

July 2, 1963

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3,095,799

AIR CONDITIONING SYSTEM

Filed March 10, 1960

3 Sheets-Sheet 1

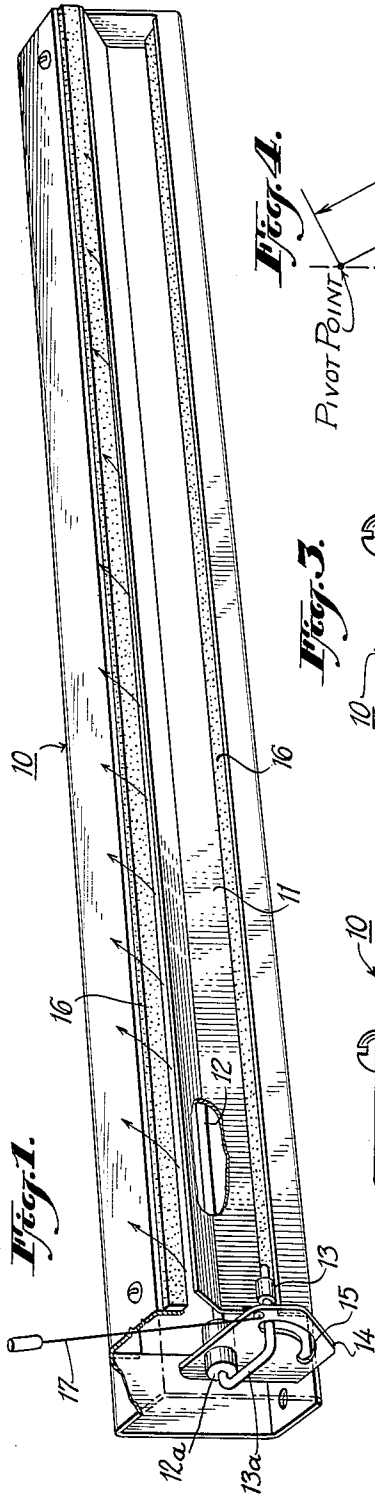
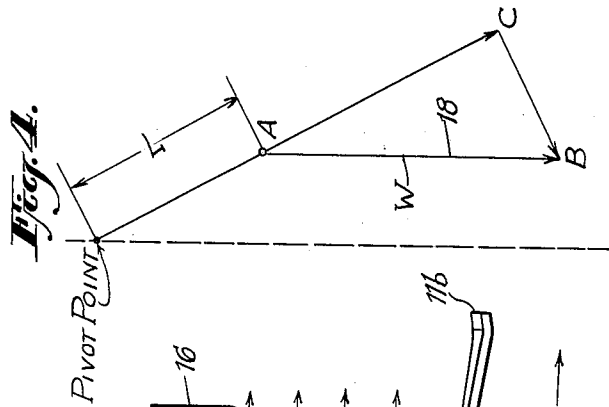
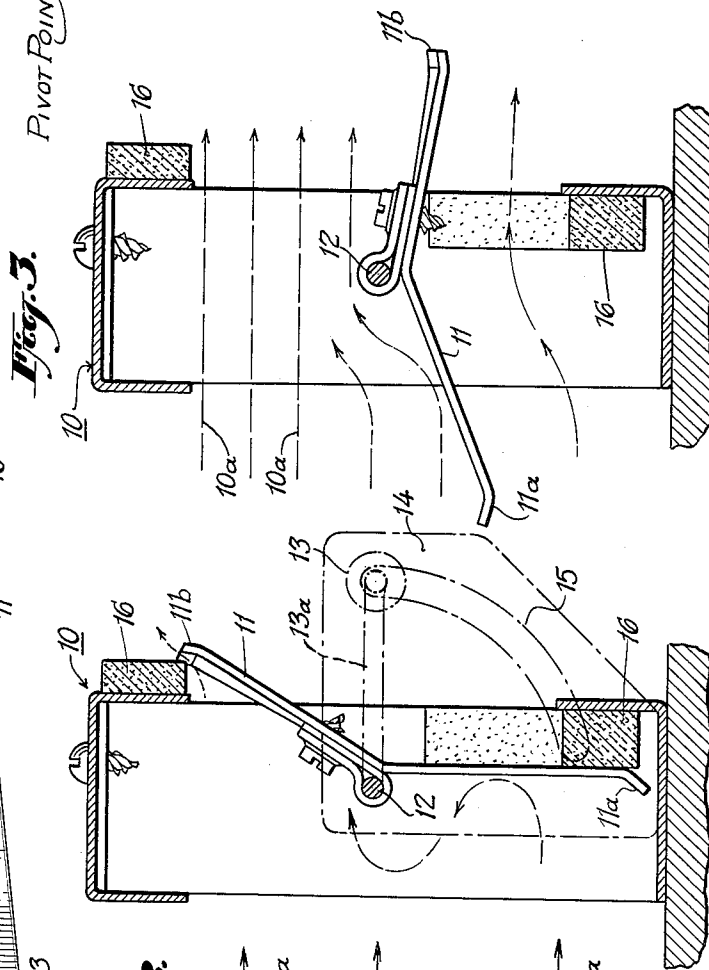


Fig. 2.

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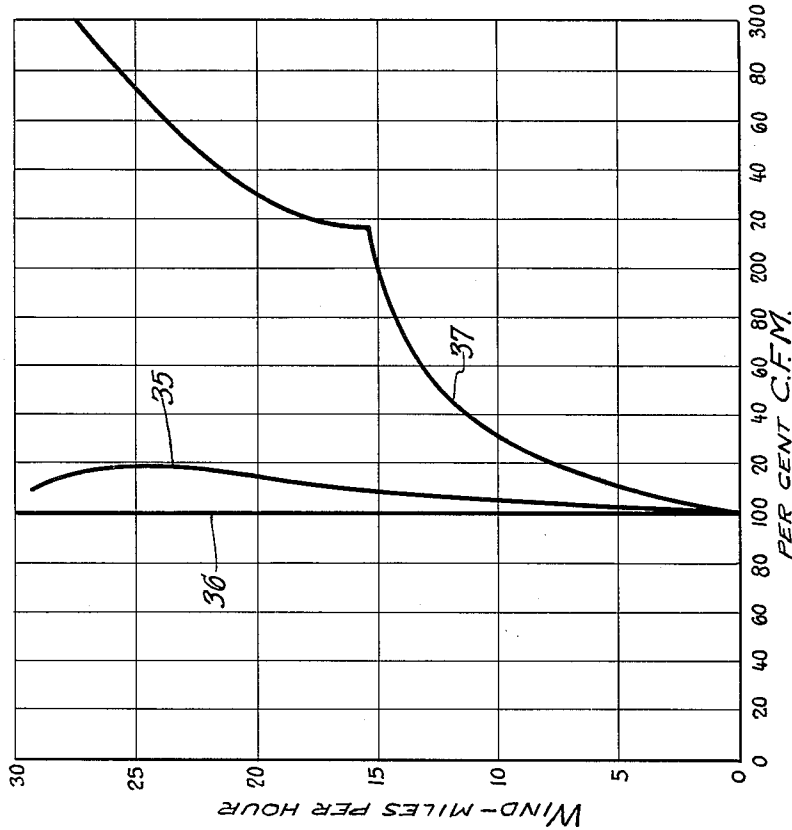
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Fig. 6.



100% = AIR PASSING THROUGH DAMPER WITH NO WIND.
 100% = (E.G.) 97 CFM FOR PRIOR ART DAMPER AT NO WIND.
 100% = (E.G.) 460 CFM FOR PRESENT INVENTION AT NO WIND.

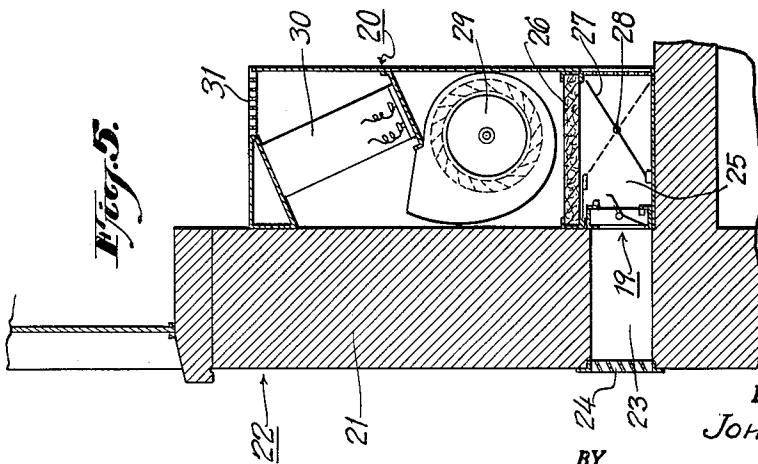


Fig. 5.

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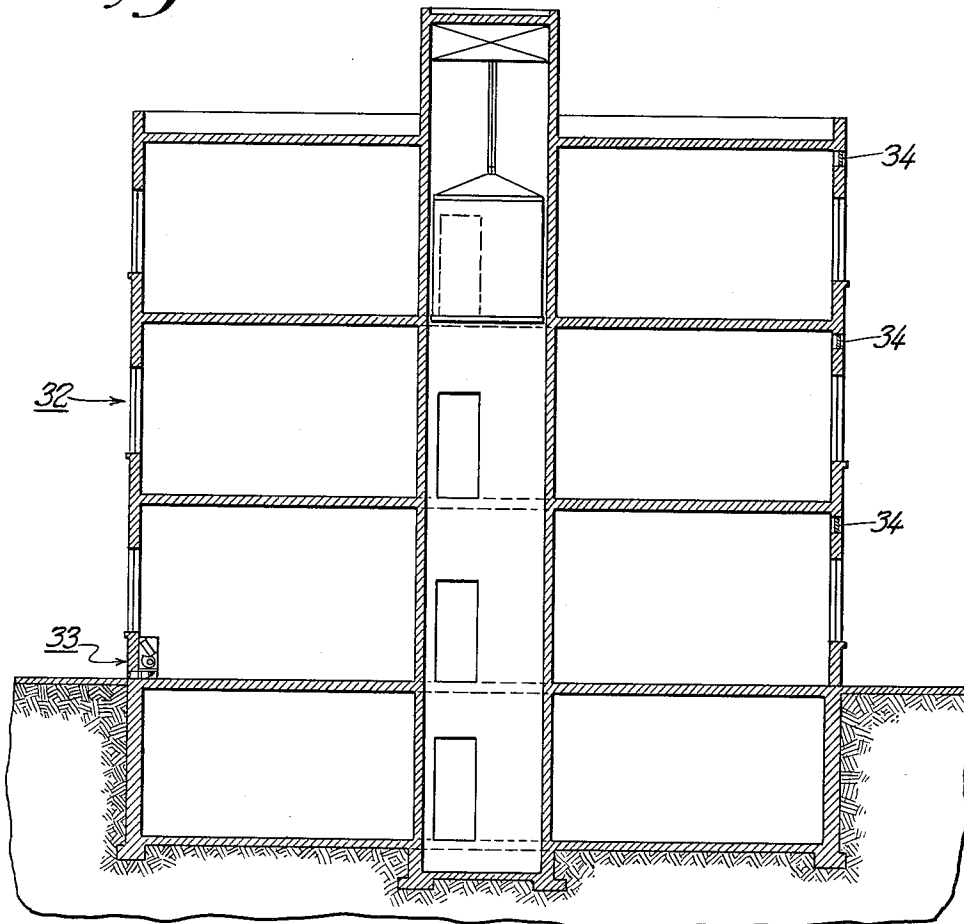
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3 Sheets-Sheet 3

Fig. 7.



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AIR CONDITIONING SYSTEM

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Filed Mar. 10, 1960, Ser. No. 14,044

2 Claims. (Cl. 98-37)

This invention relates to air conditioning methods and apparatus, and more particularly to a novel air conditioning system. The invention also relates to novel damper means which may be used advantageously in connection with such air conditioning system, such damper means having as one of its principal objectives the control of the volumetric flow rate of air from the outside of a building to the inside, that is, the control of "ventilation air."

The present invention is adapted for buildings of all sizes but is particularly well adapted for multistoried buildings where outdoor air for ventilation must be brought in.

Broadly, air conditioning systems are divided into two categories as follows:

(1) The central system wherein air is brought from various spaces of the building to a central air conditioning region usually within the building. At such central region the air so brought is, for example, filtered, cooled, heated, dehumidified and mixed with outdoor air as required, and is then returned to the same spaces.

(2) The remote system wherein each individual space to be air conditioned within the building is provided with an individual air conditioning unit which functions to circulate, filter, cool, heat and dehumidify the air. Such individual air conditioning unit normally is relatively small and may be supplied with hot or chilled water or refrigerant from a central source. Alternatively, it may be heated by steam or electricity and cooled (and also heated in the case of the heat pump) by means of a self-contained refrigerant device which, for example, may employ a water-cooled or air-cooled condenser, often such air-cooled condenser extending through a wall of the building into the outdoors.

Such remote system is considered to be the more economical and flexible of the two. However, prior to the present invention, the ventilation function could not adequately be incorporated in a remote system for the following reasons:

In order for a number of such relatively small air conditioning units to ventilate their respective spaces, they must bring outdoor air in through openings in the wall of the building. This requires that there be a number of relatively small openings usually through all four sides of the building. Each such opening leads into one of the relatively small air conditioning units. This results in three very substantial disadvantages as follows:

(1) In order to provide a definite amount or volume of ventilation, a separate exhaust system especially designed for the purpose must be provided. This is unduly expensive and places this particular system (remote) at an intolerable commercial disadvantage due to high cost of such separate exhaust system. Also, such separate exhaust system places the building under a slight vacuum resulting in the leakage into the building of unheated air from the outside through any crack or opening in the building structure. If it is desired to eliminate this vacuum, it is possible to employ a complete ventilation system comprising an air supply system and an air exhaust system but if such two systems are employed, the very large cost of a central system is approached plus the cost of a remote system. Since the central system is far more costly than the remote sys-

tem, this results in a very substantial commercial disadvantage for the remote system.

(2) At times of high winds, the wind will blow into the building on one side and out on the other through the outdoor air openings located at each air conditioning unit. The volumetric rate of influx of ventilation air thus can be elevated four to six times its normal value. This causes extensive drafts and discomfort, and is exceedingly costly due to increased fuel consumption.

(3) In tall buildings, a chimney effect occurs in which, in cold weather, outdoor air passes into the building through any openings at the bottom region of the building and up through passageways such as stairwells, ducts, or elevator shafts, and out through any openings near the top region of the building. This occurs in all buildings but is more pronounced where many openings exist in a building as are required in a remote system embodying the prior art. Such chimney effect also is very costly in fuel consumption. Furthermore, the lower floors are excessively drafty because of it.

For the above reasons the remote air conditioning system of the prior art is not favored at the present time by engineers and architects for use in large buildings, in spite of low initial cost of such remote system.

The present invention overcomes fully the disadvantages set forth above and accomplishes the aforementioned objectives. Furthermore, in the case where the damper means embodying the present invention are employed with a conventional proportioning damper (for mixing outdoor and indoor air prior to entering an individual air conditioning unit fan in such a remote system), the unit fans themselves, in each room or space, will draw a predetermined quantity of outdoor air into the building and thus will maintain the building under a positive pressure. Furthermore, simple and conventional "relief openings," to be defined more fully hereinafter, plus exhaust fans (where local building codes require it, e.g., in laboratories) are all that are required to exhaust such ventilation air in the system embodying the present invention.

Thus, in order to accomplish the objectives aforementioned, it is desired to control the volumetric rate of flow of ventilation air into the building so that it remains substantially constant or at least within preselected narrow limits regardless of the outside wind velocity or wind pressure. Thus, it is desired to limit the inflow of outside air into a given region in a building so that it is always approximately 100% of the "no wind" value thereof regardless of the outside air pressure or regardless of the velocity of the outside wind blowing against the building.

A further objective of the invention is to maintain a substantially constant volumetric inflow rate of air into a ventilating system within preselected limits by virtue of a counterweighted damper blade having an airfoil cross-section, the damper construction operating to maintain such substantially constant inflow rate of outside air between preselected limits regardless of outside air pressure, and by virtue of a balance between mechanical forces acting on the damper blade due to such counterweight and the forces due to air acting thereon, the damper blade responding to air velocity in a manner analogous to an airfoil.

The invention, in one aspect thereof, comprises in combination: a damper housing having an inlet and an outlet, there being mounted in such housing a damper blade which is mounted for angular motion within preselected limits about the longitudinal axis of such blade. The damper blade is at an open position at one limit of its angular motion and at the other limit thereof it is substantially closed. The damper blade, as aforementioned, is in cross-section of airfoil configuration. Means, such

as the aforementioned counterweight, are also provided for exerting a mechanical torque upon the damper blade which torque increases in response to the angular movement of the damper blade towards the aforementioned substantially closed position. The airfoil cross-section of the damper blade and the position of its axis of angular movement are selected in such a way that forces acting on the blade due to mechanical torque attributable to such mechanical torque exerting means, are balanced by forces acting on the damper blade due to the movement of air thereover. The forces tending to close the damper blade are a function of the velocity of such air movement thereover, and are expressed in terms of a formula discussed in more detail below which is analogous to the classic aerodynamic lift formula.

Thus in effect the constant ventilation damper embodying the present invention is of such design that it is operated responsive to the velocity of air passing through it. As the wind velocity increases therethrough, the force tending to close the damper increases rapidly and approximately in accordance with the square of wind velocity which is a parabolic curve. The damper construction operates to maintain a substantially constant volumetric inflow rate of outside air between preselected limits regardless of the outside air pressure at the inlet of the damper housing, this being true by virtue of the balance between such mechanical forces acting on the damper blade with the air forces acting thereon under the conditions aforementioned.

The above and further objects and novel features of the invention will more clearly appear from the detailed description set forth below when read in connection with the accompanying drawings, it being understood that such drawings are for purposes of illustration only and do not constitute a definition of the limits of the invention, reference for this latter purpose being had to the appended claims.

In the drawings:

FIG. 1 is a perspective view of a damper construction embodying the present invention;

FIG. 2 is a cross-sectional view, partly in section and with parts broken away, of the damper construction of FIG. 1, the airfoil damper blade being shown in a substantially closed position;

FIG. 3 is a cross-sectional view of the same damper construction of FIG. 1 but showing the airfoil damper blade in an open position;

FIG. 4 is a vector diagram showing one example of the resolution of forces acting on the damper blade of the present invention at one operating condition;

FIG. 5 is a cross-sectional view, partly in section and with parts broken away, of an air conditioning unit of the aforementioned remote system, which unit is equipped with the constant volume damper embodying the invention, the unit being shown in combination with the wall of a building and a portion of a room of such building;

FIG. 6 is a graphical representation showing curves of wind velocity plotted against percentage of volumetric airflow rate in cubic feet per minute and showing the performance of the apparatus embodying the present invention as compared to typical apparatus embodying the prior art; and

FIG. 7 is a schematic cross-sectional showing on a reduced scale of a building embodying one form of the present invention.

Referring to the drawings in greater detail, with particular reference to the damper of FIGS. 1-4, the principal elements of construction of this form of the invention comprise a damper housing 10 in which there is mounted a damper blade 11 which can pivot about the axis of a shaft 12, rotatable in bearing 12a mounted on the housing 10, to which it is secured within the housing 10. Such damper blade 11 can move from the open condition shown in FIG. 3, which exists at very low or no wind or pressure conditions exterior to the damper con-

struction (or the room in which it is used), to the substantially closed condition shown in FIG. 2 which occurs in response to the existence of a high wind acting in the direction of arrows 10a (FIGS. 2 and 3).

The damper blade 11 has an airfoil cross-section and behaves in a manner analogous to an airfoil in response to air flow over it.

Such blade 11 is of airfoil configuration by virtue of its dished cross-sectional shape although other suitable airfoil shapes can be used. The longitudinal edges 11a and 11b thereof are slightly turned or crimped in the manner shown in FIGS. 2 and 3, such turning or crimping being in an upward direction when the dished damper blade is substantially horizontal as shown in FIG. 3 with its concavity facing downwardly. Such shaping of the edges contributes to the satisfactory operation of the damper by aiding in the balancing of wind forces against mechanical forces acting thereon as aforementioned.

It will be observed from FIG. 3 that the cross-section of the portion of the blade identified by the references 11 and 11a, as projected on a plane is relatively small compared to the extent of the surfaces thereof in the direction from the forward edge of the blade portion, that is, the edge nearest the source of the incoming air, to the edge of such blade portion at the shaft 12 where it joins the remainder of the blade. Furthermore, the lower surface of such blade portion is convex providing a forward surface on such blade portion (identified by the reference 11a) which extends transversely to the direction of air flow when the blade is in the open position as shown in FIG. 3. Due to such configuration, the air impinges on the forward portion and is deflected and the air moving across such blade portion produces a force (sometimes called "lift" or airfoil action) tending to rotate the blade which is in addition to any force caused by the impingement of air on the upper surface of such blade portion. Such "lift" or airfoil action is produced with such configuration even if the portion of the blade identified by the numeral 11 extends horizontally as viewed in FIG. 3 and hence is parallel to the direction of flow of the incoming air.

In order to insure that the damper blade 11 will not flip closed or quickly angularly shift to a closed position at low flow rates, it is necessary to conform the cross-section of the damper to prevent this and whereby said balancing of forces takes place with the aid of means for exerting a mechanical torque on the blade 11 to be set forth in detail herebelow. Thus the angular position of the damper is responsive to the velocity of the air flowing over it as at 10a.

Such means for exerting a mechanical torque on the damper blade acts to exert a torque at its minimum value when such blade is in its full open position, and which torque increases as the blade moves towards its substantially closed position whereby, when the blade has reached the position shown in FIG. 2, a maximum mechanical torque is acting thereon. Such means, in the form shown, comprise the aforementioned counterweight herein designated 13 (also referred to as a compensating weight) which is at its lowermost position, as aforementioned, at the "no wind" condition (FIG. 3). Weight 13 is mounted on the end of arm 13a which is secured to shaft 12 for angular movement therewith. In a high wind the weight 13 will move to its uppermost position as shown in FIG. 2 and will exert its maximum torque on the damper blade tending to open same, this being true because of the increased length of the moment arm which occurs as arm 13a approaches the horizontal.

For the purpose of adjusting the limits of the angular movement of the blade 11, there is provided a limit-stop member 14, for example, of plate-like shape having formed therein a limit-stop slot 15 which, by virtue of its opposite slot extremities, provides limits for the angular motion of the arm 13a.

In operation, as aforementioned, there is achieved a

balance between the mechanical forces acting on the damper blade due to the weight 13, the distribution of weight of the blade relative to the axis of shaft 12, and the forces acting on the blade attributed to the flow of air through the housing 10, such forces being responsive to the formula

$$F = dV^2 \frac{A}{2g}$$

where:

F =wind force in lbs;

d =density of air in lbs./ft.³;

V =vector change in air velocity due to striking airfoil damper blade;

g =acceleration of gravity; and

A =area of airfoil damper blade.

Thus, as aforementioned, as the wind velocity increases, the force tending to close the damper increases rapidly approximately as the square of the wind velocity which is a parabolic curve. Since all of the elements expressed in the above formula, except F and V , remain relatively constant, such equation demonstrates that the wind force increases substantially as the square of the wind velocity. Due to this rapid buildup in force, a very slight wind would close the damper completely were it not for the action of compensating or counterweight 13. The weight 13 is arranged at such an angle that as the damper closes, the effect of the weight tending to open the damper increases rapidly in accordance with a sine curve.

Such compensation weight 13 is arranged bearing in mind the other weights acting on the damper, and weight 13 is selected so that the torque exerted by it tending to close the damper is expressed in accordance with the vector diagram of FIG. 4, and also in accordance with the following equation:

$$T = LW \text{ sine of angle } CAB$$

where:

T =the closing torque in pound feet;

L =the length of the lever arm in feet; and

W =the weight of the compensation weight 13 in pounds.

Since all of the quantities in the latter expression are constant except T and the angle CAB , such equation demonstrates that T varies in accordance with the sine of the angle CAB .

The forces symbolized by the aforementioned parabolic curve of increasing wind force (responsive to the aforementioned lift formula) are closely balanced by the forces symbolized by the aforementioned sinusoidal curve representing the effect of the compensating weight 13. This results in a heretofore unattained smooth operation and constant ventilation air delivery, or substantially constant, at any wind velocity to be expected in normal operation of the apparatus. The aforementioned compensation or balancing of forces symbolized by said parabolic and sinusoidal curves results in damper performance and system performance not heretofore attained by the prior art. For example, the graphic representation of FIG. 6 demonstrates that the apparatus embodying the present invention allows a maximum variation in the volumetric inflow rate of ventilation air of only 19% from a selected norm as the wind velocity increases; whereas apparatus typifying the prior art results in a maximum variation of air volume of over 300%.

The damper embodying the present invention not only maintains a substantially constant volumetric rate of ventilation air inflow, but also serves as a shutoff damper. For example, the limit-stop member 14, which in effect comprises a cam, when shifted angularly counterclockwise, as viewed in FIG. 1, about the axis of the shaft 12, operates against a portion of the arm 13a which passes through the slot 15 and thereby can close the damper positively against resilient strips or air seals 16 (FIG.

1) which can be of any suitable material, for example, resilient foam plastic.

Thus the employment of the novel constant ventilation damper above described has the important advantage of bringing the remote type of air conditioning system costwise into a very strong competitive position not heretofore attained. One of the principal reasons for this is that this system reduces the amount of ducts employed in such system and thereby vastly reduces the cost.

One of the principal objectives of the present invention is to reduce the cost of the remote system type of air conditioning.

Consequently in all constructions embodying the present system, it is desired to bring in outside air, as via a passage in the wall of a building, for purposes of ventilation and to do this with minimum duct work for the reasons aforementioned.

Referring to FIG. 1, the aforementioned limit-stop element or cam 14 can be positioned in any desired adjusted position by means of an adjusting rod 17 which can be shifted, for example, by hand.

Referring to FIG. 4, vector 18 represents the compensating or counterweight W above mentioned, shown in this form of the invention at 13, and L represents the length of the lever arm between the axis of the shaft 12 and the weight 13, the effective length of this lever arm being, of course, a function of the angle CAB . Hence, as the weight 13 is raised from its lowermost position towards its uppermost, the effective lever arm increases.

Any suitable means may be operatively connected to the damper to accomplish the function of the weight 13 and to apply a gradually increasing moment of force thereupon in response to the increase in the angular displacement of the damper from its position shown in FIG. 3 to that shown in FIG. 2, for example, a spring may be employed.

It may be possible in a different and non-analogous form of the invention of eliminate the weight 13 or spring aforementioned acting on the damper blade 11 and to substitute therefor a specially shaped wind force responsive surface operatively connected to the blade, which surface is productive of a mechanical force by virtue of airflow thereover or wind force thereon which will provide a progressively increasing moment of force tending to restrain the closing of the blade.

Referring now to FIG. 5, there is shown a remote air conditioning unit, that is, a unit of the aforementioned remote system which is provided with a constant ventilation or constant volume damper, generally indicated at 19, embodying the construction of FIG. 1.

Such remote air conditioning unit is generally designated 20 and is mounted, in the form shown, adjacent a wall 21 of a building 22, the wall having a passage 23 therethrough, the outer orifice of which is covered by an outdoor air louver 24. The constant volume damper 19 is positioned as shown at the inner orifice of the passage 23 which in this form is beneath the air conditioning unit 20 and at the inlet of the passage 25. Over the damper a filter 26 is positioned. At the opposite extremity of said passage 25 there is located a proportioning damper 27 which is mounted for angular motion about a pivot 28. A fan 29 is positioned above the filter 26 and, in this form of the invention, below a heat transfer device 30, the air conditioning unit having an outlet 31 from which emanates the conditioned air into the room.

The proportioning damper 27 is shown in solid lines in one operating position and in such position the aforementioned remote unit will drawn all of its air from the outside. However, by positioning such proportioning damper 27 in accordance with the broken lines, no outdoor air will be admitted. In any intermediate position proportionate mixing of the outside air with inside air will take place. Thus in an air conditioning system embodying the present invention and for a multi-room

building, there are employed a plurality of individual air conditioning units, for example, of the type shown at 20 in FIG. 5, one such unit for each room. These units embrace filters and heat transfer means, the latter embodying cooling and dehumidifying means. In such a system embodying the present invention, outside air or ventilation air is admitted into the building solely through the novel constant volume damper 19, air being exhausted from the building solely through "relief openings." Thus the building is provided, in so far as its air conditioning system is concerned, with only the aforementioned passages 23 in which the outside air can be admitted, plus the aforementioned "relief openings" which are of low cost and which do not enhance the cost of the remote air conditioning system.

A system such as that described in the preceding paragraph may be employed but utilizing "relief openings" for partial exhaust of the ventilation air and also employing power exhaust for certain regions of the building, for example, in lavatory spaces thereof.

Also, in a system of this type, such as that described in the aforementioned preceding paragraph, air recovery filters may be employed to minimize the amount of outside air required, exhaust air being eliminated through such relief openings or by power exhaust. Such air recovery filters are not to be confused with the filter 26 of FIG. 5 but refer to filters for the purpose of reconstituting air which is recirculated in the system. For example, an air recovery filter may be laden with activated carbon for the purpose of removing odors or impurities from the air which is recirculated.

Referring to FIG. 7, there is shown a multi-roomed building 32 having located at 33 a remote air conditioning unit analogous to unit 20 shown in FIG. 5, the building being provided with relief openings 34.

The cost of such openings is small and, since they are normally required by local building codes regardless of the employment of a remote air conditioning system, such a cost is not in fact related to nor does it increase the cost of such remote system when it is employed. However, if by any reckoning or accounting procedure such cost of the relief openings is considered a part of the cost of a remote air conditioning system, then it is of only small proportions relative to the whole cost of such system.

One of the principal objects of the present invention is to take advantage costwise of such relief openings to eliminate duct work and thereby to reduce the cost of the remote system by a very appreciable amount while gaining advantages heretofore attained only in the far more expensive central system.

Referring to FIG. 6, the curve 35 represents the operation of an apparatus embodying the present invention and shows the relatively minor departure of the performance curve from the optimum which comprises a straight line 36 extending vertically above the 100% mark.

The damper curve 35 very closely approximates the ideal line 36. At higher wind velocities the departure from the optimum line 36 of the performance curve 35 is only about 19%. Such departure can be less.

FIG. 6 represents a graphical plot of wind velocity in miles per hour against percentage of air in cubic feet per minute passing through the damper construction of FIG. 1, the norm 100% cubic feet per minute being the air passing through such damper with no wind condition.

The curve 37 illustrates the performance of a typical prior art apparatus. With respect to such prior art apparatus, 100% of the outside air passing through its damper, for example, may be 97 c.f.m. whereas 100% of outside air passing through the damper embodying the present invention may be 460 c.f.m. As the wind increases to 25 miles per hour the volumetric rate of air influx through the prior art apparatus increases by 270%; so that, instead of 97 c.f.m., 262 c.f.m. of ventilation air will be passing through the prior art apparatus and into

the building. At 25 miles per hour the volumetric rate of air influx through the damper embodying the present invention increases only 19%; so that instead of 460 c.f.m., 549 c.f.m. of ventilation air will be passing through the present invention. From this it is seen that the present invention is capable of holding ventilation airflow rate (volumetric) closer (within 19%) to a much higher selected norm than is the prior art device symbolized by curve 37, which strays from the norm over 300% at the maximum wind speed shown.

The performance curve or damper closing curve 37 of the typical prior art apparatus is not representative of one of less desirable character but one of the best presently available and thus comprises what is believed to be the closest competitor to the apparatus embodying the present invention.

Reverting to rod 17 and cam 14, any suitable calibrated scale angular or straight (not shown) may be employed for aiding in adjusting the position of such limit-stop cam and hence adjusting the limit-stops of angular motion of the shaft 12.

Normally a calibrated scale is not needed and it is only required that the cam 14 be positioned either in a shutoff or a wide open position.

The damper blade 11 is slightly twisted for the purpose of insuring that when the damper reaches its maximum angular displacement at one extremity of its motion, for example, as shown in FIG. 2, a part of the damper blade (for example, one end of the blade edge) will be up against its resilient or cushion limit-stop 16 but the remaining parts of the blade edge will be slightly spaced from such cushion and thus not be fully closed. This is for the purpose of insuring a continuity of airflow over the blade despite the fact the damper has come up against its limit-stop as in the position shown in FIG. 2. The continuity of airflow over the airfoil is required to make the airfoil work as such in response to the lift formula. An alternative to such twist of the blade may be employed, for example, the blade may be untwisted and a spacer device provided to hold the upper blade edge (FIG. 3) spaced from the cushion 16 even when the blade has moved to its extreme position counterclockwise as in such FIG. 2.

The invention thus is not limited to the employment of such twisting of the blade 11 as above described nor to the turning of the edges 11a.

Reverting to the above-described curve 35, this represents the performance of the invention at high wind velocities and at the highest velocity shown, namely, in the neighborhood of 25 to 30 m.p.h. the curve tends to veer back towards the vertical 100% line. This represents the gradual or progressive closing of the damper blade 11 when one end of the blade is against the upper limit-stop and the air forces tend to untwist the blade.

If the forces acting upon the damper are sufficiently great to close it all the way, then there would be no airflow over it and there would be no operation thereof as an airfoil.

The practical significance of the characteristics of the construction as represented by the curve 35 of FIG. 6 is that the present invention insures that the heat loss resulting from inflow of ventilating air is within precisely controlled limits. Hence, fuel losses attributable to this factor are minimized because precisely controllable. Apparatus of the prior art have not heretofore controlled heat loss attributable to unwanted ventilation air in this manner.

Furthermore, except in extraordinary climates, air velocities or wind velocities in excess of 25 to 30 m.p.h. are relatively uncommon. If they do occur, they will not affect appreciably fuel consumption in a building providing a system embodying the present invention is used therein. By means of the present invention, it is possible to achieve a positive and precise control of the inflow of

ventilation air, as shown in FIG. 6 and still remain within

the very low cost range (initial system and operation cost) of the lowest cost remote air conditioning systems presently being manufactured. There is a very substantial difference in the cost of prior art systems which accomplish the objectives of the present invention and the cost of a system embodying the present invention.

Reverting to alternative means for exerting a progressively increasing mechanical force or torque on the damper blade, such means can comprise in a separate and non-analogous form of the invention, for example, a wind velocity sensing device in a location remote from the damper and connected by suitable operative interconnection including, e.g., servo means to the damper blade. For example, there may be mounted on the roof of a building in which a remote unit, such as that of FIG. 5 is employed, a rotary wind velocity sensing device and this may be operatively interconnected to the aforementioned damper blade 11 by suitable means which will exert a mechanical torque or force upon it responsive to wind velocity thereby to control the angular position of the damper. If such air velocity sensing device were employed, it would not be necessary for the damper to have an airfoil cross-section. Thus such airfoil cross-section of the damper serves the function of being responsive to wind velocity, the angular position of such damper being a function of wind velocity in the environment of elements of FIGS. 1-5.

What is claimed is:

1. Apparatus for controlling the flow of air from a source to a room comprising a housing having an opening therein for the passage of air from said source through, a plate-like damper blade which is thin relative to its length and width and which is bent along a portion thereof disposed centrally of the length dimension thereof forming a longitudinally central ridge extending in the direction of the width dimension of the blade, pivot means engaging said blade at said ridge and supported from said housing at said opening for pivoting said blade around a pivot axis extending along said ridge, said blade having first and second portions extending in opposite directions away from said axis and said blade being rotatable about said axis from a first position in which the length and width thereof extend for substantially the full length and width of said opening and substantially closes said opening with one surface of said first portion facing away from said source to a second position in which the length of said blade extends generally in the direction of the air movement through said opening, said first portion is intermediate said source and said axis and said one surface of said first portion is intermediate said opening and an imaginary plane substantially perpendicular to a plane containing said opening and parallel to and intersecting said axis, the edge portion of said first portion of said blade most remote from said axis being bent oppositely to the direction of the bend forming said ridge, whereby in said second position said first portion of said blade has an effective cross-section transverse to said path corresponding to the cross-section of an airfoil, means connected to said blade for exerting thereon a variable mechanical moment urging said blade towards said second position, said moment increasing with the movement of

said blade away from said second position and being substantially equal to the moment exerted on said blade by the impingement of air thereon in different positions of said blade, and stop means connected to said blade for preventing movement of said first portion of said blade beyond said second position thereof in a direction away from said first position.

2. Apparatus for controlling the flow of air from a source to a room comprising a housing having an opening therein for the passage of air from said source through and along a substantially linear path extending from a point between said source and said opening to said opening and substantially perpendicularly to a plane containing said opening, a plate-like damper blade which is thin relative to its length and width and which is bent along a portion thereof disposed centrally of the length dimension thereof forming a longitudinally central ridge extending in the direction of the width dimension of the blade, pivot means engaging said blade at said ridge and supported from said housing at said opening for pivoting said blade around a pivot axis extending along said ridge, said blade having first and second portions extending in opposite directions away from said axis and said blade being rotatable about said axis from a first position in which the length and width thereof extend for substantially the full length and width of said opening and substantially closes said opening with one surface of said first portion facing away from said source to a second position in which the length of said blade extends generally in the direction of the air movement through said opening, said first portion is intermediate said source and said axis and said one surface of said first portion is intermediate said opening and an imaginary plane substantially parallel to said path and parallel to and intersecting said axis, the edge portion of said first portion of said blade most remote from said axis being bent oppositely to the direction of the bend forming said ridge, whereby, in said second position, said first portion of said blade has an effective cross-section transverse to said path corresponding to the cross-section of an airfoil, means connected to said blade for exerting thereon a variable mechanical moment urging said blade towards said second position, said moment increasing with the movement of said blade away from said second position and being substantially equal to the moment exerted on said blade by the impingement of air thereon in different positions of said blade, and stop means connected to said blade for preventing movement of said first portion of said blade beyond said second position thereof in a direction away from said first position.

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