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Fujii

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[45] **Feb. 27, 1973**

[54] **AUTOMATIC AIR FLOW SMOOTHING APPARATUS**

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[21] Appl. No.: **110,064**

[52] **U.S. Cl.**.....**137/512.1,** 137/517, 251/DIG. 2

[51] **Int. Cl.**.....**F16k 17/06,** F16k 17/08

[58] **Field of Search**.....137/517, 518, 527, DIG. 7, 137/DIG. 2, 512.1; 251/337

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Assistant Examiner—William H. Wright
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[57] **ABSTRACT**

The present invention relates in general to an automatic air flow smoothing apparatus assuring a constant output air flow and more particularly to an automatic air flow smoothing apparatus, assuring a constant output air flow achieved by a suitable built-in automatic flow regulating means, despite an eventual change in the pressure of the input air flow.

6 Claims, 12 Drawing Figures

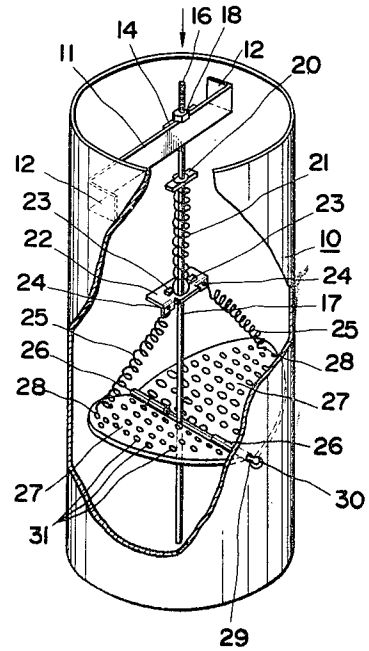


FIG. 1a

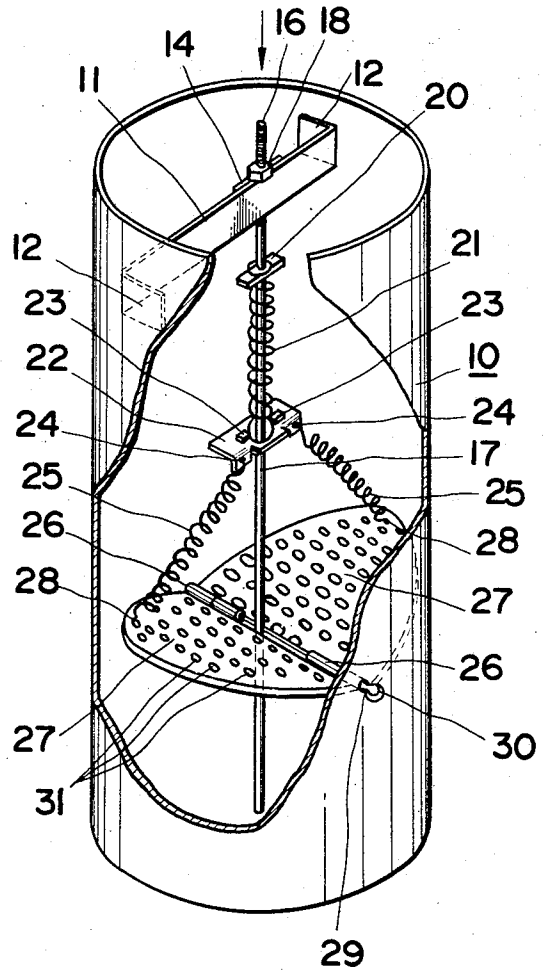
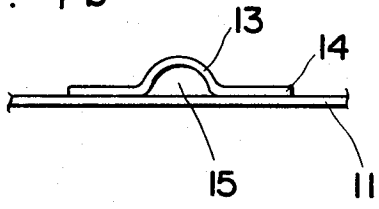


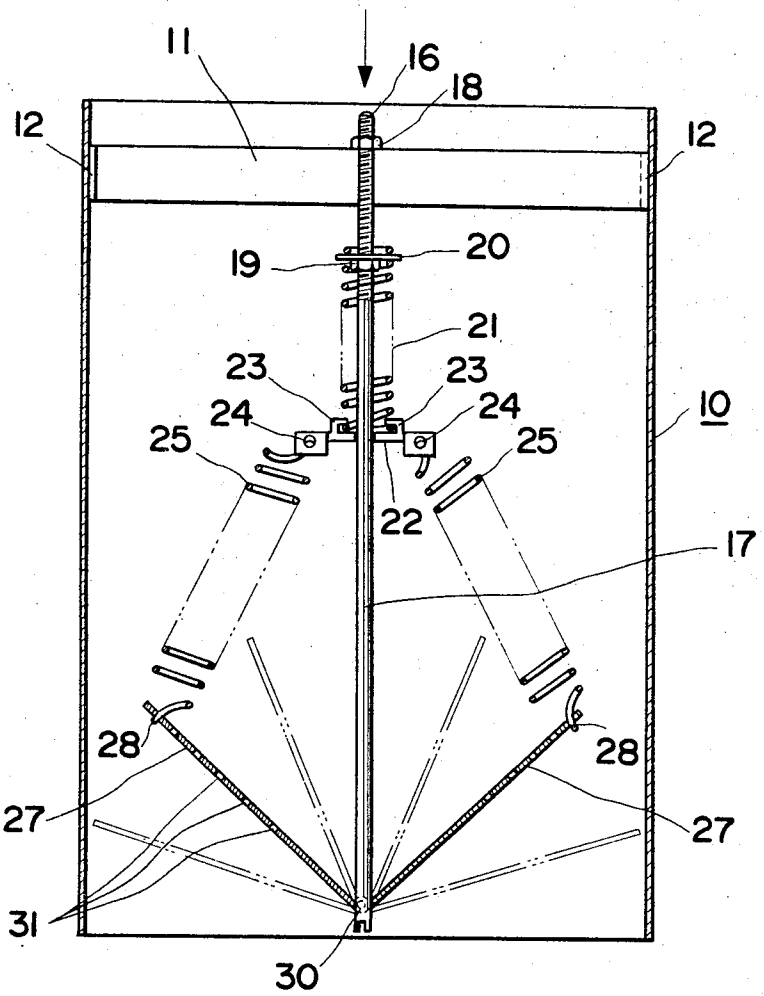
FIG. 1b



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FIG. 2



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FIG. 3a

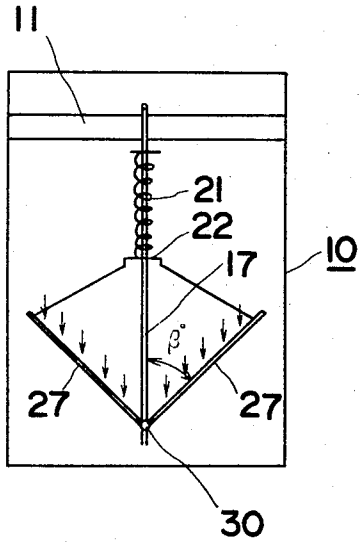
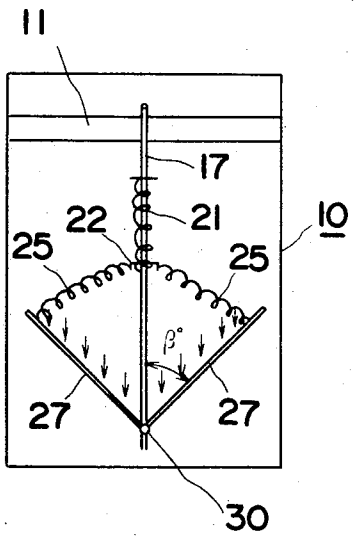


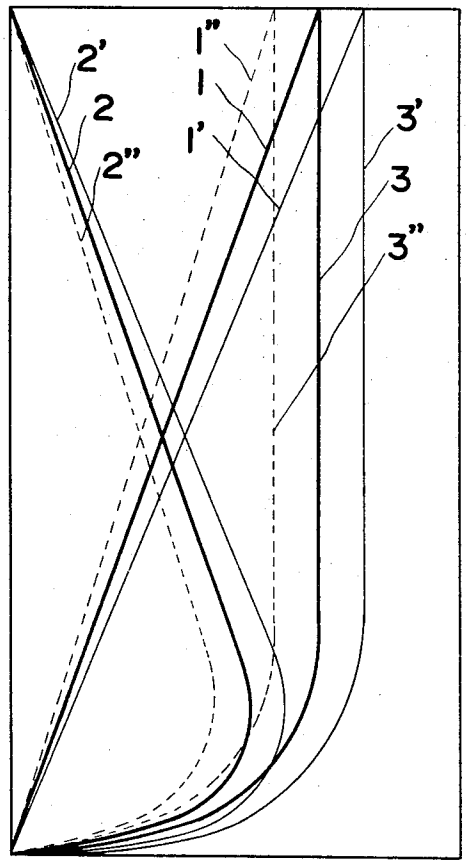
FIG. 3b



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FIG. 4

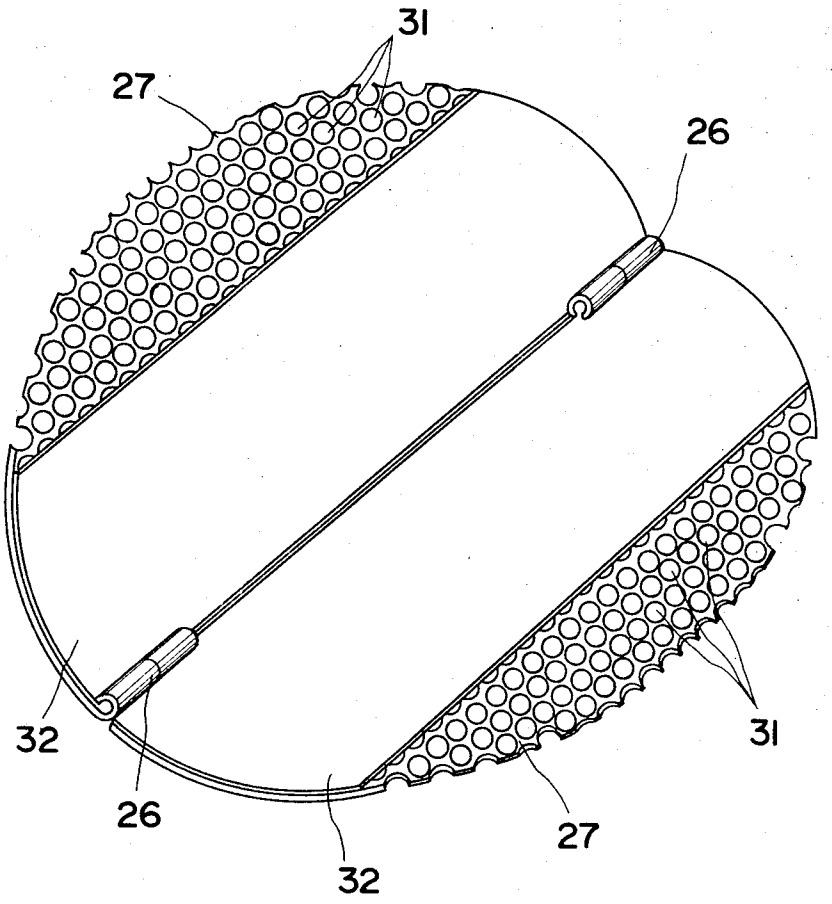


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FIG. 5

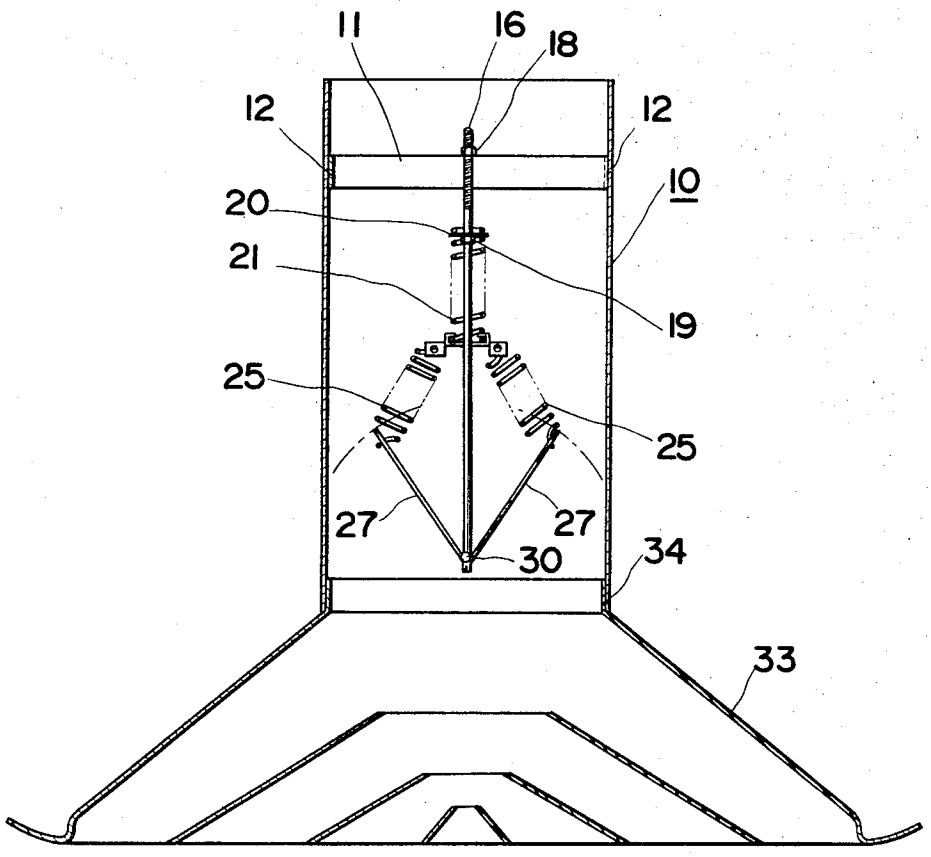


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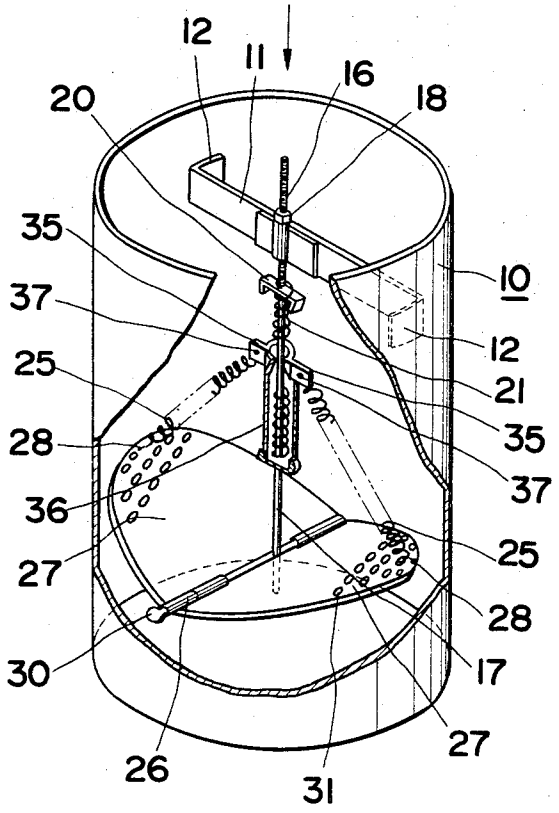
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FIG. 6



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FIG. 7

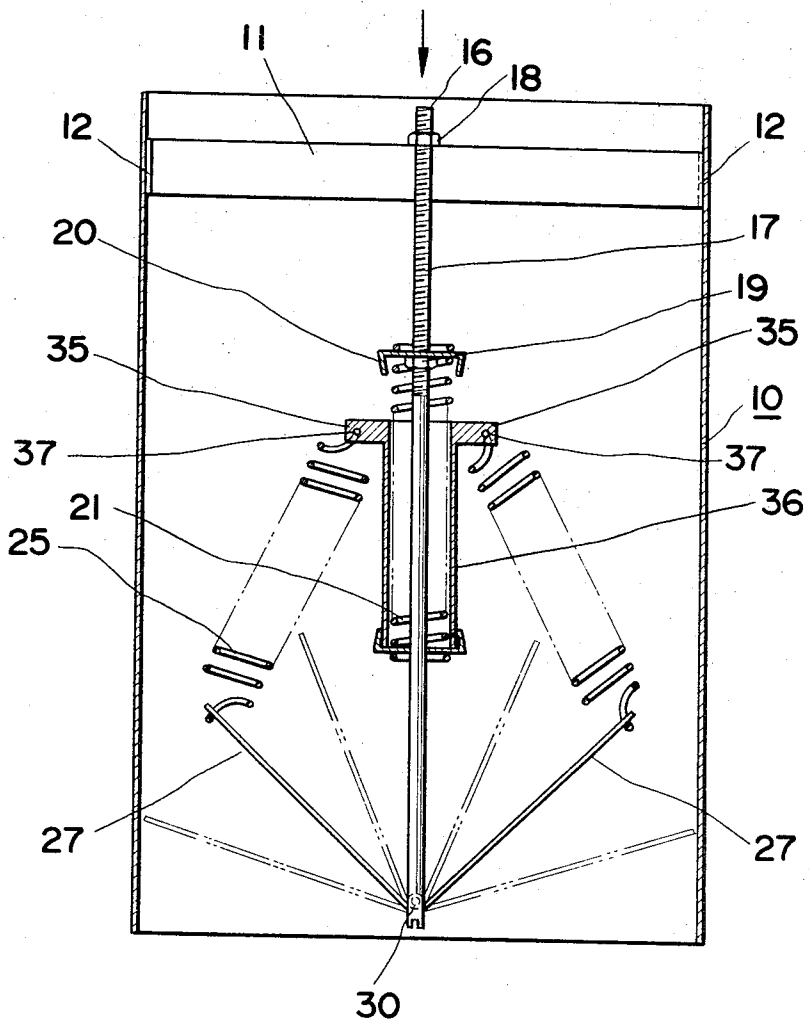


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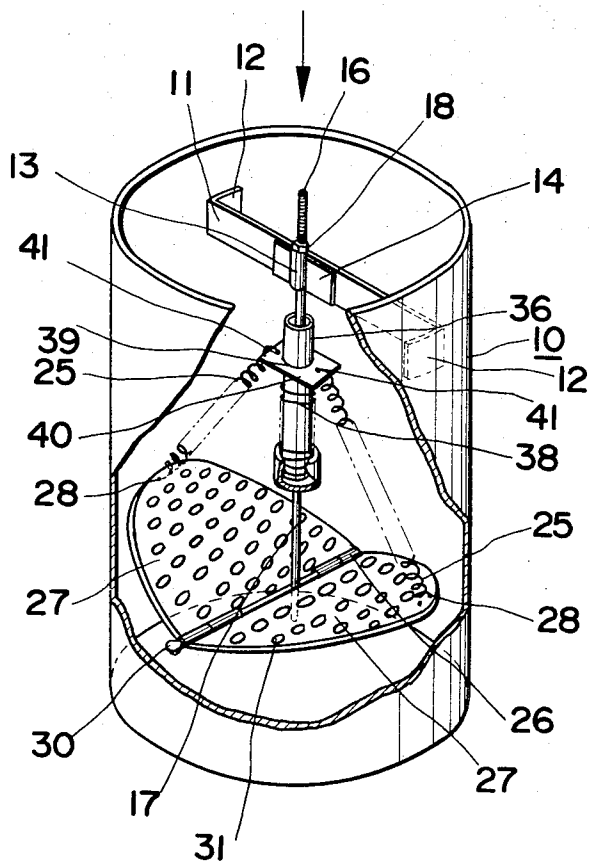
FIG. 8



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FIG. 9

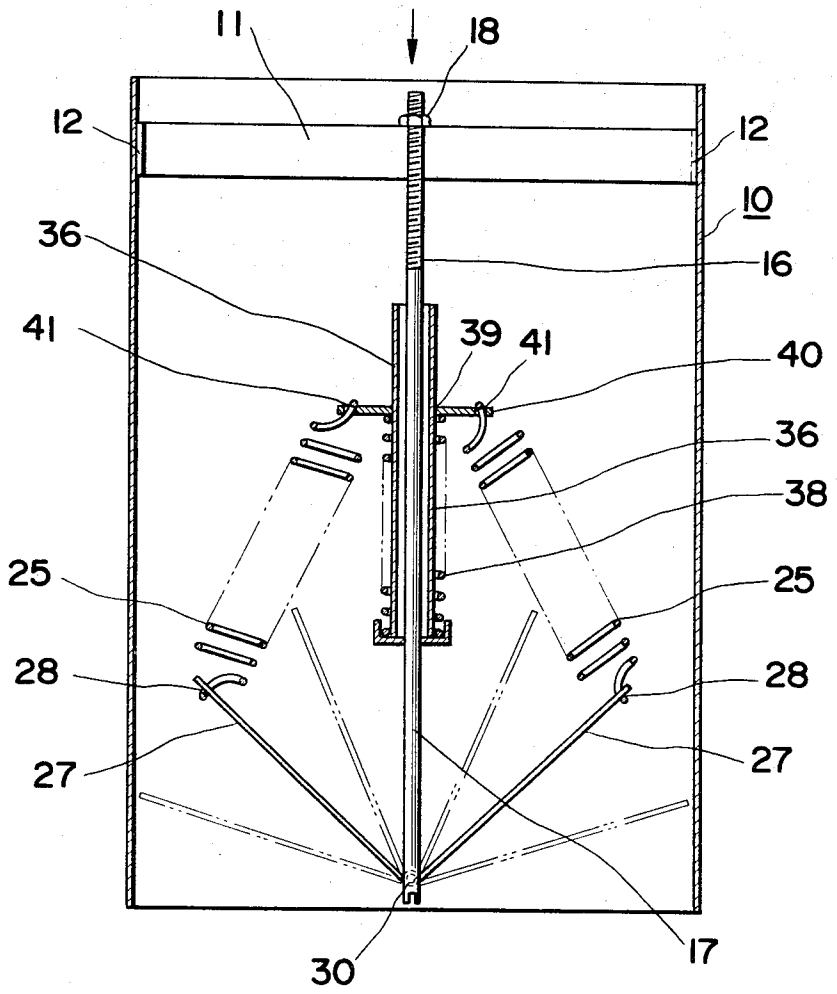


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FIG. 10



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AUTOMATIC AIR FLOW SMOOTHING APPARATUS

BACKGROUND OF THE INVENTION

Without a proper means, it is extremely difficult for an apparatus to smooth the output air flow, ensuring a constant output flow in spite of the highly probable change in the pressure of the input air flow.

The conventional apparatus of this type has deficiencies which require worrisome manual readjustment of the output air flow on every occasion of changed pressure of the input air flow which means the intolerably great operating inconvenience and imperfection, and also exerts an unfavorable effect on the next air flow smoothing apparatus in a ventilation or similar system due to said manual readjustment. For example, a readjustment of said apparatus for a reduction of the output air flow always results in a corresponding rise in the same of next apparatus and another readjustment of said apparatus for a rise of the output air flow always results in a corresponding drop in the same of next apparatus.

SUMMARY OF THE INVENTION

The primary object of invention is to provide a novel and improved automatic air flow smoothing apparatus, quite free from the functional imperfection inherent in the conventional types of said apparatus, low in cost and capable of being controlled with a high degree of smoothness and dependability. Another object of the present invention is to provide a unique automatic air flow smoothing apparatus assuring a constant output air flow, regardless of the level of the pressure of the input air flow, achieved by joint action of an automatic change of the position of perforated flap disc halves linked with coiled springs to balance with said pressure which in turn gives rise to a corresponding change in the air passage through the perforations in said disc halves and a corresponding change in the gap between the contour of said disc halves and the inside surface of the cylindrical casing containing them.

Still another object of present invention is to provide a new automatic air flow smoothing device capable of being adjusted to provide a desired constant output air flow by means of an adjusting threaded rod linked with and suspended from a diametral member located at the inside top of a cylindrical casing and carrying a primary coiled spring mounted at approximately the middle section thereof, with one end thereof secured, and connected, on another end thereof and through a suitable segment, with two secondary coiled springs, one on the right and the other on the left, which in turn are anchored to the respective two perforated flap disc halves hinged together and which can be properly adjusted to a desired pulling force thereof applicable to said disc halves by a change of the vertical position of said primary coiled spring by properly turning a nut mounted at the top of said adjusting threaded rod.

Still another object of the present invention is to provide an improved automatic air flow smoothing apparatus which is quite compact with respect to the total capacity thereof, by virtue of design ingenuity in that the primary coiled spring is mounted on the adjusting threaded rod at the approximate center section thereof and contained in the cylindrical casing of the apparatus.

A further object of the present invention is to provide a novel automatic air flow smoothing apparatus ensuring a highly reduced cost of a system comprising said apparatus yet assuring an unusually high dependability in performance which can be satisfactorily achieved with an unprecedentedly low minimum static pressure required to cause the perforated flap disc halves to start the swing action thereof, representing one of the key points of the present invention. This is realized by a unique feature that said disc halves hinged together can be placed under the influence of the pressure of input flow with an unusually high sensitivity to react to an unprecedentedly low pressure, as compared with any conventional air flow smoothing apparatus.

Any one and all of the above mentioned objects may be achieved by virtue of various parts, improvements, combinations and functions of the embodiment of the present invention.

Other objects and a fuller understanding of the present invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings. The output air flow smoothing apparatus according to the present invention comprises a cylindrical casing combined with an air supply duct, an adjusting threaded rod on an axial center line of said cylindrical casing and suspended from said duct, a primary coiled spring mounted on the approximate center section of said threaded rod, with one end thereof properly fixed, two secondary coiled springs, one on the right and the other on the left, connected to and suspended from said primary coiled spring through a suitable link segment and two perforated flap disc halves hinged together to anchor said two secondary coiled springs and installed in said cylindrical casing and pivoted on a hinge pin thereof for free swinging according to the magnitude of the applied pressure of the input air flow for the ultimate purpose of automatically controlling the available output air flow to a given level.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1*a* is a partly cut-away perspective view showing the inside of an automatic air flow smoothing apparatus according to the present invention.

FIG. 1*b* is a plan showing the diametral member shown in FIG. 1*a*.

FIG. 2 is a vertical sectional view of the automatic air flow smoothing apparatus illustrated in FIG. 1*a* and illustrates the angular positions of the perforated flap disc halves for max. and min. air flow through the perforated flap disc halves as represented by an imaginary line (dash - and -line).

FIG. 3*a* is a vertical sectional view of a conventional automatic air flow smoothing apparatus comprising a single coiled spring.

FIG. 3*b* is a vertical sectional view of an air flow smoothing apparatus according to the present invention comprising one primary coiled spring and two secondary coiled springs.

FIG. 4 is a graph illustrating the constant output air flow characteristics of the air flow smoothing apparatus and shows the correlation between the angular position of the perforated flap disc halves and the available output air flow.

FIG. 5 is an illustration of a method of how the air flow passage through the perforated flap disc halves can be controlled.

FIG. 6 is a vertical sectional view of an automatic air flow smoothing apparatus according to the present invention combined with an air diffusing means.

FIG. 7 is a partly cut-away perspective view of an automatic air flow smoothing apparatus representing one of the variations of the embodiment of the present invention.

FIG. 8 is a vertical sectional view of the automatic air flow smoothing apparatus illustrated in FIG. 7.

FIG. 9 is a partly cut-away perspective view of an air flow smoothing apparatus representing another variation of the embodiment of the present invention.

FIG. 10 is a vertical sectional view of the automatic air flow smoothing apparatus shown in FIG. 9.

DESCRIPTION OF THE EMBODIMENT

In FIG. 1 and FIG. 2, an air flow smoothing apparatus according to the present invention comprises a diametral member 11 (a rectangular strip) having both ends 12 bent at a right angle and welded to the inside surface of the cylindrical casing 10. Said member has a center segment 14 welded thereto having a semicircular portion 13 to provide a semicircular space 15 and has a nut 18 thereon fixed to hold the top thread 16 of the adjusting threaded rod 17 going through said semicircular space. On the upper section of the adjusting threaded rod and particularly below diametral member 11 is welded a top seat 20 for a primary coiled spring. On said adjusting threaded rod 17 is mounted the primary coiled spring 21 secured, at the top thereof, to top seat 20 and having suspended from the bottom thereof, a ported segment 22 having hooks 23 fabricated by cutting parts out of said segment to leave a hole through which said threaded rod 17 extends downwards. Said ported segment 22 in turn has two secondary coiled springs 25 engaged therewith at the small holes 24, 24 drilled therein and, at the bottom thereof, in small holes 24 drilled therein and the bottom of said springs are secured in the holes 28 provided in two perforated flap disc halves 27 connected together by means of the hinges 26 located in the lower half of the cylindrical casing. Said perforated disc halves 27 are held in place for free swinging by means of pins 30 inserted from outside into the hinge joints 26 through the holes 29 drilled in the wall of the cylindrical casing.

The perforated flap disc halves 27 are swung to a certain angular position thereof as defined by a balance achieved by joint action of the pressure of input air flow in the direction represented by the arrow shown in FIG. 1a and FIG. 2 and pulling forces provided by all three coiled springs, primary and secondary. A system set up by the single primary coiled spring 21 and the two secondary coiled springs 25 combined in a star connection as compared with another spring system with single coiled spring 21 shown in FIG. 3a differs in function as described in the following.

Both systems of the coiled springs apply an equal load W kg to the perforated flap disc halves 27, which, however, depends on the angular position of said flap disc halves as balanced and the pressure P kg/cm^2 applied thereto by input air flow and effective perforation rate X percent as expressed by the following equation.

$$W = P\pi ab \times \sin\beta \quad (1)$$

where ab is the total area of the perforated flap disc halves.

With the single coiled spring system, the elongation δ mm of the coiled spring complies with the following equation:

$$\delta = (64nR^3P\pi ab \times \sin\beta / d^4 G) \quad (2)$$

where

n: = effective turns of coiled spring
R: = radius of coiled spring mm
W: = applied load kg
d: = diameter of spring wire mm
G: = shearing moduls kg/mm
β: = angular position of perforated flap disc halves

The spring constant K kg/mm for the single coiled spring system can be expressed by the equation:

$$K = W/\delta = (d^4 G/64nR^3) \quad (3)$$

On the other hand, with combined primary and secondary coiled springs in a star connection, for a given angular position of the two perforated flap disc halves 27 the distribution of the load among the primary coiled spring 21 and two secondary coiled spring 25 can be given by formulas (4) and (5).

For the primary coiled spring 21, the load Wp (kg) is

$$W\text{p} = (2-\sqrt{2})\, P\pi ab \times \sin\beta \quad (4)$$

and for each secondary coiled spring, the load Ws (kg) is

$$W = \frac{(2-\sqrt{2})P\pi ab \times \sin\beta}{2} \quad (5)$$

The spring constant KM of the primary coiled spring 21 can be given by the equation

$$Kp = \frac{(2-\sqrt{2})d4G}{64nR3} \quad (6)$$

resulting from putting of Wp given by equation (4) into the equation (3).

Another spring constant Ks of each secondary coiled spring 25 may be determined by the equation.

$$Ks = \frac{(2-\sqrt{2})d4G}{128nR3} \quad (7)$$

resulting from putting of W given by the equation (5) into equation (3).

Therefore, the comparison of the spring constant kg/mm among the different springs gives the following results, with the single coiled spring taken as a reference represented by 1.

single coiled spring	1
primary coiled spring	$2-\sqrt{2}$
secondary coiled spring	$\frac{2-\sqrt{2}}{2}$

The spring constant K kg/mm of the primary coiled spring may be about three-fifths that of the single coiled spring and that of the secondary coiled springs be two-sevenths that of the single coiled spring.

As mentioned above, a system of combined primary and secondary coiled springs is favored by the reduced spring constant K kg/mm as compared with another system a single coiled spring; this means that the former system is more sensitive to any reduced pressure of input air flow as represented by higher response of the primary and secondary coiled springs to the applied lower pressure of said air flow resulting in quicker and

more delicate response of the perforated flap disc halves 27 because of the lower spring constant K kg/mm, with the result of extremely improved stability of output air flow at a constant rate for a reduced pressure of input air flow and compactness of the apparatus as compared with the same comprising a single coiled spring.

Correlation between the angular position of the perforated flap disc halves and corresponding air flow therethrough is graphically illustrated in FIG. 4 in which the left and right coordinate axes show the pressure loss across said disc halves and the angular position respectively, while the abscissa represents the output air flow.

FIG. 4 gives the curves designed to facilitate the understanding of the performance of the automatic control for the output of the air flow offered by the automatic air flow smoothing apparatus according to the present invention.

With the perforated flap disc halves 27 at the angular position thereof corresponding to the minimum pressure of input air flow as represented by the imaginary line in FIG. 2, said disc halves provide the max. air flow around them and the reduced air flow through the perforations 31 in them.

With the gradual rise of the applied pressure of input air flow, the perforated flap disc halves 27 are swung to another position thereof to provide a reduced air flow around them accordingly, overcoming the pulling force of the combined primary 21 and secondary coiled springs 25 with the result that the air flow through the perforations 31 rises along the curve 1 in FIG. 4.

Another air flow through the clearance between the inside surface 10 of the cylindrical casing and the contour of the perforated flap disc halves 27 changes along the ascending section of the curve 2 in FIG. 4 showing a rising trend of said air flow according to the gradual rise of the applied pressure of input air flow along the curve 2, but a certain level of pressure having been exceeded, perforated disc halves 27 are both swung towards another position thereof, overcoming the pulling force of the combined primary and secondary coiled springs, resulting in gradual reduction of air flow around said disc halves 27 because of the angular position thereof.

It is to be specially noted that a low pressure of input air flow to the automatic air flow smoothing apparatus according to the present invention gives rise to several times greater air flow through the clearance around the contour of the perforated flap disc halves as that through the perforations in the perforated flap disc halves, because of said clearance being larger than the total area of the perforations 31 in said disc halves 27. The total of the two different air flows is the available output of the automatic air flow smoothing apparatus according to the present invention and follows characteristically the curve 3 in FIG. 4 until the minimum pressure required for maintaining a constant output air flow is reached, after which said loss can be kept constant regardless of the applied pressure of input air flow.

With the further rise of the pressure of input air flow, the perforated flap disc halves 27 are swung towards another position thereof, overcoming the pulling force of the combined primary 21 and secondary coiled springs 25 for reduced air passage around them thereby causing a rise of the air flow through the perforations 31 in said disc halves 27 along the curve 1 in FIG. 4.

With the swing of the perforated flap disc halves 27 mentioned above, the clearance between the inner surface of the cylindrical casing 10 and the contour of perforated flap disc halves 27 is gradually reduced accordingly, resulting in the gradual reduction of air flow through said clearance along the curve 2 in FIG. 4 to provide an output air flow along the curve 3 in FIG. 4 which is a composite of the two curves 1 and 2 in FIG. 4. Additional rise of pressure of input air flow causes the perforated flap disc halves 27 to be swung to mid-position in the stroke of swing thereof, overcoming the pulling force of the combined primary 21 and secondary coiled spring 25, and results in the equality between the air flow through the perforations 31 drilled in said disc halves and that through the clearance around said disc halves 27 as represented by an intersection of the curve 1 and 2 in FIG. 4 and the total of said two different air flows will always be constant as shown by the curve 3 in FIG. 4, despite the raised pressure of input air flow.

Having been subjected to the additionally raised pressure of input air flow, the perforated flap disc halves 27 are then moved to another angular position thereof as represented by an imaginary line in FIG. 2 to provide a minimum air flow therethrough, overcoming the pulling force of the combined primary coiled spring 21 and secondary coiled springs 25, 25, with the result that the clearance between the inner surface of the cylindrical casing 10 and the contour of the perforated flap disc halves 27 is reduced to zero, meaning zero air flow through said clearance which is shown by the curve 2 in FIG. 4.

At the angular positions of the perforated flap discs halves mentioned above, the air flow through the perforations 31 drilled in said disc halves 27 is increased along the curve 1 in FIG. 4 and the total output of the air flow of the automatic air flow smoothing apparatus according to the present invention can be kept constant as illustrated by the curve 3 in FIG. 4.

If some of the perforations in the perforated flap disc halves 27 are covered with a tape film 32, as shown in FIG. 5 the effective area of air passage through said disc halves 27 is reduced owing to the reduced number of the exposed perforations 31, which results in reduced air flow through said perforations 31 and reduced constant air flow as an output of the automatic air flow smoothing apparatus according to the present invention.

In FIG. 4, the slope of the curve 1 approaches a vertical starting at the origin of coordinates, with the gradual reduction of the total effective area of the perforations. This means a reduced air flow through the perforated flap disc halves 27.

The reduced total effective area of the perforations in the perforated flap disc halves 27 is in turn a cause of the increase in the area of said disc halves 27 subject to pressure of input air flow because of which the air passage around said disc halves 27 is reduced as they are swung to lower angular position, exceeding the pulling force of the combined primary coiled spring 21 and secondary coiled springs 25 resulting in reduced air flow through the clearance between the inner surface

of the cylindrical casing 10 and the contour of said disc halves 27 and in the deviation of the curve 2'' towards the left coordinate axis to provide the curve 3'' which represents the resultant of curves 1'' and 2'', suggesting the reduction in the output air flow through the said clearance and constancy of the total (output) air flow.

With all the perforations 31 drilled in the perforated flap disc halves 27 covered with the tape film 32, the effective area of air passage through said disc halves 27 is zero. The condition of zero effective area of said air passage corresponds to the gradual erection of the curve 1 in FIG. 4 until it just overlaps the left coordinate axis with the gradual reduction in the effective area of air passage through the perforated flap disc halves 27.

When curve 1 in FIG. 4 reaches the vertical, namely coordinate axis, this represents the condition when air flow through the perforations 31 in the perforated flap disc halves is reduced to zero and the air flow through the clearance between the inner surface of the cylindrical casing 10 and the contour of said disc halves is reduced to a minimum within the range of constant flow regulation, meaning the maintenance of the constant output air flow of the air flow smoothing apparatus according to the present invention.

In short, the minimum air flow at constant rate is ensured not by the air flow through the perforations 31 in the perforated flap disc halves 27, but only by another air flow through the clearance between the inner surface of the cylindrical casing 10 and the contour of said disc flaps 27 represented by the curve 2 in FIG. 4 overlapping another curve 3, assuring the constant output air flow of the automatic air flow smoothing apparatus according to the present invention, regardless of the pressure of the input air flow.

On the other hand, maximum air flow at constant rate is ensured by the 100 percent passage through all the perforations 31 in the perforated flap disc halves 27; an increase in the size of every perforation 31 in said disc halves 27 means an additional total area of all the perforations 31 which in turn provides a maximum output air flow at constant rate increased accordingly.

On the contrary, a decrease in the size of all the perforations 31 in the perforated flap disc halves 27 means a reduction in total area of said perforations 31 providing the same effect as reduction of said area by covering some of them with the tape film 32 which in turn reduces the output air flow at a constant rate accordingly.

The minimum output air flow at a constant rate is obtained when all the perforations 31 in the perforated flap disc halves 27 are covered with the tape film 32: this is equivalent to the condition of the use of the disc halves without perforations drilled therein.

A fine adjustment of the output air flow can be accomplished by properly turning the adjusting threaded rod 17 in FIG. 1*a* and FIG. 2 in order to lower or raise said threaded rod 17 with the top seat 20 thereon to set the primary coiled spring 21 to a desired height.

When the top seat 20 is moved upwards together with the adjusting threaded rod 17, the primary coiled spring 21 also moves upward accordingly, resulting in a rising movement of the link segment 22 engaged with the bottom end of the primary coiled spring 21 which in turn gives rise to a similar movement of the secondary coiled springs 25. Inasmuch as said secondary coiled springs 25 are anchored to the outermost perforations 28 in the perforated flap disc halves 27 and, in the absence of the pressure of input air flow applied to said disc halves 27 the position thereof is maintained so as to provide the maximum output air flow, the bottom ends of the secondary coiled springs 25 are fixed at the outermost perforations 28, 28 in the perforated flap disc halves 27 regardless of the movement of the top seat 20.

In other words, the top seat 20 having been moved upwards together with the adjusting threaded rod 17 as a result of turning said thread rod 17, the primary coiled spring 21 and secondary coiled springs 25 are stretched to provide an additional force thereof, so that the perforated move disc halves 27 flap at a later time in response to the pressure of input air flow impinging upon them. This means an increased pressure of input air flow is necessary to move said disc halves 27 to change the angular position thereof.

A rise of the pressure of input air flow applied to the perforated flap disc halves 27 results in a corresponding rise of the air flow through the perforations 31 in said disc halves 27 and that of another air flow through the clearance between the inner surface of the cylindrical casing 10 and the contour of said disc halves 27 with the result that the output air flow at a constant rate of the automatic air flow smoothing apparatus according to the present invention can be increased accordingly.

The above disclosure is represented in FIG. 4 by the curve 1' for the air flow through the perforations 31 in the perforated flap disc halves 27 the curve 2' for the air flow through the clearance between the inner surface of the cylindrical casing 10 and the contour of the perforated flap disc halves 27 and the curve 3' for the total output air flow at a constant rate, a composite of the curves 1' and 2'.

The adjusting threaded rod 17 and the top seat 20 having been lowered as a result of turning said threaded rod 17 in a direction opposite to that described above, the secondary coiled springs 25 as well as the primary coiled spring 21 and the link segment 22 also move downwards accordingly.

The downward movement of the adjusting threaded rod 17, top seat 20 and the link segment 22 gives rise to a reduction in the maximum effective area of air flow passage through the perforated flap disc halves 27 corresponding to the distance of downward movement of the secondary coiled springs 25, even when the input air flow is zero and the pressure of input air flow applied to said disc halves 27 is also zero.

In other words, the total area of air passage through the perforations in the perforated flap disc halves 27 is reduced and the projected area of the perforated flap disc halves 27 on the inner surface of the cylindrical casing is increased according to the downward movement of the secondary coiled springs 25, resulting in a corresponding addition of the area of said disc halves 27 subject to the pressure of the input air flow.

This in turn results in a quicker response of the perforated flap disc halves 27 to a given change of the pressure of the input air flow, and accordingly a drop of the pressure of input air flow affecting said disc halves 27 accompanied by a corresponding reduction in the

air flow through the perforations 31 in said disc halves 27.

A low angular position of the perforated flap disc halves 27 means a clearance between the inner surface of the cylindrical casing 10 and the contour of said disc halves is reduced accordingly, which in turn gives rise to a corresponding drop of the output air flow therethrough with a corresponding reduction in said air flow at a given rate at the setting desired. It is possible for the manual adjustment of the output air flow to a given rate to be done from outside at the air outlet of the air flow smoothing apparatus according to the present invention with added ease, if the adjusting threaded rod 17 extends down to said air outlet.

With the design of the automatic air flow smoothing apparatus according to the present invention described above, the output air flow at a given rate may also be altered by changing the primary coiled spring 21 and secondary coiled springs 25 for those with another spring constant.

With the automatic air flow smoothing apparatus according to the present invention mounted on the top 34 of an air diffuser 33, as shown in FIG. 6 said smoothing apparatus turns into an air diffuser operating at a constant flow rate which needs no manual adjustment of the output flow, the setting having previously been made to a desired level of the output air flow.

An example of the variant embodiment of the present invention illustrated in FIG. 7 and FIG. 8 comprises an adjusting threaded rod 17 extending down, through the a closed bottom tube 36 having top lugs 35 projecting laterally therefrom and having primary coiled spring 21 engaged with the top seat 20, the same as in the example shown in FIGS. 1 and 2. The primary coiled spring 21 is housed in said bottom-closed tube 36 and attached to the bottom thereof, and the secondary coiled springs 25 are engaged with holes 37 in said top lugs 35 at the top end of tube 36 and are anchored at the holes 28 in the perforated flap disc halves 27.

In this variant of the embodiment, the perforated flap disc halves 27 are positioned to provide a maximum output air flow as illustrated by the imaginary line in FIG. 8 by the pulling force of the combined primary coiled spring 21 and secondary coiled springs 25, when the pressure caused by an input air flow along the arrow is relatively low.

Contrarily, with a relatively high pressure of the input air flow, the perforated flap disc halves 27 are repositioned for a minimum output air flow as illustrated by another imaginary line in FIG. 8, which does not result in a change of total output air flow of the air flow smoothing apparatus according to the present invention, which is a composite of the air flow through the perforations 31 in the perforated flap disc halves 27 in the flow of the input air and the air flow through the clearance between the inner surface of the cylindrical casing 10 and the contour of said disc halves 27, the constant flow rate characteristics being the same as precedingly described in conjunction with FIG. 1, FIG. 2 and FIG. 4. Control for a constant rate of output air flow and fine adjustment with the adjusting threaded rod 17 are accomplished in the same manner as with the above described embodiment even when the primary coil spring 21 is housed in the closed-bottom cylindrical casing 36 having the lugs 35 on both sides of the top thereof. Nevertheless, the described variant is more advantageous than the embodiment as illustrated in FIG. 1 and FIG. 2 in that the automatic air flow smoothing apparatus according to the present invention may be designed with a shorter axial length cylindrical casing.

In another variant of the embodiment of the present invention, illustrated in FIG. 9 and FIG. 10 the closed bottom tube 36 shown in FIG. 7 and FIG. 8 is welded, at the bottom end thereof, to the middle section of the adjusting threaded rod 17 and has the thereon mounted primary coiled spring 38 partially compressed between the bottom of tube 36 and a top sliding flange 40 having a center hole 39 through which tube 36 extends. Flange 40 has end holes 41 in which are engaged the secondary coiled springs 25 anchored in the holes 28 in the perforated flap disc halves 27.

The pressure of input air flow in the direction of the arrow in FIG. 9 and FIG. 10 having been reduced to a low level, the perforated flap disc halves 27 are forced to be swung to a position to provide a maximum air passage through the perforation 31 in said disc halves 27 as represented by the imaginary lines in FIG. 10 by the force of the combined primary coiled spring 38 and secondary coiled springs 25.

The pressure of the input air flow in the direction of the arrow in FIG. 9 and FIG. 10 having been again raised to a high level, the perforated flap disc halves 27 are forced to be returned to another angular position thereof to provide a minimum air passage through the perforations 31 in said disc halves 27 as represented by other imaginary lines in FIG. 10, overcoming the joint compressive force of the primary coiled spring 38 and tension force of the secondary coiled springs 25. It is to be noted that the total air flow through the perforations 31 in the perforated flap disc halves 27 and the air flow through the clearance between the inner surface of the cylindrical casing 10 and the contour of said disc halves 27 can always be constant in accordance with the air flow characteristic curves plotted in FIG. 4 for the example of embodiment of the present invention illustrated in FIG. 1 and FIG. 2. The principle and effect achieved by control of the air flow at a given rate and fine adjustment of the output air flow with the adjusting threaded rod 17 is no different from that for the above described embodiments, even with the compressive action of the primary coiled spring 38 and provided the design advantage of reduced longitudinal length of the cylindrical casing.

As is clear from the above disclosure, the automatic air flow smoothing apparatus according to the present invention is advantageous in that it is quite simple in construction, low in manufacturing cost and easy and smooth in adjustment and is assures stabilized automatic control of the output air flow to a desired rate.

Although the description of the present invention has been made with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the present invention as hereinafter claimed.

What is claimed is:

1. An automatic air flow smoothing apparatus comprising a hollow enlongated open-ended casing, a rod mounted in the upper end of said casing and depending therealong, a primary coiled spring means mounted on said rod, a pair of secondary coiled springs having the upper ends attached to said primary coiled spring means, and a pair of flap disc halves hinged together within the lower end of said casing, the lower ends of said secondary coiled springs diverging from said primary coiled spring means and having the lower ends attached to the respective flap disc halves.

2. An automatic air flow smoothing apparatus comprising a cylindrical casing, a diametral member fixed inside the upper end of said cylindrical casing, a vertical adjusting rod adjustably mounted on said diametral member for movement along said casing, a primary coiled spring means mounted around said rod and secured thereto, two secondary coiled springs having the upper ends attached to said primary coiled spring means, and a pair of flap disc halves perforated at least over part of the area thereof and hinged together within the lower end of said casing, the lower ends of said secondary coiled springs diverging from said primary coiled spring means and having the lower ends attached to the respective flap disc halves.

3. An automatic air flow smoothing apparatus as claimed in claim 2 in which said primary coiled spring means comprises a top seat secured to said adjusting rod, a primary coiled spring having the upper end attached to said top seat, a link at the bottom of said primary coiled spring to which the bottom of said primary coiled spring is attached, the upper ends of said secondary coiled springs being attached to said link.

4. An automatic air flow smoothing apparatus as claimed in claim 2 in which said primary coiled spring means comprises a top seat secured to said adjusting rod, a primary coiled spring having the upper end attached to said top seat, a vertical tube around said rod and within which said primary coiled spring is positioned, the bottom of said primary coiled spring being attached to the bottom of said vertical tube, and the upper ends of said secondary coiled springs being attached to the upper end of said vertical tube.

5. An automatic air flow smoothing apparatus as claimed in claim 2 in which said primary coiled spring means comprises a vertical tube positioned around and secured to said adjusting rod, a primary coiled spring around said vertical tube and attached to the bottom of said tube, a flange slidably positioned around said tube and having the upper end of said primary coiled spring engaged therewith, the primary coiled spring being compressed between the bottom of said vertical tube and said flange, and the upper ends of said secondary coiled springs being attached to the slidable flange.

6. An automatic air flow smoothing apparatus as claimed in claim 2 in which said diametral member has a nut secured thereto, and said adjusting rod is a threaded rod threaded through said nut for adjustment along the length of said casing.

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