United States Patent

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[54] WEB SUPPORT NOZZLES FOR DRIER

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[52] **U.S. Cl.** **34/156**

[51] **Int. Cl.** **F26b 13/00**

[58] **Field of Search** 34/23, 156, 155, 115; 226/97

[56] **References Cited**

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[57] **ABSTRACT**

A nozzle structure for a web-drying apparatus, in which a web is supported between upper and lower pressurized airflows, is provided by a plurality of airflow passageways arranged in a honeycomb configuration, each passageway being supplied through a supply orifice of smaller cross section than the cross section of the passageway, and with the honeycomb providing multiple transverse rows in juxtaposition so as to provide an elongated layer of air between the nozzle and the web which operates to prevent contact between the web and the nozzle during high-speed transport through the drier.

12 Claims, 5 Drawing Figures

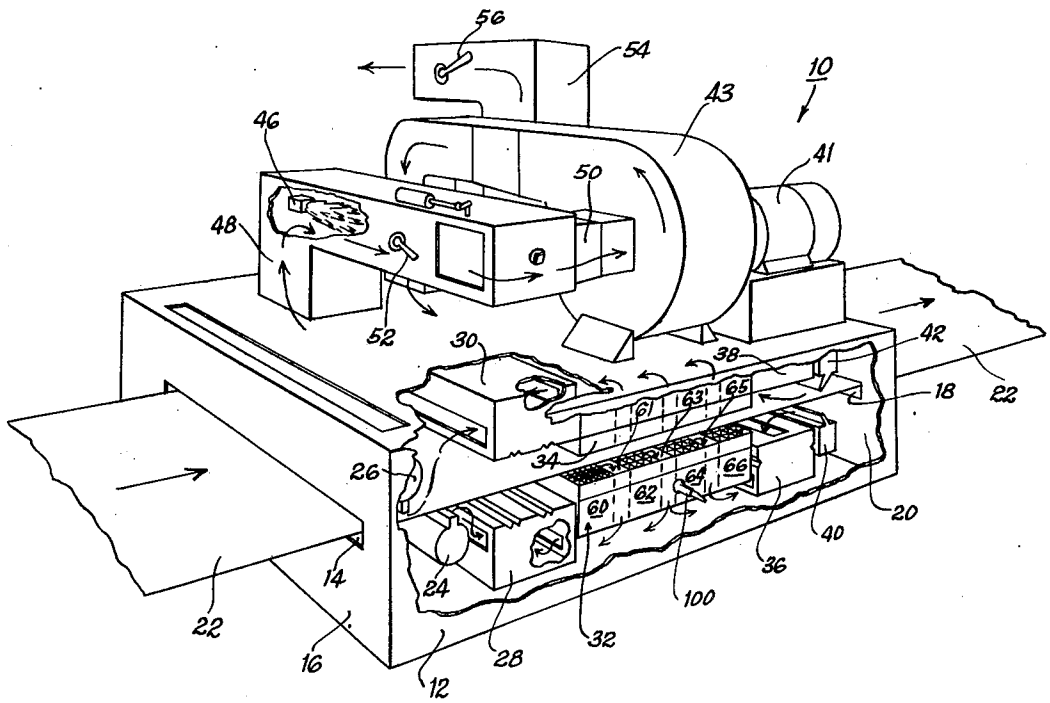
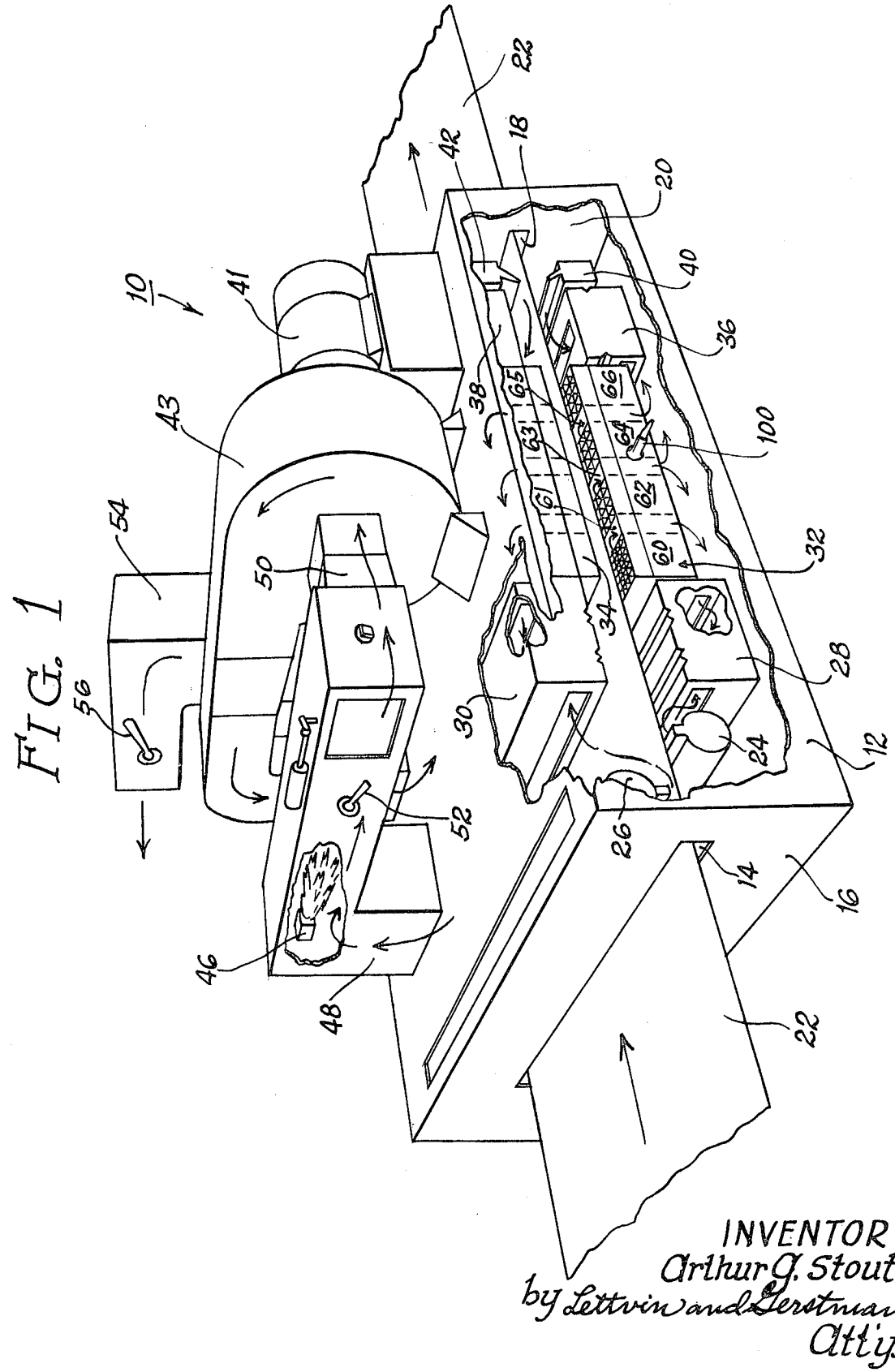


FIG. 1



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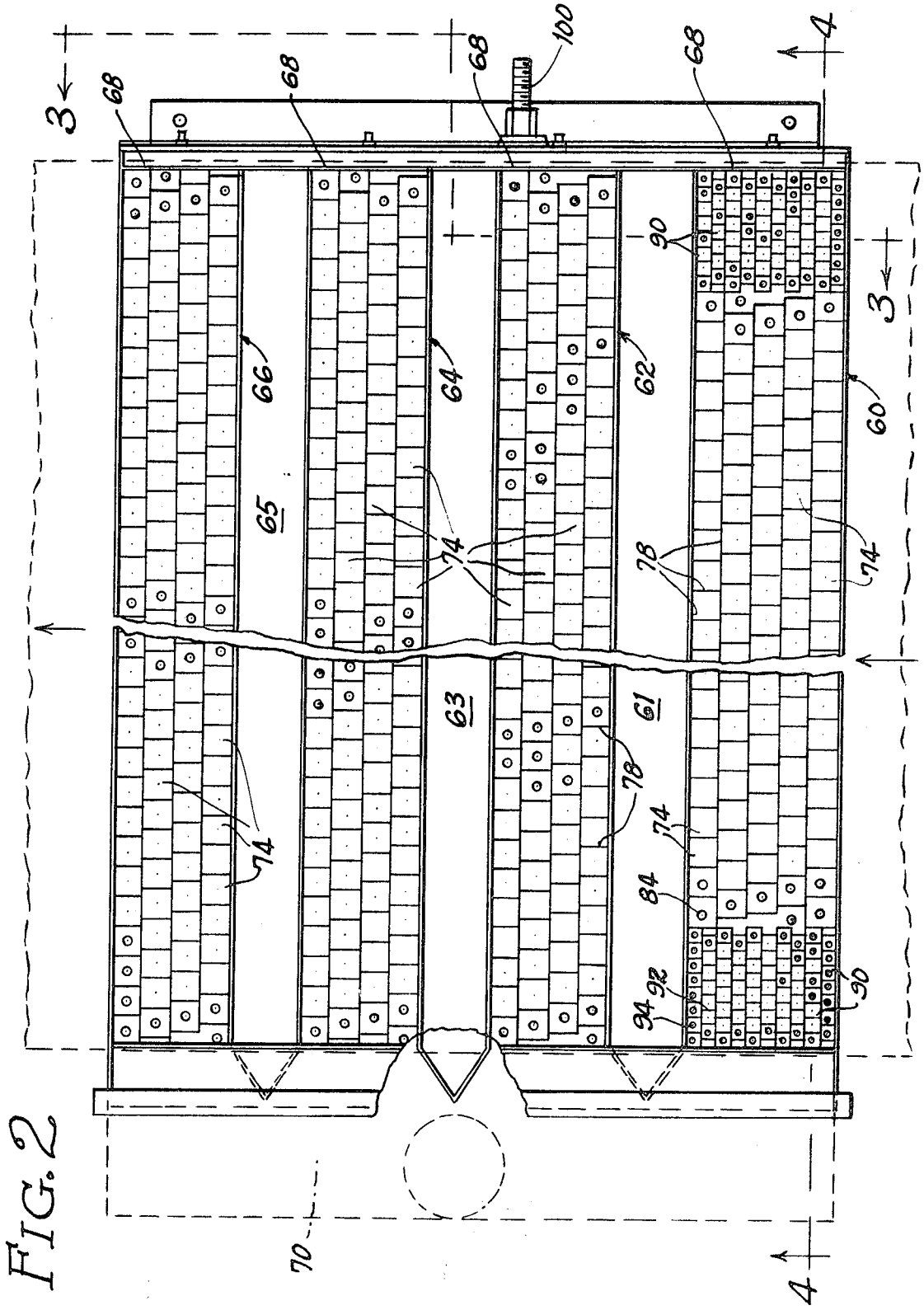


FIG. 2

FIG. 3

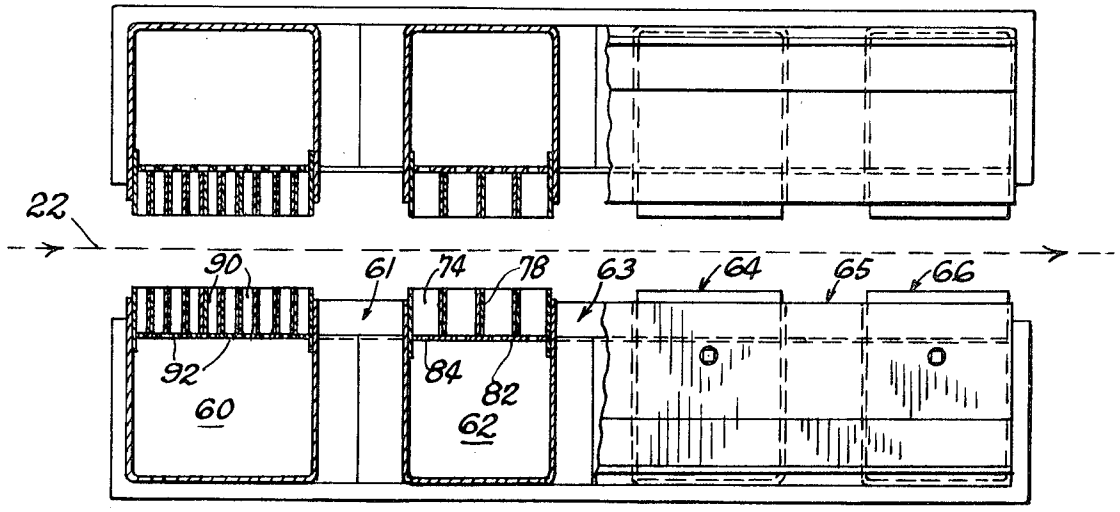


FIG. 4

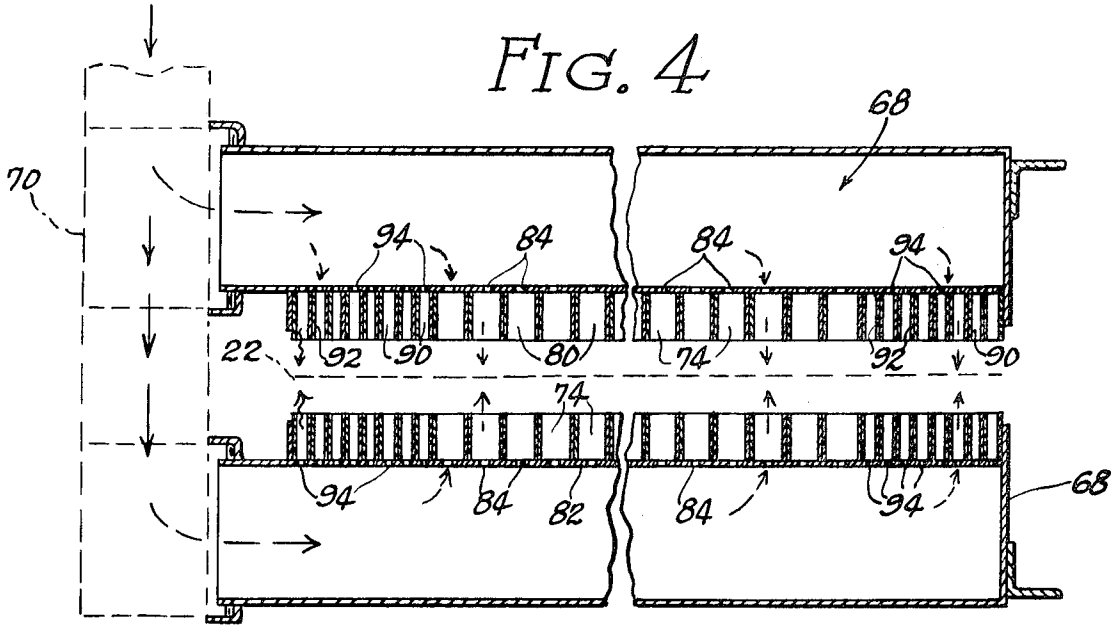
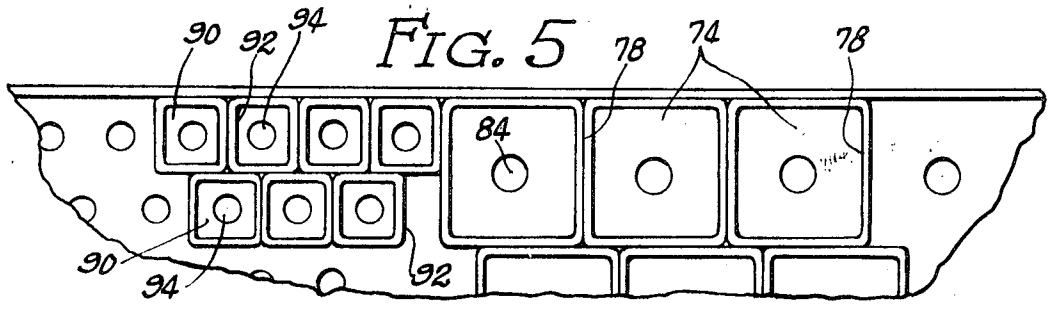


FIG. 5



WEB SUPPORT NOZZLES FOR DRIER

FIELD OF THE INVENTION

This invention relates to an improved nozzle arrangement for web-drying apparatus of the type wherein a web is transported and supported between upper and lower drying airflows.

BACKGROUND OF THE INVENTION

In a typical web-drier arrangement, the web being dried is transported between support nozzles which force heated air against opposite sides of the web to maintain a desired drying temperature. Additional stripper nozzles that provide very high velocity flow are provided for penetrating the boundary layer adjacent the web in order to strip away the layers of air that are immediately adjacent the web and which contain vapors from the material being dried.

The web generally is transported and supported through the web-drying apparatus between upper and lower airflows from the support nozzles, with the air pressure hopefully adjusted to prevent the web from contacting any part of the apparatus. Heretofore, it has been an important requirement that the tension on the web be accurately maintained so as to achieve the said desired transport through the drier at high speed without the web contacting the nozzle or drier structure and without the edges of the web curling as it enters the drier. Since some webs are more than 3 feet wide and travel at speeds greater than 1,000 feet per minute, it is very important that the air forced against the web have a high enough pressure, temperature and uniformity of flow to achieve the results desired. While some acceptable results have heretofore been achieved, it will be readily understood that the foregoing variables present problems that have made successful operation difficult and expensive to achieve.

The web-drying apparatus of the present invention includes air supply nozzles of a shape and configuration, and of an arrangement, such as to desirably provide for web support and transport that is superior in performance to nozzles and driers heretofore used, in that the web-tension requirements are reduced, the length of the drier in which support is effected solely by airflow is increased, the speed of transport of the web through the drier may be maintained and even increased without undesirable contact being effected between web and drier structure, and curl of the edge of the web may be avoided.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided an air supply system and nozzle arrangement for use in a web-drying apparatus of the type having a passage for the transport of a web that is maintained between upper and lower airflows from supply nozzles. As part of the drier, an elongated tube is provided for supplying forced air at an elevated temperature to a plurality of air outlet nozzles arranged in juxtaposition as in a generally honeycomblike configuration, with each nozzle in the honeycomb of nozzles defined by a plurality of upstanding walls forming an elongated flow chamber with the air discharge end thereof having a larger cross section than the area of the orifice at the intake end of the chamber.

In the illustrative embodiment of the invention, a drier is provided with a plurality of nozzle banks on opposite sides of the path along which the web travels. In each there are a plurality of transverse rows of elongated tubes and each row includes a plurality of individual air outlet nozzles. A return air opening is located between spaced nozzle banks and the width of the return, in the direction of movement of the web has a smaller dimension than the width of the nozzle bank.

The nozzle bank at the entry end of the web-drying apparatus is provided with more individual nozzle flow chambers than the other nozzle banks of the drier, and the nozzle banks at the entry end of the drier may be provided with many more individual nozzles at the lateral ends of the nozzle bank to help prevent curling of the web.

A more detailed explanation of the invention is provided in the following description and claims, and is illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view, with portions partially broken away, of a web-drying apparatus utilizing the principles of the present invention;

FIG. 2 is a fragmentary top plan view of the DRAWING lower set of nozzles used in the web-drying apparatus illustrated in FIG. 1;

FIG. 3 is a fragmentary sectional elevation taken substantially along the line 3—3 of FIG. 2, showing the sets of nozzle banks arranged longitudinally in the drier;

FIG. 4 is a fragmentary sectional elevation thereof, taken substantially along line 4—4 of FIG. 2, with the broken lines and arrows illustrating typical airflow paths; and

FIG. 5 is an enlarged fragmentary plan view of a portion of the bank of air nozzles at the entry end of the drier, according to certain principles of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENT

Referring to the drawings, web-drier **10** generally is shown as including a housing **12** with an entry slot **14** at the input wall **16** of the drier for accommodating passage of a web **22**. A similar outlet slot **18** is provided at the output wall **20** of the drier. A typical web **22** used with the present invention comprises flexible paper stock having a 38 inch width that is being fed directly to the web drier from the output of ink-printing apparatus as is well known in the art.

Web **22** is intended to pass through housing **12** without contacting any portion of the drier apparatus located within the housing. In a typical layout within the housing there may be positioned a lower line burner **24** and an upper line burner **26**, lower and upper exhaust intake manifolds **28** and **30**, respectively, a series of lower and upper air-drying supply nozzle sections **32** and **34**, respectively, generally indicated at lower and upper exhaust intake manifolds **36** and **38**, respectively, and upstream, or rearwardly, inclined stripper nozzles **40** and **42**. The heat-circulating system typically includes an electrically energized blower motor **41** which drives a circulating fan (not shown) located within conduit **43** for forcing air in the direction of the arrows downwardly into a manifold within the housing **16** for channeling the forced air through transverse ducts to the upper and lower nozzle bank sections **32** and **34**.

An air heater **46** may be located within a return conduit **48** into which recirculating air moves upwardly from the housing in the direction of the arrows, and via a coupling conduit **50** to the circulating fan within conduit **43**. A damper control handle **52** is provided on conduit **48** for adjusting the volume of recirculating air that enters conduit **43**. An exhaust duct **54** having an exhaust damper control handle **56** connected thereto, extends from the housing **12** and directs the exhaust air to outside the area, as required. The foregoing, except for general reference to the improved nozzle banks, describes a typical environment in which the improved nozzle banks of this invention are to be used.

Now, as web **22** passes through the housing, an open gas flame is first applied to opposite sides of the web by line burners **24** and **26** to elevate the web temperature quickly. The web then is caused to pass between the upper and lower improved nozzle-banks sections **32** and **34** of this invention. As shown in the drawings, the improved air-drying nozzle sections **32** and **34** each includes a plurality of clustered nozzle banks. Typically there are four banks as seen in FIGS. **1** and **3**, which are fed by ducts **60**, **62**, **64** and **66**. In the arrangement disclosed herein, heated air is provided through the nozzles at approximately 500° to 600° F. and at about 10,000 feet per minute nozzle velocity.

The high temperature causes the solvents to evaporate, and when the ink solvents first evaporate, they enter the boundary

layer of gas and tend to cling to the web. The high velocity of heated air from the stripper nozzles **40**, **42** operate to strip away said three boundary layers of gas containing solvent, so that the ink evaporate will not cling to the web. Stripper nozzles **40**, **42** are inclined upstream (toward the input end **16** of the housing) to obtain the desired stripper action, in contrast to the perpendicular direction of airflow provided by the air supply nozzles of sections **32** and **34**.

Supply ducts for both air nozzle sections **32** and **34** each comprises four metal tubes **60**, **62**, **64** and **66** which are spaced by air return openings **61**, **63** and **65**. The duct tubes each are closed off at one end **68** thereof and communicate at the other end thereof with intake manifold **70** which supplies heated air to each of the tubes. Each of the tubes **60**, **62**, **64** and **66** leads to a separate nozzle bank that includes a large plurality of air-outlet nozzles **74**. In the illustrative embodiment, each of the air-outlet nozzles has the cross section of a cubicle and each cubicle lies adjacent to other air-outlet nozzles of cubical cross section. In effect, each cubicle can be considered an individual cell of a generally honeycomb configuration, with each of the cells having four vertical walls **78** which are equal in width and are perpendicular to, and connected to other walls **78** at the corners of the cubicle.

The air-discharge end **80** of each of the cubicles is open and is of the same cross section as the spacing of walls **78**, while the air intake end **82** of each cubicle is of smaller cross section than the outlet, being defined by a transverse wall that would normally close the inlet end of the cubicle but for the presence of an inlet orifice in said transverse wall. The orifice **84** leads to the inside of the respective cubicle for establishing communication between the feeder duct and the respective nozzle cubicle. The opening of orifice **84** is much smaller than the opening at the air discharge end **80** of the cubicle. This provides that air entering through orifice **84** at a certain velocity pressure and static pressure exits from outlet end **80** at a lower velocity pressure and higher static pressure, which condition provides a superior lifting action at the face of the web **22**.

In order to provide an approximately elongated air cushion (elongated in the direction of motion of the web) for the longitudinally moving web to maintain the web spaced from the nozzles, it is desired that each nozzle bank have at least two, and preferably three or more transverse rows of cubicles, with each row being immediately adjacent to another row. In the illustrative embodiment, no nozzle bank has less than four rows of cubicles lying transversely of the direction of movement of the web. A substantially constant cushion of air is provided by dimensioning each air return opening **61**, **63**, **65** so as to be smaller in the web travel direction than the dimension of each adjacent nozzle bank taken in that direction. In this manner, the air from the cubicles of one duct and nozzle bank cooperates with the air from the cubicles of an adjacent nozzle bank, and the resulting air cushion provided thereby will help prevent the moving web from contacting any of the equipment in the drier.

Occasionally the lateral edges of the web tend to curl adjacent the input side **16** of the web drier housing. In order to alleviate such curl, the upper and lower nozzle banks supplied by ducts **60**, which are closest to the input end of the housing, are provided with a greater number of cubicles than the other air nozzle banks. Thus, smaller cubicles **90**, which have one-quarter the cross section area of cubicles **74**, are located adjacent the ends of tube **60**, as best seen in FIG. **1** and **5**. Additionally, while in the illustrative embodiment ducts **62**, **64** and **66** each supply four rows of cubicles **74**, duct **60** is arranged to supply five rows of cubicles **74** and ten rows of smaller cubicles **90** at each end thereof.

Cubicles **90** are constructed similarly to cubicles **74** except that the spacing of the upright walls **92** which define the cubicles are one-half the spacing of the walls **78** of cubicles **74**, while the vertical dimensions of walls **92** are equal to the similar dimensions of walls **78** as seen most clearly in FIGS. **3** and **4**. Of course, the inflow orifice **94** of each cubicle **90** is proportionately smaller (approximately one-quarter the area) than the inflow orifice **84** of cubicle **74**.

Referring to FIGS. **2** and **5** in particular, it will be seen that cubicles **74**, as well as cubicles **90**, are preferably arranged in offset, or nonaligned, longitudinal relationship with respect to adjacent cubicles. As seen in FIG. **2**, the offset relationship is such that each row is transversely offset relative to the previous transverse row by an amount approximating one-quarter of the width of a cubicle **74**, so that the cubicles **74** in the first and fifth row of the first nozzle bank are aligned longitudinally with the intermediate rows each offset a reciprocal portion of the width of a cubicle.

It will further be understood that upper air nozzle section **34** is desirably symmetrical to lower air nozzle **32** so that the airflow from nozzle section **34** can be balanced with the airflow from nozzle section **32**. To this end, one or more nozzle balance adjustments **100** (FIG. **1**) in the form of a damper that diverts a portion of the airflow is provided for enabling the operator to balance the equipment to allow web **22** to be transported through housing **12** without contacting any of the equipment within the housing.

Although one illustrative embodiment of the invention has been shown and described, it is to be understood that various substitutions and modifications may be made by those skilled in the art without departing from the spirit and scope of the present invention. While the generic term web has been used herein, it will be understood that such term is not limited to any material, as the invention should be useful with all webs including those of paper, textile, metal foil, synthetic plastics and the like.

What is claimed is:

1. In a web drier wherein at least one of the opposite sides of an elongated web, moving longitudinally at great speed, is subjected to a flow from nozzles of drying air that also is intended to maintain the web spaced from said air-supplying nozzles during transport of the web through the drier, an improved nozzle-bank construction comprising, in combination, a large plurality of individual flow passageways arranged in at least two rows lying transversely of the direction of movement of the web through the drier and having sidewalls forming a generally honeycomb configuration, each of the passageways having a larger air discharge opening than the air intake opening to the passageway, and each of the rows of passageways being immediately adjacent to another row of passageways to combine to provide an elongated air cushion for the longitudinally moving web to maintain the web spaced from the nozzle-bank.

2. In a web drier as described in claim **1**, including a plurality of nozzle-banks with air-return openings located between adjacent banks, the dimension of each of the air-return openings in the direction of web transport being smaller than the dimension of each adjacent nozzle-bank in the said direction of web movement, whereby a more elongated cushion of air is provided for the longitudinally moving web.

3. In a web-drying apparatus having a passage for the transport of a web that is maintained between an upper column and a lower column of air supply nozzles without physical contact against the nozzles, the improvement comprising, in combination, an elongated duct for carrying forced air at an elevated temperature, said duct having a plurality of air outlet nozzles disposed on a surface thereof, each of said air outlet nozzles comprising a cell, and a plurality of said cells being grouped together to form a generally honeycomb configuration whereby air is directed toward said web via each of said cells, each of said cells having a plurality of upstanding walls forming a closed-sided chamber with the air discharge end of the chamber having a larger opening than the opening at the air intake end of the chamber, said air intake end opening being in communication with the inside of the elongated duct.

4. In a web-drying apparatus as described in claim **3**, said closed-sided chamber having a polygonal configuration with all of said walls extending perpendicularly with respect to a single-imaginary plane.

5. In a web-drying apparatus as described in claim **3**, including a plurality of elongated ducts and wherein each elongated duct carries a plurality of rows of air outlet nozzles: and a

return air opening located between adjacent elongated ducts, the return air opening having a smaller dimension in the direction of the web transport than the overall dimension of the outlet nozzle rows in said direction.

6. In a web-drying apparatus as described in claim 3, including a plurality of elongated ducts and wherein the elongated duct closest to the input end of the web-drying apparatus carries more cells than other elongated ducts positioned toward the output end of the web-drying apparatus.

7. In a web-drying apparatus as described in claim 6, wherein the elongated duct closest to the input end of the web-drying apparatus carries more cells per unit area adjacent the ends of the elongated duct than at the central portion thereof.

8. In a web-drying apparatus as described in claim 3, wherein said air intake end opening has a generally curvilinear outline.

9. In a web-drying apparatus as described in claim 3, wherein said chambers are cubilinear and said air intake openings are circular in outline.

10. In a web-drying apparatus as described in claim 3, wherein said elongated duct carries a plurality of rows of air-outlet nozzles with the nozzles of one row being offset with respect to the nozzles of an adjacent row.

11. A web drier as in claim 1 wherein the individual flow passageways are substantially polygonal in cross section.

12. A web drier as in claim 1 wherein nozzle-banks are arranged in spaced, opposed relation to each other to define a space in which the web moves between similar nozzle-banks.

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