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AIR CONDITIONING APPARATUS

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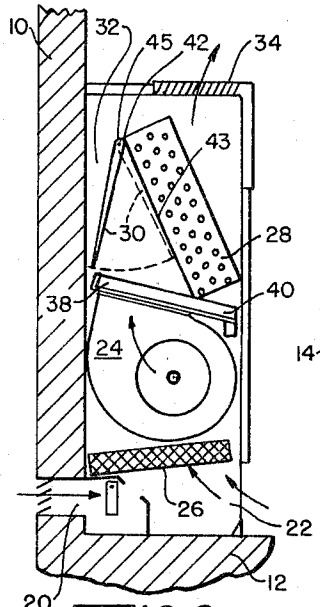


FIG. 2

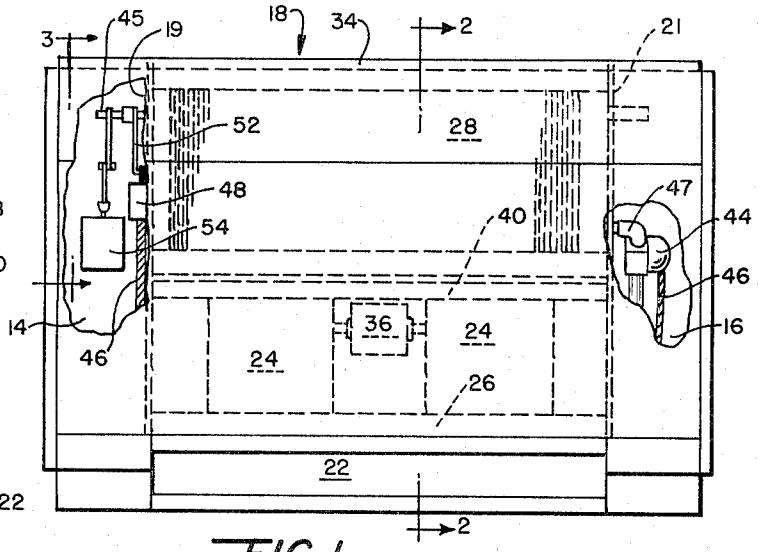


FIG. 1

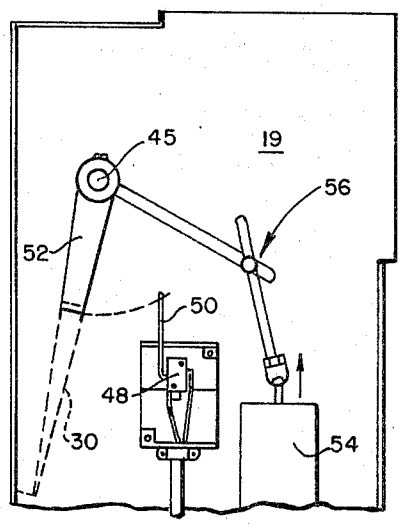


FIG. 3

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AIR CONDITIONING APPARATUS

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This invention relates to air-conditioning apparatus of the fan-coil type, and more particularly to a control arrangement therefor.

Fan-coil units are typically used to heat or cool a conditioned space by passing air through a heat exchange coil which usually receives hot or chilled water generated at a remote location and piped to the fan-coil unit. One commonly used means for controlling the discharge air temperature of the fan-coil unit to meet the temperature demands of the conditioned space has involved the use of a valve controlling the flow of water to the coil in accordance with variations in temperature of the conditioned space. This so-called valve control has for the most part been favored over an alternate type of control termed face and bypass damper control because it permits a more compact fan-coil unit than a damper control arrangement since no space for a bypass passage and a damper therein is required.

However, if valve control is compared with damper control from a strictly technical standpoint with respect to temperature and humidity control of the air, many believe that a damper control arrangement provides superior results. This is particularly true with respect to the problem of providing continued moisture removal from the air passing through the unit at times when there is no corresponding requirement for the unit to exert its full cooling capacity. For example, with one type of valve control using a single valve which modulates in accordance with room temperature variations, the typical flow characteristics of the valve results in an early reduction in quantity of chilled water admitted to the coil with slight reduction in cooling demand of the room. The resulting higher surface temperature of the coil results in a sharply reduced moisture removal capacity and the ultimate evaporation of condensate from the coil surface with a concomitant release of concentrated odors.

An alternate type of valve control is the so-called multi-port valve control. Here the coil is divided into separate circuits with each circuit being fed through a separate port of the valve. Thus successive portions of the coil are deprived of the chilled water as the cooling demand in the room is reduced. The theory is that the circuits receiving chilled water will continue to remove adequate moisture for dehumidifying purposes. In addition to the fact that separate circuit coils and multi-port valves are both relatively expensive, a further disadvantage of such an arrangement is that those parts of the coil which are deprived of chilled water as the successive circuits of the coil are cut off will warm up and release concentrations of odors. Further, even though the multi-port valve is of the character that each section is of the modulating type, unless the sections of the coil itself are physically isolated and separated from each other, the influence of one extends to the other sections. As a result even the part of the coil which continues to receive chilled water has a higher surface temperature than it would have if unconnected physically to the other parts of the coil.

In summary then, the disadvantage with respect to humidity control stemming from valve control, as contrasted to damper control, is that as cooling requirements are reduced in the room there is a reduction of

temperature differential between the coil and the air going through the coil. This increases the likelihood that the surface of the coil will become warmer than the dew point of the air so that the coil then not only does not remove moisture from the air passing through it but in fact may release moisture to the air.

In contast with a valve control arrangement, a damper control arrangement results in a coil surface temperature which actually decreases as the temperature demands of the room for cooling decrease. This results from a continued full flow of chilled water with a reduced air flow through the coil. Consequently, that part of the air which is directed through the chilled coil is subject to greater dehumidification than if the demand of the room for cooling were greater. While this advantage of damper control over valve control for purposes of dehumidification is generally accepted in the art, it is substantially nullified when the bypass damper reaches a closed position so that no air passes through the coil. In other words, when there is very little demand for cooling, the closed damper prevents the air from contacting the coil and therefore from being dehumidified.

The present invention provides an arrangement in which the advantages of damper control are not lost when the damper approaches its extreme closed position. Further, the arrangement according to the invention facilitates a compact arrangement of parts in a fan-coil type of unit as required by the market for such units. In accordance with the arrangement of the invention, the face and bypass damper provided is dimensioned so that in its fully-closed position it extends over and covers a major portion of, but substantially less than, the entire face area of the coil. Accordingly, even while the damper is in a range approaching a fully-closed position against the face of the coil, air flow through the coil, and accordingly dehumidification, continues. When under these conditions the cooling requirements of the conditioned space are fully met, a simple on-off valve controlling the flow of tempering medium to the coil is actuated to a closed position to prevent cooling beyond the desired point.

The arrangement not only provides substantial advantages in a cooling cycle operation (chilled water), but also operates quite satisfactorily during the heating cycle when the unit receives hot water. Obviously, dehumidification is not a problem during the heating season, and consequently the continued flow of air through the coil when the damper is fully closed does not have the significance in the winter heating season that it does in the summer cooling season. In the case of the coil receiving hot water, after the damper has removed to a fully-closed position indicating the temperature demands of the room are met, the same on-off valve is actuated to a closed position. Thus, any further temperature pick-up is avoided, providing in a sense an advantage over the conventional damper control arrangements which have no valve.

The invention will be explained in some detail in connection with the accompanying drawing wherein:

FIGURE 1 is a partly broken front elevational view of a floor model fan-coil unit with certain principal interior parts being shown in broken-line outline form;

FIGURE 2 is a somewhat diagrammatic view in the nature of a vertical section corresponding to one taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a fragmentary elevational view inside an end compartment showing one example of an arrangement for a damper motor and other control elements.

The floor model unit illustrated in FIGURES 1 and 2 is disposed with its back side against room wall 10 and

its bottom resting upon floor 12. The interior of the unit is divided generally into left-hand and right-hand end compartments 14 and 16, respectively, on opposite sides of the center compartment 18 defined between opposite end vertical partitions 19 and 21. Piping, electrical and control components are accommodated within the end compartments, while the center compartment generally defines the path for the flow of air to be treated and contains the principal elements for so treating the air.

Air to be conditioned is drawn into the lower part of the center compartment 18 through an outdoor air inlet 20 and a room air inlet 22 by fans 24. After passing through a filter 26, the air is discharged upwardly by the fans toward the extended surface heat exchange coil 28. Depending upon the position of the face and bypass damper 30, the air will pass through the coil, or through the adjacent bypass passage 32, or as a third alternative, partly through the coil and partly through the bypass passage if the damper is in intermediate position. The conditioned air is then discharged from the center compartment into the conditioned space through the outlet grille area 34. Of course the air passing through the coil is tempered in accordance with the character of the tempering medium in the coil, and in this sense the passage defined by the coil perimeter may be said to be an air tempering passage.

The fans 24 and drive motor 36 therefor are mounted on an inclined motor board 38 having openings therein in the rear part to accommodate the discharge of the fans. The forward part 40 of the board which underlies the bottom edge of the coil 28 serves as a drip pan for moisture condensed from the air and which drips from the coil onto the pan. The inclined disposition of the motor board and the generally illustrated disposition of the fan housings as best shown in FIGURE 2 save substantial space with respect to both height and depth of the unit and also automatically result in the desirable corresponding inclination of the drip pan 40 portion of the motor board.

As best illustrated in FIGURE 2, the coil 28 is inclined generally as shown with its lower edge adjacent the front of the fan-coil unit, and its upper edge closer to the rear of the unit, and with the upper rear corner 42 of the coil frame defining the forward boundary of the bypass passageway 32. Thus, the air entering face 43 of the coil is in a plane lying at an acute angle with respect to the usually vertical front and rear walls of the unit. The bypass damper 30 is pivotally mounted on a shaft 45 which extends between the opposite end compartments along a line parallel to and closely adjacent this forward boundary of the bypass passageway 32.

The bypass damper 30 is as wide as the coil 28, but has a height dimension which is only about three-fourths of the height dimension of the air entering face 43 of the coil 28. Thus, as best shown by the broken-line outline in FIGURE 2, when the damper 30 is in its extreme position against the air entering face of the coil, the damper covers only about three-fourths of this face area of the coil with about the lower one-fourth of the face area being open to receive air flow through the coil. The arrangement in which the lower portion of the coil face is left open is preferred since the supply of water is first supplied to the lower part of the coil. It will be also noted that the exposed lower part of the coil is closer to the cutoff part of the centrifugal fan 24 than the part of the fan outlet adjacent the rear side of the unit.

To connect the unit for service, piping connections are made in one end compartment with the electrical connections and damper motor in the opposite end compartment. As illustrated in FIGURE 1, the right end compartment 16 contains a solenoid valve 44 in the water supply line 47 to the coil 28. An electrical line 46 extends from the solenoid valve to a switch 48 in the left end compartment 14 for controlling the actuation of the valve 44.

As seen in FIGURE 3, the electrical switch 48 includes an operator arm 50 disposed in the path of movement of the end of an actuating lever 52 secured to the damper shaft 45 so as to turn therewith. The lever 52 extends from the shaft in substantial alignment with the damper 30 shown in broken-line outline in FIGURE 3. The position shown corresponds to one in which all of the air is directed through the coil as if the room being served were demanding the full capacity of the unit. To effect movement of the damper shaft 45, a damper operator 54 is provided with its linkage arrangement 56 connected to the shaft 45. The operator may be of any of the well-known types.

Positioning of the bypass damper 30 is controlled in accordance with room temperature variations. Specifically, assuming the unit is operating in a cooling cycle, the system is arranged so that the damper is moved in a direction to block the bypass passage 32 upon a demand for cooling, and in the other direction to block the coil upon a decreased demand for cooling. The preferred arrangement is such that the damper is moved in modulating fashion as distinguished from two-position movement. The arrangement gives, within limits, an increasing proportion of air directed through the coil or tempering passage 28 upon an increase in room temperature above the set point, and an increasing proportion of the air directed through the bypass passage 32 upon a decrease in room temperature below the set point.

While the damper 30 is in its range of modulating movement, solenoid valve 44 remains in its normal open position giving full flow of chilled water through the coil. However, when the demand for cooling in the room is substantially satisfied, the movement of the damper to a corresponding position signals the satisfaction of the demand by reaching a position substantially against the face of the coil. In this position, lever 52 engages the actuating arm 50 of the valve switch 48 so as to cause the solenoid valve to close and cut off chilled water to the coil. If thereafter additional cooling is required for the conditioned space, the movement of the damper back away from the face of the coil will result in the solenoid valve 44 again opening to permit the flow of chilled water to the coil.

The temperature control requirements of a typical installation are usually adequately satisfied by arranging for the switch 48 to be actuated to a valve-closing position during the final increment of travel of the bypass damper against the face of the coil. For example, the parts may be disposed so that when the damper 30 reaches a point about five degrees away from the coil face, the switch will be actuated. However, in some circumstances it may be desirable that the damper 30 be able to move to a final position against the face of the coil without automatically effecting closure of the solenoid valve 44 in that position. In other words, it may be desirable that there be a further increase in room temperature required after the damper 30 is in its final position before the valve 44 is closed. This may be provided, if desired, in any of several different ways, one of which may be the provision of a spring-loaded connection between the lever 52 and the damper shaft to permit the lever to have an increment of over-travel after the damper 30 reaches its extreme position against the face of the coil.

The description of the operation has proceeded with chilled water being the principal tempering medium example. In a heating cycle, hot water is supplied with the operation being much the same except that the movement of the damper 30 is opposite to that described upon room temperature increases and decreases.

As noted before, the provision of the valve 46 to cut off the supply of water in the final position of the damper against the coil face reduced cabinet sweating in the summer, and temperature pick-up in the winter. In that connection, it is noted that a bypass damper control system is ordinarily not completely effective in pre-

venting all heat exchange between the bypass air and the coil. Thus, another advantage of the instant arrangement is that the sealing requirements of the damper are not as stringent since the final valve shutoff obviates the need. However, perhaps the principal advantage of an arrangement according to the invention is experienced in the cooling cycle with the extended dehumidification provided. Thus, as the damper moves toward the coil face, a colder coil face temperature automatically results. Consequently any air which passes through the coil is subjected to greater humidity removal than if the coil were fully open to air flow. Further, with an arrangement in which there is always some air passing through the coil, drying of the coil surface at a time when concentrated odors would present a problem is practically precluded.

I claim:

1. An air-conditioning apparatus comprising:

a casing including means defining a path for the flow of air therethrough, and including a recirculation air inlet and an air outlet in communication with said path;

means for inducing a flow of air through said path;

heat exchanger means extending substantially along the length of said path and across a part of the width of said path;

a bypass passage adjacent a downstream edge of said heat exchanger means for air to pass around said heat exchanger means;

damper means extending along the length of said air flow path and pivoted adjacent said downstream edge of said heat exchanger means to move into a stream of air flowing through said path to one extreme position entirely closing said bypass passage, and to move to an opposite extreme position covering at least a major portion but substantially less than all of the face of said heat exchanger means; and

means for terminating the flow of the tempering medium to said heat exchanger means in response to said damper means moving to said opposite extreme position.

2. Air-conditioning apparatus comprising:

means defining a path for the flow of air to be treated;

a heat exchange coil disposed with its face extending substantially along the length of said path and across

part of the width of said path to divide said path into an air tempering passage for air passing through said coil, and a bypass passage adjacent a downstream edge of said coil;

bypass damper means for controlling the flow of air through said passages, said bypass damper means extending substantially along the length of said air path and pivoted along said downstream edge of said heat exchange coil to move into said stream of air to one extreme position sealing said bypass passage to prevent flow therethrough, and to move to an opposite extreme position in which more than half but substantially less than all of said coil face is blocked; and

means responsive to the position of said damper means in said latter noted position to completely terminate the flow of tempering medium to said coil.

3. Air-conditioning apparatus according to claim 2 in which:

said coil is inclined with its said face extending at an acute angle with respect to the parallel planes coincident with the front and rear walls defining said path; and

said bypass damper means is pivotally mounted along the upper edge of said coil dividing said path into said tempering passage and said bypass passage.

4. Air-conditioning apparatus according to claim 3 in which:

said bypass damper means is of substantially less height than the height of said coil face so that the bottom part of said coil face remains open to air flow in said opposite extreme position.

References Cited by the Examiner

UNITED STATES PATENTS

2,327,663	8/1943	Otis	165—122
2,828,110	3/1958	Baker et al.	165—103
3,129,753	4/1964	Davis et al.	165—36

FOREIGN PATENTS

379,430	9/1952	Great Britain.

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