Jan. 15, 1963 T. G. CRIDER 3,073,132

AIR CONDITIONERS AND CONTROLS THEREFOR

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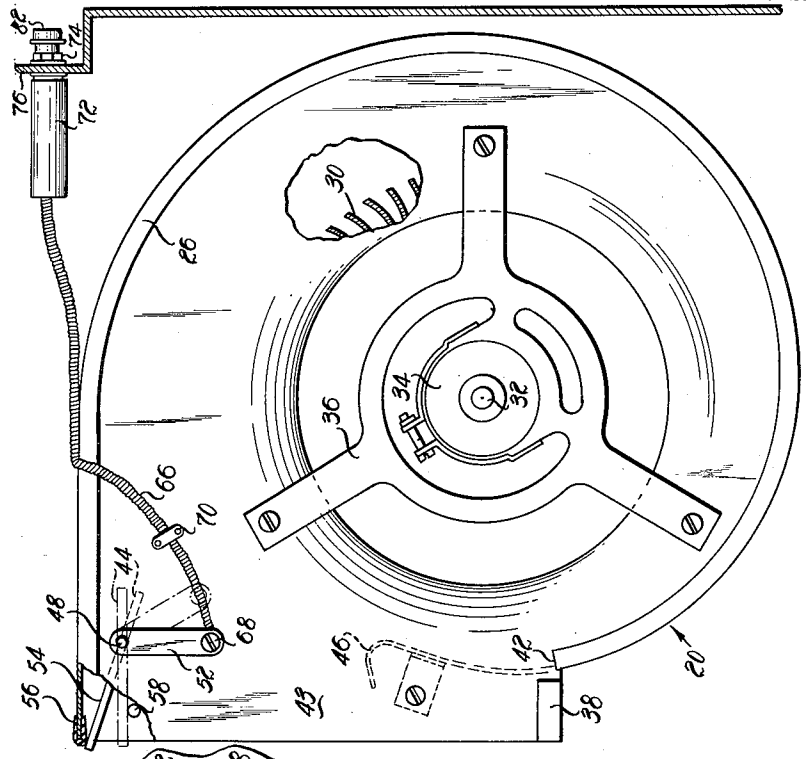


FIG. 2

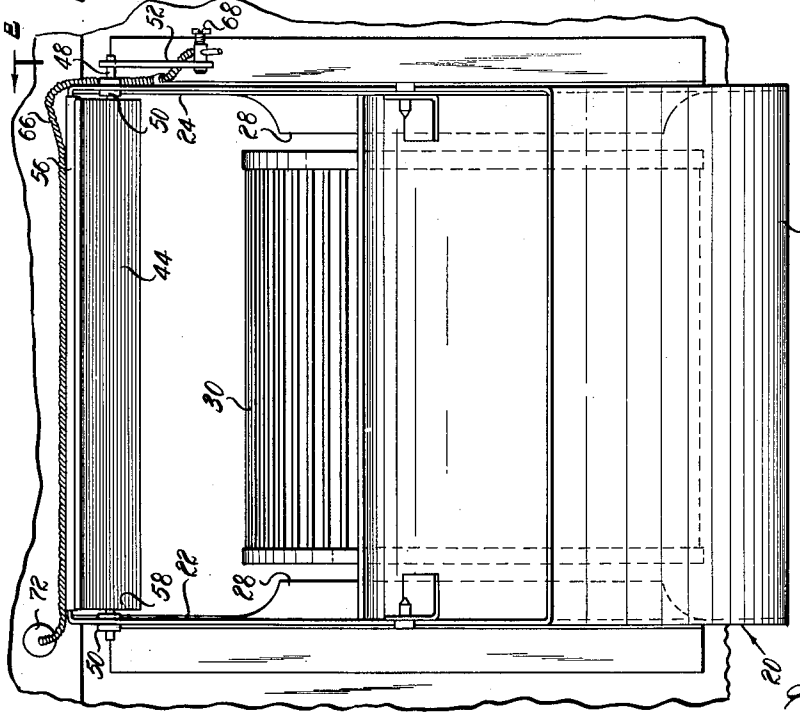


FIG. 1

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AIR CONDITIONERS AND CONTROLS THEREFOR

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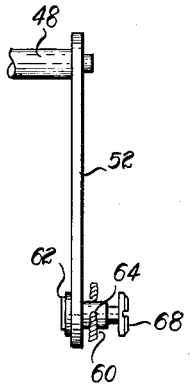


Fig - 3

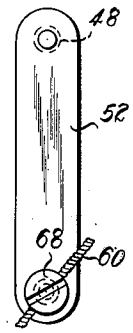


Fig - 4

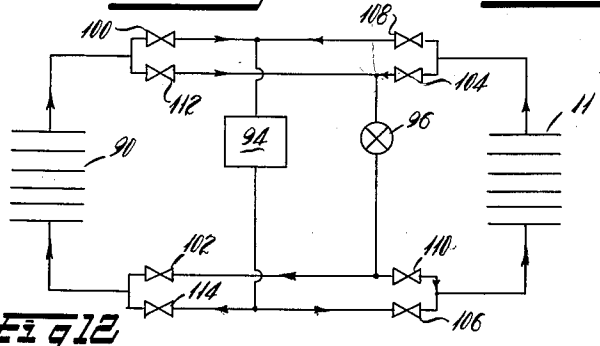


Fig 12

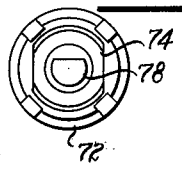


Fig - 6

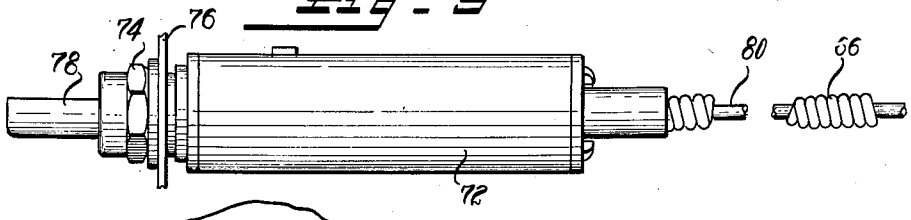


Fig - 5

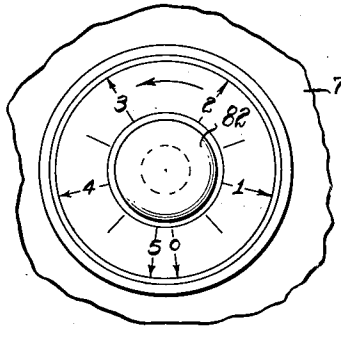


Fig - 7

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AIR CONDITIONERS AND CONTROLS THEREFOR

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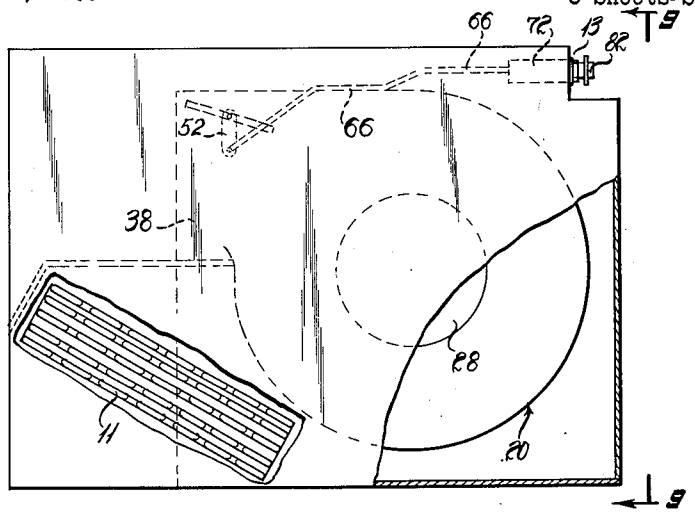


Fig. 8

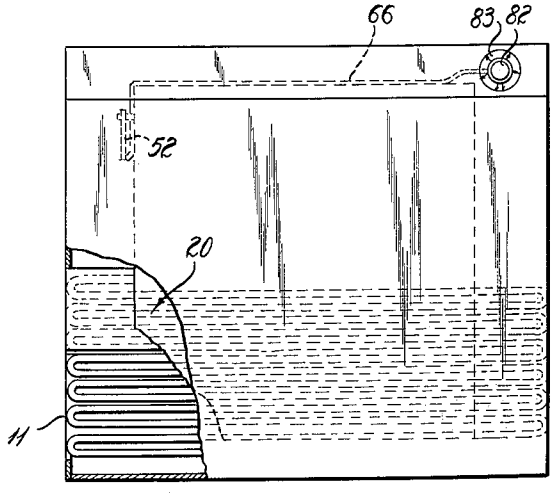


Fig. 9

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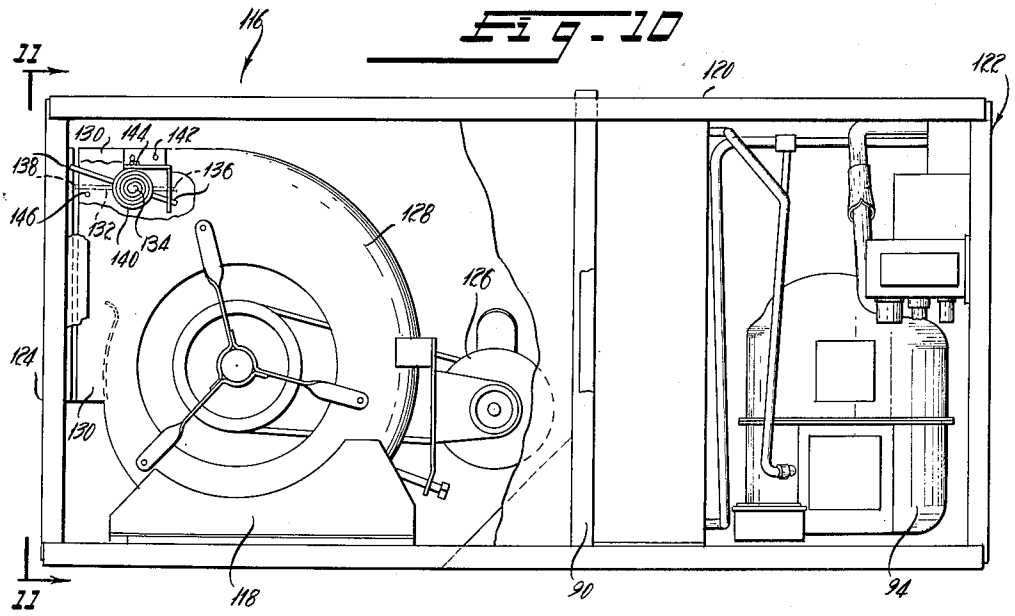
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Fig. 10



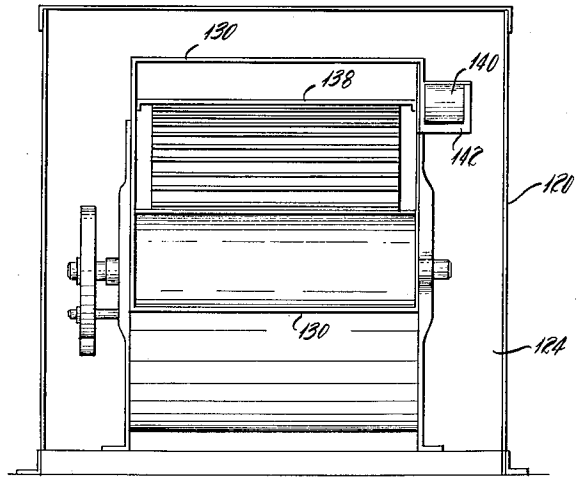


Fig. 11

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AIR CONDITIONERS AND CONTROLS THEREFOR

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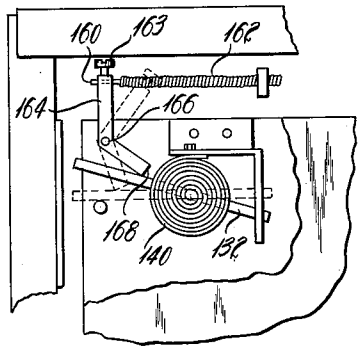


Fig. 13

Fig. 14

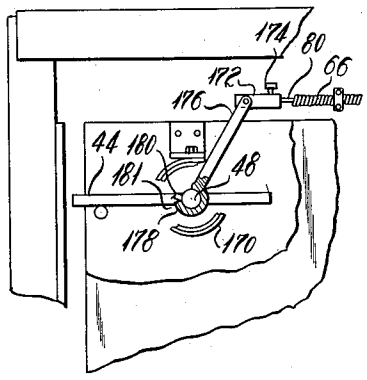
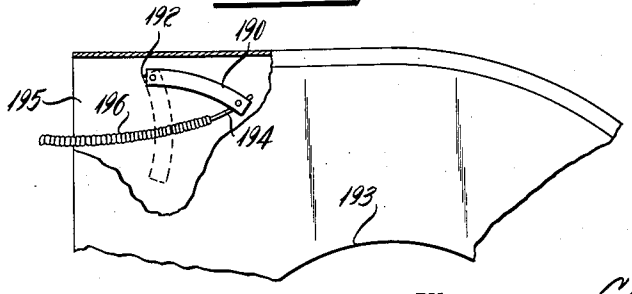


Fig. 15



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United States Patent Office 3,073,132 Patented Jan. 15, 1963

3,073,132

AIR CONDITIONERS AND CONTROLS THEREFOR

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Filed Jan. 21, 1959, Ser. No. 788,104
10 Claims. (Cl. 62—183)

This invention relates to air conditioning systems and more particularly to methods and controls for modulating the capacity of air conditioning assemblies to provide novel humidity and ventilation regulation and to avoid operational difficulties resulting from variations in ambient temperature.

As used herein the term "air conditioning systems" and similar expressions are intended to embrace apparatus of the heat pump types as well as units which are effective only to cool the space to be served by the units.

In one of its aspects, the invention is concerned with central air conditioning systems of the type employing a centrifugal blower to draw air over evaporating coils and impel it through distributing ducts to a space to be cooled. In such systems the blower and refrigeration unit have operating characteristics conforming to standards which have been predetermined by the manufacturer based upon average service conditions for similar units. In a given installation of such a system, however, a variable is introduced which will appreciably affect the system's ability to operate satisfactorily and which is not factory-controllable under practicable manufacturing conditions. More specifically, the variants in static pressure (depending upon the ducting lengths, ducting cross-sectional area and particular configuration of the ducting system) will substantially alter the performance of a given system. Thus, with a tortuous ducting configuration, a different quantity of air per unit of time will be provided than with ducting of linear construction.

In the past, adjustment for variations in static pressure and other variables in a given air conditioning system at the site of the installation was accomplished by laborious adjustment of complex damper arrangements which were unsatisfactory in operation.

In addition to the difficulty discussed above, additional problems are created due to humidity variations. Most air conditioning systems in current use are equipped with thermostatic controls which are responsive solely to fluctuations in temperature. The conventional type of thermostate is an "on-off" device which is adapted to either turn the blower on and off or, alternatively, to cycle the compressor-condenser-evaporator system. Conventional cooling systems are not equipped with a separate humidity control and, to applicant's knowledge, no such control is available which is both reliable and inexpensive enough to be usable in such systems.

Still another aspect of this invention relates to the prevention of icing on the surfaces of the evaporator coil of an air conditioning system. It has become common practice with summer air conditioning units for homes, office buildings, and the like to locate an air-cooled compressor-condenser assembly remotely from the evaporator, the most convenient place usually being outdoors in a suitable weatherproof cabinet. There are many advantages in locating the compressor-condenser assemblies outdoors such as the elimination of noise in the air-conditioned room and a saving of space inside the building.

While the foregoing advantages are obvious, such arrangements present certain operational problems. With a compressor-condenser assembly in an outdoor location, the condensing rate or capacity of the condenser is dependent upon the temperature of the outdoor air being forced by the blower over the condenser. The operating

pressure on both the high pressure and low pressure side of the refrigeration system is also dependent upon the outside ambient air temperature. Thus, when the outside ambient temperature is low, the condensing rate is high resulting in both the high and low operating pressures being lowered. If the outside ambient temperature is low enough, the suction pressure on the low pressure side of the system can drop to a value where the temperature of the evaporating coil is low enough to cause ice to form on the coil surfaces.

To prevent icing of the evaporator coils, the American Refrigeration Institute, using the design conditions established throughout industry, has set 65° F. as a minimum ambient temperature for operating air-cooled air conditioning condensers. If the ambient temperature drops below this figure, an electrical control opens the circuit to the compressor to shut off the air conditioning system.

While the foregoing arrangement prevents ice from forming on the evaporator coils, it has certain inherent disadvantages. For example, if the ambient temperature for the compressor-condenser assembly hovers at the point of cut-off, there will be a continual "off" and "on" cycling of the compressor with very little refrigerating effect in the room that is being air conditioned. This condition is particularly undesirable when the temperature of the air conditioned room is high enough to require substantial heat removal. This invention also solves this problem through the use of a novel control means for controlling the flow of air over the condenser including an air-flow controlling damper positioned by a temperature sensitive element.

The problem of evaporator coil icing, however, does not only exist where the air conditioning system is used for refrigeration or cooling (i.e., where the indoor coil serves as the evaporator) but exists as well when the system is used as a heat pump to heat the indoor space and wherein the outdoor coil serves as the evaporator. In such a system, icing of the evaporator coil is likely due to the additional cooling effect on the evaporator coil provided by the cold ambient air, which, conceivably, could drop to zero or sub-zero temperatures under severe winter conditions.

It is accordingly a primary object of this invention to provide a novel air conditioning system which affords improved humidity and ventilation regulation and which avoids evaporator coil icing.

Other objects of this invention are to provide a novel air conditioning system:

(1) Effective for heat pump operation in which each of the heat-exchange coils serves alternatively and oppositely as a condenser and an evaporator and in which means are provided to eliminate icing on the surfaces of each coil during its service as an evaporator;

(2) Effective for heat pump operation in which each of the heat-exchange coils serves alternatively and oppositely as a condenser and an evaporator and in which separate air flow control units are provided to eliminate icing on the surfaces of each coil during its service as an evaporator, one of the units additionally being operative to provide improved humidity and ventilation control;

(3) Including an air cooled condenser-compressor assembly having an automatic ambient temperature cut-off, and including novel means to permit the setting of the cut-off temperature at a point much lower than is specified for conventional air cooled compressor and condenser assemblies;

(4) Having novel means for modulating the capacity of an air cooled condenser in accordance with the ambient temperature in which it is operating, the capacity being reduced in proportion to the drop in temperature below a predetermined point;

(5) Including an improved air cooled compressor and

condenser assembly wherein the volume of cooling air moved over the compressor and condenser is decreased at a predetermined drop in ambient temperature by an air flow controlling damper which is positioned by a spiral bimetal spring responsive to changes in temperature;

(6) Wherein manually operable control means is provided for eliminating icing on the surfaces of the outdoor coil of said system when said coil is functioning as an evaporator, said means being additionally operative to provide improved humidity and ventilation regulation when said outdoor coil is functioning as a condenser and said system is used to cool or refrigerate.

Another primary object of this invention is to provide simple means to compensate for performance variations caused by variations in duct arrangements and to effectively regulate humidity in operation.

Still other objects of this invention are to provide humidity and ventilation control means for use in air conditioning systems:

(1) Which are reliable and inexpensive;

(2) Which are simple in construction and which may be readily and easily operated by users of the system;

(3) Which have relatively few moving parts and which are provided with a vernier control for fine adjustment;

(4) Which include a movable vane or restrictor element positioned in the throat of a centrifugal blower and which are adapted to restrict the flow of air through said throat and to lower the volume per unit time of the air passing through the throat; and

(5) Which adjust the ambient humidity by varying the volume per unit time of air passing over the cooling coils of an air cooling system, without varying the power input to the system. These and other objects of the invention will become more fully apparent from the following description and appended claims taken in connection with the accompanying drawings, showing a preferred structure and embodiment, in which:

FIGURE 1 is a front elevational view of a portion of the indoor assembly incorporating a novel control means of the instant invention;

FIGURE 2 is a partly sectioned side view, taken along line 2—2 of FIG. 1;

FIGURE 3 is an enlarged view of a component of the assembly of FIG. 1 of the instant invention;

FIGURE 4 is a side elevation of the unit shown in FIG. 3;

FIGURE 5 is a partly sectioned enlarged view of a component of the adjustment mechanism;

FIGURE 6 is a view in end elevation of the component shown in FIG. 5;

FIGURE 7 is a detail view of the control knob and dial which form a part of the novel control means of the instant invention;

FIGURE 8 is a side elevation partly broken away to show the position of the indoor blower assembly;

FIGURE 9 is an end elevation partly broken away to show the position of the heat-exchange coils relative to the indoor blower assembly;

FIGURE 10 is a side elevation of the compressor and outdoor heat-exchange coil assembly of this invention with portions of the side of the housing therefor removed for clarity;

FIGURE 11 is an end elevation of the compressor and heat-exchange coil assembly taken along the line 11—11 of FIGURE 10;

FIGURE 12 is a schematic diagram of the entire system of the instant invention as arranged for heat-pump, reverse cycle, operation;

FIGURE 13 is a fragmentary view in side elevation of an alternative construction of the control elements for the outdoor blower assembly; and

FIGURES 14 and 15 are fragmentary views in side elevation of alternative constructions of the control elements for the indoor blower assembly.

The system in which the novel control means of the instant invention is used is shown schematically in FIGURE 12. Outdoor heat-exchange coil 90, indoor heat-exchange coil 11, compressor 94 and expansion valve 96 are associated with one another as clearly shown, with valves 100, 102, 104, 106, 108, 110, 112 and 114 interposed in the system to convert it from refrigeration to heat pump operation, as will more fully be described hereinafter.

The indoor portion of the instant air conditioning system is shown generally in FIGURES 8 and 9. Heat-exchange coil 11 is positioned adjacent circular openings 28 in the side walls of blower 20, whose outlet or neck 38 communicates either directly with a space to be cooled or with ducts (not shown) leading to such space. A control cable or Bowden wire assembly 66 is operatively connected to an air flow control member 44 (details of this arrangement will be hereinafter described) at one end and to a control assembly designated generally at 13 at the other. As best seen in FIGURE 9, a control knob 82 and suitably calibrated dial 83 provide means to manually adjust the essential operating mechanism which provides the novel control of the instant invention.

As is shown more specifically in FIGURES 1 and 2, the indoor portion of the novel air conditioning system here involved comprises a centrifugal impeller or blower, designated generally at 20. Blower 20 comprises end walls 22 and 24 and a peripheral wall 26. End walls 22 and 24 are provided with relatively large circular openings 28 about which the walls are gradually curved inwardly and it is through these openings that air is drawn when the squirrel cage rotor 30 of the blower is rotated. The design and construction of the rotor follows standard practice. A shaft 32 on which the rotor is fixedly mounted is journalled in bearings 34 which are supported centrally of the openings 28 by spiders 36 attached to each end wall of the blower casing. One end of shaft 32 is suitably connected to a fractional horsepower electric motor for rotating rotor 30.

While the vertical dimension of the neck 38 of the blower casing exceeds the diameter of the rotor 30 and is more than half the height of the casing, its effective cross-sectional area is reduced by a cut-off 40, which is suitably attached at the junction 42 of the neck 38 and the peripheral wall 26.

Pivotally supported between end walls 22 and 24 and in an area generally designated as the throat 43 of the blower, is a restricting damper 44. The throat 43 of the blower is the general region of the blower located between the upper edge 46 of the cut-off 40 and the portion of the peripheral wall 26 of the blower casing approximately opposite said edge, said region extending slightly inwardly of a vertical plane passing through the cut-off 40. Damper 44 is positioned in the portion of throat 43 adjacent peripheral wall 26 of the blower casing where, due to the centrifugal action of rotor 30, the volume of impelled air is greatest.

The specific distance which separates damper 44 and peripheral wall 26 of the blower casing may be varied within reasonable limits, depending upon the capacity and type of blower used. So long as the damper 44 is positioned generally in the above described portion of the blower casing, however, the surface area of the damper may be considerably less than that of conventional damper-type elements. The damper functions to reduce the volume of air per unit time delivered by the blower.

Specific details of construction of damper 44 may be found in Reissue Patent 24,421 issued January 28, 1958, to M. W. Patrick, especially in column 4, lines 48–67. As described therein and in other portions of said patent, damper 44 is so designed as to offer practically no obstruction to the flow of air when it is in non-restricting position.

Damper 44 is secured to a shaft 48 which is parallel

with the axis of rotor **30** and which is journalled in bearings **50**, preferably of a rubber composition especially suited to such purposes and mounted in openings in end walls **22** and **24**. Due to the fact that the forces exerted on the portions of damper **44** which are closest to rotor **30** are greater than those exerted against the furthest portions, the damper should preferably be mounted on shaft **48** with its trailing edge substantially further from the shaft than its leading edge. This off-setting will tend to balance these forces and to relieve the stress on the damper.

Fixedly secured to one end of shaft **48** is an arm **52** (see especially FIGURES 3 and 4), which is at approximately 120° to the forward portion **54** of damper **44**. Accordingly, when damper **44** is in its fully operative position, arm **52** will extend downwardly toward rotor **30** in a substantially vertical line and the outer end of damper **44** will project slightly beyond a rubber cushion **56**. When in a fully non-restricted position, with damper **44** in a substantially horizontal position, arm **52** is at approximately 30° to the vertical. Stop element **58** is provided in end wall **22**, immediately beneath the horizontal plane passing axially through shaft **48**, to restrict maximum pivotal movement of damper **44** to the horizontal position.

At the lower end of arm **52** is an internally threaded member **60** which passes through an opening at the end of said arm and is rigidly fixed thereto by brazing or the like. Flange **62**, secured to the end of threaded member **60**, serves to provide added support to maintain member **60** rigidly in relation to arm **52**. Running transversely through internally threaded member **60** is a centrally threaded bore **64**. Wire **80** of a conventional Bowden wire assembly **66** passes through said centrally threaded bore **64** and is secured rigidly therein by means of screw **68** in internally threaded member **60**. The Bowden wire assembly **66** is secured at an intermediate point along its length by means of bracket **70** which is secured to the end wall **24** of blower assembly **20**. Bowden wire assembly **66** extends over the peripheral wall **26** of the blower assembly into a housing **72** (see FIGURES 5 and 6), which is secured by means of nut **74** to front panel **76** of the outer casing of the air cooling assembly. Control knob **82** is non-rotatably mounted on support shaft **78** and is provided with a suitable indicator mark **79** which, in conjunction with the calibrations **81** on fixed dial **83** (see FIGURE 9) which surrounds said knob, serves to permit easy adjustment of the position of damper **44**. For example, the dial may be calibrated so that when indicator mark **79** is positioned adjacent the number "0" (see FIGURES 7 and 9), damper **44** will be in its fully restricted, or angular, position; when control knob **82** is rotated approximately 345° counterclockwise (to the number "5"), the damper will be in its non-restricting, or horizontal, position.

Housing **72** is a conventional assembly designed to translate rotary motion into longitudinal movement, and is similar in many respects to the feed mechanism of conventional mechanical pencils. It comprises generally a sleeve fixedly mounted around shaft **78** and within housing **72**, said sleeve (not shown) having a helical slot therein through which a projection fixed normally on wire **80** of Bowden wire assembly **66** projects. The projection on wire **80** also extends through a longitudinal slot formed in a sleeve of smaller outer diameter than said first mentioned sleeve which is concentric therewith and is rigidly fixed against movement with respect to said housing **72** and through which said wire **80** passes. Accordingly, when rotary movement is imparted to shaft **78**, thus rotating the outer, helically slotted sleeve, the projection on wire **80** extending through said helical slot will be moved longitudinally forward or rearward, depending upon the direction of rotation of said sleeve. The inner sleeve containing the longitudinal slot prevents rotation of wire **80**. When wire **80** is moved longitudinally away from front panel **76**, in a direction toward said blower assembly **20**, the lower end of arm **52** will be moved clockwise as viewed in FIGURE 2. Inasmuch as damper **44** is fixedly associated with arm **52**, it also will be rotated in a clockwise direction and will, accordingly, restrict the effective throat outlet area **43** of said blower assembly **20**. When shaft **78** is so rotated that wire **80** is forced longitudinally toward front panel **76** and away from said blower assembly **20**, the lower end of arm **52** will be pulled counterclockwise, thus causing damper **54** to pivot towards its fully inoperative position (i.e., towards stop element **58**).

The outdoor portion of the instant air conditioning system is shown in FIGURES 10 and 11. A compressor-heat-exchange coil assembly indicated generally at **116** comprises a compressor unit **94**, heat-exchange coil **90**, and a blower **118** mounted in an elongated housing **120** of rectangular cross-section and having an air inlet opening **122** and an air outlet opening **124** at opposite ends thereof. Blower **118** which is belt driven by a motor **126** is of a conventional centrifugal type having a snail shell casing **128** which merges into an air exhaust throat **130** directed toward air outlet opening **124**. Mounted in the throat **130** adjacent the top thereof is an air flow restricting damper **132** shown in closed position in full line and in open position in dotted lines. The damper is mounted on a shaft **134** extending through the side wall of throat **130** to dispose its leading edge **136** closer to the pivot axis than its trailing edge **138** to stabilize the damper (as in the indoor assembly described hereinbefore). In general, the details of design and construction of damper **132** are the same as those of damper **44** in the indoor assembly.

A spiral bimetal spring **140** has its inner end rigidly connected to damper shaft **134** and its outer end adjustably connected to the horizontal wall of a bracket **142** mounted on an outer side of throat **130**. Adjustment of the position of the outer end of spring **140** relative to bracket **142** to vary the tension of the spring is accomplished by a bolt **144**, slidable in a slot (not shown) through bracket **142**, the bolt **144** clamping the outer end of the spring to the bracket at a desired point.

As aforestated, the indoor and outdoor assemblies will be operatively connected in use as shown schematically in FIGURE 12. The reverse-cycle, heat pump operation of the system is as follows: when the system is used to cool or to refrigerate (i.e., with indoor heat-exchange coil **11** serving as the evaporator and outdoor coil **90** functioning as the condenser), valves **100**, **102**, **104** and **106** will be closed and valves **108**, **110**, **112** and **114** will be opened; when the system functions to heat (i.e., with the indoor coil **11** serving as the condenser and the outdoor coil **90** as the evaporator), valves **100**, **102**, **104** and **106** will be opened and valves **108**, **110**, **112** and **114** will be closed. The direction of refrigerant fluid flow, as indicated by arrows in FIGURE 12, will always be from the evaporator to the compressor to the condenser to the expansion valve to the evaporator.

The Cooling Cycle

When the system functions to cool or to refrigerate, several aspects of the instant invention come into play, the first of which relates to the icing of the surfaces of the indoor evaporator coil due to a drop in ambient (outdoor) temperature below a certain point. Bimetal spring **140** in the outdoor assembly **116** is so adjusted that for temperatures above a certain point, for example 65° F., damper **132** rests in a horizontal position (shown in dotted lines) against a suitable stop **146** whereby the maximum volume of air is drawn through housing **120**. Should the ambient temperature fall below the point where conventional compressor-condenser units are automatically stopped, bimetal spring **140** will bias the trailing edge **138** of damper **132** toward the top of throat **130** thus reducing the amount of cooling air being drawn over condenser **90**.

The condensing rate or capacity of condenser **90** is thus reduced proportionately to the decrease in volume of air drawn through the housing **120**. This reduction in the rate of refrigerant condensation maintains the low pressure on the low side of the refrigeration system at a point above that which is likely to produce icing on the evaporator coil **11** (in the indoor assembly). Thus, through this invention it is possible to set a much lower cut-off temperature than 65° F. for a condenser-compressor assembly to eliminate the objectionable "on" and "off" cycling that occurs at presently specified cut-off temperatures.

Another aspect of the invention which comes into play during the cooling cycle relates to himidity control and is primarily concerned with the indoor assembly of the instant air-conditioning system.

Relative humidity is a direct function of temperature. The lower the temperature of the air, the less is its capacity to retain water vapor. Accordingly, dehumidification of the air passing over the cooling coils of an air conditioner is proportional to the reduction in the air temperature. When air passes over an evaporating unit or other cooling unit of an air cooling system, the air is cooled in direct heat exchange relationship with the unit. One of the factors which will determine the degree of cooling which takes place is the length of time during which the air to be cooled is in heat-exchange relation with the cooling unit. The longer the contact, the greater the degree of cooling.

It follows from the above that if the volume per unit time of the air passing over the cooling unit is decreased, the degree of cooling of the air and the dehumidification will increase correspondingly for each pass over the cooling unit and vice versa.

Thus, when damper **44** is pivoted toward its flow-restricting position (i.e., when control knob **82** is turned towards number "0" on dial **83**), greater cooling of the air and, correspondingly, greater dehumidification results. Therefore, by adjusting damper **44** between its fully open and fully restricted positions (i.e., between number "0" and "5" on dial **83**), the relative humidity of the air delivered by the cooling system may be adjusted within a fairly wide range.

The Heating Cycle

When the system functions to heat, still another feature of the instant invention is significant. As heretofore discussed, evaporator coil-icing problems exist not only when the air-conditioning system is functioning to refrigerate or cool but also when it is on heat pump operation and the outdoor coil serves as the evaporator. The combination of cool air flowing over coil **11** which now functions as the condenser and cold air impinging on coil **90** which now functions as the evaporator may cause ice to form on the surfaces of the latter coil.

Icing on coil **90** may be prevented or reduced by restricting the position of damper **44** in the indoor assembly by means of the Bowden wire assembly described above and thus reducing the amount of evaporation which will take place in outdoor evaporator coil **90** as described heretofore in connection with the system's operation when on cooling cycle. In this manner the temperature at which the outdoor evaporator coil **90** will freeze may be reduced by 5° or 6° F.

To permit the operator of the instant system to adjust damper **44** to the proper restricted position to avoid icing on coil **90**, a suitably calibrated dial (not shown) may be mounted adjacent fixed dial **83** (see FIGURE 9), which dial would indicate the damper position corresponding to predetermined ranges of temperature conditions. By checking the temperature at any given time ,the operator may easily adjust the position of damper **44** by rotating control knob **82**.

Again, there will be an interplay between the heating and ice-prevention functions of the indoor assembly: as damper **44** is restricted, air flow across condenser **11** is reduced and less total heat is extracted for use in heating. Such restriction, however, serves to decrease the freezing temperature of outdoor coil **90**. These conflicting interests will, of necessity, have to be balanced on the basis of prevailing service conditions and heating and ice-prevention demands.

It is a well known fact, however, that air flow requirements for efficient heating are much less than those for efficient cooling. For this reason, damper **44** will be in a partially restricted position during normal heating operation and thus at least some beneficial effects relative to ice-prevention will be obtained even when heating demands are greatest.

As heretofore discussed, bimetal spring **140** is so adjusted that for temperatures above a certain point, damper **132** rests in a horizontal, non-restricting position. Below that point, however, the bimetal spring will bias damper **132** towards its fully restricted position. Since ambient outdoor temperatures under heating conditions will usually be below this predetermined point, damper **132** will be in its flow restricting position substantially throughout the heating cycle. Since there may be times during the heating cycle when it would be more desirable to have greater air flow across coil **90** than is obtainable under restricted flow conditions, means (not shown) may be provided to maintain damper **132** in its non-restricted position throughout the heating cycle. Such means may include a source of heat (i.e., a resistance heater element) operative automatically or manually when the heating cycle begins to heat bimetal spring **140** to a temperature greater than that at which restriction begins. The heat source is rendered inoperative upon the commencement of the cooling cycle and will accordingly eliminate an otherwise uncontrolled influence on the functioning of the air conditioning system.

In addition to the inventive aspects discussed above, there are other significant features of the instant invention. When an air conditioning system containing the novel control means of the instant invention is installed, an initial calibration must be made to compensate for variants in air delivery capacity resulting from the varying characteristics of each of the delivery ducts connecting the system to the rooms or other spaces to be cooled. As heretofore indicated, the volume of cooling air per unit time discharged through the throat of the blower assembly will vary considerably depending upon the position of the indoor damper **44**. To compensate for the varying duct delivery capacities and static pressure variations, therefore, the position of damper **44** may be adjusted to permit the discharge through the throat of the blower assembly of the volume of air per unit time required for optimum operation under normal conditions. This adjustment may be made, of course, by merely rotating the control knob **82** until indicator mark **79** thereon is adjacent the proper calibration on dial **83** on the front panel of the air conditioning unit.

Thus, if the quantity of air per unit time delivered is too great, the control knob should be rotated to move damper **44** toward its flow-restricting position, or towards number "**0**." By so reducing the delivery capacity of a given duct, however, the respective delivery capacities of other ducts in the system will be correspondingly reduced. A mean position of the damper between numbers "**0**" and "**5**," is selected to strike a balance between the delivery capacities of the respective ducts in the system and the corresponding cooling demands of the rooms or other spaces to be cooled with which they communicate. The dial setting as obtained by the foregoing procedure will be suitable for average ventilation and humidity conditions.

Though the foregoing description represents the preferred embodiment of the instant novel air conditioning system, various modifications of the system may be made

without departing from the spririt or essential characteristics thereof. For example, instead of employing a damper such as restricting damper **44** in the indoor portion of the instant novel air conditioning system, the arrangement shown in FIGURE 15 may be used. In this embodiment, a damper **190** is pivotally supported between the end walls of the blower with its axis of rotation passing through the edge **192** of the damper and being parallel to the axis of rotation of the rotor **193**. This damper is located in approximately the same position in the throat **195** of the blower casing as damper **44**, in the embodiment heretofore described. Secured to the lower edge of damper **190**, at one end thereof, is the end of wire **194** of Bowden wire assembly **196**. The other end of the bodwen wire assembly (not shown) is associated with a housing for translating rotational into longitudinal movement and a control assembly identical to that heretofore described in connection with the indoor assembly (see FIGURES 2 and 5–9). Damper **190** is adapted to be pivoted between a first fully restricted position (shown in dotted lines) and a second, non-restricted position (shown in solid lines) which allows unobstructed flow of air through the exhaust throat of the blower. Also, though the system has been set forth as including an indoor manual damper control and an outdoor automatic, bimetal spring control, additional or substitute controls may be added to the system for more effective and selective operation.

One such control (not shown) usably when outdoor coil **90** is functioning as a condenser (i.e., during cooling cycle) involves the substitution of a conventional thermostat for bimetal spiral spring **140** and its accompanying assessories (i.e., bracket **142** and bolt **144**), said thermostat performing a function substantially identical to that of bimetal spiral spring **140** (i.e., the prevention of freezing of indoor coil **11**). The thermostat is positioned so that it is responsive to the temperature of the ambient outdoor air. When the temperature falls below a predetermined point (i.e., 65° F.), the thermostat operates a solenoid which will move damper **132** to its restricted position. In so doing, the solenoid will overcome the opposing force of a spring which normally biases the damper toward its non-restricted position. When the ambient temperature rises above 65° F., the thermostat-solenoid circuit will be broken and the spring bias will force damper **132** back to its non-restricted position.

To overcome the tendency of the thermostat-solenoid circuit to urge damper **132** toward its restricted position during the heating cycle (the ambient temperature in such case would normally be below 65° F.), the circuit may be disconnected during said heating cycle.

A conventional thermostatic structure as above described (or an outdoor bimetal spiral spring structure, as the case may be) may be effectively utilized to prevent freezing of the indoor evaporator coil **11** during cooling cycle when the outdoor ambient temperature drops below 65° F. There is an outdoor ambient temperature lower limit, however, below which the indoor evaporator coil **11** will freeze even when damper **132** is in its fully restricted position.

To avoid freezing of the indoor coil **11** at this lower temperature limit, a conventional thermostat, responsive to outdoor ambient temperature, is operatively connected to a relay circuit which is designed to shut off power to the blower **118** when closed by means of the thermostat. When the ambient temperature reaches said lower limit, the relay circuit will be closed and the outdoor blower **118** will be shut off. Freezing of the indoor evaporator coil **11** will accordingly be avoided.

To prevent the thermostat-relay circuit from keeping the blower in its "off" position during the heating cycle, the thermostat-relay circuit must either be disconnected or, as heretofore discussed in connection with bimetal spring **140**, heating means may be provided to maintain the blower in its "on" position by maintaining the thermostat at a temperature above said lower limit.

Another such control (not shown) usable when outdoor coil **90** is functioning as an evaporator utilizes an additional Bowden wire assembly equivalent to that described in connection with the control of indoor damper **44**. One end of the Bowden wire is operatively connected to damper **132** through elements such as shaft **48**, arm **52** and internally threaded member **60** (see FIGURES 3 and 4), the other end being connected to a suitable housing for translating rotary into longitudinal movement which may be controlled by a suitable control knob located in the proximity of control knob **82**. A dial calibrated to indicate the position of damper **132** corresponding to predetermined ranges of outdoor ambient temperature may be provided adjacent the control knob. By checking the outdoor ambient temperature at any given time, the operator may easily adjust the position of damper **132** to modulate the air flow over heat-exchange coil **90** when it is functioning as an evaporator. This will provide effective ice-prevention control to supplement that afforded by restriction of indoor damper **44**.

This additional manual control may be used in lieu of and will thus eliminate the necessity for heating means to maintain damper **132** in its non-restricted position throughout the heating cycle, as heretofore described.

If desired, the Bowden wire need not be physically connected to damper **132** as described above but may be physically connected to an adjustable stop as shown in FIGURE 13. Wire **160** of a Bowden wire assembly **162** is secured at one end by means of a screw **163** to internally threaded angle element **164** which is pivoted for rotative movement about a pivot **166**. The other end of wire **160** (not shown) is connected to a housing for translating rotary into longitudinal movement which may be controlled by a control knob located near control knob **82**, as has been more fully described above.

Since no heating means to maintain damper **132** in its non-restricted position during the heating cycle is present, bimetal spring **140** will bias damper **132** toward its fully restricted position (shown in dotted lines) under normal ambient outdoor heating cycle conditions (as heretofore discussed). When it is desired to maintain damper **132** in its non-restricted position, therefore, the control knob should be rotated so that wire **160** is moved to the right (as shown in FIGURE 13). Angle element **164** will be pivoted about pivot **166** in a clockwise direction and the end **168** of angle element **164** urging against damper **132** will overcome the bias of bimetal spring **140** and force damper **132** toward its non-restricting position.

When it is desired to restrict damper **132**, the control knob should be rotated so that angle element **164** is pushed counterclockwise, allowing the normal bias of bimetal spring **140** to urge damper **132** toward its flow-restricting position.

In addition to the above modification (or independently thereof, if desired), a bimetal spiral spring (see FIGURE 14) set to function during the heating cycle in the manner described in Patrick Reissue patent 24,421, mentioned above, may be added to supplement the heat-controlling function of the indoor manually operable control during heating cycle. As described in said reissue patent, a bimetal spring element used in the manner therein disclosed, avoids the discomfort attending the operation of conventional air conditioning systems upon the starting and stopping thereof.

Where such a bimetal spring is used as taught in Patrick reissue patent, however, a modification of the basic indoor manual control for damper **44** must be made for operation during the heating cycle. Such a modification is shown in FIGURE 14. A bimetal spring assembly indicated generally at **170** is identical to that described above for use in connection with the outdoor blower as-

sembly. Wire 80 of Bowden wire assembly 66 is secured in an internally threaded connecting link 172 by means of screw 174. The other end of connecting link 172 is pivotally connected to one end of a crank arm 176 which is rigidly secured at its other end to a sleeve 178 which is rotatable about an end portion of damper-supporting shaft 48. A stop pin 180 projects out from shaft 48 through a slot 181 in sleeve 178. The other end of wire 80 is secured to knob 82 through housing 72 as has been heretofore described.

When the system is used during the heating cycle, the damper 44 will assume the full open position as shown in FIG. 14. If it is desired to restrict the air flow to protect the outside evaporator coil or for other reasons, knob 82 is turned sufficiently to move wire 80 to the right (see FIGURE 14) which, in turn, will rotate sleeve 178 clockwise carrying stop pin 180 and damper 44 with it. This construction permits the bimetal spring to move freely to urge damper 44 toward its restricted position during the initial surge of cold air at the beginning of the heating operation.

During summer operation, the bimetal spring will normally function to maintain the damper in a restricted position. This action may be prevented by setting control knob 82 at the desired position. For example, if the wire 80 is moved to the left the sleeve 178 will be rotated in a counterclockwise direction carrying pin 180 with it to move damper 44 away from its restricted position, any desired amount.

In this manner, the advantages of the Patrick structure and operation may be obtained wtihout undue interference with the beneficial functions described hereinbefore.

In lieu of the bimetal spiral spring structure, an alternative structure employing a conventional thermostat may be utilized to avoid the discomfort attending the starting and stopping of the blower during heating cycle operation. In such an embodiment a conventional thermostat (not shown) is positioned in the indoor blower casing in such a manner that it will sense any change in the temperature of the air delivered by the blower. At a predetermined temperature, i.e., 110° F., the thermostat operates a solenoid (not shown) which will move the damper to non-restricted position. In so doing, the solenoid will overcome the opposing force of a spring (not shown) which normally biases the damper toward its restricted position. When the temperature of the air passing over the thermostat falls below the predetermined temperature, the thermostat-solenoid circuit will be broken and the spring bias will force the damper back to its restricted position.

This embodiment functions, in principle, substantially the same as the bimetal spring structure described above. Where the thermostat is employed, however, only two position operation is obtainable, as contrasted with the wide-range control provided by the bimetal spring structure.

Though the spring bias would maintain the damper in a restricted position when the system is operating on cooling cycle, this force may be overcome by the manual adjustment of control knob 82.

To supplement the bimetal spiral spring or the alternative thermostat structure above discussed, an additional thermostat (not shown) may be placed in direct heat exchange contact with the indoor heat-exchange coil to control a conventional relay circuit (not shown) which, in turn, will shut off the blower whenever the temperature of the indoor coils falls below a certain temperature, i.e., 100° F.

The use of such a thermostat eliminates the problem which would arise were the blower to force air into the space to be heated at the beginning of a heating cycle, before the indoor coil has had an opportunity to reach a temperature at which it is effective to heat the air passing over it. If the blower were turned on immediately, cold air (in addition to the residual cold air in the distributing ducts) would be exhausted by the blower until such time as the coil temperature increased sufficiently. In view of the fact that the indoor heat-exchange coil functions also as an evaporator during the cooling cycles, it is necessary of course to disconnect the thermostat-relay circuit to permit blower operation during normal cooling periods.

If desired the air conditioning system embodying novel control means as described herein may also be used solely to ventilate, by operating indoor blower 20 without turning on the refrigerant unit. By adjusting the position of damper 44, more or less air may be injected into the space to be ventilated. Also, while this invention is particularly suited for use in cases wherein one of the heat-exchange units is located outdoors remotely from the other heat-exchange unit, it is also useful as a modulating control in a self-contained unit, wherein all of the units are located indoors.

The invention may be embodied in still other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. An air conditioning system comprising: first and second heat exchange units; a closed conduit system connecting said units; a compressor and expansion valve means in said conduit system; valve means in said conduit system to permit selective alternate operation of said first and second units as a condenser and as an evaporator; a first blower adapted to blow air over said first unit; a second blower adapted to blow air over said second unit; each of said blowers having an air exhaust throat; an air damper plate pivotally mounted in the throat of each blower for controlling the volume of air passing therethrough; and a temperature responsive control device to urge said damper plate in said first blower in a direction to decrease the volume of air passing through the throat of said blower upon a drop in temperature whereby the volume of air passing over said first unit is decreased proportionately.

2. The air conditioning system of claim 1 wherein the air damper plate in said first blower is pivotally mounted on a shaft in the throat of said blower and wherein said temperature-responsive means comprises a spiral bimetal spring having its inner end connected to said damper plate shaft, a bracket fixedly positioning the outer end of said spring.

3. The air conditioning system of claim 1 additionally comprising means to selectively maintain the air damper plate in said first blower in its fully open position.

4. The air conditioning system of claim 1 additionally comprising adjustable stop means effective selectively to overcome the tendency of said damper plate in said first blower to pivot to a position to decrease the volume of air passing through the throat of said blower upon a drop in temperature.

5. An air conditioning system comprising an elongated housing having a pair of air openings therein; a compressor and a first heat-exchange coil mounted in said housing between said openings; a first blower mounted in said housing adapted to blow air into one of said openings and over said compressor and first heat exchange coil and out the other opening; a second heat exchange coil; a second blower adapted to blow air over said second coil and ultimately into a space to be air conditioned; a closed conduit system connecting said coils and said compressor; an expansion valve means in said conduit system; valve means in said conduit system to permit selective alternate operation of said first and second coils as a condenser and as an evaporator; each of said first and second blowers

having an air exhaust throat, an air damper plate pivotally mounted in the throat of each of said blowers for controlling the volume of air passing therethrough; manual means operative to pivot one of said air damper plates, and temperature responsive means operative to pivot the other air damper plate in a direction to decrease the volume of air passing through the throat of its associated blower upon a drop in ambient temperature when its associated heat exchange coil is operating as a condenser.

6. A compressor-condenser assembly for an air conditioner comprising an elongated housing having an air inlet opening and an air outlet opening therein, a compressor and a condenser mounted in said housing between said inlet and outlet openings, a blower mounted in said housing having an air exhaust throat mounted in said air outlet opening, said blower being operative to draw air through said inlet opening and over said compressor and condenser before entering said throat, an air damper plate pivotally mounted on a shaft in said throat, the distance between the shaft axis and the trailing edge of the plate being sufficient for the trailing edge of the plate to engage a wall of the throat when the plate is pivoted in one direction, a spiral bimetal spring having its inner end connected to said damper plate shaft, a bracket fixedly positioning the outer end of said spring, said bimetal spring being operative to pivot said damper plate in said one direction to a position to decrease the volume of air passing through said throat in response to a drop in the ambient air temperature whereby the volume of air passing over said compressor and condenser is decreased proportionately.

7. The assembly of claim 6 in which said compressor is mounted adjacent said air inlet opening.

8. The assembly of claim 6 in which said air inlet and outlet openings are at opposite ends of said housing, said compressor being mounted adjacent said air inlet opening.

9. The assembly of claim 6 in which said blower is a centrifugal blower having a snail shell casing merging with said discharge throat.

10. A compressor-condenser assembly for an air conditioner comprising an elongated housing having an air inlet opening and an air outlet opening at opposite ends thereof, a compressor and a condenser being mounted in said housing between said inlet and outlet openings with the compressor being mounted adjacent the inlet opening, a centrifugal blower mounted in said housing, said blower having a snail shell casing merging into an air exhaust throat disposed in said outlet opening, said blower being operative to draw air through said inlet opening and over said compressor and condenser before entering said throat, an air damper plate pivotally mounted on a shaft in said throat for decreasing the volume of air passing therethrough, said damper plate having a leading edge and a trailing edge disposed transversely of the air stream in said throat, the shaft axis being nearer the leading edge of the plate than the trailing edge thereof, the distance between the shaft axis and the trailing edge of the plate being sufficient for the trailing edge of the plate to engage a wall of the throat when the plate is pivoted in one direction, a spiral bimetal spring having its inner end connected to said damper plate shaft, a bracket fixedly positioning the outer end of said spring, said bimetal being operative to pivot said damper plate in said one direction to a position to decrease the volume of air passing through said throat in response to a predetermined drop in ambient air temperature whereby the volume of air passing over said compressor and condenser is decreased proportionately.

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