

[54] APPARATUS FOR DRYING MATERIALS

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[51] Int. Cl. F26b 13/00

[58] Field of Search 34/46, 47, 48, 50, 34/155, 156, 158, 160

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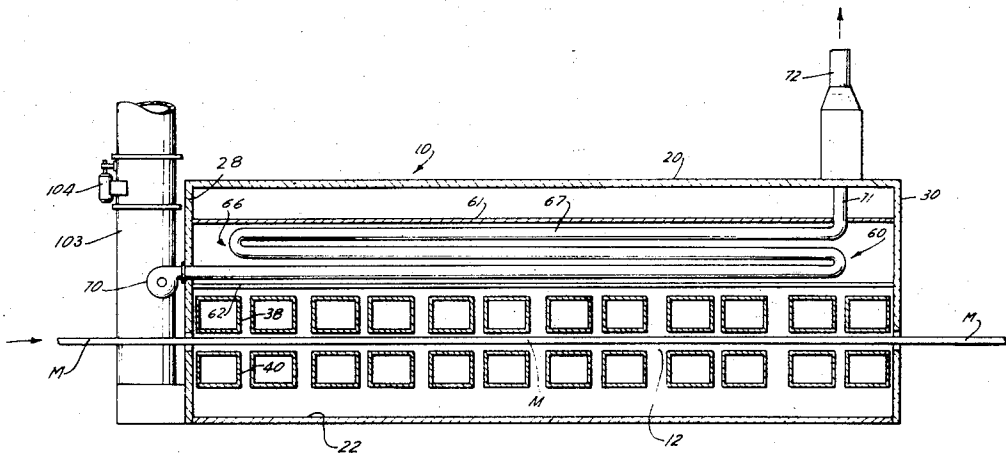
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[57] ABSTRACT

Apparatus and method for continuous drying of materials including means and steps for passing the material to be dried into a drying chamber having a plurality of drying zones; uniformly directing heated fluid through the drying zones, each drying zone having means to direct the heated fluid substantially uniformly over the surfaces of the material to be dried; and having discharge fluid collecting means in communication with the drying zones to collect the discharged fluid, and means for moving substantially all of the discharged fluid through a heat exchanger means so as to uniformly heat substantially all of the discharged fluid to a desired temperature and means to conduct the uniformly heated fluid to the distributing means and temperature control means to maintain the fluid temperature in the drying chamber and then passing fluid through the distributing means whereby the uniformly heated fluid is conducted through the drying zones to continuously dry the material uniformly.

8 Claims, 10 Drawing Figures



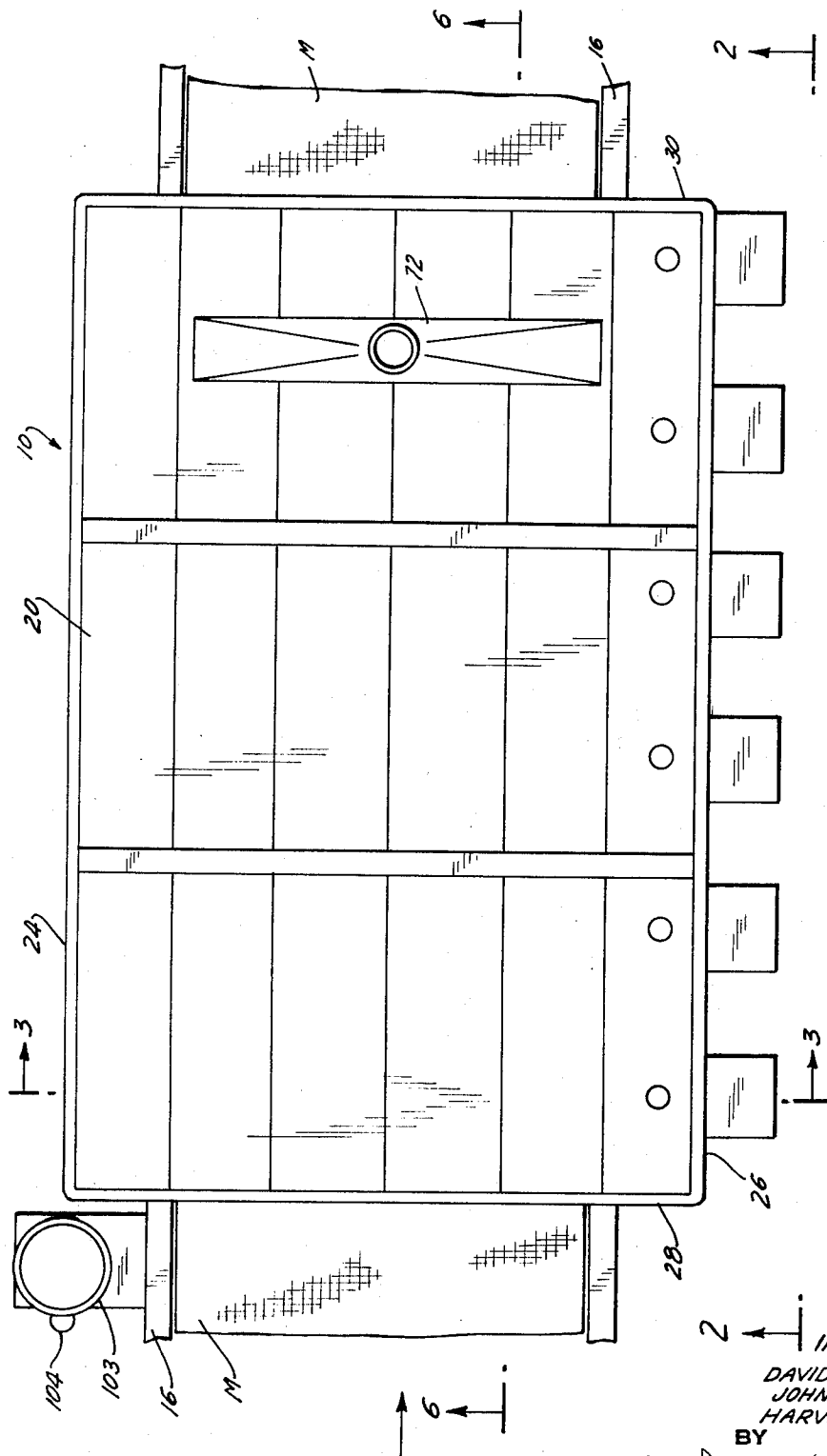


FIG. 1

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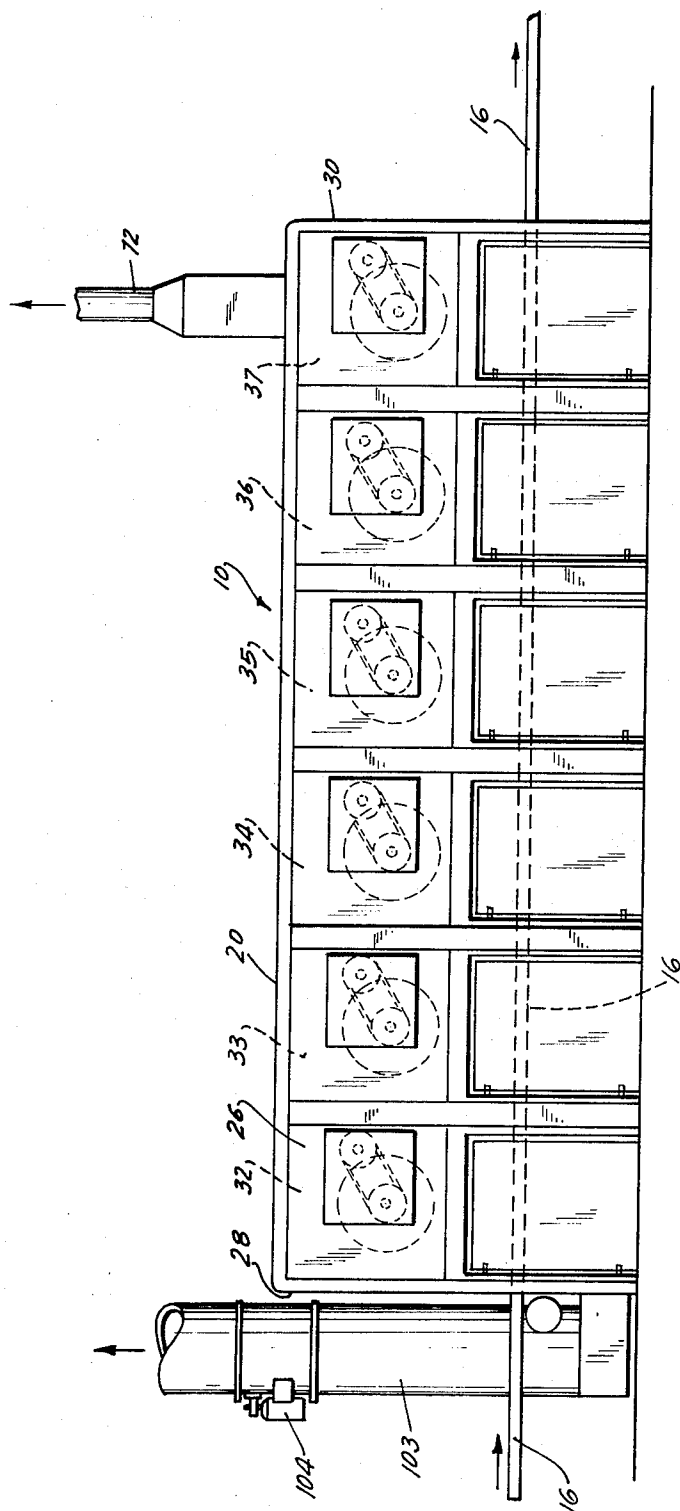


FIG. 2

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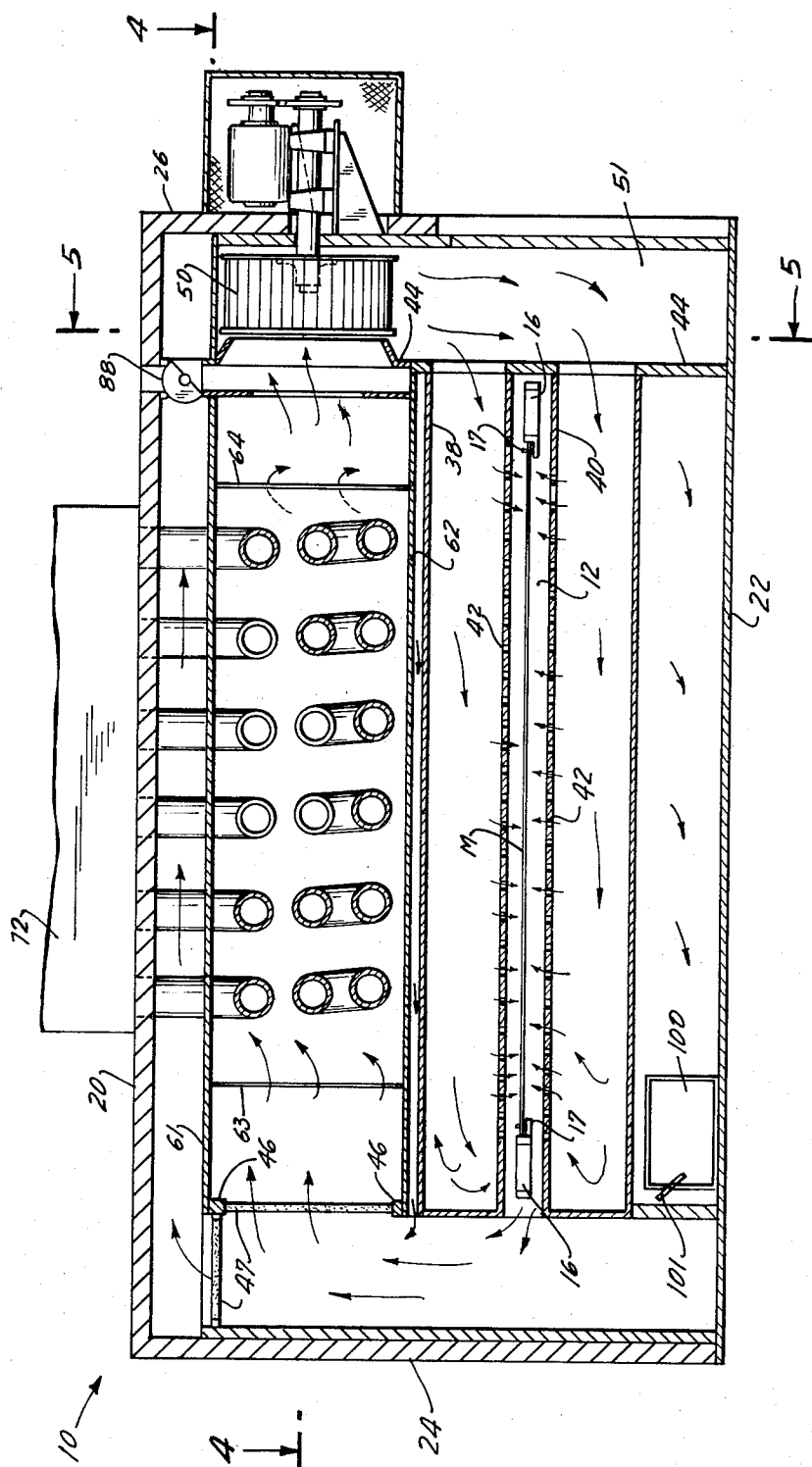


FIG. 3

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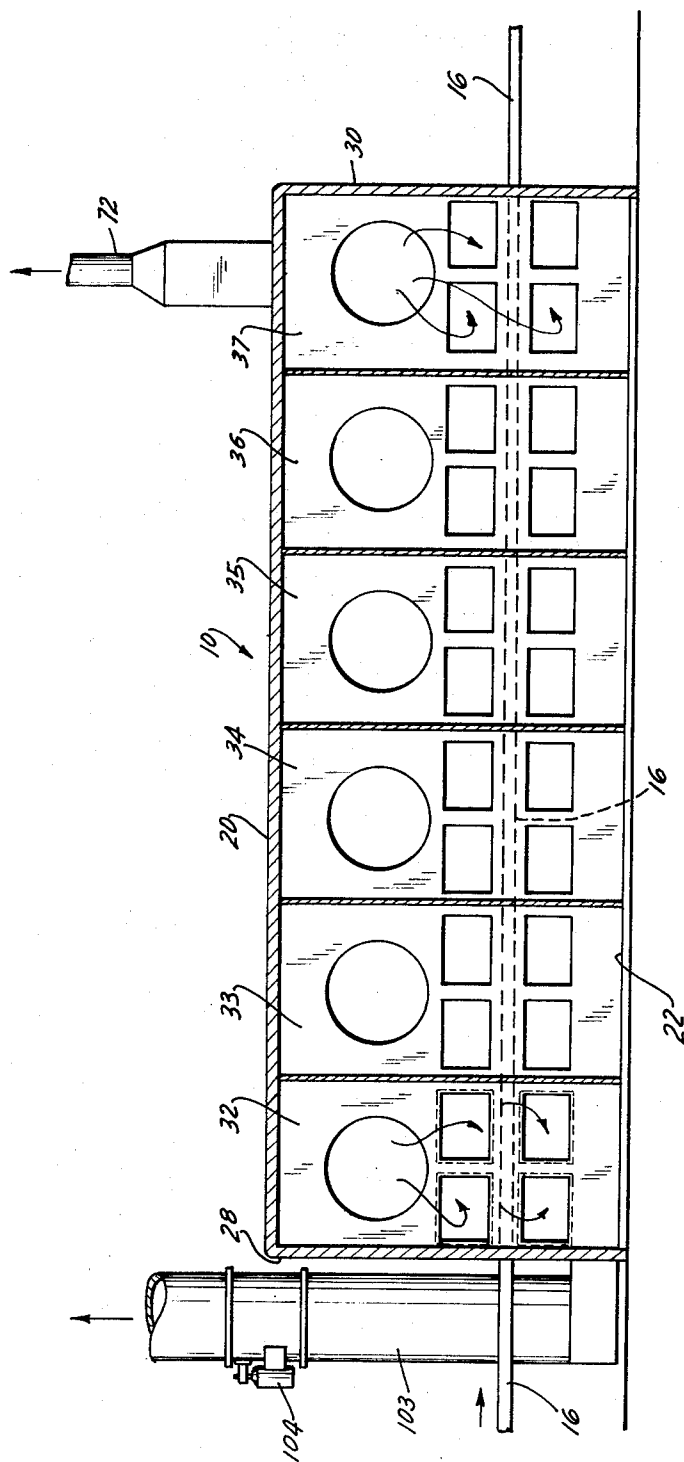


FIG. 5

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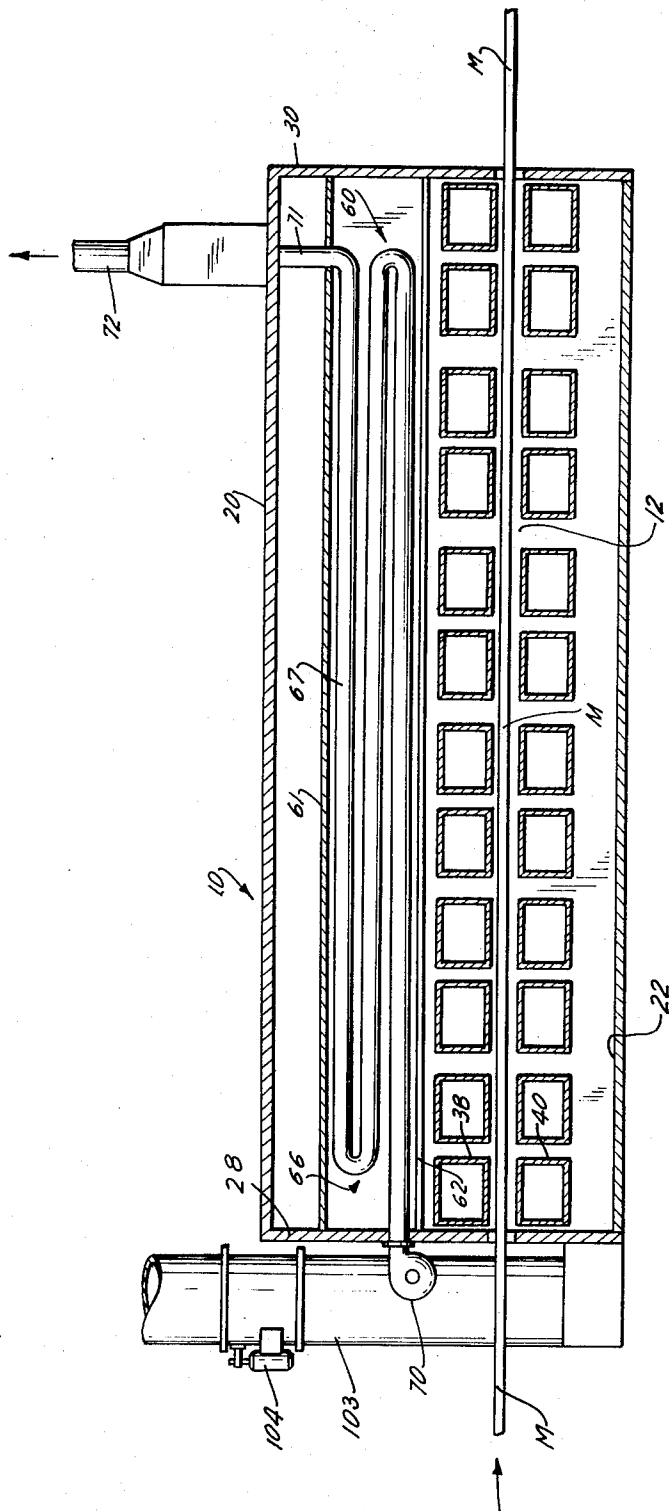


FIG. 6

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FIG. 7

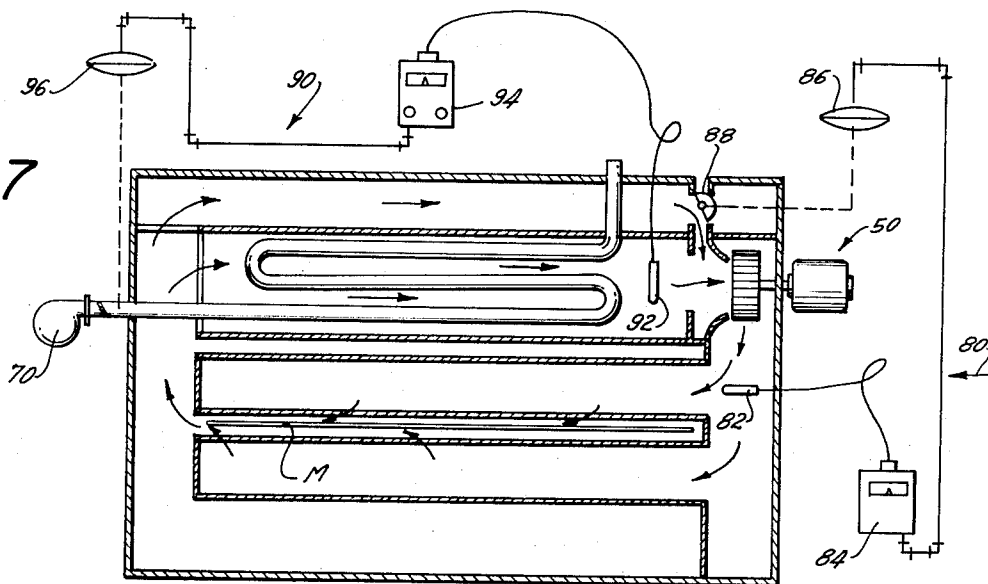


FIG. 8

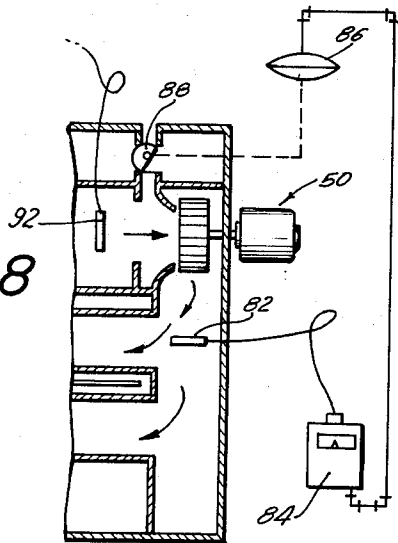
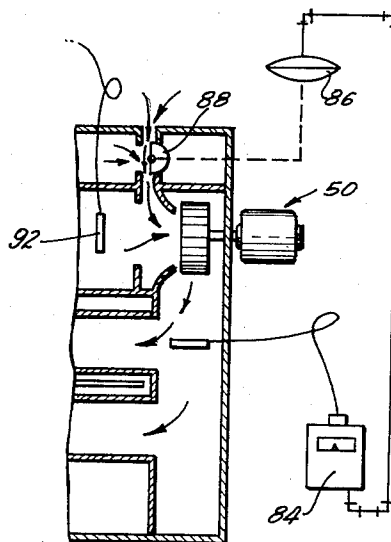


FIG. 9

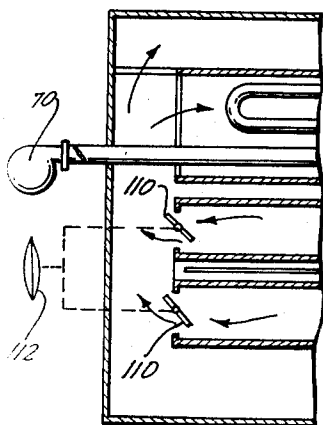


FIG. 10

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APPARATUS FOR DRYING MATERIALS

BACKGROUND OF THE INVENTION

Various methods and apparatus have been used to dry materials, particularly web like materials for the textile industry. Where material is to be dried or otherwise treated and finished, it is generally suspended between a pair of moving rails and then passed through a drying apparatus. Such a device is commonly referred to as a tenter machine having a drying chamber coupled thereto. The tenter conveys the fabric through the drying chamber which includes multiple units or modules separately controlled. Each unit uses a heat exchanger to heat the air which is circulated through that unit. To compensate for the drop in temperature of the returned air, the temperature in succeeding units is increased to dry the material and is therefore non-uniform. Thus, because of the use of multiple heat exchangers, a constant supply of heated air at uniform temperature is impossible. Other drying units use a combination of air and superheated steam to try and maintain a uniform temperature. However, these dryers have the same problems and difficulties of the type described above.

Further, the prior art dryers provide means for passing the heated air or heated air and superheated steam through the web material generally from below the moving material which causes a billow to form and, consequently, can alter the physical characteristics of the material such as drape, hand and resiliency at drying temperatures particularly if the material is a synthetic material. Also, these dryers will ruin or destroy the material to be dried if the machine for any reason is caused to stop. The drying zones cannot be brought to ambient temperatures to prevent the destruction, burning or discoloration of the web material within the drying apparatus.

SUMMARY OF THE INVENTION

This invention generally relates to drying apparatus particularly adapted for use in textile industries in connection with tenter machines. The invention contemplates providing a drying apparatus for drying materials comprising a drying chamber having a plurality of drying zones therein, each drying zone having a pair of conduit means for directing heated fluid to each side of the material to be dried, a fluid discharge chamber coupled to the conduit means from each drying zone and disposed remotely from the conduit means for conducting discharged fluid from the drying zone to a heating means to uniformly heat the discharged fluid to a desired temperature, heat exchanger means for heating substantially all of the discharged fluid conducted therethrough, distributing means mounted to the drying zones and coupled thereto to conduct the uniformly heated fluid to each drying zone and then passing the uniformly heated fluid through the distributing means whereby the uniformly heated fluid is conducted through conduit means in the drying zone to uniformly dry the material passing therethrough.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 represents a top plan view of our improved drying apparatus.

FIG. 2 is a side elevational view taken along the lines 2—2 of FIG. 1.

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 1.

FIG. 4 is a sectional view taken along lines 4—4 of FIG. 3 showing the heat exchanger section and path of fluid taken through the heat exchanger.

FIG. 5 is a sectional view taken along lines 5—5 of FIG. 3.

FIG. 6 is a sectional view taken along lines 6—6 of FIG. 1.

FIGS. 7—10 are schematic illustrations which show the controls for regulating the flow of fluid through the drying apparatus and means for distributing the fluid therethrough.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

For a better understanding of the invention, reference is made to the drawings, particularly FIGS. 1 through 6. The drying apparatus embodied in FIGS. 1—6 is generally indicated by numeral 10 and is enclosed around a tenter frame, shown in a fragmentary section only. The drying apparatus is formed with a horizontal passage 12 which extends therethrough so as to provide a path for the textile material "M." Textile material M is preferably removably mounted on a high speed pin type tenter chains 16 by pins 17 such as disclosed in U.S. Pat. No. 3,050,816. Drying apparatus 10 is mounted around the tenter chains so that tenter chains 16 and the textile material M as shown in FIGS. 3, 5 and 6 pass through the entire length of the drying apparatus 10 through passage 12.

Drying apparatus 10 is generally rectangular in shape and is provided with a top or roof portion 20, a bottom or floor portion 22, side walls 24 and 26, and front and rear walls 28 and 30. Front and rear walls 28 and 30 are formed with horizontally extending openings forming the entrance and exit openings 13 and 14 of passage 12.

Drying apparatus 10 is constructed having a plurality of means forming drying zones 32, 33, 34, 35 and 36 of similar structure. Thus, in describing the portions of drying zone 32, the similar portions of drying zones 33, 34, 35 and 36 need not be described. Means forming drying zone 32 is shown most clearly in FIG. 3 and is enclosed by top, bottom and side walls 20, 22, 24 and 26.

Spaced conduits comprising an upper pair 38 and a lower pair 40 are disposed in parallel relationship to each other and extend across the drying apparatus so as to be positioned above and below tenter chains 16. Upper conduits 38 and lower conduits 40 are formed so that the surfaces lying in close proximity to the tenter chains 16 are provided with openings 42. The conduits 38 and 40 are mounted in position by upstanding partition 44. Partition 44 is formed with openings substantially equal to the openings formed by conduits 38 and 40 so that fluid may pass into the conduits and through the openings 42 so that the fluid passing through openings 42 comes in contact with the upper and lower surfaces of the material M to be dried. Partition 44 is spaced from side wall 26 which provides a passage for heated fluid to enter conduits 38 and 40 as shown by the arrows in FIG. 3.

An unhooded type fan 50 is mounted on partition 44 so as to direct heated fluid from the heating zone through conduits 38 and 40 so that the heated fluid contacts the textile material M by passing through openings 42 of conduits 38 and 40. The heated fluid

contacts the surfaces of textile material M substantially uniformly over the entire upper and lower surfaces so that the textile material M is supported by the fluid and lies substantially in a horizontal plane while passing through passage 12 of the drying apparatus. The heated fluid impinges on the material M from above and below and always at a desired set temperature. This promotes uniform drying from each side of the material M as well as a gradual even drying throughout the entire length of the drying apparatus.

As will be explained hereinafter, conduits 38 and 40 may be provided with means to automatically open damper devices mounted at the ends thereof to provide a bypass for heated air if the tenter chains should cease to operate for any reason. Such a system obviates the possibility of loss of material M due to excessive heat that may be present in the drying apparatus. Also, provisions are made for bypassing substantially all of the fluid through the heating means while the drying apparatus is not in operation. This obviates any damage to material that may be in passage 12 of the drying apparatus.

Partition 46 is spaced from side wall 24 and is filled with filters to provide a return fluid plenum of exhausted fluid from the discharge chamber 52 which is formed by floor 22 bottom 62, portions of front and rear walls 28 and 30, portions of partition 44 and side wall 24. The chamber 52 provides fluid communication between the heated fluid being conducted through conduits 38 and 40 and the discharged fluid being conducted to the heating means. Note in FIG. 3 direction of the arrows which indicate the path of the fluid as it passes through drying zone 32. Mounted in partition 46 are a plurality of filters or screens 47, which remove any lint that may be present in the discharge fluid after passing over the surfaces of textile material M. The screens are preferably removably mounted in partition 46 for periodic cleaning. The heating means 60 is mounted preferably above drying zones 32, 33, 34, 35 and 36 and extends substantially the length of the drying chamber 10.

The heating chamber 60 is generally rectangular in shape and is provided with top, bottom and side walls 61, 62, 63 and 64 and is best illustrated in FIGS. 3, 4 and 6. Mounted within heating chamber 60 is heat exchanger 66 which extends over substantially the entire length of drying apparatus 10 and is illustrated in side elevating in FIG. 6. Heat exchanger 66 is formed having an elongated tubular member 67 which extends substantially the length of heating chamber 60 and is bent upon itself so as to form a serpentine path through heating chamber 60. Heating unit 70 is mounted on entrance end 68 of tubular member 67 and may be either an oil or gas fired burner which causes hot gases to flow through tubular member 67; through the discharge end 71 to pass the hot gases into chimney 72.

FIG. 4 is a top plan view of heating chamber 60 and heat exchanger 66. A plurality of tubular members comprise heat exchanger 66. Thus, at the entrant end 68 one or more heating units 70 may be mounted thereto to provide required amount of BTUs to uniformly heat fluid to a desired preset temperature. The fluid is preferably air although other gaseous substances may be employed so long as those substances, when heated, will uniformly dry a material such as a textile web. Obviously, many changes in design are possible. However, each heat exchanger used is designed

for a maximum output of BTUs. Also, the heating unit need not be an oil or gas fired unit, it could be electric. A heated fluid such as oil could be circulated through tubular members 67. Obviously the type of heating unit and heat exchanger means will be dictated by economics.

The heating chamber 60 is provided with a pair of up-standing partition or walls 63 and 64. Partition 63 is spaced from filters 47 to form a conduit or duct 72 for the passage of return air to be heated. Partition 63 is rigidly mounted to bottom wall 62 of the heating chamber 60 and end wall 30 of drying apparatus 10 as illustrated in FIGS. 4 and 6. The other end 73 of partition 63 is spaced from front wall 28 to provide an entrant opening 75 to heating chamber 60 for return air or fluid to be heated. Partition 64 is mounted in heating chamber 60 in a similar fashion as in partition 63. As illustrated in FIG. 4, the fluid discharge opening 76 is diametrically disposed from entrant opening 75 so that all return air passing through entrant opening 75 into heating chamber 60, as illustrated by the arrows in FIG. 4 will be uniformly heated and subsequently pass through discharge opening 76 through fluid distributing plenum 78 and into the intake opening of fan 50. A plurality of fans 50 are provided, one for each drying zone 32, 33, 34, 35 and 36 to move substantially equal volumes of uniformly heated fluid through each drying zone.

Fans 50 are mounted in opening 45 of partition 44 and are separated from each other by walls 41, 43, 45, 57 and 49 thus forming a compartment means or fan duct 51 for passage of uniformly heated fluid discharged from the heat exchanger to conduits 38 and 40 of drying zones 32, 33, 34, 35 and 36. In conjunction with the flow of fluid through drying apparatus 10, a by-pass fluid flow system may be employed and is shown in FIGS. 3 and 7-10. After the fluid has passed through openings 42 of conduits 38 and 40 it is drawn to the discharge side of drying zone 32. A fluid by-pass duct 33 of drying zone 32 is formed by top wall 20, bottom wall 61 which is also the top wall of heating chamber 60, the upper portions of front and rear walls 28 and 30 and the upper portions of side walls 24 and 26. Damper assembly 88 which may be manually or automatically operated controls the amount of by-pass air which is fed into the heated air to maintain the desired uniform temperature. In FIG. 3, damper 88 is closed to ambient air and by-pass air. Thus, only uniformly heated air can pass through drying zone 32. In FIG. 7 a mixture of by-pass and heated air is circulated through fan 50. In FIG. 8, the damper position is similar to the damper position of FIG. 3. In FIG. 9 the damper functions as a 3-way valve in which a mixture of outside air, unheated return air and uniformly heated air from the exchanger is allowed to enter fan 50 for circulation through the drying zone.

Positioned along the bottom wall 22 of drying apparatus 10 is exhaust duct 100. Exhaust damper 101 is pivotally mounted in exhaust duct 100 and may be manually or automatically operated to remove warm moist air or fluid. Exhaust duct 100 is connected to exhaust stack or chimney 103. A motor driven suction fan assembly 104 mounted on stack 103 establishes the necessary exhaust pressure for removal of moist warm air from drying apparatus 10. In practice, it has been found that moist exhausted air discharged from drying zones 32 and 33 contains higher moisture content than exhausted air from drying zones 34, 35 and 36 and is

therefore removed from the drying zones in greater volumes than exhaust air from drying zones 34, 35 and 36. About five complete air changes per minute maintains a relative humidity of heated air which is suitable for drying material being passed through the drying chamber 10.

FIG. 7 schematically illustrates the temperature and fluid control system of apparatus 10 for drying material. Drying zones 32, 33, 34, 35 and 36 may be provided with temperature zone control means 80. Zone control means may include temperature sensor bulb 82 connected to a temperature controller 84 which in turn is connected to damper operator device 86. Damper operator device 86 is connected to damper assembly 88 which has means to direct fluid at ambient or near ambient temperature into intake opening of fan 50. By controlling the damper assembly and directing the proper amount of fluid or air into the drying zone, uniform fluid temperature may be maintained or, if desired, a temperature gradient may be maintained between each drying zone or zones.

Heat control means 90 maintains a constant desired temperature in the heat exchanger means 66 so that the fluid passing through the heat exchanger chamber 60 is heated uniformly and at a desired preset temperature. A temperature sensor bulb 92 is connected to temperature controller 94 which is also connected to burner operator device 96. Burner operator device 96 is connected to heating unit 70. In operation temperature controller 94 is set as a desired temperature so as to maintain uniformly heated fluid or air being discharged from the heating chamber 60. Temperature sensor bulb 92 will send a signal to temperature controller 94 when the fluid temperature is below the desired preset temperature which, in turn, will cause heating unit 70 to operate. Likewise, when the desired temperature of the heated fluid is too high, a signal is transmitted from temperature sensor bulb 92 through temperature controller 94 which then causes heating unit 70 to shut down. In this manner uniformly heated fluid is maintained to allow uniform drying of material M.

The damper assembly 88 is controlled in similar manner as heating unit 70 by temperature sensor bulb 82 and temperature controller 84.

When operating drying apparatus 10 textile material M to be dried is mounted on pins 17 of tenter chains 16. Wet or moist material M is moved at about 210 to 300 feet per minute through drying apparatus 10 in which uniformly heated air at about 300°F. is continuously circulated through drying zones 32, 33, 34, 35 and 36. Heated air at 300°F. is passed under positive pressure from fan 50 through fan duct 51 and into conduits 38 and 40 of drying zone 32, 33, 34, 35 and 36. Conduits 38 are mounted above tenter chains and are positioned transversely of drying apparatus 10. Conduits 40 are mounted similarly to conduits 38 but are positioned transversely below the moving web material. Openings 42 formed in conduits 38 and 40 are spaced from each other in face to face relationship so that heated or conditioned air being passed through conduits 38 and 40 will contact the upper and lower surfaces of the moving web material M at approximately equal velocities and equal volumes thus allowing textile material M to be passed through drying apparatus 10 in a substantially weightless condition. It has been observed when textile material M is being passed through drying apparatus 10 substantially no air passes through

textile material M and, as a result, it appears to be floating through drying apparatus 10 on a cushion of air with substantially no billowing of textile material M. The exhausted or spent heated air accumulates at the discharge side of the drying zone and is conducted upwardly through filters 47 and through common entrant opening 75. The air is then caused to pass through and over heat exchanger means 67 so that the air passing out of the heat exchanger means will pass through common discharge opening 76 and be conducted along distributing conduit 78 to subsequently be drawn into the intake opening of fans 50.

Fans 50 are controlled so that equal volumes of heated air, which have been heated to a predetermined preset temperature, are drawn through fans 50 to be recycled through conduits 38 and 40 for continuously drying textile material M. In actual tests conducted using the drying apparatus herein acetate textile material of 200 inches in width was uniformly dried with substantially no temperature variation across the material and through the plurality of drying zones. The temperature measured at the right, left and center showed temperature curves substantially identical. The temperature of the acetate material before entering was about 80°F. along the right, left and center of the acetate. Almost immediately upon entering the first drying zone the temperature uniformly rose to about 300°F. and remained at this set temperature with less than about 10° variation throughout the entire drying time the acetate was passing through apparatus 10. Such runs are reproducible from day to day and the temperature desired need only be preset to allow uniform drying over the entire surfaces of textile materials.

As described in FIGS. 7-9, the temperature of the air may be controlled by employing damper means 88. For example, if a desired temperature which is different from the temperatures of the other drying zones is required, the damper means 88 of a particular fan 50 will be set for sensing the temperature required so that bypass air can be introduced into the particular fan in question thereby effecting a temperature gradient between drying zones.

In FIG. 10 a damper means 110 is mounted at the exit ends of conduits 38 and 40 and may be either manually operated or automatically controlled. A damper control device 112 is connected to damper means 110 and to the tenter machine. In the position as shown in FIG. 10 the damper control device would have caused a signal to be transmitted to the damper actuating means to cause the damper means to open since the tenter machine would have stopped. To avoid loss of fabric due to overheating, the dampers would cause the heated air to pass therethrough while only a minimum of heated air would pass through openings 42 of conduits 38 and 40. At the same time, damper means 110 would be in the open position outside or ambient temperature air would be passed into drying apparatus 10 to reduce the temperature thereof before being conducted through the apparatus.

While the invention herein has been described for drying a textile material, it should be understood that the drying apparatus may be used for drying films or other fibrous materials. Also, the heated air may be conditioned with other drying mediums such as superheated steam where desired.

It is apparent that many modifications may be accomplished and redesign of component parts of the ap-

paratus may be had without departing from the spirit and scope of the invention described herein.

We claim:

1. An apparatus for uniformly drying material comprising:

a generally rectangular drying chamber including side walls, a top wall, a bottom wall, front and rear walls;

said front and rear walls having horizontally extending openings forming a lined entrant and exit opening between the front and rear walls of said chamber to define a pathway therebetween for the passage of the material to be dried therethrough;

an upstanding partition mounted in the drying chamber between said side walls;

a plurality of spaced parallel panels mounted transversely between said upstanding partition and one of said side walls to form a plurality of compartment means;

a plurality of fluid supply means mounted in said drying chamber and being in fluid communication with each of said compartment means;

and means forming a plurality of drying zones in said chamber and spaced along said pathway, each drying zone including at least a pair of spaced parallel conduits positioned above and below said pathway; said conduits being mounted horizontally in said drying chamber and being in fluid communication with said compartment means;

a plurality of fluid supply openings of predetermined size and spacing in said conduits and said openings facing the pathway to provide a uniform distribution of fluid to the entire surface of the material to be dried in said chamber;

means forming a fluid heating chamber between the side walls and extending the length of the drying chamber and being in fluid communication with said compartment means and said pathway;

means placing said fluid heating chamber in communication with each of said fluid supply means;

heat exchanger means disposed in said fluid heating chamber for heating and conditioning the fluids to be distributed through the fluid supply means;

means forming an exhaust passageway being in fluid communication with said pathway to conduct the exhaust fluid through said fluid heating chamber so that the heat exchanger means will uniformly heat the fluid prior to distributing the heated fluid

through said fluid supply means;

a partition in said heating chamber extending from said rear wall and stopping just short of said front wall for directing all of the fluid from the exhaust passageway to the front of said heating chamber;

a further partition in said heating chamber extending from said front wall and stopping just short of said rear wall for directing all of the fluid from said heating chamber to one end of a fluid distributing plenum formed between said further partition and said upstanding partition to distribute heated fluid to said plurality of compartment means.

2. The apparatus of claim 1 wherein the heat exchanger means comprises a plurality of elongated tubular members extending substantially the entire length of the heating chamber; heating means for heating the elongated tubular members, said heating means being mounted thereto.

3. The apparatus of claim 2 wherein the heating means is a gas fired burner in which the hot gases of combustion are conducted through the elongated tubular members so that fluid contacting the exterior surfaces of the tubular members is heated to a desired pre-set temperature.

4. The apparatus of claim 2 wherein the heating means is oil fired.

5. The apparatus of claim 1 wherein the fluid supply means for conducting heated fluid through said means forming a plurality of drying zones comprises an un-housed fan.

6. The apparatus of claim 1 wherein said conduits include a fluid entry opening in fluid communication with said compartment means and a normally closed end, said closed end having damper means mounted thereon which is adapted to be opened to provide a heated fluid bypass to prevent said heated fluid from contacting the surfaces of the material to be dried.

7. The apparatus of claim 1 wherein said means forming an exhaust passageway includes filter means for filtering particulate material from the discharge fluid.

8. The apparatus of claim 1 wherein said drying chamber includes a discharge fluid exhaust conduit having damper means mounted thereon, said damper means being in fluid communication with said means forming a common exhaust passageway for controlling the amount of discharge fluid exhausted therethrough.

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