Aug. 31, 1965 S. BECKWITH 3,203,337

REFRIGERATED DISPLAY CASE AND ELEMENTS THEREOF

Filed Feb. 27, 1961 3 Sheets-Sheet 1

FIG. 1



FIG. 2

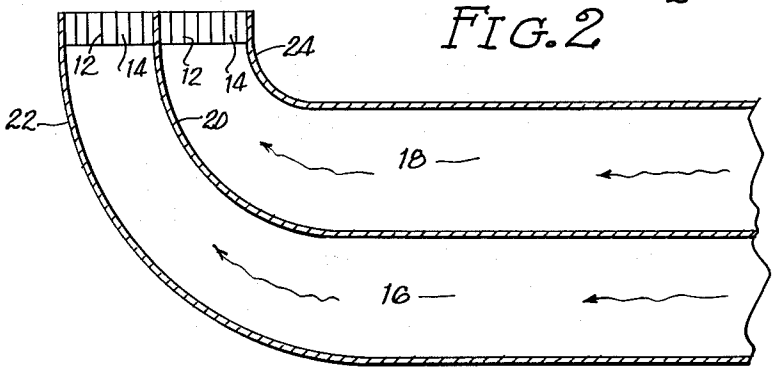
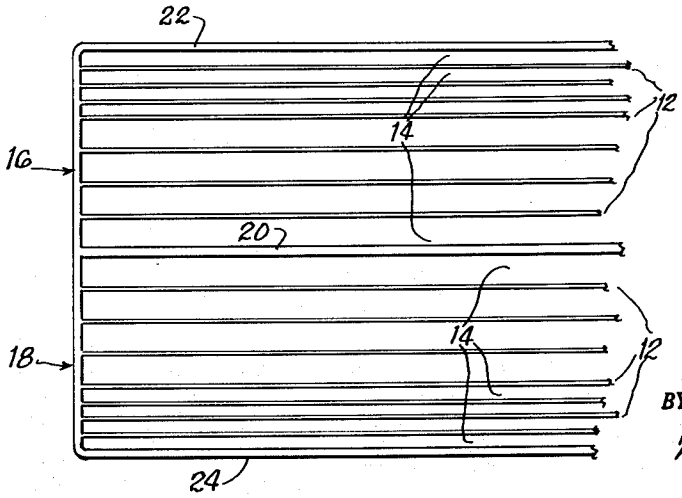


FIG. 3



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REFRIGERATED DISPLAY CASE AND ELEMENTS THEREOF

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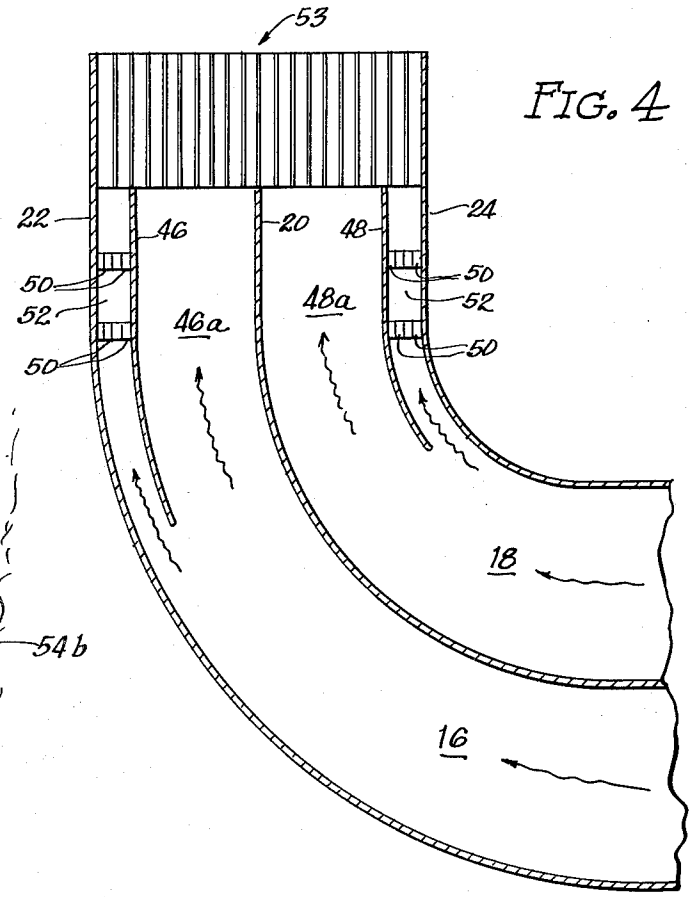


FIG. 4

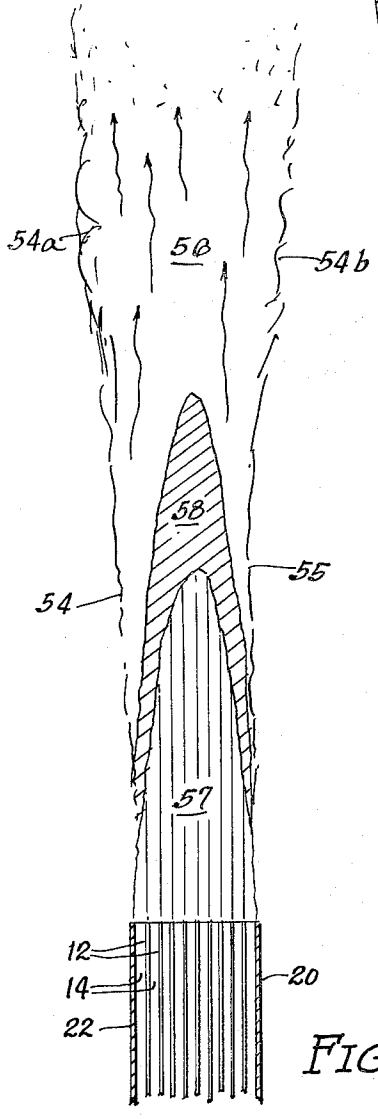


FIG. 6

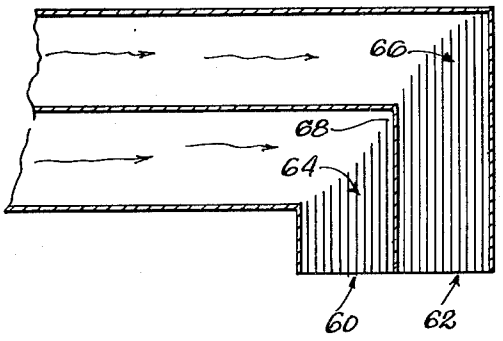


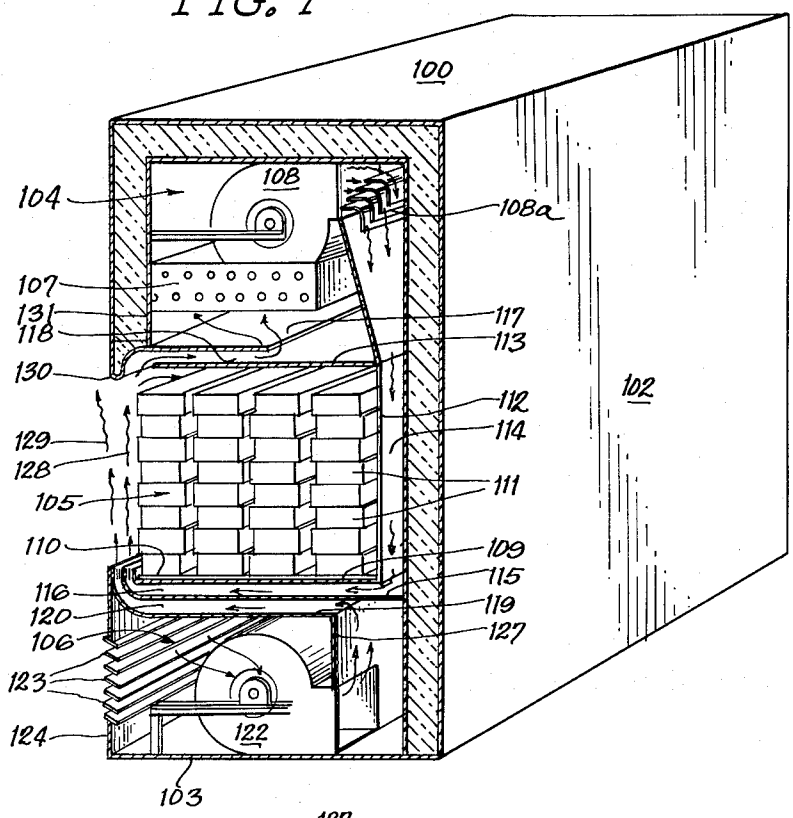
FIG. 5

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FIG. 7



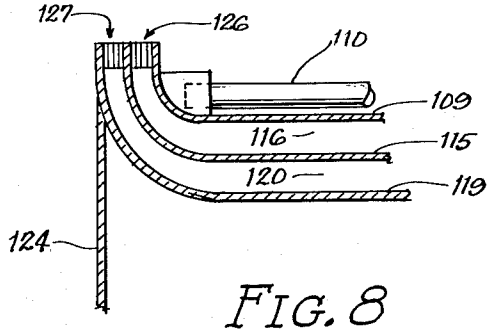


FIG. 8

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United States Patent Office

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3,203,337

REFRIGERATED DISPLAY CASE AND ELEMENTS THEREOF

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Filed Feb. 27, 1961, Ser. No. 91,875
3 Claims. (Cl. 98—36)

This invention relates to a method and means for maintaining a controlled atmosphere within a space having an open side and it relates more particularly to a method and means for projection of a gaseous curtain continuously across and open side of an otherwise enclosed space for the purpose of maintaining a controlled atmosphere therein. The invention will hereinafter be described with reference to the method and means for maintaining a refrigerated state within an open-sided storage space. It will be understood that the same concepts can be adapted to use for maintaining a warm, cold, inert, oxidizing, reducing, or the like atmosphere by proper substitution of elements making up the gaseous curtain which is continuously projected across the open side of the space.

In accordance with the practice of this invention, the desired atmospheric condition is maintained within the open-sided space by continuously moving a panel of gaseous material across the open side of the space with the inner portion of the panel corresponding to the conditions desired to be maintained within the space while outer portions of the panel correspond more to the room conditions existing outside of the space and it is a further concept of this invention to provide a nozzle arangement and construction for use in combination with the enclosed space to produce a panel formed of elements having a high degree of laminar flow to produce a conditioning curtain which extends across the open space.

When used to produce a refrigerated space, the described panel is formed with an inner portion containing refrigerated or cold air while outer portions contain warmer air. To produce a heated space, the conditions would be reversed to provide the heated portion in the interior with the colder portions outwardly thereof. Similarly, to produce an inert atmosphere, the inner portion of the panel will be formed of an inert or inertive gas while outer portions will be less inert, etc.

To the present, it has been common to manufacture cold storage containers for packaged foods, meats, beverages and the like in the form of an open top, rectangular container. The merchandise is displayed by packing the items one upon the other. While keeping the contents sufficiently cold to prevent spoilage, such display cases have the disadvantage of being awkward from the standpoint of the consumer's use since only the uppermost items in the stack are visible and it becomes necessary to bend over to remove items from within such containers.

The present invention is adaptable to a new type of open side cold storage container for displaying frozen goods. In such container, it is possible for the various goods to be observed by the prospective purchaser and it is a simple matter to effect removal of the desired number of such goods without the necessity for bending or stooping to make selections.

In order to maintain a sufficiently cold atmosphere within the open-sided container, a panel of substantially parallel layers of cold and warm air, for example, is projected across the open side of the container. The inner portion of the panel which is adjacent the interior of the container is formed with cold air having a temperature similar to that of the interior. The outer portion of the panel has a temperature more closely approximating the temperature of the outside ambient atmosphere or a temperature intermediate therebetween.

To function as a barrier to retain the cold within the container, both the warm and cold air layers are projected at about corresponding velocities, such for example as at 50 to 1500 feet per minute, and preferably 200 to 500 feet per minute, whereby entrainment is minimized.

To project the cold and warm air layers, hereinafter referred to as a panel, across the open side of the container, use is made of nozzles positioned across one edge of the container with such nozzles being arranged in side-by-side parallel relation. For example, the nozzles may extend across the bottom edge to direct the air streams towards the top edge, or the nozzles may be in the top edge to direct the streams downwardly towards the bottom edge, or they may be in one of the side edges to direct the streams across towards the opposite side. The cold air nozzle is on the inside and is directed towards an inlet in the opposite edge for recirculation of the cold air and the warmer air nozzle, on the outer side, may be directed either into the ambient atmosphere or it too may be directed to an inlet for recirculation.

For a more complete description of the open-sided refrigerated storage space, reference may be had to the Simons Patent No. 2,862,369, issued December 2, 1958, and entitled Air Conditioned Display Compartment and Method.

The concepts of this invention are addressed to an improvement to minimize turbulence and maximize laminar flow between the air streams making up the air panel whereby intermixing of warm with cold air is minimized greatly to increase the efficiency of operation and maintenance of the desired atmospheric condition at minimum expense, and it is an object of this invention to provide a method and means for achieving same.

Another object is to provide a method and means for generating an air curtain of the type described which is characterized by a high degree of laminar flow substantially throughout the length and cross-section thereof.

A particularly important object of this invention is to provide laminar flow along the inner face between the moving streams of cold and warm air making up the air curtain or panel and it is a related object to provide and improved nozzle arangement which functions to provide air panels of the type described.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawings, in which:

FIG. 1 is a fragmentary top plan view of a nozzle assembly embodying the features of this invention;

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary top view of another modification of a nozzle assembly;

FIG. 4 is a sectional elevational view of the nozzle assembly of FIG. 3;

FIG. 5 is a sectional elevational view of a still further modification of a nozzle construction;

FIG. 6 is a schematic illustration of the air flow from a nozzle arrangement of the type shown in FIG. 1;

FIG. 7 is a cross-sectional perspective view of an open-sided refrigerated display case of the type with which the nozzles of this invention may be employed; and

FIG. 8 is an enlarged sectional view of a portion of the cabinet of FIG. 7 showing in greater detail a nozzle construction which may be employed in the practice of this invention.

Before going into a detailed description of the nozzle asesmblies of the invention, their mode of operation and the specific details of their construction, consideration will first be given to a typical open-sided refrigerated display case of the type with which the nozzle assemblies are intended to be used. With reference to FIGS. 7 and 8,

the refrigerated display cabinet is constructed with a top wall 100, rear wall 102, bottom wall 103, and opposed end walls (not shown). Within the cabinet is an upper compartment 104, an intermediate compartment 105 and a lower compartment 106. Within the upper compartment there are provided refrigeration coils 107 and one or more centrifugal blowers 108.

The middle or intermediate compartment 105 defines the area adapted to be conditioned and within which the material 111 is positioned on a bottom wall 109 with the exception that shelf 110 is preferably located on the bottom wall for support of the material 111.

The bottom wall 109 extends to the end walls of the cabinet and to a rear wall 112 which defines the rear wall of the intermediate compartment 105. The rear wall 112, which is spaced inwardly from the rear wall 102 of the cabinet, extends upwardly from the bottom wall 109 to a position beyond the rear edge of the top wall 113 separating the compartment 105 from the compartment 104. The upper portion of wall 112 is apertured for communication with the outlet of a blower 108 and is provided with turning vanes 108a for directing the stream of air from the blower into the passage 114 defined by the wall 112 and the rear wall 102 of the cabinet, which passage extends downwardly to the rear edge of the wall 109 of the compartment 105.

A plate 115 spaced below the bottom wall 109 of the compartment 105 extends from the forward side of the compartment to the rear wall 102 of the cabinet. Thus plate 115 and bottom wall 109 form a continuation 116 of the passage 114.

Below the refrigeration coils 107 and above the top wall 113, the assembly is provided with a plate 117 which extends rearwardly from the front wall 131 of the upper compartment 104 to overlap a portion of the top wall 113 of compartment 105 and in spaced relationship therefrom. Thus the wall 113 and plate 117 define a passage 118 therebetween which is open to the forward side of the cabinet adjacent the upper side of the compartment 105 and which communicates with the upper compartment 104 at a point forwardly of the wall 112.

Air flow through the passage 118 and into the upper compartment 104 passes across the refrigeration coils 107 before entering the inlet to blower 108. Thus the passages 114 and 116 represent the cold air passages the walls of which define two of the walls of the compartment 105 and thereby assist in conditioning air in compartment 105 to the desired temperature.

Below plate 115 there is provided a spaced parallel wall 119 which extends rearwardly from the forward lower side of the compartment to define a passage 120 therebetween. The rear edge of plate 119 terminates short of the rear wall 102 of the cabinet and then extends downwardly at 121 to the bottom 103 of the cabinet. A blower 122 is positioned within the lower compartment 106 with its outlet in communication with the passage 120 so that the air from the blower will be caused to flow through the passage 120. Inlet louvers 123 in the front wall 124 of the compartment 106 provide for the entry of atmospheric air to the inlet of the blower 122.

The walls defining the passages 116 and 120 are turned at their forward edge to extend in an upwardly direction, as shown in FIG. 8, to provide a pair of elongated upwardly directed nozzles 126 and 127 which extend in side-by-side relationship across the lower edge of the open front of compartment 105. The air forced through passages 116 and 120 issues upwardly from the nozzles and across the front open side of the compartment 105 in adjacent layers 128 and 129.

The inner layer 128 represents the refrigerated air issuing from the passage 116 through the nozzle 126 while the outer layer 129 represents the warmer air recirculated from the atmosphere from the passage 120 through the nozzle 127. Above the pair of nozzles 126 and 127 and across the upper edge of the compartment 104 is a depending lip 130 which functions as a divider to separate the refrigerated layer 128 from the warmer layer 129 whereby the air recirculated therough the refrigeration coils and into passages 114 and 116 is air formed mostly of the cold air originally making up the cold air panel thereby to save on the cost of refrigeration and therefore also better to stabilize the cold temperature conditions existing within the refrigerated space.

The inner and outer layers 128 and 129 issuing from the nozzles 126 and 127 may be easily adjusted by controlling the output fans. The refrigerated space is thus protected by a layer of air having a temperature substantially corresponding to the temperature at which it is ejected from nozzle 126, which may be at about —10° F to about —30° F. and which is therefore adequate to maintain a temperature of approximately 0° F. within the refrigerated space. Little, if any, entrainment occurs between the layers 128 and 129 which are moved in substantially laminar flow at substantially the same velocity.

With the arrangement described, free access is had to the material 111 through the open front side of the storage space. Where the materials are in separate packages, they can be readily removed through the open front in the same manner as any other package or article can be removed from conventional shelves. The labels are readable and the packages can be arranged so that they will not interfere one with another.

The concepts of this invention are also adapted for use where the warmer air in the outer panel or panels is also separately recirculated as described in the copending application of Hagen et al. Ser. No. 54,077, filed September 6, 1960, and entitled Refrigerated Display Case. In the arrangement of the Hagen et al. application, both the refrigeration or cold air jet and the warmer or guard air jet are projected for laminar flow across the open space from the nozzles extending across the top edge of the open space. The panels are directed downwardly against the open space towards the correspondingly arranged inlets for separation of the cold air panel for recirculation through the refrigerated coils and panels to the nozzles and jets, as previously desecribed, and for separation of the warmer air panel for recirculation through passages between the refrigeration passages and the outer walls of the cabinet to the nozzles or jets from which the warmer air is ejected across the open space. The air in the guard jet will be warmer than the air in the refrigeration jet but colder than the ambient atmosphere so that the slight amount of guard air which intermixes with the refrigeration air during passage together across the open space will have minimum effect on the horsepower of refrigeration required to maintain the desired conditions within the refrigerated space 105. Thus the desire for laminar flow to minimize turbulence of intermixing of air from the adjacent air panels is present where the refrigeration air jet is recirculated alone or in combination with one or more guard jets.

In accordance with the practices of this invention, it has been found that the turbulence may be substantially reduced by providing nozzles of the type illustrated in FIGS.1 and 2, but preferably arranged with a slight degree of convergence as between the inner cold air nozzle and the outer warm air nozzle to avoid dead spots between panels and to promite laminar flow. These nozzles, for the most part, are adaptable to constructions of the type shown in FIGS. 7 and 8.

The nozzle of FIG. 1 is designated generally by the numeral 10. It consists of a plurality of parallel, longitudinally spaced vanes or members 12 which subdivide the nozzle into a number of closely separated, parallel passages 14. The nozzle is shown in FIG. 2 as being a continuation of the warm air duct 16 and the cold air duct 18 divided by a wall 20. The outer wall of the warm air nozzle is designated by the numeral 22 and the inner wall of the cold air nozzle by the numeral 24. It has been found that for minimum turbulence, it is desirable to

maintain minimum spacing between the jets issuing from the nozzles. For this purpose, it is desirable to minimize the cross-section of the vanes or walls between the open spaces from which the air jets issue. Satisfactory results are secured when the wall space comprises less than one-fourth of the cross-section of the nozzle or, in other words, when the nozzle is at least 75 percent open and less than 25 percent occupied by vanes or walls **12**. Best results are secured when the nozzle is 90 precent or more open and only 10 percent or less wall or vanes. Typical of a preferred construction is a honeycomb or vaned nozzle having a vane or wall thickness of 0.001 inch and a bore or open space between the walls of about 0.125 inch.

A nozzle of the type described is designed so that the air columns issuing from the air channels **16** and **18** comprise a plurality of fine air streams which merge into adjacent panels of refrigerated and warm air characterized by substantially laminar or non-turbulent flow. In the preferred practice of this invention, the nozzle sections comprise vane sections in the form of honeycomb or thin wall sections, such as formed of sheet aluminum. Best use is made of honeycomb slabs having a depth greater than ½ inch and preferably greater than 1 to 2 inches so that the stream of air issuing from said honeycomb openings will be guided in laminar flow from the nozzles to provide for substantially laminar flow across the access opening in the front wall of the container. As a general rule, it may be stated that the passages between the dividing walls should be such that the air emanating therefrom has a Reynolds number below 2300 (based upon a channel having an equivalent diameter equal to one-half of the hydraulic radius), as corrected for the type of chamber used in forming the cold and warm air panels. Since the determination of Reynolds numbers of critical velocities can best be achieved while in the steady state and while conversion from the steady state characteristic of laminar flow to a transient state can include turbulent flow, it is sometimes easier to make use of trial and error in conjunction with visual inspection, as by means of a smoke, to determine optimum velocities of the air stream with a particular set of conditions for maximizing laminar flow.

In the smoke tests with the nozzle assembles of the type illustrated in FIGS. 1 and 2, it was noted that substantial laminar flow between the air panels occurred substantially throughout, with the possible exception of the trailing edge of the panels where some degree of turbulence was noted in the inner face between the adjacent cold and warm air panels. It was further noted that the extent of laminar flow increased with an increase in the number of guard jets and decreased in proportion to the spaced relationship between the jets. Across an opening of about 24 inches, only a small fraction, corresponding to less than 20 to 30 percent and preferably less than 10 percent of the warm air panels, entered the colder air panels at the cutoff point where both panels were recirculated. A slightly greater degree of turbulence was experienced in upward flow of the air panels across the open space, as illustrated in FIGS. 7 and 8, as compared to down-flow from the top side to the bottom side, as illustrated in the aforementioned copending application. This difference is believed to be influenced somewhat by the gravitational effect.

It has been found further that improvement in laminar flow or decrease in turbulence can be achieved by a slight modification in the construction of the nozzles of the type described and illustrated in FIGS. 1 and 2 to decrease the spaced relationship between the vanes **12** in the outer portion of the outer nozzle and the inner portion of the inner nozzle, as illustrated in FIG. 3. The decrease in spacing can take place gradually from the inner edge towards the center and from the outer edge towdar the center, or it may be limited to only the outer edge portion of the outer nozzle and the inner portion of the inner nozzle with the spacing throughout the remainder being somewhat the same.

In another modification, illustrated in FIG. 4, the central portion or area between both nozzles **46a** and **48a** is provided with a current of air from chambers **16** and **18**. A small portion of the stream in chamber **16** is cut off by the wall **46** for passage between the walls **46** and **22** while a small portion of the cold air stream in chamber **18** is cut off by wall **48** for passage between the walls **48** and **24**. These walls define passageways **52** which are provided with vaned sections **50**, such as honeycomb sections, whereby velocity in the outer portion of the warm air stream and consequently turbulence in the inner portion of the cold air stream is reduced. The streams from the passages **16**, **18** and **52** are finally advanced through the vaned sections of honeycomb **53** to define the air panels projected across the open space.

A still further modification for subdivision of the air streams and regulating flow is shown in FIG. 5 wherein the air streams are turned at sharp angles for issuance from the nozzles **60** and **62** by vaned or honeycomb sections **64** and **66**, which are formed to curvilinear shape at their leading edges to intercept variable amounts of the air streams passing through the chambers. This procedure is adapted to increase or decrease the volume of air issuing from selected cross-sections of the nozzles. In the modification illustrated in FIG. 5, the curvilinear contour at the intercepting leading edge portions of the turning vanes is such that smaller amounts of the air stream are intercepted at the inner edge portion of the cold air stream and at the outer edge portion of the warmer air stream so that a less volume of the stream issues from the inner edge portion of the cold air nozzle and the outer edge portion of the warm air nozzle with maximum volume from the remainder. For this purpose, the turning vanes are curved to extend across the path of the air stream with a flattened portion **68** of the curve in the inner edge portion of the section **64** with the steepest portion of the curve at the outer edge portion of said nozzle section. Similarly, the honeycomb in the nozzle **62** is formed with the steepest portion of its curve at the inner edge with the flatten portion at the outer edge so that minimum volume of the air streams in the feeding channels will be cut off for passage through the vanes having the more flattened curvature.

As previously mentioned, an expedient method for arrangement of the nozzle assemblies embodying the features of this invention is to introduce a smoke for visual reproduction of the characteristics of the air curtain issuing from the particular nozzle arrangement. FIG. 6 illustrates the type of air curtains produced by a nozzle assembly of the type shown in FIG. 1. The striated smoke panel **57** emanating from the nozzle possesses characteristics of laminar flow in the central portion of the nozzle at the inner face between the air panels for a distance greater than the portions **54** and **55** adjacent the outer edges of the panel. When the smoke reaches a substantial height above the nozzle area, turbulence begins to be experienced at the inner face between the panels, as shown in the figure at **56**. At the inner face between the panels, characteristics of the air flow are maintained for a substantial distance, as shown by the numeral **58**.

Since pressure differences exist as between the interior of the enclosed space and the exterior or ambient atmosphere and since such pressure differences may vary over a period of time and from one edge to the other across the open space, it is desirable to embody means to position the nozzles at an angle so that the resultant merged jet issuing from the nozzle is so directed that the inertia forces deflecting the jet from a straight line oppose any differences in pressure across the opening. It is desirable also to angle the jet to oppose uniform pressure differences along the length of the jet. It is also desirable to embody means for adjusting the angle of the jets to oppose variable pressure differences across the width of the jet and to vary the angle or aim to compensate for

variations in pressure with time. For non-varying conditions, the angle of the jets can be fixed to provide a resultant stream which bends in response to pressure differences across the opening to bring the trailing edge of the stream to the inlets for proper cutoff and recirculation. For transient conditions, the angle or aim of the jets should also be transient or variable to oppose variation in pressure. Such adjustment can be made responsive to pressure differences existing across the opening.

It will be apparent from the foregoing that I have provided a simple and expedient means for maintaining laminar flow between adjacent panels of air making up an air curtain projected across a conditioned space whereby the desired conditions can be maintained within said space with a minimum expenditure of conditioning material, cold, heat or other atmospheric control means.

It will be understood that changes may be made in the details of construction, arrangement and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. A nozzle assembly for use in maintaining non-entraining parallel panels of differently conditioned air across the open side of an otherwise enclosed space which comprises at least two nozzles arranged in side-by-side relationship to extend continuously along the length of one edge of the open side and positioned to direct the air panels towards the opposite edge thereof, one of said nozzles being an inner conditioned air directing nozzle having an inner edge portion positioned adjacent the open side of the enclosed space, the other nozzle being an outer differently conditioned air nozzle having an outer edge positioned towards the ambient atmosphere, said nozzles embodying means for issuing the air streams at lower velocity from the inner portion of the inner nozzle and from the outer portion of the outer nozzle than the air streams issuing from other portions of the inner and outer nozzles, said means comprising a plurality of vanes extending lengthwise across each of the nozzles dividing the nozzles into vaned sections, and additional vaned sections in communication with the vaned sections in the inner portions of the inner nozzle and the outer portions of the outer nozzle to impart resistance to gaseous flow whereby the volume of air passing through said vaned sections having barriers is less than through the remainder of the vaned sections with corresponding decrease in velocity of air issuing from the corresponding inner portions of the inner nozzle and outer portions of the outer nozzle.

2. A nozzle assembly for use in maintaining non-entraining parallel panels of cold and warm air across the open side of a cold storage container which comprises at least two nozzles in side-by-side relationship and extending continuously across the length of one edge of said open side for directing the air panels towards the opposite edge thereof, one nozzle being a cold air directing nozzle having its inner edge positioned adjacent to the open side of the cold storage container, the other nozzle being a warmer air directing nozzle having an outer edge positioned towards the ambient atmosphere, comprising an inner air passageway communicating with the inner nozzle and an outer air passageway communicating with the outer nozzle, walls spaced from the outer

walls of the two passageways and projecting into the passageways subdividing the passageways into inner and outer passages in communication with the nozzles, flow restriction means within the inner passage of the inner air passageway and within the outer passage of the outer air passageway for slowing air flow whereby the air issues from the nozzles at a lower velocity from the inner portion of the inner nozzle and from the outer portion of the outer nozzle by comparison with the remainder.

3. A nozzle assembly for use in maintaining non-entraining parallel panels of differently conditioned air across the open side of an otherwise enclosed space which comprises at least two nozzles arranged in side by side parallel relationship to extend continuously along the length of one edge of the open side and positioned to direct the air panels towards the opposite edge thereof, one of said nozzles being an inner conditioned air directing nozzle having an inner edge portion positioned adjacent the open side of the enclosed space, the other nozzle being an outer differently conditioned air nozzle having an outer edge positioned towards the ambient atmosphere, said nozzles embodying means for issuing air streams at lower velocity from the inner portion of the inner nozzle and from the outer portion of the outer nozzle than from the air streams from the outer portion of the inner nozzle and the inner portion of the outer nozzle, said means comprising a plurality of vanes extending lengthwise across each of the nozzles in substantially equally spaced apart relationship to subdivide each nozzle into a plurality of vaned sections of substantially equal cross section, air passageways leading into each of said nozzles from a direction substantially perpendicular to said nozzles, said vanes terminating at their rearward ends in said passageways with each adjacent vane progressively extending inwardly by increasing amounts from the inner end outwardly in the inner nozzle and from the outer end inwardly from the outer nozzle whereby the increments of air cut off for passage into each of the vaned sections increases from the inner end outwardly in the inner nozzle and from the outer end inwardly in the outer nozzle with corresponding difference in the velocity of air issuing from the vaned sections of the nozzles.

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