Aug. 2, 1966 C. A. STICKLE 3,263,344

DRYING SYSTEM FOR PAPER-MAKING MACHINERY AND THE LIKE

Filed July 31, 1963 2 Sheets-Sheet 1

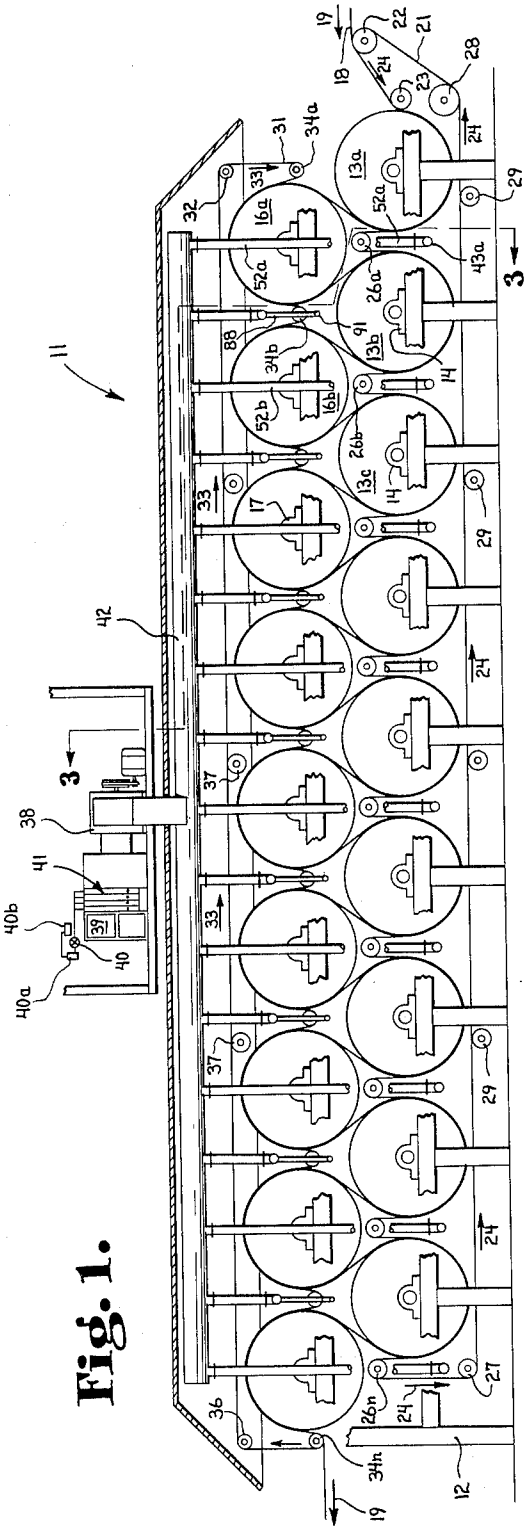

Fig. 1.

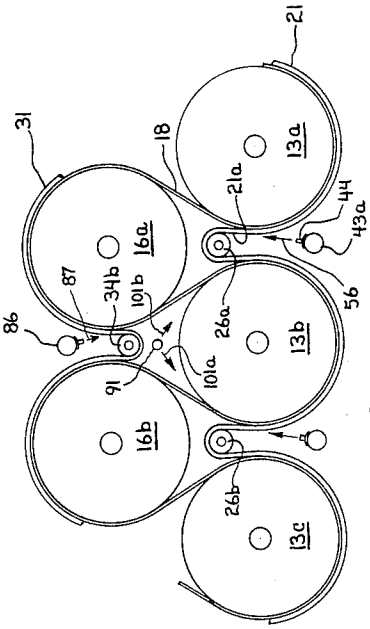

Fig. 2.

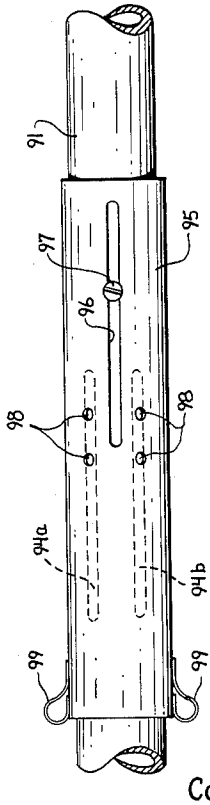

Fig. 5.

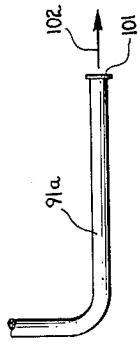

Fig. 6.

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DRYING SYSTEM FOR PAPER-MAKING MACHINERY AND THE LIKE

Filed July 31, 1963 2 Sheets-Sheet 2

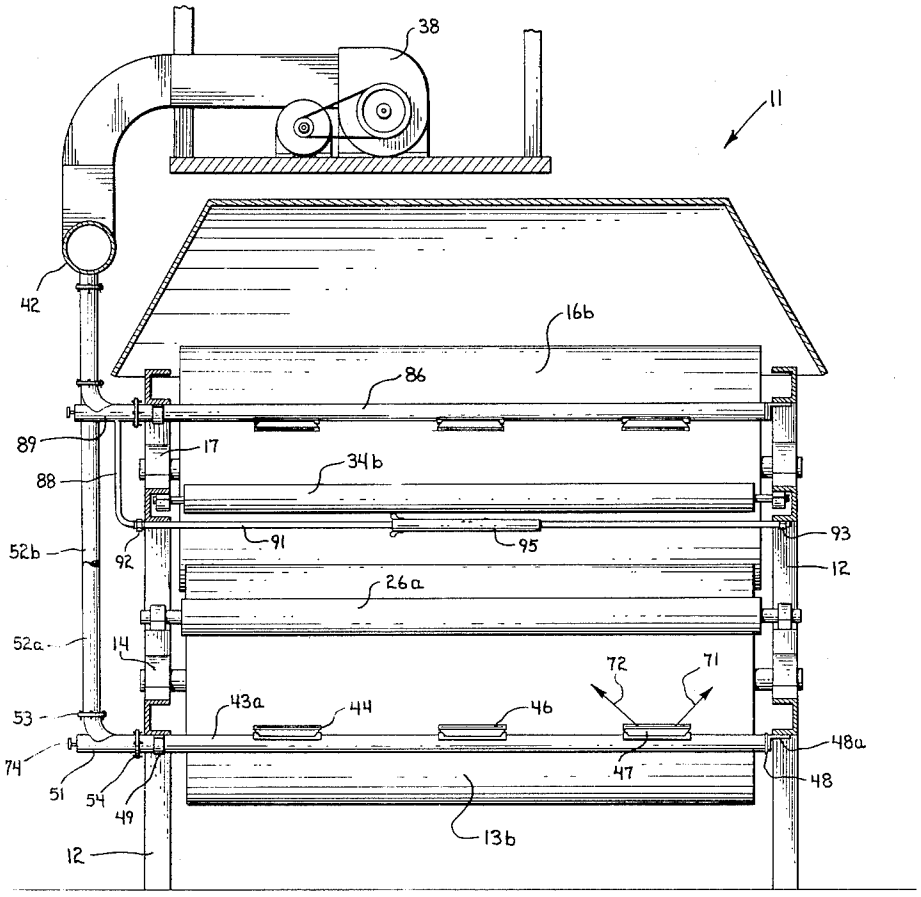

Fig. 3.

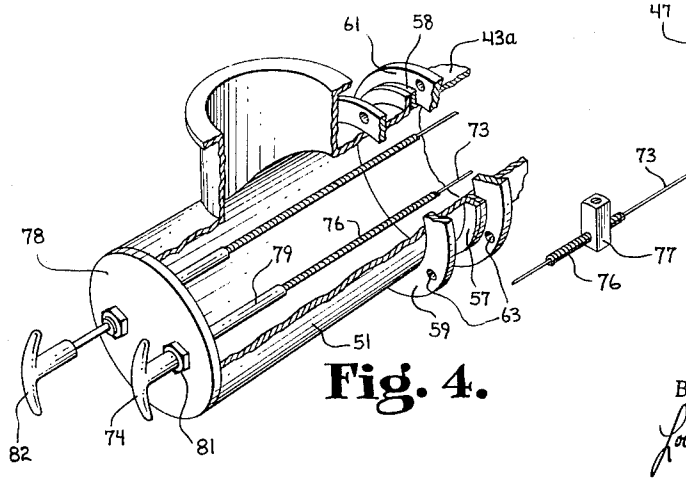

Fig. 4.

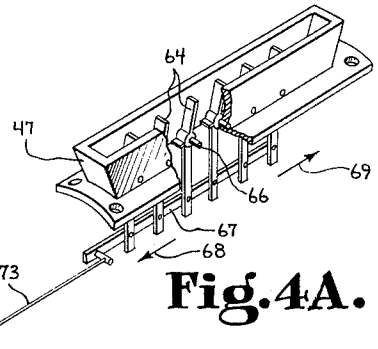

Fig. 4A.

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United States Patent Office 3,263,344 Patented August 2, 1966

3,263,344

DRYING SYSTEM FOR PAPER-MAKING MACHINERY AND THE LIKE

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Filed July 31, 1963, Ser. No. 298,827
7 Claims. (Cl. 34—116)

This invention relates generally to drying systems and more particularly to a drying system well suited to employment with conventional paper drying machinery.

In the manufacture of paper, a drying machine is employed which utilizes a series of heated drying rolls and felt moisture absorbing belts. Two endless felt belts are usually employed. One of the belts operates on an upper series of drying and guiding rolls and the other operates on a lower series of drying and guiding rolls. Wet paper sheeting leaving a Fourdrinier machine enters the drying machine between the first drying roll and the first felt belt and is sandwiched therebetween and is carried around the drying roll. Upon leaving the first roll, it moves between the next drying roll and the second felt belt. The felt removes moisture from the paper.

Ordinarily, it is quite difficult, if not impossible, to establish a uniform moisture content across the paper sheet from one edge of the sheet to the other. Usually the moisture content is excessively high in the center of the sheet. Consequently, the outer edges of the sheet dry much sooner than the center of the sheet. In fact, it sometimes happens that by the time the center of the sheet is sufficiently dry as the paper moves through the drying machine, the outer edges have become scorched. Also, from time to time, the location of high moisture content will vary along the width of the sheet, a condition which is difficult, if not impossible, to handle effectively with conventional equipment.

These circumstances usually result in a substantial amount of waste or scrap paper. Also, they make it difficult for paper manufacturers to produce paper having the uniformity quality, and other characteristics presently required by publishers and others who use paper.

It is, therefore, the general object of the present invention to provide an improved drying system for sheet material such as paper, for example.

A further object is to provide a drying system capable of providing uniformity of moisture content across paper sheet in a drying machine.

A further object is to provide a drying system having increased capacity for drying within the confines of conventional machinery.

A further object is to provide a machine wherein a tendency toward non-uniform drying across a sheet can be substantially counteracted.

A further object is to provide means achieving the foregoing objects and further characterized by simplicity and reliability.

Described briefly, a typical embodiment of the present invention as incorporated in a typical paper drying machine employs a blower and steam heater to provide a flow of warm air feeding a supply duct which in turn feeds a set of horizontal distribution ducts. The distribution ducts are disposed adjacent the felt belts and extend transversely across the machine from the tending side to the drive side.

Each of the distribution ducts has a plurality of nozzles with each nozzle having a set of adjustable louvers therein. The set of louvers in each nozzle is controlled independently of the set in each of the other nozzles. The louvers can be adjusted to direct flow of warm dry air against different portions of the belt so as to apply greater drying rates to specific areas of the belt.

Each of the distribution ducts is mounted to permit rotation thereof on an axis transverse to the length of the drying machine so as to direct the flow from the nozzles to a portion of the belt spanning a space between belt supporting rolls.

The felts act as an agent to absorb moisture from the paper sheet and the absorbed moisture is then evaporated from the belts. By directing different amounts of hot air to different sections of the belt according to this invention and thereby giving varying absorption powers to these sections, there is a direct effect upon the drying of the sheet. This helps in the attainment of uniform sheet moisture content profile.

A further feature according to the invention includes auxiliary air tubes with apertured sleeves thereon. These sleeves are variably positionable transversely of the machine to discharge air where desired in the machine to eliminate "pocketing" of stagnant saturated air.

A still further feature according to the present invention provides a series of nozzles on one side of the machine directing a flow of air to the opposite side of the machine. These nozzles are useful to move moisture laden air from the area between the rolls of the machine to assist in the circulation of dry air through the machine, thereby maintaining high efficiency.

The full nature of the invention will be understood from the accompanying drawings and the following description and claims.

FIG. 1 is an elevational view of the front or tending side of a paper drying machine wherein the paper sheet flow is from right to left and wherein a typical embodiment of the present invention is illustrated.

FIG. 2 is an enlarged fragmentary elevational view thereof showing the arrangement of drying rolls, felt, belt, belt rolls and discharge nozzles according to the typical embodiment of the present invention.

FIG. 3 is an enlarged transverse section through the machine taken along the line 3—3 in FIG. 1 and viewed in the direction of the arrows.

FIG. 4 is an enlarged fragmentary perspective view of a portion of a distribution duct and nozzle louver control assembly according to the typical embodiment.

FIG. 4A is an enlarged fragmentary perspective view of a nozzle portion of the distribution duct according to the typical embodiment of the invention.

FIG. 5 is an enlarged fragmentary plan view of an auxiliary air discharge means according to the typical embodiment of the invention.

FIG. 6 is an enlarged side view of an alternative auxiliary air discharge device employed according to the present invention.

Referring to the drawings in detail and particularly to FIGS. 1, 2, and 3 thereof, the drying machine **11** is provided with a frame **12** supporting a row of drying rolls **13** which are usually steam heated, though the steam supply and condensate return details, therefor, are not shown in the drawing. The rolls **13** are cylindrical in form and are mounted to the frame by pillow blocks **14** whereby the cylindrical axes of the rolls 13 are disposed in parallel, equally spaced relation in a horizontal plane and are tranverse to the direction of paper flow through the machine.

The frame supports a second set of drying rolls **16**. These are also cylindrical in form and of the same size as the rolls **13**. They are mounted to the frame by the pillow blocks **17** and consequently, the axes of the rolls **16** are parallel to each other and equally spaced and lie in a common horizontal plane vertically spaced above the first mentioned horizontal plane. These rolls, therefore, provide means whereby the paper sheeting **18** entering the right hand or "wet" end of the machine can pass around the rolls in alternate sets in serpentine fashion and leave

the machine at the left-hand end, the paper moving in the direction indicated by the arrow **19**.

A first endless belt **21** is provided and passes around the rolls **22** and **23** at the wet end of the machine, the belt moving in the directions indicated by arrows **24** located at various places along the belt. The belt passes around and under the first lower dryer roll **13***a*, up and around the first lower felt supporting roll **26***a*, and down and around the second lower dryer roll **13***b*. It passes around roll **13***b* and up over the felt supporting roll **26***b* and down and around roll **13***c* and continues in this manner to the paper discharge or "dry" end of the drying machine. At the dry end of the machine, the belt passes around the roll **26***n* and down around the roll **27** and back to the roll **28**. Suitable supporting rolls **29** are provided at spaced intervals along the return run of the belt. Thus, it is seen that a series of felt supporting rolls **26** is provided in a set having parallel horizontal axes disposed in a horizontal plane intermediate between the planes of the axes of the lower dryer rolls **13** and the axes of the upper dryer rolls **16**. These rolls **26** provide for the reversal of the felt belt to facilitate its passage around the dryer rolls of the first set.

Similarly, a second or upper belt **31** is provided and passes around the roll **32** at the wet end of the machine and down in the direction of the arrow **33** and around the roll **34***a*. From the roll **34***a*, it passes up around the first upper drying roll **16***a* from which it passes down around the roll **34***b*. It passes around roll **34***b* and up around the dryer roll **16***b*. It continues its motion in like manner to the discharge end of the machine where it passes down around the roll **34***n* and up around the roll **36** and back to the wet end of the machine. Suitable supporting rolls **37** are provided at intermediate locations on the return run. Up to this point, this description has identified the various parts of a conventional paper drying machine, and the belts are of the usual felt type conventionally employed.

According to the present invention, a supply of hot air is provided by a blower **38** drawing air through filters **39** and a steam heated exchanger **41**. A pressure controller **40** and diaphragm motor valve **40***a* combination are used to control the steam pressure to the heating coils of the heat exchanger. The blower discharges the hot air into a supply duct **42** extending the length of the drying machine on the tending side. The supply duct feeds a number of distribution ducts which will now be described.

A distribution duct is provided in the form of a horizontal tube **43***a* of circular cross section having nozzles **44**, **46**, and **47** mounted therein. The rear end of the tube **43***a* is provided with a cap **48** which is pivotally mounted to bracket **48***a* which is secured to the frame. This accommodates rotation of the tube on its longitudinal tubular axis. The front end portion of the tube is supported by a U-shaped hanger **49** attached to the frame which also accommodates rotation of the tube on its tubular axis.

A T junction **51** provides communication between the tube **43***a* and the vertically extending pipe **52***a* connected to the supply duct **42**. A slip flange is provided at the connection of the junction **51** to the tube **52***a* and a slip flange **54** is provided at the connection of the junction with the tube **43***a*. In FIG. 4, some of the details of the slip flange are shown. The T junction **51** has a collar **57** thereon. The tube **43***a* has a collar **58** thereon. These collars are brought together in abutting relation. The slip flange clamping is provided by flange or ring **59** around the junction **51** and the flange **61** around the tube **43**. Bolts passing through the apertures **63** in these flanges pull them together to secure the two collars **57** and **58** in air tight abutting relation. This means that by merely loosening the nuts on the flange bolts, the tube **43***a* can be rotated as desired.

As shown in FIG. 2, a portion **21***a* of the lower felt belt **21** spans the space between the lower drying roll **13***a* and the felt roll **26***a*. The distribution tube **43***a*

is disposed directly below the axis of the felt roll **26***a*. The tube **43***a* is, therefore, normally rotated to a position where the air discharging from the nozzles **44**, **46**, and **47** is discharging in the direction of the arrow **56** so that it impinges upon and can penetrate the felt in the area spanning the space between the rolls **13***a* and **26***a*. The angle of this discharge from the vertical may be 10°, for example, where this provides the most effective action in the particular machine installation. In other machines, other angles may be found preferable.

Referring now to FIG. 4A, the rear nozzle **47** of FIG. 3 is shown. It has a number of louvers **64** therein, the louvers being pivotally mounted by means of the pins **66**. A draw bar or link **67** is pinned to the lower ends of the louvers and operates them in unison. If the link is moved in the direction of the arrow **68**, all of the louvers can be moved to a closed position to prevent discharge of air from nozzle. By moving the link in the direction of the arrow **69** from the closed position, the air can be discharged toward the inner or rear end of the machine or in any direction from there to a direction of discharge toward the front of the machine. In other words, referring to FIG. 3, the air can be discharged in the direction of the arrow **71** or it can be discharged in the direction of the arrow **72** or it can be discharged in any intermediate direction at will.

In order to accomplish the movement of the link **67**, a Bowden wire **73** is connected to the link and to a handle **74** (FIG. 4). The usual Bowden cable **76** is provided and is anchored to the tube **43***a* by the anchor block **77** which is mounted inside tube **43***a*. The other end of the cable is anchored to a sleeve **79** which is mounted to the front end plate **78** of junction **51** and secured by a locking nut **81**. The sleeve **79** incorporates a conventional built-in handle rod locking device whereby a quarter turn of the handle is effective to lock the rod in any specific position. Therefore, in the example of the handle **82**, which is shown partially pulled out, rotation of the handle one quarter turn on its axis from the position shown is effective to lock the handle in the position shown. Therefore, once the handle is pulled to the position giving the air discharge direction desired, it can be locked in this position.

The louvers and mechanism for the front nozzle **44** can be identical to that for the rear nozzle **47**. Likewise, the same type of louvers and mechanism can be provided for the center nozzle **46**. Ordinarily, however, these louvers are not operated by a handle and are, instead, fixed in the position desired by the use of a set screw. If at some time it is found desirable to direct the air flow other than specifically to the central area of the felt, the set screw (not shown) can be loosened and the louvers moved to the desired position whereupon the set screw is again tightened.

An upper distribution duct tube **86**, identical to the tube **43***a* is provided and employs the same sort of mechanism. In this instance, the discharge of air is in the direction of the arrow **87** in FIG. 2 which, in a typical machine may be in a plane disposed 15° from vertical, for example. Slip flanges are used to facilitate changing this angle, if desired. Again, the direction of discharge in this plane is controlled by control handles as previously described.

For particularly difficult drying situations, auxiliary air discharge means are provided according to the present invention. This includes a vertical feed pipe **88** supplied by the junction **89** and to which a horizontal pipe **91** is attached by the union **92**. The pipe or tube **91** is supported at its inner end by a U-shaped hanger **93**, the inner end being plugged or capped. As shown in FIG. 5, this tube **91** has a pair of longitudinal slots **94***a* and **94***b* extending parallel to the axis of the tube, which is, of course, transverse to the length of the machine. A movable sleeve **95** is mounted on the tube **91** and has a slot **96** therein. A screw **97** secured to the tube **91** provides a

guide for the slot **96**. Transverse apertures or orifices **98** are provided in the sleeve. The orifices are in position to register with the slots **94***a* and **94***b* in the tube and normally discharge air in the direction of arrows **101***a* and **101***b* (FIG. 2). Metal loops **99** are mounted on the tending side of the sleeve to facilitate its movement inwardly and outwardly by the machine operator. By movement of the sleeve in and out, the transverse location of discharge of air from the sleeve can be controlled. In this manner, air can be discharged into the spaces between the dryer rolls and in direct communication with the paper passing between the upper and lower sets of rolls to prevent pocketing of stagnant saturated air in these spaces. It thereby further assists in the drying of the central portion of the paper and increases the drying capacity of the machine. The ability to turn the tube **91** on its axis if desired, as well as move the orifices transversely of the machine provides a good range of discharge locations and directions.

In certain instances, where space does not permit the extension of the auxiliary pipe **91** the entire distance from the tending side to the drive side of the machine as shown in FIG. 3, the pipe is terminated as shown in FIG. 6, the pipe being designated by **91***a*. In this instance, an orifice plate **101** terminates the pipe and the air discharges therefrom in the direction of the arrow **102** toward the tending side of the machine. This is effective to supply fresh warm dry air into spaces in the machine which would ordinarily tend to accumulate saturated air and, therefore, further facilitates the drying function. It is normally desirable to discharge the air from one side of the machine to the other such as from the front to the rear.

In the practice of the present invention, it is normally desirable to provide the nozzle outlets from 16 to 18 inches from the felt. The ability to move the nozzles and louvers therein to direct the discharge of air is extremely beneficial in that it permits careful control of the moisture content across the paper and it permits continuous control thereof. The present invention also provides means for maintaining circulation of warm dry air throughout the machine. It is normally desirable to supply the air at 300° F. and 12 to 16 inches of mercury static head in the supply duct.

Increasing or decreasing steam pressure to the steam coils will increase or decrease, respectively, the temperature of the hot air delivered to the paper machine felts. This feature is valuable when the moisture profile has been established but the overall sheet is running either wet or dry.

The present invention does not necessitate excessive drying the edge portions of the sheet in order to get adequate drying of the central portions as was previously required and thus removes the necessity of discarding the outer portions of the sheet and contributes to uniformity of product. It achieves the objects set out hereinabove as well as providing other advantages not specifically mentioned herein.

As is well known, paper and sheet material drying machines exist in a number of forms. In the drawings of this application, the machine illustrated is of the "two-deck" type in which there are two sets of dryer rolls. There are "single-deck" machines which have but a single row of dryer rolls and there are also machines having three or more decks of dryer rolls. In some machines, the felt belt is not used in association with all of the dryer rolls.

The system of the present invention can be readily employed with all of these various types of machines as well as other types. In the cases where there is no felt belt employed, the discharge of the nozzles of the present invention is directed to the paper or sheet material to be dried as it spans a space between rolls, and it need not require a span between a pair of dryer rolls as a span between a dryer roll and a reversing or idler roll can be used as well. The claims appended hereto should be understood, therefore, not to limit the scope of this invention to employment in a machine of only the type illustrated as the performance of many varieties of machines can be improved substantially according to the present invention.

While the invention has been disclosed and described in some detail in the drawings and foregoing description, they are to be considered as illustrative and not restrictive in character, as other modificaions may readily suggest themselves to persons skilled in this art and within the broad scope of the invention, reference being had to the appended claims.

The invention claimed is:

1. A drying machine comprising: a first row of rolls having parallel axes lying in a first plane, with the successive rolls in said row being in spaced relation and each roll extending from the front of the machine toward the rear of the machine; a second row of rolls having parallel axes lying in a second plane with the rolls in said second row being in spaced relation; a belt operable on the rolls of said first and second rows, said belt spanning a space between each of the rolls of said first row and each the rolls of said second row; a supply source for heated air; and a plurality of distribution ducts coupled to said supply source, with each duct of said plurality having discharge means therein to discharge warm air on said belt in said space, one of said ducts having a plurality of discharge nozzles spaced therealong, each of said nozzles having a plurality of air guiding louvers therein determining the direction of flow of air discharged from said nozzle and directing the air discharged from the nozzle onto a portion of said belt spanning a certain space between a first roll of said first row and a second roll in said second row, adjusting means connected to the louvers in one of said nozzles and operable, when actuated, to move said louvers therein in unison, said adjusting means being movable to direct the air from the nozzle generally toward the front of the machine onto said spanning portion and in the alternative to direct the air away from the front of the machine onto said spanning portion.

2. In a continuous sheet drying machine or the like, the combination comprising: a plurality of ducts disposed along the length of said machine and extending transversely thereof, from the front of the machine toward the rear of the machine, said ducts having discharge outlets therein to direct air in a direction generally transverse to the direction of extension of said ducts; a material to be dried; and movable directing means in said outlets to further direct the discharge of air from said outlets; and control means coupled to said directing means for operating said directing means to vary the direction of discharge of air from said outlets as desired said directing means being movable by said control means to cause flows of air onto said material from said outlets along inclines having selected degrees of inclination toward the rear of the machine.

3. In a continuous sheet material drying machine or the like, the combination comprising: a source of hot air; a plurality of distribution ducts supplied by said source and disposed transversely of the direction of sheet material flow in said machine, each of said ducts having nozzle means therein with discharge directional control means in said nozzle means, said control means being adjustable to selectively vary the direction of flow of air onto the sheet material from said nozzle means, said control means on one of said nozzle means effecting air flow therefrom onto the sheet material at a predetermined distance from one lateral edge of the sheet material, and said control means on said one nozzle being adjustable to effect said air flow therefrom onto the sheet material at selectively greater distances from said one lateral edge and selectively lesser distances from the opposite lateral edge of said sheet.

4. In a machine as set forth in claim 3, joint means accommodating rotation of said nozzle means about axis

transverse to the direction of sheet material flow in said machine.

5. A drying machine comprising: a first set of rolls having parallel horizontal axes lying in a horizontal plane, said rolls being cylindrical and being in horizontally spaced relation in the row; a second row of cylindrical rolls having parallel axes lying in a horizontal plane above the horizontal plane of the first set of rolls, said second set being in a row disposed above said first row with the axes of the rolls of said second row lying in vertical planes disposed between the axes of the rolls of the first row; a third set of rolls having parallel axes lying in a third horizontal plane between the first and second mentioned horizontal planes with the rolls of said third set being substantially smaller than the rolls of said first set and disposed between portions of said rolls of said first set; a fourth set of rolls disposed in a row and having parallel axes lying in a fourth horizontal plane disposed between said second mentioned and said third mentioned horizontal planes with the rolls of said fourth set being disposed between portions of the rolls of said second set and above rolls of said first set; a first endless felt belt operating on the rolls of said first and third sets; and a second endless felt belt operating on the rolls of said second and fourth sets; a warm air supply source; a plurality of horizontally disposed distribution ducts extending transversely of the machine and communicating with said source, said ducts being divided into a first group disposed below the rolls in said third set and a second group disposed above the rolls in said fourth set, with said ducts of the first group having discharge nozzles discharging air on portions of said first felt belt spanning spaces between rolls of said first and third sets and said ducts of the second group having discharge nozzles discharging air on portions of said second felt belt spanning spaces between rolls of said second and fourth sets, to dry said spanning portions of said belts, said ducts being adjustable by rotation on axes parallel to the axes of said rolls, one of said ducts of said first group having first, second and third discharge nozzles spaced along the length thereof and each of said first, second and third nozzles having a set of adjustable louvers therein, all louvers of a set being adjustable equally and simultaneously and being in parallel relationship to each other, and the set in each nozzle being adjustable independently of the sets in the other nozzles, all nozzles in said one duct being oriented to discharge air unilaterally from the duct and primarily in one plane containing the axis of rotation of the duct, said second nozzle being between said first and third nozzles, and said louvers in said second nozzle being adjustable to discharge air in said plane onto a space spanning portion of said first belt intercepted by said plane selectively from the left of center of the belt to the right of center of the belt, and said louvers in said first nozzle being adjustable to discharge air in said plane onto said spanning portion selectively from the left of center of the belt to farther left on the belt, and said louvers in said third nozzle being adjustable to discharge air in said plane onto said spanning portion selectively from right of center of the belt to farther right on the belt, said one duct being adjustable by rotation on its axis to tilt said one plane of discharge to selected angles with respect to vertical; and auxiliary duct means including tubes communicating with said source and extending transversely of said machine and having longitudinal slots therein, said auxiliary duct tubes being disposed below the rolls of said fourth set and above the rolls of said first set, said auxiliary duct means having sliding sleeves on the tube thereof, said sliding sleeves having transverse apertures therein registering with slots in the tube portions thereof to discharge air therefrom, whereby sliding of said sleeves is effective to move the air discharge thereof transversely of said machine to provide dry air at desired locations in said machine.

6. A drying machine comprising: a first row of rolls having parallel axes lying in a first horizontal plane with the successive rolls in said row being in horizontally spaced relation; a second row of rolls having parallel axes lying in a second horizontal plane above said first horizontal plane with the rolls in said second row being in horizontally spaced relation; a third set of rolls having parallel axes and disposed in a row with their axes in a horizontal plane above said first horizontal plane and below said second horizontal plane, said rolls being disposed between the rolls of said first row; an absorbent belt operable on the rolls of said first and third sets, said third set reversing the direction of said belt, said belt spanning a space between a first roll of said first row and a first roll of said third set; a supply source for heated air; and a plurality of distribution ducts coupled to said supply source, with each duct of said plurality having discharge means therein to discharge warm air on said belt, one of said ducts having a discharge nozzle extending between said first roll of said first row and a second roll of said first row, said nozzle being oriented to discharge a stream of air onto the portion of the belt spanning said space, said nozzle having a plurality of air guiding louvers therein connected together and directing said stream, said nozzle and louvers being arranged to limit the width of the stream to impinge onto a limited area of said spanning portion and limit the width of said area to less than one half the width of said first roll; and an adjusting member connected to said louvers and operable, when actuated, to simultaneously move said louvers in the same direction in unison to change the direction of said air stream to move the said area parallel to said axes, and thereby concentrate the air stream on a desired portion of the width of the belt while avoiding movement of said nozzle across the width of the belt.

7. A drying machine comprising: a first row of rolls having parallel axes with successive rolls in said row being in spaced relation, each roll extending from the front of the machine to the rear of the machine; a second row of rolls having parallel axes with the rolls in said second row being in spaced relation; material to be dried extending around said rolls and spanning spaces between said rolls; a supply source for heated air; and a plurality of distribution ducts coupled to said supply source, with each duct having discharge means therein to discharge heated air on said material to be dried, the direction of discharge from said discharge means being controllable, said discharge means including a plurality of louvers determining the direction of flow of air from the duct onto said material; and adjusting means connected to said louvers and operable, when actuated, to move said louvers in unison to change the direction of said flow between a direction of flow toward the rear of the machine and a direction of flow toward the front of the machine.

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