APPARATUS FOR DRYING A WET COATING ON A SURFACE

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ATTORNEYS
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Sheet 3 of 8

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<table>
<thead>
<tr>
<th>ZONE LOSS %</th>
<th>FROM SPAY TO APPARATUS IN ATMOSPHERE</th>
<th>THROUGH PRE-VENTILATION CHAMBER</th>
<th>THROUGH OVEN CHAMBER</th>
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<tr>
<td>77.25 %</td>
<td>15 %</td>
<td>7.5 %</td>
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<tr>
<td>CUMUL. LOSS %</td>
<td>77.25 %</td>
<td>92.25 %</td>
<td>99.95 %</td>
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Graph with data points and curves indicating solvent loss over time and temperature.
APPARATUS FOR DRYING A WET COATING ON A SURFACE

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32 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to an apparatus having a chamber, a plurality of racks for conveying can bodies through the chamber, each rack being constructed to receive and support therein a plurality of can bodies, and each of said racks having oppositely disposed side portions with an opening formed therein, each side portion being positioned adjacent a corresponding end of a can body, means for feeding can bodies into each rack and for controlling the number of can bodies fed to each rack. The apparatus includes means for supplying a gas stream of elevated temperature having a velocity of approximately 5,500 f.p.m. in a direction substantially parallel to the surfaces of the can bodies and means to create a turbulent gas flow adjacent the can bodies.

Background of the invention

Hereinafter, 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, were expensive to install and require, and required several personnel to operate the apparatus. Some of the apparatuses utilized large oven chambers in which were disposed a large number of can bodies all of which were less than 60 feet long and 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 apparatus 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 15 minutes 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 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 in 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 surface 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 apparatus 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 an extremely compact apparatus for curing a wet coating deposited on the inner surface of tubular can bodies.

Another object of this invention is to provide an apparatus for curing a wet coating deposited on the inner surface of tubular can bodies which apparatus can be preassembled and tested and thereby minimized heretofore associated with shipping, exporting, and installing apparatuses of this type.

Another object of this invention is to provide an improved apparatus for curing a wet coating deposited on the inner surface of tubular can bodies which is not only compact and inexpensive in construction but also processes a large number of can bodies in a short period of time.

Another object of this invention is to provide an improved apparatus for cleaning the inner and outer surfaces of a generally annular, tubular body or container.

Another object of this invention is to provide an improved apparatus as aforesaid which requires less fuel and electricity to operate than prior art apparatuses.

Another object of this invention is to provide an improved apparatus as aforesaid in which the loading and unloading thereof occurs at one end thereof.

Another object of this invention is to provide an apparatus for curing a wet coating deposited on the inner surface of tubular can bodies, said apparatus comprising a chamber, a plurality of racks, each rack being constructed to receive and support therein a plurality of can bodies and each of said racks having oppositely disposed side portions with an opening formed therein, each side portion being positioned adjacent a corresponding end of a can body to be disposed within said rack, means for conveying a plurality of can bodies into each of said racks, said feed means including means for controlling the impact loading exerted upon the can body or bodies to be disposed in each rack by the feeding of successive can bodies into each of said racks, means for conveying said cans through said chamber, means for supplying a high velocity gas stream at an elevated temperature in a direction substantially parallel to the coated surfaces of the can bodies to be disposed within said racks at least part of the time said racks are moving.
through said chamber, and means for removing from said racks said can bodies to be disposed therein.

Another object of this invention is to provide an apparatus as hereinafore described in which the feed means also includes means for controlling the number of can bodies to be fed into each rack.

Another object of this invention is to provide an improved apparatus as hereinafore described in which the impact loading control means of said feed means includes a magnetic field or a stream of gas.

Another object of this invention is to provide an apparatus as hereinafore described including means for detecting the presence of a can body within each rack and generating a signal in response thereto and means responsive to the generated signal for controlling the feed means whereby said responsive means prevents said feed means from feeding can bodies into a rack having a can disposed therein.

Another object of this invention is to provide an apparatus as hereinafore described in which each rack has a can body receiving aperture and in which said feed means includes a member having an aperture formed therein and through which can bodies may pass, said member being mounted for translatory movement in a direction parallel with the direction of said racks at a speed equal to the speed of movement of said racks whereby the member's aperture and the rack's can receiving openings are coaligned for a predeterminated interval of time, said feed means including means for moving said member in a direction opposite to that direction of movement of each rack until the member's aperture becomes coaligned with the can receiving opening of a succeeding rack.

Another object of this invention is to provide an apparatus as hereinafore described in which said feed means includes conduit means pivotally connected to said feed means' translatably mounted member and constructed to convey can bodies to said member's aperture and means for controlling the feeding of can bodies through said conduit means, said feed control means including an upstream and a downstream gate means, and means for actuating said gate means whereby said downstream gate means permits passage of can bodies through said conduit means during the time said member's aperture is coaligned with the can receiving opening of one of said racks but prevents passage of can bodies through said conduit means during the time said member's aperture is not aligned with a can receiving opening of one of said racks, and said upstream gate means being controlled by said gate actuating means to limit the number of can bodies passing through said conduit means during a predetermined interval of time.

Another object of this invention is to provide an apparatus as hereinafore described in which said rack conveying means includes an actuating member associated with each of said racks, said feed means' translatably mounted member including a surface portion constructed for successively engaging each actuating member associated with each adjacent rack whereby movement of said actuating member produces a corresponding movement of said feed means' member, said feed means also including means for disengaging said surface portion of said member from each of said actuating members and, upon disengagement thereof, moving said member of said feed means in a direction opposite to the direction of movement of said racks.

Another object of this invention is to provide an apparatus as hereinafore described in which said rack conveying means includes a can body exit aperture and said removal means includes a cam member and a member actuated by said cam, said cam actuated member having, in one position thereof, a portion disposed to prevent passage of can bodies through said can body exit aperture and, in another position thereof, to permit passage of can bodies of said can body exit aperture.

Another object of this invention is to provide an apparatus as hereinafore described including means for creating a turbulent gas flow adjacent the coated surfaces of the can body to be disposed within said racks at least part of the time said racks are moving through said chamber.

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 180°F. and more and retaining said excited molecules of solvent by depositing the surface of said coating to a gas stream having a speed of approximately 5,500 feet per minute or more and, preferably, 7,500 feet per minute or more.

Another object of this invention is to provide a process for simultaneously removing a solvent from a wet coating of 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 they come in contact with said surface, the velocity of the gas stream being such that it produces a substantially uniform layer of deposited solute wherein the surface thereof will be substantially smooth.

Another object of this invention is to provide an apparatus for treating the inner surface of a generally annular, tubular body.

Brief description of the drawings

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

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

FIGURE 2 is a plan view taken along line 2—2 FIGURE 1;

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

FIGURE 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;

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

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

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

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

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

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

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

FIGURE 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;
FIGURE 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 FIGURE 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 FIGURES 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 conveying 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 FIGURE 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 FIGURE 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 FIGURE 3). The burning of fuel within combustion chamber 38 raises the temperature of the products of said combustion and the said 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 preheating chamber 45 and to a cooling chamber 46, see FIGURE 2. Air is exhausted from the preheating and cooling chambers through duct 48. It will be understood that during cold weather operations the air passing through the preheating 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 FIGURE 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 FIGURE 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 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 66 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 when 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 FIGURE 5, in FIGURE 5 is shown a view similar to that of FIGURE 4 except that FIGURE 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 FIGURE 5 is identical in construction to the rack shown in FIGURE 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 FIGURE 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 member 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 the can body exit aperture 58.

Referring now to FIGURES 6 and 7, and 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 FIGURE 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 FIGURE 6. The feed control means includes a first position 87, a second position 88 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 coaligned with a can receiving opening 56 on any of the racks 24. For example, when
member 82 is in the position shown in FIGURE 9, a depressible portion of valve means 88 contacts stop 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 aforesaid, pressurized fluid is transmitted from a source (not shown) through conduit 97 to the downstream gate means 86. The supply of pressurized fluid to the downstream gate means 86 in this manner results in the downstream gate means 86 opening whereby the members 88 of the valve means 88 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 open 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 FIGURES 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 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 FIGURES 2, 3, 9 and 10 is shown means 27 (see FIGURE 3) for conveying the racks 24 through the chamber 22. Means 27 includes an endless chain belt type of mechanism 99 (see FIGURE 2) upon which is mounted each of the racks 24, a motor 106, a gear reducer 102, a vertically spaced-apart idler 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 rack engaging portions 112. Said actuating 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 with each rack 24 whereby longitudinal movement of said actuating belt 99 includes 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 member 114 and member 112. Said spring 122 is also contained in part by a hydraulic or pneumatic cylinder 128 (see FIGURE 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 disposed pin 146. 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 member 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. Rotation of the cylinder 128 in this manner causes 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 spring 122 assist in returning member 82 to the position shown in FIG. 9. However, it will also be understood 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 response thereto. This means may be of various types and the particular embodiment shown will be understood to be illustrative. It will be understood that the means for detecting the presence of a can body within a rack will be positioned 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 it can be seen of the possibility of using 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 nozzle 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 such makes contact therewith. In addition to the use of a gas stream of high velocity, the creating of turbulence within said gas stream 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 impingement 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 particularly bothersome problem where the cross section of the can body becomes non-circular in configuration. Understandingly, the amount of impact loading is maintained at a minimum when the feed means 26 limits the feeding of the cans 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 a use of a pair of electromagnets 166 which are disposed on either side 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 down sloping 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 84a and 84b, said portions 84a and 84b 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 can body 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 toluol. 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 rubbers and butadiene-acrylate 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 spray apparatus. The can bodies are then processed through the machine or apparatus as aforesaid 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 metal 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 prevention 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 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, then continued removal of the solvent from the coating will rupture the outer surface of the coating thereby destroying the value of such coating. Hereofore, 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 they 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 surface to the 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 prevention and cooling chambers is preferably maintained somewhat between 5,500 to 6,000 feet per minute although higher velocities may be used if so desired.

FIGURE 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 FIGURE 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 seconds 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 prevention chamber 45 of the apparatus 20. Finally, approximately 7.5 percent of solvent is removed during the approximately 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 rate of solvent removal is 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 prevention chamber 45, 15 percent of the solvent evaporated during the 21 seconds the can body traveled through the prevention 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 cans 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 above described that a positive cure was obtained for temperatures 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 reweighing same. This process is referred to as “over baking” 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 coating in said spray apparatus.

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 electrolyte 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 millamps. 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 for 380°F. involved. It is believed that an increase in milliampere 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 milliampere reading was
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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 FIGURE 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 and apparatus 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 3/8 of the cost of installing current competitive models having the same processing rate, i.e., approximately $50 for the apparatus of this invention as compared with approximately $15,000 for competitive models. The apparatus of this invention may be reassembled 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 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 cans bodies through the oven chamber all of the can bodies contained within the oven chamber will be lost due to baking 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 and apparatus 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 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. An apparatus for removing a solvent from a wet coating deposited on the inner surface of a tubular sheet metal can body and curing said coating, said apparatus comprising: a chamber; a plurality of generally vertically disposed racks, each rack being constructed to receive and support therein a plurality of can bodies, each rack having oppositely disposed side portions with an opening formed therein, each side portion being positioned adjacent a corresponding end of a can body to be disposed with said rack, each rack including a can body receiving aperture formed adjacent the upper end thereof and a can body exit aperture formed adjacent the lower end thereof; means for feeding a plurality of can bodies into each of said racks, said feed means including a translatably mounted member having an aperture formed therein and through which can bodies may pass, said member being mounted for movement in a direction parallel with the direction of movement of said racks and at a speed equal to the speed of movement of said racks whereby the member's aperture and the rack's can receiving opening are coaxiagd with a predetermined interval of time, said feed means also including conduit means constructed to convey can bodies to said member's aperture and means for controlling the feeding of can bodies through said conduit means, said feed control means including a gate means, and means for controlling said gate means to limit the number of can bodies passing said conduit means during a predetermined interval of time; said feed means also including 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; means for supplying a gas stream of elevated temperature and having a velocity of approximately 7000 feet per minute or more in a direction substantially parallel to the coated surfaces of can bodies to be disposed within said racks at least part of the time said racks are moving through said chamber; and means for removing said said racks said can bodies to be disposed therein, said removal means including a cam and a member actuated by said cam, said cam actuated member having, in one position thereof, a portion disposed to prevent passage of said bodies through said can body exit aperture and, in another position thereof, to permit passage of said bodies through said can body exit aperture.

2. An apparatus as described in claim 1 in which said rack conveying means includes an actuating member associated with each of said racks, said feed means member includes a surface portion constructed for successively engaging each actuating member associated with each rack whereby movement of said actuating member produces a corresponding movement of said feed means member, and said feed means also includes means for disengaging said surface portion of said feed means member from each of said actuating members and, upon disengagement thereof, moving said member of said feed means member in a direction opposite to the direction of movement of said racks.

3. An apparatus as described in claim 2 in which the member of said feed means is biased in a direction opposite to the direction of movement of said racks.

4. An apparatus as described in claim 1 including means for detecting the presence of a can body within each rack.
and generating a signal in response thereto, and means responsive to said generated signal for controlling said feed means whereby said responsive means prevents said feed means from feeding can bodies into a rack having a can disposed therein.

15. An apparatus as described in claim 1 including means for creating turbulence within that portion of the gas stream flowing adjacent the coated surfaces of the can bodies to be disposed within said racks at least part of the time said racks are moving through said chamber.

16. An apparatus as described in claim 1 in which said feed means includes a second gate means, said second gate means being located upstream of the other gate means, and means for actuating said other gate means whereby said other gate means permits passage of can bodies through said conduit means during the time said member's aperture is co-aligned with a can receiving opening of one of said racks but prevents passage of can bodies through said conduit means during the time said member's aperture is non-aligned with a can receiving opening of any of said racks, and means for actuating said second gate means whereby said second gate means limits the number of can bodies passing through said conduit means during a predetermined interval of time.

17. An apparatus as described in claim 1, in which said means for controlling said gate means includes means for sensing the number of can bodies passing through said conduit means and generating a signal in response thereto, and means responsive to said generated signal for controlling said gate means.

18. An apparatus as described in claim 1 in which said impact loading control means of said feed means includes a magnetic field.

19. An apparatus as described in claim 1 in which said impact loading control means of said feed means includes a stream of gas.

20. An apparatus as described in claim 1 in which said conduit means includes a terminating portion, said terminating portion including a downstream generally vertically disposed part and an adjacent upstream part, the extension of said upstream part forming an included angle with a generally horizontal plane of approximately 45 degrees or less.

21. An apparatus as described in claim 1 in which said feed means includes a terminating portion, said terminating portion including a downstream generally vertically disposed part and an adjacent upstream part, the extension of said upstream part forming an included angle with a generally horizontally plane of approximately 45 degrees or less.

22. An apparatus as described in claim 12 including means for detecting the presence of a can body within each rack and generating a signal in response thereto, and means responsive to said generated signal for controlling said feed means whereby said responsive means prevents said feed means from feeding can bodies into a rack having a can disposed therein.

23. An apparatus as described in claim 12 in which said rack has a can body receiving aperture and in which said feed means includes a member having an aperture formed therein and through which can bodies may pass, said member being mounted for translatory movement in a direction parallel with the direction of movement of said racks and at a speed equal to the speed of movement of said racks whereby the member's aperture and the rack's can-receiving opening are co-aligned for a predetermined interval of time, said feed means including means for moving said member in a direction opposite to that direction of movement of each rack until the member's aperture becomes co-aligned with the can-receiving opening of the adjacent rack.

24. An apparatus as described in claim 18 in which said feed means includes conduit means pivotally connected to said member and constructed to convey can bodies to said member's aperture and means for controlling the feeding of can bodies through said conduit means, said feed control means including an upstream and a downstream gate means, and means for actuating said gate means whereby said downstream gate means permits passage of can bodies through said conduit means during the time said member's aperture is co-aligned with a can receiving opening of one of said racks but prevents passage of can bodies through said conduit means during the time said member's aperture is non-aligned with a can receiving opening of one of said racks, and said upstream gate means being controlled by said gate actuating means to limit the number of can bodies passing through said conduit means during a predetermined interval of time.

25. An apparatus as described in claim 18 in which said rack conveyor means includes an actuating member associated with each of said racks, said feed means member includes a surface portion constructed for successively engaging each actuating member associated with each adjacent rack whereby movement of said actuating member produces a corresponding movement of said feed means member, and said feed means also includes means for disengaging said surface portion of said member from each of said actuating members and, upon disengagement thereof, moving said member of said feed means in a direction opposite to the direction of movement of said racks.

26. An apparatus as described in claim 12 in which said rack includes a can body exit aperture and said removal means includes a can member and a member actuated by said cam, said cam actuated member having, in one position thereof, a portion disposed to prevent passage of can bodies through said can body exit aperture and, in another position thereof, to permit passage of can bodies through said can body exit aperture.

27. An apparatus as described in claim 21 in which said feed means also includes means for controlling the number of can bodies to be fed into each rack, and in which each rack is generally vertically disposed with the can receiving aperture thereof being formed in the upper portion of said rack and the can body exit aperture being formed adjacent the lower portion of said rack.
23. An apparatus as described in claim 11 including means for creating a turbulent gas flow adjacent the coated surfaces of the can body to be disposed within said racks at least part of the time said racks are moving through said chamber.

24. An apparatus as described in claim 19 in which the member of said feed means is biased in a direction opposite to the direction of movement of said racks.

25. An apparatus as described in claim 11 including a prevention chamber and a cooling chamber and means for supplying a stream of gas flow to each of said chambers.

26. An apparatus as described in claim 12 in which said means for controlling said gate means includes means for sensing the number of can bodies passing through said conduit means and generating a signal in response thereto, and means responsive to said generated signal for controlling said gate means.

27. An 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, each rack being constructed to receive and support therein a plurality of can bodies and each of said racks having oppositely disposed side portions with an opening formed therein, each side portion being positioned adjacent a corresponding end of a can body to be disposed within said rack; means for feeding a plurality of can bodies into each of said racks, said feed means including 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; means for conveying said racks through said chamber; means for supplying through said racks a fluid in a direction substantially parallel to the surfaces of said racks to be disposed within said racks at least part of the time said racks are moving through said chamber; and means for removing from said racks said can bodies to be disposed therein.

28. An apparatus for treating the inner surface of a generally annular tubular body, said apparatus comprising: a treating chamber; a plurality of racks, each rack being constructed to receive and support therein a plurality of tubular bodies and each of said racks having oppositely disposed side portions with an opening formed in at least one side portion, each side portion being positioned adjacent a corresponding end of a tubular body to be disposed within said rack; means for feeding a plurality of tubular bodies into each of said racks, said feed means including means for controlling the impact loading exerted upon the tubular body or bodies to be disposed within each rack by the feeding of successive tubular bodies into each of said racks; means for conveying said racks through said chamber; means for supplying through said racks a fluid in a direction substantially parallel to the inner surfaces of said racks to be disposed within said racks at least part of the time said racks are moving through said chamber; and means for removing from said racks said tubular bodies to be disposed therein in an inclined position with respect to a horizontal plane.

29. An apparatus as described in claim 28 in which each rack includes means for supporting tubular bodies to be disposed therein.

30. An apparatus as described in claim 29 in which said feed means includes means for controlling the number of tubular bodies to be fed into each rack.

31. An apparatus as described in claim 30 in which each rack has a tubular body receiving aperture and in which said feed means includes a member having an aperture formed therein and through which tubular bodies may pass, said member being moved for traverse movement in a direction parallel with the direction of movement of said racks and at a speed equal to the speed of movement of said racks whereby the member's aperture and the rack's tubular body receiving opening are coaxial for a predetermined interval of time, said feed means including means for moving said member in a direction opposite to that direction of movement of each rack until the member's aperture becomes coaxial with the tubular body receiving opening of the adjacent rack.

32. An apparatus as described in claim 31 in which said feed means includes conduit means pivotally connected to said member and constructed to convey tubular bodies to said member's aperture and means for controlling the feeding of tubular bodies through said conduit means, said feed control means including an upstream and a downstream gate means, and means for actuating said gate means whereby said downstream gate means permits passage of tubular bodies through said conduit means during the time said member's aperture is coaxial with a tubular body receiving opening of one of said racks but prevents passage of tubular bodies through said conduit means during the time said member's aperture is non coaxial with a tubular body receiving opening of one of said racks, and said upstream gate means being controlled by said gate actuating means to limit the number of tubular bodies passing through said conduit means during a predetermined interval of time.

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