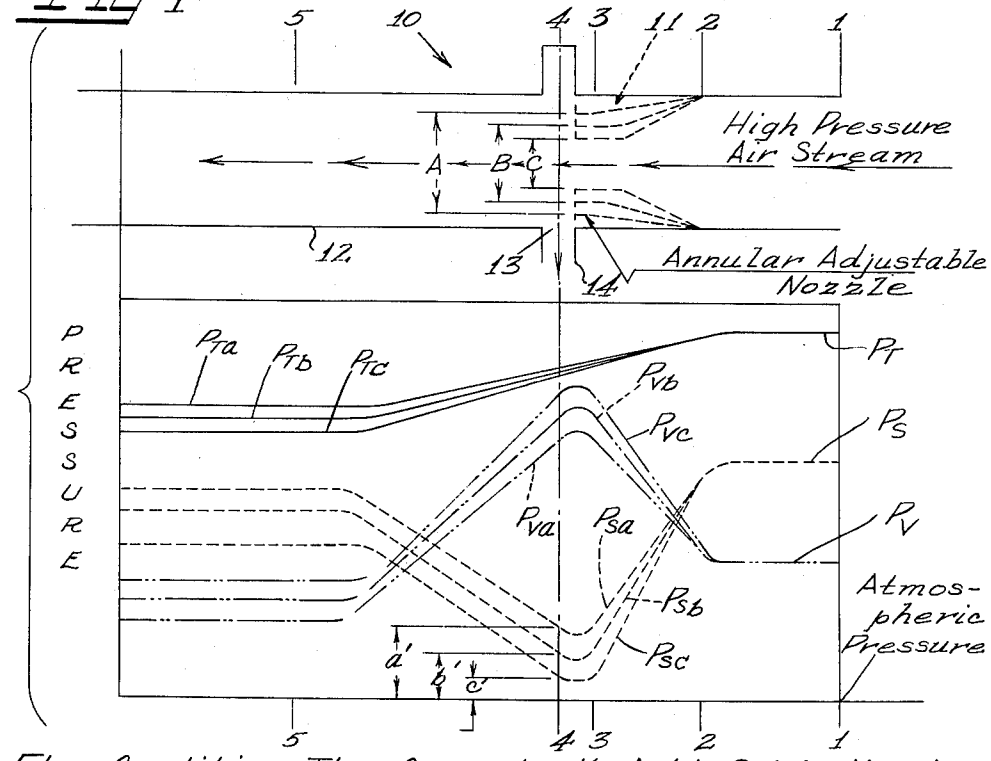
March 13, 1956 E. J. KUREK 2,737,977

HIGH PRESSURE CONVERTER

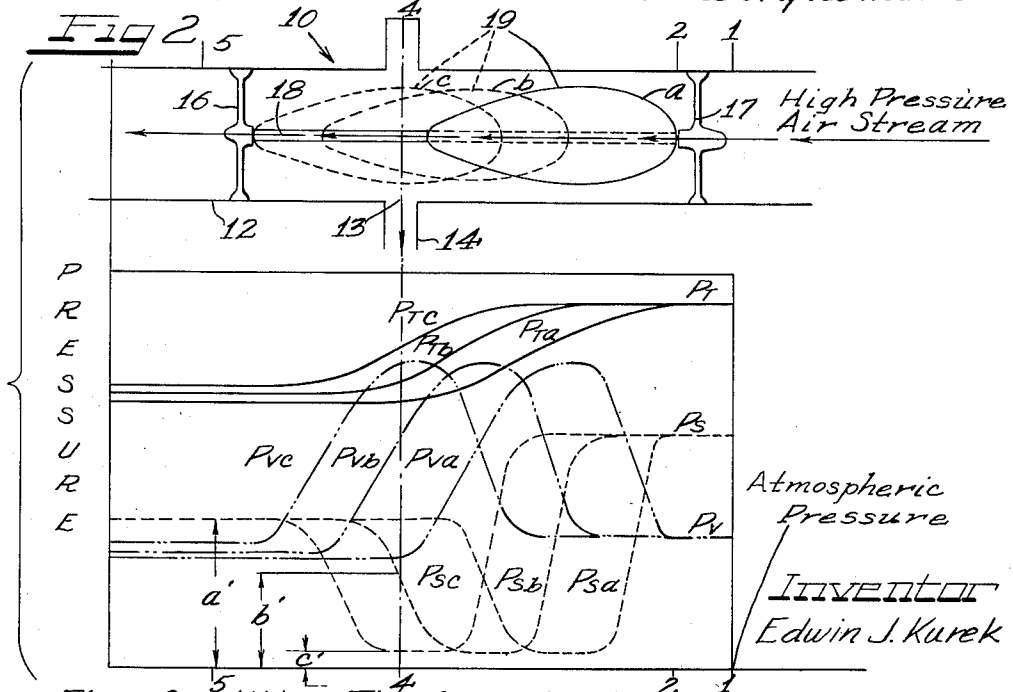
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Fig 1



Flow Conditions Thru Converter Variable Orifice Nozzle

Fig 2



Flow Conditions Thru Converter Annular Nozzle

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HIGH PRESSURE CONVERTER

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Fig 3

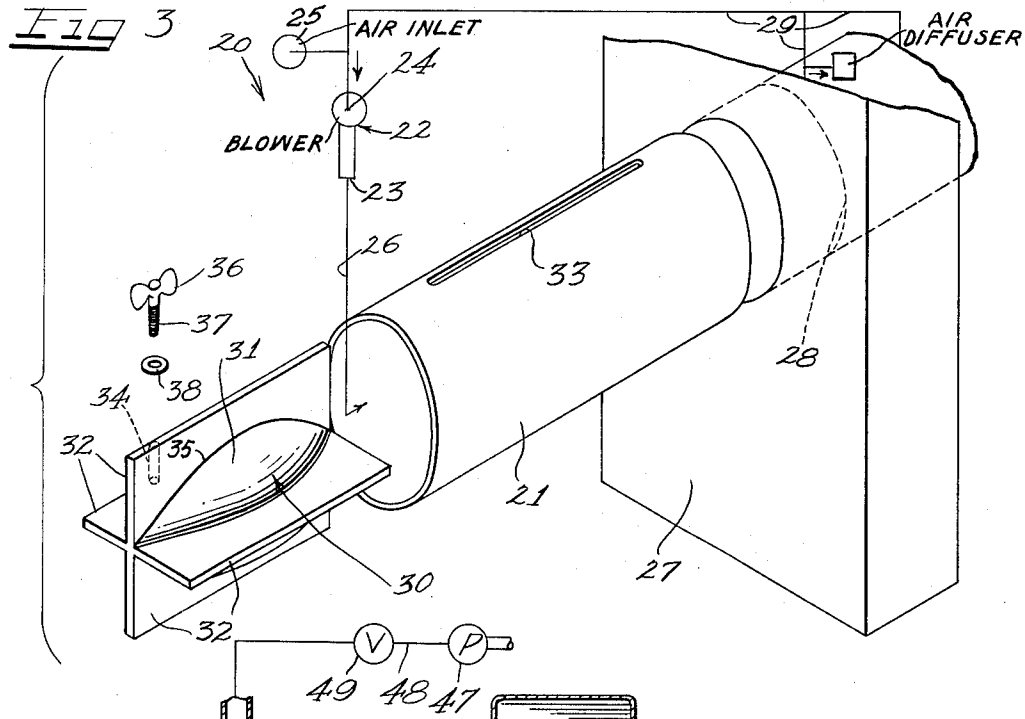
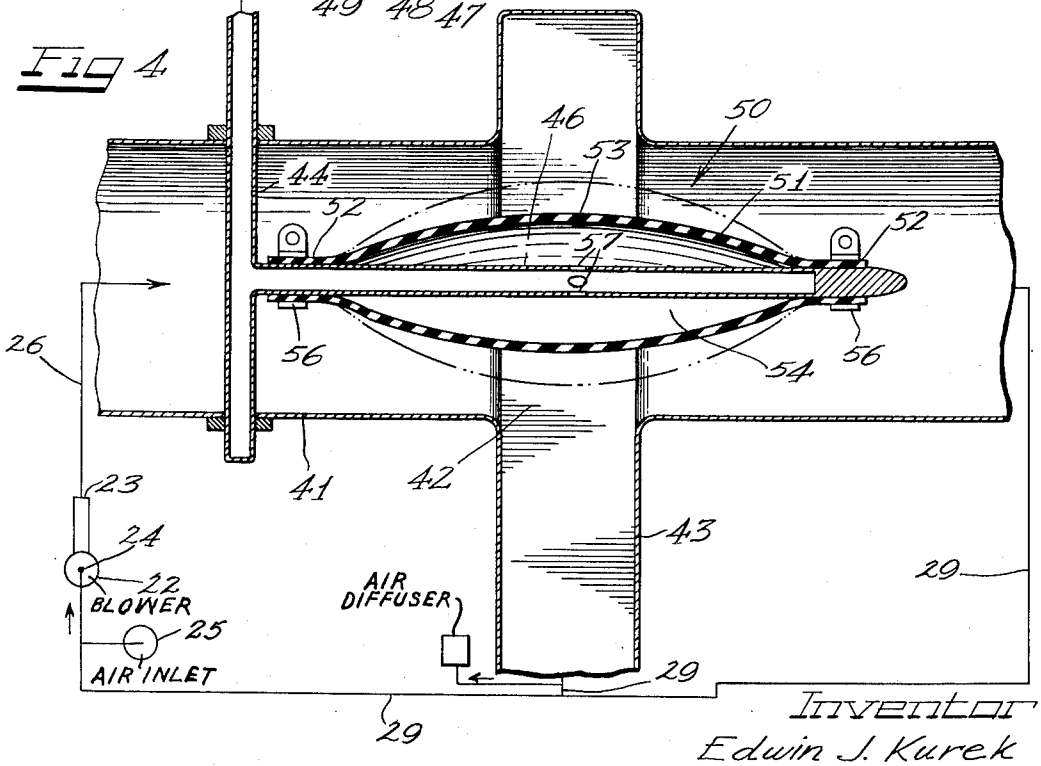


Fig 4



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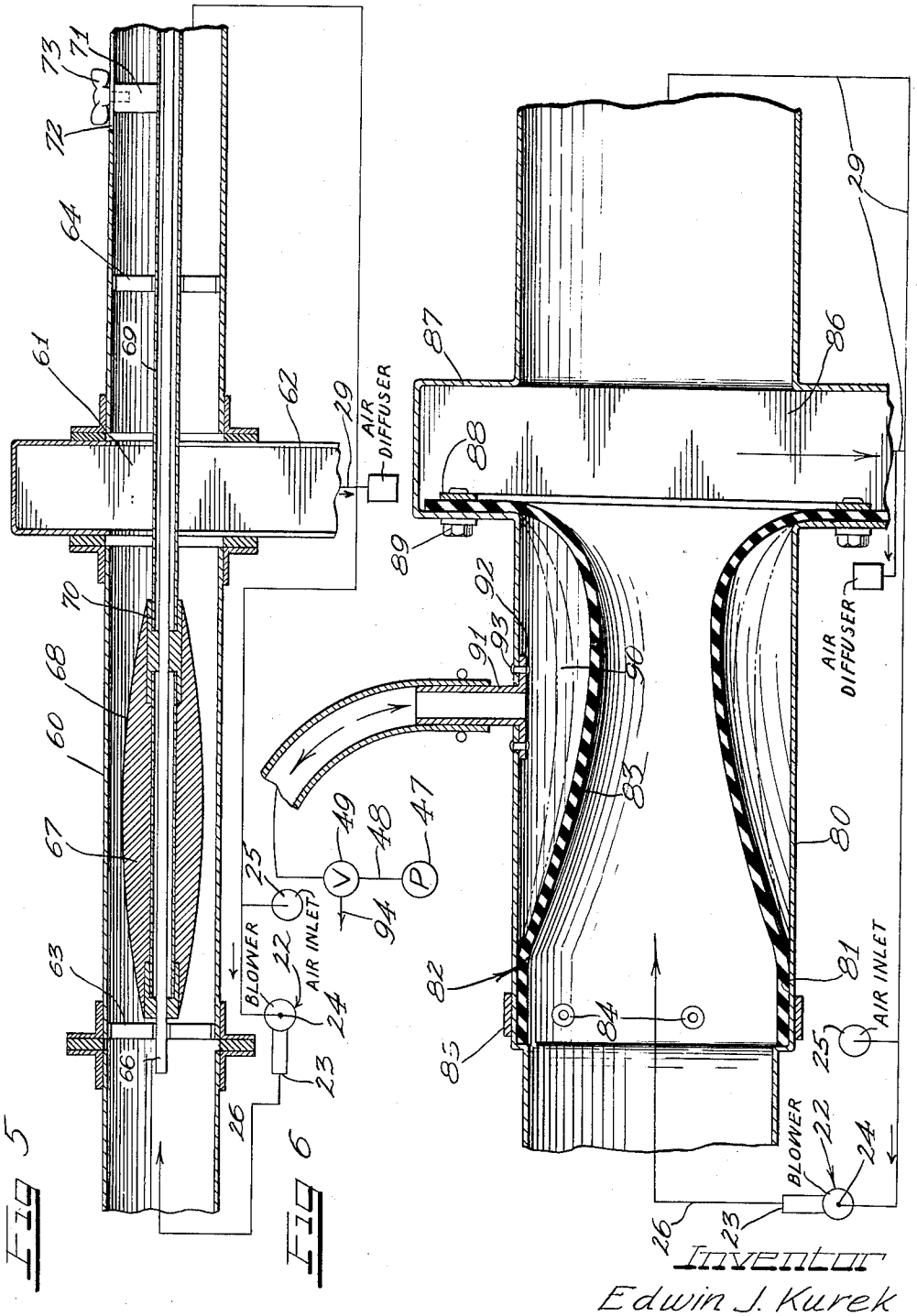


Fig 5

Fig 6

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2,737,977

HIGH PRESSURE CONVERTER

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Application July 30, 1953, Serial No. 371,389

9 Claims. (Cl. 137—561)

This invention relates generally to ventilating apparatus and more particularly to a ventilating system of the type comprising duct means providing a fluid circuit and including a main supply duct in the circuit receiving the discharge from a blower means at one point in the circuit provided to pressurize a supply of ventilating fluid to pressures in excess of atmospheric pressure, thereby to drive a stream of ventilating fluid into the main air supply duct and through the circuit. Flow restriction means are located at points in the circuit downstream of the pressurizing means to transitorily depress the pressure of the fluid to a pressure less than the pressure upstream of each respective point but greater than the atmospheric pressure so that branch duct means in the circuit at each point will receive a quantity of ventilating fluid from the main air supply duct at the corresponding transitorily depressed pressure. Return duct means are provided for the system to carry return fluid to the blower means. Fresh air inlet means into the circuit can also be provided.

The disclosure of the present application constitutes a continuation-in-part of my copending application U. S. Serial No. 232,554, filed June 20, 1951.

Recent developments in the ventilating art have indicated a trend toward the utilization of comparatively high pressure fluid in a ventilating system comprising a network of air ducts. In such systems the main trunk will be provided which is adapted to carry a stream of ventilating air pressurized to a value as high as 5 or 6 inches of water gauge. Connected to the main trunk will be a plurality of branches each having separate low pressure air diffusion means. In order to bleed off selected quantities of air from the main trunk into each respective branch duct system, it is necessary to utilize some form of pressure conversion means between each branch and the main trunk.

In the devices heretofore provided for effecting such pressure conversion, serious deficiencies have been manifested. It will be apparent that it is highly desirable to provide an adjustable form of pressure conversion means so that the entire ventilating system network can be adequately balanced. Moreover, the pressure conversion means should be of simplified design and should comprise a reduced number of simplified elements which are easy to install and maintain and which may be serviced by relatively inexperienced personnel.

Moreover, the pressure conversion means should operate quietly, without whistling and should operate efficiently to bleed off only as much air as is required in each respective branch.

It is an object of the present invention, therefore, to provide a ventilating system of the character described wherein a network of air ducts is provided including a main trunk and a plurality of branch ducts and wherein improved pressure conversion means are utilized.

It is a particular object of the present invention to provide pressure conversion means which overcome the deficiencies heretofore manifested by the prior art devices.

Another object of the present invention is to provide a

pressure conversion means wherein male and female members provide a fluid restriction passage having a structural flow contour to produce a local transitory depression of pressure in a fluid path so that selective quantities of air at positive gauge pressure may be bled off from the fluid path into a branch duct system.

Yet another object of the present invention is to provide flow restriction means including a flexible wall device and adjustable fluid delivery means whereby a resultant profile may be selectively adjusted to vary the quantitative amount of transitory depression in a fluid path.

A further object of the present invention is to provide a flow restriction means wherein an axial adjustable plug movable in upstream or downstream direction may be utilized to vary the quantitative amount of transitory depression with respect to a bleed-off opening.

Another object of the present invention is to provide pressure conversion means utilizing a contractable nozzle.

Many other features, advantages and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows and the accompanying sheets of drawings in which a preferred structural embodiment incorporating the principles of the present invention is shown by way of illustrative example only.

On the drawings:

Figure 1 is a composite schematic view showing in the upper portion thereof a diagrammatic view of a conversion mechanism utilizing a contractable nozzle provided in accordance with the principles of the present invention and indicating in the lower portion thereof the variations in pressure occurring within the conversion mechanism, wherein the curves represent the velocity pressure, the static pressure, and the total pressure variations along the conversion mechanism.

Figure 2 is a composite schematic view showing in the upper portion thereof a diagrammatic view of a conversion mechanism utilizing an adjustable plug providing an adjustable flow restriction means of graduated divergence and convergence in accordance with the principles of the present invention and indicating in the lower portion thereof the variations in pressure occurring within the conversion mechanism.

Figure 3 illustrates one embodiment of the present invention wherein an adjustable plug is utilized;

Figure 4 is a cross-sectional view partly diagrammatic showing a contractable nozzle provided in accordance with the principles of the present invention;

Figure 5 is a cross-sectional view with parts shown in elevation and with parts shown diagrammatically showing a pressure conversion means provided in accordance with the principles of the present invention and utilizing an adjustable plug means providing an annular nozzle in a flow path; and

Figure 6 is a cross-sectional view of another embodiment of a pressure conversion means in accordance with the principles of the present invention and shows, partly diagrammatically, a ventilating system utilizing a contractable nozzle.

As shown on the drawings:

As is well known, air flow through any given section of duct work is characterized by the relationships of pressure and velocity. The sum of velocity and static pressure at any given duct section is called the total pressure. Total pressure is highest at the discharge of the pressurizing means and lowest at the outlet of the duct system where it is equal to the velocity head, the static pressure having been reduced to zero relative to the atmosphere by frictional losses. Although velocity and static heads are mutually convertible, their sum must always equal the total pressure for any given flow section.

By using an efficiently designed nozzle or a similar flow

restriction means, it is possible to convert a high static, high velocity pressure stream to a low static and higher velocity stream in or at the restriction, such as at the throat of the nozzle.

Moreover, by providing an "after" section in such a system, the velocity of the stream will be decreased due to the reexpansion of the flow area thereby resulting in a regaining of some of the initial static pressure.

In accordance with the principles of the present invention, the static pressure of an air stream in a duct is temporarily depressed in the vicinity of a lateral orifice through the reduction of the duct area, thereby rendering possible the "bleeding off" of variable quantities of air at conveniently low pressures. Thereafter, the original duct area is restored in such a manner as to reestablish substantially the original static pressure for flow to the next bleed-off point.

In my copending application, Serial No. 232,554, filed June 20, 1951, there is disclosed a slidable nozzle which can be moved relative to the lateral orifice so as to impose across the orifice variable static pressures from a maximum available static pressure to a minimum static pressure in excess of the back pressure at the bleed-off point. In this manner, the output of the lateral orifice is controlled.

In the present disclosure, there is provided means for varying the cross-sectional area of the flow path across the duct at a fixed point in the duct which may comprise a streamlined plug which is movable longitudinally relative to a lateral orifice, the plug having a nozzle profile so as to provide a flow restriction throat forming means in the duct which will transitorily depress the fluid pressure in the flow path in the vicinity of the lateral opening to a pressure lower than the pressure upstream of the opening but higher than the back pressure in the opening. A contractable nozzle is also provided in accordance with the present disclosure and will function in a similar manner to produce similar results.

In Figure 1 there is shown diagrammatically a pressure conversion device **10** having a contractable nozzle **11** located in a main air supply duct **12** of uniform cross-section. A lateral bleed-off opening **13** is provided in the main air supply duct **12** and is connected to a branch duct **14** which, in accordance with the principles of the present invention may comprise branch duct of a plurality of branch ducts forming together with the main air supply duct **12** a ventilating system network.

The contractable nozzle **11** is provided in the main air supply duct **12** adjacent the lateral bleed-off opening **13** and is adjustable in radially inwardly and outwardly directions to adjust the profile thereof, thereby affording different sizes of nozzle profiles which will transitorily depress the fluid pressure in the main air supply duct **12**.

The graph of Figure 1 plots gauge pressures above atmospheric pressure against flow conditions or characteristics through the pressure conversion means. Longitudinally spaced points in the pressure conversion means correspond to spaced points on the X co-ordinate of the graph. Thus, the point **1** on the main air supply duct **12** corresponds to point **1** as indicated on the graph. At point **1**, the total pressure indicated by P_t comprises a velocity component indicated by the legend P_v and a static pressure component which is indicated by the legend P_s.

Since the main air supply duct **12** is of uniform cross-section, these values remain substantially constant until point **2** is reached, the beginning of the flow restriction means provided by the contractable nozzle **11**.

Point **3** on the main air supply duct **12** and on the graph of Figure 1 corresponds to the smallest cross-sectional area of the contractable nozzle **11** and it will be noted that between point **2** and point **3**, the curve P_v will rise and the curve P_s will fall, thereby indicating the action of the contractable nozzle **11** in transitorily depressing the fluid pressure in the flow path.

Point **4** on the main air supply duct **12** and on the graph of Figure 1 corresponds to the center line of the lateral bleed-off opening **13** and point **5** on the main air supply duct **12** and on the graph of Figure 1 is located downstream of the lateral bleed-off opening **13** a sufficient distance so that the velocity of the stream has decreased due to the enlargement of the flow area downstream of the nozzle and so that there will be some regain of the initial static pressure.

The widest opening through the contractable nozzle **11** shown in Figure 1 is indicated as the dimension A. For this position of the contractable nozzle **11**, the curve P_s will follow that portion of the curve indicated by P_{sa}. Likewise, the curve P_v will follow that portion of the curve indicated by P_{va}. Under these conditions, the static pressure gauge available at the lateral bleed-off opening **13** (point 4 on the graph) for purposes of bleeding off a quantity of air will be equal to the value *a'*. It is understood, of course, that bleed-off into the branch duct **14** will not occur unless the pressure therein is less than the value *a'* which, as indicated, is measured at gauge above atmospheric.

If it is desired to bleed-off smaller quantities of air at the lateral bleed-off opening **13**, the contractable nozzle **11** may be adjusted to assume the nozzle profile corresponding to the dimension identified by B. Under these conditions, the curves will follow the portions indicated P_{vb} and P_{sb} and the static pressure (gauge above atmospheric) available at the bleed-off opening **13** (point 4 on the graph) will be indicated by the dimension *b'*.

To obtain a minimum bleed-off, the profile of the contractable nozzle **11** may be adjusted to the position of smallest cross-sectional area indicated by the dimension C, thereby moving the curves to the portions indicated at P_{vc} and P_{sc}. Under these conditions, the static pressure available (point 4 on the graph) will be equal to *c'*.

It will be understood that the curve P_T indicating total pressure will vary and to indicate on the graph of Figure 1 such variance and particularly to demonstrate the decreasing amounts of "regain," the curve P_T is shown as following the portions P_{Tc}, P_{Tb} and P_{Ta}, respectively.

In Figure 2 a main air supply duct **12** has brackets **16** and **17** spaced on opposite sides of the lateral bleed-off opening **13** and a support rod **18** extends therebetween to slidably carry a rigid plug **19** prescribing a nozzle profile alternately diverging and converging so as to provide a streamlined contour. The plug **19** is moved longitudinally so as to adjust in upstream and downstream direction with respect to the lateral bleed-off opening **13**, thereby adjusting the quantitative value of transitory depression for varying the quantity of air or fluid bled off into the branch duct **14**.

In the arrangement of Figure 2, the plug **19** is illustrated as being in three different positions labeled *a*, *b* and *c*. In the graph of Figure 2, it will be noted that the respective curves are displaced longitudinally with respect to the lateral bleed-off opening **13**, thereby varying the quantitative amount of transitory static depression in the locale of the lateral bleed-off opening **13** so as to adjust the amount of air bled off into the branch duct **14** from the main air supply duct **12**. Again, it will be understood, of course, that bleed-off into the branch duct **14** will not occur unless the pressure therein is less than the pressure available for bleed-off which, as is indicated, is measured at gauge above atmospheric.

Referring now to Figures 3–6, various structural embodiments incorporating the principles of the present invention are shown. In Figure 3 is provided a ventilating system **20** comprising a network of air ducts including a main air supply duct or main trunk **21** carrying pressurized ventilating air supplied thereto by a fan or a blower means **22** having an outlet **23** and an inlet **24**, the outlet **23** being connected to the main air supply duct or main trunk **21** as at **26**.

The ventilating system network further comprises a plurality of branches each having separate low pressure air diffusion means, one of the branches being indicated

at 27. Each of the branches is connected to the main trunk 21 at a lateral bleed-off opening 28.

Return duct means 29 carry return air back to the fan or blower means 22. Since the blower means outlet is connected to the main air supply duct 21 and since the return air means 29 are connected to the blower means inlet 24, there is provided a fluid circuit through which a stream of ventilating air may be driven at pressures in excess of atmospheric pressure. Fresh air inlet means are also indicated at 25 to introduce fresh air into the circuit in supplementation of the return air. The term "return air" is used herein as it is commonly used in the heating and ventilating arts, the return air means 29 being merely a diagrammatic representation of a conventional return air arrangement as commonly utilized in the normal air circuit of a circulating air type heating or ventilating system.

In accordance with the principles of the present invention, pressure conversion means are provided at each bleed-off point so as to bleed off selected quantities of ventilating fluid from the main air supply duct 21 into each of the respective branch duct means 27.

In the embodiment of Figure 3, the main air supply duct 21 comprises a female member and there is also provided a male member 30 which cooperate together to form a flow restriction passage in the main trunk having a structural flow contour to produce a local transitory depression of static pressure in the main trunk at the locale of the lateral bleed-off opening 28.

More specifically, the pressure conversion means of Figure 3 include a rigid plug constituting the male member 30 and having a curved circumferentially continuous peripheral surface 31 shaped to provide the graduated diverging and converging profile of substantially a teardrop contour. There is also provided on the plug or male member 30 a plurality of circumferentially spaced radially outwardly extending fins or ribs 32 secured thereto as by welding 35 or any other suitable fastening means which are adapted to slidably engage the walls of the main air supply duct or main trunk 21.

Adjustment means are also provided to lock the plug or male member 30 in selected positions relative to the lateral bleed-off opening 28. In this connection, an elongated longitudinal slot 33 is formed in the wall of the main air supply duct 21 or main trunk and a threaded aperture 34 is provided in one of the ribs or fins 32, thereby to lie in register with portions of the slot 33.

A fastener 36 is provided with a threaded portion 37 threadedly engaging the walls of the recess 34 and a washer 38 is provided to be interposed between the fastener 36 and the outer walls of the main air supply duct 21 or main trunk 21. Thus, the plug or male member 30 is selectively adjusted and may be locked in adjusted position by turning up the fastener 36 after passing the nut 36 through the washer 38, through the slot 33 and into the threaded aperture 34 in the rib or fin 32. It will be understood that the plug or male member 30 is adjusted relative to the lateral bleed-off opening 28 to transitorily depress the fluid pressure in the flow path through the main air supply duct 21 to a pressure lower than the pressure upstream of the bleed-off opening 28 but higher than the back pressure in the branch duct 27.

In the embodiment of Figure 4, the ventilating system network also comprises the blower means 22 having the outlet 23, the inlet 24 and the main air supply duct or main trunk 41. A duct connection 26 is provided to discharge pressurized ventilating fluid from the blower means 22 into the main air supply duct 41. Return duct means 29 are also provided which are connected to the blower means inlet 24. The main air supply duct 41 is provided with a lateral bleed-off opening 42 communicating with a branch duct 43 adapted to supply air to diffusion means.

Upstream of the bleed-off opening 42 a T-shaped conduit 44 is provided, the long leg of the T-shaped conduit 44 being indicated at 46 and extending longitudinally of the main air supply duct 41 substantially coaxially thereof and past the lateral bleed-off opening 42.

The opposed end legs of the T-shaped conduit 44 extend laterally of the main air supply duct 41 and one of the legs is connected to a source of pressure indicated at 47 by means of a conduit 48 controlled by a valve 49. A plug means for varying the cross-sectional area of the flow path across the duct is indicated generally at 50 and comprises flexible wall means 51 taking the form of a flexible sleeve or rubber sleeve having reduced neck portions 52 at opposite ends thereof and an enlarged medial section 53 forming a fluid tight chamber 54. The reduced neck portions of the sleeve 51 are clamped securely by means of clamp 56 to spaced apart points on the leg 46 and openings 57 are provided in the leg 46 to conduct a control fluid into the chamber 54.

Upon adjusting the valve 49, pressurized fluid is delivered through the T-shaped conduit 44 into the chamber 54 so as to adjustably flex the sleeve 51 radially outwardly, thereby to selectively form a graduated diverging and converging profile to transitorily depress the fluid pressure in the flow path at the vicinity of the bleed-off opening 42 to a pressure lower than the pressure upstream of the opening 42 but higher than the back pressure in the branch duct 43.

In the embodiment of Figure 5, the main air supply duct is indicated at 60 and is provided with a lateral bleed-off opening 61 communicating with a branch duct 62. At opposite sides of the lateral bleed-off opening 61 are provided diametrically extending support members 63 and 64.

A support rod 66 is stationarily supported within the main air supply duct 60, preferably coaxially therewith and a flow restriction means comprising a plug means is slidably carried by the support rod 66 in the fluid path for adjustment in upstream and downstream direction relative to said lateral bleed-off opening 61.

The plug means is indicated at 67 and provides a profile 68 of graduated divergence and convergence to transitorily depress the fluid pressure in the flow path at the locale of the bleed-off opening 61 to a value lower than the pressure upstream of the opening but higher than the back pressure in the branch duct 62.

To adjust the position of the plug means 67, a hollow tube 69 is firmly connected as at 70 to the plug means and is slidably supported by the support member 64. A bracket member 71 is firmly attached to the tube 69 and registers with a slot 72 which is elongated in longitudinal direction in one wall of the main air supply duct 60. A locking member 73 threadedly engages the bracket member 71 and may be drawn up tightly to lock the plug means 67 in any adjusted position relative to the lateral bleed-off opening 61.

In the embodiment of Figure 6, a main air supply duct 80 is provided with a recess 81 in the walls thereof seating a plug means 82 for varying the cross-sectional area of the flow path across the duct taking the form of a flexible sleeve, for example, a rubber sleeve 83. The end of the sleeve 83 is shown connected to the main air supply duct 80 by means of a connecting strap 85 and suitable fasteners 84.

The other end of the sleeve 83 is shown overlapping the edges of a lateral bleed-off opening 86 formed in the main air supply duct 80. The lateral bleed-off opening 86 communicates with a branch duct 87 providing wall means backing up the edges of the sleeve 83. A mounting flange 88 engages the sleeve 83 and suitable fasteners 89 are provided to clamp the end of the sleeve in firm assembly with the walls of the duct work.

There is thus provided between the walls of the main air supply duct 80 and the sleeve 83 a control chamber 90 which is adapted to receive a pressurized control fluid so as to selectively flex the walls of the sleeve 83 radially inwardly.

To control the admission of pressurized fluid from the

pressure source 47 through the conduit 48, the control valve 49 is connected to a nipple 91 opening into the control chamber 90 and attached to the walls of the main air supply duct 80 by a flange 92 and suitable fasteners 93. The valve 49 is also provided with a pressure release means indicated at 94 so that the pressure in the control chamber 90 may be effectively regulated.

When the flexible walls provided by the sleeve 83 are moved radially inwardly by delivering fluid pressure into the control chamber 90, the size of the flow path will be restricted. By varying the degree of restriction, it is possible to adjust the quantitative amount of transitory depression at the locale of the bleed-off opening 86. A proper adjustment is made to transitorily depress the fluid pressure in the flow path through the main air supply duct 80 at the bleed-off opening 86 to a pressure lower than the pressure upstream of the opening 86 but higher than the back pressure in the branch duct 87.

Although various minor structural modifications might be suggested by those versed in the art in connection with the preferred structural embodiment herein described by way of illustrative example, it should be understood that I wish to embody within the scope of the patent warranted here all such modifications as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. In a ventilating apparatus, a supply duct for carrying an air stream at an appreciable velocity from an upstream source exhibiting a total pressure appreciably above atmospheric pressure to a downstream zone exhibiting a lesser total pressure, said duct having upstream and downstream duct portions of substantially equal cross-sectional area, and means in said duct between said upstream and downstream portions for varying the cross-sectional area of the flow path across the duct at a fixed point in said duct, whereby the static pressure and the velocity pressure components of the total pressure of the airstream are mutually converted at said point and are reconverted in a discrete zone in said duct extending downstream from said point, and means forming an opening in said duct at said discrete zone providing a ventilating air outlet for supplying ventilating air to a point of utilization, the relationship of the reduced cross-sectional area and the cross-sectional area of said duct and the relationship of the axial distance between said point and said opening being such that the static pressure inside of said duct at said opening is maintained in excess of the pressure outside of said duct at said opening, thereby to bleed a quantity of air from said duct outwardly through said opening.

2. In a ventilating apparatus as defined in claim 1, said means for varying the cross-sectional area comprising a rigid plug having a peripheral surface shaped to form a profile of graduated divergence from one end towards an intermediate portion and convergence from the intermediate portion towards the other end, and means for adjusting said plug in upstream and downstream direction with respect to said opening, whereby the quantum of excess pressure at said opening may be varied.

3. In a ventilating apparatus as defined in claim 1, said means for varying the cross-sectional area comprising a plug having flexible peripheral walls and means for adjusting said walls to adjust the profile of said plug by positioning said flexible walls to vary said cross-sectional area of the flow path across the duct, thereby to vary the quantum of excess pressure at said opening.

4. In a ventilating apparatus as defined in claim 1, said means for varying the cross-sectional area comprising an annular flexible wall connected to said duct and adjustable radially inwardly to form an adjustable profile of graduated divergence and convergence, and means for acting upon said flexible wall to vary the said cross-sectional area of the flow path across said duct, thereby to vary the quantum of excess pressure at said opening.

5. In a ventilating apparatus as defined in claim 1, said means for varying the cross-sectional area comprising means forming an annular flexible wall spaced inwardly of the walls of said duct, and means for adjusting said wall radially outwardly to vary the degree of graduated divergence and convergence of the profile formed by said flexible wall, thereby to vary the quantum of excess pressure at said opening.

6. In a ventilating apparatus as defined in claim 2, said adjustment means including slide track means in said duct supporting said plug for movement and locking means to fix said plug in adjusted positions.

7. In a ventilating apparatus as defined in claim 3, said plug comprising a rubber sleeve forming together with said duct an annular fluid control chamber, said adjustment means comprising fluid control means delivering fluid into said chamber to vary the profile of said rubber sleeve.

8. In a ventilating apparatus as defined in claim 3, said plug comprising a hollow rubber member having a fluid chamber formed therein, said adjustment means comprising fluid control means delivering fluid into said chamber to vary the profile of said rubber member.

9. In a ventilating apparatus as defined in claim 1, said means for varying the cross-sectional area comprising a plug member having a profile of substantially tear-drop contour, radially outwardly extending fins secured on said plug member slidably engaging said duct means to support said plug member for movement, and adjustment means to lock said plug member in adjusted positions with respect to said opening, whereby the quantum of excess pressure at said opening may be varied.

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