United States Patent

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[72] Inventors **James B. Hoaglund**
Jenkintown;
Franz A. Kantz, Philadelphia,
Pennsylvania; George A. Story, Cherry
Hill, New Jersey

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[73] Assignee **International Telephone and Telegraph**
Corporation
New York, New York
a corporation of Delaware

[54] **ROOFTOP MULTIZONE AIR CONDITIONING UNITS**
9 Claims, 14 Drawing Figs.

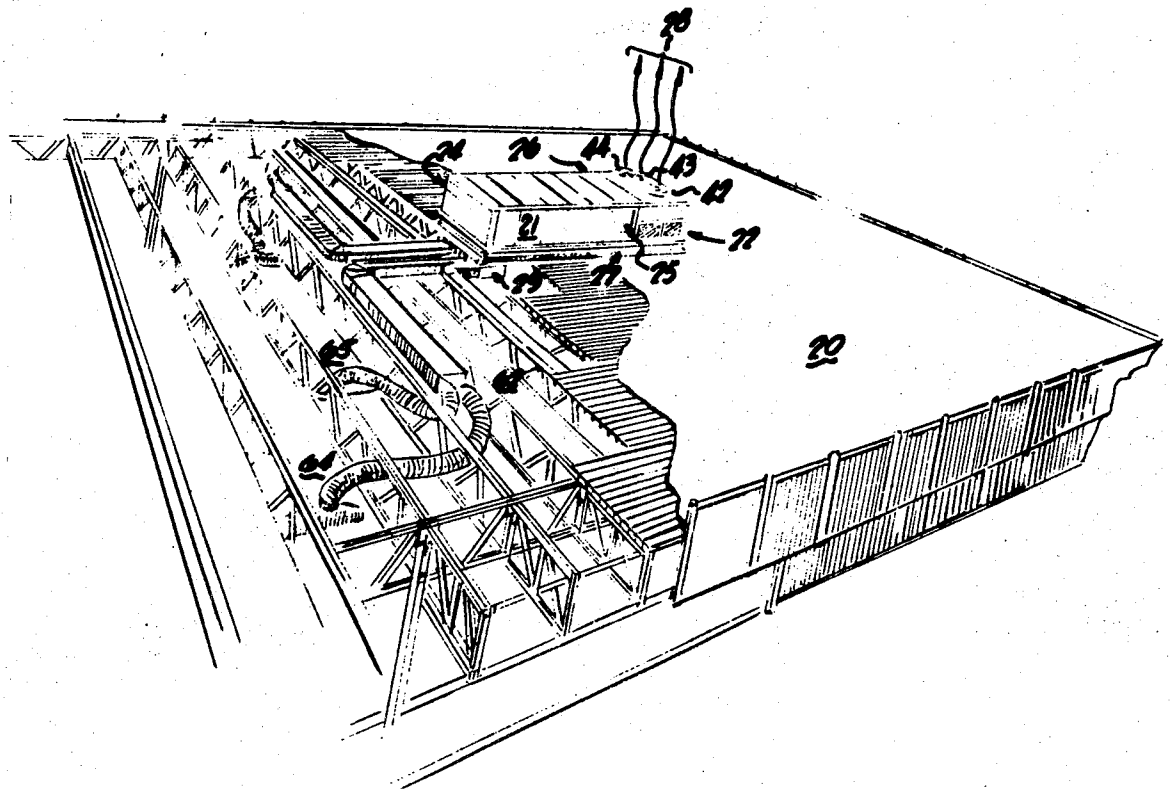
[52] **U.S. Cl.** **165/22,**
165/57; 62/90; 236/13
[51] **Int. Cl.** **F24f 3/00**
[50] **Field of Search** 62/90, 173,
428, R&C; 165/29, 30, 96, 22, 50, 57; 236/13

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Primary Examiner—Charles Sukalo
Attorneys—Walter J. Baum, C. Cornell Remsen, Jr., Rayson P. Morris, Percy P. Lantzy, J. Warren Whitesel and Delbert P. Warner

ABSTRACT: A housing unit has an air intake at one end and hot and cold decks at the opposite or output end. To cool and dehumidify all incoming air, an evaporator coil is placed in the housing assembly near its inlet end. A reheat coil is located downstream in the hot deck section of the housing, and arranged to be in series with and normally act as a part of a condenser coil. The reheat coil is thus supplied with a flow of refrigerant emanating from the condenser coil. The exchange of heat, in the reheat coil, heats the air passing through the hot deck and subcools the refrigerant before it enters the evaporator coil. When higher levels of heating are required during periods when the furnace operation is not desired, a bypass valve places the condenser and reheat coils at least partially in parallel, and the compressor supplies some superheated refrigerant gas which is injected directly into the liquid refrigerant flowing into the reheat coil. A thermostat within the hot deck modifies zone thermostat command signals as a function of prevailing temperatures within the hot deck.



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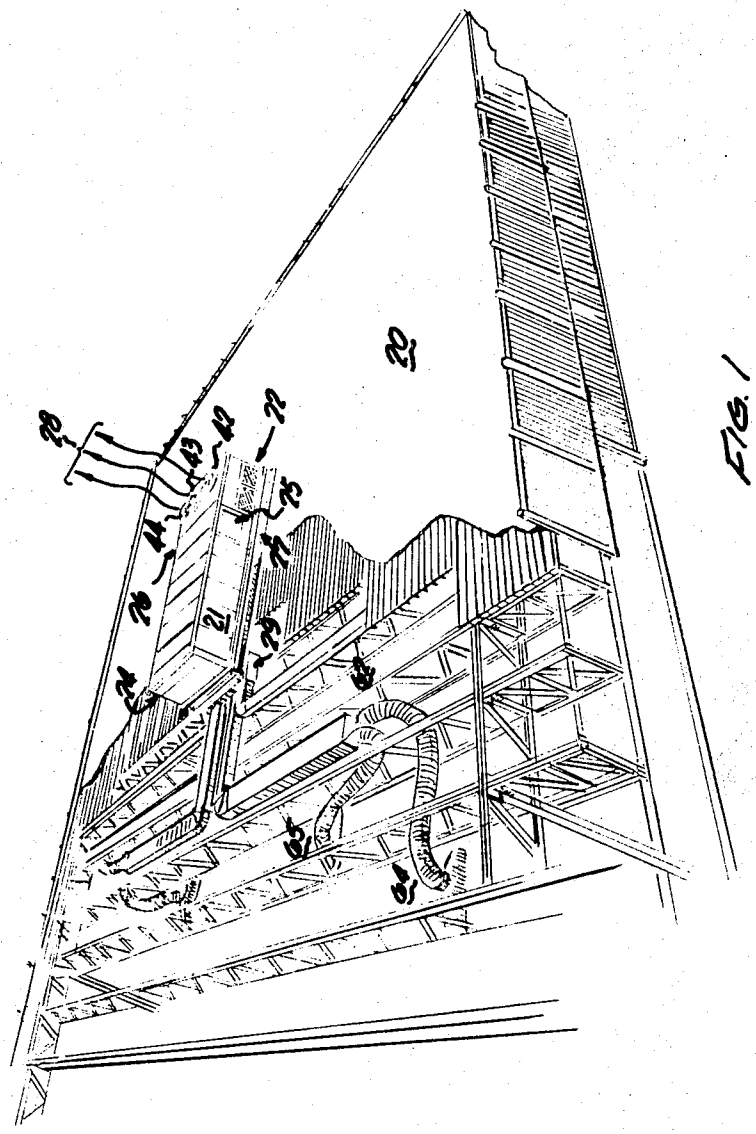


FIG. 1

INVENTORS
JAMES B HOAGLUND
FRANZ A KRUTZ
GEORGE A STORY
BY
ATTORNEY

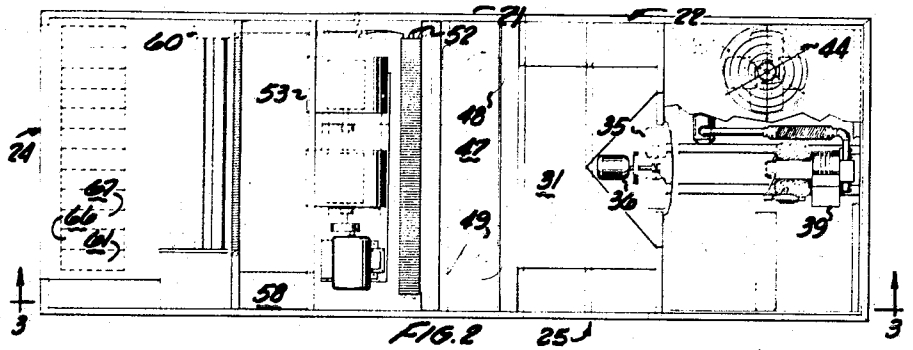


FIG. 2

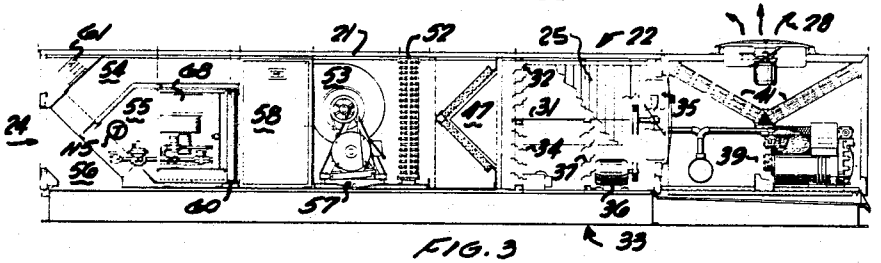


FIG. 3

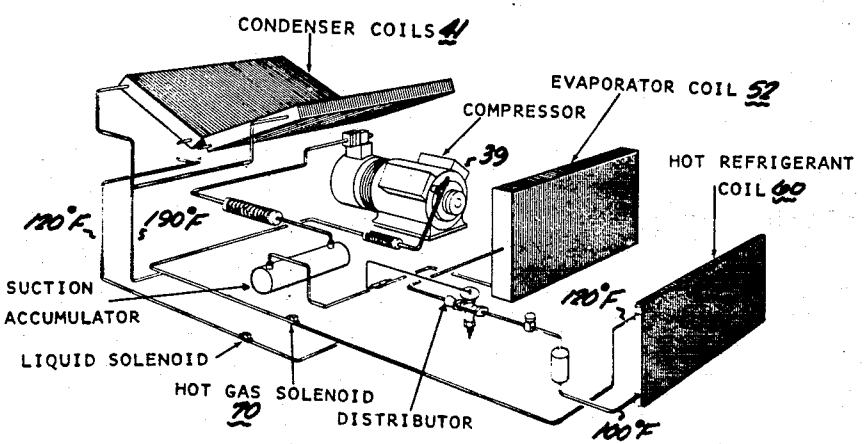


FIG. 7

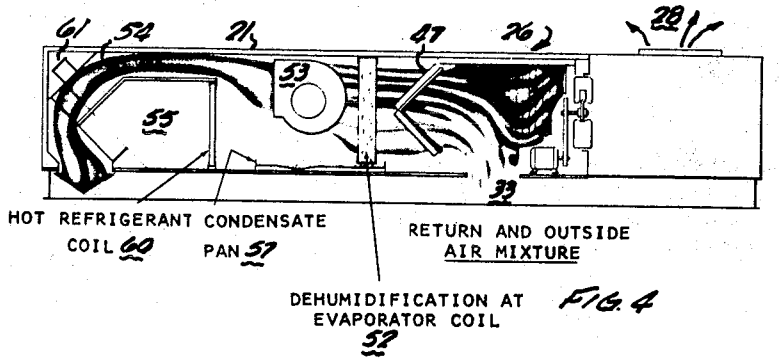


FIG. 4

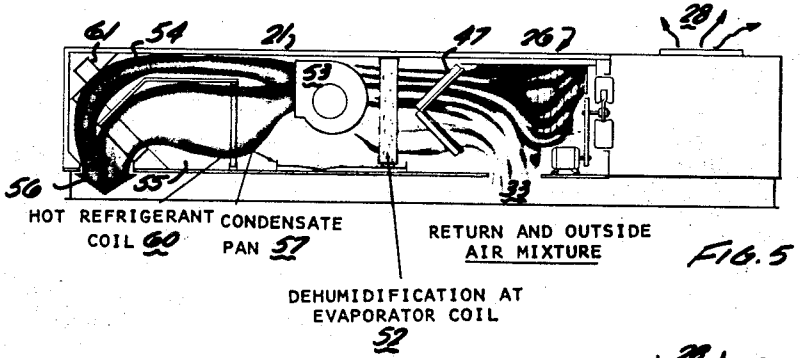


FIG. 5

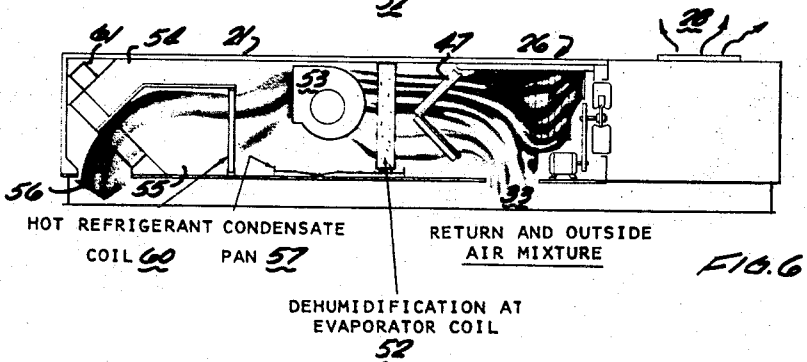


FIG. 6

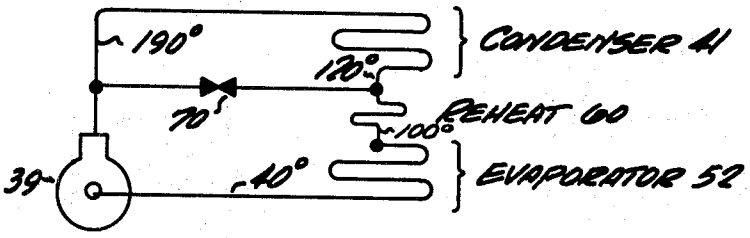


FIG. 8

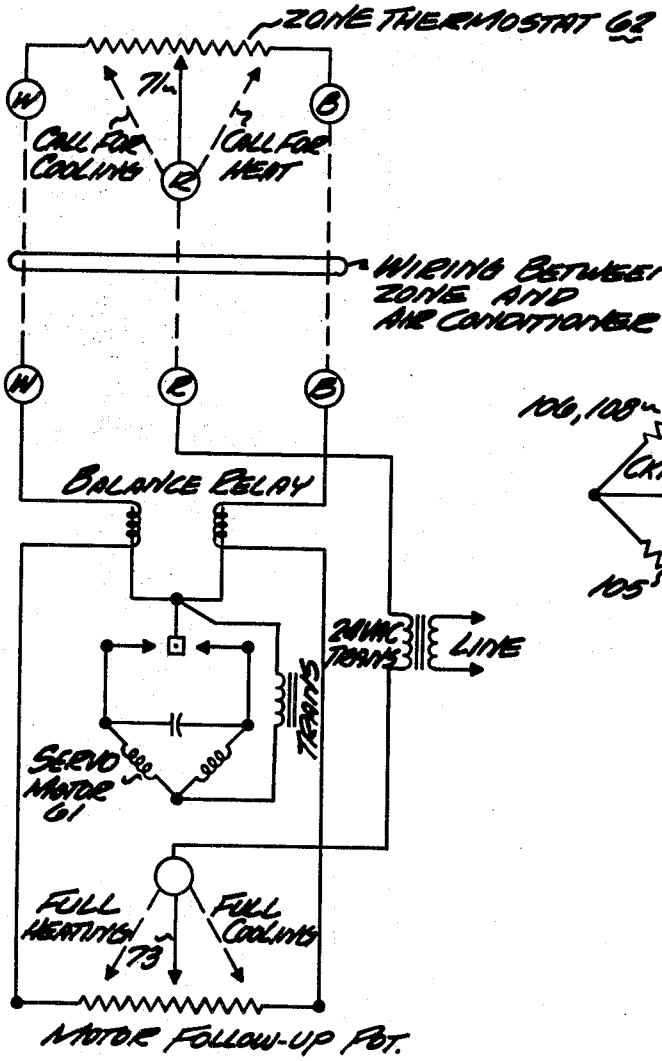


FIG. 9

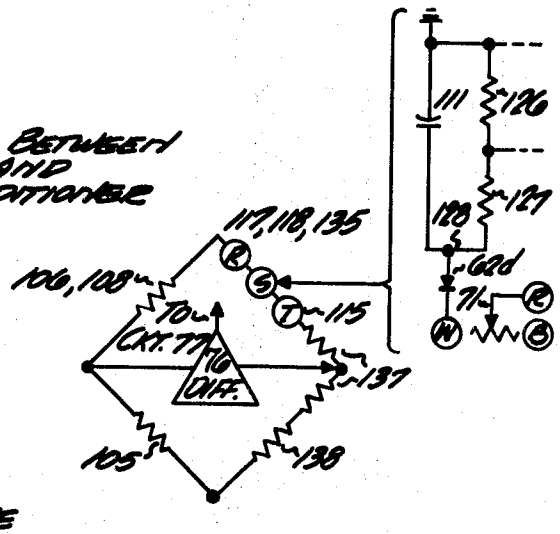


FIG. 11

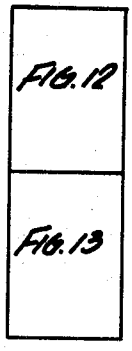
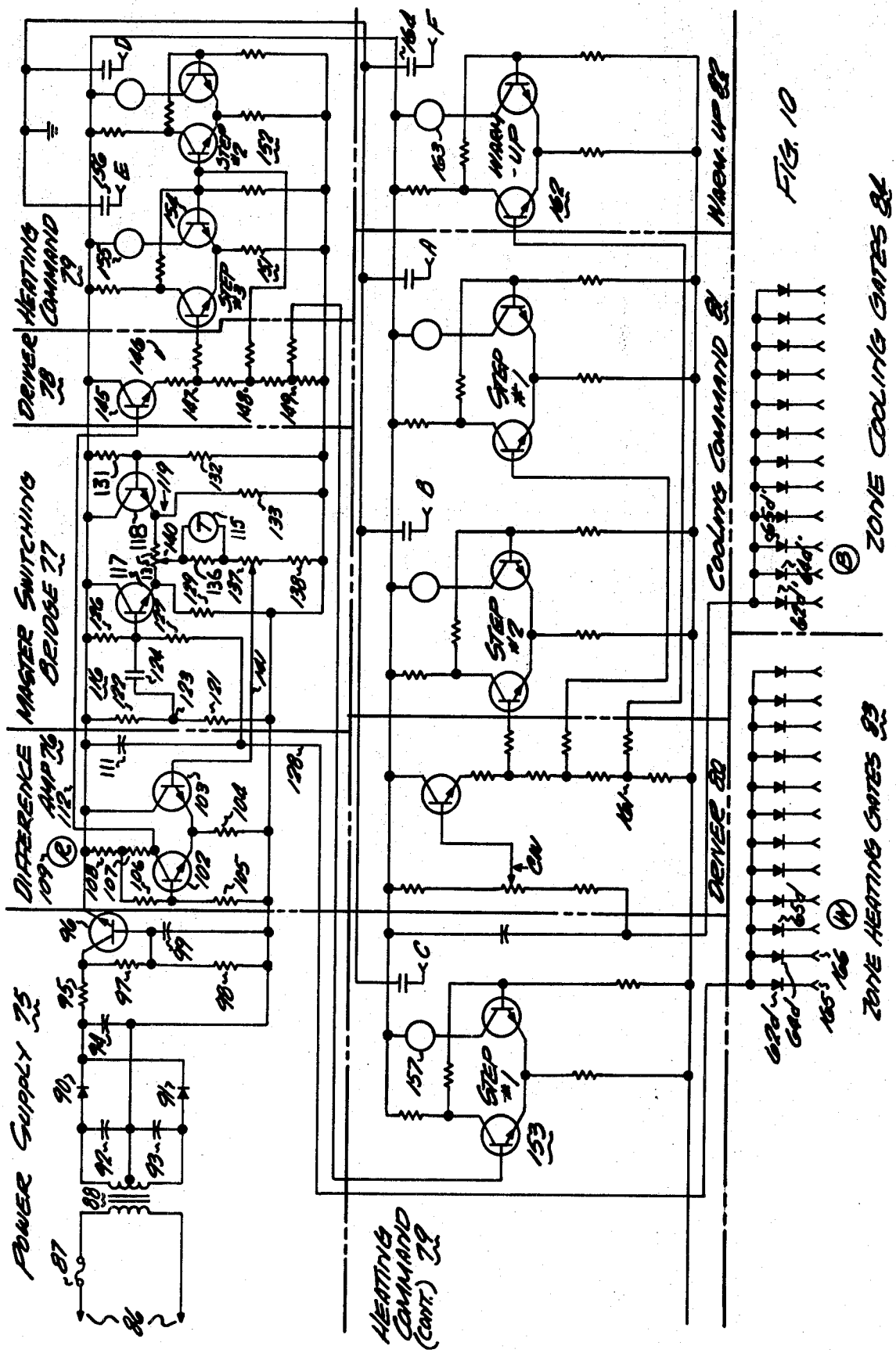


FIG. 14


POWER SUPPLY 25
DIFFERENCE AMP. 26
MASTER SWITCHING DEVICE 27
DEMAND HEATING COMMAND 29
HEATING COMMAND (CONT.) 29
COOLING COMMAND 31
DEMAND 30
WARM-UP 32
ZONE HEATING GATES 33
ZONE COOLING GATES 34
STEP #1
STEP #2
WARM-UP
FIG. 10

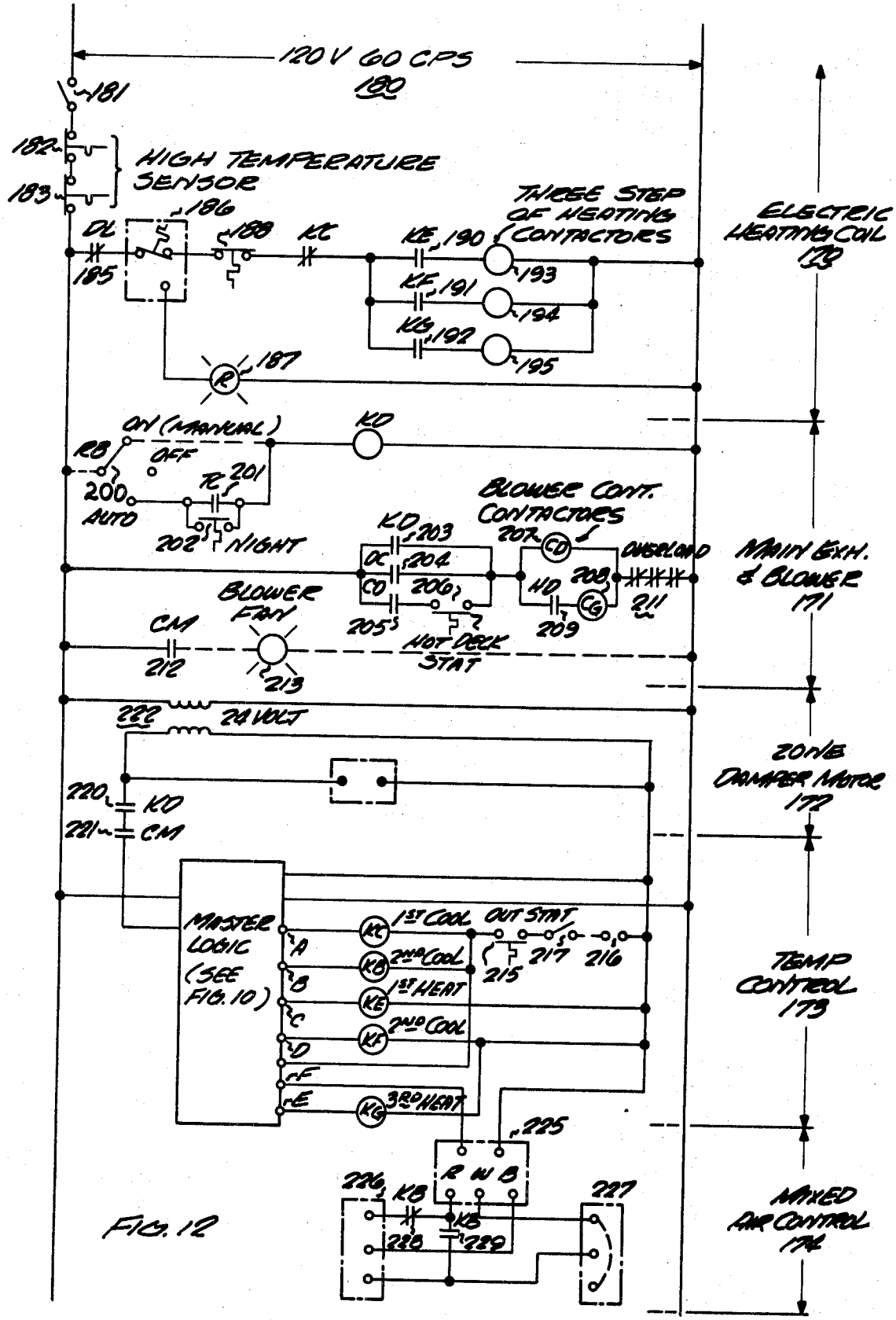

120 V 60 CPS
180
181
182
183
HIGH TEMPERATURE SENSOR
186
188
DL
185
KC
KE 190
KF 191
KG 192
THREE STEP OF HEATING CONTACTORS
193
194
195
ELECTRIC HEATING COIL
178
187
R
ON (MANUAL)
KD
RB
OFF
200
AUTO
TC 201
202
NIGHT
BLOWER CONT. CONTACTORS
KD 203
DC 204
CD 206
205
207
CD
OVERLOAD
208
HD
209
CG
211
MAIN EXH. & BLOWER
171
BLOWER FAN
CM
212
213
HOT DECK STAT
222
24 VOLT
ZONE DAMPER MOTOR
177
220
KD
221
CM
MASTER LOGIC (SEE FIG. 10)
A
B
C
D
F
E
1ST COOL
2ND COOL
1ST HEAT
2ND COOL
3RD HEAT
OUT STAT
215
217
216
TEMP CONTROL
173
225
R W B
226
KB
228
KB
229
227
MIXED AIR CONTROL
174

FIG. 12

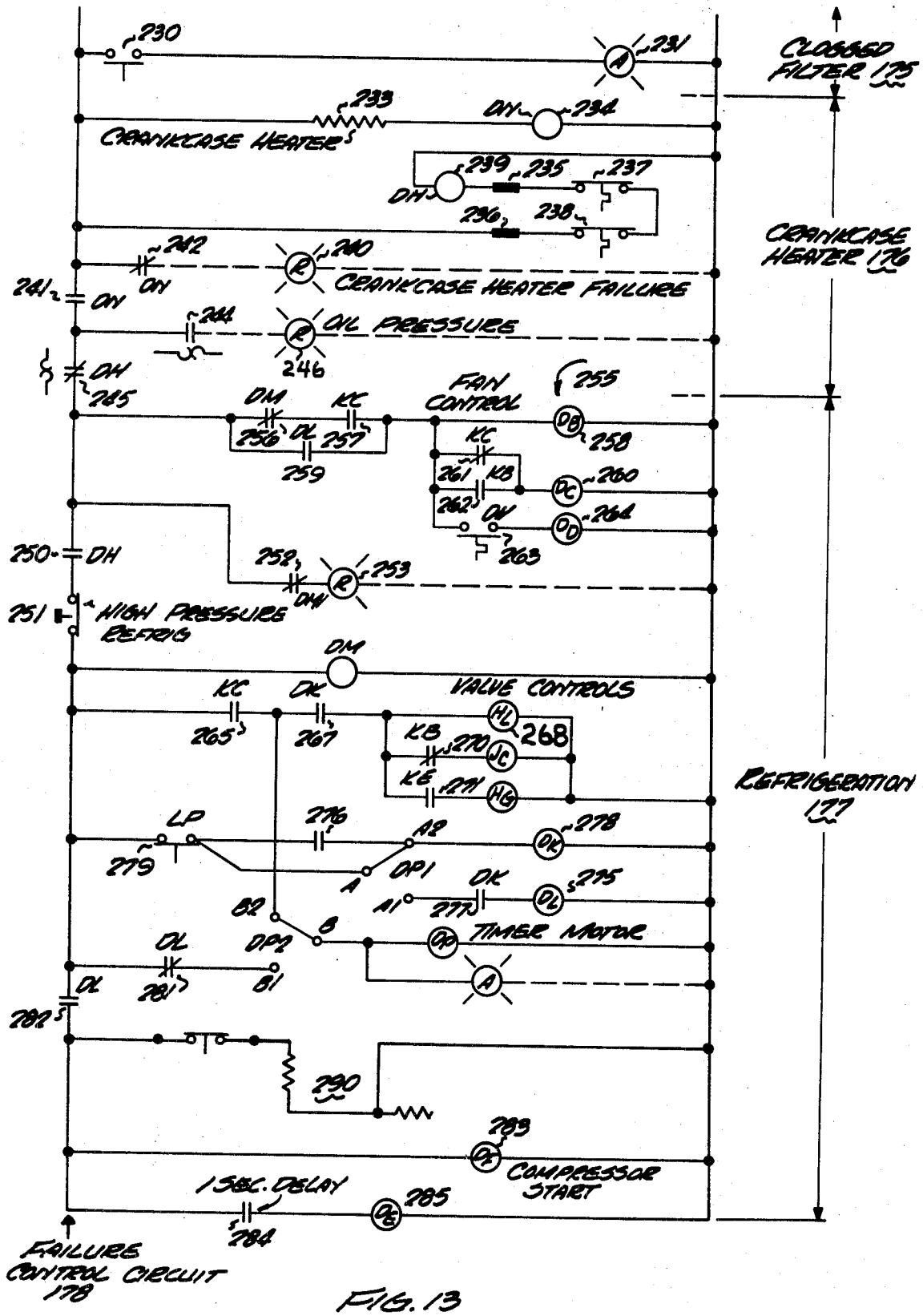

230
231
CLOGGED FILTER 175
233
OH
234
CRANKCASE HEATERS
239
235
237
OH
236
238
CRANKCASE HEATER 176
242
240
241
OH
OH
CRANKCASE HEATER FAILURE
244
OIL PRESSURE
246
OH
245
255
FAN CONTROL
OM
KC
256
OL
257
259
KC
261
KB
262
OW
263
DB
258
DC
260
DD
264
250
OH
252
253
OM
251
HIGH PRESSURE REFRIG
OM
VALVE CONTROLS
KC
OK
265
267
HL
268
KB
270
JC
KE
271
HG
REFRIGERATION 177
LP
276
A2
OK
278
279
A
OP1
OK
275
A1
277
OL
B2
B
OP2
TIMER MOTOR
OL
281
B1
OL
282
290
283
OE
COMPRESSOR START
15SEC. DELAY
285
284
FAILURE CONTROL CIRCUIT 178

FIG. 13

ROOFTOP MULTIZONE AIR CONDITIONING UNITS

This invention relates to rooftop, multizone air-conditioning units and more particularly to improved, preassembled units, each unit including all of the apparatus required for heating, ventilating, cooling, and filtering air which is pumped into the building.

A preassembled rooftop multizone air-conditioning unit saves both interior and exterior spaces, gives flexibility in arrangement and size, and provides year around heating, ventilating, and air conditioning. Very often air-conditioning systems of the type which use these units are adapted to send individual mixtures of hot and cold air to each of a plurality of zones inside the building. The ratio of hot to cold air in the mixture going to any given zone is fixed responsive to the setting of a thermostat in that zone. The duct work, heating, and cooling equipment—within the unit through which the hot and cold air flows before it is mixed—is conventionally called the "hot" and "cold" decks. The output end of the equipment is called the "zone mixing" area.

The air-conditioning equipments of the described types maintain optimum temperatures without appreciable overheating, extra operating expenses, overshooting, cooling, or warmup. Nevertheless, some problems have been unduly troublesome. Among other things, the hot deck may operate at a higher temperature than needed for a particular heating load. During this time, overheating may occur because of leakage around zone dampers or air turbulances within the deck. Thus, when a zone thermostat is not calling for heat, there is a tendency for the system to unanticipatedly deliver heat. The problem of overheating may bring a demand for mechanical cooling and both heating and cooling systems must operate during periods when only one system is required. Other problems are that the known systems were not able to satisfy all of the air-conditioning load ratios imposed under varying conditions of occupancy and lighting, temperature control systems have not been able to recognize various load conditions, and unduly small refrigeration loads may occur if the system is able to use only a small percentage of the cold deck air flow. Those who are skilled in the art will readily perceive still other problems, disadvantages, and shortcomings of these and other prior art systems.

Air-conditioning systems engineers have sometimes turned to a so-called "reheat" system in order to solve these and other problems. However, at an early date, these engineers recognized the practical difficulties of providing reheat cycles, including costly heat exchange equipment and controls. Among other things this was because the reheat principle could not be used without auxiliary heating apparatus, even during the summer season. Since the energy released into the reheated air is not normally recovered in the refrigeration cycle, the waste heat pumped into the systems conventionally require added refrigeration capacity. Therefore, known reheat cycles increase the refrigeration load at the evaporator and, therefore, increase the size and cost of the refrigeration apparatus. Furthermore, a hot gas coil may cause operating problems if not controlled because zone dampers usually permit air leakage. Control of refrigerant gas and oil flow in the refrigeration condensing circuit requires careful piping and circuit design.

Accordingly, an object of the invention is to provide new and improved air-conditioning systems using reheat cycles. In this connection, an object is to provide superior comfort during warm weather operation by wringing moisture out of both the outdoor and return air. Here, an object is to provide a hot refrigerant coil that puts waste heat to work and provides humidity control, even in spaces requiring less than maximum cooling. Another object of the invention is to provide new and improved control over mixed air systems. Here, an object is to detect conditions wherein an over demand of either heating or cooling is likely to occur. More particularly, an object is to make the system respond to heating or cooling demands with reference to actual load conditions occurring within the air-conditioned space, as distinguished from a sole reliance upon the anticipated load conditions within the space. Further an object is to control the ratio of fresh to returning air at the intake end of the unit.

Still another object is to provide a single system for supplying heat to many zones which may then be placing a great variety of demands for different levels of heating or cooling. In greater detail, an object is to provide improved controls for such systems.

Another object of the invention is to reheat previously cooled air without wasting heat from the refrigeration cycle.

In keeping with an aspect of the invention, these and other objects are accomplished by providing a housing unit having an air intake at one end and hot and cold decks at the opposite or output end. To cool and dehumidify all incoming air, an evaporator coil is placed in the housing assembly near its inlet end. A reheat coil is located downstream in the hot deck section of the housing, and arranged to be in series with and normally act as a part of a condenser coil. The reheat coil is thus supplied with a flow of refrigerant emanating from the condenser coil. The exchange of heat, in the reheat coil, heats the air passing through the hot deck and subcools the refrigerant before it enters the evaporator coil. When higher levels of heating are required during periods when the furnace operation is not desired, a bypass valve places the condenser and reheat coils at least partially in parallel, and causes the injection of superheated refrigerant gas directly into the liquid refrigerant flowing to the reheat coil. A thermostat within the hot deck modifies zone thermostat command signals as a function of prevailing temperatures within the hot deck.

The above-mentioned and other features and objects of this invention and the manner of obtaining them will become more apparent, and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view of a rooftop installation showing the inventive air conditioner upon it;

FIG. 2 is a top plan view of the air conditioner unit of FIG. 1 with all but a portion of its roof broken away;

FIG. 3 is a side or elevation view taken along line 3–3 of FIG. 2 showing the air conditioner unit and the location of the major subassemblies therein;

FIG. 4 is a side elevation simplification of FIG. 3 which shows a stream of air extending from an intake mixture of outside and return air on the right and through the cold deck to a mixing zone on the left;

FIG. 5 and 6 are similar to FIG. 4 showing the mixing of air from hot and cold decks and the flow of air through the hot deck, respectively;

FIG. 7 is a schematic view of condenser, reheat, and evaporation coils—together with the compressor and certain valve and sensing arrangements—used to control the refrigerants in the coils;

FIG. 8 is a simplified form of FIG. 7;

FIG. 9 shows a conventional thermostat and damper motor servo system for controlling the mixture of output air depicted in FIGS. 4—6;

FIG. 10 is a schematic circuit diagram which shows an electronic system for controlling the rooftop unit responsive to signals from the thermostat of FIG. 9;

FIG. 11 is a simplified version of FIG. 10 explaining a part of the operation thereof;

FIGS. 12 and 13 form a schematic diagram which shows how the electronic controls of FIG. 10 may be used as master logic in an airconditioner system; and

FIG. 14 shows how FIGS. 12 and 13 may be joined to provide a complete and understandable circuit.

FIG. 1 shows a rooftop airconditioner unit as one exemplary use of the invention. In greater detail, an air-conditioned building 20 has a housing 21 mounted on its roof. One end 22 of the housing 21 provides for the intake of air, and the other end 24 provides for the outlet of the air into the building 20. While it travels through the housing 21, the air is conditioned

in any known manner. The intake end 22 of the housing 21 includes, on its sides, a pair of fresh air intake louvers 25, 26 the louver 26 being hidden from view in FIG. 1. Air inside the building returns through ducts (not shown) at 27 to the housing 21 where a part of the returning airstream is exhausted to the atmosphere at 28 and a part is mixed with fresh air flowing into the louvers 25, 26. The output end 24 of housing 21 includes a number of ducts 29 for carrying individual streams of the conditioned air into the various zones of the building responsive to the settings of thermostats at each of those zones. This is the same air which returns to the housing 21 via the duct work at 27.

One problem is to draw a stream of fresh air through the louvers 25, 26 on each side of the housing and to mix it, in proper ratio, with the stream of air returning from the inside of the building via the ducts 27. The problem is complicated because the prevailing winds blow strongly against one side of the housing 21 where they build a pressure while the same wind sweeps over the other side of the housing 21 where it builds a partial vacuum. Thus, the air intake damper settings commanded by the system may be inadequate, and the fresh air may flow from louver 25 directly to 26, for example, instead of from the louvers 25 and 26 into the housing 21.

The manner in which the system copes with these and other problems may become more apparent from a study of the remaining FIGS.

Briefly, FIGS. 2 and 3 show the housing 21 with its inlet end 22 on the right, and its outlet end 24, on the left. The exact location of the actual input and output ducts 27, 29 may change with location and installation.

A compressor 39 may be put at any convenient location; it is here shown inside the housing 21, upstream from the input louvers 25, 26 where the exhaust stream of return air flows. The compressor drives a superheated refrigerant (such as Freon 22) into the condenser coils 41. Preferably, a plurality of fans 42—44 may be located adjacent the coils 41 to cause a stream of air to move over them. If there are three fans, as shown by way of example, the air conditioner may be adapted to operate at one-third capacity when one fan is running, two-thirds capacity when two fans are running, and full capacity when all three fans are running.

To provide for the mixing of fresh outside and previously conditioned return air, the intake part of the housing 21 is divided into two parts by the deck or floor 31. The outside airstreams enter the louvered inputs at 25, 26, deflects and flows above the floor 31 through an opening controlled by dampers 32. The air returning from inside the building, flows, in part, upwardly at 33 into the space below the floor 31 and then through the space controlled by the dampers 34 into housing 21. An exhaust fan 35, driven by motor 36, drives the remainder of the airstream 33 outwardly from the space beneath the floor 31 to the atmosphere via dampers 37. The spaces closed by dampers 32, 34, 37 may be opened or closed in any degree by suitable servomotors which are driven responsive to the control circuit of FIGS. 12, 13. Thus, for example, dampers 32 may be set relatively wide open, and dampers 34 may be set much less widely opened to provide an in-housing mixture of 75 percent outside air and 25 percent return air.

The refrigerant leaving compressor 39 and entering coils 41 might be superheated well above the saturation level to about 190°F., for example. In the condenser coil 41, the refrigerant is cooled to the condensing temperature by the airstream driven through coil 41 by the fans 42—44 to an exemplary 120°F., for example. Ideally, the heat cycle interchange within coil 41 is limited to a change in the state of the refrigerant from a superheated gas to a liquid, with all heat lost by the refrigerant being transferred to the airstream 28, exhausted into the atmosphere.

The stream formed by a mixture of outside-to-return air is driven through dampers 32, 34 and filtered at 47. FIG. 2 shows the filter as a blanket of material, such as fiberglass, pulled from a supply roll 48 and wound on a take up reel 49. FIG. 3 shows the filter as a pair of flat frames, each including suitable filter material such as fiberglass on dense foam.

After it is filtered, the air is forced through an evaporator coil 52 by a blower 53. The evaporator coil 52 is located in housing 21 ahead of both the main blower fan 53 and the cold and hot decks 54, 55 instead of in the conventional cold deck location. In the evaporating coil 52, the temperature of the refrigerant is dropped to about 40°F. under the heat cycle temperatures assumed above. This both cools and dehumidifies the total airstream. A suitable drip tray 57 beneath the evaporator coil 52 catches the water extracted from the air and allows it to runoff in any suitable manner. Thus, both the return air and outside air are positively dehumidified during the mechanical refrigeration cycle. Thereafter, the dew points are identical for both the hot and cold airstreams, which are mixed at 56 to satisfy the demands of the conditioned space. Regardless of any fluctuations in the demand for sensible cooling, positive dehumidification of all spaces in thus assured. This is of prime importance in applications where high latent loads occur with low sensible heat ratios especially during periods while lighting is at nonstandard levels.

The panel 58 gives access for servicing the unit and provides for mounting some of the controls of FIGS. 12, 13.

The cooled and dehumidified airstream in the outlet from the blower 53 is divided into two airstreams, one of which flows through the cold deck 54, and the other of which flows through the hot deck 55.

Means are provided for reheating the cool stream of dehumidified air emanating from the blower 53. This reheating is accomplished at virtually no cost by the refrigerant, independently of all other heating equipment. In greater detail, inside the hot deck 55, leading to outlet ducts 29, (FIG. 1), is a reheat coil 60 which is coupled in series between the condenser coil 41 and the evaporator coil 52. The stream of air blown over the reheat coil 60 further cools the liquid refrigerant—from approximately 120°F. to a subcooled temperature of 100°F., for example—under the assumptions given above. This portion of the heat cycle gives up heat to the outflowing stream of air in hot deck 55 and warms it sufficiently for light-to-moderate heating needs. Moreover, the resulting subcooling of the refrigerant causes increased cooling in the evaporator coil 52. Thus, the energy dissipated in reheat coil 60, in the form of heat lost to an airstream in hot deck 55, is regained in the cooling capacity of the subcooled refrigerant in the evaporator coil 52.

A servomotor 61 is individually associated with each zone duct to control dampers which mix the air from the hot and cold decks. Thus, for example, a thermostat in a zone area 62 (FIG. 1) may be set for a given temperature. This temperature occurs in that zone when the air in cold and hot decks 54, 55 is mixed on, say a 30 percent—70 percent basis, for example. Thus, the problem is to drive the motor 61 to set the dampers to a position that will cause such a 30 percent—70 percent mixture. The side view of FIG. 3 shows only one of many such zone motors. There are, of course, many such motors, as is apparent from FIG. 2, each controlling the dampers in a separate set of zone ducts 29 leading to different areas of a building. Thus, for example, a thermostat at each of the zones 64, 65, controls motors 66, 67. There could be, say, 12 different and entirely separate mixes of hot and cold air forming 12 entirely different air temperatures for each of 12 different zones.

This introduces a principle of individual zones having separate temperature controls depending upon the modulation of hot and cold streams of air fed to those zones. More particularly, as shown in FIG. 4, a first mode of operation involves the mixing of outside and return air at 26, 33 with cooling and dehumidifying at 52, after which all of the air is delivered to the cold deck 54 because the hot deck zone dampers are shut by the zone motor 61. This mode of operation is appropriate in the summer when there is no demand whatsoever for warm air. The second mode of operation is shown in FIG. 5 where the air which is cooled and dehumidified at 52 is sent through both the hot and the cold decks 55, 54 and

mixed in some ratio by the dampers controlled by the zone damper motor 61. Zones requiring less than the maximum sensible cooling receive a mixture of cold air and warm tempered air which has been reheated by the hot refrigerant in the reheat coil 60. However, both airstreams remain at the same dew point. This second mode of mild heating is appropriate during spring and fall when some zone thermostats are calling for heating and others for cooling. The third mode of operation, appropriate during the winter, is shown in FIG. 6 where the servomotor 61 closes the zone dampers in the cold deck 54 and the entire stream of air is sent through the hot deck 55. All zones that require heating receive warm air which has been heated by a direct fired furnace 68. This air is also at the same dew point as the air being supplied to blower 53. The foregoing simplification, refers to seasonal air control which occurs during summer, fall, winter, and spring; whereas any of the three modes of operation could occur at any time, depending upon the demands of the zone thermostats.

Next to be described is the manner in which the thermostats sense these temperatures and select between these three modes of operation. First, there is the outside temperature which may be sensed by conventional outdoors thermostats. When the weather is below a certain temperature, it is cold enough so that the compressor may be shut down completely. The coldness of the outdoor air may be used in place of the cooling by the evaporator coil. At this time, the furnace 68, in the hot deck 55, supplies all of the heat. When the outside air is above a certain temperature, the furnace may be shut down, but there is upstream mechanical cooling at 52 so the outside air is not used for heating. It is at this time that the reheating coil 60 supplies the heated air mixed (FIG. 5) with the cold air.

There are two separate heating situations during the periods when the mechanical refrigeration is operating. One, the moderate situation, occurs when demands for reheat are minimal, and the reheat coil 60 receives adequate heat from the hot liquid refrigerant. The other situation occurs when the liquid refrigerant does not provide enough heat to satisfy more severe demands for reheat during mild weather. For most applications, a multizone unit never sees a full cooling load in every zone simultaneously except at a startup condition, when full cooling is required. Calculations show the requirement for hot deck airflow at design conditions to be relatively small, about 8 percent, for example. During this period liquid refrigerant furnishes adequate reheat.

In keeping with the invention, the more severe demands for reheat—during periods while the furnace is not running—are met by providing a valve 70 which may be opened to transmit a selected amount of hot refrigerant gas from the compressor 39 directly into the liquid refrigerant flowing to reheat coil 60. Thus, the condensor and reheat coils are effectively connected both in series and in parallel during this mode of operation. That is, there is a first stream of gaseous refrigerant flowing from the compressor 39 through the coils 41 and 60 in series and a second stream flowing at 190°F. through valve 70 and coil 60 in parallel with the first stream from the coil 41 at 120°F. Most heat given off by the refrigerant in the first stream occurs in condenser coil 41 and is wasted by being blown into the atmosphere by the fans 42—44. However, all of the heat given off in the second stream is used to heat the hot deck airstream, and by proper design, the cooling power of coil 52 is also increased by subcooling the refrigerant at coil 60. Hence, upon reflection, it should be apparent that by properly controlling the valve 70 the stream of hot gas may be increased or decreased to increase or decrease the heat given off by the reheat coil 60.

The electrical controls for accomplishing the described functions are shown in the remaining figures. More particularly, FIG. 9 shows a conventional thermostat-damper motor servosystem which is used to control a motor at the output end of the air-conditioning unit 21. For example, the zone thermostat might be one in the zone shown at 62 in FIG. 1, and the motor may be that shown at 61 in FIGS. 2 and 3. In FIG. 9, the letters R, W, and B, stand for the conventional color-coding of the red, white, and blue wires used in many thermostats. Since this is a well known circuit, it is enough to here note that it is basically a bridge wherein an arm 71 may be moved left or right to call for cooling or heating, respectively. The relative distance of movement in either direction fixes the relative amount of heating or cooling that is demanded. Responsive thereto, the servo motor 61 drives a potentiometer arm 73 while it controls the dampers in the hot and cold decks. When the dampers reach the required settings, the bridge of FIG. 9 is in balance, and the hot-cold air mix is that which provides temperatures requested by the zone thermostat setting. Again, this drawing represents any of many commercially available damper motor controls such as the Honeywell "Series 90." It is cited here merely to identify the R, W, and B wires and to indicate the nature of the voltage variations, appearing at the points, R. W. and B (FIG. 10) as a result of the thermostat operations.

With the nature of the servocontrol system in mind, the details of the inventive control system will become more apparent from a study of FIGS. 10—12.

FIG. 10 may be conveniently divided into ten parts, as shown by dot-dashed lines, as follows: a power supply 75, a difference amplifier 76, a master switching bridge 77, a driver 78, a three step heating command circuit 79, a driver 80, a two step cooling command circuit 81, a warmup control circuit 82, a diode zone heating gate circuit 83, and a diode zone cooling gate circuit 84. Each diode in gate 83 connects to a white wire W in a corresponding zone thermostat and each diode in gate 84 connects to a blue wire B in a thermostat of a corresponding heating zone. For example, by way of identification, the thermostats in zones 62, 64, 65 (FIG. 1) may be connected via their white wires to diodes 62*d*, 64*d*, and 65*d* (FIG. 10) and via their blue wires to diodes 62*d'*, 64*d'*, and 65*d'*. All zone thermostat red wires connect to point R in the differential amplifier 76.

The power supply circuit 75 may take any suitable form. It is here shown as including a power source 86 (which might be standard commercial 115V, 60 c.p.s. power), a fuse 87, and a transformer 88. The output of the transformer 88 is connected to a full wave rectifier 90, 91 bridged by capacitors 92, 93 which bypass transformer voltage spikes to ground. Coupled across the rectifier 90, 91 is a capacitor 94 which smooths the rectified voltages. A resistor 95 is coupled between the rectifier 90, 91 and a collector of a transistor 96. The base of this transistor 96 is biased by a pair of voltage dividing resistors 97, 98, and bypassed to ground by a capacitor 99 for further smoothing of the ripple voltage.

Means are provided for modifying any command signals received from a zone thermostat by the temperatures actually prevailing in the air-conditioning unit 21. More particularly, the difference amplifier 76 provides a means for comparing the voltage at the servocircuit (FIG. 9) demanding the worst case of heating with the temperature actually prevailing in the hot deck 55 of the air-conditioning unit. The details of how this amplifier 76 operates in conjunction with other parts of the system may become more apparent from a study of FIG. 11, explained in greater detail hereinafter.

The principal components of the difference amplifier are two NPN transistors 102, 103 sharing a common resistor 104, which is used to supply an emitter bias. The base bias for the transistor 102 is provided via a resistor 105 which is also part of a bridge circuit, as shown in FIG. 11. A resistor 106 is coupled between the collector and base of transistor 102 to feedback a signal for swamping the effects of manufacturing tolerances. The resistor 107 is a collector load. Resistor 108 aids in setting proper voltage divisions. The red wire R in each zone thermostat (FIG. 9) is connected at 109. A signal which varies as a function of the temperature in the hot deck is applied to the base of the transistor 103. The capacitor 111 smooths a signal voltage applied through the zone heating gates 83.

The difference amplifier **76** compares the signals which it receives (*i.e.* a reference and the worst case demand for heat received via gate **83** and sent over the wire **128**) to give an output signal which is proportional to the amount of heat actually required, considering the prevailing deck temperatures. More particularly, the difference amplifier **76** is fed from a bridge (FIG. **11**) formed by a number of resistors, a thermistor in the hot deck, the zone thermostat sensor signal, and a source of a reference potential established by a transistor and resistor network. Thus, a demand for heat is modified by temperatures actually prevailing in the hot deck at the time when the demand is made.

The master switching bridge **77** includes the thermostat at **115** located in hot deck **55**, a clamp circuit **116**, a pair of NPN common emitter transistors **117**, **118**, and a reference voltage circuit **119**. The clamp circuit **116** includes a voltage divider **121**, **122** connected across the power supply for establishing a predetermined reference potential at the point **123**. Relay contacts **124** are a suitable device for applying the potential at point **123** to the base of transistor **117** to inhibit the master switching bridge **77** during periods when predetermined amounts of mechanical cooling are required. During non-clamped conditions, the base of the transistor **117** is biased from a voltage divider comprising the resistors **126**, **127**, connected between the output voltage of power source **75** and a zone thermostat. Resistor **129** supplies an emitter bias. Thus, the current through the transistor **117** varies as a function of the potential on the white wires unless there is a cooling demand which exceeds at least a predetermined level, in which case contacts **124** are closed, and the output current from the bridge **77** is a steady state resultant of the clamping potential appearing at the point **123**. The base of the transistor **118** is biased from a voltage divider **131**, **132** connected across the power source **75**. The emitter bias is supplied via a resistor **133**.

Means are provided for modifying any heating demands from a zone thermostat by the temperature actually prevailing in the hot deck **55**. This means is incorporated in a bridge circuit appearing in FIGS. **10** and **11**. In greater detail, the circuit coupled between the emitters of the transistors **117**, **118** provides part of the bridge shown in FIG. **11** which includes a thermistor **115** located in the hot deck **55**. This circuitry also includes a potentiometer **135** having an arm which may be moved to any point for establishing a reference potential. If moved all the way to the left, the reference is for a maximum allowable temperature, such as 140°F. inside the hot deck. If moved all the way to the right, the reference is for the minimum temperature, such as 70°F. inside the hot deck. Connected to the potentiometer arm is the upper end of a parallel combination of the thermistor **115** which is bypassed by a resistor **136**. This parallel combination of thermistor and resistor provides a more linear responsive curve than is normally available from a thermistor, per se. The lower end of the parallel combination is connected to a variable resistance **137**, in series with a fixed resistor **138**, which is useful for selecting an operating level.

The operation of the master switching bridge circuit **77** should now be clear. Transistor **118** is applying a fixed potential to the right-hand end of potentiometer **135** responsive to the fixed voltage divisions appearing across the resistors **131**, **132**. The transistor **117** is applying a nonfixed variable potential to the left-hand end of potentiometer **135**, according to the voltage on the white wire W received from a zone thermostat at **128** unless contacts **124** are closed to provide a clamping potential. The variable potential is picked up in a voltage division established by a potentiometer which is preset at 140. The thermistor **115** modifies the picked up potential by dropping it by an amount which reflects temperature in the hot deck of the air-conditioning unit. Then, this modified potential is applied over wire **141** to the base of the difference amplifier transistor **103** where it is compared with the fixed voltage that is used for driving the transistor **102**. Thus, the difference amplifier **76** has an output **112** which represents a summation of all of these variables including demands from the zone thermostat and temperatures prevailing in the hot deck **55**.

Means are provided for satisfying the worst case demand for heating or cooling. The signals representing this worst case demand may be seen in FIG. **9**. If the thermostat wiper arm **71** is placed closest to the blue wire B, then the voltage potential between terminals W and R will be at a maximum value. When fed through a gate, for example, gate **62***d*, this voltage is rectified to provide a half-cycle DC signal which has the highest voltage level, and thermostats having any other settings have lower voltage levels. If arm **71** is placed closest to the white wire W, the voltage between terminals B and R is at the highest voltage level. In the same way, this voltage may be fed through a gate, for example, gate **62***d*, to produce a highest level DC signal. During periods of mechanical cooling, a relay (not shown) closes contacts **124** to clamp the voltage at the base of the transistor **117**, and thereby inhibit the more extreme demands for heating which may otherwise be transmitted through the master switching bridge **77**. This action is necessary so that the refrigeration system may function properly while providing the source of heating through coil **60**.

In greater detail, the output of the differential amplifier **76** is coupled to the driver stage **78**. Here an NPN transistor **145** is connected at its base to the wire **112**, at its collector to the output of the power source **75**, and at its emitter to a series of resistors **146**. It should be apparent that the potentials appearing at the points **147**, **148**, **149** will vary as a function of output current from the difference amplifier, the output being applied to the base of the driver transistor **145**. Each of these three points **147**, **148**, **149** is connected to an individually associated one of three Schmidt trigger circuits **151**, **152**, **153**, respectively. It is thought that there is no need to describe the circuits **151-153** in detail since the design of these Schmidt trigger circuits is entirely conventional except for an inclusion of a relay in the load of one of the trigger circuit transistors. For example, the relay **155** is shown in the collector load of the transistor **154** of trigger circuit **151**. When Schmidt trigger circuit **151** switches "on", relay **155** operates and closes contacts **156** and when it switches "off", relay **155** releases and opens contacts **156**. Thus, depending upon the amount of current flowing through the driver transistor **145**, the potential either at point **149**, or at points **149**, **148**, or points at **147**—**149** may raise to a level which is adequate to trip the associated Schmidt trigger circuit. The relay contacts **156** are also used to pilot switching on and off of the reheat solenoid valve **70** during refrigeration mode of operation. Therefore, precisely speaking, the clamp circuit is not to inhibit the furnace, but rather to maintain the control point of hot deck thermistor **115** at a value not to exceed about 78°F. for mild weather and summer operation. The clamp opens when refrigeration is deenergized, and the heating is taken over by the furnace. This switching and interlocking is performed externally to the logic circuit of FIG. **10**.

As the current through transistor **145** increases, the voltage levels **147**, **148**, **149** increase and turn off or release the relays, *i.e.*, contacts **156**, etc. open. Conversely, as the voltage levels **147**, **148**, **149** decrease, the Schmidt triggers turn on or operate the relays. That is why relay **157** with the lowest driver voltage at point **149** is the first step of heating.

The mode of furnace control operation should now be clear. A zone thermostat is set in each zone (such as **62**, **64**, **65**–FIG. **1**) and a corresponding voltage is fed over the white or blue wires to the gates **83**, **84**. The diode receiving the highest voltage from a zone thermostat conducts on the appropriate half-cycle, in this case the negative half-cycle. Thus, if the white wire **165** is the most negative, the diode **62***d* conducts and makes the anodes of all other diodes (such as diode **64***d*, **65***d*) equally negative. Since it has been assumed that white wire **165** is more negative than any other white wire, such as **166**, the anodes of all other diodes are more negative than the cathodes, and all of the other diodes in the gate **83** are back

biased. Hence, it should be clear that the furnace is controlled by only the most negative voltage representing the highest demand for heat. Obviously, the furnace can meet all demands if it can meet the worst demands, which is the reason for calling this a "worst demand" system.

The driver 80 and cooling command circuit 81 are essentially the same as the driver 78 and heating command circuit 79.

The cooling zone gate 84 operates in essentially the same manner responding to the worst case demand or the highest level of cooling. Again, if the worst case is satisfied, the more moderate demands for cooling may also be satisfied. However, there is no need for the master switching bridge circuit 77—or a comparable circuit—in the cooling cycle because there is no need for a thermostat in the cold deck 54.

The normal functioning at night and early morning is for the building to be under operation at a lowered night temperature when it is unoccupied. All zone thermostats are, therefore, calling for full heating during a warmup period before the building reaches normal day temperature. During the cycle, fuel is saved by keeping the outside air damper completely closed. The potential at the point 161 reaches a value which switches the warmup Schmidt trigger circuit 162 to turn off or release the relay 163 and open its contacts 164 but only when no zones are calling for cooling. The logic is that if no zones are demanding cooling, all zones must be demanding full heating. Contacts 164 open to cause other controls to drive the outside air damper 32 completely closed.

The circuit of FIG. 10 is used as a master logic, decision-making, unit for driving a relay control circuits FIGS. 12, 13 which provides the interface for the air conditioning, heating, and ventilating system mounted in the housing 21. Among other things, this interface circuit controls the intake of both the fresh outside air and the previously conditioned inside air, and mixes them together in a ratio which is set by prevailing conditions. When weather conditions are neither hot nor cold, commands may cause ambiguous effects as when a system might call for outside (or return) air under conditions when no outside (or return) air is required with a result that the air conditioning (or furnace) is overworked. Thus, as the interior of the air-conditioned building becomes colder, the zone thermostat calls for more heat, but the thermostat does not know the reason for the apparent drop in temperature. The change might not occur as a result of a drop in outdoor temperature. Perhaps, the drop could result from the initial cold deck cooling when the refrigeration apparatus is first put into operation. Under these conditions (refrigeration energized) the positioning of dampers 32, 34 (FIG. 3) may be set to cut off all outside air and to use all return air, which could be opposite to the desired effect. There is a similar problem with regard to the interface control over the reheat coil 60.

For an understanding of how the interface operates, reference is made to FIGS. 12, 13. The circuit of FIG. 10 provides the master logic which fills the box in the lower left hand corner of FIG. 12. The wires A–F of FIG. 10 connects to the wires A–F of FIG. 12.

The major subdivisional elements of this diagram (FIGS. 12, 13) are a heating command circuit 170, a blower control 171, a zone damper motor 172, a temperature control circuit 173, a mixed air control circuit 174, a clogged filter detector 175, a crankcase heater 176, a refrigeration control unit 177, and a failures control circuit 178. Any suitable power source 180 may be connected across the two vertical busses. This could be a standard 120 volt, 60 c.p.s. commercial power source, for example. Any suitable on–off switch 181 may be provided to apply or remove the power. Sensors 182, 183 may also be provided to remove power when excessive temperatures occur, as for example, a high temperature sensor 182 may be in the hot deck and another 183 in the return air duct.

The heating command circuit 170 includes a set of contacts 185 which may be opened during an interval controlled by a DL relay, as explained below. The device 186 is a thermostat, with either automatic or manual reset, for protecting the unit when excessive heat begins to flow. A light 187 indicates when the circuit has opened to break the power connection to the furnace. The contacts 185 are part of a lockout device, which may be associated with compressor hardware, for preventing the furnace from coming on while cooling is required and whenever the refrigeration compressor 39 is running. Thus, the furnace 68 and air-conditioning equipment will not fight each other. Contacts 188 are an auxiliary temperature protection device.

The contacts 190—192 are provided to energize one, two, or three electrical coil controlling contactors 193—195, thereby providing three steps of heating. These contacts 190—192 are closed responsive to commands from FIGS. 10 sent over wires C, D, E. Thus, for example, if the relay KE operates, the KE contacts 190 close, contactor 193 operates, and one-third of the heating capacity is provided. If relays KF and KG operate, contacts 191, 192 close, and the remaining capacity comes into action.

The blower control circuit 171 includes a switch 200 which may be remotely located, away from the air-conditioning unit. It includes a first position "MANUAL" for manually turning on the blower 53 by operating a relay KD. A second position "OFF" turns the blower "OFF". A third position "AUTO" places the blower 53 under the control of either a time clock contact 201 or a night thermostat 202 which maintains a preset minimum temperature when the building is not occupied. In any event, a circuit may be completed through either the MANUAL position or the AUTOMATIC position of the switch to operate a relay KD which closes a circuit at contacts 203 to turn on the blower 53.

In parallel with the relay contacts 203 are an interlock set of contacts 204 which keep the blower 53 running whenever the compressor 39 is in operation. Another set of contacts 205 provide a lockout circuit which prevents the blower 53 from restarting after device 206 has opened. Device 206 provides for running the blower 53 to dissipate hot deck heat whenever such temperature is above a prescribed maximum generally falling within the range of 100°F. to 130°F. A pair of contactors 207, 208 are the devices which close the circuits that actually operate the blower 53 and exhaust fan motor 36, respectively. The contacts 209 are on a switch which reacts to the position of the exhaust damper, and they prevent the exhaust fan from operating when the dampers 32, 34 are closed. The contacts at 211 are any suitable overload devices such as circuit brakers, temperature sensitive thermostats, or the like. Contacts 212 are closed to light lamp 213 whenever the blower 53 is running.

Next to the described are the zone damper motor circuit 172 and the temperature control circuit 173. Associated with the cooling cycle equipment, and perhaps with one stage of heating also, is an outdoor thermostat 215 for preventing cooling during periods when the outside temperature is below, say 50°F., or the like. Also associated with this circuit is a manual switch 216 which serves any suitable function, such as providing for maintenance shut down, while contacts 217 are a manual override for preventing the thermostat 215 from operating the refrigeration equipment. The contacts 220, 221 lead to the master logic circuit switching system. The KD contacts 220 are closed whenever the unit is commanded to operate. The contacts 221 are closed whenever blower 53 is running. These contacts may represent any suitable interlocks; for example, contacts 220 and 221 are closed if the main blower is running. The transformer 222 supplies 24-volts power to the servomotors. These motors may work in conjunction with any suitable room thermostats, such as a Honeywell T921A room thermostat acting together with a M934A motor, for example. These motors set the individual mixing zone dampers leading from the hot and cold decks 54, 55 to the ducts 29 in order to mix the heated and cooled air in a ratio which establishes a desired temperature for each zone.

The mixed air controller modulates the flow of outside and return air to provide a single mainstream having a predetermined mixture. In greater detail, item 225 is a standard com-

mercial servomotor—again any suitable device may be used for providing this function, such as a Honeywell motor M905E controlled by mixed air controller **226**—which could be a Honeywell controller device, T991A. Again the letters R, W, and B identify the red, white, and blue wires. Item **227** is an override device. When the master logic circuit of FIG. **10** is not on the second cooling step, the relay KB is not operated, and motor **225** operates the mixed air dampers to bring in an amount of fresh air which is commensurate with the building air conditioning needs. For example, the dampers **32**, **34**, (FIG. **3**) may be set to provide a mainstream having a predetermined ratio of inside to outside air which meets prevailing building needs in view of atmospheric conditions.

In operation, mixed entering air controller **226** is located in the cold deck, downstream from evaporator coil **52**. It functions to control dampers **32**, **34** and, therefore, the mixed entering air at a predetermined temperature. There are two modes of operation. First, during the heating cycle when the refrigeration equipment is inoperative and outside air is generally colder than the controller **226** setting, the controller maintains desired temperature of the mixture by closing outside air damper **32** and opening return air damper **34** in proportion to the amount of the temperature drop below the desired value at cold deck **54**. Second, during periods when the master logic control panel has energized the first stage of refrigeration, the controller **226** continues to respond to a drop in cold deck temperature by positioning the outside air damper in a closing direction and opening the return air damper. During this sequence, the mixed air temperature at **47** will rise as long as outside air is at a lower temperature than return air, but the overall system adjustment is different than might first appear. The problem during mild weather (55°F. to 65°F.) when refrigeration is first energized, is to present enough load at the evaporator to balance the refrigeration apparatus at reasonable and desired temperatures. Thus this control system solves this problem by repositioning outside and return air dampers to increase the air temperature entering the evaporator when controller **226** senses a drop in cold deck temperature. An increase in temperature of the air entering the evaporator causes a new balance point for the refrigeration apparatus and, thereby, enables controller **226** to maintain a desired, predetermined cold deck temperature (typically 55°F.).

An important advantage of this arrangement is that the intake air mixing dampers modulate the mainstream mixture of fresh and preconditioned air as a function of both prevailing atmospheric conditions and the cold deck temperature conditions. The contacts **228**, **229** disable this circuit when the commands of the logic circuit (FIG. **10**) go to a second step cooling, and the relay KB operates. At that time, the outside weather is assumed to be very warm and the dampers assume some predetermined position. For example, they may form a mainstream consisting of 25 percent fresh air and 75 percent return air.

The clogged filter circuit **175** comprises a switch **230** that lights a lamp **231** when the filter needs replacing. Some filters **47** (FIG. **2**) are in the form of large rolls or blankets of filter material, such as glass fibers, for example. These rolls advance a step at a time, slowly presenting clean filter material at intervals which are fixed by the needs of the area involved. Here, the switch **230** may be a limit switch that is actuated near the end of the roll. In another case, the filters **47** are stationary devices, and the switch **230** may be a device for measuring the air pressure on opposite sides of the filter. Contacts **230** close when the pressure differential exceeds a predetermined amount. In any event, a light **231** lights when the filter **47** needs replacing.

In compressors of the described type, the refrigerant sometimes finds its way into a crankcase filled with oil. When it does, the compressor could be damaged severely. Therefore, a heating element **233** is placed in the crankcase to heat the oil therein to a temperature which is high enough to boil out the refrigerant without damaging the oil. As current flows through this heater coil **233**, a current sensitive relay **234** operates. Failure of the crankcase heater **233** causes relay **234** to drop out and contacts **241** to open. A lamp **240** goes on when the crankcase heater burns out to release the relay **234** and close contacts **242**. A pair of fuses **235**, **236** and thermostats **237**, **238** break a power supply circuit under compressor failure conditions to release relay **239**. This failure causes DH contacts **250** to open the circuit to the refrigeration control circuit **177** when the compressor motor temperature becomes too high. Contacts **244**, **245** are thermal sensitive devices which are actuated by the crankcase oil pressure through a heater circuit. The lamp **246** indicates when the crankcase oil pressure has dropped to a dangerously low value.

A high refrigerant pressure device **251** also disables the compressor. In the event of an opening of contacts **250** or **251**, power is removed from the compressor failure relay DM, which releases, and contacts **252** close to light the lamp **253** and thereby indicate the nature of the trouble.

The selection of the desired cooling capacity is made responsive to master logic decisions (FIG. **10**) that operate or release the cooling relays KC, KB (FIG. **12**) which, in turn, control the relays **255**. That is, the roof top refrigeration unit includes three condenser fans **42**—**44** (FIG. **1**), each of which provides a step of condensing capacity when it is running; thus, there may be one-third, two-thirds, or a full three-thirds of condensing capacity. When there is no failure shutting down the compressor, relay DM is operated, and contacts **256** are open. If there is a demand for cooling, at the first level, contacts **257** are closed. If a timer-controlled relay DL is operated, contacts **259** close and relay **258** operates to run one fan **42**. When the master logic circuit (FIG. **10**) commands second step cooling, relay KB (FIG. **12**) operates and closes contacts **262**. Hence, both of the relays **258**, **260** operate, and two fans, **42**, **43** are running. A thermostat **263** senses atmospheric temperature, operates relay **264**, and turns on the fan motor **44** whenever the outside air is above a given temperature, thus providing a maximum condensing capacity.

The next circuit includes valves HL, JC, and HG and has to do with the condition wherein the zone thermostats are likely to demand both cooling and heating at the same time. Here, care is required to be certain that the furnace and refrigeration equipments are not fighting each other. In greater detail, under these conditions one zone thermostat may be asking for the first step of cooling, and relay KC is operated. Contacts **265** are closed. Contacts **267** are part of a timer lockout circuit which is not immediately pertinent; if there is no timer controlled lockout, contacts **267** are closed. This operates a hot liquid solenoid **268** which permits flow of the hot liquid refrigerant into the reheat coil **60**. During this condition (first stage of cooling), a zone thermostat could ask for either more cooling or more heating. If more cooling is required, relay KB (FIG. **12**) operates to open the contacts **270** and thereby release the solenoid JC. The solenoid JC thereupon applies a heavier load upon the compressor and brings the refrigeration unit's cooling capacity up to a higher level. On the other hand, if heat is requested, the relay KE operates to close the contacts **271**. This operates the hot gas solenoid HG to close the valve **70** and thus supply hot refrigerant gas to the reheat coil (this is the series circuit including the coils **41**, **60**). Thus, the system may move from first step cooling (relay KC operated; solenoids HL, JC operated) to either full cooling (relay KB operated; solenoid JC released) or to first stage heating (Relay KE operated; solenoid HG operated).

The final part of the refrigeration control circuit **177** is a timer which precludes the circuit from coming on for a predetermined period after it has turned off. This prevents a rapid cycling of the compressor which could cause damage to compressor valves and bearings. The major component in this circuit is a 4-minute timer motor DP and its two contacts DP1, DP2. An associated relay **275** controls the energization of the timer motor DP and the compressor starting circuits. The remainder of the timer circuit may be understood best from a description of one time cycle.

Assume first that the air-conditioning equipment is in operation and that the compressor is running normally. The timer is not running and is setting in a normal condition with its moving contacts DP1 making a connection from terminal A to A1 and its moving contacts DP2 making a connection from terminal B to terminal B1. Relays 275, 278 have operated previously, and are locked operated via contacts 276, 277.

Next, assume that there is a shutdown, which could result from either a loss of electrical power or a low pressure in the refrigeration system, or a thermostat-controlled demand signal. The contacts 279 open responsive to any suitable low pressure sensor. Either contacts 279 or a power supply failure releases the relays 275, 278. Relay 278 prohibits operation of the refrigeration unit during the shutdown conditions. Relay 275 closes its break contacts 281 to start or prepare a start circuit for the timer motor DP. Recall that the timer motor DP normally stands so that contacts B–B1 are made at this time. Eventually the fault is corrected, or the electrical power returns to the line. The time motor DP starts via the circuit including the contacts 281, B1–B, and the winding of the timer motor DP. The motor DP then starts and drives itself through a 4-minute cycle. After the motor has run for 4 minutes, the contacts B–B1 open, and the contacts B–B2 close.

Nothing further happens unless there is or until there is a demand for cooling which presumably is responsive to a zone thermostat. At that time, the relay KC operates, and the contacts 265 close. The timer motor restarts via the contacts 265 and B–B2. After 8 seconds, the contacts DP1 switch from A–A1 to A–A2 and relay 278 operates via contacts 279. Relay 278 operates to prepare a self-locking circuit at contacts 276 and to prepare to operate relay 275 at contacts 277.

The timer motor continues to drive for another 17 seconds at which time the contacts DP1 close A–A1 and contacts DP2 close B–B1. When the contacts A–A1 close relay 275 operates to close contacts 282 and thereby operates the contactor 283, which starts the compressor 39. Some compressors may start on half its windings. Then, any suitable device (such as a dash-dot) measures 1 second and thereafter closes contacts 284. The contactor 285 operates to start the other half of the compressor. Also responsive to the operation of relay 275, the contacts 281 open to stop the timer motor DP.

Briefly, in review, on a normal shutdown of the compressor, the timer runs 4 minutes during which the compressor cannot restart because contacts 282 are open. If a demand for cooling recurs during this period, (relay KC operates), there is no effect until after the end of the 4-minute period when the contacts 282 close and the compressor is able to restart. If the demand for cooling recurs after the 4-minute period, the compressor starts after a 25 second delay with no further delay. On a normal shutdown, the relay KC is released and a pumpdown occurs in a normal manner until the refrigeration pressure is reduced to 10 p.s.i. for example. The contacts 279 open to release the relays 278 and 275, and the resulting opening of contacts 282 releases the contactors 283, 285. This stops the compressor, and closure of contacts 281 drives the timer through its cycle. In normal operation, the contacts 279 reset, the compressor may be restarted which cannot in any event occur within the 4 minutes immediately following shutdown, as measured by the cycle of the timer motor.

The reference numeral 290 identifies a conventional oil pressure safety circuit.

While the principles of the invention have been described above in connection with specific apparatus and applications, it is to be understood that this description is made only by way of example and not as a limitation on the scope of the invention.

We claim:

1. An air-conditioning unit for supplying heated or cooled air to at least one air-conditioned zone, a thermostat in said zone for demanding a delivery of said air to said zone at a predetermined temperature, said unit comprising a housing having an air intake, including means for combining return air and outside air, and an air outlet with upstream cooling means for lowering the temperature of a mainstream of air flowing from said intake through said housing to said outlet, means for splitting said mainstream of air downstream of said cooling means into first and second parts, means for heating the air in said first part of said mainstream, means for sensing the temperature of said heated first part of the airstream, means responsive jointly to said zone thermostat and said sensed temperature for mixing said two parts of said airstream in a ratio which provides a stream of air having said predetermined temperature, and means in said second part of said airstream for controlling said means for combining return and outside air so as to maintain a predetermined temperature in said second part of said airstream.

2. The air-conditioning unit of claim 1 wherein said housing includes a refrigeration circuit comprising, in series, a condenser coil, a reheat coil, and an evaporator coil, said evaporator coil comprising said upstream cooling means, and being mo unted in said housing upstream with respect to said reheat coil to cool all air entering said intake, said reheat coil being downstream in a part of said housing through which said first part of said airstream flows.

3. The air-conditioning unit of claim 2 and a compressor for supplying a superheated refrigerant gas to said condenser coil, and means comprising said reheat coil for subcooling the refrigerant emanating from said condenser coil, whereby heat given off during said subcooling heats said first stream of air and said subcooled refrigerant provided increased refrigeration capacity in said evaporator coil.

4. The air-conditioning unit of claim 1 and an electrical control circuit for commanding said mixing means, to modulate the first and second parts of said main airstream, said control circuit including a bridge having means connected across the null point thereof for comparing a command signal with a reference potential, and means comprising a circuit extending from said zone thermostat through said sensing means to one arm of said bridge for supplying said command signal to said bridge.

5. The air-conditioning unit of claim 4 wherein said sensing means includes a thermistor connected in parallel with means for supplying a linear signal.

6. The air-conditioning unit of claim 1 and means responsive jointly to atmospheric and in-air-conditioner conditions for mixing the intake of fresh and preconditioned air in a predetermined ratio.

7. A master logic control circuit in combination with a heating and cooling system, said circuit comprising a pair of gates for emitting a plurality of signals representing demands for heating or cooling, means for selecting the worst case demand signal for either heating or cooling and for inhibiting all other signals, and means for modifying said worst case demand signal as a function of conditions then prevailing in said system, wherein said modifying means comprises a difference amplifier having a reference potential connected to one input and the output of said gates connected to another of said inputs, the circuit extending from said gates to said difference amplifier being connected via a thermistor located in a heating part of said system, said modified worst case demand signal being used for actuation of said system.

8. A master logic control circuit in combination with a heating and cooling system, said circuit comprising a pair of gates for emitting a plurality of signals representing demands for heating or cooling, a bridge circuit having a difference amplifier connected across the null points thereof, one arm of said bridge including a temperature sensing means, said gates and a zone thermostat selected by said gates, means for selecting the worst case demand signal for either heating or cooling and for inhibiting all other signals, and means for modifying said worst case demand signal as a function of conditions then prevailing in said system, said modified worst case demand signal being used for actuation of said system.

9. The circuit of claim 8 and a driving means coupled in series with a multi-tap voltage divider, means for coupling the output of said difference amplifier to said driving means, said

driving means having characteristics such that the potential at said taps decreases when said worst case demand signal increases in intensity, and a plurality of voltage sensitivity trigger circuits individually associated with said taps whereb a number of said trigger circuits which switches is a functio of said intensity of said demand.