

SPECIFICATION

Improvements in or relating to control assemblies for conditioned air distribution systems

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This invention relates to control assemblies for conditioned air distribution systems and, more particularly, is concerned with control assemblies for conditioned air distribution systems of the type

10 wherein air, conditioned at a central source, can be distributed to a plurality of different zones, e.g. rooms or area within a room.

Air is used as the medium of thermal transfer in forced air heating and air conditioning systems. In

15 such systems, air is heated and/or cooled at a central source and the conditioned air (which term is used herein to mean heated or cooled air) is distributed to a plurality of zones through a system of ducts and outlets. There are generally two different methods

20 for controlling the flow of conditioned air, the constant volume method and the variable volume method. In the constant volume method, the rate of flow of conditioned air into any zone is substantially constant but the temperature of the conditioned air

25 is varied either by changing the source of air or by mixing hot and cold air. The constant volume system thus requires a constant source of different types of conditioned air. This system generally requires ducting and also requires a means for controlling the

30 mixing of the hot air and cold air. In the variable volume method conditioned air is employed at a substantially constant temperature but the volume of conditioned air delivered to any particular zone is varied in response to the demand of the zone. The

35 variable volume method offers many advantages over the constant volume method. The variable method requires only one source of conditioned air at a substantially constant temperature while the constant volume method requires two sources of thermal energy. The variable volume method requires only a single duct system while the constant volume method requires a dual thermal energy system with means for controlled mixing of the different thermal levels of conditioned air. The

45 variable volume method is advantageous for heating or cooling the interior of standard office buildings, particularly perimeter or exterior facing rooms. Larger energy savings are possible with variable volume methods than with other methods of controlling the heating and cooling of a building.

50 Even though the variable volume method is generally preferred, it is not without its own drawbacks. Humidity controls of the air is not as good as with other methods. Variable volume methods can be reduced to very low room air changes and, where heavy smoking is present, an insufficient air change can occur. Most control assemblies used in the variable volume method are designed to operate within a certain volume range and operation outside

60 this range causes undesirable levels of noise and, in fact, operation within the range usually causes considerable noise. Known variable volume control assemblies have high pressure loss values and require excessive fan horse-power to deliver the

65 desired volume of air. Additionally, the air flow

pressure sensing means used in existing variable volume control assemblies is not as sensitive as desired and does not offer pressure independent control over a wide range of flow rates.

70 According to the invention there is provided a variable volume control assembly, for controlling the flow of conditioned air into a zone, said assembly comprising a box which has an expansion chamber provided with a plenum inlet for receiving conditioned air from a source of conditioned air and an outlet chamber provided with an outlet for delivering conditioned air to the zone, a throttle device for controlling the flow of air through the box, the throttle device being located between the expansion

75 chamber and the outlet chamber; an air flow measuring assembly for measuring the flow of air through the box; motor means for controlling the opening and closing of the throttle device; and control means responsive to the temperature in the zone and the flow of conditioned air through the box for controlling the operation of the motor means; wherein the air flow measuring assembly comprises an air flow amplifier measurer including a tube having an upstream end and a downstream end

80 connected by an orifice, there being an abrupt expansion of the orifice in the downstream end of the tube to form an expanded orifice section, a total pressure probe having an opening lying in a plane substantially perpendicular to the intended direction of flow of gas through the tube in the expanded orifice section of said tube, and means connecting the total pressure probe and static pressure probe to the control means.

85 Preferably, the variable volume control assembly of the invention further comprises a vortex filter associated with the outlet chamber of the box.

90 Preferably, in the variable volume control assembly of the invention, the ratio of the through flow cross-section area of the plenum inlet to the through flow cross-sectional area of the expansion chamber ranges from about 1:1.25 to about 1:2.

The variable volume control assemblies of the present invention have particular usefulness in air distribution systems where air, conditioned at a central source, is delivered at a substantially constant temperature in varying volumes to a plurality of zones, for example rooms. The desired temperature in any one zone can be adjusted by varying the volume of conditioned air delivered to that zone. In the variable volume control assemblies known heretofore, the volume of air delivered to a zone is usually regulated by a thermostat located within the zone. The volume of conditioned air delivered into the zone is controlled by a throttle device located in a

100 variable volume control box for that zone. When the thermostat calls for additional conditioned air, the throttle device, usually a damper means, is driven to a further-open position thus delivering additional quantities of conditioned air. When the desired temperature is reached, the thermostatic control drives the damper means to a further closed position thus reducing or stopping the flow of conditioned air. Unless a limit means is placed on the opening of the throttle device, the throttle device will continue

105 to open until it is in its maximum open position.

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When the throttle device is open to this extent, the flow of air may exceed the optimum level creating undesirable noise, drafty conditions within the zone, and over-conditioning of the zone with a resultant

5 waste of energy. Accordingly, it is desirable to have a high limit means to control the opening of the throttle device. Similarly, unless a limit means is placed on the closing of the throttle device, the flow of conditioned air may be below the desired mini-
10 mum or even stopped completely. Accordingly, it is desirable to have a low limit means.

In the variable volume control assemblies of the present invention, it is desirable to have a high limit and a low limit, although the low limit is optional.

15 The high limit and low limit means for limiting the opening and closing of the throttle device is controlled by an air flow measuring assembly that acts upon the measured differential between the total pressure and static pressure in the variable volume
20 control assembly. In the desired operation, if the pressure differential caused by the flow of conditioned air through the control assembly exceeds the upper control limit, the thermostatic control is overridden and the throttle device has been closed
25 sufficiently to bring the flow rate (and resulting pressure differential) to acceptable levels, a velocity-pressure sensitive limiting means is taken out of the control circuit and the flow of conditioned air is controlled by a thermostatic control. In a preferred
30 mode of operation, the variable volume control assembly also has a minimum pressure differential to make sure that the volume of air to the zone is not reduced below a certain minimum level thus stopping necessary air circulation.

35 As mentioned above, one of the main drawbacks of the prior art variable volume control assemblies is the air flow measuring assembly, the assemblies not being as sensitive as desired. Accordingly, larger quantities of air than are actually needed are deli-
40 vered to the various zones. When the thermostatic control calls for additional conditioned air, more than the necessary amount will be delivered because of the inability to limit precisely the maximum flow. The result is a zone that is temporarily overheated or
45 overcooled. This over-conditioning is inefficient from an energy stand-point. Moreover, even when the thermostatic control is not demanding additional conditioned air, too much conditioned air be delivered. Because of the inability to control the flow
50 at low rates, more air is really needed to maintain the zone at the desired temperature is constantly being delivered. This is a very inefficient and costly use of conditioned air and energy.

The variable volume control assemblies of the
55 present invention may have an air flow measuring assembly that includes means which amplifies the difference between the total pressure and the static pressure. By amplifying the difference between the static pressure and the total pressure, the improved
60 measuring means gives much better control over the volume of conditioned air delivered to any particular zone along with concomitant energy savings.

The present invention also provides in some
65 embodiments thereof a new way of obtaining con-

ing assembly without the need for two to three
diameters of straight duct ahead of the variable
volume control assembly as is necessary with
existing equipment. A flow collector-straightener, or
70 scrim, is placed in the plenum inlet to reduce turbulent air flow and gather and collect air flow of a rather constant magnitude regardless of inlet duct configuration. This enables the air flow measuring device to measure more accurately the flow condi-
75 tions.

Some embodiments of the variable volume control assemblies of the present invention may also have a lower pressure loss than the prior art assemblies. The lower pressure loss results in a
80 lower pressure differential and is, to a large extent, the result of the ratio of the cross-sectional area of the inlet plenum to the cross-sectional area of the expansion box of the control assembly. By controlling the ratios of these cross-sectional areas, the
85 pressure loss across the assembly can be kept to a minimum thus saving on the amount of energy necessary to deliver any given flow of conditioned air to a zone.

In addition, some embodiments of the variable
90 control assemblies of the present invention generate less noise than the prior art assemblies. These assemblies have a vortex filter that breaks up larger turbulences and increases their frequency. Higher frequencies can be absorbed more easily with
95 simple sound traps and insulation thus causing an improved and lower sound discharge. The vortex filter is strategically located in the outlet chamber of the control assembly to break up the turbulence caused by the conditioned air passing through the
100 assembly in addition to any incoming turbulence that still remains.

For a better understanding of the invention, and to show more clearly how the same may be carried into effect, reference will now be made, by way of
105 example, to the accompanying drawings in which:

Figure 1 is a perspective view of one embodiment of a variable volume control assembly;

Figure 2 is a cross-sectional side view of a variable volume control assembly similar to that shown in
110 *Figure 1* but incorporating a modified damper means.

Figure 3 is an end view into an air flow measuring assembly;

Figure 4 is a schematic side view of part of the air flow measuring assembly of a variable volume
115 control assembly;

Figure 5 is an end view of the part of the air flow measuring assembly shown in *Figure 4*;

Figure 6 is a side view of the part of the air flow measuring assembly shown in *Figure 4*;

Figure 7 is a schematic side view of part of an alternative flow of air measuring assembly; and

Figure 8 is a schematic side view of part of another alternative air flow measuring assembly.

125 With reference to *Figures 1, 2 and 3*, a variable volume control assembly 2 comprises a generally rectangular-shaped box 4 having an inlet 6 at one end, the upstream end, thereof and an outlet 8 at the opposite end, or downstream end, thereof. The box
130 is made of sheet metal, but can be made of any other

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suitable material, and is lined with insulation material 10. The inlet 6 comprises a circular plenum collar 18 that is attached, by suitable fastening means 12 including gaskets 14, to the box. Located centrally within and affixed to the plenum inlet is an air flow measuring assembly 16. Located near the centre of the box is a throttle device 20 for controlling the flow of air through the box. In Figure 1, the throttle device is a damper means having two blades, while the throttle device in Figure 2 is a damper means having a single blade. The damper means 20 divides the box into an expansion chamber 22 and an outlet chamber 24. Located downstream of the damper means and associated with the outlet chamber, generally being located in the outlet 8, is a vortex filter 26 for reducing turbulence caused by the damper means, the air flow measuring assembly, and any turbulence remaining in the incoming air. Located externally of the box is a motor means 28 for moving the damper means and a logic analyzer control means 30 for actuating the motor means.

As mentioned above, disposed centrally within the inlet plenum 18 is an air flow measuring assembly 16. The air flow measuring assembly is oriented for maximum effectiveness. The air flow measuring assembly comprises a flow collector-straightener, or scrim, 32 and an air flow amplifier measurer 34. The air flow collector-straightener 32 is affixed to the plenum inlet 18 by a web assembly 36. The air flow amplifier measurer 34 is affixed to the flow collector-straightener 32 by web assembly 38. Web assemblies 36 and 38 can be combined into one assembly; alternatively, the scrim 32 and air flow amplifier measurer 34 may be held in position by numerous other well-known methods.

The flow collector-straightener 32 is preferably disposed centrally within the plenum inlet 18 and the air flow amplifier measurer 34 is disposed centrally within the flow collector-straightener 32. The collector-straightener 32 makes sure that a representative sample of incoming air is sampled by the air flow amplifier measurer 34.

The collector-straightener 32 is preferably a perforated tubular member of which about 50 percent of the surface area is free area. The flow collector-straightener may be in the form of a solid tubular member; but a solid tubular member may cause a pressure loss across the variable volume control assembly. Accordingly, it is preferred that the flow collector-straightener be made from perforate material. The free space of the perforate material may comprise as much as about 70 percent of the surface area. If the free space comprises substantially more than about 70 percent of the surface area, the collector-straightener will not ensure representative sampling, particularly when the duct coming from the air source is attached to the plenum inlet at a 90° angle, and therefore the collector-straightener 32 is preferably made from perforate material having about 50 percent free area. Flow collector straighteners having the above mentioned preferred structure actually bite into the incoming air and provide a good representative sample to the air flow amplifier measurer substantially independently of the duct inlet approach. Alternatively, the flow collector-

straightener 32 may be in the shape of a truncated cone that is inwardly tapered in the direction of flow. The cone angle may vary from about 45° up to 90° (when it is tubular). If the cone angle is substantially less than about 45°, the flow collector-straightener would be more like a plate that obstructs the flow. This would cause an increased pressure loss across the assembly and would not provide representative samples when the inlet duct was at an angle.

Accordingly, cone angles of 45° and above, up to 90, are preferred. The cone is preferably made of perforate material as described above for the tubular-shaped flow collector-straightener. Cone-shaped flow collector-straighteners having the above described structure have been found to be as effective as the tubular-shaped flow collector-straighteners. The tubular-shaped collector-straighteners are preferred because of their ease of construction and use. The flow collector-straightener is arranged facing upstream and preferably so that the tubular or larger conular opening lies in the plane of the plenum inlet opening.

The flow amplifier measurer, which is located substantially coaxially with the axis of the collector-straightener, is an important feature of the present invention. For achieving increased sensitivity, the amplifier measurer has a tube with either a constant diameter or a tapered orifice section followed by a section where there is an abrupt expansion of the orifice which then preferably remains constant across the rest of the length of the tube. A total pressure sensing probe, or tap, is provided in the section of the tube with the smaller orifice, and a static pressure probe or tap is provided in the section of the tube with the expanded orifice near the point where the abrupt expansion of the orifice occurs. The flow pressure, or velocity, of the flowing gas is determined from the sensed total pressure and the sensed static pressure. The total pressure being equal to the sum of the static pressure and the flow pressure.

The static pressure probe is preferably located in the tube orifice at the point where the abrupt expansion of the orifice amplifies the sensed pressure differential by reducing the sensed static pressure. The abrupt expansion of the orifice causes a false static pressure reading in the area immediately after the abrupt expansion that is lower than the true static pressure of the system. The area immediately following the abrupt expansion has an artificially reduced static pressure. By locating the static pressure probe where the sensed static pressure is artificially depressed, a larger pressure differential between total pressure and static pressure is obtained. This amplification of the pressure differential, and hence flow pressure, occurs at even low flow velocities thus providing a more sensitive measuring apparatus. The amount of depression of the static pressure is related to the ratio of the orifice area immediately before expansion. If the areas of the orifice after and before expansion are close, the amount of depression of the static pressure will be small. As this ratio increases, the amount of depression of static pressure will increase; however diminishing returns will occur.

The total pressure sensing probe is located in the centre of the tube in the constant diameter or tapered orifice section and is arranged parallel to the flow of gas with its opening facing upstream. By

- 5 locating the total sensing probe near the centre of the tube, a more representative reading of total pressure is obtained. The tube also acts as a flow collector and straightener, thereby providing a more representative reading of total pressure. The total
- 10 sensing probe may be located anywhere in the constant diameter or tapered orifice section and may even be located slightly into the expanded orifice section. Preferably the total pressure probe should not be too near the upstream opening of the tube or
- 15 too far into the expanded orifice section since the advantages of the tube acting as a flow collector straightener would not then be realized, but it should be also pointed out that the total pressure probe can be located externally of the tube. If the total pressure
- 20 probe is located externally of the tube, it is desirable that it be located within flow collector-straightener 32. As mentioned above, the orifice in the upstream end of the tube may be of constant diameter or tapered but it is preferred that it be tapered so that a
- 25 greater expansion of the orifice can be obtained.

- The amplifier measurer 34 is better described with respect to Figures 3-6. Thus, it can be seen that a tube 40 is provided through which a portion of the air flowing in plenum inlet 18 must pass. The tube
- 30 has an upstream end 42 and a downstream end 44 and it is arranged with the orifice of the tube parallel to the direction of flow. The orifice at the upstream end is tapered inwardly to form a tapered orifice section 46 constituting an area of constricted flow. A
 - 35 total pressure probe, or tap, 48 is positioned in the centre of tapered orifice section 46 and has its passageway 50 parallel to the flow of gas and facing upstream. The tapered orifice section 46 adjoins at
 - 40 52 an abruptly expanded orifice section 54 of tube 40. The expanded orifice is then preferably of constant diameter across the remainder of the tube although it may be tapered inwardly or outwardly. A static pressure sensing probe, or tap, 56 is located in the walls of the tube immediately after the abrupt
 - 45 expansion. The opening 58 of the static pressure probe is preferably perpendicular to the flow of gas. Sensing probes 48 and 56 are connected by tubes 60 and 62, respectively (not shown in all Figures), to control logic means 30. Control logic means 30 is
 - 50 responsive to the pressure differential sensed by probes 48 and 56 and is used to operate motor means 28 to open or close damper means 20. The probe 48 is suitably held in place by webs 64 which are preferably made as one integral unit with the rest
 - 55 of the sensor. The opening 58 of the static pressure probe 56 is perpendicular to the flow of gas and is located in the walls of tube 40 immediately after the abrupt expansion of the orifice. Tube 40 also has a nipple 66 which is optional and which is useful for
 - 60 holding the air flow amplifier measurer 34 in collector-straightener 32.

- Figure 7 shows an alternative embodiment of the amplifier measurer of the present invention. Tube 70 has an upstream end 72 and a downstream end 74.
- 65 The orifice section expands at 76 to form an

expanded orifice section 78 and a tapered orifice section 80. A total pressure sensing probe 82 is located at the end of the tapered orifice section 80 and has its opening 84 parallel to the flow of gas and facing upstream. A static pressure sensing probe 86 is located in the wall of the tube in expanded orifice section 78. The opening 88 of static pressure probe 86 is perpendicular to the flow of gas and facing downstream.

- 75 Figure 8 shows another alternative embodiment of the amplifier measurer of the present invention. Tube 90 has an upstream end 92 and a downstream end 94. The orifice section at the upstream end is of constant diameter and abruptly expands at 96 to
 - 80 form an expanded orifice section 98 and a constant diameter section 100. A total sensing probe 102 is located externally of tube 90 and has its opening 104 perpendicular to the flow of gas and facing upstream. A static pressure sensing probe 106 is
 - 85 located in the walls of the expanded orifice section 98 and has its opening 108 parallel to the flow of gas.
- In Figures 7 and 8, total pressure taps 82 and 102 and static pressure taps 86 and 106 would be connected to logic analyzer 30 by appropriate tubing or hoses.

- 90 Other embodiments of the amplifier measurer of the present invention are possible. The important feature being that the static pressure probe is located in the expanded orifice section of the tube,
- 95 preferably in the area of artificially reduced static pressure, that is, immediately after the abrupt expansion of the orifice.

- The box 5 is divided into two chambers, an expansion chamber 22 and an outlet chamber 24, by the damper means 20. An important feature of the present invention is the ratio of the throughflow cross-sectional area of the plenum inlet to the throughflow cross-sectional area of the expansion chamber. It has been found that when the ratio of the throughflow cross-sectional area of the plenum inlet to the throughflow cross-sectional area of the expansion chamber ranges from about 1:1.25 to about 1:2, preferably from 1:1.4 to 1:1.6, the pressure loss across the unit is minimized. When the ratio of the throughflow cross-sectional area of the plenum inlet to the throughflow cross-sectional area of the expansion chamber is around 1:1, there is a high pressure loss across the assembly and more energy is required to get the necessary flow of air through the assembly. Similarly, if the ratio is much above 1:2, too much expansion will occur in the expansion chamber thus increasing the amount of energy used.

- In general, the variable volume control assembly of the present invention is quieter than prior art assemblies. The reduced noise level is a result of the strategic location of the vortex filter 26. The vortex filter conveniently takes the form of a piece of perforate material which may be V-shaped or truncated V-shaped, as illustrated in Figures 1 and 2. The vortex filter is located in the box 4 downstream of the damper means 20 with the point of the V pointing downstream. The point of the V or the truncated flat surface is preferably in the vertical plane of the outlet although it may be located slightly downstream or upstream without substan-

tially affecting its operation. It is important that the filter be located downstream of the damper means. By being downstream of the damper means, the vortex filter filters vortices that are created by the damper means and also any vortices that are created by the air flow measuring assembly. It also filters any remaining large vortices that were in the incoming air stream. By breaking up the large turbulence of the vortices, the vortex filter aids in the reduction of the noise level. It breaks up the vortices and thus increases their vibration frequency thus making their attenuation by sound traps and insulation material more easily attainable.

As mentioned above, the vortex filter is V-shaped or truncated V-shaped with the point of the V or the flat truncated surface pointing downstream. The V-shaped filter is preferred when the damper means has more than one blade. The V-shaped or truncated V-shaped filter is generally attached to the top and the bottom of the box. The filter extends substantially over the width of the box. While the filter may extend from one side of the box to the other, it is preferred that the width of the filter be about 70 percent of the length of the damper. It has been found that this allows a lower pressure loss across the box.

The vortex filter is conveniently made out of perforate material. The free space of the perforate material may vary from about 25 percent to about 70 percent, and preferably the free space is about 50 percent, of the surface area of the filter. If more than about 70 percent free space is used, the filter will not be as effective in reducing turbulence and resulting noise as desirable. Also, if less than about 25 percent free space is used, the filter will not only fail to reduce the turbulence as desired, but will increase the pressure loss across the unit.

Mounted within box 4 to control the flow of conditioned air through the box is damper means 20. Damper means 20 may comprise a single damper, as illustrated in Figure 2, or multiple dampers, as illustrated in Figure 1. The single damper of Figure 2 comprises a blade 68 which is adapted to rotate about rod 67 which passes between the side walls of box 4 and is journaled in bearings (not shown). The rotation of the damper is effected by motor means 28 in response to a signal from logic analyzer means 30. The damper means may be connected to the motor means by any of the well-known methods. Preferably, damper stops, or gaskets, 69 are provided along the top and bottom walls of the box to allow the damper to reach a securely closed position within the terminal box. A damper stop (not shown) may also be positioned within the centre of the outlet chamber to limit the rotation of the damper to a fully open position. The damper means of Figure 1 comprises a plurality of blades and rods that are mounted for individual rotation or for collective rotation when one of the rods is rotated. A damper means having a plurality of blades is preferred for larger size assemblies. A damper means having a single blade is preferred for smaller assemblies.

Located externally of box 4 is motor means 28 and logic analyzer means 30. Motor means 28 and logic analyzer means 30 are preferably attached to the

side of box 4 and covered by a protective shroud. Motor means 28 causes the damper means to open or close in response to a signal from logic analyzer. Logic analyzer means 30 is operably connected to total pressure sensing probes 48, 82 or 102 and static pressure sensing probes 56, 86 or 106 by appropriate means such as tubing members 60 and 62. Logic analyzer 30 is also operably connected to a thermostatic control that is located at some appropriate point within the zone to be conditioned and to a source of power. A convenient source of power is a 20 psi main air source.

Logic analyzer 30 continually receives readings from the total pressure sensing probe, static pressure sensing probe and thermostatic control. Then, depending on the manner in which the logic analyzer has been programmed, it sends a signal to motor means 28 to open or close the device, e.g. the damper means. Logic analyzer may have a high limit, a low limit or a combination of high and low limits. Logic analyzer may also require air to be bled into the air flow measuring means through the static pressure probe.

90 CLAIMS

1. A variable volume control assembly, for controlling the flow of conditioned air into a zone, said assembly comprising a box which has an expansion chamber provided with a plenum inlet for receiving conditioned air from a source of conditioned air and an outlet chamber provided with an outlet for delivering conditioned air to the zone; a throttle device for controlling the flow of air through the box, the throttle device being located between the expansion chamber and the outlet chamber; an air flow measuring assembly for measuring the flow of air through the box; motor means for controlling the opening and closing of the throttle device; and control means responsive to the temperature in the zone and the flow of conditioned air through the box for controlling the operation of the motor means; wherein the air flow measuring assembly comprises an air flow amplifier measurer including a tube having an upstream end and a downstream end connected by an orifice, there being an abrupt expansion of the orifice in the downstream end of the tube to form an expanded orifice section, a total pressure probe having an opening lying in a plane substantially perpendicular to the intended direction of flow of gas through the tube and facing upstream, a static pressure probe located in the expanded orifice section of said tube, and means connecting the total pressure probe and static pressure probe to the control means.

2. A variable volume control assembly as claimed in claim 1, wherein the total pressure probe is located externally of the tube.

3. A variable volume control assembly as claimed in claim 1, wherein the upstream section of the orifice is of constant diameter and wherein the total pressure probe is located in the constant diameter upstream section of the orifice.

4. A variable volume control assembly as claimed in claim 1, wherein the upstream section of



tially affecting its operation. It is important that the filter be located downstream of the damper means. By being downstream of the damper means, the vortex filter filters vortices that are created by the damper means and also any vortices that are created by the air flow measuring assembly. It also filters any remaining large vortices that were in the incoming air stream. By breaking up the large turbulence of the vortices, the vortex filter aids in the reduction of the noise level. It breaks up the vortices and thus increases their vibration frequency thus making their attenuation by sound traps and insulation material more easily attainable.

As mentioned above, the vortex filter is V-shaped or truncated V-shaped with the point of the V or the flat truncated surface pointing downstream. The V-shaped filter is preferred when the damper means has more than one blade. The V-shaped or truncated V-shaped filter is generally attached to the top and the bottom of the box. The filter extends substantially over the width of the box. While the filter may extend from one side of the box to the other, it is preferred that the width of the filter be about 70 percent of the length of the damper. It has been found that this allows a lower pressure loss across the box.

The vortex filter is conveniently made out of perforate material. The free space of the perforate material may vary from about 25 percent to about 70 percent, and preferably the free space is about 50 percent, of the surface area of the filter. If more than about 70 percent free space is used, the filter will not be as effective in reducing turbulence and resulting noise as desirable. Also, if less than about 25 percent free space is used, the filter will not only fail to reduce the turbulence as desired, but will increase the pressure loss across the unit.

Mounted within box 4 to control the flow of conditioned air through the box is damper means 20. Damper means 20 may comprise a single damper, as illustrated in Figure 2, or multiple dampers, as illustrated in Figure 1. The single damper of Figure 2 comprises a blade 68 which is adapted to rotate about rod 67 which passes between the side walls of box 4 and is journaled in bearings (not shown). The rotation of the damper is effected by motor means 28 in response to a signal from logic analyzer means 30. The damper means may be connected to the motor means by any of the well-known methods. Preferably, damper stops, or gaskets, 69 are provided along the top and bottom walls of the box to allow the damper to reach a securely closed position within the terminal box. A damper stop (not shown) may also be positioned within the centre of the outlet chamber to limit the rotation of the damper to a fully open position. The damper means of Figure 1 comprises a plurality of blades and rods that are mounted for individual rotation or for collective rotation when one of the rods is rotated. A damper means having a plurality of blades is preferred for larger size assemblies. A damper means having a single blade is preferred for smaller assemblies.

Located externally of box 4 is motor means 28 and logic analyzer means 30. Motor means 28 and logic analyzer means 30 are preferably attached to the

side of box 4 and covered by a protective shroud. Motor means 28 causes the damper means to open or close in response to a signal from logic analyzer. Logic analyzer means 30 is operably connected to total pressure sensing probes 48, 82 or 102 and static pressure sensing probes 56, 86 or 106 by appropriate means such as tubing members 60 and 62. Logic analyzer 30 is also operably connected to a thermostatic control that is located at some appropriate point within the zone to be conditioned and to a source of power. A convenient source of power is a 20 psi main air source.

Logic analyzer 30 continually receives readings from the total pressure sensing probe, static pressure sensing probe and thermostatic control. Then, depending on the manner in which the logic analyzer has been programmed, it sends a signal to motor means 28 to open or close the device, e.g. the damper means. Logic analyzer may have a high limit, a low limit or a combination of high and low limits. Logic analyzer may also require air to be bled into the air flow measuring means through the static pressure probe.

90 CLAIMS

1. A variable volume control assembly, for controlling the flow of conditioned air into a zone, said assembly comprising a box which has an expansion chamber provided with a plenum inlet for receiving conditioned air from a source of conditioned air and an outlet chamber provided with an outlet for delivering conditioned air to the zone; a throttle device for controlling the flow of air through the box, the throttle device being located between the expansion chamber and the outlet chamber; an air flow measuring assembly for measuring the flow of air through the box; motor means for controlling the opening and closing of the throttle device; and control means responsive to the temperature in the zone and the flow of conditioned air through the box for controlling the operation of the motor means; wherein the air flow measuring assembly comprises an air flow amplifier measurer including a tube having an upstream end and a downstream end connected by an orifice, there being an abrupt expansion of the orifice in the downstream end of the tube to form an expanded orifice section, a total pressure probe having an opening lying in a plane substantially perpendicular to the intended direction of flow of gas through the tube and facing upstream, a static pressure probe located in the expanded orifice section of said tube, and means connecting the total pressure probe and static pressure probe to the control means.

2. A variable volume control assembly as claimed in claim 1, wherein the total pressure probe is located externally of the tube.

3. A variable volume control assembly as claimed in claim 1, wherein the upstream section of the orifice is of constant diameter and wherein the total pressure probe is located in the constant diameter upstream section of the orifice.

4. A variable volume control assembly as claimed in claim 1, wherein the upstream section of



the orifice tapers and wherein the total pressure probe is located in the tapered upstream section of the orifice.

5. A variable volume control assembly as claimed in claim 1, 2, 3 or 4 wherein the static pressure probe has an opening lying in a plane parallel to the intended flow of gas through the expanded orifice section of said tube.

6. A variable volume control assembly as claimed in claim 1, 2, 3, or 4, wherein the static pressure probe has an opening lying in a plane perpendicular to the intended flow of gas through the expanded orifice section of said tube and facing downstream.

7. A variable volume control assembly as claimed in any one of claims 1 to 6, wherein the air flow measuring assembly is located in the plenum inlet and wherein the air flow amplifier measurer is located substantially coaxially with the axis of a collector-straightener means, the collector-straightener means comprising a tubular member having its inlet and outlet openings lying in planes substantially perpendicular to the intended direction of flow or air.

8. A variable volume control assembly as claimed in any one of claims 1 to 6, wherein the air flow measuring assembly is located in the inlet plenum and wherein the air flow amplifier measurer is located substantially coaxially with the axis of a collector-straightener means, the collector-straightener means comprising a cone-shaped member having its inlet and outlet openings lying in planes perpendicular to the intended direction of flow of air with the smaller opening being downstream.

9. A variable volume control assembly as claimed in claim 7 or 8, wherein the tubular member or cone-shaped member of said collector-straightener is formed from a perforate material.

10. A variable volume control assembly as in claim 7 or 8, wherein the tubular member or cone-shaped member of said collector-straightener is formed from an imperforate material.

11. A variable volume control assembly as claimed in any one of claims 1 to 10, and further comprising a vortex filter associated with the outlet chamber of the box.

12. A variable volume control assembly as claimed in claim 11, wherein the vortex filter comprises a piece of perforate material.

13. A variable volume control assembly as claimed in claim 12, wherein the piece of perforate material has either a substantially V-shape cross-section and is arranged with the point of the V pointing downstream or has a truncated V-shape cross-section with its flat truncated surface pointing downstream.

14. A variable volume control assembly as claimed in claim 12 or 13, wherein the free space of the perforate material constitutes from about 25 to about 70 percent of the surface area of the vortex filter.

15. A variable volume control assembly as claimed in claim 14 when appendant to claim 13, wherein the tip of the V is in the outlet of the box.

17. A variable volume control assembly as claimed in claim 14 when appendant to claim 13, wherein the flat truncated surface is in the outlet of the box.

18. A variable volume control assembly as claimed in any one of claims 1 to 16, wherein the ratio of the throughflow cross-sectional area of the plenum inlet to the through flow cross-sectional area of the expansion chamber ranges from about 1:1.25 to about 1:2.

19. A variable volume control assembly as claimed in claim 17, wherein the ratio of the through flow cross-sectional area of the plenum inlet to the through flow cross-sectional area of the expansion chamber ranges from 1:1.4 to 1:1.6.

20. A variable volume control assembly as claimed in any one of the preceding claims, wherein said throttle device is damper means which divides said box into said expansion chamber and said outlet chamber.

21. A variable volume control assembly as claimed in any one of the preceding claims, wherein said motor means is located externally of the box.

22. A variable volume control assembly, for controlling the flow of conditioned air into a zone, comprising a box having an expansion chamber

provided with a plenum inlet in one side for receiving conditioned air from a source of conditioned air and an outlet chamber provided with an outlet in a side opposite said one side for delivering conditioned air to the zone; damper means located within the box for controlling the flow of air through the box, the damper means dividing the box into said expansion chamber and said outlet chamber, the ratio of the through flow cross-sectional area of the inlet plenum to the through flow cross-sectional area of the expansion chamber ranging from about 1:1.25 to about 1:2; motor means located externally of the box for controlling the opening and closing of the damper means; control means located externally of the box and responsive to the temperature in the zone and the flow of conditioned air through the box for controlling the operation of the motor means; an air flow measuring assembly for measuring the flow of air through the box comprising an air flow amplifier measurer including a tube having an upstream end and a downstream end connected by an orifice, there being an abrupt expansion of the orifice to form an expanded orifice section in the downstream end of the tube, a total pressure probe located in or adjacent the upstream end of the orifice and having its opening lying in a plane perpendicular to the intended direction of flow of gas and facing upstream, a static pressure probe located in the expanded orifice section of the tube, and means for connecting the total pressure probe and static pressure probe to the control means; and a vortex filter associated with the outlet chamber of the box, the vortex filter comprising a piece of perforate material.



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23. A variable volume control assembly substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

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