United States Patent

McGrath

[15] **3,653,589**

[45] **Apr. 4, 1972**

[54] AIR CONDITIONING SYSTEM

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

[73] Assignee: **Carrier Corporation**, Syracuse, N.Y.

[22] Filed: **July 27, 1970**

[21] Appl. No.: **58,312**

[52] **U.S. Cl.** **236/49**, 236/78

[51] **Int. Cl.** **F24f 7/06**

[58] **Field of Search** 236/38, 11; 165/55, 57, 121–123

[56] **References Cited**

UNITED STATES PATENTS

2,855,185	10/1958	Runte	165/57 X
3,343,473	9/1967	Gillick	165/123 X
3,486,693	12/1969	Stang	236/11 X
3,489,345	1/1970	Moreland	236/11 X

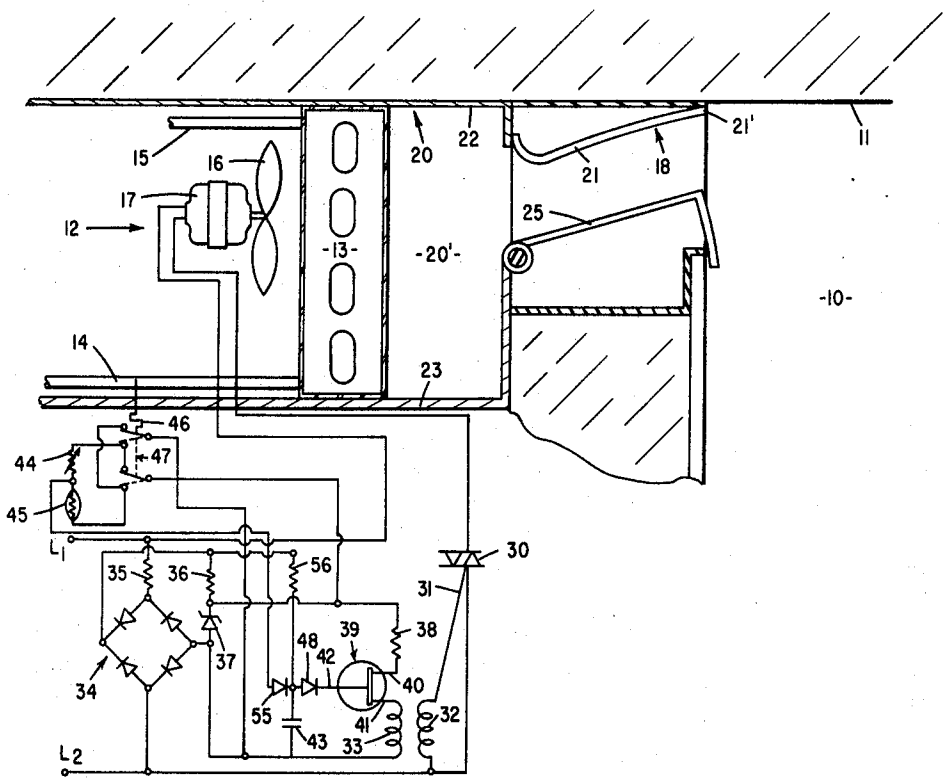
Primary Examiner—Edward J. Michael

Attorney—Harry G. Martin, Jr. and J. Raymond Curtin

[57] **ABSTRACT**

A system for supplying treated air to an enclosure including a heat exchanger through which a heat exchange medium flows and a fan arranged to route air to be treated over the heat exchanger in heat transfer relation with the medium. A control operates to vary the speed of the fan in response to changes in room temperature. At least one outlet is provided for discharging the treated air from the system, the outlet being positioned so that the treated air is discharged with minimal turbulence substantially adjacent and parallel to the ceiling of the enclosure.

2 Claims, 2 Drawing Figures



Patented April 4, 1972 3,653,589

2 Sheets-Sheet 1

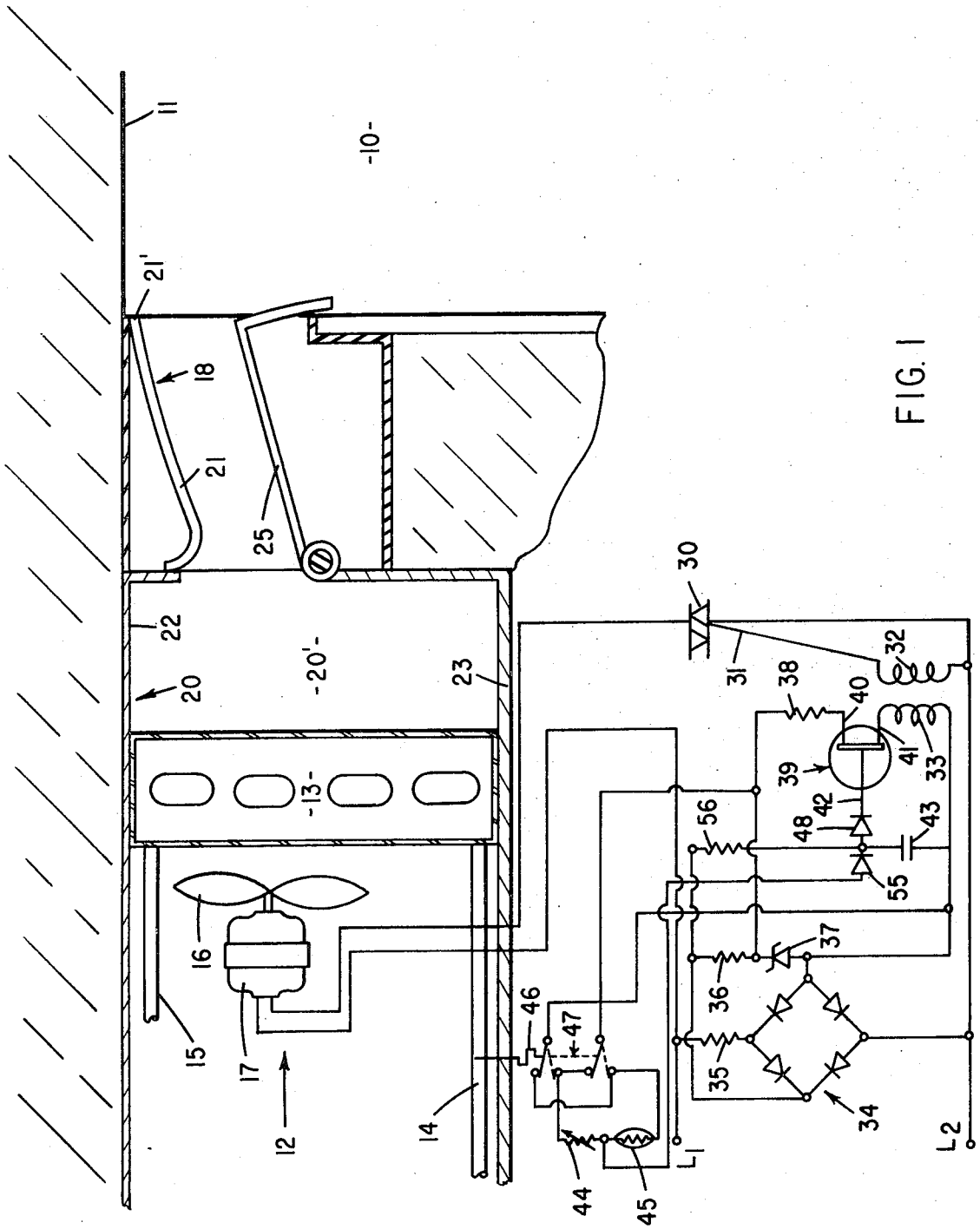


FIG. 1

INVENTOR.
WILLIAM L. McGRATH
BY Barry & Deutsch
ATTORNEY

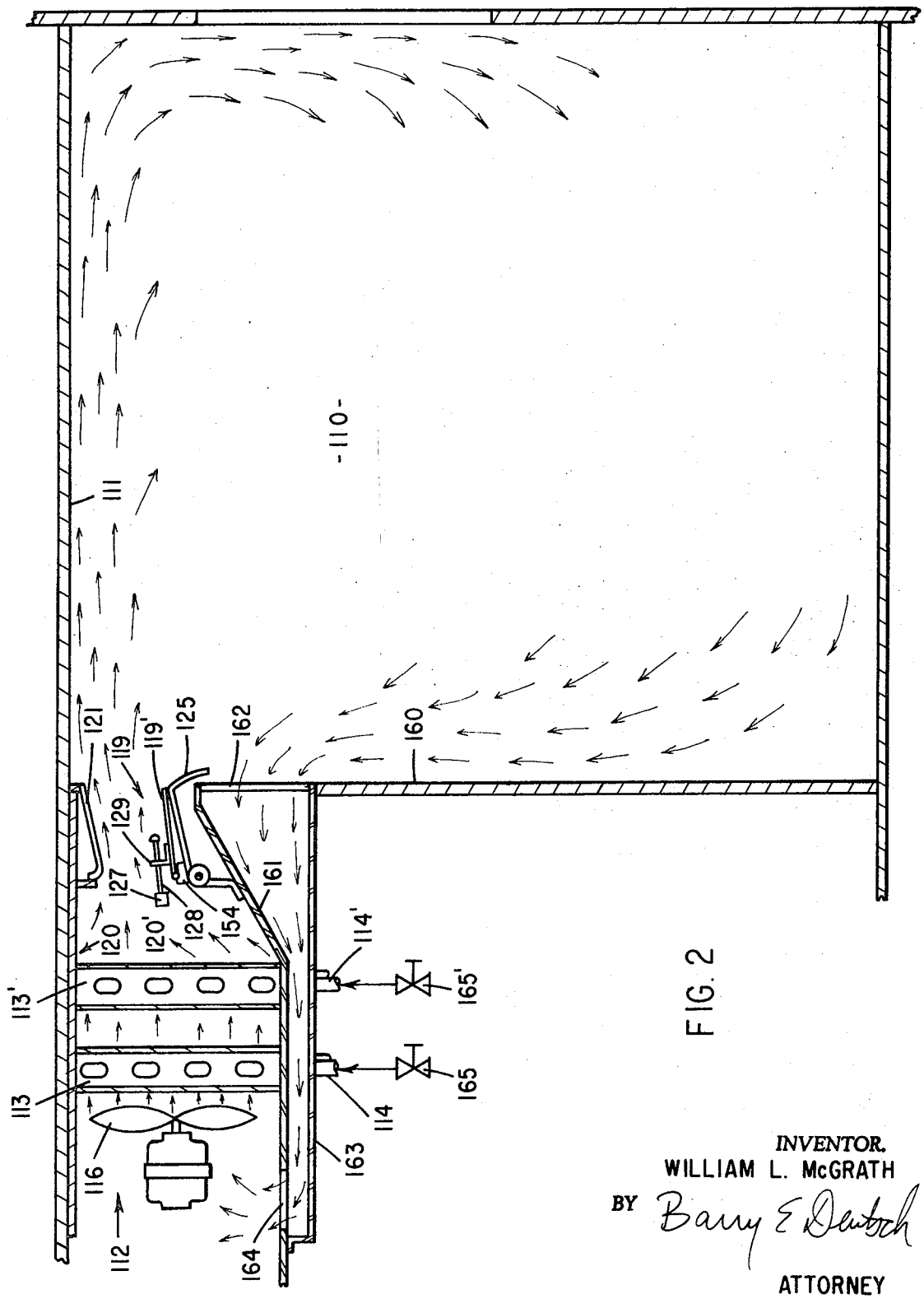


FIG. 2

INVENTOR.
WILLIAM L. McGRATH
BY Barry E Deutsch
ATTORNEY

AIR CONDITIONING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to an air conditioning system and more particularly to an arrangement for directing the discharge of treated air from said system in a predetermined path.

Air conditioning apparatus of the type employing a heat exchange coil to circulate a heat exchange medium therethrough, for example chilled or warm water, and having a fan for bringing air to be conditioned into heat exchange relation with the medium flowing through the coil are well known and widely employed by those skilled in the air conditioning art. Such apparatus are generally referred to as fan coil units.

Fan coil units are employed with central station apparatus for cooling and heating circulating water for conditioning multi-room buildings, such as motels, hotels, and apartments. Such apparatus afford a relatively effective means for simultaneously conditioning a plurality of areas in a common enclosure, while providing individual control by the occupants of each area. In addition, fan coil units are relatively simple to install and to maintain in operating condition and are relatively inexpensive, making such units particularly suitable for low-cost multiple dwelling housing. However, certain problems have been encountered which reduce the overall efficiency and effectiveness of their operation.

For example, the on-off cycling of the fan in a typical fan coil unit creates annoying sound variances. In addition, an on-off type of control does not provide uniform air distribution, and can be annoying from the standpoint of noise. Particularly, temperature variations of a considerable magnitude above and below the room setpoint may be produced in portions of the room, the variations being caused by stratification of the air during the off cycle.

To overcome these problems, a variable speed control for the fan motor, to modulate the discharge of conditioned air from the apparatus, has been considered. A typical fan motor control is the subject of co-pending application, Ser. No. 58,315, filed July 27, 1970, Ronald L. Roof, inventor. The variable fan speed control obviates the noise problem by continuously operating the fan at the lowest speed consistent with the cooling or heating load thereon. However, at low fan speeds, problems have resulted due to the low velocity of the conditioned air being discharged into the conditioned space, particularly when the air is at a relatively cold temperature.

Such low velocity causes the air stream to lose momentum, resulting in the relatively cold air spilling into the room, rather than following a trajectory above the occupied space until mixing is complete, thus causing discomfort to the occupants by producing wide variations in temperature across the room and from floor to head level.

In addition, with a typical discharge outlet employed with fan coil units, considerable discoloring of the ceiling of the enclosure being served by the apparatus will normally occur, particularly when warm air is being supplied. The discoloring occurs due to turbulence created between the top of the discharged treated air stream and the lower surface of the ceiling.

The object of this invention is an improved air conditioning system employing a novel conditioned air discharge outlet, operable to obviate the problems hereinabove described.

SUMMARY OF THE INVENTION

This invention relates to an air conditioning system and more particularly to an improved outlet for directing the flow of treated air from such system in a predetermined path.

The system includes an air conditioning apparatus employing a heat exchanger adapted to receive a heat exchange medium such as chilled or warmed water which may be treated in a central station or other remote location. A fan is operable to route air to be treated over said heat exchange coil in heat exchange relationship with the medium flowing therethrough. A temperature sensing element is installed in the area being

conditioned, and is operable to generate a signal, the magnitude thereof being related to the sensed temperature in the conditioned area. The signal is supplied to the fan motor and is operable to vary the speed thereof in proportion to the temperature of the room to vary the static pressure produced by the treated air.

The treated air from the heat exchange medium is passed to one or more outlets of the system. The outlets are positioned so that the point of egress therefrom is substantially adjacent the ceiling of the enclosure. The treated air will therefore be discharged from the outlet substantially parallel to and adjacent the ceiling.

The air being discharged from the outlets will adhere to the surface of the ceiling due to the natural phenomenon known as the "Coanda effect." The treated air will flow along substantially the entire length of the ceiling even when the volume is substantially reduced, thus avoiding the prior art defects.

In a second embodiment, means are included in the outlet to vary the area of the discharge opening in response to changes of static pressure of the treated air supplied thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic and cross-sectional view of an air conditioning system and apparatus embodying invention, and includes a schematic wiring diagram of the control employed in the apparatus; and

FIG. 2 is a cross-sectional view of a second embodiment of my invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, there is shown a preferred embodiment of an air conditioning system including the invention disclosed herein.

Referring in particular to FIG. 1, reference numeral **10** indicates an area in an enclosure which is to be treated by having air at a predetermined temperature discharged therein. Although it is within the scope of the invention to have only one such area or room being served, it should be understood that several rooms, each employing at least one outlet in accordance with this invention, may be conditioned simultaneously. Area **10** includes ceiling **11**.

The embodiment illustrated by FIG. **1** includes an air conditioning apparatus **12**. Apparatus **12** includes a heat exchange coil **13** to which a heat exchange medium such as cold or warm water is supplied via conduit **14**. The heat exchange medium is supplied at a predetermined temperature which is regulated by central station refrigeration machinery (not shown). The heat exchange medium is returned to the central station machinery via conduit **15**. Fan **16**, operatively connected to motor **17**, routes ambient air over the heat exchange coil in heat transfer relation therewith. The ambient air is treated by passing in heat transfer relation with the heat exchange medium flowing through the coil. The air conditioning apparatus is disposed in housing **20**, which includes upper wall **22** and lower wall **23**, said walls defining a plenum **20'**. The upper wall **22** is connected to the lower surface of the ceiling by suitable means (not shown).

Communicating with plenum **20'** is outlet **18**. The opening defined by the outlet may include a protective screening which would discourage access to the interior of the unit, without disturbing the air flow pattern. Outlet **18** includes a first member **21** having an end **21'** disposed substantially planar with the surface of the ceiling. Spaced below member **21** is a second member **25**. Members **21** and **25** define therebetween the exit passage for the treated air being discharged from the apparatus.

In accordance with this invention, it is desirable to operate fan motor **17** at a variable speed. Preferably, fan motor **17** is an alternating current motor which is connected to a source of alternating current, such as power line terminals L_1 and L_2. Switch **30** operates to connect the motor **17** to the source of electrical current. Switch **30** is preferably a bi-directional

gated solid state switch of a type sold under the trademark "-Triac." Switch **30** is provided with a gate **31** in series with a secondary winding **32** of a pulse transformer by which the switch is triggered to a conducting state by either a positive or negative pulse being applied to gate **31**. Switch **30** should be sufficiently fast in operating so that it may be switched on during any desired portion of each half cycle of alternating current supplied to motor **17** to arrive at a desired average power, so that the motor speed and consequent fan speed is varied in accordance with the capacity demand of the room served by the system.

A control circuit is provided to control the operation of switch **30** in accordance with the desired speed of the motor **17**. As shown in the drawing, a full wave diode rectifier circuit **34** is connected in series with a dropping resistor **35** to provide a source of .C. voltage across a series connected resistor **36** and Zener diode **37**. It will be appreciated t hat Zener diode **37** has a very low resistance characteristic such that it provides a constant voltage drop across its terminals. A series circuit comprising unijunction transistor **39** having one base **40** connected in series with resistor **38** and another base **41** connected in series with the primary winding **33** of the pulse transformer is connected across Zener diode **37** to provide a constant voltage to the series circuit.

Thermostat elements **44** and **45** are connected in series with the constant voltage provided by Zener diode **37**. Element **44** is preferably a variable resistance element, such as a potentiometer, that may be selectively regulated by the occupant to obtain a desired temperature in the enclosure. Element **45** D.C. preferably a NTC thermistor, positioned to sense the temperature of the air in the enclosure that be explained hereinafter. Elements **44** and **45** operate in combination to provide a voltage signal, the magnitude thereof being related to the temperature of the air sensed and to the mode of operation of the apparatus. Switch **47** is of the type known as a double-pole, double throw switch. Switch **47** selectively connects the terminals of elements **44** and **45** in the circuit depending upon whether heating or cooling is desired. The operation of switch **47** may be controlled by bimetal **46** which is mounted about conduit **14**, in heat transfer relation therewith, to sense the temperature of the medium flowing therethrough. When switch **47** is in the position shown by the solid lines, the control is set for heating mode operation. If bimetal **46** senses that a cold medium is being supplied to coil **13**, it operates to position switch **47** in the dotted line position of FIG. **1**.

Emitter **42** of unijunction transistor **39** is connected through a diode **48**, which prevents leakage current from charging capacitor **43**. Additionally, the circuit includes diode **55** which prevents current flow in an undesirable direction. Connected in series with capacitor **43** is resistor **56**. Capacitor **43** and resistor **56** combine to provide a "fixed ramp" voltage signal to transistor **39** as is obvious to those skilled in the art. It may be desirable in practice to add various additional circuits to prevent spurious gating of switch **30**.

It will be appreciated that the circuit shown is illustrative generally of a phase control type of motor speed control. The circuit shown is merely illustrative of one type of motor speed control system, and other types of motor speed control can be adapted to this invention.

In operation, switch **30** is in a nonconducting state, and motor **17** is deenergized until a pulse is applied to gate **31**. A charge builds up on charging capacitor **43** at a rate which is determined by the resistance of resistor **56**. Since resistor **56** is fixed, the charging rate of capacitor **43** is fixed. When the charge on capacitor **43** reaches a predetermined value, a predetermined voltage signal is supplied to transistor **39**. This signal is referred to as the "ramp" voltage. The magnitude thereof is insufficient to place transistor **39** in its conductive state. To the ramp is added a second voltage signal, which is known as the "pedestal." The magnitude of the "pedestal" voltage is variable and is dependent upon the temperature of the air in the enclosure and upon the mode of operation. When the combined ramp and pedestal signal reaches a predetermined value, transistor **39** becomes conductive, discharging a pulse through primary winding **33** of the pulse transformer. A pulse is thereby induced in secondary winding **32** of the pulse transformer which is applied to gate **31** of switch **30**, causing the switch to conduct.

Switch **30** is preferably a solid state device having the characteristic that once it is turned on by a pulse being applied to gate **31**, it remains in the conducting state until the current through the device becomes zero. Consequently, switch **30** remains conducting after a pulse is applied to gate **31** until the end of the half cycle of the alternating current during which it begins conducting. The value of the electrical components are chosen so that switch **30** is turned on for a time during each half cycle by the control circuit such that the power supplied to motor **17** is just sufficient to rotate fan **16** at a speed which provides the desired air flow over heat exchange coil **13**.

As noted hereinbefore, it is desirable to operate the fan motor and thus the fan at the lowest speed consistent with the cooling or heating load on the air conditioning apparatus, to obviate the difficulties presented by the on-off cycling of a typical fan coil unit. However, as also noted hereinbefore, by producing a concurrent decrease in the velocity of the air being discharged when the fan speed is decreased, poor air distribution has resulted due to air spilling into the room, particularly when the air is at a relatively cold temperature.

If on cooling mode operation, and the temperature of the enclosure increases above the setpoint of thermostat element **44**, thermistor **45** will sense the increase and will generate a control signal so that the speed of fan motor **17** increases. As the temperature of the enclosure approaches the setpoint, the signal generated by thermistor **45** will operate to reduce the speed of the motor.

Similarly, if on heating mode operation, the temperature of the enclosure decreases below the setpoint, thermistor **45** will generate a control signal to increase the speed of motor **17**. As the temperature of the enclosure increases, the signal generated by thermistor **45** will operate to decrease the speed of the fan to the desired speed to maintain the desired temperature.

The present invention relates to an air discharge outlet which directs the air being discharged from the apparatus in a path which will prevent the problems hereinbefore discussed. In addition, improved heating performance will be obtained by utilization of the novel outlet disclosed herein as shall be more fully explained hereinafter.

In particular, by positioning the outlet to discharge the treated air so that the air stream is directed substantially adjacent to the surface of the ceiling, the air stream will adhere to the ceiling and flow therealong. Thus, air circulation will be maintained in the area being treated, irrespective of the static pressure in plenum **20'** and thus irrespective of the discharge velocity.

The reason that the air stream will adhere to the surface of the ceiling when discharged adjacent thereto is based upon the natural phenomenon known as the "Coanda effect." By providing an outlet that directs the air stream in a manner so that the advantages produced by the Coanda effect are obtained, the prior art defects are obviated.

In addition, when the apparatus is providing warmed air to the enclosure, improved heating will be obtained by the employment of the novel outlet of this invention. Heating of the room air is obtained in two ways. The discharged treated air will induce the room air to flow in a stream parallel thereto and to mix therewith. By maintaining the flow of the treated air for substantially the entire length of the enclosure, more uniform mixing with the room air will be obtained, thus reducing stratification problems.

In addition thereto, the discharged treated air will warm the surface of the ceiling for the entire length thereof. The surface of the ceiling will then radiate its heat toward the floor of the enclosure causing it to warm up, thus providing the upper and lower surfaces of the enclosure at an elevated temperature, thus increasing the mean radiant temperature within the enclosure, thereby providing improved comfort.

Referring now to FIG. 2 of the drawing, there is shown a modified outlet in accordance with this invention. In referring to the drawings, like numerals shall refer to like parts, except for the addition of the numeral 1 in front of all numerals employed in discussing the components of FIG. 2. To increase the desirability of the air conditioning system, apparatus 112 includes two heat exchange coils 113 and 113'. A relatively cold heat exchange medium is available at all times to coil 113 via conduit 114, the flow thereof being controlled by valve 165. A relatively warm heat exchange medium is available at all times to coil 113' via conduit 114', the flow thereof being controlled by valve 165'. By including two heat exchange coils in apparatus 112, the occupant of the enclosure may obtain heating while the occupant of a second enclosure may obtain cooling. Preferably, valves 165 and 165' are electrically operated.

The outlet shown in FIG. 2 includes a movable damper blade assembly 119 positioned to regulate the area of the outlet from the apparatus as defined by members 121 and 125, in response to changes of the static pressure in plenum 120'. It should be specifically noted that damper blade assembly 119 operates so that all throttling of the discharge area is done at the lower portion thereof to maintain the flow of treated air discharged from the apparatus substantially adjacent to the surface of ceiling 111.

It has been found that by varying the area of the discharge opening in response to changes of the static pressure in plenum 120' in accordance with variations of fan speed 116, a substantially constant discharge velocity will be obtained. Damper blade assembly 119 includes a counterweight 127 attached to a rod 128. Rod 128 is connected to a member 129 which is connected to blade 119' to move therewith. The blade is pivotally mounted to rotate about bearing 154.

The control circuit for varying the speed of the fan motor is the same as heretofore described and is not shown. However, the terminals of the thermal elements will be properly positioned for the desired mode of operation by the occupant of the enclosure, manually moving the double-pole, double throw switch, in lieu of the bimetal switch shown in FIG. 1. The handle for the double-pole switch will also be connected to means for selectively energizing either valve 165 or valve 165' to obtain the proper heat exchange medium for the mode of operation desired.

In operation, as the speed of the fan increases in response to the signal provided to the control circuit, the quantity of air supplied to plenum 120' increases, thus increasing the static pressure operating on the surface of the blade to rotate the blade in a clockwise direction, to increase the area of the discharge opening from the apparatus.

If the control signal to the fan motor indicates that a slower speed is required to meet a decreased demand for treated air, a reduced flow of air will be routed over the heat exchange coils. The reduction in air flow produces a reduction in pressure in plenum 120' of housing 120. Counterweight 127, due to the reduction in force acting on blade 119', moves in a counterclockwise direction, pivoting the blade upwardly to partially close the discharge opening. The reduction in the discharge opening caused by the rotation of blade 119' compensates for the reduction in static pressure to thus maintain the velocity of the air discharged from the apparatus substantially constant.

Irrespective of the speed of the fan, the air being discharged from the apparatus will flow along the surface of ceiling 111 as indicated by the arrows of FIG. 2 for substantially the entire length of area 110. Return air to be treated by apparatus 112 passes through opening 162 in wall 160 and is directed through a passage defined by walls 161 and 163 through a filter 164 into housing 120. The air is then passed in heat transfer relation with the heat exchange medium supplied to either coil 113 or coil 113'. The air being supplied to the enclosure will follow the path as indicated by the arrows, regardless of the mode of operation of the system. By employment of the novel control device, improved circulation and performance will be obtained.

In addition to the advantages previously discussed which are obtained by operating the fan continuously, it has been determined that a more efficient control of the humidity level, when the apparatus is operating on cooling mode, may be obtained by continuously operating the fan, rather than employing an on-off cycle, or modulating the cold water flow to the heat exchange coil.

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

I claim

1. A method of regulating the temperature of air circulating within an enclosure having communication with a structure serving as an air passage and provided with at least one outlet through which treated air is delivered, comprising the steps of:

A. passing air to be treated through a heat exchanger in heat transfer relation with either a relatively warm heat exchange medium or a relatively cold heat exchange medium;

B. sensing the temperature of the air in the enclosure;

C. creating a control signal which is a function of the sensed temperature;

D. varying the quantity rate of air passing through said heat exchanger, the magnitude thereof being a function of the control signal; and

E. discharging the treated air from the air passage substantially adjacent to the ceiling of the enclosure to cause the treated air stream to adhere to the ceiling and flow therealong to substantially uniformly mix with the treated air in the enclosure irrespective of the quantity of treated air delivered to the air passage and irrespective of the temperature thereof.

2. An air conditioning system for supplying treated air to a conditioned space, comprising:

A. means for sensing the temperature of the air in the conditioned space;

B. means for supplying a control signal which is a function of the sensed temperature;

C. means for receiving the control signal;

D. means operable to produce treated air, the quantity of treated air being a function of the control signal, said means being selectively operable to provide either relatively warm air for heating the conditioned space or relatively cool air for cooling same;

E. supply means for delivering the treated air to the conditioned space, said supply means including a pressurized chamber; and

F. discharge means communicating the conditioned space with said pressurized chamber, said discharge means having a first member spaced from the ceiling of the conditioned space so as to define an air passage between said member and said ceiling so that the treated air is discharged parallel to and substantially adjacent to the ceiling, means operable to vary the area of said discharge means, said last mentioned means being responsive to the pressure of the treated air in the pressurized chamber, said discharge means causing treated air passing therethrough to adhere to the ceiling and flow therealong to substantially uniformly mix with air in the conditioned space irrespective of the quantity of air delivered to the pressurized chamber and irrespective of the temperature thereof.

* * * * *