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Runciman

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[54] **METHOD AND APPARATUS FOR DRYING LUMBER**

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[52] **U.S. Cl.** **34/9.5,** 34/13.8, 34/13.4, 34/48, 34/DIG. 19, 432/66

[51] **Int. Cl.** **F26b 3/04**

[58] **Field of Search** ..... 34/9.5, 13.8, 13.4, 34/14, 16.5, 15, 77, 78, 100, 196, DIG. 19, 48, 201, 212, 216, 217; 832/1, 2, 6, 9, 14, 23, 66, 126, 187

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Assistant Examiner—Henry C. Yuen
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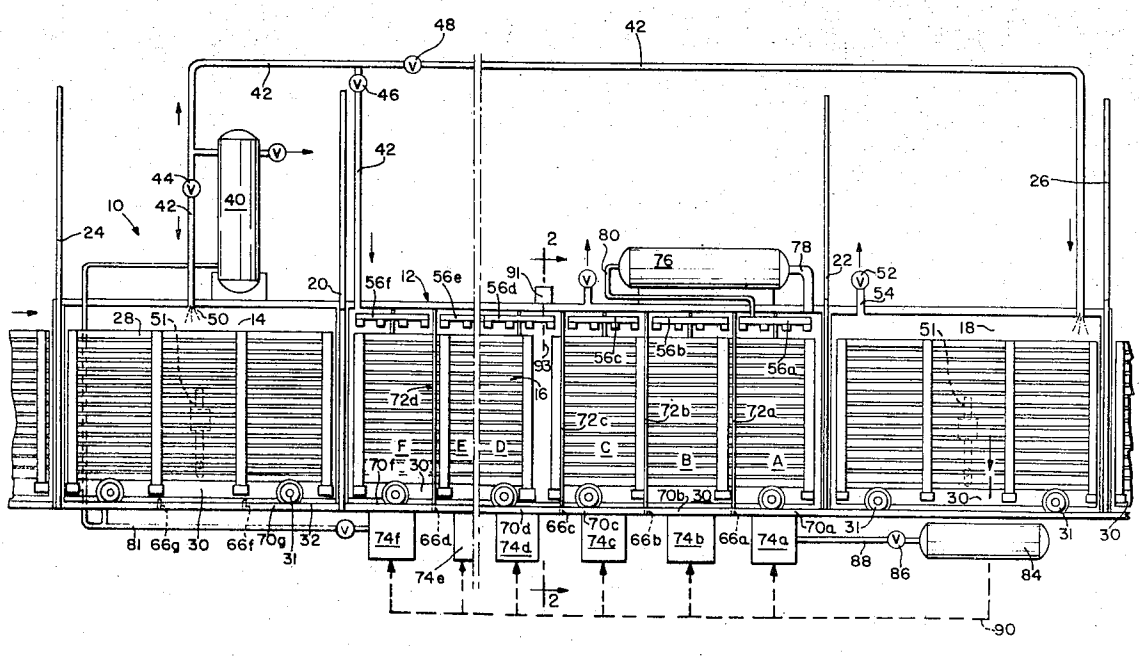
[57] **ABSTRACT**

A method and apparatus for drying stacked lumber by solvent extraction, said apparatus including an elongate chamber through which stacked batches of lumber to be dried are moved. The elongate chamber includes a first compartment in which a stacked batch of lumber is steamed. A second longitudinally adjacent compartment wherein a liquid mixture of a solvent and water near its boiling point wets the stacked lumber in the presence of a vapor mixture of steam and solvent such that the solvent in the liquid phase replaces water within the lumber. As the stacked lumber is moved through this second compartment both the liquid and vapor phases in contact with the lumber have progressively greater solvent contents. The wetting liquid flows progressively through a series of weirs counter the direction of lumber movement, while the vapor moves between the stacked lumber in the direction opposite liquid flow and in this manner, the solvent drying the lumber is itself distilled within the chamber. A condenser adjacent the exit end of the second compartment withdraws vapor having a high solvent content from the compartment and returns solvent condensed therefrom to the dry wood end of the compartment where it is again used to wet the lumber. A third compartment is provided longitudinally adjacent the second compartment wherein the stacked lumber is subjected to steam or a steam and air combination to remove a desired percentage of solvent in the wood to produde substantially dry lumber.

A method of drying lumber by solvent extraction including the steps of steam conditioning wood for drying; wetting the lumber to be dried with a substantially closed chamber with a water-solvent liquid mixture maintained at or near its boiling point; increasing the solvent content of the liquid mixture such that solvent replaces substantially all of the moisture in said lumber; simultaneously distilling the solvent within the substantially close chamber; and raising the temperature of the lumber to drive off the solvent therein to produce substantially dry lumber.

23 Claims, 6 Drawing Figures



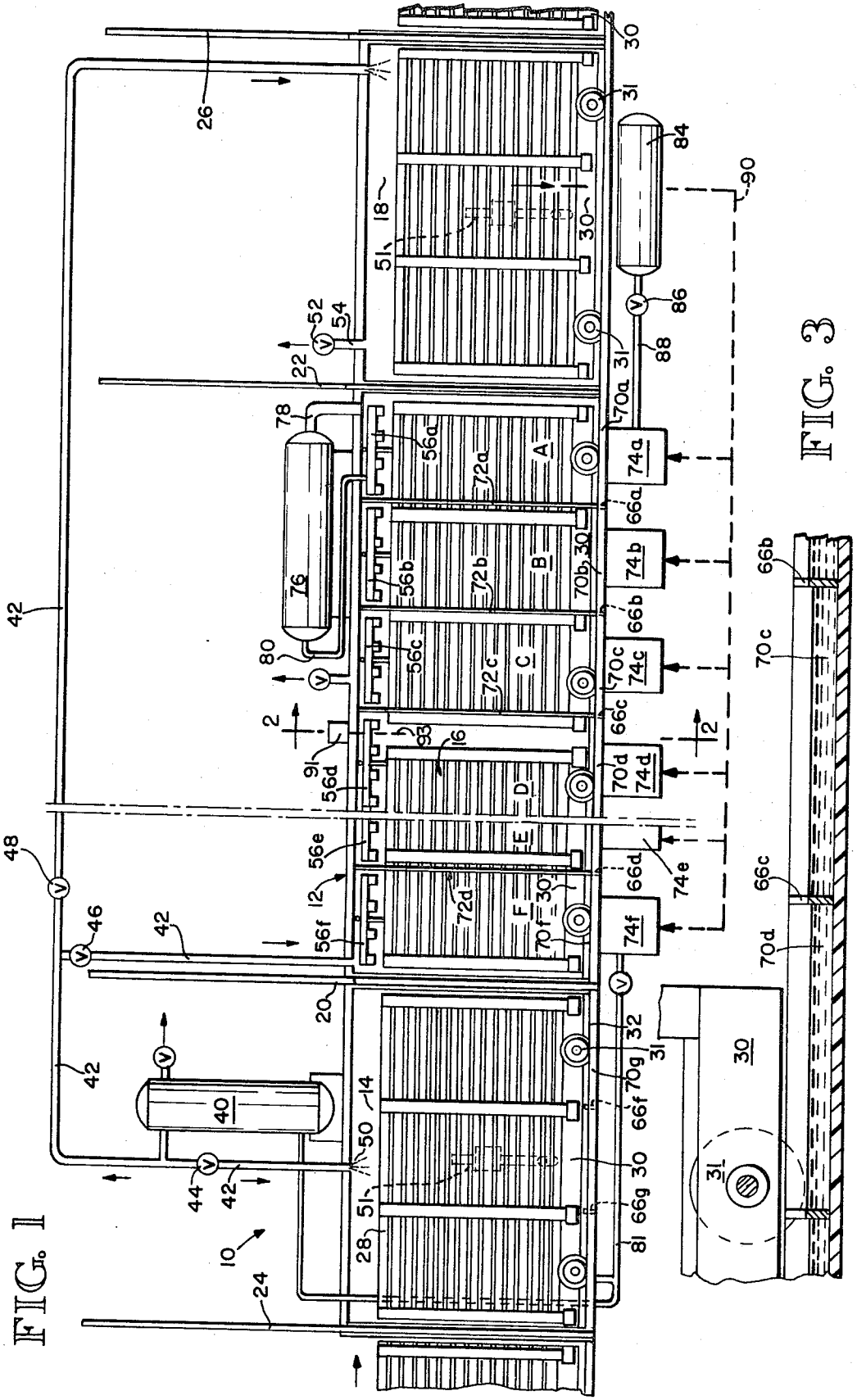

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FIG. 1

FIG. 3

FIG. 2

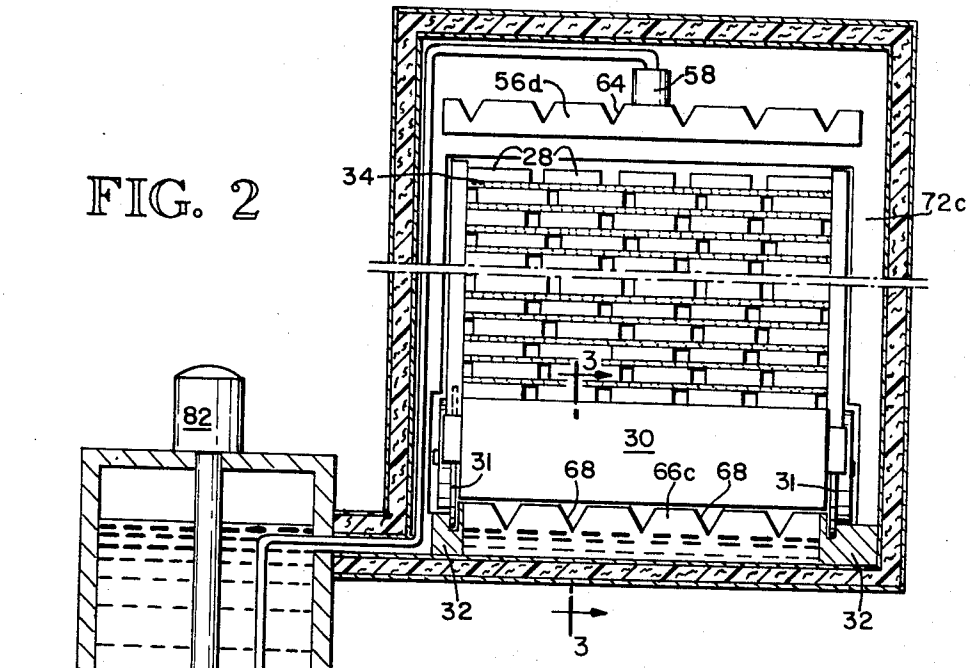
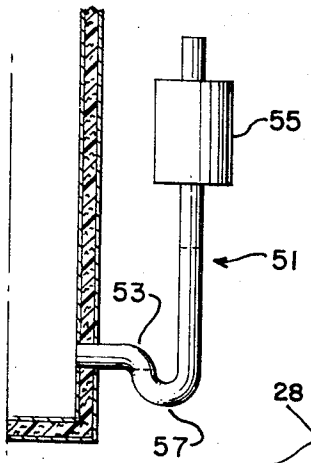


FIG. 6



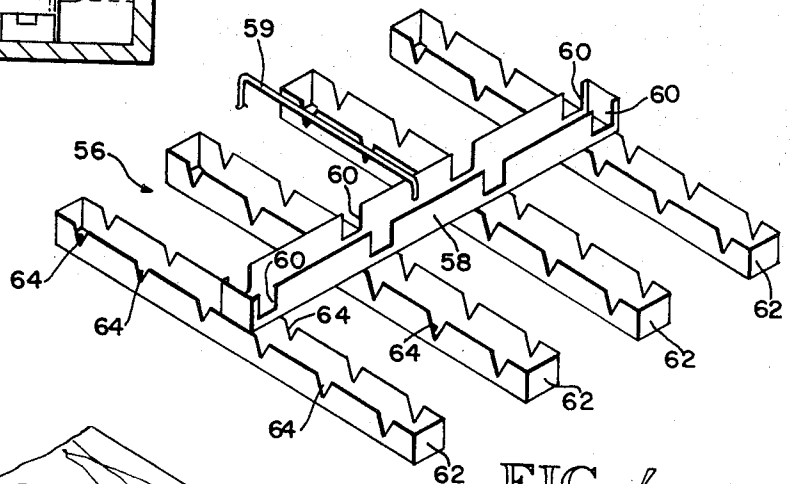


FIG. 4

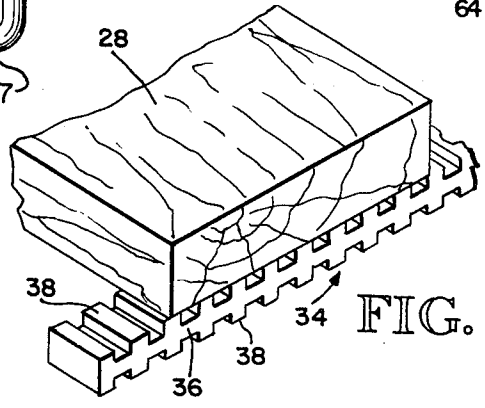


FIG. 5

METHOD AND APPARATUS FOR DRYING LUMBER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, in general, to a method and apparatus for drying lumber, and in particular, to a method and apparatus for drying lumber rapidly by solvent extraction without a separate solvent distillation unit.

2. Description of the Prior Art

In general, it is known that lumber may be dried by heating it in an immiscible solvent maintained at a temperature above the boiling point of water until all the water within the lumber boils off. It is also known that when wet wood is placed in continuous contact with a solvent which is miscible with water, the solvent will remove the water from the wood even if the solvent is used cold or at any other temperature below the boiling point of water. Alcohol is a common example of such a solvent and this principle has long been used in the seasoning and treating of green wood.

While the use of solvent to extract moisture from lumber is known per se, most prior processes have submerged the wood to be dried in a series of tanks containing solvent. The solvent is circulated through the tanks until the moisture content of the wood has been reduced to a desired level and the wood is then removed from the tanks and the solvent stripped therefrom by conventional means. The solvent-water liquid mixture remaining in the tanks is passed through a conventional distillation column where water is separated from the solvent and the dry solvent returned to the tanks. The construction cost of a conventional distillation column is substantial, and this factor has generally prevented commercial acceptance of these processes.

One known method of drying lumber developed by the Western Pine Association comprises the steps of standing lumber on end in a closed drying chamber and continuously wetting the lumber with hot acetone until the desired water removal is accomplished. The acetone, containing both water and the pitch from the wood, is continuously drained from the extractor and recirculated through a storage tank and heater back to the spray head. When the water contant of the mixture becomes too great, some of the mixture is drawn off from the storage tank and distilled to separate the water and the extractives and to recover pure acetone. After the spray is shut off, heated air is passed over the lumber to complete drying and remove the acetone. Finally, an inert gas is introduced into the extractor to reduce the fire hazard and increase acetone recovery. Again the need for a separate distillation column has limited commercial acceptance of this process.

U.S. Pat. No. 2,860,070 discloses a wood drying process employing the commercial dry cleaning solvent perchloroethylene. The wood is placed horizontally in a closed chamber and submerged in the solvent which is then heated until an azeotropic mixture of water and the solvent boil off. Vapors are collected in a condenser, separated, and the solvent returned to the closed chamber. Since the solvent is not miscible in water, the drying phenomenon is similar to known boiling-in-oil processes, such as that disclosed in U.S. Pat. No. 3,205,589 for example.

One problem to which the instant invention has particular application is that of drying redwood timber.

Most redwood lumber must be dried to a moisture contant of between 8 percent and 10 percent prior to its final utilization, and since redwood is a slow drying species, requiring the longest drying time of any commercial soft wood species, this represents a major problem in the industry. A good discussion of some of the problems involved in the drying of redwood is found in U.S. Pat. No. 3,309,778 which discloses a method of drying redwood including freezing the wood prior to drying.

A method of solvent drying redwood using methanol has been described in an article titled "Solvent Drying of California Redwood," published at pp 297 et seq. of the July, 1965 issue of *Forest Products Journal*. In the described process, lumber to be dried was inserted in a closed extractor and methanol was distributed over each board. Periodically a portion of solvent mixture in the extractor was removed and distilled and fresh solvent added. When a desired moisture content of the lumber was reached, the solvent was drained from the extractor and the solvent removed from the lumber by air circulation and steaming. Again, this process requires relatively expensive separate distillation equipment to purify the methanol, while disclosing a vapor sealed chamber which is costly to construct and cannot be loaded or unloaded with lumber without shutting down the drying process or risking a serious explosion.

BRIEF SUMMARY OF THE INVENTION

The instant invention relates to a method of drying lumber by solvent extraction, including passing the lumber through a drying chamber wherein a liquid mixture of solvent and water containing progressively lesser amounts of water and greater amounts of solvent is sprayed over the lumber as it passes there-through such that the solvent replaces water within the lumber. The liquid mixture flows from the dry wood exit end of the chamber toward the wet wood entrance end. Simultaneously, steam enters the drying chamber at its wet wood entrance end and moves through the chamber causing solvent in the liquid mixture to vaporize. At the dry wood exit end of the chamber, the vapor phase, which has a high solvent content, is condensed and the condensate employed to again wet the stacked lumber. The solvent is thus continually distilled within the wood drying chamber itself. When the solvent has replaced a desired amount of the water within the lumber, the lumber is heated by steam to drive off the solvent, thus producing substantially dry lumber.

One apparatus for drying lumber in the disclosed manner includes an elongated chamber having a first compartment wherein the lumber to be dried is steamed, a longitudinally spaced second compartment wherein the lumber is wet by a liquid mixture of solvent and water in the presence of steam such that the solvent replaces the water in the lumber, and a longitudinally spaced third chamber wherein the solvent which has replaced the water in the lumber is removed by heating. Each of the compartments include end positioned sealable doors so that lumber may be moved through the elongate chamber while maintaining relatively constant conditions within the second wood drying compartment while further minimizing the entrance of air into the wood drying compartment or the escape of vapor from the wood drying compartment to the air to reduce the hazard of explosion. The second compartment includes a pluraity of solvent distribution

means spaced along its top portion to distribute solvent over the lumber to be dried. Basins are arranged below each solvent distributor to catch liquid runoff from the lumber, and these basins are arranged so that liquid flows from basin to basin from the dry wood exit end of the second compartment toward the entrance end of the elongate chamber and thence to a reboiler. The solvent-water mixture employed to wet the lumber is continually maintained at its boiling point and sumps are associated with each basin so that the solvent-water mixture is recirculated to the overhead sitributor.

It is an object of the present invention, therefore, to provide a method and apparatus for drying lumber by solvent extraction which does not require the construction of a separate distillation column to purify the solvent.

Another object of the present invention is to provide a method and apparatus for solvent drying lumber wherein the solvent is continually distilled within the drying chamber itself.

Still another object of the present invention is to provide a method and apparatus for drying lumber including a single elongate chamber through which lumber may be moved for drying.

One more object is to provide apparatus for drying lumber which may be easily automated thus reducing operational manpower requirements.

Still another object is to provide apparatus for drying lumber by solvent extraction which requires the use of a relatively small amount of solvent at any one time as compared with known immersion techniques.

One more object is to provide a method and apparatus for drying lumber using methanol as a solvent which is safe from fire and explosion.

Still another object is to provide a method and apparatus for drying all types of lumber, but which is particularly useful for drying difficult to dry woods such as redwood.

One more object is to provide an apparatus for drying lumber which is in effect a packed distillation column lying on its side wherein the wood to be dried functions as the packing for the column.

Another object is to provide a method and apparatus for rapidly during lumber which produces high quality dried lumber.

Other and additional advantages will be apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of a typical lumber drying apparatus made according to the instant invention.

FIG. 2 is a section taken along line 2—2 of FIG. 1.

FIG. 3 is a section view taken along line 3—3 of FIG. 2.

FIG. 4 is a perspective view of a typical solvent distribution apparatus useful in the instant invention.

FIG. 5 is a partial perspective view of a typical spacer used to hold pieces of lumber to be dried at a distance from each other.

FIG. 6 is a partial side elevation view of a typical air vent for use in the end compartments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring initially to FIG. 1, an apparatus indicated generally by the index number 10 for drying lumber by solvent extraction and made according to the teachings of the instnt invention is disclosed. As shown, apparatus 10 includes an elongate chamber 12 comprising a first compartment 14, a second compartment 16, and a third compartment 18 separated from each other by sealable doors 20 and 22 which, as shown, are movable vertically in tracks to allow the second compartment to be sealed with respect to the first and third longitudinally spaced compartments in elongate chamber 12. Overhead sealable doors 24 and 26 are shown similarly mounted on the entrance and exit ends of elongate chamber 12 to allow the first and third compartments to be sealed with respect to the atmosphere. Seals of varying types, including inflatable seals which employ controlled air pressure to expand the seal, may be mounted on all of the doors to reduce degradation of the temperature and vapor conditions within the apparatus during lumber drying.

Pieces of wet lumber 28 to be dried are stacked on a conveying apparatus such as cart 30 including pairs of wheels 31 which run on tracks 32 which extend longitudinally through chamber 12. Carts 30 are preferably constructed of wood, stainless steel, or some other material which will not be damaged by prolonged contact with the solvent and solvent laden vapor within the drying chamber. In one embodiment of the instant wood drying apparatus, carts 30 may be 20 feet long, 4 feet wide and have side supports 8 feet high, while chamber 12 is approximately 120 feet long but of similar cross-section such that six carts loaded with lumber may be within the chamber at one time. Chamber dimensions, including its length, may be varied depending on the volume and average condition of lumber to be treated, for instance the chamber may be constructed 20 feet wide such that lumber carts having 20 foot long pieces of lumber stacked crosswise thereon may be moved through the chamber in a high volume operation. Treatment time within the chamber for each cart load of lumber may vary between 3 and 6 days depending on the type and condition of the lumber treated and other known factors. If longer drying times are needed for very wet wood, the chamber may be lengthened thereby increasing the length of time the wood is treated therein.

Chamber 12 may be laid horizontally in a horseshoe or circular shape depending on space requirements and it is also contemplated that the chamber could be disposed vertically, thereby eliminating the need for the plurality of solvent pumps described hereafter with reference to the horizontal unit, but requiring elevator apparatus capable of lifting the wood to be dried therethrough. Forms of conventional horizontal conveying apparatus other than that illustrated, may be used with the apparatus disclosed in FIG. 1, including continuous belt conveyors, for example. While a motive apparatus for the carts 30 has not been illustrated, it will be understood that they may be moved through elongate structure 12 by any conventional means such as a continuous tugger chain or cable or the like.

FIG. 5 illustrates one type of spacer 34 positionable between the pieces of lumber 28 as they are stacked on carts 30 to maintain vapor circulation gaps therebetween. Spacer 34 may include a central spine portion 36 and oppositely disposed space ribs 38 as shown, or any other similarly functioning shape. In the illustrated embodiment, spacer 34 may be ½ inch high, 1½ inches

wide and 48 inches long such that when it is positioned transverse cart **30** it substantially spans the width of the cart. As will be more completely described hereafter, heated vapor travels longitudinally through the spaces between the stacked lumber from the wet wood input end of compartment **16** toward the dry wood exit end of the compartment to assist in solvent wetting of all surfaces of the stacked lumber. It will be understood that the lumber is stacked on the carts such that the treating liquid may flow over and around all sides of each piece.

In one mode of operation, compartment **16** is filled with four carts **30** of lumber stacked with spacers **34** between individual pieces while compartment **18** houses a single cart load of lumber. Initially, doors **20, 22** and **26** are closed and sealed while door **24** is opened to allow a cart of wet lumber to be moved into the compartment **14** to the position shown in FIG. **1.** Reboiler or steam generator **40** of a conventional type operates slightly over atmospheric pressure and is interconnected by means of steam carrying conduits **42** to each of the compartments **14, 16** and **18.** Steam may be directed to one or more of the compartments as desired during operation by opening or closing valves mounted along the conduits **42.** For example, with doors **20, 22** and **26** sealed and door **24** opened, valve **44** is closed while valves **46** and **48** are opened such that steam is directed from reboiler **40** to both of the compartments **16** and **18.** When the wet stacked lumber is moved into compartment **14,** door **24** is closed and sealed, door **20** raised, and valve **46** closed while valve **44** is opened to direct steam directly into compartment **14** through orifice **50.**

Air vent **51** is shown in FIG. **1** mounted on the side of compartment **14** and is more completely disclosed in FIG. **6.** As steam enters the top of chamber **14,** the cold air therein is pushed out tube **53** near the bottom of the compartment. When the cold air has been substantially exhausted from the compartment and steam begins to be forced out pipe **53,** the steam is condensed in condenser **55,** filling the neck **57** of tube **53** until the differential pressure is sufficient to stop the flow of steam therethrough. A similar air vent **51** is also shown in FIG. **1** to be mounted on compartment **18** to operate in a similar manner when cold air is driven therefrom afte the closing of door **26.**

As described more completely hereafter, the steam overflows compartment **14** into compartment **16** and moves between the lumber stacked on the carts therein toward the dry wood exit end of the compartment at door **22.** As the steam moves through compartment **16** it is progressively cooled by contact with boiling solvent wetting the lumber. The steam or vapor phase, as it is more properly called, takes on a progressively greater vaporized solvent content as it moves toward the dry wood exit end of compartment **16,** while the solvent or liquid phase flowing from the dry wood end of the compartment toward the wet wood entrance end takes on a progrssively grater water content. Further, as the solvent flows toward the wet wood entrance end of compartment **16,** it encounters a vapor phase having a progressively higher temperature such that progressively greater amounts of solvent are vaporized, which vaporized solvent, as mentioned above, is driven toward the dry wood wxit end of the compartment. In this manner it will be understood that the compartment **16** continually distills the solvent employed to replace the water within the lumber, thus eliminating the need for the separate distillation column found generally in the prior art.

The steam entering compartment **14** is heated by reboiler **40** to approximately 212°, and the steam treatment of the cart load of wet lumber within chamber **14** performs the multiple function of cleaning the lumber of sawdust and dirt which may have accumulated thereon, raising its temperature to near 212°, and opening the pores of the wood thereby conditioning it for the subsequent portion of the drying treatment carried out in compartment **16.** In operation, all of the lumber carts within chamber **12** will be moved one cart position forward toward dry wood exit door **26** after a uniform time interval. The length of the time interval between movements in controlled by the solvent wetting operations carried on in compartment **16** wherein the moisture in the lumber is replaced by solvent such that a cart load of stacked lumber leaving compartment **16** will have reached a desired minimal moisture content prior to solvent stripping in compartment **18.**

At the expiration of one treating interval, valve **48** is closed and door **26** opened while door **22** remains sealed such that the cart of dried lumber within compartment **18** may be removed. The solvent removal process in compartment **18** may be controlled such that the lumber leaving chamber **12** has a water content of between 8 percent and 10 percent and a solvent content of approximately 2 percent. Door **26** is then closed and sealed and valve **48** opened to refill chamber **18** with steam. During refilling of compartment **18** with steam, valve **52** on exhaust pipe **54** extending from compartment **18** is initially opened to allow the air within the chamber **18** to be substantially exhausted, at which time valve **52** is closed. Door **22** is then opened and the five remaining carts of stacked lumber are moved forward one cart length such that a cart is positioned within compartment **18** while compartment **14** is emptied. Doors **20** and **22** are then closed, valve **46** opened, valve **44** closed, and door **24** raised to allow a new cart of wet lumber to be moved into the chamber as previously described. With the new cart load of wet lumber within chamber **14,** door **24** is closed, and valve **44** opened to allow steam to replace the air within chamber **14.** When a steam atmosphere and temperature of near 212°F. is obtained within compartment **14,** door **20** is opened and valve **46** closed thus producing the general treating arrangement wherein all doors but door **20** are closed and sealed and wherein steam is fed directly into compartments **14** and **18.**

Referring now to FIG. **2,** solvent distributing weir **56d** is shown mounted at the top of compartment **16** above the stacked lumber. It will be understood that compartment **16** includes a plurality of such weirs **56*a*—56*f*** similarly mounted and spaced longitudinally along the top portion of the compartment. FIG. **4** more completely discloses the construction of a typical distributing weir, including a first main distributing trough **58** into which solvent is fed through pipe **59** running from one of a plurality of sumps at the bottom of the compartment. Trough **58** includes a plurality of spaced openings **60** through which the solvent drains into a plurality of transversely oriented troughs **62** each of which include a number of spaced solvent distributing notches **64** through which solvent flows onto the stacked lumber therebelow. The size and trough and notch arrangement of weirs **56** may be varied to

achieve maximum spreading of the solvent over the lumber so that a substantial portion of the lumber is wet directly by the solvent, but direct wetting of all surfaces of the lumber is not necessary since the vapor phase composed of steam and solvent passing the unwetted lumber also tends to condense thereon thus wetting every exposed surface of the stacked lumber.

A conventional spray system comprising pipes having a plurality of spray nozzles positioned around the stacked lumber may be used in place of the illustrated weir trough distributors. However, since higher pumping pressures are required for spray nozzles, and sawdust or other particulate matter tends to plug the nozzles, spraying the boiling solvent presents economic and operational problems which need not be considered when using a weir trough distribution system of the type commonly used in packed distillation columns.

As is best ssen in FIG. **2**, a flow barrier or weir **66***c* including laterally spaced notches **68** is mounted on the bottom of compartments **16**. FIG. **1** discloses a plurality of weirs **66***a*–**66***g* spaced on the bottoms of compartments **14** and **16** to define catch basins **70** in which the liquid dripping from the stacked lumber is caught. The liquid fills the catch basins **70** to a depth regulated by the notches in weirs **66** and then overflows through the notches into the next adjacent basin toward the wet wood entrance end of the chamber. The flow from basin to basin may be induced by sloping the floor of the elongate chamber a slight amount such as 2 inches over the length of the entire chamber, or progressively lowering the bottoms of the notches **68** in the weirs all illustrated in FIG. **3**.

Again as seen in FIG. **2**, baffle **72***c* is positioned within compartment **16** above weir **66***c* such that it substantially fills the cross sectional area of compartment **16** except for an opening through which carts **30** and their loads of stacked lumber may be moved. FIG. **1** discloses that similarly shaped baffles **72***a*—**72***d* are positioned above each of the weirs in compartment **16** and are thus located between each of the longitudinally spaced weir rough distributors **56***a*—**56***f*. The baffles **72** snugly surrounds the carts and their loads of stacked lumber and thus prevent the rapid passage of the vapor phase from the wet wood end of compartment **16** to its dry wood end except through the longitudinal spaces between the individual pieces of the stacked lumber. In one embodiment, baffles **72** may be constructed of plastic strips stiffened with wire to allow a degree of flexibility should a baffle be contacted by one of the pieces of lumber stacked on a cart, however, it will be understood that a variety of other materials might also be satisfactorily used to accomplish a similar purpose.

The baffles define a series of subcompartments A–F within compartment **16**, each of which subcompartments includes a weir trough solvent distributor **56**, a catch basin **70** and a sump **74** including a pump **82** for pumping the solvent at its boiling temperature from the bottom of each subcompartment through pipe **59** to the weir trough distributor spaced thereabove. Sumps **74** may have a depth of from 2 to 3 feet to provide a positive head for pumps **82** thus allowing the solvent within the sump to be pumped at its boiling temperature to the weir trough distributor thereabove without having the boiling liquid flash to the vapor state. The recirculation rate of solvent should be such that the top surface of the stacked lumber is continuously flooded with the solvent running onto the pieces of lumber stacked therebelow. A seal-less immersible centrifugal pump of a type commercially available may be satisfactorily used to pump the boiling solvent. The sumps reduce the amount of solvent needed within the system as well as reducing the required weight of the entire drying chamber.

FIG. **2** illustrates one mode of constructing chamber **12** wherein an inner sheet metal wall is spaced from an outer surface of tar paper or the like by approximately three inches of fiberglas insulation. It will be understood that the sheet metal walls are appropriately stiffened to withstand the slight pressure head which may be developed within the chamber during operation. The floor of the chamber as well as the walls and ceiling thereof may be constructed in this manner to provide a well insulated but extremely inexpensive structure. Other like materials may also be substituted therefor within the scope of this invention.

Condenser **76**, which may be of any suitably sized commercially available type, is connected to a subchamber A located at the dry wood exit end of compartment **16** by means of conduit **78** through which the vapor phase which has been driven to this subcompartment is drawn off. Conduit **80** is illustrated returning the condensed vapor phase at a temperature near its boiling point to weir trough distributor **56***a*.

In operation of the disclosed apparatus to continuously dry lumber and using methanol as a solvent, steam at near 212°F. flows from reboiler **40** through orifice **50** into compartment **14**. As the steam fills compartment **14**, it overflows into compartment **16** where it moves between the spaced lumber mounted on the longitudinally aligned carts through the successive subcompartments F to A in chamber **16** toward the dry wood exit end thereof. Simultaneously, substantially pure methanol from condenser **76** is fed at near its boiling temperature of 148°F. to weir trough distributor **56***a*. The boiling solvent is distributed over and wets the stacked lumber within subchamber A, and then drains into basin **70***a* and associated sump **74***a* where it is pumped back to weir trough distributor **56***a*. When basin **70***a* is filled, the solvent flows through the notches in weir **66***a* into the next adjacent basin **70***b* where it is again circulated over the stacked lumber in subcompartment B. As the boiling solvent at near 148°F. runs over the stacked lumber in the presence of the vapor phase which has migrated through the subcompartments F-A from chamber **14**, the solvent tends to condense a portion of the higher temperature water vapor in the vapor phase thus causing the solvent to take on water as it flows toward the wet wood entrance end of compartment **16**. Simultaneously, the high temperature water vapor in the vapor phase vaporizes a portion of the boiling solvent threby causing the vapor phase to take on a progressively greater percentage of solvent as it moves toward subcompartment A where it is withdrawn and condensed. The vapor phase within each of the subchambers is a mixture of water and solvent at its boiling point tending toward heat and mass equilibrium, while the liquid phase employed to wet the stacked lumber in each of the subcompartments is a water and boiling liquid solvent mixture which is also tending toward heat and mass equilibrium. It will thus be understood that the entire drying chamber is designed to approach and be maintained at the boiling point of the phase mixture at any point therein.

For example, in subqompartment F at the wet wood entrance end of compartment **16**, the liquid and vapor phases may consist of over 98 percent water and less than 2 percent methanol, thus having a boiling point of approximately 205°F. On the other hand, the composition of the liquid and vapor phases in subcompartment A at the dry wood exit end of compartment **16**, may consist of over 95 percent methanol and less than 5 percent water, for example, and thus have a boiling point of approximately 149°F. Subcompartments E through B are filled with liquid-vapor phases having progressively greater proportions of methanol and lesser proportions of water at progressively lower temperatures running between the 195°F. temperature in subchamber F progressively downward to the 149°F. temperature in subchamber A. As the lumber is moved toward the dry wood exit end of compartment **16**, the progressively more concentrated solvent liquid and vapor phases encountered cause the solvent to progressively replace a greater portion of the water within the lumber, until when the stacked lumber is ready for removal into compartment **18**, substantially all of the water in the lumber has been replaced by methanol. It will be understood that in this process, water is removed from the lumber as a liquid, not a vapor, thus further adding to the water content of the liquid phase within compartment **16** as it flows toward the wet wood entrance end thereof.

It has been calculated that in order to obtain a moisture content blow 10 percent after solvent stripping in compartment **18**, the methanol returned to compartment **16** by the condenser **76** should be 98 percent by wt. methanol. This may be accomplished by maintaining the amount of methanol in the system high enough to produce this purity level. The length of compartment **16** is important in this context, because if the compartment is too short the concentration of the liquid mixture pumped to the reboiler may exceed the relatively low methanol level necessary for economic operation, i.e., for minimal methanol loss in the reboiler. It is estimated that ideally the concentration should be less than 0.2 percent by wt. methanol, but higher methanol concentrations could be tolerated and still maintain economic operation. The effect of a short chamber may be partly overcome by increasing the amount of steam pumped from the reboiler to compartment **14**, although this would also increase operating cost to some extent as well as increasing the reflux ratio, overflow/product, of compartment **16**. Ideally, it is estimated that the heat input to the reboiler should be such that four times as much methanol is condensed by the condenser **76** as is carried out to compartment **18** in the lumber. This ratio approximates the reflux ratio in a normal distillation column.

Since the methanol content of the liquid phase is quite small by the time it is drawn off from either sump **74***f* by condit **81** as illustrated in FIG. **1** or drawn off at the wet wood entrance end of compartment **14**, and pumped to reboiler **40**, the amount of methanol boiled off and lost is small. To make up for this solvent loss, and for the solvent carried out of the system by the dried lumber, solvent storage container **84** including valve **86** is interconnected with sump **74***a* by means of conduit **88**. Water soluble extractives from the wood, as well as liquid borne debris may be removed from the liquid by skimming or a like process in the reboiler. Chemicals extracted from the lumber by the methanol may be topped off at any desired point within compartment **16** if desired or they may be allowed to remain within the system. If not removed, the methanol extractives are washed into the basins **70** and carried toward the wet wood entrance end of the compartment with the liquid phase. As the water content of the liquid phase increases, the chamical extractives precipitate out of the liquid phase and are either again deposited on the lumber where they are carried with the lumber toward the dry wood exit end of the compartment or carried in the liquid phase to the reboiler where they may be skimmed. Non-condensibles carried by the vapor phase to the condenser **76** may be vented to the atmosphere.

A thermocouple **91** having a sensor **93** within compartment **16** is illustrated to show one means for monitoring the temperature within the wood drying chamber during operation. It will be understood that similar temperature sensing devices could also be positioned within each of the subcompartments of compartment **16**. Means may also be provided at intervals within the chamber **12** to allow the specific gravity of the liquid phase to be measured. Variations in specific gravity may be related to the rate of water removal from the lumber within the chamber and this information is useful for determining the length of treatment times.

When a cart load of stacked lumber has moved through compartment **16** and substantially all of the water therein has been removed and replaced by solvent, the cart is moved into compartment **18** in the manner described heretofore. The stacked lumber is steamed in this compartment to remove the solvent from the lumber, thus leaving the lumber with a desired water content which may be between 8 percent and 10 percent, for example. The dried lumber may then be removed from the elongate chamber.

During the steaming operation in compartment **18**, it will be understood that the solvent driven off of the wood mixes with the steam to create a mixture composed of varying proportions of solvent and water during different stages of the solvent removal. A pump and conduit system illustrated by dotted line **90** and having interconnections with the various subcompartments A-F in compartment **16** may be used to direct the mixture removed from chamber **18** to a subcompartment having a like mixture of solvent and water. In this manner, the heat in compartment **18** may be reused rather than merely exhausted to the atmosphere thereby improving oprerating efficiency. A monitoring and valve switching system may be used to measure ths solvent content of the mixture withdrawn from chamber **18** and direct it to the appropriate subchamber A-F.

The disclosed apparatus, is thus useful for carrying out a method of drying lumber wherein stacked lumber is first heated by steam and then treated with boiling solvent-water mixtures having progressively greater solvent contents in the presence of a similarly constituted vapor such that the water within the lumber is progressively replaced by solvent. Simultaneously with this treatment, and within the treating chamber, the solvent is continually distilled thereby eliminating the need for a separate distilling column. When substantially all of the water within the lumber has been replaced by solvent, the lumber is stripped of solvent by steaming to produce substantially dry lumber in a relatively short time.

The invention may be embodied in other specific forms without departing from the spirit or central characteristics thereof. The present embodiments are 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 to be embraced therein.

What is claimed is:

1. A method of drying lumber of solvent extraction comprising the steps of:
conveying said lumber within a substantially closed chamber;
wetting said lumber with a boiling liquid mixture of solvent and water in the presence of a vapor mixture of solvent and water such that said solvent replaces a portion of the water in said lumber;
progressively increasing the solvent content in said liquid and vapor mixtures to replace substantially all of the water in said lumber; and
stripping said lumber to remove the solvent therein to produce substantially dry lumber.

2. The method of claim 1 including the step of simultenaeously distilling said solvent within said closed chamber.

3. A method of drying wet lumber by solvent extraction comprising the steps of:
steaming said lumber to raise its temperature to near the boiling point of water;
wetting said lumber with a boiling liquid mixture of water and a minor amount of solvent in the presence of a vapor mixture of water and solvent to cause said solvent to replace a minor portion of the water in said lumber;
progressively increasing the amount of solvent in said liquid and vapor mixtures till said solvent comprises a major portion of said mixtures while maintaining said liquid mixture at its boiling point to cause said solvent to replace a major portion of the water in said lumber; and
heating said lumber to raise its temperature above the boiling point of said solvent to clean said lumber.

4. A method of drying stacked wet lumber in a methanol distillation column having a relatively cold end wherein liquid methanol at its boiling temperature enters said column and a hot end wherein steam enters said column, including the steps of:
conveying said stacked lumber into the hot end of said distillation column such that said lumber substantially fills the cross sectional area of said column and acts as the packing therefor;
steaming said lumber;
wetting the surface areas of said stacked lumber with a boiling liquid mixture of water and a small amount of methanol in the presence of said steam to replace a small portion of the water in said wood with methanol;
moving said stacked lumber progressively from said hot end toward said cold end of said distillation column while continually wetting said lumber with a boiling liquid mixture of water and methanol in the presence of a steam and methanol vapor mixture;
increasing the methanol content of said lumber wetting mixtures as said lumber moves toward said cold end of said column to replace substantially all of the water in said wood with methanol; and
removing said stacked lumber from the relatively solc end of said distillation column and stripping the methanol from said lumber to produce substantially dry lumber.

5. The method of claim 4 including the step of distilling said methanol within said column as said stacked lumber moves toward the relatively cold end of said column.

6. The method of claim 4 including the step of withdrawing and condensing the vapor mixture from the cold end of said column to produce substantially pure methanol.

7. A method of drying wet lumber by solvent extraction comprising the steps of:
moving said wet lumber into a first end of a sealable longitudinal chamber and sealing said chamber;
directing steam into said chamber at its first end such that said stem surrounds said lumber and migrates toward the second end of said chamber;
directing a boiling liquid solvent having a boiling point below 212°F. into said chamber at its second end in a manner such that said solvent wets said lumber and is prgressively distilled by contact with said steam as it flows toward said first end;
progressively moving said lumber from said first end toward said second end to allow said solvent to replace the water within said lumber; and
steaming said lumber to strip substantially all of said solvent therefrom to produce substantially dry lumber.

8. The method of drying wet lumber of claim 7 including the steps of:
withdrawing liquid from the first end of said longitudinal chamber;
reboiling said liquid to produce steam; and
directing said steam into said first end of said chamber.

9. The method of drying wet lumber of claim 7 including the steps of:
withdrawing vapor from the second end of said longitudinal chamber;
condensing said vapor to produce substantially pure, boiling solvent; and
directing said boiling solvent into the second end of said chamber.

10. The method of drying lumber of claim 9 including the step of adding additional solvent to said boiling solvent leaving said condenser to make up for solvent losses.

11. The method of claim 7 including the steps of periodically monitoring the water content of said lumber as it moves through said longitudinal chamber.

12. Apparatus for drying stacked pieces of wet lumber by solvent extraction including:
a sealable elongate chamber having a first wet lumber entrance end and a second dry lumber exit end;
means conveying lumber through said chamber from said entrance end to said exit end;
boiler means directing steam into said chamber at said entrance end such that it moves toward said exit end;
means directing solvent into said chamber at its exit end such that it flows toward said entrance end;
means spaced along said elongate chamber wetting said lumber with said solvent in the presence of

said steam such that said solvent replaces water within said lumber as said lumber moves toward said exit end; and

means stripping said lumber to remove said solvent therefrom to produce substantially dry lumber.

13. The apparatus of claim **12** wherein said elongate chamber includes baffle means spaced therealong to snugly surround said lumber such that said steam moves from said entrance end toward said exit end between said stacked pieces of lumber.

14. The apparatus of claim **13** including spacer means inserted between said pieces of stacked lumber to form passageways through which said steam travels from said entrance end to said exit end of said chamber.

15. The apparatus of claim **12** wherein said elongate chamber includes substantially airtight outer doors at said entrance and exit ends and substantially airtight inner doors spaced from said outer doors to define heating compartments at each longitudinal end of said chamber.

16. The apparatus of claim **12** wherein said means wetting said lumber with solvent include solvent distribution means spacedly mounted along the top of said elongate chamber, a sump associated with each of said solvent distribution means and positioned therebelow to catch solvent running off said lumber; and, pump means associated with each of said sumps to recirculate solvent from said sump to said solvent distribution means thereabove.

17. The apparatus of claim **12** wherein the means directing solvent into the exit end of said chamber includes condenser means withdrawing solvent vapor from said chamber, condensing it to liquid and returning said liquid solvent to said chamber.

18. Apparatus for drying stacked lumber by solvent extraction including:

an elongate sealable chamber having a cross-section sized to closely surround stacked lumber positioned therein;

stacked lumber conveying means within said elongate chamber moving said lumber from the entrance end of said chamber to its exit end;

a first compartment within said elongate chamber positioned adjacent said entrance end;

means steaming said stacked lumber within said first compartment;

a second compartment within said elongate chamber adjacent said first compartment wherein said stacked lumber is wet by progressively stronger boiling liquid mixtures of solvent and water in the presence of like proportioned vapor mixtures of solvent and water such that said solvent replaces water within said lumber; and

a third compartment adjacent said exit end of said chamber wherein said stacked lumber is heated to drive off the solvent within said lumber to produce substantially dry lumber.

19. The apparatus of claim **18** including means holding said stacked pieces of lumber at a spaced distance from each other such that steam from first compartment flows between said pieces of stacked lumber through said second compartment toward said third compartment.

20. The apparatus of claim **18** including door means positioned at each end of said compartments such that each of said compartments may be separately sealed.

21. The apparatus of claim **18** wherein the means wetting said stacked lumber within said second compartment includes a plurality of weir trough distributors spacedly mounted along the top of said compartment; sump means positioned below each of said weir trough distributors to catch solvent runoff from said lumber; and pump means recirculating solvent from said sumps to said weir trough distributors.

22. The apparatus of claim **21** including baffle means surrounding said stacked lumber between each of said weir trough distributor means such that steam from said first compartment means flows toward the exit end of said second compartment means between said stacked lumber.

23. The apparatus of claim **22** including condenser means withdrawing vapor from adjacent the exit end of said second compartment and returning condensed liquid solvent to said weir trough distributor means adjacent said exit end.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,757,428 Dated September 11, 1973

Inventor(s) DONALD A. RUNCIMAN

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

In the Abstract, third line from the end, change "close" to -- closed --.
Column 1, line 45, change "contant" to -- content --.
Column 2, line 19, change "of" to -- in --.
Column 3, line 11, change "sitributor" to -- distributor --.
Column 5, line 46, change "afte" to -- after --; line 59, change "grater" to -- greater --; and, line 65, change "wxit" to -- exit --.
Column 6, line 16, change "in" to -- is --.
Column 7, line 41, change "rough" to -- trough --.
Column 9, line 1, change "subqompartment" to -- subcompartment --; and, line 30, change "blow" to -- below --.
Column 10, line 50, change "oprerating" to -- operating --.
Column 11, line 67, change "mixtures" to -- mixture --.
Column 12, line 3, change "solc" to -- cold --.
Column 14, line 17, before "first" insert -- said --.

Signed and sealed this 25th day of December 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

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