Jan. 9, 1968 E. BERNER ET AL 3,362,469

AIR CURTAIN

Filed Jan. 3, 1966 2 Sheets-Sheet 1

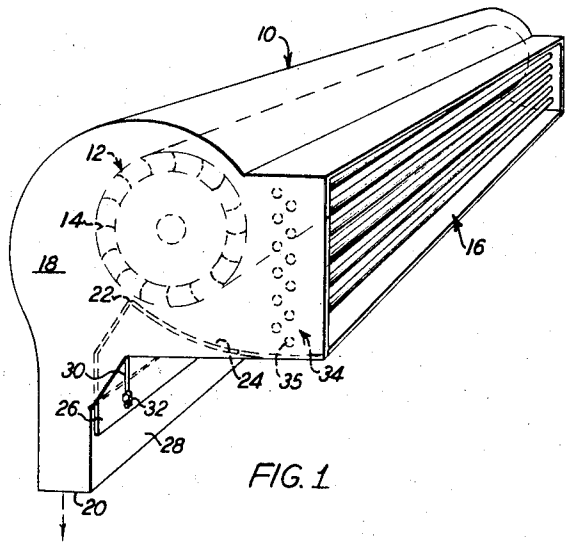


FIG. 1

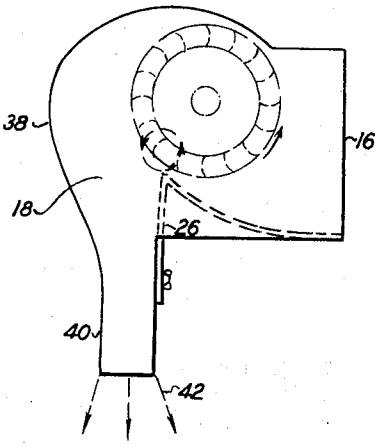


FIG. 2

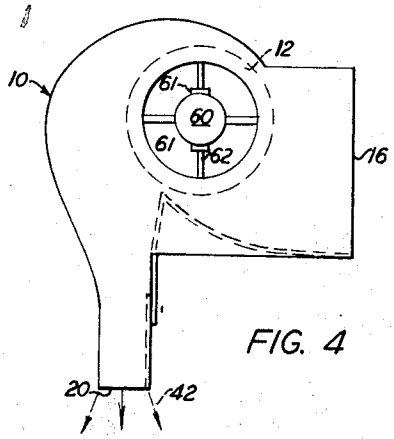


FIG. 4

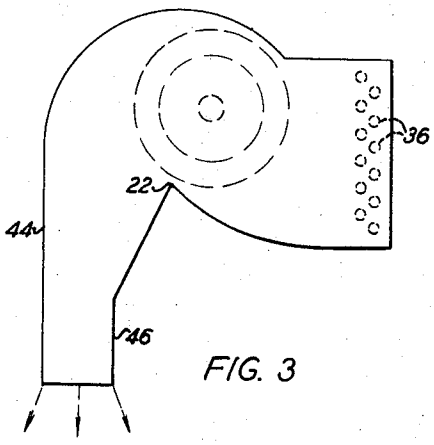


FIG. 3

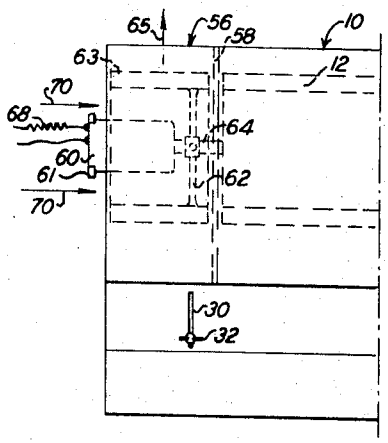


FIG. 5

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Filed Jan. 3, 1966 2 Sheets-Sheet 2

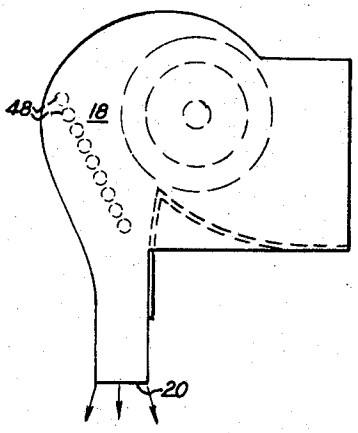


FIG. 6

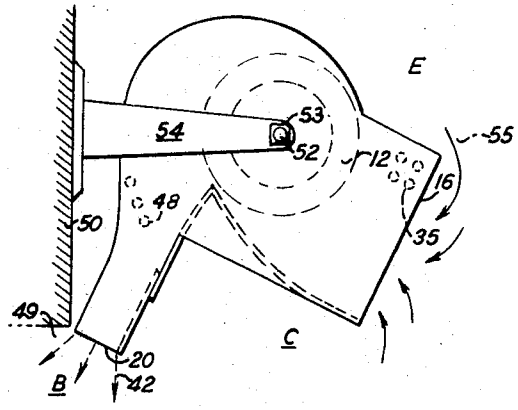


FIG. 7a

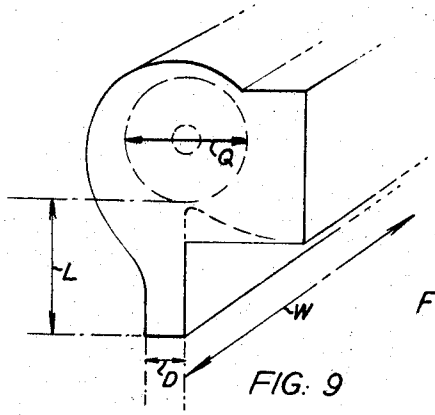


FIG. 9

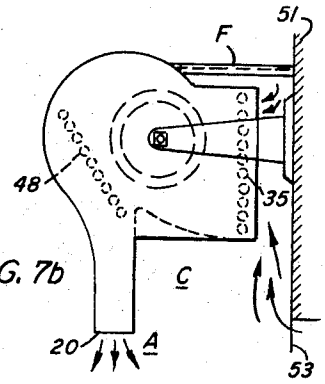


FIG. 7b

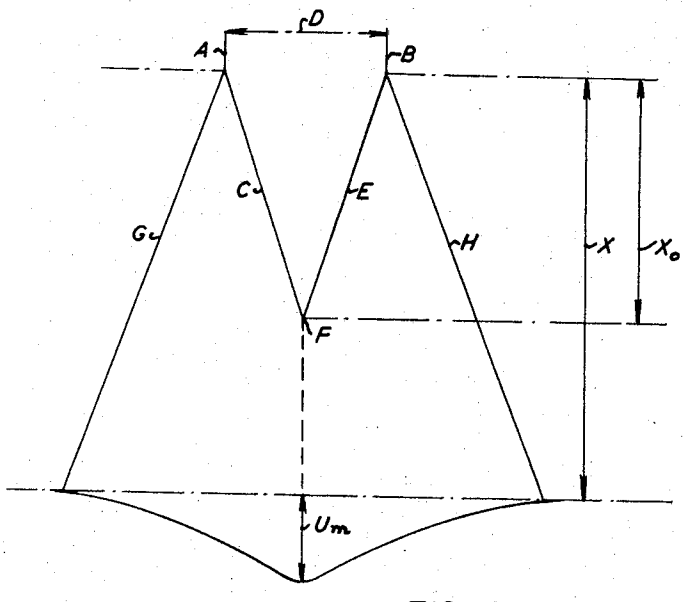


FIG. 10

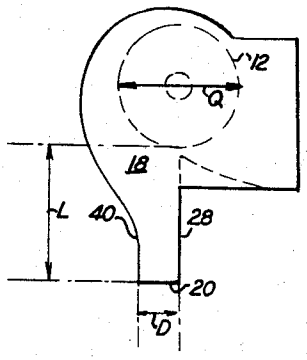


FIG. 8

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AIR CURTAIN

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Filed Jan. 3, 1966, Ser. No. 518,094
20 Claims. (Cl. 165—122)

ABSTRACT OF THE DISCLOSURE

A method and apparatus are provided to form an air screen for protective mounting over a doorway separating warm and cold spaces to prevent air intermixture therethrough, the housing being adjustably mounted to vary the angle with respect to the doorway in order to take controlled amounts of cold air admixed with warm air, the apparatus being particularly unique in that a tangential type of impeller is used having the characteristic of impelling the air in a laminar flow so that the air screen produced is of uniform strength and homogeneity substantially free of turbulence and may be a laminated association of hot and cold layers.

This invention relates to an air curtain and particularly to the combination in an air curtain device having an elongated outlet air sheet projecting nozzle with a tangential-type blower, the device being mountable to project a curtain of air protectively across an opening.

Air curtain devices having centrifugal or axial blowers are known to be mounted protectively over a doorway, window-opening, or the like, such as described in U.S. Patent No. 3,157,105, to effectively form an air curtain to prevent the loss of heat or moisture quality of the air and discourage passage of insects through such opening; such air curtain serving to partition apart or to prevent admixture of outside air with inside air in, for example, a building, store, storage chamber or the like. Air curtain devices usually with axial flow, are commonly used as shown in that patent. One outstanding weakness of such devices has been that the air has not been efficiently expelled from the nozzle across such opening with sufficient velocity or pressure as a thin cohesive sheet over large openings needed to overcome convection currents, except by use of large blowers. It is desirable to economize on both overall efficiency and space required for a large blower installation over an exposed doorway. Moreover, that kind of air curtain device usually needs a rotor operated at high speed to effect the adequate air pressure and air flow velocity through the nozzle to establish a useful air curtain, which usually includes a substantial and undesirable noise factor. For the centrifugal or axial fan or blower, it is difficult to produce an air flow emitted from the curtain nozzle of even pressure and air velocity equalized throughout, particularly to protect wide doorway openings. Such wide air curtain does not have its air flow readily balanced and the resulting curtain produced is not of even quality, but is easily disrupted by draft currents.

According to the present invention it is found that a fine, high-quality air curtain is established by combining a low diameter dimension Q tangential blower with an air screen type nozzle having a controlled ratio of blower diameter Q to air screen nozzle outlet width D so that the ratio Q/D is in the range of 1:1 to 10:1. Such combination is superior to other air screens, overcoming the weaknesses listed above, and is superior as well to other tangential blower constructions.

The tangential blower intakes air tangentially, small vortext currents being set up around impeller blades, and

sweeps the air out of the housing at higher and more homogeneously even pressure along the entire width of the nozzle outlet to protectively cover an outlet with a better air screen. The relatively narrow intake inlet disposed along a tangential edge of such impeller requires a much smaller housing both for inlet purposes and producing the necessary air flow. The outlet pressure produced by the tangential sweep of the impeller combined with an elongated preferably rectangular nozzle, produces a high velocity, evenly homogeneous air screen. Such tangential impeller, therefore, is overall superior in that it is far more efficient in combination with an air screen-type nozzle than a centrifugal or axial type blower and, may be formed more compactly with a great space saving. Consequently, such air curtain is of even draft resistant quality and has a low turbulence factor as resulting from this combination of tangential flow blower with a properly dimensioned air screen outlet nozzle in an air curtain device. An inherent bonus of this combination is that the tangential blower operates with a contrastingly low noise factor.

Further modifications of this combination are available and within the scope of this invention; particularly it is flexibly possible in this combination to use a larger diameter tangential rotor than is needed only for the benefit of operating at quite low speeds, allowing a minimal noise factor.

It is possible to independently house a driving motor in direct coaxial drive of the tangential blower impeller and separate the driving motor housing from the air curtain housing by a partition. The housing by a partitioned driving motor can simultaneously drive a centrifugal blower to draw air axially into its independent housing, and expel the air centrifugally from its independent housing outlet. Such sub-housing construction allows independent coaxial drive of the tangential impeller in the independent housing construction of this invention, while providing it separate and independent air flow circuit in a centrifugal type blower to pass axially over the driving motor to keep it cool and separate and expel the cooling air from the separate motor housing chamber. That construction amounts to combined air flow circuits, a main air circuit from the tangential impeller to establish and maintain the air curtain from said tangential impeller and a secondary circuit to axially flow air over the drive motor and in that way both allow the motor to remain cool and to form part of the air curtain.

It is an advantage to regulate the air volume of the air curtain either by varying the throat of the tangential impeller with the housing, thereby varying the air flow velocity, or by regulating the speed of the motor, and thereby the tangential rotor speed, and both. As mentioned, a low air curtain turbulence factor is desirable, and this may be obtained in part by selecting a high ratio of nozzle depth to nozzle width as explained in detail below.

The elongated housing shape to lie across a wall opening to form a partitian curtain thereacross, intakes and blows air generally in a long, narrow strip and is readily combined wth elongated heating elements for easy, very efficient, heat transfer to the air stream, either on the inlet or outlet side. Such heating elements may be elongated resistance strips or hot gas such as steam pipes, air fin pipe etc., over which the air flows, entering or leaving the blower. With such construction, very little space is taken up by the heating element, and the very compact construction available in a tangential blower, particularly useful for an air curtain, is maintained even by addition of heat elements.

The outlet volume of the tangential impeller is readily adjusted with the housing throat if this is made movable

whereby the air velocity and the pressure is changed. Such adjustment is usually done manually, but it can be made automatic.

Similarly, the rotational speed of the rotor can be varied manually or automatically by a resistance or common variator control.

Another desirable modification is in means for varying the angle of nozzle mounting with respect to the outlet to overcome the effect of the wind turbulence in the region of the doorway. This may be done by mounting the blower axis near the wall of the door opening, with means provided for rotating the nozzle direction to a selected angle with respect to such opening. Other modifications will be inherent in the further descriptions made in conjunction with the drawings wherein:

FIG. 1 is a typical overall working model illustrating the air screen apparatus diagrammatically and in perspective;

FIG. 2 illustrates theoretical operation of the tangential impeller and preferred overall housing contour;

FIG. 3 illustrates an alternate form of housing which also illustrates an alternate mounting of hot gas heat exchangers;

FIG. 4 illustrates inside elevation the axial mounting of a driving motor combined both with a centrifugal fan to induce a motor cooling air stream and for direct coaxial drive of a tangential impeller;

FIG. 5 is a front elevational view of FIG. 4;

FIG. 6 is an end view similar to FIG. 3 illustrating an alternate mounting of heat exchangers within the nozzle;

FIG. 7*a* illustrates mounting of the air curtain above a doorway pivotally for controlled direction of the angle air screen across the doorway, the air inlet being disposed and directed to take air in from a warm air section C toward the center of the room, away from the doorway opening;

FIG. 7*b* illustrates mounting of the air curtain above a doorway pivotally for controlling direction of the angle of the air screen across the doorway, the air inlet being disposed and directed to take air in, at least in part, from the cold air doorway, and in a tilted position, in part from warm air section C;

FIG. 8 is a detail illustrating the definition of measurement of critical dimensions of the device;

FIG. 9 is a detail similar to FIG. 8 illustrating other dimensions; and

FIG. 10 is a diagram illustrating the functional relationship of velocity to distance below the nozzle outlet.

Referring first to FIG. 1, a housing **10** has a tangential impeller **12** having blades **14** rotated in the housing to draw air from an elongated inlet **16** and expelling the air at high presure and velocity through the outlet side plenum **18** within the housing, leading in suitable contour, as preferably shown, to an elongated outlet nozzle **20**. As shown, the inlet **16** and the nozzle outlet **20**, both preferably are rectangular, the nozzle outlet usually being of controlled narrow depth and extended length defined below, also depending substantially upon whether the air screen is to be of high or low velocity design.

The velocity of air flow may be varied, as usual, by variation of the rotational speed of the impeller **12**. However, considerable variation is also available in a tangential blower by controlled spacing of the housing shoulder **22** from the edge of the impeller blades **14**. The housing is usually of sheet metal or at least the under-wall **24** thereof is of resilient material so that the shoulder **22** may be raised or lowered toward or away from the impeller blades **14** having the construction at this point as desired. For this purpose the wall **24** is curved downward to form the upper portion **26** of the nozzle, and is separated from the lower nozzle side wall **28** at about their juncture by overlap of mating sections **26** and **28**. A series of slots **30** are cut across the lower end of the wall **26** to receive studs and wing nuts **32**, so that the position of the shoulder **22** may be varied, raising or lowering the shoulder and resilient lower wall **24** to a selected clearance from the impeller blade, usually a fraction of an inch or more, depending upon impeller diameter, between ¼" and 1" for an impeller diameter of 3 inches, and then setting the adjusted clearance by fastening of the wing nuts **32** upon the wall **26** in its adjusted position within slots **30**. Thus, the clearance of the shoulder **22** may be set and fixed manually and held in the adjusted position by wing nuts **32**. The position of the shoulder **22** can also be adjusted by a servomotor being part of a control system.

A heat exchanger bank **34** comprising elongated strip-like supports **35** for electrical heating elements, may be inserted as a bank across the entire cross-sectional area of the inlet **16**, very easily serving to preheat the inlet air as it enters the housing inlet **16** to be picked up by impeller **12** after being preheated to a desired temperature by efficient close contact with the heat exchanger **34**.

As shown in FIG. 3, the heating elements may be a series of fin tubes **36** which carry a heat transfer fluid such as steam and for optimum heat transfer. When the airscreen of an aircurtain of the non-recirculating type reaches the floor it usually splits into one ingoing and one outgoing airstream. In case such an air curtain is used for preventing influx of cold air into a heated room, the ingoing airstream will create a feeling of cold drafts, unless the temperature of the airstream is higher than room temperature. To achieve this the air in the air curtain can be heated. Substantial heating can be saved if the outgoing airstream does not have to be heated. With this type of an air curtain the air will remain stratified from the inlet to the outlet of the unit and for a substantial distance in the airscreen. Thus by heating the air selectively the main portion of the heated air will be in the ingoing airstream and the main portion of the unheated air will be in the outgoing.

As more clearly shown in FIG. 1, the inner nozzle wall **26** overlapping inner lower wall **28** are preferably designed for vertical downward flow and the outer housing wall **38** is preferably contoured around impeller outlet plenum **18**, which is faired or tapered downwardly toward the rectangular outlet **20** so that the lower outer wall **40** is similarly vertical and substantially parallel to the inner wall **28** as the elongated nozzle approaches the outlet **20**. Such fairing or construction is preferred because of a smooth improved homogeneity of velocity and pressure within the body of gas flowing through the nozzle outlet **20** to form a homogeneous air screen **42**.

As shown in FIG. 3, however, it is sometimes preferred to have the outer wall **44** designed as a straight or substantially vertically downward disposed wall with the inner wall portion **46**, faired diagonally inward from the adjustment shoulder **22**, a contour of somewhat lower efficiency but preferable for certain applications.

Moreover, as shown in FIG. 6, it is sometimes useful to mount heat exchange elements **48** in the after plenum **18** which may likewise be either a bank of electrical strips **34** or fin-tubes carrying heat exchange fluid **36**, as described above, whereby the high pressure, high velocity gas only upon leaving the impeller is then heated.

The position of the nozzle itself to direct a curtain of air at various angles with respect to an opening **49** in a wall **50** is illustrated in FIG. 7*a*, the inlet portion **16** thereof being directed toward the center of the warm air space C. An axial support **52** is journaled at both axial ends of the housing (the axial supports **52** not necessarily being concentric with the impeller), the nozzle **20** being positioned across the opening **49** and the entire housing and nozzle outlet attached thereto are rotatably mounted at ends of a pair of supports **54** and fixed at a desired outlet angle of the air screen **42**. That angle may be set by loosening and tightening a fastening nut **53** upon each threaded axial support and extending through the support **54**. The angle may also be adjusted by means of an automatic device.

As shown in the full line wall position of FIG. 7*a*, the

inlet is disposed toward the ambient air portion C away from the wall. That mounting position as shown in FIG. 7*a*, however, for some purposes may be reversed as shown in FIG. 7*b* so that the inlet is disposed at various adjusted angles but now adjacent the wall **51**, protecting a doorway opening **53**, the air device being supported in the same way thereabove by brackets **55**. The reverse type of mounting of FIG. 7*b* is particularly useful in the present type of air screen device to protect an opening **53** in a wall separating the area C from a refrigerated air space, because of the high integrity of this type of air screen produced by the tangential impeller and elongated air screen nozzle.

For instance, with the present homogeneous air screen, mounting of the nozzle to direct the flow vertically downward as in outline position A of FIG. 7*b* protectively over the opening **53** in the low temperature or refrigerated room, draws cold air into the inlet **16** from within the refrigerated room through the protected doorway **53** which is the only source. The air from such air screen **42** becomes recirculated through the opening **53** to overcome or reduce a fogging problem which often results in other constructions where an air screen is used to protect an opening **53** with a large temperature differential between warm space C and the refrigerated room. In such prior constructions the mixing of cold refrigerated air with moist ambient air from a warm space C, even when separated by the air screen because of its turbulence causes fogging. The air screen of this invention, directed downward in position A of FIG. 7*b*, draws cold internal air from within the refrigerated space through opening **53**, which is recirculated to the inlet **16** of the air screen device.

Moreover, if there are other openings in the room and the inlet **16** is disposed at various angles with respect to the opening **53**, the effect will still be to selectively draw some cold room air into the air screen device inlet. Since the air screen per se will thus have less moisture than the outside air in space C, no or less fogging will arise.

On the other hand, still using the present device protectively mounted across a wall opening **53** to separate a refrigerated space from ambient warm air space C, where there is no danger of fogging, the device can be tilted to any angle or reversed as in the position B of FIG. 7*a*. Warm air from the space C is then drawn into the blower inlet and no fogging again would result from a warm air screen. Indeed, if both warm and cool air are drawn into the inlet as shown by the arrows, the screen **42** is stratified in layers, and will tend, by this type of tangential blower, to remain stratified, thus to provide an air screen in which the outer layer of the air curtain adjacent to space C is warmer than the inner layer adjacent the opening **53**.

Thus, the ability to mount the present air screen device protectively over a doorway separating refrigerated from warm spaces at a selected angle, is useful both to prevent or reduce fogging at the doorway as well as to produce an air screen having a temperature differential from the warm side to the cold side, a condition which will be maintained by the wide angle setting of the air screen device in position B. If the conditions are such that no warm air is to enter the blower, a baffle F can be used to prevent warm (possibly humid) air from entering the blower at any of the tilted positions. Thus, an ordinary air screen construction, when the humidity of the warm air is very high, condensation and fogging will occur therewith on the side of the air curtain which faces the warm air. This can be avoided by heating the air entering or leaving the blower as in FIGS. 3 or 6 by mounting therein heating elements **35** or **48**. If only the air is heated on the side of the blower which entered the inlet of the blower from the warm area C as shown in FIG. 7*a*, the efficiency of the air curtain will be higher as the recirculating part of the curtain consisting largely of air taken from the cold space D is not being heated and less heat transfer will occur into the low temperature room.

In a modification shown in FIG. 4 and FIG. 5, the housing **10** may have an auxiliary axial flow through a subhousing **56** which may be partitioned apart by a wall **58** separating a cooling axial air flow through housing **56** from normal tangential for air screen **42** accommodates a flow into housing portion **10**. The construction driving electric motor **60** supported by bracket ends **61** extends from external supports (not shown). Radial arms **62** are mounted from armature **64** to drive a conventional squirrel cage impeller blade **63**, inducing air flow axially along the sides of motor **60**. A centrifugal outlet **65** is provided for the centrifugal motor cooling air flow. The armature **64** is further connected coaxially for drive of the tangential impeller **12** through the partitioning wall **58**, whereby independent air flows are impelled, the motor cooling centrifugal flowthrough housing **56** and an independent tangentially impelled flowthrough housing **10** for producing the air screen. Thus, the motor **60** is operated, drawing cooling air axially inward, as shown by the arrows **70**, impelled by impeller **63** flowing out of the end of housing **56**, as shown by arrows **65**. The flow of gas thereby cools the motor **60**. Simultaneously, operation of the tangential impeller **12** by motor **60** draws air through inlet **16** and expels it through outlet **20** as an air screen as described above. The motor **60** is variable in speed, controllable either through adjustment of resistance **68** or by control of the current frequency, depending on the type of motor as known in the art.

Referring to FIG. 8, the impeller **12** is shown to have a diameter dimension Q which measures the distance through the center from the outer blade edge to opposite outer blade edge. The distance L is the dimension from the outer blade edge to the nozzle outlet **20**. The distance D defines the width of the nozzle outlet from the inner wall **28** to the outer wall **40**. For purposes of defining a useful air screen nozzle, for use with a tangential type blower, according to the present invention, the minimum ratio of impeller diameter Q to nozzle width D should be more than 1:1, and more practically, more than 1.1:1, up to about 10:1 as a maximum for a very high velocity air curtain. Such maximum ratio of Q/D is usually not greater than 6:1.

The air screen curtain nozzle is elongated for purposes of modifying the air stream leaving the impeller **12** within the plenum **18**. The air pressure and velocity entering plenum **18** may vary, depending upon the particular position therein with respect to the impeller blades **14**, whereby elongated nozzle specifically serves to modify prevailing irregularities in air pressure and velocities as the air passes from the upper end of the plenum to the nozzle outlet **20**, so that as the air body leaves the nozzle **20**, its velocity and constant pressure is homogeneous throughout. Consequently, the length of the nozzle defines the distance usually needed in this air screen device, using a tangential impeller to allow the air to become homogeneous before it leaves the nozzle **20**. Again, for definition of the dimension intended, reference is made to the diagram of FIG. 9. The dimension L again measures the distance from the lower end of the impeller blade **14** to the nozzle outlet **20**. For design purposes herein, it is preferred that the ratio of the length of nozzle **20** to its width D, L/D, as defined above, is greater than 1.5:1, and preferably at least 2:1. In practical dimensions for a low velocity air curtain, the dimension D may be greater than 6 inches, such as two feet or more. The dimension W is included to illustrate the indefinite extension of a nozzle to establish an air screen as wide as needed to protectively cover a doorway or other wall opening.

The air curtain nozzle as normally designed widely distinguishes the typical outlet of ordinary fans, having blowers of any type pass gas into ducts for general purposes other than as an air curtain. The dimensions of such air curtain nozzle are illustrated in the diagram of FIG. 8 and the critical ratio of D/Q is stated above. The

cross-sectional area of the air screen is DW. The length L is a distance sufficient at least 1½ the outlet depth D to give a homogeneous air pressure characteristic (velocity) over the entire outlet area DW. In general, for a so-called "low velocity" curtain the depth dimension D of the nozzle may be several feet, usually about the order of 2 feet, and sometimes higher, while well protecting a doorway, will cause no substantial annoyance to persons passing through the air curtain while still protecting the doorway. That is, it will not blow off hats, disarrange hair or wrinkle or twist clothing of persons passing through. A high velocity curtain on the other hand, adopted to protect a doorway against passage of insects and temperature exchange between opposite sides of the air curtain partition may have a considerably narrower dimension D such as 6 inches, but usually less than 5 depending upon the maximum design velocity in the required distance length to be protected below the nozzle.

An air curtain nozzle, moreover, is distinct from ordinary blower nozzles in other characteristics, as will be apparent by reference to the diagram to FIG. 10. For instance, assuming a nozzle width D between upper and lower right hand A and left hand B walls of the nozzle outlet, the air emitted at high velocity forms a core whose conical walls are defined by the lines C and E meeting at the apex F a distance X_o below the nozzle outlet. The velocity V_o within the duct at its outlet and is homogeneous throughout and down to the apex of the core within the conical walls C and E. Surrounding ambient air is drawn by a suction, venturi or turbulence factor, into the jet so that the outlet air from the nozzle assumes an opposite conical pattern defined by the walls G and H. At a distance X from the nozzle outlet the mixed ambient and nozzle emitted air has then in a cross section assumed a maximum velocity of U_m. A curve drawn to illustrate linear velocity of the wet at the point X shows a typical distribution curve (1) where the maximum velocity obviously is at the center point of the apex below the core F. This velocity condition can be calculated by the equation

$$(1) \qquad U_m = U_o^2 \sqrt{\frac{X_o}{X}} = U_o \left(\frac{X_o}{X}\right)^{1/2}$$

where it will be seen that the relationship between the velocity at any point X from the nozzle to the outlet velocity X_o is a typical square root factor. The value X_o is a simple ratio of the nozzle depth dimension D to *m*, the turbulence factor. A typical turbulence factor for an ordinary fan outlet is in the range of 0.1 to 0.3 by solving the equation

$$(2) \qquad X_o = \frac{D}{m}$$

It is found, however, for any useful design of a nozzle intended for use as an air curtain that the root K of the ratio of initial outlet velocity X_o to the velocity at any point X below the nozzle as given by the Equation 3

$$(3) \qquad U_m = U_o^K \sqrt{\frac{X_o}{X}} = U_o \left(\frac{X_o}{X}\right)^{1/K}$$

preferably should be in the range of about 2.1 to 3.2, substantially above that of a typical outlet nozzle of any ordinary blower, including tangential blowers for other uses. The factor K is of greatest significance where the distance X_o is less than X where the dimension D is small, as in the high velocity air screen in which the need for a low turbulence factor is important. In any case, whether for a high velocity or low velocity screen, the length of the nozzle L usually being at least 1½ that of the dimension D would characterize the air screen nozzle.

As thus described, a very improved air screen is formed in the combination of a tangential flow blower with an elongated air screen nozzle, preferably of selected impeller diameter, nozzle width and length dimensions.

Certain modifications will occur to those skilled in the art for production of air curtains. The inlet air may be hooked up to a source of cooled air so that the screen may be formed of refrigerated air or it may be hooked up to a humidity controlled supply of air. Accordingly, it is intended that the above description and drawings be regarded as illustrative and not limiting except as defined in the claims appended hereto.

We claim:

1. In combination with means providing an opening to an enclosure, an air screen device comprising a housing having an inlet extending axially across the housing and a tangential impeller element having a diameter Q mounted to receive air flow radially from said inlet and an elongated narrow outlet nozzle extending a substantial distance downward from the edge of said tangential impeller, said nozzle having parallel side walls in the plane of its outlet and terminating in an elongated plane or rectangular outlet opening, constraining the air flow therethrough to a cubical body of substantial homogeneous texture, the ratio *Q/D* of the diameter Q of said impeller to narrow width dimension D of the nozzle outlet being in the range of about 1:1 to 6:1, and nozzle design factor K is in the range of 2.1 to 3.2.

2. The device as defined in claim 1 wherein the *L/D* ratio is in the range of 1.5:1 to 6:1.

3. Air screen device as defined in claim 1 wherein the ratio *Q/D* is in the range of 1.1:1 to 6:1, the *L/D* ratio is greater than 2:1 and the nozzle design factor K is in the range of 2.1 to 3.2.

4. Air screen device as defined in claim 1 wherein an elongated heat exchanger bank is mounted across the inlet of said housing to intercept the inlet air before it reaches said tangential impeller.

5. Air screen device as defined in claim 4 wherein the said heat exchanger is mounted at least partially across the inlet of said housing to intercept at least a portion of the inlet air before it reaches said tangential impeller and comprises a bank of electrical heating strips.

6. Air screen device as defined in claim 4 wherein the heat exchanger is mounted at least partially across the inlet of said housing to intercept at least a portion of the inlet air before it reaches said tangential impeller and comprises a bank of tubular ducting through which heat exchange fluid is circulated.

7. Air screen device as defined in claim 1 wherein an elongated heat exchanger bank is mounted in a plenum for heat exchange contact with gas leaving said impeller.

8. Air screen device as defined in claim 1 wherein the underside of said housing is vertically adjustable below the tangential impeller to control the size of the air passage clearance between the lower end of said impeller and the underside of said housing.

9. Air screen device as defined in claim 1 wherein the elongated side walls of said nozzle extend a substantial distance upward from the outlet as a pair of substantially parallel walls, and the inner wall closest to said inlet extends substantially vertically to a point immediately below the underside of said impeller, and the cooperating outer wall is contoured from the upper housing about said impeller inward to join toward the upper end of said outer nozzle wall.

10. Air screen device as defined in claim 1 wherein the elongated side walls of said nozzle extend a substantial distance upward from the outlet as a pair of substantially parallel walls and the outer nozzle wall is a vertical extension into which the top of the housing is smoothly contoured, and the inner nozzle wall is vertically parallel to said outer wall and is faired continuously inward to approach the underside of said housing beneath the impeller blade.

11. Air screen device as defined in claim 1 wherein the device is supportable by brackets extending from the wall surrounding the doorway to be protected by said air screen at opposite axial housing ends, the housing has axially extending supporting pins parallel with the im-

peller drive, and the housing is fastened radially adjustable to said supporting brackets in a manner to set the angular position of said nozzle with respect to the doorway to be protected to discharge an air curtain at an adjustably selected angle.

12. Air screen device as defined in claim 1 wherein the elongated housing has mounted coaxial therewith an annular sub-housing, an axial inlet and radial outlet for air flow through said sub-housing, a driving motor centrally mounted within said sub-housing having its armature drive connected for coaxial drive of said tangential impeller and having an impeller mounted therefrom to impell air flow axially into said sub-housing in cooling contact with said motor and centrifugally outward thereof as a motor cooling air flowing circuit independent of the simultaneously produced air flow induced by said tangential impeller discharged from said nozzle as an air screen.

13. Air screen device as defined in claim 1 wherein the driving motor is combined with means for varying its rotational speed.

14. The method of protectively screening an opening in a wall enclosing a refrigerated space from warm ambient air disposed in the outside of said wall opening, comprising mounting upon said wall over said opening an air curtain device of the tangential fan type to extend substantially from side to side thereof, varying the angle of the outlet of said device to direct the air curtain at a selective angle from vertically downward across said opening, to reduce fogging of the air adjacent to said opening, to a substantial angle oblique from the vertical, drawing air into said air curtain device from the cold side of the air screen and heating the air as it passes therethrough.

15. The method of protectively screening an opening in a wall separating cold air from warm air, comprising mounting upon said wall an air curtain device of the tangential fan type to extend substantially from side to side over said opening impelling said air passing through said device in laminar flow as an air curtain across said opening, and heating only a portion of the air passing in laminar flow through, said device to provide a heated layer of air adjacent to the warm side of the wall opening.

16. The method of protectively screening an opening in a wall enclosing a refrigerated space from warm ambient air disposed on the outside of said wall opening to reduce fogging resulting from intermixture of warm moist ambient air with the cold air flowing through said opening, comprising adjustably mounting upon said wall over said opening to extend substantially from side to side thereof an air current device of the tangential fan type, drawing air into said inlet passing adjacent to said wall and impelling said air in laminar flow as an air curtain, baffling the flow of warm air adjacent said wall to impede its passage into the inlet of said fan while favoring the passage of cold air flow into said inlet, whereby said air curtain is composed of air taken from the cold side of said air screen.

17. The method as defined in claim 16 wherein the air passing through said tangential fan is heated to provide an air curtain at a temperature substantially above the cold air side of the air screen.

18. The method of protectively screening an opening in a wall enclosing a refrigerated space from warm ambient air disposed on the outside of said wall opening to reduce fogging resulting from intermixture of warm moist air with the cold air passing through said opening, comprising mounting over said wall opening and extending substantially from side to side thereof an air curtain device of the tangential fan type, adjustably varying the angle of the intake of air to said tangential fan to direct a portion of the air passing thereto from the warm air surrounding said tangential fan and another portion of the inlet air from cold air passing upward to said fan from said wall opening, drawing the air into said fan inlet in laminar flow from both of said sources and discharging said air from the outlet of said tangential fan as a laminated air screen directed at said selected angle downward protectively across said wall opening, the warm air layer of said laminated air screen being disposed outward adjacent to the warm ambient air side and the cold layer disposed adjacent to the cold air side of said opening.

19. The method as defined in claim 18 wherein the air screen device is mounted on the cold side of said wall opening whereby the streams of cold and warm air passing to the inlet of said fan and the positions of cold and warm air layers in the laminated air screen with respect to said opening are reversed.

20. A method as defined in claim 18 wherein only the air passing through the impeller in laminar flow which was taken from the warm area is heated.

References Cited

UNITED STATES PATENTS

1,886,513	11/1932	Anderson	230—125
2,685,476	8/1954	Spreng	230—114
2,827,266	3/1958	Ruff	98—36 X
2,942,773	6/1960	Eck	230—125
3,018,712	1/1962	Wacker	98—36
3,038,400	6/1962	Ruff	98—36
3,157,105	11/1964	Tamm et al.	98—36
3,177,794	4/1965	Laing	98—2
3,249,292	5/1966	Eck et al.	230—114
3,256,798	6/1966	Melzer	98—36

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