

[54] **AIR CONDITIONING SYSTEM**
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[52] U.S. Cl. **236/38, 236/78 R**
[51] Int. Cl. **F24f 11/04**
[58] Field of Search **236/38, 49; 98/40**

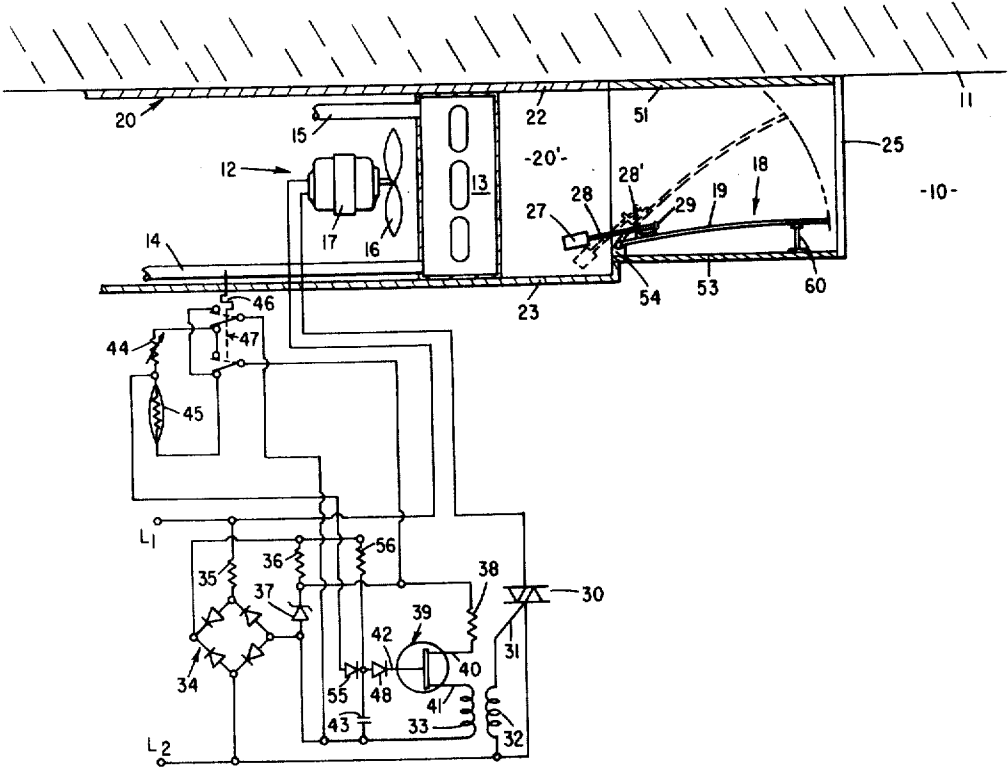
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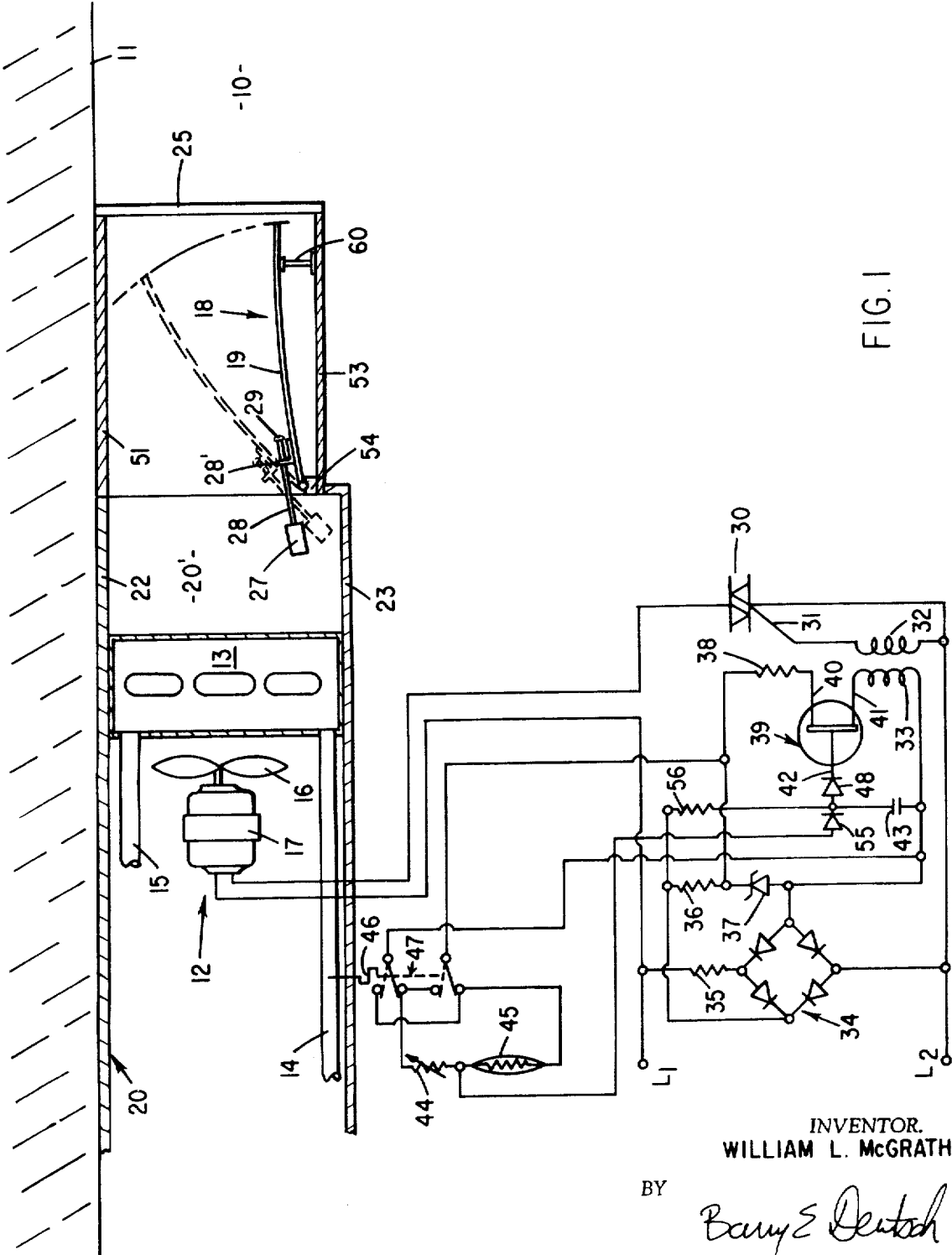
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[57] **ABSTRACT**
A system for supplying treated air to an enclosure, including a heat exchanger through which a heat exchange medium flows and a fan arranged to route air to be treated over the heat exchanger in heat transfer relation with the medium. A control operates to vary the speed of the fan in response to changes in room temperature. One or more damper assemblies operate to maintain the discharge of treated air from the system at a substantially constant velocity, irrespective of the speed of the fan.

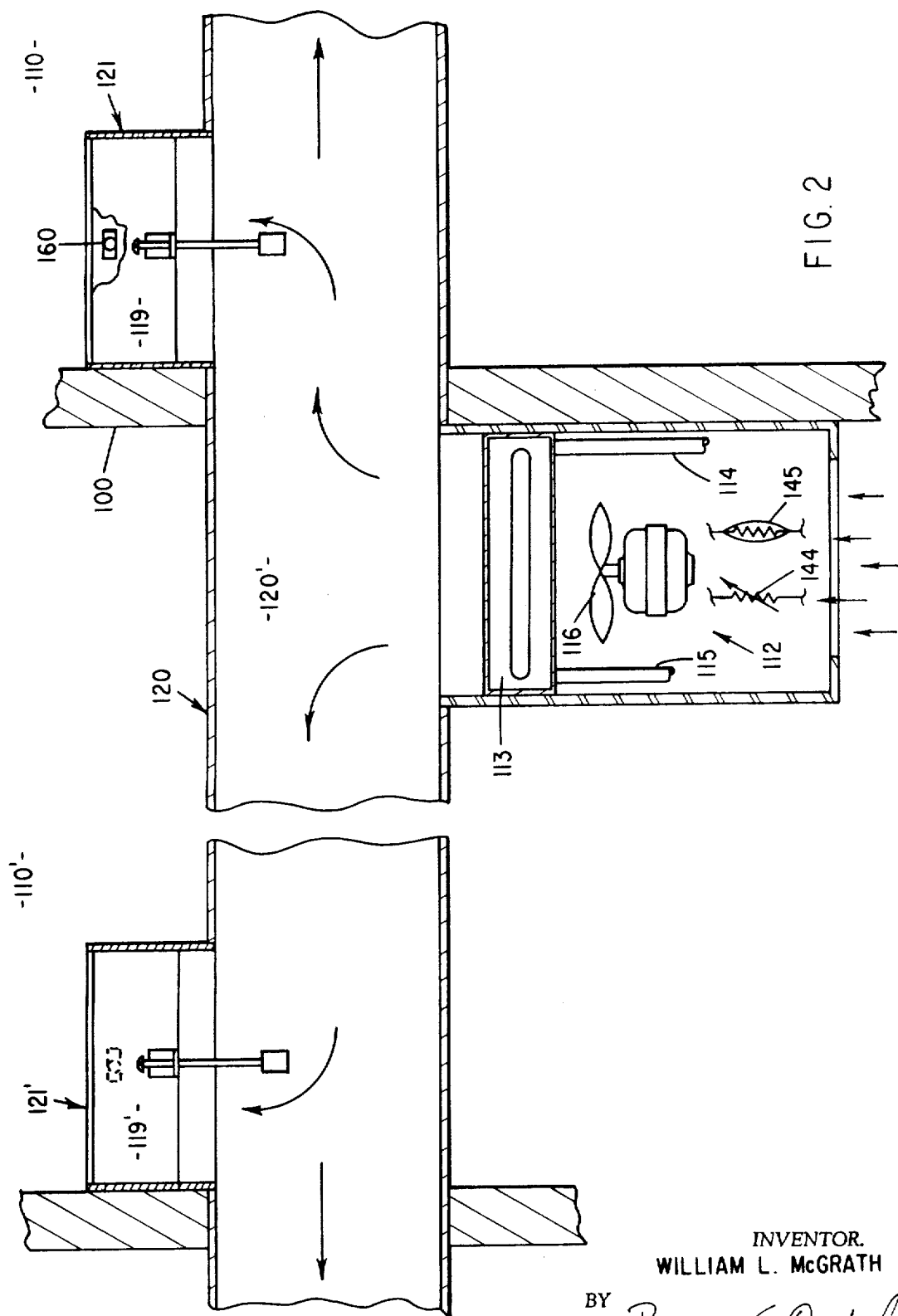
1 Claim, 3 Drawing Figures



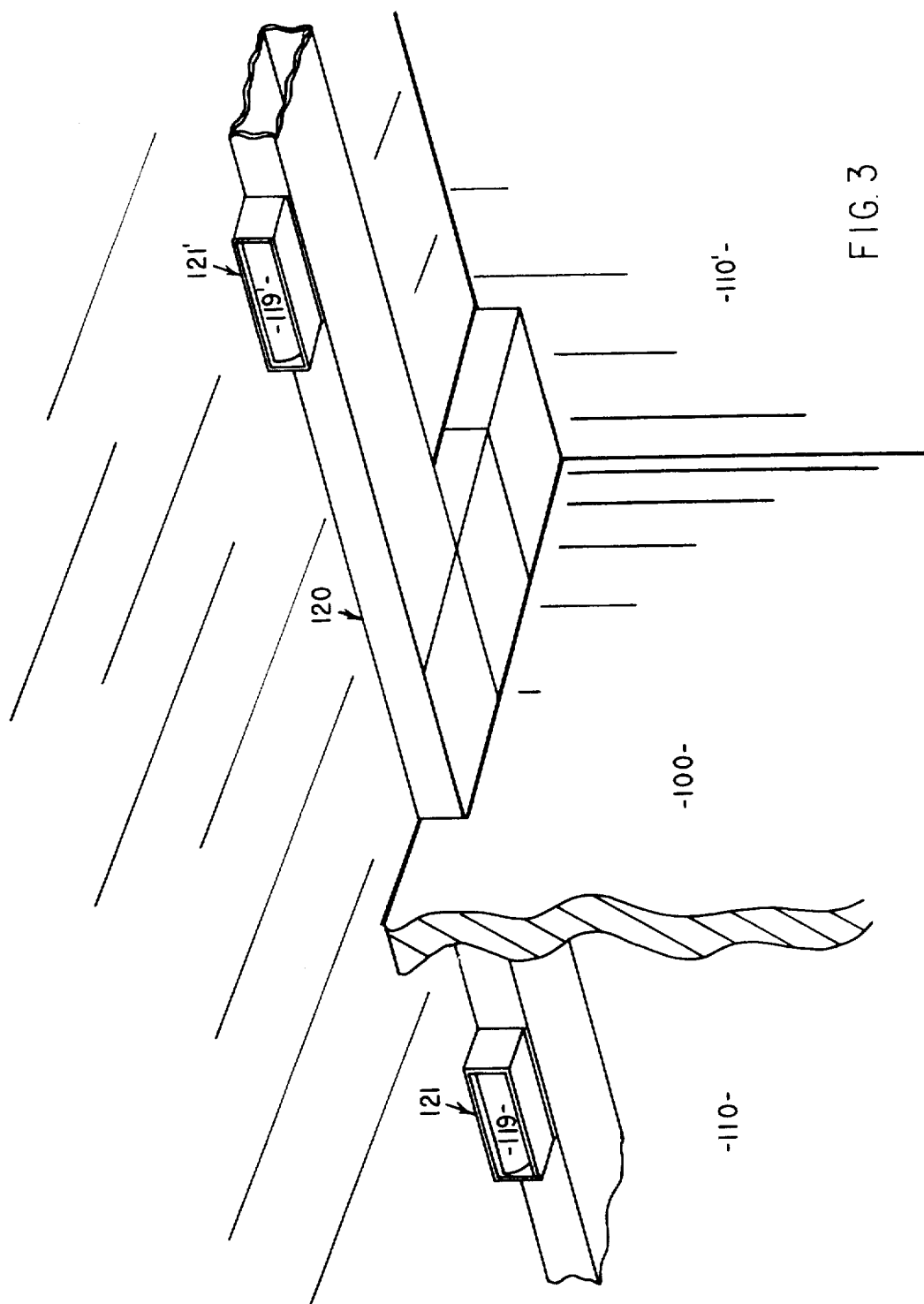


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AIR CONDITIONING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to an air conditioning system and, more particularly, to an arrangement for controlling the discharge of treated air from said system.

Air conditioning apparatus of the type employing a heat exchange coil to circulate a heat exchange medium therethrough, for example, chilled or warmed 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 cooling and heating machinery 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, some problems have been encountered which reduce the overall efficiency and effectiveness of their operation.

For example, the on-off cycling of the typical fan coil unit creates annoying sound variances. In addition, an on-off type of control does not provide uniform air distribution. 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.

It has been proposed prior to this invention, for example see U.S. Pat. No. 2,112,955, to employ a plurality of counter-weighted blades in the discharge outlet to regulate the flow of treated air. The movement of the blades varied in response to changes of static pressure in the supply duct in communication therewith. The object of the prior art was to maintain the velocity of the discharged air substantially constant, irrespective of the magnitude of static pressure. However, such multi-bladed outlets did not function as desired, particularly at low static pressure. At such low pressures, the discharged air streams would be relatively small in height due to the movement of the blades, acting to reduce the area of the discharge outlet. The thin air streams presented an increased surface area for the induced room air to be mixed therewith. By thus increasing the rate at which the treated air and room air mixed, the dissipation of the energy of the discharged treated air also increased, resulting in a loss of velocity. Thus, the prior art discharge outlets did not prove satisfactory.

The object of this invention is an improved air conditioning system employing novel conditioned air discharge devices operable to maintain the velocity of the air discharged into the conditioned space at a substantially constant magnitude, irrespective of variations in the static pressure resulting from changing the speed of the fan employed in such system.

SUMMARY OF THE INVENTION

This invention relates to an air conditioning system and, more particularly, to an improved air discharge device for regulating the flow of treated air from such system.

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. At each outlet, a damper assembly operates in response to the static pressure of the treated air supplied thereto, to vary the discharge area of the outlet, to maintain the discharge of air at substantially constant velocity, irrespective of the static pressure of the treated air. It should be understood that although the term "substantially constant velocity" is employed hereinafter, the term as used includes maintaining the discharge velocity at a predetermined minimum at minimum load, and increasing the velocity as the load increases.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 2 is a somewhat schematic cross-sectional plan view, illustrating the invention being employed to simultaneously discharge treated air into a plurality of areas; and

FIG. 3 is a perspective view of the embodiment of the invention shown in FIG. 2.

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 conditioned, it should be understood that several rooms, each employing a separate discharge air control device, may be conditioned simultaneously, as is illustrated by FIGS. 2 and 3. Area 10 includes ceiling 11.

The embodiment illustrated by FIG. 1 includes an air conditioning system employing 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.

A discharge air control device 18, to be more fully explained hereinafter, is operable to regulate the discharge of treated air from apparatus 12 into area 10. The air conditioning apparatus 12 is disposed in housing 20 which includes upper wall 22 and lower wall 23, said walls defining a plenum 20'. Upper wall 22 is connected to the lower surface of the ceiling 11 by suitable means (not shown).

Communicating with plenum 20' is discharge air control device 18. The opening may include a discharge grille 25, attached to walls 51 and 53, to define the exit from the apparatus.

Control device 18 disposed in housing 20 includes blade 19 connected to bottom wall 53 by means such as bearing member 54, which functions as a pivot or fulcrum. Frame member 28', connected to blade 19 to pivot therewith, has rod 28 extending therethrough. Counterweight 27 is suitably connected to one end of rod 28, and the opposed end has a portion 29 for receiving a tool such as a screwdriver which may be employed to vary the distance between counterweight 27 and pivot 54. Stop member 60 limits the movement of device 18 to provide a maximum discharge opening which may be varied by repositioning the member. As shall become more apparent hereinafter, control device 18 operates to regulate the discharge of treated air from apparatus 12 to the area being treated 10.

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 L₁ and L₂. 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 D.C. voltage across a series connected resistor 36 and Zener diode 37. It will be appreciated that 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 is preferably a NTC thermistor, positioned to sense the temperature of the air in the enclosure as shall 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 is controlled by bimetal 46 which is mounted about conduit 14, in heat transfer relation therewith, to sense the temperature of the medium flowing therethrough.

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. The manner in which elements 44 and 45 operate to regulate the speed of motor 17 shall be explained more fully hereinafter.

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.

The present invention relates to an air discharge control which tends to maintain the velocity of the air being discharged from the apparatus at a constant magnitude, irrespective of the speed of the fan.

In particular, as the speed of the fan 16 decreases, the quantity of air being routed over heat exchange coil 13 is reduced. The reduction in air flow produces a reduction in pressure in plenum 20' of housing 20. Counterweight 27, due to the reduction in force acting on blade 19, moves in a counter-clockwise direction, pivoting control device 18 upwardly to partially close the discharge opening, for example to the dotted line position shown in FIG. 1. The reduction in the discharge opening, caused by the rotation of blade 19 to the dotted line position, compensates for the reduction in static pressure to thus maintain the velocity of the air discharged from the apparatus substantially constant.

Counterweight 27 functions to rotate the blade to a position related to the speed of fan 16. Thus, as the fan speed increases, the force acting on blade 19 is increased, thereby causing the blade to move in a clockwise direction to thereby increase the discharge opening from the apparatus. The increased size of the discharge opening compensates for the increase of static pressure. It is thus readily observable that the size of the opening is a function of the static pressure produced by the air routed over heat exchange coil 13. Since the static pressure is a function of fan speed, the position of the blade is modulated in response to the speed of the fan to

maintain the desired substantially constant velocity of the air being discharged.

Element 45 is positioned to sense the temperature of the air in the enclosure. Preferably, the thermistor will sense the temperature of the air being returned to the apparatus prior to its being treated, particularly when the apparatus is being employed to simultaneously treat the air in a plurality of areas, as shown in FIGS. 2 and 3. When a relatively cold heat exchange medium is flowing in conduit 14, bimetal 46 positions switch 47 to connect thermistor 45 and variable resistor 44 in the control circuit as shown in the solid line position of FIG. 1. Conversely, when a relatively warm heat exchange medium is flowing through conduit 14, the bimetal positions switch 47 so variable resistor 44 and thermistor 45 are connected in the circuit as shown in the dotted line position.

Assume a relatively cold medium is flowing through the conduit and thus elements 44 and 45 are connected in their solid line position. Since thermistor 45 is of the NTC type, its resistance goes down as room temperature increases. Thus, when the room temperature is above a preselected point, as determined by the setting of element 44, the resistance of thermistor 45 is of a relatively small magnitude. The pedestal voltage is therefore relatively large in magnitude, and transistor 39 is placed in its conducting state at a relatively rapid pace, thereby increasing the current flow through fan motor 17 to increase the speed thereof.

As the speed of fan 16 increases, the air flow is concurrently increased, thus increasing the static pressure in plenum 20'. The increased force acting on blade 19 pivots the blade about bearing 54 in a clockwise direction, thus increasing the discharge opening. As noted before, the increased discharge opening offsets the increase of static pressure in the plenum which would otherwise increase the velocity of the air being discharged. The proportional increase in the size of the opening maintains the velocity of the air being discharged at a substantially constant magnitude. If the velocity were to increase beyond a predesigned point, annoying and undesirable drafts of relatively cold air would be present in the room being treated. Conversely, if the velocity were to be reduced below the predetermined point, the air would spill into the room; and portions of the room remote from the discharge opening would not receive any treated air.

As the temperature of the air in the room decreases, the resistance of the NTC thermistor 44 increases, thereby reducing the rate at which transistor 39 is placed in its conducting state. This decrease delays the triggering of switch 30, thereby decreasing the current flow to fan motor 17 to thereby decrease the speed thereof.

The reduced static pressure in plenum 20', caused by the reduction in the speed of fan 16, causes the blade to be positioned to decrease the size of the discharge opening from apparatus 12 as hereinbefore described.

Assume now that a relatively warm heat exchange medium is flowing through conduit 14. Bimetal 46 positions switch 47 to connect elements 44 and 45 in the circuit as shown in the dotted line position of FIG. 1. As the temperature of the room is below the selected point, the resistance of the NTC thermistor is of a relatively large magnitude. Thus, the pedestal voltage supplied to transistor 39 is of a relatively large magnitude and the transistor is placed in its conducting state at a relatively rapid pace. Switch 30 is thence triggered relatively early in the alternating current cycle to increase the current flow to fan motor 17 to increase the speed of fan 16. Concurrently, the pressure in plenum 20' is increased, and control device 18 is positioned to increase the size of the discharge opening as heretofore explained.

As the temperature in the room increases, the resistance of thermistor 45 concurrently decreases, thereby decreasing the current flow to the fan motor to decrease the speed thereof.

The reduction in speed of fan 16 operatively connected to fan motor 17 decreases the pressure in plenum 20', thereby decreasing the size of the discharge opening from apparatus 12 as heretofore explained. Thus, the size of the discharge

opening is modulated in response to the speed of the fan to maintain the velocity of the air being discharged at a substantially constant value.

Referring now to FIGS. 2 and 3, there is illustrated an embodiment indicating the manner in which the invention may be employed to simultaneously treat the air in a plurality of areas or rooms in a common enclosure, such as the several rooms in a house or an apartment in an apartment building.

Thermal elements 144 and 145 are similar to elements 44 and 45 of FIG. 1. Element 145 is positioned to sense the temperature of the air returning to apparatus 112, prior to its being routed over heat exchange coil 113 by fan 116.

The treated air having passed in heat transfer relation with the heat exchange medium flowing in coil 113 and supplied thereto via conduit 114 passes through duct 120. Duct 120 has a plurality of outlets therefrom, as defined by discharge housings 121 and 121', the housings delivering treated air into rooms 110 and 110' respectively. The rooms are separated by common wall 100 through which duct 120 passes. Damper blades 119 and 119', regulated in the same manner as blade 19 previously described, control the discharge of treated air from the respective openings to maintain the velocity thereof substantially constant.

If the occupant of room 110 desired a different air temperature in his room than that called for by the thermostat setting, the occupant may vary the outlet opening from housing 121 by varying the position of the maximum opening stop 160. Thus, for a given flow of air as provided by fan 116, a different discharge velocity may be obtained by each of the occupants of a plurality of rooms served by the common apparatus 112.

The present invention produces a relatively constant velocity air stream irrespective of changes in the speed of a fan employed in the air conditioning system. The system is relatively inexpensive and easy to regulate and is thus particularly adaptable for treating air in multi-room housing projects.

Additionally, it should be understood that although the system is shown installed so that the treated air discharged therefrom is substantially adjacent the ceiling of the room being treated, it is within the scope of this invention for the discharge therefrom to be positioned in any other convenient manner. For example, the unit may be installed substantially adjacent to the floor, with the discharge therefrom being located so the treated air is discharged in a vertical direction. Furthermore, although the invention has been embodied in a system including a fan coil unit, it should be understood that the invention may be employed in a similar manner with other types of air conditioning equipment employing a fan.

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 should be understood that my invention is not limited thereto, since it may be otherwise embodied within the scope of the following claims.

I claim:

1. An air conditioning system for supplying treated air to an enclosure, comprising:
 - A. a heat exchanger;
 - B. means to supply heat exchange medium to said exchanger;
 - C. a fan arranged to pass air to be treated over said heat exchanger in heat transfer relation with said heat exchange medium;
 - D. a motor arranged to drive said fan, said motor being adapted to be connected to a source of energy;
 - E. means responsive to temperature in the treated enclosure to vary the speed of said fan motor to regulate the quantity of air being delivered by said fan;

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F. means to supply the treated air in a single stream from the heat exchanger through an outlet to the enclosure, the pressure in said air supply means being a function of the quantity of the air supplied thereto;

G. means operable to regulate the supply of treated air discharged in a single stream through the outlet into the enclosure from said supply means, said heat exchanger being disposed in said air supply means between said fan and said regulating means, said regulating means being responsive to the pressure in said supply means, said regulating means being operable to maintain the discharge of the single stream of treated air at a pre-determined

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velocity irrespective of variations of pressure in said supply means, said regulating means comprising a single damper blade mounted adjacent the outlet responsive to the pressure of the treated air in said air supply means to discharge the single stream of treated air into the treated enclosure; and

H. biasing means connected to said damper blade to move said damper blade in a direction opposite to the direction said damper blade is moved by the force created by said pressure in said supply means.

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