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AIR OUTLET NOZZLES FOR AN AIR CURTAIN DEVICE

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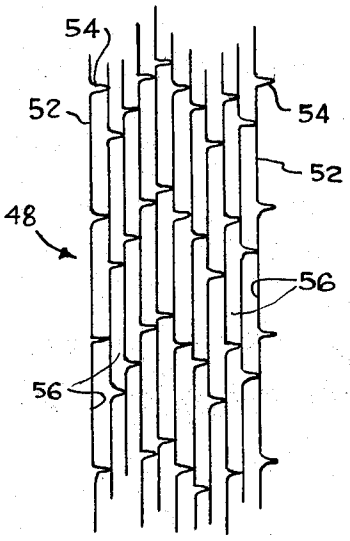

FIG. 2

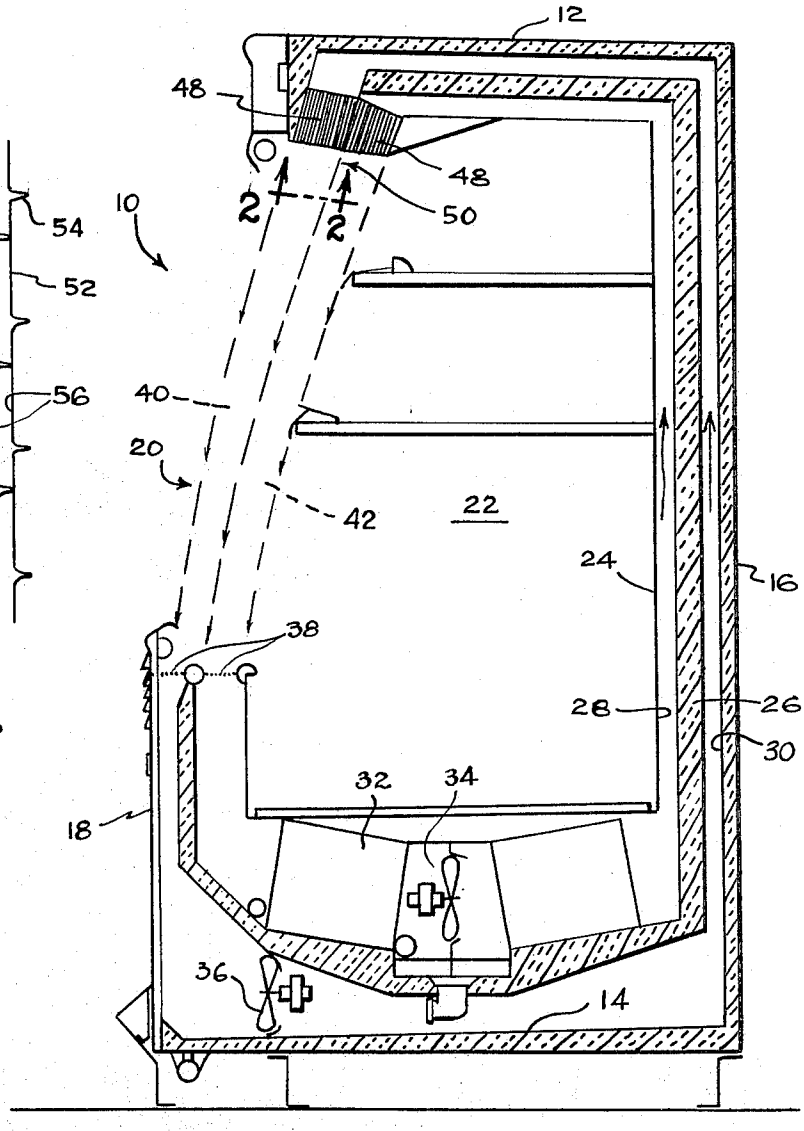

FIG. 1

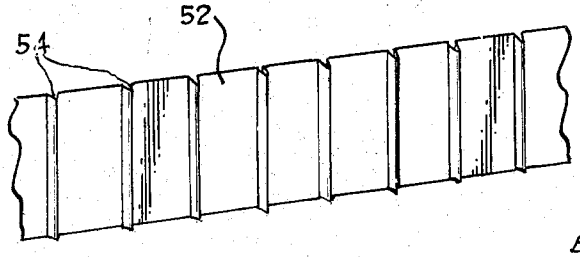

FIG. 3

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AIR OUTLET NOZZLES FOR AN AIR CURTAIN DEVICE

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The invention set forth herein is concerned with nozzle constructions adapted to handle air or other gases which pass out of an exit opening and then move, in a more or less stable form, in unconfined space. Air curtains of the type described are well-known and have a wide variety of uses.

The instant invention will be described with reference to refrigerated cabinet constructions. In such constructions, air curtains are moved across an access opening for the cabinets and the character of the curtains is important with regard to efficient operation of the construction. It will be understood, however, that the nozzles employed herein can be utilized for the handling of air streams in other constructions where the necessary characteristics of the stream are similar to the characteristics required of streams in refrigerated cabinets.

In an application of Hagen et al., Ser. No. 54,077, filed Sept. 6, 1960, now Patent No. 3,134,243, and in the issued Simons Patent No. 2,862,369, there are described refrigerated display cabinets which are provided with access openings exposed to the atmosphere while still being capable of maintaining the contents in a refrigerated state. Loss of refrigeration from the enclosed space through the access opening in reduced in a highly effective manner in these constructions by the use of a gaseous, preferably air, curtain which is continuously advanced across the open side from one edge of the opening to the opposite edge. The air curtain in these constructions is adapted to be formed of adjacent panels of air, with the innermost panel comprising a refrigerated cold air panel, and with one or more outer panels having temperatures approaching the ambient temperature. It has been found that it is desirable to recirculate the inner cold air panel and to provide means for circulating the adjacent guard panels, to conserve the refrigeration and to maintain the enclosed space in a satisfactory refrigerated state.

In these constructions there are described assemblies which include nozzles extending across the bottom edge of the access opening to direct the air panels upwardly across the opening towards inlets which extend across the top side of the access opening. As an alternative, the nozzles are located across the upper edge for projecting the air panels downwardly toward inlets arranged across the bottom edge. It is also contemplated that the air nozzles be located across one of the lateral edges of the opening for directing the corresponding air panels across the opening toward inlets in the opposite edge. Because of the more desirable effect of gravity on the higher density cold air, it has been found preferable to provide the air curtains with a downward movement from nozzles across the top to inlets across the bottom. The following description will refer to this preferred construction, although it will be understood that the concepts to be described are also applicable to other directions of flow.

In the use of cabinets of the type described, it is, of course, desirable to provide maximum efficiency insofar as the amount of power consumed is concerned. In refrigeration systems of this type, the consumption of power is primarily due to the refrigeration of the moving air streams which pass over the access opening for the cabinet. To a somewhat lesser degree, power is consumed during defrosting cycles and due to the driving of fans for circulation of the streams. As far as the refrigeration of the streams is concerned, a major factor contributing to the amount of power consumption is the loss of refrigeration (or intake of heat) through the access opening.

Loss of refrigeration can be attributed to a substantial degree to turbulence which is set up between moving air streams and still air adjacent the moving air streams. Specifically, it has been found that the movement of a stream adjacent still air or adjacent a stream moving at a substantially different speed will create turbulence and will result in a "whipping" action. The moving streams of air when characterized by such action, move out of their intended paths periodically, and large masses of the air can be completely lost insofar as the circulating streams are concerned. Where these masses are refrigerated, the natural result is to increase the load on the refrigerating means for the cabinet so that the loss of refrigeration can be accommodated.

In refrigerated cabinets previously conceived, nozzle constructions usually included a section of honeycomb which was found to provide a highly ideal air curtain. In such constructions, the use of honeycomb was considered advantageous since the streams issuing from the honeycomb essentially comprised a plurality of individual streams which were broken up by the honeycomb design. This arrangement greatly reduced turbulence in the operation of a machine of the type described; however, it has been observed that the undesirable turbulence and whipping action could not be completely controlled with arrangements of this nature.

It is an object of this invention to provide an improved nozzle means for a refrigerated cabinet construction.

It is a further object of this invention to provide a honeycomb construction which can be relatively easily manufactured and which can accomplish substantially all of the beneficial characteristics of nozzles employing honeycomb sections.

These and other objects of this invention will appear hereinafter and for purposes of illustration but not of limitation, specific embodiments of this invention are shown in the accompanying drawings in which:

FIGURE 1 is a vertical sectional view of a refrigerated cabinet including nozzle means of the instant invention;

FIGURE 2 is an enlarged detail view of a nozzle design as it appears when seen along the line 2—2 of FIGURE 1; and

FIGURE 3 is a fragmentary perspective view of a sheet member of the type employed in the production of the nozzle means of this invention.

The improvements of this invention are particularly directed to constructions which employ air curtains moving in side-by-side relationship in an unconfined manner. Such air curtains are commonly employed for the purpose of forming barriers to prevent or minimize heat transfer and for similar reasons.

The improvements of this invention will be defined with respect to refrigerated enclosures of the type defining an access opening in one wall whereby communication with the space within the enclosure can be accomplished. The enclosures or cabinets of this invention are provided with a plurality of nozzles arranged in side-by-side relationship across one edge of an access opening and corresponding inlets are located across the opposite edge of the access opening. The inner nozzles and inlets are provided for the passage of a refrigerated stream across the access opening while the adjacent outer nozzles and inlets circulate progressively warmer air panels. The inner refrigerated stream is circulated through a passage having

refrigeration coils located therein and one or more of the outer adjacent streams may also be refrigerated.

Prior constructions of the type described have utilized various means for forming the nozzles through which the streams of air pass prior to movement across the access opening. Honeycomb materials have been found to be suitable for use in the construction of such nozzles since the plurality of passages in the honeycomb tend to form the air passing through the nozzles in a manner such that a desirable flow of the air can be achieved. The use of the honeycomb sections tends to distribute the air in a more or less uniform fashion across the width of a nozzle. Such uniformity is desirable since it greatly reduces a tendency toward turbulence and the so-called "whipping" action.

It has been found, however, that nozzle constructions can be produced which materially improve the operating efficiency of a refrigerated enclosure when compared with enclosures having nozzles formed of honeycomb sections. Specifically, it has been found that desirable nozzle constructions can be formed by employing a plurality of thin sheet members which are assembled whereby they overlie each other. Each of the sheet members is characterized by a plurality of outwardly protruding elements in at least one face whereby the overlying members will be maintained in spaced-apart relationship.

The outwardly protruding elements formed in the sheet members are relatively small in dimension when compared with their spacing with respect to each other on the face of a sheet member. These relative dimensions result in the formation of a plurality of channels in the improved nozzle, each of said channels being relatively long and narrow in cross section. The dimensions of the channels are critically different from the dimensions of the channels defined by honeycomb sections. In such sections, the diametrical dimensions of the channels defined therein are substantially the same in any given direction.

The accompanying figures illustrate the improvements of this invention. In FIGURE 1, there is shown a refrigerated cabinet **10** which includes a top wall **12**, a bottom wall **14**, a back wall **16** and a front wall **18**. The front wall **18** defines an opening **20** which provides access to the interior **22** of the refrigerated cabinet. An inner wall **24** defines the extent of the refrigerated space.

A partition **26** is formed to define an inner passage **28** and an outer passage **30** in the construction. The inner passage **28** carries a refrigerating means **32** and a circulating fan **34** provides for movement of air past the refrigerating means and through the passage **28**. A similar circulating fan **36** is provided for the outer passage **30**.

Inlets **38** are provided for each of the passages **28** and **30**. The streams **40** and **42** which cross the access opening pass into these inlets and are driven through the passages to outlet nozzles **48**. Screens may be included over the inlets **38** to prevent entry of insects or other foreign material into the passages. Where the screens are provided, they should be associated with heating means whereby the surface temperature of the screens will be maintained a few degrees above the temperature of the air stream. This arrangement reduces the tendency toward frost accumulation on the screens.

The nozzles **48** illustrated in FIGURE 1 are located whereby all air circulating in the passages **28** and **30** will pass therethrough. Upon passage of the air out of the nozzles, the air will ideally move in the form of streams **40** and **42** to the inlets **38**. Laminar flow of the air in the streams **40** and **42** during the entire movement across the access opening is understandably desired since there will then be no movement of portions of cold air away from the access opening and the operating efficiency of the structure will be greatly improved. Any departure from the laminar flow characteristics will tend to set up a "whipping" action which causes amounts of air to spill out into the surrounding atmosphere.

It has been determined that the use of honeycomb sections results in the setting up of turbulence at the interface between the streams **40** and **42**. This turbulence is noticeable in the area indicated by the numeral **50**, that is in the location immediately beyond the nozzles **48**.

It has been found that by forming the outlet nozzles of sheet members **52** of the type illustrated in FIGURE 3, the turbulence at the interface between the streams **40** and **42** can be largely eliminated. These sheet members comprise integral members which are characterized by folds **54** formed at intervals whereby they protrude outwardly on one side of the sheet member. As best shown in FIGURE 2, the sheet members, when they are caused to overlie each other, form a construction defining a plurality of channels **56**.

It will be noted that the channels **56** are relatively long and narrow and the differences between these channels and the channels defined in honeycomb sections will be readily apparent. The particular dimensions of the channels are accomplished by employing folds which extend outwardly from the sheet member for a distance which is relatively small compared to the distance between the respective folds. A spacing between the folds of at least two times the outward extent of the folds is preferred.

Although there is no intention to limit the instant invention to any particular theory of operation, it is believed that the improved results of this invention are directly attributable to the general form of the channels **56**. Thus, the air streams issuing from each of these channels comprise streams which are more or less flat and are, therefore, capable of achieving excellent laminar flow characteristics. In the area **50** near the exit end of the nozzles, the results are particularly apparent.

It is believed that the most important structural attribute of the channels is the relatively long distance between folds **54**. The elimination of lateral partitions and consequent reduction in lateral contact of the streams provides great improvements over honeycomb structures used for nozzles.

As shown in FIGURE 2, the nozzles are formed by the overlying sheet members in a manner such that the widest dimension of the openings **56** defines a face which is parallel to the front surface of the cabinet. The presentation of these relatively wide flat faces to adjacent faces issuing from the channels **56** provides the most successful results insofar as this invention is concerned.

One important feature of the instant invention relates to the economical manner in which the sheet members can be formed and assembled to form the desired nozzle constructions. Aluminum sheet can be employed, and this sheet may have a thickness in the order of about $\frac{5}{1000}$ inch so that the sheet can be easily formed and handled. A simple press operation can be undertaken in order to form the folds in the face of a sheet. In a typical combination, the folds extend outwardly approximately $\frac{1}{8}$ inch from the surface of the sheet and the folds are spaced about one inch apart.

In the actual construction of a nozzle, it is often desirable to provide variations in spacings across the nozzle. This arrangement is desirable since it has previously been recognized that a variation in the air flow across the nozzle is advantageous. With such variations, the air velocity can be made to vary, and this benefits cabinet operation from the standpoint of the amount of turbulence produced. In the past, baffles, turning vanes and other devices have been employed for achieving variations in air flow but, as indicated, the nozzle of this invention permits elimination of such added devices.

To achieve variations in spacing, it is simply necessary to produce sheet members **52** having folds **54** of varying dimensions. In other words, one sheet member will have folds of one dimension and an overlying sheet member will have folds of a different dimension so that the succeeding spaces between the sheet members can progressively vary. It will be appreciated that the arrangements

described are capable of being assembled in various ways to achieve different results. The essential element of novelty insofar as this invention is concerned relates to the provision of spacing variations in a nozzle itself to provide for variations in air flow and to permit elimination of baffles and vanes. Furthermore, the particular character of the sheet members 52 permits the accomplishment of the spacing variations in an extremely simple fashion.

It will be appreciated that other materials and other dimensional relationships will be suitable depending on the particular application for the nozzles which is involved. Furthermore, other methods may be employed for providing the protruding elements on the sheet members, and in this connection, the elements are not necessarily formed integrally with the sheet.

In the assembly illustrated, the protruding folds are staggered with respect to each other so that the folds on one sheet will not enter the openings defined by the folds on an adjacent sheet. Other manufacturing techniques could eliminate this necessity although this is not critical to the results of this invention.

It will be understood that various changes and modifications may be made in the above described invention which provide the characteristics of this invention without departing from the spirit thereof particularly as defined in the following claims.

That what is claimed is:

1. In a construction of the type defining an open side for access to the interior of the construction and including air inlet means and a plurality of air nozzles extending in side-by-side relationship across opposite edges of said open side, passages defined in said construction communicating each of the corresponding inlets and nozzles, and circulating means located in at least one of the inner ones of said passages for driving air streams through said passages and out of said nozzles for movement across said open side in the form of air curtains between corresponding inlets and nozzles, said air curtains crossing said open side in side-by-side contacting relationship, the improvement in said nozzles comprising thin sheet members overlying each other, said sheet members defining a plurality of elements extending outwardly from the faces thereof, said elements operating to maintain said sheet members in spaced-apart relationship with respect to each other, said elements extending outwardly a relatively short distance and being spaced apart a distance substantially greater than their outward extent whereby a plurality of channels which are relatively long and narrow in cross section are formed by said sheet members, said sheet members being aligned lengthwise of the outlet ends of said passages with said elements extending in the direction of air flow whereby said channels are adapted to carry the air streams in said passages for movement as said air curtains across said access openings.

2. A construction in accordance with claim 1 wherein said sheet members define folds formed at intervals therein, and wherein said folds form said protruding elements.

3. A construction in accordance with claim 2 wherein all of the sheet members making up a nozzle define said folds, and wherein said folds extend outwardly in the same direction from a single face of any sheet member.

4. A construction in accordance with claim 3 wherein said sheet members are formed from thin sheet metal.

5. A construction in accordance with claim 1 wherein said sheet members comprise thin sheet metal, and wherein each of said members has folds formed therein, said folds extending lengthwise of said sheet members and in substantially parallel alignment with respect to each other, said folds extending lengthwise of said sheet members and in substantially parallel alignment with respect to each other, said folds forming the protruding elements on said members.

6. A construction in accordance with claim 5 wherein each of said sheet members defines said folds, and wherein said folds extend outwardly in the same direction from a single face of the respective sheet members.

7. In a refrigerated cabinet of the type which defines an access opening in one wall communicating an otherwise enclosed space with the ambient atmosphere, said cabinet being provided with a plurality of air inlets and a plurality of air nozzles, said inlets and nozzles extending in side-by-side relationship across opposite edges of said access opening, passages communicating each of the corresponding inlets and nozzles, refrigeration means disposed in at least the innermost one of said passages to refrigerate at least the innermost stream passing through said passages and across said access opening, and circulating means included in said innermost passage and in an adjacent outer passage for moving the streams of air through said passages, the improvement in said nozzles comprising thin sheet members overlying each other, said sheet members defining a plurality of outwardly extending elements in a face thereof whereby adjacent sheet members are maintained in spaced-apart relationship with respect to each other, said elements operating to maintain said sheet members in spaced-apart relationship with respect to each other, said elements extending outwardly a relatively short distance and being spaced apart a distance substantially greater than their outward extent whereby a plurality of channels which are relatively long and narrow in cross section are formed by said sheet members, said sheet members being aligned lengthwise of the outlet ends of said passages whereby said channels are adapted to carry the air streams in said passages for movement across said access opening.

8. A construction in accordance with claim 7 wherein said members are formed of thin sheet metal and wherein folds are formed in said sheet members at intervals across the width thereof, said folds also extending lengthwise of said members along substantially the entire length thereof whereby the separate channels carry portions of said air streams in substantially parallel relationship for discharge from said channels and for movement across said access opening.

9. In a refrigerated cabinet of the type defining an access opening in one wall communicating an otherwise enclosed space with the ambient atmosphere, said cabinet including means for moving an air stream across said access opening, the improvement comprising a nozzle construction for said cabinet including thin sheet members overlying each other, said sheet members defining a plurality of outwardly protruding elements whereby adjacent sheet members are adapted to be maintained in spaced-apart relationship with respect to each other, said elements being relatively small in outward extent and being spaced-apart a distance substantially greater than their outward extent whereby a plurality of channels which are relatively long and narrow in cross section are formed by said sheet members, the channels defined by said sheet members being aligned lengthwise in said construction whereby the channels provide a means for issuing of the air stream prior to passage across said access opening.

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