Nov. 30, 1971 H. L. SMITH, JR 3,623,235

DRYING APPARATUS FOR VENEERS AND OTHER MATERIALS OF SHEET AND WEB FORM

Filed Oct. 7, 1970 3 Sheets-Sheet 1

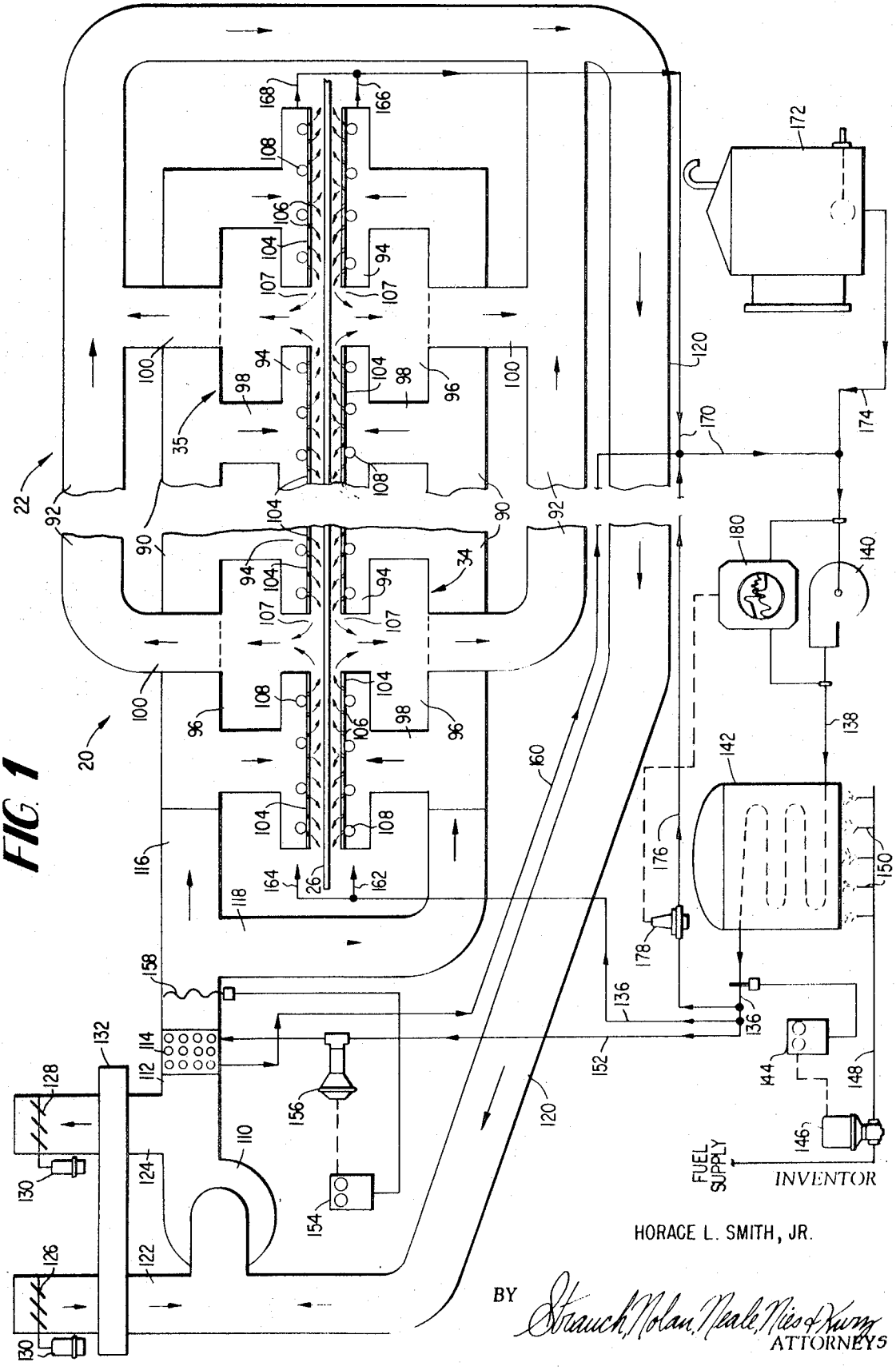


FIG. 1

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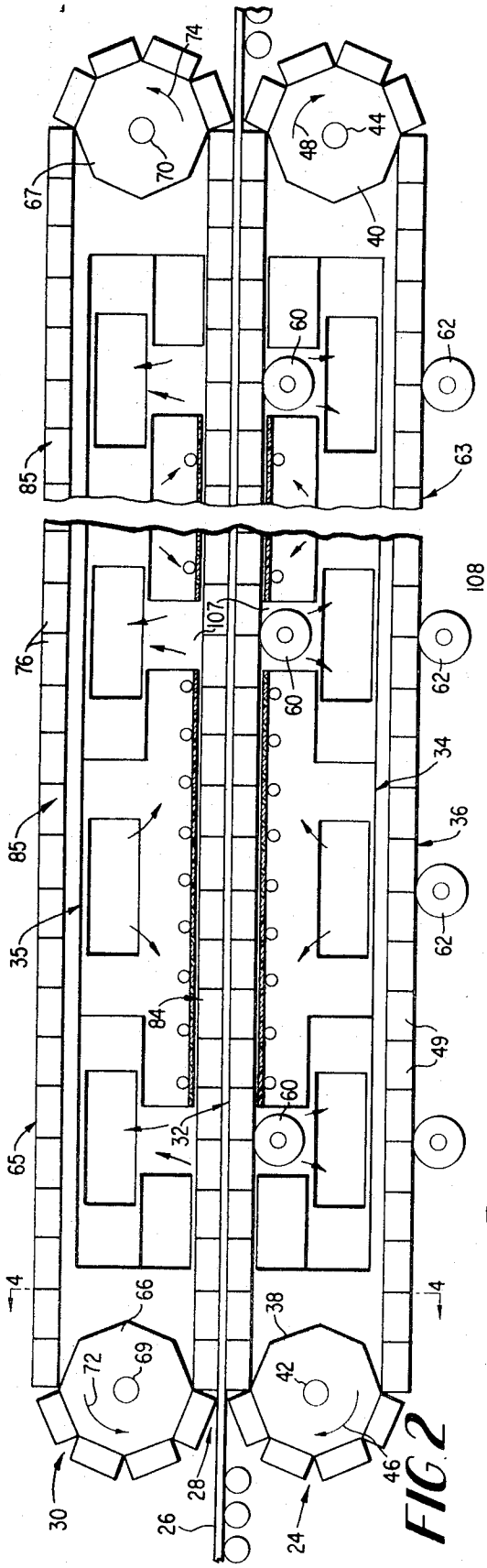


FIG 2

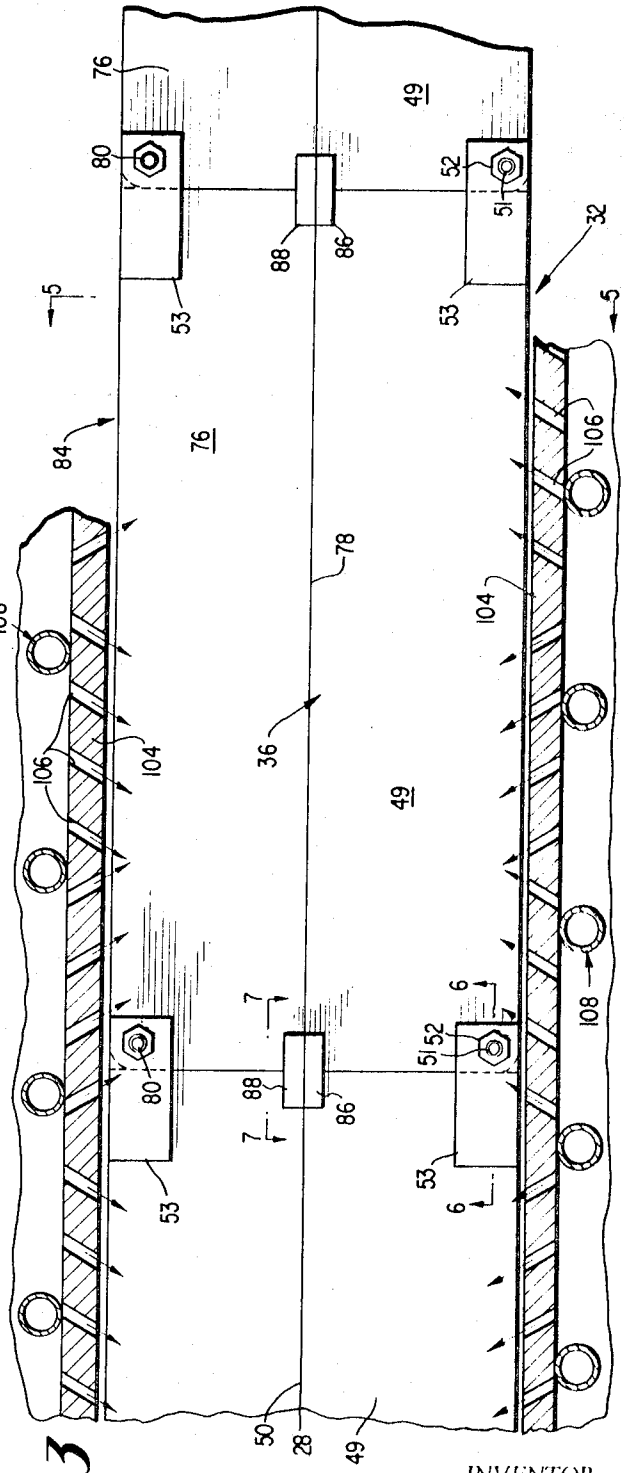


FIG 3

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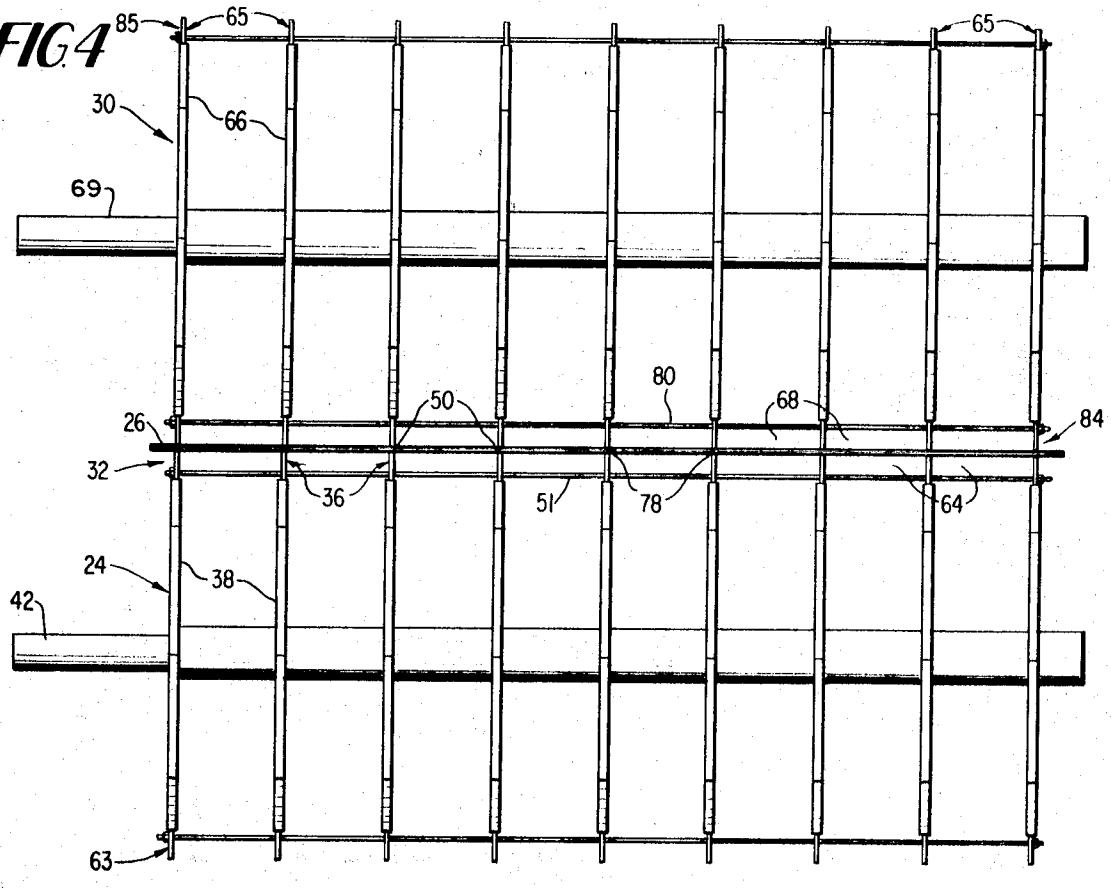
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DRYING APPARATUS FOR VENEERS AND OTHER MATERIALS OF SHEET AND WEB FORM

Filed Oct. 7, 1970 3 Sheets-Sheet 3

FIG. 4



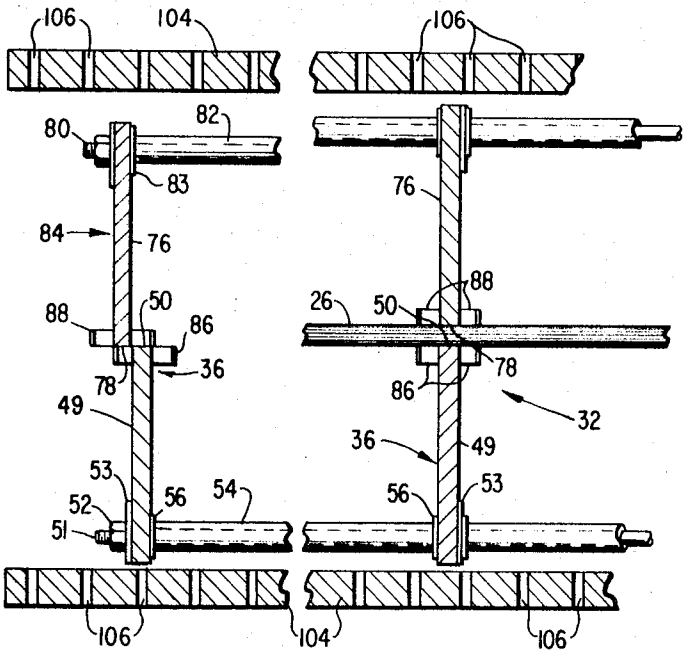


FIG. 5

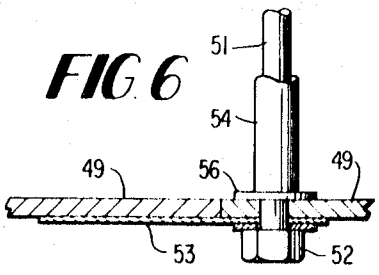


FIG. 6

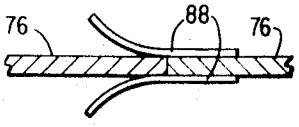


FIG. 7

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3,623,235

DRYING APPARATUS FOR VENEERS AND OTHER MATERIALS OF SHEET AND WEB FORM

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Filed Oct. 7, 1970, Ser. No. 78,795
Int. Cl. F26b *13/00*
U.S. Cl. 34—48 22 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for drying veneers and other materials in sheet and web form including a dryer which has a conveyor for transporting the material through a passage between juxtaposed radiant heat-fluid impingement units and a hold-down arrangement for pressing the material against the conveyor as the material moves through the passage. The apparatus also includes a system for supplying a heated gas and a heat transfer liquid to the radiant heating-fluid impingement units.

This invention relates to drying apparatus and, more particularly, to novel, improved apparatus for drying veneers and other materials in sheet and web forms.

In modern dryers for veneers and similar materials, the materials to be dried is conveyed between juxtaposed air heaters and is heated by convection as it passes therebetween. Green veneers are very thin and flexible and must accordingly be continuously supported or supported at closely spaced intervals along and across the width of the material as they pass through the dryer.

One or the other of two types of supporting arrangements are generally employed in conventional veneer dryers. In one of these the veneer is supported on an open mesh apron conveyor. In the other the veneer is supported on closely spaced, transversely extending rollers.

As discussed in my U.S. Pat. No. 3,460,265, issued Aug. 12, 1969, for Methods of Drying, much faster drying times and other benefits can be obtained by drying sheet and web type materials with a combination of radiant heat and high velocity, impinging air instead of convectively drying them as is done in conventional dryers for veneers and other sheet and web materials.

This novel technique is, however, incompatible with the support systems which are employed in conventional dryers. More specifically, if closely spaced rollers are employed, adequate amounts of radiant heat cannot be transmitted through the support arrangement to the material being dried at a realistic cost.

In the apron conveyor type of support system, the open mesh belt must be supported at closely spaced intervals since only small amounts of sag will disturb the flow pattern of the impinging air, resulting in unacceptably high pressure drops. Therefore, in this system also, there are too many obstructions to the passage of radiant energy to make it compatible with the use of radiant heaters.

I have now invented a novel material support arrangement or conveyor for dryers designed to accommodate sheet and web type materials which does not have the drawbacks of the heretofore employed dryer conveyors. This novel conveyor offers only an insignificant impediment to the passage of radiant heat and gases and is accordingly compatible with apparatus employing a combination of radiant heat and fluid impingement.

Generally speaking, this novel conveyor arrangement includes a plurality of endless support loops disposed in parallel, spaced apart relationship and trained over rotatably mounted drive members at opposite ends of the dryer section. Each loop is made up of a series of platelike

support members oriented with their thin edges facing a source of radiant energy and impinging fluid which is located on the opposite side of the material supporting leg of the conveyor from the supported material. Pins extending transversely across the conveyor hingedly connected adjacent support members in each loop, allowing the loops to flex around the rotatable members about which they are trained.

Due to the manner in which the supporting members of the loops are connected, the material supporting legs of the loops act essentially as solid members or beams. Accordingly, the material supporting legs of the loops need be supported only at infrequent intervals. Thus the supports for the material bearing leg of the conveyor, like the material supporting members of the loops, do not significantly impede the passage of radiant energy or impinging fluid.

In a typical dryer constructed in accord with the principles of the present invention, the radiant energy sources are horizontally oriented plates located above and below the path of the material being dried through the dryer with the lower plate being immediately beneath the lower side of the material supporting leg of the conveyor. The novel conveyor arrangements of the present invention have the additional advantage that the hinge pins act as scrapers, clearing knots, splinters, and other debris from the radiant plates to locations where this debris can be conveniently removed from the dryer. In contrast, open mesh type apron conveyors present a decided problem as far as debris removal is concerned.

Also, in dryers according to the present invention, the best results are obtained if the flow of the impinging air as it is directed toward and exhausted from adjacent the material being dried is confined to paths extending in the same direction as the path of the material being dried through the conveyor. The material supporting members of the conveyor loops divide the space between the material being dried and the radiant heating-fluid impingement units therebeneath into a series of parallel channels extending in the direction of material movement and thereby confine the flow of impinging air to paths extending in this same direction.

Dryers for veneers and similar materials are universally equipped with a "hold-down" arrangement to keep the material being dried from curling or warping as it moves through the dryer. In the novel dryers of the present invention the hold-down arrangement is preferably a conveyor of the same type as is used to transport the material being dried through the dryer. The hold-down conveyor is spaced closely adjacent the lower or support conveyor. Accordingly, the members in the lower legs of the loops of the upper conveyor press the material being dried against the material supporting upper leg of the lower conveyor.

The upper conveyor also preforms a second, highly useful function. In dryers according to the present invention, materials may be dried from both sides by radiant heating-fluid impingement units disposed above and below the path of the material being dried through the dryer as mentioned above. The upper unit is disposed between the lower and upper legs of the hold-down conveyor. Accordingly, the loop members of the upper conveyor lower leg direct the flow of impinging air from the upper unit along paths parallel to the direction of material movement. Consequently, when the preferred hold-down arrangement is employed, the flow of impinging air from the upper radiant heating-fluid impingement unit, as well as that from the lower unit, is confined to the direction required for best results.

Another advantage of the present invention is that dryers constructed in accord with its principles have a rela-

tively low initial cost. Maintenance costs are also comparatively low.

From the foregoing it will be apparent that one prmary object of the present invention resides in the provision of novel, improved dryers for veneers and other sheet and web type materials.

A related and important object of the invention resides in the provsion of novel improved drying apparatus for veneers and other sheet and web materals in which the material is dried by a combination of radiant heat and impinging fluid.

Another primary object of the invention is the provision of novel, improved material transporting and material holddown arrangements for sheet and web type material dryers having drying units designed to supply a combination of radiant heat and impinging gas to the material being dried.

A related and also important object of the invention is the provision of material transporting and hold-down units capable of confining the flow of an impinging gas directed against and exhausted from adjacent the material being dried to the direction which will produce the best results.

Yet another important object of the invention is the provision of novel, improved dryers for veneers and other sheet and web material which have a relatively low initial cost and are comparatively inexpensive to maintain.

Another important but more specific object of the invention resides in the provision of a material supporting conveyor for dryers designed to dry veneers and other sheet and web type materials which is capable of keeping a platelike radiant heat source disposed beneath the material supporting leg of the conveyor clear of knots, splinters, and other debris.

Other important objects and features and further advantages of the present invention will become apparent from the appended claims and as the ensuing detailed description and discussion proceeds in conjunction with the accompanying drawing, in which:

FIG. 1 is a generally diagrammatic illustration of a system for drying veneers and other sheet and web type materials which includes a dryer constructed in accord with the principles of the present invention;

FIG. 2 is a side view of the dryer with certain sheet metal components omitted to better show the major components of the dryer;

FIG. 3 is a fragment of FIG. 2 to an enlarged scale;

FIG. 4 is a section through FIG. 2, taken substantially along line 4—4 of FIG. 3;

FIG. 5 is a section through FIG. 3, taken substantially along line 5—5 of the latter figure;

FIG. 6 is a section through FIG. 3, taken substantially along line 6—6 of the latter figure; and

FIG. 7 is a section through FIG. 3, taken substantially along line 7—7 of the latter figure.

Referring now to the drawing, FIG. 1 depicts a system 20 for drying veneers and other sheet and web type materials. This system includes a dryer 22 constructed in accord with the principles of the present invention.

The major components of dryer 22 include a conveyor 24 for transporting the mateiral 26 to be dried along a predetermined path 28 through the dryer and a hold-down arrangement 30 for pressing material 26 against the upper run 32 of conveyor 24 to keep the material from warping or curling. Other major components of dryer 22 are lower and upper radiant heating-fluid impingement units 34 and 35 for drying the material as it moves through the dryer.

Referring now to FIG. 2, conveyor 24 serves the dual function of moving material 26 through dryer 22 and channeling the impinging gas from unit 24 as well as the fluid exhausted from adjacent the material into paths such that maximum drying efficiencies will be obtained. Conveyor 24 includes a series of endless loops or bands 36 disposed in parallel, spaced apart relationship and trained around spaced apart members 38 and 40 at opposite ends of dryer 22. Members 38 and 40 are fixed in any convenient fashion to transversely extending, rotatably mounted shafts 42 and 44. One or both of these shafts are rotatably driven in the directions indicated by arrows 46 and 48 in FIG. 2 by an appropriate drive arrangement (not shown).

Each of the loops 36 trained around driven members 38 and 40 includes a series of platelike members 49 oriented with their edges 50 facing the path 28 of the material 26 being dried. Adjacent members 49 are hingedly or pivotally connected by transversely extending hinge pins 51 which span conveyor 24 and are secured in place as by nuts 52.

As best shown in FIGS. 3 and 6, a barlike connector 53 is fixed to one end of each member 49 at the inner edge thereof [1] with the connector overlapping the apposite end of the adjacent member 49. Pins 51 extend through the overlapping part of the connector and the overlapped end of the adjacent member 49 to pivotally connect the adjacent members. Tubular spacers 54 surrounding pins 51 and separated from the members 49 of adjacent loops 36 as by washers 56 keep the loops properly laterally spaced between rotatably mounted support members 38 and 40.

Intermediate support members 38 and 40 the loops 36 of conveyor 24 are supported by transversely extending idler rollers 60 and 62 with rollers 60 supporting the upper leg or run 32 of the conveyor and rollers 62 supporting the lower conveyor leg 63. The members 49 in the upper leg or run 32 of the conveyor act essentially as a solid rigid beam because of the manner in which they are connected to each other. Accordingly, the loops need be supported only at infrequent intervals in upper conveyor run 32.

The dimensions of the material supporting conveyor will of course vary from application to application of the invention. Typically, however, loops 36 will be spaced one foot apart and its upper leg 22 will be supported by idler rollers 60 at ten-foot intervals. The members 49 of the loops will in this case typically be one-eighth of an inch thick, two inches wide, and twelve inches long. Under a typical load the maximum deflection of the upper legs of the loops will be minimal (one-eighth of ar inch).

The lower radiant heating-fluid impingement unit 34 is disposed between the upper and lower legs 32 and 63 of conveyor 24, the impinging fluid and radiant energy passing through the conveyor leg to the material being dried. Because the conveyor loops are thin and widely spaced and because the idler rollers 60 are so far apart, the conveyor does not present a significant obstruction to the passage of the gas or radiant energy. At the same time the relatively deep members of the loops divide the space between the radiant heating-fluid impingement unit and path 28 into a series of side-by-side flow channels 64 extending in the same direction as the path 28 of the material being dried. Accordingly, the conveyor loops channel the fluid emanating from the radiant heating-fluid impingement unit as well as the fluid exhausted from adjacent the material being dried into paths extending in the direction of material movement. As explained above, this produces maximum effectiveness of the impinging fluid.

Referring again to FIGS. 2–7, the preferred hold-down mechanism 30 is a conveyor of the same design as the material supporting conveyor 24 just described. Conveyor 30 includes endless loops 65 disposed in parallel, spaced apart relationship and trained around members 66 and 67 at opposite ends of dryer 20. Members 66 and 67 are fixed in any convenient fashion to transversely extending, rotatably mounted shafts 69 and 70 to provide flow channels 68 similar to the channels 64 described

[1] By inner edge is meant the edge facing radiant heating-fluid impingement unit 34.

above. One or both of these shafts are rotated in the directions indicated by arrows **72** and **74** in FIG. 2 by an appropriate drive arrangement (not shown).

Each of the loops **65** trained around driven members **66** and **67** includes a series of platelike members **76** oriented with their edges **78** facing the path **28** of the material **26** being dried. Adjacent members **76** are hingedly or pivotally connected by transversely extending hinge pins **80**, which span conveyor **30** in the manner discussed above in conjunction with conveyor **24**. Tubular spacers **82** surrounding pins **80** and separated from members **76** by washers **83** maintain the desired spacing between adjacent loops **65** of conveyor **30**.

As is shown in FIG. 2 of the drawing, hold-down conveyor **30** is mounted with its lower leg **84** immediately above the upper leg **32** of conveyor **24**. The segments or members **76** in the lower legs of the loops are free to sag because of the location of hinge pins **80**. Accordingly, these members rest on the material **26** being dried, keeping it from curling or warping as it passes through dryer **22**.

The upper run **85** of hold-down conveyor **30** need not be supported since the links of this leg essentially constitute solid beams, and the small degree of deflection between rotatable drive members **66** and **67** is of no consequence.

Referring now to FIG. 7 clips **86** and **88** are fixed to the outer edges of the members **49** and **76** of material supporting and hold-down conveyors **24** and **30** at one end thereof. These clips embrace the apposite ends of adjacent members **49** and **76**, thereby keeping the outer edges of the members making up loops **36** and **65** aligned. Also, when there is no material in dryer **22**, clips **86** and **88** co-operate to keep the lower leg **84** of hold-down conveyor **30** properly positioned above material supporting leg **32** of conveyor **24** as shown at the left-hand end of FIG. 5.

As best shown in FIG. 2, the upper radiant heating-fluid impingement unit **35** is located above the lower run **84** of hold-down conveyor **30**. Therefore, the preferred form of conveyor not only performs the hold-down function just described but also channels the fluid from the upper units and exhausted from adjacent the upper side of material **26** into paths of maximum effectiveness as discussed above in conjunction with material supporting conveyor **24**.

Referring now to FIG. 2, each of the fluid impingement-radiant heating units **34** and **35** incorporated in dryer **22** includes main supply and return ducts **90** and **92** which extend lengthwise of dryer **22**. Each of these units also includes a number of generally T-sectioned branch supply and return ducts **94** and **96** extending transversely from the associated main supply duct to the main return duct in an array of adjoining, internested ducts with branch supply and return ducts alternated. The T-sectioned branch ducts are connected to the main ducts by branch supply ducts **98** and branch return ducts **100**.

Preferably, vanes or other distributors (not shown) are employed in branch supply ducts **94** to provide a generally uniform distribution of the treating fluid over the span of the impingement units and, accordingly, over the span of the material **26** being dried. By dimensioning and positioning the vanes in accord with available technique, a generally uniform distribution of fluid across the span of the supply ducts can be provided.

The fluid supply arrangement just described minimizes resistance to fluid flow and promotes a discharge of fluid from the branch supply ducts which is substantially uniform over the entire width of the material **26** being treated. This promotes uniform treatment of material **26** across its entire width and, consequently, the production of a highly uniform treated product. The minimization of flow resistance in the impingement units by the structure described above also reduces to an appreciable extent the power required to circulate the fluid treating medium through units **34** and **35**.

Referring again to FIG. 2 flow plates **104** form the outer walls of branch supply ducts **94** (i.e., the walls facing path **28**). Air or other treating fluid is accelerated and directed at high velocity against material **26** through flow apertures **106** drilled in a predetermined pattern through each of the flow plates **104** to scour evolved volatiles from adjacent the upper and lower surfaces of the material **26** being dried in addition to assisting in evolving the volatiles.[2, 3]

Preferably, flow apertures **106** are drilled so that the fluid exiting through them impinges upon material **26** at an angle rather than normally as in the conventional arrangement. By inclining the flow apertures at an angle to the web a velocity and pressure distribution pattern which will result in minimization of flutter can be produced. Also, the arrangement just described virtually eliminates areas in which the flow velocities are too low to produce the desired scouring effect. Thus there is more uniform and efficient treatment of the material in the present invention than in the typical conventional arrangement.

The inclined nozzle arrangement is particularly important in dryers of the type shown in FIG. 2 in which impingement units are located on both sides of the material being dried. In this type of arrangement, the instability caused by one flow plate is apt to reinforce that caused by the other, materially aggravating flutter, drift, and lack of stability.

Preferably the majority of the flow apertures are so oriented that the treating fluid discharged from them impinges upon material **26** in a direction opposite to the direction of movement of the web. As a result, the velocity of the web and the velocity component of the treating fluid in a direction parallel to the web are additive. Thus for a given velocity of fluid flow through apertures **106**, maximum effectiveness of the impinging fluid can be obtained.

Also, the flow arrangement just described produces greater turbulence than would be obtained if the treating fluid impinged on the web at right angles to the direction of movement of the web. The net result of the foregoing factors is that treating fluid impinging on the web in the manner just discussed has a significantly greater scouring action than could be obtained if the fluid impinged upon the web at right angles or in the direction of web movement.

Referring again to FIG. 1, the spent treating fluid, together with its burden of evolved volatiles, flows into branch return ducts **96** through inlet apertures are exhaust openings **107**. These extend the width of the dryer and accordingly minimize the resistance to the flow of the treating fluid and evolved volatiles into the return ducts. Moreover, since the exhaust openings span the material there is virtually no lateral flow of the spent fluid and evolved volatiles. This is important since lateral flow of the fluid and volatiles can produce variations in drying conditions across the sheet and, accordingly, a nonuniform product.

Referring now to FIG. 2, each of the flow plates **104** (except for those on the ends of impingement units **34** and **35**) is located between the inlets **107** to two successive branch ducts; and the rows of flow apertures **106** adjacent each of the exhaust openings are so oriented that the treating fluid discharged from them is inclined

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[2] As discussed in my Pat. No. 3,460,265, issued Aug. 12, 1969, for Dryers, this scouring effect is of considerable importance in obtaining efficient drying of veneers and similar materials. The foregoing patent is hereby incorporated herein.

[3] As shown in FIG. 5, the tubular spacers 54 on the transverse pins 51 of conveyor 24 scrape across the upper surfaces of the flow plates 104 in lower radiant heating-fluid impingement unit 34 as the pins move through dryer 22. The tubular spacers thereby perform the important function of removing debris from the flow plates. This debris falls through exhaust openings 107 into branch return ducts 96 and is removed from the latter through appropriate trap doors (not shown).

toward the branch duct inlets. Accordingly, the fluid discharging toward the inlets to the return ducts tend to force the spent fluid and evolved volatiles adjacent material **26** through inlets or exhaust openings **107** into branch return ducts **96.**[4]

Volatiles may be evolved from material **26** merely by effecting a flow of air or other treating fluid at high velocity and high temperature through flow plates **104** into contact with the material being dried. However, volatiles are evolved much more rapidly, thereby materially increasing the efficiency of units **34** and **35**, by heating flow plates **104** to temperatures above that of the treating fluid so that emission of radiant energy in the infrared portion of the electromagnetic spectrum from the plates will be enhanced. Thus, the material being treated will be dried by radiant energy as well as impinging fluid.

In the fluid impingement-radiant heating units **34** and **35** illustrated in FIG. 2, heating of flow plates **104** is readily and simply accomplished by welding or otherwise fixing tubular type heaters **108** in heat conductive relationship to the inner or back sides of the flow plates as shown in FIG. 3.[5]

The flow plates will preferably be fabricated of a material which is a good thermal conductor and has a relatively high coefficient of emission yet can be drilled and welded without undue difficulty. One satisfactory material is sheet steel.

To increase the absorptivity of heat from tubular heaters **108** and the emissivity of the flow plates, the surfaces of the latter may be covered with a high emissivity coating. A number of satisfactory coatings are described in my Pat. No. 3,262,494, issued July 26, 1966, for Heat Exchangers.

Referring next to FIG. 1, the treating fluid is supplied to units **34** and **35** by a blower **110** connected through a duct **112** to a fluid heater or heat exchanger **114.** From heater **114**, the fluid flows through supply trunks **116** and **118** into main supply ducts **90** and then into branch supply ducts **94** of the units. Similarly, the spent treating fluid and its burden of evolved volatiles flows from the branch return ducts **96** of units **34** and **35** into the associated main return ducts **92.** From these ducts, the spent fluid and its burden of evolved volatiles flows into a schematically illustrated return trunk identified by reference character **120** in FIG. 2.

In the present invention, return trunk **120** is preferably connected to the inlet of circulating blower **110** so that the spent treating fluid may be recirculated through the system. This eliminates the loss of sensible heat which would result if the spent fluid were discharged from the system.

In many applications of the present invention, the percentage of moisture or other volatiles in the treating fluid must be closely controlled to produce the desired characteristics in the treated product. To permit such control, return trunk **120** is provided with a make-up duct **122**; and a vent duct **124** branches from the duct **112** between blower **110** and fluid heater **114.** Valves **126** and **128** control the flow through make-up and vent ducts **122** and **124**, respectively. By adjusting valves **126** and **128**, recirculated fluid can be discharged from the system and replaced with fluid having a lower content of volatiles to maintain the volatile content at the desired level.

[4] Division of the impinging gas into streams flowing both in the direction of material movement and in the opposite directon has the additional advantage that, all other parameters remaning the same, the distance between support rolls 60 can be increased. This reduces the obstructions to the passage of impinging fluid and radiant energy presented by the support rolls.

[5] As in the case of the impinging gas, support and hold-down conveyors 24 and 30 do not unacceptably obstruct the passags of radiant energy from units 34 and 35 to material 26. To minimize the dissipation of the radiant energy emitted from flow plates 104, especially near the edges of the flow plates, and thereby increase drying efficiency and uniformity, the platelike members 49 and 76 may be aluminized or otherwise provided with surfaces having high reflectivity.

Valves **126** and **128** may be adjusted manually or, if desired, may be automatically adjusted by diagrammatically illustrated controllers **130** of any suitable type or by a system of the type described in my Pat. No. 3,208,158, issued Sept. 28, 1965 for Dryers.

An economizer **132** of conventional construction may be connected between the vent and make-up ducts to extract sensible heat from the vented fluid and add it to the make-up fluid. This recovers otherwise wasted heat, increasing the efficiency of the drying system.

Referring still to FIG. 1, fluid heater **114** and radiant heaters or radiators **108** are all of the type through which a heated fluid heat transfer medium is circulated to elevate them to the desired temperature. The preferred heat transfer mediums are high boiling point organic liquids and eutectic mixtures of inorganic salts as these media can be circulated at extremely high temperature in liquid form.[6] The advantage of employing such a liquid heat transfer medium is that it may be heated to a temperature of several hundred degrees Fahrenheit yet circulated at low pressure, thus avoiding the problem appurtenant to the extremely high pressures associated with high temperature steam.

The system illustrated in FIG. 1 for heating and circulating the liquid heat transfer medium includes a storage tank (not shown) from which the liquid can be pumped to the main circulation system. This includes main supply and return conduits **136** and **138** and is a closed loop through which the liquid is circulated by a pump **140.**

From main return conduit **138** the heat transfer liquid flows into a liquid heating unit **142** where it is heated to the desired temperature. This unit may be of any desired construction and preferably includes a temperature responsive controller **144** which so regulates the flow of fuel through valve **146** and conduit **148** to burners **150** as to maintain the temperature of the heated liquid flowing into main supply conduit **136** substantially constant.

From main supply conduit **136**, part of the heated liquid flows through branch supply conduit **152** to fluid heater **114.** The volume of flow through conduit **152** is controlled by a temperature responsive controller **154** which is connected to a valve **156** in conduit **152** and has a sensor **158** in main supply trunk **116.** Controller **154** regulates valve **156** so as to maintain the temperature of the treating fluid flowing into the supply trunk substantially constant. From fluid heating unit **114**, the heat transfer liquid flows through return conduit **160** back into main return conduit **138.**

The remainder of the heat transfer liquid flowing through main supply conduit **136** is diverted through supply conduits **162** and **164** to the heaters **108** in fluid impingement-radiant heating units **34** and **35** of dryer **22.** From heaters **108** the heat transfer liquid flows through conduits **166** and **168** and return conduits **170** and **138** back to heating unit **142.**

The heat transfer liquid circulation system also includes an expansion tank **172** connected to main return conduit **138** by branch conduit **174** and a bypass conduit **176** connected between supply conduit **136** and return conduit **138.** A valve **178** in bypass conduit **176** insures continued flow under abnormal conditions such as conduit blockage and therefore prevents such abnormal conditions from causing damage to the system.

More specifically, flow through valve **178** is controlled by a differential pressure controller **180** connected to the discharge and inlet sides of main circulating pump **140.** Differential pressure controller **180**, which may be of any conventional construction such as the Differential Pressuretrol manufactured by Minneapolis Honeywell Regulator Company, takes advantage of the well-known fact that, if a constant differential is maintained between the suction and discharge pressures of a pump, the

[6] Suitable media of this type are discussed in detail in Pat. No. 3,262,494.

volume of liquid circulated by the pump will remain constant.

Therefore, should a condition arise tending to restrict flow through the system, the differential between the suction and discharge pressures will increase. In this circumstance, differential pressure controller **180** will open by-pass valve **178**, allowing the circulating medium to flow from main supply conduit **136** through by-pass conduit **176** into main return conduit **138**, maintaining the flow of liquid through heating unit **142** constant and thereby preventing the circulating medium from overheating.

When the resistance to the flow of fluid through the main circulating system is removed, the differential between the pump suction and discharge pressures will decrease. Differential pressure controller **180** will then throttle by-pass valve **178**, decreasing the flow of liquid through bypass conduit **176** and increasing the flow through the main circulating system.

Many modifications may of course be made in the exemplary embodiment of the invention described above without exceeding the scope of the invention. For example at the temperatures to which they become heated in operation, conveyors **24** and **30** may tend to mark the material **26** being dried. To avoid this, the outer edges of material supporting conveyor members **49** and/or **76** can be serrated or scalloped or fashioned with a knife edge or otherwise configured to reduce the contact between the conveyor and material **26**. Alternatively, or in addition, the material contacting portions of the members can be fashioned from a material having low heat conductivity such as asbestos or fiberglass.

As a further example, locating members **86** and **88** need not be separate components. Instead, they can be bent from the outer edges of conveyor members **49** and **76**.

As an additional example of modifications which may be made to the illustrated apparatus, cross members may be attached to the members of conveyor **24** or conveyor **30** or both at their outer edges to provide additional support as when very thin and flexible materials are being dried, for example. The use of cross members also permits the length of the conveyor members to be increased and makes the use of positioning members **86** and **88** unnecessary.

These and many modifications of a like nature will readily occur to those skilled in the arts to which the present invention pertains. To the extent that such modifications are not expressly excluded from the appended claims, they are fully intended to be converted therein.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by Letters Patent is:

1. Apparatus for drying veneers and other materials in sheet, web, and similar forms, comprising radiant heating-fluid impingement units disposed in juxtaposed relationship with a passageway therebetween; conveyor means for conveying the material to be dried through said passageway to expose said material to radiant heat and high velocity gas emanating from said radiant heating-fluid impingement units and thereby dry said material, said conveyor means comprising means for directing gas emanating from one of said radiant heating-fluid impingement units along paths extending in the same direction as the path of movement of the material being dried through the drying apparatus; and hold-down means for pressing the material being dried against said conveyor means to thereby prevent warping and curling of the material being dried.

2. Apparatus for drying veneers and other materials in sheet, web, and similar forms, comprising radiant heating-fluid impingement units disposed in juxtaposed relationship with a passageway therebetween; conveyor means for conveying the material to be dried through said passageway to expose said material to radiant heat and high velocity gas emanating from said radiant heating-fluid impingement units and thereby dry said material, said conveyor means comprising rotatably mounted members at opposite ends of said passageway and a plurality of parallel, spaced apart, endless support means trained around said rotatably mounted members, each of said endless support means including a series of elongated support members and means hingedly connecting each said member to the adjacent members of said support means; and hold-down means for pressing the material being dried against said conveyor means to thereby prevent warping and curling of the material being dried.

3. Apparatus for drying veneers and other materials in sheet, web, and similar forms, comprising radiant heating-fluid impingement units disposed in juxtaposed relationship with a passageway therebetween; conveyor means for conveying the material to be dried through said passageway to expose said material to radiant heat and high velocity gas emanating from said radiant heating-fluid impingement units and thereby dry said material; and hold-down means for pressing the material being dried against said conveyor means to thereby prevent warping and curling of the material being dried, said hold-down means comprising rotatably mounted members at opposite ends of said passageway and a plurality of parallel, spaced apart, endless support means trained around said rotatably mounted members, each of said endless support means including a series of elongated support members and means hingedly connecting each said member to the adjacent members of the support means.

4. The apparatus of claim **23**, wherein said radiant heating-fluid impingement unit comprises a branch supply duct; a branch return duct; a flow plate extending across the side of the branch supply duct nearest the path adjacent the radiant heating-fluid impingement unit, there being apertures in said flow plate through which a fluid medium can flow toward said path and impinge on the material to be dried; an inlet to said branch return duct spanning said path through which fluid can flow into the return duct; and means for heating the flow plate to a temperature at which it will emit energy in the infrared portion of the spectrum toward said path for impingement on the material being dried.

5. Apparatus for drying material in sheet, web, and similar forms, comprising at least one radiant heating-fluid impingement unit and conveyor means for conveying the material to be dried along a path adjacent said radiant heating-fluid impingement unit to expose said material to radiant heat and high velocity gas emanating from said unit and thereby dry said material, said conveyor means including means for directing gas emanating from said radiant heating-fluid impingement unit along at least one path extending in the same direction as the path of movement of the material being dried through the drying apparatus.

6. In apparatus for drying materials in sheet, web, and similar forms comprising conveyor means for supporting and moving the material to be dried along a predetermined path and means for directing a gas at high velocity through said conveyor means against and removing it from adjacent the material being dried to evolve volatiles from said materials, the improvement wherein said conveyor means comprises means for channeling said gas as it flows to and is exhausted from adjacent the material being dried into paths extending in the sme direction as the path through the drying apparatus of the material being dried.

7. The apparatus of claim **6**, together with hold-down

means for pressing the material being dried against the conveyor means to thereby keep said material from curling and warping and means for directing a gas at high velocity through said hold-down means against and thereafter removing it from adjacent the material being dried to assist in evolving said volatile from said material, said hold-down means comprising means for channeling said gas as it flows to and is exhausted from adjacent the material being dried into paths extending in the same direction as the path through the dryer of the material being dried.

8. The apparatus of claim **7**, wherein said conveyor means and said hold-down means are of similar construction and each includes rotatably mounted members at the ends of and adjacent the path through which the material being dried moves, said rotatably mounted members extending at right angles to said path, and a plurality of endless loops trained around said rotatably mounted members to provide legs adjacent said path for supporting the material being dried and for holding the material down to prevent curling and warping, said loops each comprising a series of hingedly connected platelike members oriented with their edges facing said path, whereby the legs of the loops adjacent said path in said conveyor means and in said hold-down means define a series of side-by-side channels extending in the direction of material movement for confining the flow of the impinging air to the direction of material movement.

9. The apparatus of claim **8**, wherein the platelike members of the conveyor means and of the hold-down means are hingedly connected by hinge pins extending transversely through the loops in each of said means adjacent the edges of the platelike members which contact the rotably mounted members as the loops travel thereabout, there being means at the opposite edges of said platelike members for aligning said opposite edges of adjacent members in each of the loops of the hold-down and conveyor means and for preventing misalignment of the aforesaid legs of the conveyor means and the hold-down means when there is no material therebetween.

10. The apparatus of claim **1**, wherein said hold-down means comprises means for directing gas emanating from another of said radiant heating-fluid impingement units along paths extending in the same direction as the path of movement of the material being dried through the dryer.

11. The apparatus of claim **2**, wherein said conveyor means has a material supporting leg, wherein one of the radiant heating-fluid impingement units includes a platelike radiant energy emitting component adjacent the side of said conveyor means leg opposite that on which the material being dried is supported, and wherein said connecting means comprise hinge pins extending transversely across said conveyor means, said hinge pins being so disposed that, as said material supporting leg moves relative to said one radiant heating-fluid impingement unit, said hinge pins move across said platelike radiant energy emitting component to thereby remove debris from said component.

12. The apparatus of claim **4**, together with main duct means connected to said branch supply and return ducts; means for circulating the fluid medium through said main duct means; a vent duct connected to said main duct means; a make-up duct connected to said main duct means; and selectively adjustable valves in said vent and make-up ducts for adjusting the amount of fluid medium respectively discharged and admitted through the vent and make-up ducts, respectively.

13. The apparatus of claim **12**, together with economizer means operatively connected to said vent and make-up ducts for transferring heat from fluid exiting from said vent duct to fluid entering through the make-up duct.

14. The apparatus of claim **4**, wherein said heating means comprises a radiator adapted to have a heat transfer liquid circulated therethrough and including means for heating the fluid discharged into said branch supply duct including a heat exchanger adapted to have the heat transfer liquid circulated therethrough and means for independently regulating the flow of the heat transfer liquid through said radiator and said heat exchanger.

15. The apparatus of claim **14**, wherein the heat transfer liquid is a heat degradable liquid and wherein said apparatus further includes a unit for heating the heat transfer liquid; a closed circulating system including main supply and return conduits connecting said heating unit to said radiator and to said heat exchanger; and means for continuously maintaining a minimum rate of flow of the circulating heat transfer liquid through the heating unit to prevent the overheating and consequent decomposition of said liquid comprising a bypass conduit connected between the main supply and return conduits ahead of the radiator and heat exchanger and means continuously and automatically responsive to a decreasing rate of flow of the circulating heat transfer liquid through said closed circulating system to divert sufficient flowing liquid from the main supply conduit through the bypass conduit into the main return conduit and through said heating unit to maintain said minimum rate of flow therethrough.

16. In apparatus for drying veneers and other materials in sheet, web, and similar forms comprising conveyor means for supporting and moving the material to be dried along a predetermined path; means for directing radiant heat through a material supporting leg of said conveyor means against the material to be dried as it is moved along said path by said conveyor means to evolve a volatile therefrom; and means for directing a gas at high velocity through said conveyor means leg against and removing it from adjacent the material being dried to assist in evolving said volatile from said material, the improvement wherein said conveyor means comprises means for channeling said gas as it flows to and is exhausted from adjacent the material being dried into paths extending in the same direction as the path through the drying apparatus of the material being dried.

17. The apparatus of claim **16**, together with hold-down means for pressing the material being dried against the material supporting leg of the conveyor means to thereby keep said material from curling and warping; means for directing radiant heat through said hold-down means against the material to be dried as it is moved along said path by said conveyor means to evolve a volatile therefrom; and means for directing a gas at high velocity through said hold-down means against and thereafter removing it from adjacent the material being dried to assist in evolving said volatile from said material, said hold-down means comprising means for channeling said gas as it flows to and is exhausted from adjacent the material being dried into paths extending in the same direction as the path through the dryer of the material being dried.

18. The apparatus of claim **17**, wherein said conveyor means and said hold-down means are of similar construction and each include rotatably mounted members at the ends of and adjacent the path through which the material being dried moves, said rotatably mounted members extending at right angles to said path, and a plurality of endless loops trained around said rotatably mounted members to provide legs adjacent said path for supporting the material being dried and for holding the material down to prevent curling and warping, said loops each comprising a series of hingedly connected platelike members oriented with their edges facing said path, whereby the legs of the loops adjacent said path in said conveyor means and in said hold-down means define a series of side-by-side channels extending in the direction of material movement for confining the flow of the high velocity gas to the direction of material movement.

19. The apparatus of claim **18**, wherein the platelike members of the conveyor means and of the hold-down means are hingedly connected by hinge pins extending transversely through the loops in each of said means

adjacent the edges of the platelike members which contact the rotatably mounted members as the loops travel therearound, there being means at the opposite edges of said platelike members for aligning said opposite edges of adjacent members in each of the loops of the hold-down and conveyor means and for preventing misalignment of the aforesaid legs of the conveyor means and the hold-down means when there is no material being dried therebetween.

20. The apparatus of claim **19**, wherein the channel forming sides of said platelike members are coated with a material having a high coefficient of reflectivity for radiation in the infrared portion of the electromagnetic spectrum.

21. The apparatus of claim **19**, wherein the means for supplying radiant heat to the material being dried and for supplying gas to and exhausting it from adjacent said material comprise radiant heating-fluid impingement units disposed in juxtaposition to the material supporting leg of the conveyor means and the juxtaposed leg of the hold-down means adjacent the path of material movement and on the opposite sides of said legs from the path of material movement through the dryer.

22. The apparatus of claim **21**, wherein the radiant energy supplying components of said radiant heating-fluid impingement units include platelike radiant energy emitting members disposed in generally parallel relationship to the path of material movement and wherein the means for supplying high velocity gas comprise nozzle-like apertures through said platelike members, part of said apertures being oriented to direct gas flowing therethrough in the direction of material movement and the reminder of said apertures being oriented to direct the gas flowing therethrough in the opposite direction.

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CARROLL B. DORITY, JR., Primary Examiner

U.S. Cl. X.R.

34—86, 155, 162

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,623,235 Dated November 30, 1971

Inventor(s) H. L. Smith, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 28, change "materials" to --material--.

Column 2, lines 5 and 6, change "connected" to --connect--.

Column 3, line 3, change "prmary" to --primary--.
, line 8, change "provsion" to --provision--.
, line 9, change "materals" to --materials--.
, line 62, change "mateiral" to --material--.

Column 4, line 39, change "22" to --32--.

Column 7, Footnote 4, line 3, change "directon" to --direction--.
, Footnote 4, line 4, change "remaning" to --remaining--.
, Footnote 5, line 3, change "passags" to --passage--.

Column 10, line 39, change "23" to --5--.
, line 70, change "materials" to --material--.
, line 73, "sme" should be --same--.

Column 11, line 34, change "rotably" to --rotatably--.

Column 14, line 11, change "reminder" to --remainder--.

Signed and sealed this 6th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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