Feb. 6, 1951

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ROOM AIR CONDITIONER MIXING FRESH AND RECIRCULATED AIR

2,540,957

Filed April 12, 1947

2 Sheets-Sheet 1

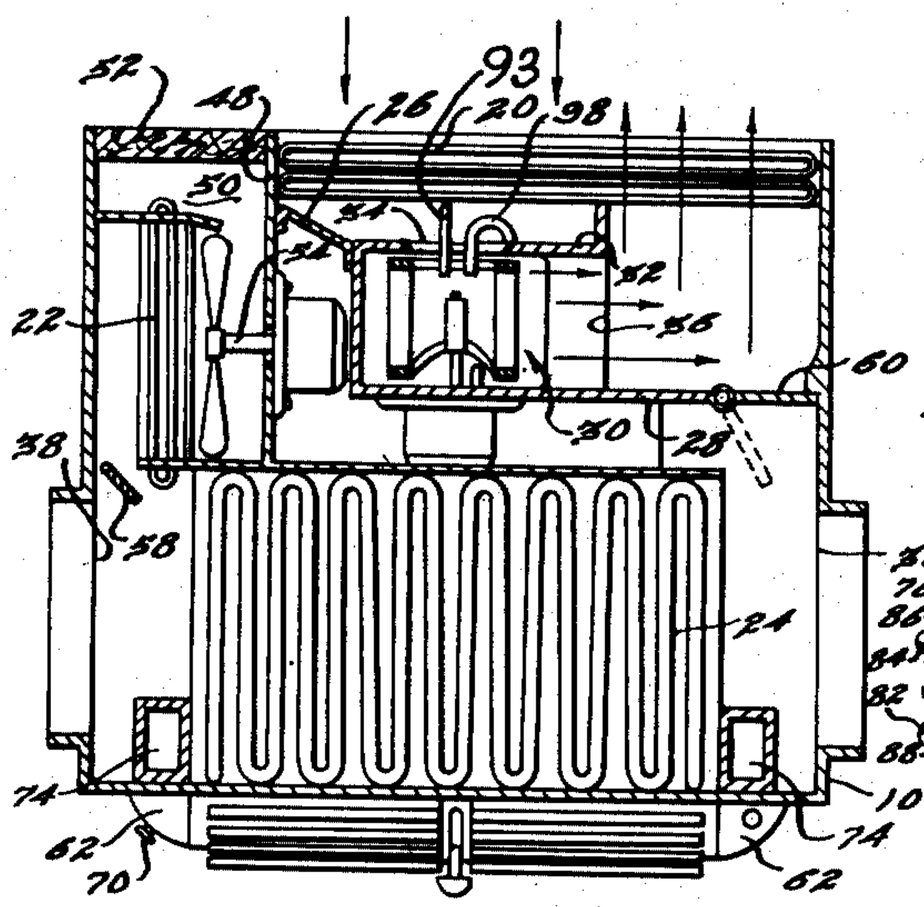

FIG. 1.

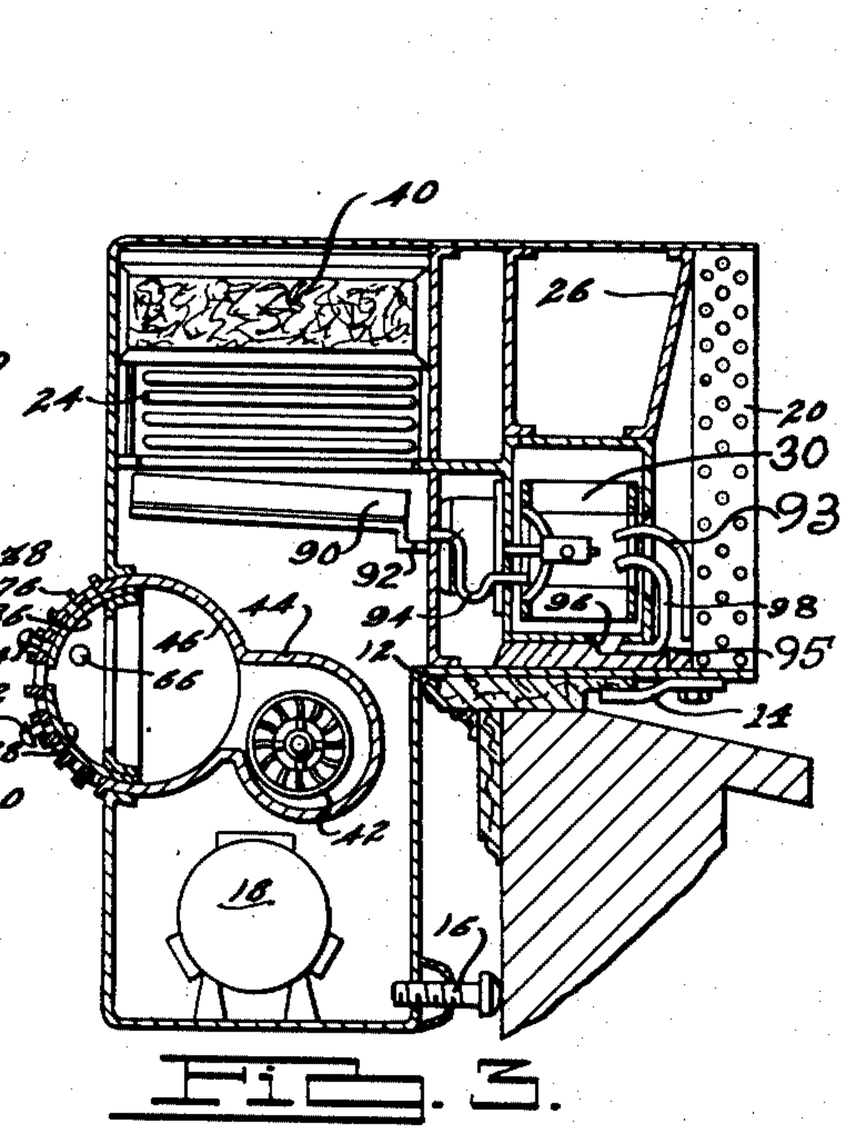

FIG. 3.

FIG. 2.

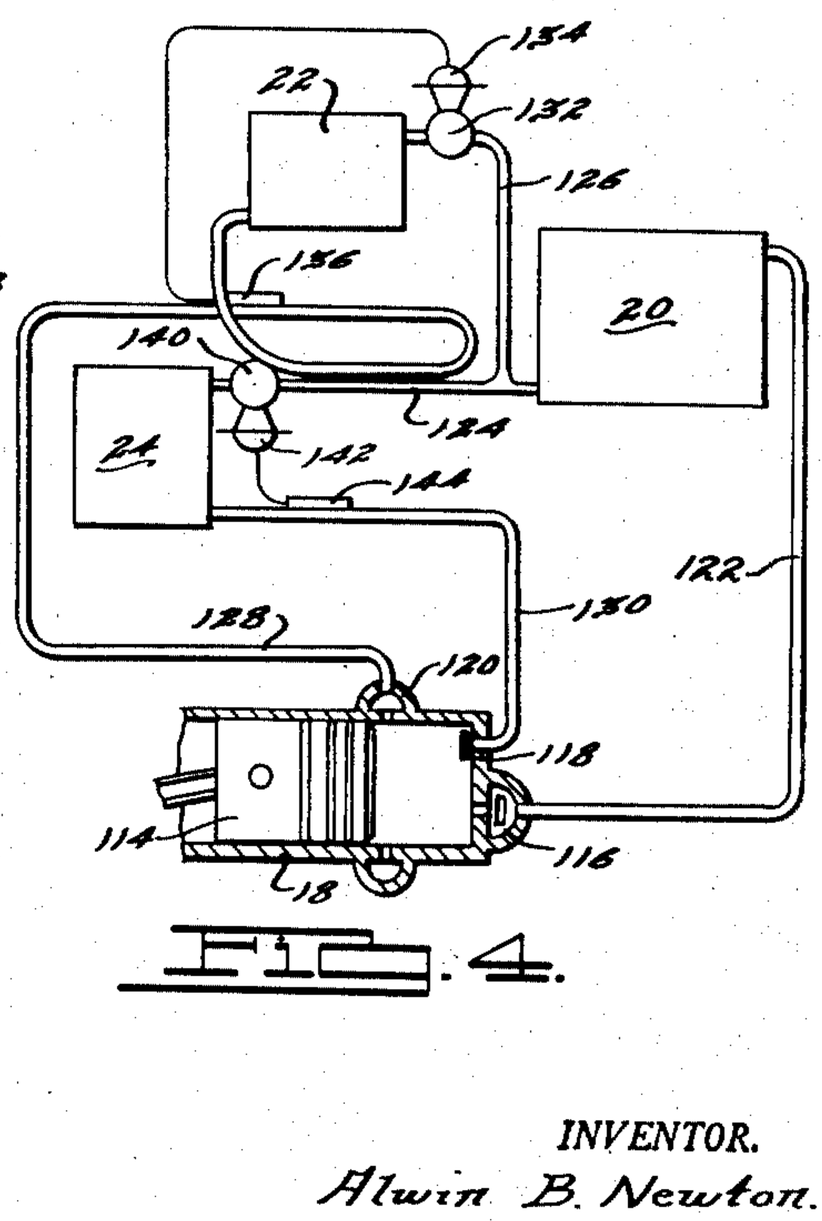

FIG. 4.

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2 Sheets-Sheet 2

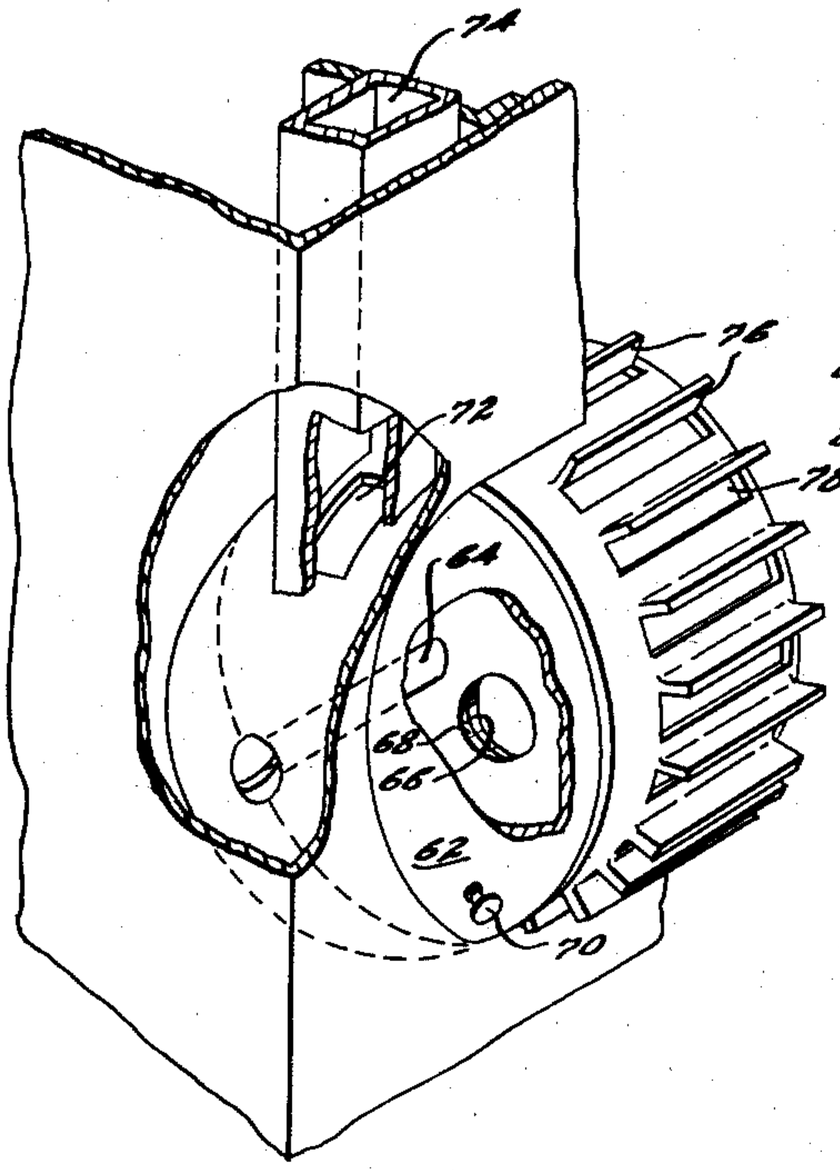

FIG. 5.

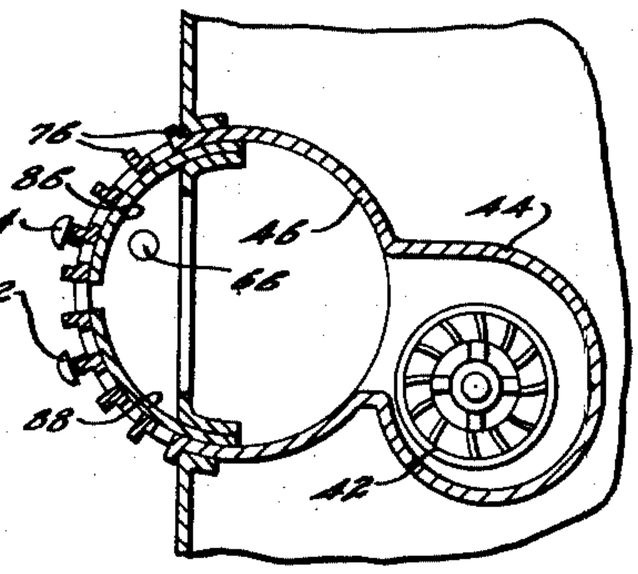

FIG. 6.

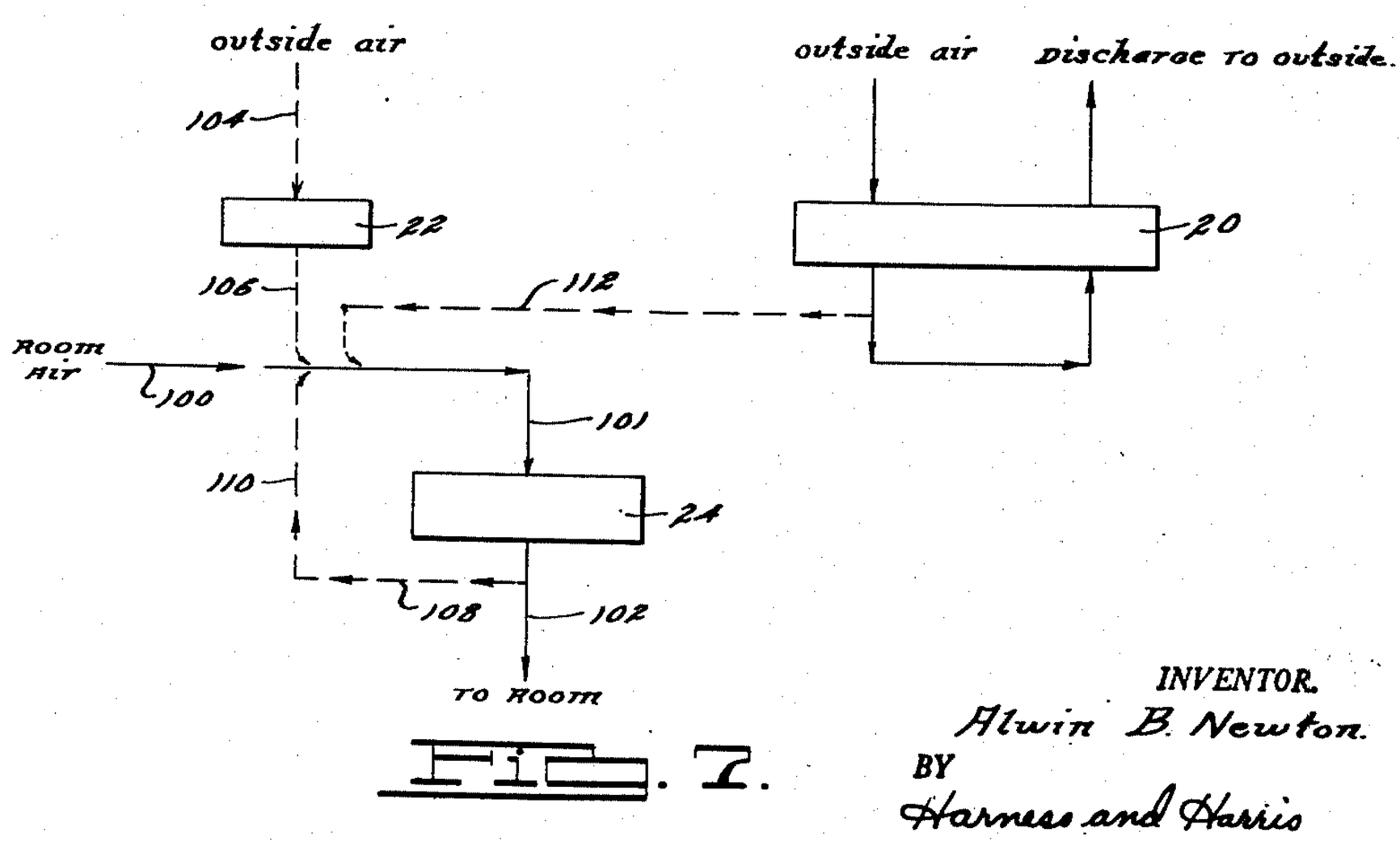

FIG. 7.

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Patented Feb. 6, 1951

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UNITED STATES PATENT OFFICE

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ROOM AIR CONDITIONER MIXING FRESH AND RECIRCULATED AIR

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Application April 12, 1947, Serial No. 741,982

10 Claims. (Cl. 62—129)

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This invention relates to apparatus adapted to utilize a multiple effect refrigeration system in a room air conditioner.

It is an object of this invention to incorporate in a room air conditioner a refrigeration system having two cooling coils, one of which cools fresh incoming air and the other of which is maintained at a relatively lower temperature to cool recirculated room air. The latter coil, if desired may also additionally cool the fresh incoming air. Both of these coils are operatively associated with one compressor provided in the system.

It is a further object of the invention to provide in an airstream two cooling coils arranged in series and each adapted to discharge into one compressor. The upstream cooling coil discharges into the compressor cylinder at a location between the limits of piston travel. The downstream cooling coil discharges into the compressor through the usual suction valve located in the head of the compressor cylinder.

An additional object of the invention is to improve the efficiency of refrigeration apparatus used in a room air conditioner by utilizing a plurality of cooling coils each operating at its optimum pressure and temperature.

It is a further object of the invention to obtain a maximum dehumidification of air being cooled with a minimum of volume of refrigerant. It has been found by experience that dehumidification does not occur unless there is about a 30° temperature differential between the temperature of the refrigerant in the system and the temperature of air being cooled by the system. In an air conditioner where recirculated air is to be mixed with fresh incoming air if one cooling coil only is used to cool the mixture it is necessary that this coil operate inefficiently by handling an excessive volume of refrigerant if the 30° differential in temperature is to be obtained. If the fresh incoming air is cooled by one coil and the mixed fresh air and recirculated room air are cooled by another coil the 30° differential may be obtained between each coil and its associated air with a maximum of efficiency.

It is an additional object of the invention to utilize the exhaust refrigerant from one cooling coil to pre-cool the refrigerant entering a second cooling coil of the same refrigerating system where the two coils are operated by one compressor.

The room air conditioner which incorporates my invention provides a novel means of increasing the dehumidification of air by recirculating a portion of the air back through the system so

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that it may make a plurality of passes over the cooling coils before being discharged from the conditioner to the room.

A further object of the invention is to provide a unit capable of supplying correctly conditioned air in the amounts and in the direction desired by the occupants of a room. This includes means to treat fresh air and recirculate room air in the respective quantities desired for proper ventilation of the room. This also includes means for controlling the direction of flow of air into the room from the unit and means for controlling the velocity thereof so as to prevent objectionable drafts.

Means are also provided herein to permit fresh outside air to be mixed with room air being circulated through the conditioner and to provide a selection of precooled or preheated outside air or a combination of the two for this mixture.

In the drawings:

Fig. 1 is a plan view of the unit with the top removed,

Fig. 2 is a front elevation of the unit with parts thereof broken away to illustrate interior details,

Fig. 3 is a vertical section taken on the line 3—3 of Fig. 2,

Fig. 4 is a schematic drawing of the refrigeration system used in the unit,

Fig. 5 is a perspective view of a portion of the unit and has parts thereof broken away to illustrate details,

Fig. 6 is an enlarged view of the air discharge control means, and

Fig. 7 is a schematic diagram showing the paths of air relative to the refrigeration system in the unit.

A casing 10 houses the unit. The casing preferably is in the shape of an inverted L with the leg thereof extending outwardly through an opening in the room such as a window. The casing is adapted to rest on the window sill 12 and is retained in place by a finger 14 engaging the sill 12. Screws 16 may be provided to extend from the lower portion of the unit to the wall to provide adjustable means for leveling the unit in place.

The refrigeration system used in the unit comprises a motor driven compressor 18, a condenser 20, a first evaporator 22 and a second evaporator 24. These components of the refrigeration system are connected in refrigerant flow relationship as illustrated in Fig. 4 and are controlled by apparatus to be described herein. They operate on the well-known multiple effect refrigeration cycle which will be discussed herein.

The condenser 20 extends across most of the outer portion of the unit and has associated therewith means for creating a circulation of outside air inwardly over a portion of the condenser and outwardly through another portion of the condenser. This circulation of outside air through the condenser cools the condenser and dissipates heat therefrom. Fig. 1 illustrates the means by which this circulation of outside air is induced. The walls 26 and 28 illustrated in Fig. 1 form a compartment behind the condenser, a blower 30 is positioned in this compartment, a partition 32 divides the compartment and condenser. The blower 30 has an inlet opening positioned in operative relation with one portion of the condenser. The blower is adapted to discharge air to the other portion of the compartment and condenser unit defined by the partition 32. The inlet orifice on the blower has been designated 34 and the discharge orifice has been designated 36.

The air conditioning unit is adapted to circulate room air and to cool this circulated room air as it passes through the unit. Each side wall of the housing 10 is provided with an opening 38 through which air may be drawn from the room. Air entering the housing through the openings 38 is drawn through a pair of filters 40 to a plenum chamber 56. The air is then drawn downwardly through the evaporator 24 and cooled. The circulation of air is created by a blower 42. The scroll 44 of the blower 42 has a discharge opening in the back of a drum 46. Suitable control means is associated with the drum 46 so that the air from blower 42 may be discharged into the room. This control means will be described herein.

In addition to the circulation of room air described above fresh air may be drawn from the outside of the building and mixed with the circulating room air. A partition 48 cooperates with a side wall of the housing to form a passage 50 which has one end thereof projecting through the window to the outside air. A filter 52 is positioned across the entrant portion of the passage 50. The evaporator 22 previously referred to is positioned in the passage 50 and a fan 54 driven by a suitable electric motor is adapted to force outside air through the evaporator 22 and into the plenum chamber 56. Control of the fan 54 and a damper 58 regulate the amount of air, if any, which is to be drawn through the passage 50 into the plenum chamber 56.

In addition means are provided for the optional admission of warmed fresh outside air into the plenum chamber 56. A damper 60 is associated with the partition 28 so that the air being drawn in through the condenser 20 by the blower 30 may have a portion thereof deflected into the plenum chamber 56 by opening the damper 60.

In addition to the circulation of room air and the optional mixture therewith of cold fresh air or warm fresh air, a means is provided for recirculating a portion of the air mixture through the evaporator 24 a plurality of times before it is discharged from the housing. The drum 46 briefly referred to above is substantially cylindrical in shape and provided with a pair of end bells 62 which are rotatably mounted on shafts 64. Each end wall of the drum 46 is provided with an opening 66 and the adjacent flat wall of the associated end bell 62 is provided with an opening 68. The openings 66 and 68 are eccentrically positioned relative to the axis of the cylindrical drum and relative to the shaft 64. The opening 68 is adapted to register with the opening 66 when the end bell is suitably rotated by means of a knob 70. The outer surface of the end bell is provided with a segmental escape opening 72. A stack 74 is provided in the housing 10. The opening 72 in the end bell is so positioned that it registers with the stack 74 when the opening 68 is registering with the opening 66. Air may be by-passed from the drum 46 through the openings 66 and 68 into the end bell 62 from whence it may pass upwardly through the escape opening 72 and through the stack 74 into the plenum chamber 56 to be recirculated through the evaporator coil 24 for additional cooling. It has been found that treating a portion of the air adds very appreciably to the total effective cooling by increasing the ratio of dehumidification on mild very humid days.

The drum 46 has a cylindrical contour and a hemicylindrical portion thereof projects outwardly beyond the front face of the casing 10. The hemicylindrical portion of the drum 46 is provided with a plurality of directional vanes 76 which are preferably provided adjacent stamped slots in the surface of the drum. The vanes 76 are substantially radially arranged relative to the cylindrical drum 46. The vanes 76 cooperate with the associated slots 78 to direct air from the drum 46 into the room in desired directions. The drum 46 is preferably arranged on a horizontal axis. The vanes and slots preferably extend longitudinally of the drum, but there is provided a centrally located peripheral portion which is uninterrupted by these slots or vanes. The central peripheral portion is provided with a slot 80 which extends circumferentially about a portion of the drum. The slot 80 provides a means by which a pair of exterior handles 82 and 84 may connect with a pair of dampers 86 and 88. The dampers 86 and 88 are arcuate and adapted to slide relative to the internal surface of the drum 46. The damper 86 is positioned in the upper portion of the drum 46 and adapted to control the discharge of air through the slots 78 in the upper segment of the drum. The damper 88 is adapted to control the discharge of air through the slots 78 in the lower segment of the drum. The dampers 86 and 88 may be brought into abutting relationship on a substantially horizontal line thus preventing the discharge of air from the unit. By selectively moving the damper 86 or the damper 88 the direction of discharge of air may be controlled by selecting which slots are to be exposed. By varying the number of slots exposed the velocity of the air being discharged may be varied.

The refrigerant apparatus discussed herein is provided with suitable means for the disposal of moisture which accumulates on the evaporator 24 as air is being cooled and dehumidified by its heat exchange relation with the evaporator 24. The moisture which precipitates on the evaporator 24 drops by gravity and is collected by a series of collectors 90 which are so arranged that they do not impede the flow of air but do present surfaces to catch falling moisture. Each collector 90 is inclined rearwardly of the unit and is operatively associated with a trough 92. The trough 92 is drained by a tube 94 preferably having a U bend therein to provide a liquid seal between the compartments. The end of the tube 94 projects through the scroll housing of the blower 30 and is positioned above the rotor blades of the blower 30 so that the condensed moisture dropping from the tube 94 will be contacted by the rotor blades and beaten into a fine spray which facilitates evapora-

tion by the previously heated condenser cooling air. The evaporated moisture may be carried outside the building with the condenser cooling air. The bottom portion of the scroll of the blower 30 is provided with a drain 96. A tube 98 is adapted to operatively connect the drain 96 with the interior portion of the blower 30. Moisture from the tube 94 which is not evaporated by the condenser cooling air will collect in the scroll housing of the blower 30. The differential in pressure between the interior portion of the blower and the drain 96 will provide a means for lifting the moisture through tube 98 back into contact with the rotor blades. There is thus provided means for recirculating the moisture until it is evaporated.

An additional tube 93 is provided to dispose of any moisture which may collect on the floor 95 of that portion of the unit which projects through the wall of the building. This moisture could be derived from either spray escaping from the blower 30 or rain water being driven in through the condenser 20. The tube 93 is adapted to utilize the differential in pressure between the interior of the blower rotor and the atmosphere to lift the moisture in the tube 93 into the interior of the blower in the same manner that the tube 98 operates.

Fig. 7 illustrates a schematic drawing of the various paths of air through the condenser unit. The path of room air through the evaporator 24 has been designated by the lines 100, 101 and 102. The path of fresh outside air through the evaporator 22 has been designated by the lines 104 and 106. The line 106 merges with the line 100. The recirculation of air through the evaporator 24 by means of the end bell 62 has been designated by dotted lines 108 and 110. The bleeding of warmed condenser cooling air through the damper 60 has been designated by the line 112.

Referring to Fig. 4 the refrigeration system employed herein is illustrated. This system is of the type generally referred to as a multiple effect system. The compressor 18 is provided with a reciprocating piston 114, a discharge valve 116, a suction valve 118 and supplemental suction ports 120 which are positioned in the walls of the compressor cylinder at a location between the limits of piston travel. The discharge valve 116 of the compressor 18 is connected by pipe 122 with the condenser coil 20. A pipe 124 provides a fluid flow connection from the condenser 20 to the evaporator 24 for the passage of liquid refrigerant. A branch line 126 which is connected to the pipe 124 operatively connects the condenser 20 and the evaporator 22. An important feature of this invention resides in the fact that two separate evaporators operating at different temperatures and pressures from one compressor are provided in the room air conditioning unit. The outside air is usually at a higher temperature than the cooled room air. It is therefore possible to maintain a sufficient differential in temperature between the outside air and its associated evaporator 22 by having the evaporator 22 operate at a higher temperature than is possible with the evaporator 24. This increases the efficiency by having the refrigerant operate at a higher temperature, pressure and density. The dehumidification of air being cooled requires that a sufficient differential in temperature exist between the air and the evaporator. The differential has been found to be in the neighborhood of 30°. A suitable differential for the dehumidification may be obtained even though the evaporator 22 operates at relatively high temperature. Previous systems attempting to maintain a sufficient differential have provided a relatively large evaporator, which although it does provide the required differential for dehumidification, operates very inefficiently because the refrigerant volume is great. The suction line 128 of coil 22 is connected with the suction ports 120 of compressor 18. A suction line 130 of the evaporator 124 is connected with the suction valve 118 of the compressor 18. The admission of refrigerant to evaporator 22 is controlled by an expansion valve 132 operated by a differential pressure controlled valve 134 which is responsive to a heat sensitive bulb 136 connected to the discharge line 128. The admission of refrigerant to the evaporator 24 is through an expansion valve 140 operated by a diaphragm motor 142 controlled by a heat sensitive bulb 144 attached to the pipe 130.

The suction line 128 from evaporator 22 contains refrigerant still able to do some cooling and is preferably positioned in heat transfer relation with the liquid refrigerant entering evaporator 24 through line 124 so that a pre-cooling of the refrigerant for evaporator 24 is obtained. The heat transfer is preferably such that the directions of travel of the cold refrigerant in line 128 and the liquid refrigerant in line 124 are in opposite directions. This facilitates the pre-cooling of the liquid refrigerant by assuring that the coldest portion of the line 128 (this is the portion containing refrigerant which has not yet passed in heat transfer relation with line 124) is positioned adjacent that portion of the line 124 containing liquid refrigerant which has been cooled. The pre-cooling is facilitated by the proximity between the coldest portions of each line rather than having the coldest portion of one line in contact with the hottest portion of the other line.

Experience has shown that the optimum benefit of the multiple effect system may be obtained with approximately a 4 to 1 ratio between the sizes of the evaporators. This experience is however based upon the humidity generally prevalent in the U. S. The proper ratio for any other climate may be computed.

In a unit drawing 270 C. F. M. over coil 24 and 60 C. F. M. over coil 22 under certain conditions of outside and inside wet bulb temperatures an increase of as much as 110% in total cooling effect over a conventional system may be achieved as illustrated in the following tables.

Table 1

Outside Wet Bulb	80	75	70	65	60	55
Inside Wet Bulb	67	67	67	67	67	67
Wet Bulb Leaving Coil 22	66.2	66.2	66.2	66.2	66.2	66.2
Wet Bulb Leaving Coil 24	56.1	56.1	56.1	56.1	56.1	56.1
Suction Temp. °F	62.5	59.5	57.5	55	53	50.5
BTU by Coil 22	3000	2400	1860	1344	960	540
BTU by Coil 24	9000	9000	9000	9000	9000	9000
Total	12000	11400	10860	10344	9960	9540
BTU-Conventional	6150					8540
% Increase	95					11.5

Table 2

Outside Wet Bulb	80	75	70	65	60	55	50
Inside Wet Bulb	62	62	62	62	62	62	62
Wet Bulb Leaving Coil 22	66.2	66.2	66.2	66.2	66.2	66.2	66.2
Wet Bulb Leaving Coil 24	56.1	56.1	56.1	56.1	56.1	56.1	56.1
Suction Temp. °F	59	56.5	54	51	49	47	45
BTU by Coil 22	3480	2844	2280	1740	1210	840	480
BTU by Coil 24	8000	8000	8000	8000	8000	8000	8000
Total	11480	10844	10280	9740	9210	8840	8480
BTU-Conventional	5460						7580
% Increase	110						11.8

In the above, Table 1 illustrates the advantage achieved when the outside air wet bulb is at the figures given and the inside wet bulb is main-

tained at substantially 67° Fahrenheit while Table 2 illustrates the advantage achieved when the outside wet bulb is at the figures given and the inside wet bulb is maintained at substantially 62° Fahrenheit.

I claim:

1. In an air conditioner adapted to air condition a space, a multiple effect refrigerating system comprising a compressor, a condenser and first and second evaporators arranged in refrigerant flow relationship, means to maintain the refrigerant in said first evaporator at a higher temperature and pressure than the refrigerant in said second evaporator, means to receive fresh air from outside said space and to circulate said fresh air over said first evaporator, means to admit air from said space to said conditioner and mix said air from said space with the cooled fresh air, means to pass the resultant mixture over said second evaporator and eject the cooled mixture into the space, means for receiving air from outside said space and passing it in heat exchange relation with said condenser to cool said condenser and means for selectively admitting in controllable amounts to said space a portion of the air heated by the condenser.

2. In an air conditioner, first means to receive air from a space to be air conditioned and to circulate such air through said conditioner, second means to receive fresh air from outside said space and to circulate said fresh air through said conditioner in controllable amounts, a refrigeration system of the multiple-effect type in said air conditioner, said system comprising a first evaporator adapted to cool said fresh air, a second evaporator adapted to cool the recirculated air from said space, means to maintain said first evaporator at a higher temperature than said second evaporator, said first and second means being arranged to mix said first mentioned air with the cooled fresh air and to pass the resulting mixture over said second evaporator and eject the cooled mixture into said space.

3. An air conditioner containing a first means to cool air and deliver it to a space to be cooled, a second means associated with said conditioner and adapted to obtain the air to be cooled from a plurality of sources, the first of said sources being the space to be cooled and a second of said sources being outside of said space, a third means associated with said conditioner and adapted to cool air obtained from said second source and a fourth means associated with said conditioner and adapted to heat air obtained from said second source, said third means and said fourth means being adapted to respectively pre-cool and pre-heat air from said second source prior to its association with said first means.

4. An air conditioner containing a first means to cool air and deliver it to a space to be cooled, a second means associated with said conditioner and adapted to obtain the air to be cooled from a plurality of sources, the first of said sources being the space to be cooled and a second of said sources being outside of said space, a third means associated with said conditioner and adapted to cool air obtained from said second source and a fourth means associated with said conditioner and adapted to heat air obtained from said second source, said third means and said fourth means being adapted to respectively pre-cool and pre-heat air from said second source prior to its mixture with air from said first source and association of the mixture with said first means.

5. An air conditioner containing a first means to cool air and deliver it to a space to be cooled, a second means associated with said conditioner and adapted to obtain the air to be cooled from a plurality of sources, the first of said sources being the space to be cooled and a second of said sources being outside of said space, a third means associated with said conditioner and adapted to cool air obtained from said second source and a fourth means associated with said conditioner and adapted to heat air obtained from said second source, said third means and said fourth means being adapted to respectively pre-cool and pre-heat air from said second source prior to its mixture with air from said first source and association of the mixture with said first means and means to control the amount of air from said third means and said fourth means that is to be mixed with air from said first source.

6. In an air conditioner adapted to cool air and discharge the cooled air to a space to be air conditioned, means to control the velocity and direction of discharge of said air to said space, said means comprising a curved housing, means forming a plurality of slots in said housing, a vane projecting outwardly from said housing adjacent each of said slots, blower means to discharge air from said housing and a third means to selectively cover said slots whereby a variation in the number of slots covered by said third means varies the velocity of the air being discharged and the selection as to which slots are covered determines the direction of discharge of said air.

7. In an air conditioner adapted to cool air and discharge the cooled air to a space to be air conditioned, means to control the velocity and direction of discharge of said air to said space, said means comprising a curved hemi-cylindrical housing, means forming a plurality of slots in the curved surface of said housing, blower means to discharge air from said housing through said slots, a pair of curved plates slidably mounted in said housing and adapted to cover and uncover said slots, one of said plates being adapted to be moved in a first direction so that one of its edges travels between the limits of a substantially horizontal position and a remote position, the other of said plates being adapted to be moved in a second direction so that one of its edges travels between the limits of a substantially horizontal position and a remote position whereby the selective movement of said plates selects the segment of said housing from which air is discharged and thereby controls the direction and velocity of air discharge.

8. In an air conditioner an evaporator adapted to cool air, a condenser, a blower having a scroll and a rotor adapted to circulate air through said condenser to cool the condenser, means to collect condensate from the evaporator and discharge the condensate on to the blower rotor whereby the condensate will be broken up into a fine spray which will facilitate evaporation by the condenser cooling air, and a tube penetrating the bottom of said scroll and having an open end directed in close proximity with the interior of said rotor whereby a differential in air pressure may be utilized to recirculate unevaporated moisture in said scroll into contact with said rotor.

9. In an air conditioner adapted to cool air and discharge the cooled air to a space to be

air conditioned, means to control the velocity and direction of discharge of said air to said space, said means comprising a curved hemicylindrical housing having its axis arranged in a substantially horizontal plane, means forming a plurality of horizontal slots in the curved surface of said housing, blower means to discharge air from said housing through said slots, a pair of curved plates slidably mounted in said housing and adapted to cover and uncover said slots, one of said plates being adapted to be moved upwardly to expose the slots in the upper portion of said housing, the other of said plates being adapted to be moved downwardly to expose the slots in the lower portion of said housing whereby the selective movement of said plates selects the segment of said housing from which air is discharged and thereby selects the vertical component of the direction of air discharge and controls the velocity of air discharge.

10. In an air conditioner, first means to receive air from a space to be air conditioned and to circulate such air through said conditioner, second means to receive fresh air from outside said space and to circulate said fresh air through said conditioner in controllable amounts, a refrigeration system of the multiple-effect type in said air conditioner, said system comprising a

first evaporator adapted to cool said fresh air, a second evaporator adapted to cool the recirculated air from said space, means to maintain said first evaporator at a higher temperature than said second evaporator, said first and second means being arranged to mix said first mentioned air with the cooled fresh air and to pass the resulting mixture over said second evaporator and eject the cooled mixture into said space, and means for recirculating a portion of the cooled mixed air back for a second pass through said second evaporator.

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