METHOD FOR DRYING A WET COATING ON A SURFACE

Original Filed Sept. 13, 1967 8 Sheets-Sheet 1

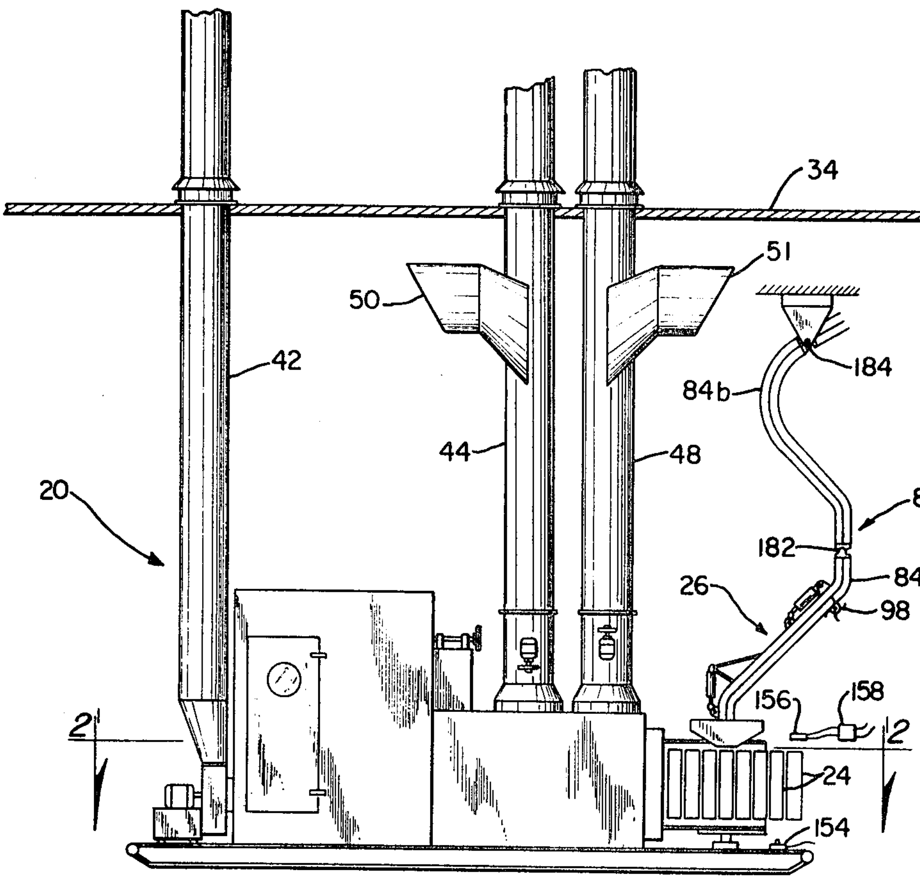

FIG. 1

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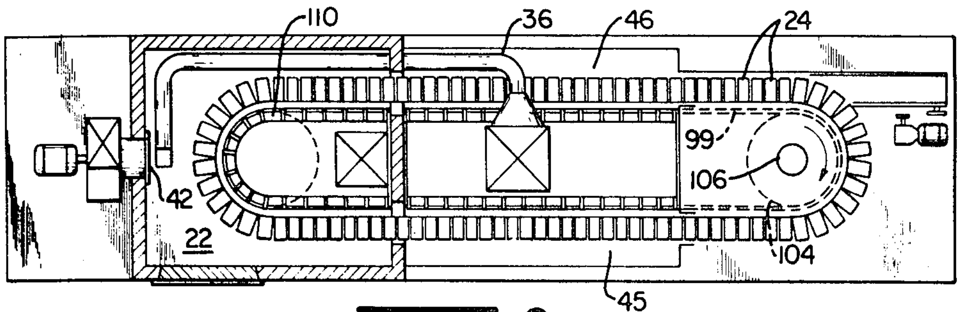

FIG. 2

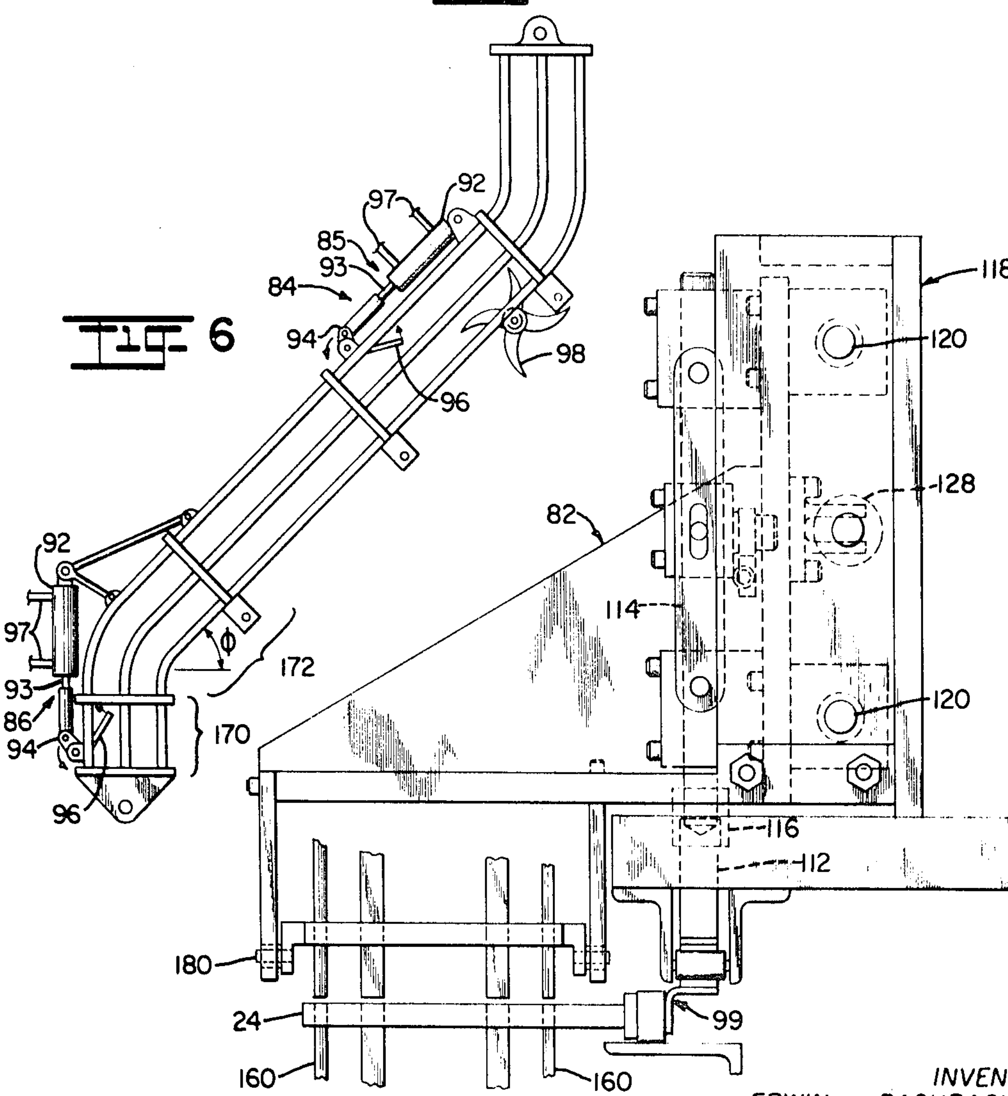

FIG. 6

FIG. 11

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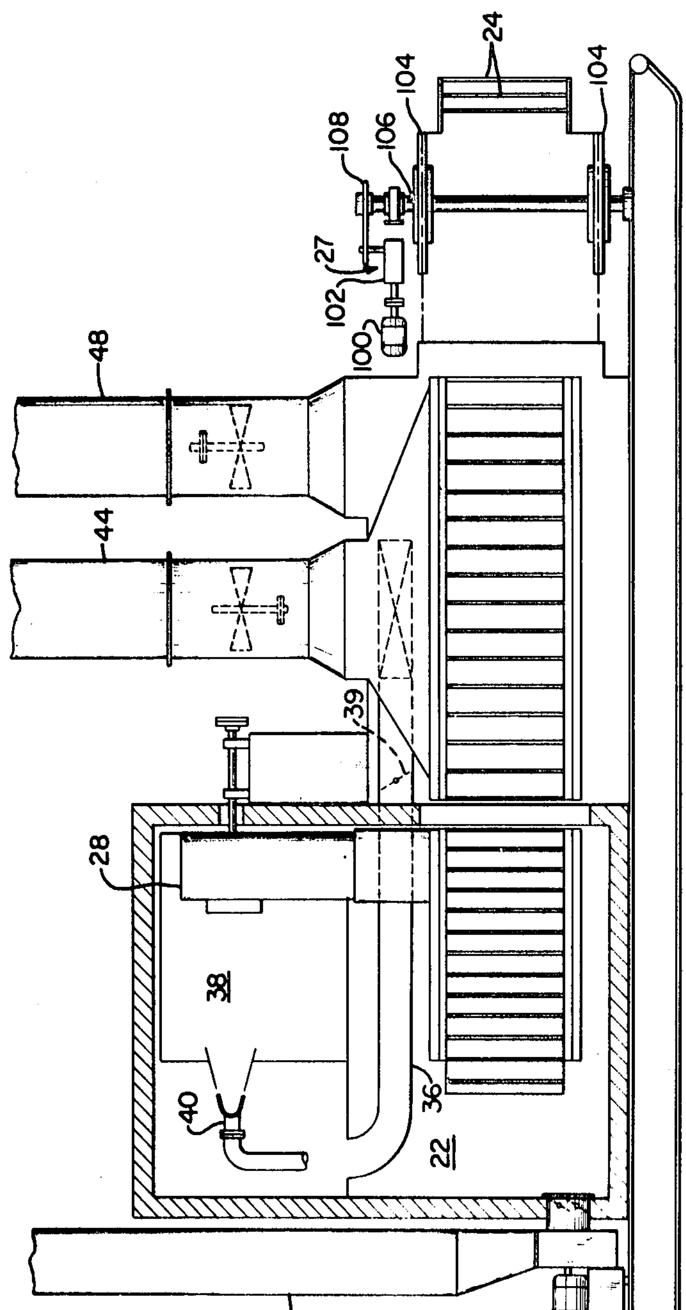

FIG. 3

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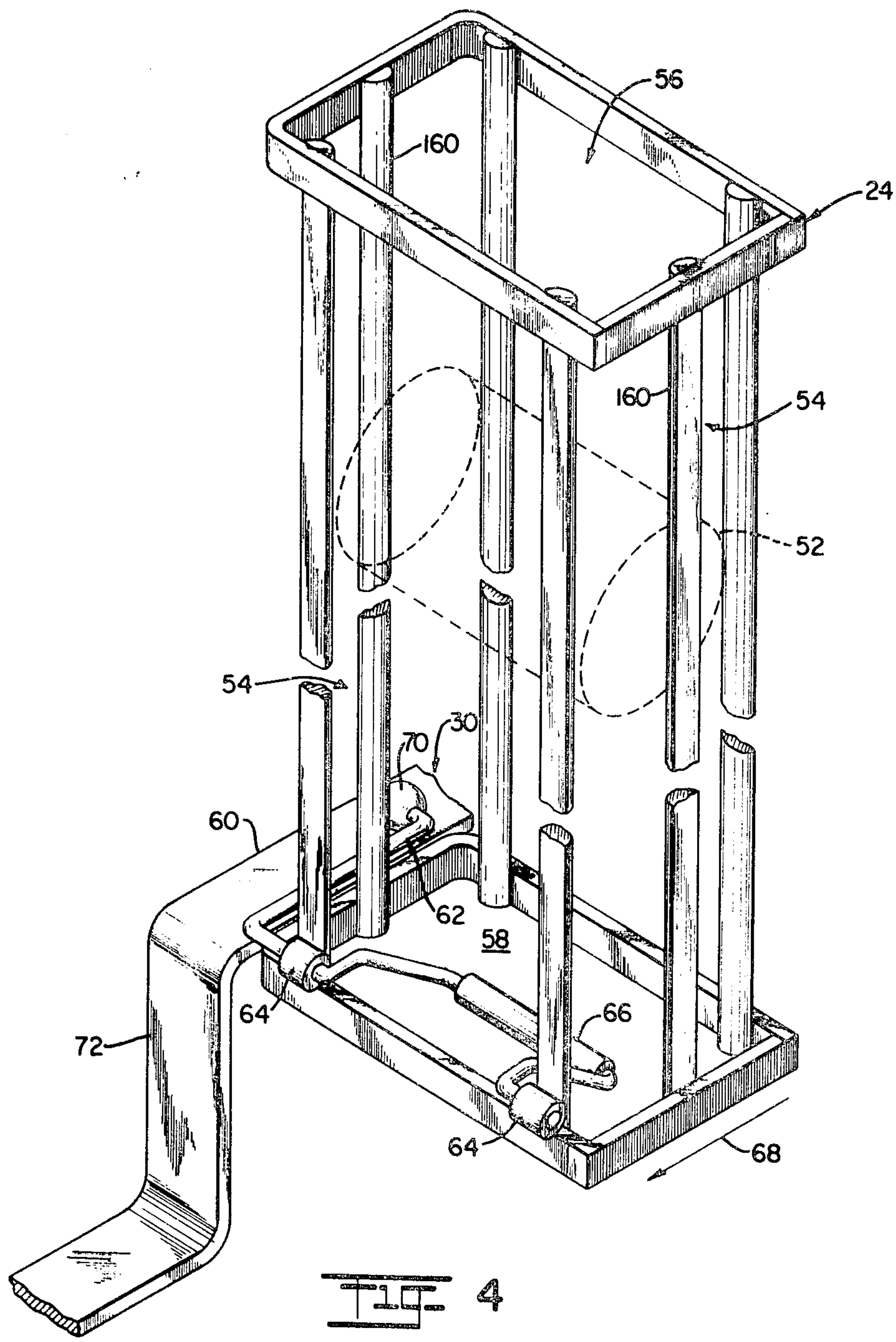

FIG. 4

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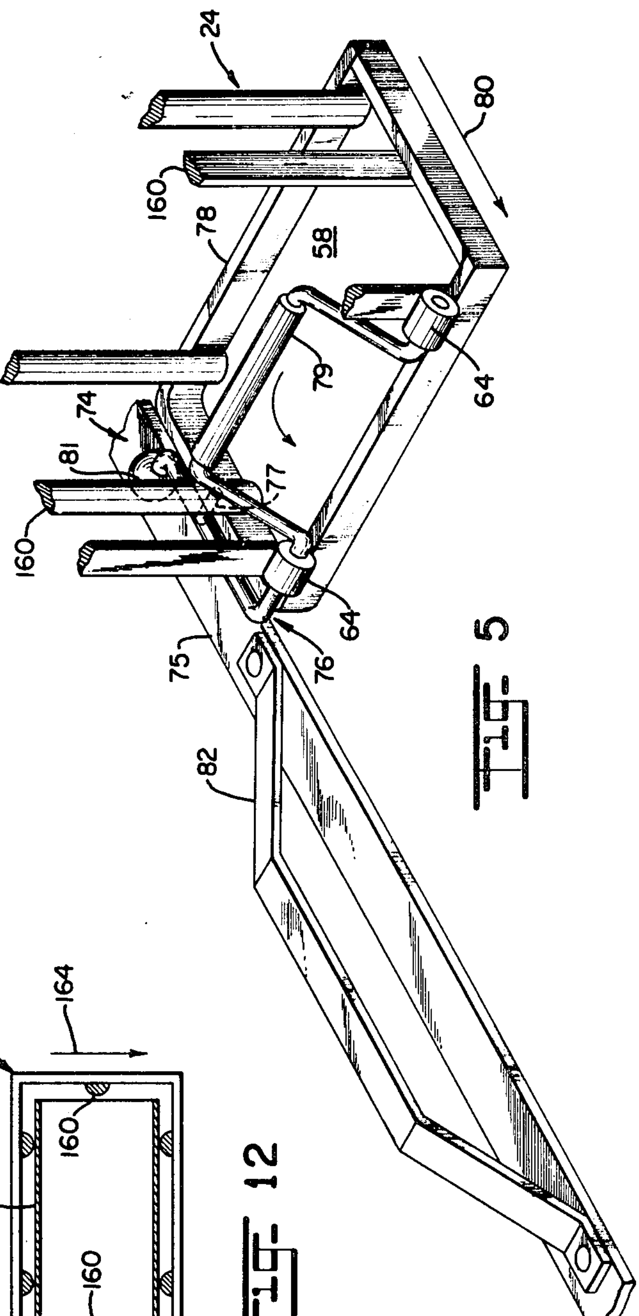

FIG. 5

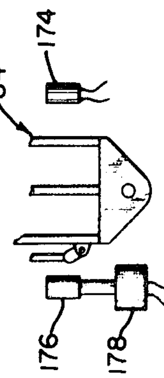

FIG. 13

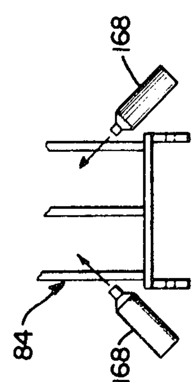

FIG. 8

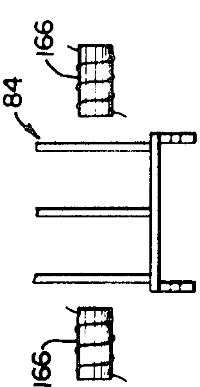

FIG. 7

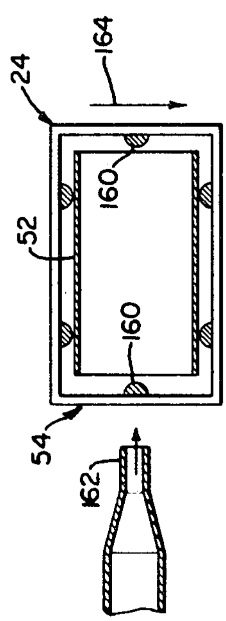

FIG. 12

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METHOD FOR DRYING A WET COATING ON A SURFACE

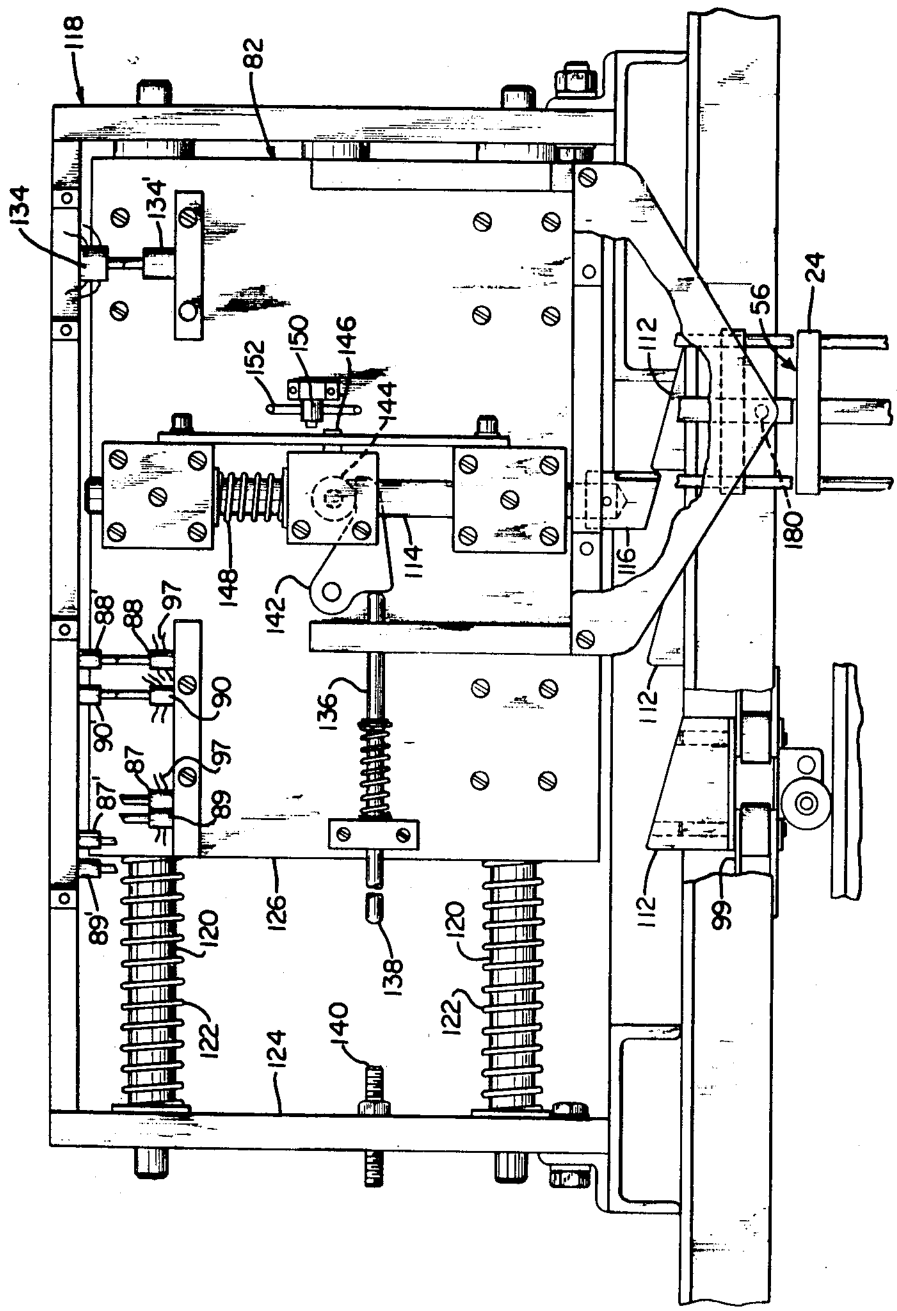

FIG. 9

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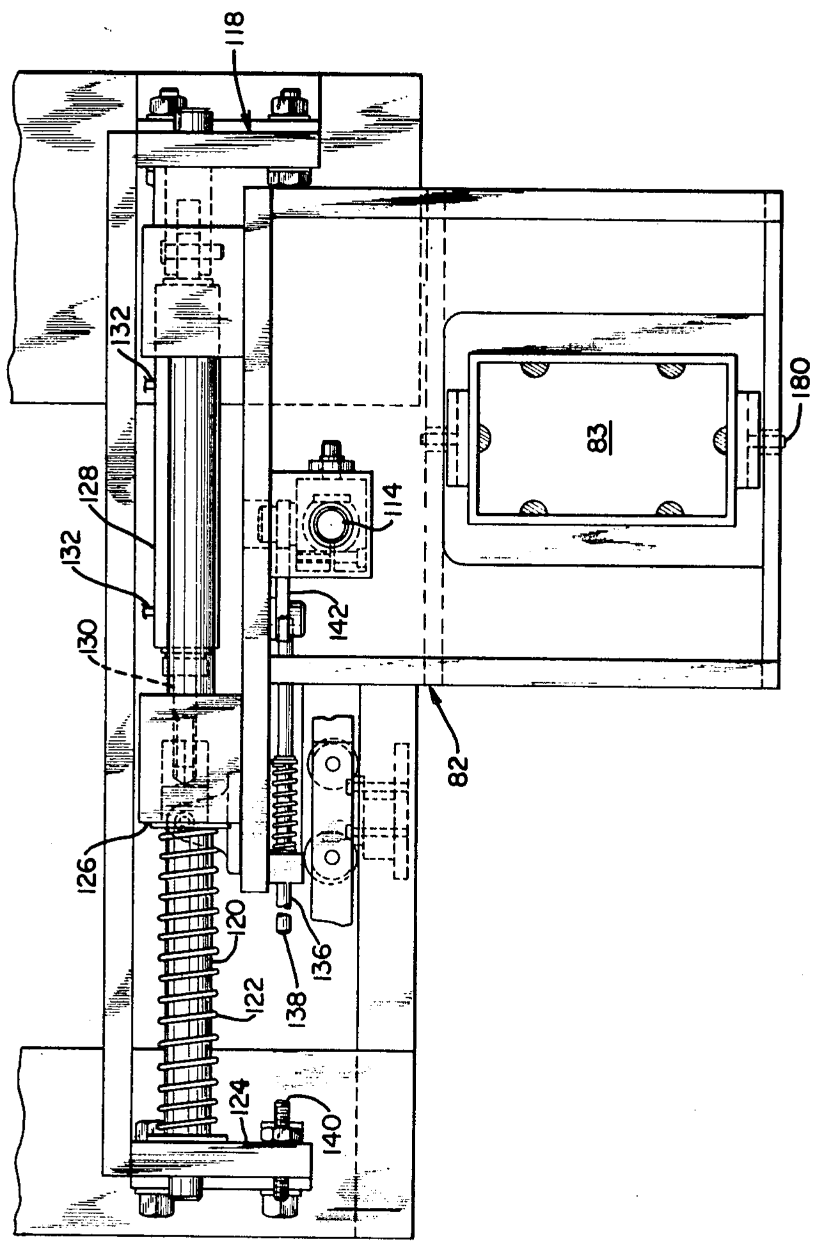

FIG. 10

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	SOLVENT LOSS		
	FROM SPAY TO APPARATUS IN ATMOSPHERE	THROUGH PRE-VENTILATION CHAMBER	THROUGH OVEN CHAMBER
ZONE LOSS %	77.25 %	15 %	7.5%
CUMUL. LOSS %	77.25 %	92.25 %	99.95 %

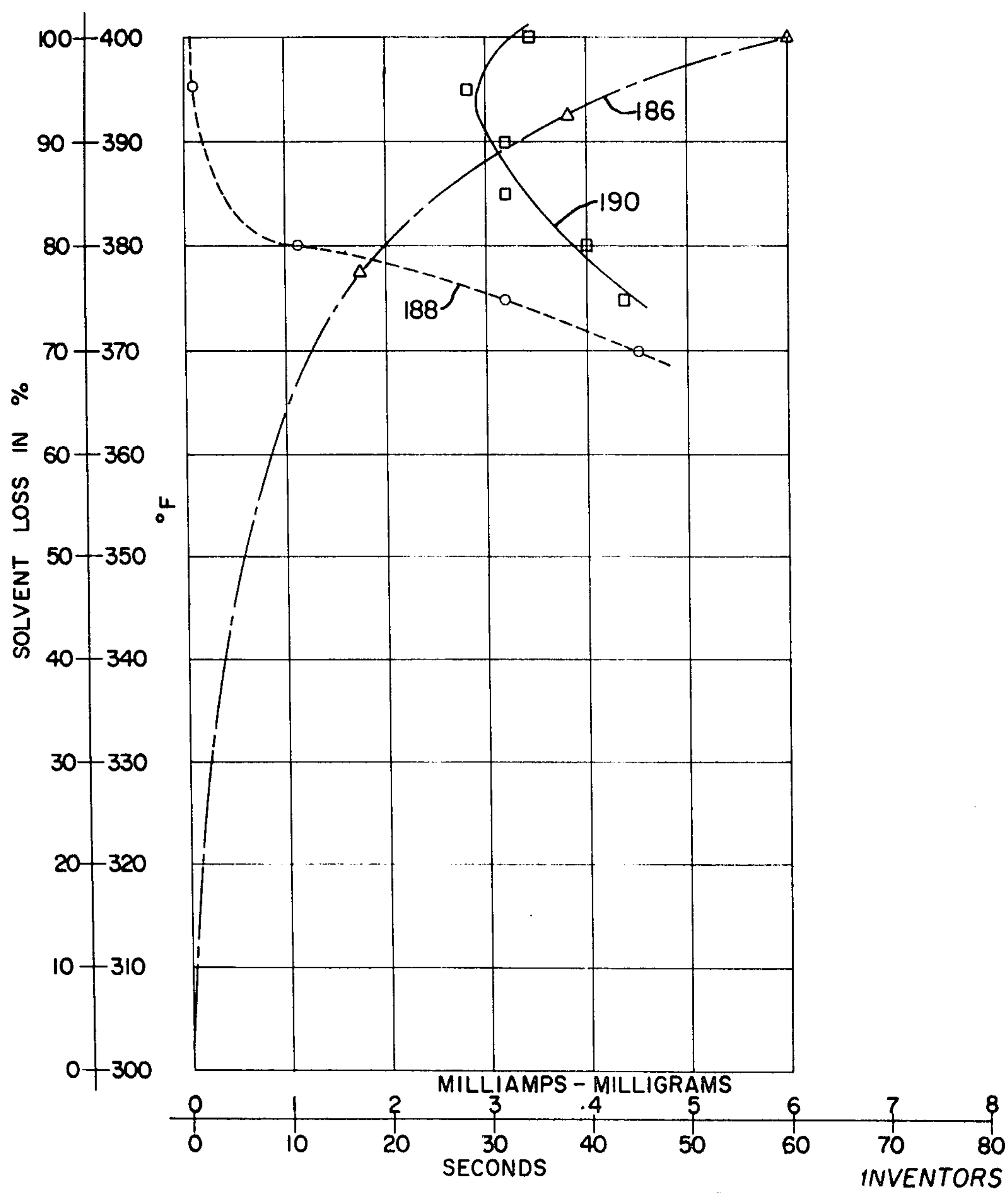

FIG. 14

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United States Patent Office

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Patented Oct. 5, 1971

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3,609,876
METHOD FOR DRYING A WET COATING ON A SURFACE

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Original application Sept. 13, 1967, Ser. No. 667,705, now Patent No. 3,438,138. Divided and this application Feb. 24, 1969, Ser. No. 844,679
Int. Cl. F26b 19/00
U.S. Cl. 34—17 9 Claims

ABSTRACT OF THE DISCLOSURE

A process of removing solvent from a wet coating on the inside surface of a can body, such as a beer can, characterized by conveying the can body through a zone of heated air and passing high velocity air through the can body to remove solvent driven to the surface, the rate of solvent removal being so controlled to prevent premature drying or crusting of the wet surface which might subsequently be ruptured by remaining solvent therebeneath driven toward the surface. The cans are continuously conveyed across stationary air stream delivery stations and, since the air streams are of relatively high velocity tending to move the cans, they are restrained against such movement away from predetermined positions of orientation in their path of travel. As compared with prior art methods, the drying is effected within a considerably smaller space and with reduced residence time in same.

This is a division of application Ser. No. 667,705, now Pat. No. 3,438,138, filed Sept. 13, 1967.

BACKGROUND OF THE INVENTION

Heretofore, many methods and apparatuses have been proposed for removing solvent from a wet coating deposited on a surface and curing the solute (which is normally a resin) contained within said coating. However, each of these methods and apparatuses have suffered from one or more disadvantages. For example, some of the methods and apparatuses involved entirely too much time and, thus, were quite inefficient. Other methods and apparatuses involved expensive and bulky equipment, occupied a relatively large amount of floor space (as much as 150 feet in length), required a considerable amount of fuel and electricity to operate same, were expensive to install and remove, and required several personnel to monitor the operation thereof. Some of the apparatuses utilized large oven chambers in which were disposed a large number of can bodies all of which were lost due to "burning" or over curing of the coating contained thereon when same were left within the oven chamber too long such as occurs when the system conveying can bodies through the oven chamber breaks down.

BRIEF DESCRIPTION OF THE INVENTION

It has been found that each of the foregoing disadvantages may be easily and quickly overcome through the use of the method of this invention. More specifically, it has been found that the solvent contained within a wet coating deposited on a metal surface may be removed simultaneously from a large number of cans within a processing time as short as approximately ⅓ of a minute by driving the solvent to the surface of the coating by quickly thermally exciting same and removing the molecules of solvent that collect on the surface of the coating by subjecting same to a stream of gas flow traveling at a velocity sufficient to remove the molecules from said surface as soon as they collect thereupon. Driving the excited molecules of solvent to the surface is aided by

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reducing the pressure exterior of the surface of the coating. Removing the molecules of solvent that collect on the surface is aided by subjecting said surface to a turbulent stream of gas flow traveling at a speed of at least approximately 5,500 feet per minute or more and preferably approximately 7,000 feet per minute or more. Excellent results are obtained with gas flow velocities of approximately 12,000 feet per minute. It has also been found that the foregoing disadvantages may be overcome through the use of a compact inexpensive to manufacture, easy-to-install-and-remove apparatus for curing a wet coating deposited on the inner surface of a tubular can body, said apparatus comprising a chamber, a plurality of racks, means for feeding a plurality of can bodies into each of said racks, means for conveying said racks through said chamber, and means for supplying a gas stream of elevated temperature having a velocity of approximately 5,500 feet per minute or more in a direction substantially parallel to the coated surfaces of the can bodies to be disposed in said racks, and means for removing from said racks said can bodies to be disposed therein. This apparatus also includes means for controlling the impact loading exerted upon the can body or bodies to be disposed within each rack by the feeding of successive can bodies into each of said racks.

Accordingly, one of the principal objects of this invention is to provide an improved method for removing solvent from a wet coating deposited on a surface, said coating including a solute, and curing said solute.

Another object of this invention is to provide a process for removing solvent from a wet coating on the interior of a tubular sheet metal body comprising driving the solvent to the surface of the coating by thermally exciting molecules of solvent by elevating the temperature thereof to a temperature of approximately 380° F. or more and removing said excited molecules of solvent by exposing the surface of said coating to a gas stream having a speed of approximately 5,500 feet per minute or more and preferably 7,000 feet per minute or more.

Another object of this invention is to provide a process for simultaneously removing a solvent from a wet coating on a surface, said coating including a solute, while producing a substantially uniform, continuous cured layer of solute on said surface, comprising the steps of curing the solute by elevating the temperature thereof, driving the molecules of the solvent to the surface of the coating by thermally exciting the molecules of the solvent within said coating and reducing the pressure exterior of the surface of said coating, and removing the molecules of the solvent from said surface of said coating by subjecting said surface to a stream of turbulent gas flow traveling at a velocity sufficient to remove the molecules from the surface of said coating as soon as same collect thereupon but below that which will produce flow of any substantial part of said solute whereby the cured solute will be substantially uniform in thickness and the surface thereof will be substantially smooth.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and advantages will become more apparent from the specification and accompanying drawings in which:

FIG. 1 is an elevational view of an apparatus constructed in accordance with the subject invention;

FIG. 2 is a plan view taken along line 2—2 FIG. 1;

FIG. 3 is an elevational view, in partial cross section, taken longitudinally of the apparatus shown in FIG. 1;

FIG. 4 is a perspective view of a rack which is constructed to receive and support therein a plurality of can bodies and one embodiment of a means for effecting removal of can bodies from the rack;

FIG. 5 is a view similar to FIG. 4 showing another embodiment of the means for effecting removal of can bodies from the rack;

FIG. 6 is an enlarged elevational view of a portion of the conduit means used to convey can bodies to the racks;

FIG. 7 shows, in schematic for, a side view of the terminal portion of the conduit means and one embodiment of the impact loading control means of the feed means;

FIG. 8 is a view similar to FIG. 7 and showing another embodiment of the impact loading control means of the feed means;

FIG. 9 is a front elevation of a part of the feed means of the subject apparatus;

FIG. 10 is a plan view of a part of the feed means shown in FIG. 9, some parts being omitted for sake of clarity;

FIG. 11 is a right end elevation of part of the feed means as shown in FIG. 9, some parts being omitted for sake of clarity;

FIG. 12 is a schematic view, in plan form, showing the means for creating turbulent flow adjacent the surface of the wet coating deposited on the interior of the can body;

FIG. 13 is an elevational view of the terminal portion of the conduit means showing a modified means for limiting the number of can bodies to be fed into each rack; and

FIG. 14 is a chart showing various time, temperature, metal exposure and solvent loss relationships.

DESCRIPTIONS OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, in FIGS. 1–4 is shown generally an apparatus **20** constructed in accordance with the subject invention. The apparatus **20** comprises an oven chamber **22**, a plurality of generally vertically disposed racks **24**, means **26** for feeding a plurality of can bodies into each of said racks, means **27** for conveying said racks through said chamber **22**, means **28** for conveying a gas stream of elevated temperature to said oven chamber **22**, and means **30** (see FIG. 4) for removing from said racks **24** can bodies which are to be disposed therein. The apparatus **20** receives a continuous supply of fresh air through an air supply duct **44** which passes through the roof **34** of the building and has its inlet located externally of the building. A portion of the air passes through a duct **36** into a combustion chamber **38** (see FIG. 3). The flow of air through duct **36** is controlled by damper means **39**. Fuel is suitably supplied to burner **40** (only one of which is shown in FIG. 3). The burning of fuel within combustion chamber **38** raises the temperature of the products of said combustion and the air which is being supplied through duct **36**. The resulting hot gas is compressed by a fan included within means **28** and then supplied to the oven chamber **22** at a predetermined high rate of velocity. The hot gas is exhausted from the oven chamber **22** through duct **42**. A portion of the air is also supplied to a preventilation chamber **45** and to a cooling chamber **46**, see FIG. 2. Air is exhausted from the preventilation and cooling chambers through duct **48**. It will be understood that during cold weather operations the air passing through the preventilation and cooling chambers will preferably be supplied from within the building through the duct **50**, which is connected to duct **44**. Additionally, the air flowing through duct **48** may be exhausted within the building through duct **51** which is attached to duct **48**.

Referring now to FIG. 4, each rack **24** is constructed to receive and support therein a plurality of can bodies, one of which is shown in dotted lines in FIG. 4 and designated with the numeral **52**. Each rack **24** has oppositely disposed side portions **54** each of which has an opening formed therein. Each side portion **54** is positioned adjacent a corresponding end of each of the can bodies to be disposed within said rack. Each rack **24** includes a can body receiving aperture **56** formed adjacent the upper end of the rack **24** and a can body exit aperture **58** formed adjacent the lower end of each rack. It will be understood that each can body disposed in each rack is open at opposite ends thereof for a purpose which will be later described.

The means **30** for removing from each rack **24** can bodies which are to be disposed therein includes a cam **60** and a member **62** actuated by said cam **60**. The cam actuated member **62** is mounted within journals **64**, which are secured to the rack **24**, for pivotal movement relative to a portion of rack **24**. The cam actuated member **62** has a portion **66** disposed in one position thereof to prevent passage of can bodies through said can body exit aperture **58** and, in another position thereof, to permit passage of can bodies through said can body exit aperture **58**. It will be readily apparent when the rack **24** and the cam actuated member **62** move in the direction indicated by arrow **68** as shown in FIG. 4, cam surface **60** being stationarily disposed, the portion **70** of cam actuated member **62** will move down the portion **72** of the cam surface **60** thereby causing portion **66** of cam actuated member **62** likewise to move downwardly and, thus, no longer being disposed to obstruct the can body exit aperture **58**. It will be noted that portion **66** of cam actuated member **62** extends downwardly from a generally horizontal plane by an amount equal to approximately 45 degrees. It is desirable that the portion **66** be inclined with respect to a generally horizontal plane in order that portion **66** does not interfere with the passage of can bodies through the can body exit aperture **58** when the portion **70** of cam actuated member **62** completes its descent along portion **72** of cam surface **60**. Although not shown, it will be understood that cam **60** includes at a remote location an inclined surface portion, similar to portion **72**, which functions to raise portion **70** of cam actuated member **62** to a substantially horizontal position whereby portion **66** of cam actuated member **62** will again effectively prevent can bodies from passing through the can body exit aperture **58**.

Referring now to FIG. 5, in FIG. 5 is shown a view similar to that of FIG. 4 except that FIG. 5 shows another embodiment of a means **74** for controlling or effecting the removal of can bodies through the can body exit aperture of the rack **24**. The rack **24** shown in FIG. 5 is identical in construction to the rack shown in FIG. 4. The means **74** for controlling the removal of can bodies through the can body exit aperture **58** of the rack **24** includes a cam **75**, a member **76** actuated by said cam **75** and a support member **77** which is attached to the lower portion **78** of the adjacent side of the rack **24**. The member **76** is mounted within journals **64** for pivotal movement relative to a portion of the rack **24**. Said journals **64** are secured to the rack **24** as shown. The cam actuated member **76** has a portion **79** disposed in one position thereof to prevent passage of can bodies through said can body exit aperture **58** and, in another position thereof, to permit passage of can bodies through said can body exit aperture **58**. An examination of FIG. 5 readily discloses that when the rack **24** and the cam actuated member **76** move in the direction indicated by the arrow **80**, the portion **81** of the cam actuated member **76** moves up the inclined surface portion **82** of the cam surface **75** thereby causing portion **79** of the cam actuated member **76** likewise to move upwardly. In this new position, portion **79** no longer obstructs the can body exit aperture **58**. It will be noted that the portion **79** of the cam actuated members **76** extends upwardly from a generally horizontal plane by an amount equal to approximately 45 degrees. As a consequence, it will be appreciated that after only a slight movement of portion **79** in the upwardly direction, the combined weight of the can bodies within the rack 24 exerts a force against portion 79 thereby assisting in the opening of can body exit aperture 58.

Referring now to FIGS. 1, 6 and 9–11 the means 26 for feeding a plurality of can bodies into each of the racks 24 is shown comprising a translatably mounted member 82 having an aperture 83 formed therein and through which can bodies may pass. The member 82 is mounted for movement in a direction parallel with the direction of movement of the racks 24 and at a speed equal to the speed of movement of the racks 24 whereby the member's aperture 83 and the rack's can receiving opening 56 are coaligned for a predetermined interval of time. The feed means 26 also includes conduit means 84 (see FIG. 6) pivotally connected to a portion of said member 82 and constructed to convey can bodies from a remote location through said member's aperture 83. The feed means 26 also includes means for controlling the feeding of can bodies through said conduit means 84. The feed control means includes an upstream gate means 85 and a downstream gate means 86, see FIG. 6. The feed control means includes means 87 and 88 (see FIG. 9) for actuating said downstream gate means whereby said downstream gate means 86 permits passage of can bodies through said conduit means 84 during the time said member's aperture 83 is coaligned with a can receiving opening 56 with one of said racks 24 but prevents passage of can bodies through said conduit means 84 during the time said member's aperture 83 is not aligned with a can receiving opening 58 on any of the racks 24. For example, when member 82 is in the position shown in FIG. 9, a depressible portion of valve means 88 contacts top 88′ thereby actuating the normally closed valve 88. Valve means 88 is connected to the downstream gate means by a flexible conduit 97. When valve means 88 is open in the manner as aforedescribed, pressurized fluid is transmitted from a source (not shown) through conduit 97 to the downstream gate means 86. The supplying of pressurized fluid to the downstream gate means 86 in this manner results in the downstream gate means being opened whereby can bodies may pass through the terminal portion of conduit means 84. When the depressible portion of the normally closed valve means 87 engages the stop 87′, pressurized fluid is transmitted through the conduit line 97 to the downstream gate means 86. Actuation of the downstream gate means 16 in this manner results in the downstream gate means moving to a position to prevent passage of can bodies through the terminal portion of said conduit means 84. The feed control means also includes normally closed valve means 89 and 90 for actuating said upstream gate means 85 whereby said upstream gate means 85 limits the number of can bodies passing through the conduit means 84 adjacent said upstream gate means 85 during a predetermined interval of time. For example, each rack 24 is constructed to hold a predetermined maximum number of can bodies, such as eight. Thus, the upstream gate means 85 is open when the depressible portion of valve means 89 engages the stop 89′ and is closed when the depressible portion of valve means 90 engages the stop 90′. In this manner, the upstream gate means 85 is open for a sufficient period of time to permit not more than a predetermined number of can bodies to pass thereby. It will be readily understood that the interval of time during which the upstream and downstream gate means are opened and closed can be varied by changing the locations of the stops and/or the locations of the corresponding valve means relative to the stops, or by changing the speed of travel of the racks 24. In FIGS. 6 and 9, the location of gate 85 and its actuating means is such that it closes after eight or nine can bodies have passed thereby. Gate 86 and its actuating means are located to permit eight can bodies or less to pass thereby.

Each of the gate means 85 and 86 includes a hydraulically or pneumatically operated cylinder 92, a piston (not shown) and a piston rod 93 disposed therein, a portion of said piston rod 93 extending outwardly from said cylinder 92, a pivotally mounted member 94 which has one end attached to the piston rod 93 and the other end 96 constructed, in one position of said member 94, to extend into the passageway defined by said conduit means 84 and thereby prevent passage of said can bodies through said conduit means 84. Each cylinder 92 has a pair of conduits 97 which are used to carry pressurized fluid to a predetermined side of the piston disposed within the cylinder 92 and to exhaust fluid from the other side of the piston disposed within the cylinder 92. The conduit means 84 preferably includes one or more star wheels 98 mounted adjacent either the upper or lower portion of the conduit means 84. The purpose of star wheel 98 is to decrease the velocity of the can bodies passing through the conduit means 84 and thereby minimize or substantially eliminate undesirable deformation or changing of the circularity of the can bodies when the movement of same is arrested such as by the closing of the upstream gate means 85.

In FIGS. 2, 3, 9 and 10 is shown means 27 (see FIG. 3) for conveying the racks 24 through the chamber 22. Means 27 includes an endless chain belt type of mechanism 99 (see FIG. 2) upon which is mounted each of the racks 24, a motor 100, a gear reduction box 102, a pair of aligned, vertically spaced-apart sprocket wheels 104, each of which is mounted upon a generally vertically disposed axle 106, an endless pulley belt 108 interconnecting a portion of the gear box 102 and a portion of the axle 106 in driving-driven relationship, and a second pair of aligned, vertically spaced-apart idler sprocket wheels 110. The endless chain belt 99, upon which is mounted each of the racks 24, includes a plurality of actuating members 112, see FIG. 9. Endless belt 99 includes an actuating member 112 for each of the racks 24 mounted thereon. The feed means' member 82 includes a vertically translatable member 114 having a lower surface portion 116 thereof disposed for successively engaging each actuating member 112 associated wtih each rack 24 whereby horizontal movement of said actuating member 112 produces a corresponding horizontal movement of member 114 and member 82. When member 112 engages surface portion 116 of member 114, the movement of the endless belt 99 is transmitted to member 82 by actuating member 112 and member 114. In this manner, member 82 is moved to the left as viewed in FIG. 9, such movement being relative to the stationarily disposed supporting frame 118 for member 82. Supporting frame 118 includes a pair of horizontally disposed bars 120. Member 82 is mounted for translatory movement along said bars 120. A coil spring 122 is mounted about each of the bars 120 and disposed intermediate one end 124 of supporting frame 118 and an adjacent end 126 of member 82. Movement of member 82 is also controlled in part by a hydraulic or pneumatic cylinder 128 (see FIG. 10), which has one end thereof secured relative to the frame 118. Said cylinder 118 has a piston (not shown) disposed therein and a piston rod 130 connected to said piston and extending outwardly from one end of cylinder 128. The other end of the piston rod 130 is secured to a portion of member 82. A pair of fluid lines 132 interconnect the cylinder 128 to a source (not shown) of pressurized fluid and to an exhaust reservoir (not shown). The cylinder 128 has for its purpose to return the member 82 to the position shown generally in FIG. 9. In the position shown in FIG. 9, a normally closed valve means 134 has a portion which is depressed by engagement thereof with stop 134′. Actuation of valve means 134 in this manner opens valve 134 and permits fluid to be exhausted from cylinder 128.

Member 82 also includes a generally horizontally disposed, spring-biased rod 136 which has one end 138 thereof constructed for engaging an adjustable stop 140 and the other end thereof in contacting engagement with a pivotally mounted pawl member 142. One end of pawl member 142 engages a horizontally disposed pin 144 which is secured to the vertically translatable member 114. Also attached to said member 114 is a second horizontally disposed pin **146**. It will be noted that member **114** is biased by spring **148** which causes the member **114** to be moved downwardly following disengagement of the end **138** of rod **136** from the end of the adjustable stop **140**. Movement of the member **82** toward the left, as viewed in FIG. 9, causes the rod **136**, upon engagement of same with stop **140**, to engage pawl member **142** whereby pawl member **142** is rotated in a counterclockwise direction. Rotation of pawl member **142** in the counterclockwise direction results in the mmeber **114** being raised vertically. Displacement of member **114** vertically upwardly results in the surface portion **116** becoming disengaged from actuating member **112** and at the same time a second pin **146**, which is also attached to member **114**, depresses a portion of normally closed valve means **150**. Actuation of valve means **150** results in admitting pressurized fluid from a source (not shown) through conduit line **152** to one side of the piston disposed in the cylinder **128**. Actuation of the cylinder **128** in this manner causes the member **82** to move to the right, as viewed in FIG. 9, to the position shown in FIG. 9. When member **82** reaches the position shown in FIG. 9, the valve means **134** is actuated. Actuation of valve means **134** permits the fluid contained within cylinder **128** to be exhausted to a reservoir (not shown). It will be understood that the springs **122** assist in returning member **82** to the position shown in FIG. 9. However, it will also be understoood that movement of member **82** may be easily and quickly effected with or without the use of coil springs **122**.

Referring now to FIG. 1, apparatus **20** also includes means for detecting the presence of a can body within each rack **24** and generating a signal in responses thereto. This means includes a light source **154** and a photosensitive cell **156**. Failure of light to fall upon the photosensitive cell **156** for a predetermined interval of time results in the generation of a signal which is transmitted to means **158** which is responsive to said generated signal for controlling the feed of can bodies into the racks **24** to prevent the feeding of can bodies into any rack **24** having a can jammed or otherwise stuck therein. It will be understood that the means for detecting the presence of a can body within a rack will be posiitoned somewhere intermediate the place where the can bodies are removed from the rack and the place where the can bodies are fed into the racks.

Referring to FIGS. 4 and 12, it is noted that each rack **24** has a member **160** extending longitudinally of one of the oppositely disposed sides **54** of said rack, said sides **54** having an opening formed therein. The purpose of this member **160** is to create a turbulent gas flow within that portion of the gas stream flowing adjacent the coated surfaces of the can bodies disposed within said racks. In FIG. 12 is shown one of a plurality of stationarily disposed gas or air nozzles **162** through which gas or air travels at a high rate of velocity through one of the sides **54** of the racks **24** into the interior of the can bodies **52** and thence out the other end of the can bodies **52** and the other one of said sides **54**. It will be understood that the rack **24** is moving in the direction of the arrow **164** and, thus, as the longitudinally extending member **160** of rack **24** moves past the nozzle **162**, it being understood that said nozle extends substantially the full vertical length of the rack **24**, a turbulent gas flow of variable intensity is produced, the intensity depending upon the precise location of the member **160** relative to the exit of said nozzle **162**. The creation of turbulent gas flow in this manner insures that the molecules of solvent which are being driven to the surface of the wet coating deposited on the interior of the can body are removed as soon as same collects thereon. In addition to the use of a gas stream of high velocity, the creating of turbulence within said gas stream also further reduces the pressure existing adjacent the surface of the wet coating and thereby assists in drawing the molecules of solvent to the surface of said coating.

Referring now to FIGS. 1, 7 and 8, the feed means **26** of the apparatus **20** also includes means for controlling the impact loading exerted upon the can body or bodies

disposed within the rack by the feeding of successive can bodies into each of said racks. It is important that the impact loading exerted upon the cans disposed within the racks be kept to a minimum since otherwise the overall configuration of the can bodies may change sufficiently as to interfere with the subsequent filling of the cans with liquid or other material and sealing the can as filled. This is a particular bothersome problem where the cross-section of the can body becomes noncircular in configuration. Understandably, the amount of impact loading is maintained at a minimum when the feed means **26** limits the feeding of one can at a time into the racks. Thus, it is important that means be used to effect a physical separation between successive can bodies as same are fed into the feed racks. It has been found that this objective may be achieved in a number of ways. For example, in FIG. 7 is shown the use of a pair of electromagnets **166** which are disposed on opposite sides of the lower portion of the conduit means **84**. By controlling the force of the magnetic field created by the electromagnets **166**, it is possible to maintain a predetermined amount of physical separation between each successive can body as same passes into its respective rack. In FIG. 8 is shown another means for achieving this same objective. A pair of gas or air jets **168** have their nozzles directed to impinge upon the surface of the approaching can body and thereby reduce the speed of travel of such can body relative to the can body which has already passed thereby. It has also been found that the impact loading exerted upon the cans within a rack may be held to a minimum when the terminating portion of the conduit means **84** is formed with a downstream, generally vertically disposed part **170** and an immediate upstream part **172** with the extension of said upstream part forming an included angle ϕ, as shown in FIG. 6, of approximately 45 degrees or less, with a generally horizontal plane. It has been found that a positive separation is effected between successive can bodies due to the effect of gravity when the foregoing relationship is observed.

Referring now to FIG. 13, FIG. 13 shows the use of a light source **174** and a photosensitive cell **176** for sensing the number of can bodies passing through the conduit means **84** and generating a signal in response thereto. A signal is generated each time the can body passes between the light source **174** and photosensitive means **176**. This signal is transmitted to a counter or accumulator **178** which, upon reaching a predetermined quantity, generates a signal which is used to control the gate means **86** shown in FIG. 13. Thus, it will be readily understood that the light source **174**, the photosensitive cell **176** and accumulator **178** may be used in lieu of the upstream gate means **85** as shown in FIG. 6.

Referring again to FIGS. 1, 6 and 11, it will be noted that the conduit means **84** includes three pivotal connections **180**, **182** and **184**. Further, the conduit means **84** includes portions **84*a*** and **84*b***, said portions **84*a*** and **84*b*** being interconnected by pivot connection **182**. As indicated above, member **82** translates and reciprocates in a direction parallel to the movement of the racks **24**. Since the conduit means **84** is pivotally attached to a member **82**, it is necessary that conduit means **84** be sufficiently flexible to permit this type of movement without affecting the passage of can bodies therethrough. The use of the three pivotal connections **180**, **182** and **184** achieves this objective.

A brief description of the theory underlying the method of this invention is now described. First of all, it is to be understood that a coating on the interior of a container or can body in order to present a barrier between the substrate material of the can and the product is well known in the art. This coating is generally applied as a solution of a film-forming resin dissolved in a volatile, organic solvent. Before it can form an effective protective film on the surface of the can body, the solvent contained in the wet coating must be completely removed, so that only the dry resin film remains. Among the solvents which are useful in effecting such a coating are saturated aliphatic hydrocarbons such as mineral spirits, ketones such as methyl-ethyl ketone, methyl-isobutyl ketone, cyclohexanone, diisobutyl ketone, isophorone, ether-alcohols such as methyl-Cellosolve and Carbitol, and alcohols such as isopropanol and butanol. The above solvents may be used singly or in combination with one another and may be mixed with small amounts of aromatics such as xylol and tolual. Any resin which is soluble in the above-mentioned solvents and which is capable of forming a continuous, protective film on the inside of the can body may be used. Examples of such resins are vinyl resins such as polyvinyl chloride and vinyl chloride-vinyl acetate copolymers, stage B-phenolic resins, oleo resins, hydrocarbon polymer synthetic drying oils, alkyd resins, and synthetic rubbers such as butadiene-styrene copolymers and butadiene-acrylonitrile copolymers.

It will be understood that the interior of the can bodies are sprayed at a remote location (not shown). Following the spraying operation, the can bodies are conveyed to a suitable machine or apparatus. It will be appreciated that during the time the can bodies are being conveyed from a point where same are sprayed to the aforementioned machine or apparatus some of the solvent evaporates from the wet coating. Although the amount of solvent removed during this period of time depends upon a number of factors such as the temperature of the ambient air and the time involved in transferring such can bodies, experience shows that approximately 75–78 percent of the solvent will evaporate before the can bodies reach the apparatus of this invention. The can bodies are then processed through the machine or apparatus as aforedescribed for the purpose of removing substantially all of the remaining, and most difficult to remove, solvent or solvents contained within the wet coating and curing the resin or solute which remains upon the interior surface of the can body following the removal of the solvent. In the apparatus of this invention approximately 15 percent of the solvents are removed from the coating as a result of the can bodies passing through the preventilation chamber **45** and the remaining solvent is removed while the can bodies are passing through the oven chamber **22**.

It has been found that the removal of the solvent and curing of the solute or resin may be advantageously effected in a relatively short period of time if certain conditions are met. Understandably, from a processing rate viewpoint it is desirable to keep this total time to a minimum; however, it is important that the removal of the solvent occurs prior to the time that the outer surface of the coating sets up. If the outer surface of the coating sets up or cures prior to the time that substantially all of the solvent has been removed therefrom, continued removal of the solvent from the coating will rupture the outer surface of the coating thereby destroying the value of such coating. Heretofore, the problem in accomplishing the foregoing has been to find a way in which to decrease the amount of time required to remove the solvent from the coating without adversely affecting the quality of the finished coating or creating additional can body handling problems. The method of this invention greatly decreases the time required in removing the solvent from a wet coating by the combined steps of driving the solvent to the surface of the coating by thermally exciting molecules of solvent and removing the excited molecules of solvent from the surface of the coating by subjecting same to a stream of gas flow traveling at a velocity sufficient to remove the molecules from the surface as soon as same collect there. It is quite important to remove from the surface of the coating these molecules of solvent as soon as they collect upon said surface since the removal of these molecules increases the rate of travel of molecules from within the coating to said surface. It has been found that the removal of solvent may be increased by decreasing the pressure existing adjacent the surface of the wet coating and by creating turbulent flow within the gas stream flowing past said surface. It will be understood that the effectiveness of removing solvent from the wet coating increases with an increase in the velocity of the gas stream and, thus, a gas velocity of approximately 12,000 feet per minute or more (even up to 18,000 to 20,000 feet per minute) is more advantageous than velocity of a lesser rate. The gas stream velocity used in the preventilation and cooling chambers is preferably maintained somewhere between 5,500 to 6,000 feet per minute although higher velocities may be used if so desired.

FIG. 14 is a chart showing the relationship between the solvent loss plotted against the time the can bodies move from the sprayer (not shown) through the oven chamber **22**, the bake temperature plotted against the residual solvent in milligrams, and the bake temperature plotted against the metal exposure of the can body as measured in milliamps. In FIG. 14, curve **186** shows the amount of solvent loss, in percentage, from the time the can bodies are sprayed through the time that same pass through the oven chamber **22** of the apparatus **20**. In this connection, it will be noted that approximately 77.25 percent of the solvent evaporates from the coating during the approximate 18 second of time that the can body travels from the spraying apparatus to the apparatus of this invention. An additional 15 percent of solvent is lost from the coating during the approximate 21 seconds of time it takes the can body to travel through the preventilation chamber **45** of the apparatus **20**. Finally, approximately 7.5 percent of solvent is removed from the coating during the approximate 20–24 seconds that the can bodies remain in the oven chamber **22**. In all 99.95 percent of the solvent is removed from the coating. The data represented in curve **186** was obtained from a total of ten tests which were run at approximately 380° F. to determine the residual solvent shown in curve **186**. Upon completion of these tests, an average was taken of the results. Based on this average, it was found 77.25 percent of the solvent evaporated during the 17 seconds of time the can body traveled from the spray machine to the preventilation chamber **45**, 15 percent of the solvent evaporated during the 21 seconds the can body traveled through the preventilation chamber **45**, and 7.5 percent of solvent evaporated during the 24 seconds the can body traveled through the oven chamber **22**. The solvent involved in these tests was a mixture primarily of methyl-ethyl ketone, toluol and acetone. The coating was applied on the interior of the can to obtain a vinyl film weight of approximately 190 milligrams per 2.11 inches diameter x 4.13 inches long can shell. The method used to determine the vinyl cure was that of weighing, overbaking, and reweighing the cured can to determine the residual solvent. After performing additional tests at other temperatures, it was found for the solvent aforedescribed that a positive cure was obtained for temperature of 380° F. or more.

The curve **188** shows the relationship between the temperature of the gas being supplied to the oven chamber **22** and the amount of solvent, in milligrams, remaining within the coating. The data represented by this curve was obtained by processing can bodies through the apparatus of this invention, weighing same, then processing the same can bodies through a conventional apparatus and re-weighing same. This process is referred to as "overbaking" and the purpose of it is to determine, by overbake of the cans, how many milligrams of residual solvent remain in the cans after baking in the apparatus of this invention. A number of tests were run at different temperatures. The results of this test confirmed that good results were obtained at temperatures of 380° F. or more for the solvent mixture of methyl-ethyl ketone, toluol and acetone as described above.

The curve **190** shows the relationship between the temperature of the gas being supplied to the oven chamber **22** versus the amount of metal exposure of the can surface. The data represented by curve **190** was taken from the results of a large number of tests run at 6 different temperatures, i.e., at 5° F. intervals between 375° F. and 400° F. After the cans had been processed through the oven chamber **22**, each can was filled with an electrolytic solution. An electrode was then placed into the solution and after a 4-second delay the metal exposure of the can was ascertained as being proportional to the reading taken in milliamps. The maximum metal exposure reading permitted by one large can user is 6 milliamps at 380° F. The apparatus of this invention produces cans with a reading of 4.4 milliamps at 380° F., and this reading is decreased with an increase in temperature. For example, it was found that at 395° F. an average reading for all of the cans involved in one series of tests was 2.8 milliamps, the average reading for 395° F. being less than the average reading at any of the other temperatures involved. It is believed that an increase in milliamperage reading with temperatures above 395° F. occurs due to the "cratering"effect, i.e., the surface of the coating cures before all of the solvent has been removed therefrom and continued removal of the solvent ruptures this cured portion of the surface thereby increasing the amount of exposed metal. It will be noted, however, that even at 400° F., the average milliamperage reading was 3.4, which is considerably below the maximum metal exposure reading of 6 milliamps referred to above.

It will be understood that the apparatus of this invention may also be used to treat the inner and outer surfaces of a generally annular, tubular body. Such treatment may include the cleaning or washing of said surfaces as well as the drying thereof. When the apparatus of the invention is used to clean or wash the surfaces of a generally annular, tubular body, it will be understood that the nozzle **162** as shown in FIG. 12 will be used to direct a cleaning fluid or liquid upon the surface of any such tubular bodies. Further, a plurality of nozzles (not shown) may be used in lieu of each vertically disposed nozzle **162**. It will also be understood that it will be desirable to position the tubular bodies within each rack whereby said tubular bodies are in an inclined position with respect to a horizontal plane thereby facilitating the drainage of liquid off the surfaces of such tubular bodies following the cleaning operation. It will be appreciated that where the tubular bodies are closed at one end, the member **160** serves as a flow divider, i.e., the fluid will enter the body on one side of member **160** and exit from the other side thereof. Thus, member **160** assists in establishing a circulatory flow of fluid through the tubular body.

The method of this invention has proven to be beneficial for a number of reasons. For example, an apparatus constructed in accordance with the subject invention and using the method specified herein is extremely compact, lightweight and inexpensive to manufacture. It requires much less floor space than conveniently available models and may be suspended from the ceiling if desired or required. Further, such an apparatus can be installed for about 1/30 of the cost of installing current competitive models having the same processing rate, i.e., approximately $500 for the apparatus of this invention as compared with approximately $15,000 for competitive models. The apparatus of this invention may be preassembled and tested and, as a result thereof, readily lends itself for the export market. As previously indicated, the apparatus of this invention is easily and quickly installed or removed.

The apparatus of this invention may be operated at a substantial saving as compared with currently available competitive devices. For example, the entire operation of the apparatus of this invention may be viewed from a single work station. Further, loading and unloading of the apparatus of this invention occurs at the same end thereof rather than at opposite ends as compared with some of the currently available competitive models. Additionally, the apparatus of this invention requires approximately only one-third of the amount of fuel and only approximately one-fifth of the amount of electricity used by currently available competitive models. Further, it will be understood that in the event of breakdown of the system used to convey can bodies through the oven chamber all of the can bodies contained within the oven chamber will be lost due to overbaking or "burning" thereof. For the apparatus of this invention, this means that approximately only 200 can bodies will be lost whereas for currently available competitive models as many as 3,000 can bodies will be lost. Moreover, due to the compactness and reduced mass involved in the apparatus of this invention, the time to start up same is greatly reduced.

In view of the foregoing, it will now be readily appreciated that a vastly improved method for treating the inner surface of a tubular body including removing solvent from a wet coating deposited on a surface and curing a solute contained within said coating has been described. The properties of the cured coating obtained through the use of the method and apparatus of this invention are substantially improved over properties of coating obtained with prior arts and methods of apparatuses. When it is considered that literally billions of cans are produced each year and that most of these cans must have a coating formed on the inner surface thereof, the advantages obtained by the method and apparatus of this invention will be all the more appreciated.

It is to be understood that this invention is not limited to the exact methods and apparatuses shown and described which are merely by way of illustration and not limitation, as various other forms and modifications will be apparent to those skilled in the art, and it is therefore intended that the appended claims cover all such changes and modifications.

We claim:

1. A flameless process for removing solvent from a wet curable coating on the surface of a solvent impermeable metal body comprising driving the solvent to the surface of the wet coating by simultaneously thermally exciting molecules of solvent and reducing the pressure adjacent the exterior of said surface, and removing from said surface said molecules of solvent by subjecting said surface to a turbulent stream of gas flow traveling at a speed of at least approximately 5500 feet per minute or more.

2. A flameless process for removing solvent from a wet curable coating on the interior of a tubular sheet metal body comprising driving the solvent to the surface of the coating by thermally exciting molecules of solvent by elevating the temperature thereof with gas heated to a temperature of approximately 380° F. or more and removing said excited molecules of solvent by exposing the surface of said coating to a gas stream traveling at a speed of approximately 7000 feet per minute or more.

3. A flameless process for simultaneously removing a solvent from a wet curable coating on a solvent impermeable surface, said coating including a solute, while producing a substantially uniform, continuous cured layer of solute on said surface, comprising the steps of curing the solute by elevating the temperature thereof, driving molecules of the solvent to the surface of the coating by thermally exciting the molecules of the solvent within said coating and reducing the pressure exterior of the surface of said coating and removing the molecules of the solvent from said surface of said coating by subjecting said surface to a stream of turbulent gas flow traveling at a velocity of approximately 12,000 feet per minute or more.

4. A process for removing a solvent from a wet coating applied to an interior surface of a tubular can body having at least one open end, the wet coating including a solute adapted to provide a dry layer of same on said interior surface after removal of said solvent, comprising:

(a) continuously conveying said can body through a zone of moving air maintained at elevated temperature sufficient to drive the solvent to the surface of the coating,

(b) passing the open end of said can body successively across a plurality of air streams, each generally axially within same, each air stream having a velocity sufficient to move the can away from a predetermined position in its path of movement, if unrestrained against such movement, and,

(c) restraining the can against the tendency to so move.

5. A process in accordance with claim **4** wherein said elevated temperature and air velocity are so maintained to prevent drying of the exposed surface of the coating before substantially all solvent is removed from below same, and obviate cratering of a prematurely formed dry layer.

6. A process in accordance with claim **5** wherein said elevated temperature is between approximately 380° F. to 400° F. and said air velocity is at least 5500 feet per minute.

7. A process in accordance with claim **6** including the step of removing the major portion of the solvent by evaporation to ambient air prior to removal of solvent in said zone.

8. A process in accordance with claim **7** wherein the residence time of the solvent removal in said zone is about 18 seconds or less.

9. A process in accordance with claim **4** including the step of conveying the can bodies through said zone in discrete spaced groups of same with the longitudinal axis of the can bodies disposed substantially horizontal.

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