycles, sometimes, especially during the winter months, all the areas within the enclosure will require heating. When such is the case, the three-way valve **18** in the circulating system **10** will be positioned so cooling means **22** will be bypassed and heating means **20** will be operating to heat the water used as a heat exchange medium. The water is preferably supplied to the units **26** at a temperature from 140° F. —160° F. during this time. Regulation of the water temperature to the desired range is effected through means not shown, but such means would be associated with the heating means **20** to control the temperature as desired.

Again referring to FIG. **1**, the flow of refrigerant during the heating cycle is represented by the dotted arrows. The relatively hot water is supplied to the first heat exchanger **32** wherein it is passed in heat transfer relation with the refrigerant directed through the inner tube **31** of the heat exchanger **32**. The compressor **34** will be kept inoperable during the heating cycle by means which will be more fully explained hereinafter.

The refrigerant passing through heat exchanger **32** will be vaporized as the relatively hot water flows in heat transfer relation therewith through the annular space between inner tube **31** and outer tube **33**. The refrigerant extracts heat from the water, thereby being vaporized. Since the compressor is inoperable, the solenoid valve **54** will be in its normally open position. Without the compressor in operation, the vaporized refrigerant flows upwardly through conduit **36**, past normally open valve **54** and conduit **52** into second heat exchanger **44**. The connection between valve **54** aNd room thermostat **60** during the heating cycle will be more fully explained hereinafter.

Air within the area served by the unit is drawn through opening **42** by fan **50** and circulated over the heat exchanger **44**. The relatively cold air is warmed by passing in heat transfer relation with the vaporous refrigerant, condensing the vaporous refrigerant and being warmed thereby. The relatively warm air is then delivered to the area being served. The condensed refrigerant flows through conduit **55**, check valve **56** and conduit **38** to the first heat exchanger **32**. Conduit **55** and check valve **56** are provided in the heating circuit to bypass expansion means **40**, since the expansion means is not needed during the heating cycle. The bypass means will be operable solely during the heating cycle.

INTERMEDIATE SEASON OPERATION

At various times of the year, especially during the spring and fall seasons, individual occupants of an area being served by a unit **26** may desire to operate the unit on either the heating or the cooling cycle. The water will be supplied at such times at a temperature of about 110° F. —125° F. So long as the water does not exceed some predetermined temperature, such as 125° F. it is possible for the water to be used as either a heat sink for cooling purposes or as a heat source for heating purposes. If the temperature of the water exceeds 125° F. the compressor will become inoperable in a manner hereafter explained when the control system employed with each unit **26** will be described.

With some of the units operating on heating cycles and others operating on cooling cycles, less regulation of the temperature of the water is required before being supplied to each of the individual units **26**. Each of the units operating on a cooling cycle will be rejecting heat to the water, and each of the units operating to warm the area being served will be ex-

tracting heat from the circulated fluid. Theoretically, a heat balance may be obtained whereby neither heating means **20** nor cooling means **22** need be operated, and in any event a substantial amount of "free" heating will be obtained from units operating on cooling. Normally, either heating means **20** or cooling means **22** will be operated during the intermediate season to maintain the temperature of the water within the desired range.

It should be noted that vaporous refrigerant will collect in conduit **56** during the heating cycle. However, since the compressor mechanism, such as the piston, will offer a substantially greater restriction to the circulation of the vaporous refrigerant than will heat exchanger **44**, the refrigerant gas in conduit **56** will become virtually stagnant and therefore only a minimal quantity of refrigerant gas will collect in the compressor during the heating cycle.

Compressor discharge valve (not shown) will prevent any leakage of refrigerant gas through conduit **39** back into the discharge side of the compressor **34**. The discharge valve will act as a check valve.

Tube-in-tube heat exchanger **32** is preferably constructed so that the relatively hot water flowing therethrough during the heating cycle will transfer a small quantity of its heat to the compressor shell **34***b*. Preferably, the desired object may be obtained by constructing the heat exchanger **32** in a manner so that the outer surface thereof will be substantially in contact with the shell **34***b* of the compressor **34**. This in turn will heat the lubricating oil stored in the compressor crankcase **34***a*, thereby preventing the oil from absorbing an excessive amount of refrigeration during the heating cycle or when the compressor is otherwise inoperative.

Alternatively, a separate heat exchanger may be used in which case a crankcase heater **35** can be utilized. The heater **35** will become operable by means to be more fully explained hereinafter, to heat the oil when the compressor is inoperative.

Normally open solenoid valve **54** not only serves to partition the discharge side of the compressor from the suction side of the compressor when the compressor **34** is operable, but also serves as an equalizing mechanism so that the compressor **34** will not be forced to start against a high initial load. By having valve **54** open when the compressor is inoperable, the pressure differential between the compressor suction side and discharge side will be substantially eliminated. This in turn reduces the load against which the compressor is forced to start, which thereby decreases the torque required for the compressor to become operational.

CONTROL SYSTEM FOR INDIVIDUAL UNITS

Referring now to FIG. **2**, a preferred control circuit for an air-conditioning unit **26** is schematically shown. A room thermostat **60** located within the area being served so as to sense the temperature of the air circulating therein will automatically connect the control circuit to a source of energy represented by lines L_1 and L_2. A mode of operation switch **62** connected in series with the thermostat **60** will provide means enabling an occupant of the area to select either a heating or cooling mode of unit operation. Thus, depending upon the desires of the individual, the mode of operation switch **62** will either be set for cooling or heating. The setting of switch **62** will be especially important during an intermediate season when either heating or cooling may be provided by a unit **26**. Thus, with the water being supplied at a temperature with the 110° F.—125° F. temperature to the first heat exchanger **32**, if the person desired the area to be cooled he would set switch **62** for cooling and except under conditions to be explained hereinafter, the air-conditioning unit would commence operating when the thermostat **60** senses that the area being served is too warm. Alternatively, the occupant of the area may set the switch **62** for the heating cycle, and when thermostat **60** senses heating is required in the area being served, the air-conditiong unit will thereupon commence operating under its heating cycle as previously explained.

Assume it is desirable to cool the area being served by a unit **26**. The mode of operation switch **62** will be set for cooling. Control relay **66**, connected in series with the cooling control of switch **62** and thermostat **60**, will become energized when room thermostat **60** senses cooling is required in the area being served. Energization of relay **66** will open normally closed switch **68** and close normally open switch **70**. Fan motor **48**, operating fan **50**, will thereby become operable.

A second relay **72**, also connected in series with the thermostat **60** and the cooling element of switch **62**, will become energized except under conditions which will be explained hereinafter, simultaneously with the energization of relay **66**. Energization of the relay **72** will close normally open switch **74** and open normally closed switch **76**. The closing of switch **74** will place the compressor **34** in operation. Opening switch **76** will disconnect the crankcase heater **35**, if one is used, from the source of power. Therefore, it is readily apparent that crankcase heater **35** will be operable at all times except when the compressor **34** is operating.

Connected between switch **62** and relay **72** and in series therewith, is normally closed contacts **64** operated by a thermally actuated switch **58**. Switch **58** senses the temperature of the water supplied to the first heat exchanger **32**. If the temperature of the water exceeds the maximum predetermined temperature for cooling cycle operation, switch **58** will open contacts **64**, thereby preventing the compressor **34** from becoming operable even though the switch **62** is set for cooling and thermostat **60** has closed in response to the cooling demands of the area.

Normally open solenoid valve **54** is also connected in series with switches **62** and **64** and thermostat **60**. Thus, it is readily apparent that it is only during cooling cycle operation and only when the temperature of the water is less than the maximum predetermined amount, that the valve **54** will be energized, thereby assuming a closed position. At all other times, valve **54** will be in its normally open position.

If it is desired to heat the area, the mode of operation switch **62** will be set in its heating position. When thermostat **60** determines that heating is required, power is supplied through normally closed switch **68** to fan motor **48**, thereby making fan **50** operable. For heating cycle operation, no other apparatus need be energized.

Although I have described and illustrated the air-conditioning units as being completely contained in a single housing, it is to be understood that it is specifically within the scope of this invention for the condenser or the evaporator to be located at a remote distance from the other refrigeration apparatus.

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

I claim:

1. A method of heating or cooling air within an enclosure including a plurality of individual areas comprising:

A. incorporating in each area air-conditioning apparatus including a refrigeration cycle;

B. supplying a heat exchange medium to each of said air-conditioning apparatus;

C. passing said heat exchange medium through a first heat exchanger in said apparatus in heat transfer relation with the refrigerant of said apparatus, the heat exchange medium vaporizing the refrigerant when supplied at a first predetermined temperature level and condensing the refrigerant when supplied at a second predetermined temperature level, the vaporization of the refrigerant occurring while the compressor of the system is inactive;

D. passing the refrigerant to a second heat exchanger, while air is circulated in heat transfer relation with said refrigerant, whereby the refrigerant is condensed and the air is warmed when heating is desired, and the refrigerant is vaporized and the air is chilled when cooling is desired; and

E. supplying the heat exchange medium at a temperature level intermediate the first and second level whereby an individual apparatus may be operated to either warm or cool the air supplied in heat transfer relation with the refrigerant in the second heat exchanger.

2. A heating and cooling system for a plurality of areas including a plurality of air-conditioning units to serve each of the areas, an air-conditioning unit comprising a motor-driven compressor, a first heat exchanger, a second heat exchanger, expansion means, and means to supply air in heat transfer relation with said second heat exchanger, said heating and cooling system further including:

A. means to selectively heat or cool a heat exchange medium to be supplied to said first heat exchanger of each of said air-conditioning units;

B. means for supplying said heat exchange medium to each of said first heat exchangers, including conduit means and pump means;

C. means for alternatively operating an air-conditioning unit to either heat the area being served by said unit or cool the area being served by said unit; and

D. means operable to prevent said compressor of said air-cinditioning unit from operating when said unit is heating the area being served and to prevent said compressor from operating even though the area being served requires cooling if the temperature of the heat exchange medium supplied to the first heat exchanger has exceeded a predetermined point.

3. A heating and cooling system for a plurality of areas comprising: A. a circulating system through which a heat exchange medium is passed including:

i. a supply conduit;

ii. a return conduit;

iii. means to circulate said medium; and

iv. heating means operable to heat said medium and cooling means operable to cool said medium, said heating and cooling means being selectively operable;

B. a plurality of independently operable air-conditioning units including:

i. a first heat exchanger and means associated therewith, connecting said first heat exchanger to said heat exchange medium circulating system;

ii. a second heat exchange and means associated therewith to route air thereover, said air being thereafter supplied to the area being served by said unit, said air having passed in heat transfer relation with refrigerant in said second heat exchanger;

iii. said first heat exchanger and said second heat exchanger being operatively interconnected and interchangeably effective, respectively as a refrigerant condenser and as a refrigerant evaporator or respectively as a refrigerant evaporator and as a refrigerant condenser, depending upon whether said unit is cooling or heating the area being served;

iv. a refrigerant compressor and means associated therewith to disable said compressor when said heat exchange medium exceeds a predetermined temperature, or when said unit is operating to heat the area being served thereby; and

v. refrigeration expansion means disposed between said first heat exchanger and second heat exchanger; and

C. means for selecting either a cooling mode or a heating mode for each of said units, when said heat exchange medium is at a temperature sufficient to serve as a heat source to vaporize said refrigerant in said first heat exchanger, but said temperature being less than the maximum permissible to allow said first heat exchanger to function as a condenser, said heat exchange medium thereby serving as a heat sink.

4. A heating and cooling system in accordance with claim 3 wherein means operable when said compressor is disabled will reduce the time in which the pressure differential between said compressor suction and discharge sides will be substantially eliminated.

5. A heating and cooling system in accordance with claim 3 wherein bypass means around said expansion means will become operable when the area being served by said unit is being heated.

6. A heating and cooling system in accordance with claim 3 wherein means will be operable to heat oil within the crankcase of said compressor when said compressor is inoperable.

7. A heating and cooling system in accordance with claim 3 wherein the compressor shell and the outer surface of the first heat exchanger will be in substantial contact.