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**Verreydt**

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[54] **METHOD FOR DEAERATING A CIRCUIT FOR THE TRANSPORT OF LIQUIDS**


[75] Inventor: **Jan Baptist Verreydt,** Edegem, Belgium

[73] Assignee: **Agfa-Gevaert, a naamloze vennootschap,** Mortsel, Belgium



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[58] **Field of Search** ..... 55/43–55, 160, 55/189–199; 117/34; 118/50, 610; 137/1, 15, 240; 134/21, 22 C



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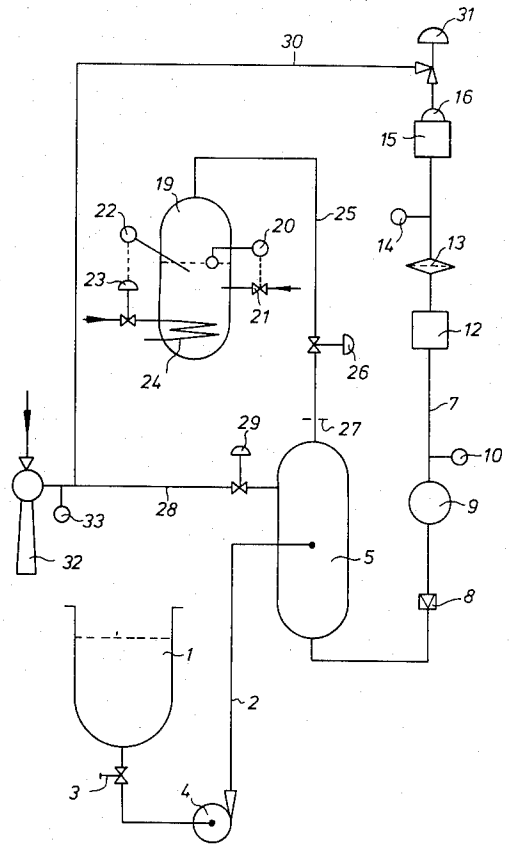
*Primary Examiner*—Samih N. Zaharna
*Assistant Examiner*—Richard W. Burks
*Attorney, Agent, or Firm*—William J. Daniel

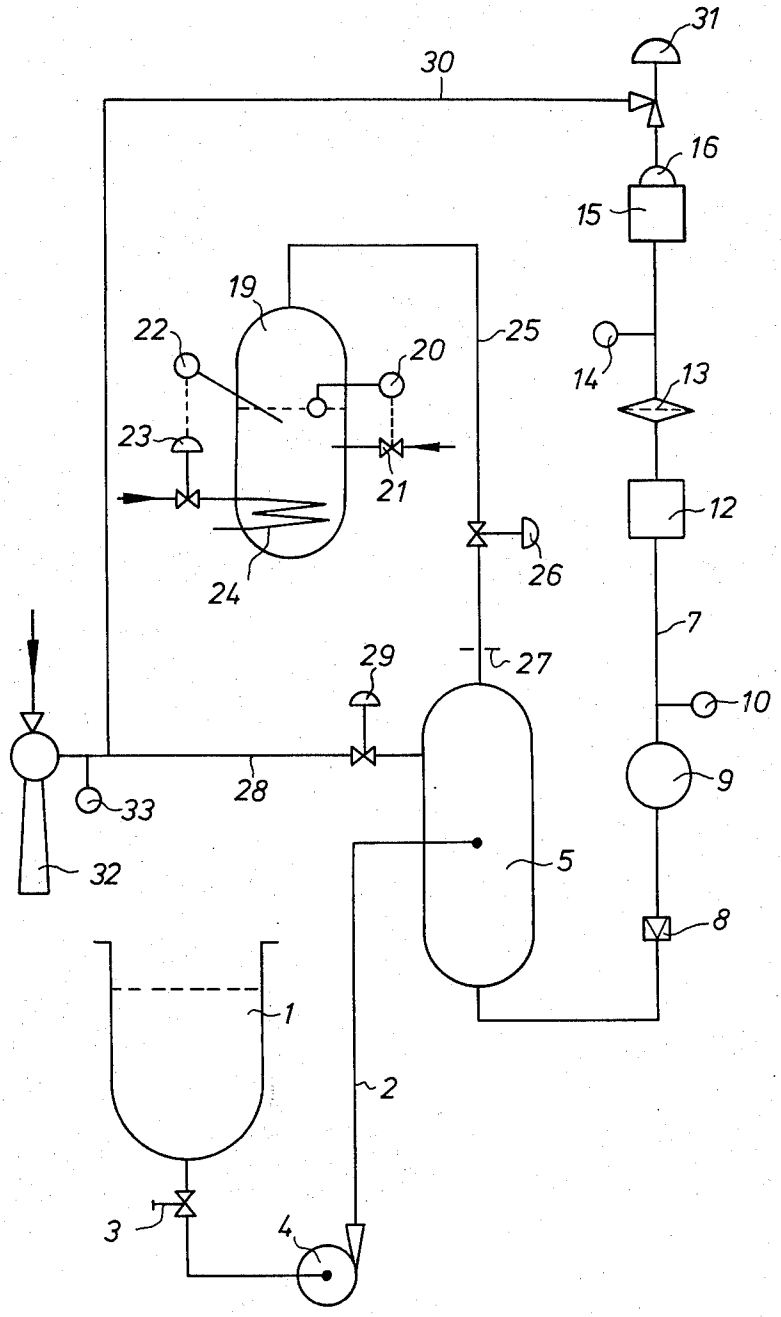


[57] **ABSTRACT**

A method for the deaeration of a liquid circuit, wherein the deaeration occurs by establishing a reduced pressure in said circuit for rarefying air or other gases present therein, by producing a saturated vapor at a pressure which is higher than the reduced pressure but lower than the atmospheric pressure and maintaining a current of said vapor through said circuit for expelling said rarefied air or other gases therefrom, and thereafter pumping a deaerated liquid through the circuit for expelling the vapor therefrom.


**7 Claims, 1 Drawing Figure**

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# METHOD FOR DEAERATING A CIRCUIT FOR THE TRANSPORT OF LIQUIDS

The present invention relates to a method for deaerating a circuit for the transport of liquids.

The invention is particularly intended for removing stagnating air or other gas bubbles in the conduits, connections, filters, measuring and metering apparatus, etc., of coating installations, especially of coating installations for the manufacturing of photographic light-sensitive material.

In many coating installations it is not possible to instal the conduits and the apparatus in such a way that the accumulation of air or gasbubbles in sinks, excavations, between joints or against walls, can be avoided. Moreover, many valves, connection systems, measuring and processing apparatus offer in the nature of their construction manifold opportunities for the accumulation of air or gas bubbles. Most coating systems for the coating of liquid layers onto webs operate horizontally and this position, in addition to the low liquid velocities which occur in the distribution channels, of said coating systems, promotes the retaining of air or gas bubbles.

It is further known that filter media in the form of woven material, of compressed fibers or of sintered material, very difficulty release air which is entrapped in meshes, pores or interstices, and the removel of this entrapped air may cause bubbles of microscopic size which may come free a long time after the filter medium has been wetted by a liquid. Furthermore, it is known that a filter medium may become quite impenetrable by air or gas bubbles as a consequence of capilary forces of the liquid in the spaces of the filter medium, so that air and gas bubbles which are carried along by a liquid may collect in front of the filter. These air or gas bubbles are removed in an irregular way in accordance with changes in flow conditions depending on the rate of flow, the viscosity and density of the liquid, etc.

The risk for the occurrence of the mentioned air or gas bubbles increases as the viscosity of a liquid becomes higher, and as an installation is used for shorter periods for different liquids, each new liquid requiring the draining and the cleaning of the circuit with the inevitable aeration of the circuit.

Known techniques comprising the use of deaerated rinsing liquids, or the establishment of a high vacuum, do not offer satisfactory results for the following reasons.

The rinsing of the circuit by means of a deaerated rinsing liquid must be carried out at different viscosities and flow rates and it should terminate preferably with a rather long rinsing phase with the process liquid to be transported through the circuit. The described technique is time consuming an may lead to considerable losses of expensive liquids, e.g. in the case of photographic coating compositions.

The deaeration of the circuit by the creation of a high vacuum in the circuit requires the use of expensive vacuum apparatus, and the evacuation of the circuit is limited by the vapor pressure due to the evaporation of residual of cleaning liquid which remain after the previous cleaning of the circuit. Furthermore, as the liquid is introduced in the circuit after the complete deaeration of the circuit, the liquid exhibits an important temperature drop as a consequence of evaporation effects



which are due to the overheating of said liquid. Said overheating is a consequence of the difference between the actual temperature of the liquid and the saturation temperature of said liquid at the high vacuum in the circuit, the saturation temperature being much lower than the temperature of the liquid entering the circuit. The described temperature drop frequently gives rise to congealing of the liquid, it may cause viscosity strands or streaks in the case of gelatineous or viscous liquids as well as foam formation in the case that tensioactive additives are present in the liquid.

The present invention aims to provide an improved method for deaerating a liquid circuit.

According to the present invention, a method for deaerating a circuit for the transport of liquids, in particular of photographic suspensions, comprises the steps of establishing a reduced pressure in said circuit for rarefying air or other gases present therein, producing a saturated vapor at a pressure which is higher than the reduced pressure but lower than the atmospheric pressure and maintaining a current of said vapor through said circuit for expelling said rarefied air or other gases from said circuit, and thereafter pumping a deaerated liquid through the circuit for expelling the vapor therefrom.

The establishment of the reduced pressure in the circuit has the effect that the volume of remaining air or gas bubbles is considerably increased, as compared with the volume at atmospheric pressure, so that said bubbles may more readily be siezed and expelled by the vapor current.

The pumping of the deaerated liquid through the circuit causes a sudden increase in pressure in said circuit so that the atmosphere at reduced pressure remaining in the circuit after the expelling of said rarefied air or other gases will be compressed to an extremely small volume which will condense or dissolve almost instantaneously as small vapor or gas bubbles into the current of deaerated liquid.

The term "circuit" as used in the present specification includes all the elements which are on the path of a deaerated liquid from the point of supply until the point where the liquid arrives at its final destination. In the example of the present specification, the circuit includes a supply tank, pumps, a deaerating station, a device controlling the rate of flow, a filter, and a coating station. It will be understood, however, that the method according to the invention may be used as well for the deaeration of liquid circuits which do not terminate in a coating station, but which may serve, for instance, for the transport of a liquid from one processing device to another.

Preferred, but non-essential, additional features of the method according to the invention are as follows.

The produced saturated vapor is admitted to the circuit through a conduit comprising an orifice controlling the rate of flow of the vapor.

The produced vapor is produced by evaporation of a liquid which is inert with respect to the physical and chemical properties of the process liquids.

A deaerated rinsing liquid is pumped through the circuit prior to the admittance thereto of a process liquid to be transported.

The invention will be described hereinafter with reference to the accompanying drawing which is a diagrammatic representation of an installation for performing the method according to the present invention.

A liquid composition, e.g. a light-sensitive photographic coating solution, is transported from a supply tank 1 with valve 3 through a conduit 2 to a deaeration apparatus 5. The liquid transport may occur by gravity, but it may also be performed by a pump, such as a pump 4 shown in the drawing. The deaeration apparatus 5 may be an apparatus known in the art, the operation of which is based on a vacuum treatment, an ultrasonic treatment or a combination of both. The coating composition is pumped by a positive displacement type pump 9, for the transport of a liquid from one processing device to another.

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The produced vapor is produced by evaporation of a liquid which is inert with respect to the physical and chemical properties of the process liquids.

A deaerated rinsing liquid is pumped through the circuit prior to the admittance thereto of a process liquid to be transported.

The present invention also comprises a method for the production of light-sensitive photographic recording material by the application of a thin layer of liquid coating composition from a coating device on a support which is moved past such coating device, wherein defects in the coated layer as a consequence of air bubbles in the coating composition are avoided by deaeration of the supply of coating composition and of the liquid circuit between the supply of coating composition and the outlet opening of the coating device, which is characterized thereby that the deaeration of said liquid circuit occurs by:

a. establishing a reduced pressure in said circuit for rarefying air or other gases present therein,

b. producing a saturated vapor at a pressure which is higher than said reduced pressure under (a) but lower than the atmospheric pressure, and maintaining a current of said vapor through said circuit for expelling said rarefied air or other gases from said circuit, and

c. thereafter pumping a deaerated liquid through the circuit for expelling the vapor therefrom.

The invention will be described hereinafter with reference to the accompanying drawing which is a diagrammatic representation of an installation for performing the method according to the present invention.

A liquid composition, e.g. a light-sensitive photographic coating solution, is transported from a supply tank 1 with valve 3 through a conduit 2 to a deaeration apparatus 5. The liquid transport may occur by gravity, but it may also be performed by a pump, such as a pump 4 shown in the drawing. The deaeration apparatus 5 may be an apparatus known in the art, the operation of which is based on a vacuum treatment, an ultrasonic treatment or a combination of both. The coating composition is pumped by a positive displacement type pump 9, such as a gear pump, through the conduit 7 which comprises a pressure sensor 10, a device 12 for measuring the rate of flow, a filter 13, and a temperature sensor 14. The conduit 7 terminates at a coating station 15 which may by any coating station known in the art, such as a dip coater, a cascade coater, an extrusion coater or a curtain coater.

A cap or hood 16 may be placed over the liquid outlet of the coater which is in communication with the air, and a rubber sealing joint (not shown) which is provided at the lower extremity of the cap may ensure an air-tight sealing between the cap and the said outlet of the coater. The conduits 2 and 7, and the different devices included in the circuit of said conduits are provided with water jackets or like means by means of which the said conduits and devices may be heated to a temperature which may be controlled by the temperature sensor 14.

The saturated vapor for expelling air or other gases from the circuit is produced in an evaporation apparatus 19 wherein the liquid to be evaporated, in the present example demineralised water, is maintained at a constant level by means of a level sensor 20 controlling the inlet valve 21 of a water supply and at a constant evaporation temperature by means of a temperature sensor 22 which controls the valve 23 of a high-pressure steam circuit which is in connection with a heating spiral 24 in the apparatus.

The vapor space in the evaporation apparatus 19 is maintained at a pressure which is lower than the atmospheric pressure in order to produce a saturated vapor at at temperature lower than 100 centigrades. Said saturated vapor may flow to the apparatus 5 through the conduit 25, the valve 26 and an extra resistance in the conduit just prior to the entrance of the apparatus 5, which resistance may be in the form of a calibrated diafragm 27 in the conduit. Up from the apparatus 5 the vapor can be conducted along two paths, viz. a first path comprising the valve 29 and the conduit 28 to a vacuum pump 32, and a second path comprising a back pressure valve 8 and the devices from pump 9 to cap 16 and a valve 31, and a conduit 30 leading to the vacuum pump 32. The vacuum pump 32 serves for sucking off air and vapor, and may be a waterjet or steamjet ejector, or a rotating wetted air pump, occasionally combined with a condensation device. The vacuum pump must create and maintain a sufficient low pressure in the circuit between the inlet valve 3 and the coating station 15 at the one hand, and between the evaporation apparatus 19 and the dearation apparatus 5 at the other hand. A vacuum meter 33 indicates the absolute pressure in the circuits.

The following sequences illustrate the operation of the arrangement without limiting, however, it thereto.

1. The circuits of conduits 2 and 7 between valve 3 and coating system 15 are free of coating composition or rinsing liquid, and they are at atmospheric pressure. The coater 15 is brought into a position wherein the deaeration may occur under the best circumstances. Valves 3, 23, 26, 29 and 31 are closed.

2. The vacuum pump 32 is started and valves 29 and 26 are opened in order to evacuate the air from the vapor space of the evaporation apparatus 19 until the vapor pressure corresponding to temperature of the unheated liquid in said apparatus is reached. In the case of water as mentioned already hereinbefore, the pressure will have to drop to 17, 5 Torr for a water temperature of 20 centigrades. Thereafter the valve 26 of the conduit 25 is closed.

3. The vacuum pump continues to remove air from the conduit 2, pump 4 and the apparatus 5 upto the back pressure valve 8, until the vacuum meter 33 indicates a sufficiently low pressure, e.g. a pressure of 10 to 20 Torr. The valve 29 is closed and the circuit may be checked for occasional leakage.

4. The hood 16 is placed over the liquid outlet of the coater 15 and valve 31 is opened so that the conduit 7 may be deaerated from the back pressure valve 8 up to

and including the conduit **30**, to a low pressure which amounts to the same order of magnitude as that attained under the sequence **3**, i.e. 10 to 20 Torr.

5. The conduits **2** and **7** and as the case may be some or all of the apparatus connected into said conduits, are heated to the temperature of the coating composition, e.g. 35 centigrades, so that residual amounts of a prior coating composition or of rinsing liquid may evaporate during this preparatory phase and condensation of water vapor during the next phase is avoided to a considerable extent.

6. After the pressures mentioned under sequences **3** and **4** have been attained, valve **31** of the conduit **30** is closed and the evaporation apparatus **19** is started by opening the steam valve **23.** The temperature of the saturated vapor which is produced in the apparatus **19** is set by means of the temperature sensor **22** so that the temperature thereof is higher than the temperature of the coating composition. Said temperature difference may amount in a preferred embodiment from 10 to 20 centigrades so that, for a coating composition temperature of 35 centigrades the temperature of the saturated vapor may amount to 55 centigrades. The vapor pressure which corresponds with this temperature at saturation is about 120 Torr.

By opening the valves **26** and **29,** the produced water vapor expands over the diafragm **27** and flows at a controlled rate through the deaeration apparatus **5** and the conduit **28** whereafter it is evacuated by the vacuum pump **32.** As a consequence of its high velocity at low density, the water expells the air which is present in the circuit at low pressure. The described expellation cycle continues for a certain time which, for a given installation may amount for instance to 30 to 120 seconds, and thereafter the valve **29** is closed.

7. Valve **31** is opened so that the water vapor now may stream via the apparatus **5,** the back-pressure valve **8** and the devices **9, 10, 12, 13** and **14,** the coater **15,** the suction hood **16** and the conduit **30** to the vacuum pump **32.** In a similar way as described hereinbefore under sequence **6,** the enclosed air and gases will be expelled from the apparatus and the conduits by the water vapor which streams during a given time at high velocity through the circuit in the direction of transport of coating composition. This second expellation cycle may continue for a period of time, say 1 to 10 minutes.

8. Valve **31** is closed, valves **29** and **3** are opened, and pumps **4** and **9** are started. The coating composition flows from the supply tank **1** through the pump **4** and the conduit **2** to the deaeration apparatus **5,** and rarefied air which might occasionally be present in the conduit **2** and the pump **4** is carried off through the deaeration apparatus **5** and the conduit **28** to the vacuum pump **32,** together with saturated water vapor which is being supplied through the conduit **25.**

After the deaeration of the coating composition in the apparatus **5,** the coating composition is pumped by the pump **9** through the conduit **7** and the corresponding devices to the coater **15.** As a consequence of the sudden pressure increase in the circuit, the water vapor atmosphere will collapse to a very small volume and will condense almost instantaneously as small droplets into the coating composition. The coating composition finally will completely fill up the circuit to the valve **31.** It will be understood that the described sequence has been carried out while the devices **9** and **12** which may control the rate of flow remained inoperative.

9. The valve **3** is closed, the pump **4** and **9** are stopped, the hood **16** is removed from the coater **15** and the latter is brought into the operative coating position. The valve **3** is re-opened, the pumps **4** and **9** are restarted, the mechanism driving the web to be coated at the coating station is started and the system controlling the rate of flow comprising devices **9** and **12** is made operative so that the proper coating can start.

It will be understood that the described operations and the devices for performing them are not limitative for the method according to the present invention, and the following embodiments illustrate only some obvious alternatives.

The flow of water vapor through the deaeration apparatus **5** can be arrested or continued at will during the sequences described under **8** and **9** by opening or closing the valves **26** and **29.**

The sequence under **8** and **9** can also be performed by means of an appropriate rinsing liquid, and the proper coating composition may be admitted to the circuit only after the rinsing liquid has flown through the circuit and the coater **15** for a certain time.

An appropriate mechanism may control the different valves, pumps, heating means, etc., so that the sequences from **1** to **9** may be controlled completely automatically.

The heating of the liquid in the evaporation apparatus may occur electrically rather by steam heating, and thus the sensor **22** may control a switch in an electric circuit for feeding an electric heater spiral mounted electrically insulated in the tank **19.**

In case the coating system does not lend itself to a ready deaeration by means of a vacuum hood as described, and if a deaeration of the circuit feeding the coater is yet required, a two-way valve may be provided in the supply circuit of the coater between the coater **15** and the filter **13,** so that the circuit of the conduit **7** may be directly connected to the valve **31** for the deaeration thereof, or that it may be connected to the coater **15** for the coating operation.

We claim:

**1.** Method for deaerating a circuit for the transport of liquids, in particular of photographic suspensions, comprising the steps of:

a. establishing a reduced pressure in said circuit for rarefying air or other gases present therein,

b. producing a saturated vapor at a pressure which is higher than said reduced pressure under (a) but lower than the atmospheric pressure, and passing a current of said vapor through said circuit for expelling said rarefied air or other gases from said circuit, and

c. thereafter pumping a deaerated liquid through the circuit for expelling the vapor therefrom.

**2.** Method according to claim **1,** wherein the produced saturated vapor is admitted to the circuit through a conduit comprising an extra resistance whereby the rate of flow of the vapor is controlled and the pressure drop in the circuit is displaced in the direction of the source of saturated vapor.

**3.** Method according to claim **1,** wherein said vapor is water vapor.

**4.** Method according to claim **1,** wherein the temperature of the produced vapor is higher than the temperature of the deaerated liquid which is pumped through the circuit for expelling the vapor therefrom.

5. Method according to claim 1, wherein said deaerated liquid is the process liquid to be transported through the circuit.

6. Method according to claim 1, wherein said deaerated liquid is a rinsing liquid which is pumped through the circuit prior to the admittance thereto of the process liquid to be transported.

7. Method according to claim 1, wherein said circuit terminates at a station for coating the transported liquid onto a moving web, and wherein the liquid outlet of said station is adapted to be put into connection with a vacuum conduit for performing steps (a) and (b).

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