

July 2, 1935.

C. A. BULKELEY

2,006,344

AIR CONDITIONING APPARATUS

Filed Aug. 5, 1933

2 Sheets-Sheet 1

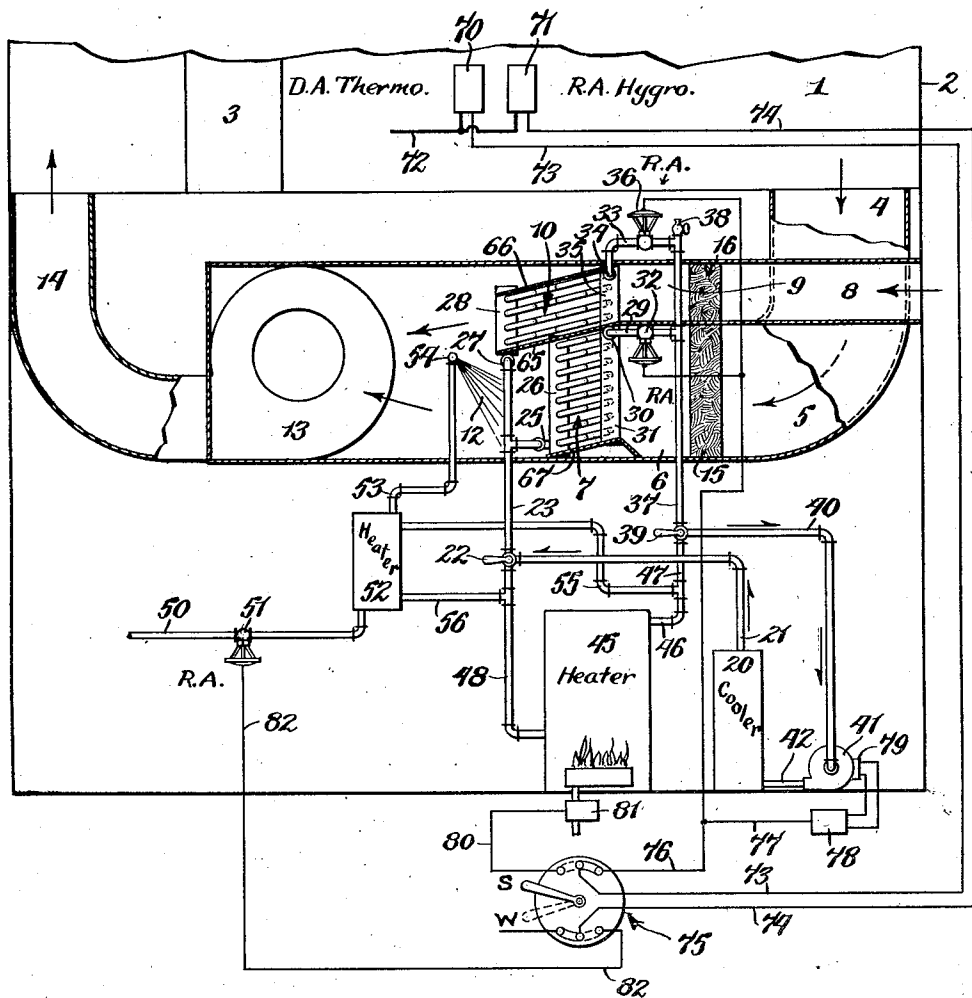


Fig. 1.

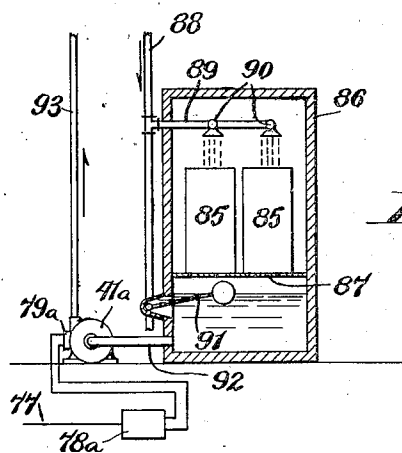


Fig. 2.

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2 Sheets-Sheet 2

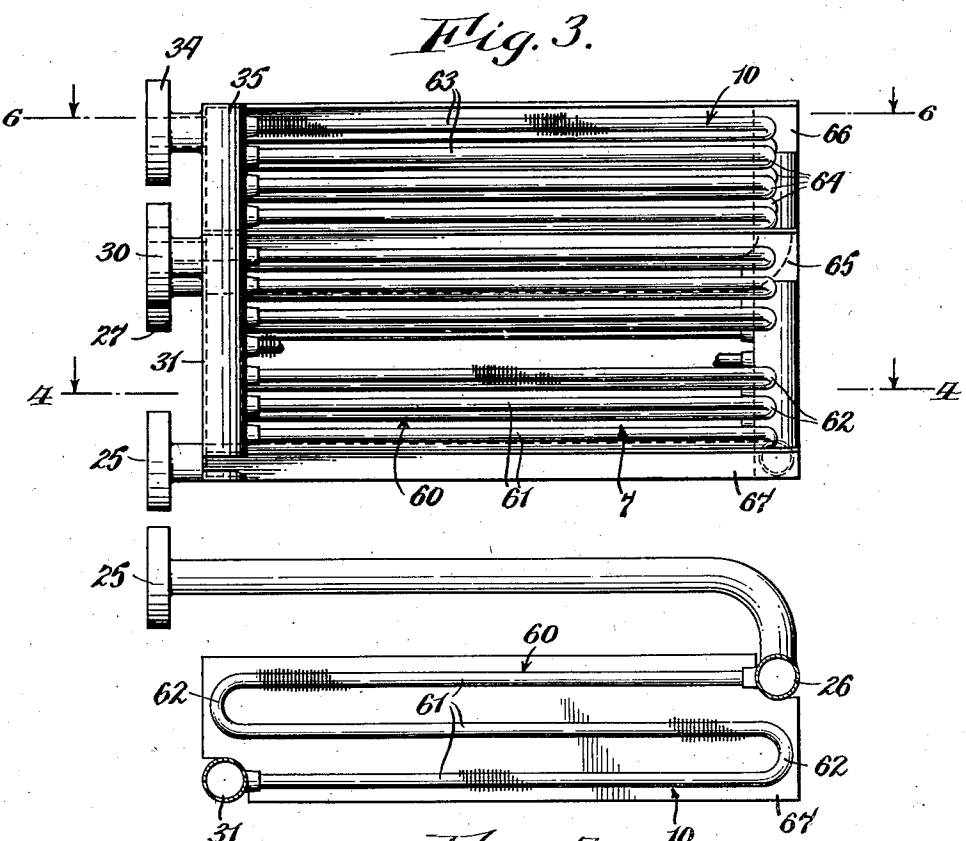
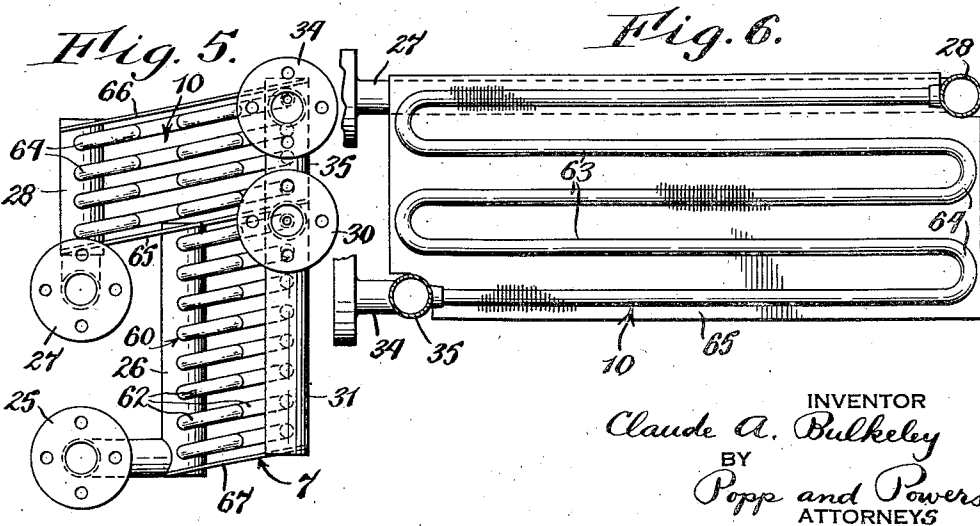


Fig. 4.



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2,006,344

AIR CONDITIONING APPARATUS

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Application August 5, 1933, Serial No. 683,783

8 Claims. (Cl. 257-8)

This invention relates to an air conditioner and more particularly to an air conditioning unit particularly adapted for domestic use or use in heating, cooling, humidifying and dehumidifying small stores and the like.

This application is a continuation in part of my co-pending application Serial No. 666,152, filed April 14, 1933.

One of the principal objects of this invention is to provide such a domestic air conditioning unit in which the same equipment, including the control equipment, and the same fan and coils can be used both for heating and humidifying during the wintertime and for cooling and dehumidifying in the summertime, thereby effecting economy in installation.

Another purpose of the present invention is to provide such a domestic unit in which the change-over from cooling to heating and vice versa is very easily and simply accomplished by operating only two three-way hand valves and one control switch, thereby avoiding the usual complications and enabling the home owner to operate the unit at all times without expert assistance.

Another purpose is to provide such a unit in which the equipment is relatively low both in first cost and operating cost, this being particularly important in domestic installations.

Another purpose is to provide such a unit, the component parts of which are not new but have long been in practical use.

Another object is to provide such a unit in which the only major moving parts are the fan and cold water pump and in which the power required to drive both, even for a relatively large residence (40,000 cubic feet) is not over one horse power. This is accomplished primarily through the unique arrangement of the coils for the passage of air and cooling or heating media.

Another aim is to provide such a system in which, when heating and humidifying, the only moving part is the air circulating fan and in which the entire arrangement operates similar to any good ventilating system.

Another object is to provide such a unit which avoids the necessity of unsightly direct radiators which occupy valuable space in the room or rooms of the house.

Another object of the present invention is to provide such a unit air conditioner which can be readily installed as a heating, ventilating and humidifying system, the dehumidifying and cooling system being omitted and, later on, this omitted cooling and dehumidifying equipment can be added with no changes whatever in the equipment

already installed and at no additional cost other than that which would have been required to put it in in the first place.

Another purpose of the present invention is to make the entire unit, including the fan housing, coils and casing of aluminum, this eliminating any possible corrosion due to the moisture necessarily always present in equipment of this kind.

Another object is to provide such an air conditioning system in which the source of heat can be any good make of steam boiler and the source of cooling can be any standard well known refrigerating system, such as melting ice or ammonia. Ammonia can be employed since the cooling water is cooled in a shell and tube cooler before passing to the cooling coils and hence there is no chance for the refrigerant to escape into the air stream in the event of a break in the shell and tube cooler.

Another purpose is to provide such a system which is adapted to unit construction, thereby expediting the transportation and installation of the equipment as well as providing equipment which is compact and of neat appearance, the latter being especially important in domestic use.

In the accompanying drawings:

Fig. 1 is a diagrammatic sectional elevation of a building equipped with a domestic air conditioning unit embodying the present invention and showing diagrammatically the arrangement and action of all of the instrumentalities used to carry out the invention.

Fig. 2 is a diagrammatic sectional elevation through a melting ice cooler suitable for use in supplying cold water when the apparatus is used for cooling and dehumidifying.

Fig. 3 is a front elevation of the cooling and heating coils employed for cooling and dehumidifying or for heating the fresh and recirculated air delivered by the apparatus.

Fig. 4 is a horizontal section taken on line 4-4, Fig. 3.

Fig. 5 is an end elevation of the cooling and heating coils shown in Fig. 3.

Fig. 6 is a horizontal section taken on line 6-6, Fig. 3.

Conditioned air is supplied to each of the rooms 1 to be conditioned of a building 2, the rooms having doors 3 through which air can escape so that an excess pressure is not built up in the rooms by the constant admission of fresh air. The various rooms 1 of the building may or may not each be provided with a recirculated air outlet 4 leading to a common duct 5 leading to a chamber 6 having a plurality of recirculated air cooling

and heating coils 7. If the rooms are not provided with outlet ducts the recirculation air duct 4 can draw its recirculated air from a common hall. The recirculated room air passes through these coils and is cooled and dehumidified when a cooling medium is flowing through these coils and heated when a heating medium is passing through these coils. Fresh air is admitted through a fresh air duct 8 to a chamber 9 in which heating and cooling coils 10 are disposed, the coils 7 for the recirculated air and the coils 10 for the fresh air being especially constructed as hereinafter more fully set forth. The fresh and recirculated air from the coils 7 and 10 is drawn past a humidifying spray 12, which is operative only when heating, by a fan 13 which thoroughly mixes the fresh and recirculated air and discharges it through a duct 14 back into the room. In order to clean all of the air handled by the apparatus a filter 15 is provided in the recirculation air duct 4 and a similar filter 16 is provided in the fresh air duct 8.

The apparatus shown in Fig. 1 is shown as set for cooling and dehumidifying operation during the summertime. During such summer operation the cooling water to the coils 7 and 10 is passed through a shell and tube cooler 20 which can be cooled in any manner such as by ammonia and the like. The outlet 21 from this cooler connects with a three-way valve 22 which, when set for summer operation, permits this water to flow into a pipe 23. This pipe 23 connects with the nipple 25 of a header 26 of the recirculation air coils 7 and also connects with the nipple 27 of a header 28 of the fresh air coils 10. A pipe 29 connects with the nipple 30 of the other header 31 of the recirculation air coils 7 and this pipe 29 contains a reverse acting diaphragm valve 32. Similarly, a pipe 33 connects with the nipple 34 of the other header 35 of the fresh air coils 10 and this pipe 33 contains a reverse acting diaphragm valve 36. The pipes 29 and 33 connect with a pipe 37, this pipe preferably having an air cock 38 at its upper end through which any air originally in the coils or accumulating therein can be relieved. The pipe 37 connects with the three-way valve 39 which, during summer operation, is set to deliver the return water to a return pipe 40 leading to the inlet of the circulating pump 41. The outlet 42 from this pump connects with the cooler 20 so that the pump continuously circulates cooling water through the system just described as long as the pump 41 is in operation.

During winter operation the heater 45 is in operation. This heater may be any good make of steam or hot water boiler and generates steam or heats the water which passes from its outlet 46 to a pipe 47. During winter operation the three-way valve 39 is set to deliver the steam or water to the pipe 37 and the steam or water passes through the pipe 33 and reverse acting diaphragm valve 36 to the header 35 of the fresh air coils 10 and also through the pipe 29 and reverse acting diaphragm valve 32 to the header 31 of the recirculated air coil 7. The condensate or cooled water from the headers 28 and 26 of the fresh and recirculated air coils respectively passes out through the pipe 23 and during winter operation the three-way valve 22 is set to return this condensate or water to the return line 48 of the heater 45.

During winter operation the air stream is humidified, under automatic control, to the degree desired, by the humidifying spray 12. The water for this spray is supplied from water sup-

ply line 50 having reverse acting diaphragm valve 51. This water is passed through a heater 52. From the heater 52 the spray water passes through line 53 to one or more spray nozzles 54 from which it is discharged in the form of finely atomized spray. Steam or hot water to the heater 52 is supplied through a line 55 which connects with the outlet 46 from the heater 45. The return from the heater 52 passes through a return line 56 to the return 48 of the heater 45.

The construction of the coils 7 and 10 is best illustrated in Figs. 3-6. As shown, the headers 26 and 31 of the recirculated air coils 7 are vertically disposed and are connected by finned tubes 60 of serpentine form and each having three horizontal runs 61 and pitched bends 62, or in other words, the plane of the tubes is at an angle to the horizontal in the direction of the air flow only, as best shown in Fig. 5. Due to the pitch of the return bends 62 of the tubes the condensate, when the coils are used for heating, passes freely through the coil without water logging or water hammer. Similarly, when cooling, any air in the tubes is carried through the coils by the cooling water and can be relieved through the air cock 38. As shown, the recirculation air coils are composed of eight such serpentine tubes arranged above one another.

The fresh air coils 10 are constructed in a similar manner consisting of four serpentine tubes connecting the headers 28 and 35. Each of the tubes consists of five horizontal runs 63 connected by return bends 64, the return bends being pitched downwardly toward the header 28 in the same manner as the recirculation air tubes.

The coils 7 and 10 are separated by a partition 65 which insures segregation of the fresh and recirculated air passing through the respective fresh air and recirculated air coils. An inclined partition 66 is also arranged over the fresh air coils 10 so as to cause the fresh air to pass through the coils parallel with their inclination and a similar partition 67 is arranged under the recirculated air coils 7. The partitions 65 and 67 also catch the condensate dripping from the coil surface during dehumidification and drain it into the humidification chamber.

The apparatus shown is under thermostat and hygrostat control, the thermostat being indicated at 70 and the hygrostat at 71. The invention is illustrated as having a pneumatic control, but it will be understood that an electrical control system is equally adaptable. These instruments are located in the room 1 although it will be understood that they could also be arranged in the air duct 4. The thermostat and hygrostat are of the direct and reverse acting intermediate type respectively and are supplied with air pressure from an air pressure supply line 72. The outlet line 73 from the thermostat and the outlet line 74 from the hygrostat connect with a double throw air switch 75 which during summer operation is thrown in the S position indicated in full lines. In this position the switch 75 connects the thermostat outlet line 73 with a control line 76 and connects the hygrostat outlet line 74 with the atmosphere. The control line 76 is connected by a line 77 with a controller 78, this controller controlling the motor 79 which drives the water circulating pump 41. As soon as cooling is required the rising air pressure in the lines 73, 76 and 77 from the thermostat 70 operates the controller 78 to start the pump 41 and hence cooling water is circulated through the cooler 20 and the coils 7 and 10 under control of the reverse act-

ing diaphragm valves 32 and 36. The line 76 from the thermostat also connects with the reverse acting diaphragm valves 32 and 36. As the room temperature rises the rising air pressure in lines 73 and 76 first opens the reverse acting diaphragm valve 36 thereby permitting the cooling water to pass through the fresh air coils 10. Under these conditions the cooling and dehumidifying is performed on the fresh air only, and little or no cooling of the recirculated air is effected, the recirculated air being at correct room temperature. As the room temperature continues to rise the rising pressure in the thermostat outlet lines 73 and 76 opens the reverse acting diaphragm valve 32. This opening of the reverse acting diaphragm valve permits the cooling water to pass in increasing amounts through the recirculated air coils 7 and thereby effects cooling and dehumidification of the recirculated air.

During winter operation the double throw air switch 75 is set to a W position, shown in dotted lines and in this position the thermostat outlet line 73 is connected to a line 80 which connects with a controller 81 controlling the admission of fuel to the boiler 45. In this position the hygrostat outlet line 74 is connected to a line 82 leading to the reverse acting diaphragm valve 51. As the room temperature falls the falling air pressure in the thermostat outlet lines 73 and 80 operates the controller 81 to admit more heat to the heater 45. The hygrostat is set to maintain a minimum relative humidity in the room and as the relative humidity in the room falls to the setting of the hygrostat 71 the rising air pressure in its outlet lines 74 and 82 operates the reverse acting diaphragm valve 51 to admit water from the supply line 50, this water passing through the heater 52 and being discharged from the nozzle 54 into the air stream.

It will be noted that each of the tubes of the fresh air coil 10 is five runs or passes 63 deep and the recirculation air coil 7 is but three horizontal runs or passes 61 deep. Thus, there is a ratio of five to three in the amount of cooling or heating surface in the fresh air coils as compared with the recirculation air coils. This ratio is in approximately correct proportion to the relative amounts of heating or cooling surface required to properly heat or cool the air. The fresh air requires more heating and cooling than the recirculated air, in both winter and summer respectively, because the recirculated air is always at substantially the correct temperature and relative humidity desired in the room.

Since there are five rows of tubes, in the direction of the air flow, for the fresh air coil and only three for the recirculated air coil, and since the same velocity for flow of air obtains in both cases, the resistance to the air flow through the two coils 10 and 7 is in the same ratio, that is, as five is to three. For use in residences and small stores the amount of fresh air should be enough to equal from one to one and one-half air changes per hour. In other words, the amount of fresh air furnished per hour should be between one and one-half times the cubical content of the space to be heated or cooled. This also furnishes the amount of fresh air required for proper ventilation. This fresh air amounts to approximately one-quarter of the total volume of air required to heat or cool the space to be conditioned when the air is furnished at the number of degrees above or below the room temperature required to maintain correct inside temperature when heat-

ing or cooling is required. It is to be understood that the apparatus is not necessarily designed to handle 25% fresh air and that the invention is equally applicable for conditions where more or less than 25% of the total air handled is fresh air. The restriction to the flow of air through either coil, as shown, is approximately in direct proportion to the number of passes or runs in each of the serpentine tubes through which the air passes to be heated or cooled, and in proportion as the square of the air velocity through the same.

When hot water rather than steam is used for heating, the size and number in depth or number of passes in each serpentine tube will probably be 4 to 3, that is, four passes for the fresh air coil and three passes for the recirculated air coil, but the four passes for the fresh air coil will have the same relative heating or cooling effect as with steam, that is, a 5 to 3 ratio. In other words, with steam, the four passes of the fresh air coil will have the same amount of surface as five passes where steam is used, as described. This is to give equal or less friction to the flow of water through the fresh air coils.

Ratios other than 1 to 3 may obtain with relation to the fresh and recirculated air with, of course, corresponding change in the relative number of coils, although the formulæ will remain the same.

The separate functioning of the fresh air coils and recirculated air coils of this unit assembly is therefore very advantageous in that it permits a lesser number of rows of tubes and consequently a less amount of cooling or heating surface to meet the small requirements as to heat transfer for the recirculation air coil while at the same time the parallel resistance of the recirculation air coil and the fresh air coil are equal, thus assuring at all times the proper proportions of fresh and recirculated air.

When cooling and dehumidifying in the summertime, since the fresh and recirculated air coils are proportioned so that each of the serpentine tubes of the fresh air coil 10 has five passes or runs as against three passes or runs in the serpentine tubes of the recirculated air coil 7, the fresh air coils will cool and dehumidify the fresh air entering at approximately 95° dry bulb and 75° wet bulb to about 65° dry bulb and 51° wet bulb, thus removing approximately 11 B. t. u. per pound from the fresh air. Under the same outside air conditions, when the system is working under full load and the cooling water is therefore also flowing freely through the recirculated air coil 7, the inside temperature will be about 80° dry bulb and 67° wet bulb and the recirculated air will be cooled to approximately the same dry and wet bulb temperatures as given for the fresh air, thus removing approximately 4 B. t. u. per pound from the recirculated air. Thus, the fresh air coil 10, under the full load conditions given, will remove approximately two and three-quarter times as much heat per pound from the fresh air as is removed from the recirculated air by the recirculated air coils 7 and this is done with only one and two-thirds times as much cooling surface. This is due to the fact that the rate of transfer (K value) for the condensation of moisture from the air is 10 to 12 times as great as for the removal of sensible heat. Furthermore, since the water goes through the fresh air coil 10 in five passes and countercurrent to the air flow, this continues to be true even when the flow of cooled water is decreased through the fresh air coil. The amount of this heat (K value) of condensation

absorbed per unit of cooling surface per degree of temperature difference between that of the coil and temperature of condensation (dewpoint of the air) is approximately fourteen times (140 to 10) as great as that for the absorption of the sensible heat (cooling) of the air. Since in the present system the cooling coils are arranged in multiple passes (three being shown for the recirculated air coil and five for the fresh air coil) and with the cooling medium flowing counter current to that of the air, it is evident that with a constant entering temperature of the cooling medium well below the desired dewpoint of the air leaving the coil, if a large part of the heat absorbed is that of condensation, the cooling water with reduced flow will warm up relatively quick, say, by the time it has completed going through the first or entering cooling water pass of the coil, which latter is contacted by the coolest air. Thus, a relatively large portion of the coil is rendered much less effective for cooling the air during the initial stages. On account of the relatively high K value of this small portion of the coil containing the initial low temperature refrigerant, this small portion of the coil will be very effective in condensing moisture out of the air but will do relatively little cooling on account of the inadequate amount of surface at this low temperature. Also the K value decreases with reduced flow of refrigerant through the pipes of the coil and this tends to render the balance of the coil inefficient for cooling the air. This K value also reduces with regard to effective condensation of moisture out of the air, but when account is taken of the fact that the transfer rate or K value is about 14 times as great for absorbing the heat of condensation compared to that of cooling the air, it is evident that only a relatively small portion of the coil is required to do the necessary condensing and that this small amount of surface is inadequate due to the rapid warming up of the reduced flow of refrigerant to accomplish much cooling of the air. Thus, the type of coil shown automatically does a relatively greater amount of dehumidifying with relation to cooling of the air, under reduced flow of refrigerant through the coil. When it is taken into account that the maximum temperature difference between air delivered to the room and that of the room is never in excess of 15° it is evident that if the air leaves the coils at say 5° below room temperature or 70° with room at 75° and the relative humidity on leaving the coil is 60%, its dew point will be approximately 55.7°, and when this air enters the room and assumes room temperature its relative humidity will be approximately 50% or well within the comfort zone.

On the other hand, if the air leaves the coil at 60° and 80% relative humidity, it will have a dewpoint of 53.6° and assuming room temperature of 75°, will have a relative humidity of 47%.

When full flow of water obtains through both the fresh air and recirculated air coils the air preferably leaves the coils at approximately 15° below room temperature from both the fresh air coil 10 and the recirculated air coil 7 and since 75% of the air handled is recirculated air, cutting off the flow of water through the recirculated air coil, as previously described, effects 75% of the full cooling capacity, while still fully cooling and dehumidifying all the fresh air and therefore maintaining correct room temperature and the relative humidity at not over 50%.

It is also apparent that since so large a percentage (in the condition cited 75%) of the maintenance of proper room temperature is controlled by the diaphragm valve 32 on the recirculated air coil 7, the diaphragm valve 36 controlling the flow of water through the fresh air coil 10, can be dispensed with relying on the circulating pump controller 78 to control the flow of cold water through the fresh air coil 10. Thus, when the room temperature drops to the setting of the thermostat the controller 78 shuts the circulating pump down. In most cases this latter method would be used and only when the percentage of fresh air is relatively high would the diaphragm valve 36 be required.

In Fig. 2 is shown a modified form of cooler which is suitable for use in connection with the present system. In this cooler melting blocks 85 of ice are employed as the refrigerating medium. These blocks of ice 85 are arranged within a suitably insulated casing 86 upon a perforated shelf 87. The return line 88 (which corresponds to the line 40 in the preferred construction) is provided with a branch 89 passing into the housing 86 and this branch line 89 is provided with shower heads 90 which distribute water over the tops of the blocks of ice 85. The cold water collects in the bottom of the body 86 and the level is preferably controlled by a float valve 91 which discharges the excess water. This float valve does not discharge the cold water from the bottom of the casing 86 but is connected with the return line 88 so as to discharge the excess water from this line. By this means a saving in refrigeration results since the discharge of excess water is the relatively warm return water rather than refrigerated ice water. The ice water from the bottom of the casing 86 is withdrawn through an outlet line 92 which connects with the inlet of a pump 41a, this pump delivering the cold water to a pipe 93 which corresponds to the pipe 21 in the preferred construction. The circulating pump 41a is provided with a controller 78a which corresponds to the controller 78 in the preferred construction and functions in identically the same manner.

While I have shown and described one form of my invention it will be understood that the system is capable of wide variation without departing from the spirit of my invention and the invention is therefore not to be construed as being limited to the particular system shown or to the particular temperatures and amounts used by way of example, but is to be accorded the full range of equivalents comprehended by the following claims. It will also be understood that while I have shown a pneumatic control system, an electrical control system is equally or more adaptable, this being especially true in domestic use where a source of electricity is more convenient than a source of compressed air.

I claim as my invention:

1. In an apparatus for ventilating and conditioning the air in a room or the like, means for continuously withdrawing air from the room to be conditioned for recirculation to said room means for continuously withdrawing outside air, two separate cooling coils one of said coils being deeper in the direction of air flow than the other, and providing a greater resistance to the air flow, the deeper of said coils being arranged in the path of said outside air and the shallower of said coils being arranged in the path of said recirculated air, means for passing a refrigerating medium through both of said coils at an entering temperature below the dewpoint of both of said

bodies of air and countercurrent to the air flow therethrough, means responsive to the dry bulb temperature in the room for controlling the velocity of said refrigerating medium in passing through both of said coils to adjust both the cooling and dehumidifying effect thereof and means for mixing the air after passing said coils.

2. In an apparatus for ventilating and conditioning the air in a room or the like, means for continuously withdrawing air from the room to be conditioned for recirculation to said room, means for continuously withdrawing outside air, two separate cooling coils, one of said coils being deeper in the direction of air flow than the other and having a smaller face area transverse of the air flow, and providing a greater resistance to the air flow, the deeper of said coils being arranged in the path of said outside air and the shallower of said coils being arranged in the path of said recirculated air, the relative resistances of said coils to their respective air flows being proportioned to provide the desired proportions of outside and recirculated air returned to said room, means for passing a refrigerating medium through said coils at an entering temperature below the dewpoint of both of said bodies of air and counter-current to the air flow therethrough, means responsive to the dry bulb temperature in the room for controlling the velocity of said refrigerating medium in passing through both of said coils to adjust both the cooling and dehumidifying effect thereof and means for mixing the air after passing said coil.

3. In an apparatus for ventilating and conditioning the air in a room or the like, means for continuously withdrawing air from the room to be conditioned for recirculation to said room, means for continuously withdrawing outside air, two separate cooling coils each of said cooling coils consisting of a plurality of tubes having serpentine passes, said tubes, being arranged so that the passing air progressively encounters the successive passes of each tube, the tubes of one of said coils having a greater effective cooling surface than the tubes of the other coil in approximate proportion as five is to three, and providing a greater resistance to the air flow, the deeper of said coils being arranged in the path of said outside air and the shallower of said coils being arranged in the path of said recirculated air, means for passing a refrigerating medium through said coils at an entering temperature below the dewpoint of both of said bodies of air and countercurrent to the air flow, means responsive to the dry bulb temperature in the room for regulating the velocity of said refrigerating medium in passing through said tubes to adjust both the cooling and dehumidifying effect thereof and means for mixing the air after passing said coils.

4. In an apparatus for ventilating and conditioning the air in a room or the like, means for continuously withdrawing air from the room to be conditioned for recirculation to said room, means for continuously withdrawing outside air, two separate coils one being arranged in the path of the outside air the other being arranged in the path of the recirculated air and each having a number of passes in the direction of the air flow, means for passing a refrigerating medium through said coils at an entering temperature below the dewpoint of both of said bodies of air and countercurrent to the air flow therethrough, and means responsive to the room air conditions for admitting said cooling medium to said fresh air coil on rising room temperature

and gradually increasing the velocity of the cooling medium passing through said fresh air coil on a further rise in room temperature, thereafter admitting said cooling medium to said recirculated air coil on a further rise in room temperature and thereafter increasing the velocity of said cooling medium through said recirculated air coil on a still further rise in room temperature, said fresh air coil having a greater effective surface in the direction of the air flow than said recirculated air coil and said recirculated air coil having a greater effective face area than said fresh air coil.

5. In an apparatus for ventilating and conditioning the air in a room or the like, means for withdrawing air, a coil in the path of said air and having inlet and outlet pipes, means for conducting the air from said coil to said room, a heater, a heat controller for said heater, a cooler, a circulating pump in circuit with said cooler, valve means for selectively connecting said heater and cooler to deliver heating and cooling media, respectively, through said pipes to said coils, a thermostat responsive to room temperatures, a diaphragm valve in one of said pipes and reverse acting with respect to said thermostat and switch means adapted in one position to connect said thermostat outlet line with said heat controller and in another position to connect said thermostat outlet line with said diaphragm valve.

6. In an apparatus for ventilating and conditioning the air in a room or the like, means for withdrawing air, a coil in the path of said air and having inlet and outlet pipes, means for conducting the air from said coil to said room, a heater, a heat controller for said heater, a cooler, a circulating pump in circuit with said cooler, a controller for said pump, valve means for selectively connecting said heater and cooler to deliver heating and cooling media, respectively, through said pipes to said coils, a thermostat responsive to room temperatures, a diaphragm valve in one of said pipes and reverse acting with respect to said thermostat and switch means adapted in one position to connect said thermostat outlet line with said heat controller and in another position to connect said thermostat outlet line with said diaphragm valve and also with the controller for said pump whereby when cooling is not required said pump is shut down.

7. In an apparatus for ventilating and conditioning the air in a room or the like, means for withdrawing air, a coil in the path of said air and having inlet and outlet pipes, means for conducting the air from said coil to said room, a heater, a heat controller for said heater, a cooler, a circulating pump in circuit with said cooler, valve means for selectively connecting said heater and cooler to deliver heating and cooling media, respectively, through said pipes to said coils, a thermostat responsive to room temperatures, a hygrometer responsive to the relative humidity of said room, a humidifying spray adapted to deliver a spray of water to the air leaving said coil, a diaphragm valve in the water supply line to said humidifying spray and direct acting with respect to said hygrometer, another diaphragm valve in one of said pipes and reverse acting with respect to said thermostat and switch means adapted in one position to connect the thermostat outlet line with said heat controller and the hygrometer outlet line with said direct acting diaphragm valve and in another position to connect said thermostat outlet line with said reverse acting diaphragm valve and to disconnect

said hygrostat outlet line from said direct acting diaphragm valve.

8. In an apparatus for ventilating and conditioning the air in a room or the like, means for withdrawing air, a coil in the path of said air and having inlet and outlet pipes, means for conducting the air from said coil to said room, a heater, a heat controller for said heater, a cooler, a circulating pump in circuit with said cooler, a controller for said pump, valve means for selectively connecting said heater and cooler to deliver heating and cooling media, respectively, through said pipes to said coils, a thermostat responsive to room temperatures, a humidifying spray adapted to deliver a spray of water to the air leaving said coil, means for heating the water to said spray through heat derived

from said heater, a diaphragm valve in the water supply line to said humidifying spray and direct acting with respect to said hygrostat, another diaphragm valve in one of said pipes and reverse acting with respect to said thermostat and switch means adapted in one position to connect the thermostat outlet line with said heat controller and the hygrostat outlet line with said direct acting diaphragm valve and in another position to connect said thermostat outlet line with said reverse acting diaphragm valve and pump controller and to disconnect said hygrostat outlet line from said direct acting diaphragm valve, the connection between said thermostat outlet line and said pump controller shutting down the pump when cooling is not required.

CLAUDE A. BULKELEY.