United States Patent

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[45] Patented **Jan. 26, 1971**

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[54] **FAN FOR THE VENTILATION OF BUILDINGS, E.G. STABLES**
7 Claims, 5 Drawing Figs.

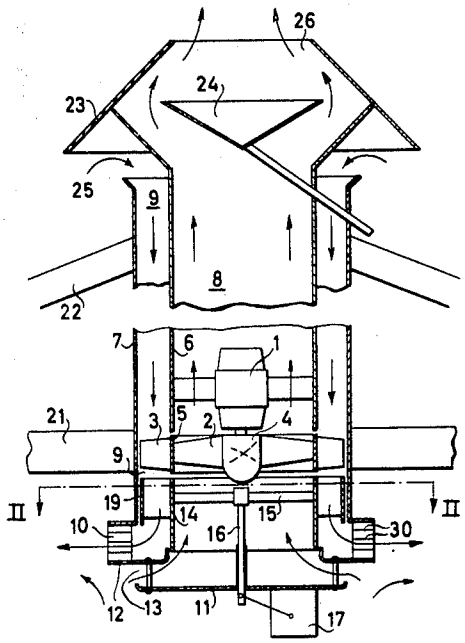
[52] **U.S. Cl.** **98/33,** 98/43; 230/122
[51] **Int. Cl.** **F24f 7/06**
[50] **Field of Search** 98/33, 43; 230/117, 122A, 114A, 114Z

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ABSTRACT: A fan for the ventilation of buildings, e.g. stables, comprising two concentrical tubes in which two sets of interconnected concentric fan vanes are disposed so as to perform an injection of air through the outer tube and an exhaust of air through the inner tube, a bypass being provided between the inner and the outer tube through a first damper which is coupled to a second damper in the outer tube and as the case may be also to one in the inner tube, in such a way that when the first damper is opened the other or others is or are closed and vice versa.

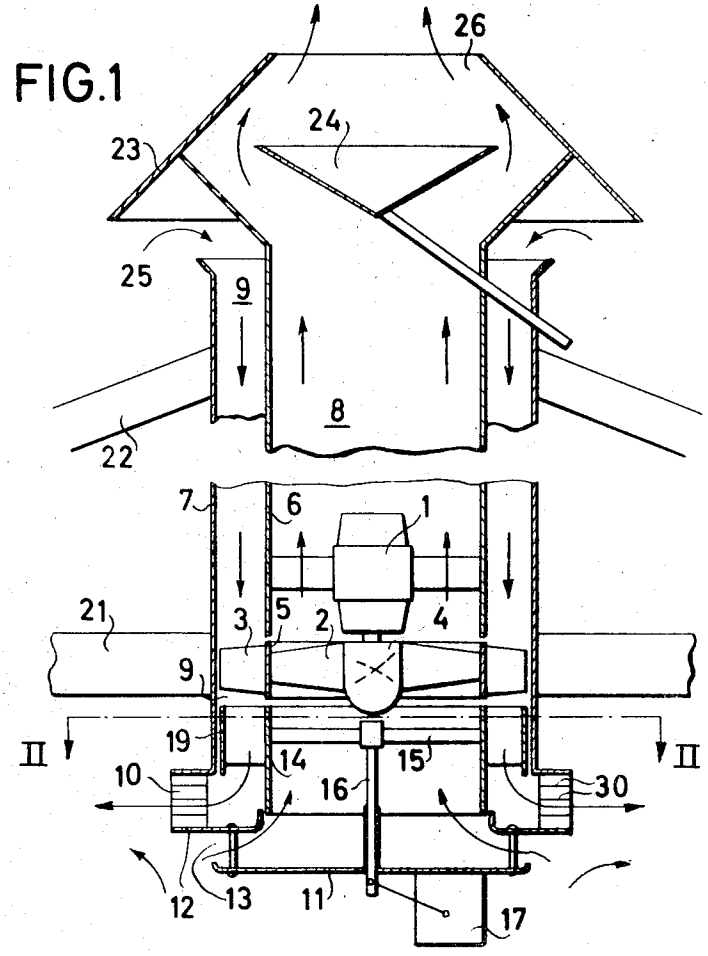


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FIG.1



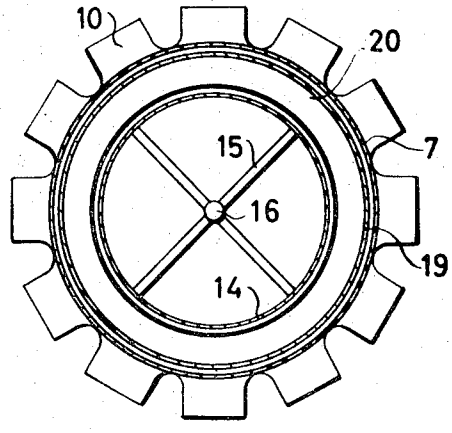


FIG.2

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FIG.3

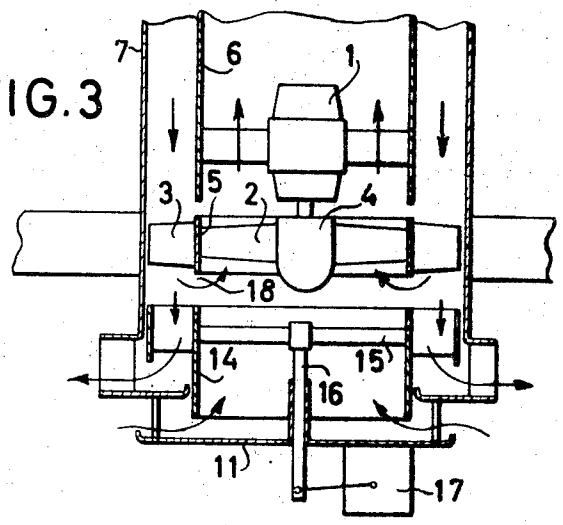
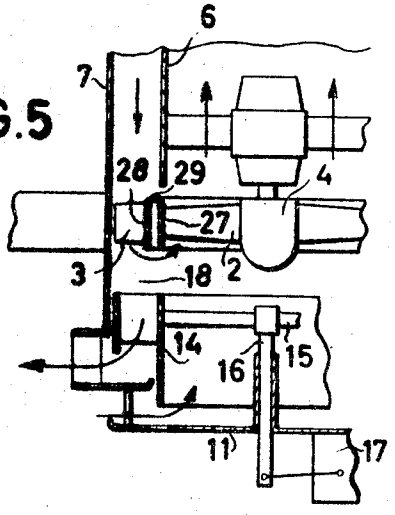


FIG.5



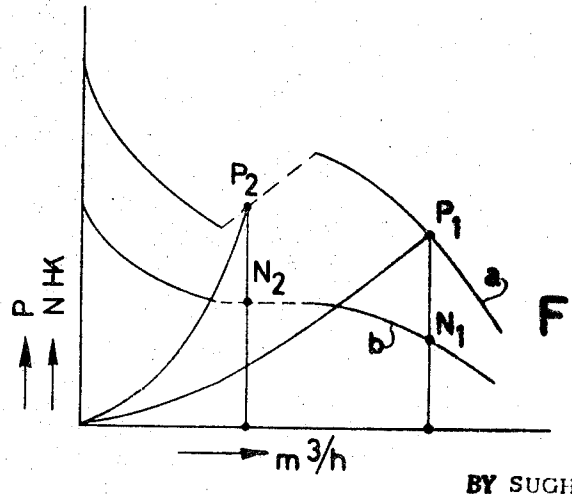


FIG.4

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FAN FOR THE VENTILATION OF BUILDINGS, E.G. STABLES

This application is a division of prior application, Ser. No. 700,549, filed on Jan. 25, 1968 now Pat. No. 3,487,767.

The invention relates to a fan for the ventilation of buildings, e.g. stables, in which the injection duct is fitted concentrically around the exhaust duct, in which exhaust duct the driving motor of the fan is fitted axially, which fan has two concentric, rigidly interconnected sets of vanes of the type used in axial flow fans, which are arranged in such a manner that one set of vanes is located in one duct and the other set of vanes is located in the other duct and in which fan in the injection duct one or more adjustable dampers are provided.

On account of the particular characteristic curve of the axial flow fans, the throttling, performed for the control of the air volume, occasions that the fan has to operate within the so-called stalling range during a great part of its operational period. In this range the fan runs rather jerkily and noisily. In addition, the power consumption of the fan rises considerably when throttled.

The invention aims at providing a type of fan of the type discussed, by means of which the desired control of the injected quantity of air is achieved without the mentioned drawbacks.

According to the invention the injection duct is connected with the exhaust duct between the set of vanes and the dampers mentioned through an adjustable damper, and the damping in the injection duct and in the connection between the two ducts are connected to each other and to a common adjustment means in such a way that simultaneously with the opening of the damper in the injection duct, the damper between the two ducts is closed, and vice versa.

Through this, a bypass is formed, which connects the pressure side of the set of vanes in the injection duct and the suction side of the set of vanes in the exhaust duct with each other, and by regulation of the damper in this bypass in dependence of the adjustment of the dampers in the injection duct it is made possible to operate with very slight variations in the pressure in the injection duct in front of the dampers fitted therein. The air volume delivered by the fan is determined by this pressure and the resistance to the outflow, and thus is chiefly proportional to the passage cross section at the dampers, which, moreover, entails a more suitable control than is the case with the known fans of the kind discussed, in which the throttling occasions a rise in pressure, so that no linear connection between the air volume delivered and the adjustment of the throttling means exists.

In addition, by means of the measures stated, a saving in the power consumption is achieved, since the power consumption of the axial flow fan, as known, rises with increasing pressure and consequently decreasing air volume on account of which the power consumption rises with the known fans when the throttling increases, while the pressure in the case of the fan according to the invention is maintained constant at a low value despite the injected air volume being throttled.

In an embodiment of the invention, a damper has also been provided in the exhaust duct, which is connected with said dampers and which respectively opens or closes simultaneously with the damper in the injection duct.

According to the invention it is advantageous that the total of the flow resistance through all the dampers is essentially constant irrespective of the adjustment of said dampers. It is thereby ensured that the fan operates constantly and essentially at the same point of its characteristic curve.

If this is employed in connection with a design of the fan in which the orifice or orifices of the injection duct runs or run in the main at right angles to the axis of the duct, it may be expedient, according to the invention, that the connection between the two ducts is formed by one or several apertures in the partition common between the two ducts, while the throttling means in this connection consists of a cylindrical piece of tubing, with a cross section corresponding to that of the common partition and which is displaceable in the axial direction in such a fashion that it can more or less cover the apertures,

and that the throttling means for the orifices consist of a cylindrical piece of tubing which adheres to the outer wall of the injection duct and is displaceable in the axial direction in such a manner that it is capable of more or less closing the orifices, in addition to which the two pieces of tubing are rigidly interconnected.

By this means a very simple construction of the coupled dampers is attained, and, in order to achieve the desired interrelation of the throttling means with the aid of the various dampers all that is required, is to appropriately dimension the aperture or apertures in the common partition between the two ducts.

Cited above, only the characteristic curve of the set of vanes in the injection duct has been taken into consideration. The characteristic curve of the set of vanes in the exhaust duct is of the same kind and plays a very important role in the dimensioning, since on account of the smaller diameter, the stalling range of the characteristic curve makes itself felt still more markedly. As to the regulating of the ventilation, it is sufficient, to be in a position to throttle the injection apertures and the supply of an additional volume of air via the connection between the injection duct and the exhaust duct employed according to the invention, entails no difficulties.

On account of other reasons, however, it is expedient to be able to close the exhaust apertures, so that during the periods in which the fan is not in use a draught occurs, and, if in this case a design is employed in which also the orifice or orifices of the exhaust duct proceeds or proceed at right angles to its axis, it is according to the invention expedient that the piece of tubing adhering to the partition common to both ducts is extended to such a degree that it can close the exhaust duct and in such a way that it is closed completely when the connection between the two ducts is opened completely.

If a damper independent of the other dampers were to be employed in the exhaust duct, the risk might arise that the set of vanes fitted in this duct would operate in the stalling range. However, this is entirely prevented in the stated embodiment of the invention, since, when the damper in the exhaust duct is closed gradually more and more, the connection between the two ducts is simultaneously being opened at the same rate, so that the inner set of vanes is being continuously supplied with that volume of air which suffices to allow it to operate at the desired point of its characteristic curve.

Since the connection between the two ducts is generally located in the immediate proximity of both sets of vanes, if the dampers are arranged between the sets of vanes and the injection nozzle of the injection duct, it can at times be difficult to achieve the desired control of the throttling of the connection between the two ducts. However, these difficulties can, according to the invention, be removed to a large extent by the injection duct possessing a larger cross section in its part located behind the set of vanes than at the level of the set of vanes.

This is being achieved in a very simple manner, in an embodiment of the invention in which the annular member connecting the two sets of vanes, possesses "U" shape, the one branch of which lies at the same distance from the axis as the common partition of the two ducts and the other branch of which has a greater distance from the axis, while the piece connecting the branches is turned against the direction of the flow in the injection duct.

A particularly advantageous embodiment of the invention is characterized in that the adjustable damper between the injection duct and the exhaust duct is arranged between the cap, and the set of vanes.

When the aperture of the said damper is made larger or smaller a larger or smaller part of the air drawn off from the building is blown back into same and at the same time a regulation of the quantity of fresh air drawn in takes place in the opposite direction, so that the volume of air blown into the room to be ventilated from the fan remains essentially more or less the same, irrespective of how much or how little fresh air is to be fed to it. This entails that the flow pattern remains al-

ways substantially the same, independent of the adjustment, whereby it is considered easier to adjust the fan in order to prevent a draught under all conditions, than in the cases in which the volume of air blown into the room is varied from zero up to a maximum value, whereby the flow pattern is a different one for each of the various adjustments so that the adjustment, which has to be effected in order to prevent the occurence of draught at all adjustments, can entail that the capacity of the fan is not being fully utilized.

Since it must be taken for granted that the fan is so dimensioned that it will satisfy the maximum ventilation requirement and that this requirement arises only on rare occasions when the weather is cool, the said damper is, as a rule, opened slightly and consequently the additional advantage is attained, that the drawn-in cold fresh air mixes itself with the stale air from the room into which it is being blown back, and thus being already slightly warmed up in the fan prior to being blown in to the room.

Moreover, the advantage is attained that the connection with the atmospheric air can be completely interrupted in those cases where no demand for fresh air exists, if one regard the ventilated room as a whole, yet the fan continues to effect the same circulation of the air so that the air in the room is in continual agitation and that the air from the various parts of the room is being mixed and thus more evenly distributed.

It can be particularly advantageous, according to the invention, that the dampers in both ducts and between same are each designed as one unit comprising two semicylindrical parts in which the diameter of the semicylindrical parts correspond to the diameter of the partition between both ducts and in which the semicylindrical parts are rotatable around an axis, which forms a diameter of both ducts as well as of these parts and which are so beveled at the top that the bevels form the same angle to both sides of the plane separating the two semicylinders when the parts are in a position in which they are aligned essentially with the partition between the ducts, and that each of the two parts, on the edges, with which it abuts upon the other part in the said position, is provided with flanges that extend to the outside and that the outer edges at these flanges and the lower edges of both parts are of such a shape, that in a position in which the beveled edges abut upon each other, their projection on to a normal plane in the ducts forms a circle, the radius of which is essentially equal to the outer radius of the injection duct.

By this means an extremely simple constructional solution of the in itself rather complicated problem is achieved to more or less block the passage through two concentric ducts and at the same time to open a connection between the two ducts through their cylindrical partition at the same rate.

Furthermore, it can be advantageous, according to the invention, to fit heating means in the injection duct between the set of vanes and the injection orifice. By means of this, the advantage which is due to the fact that the fresh air drawn in is being mixed with a greater or lesser part of the exhausted, stale air in the fan itself, is increased still further, since by the employment of heating means an appropriate preheating of the injected air is ensured even in those cases, where the ventilation requirement is so great that the damper between the two ducts is either closed or only opened slightly.

It can, furthermore, be advantageous, according to the invention, to have cooling means fitted in the injection duct between the set of vanes and the injection orifice.

In particular, if heating means have already been provided at this point with the aid of which, especially in stables, one is able to satisfy the heat supply requirement arising in connection with the ventilation, it is advantageous that cooling means do exist in the fan, so as to obviate the use of separate cooling means, and when the heating means happen to be heat exchangers through which a heating agent, e.g. warm water, is flowing, the same means can quite simply be utilized as cooling means, by having a cooling agent, e.g. cold water, flowing through same.

It is finally advantageous to have the orifice of the injection duct comprise 10—15 nozzles, the axes of which lie on a level at right angles to the axis of the duct like the radii of a circle which is concentric with the duct and that in each nozzle separately adjustable throttling means are provided. The optimum number of nozzles is 12, it is, however, possible to reduce this number to 10, or to increase it to 15 without any deleterious effect. If the number is too low, the jets continue through the room as individual jets and have the effect of a draught. If the number is too high, the jets merge on account of the flow induction immediately below the nozzles so that they form a continuous, plate-shaped stream, which fully corresponds to an air current occurring in front of an annular passage slit. Such a plate-shaped air stream often tends to deflect downwards shortly after leaving the nozzles, so that currents are being created in the room which have the effect of a draught.

On the other hand, if the number of nozzles lies within the limits indicated, the individual jets will only merge at a certain distance from the nozzles, where the velocity of the flow has become sufficiently low, so that the deleterious effects of the plate-shaped stream do not occur, but is still so high that the air flow does no longer continue through the room in the form of jets that are sharply defined against each other.

The invention will subsequently be explained in detail with reference to the drawing, which shows in:

FIG. 1 an embodiment of the invention in longitudinal section;

FIG. 2 a sectional view after the line II–II in FIG. 1;

FIG. 3 a part of the fan shown in FIG. 1 with a different setting,

FIG. 4 the characteristic curve of an axial flow fan;

FIG. 5 a part of the fan shown in FIG. 1 with a modified design of a detail,

The fan shown in FIG. 1, 2 and 3 has an impeller with two concentric sets of vanes 2 and 3 driven by a motor 1, in which impeller the vanes of the one set are, mounted on a hub 4 and are fastened at their outer extremities to a annular member 5, which carries the vanes of the set of vanes 3. The angle of pitch of these two sets differ by 180°, so that the two sets blow in directions which are opposed to each other, and in the example shown in such a manner that the inner set of vanes blows in an upward direction and the outer set of vanes blows in a downward direction.

Coaxially with the vane sets 2 and 3 has been mounted partly a tube 6, which is in alignment with the member 5, and partly a tube 7, which surrounds the outer vane set 3. In this manner an exhaust duct 8 and an injection duct 9 are formed. The injection duct 9 is at its lower part provided with a number of orifices in the form of nozzles 10, the axes of which lie on a plane at right angles to the axis of the fan, while the exhaust duct 8 is covered at its lower end by means of a plate 11 at a certain distance from the termination 12 of duct 9, so that an annular intake aperture 13 is formed.

The partition 6 is interrupted from the impeller downwards up to the termination of the duct 9, and the aperture thus resulting between the ducts 8 and 9 is screened by a cylindrical piece of tubing 14, the diameter of which is substantially the same as that of the partition 6 between both ducts. This piece of tubing is carried by a number of spokes 15, which are fastened to an adjustment rod 16, which, with the aid of an adjustment motor 17, is displaceable in the axial direction, so that the piece of tubing 14 can be displaced and the connection between both ducts 8 and 9 can be more or less opened or closed. FIG. 3 shows the fan in a position, in which the ducts 8 and 9 are in unobstructed connection with each other via the aperture 18, which is adjusted to approximately half of its possible size.

A cylindrical piece of tubing 19 has been provided on the inside of the partition 7, which piece of tubing with the aid of a number of radial plates 20 is connected with the piece of tubing 14 and which can thus be displaced together with same. The connection between the pieces of tubing 19 and 14 is of

such a kind that, when the aperture **18** is enlarged from its completely closed position to its completely opened position, the piece of tubing is displaced, downwards in front of the nozzles **10**, from a position in which the nozzles are fully open, to a position in which they are completely closed. Further the piece of tubing **14** is of such a length that it is able to slide, in the embodiment shown, downwards in front of the intake aperture **13**, so that the throttling of this aperture on the whole corresponds to the throttling of the exhaust apertures.

The fan shown is mounted in the ceiling **21** of a building. The ducts **8** and **9** are carried through the roof **22** of the building and are screened above the roof by means of cowling **23** and a screen **24**. Since the design of both cowling and screen does not concern the invention, it is superfluous to describe them in detail, it should, however, be briefly mentioned that the design is of such a kind that an intake aperture **26** for the injection duct **9** and an discharge aperture **26** for the exhaust duct **8** is formed.

In the following the effect of the measures taken by means of the invention are to be described in detail based on the characteristic curve shown in FIG. **4**. In this FIG. the curve shows the normal characteristic operating curve of an axial flow blower and the FIG. shows the pressure as the function of the air volume. The curve *b* shows the power consumption of the drive motor as function of the air volume.

The point P_1 indicates the operational point at full performance.

If the connection between the ducts **8** and **9** in FIG. **1**, indicated by the invention, does not exist, the regulation of the injected air volume can only be effected by the throttling of the injection nozzles **10** and in such throttling the operating point of the fan moves on the curve *a*. It can be seen from the curve that in the case of such throttling that the air volume is reduced to half, the operating point of the fan is at a point P_2 of the curve, which lies within the stalling range of the fan. At this point the fan runs unsteadily and very noisily. It can be seen from curve *b* that the power consumed by the drive motor thereby rises from the value N_1, which corresponds to its maximum performance, to the value N_2.

If however, one employs, as specified by the invention, a connection between the two ducts **8** and **9** and regulates the aperture thereof in dependence of the throttling of the injection apertures, one can achieve that the pressure behind the blower is maintained approximately constant at the value corresponding to point P_1 and that the air volume, which passes the blower vanes, corresponds to the value corresponding to this point. Despite this, the air volume injected is regulated in the desired manner, since it is on the whole proportional to the flow area determined by the damping means **19**. By this means it is possible to adjust the fan in such a way that it operates at all times with maximum efficiency and at a steady point of the curve at a low noise level, and that the power consumed by the drive motor is being kept at a low value.

The inner vane set **2** operates according to a curve of the same characteristic as the one shown in FIG. **4**, and even if the in connection with FIG. **1** and **3** described throttling is used in the intake duct **13**, so that the air volume drawn in is reduced in the same manner as the exhausted air volume is, this is supplemented in dependence of the air volume reduced through the adjustment by means of the air volume flowing through the direct connection from duct **9** into duct **8**, which is being regulated in the opposite direction; so that by appropriate dimensioning it can be achieved that the pressure below the interior fan blades **2** is kept approximately constant, so that this fan too operates to a certain extent at a firm point of the characteristic curve, resulting in the above-mentioned advantages.

At the same time it can be seen that more expedient progress of the throttling adjustment of the injection apertures **10** is being attained, since the air volume, as mentioned, varies linearily with the adjustment of the throttling means, which, as can be gathered easily from FIG. **4**, is not the case with the known fans, which do not possess a connection between the ducts **8** and **9** and in which the throttling not only entails a change in the flow section, but also a change in the pressure.

It can at times be difficult to achieve a sufficiently safe control of the throttling in the connection between the two ducts **8** and **9**, however, according to the invention it is shown that one can achieve a considerable improvement in this respect by the flow area of the injection duct at the level of the outer vane set **3** being smaller than in the part situated between impeller and injection apertures.

This can be expediently achieved by means of the embodiment shown in FIG. **5**, which only differs from the one shown in FIG. **1** in that instead of the cylindrical annular member **5**, which interconnects the two sets, an annular member is employed, which, in radial section possesses the form of a "U", the one branch **27** of which possesses a cylindrical form and has the same diameter as the partition **6** between both ducts and is fastened to the extremities of the vanes **2**, while the other branch **28**, which proceeds parallel to the first, also forms a cylinder, which, however, has a greater radius and carries the vanes **3**. The connection **29** between the two branches is turned against the flow direction in duct **9**. It proves that by such a measure it is easier to adapt the adjustment of the throttling means **14** to the adjustment of the throttling means **19**.

In a fan design like the one shown, the air is blown rather far away from the fan parallel to the ceiling of the building through nozzles **10** in rather sharply defined jets. If such a jet strikes a wall or some other obstacle, it may be deflected in a detrimental direction so as to create a draught, however, this can be prevented by providing individually adjustable throttling means in each of the nozzles. This way said throttling means may at the same time operate as guide vanes. By throttling the nozzles which are directed at a wall or some other obstacle, it can be ensured that the length of the sharply defined jets is shortened by so much that such deleterious deflections cannot occur.

Such a throttling will necessarily exercise a certain influence on the function of the fan since it is not accompanied by a adjustment of the connection between the ducts **8** and **9**. Thus, a change in pressure takes place, which entails that the operating point of the fan on curve *a* in FIG. **1** is displaced. Since in practice such a throttling is to occur only in a few of the nozzles **10** which are present in a fairly large number, the shifting of the operating point is of only a very limited magnitude, so that it can under no circumstances bring the fan into the critical range and the automatic control with the aid of the throttling means **9** and **14** consequently continues to take place in precisely the same manner as described above, i.e. the new operating point lies essentially fixed on the curve, irrespective of the control.

I claim:

1. Apparatus for the ventilation of a building, comprising an injection duct; and exhaust duct disposed within said injection duct in substantially concentric relation therewith, said exhaust duct having an aperture in communication with said injection duct; and axial flow fan having a first set of vanes disposed in said exhaust duct and adapted to effect air flow from the building through said exhaust duct when said fan is driven, and a second set of vanes secured to and surrounding said first set of vanes, said second set of vanes being disposed in said injection duct and being adapted to effect an air flow into the building through said injection duct when said fan is driven; means for driving said fan; and damping means movably mounted in said injection duct and being adjustable to effect opening and closing of said injection duct and simultaneous closing and opening, respectively, of said exhaust duct aperture; said damping means comprising a first section movably mounted in said exhaust duct to effect opening and closing of said exhaust duct simultaneously with the opening and closing, respectively, of said injection duct, said first section of said damping means being tubular and having a cross section corresponding to that of said exhaust duct and being in longitudinal alignment therewith, said first section being longitudinally movable toward and away from said exhaust duct aperture to effect closing and opening thereof.

2. Apparatus according to claim **1** wherein said exhaust duct comprises an inlet opening extending substantially trans-

versely to the longitudinal axis thereof, and wherein said first section of said damping means is movable into and out of the flow path through said inlet opening to effect closing and opening of said exhaust duct.

3. Apparatus according to claim 2 wherein said injection duct comprises an exit opening extending substantially transversely to the longitudinal axis thereof, and said damping means comprises a second tubular section disposed in surrounding substantially concentric relation with said first tubular section and secured thereto for movement therewith, said second tubular section being disposed in said injection duct and being longitudinally movable into and out of the flow path through said exit opening to effect closing and opening of said injection duct.

4. Apparatus according to claim 3 wherein said damping means is disposed between said exhaust duct aperture and said inlet and exit openings of said exhaust and injection ducts, whereby movement of said damping means to close or open said exhaust duct aperture results, respectively, in simultaneous opening or closing of said exhaust and injection ducts.

5. Apparatus for the ventilation of a building, comprising an injection duct, an exhaust duct disposed within said injection duct in substantially concentric relation therewith, said exhaust duct having an aperture in communication with said injection duct; and axial flow fan having a first set of vanes disposed in said exhaust duct and adapted to effect air flow from the building through said exhaust duct when said fan is driven, and a second set of vanes secured to and surrounding said first set of vanes, said second set of vanes being disposed in said injection duct and being adapted to effect an air flow into the building through said injection duct when said fan is driven; the flow area of said injection duct being reduced at the portion thereof adjacent said second set of vanes; means for driving said fan; and damping means movably mounted in said injection duct and being adjustable to effect opening and closing of said injection duct and simultaneously closing and opening, respectively, of said exhaust duct aperture.

6. Apparatus for the ventilation of a building, comprising an injection duct; and exhaust duct disposed within said injection duct in substantially concentric relation therewith, said exhaust duct having an aperture in communication with said injection duct; and axial flow fan having a first set of vanes disposed in said exhaust duct and adapted to effect air flow from the building through said exhaust duct when said fan is driven, and a second set of vanes secured to and surrounding said first set of vanes, said second set of vanes being disposed in said injection duct and being adapted to effect an air flow into the building through said injection duct when said fan is driven; said first and second sets of vanes being connected by an annular member that is U-shaped in cross section, with an inner annular branch secured to said first set of vanes and an outer annular branch secured to said second set of vanes, said inner branch being substantially the same size as an in axial alignment with said exhaust duct, said outer branch being disposed within said injection duct, and said branches being connected by an annular connecting portion at the end thereof closest to the intake of said injection duct; means for driving said fan; and damping means movably mounted in said injection duct and being adjustable to effect opening and closing of said injection duct and simultaneous closing and opening, respectively, of said exhaust duct aperture.

7. Apparatus for the ventilation of a building, comprising: an injection duct having approximately 10 to 15 nozzles at the exit end thereof, the axes of said nozzles lying in a plane which is perpendicular to the longitudinal axis of said injection duct, like radii of a circle that is concentric with said injection duct, and separately adjustable throttling means in each of said nozzles; an exhaust duct disposed within said injection duct in substantially concentric relation therewith, said exhaust duct having an aperture in communication with said injection duct; an axial flow fan having a first set of vanes disposed in said exhaust duct and adapted to effect air flow from the building through said exhaust duct when said fan is driven, and a second set of vanes secured to and surrounding said first set of vanes, said second set of vanes being disposed in said injection duct and being adapted to effect an air flow into the building through said injection duct when said fan is driven; means for driving said fan; and damping means movably mounted in said injection duct and being adjustable to effect opening and closing of said injection duct and simultaneous closing and opening, respectively, of said exhaust duct aperture.