April 15, 1969 R. D. DUBBLE ET AL 3,438,803

METHOD AND MEANS FOR VAPOR COATING

Filed May 18, 1965 Sheet 1 of 8

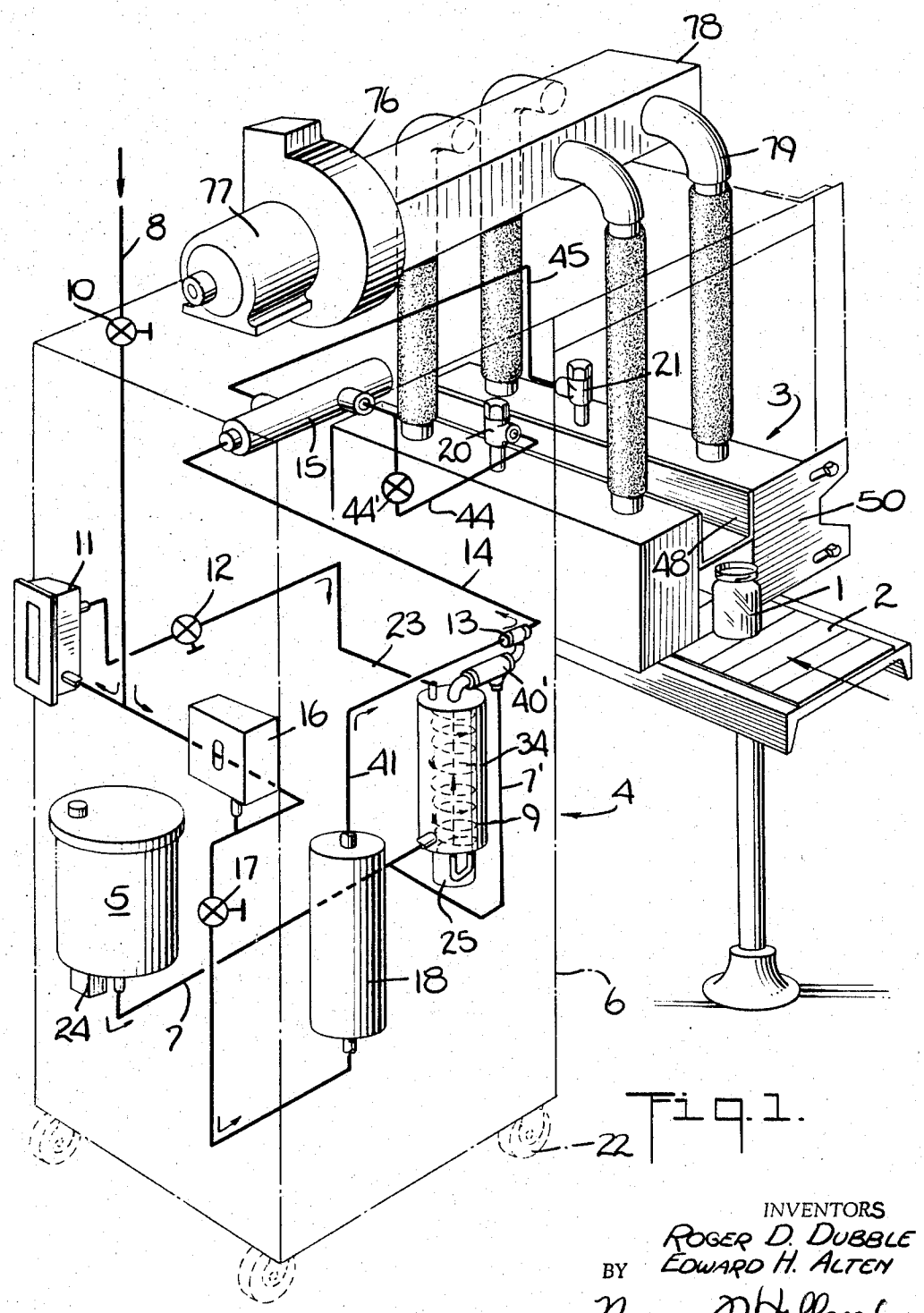

Fig. 1.

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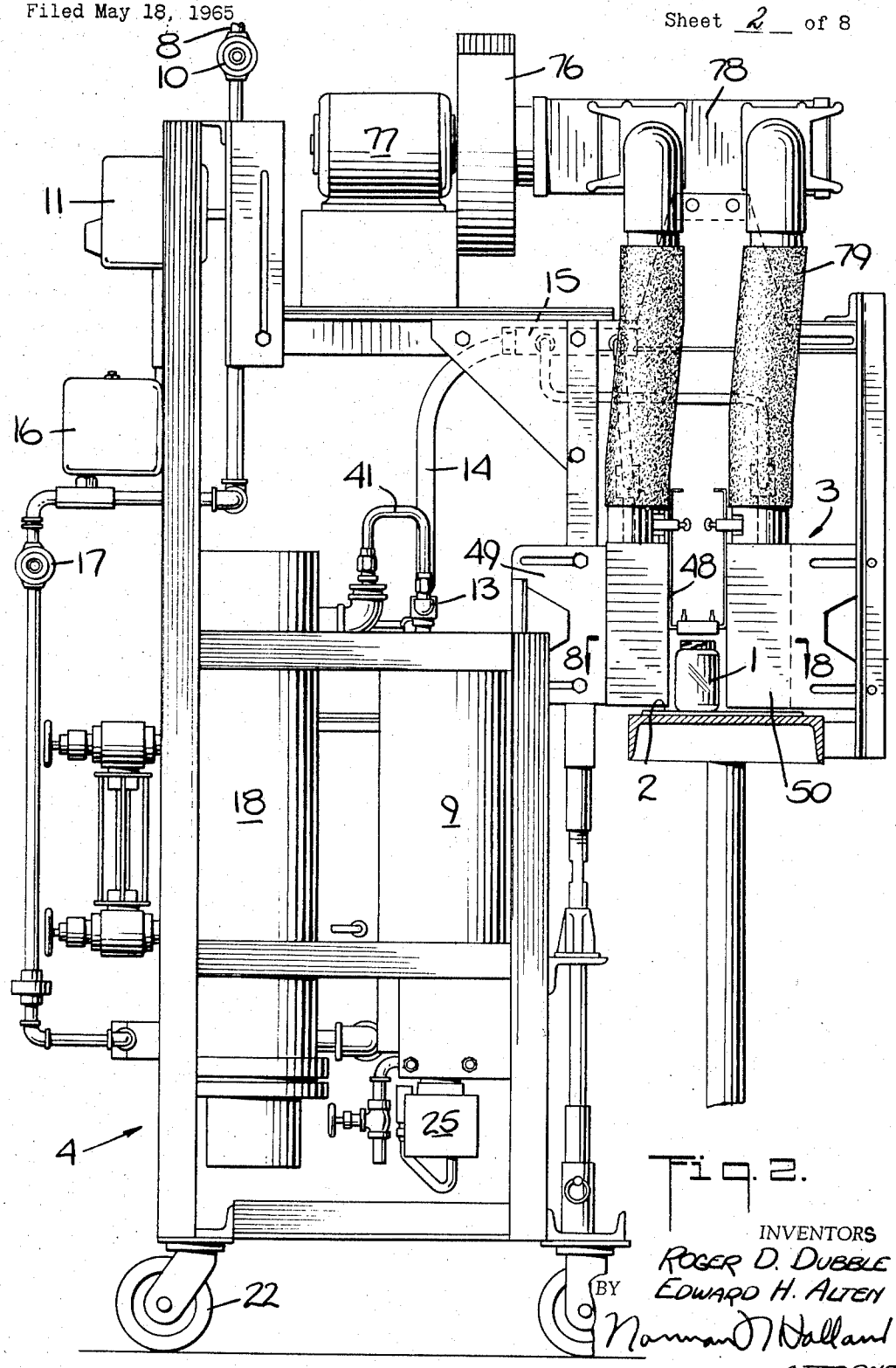

Fig. 2.

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METHOD AND MEANS FOR VAPOR COATING

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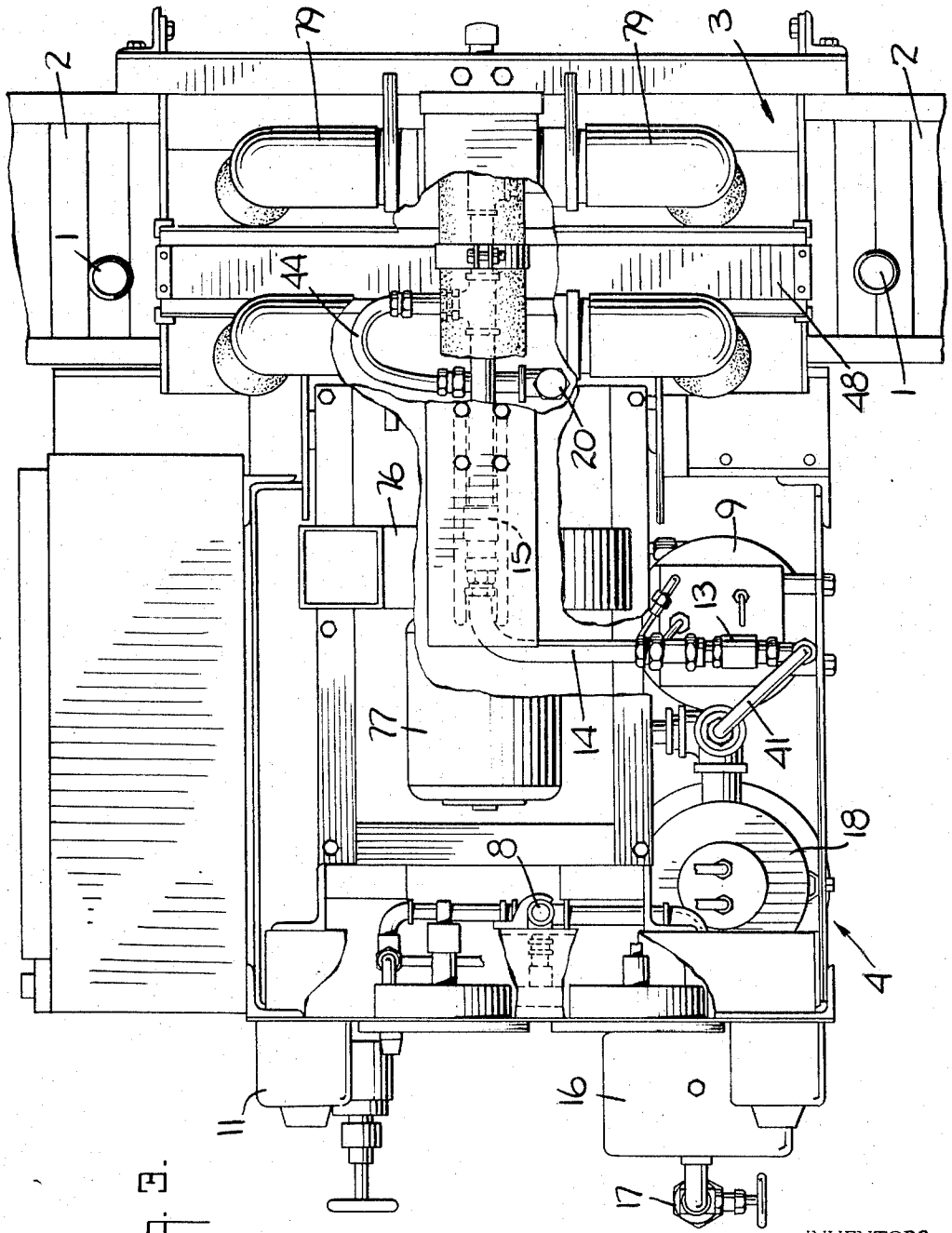

Fig. 5.

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METHOD AND MEANS FOR VAPOR COATING

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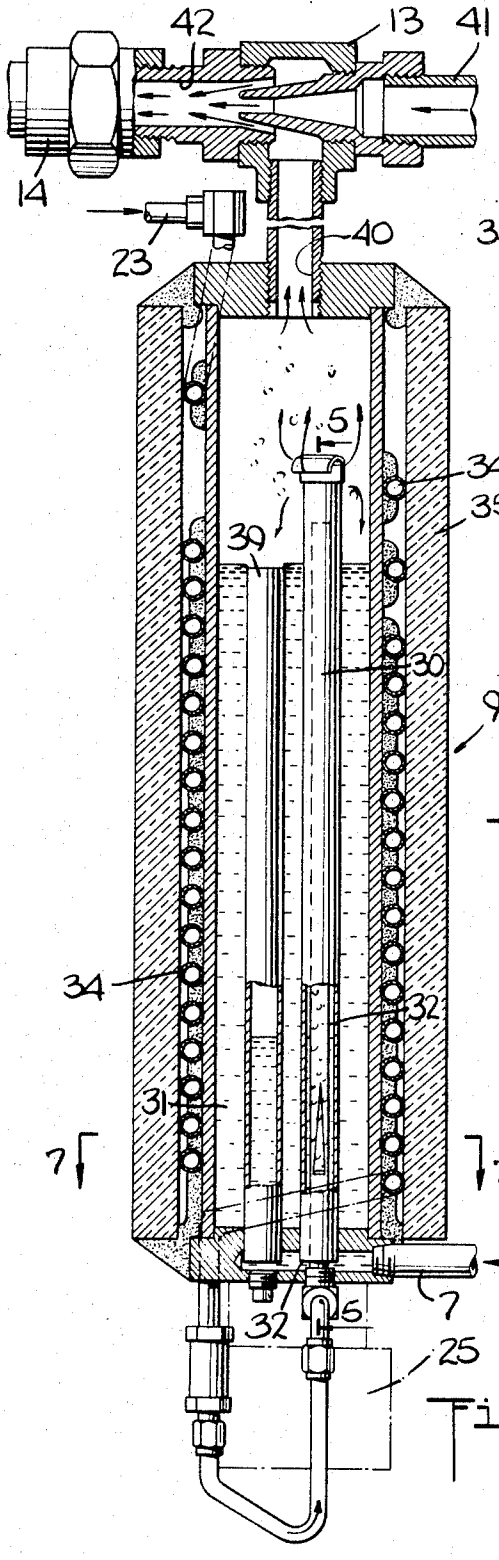

Fig. 4.

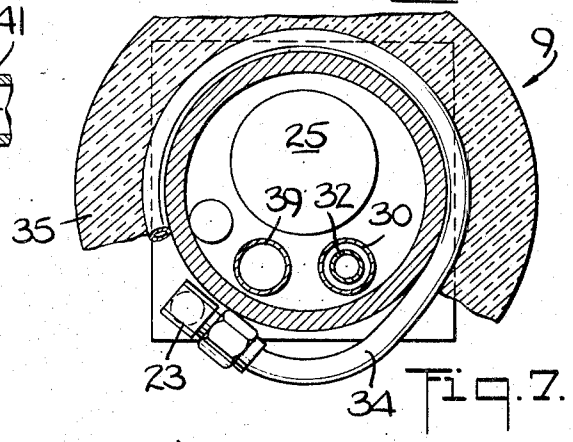

Fig. 7.

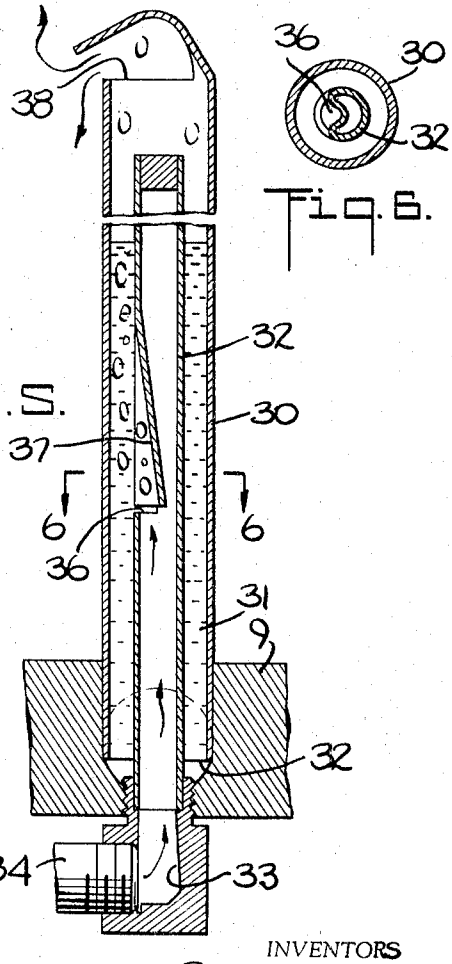

Fig. 5.

Fig. 6.

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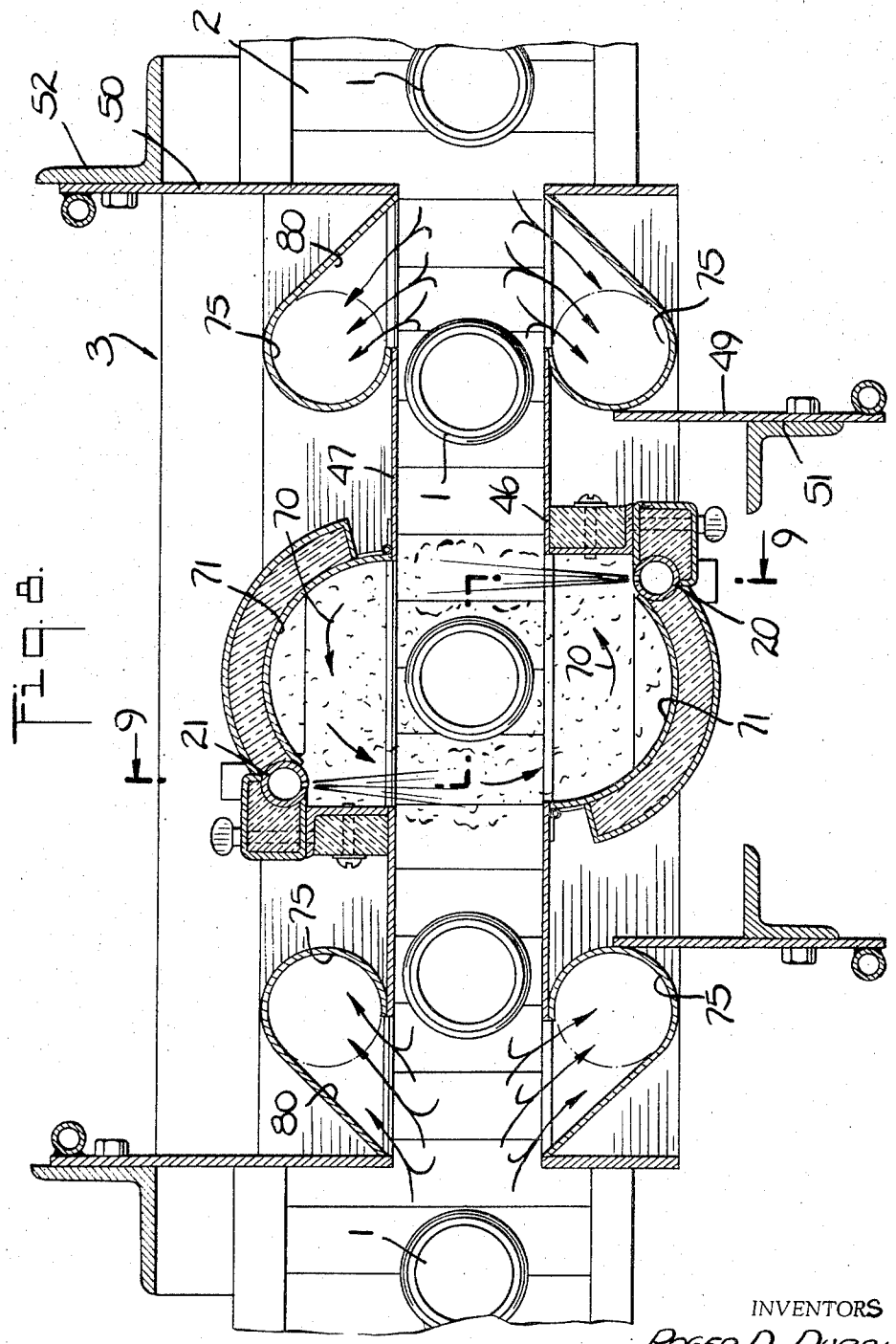

Fig. 4

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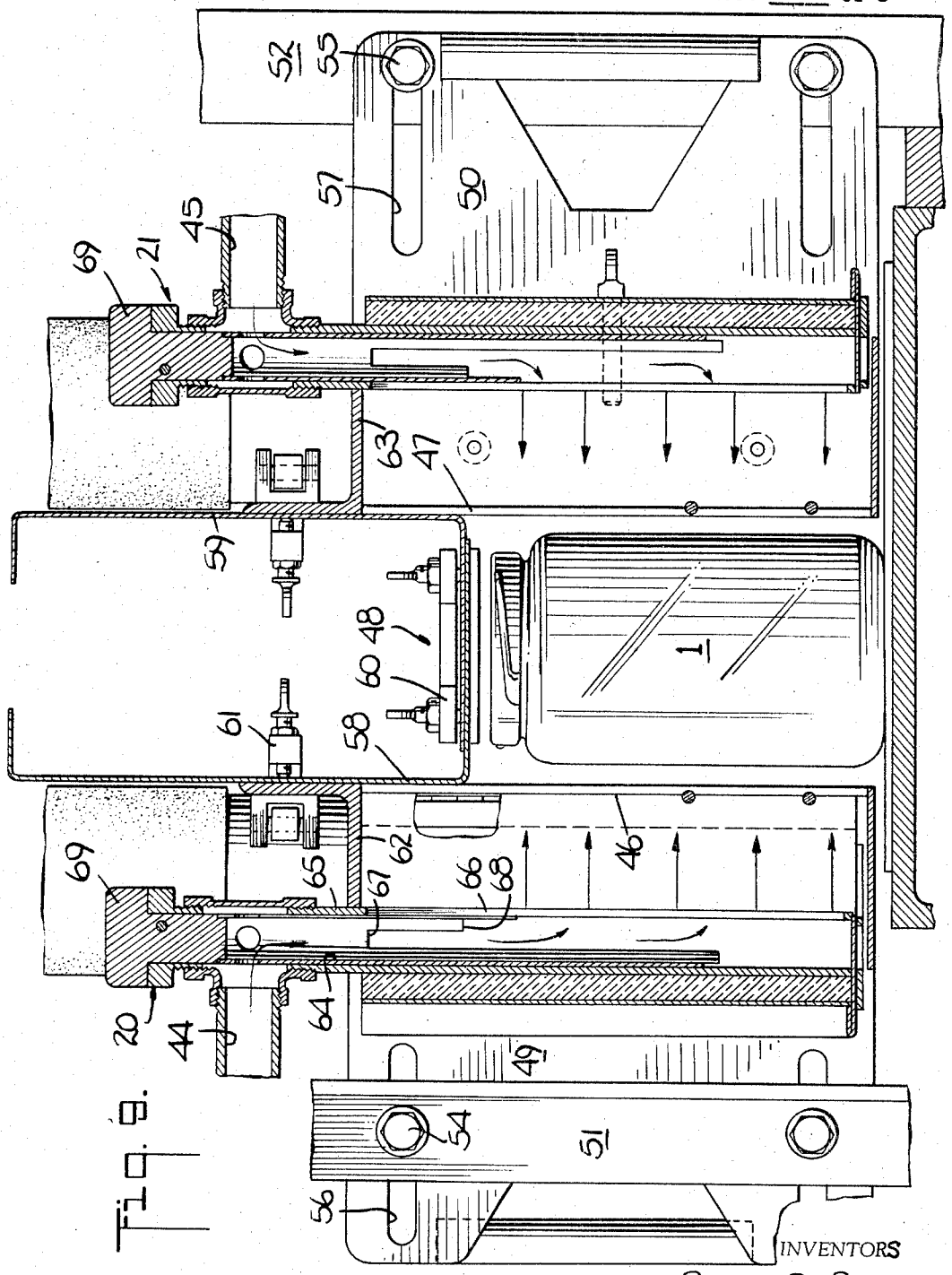

Fig. 8

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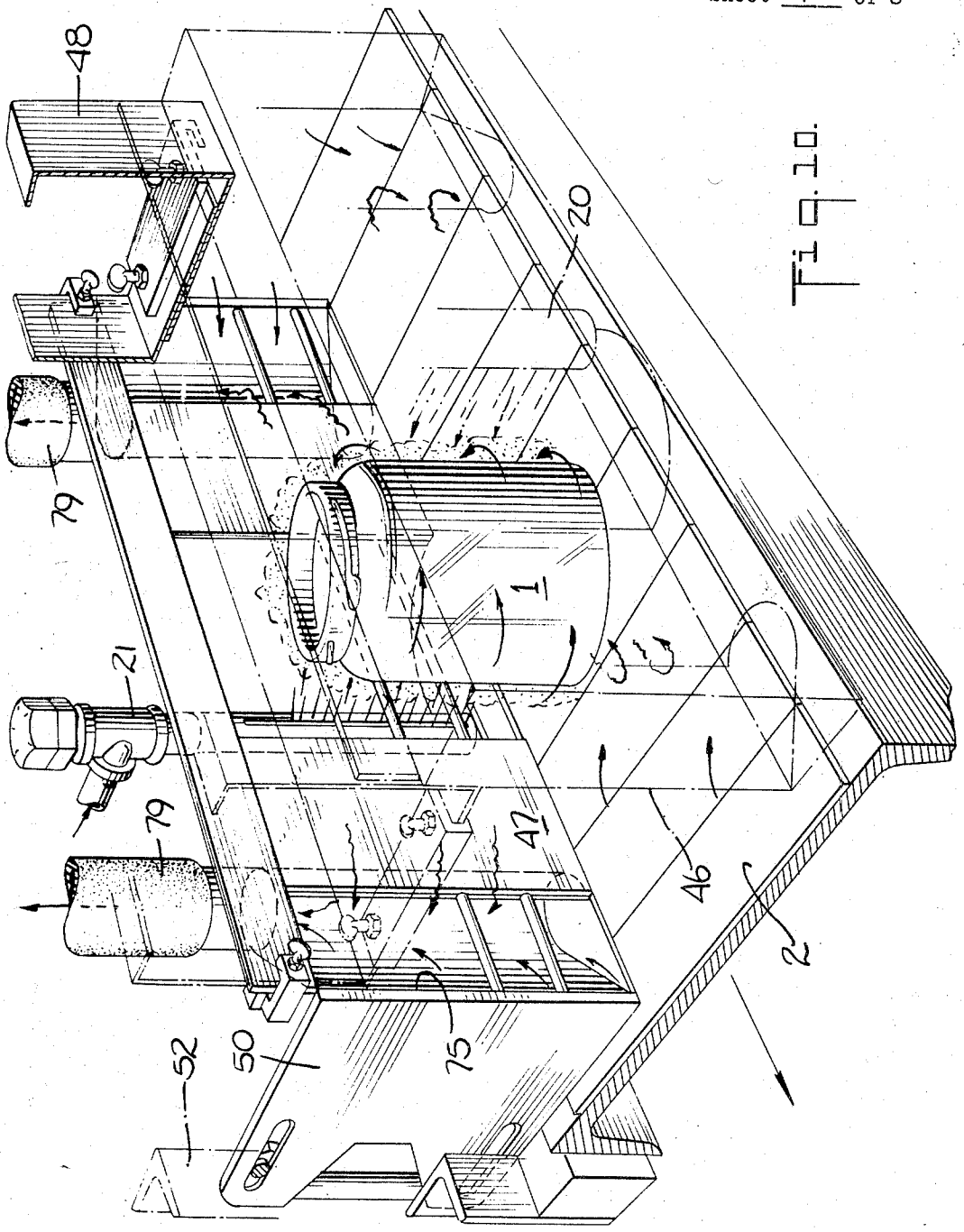

Fig. 10.

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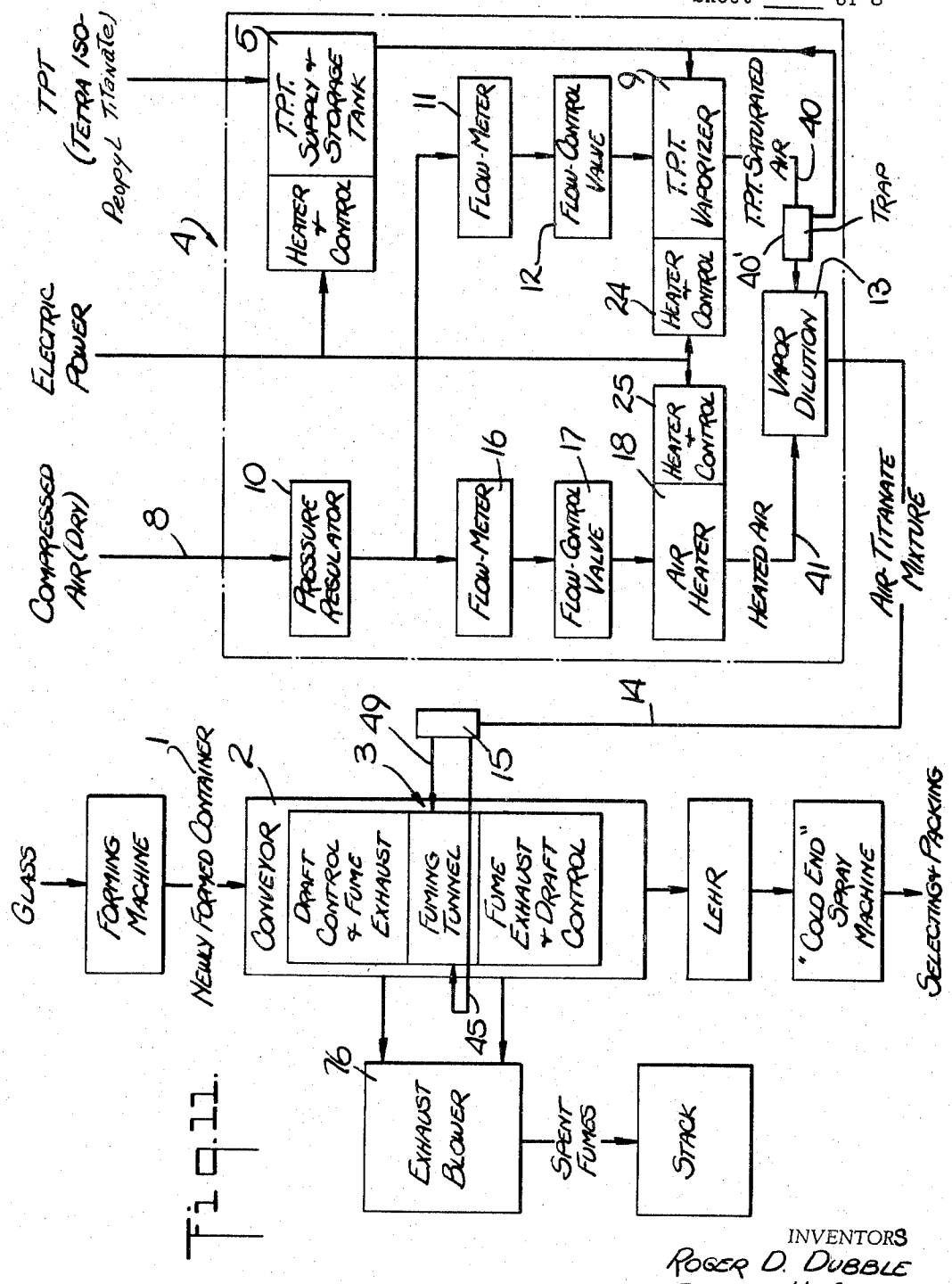

Fig. 11.

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United States Patent Office

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Patented Apr. 15, 1969

3,438,803

METHOD AND MEANS FOR VAPOR COATING

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Int. Cl. C23c *13/04, 13/08*

U.S. Cl. 117—106 9 Claims

ABSTRACT OF THE DISCLOSURE

A method and related apparatus for coating articles by exposing hot surfaces of the articles to a vapor, causing the vapor to pyrolize on the surfaces. The vapor is formed by bubbling a gas or gas mixture such as air through a liquid source of vapor. A preferred bubbler has a bubbling chamber including a vertical bubbler tube connected to the liquid source. A second tube within the bubbler tube has a closed top and a gas outlet in its side walls intermediate its bottom and a closed top which releases the bubbling gas into the bubbler tube. The heated articles, such as glass containers, are carried in an upright and spaced arrangement on a moving conveyor through a coating tunnel. Vapor nozzles are positioned in the tunnel adjacent arcuate vapor directing surfaces which form a cylindrical vapor pattern so that the axes of the moving containers are generally parallel to the axis of the vapor pattern.

The present application related to a method and means for generating a vapor and for applying the vapor to articles and more particularly to a method and means particularly adapted for applying a coating in the form of a pyrolyzed vapor on glass containers.

It has been found that the strength and scratch resistance of glass articles such as containers are increased by the formation of a coating on the outer surface of the containers. This vapor coating is advantageously formed by the exposure of hot container surfaces to the vapors of certain metallo-organic compounds where the vapors pyrolyze as they contact the hot surfaces of the glass and form thin metal oxide coatings on the glass surfaces.

The present invention provides an improved vaporizing apparatus and method and a cooperating vapor applying apparatus and method for forming a uniform coating of this type on containers and particularly for uniformly applying such coatings to closely spaced glass containers being moved at relatively high speeds past the coating device by a conveyor. The method and means of the invention generate the vapor in a predetermined and controlled concentration and with a substantial flow and direct the vapors thus formed by a novel distribution and application device forming coatings having a uniform thickness and a complete coverage of pre-determined container surfaces.

Accordingly, an object of the present invention is to provide a new method and means for applying coatings to containers.

Another object of the present invention is to provide an improved method and means for vaporizing a liquid.

Another object of the present invention is to provide an improved method and means for forming a vapor with a substantial and controlled flow and for directing the vapor uniformly over a series of moving articles.

Another object of the present invention is to provide a reliable and easily controlled method and means for forming a vapor with a pre-determined concentration and flow rate.

Another object of the present invention is to provide an improved vapor generating and applying means adaptable

for being contained in a compact and portable cabinet.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawings, forming a part of the specification, wherein:

FIG. 1 is a perspective view partially cut away illustrating a preferred embodiment of the invention;

FIG. 2 is a side elevational view of a preferred embodiment of the vaporizing and vapor applying apparatus;

FIG. 3 is a top plan view partially cut away of the apparatus of FIG. 2;

FIG. 4 is an enlarged detailed sectional view of the vaporizing chamber;

FIG. 5 is an enlarged sectional view of the bubbler tube of the vaporizing chamber taken along line **5—5** of FIG 4;

FIGS. 6 and 7 are horizontal sectional views of the vaporizing chamber taken along lines **6—6** and **7—7** on FIGS. 5 and 4 respectively;

FIG. 8 is a horizontal sectional view of the vapor dispenser taken along line **8—8** on FIG. 2;

FIG. 9 is a vertical sectional view of the vapor dispenser taken along line **9—9** on FIG. 8;

FIG. 10 is a perspective view partially cut away of the vapor dispenser; and

FIG. 11 is a flow diagram illustrating the operation of the improved vaporizing and dispersing apparatus and method.

The process and the apparatus will now be described generally with particular reference to FIGS. 1 and 11.

FIG. 1 illustrates the general arrangement of the vaporizing and dispenser apparatus. The apparatus is arranged as illustrated to apply the coating to a series of glass containers **1** being conveyed on a suitable conveyor **2** at relatively high speed through a vapor dispenser indicated generally at **3** and which is supplied with vapor from the vaporizer **4**.

As will now be more fully described, the vapor is generated from a liquid source of the particular vapor to be applied. This liquid is first vaporized and is then mixed with suitable quantities of a diluting inert carrier gas such as dry air or nitrogen or CO_2 and is passed to the vapor dispenser **3**. The final coatings applied to the articles such as glass containers are metal oxides resulting from the pyrolyzing or reduction of vapors of compounds such as terta-isopropyl titanate, tin tetrachloride, titanium tetrachloride, zirconium tetrachloride, germanium tetrachloride, vanadium tetrachloride or other vapor sources depending upon the particular coating desired. Where a titanium dioxide coating is applied tetra-isopropyl titanate is the preferred compound used as the vapor source.

The vaporizer **4** will now be described with reference to FIGS. 1 thru 3 and the flow diagram FIG. 11. The particular compound to be vaporized is stored in liquid form in the storage tank **5** within the cabinet **6**. An outlet conduit **7** feeds this liquid by gravity to the vaporizing chamber **9**, which will be described in detail below, and which generates a substantially saturated vapor. Dry air is supplied at inlet **8** and has its pressure regulated by the regulator **10** and then is passed through a flow meter **11** and a flow control valve **12** through conduit **23** to the vaporizing chamber **9**. The air acts as a pump and carrier in the chamber **9** to form a saturated air vapor mixture which passes from the top of the vaporizing

chamber 9 through a dilution nozzle or venturi mixer 13 and the conduit 14 to a vapor distributing manifold 15. Warm air is also supplied to the venturi mixer 13 from the regulator 10 through a flow meter 16 and a flow control valve 17 and finally through a thermostatically controlled air heater 18. The warm air from conduit 41 mixes with the saturated air vapor mixture passing from the top of the vaporizing chamber 9 to provide a diluted air vapor mixture for delivery to the vapor dispenser 3.

The air heater 18 is thermostatically controlled to raise the diluting air temperature so that it reaches the venturi mixer 13 at a higher temperature than that of the air vapor mixture passing out of the vaporizing chamber 9 thereby reducing the vapor concentration well below saturation to prevent condensation of the vapor in the distributing conduits, the manifold 15, or the dispenser 3. A thermostatically controlled heater 24 is used on tank 5 to keep the temperature of the tank 5 above the freezing point of the liquid to be vaporized. A thermostatically controlled heater 25 is used in the vaporizing chamber 9 to keep the temperature of the particular liquid being vaporized well above room temperature to facilitate the vaporizing action but preferably below the boiling point of the liquid.

The vapor distributing manifold 15 divides the air vapor mixture into two streams fed by conduits 18 and 19 to two vertical vapor applying nozzles 20 and 21 on opposite sides of the vapor dispenser 3 as will be described below.

The containers such as the container 1 illustrated are preferably passed through the dispenser 3 after being formed and prior to being annealed so that the container walls have a high temperature to pyrolyze the vapor being used to form the coating. The vapor pyrolyzes and decomposes upon the hot container surfaces to leave a thin metal oxide coating such as a titanium dioxide coating where tetra-isopropyl titanate is being vaporized. Such a coating has been demonstrated to provide scratch resisting and strengthening characteristics for glass containers.

As best seen in FIG. 1, the vaporizer 4 and the vapor dispenser 3 comprise a unitary and movable unit mounted on rollers 22 so that the complete vaporizer and dispenser unit may be moved into operative coating relationship with a regular forming machine output conveyor such as conveyor 2. The unit is thus particularly adaptable for use with a regular forming machine output line with little or no change in the arrangement of the forming machine output conveyor.

The construction and operation of the vaporizing chamber 9 will now be described with particular reference to FIGS. 4 thru 7.

As described above, the liquid to be vaporized is supplied from the storage tank 5 through an inlet conduit 7 to the vaporizing chamber 9. As best seen in FIG. 4, the conduit 7 communicates with a hollow bubbler tube 30 and the liquid 31 rises upwardly in the bubbler tube 30 through its lower open end 32 until the level of the liquid 31 within the bubbler tube 30 equals the liquid level of the supply tank 5.

As best seen in FIG. 5, the bubbler tube 30 has a center air pipe 32 having its lower end isolated from the liquid within the vaporizing chamber and connected through an air inlet 33 to the air conduit 23. In the embodiment of the air supply as best illustrated in FIG. 4, the air inlet conduit 23 is first wound down the outside of the vaporizing chamber in the form of a helical section 34 within insulation 35 so that the air is pre-heated to the approximate temperature of the liquid 31 within the vaporizing chamber 9. Alternatively the vaporizing air may be pre-heated by being passed through a heat exchanger mounted in the diluting air line 41 beyond the heater 18. The air may be admited to the top of pipe 32 and the bottom closed.

The vaporizing air passes upwardly through the air pipe 32 and enters into the liquid 31 between the air pipe 32 and the outer bubbler tube 30 through an air outlet 36 best illustrated in FIGS. 5 and 6. The preferred form of the outlet 36 comprises a narrow slot with an upwardly tapered groove 37 similar to an organ pipe opening permitting the air to pass outwardly in the form of bubbles in the liquid 31 which rise to the top of the bubbler tube 30 and wherein each individual air bubble accumulates or is saturated with vapor from the liquid 31 within the bubbler tube 30 as it rises through the liquid. The bubbling action results in a combined vapor forming and a liquid pumping action wherein the vapor passes upwardly to the venturi mixer 13 at the top of the vaporizing chamber 9 while unvaporized liquid is carried by the bubbles over the top 38 of the bubbler tube 30 so that liquid accumulates inside the vaporizing chamber 9.

The liquid 31 rises in the bottom of the vaporizing chamber 9 until it reaches the top of an overflow pipe 39 which returns the excess liquid to the lower open end of the bubbler tube 30 and insures that the top of the bubbler tube 30 remains above the accumulated liquid and free to operate in the above described manner.

While the exact concentration of the vapors of the various metallo-organic compounds used have not been found to be critical, it is preferable that the vapor leaving the vaporizing chamber 9 be below the saturation point to prevent condensation of the vapors on the various portions of the vapor distribution and dispensing system.

Higher concentrations approaching 100% saturation are less practical as indicated due to their tendency to condense before they are decomposed upon the hot surface of the containers 1 being coated. A trap 40' to remove liquid either carried into exit 40 by the bubbling action or condensing in the adjacent line is preferably included with a drain 7' for returning the liquid to the feed line 7 (FIGS. 1 and 11).

In order to obtain suitable concentrations as discussed above, an air mixing venturi 13 is included in the vapor transmission line. A convenient position for ths venturi is, as illustrated, just beyond the trap 40' of the vaporizing chamber 9. The substantially saturated vapor is mixed at the mixing venturi 13 with dry warm air as described above supplied through the air supply conduit 41 from heater 18 so that the final air vapor mixture passing from the mixer outlet 42 has the desired vapor concentration.

The air vapor mixture now passes through the conduit 14 to the manifold 15 which divides the flow into two conduits 44 and 45 directing the mixture to the two nozzles 20 and 21 on opposite sides of the vapor dispenser.

The preferred embodiment of the vapor dispenser will now be described with particular reference to FIGS. 8 thru 10.

In general, the dispenser includes a partially enclosed passageway or fuming tunnel having adjustably spaced side walls 46 and 47 and an adjustable cover 48. In order to provide for an adjustable width for the tunnel, the side walls 46 and 47 are mounted on lateral mounting flanges 49 and 50 adjustably attached to frame members 51 and 52 by the bolts 54 and 55 and slots 56 and 57 best illustrated in FIG. 9. The cover 48 also is adjusted for varying container widths and heights as it is formed of two separate sections 58 and 59 having overlapped bottom portions adjustably connected by the clamps 60 best seen in FIGS. 9 and 10 and being adjustably mounted for varying heights by clamps 61.

Each of the side walls 46 and 47 includes a vapor nozzle structure for providing a preferred vapor flow pattern at the central portion of the tunnel as well as a preferred exhaust system at their opposite ends which serves to reduce the entry of air into the tunnels and to exhaust excess vapor as will now be more fully described.

The vertical nozzles 20 and 21 are provided at opposite sides of the tunnel and they are attached to flange members 62 and 63 extending along the tops and outwardly of each of the side walls 46 and 47. The nozzles

20 and 21 each comprise telescoping hollow tubes 64 and 65 with a relatively narrow vertical slot 66 in the outer tube 65 positioned adjacent to the side walls of the moving containers 1. The effective height of each of the slots 66 is made adjustable to correspond generally to the height of the container side walls to be coated by having the slot 66 in the outer tube 65 extend the maximum height of the tunnel and by having a series of steps such as 67 and 68 as illustrated in FIG. 9 in the inner tube 64. By rotatably mounting the inner cylinder 64 a step of pre-determined position is placed adjacent the outer slot 66 to determine the exposed communicating portion of the outer slot 66. The adjustment is controlled by the circular knobs 69 at the tops of the inner tubes 64 slidably mounted on the outer tubes 65.

It has been found that the more uniform and better controlled vapor deposition and coating action is obtained by providing a flow pattern along the surfaces being coated. For cylindrical jars, a generally cylindrical flow at the mid-portion of the tunnel is preferred to cause the vapor to flow around the entire circumference of the jars as illustrated by the arrows 70 in FIG. 8. Such a flow is obtained by the arcuate back wall members 71 provided at each side of the tunnel and by spacing the nozzles 20 and 21 longitudinally of the tunnel and on opposite sides of the tunnel as illustrated. While two nozzles 20 and 21 are illustrated, a single nozzle may also be used for certain container sizes by eliminating one nozzle or by closing one off as by closing valve 44' (FIG. 1). The back wall members 71 and the adjacent wall structure are preferably insulated as illustrated to maintain a high temperature at the center of the tunnel to thereby prevent condensation of vapor and an accumulation of such condensed vapor within the tunnel.

In order to limit the entrance of air into the ends of the tunnel and to prevent the escape of vapor from the opposite ends of the tunnel, an exhaust system is provided including four outlets 75 positioned at opposite ends and on opposite sides of the tunnel as illustrated. This system includes an exhaust fan 76 and drive motor 77 as illustrated in FIG. 1 which are coupled through an exhaust manifold 78 to four vertical exhaust conduits 79. The conduits 79 communicate with the exhaust outlets 75 in the tunnel. The exhaust outlets 75 preferably have inclined back walls 80 best illustrated in FIG. 8 to form a curtain-like stream of air adjacent the tunnel ends to give the desired result of limiting air passage through the tunnel and at the same time to exhaust excess vapor from the tunnel to prevent an excessive pressure build up of the vapor air mixture within the tunnel.

It will be seen that an improved vaporizing and dispensing method and apparatus have been disclosed particularly adapted for producing and dispensing a vapor of pre-determined concentration and at high flow rates. The cooperating vapor dispensing is particularly useful for applying the vapor rapidly as well as uniformly to moving articles such as heated glass containers. The method and apparatus are capable of continuous operation with a consistent vapor concentration with a minimum of adjustment and supervision. They are thus particularly suited for use in high speed continuous vapor coating operations where large numbers of articles such as glass containers are continuously formed and coated. The vaporizing method described is applicable for providing protective coatings on glass containers or similar articles without interfering with the normal processes of article forming and annealing and with little or no re-arrangement of the article handling lines and with no reduction in the output rates of the forming and the annealing equipment.

Having thus described our invention, we claim:

1. A method of dispensing a vapor for decomposition on cylindrical surface portions of hot glass containers moving along a conveyor to form a uniformly thick coating thereon which comprises the steps of directing the vapor in a sheet like flow from nozzle means positioned on a side of the conveyor and generally normal to the conveyor direction and thereafter along arcuate flow directors positioned opposite one another on both sides of the conveyor thereby forming a generally cylindrical flow pattern, moving the hot containers from a forming machine into said cylindrical vapor flow pattern with the cylindrical axis of the containers being normal to said conveyor surface and generally parallel to and passing in close proximity to the axis of the cylindrical flow pattern.

2. The method as claimed in claim 1 which further comprises the step of exhausting the excess vapor from spaced points on the path of the moving containers and on opposite sides of the cylindrical flow pattern.

3. A vapor dispenser for directing a gas vapor against the side walls of generally cylindrical and moving containers comprising a conveyor, a tunnel means including a pair of spaced side walls and a top wall, nozzle means positioned on the side of the tunnel and having an elongated vapor outlet generally perpendicular to the direction of the moving containers, arcuately curved vapor directing means positioned opposite one another adjacent said walls on both sides of the conveyor and said directing means being positioned for directing the vapor from the nozzle outlet into a generally cylindrical flow pattern whose cylindrical axis is perpendicular to the conveyor surface.

4. A vaporizer comprising the combination of a liquid storage chamber, a generally vertical bubbler tube within said chamber having an open top and having its interior communicating with a source of liquid, and a second hollow tube within said bubbler tube having a closed top and having its interior coupled to a gas supply conduit and having a gas outlet in its side walls.

5. A vaporizer comprising the combination of a liquid storage chamber, a generally vertical bubbler tube within said chamber having an open top and having its interior communicating with a source of liquid, a second hollow tube within said bubbler tube having its interior coupled to a gas supply conduit and having a gas outlet in its side walls, a third generally vertical hollow tube in said chamber having an opening adjacent its upper end and having its lower end in communication with the interior of said bubbler tube, and a vapor outlet at the top of said chamber.

6. A vaporizer comprising the combination of a liquid storage chamber, a generally vertical bubbler tube within said chamber having an open top, means to supply a liquid to said bubbler tube between vertically spaced height limits, a second hollow tube within said bubbler tube having its interior coupled to a gas supply conduit, and having a gas outlet in its side walls intermediate said height limits, and a vapor outlet at the top of said chamber.

7. A vaporizer comprising the combination of a liquid storage chamber, a generally vertical bubbler tube within said chamber having an open top, means for supplying a liquid to said bubbler tube between vertically spaced height limits, a second hollow tube within said bubbler tube having its interior coupled to a gas supply conduit and having a gas outlet in its side walls, a third hollow overflow tube in said chamber vertically disposed and having an open top and having its bottom in communication with the interior of said bubbler tube, a vapor outlet for said chamber including a trap for liquid, and means for diluting the vapor with a gas.

8. A vapor dispenser for directing a gas vapor against the side walls of a generally cylindrical container comprising a conveyor, a tunnel means including a pair of spaced side walls and a top wall, a pair of vapor nozzles positioned on opposite sides of the tunnel and having elongated vapor outlets, said nozzles being spaced from another longitudinally of said tunnel, and arcuately curved vapor directing means adjacent each of said nozzles positioned to cooperate in directing the vapor from the pair of nozzle outlets into a generally cylindrical flow pattern

surrounding containers passing through said tunnel on said conveyor.

9. A vapor dispenser for directing a gas vapor against the side walls of a generally cylindrical container comprising a conveyor, a tunnel means including a pair of spaced side walls and a top wall, a pair of vapor nozzles positioned on opposite sides of the tunnel and having elongated vapor outlets, said nozzles being spaced from one another longitudinally of said tunnel and conveyor, arcuately curved vapor directing means adjacent each of said nozzles positioned to cooperate in directing the vapor from the pair of nozzle outlets into a generally cylindrical flow pattern surrounding containers passing through said tunnel on said conveyor, and exhaust means at opposite ends of said tunnel.

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U.S. Cl. X.R.

117—105.3, 124; 118—48, 314, 315, 324, 326; 261—121