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(54) **METHOD AND FILLING DEVICE FOR CONTACT FILLING AN ARTICLE WITH POURABLE PRODUCT**

(57) There is described a method for contact filling a first article (2b) with a pourable product, comprising the steps of i) arranging a first mouth (3) of first article (2b) in contact with a first filling body (10) of a first filling device (1b, 1b', 1b''); first filling body (10) defining a respective first fluidic line (11) for pourable product and comprising a shutter (15) which can be selectively set in an open position in which it allows the flow of pourable product

along first fluidic line (11) and towards first article (2b) and a closed position in which it prevents flow; ii) filling second article (2b) by setting said shutter (15) in open position for a current time interval (Δt); iii) updating current value of time interval (Δt), on the basis of the difference between an estimated actual filling volume and a desired filling volume of first article (2b) after step ii).

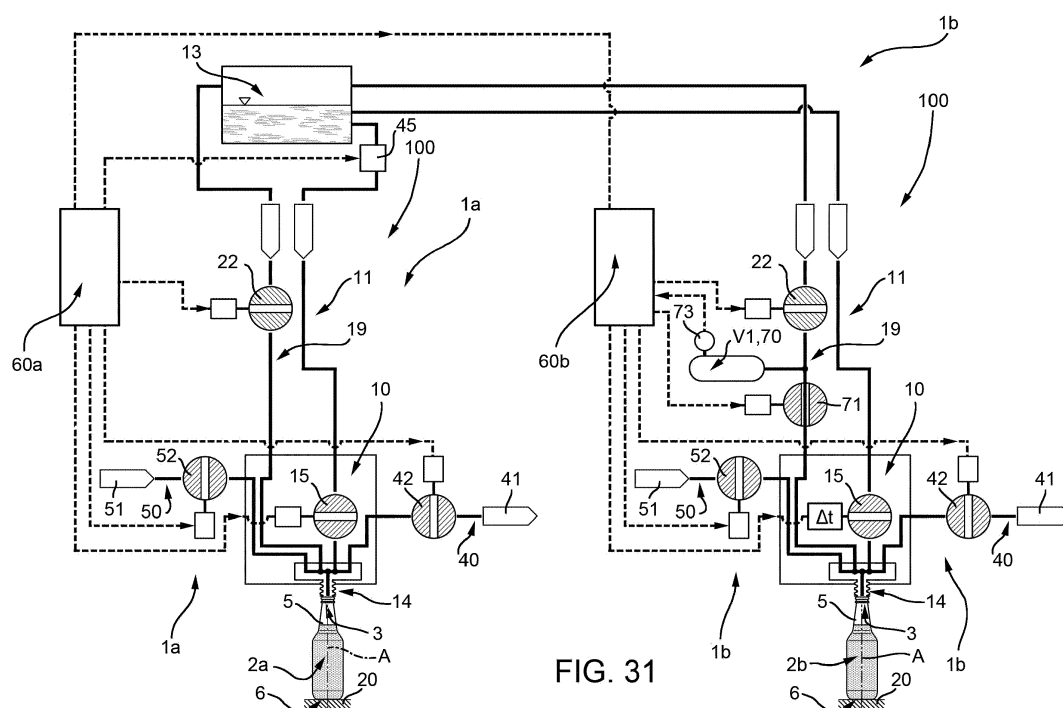


FIG. 31

Description

[0001] The present invention relates to a method and to a filling device for contact filling an article with pourable product, in particular a carbonated pourable food product such as beer or mineral water.

[0002] Filling machines are known comprising a filling station, which is fed at the input with empty articles, and supplies at the output articles filled with the pourable product.

[0003] The filling station substantially comprises a carousel conveyor rotating about an axis of rotation; a tank containing the pourable product; and a number of filling devices fluidly connected to the tank and fitted to the conveyor, radially outwards of the axis of rotation of the conveyor.

[0004] More specifically, the conveyor comprises a number of supports for positioning the mouths of the relative articles beneath the respective valves, and for moving the relative articles along an arc-shaped path about the axis of rotation and integrally with the respective valves.

[0005] Each support is also movable parallel to a respective second axis, which is parallel to and spaced from the axis of rotation of the carousel, between a lowered rest position and a raised operative position.

[0006] Each filling device substantially comprises a fastening body for attachment to the conveyor and defining a filling chamber connected fluidly to the tank, and a filling head fitted to the relative fastening body.

[0007] Each filling head comprises, in turn, a first fluidic line which extends from the tank to the mouth of the respective article, and a shutter movable inside the chamber between a closed position cutting off flow of the pourable product along the first fluidic line, and an open position connecting the chamber fluidly to the mouth to allow flow of the pourable product along the first fluidic line.

[0008] Furthermore, each filling head comprises a second fluidic line, which extends between the tank or a collector filled with a gas and the inner volume of the article and is configured to allow the pressurization of the article before the filling thereof and the return of the gas contained inside the article, during the filling thereof.

[0009] Each support receives the respective empty article to be filled at an inlet station of the arc-shaped path and discharges the filled articles at an outlet station of the arc-shaped path. Furthermore, each article is filled by relative filling head with the pourable product, as it is advanced by relative support along the arc-shaped path.

[0010] Furthermore, each support is arranged in the respective lowered rest position at the inlet station and the outlet station of the arc-shaped path. When each support is arranged in the relative lowered rest position, the relative mouth is spaced along respective second axis from the body of the relative filling device.

[0011] Each support is arranged in the relative raised operative position along the arc-shaped path. Due to the fact that each article is contact filled by relative filling device, it is arranged in tight-fluid contact with the body of relative filling device along the arc-shaped path.

[0012] Still more precisely, when each support is in the relative raised operative position and the mouth of relative article tight-fluid contacts the corresponding filling body, the following operations are carried out:

- at first, each article is pressurized to the same pressure as the pourable product during the filling process, by feeding a fluid, e.g. carbon dioxide, into it, with the shutter in the closed position;
- then, each article is filled with the pourable product, with the shutter in the open position; and
- finally, each article is depressurized, so that the pressure in the empty volume above the pourable product level equals atmospheric pressure, by discharging the aeriform contained in the article and with the shutter in the closed position.

[0013] It is known in the art to carry out a so-called "volumetric filling", i.e. to fill the article with a given volume of pourable product.

[0014] According to a known technical solution, it is known in the sector to provide the filling device with a flow-meter for measuring the flow of the pourable product which fills the article. The shutter is moved back into the closed position when the flow-meter has detected that a desired volume of pourable product has filled the article.

[0015] It has been proposed in the sector to carry out the "volumetric filling" without providing all the filling devices of the filling station with respective flow-meters or providing none of the filling devices at all with respective flow-meters.

[0016] As a matter of fact, a reduction in the number of flow-meter would dramatically reduce the overall cost of the filling station.

[0017] For example, WO-A-2005/080202 and US 5,273,082 disclose a filling station with a "master" filling valve provided with a flow-meter and a plurality of "slave" filling valves without flow-meters. In particular, the "slave" filling devices comprise respective shutters, which are kept in the respective open positions for respective time intervals.

[0018] The flow-meter of the "master" filling device is connected to a control unit, which determines, on the basis of the volume measured by the flow-meter, the time intervals of the shutters of the "slave" filling devices.

[0019] In other words, the "slave" filling devices carry out a "time-controlled filling", which is controlled on the basis of a "volumetric filling" carried out by the "master" filling device.

[0020] A need is felt in sector to increase as far as possible the precision and the repeatability of a filling station comprising at least one filling device, which is provided with a time-controlled shutter and does not have any flow-meter.

[0021] It is an object of the present invention to provide a method for contact filling an article with a pourable product, allowing to meet at least one of the aforementioned needs in a simple and cost-effective manner.

[0022] This object is achieved by a method for contact filling contact filling an article with a pourable product, as claimed in claim 1.

[0023] The present invention also relates to a filling device for contact filling an article with a pourable product, as claimed in claim 13.

[0024] Three preferred, non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

- Figures 1 to 10 are schematic views of subsequent operative steps of a first embodiment of a filling device in accordance with the present invention;
- Figures 11 to 20 are schematic views of subsequent operative steps of a second embodiment of the filling device in accordance with the present invention;
- Figures 21 to 30 are schematic views of subsequent operative steps of a third embodiment of the filling device in accordance with the present invention;
- Figure 31 is a schematic view of a filling station incorporating the first embodiment of the filling device according to the present invention and of a further filling device; and
- Figure 32 is a flow chart showing the operation of the filling station of Figure 31.

[0025] With reference to Figure 31, number 100 indicates a filling station for contact filling a plurality of articles, hereinafter referred to as containers 2a, 2b with a pourable product, especially a carbonated food pourable product, beer in the embodiment shown.

[0026] Filling station 100 substantially comprises:

- a carousel (not-shown), which is rotatable about an axis, which is in vertical, in use;
- a tank 13 filled with the pourable product; and
- a filling device 1a and a plurality of filling devices 1b which are fitted to a periphery of the carousel and are adapted to fill relative containers 2a, 2b with the pourable product.

[0027] Each container 2a, 2b comprises, in a known manner,:

- a mouth 3, through which container 2a, 2b is filled by relative filling device 1a, 1b, and the pourable product is subsequently poured from container 2a, 2b;
- a bottom wall 6, which is opposite to mouth 3; and
- a neck 5, which extends from mouth 3 towards bottom wall 6 and is detached by bottom wall 6.

[0028] In the following of the description, only one filling device 1b will be described in detail, being all filling devices 1b identical to one another.

[0029] Filling device 1b is shown in Figures 1 to 10. Filling device 1a is similar to filling device 1b and is shown only in Figures 31 and 32.

[0030] In the following of the present description, the differences between filling devices 1a and 1b will be specified.

[0031] With reference to Figures 1 to 10, filling device 1b substantially comprises:

- a body 10 defining a filling opening 14;
- a fluidic line 11, which extends between an opening 12 fluidly connected with tank 13 and filling opening 14, which is arranged on the opposite side of opening 12,;
- a shutter 15 (only schematically shown in Figures 1 to 10) arranged inside body 10 and along fluidic line 11, and which can be set either in an open position (Figure 5) in which it fluidly connects openings 12, 14 or in a closed position (Figures 1 to 4 and 6 to 10) in which it fluidly isolates openings 12, 14 and prevents the flow of pourable product along fluidic line 11; and
- a support 20 which is adapted to contact wall 6 so as to move it parallel to an axis A between a rest position and an operative position.

[0032] Tank 13 is filled, in the embodiment shown, with the pourable product and with an aeriform, carbon dioxide in the embodiment shown.

[0033] Support 20 is movable parallel to axis A between:

- a lowered rest position, in which mouth 3 is spaced along axis A by body 10 and opening 14 of filling device 1a, 1b; and
- a raised operative position, in which mouth 3 is in tight-fluid contact with body 10 and opening 14 of filling device 1a, 1b through the interposition of an annular gasket.

[0034] When support 20 is in the raised operative position, container 2b preferably undergoes the following operations according to the so-called contact filling modality:

- a vacuum generation step (not shown), during which vacuum is generated inside the inner volume of container 2b with the shutter 15 in the closed position, so as to prevent the risk of oxidation of the pourable product;
- a pressurization step (shown in Figure 4), during which the inner volume of container 2b is pressurized to the same pressure as the pourable product during the filling process with shutter 15 in the closed position, for example by feeding a pressurizing fluid, e.g. carbon dioxide, into it;
- a filling step (shown in Figures 5), during which shutter 15 moves to the open position, so as to fill container 2b with the pourable product, so as to fill container 2b according to the so-called "contact" modality, i.e. by isolating fluidic line 11 and the inner volume of container 2b by the external environment during the filling of container 2b; and
- finally a de-pressurization step (shown in Figures 7 and 9), during which the inner volume of neck 5 of container 2b is de-pressurized to the environment pressure with shutter 15 in the closed position, e.g. by connecting the inner volume of container 2b to a discharge.

[0035] It is important to stress that not all the above-identified operations are necessarily carried out before or after the filling of container 2b, and that some operations, e.g. the vacuum generation step and the pressurization step, can be repeated more than once.

[0036] Filling device 1b further comprises:

- a fluidic line 19, which extends between opening 14 and tank 13 filled with the pressurizing gas - carbon dioxide
- in the embodiment shown - and is adapted to allow the flow of the pressurizing fluid before the filling of container 2b or the return of the aeriform contained inside container 2b during the filling of container 2b; and
- a valve 22 interposed along fluidic line 19.

[0037] Alternatively, fluidic line 19 extends between opening 14 and a collector distinct from tank 13 and filled with the pressurizing gas.

[0038] In greater detail, valve 22 can be selectively set either in:

- a respective open position, in which it fluidly connects tank 13 with filling mouth 14 and container 2b (Figures 2, 4, 5 and 6); and
- a respective closed position, in which it fluidly isolates tank 13 from filling mouth 14 and container 2b (Figures 1, 3 and 7 to 10).

[0039] Furthermore, valve 22 is set in the respective open position, during the pressurization step of container 2b (Figure 4) and the filling step of container 2b while it is set in the respective closed positions during the vacuum-generation step and during the de-pressurization step (Figures 7 to 9).

[0040] Body 10 further comprises:

- a fluidic line 40, which extends between opening 14 and a discharge collector 41; and
- a valve 42, which is interposed along fluidic line 40 and can be selectively set in an open position (Figures 7 and 9), in which it fluidly connects vacuum collector 41 with opening 14, or in a closed position (Figures 1 to 6, 8 and 10) in which it fluidly isolates collector 41 and opening 14.

[0041] Valve 42 is set in the open position, during the depressurization step of container 2b while is set in the closed position while the other operations are carried out on container 2.

[0042] Furthermore, body 10 comprises:

- a fluidic line 50, which extends between opening 14 and vacuum collector 51; and
- a valve 52, which is interposed along fluidic line 50 and can be selectively set in an open position (not shown) in which it fluidly connects vacuum collector 51 with opening 14 and a closed position (Figures 1 to 10) in which it

fluidly isolates collector 51 and opening 14.

[0043] Valve 52 is set in the open position during the vacuum generation step of container 2b; and is set in the closed position during the other operations on container 2b.

[0044] Filling device 1a, 1b further comprises a control unit 60b, which is programmed to set valve 22, 42, 52 and shutter 15 in respective open positions or closed positions.

[0045] Only filling device 1a further comprises a flow-meter 45 (Figure 31), which is arranged along fluidic line 11 and upstream of shutter 15, with reference to the advancing direction of the pourable product from tank 13 to container 2a.

[0046] Flow-meter 45 is adapted to measure the flow - and, therefore, the quantity - of pourable product filled inside container 2b, when shutter 15 is in the open position.

[0047] As it will be evident from the following of the present description, control unit 60b is programmed to estimate volume Vb2 of container 2b before the filling thereof, and the empty volume Vbres2 of container 2b after the filling thereof.

[0048] Preferably, filling device 1b comprises:

- a chamber 70 having a given volume V1; and
- a valve 71, which can be set by control unit 60b either in an open position (Figures 1 and 3 to 6, 8 and 9) or in a closed position (Figures 2, 7 and 10).

[0049] When it is set in the open position, valve 71 establishes a fluidic connection between chamber 70 and filling mouth 14 and, therefore, between chamber 70 and container 2b.

[0050] When it is in the closed position, valve 71 prevents the fluidic connection between chamber 70 and filling mouth 14 and, therefore between chamber 70 and container 2b.

[0051] In the embodiment shown in Figures 1 to 10, chamber 70 and valve 71 are arranged along fluidic line 19. Valve 71 is interposed between filling mouth 14 and chamber 70 along fluidic line 11.

[0052] Furthermore, volume V1 of chamber 70 is smaller than volume Vb2 of respective container 2b.

[0053] When valve 22 is set by control unit 60a, 60b in the open position (Figures 2, 4, 5 and 6), chamber 70 is fluidly connected with tank 13.

[0054] When valve 22 is set by control unit 60b in the closed position (Figures 1, 3 and 7 to 10), chamber 70 is fluidly isolated from tank 13.

[0055] Filling device 1b also comprises a sensor 73 which is adapted to measure the pressure inside chamber 70.

[0056] In the embodiment shown, sensor 73 is arranged at chamber 70 and has a sensible element arranged inside chamber 70.

[0057] Preferably, control unit 60b is programmed, when shutter 15 is in the closed position and before the filling of container 2b to:

- set valve 71 in the closed position, so as to fluidly connect chamber 70, and filling mouth 14 and inner volume of container 2b (Figure 2);
- generate pressure p2 inside filling mouth 14 and container 2b, and pressure p1 inside chamber 70 (Figure 2);
- set valve 71 in the open position, so as to generate an equalizing pressure pT inside chamber 70, filling mouth 14 and container 2b (Figure 2); and
- estimate actual volume Vb2 on the basis of volume V1 of chamber 70, pressure p2, pressure p1 and pressure pT (Figure 3).

[0058] In other words, control unit 60b is programmed to estimate actual volume Vb2 of containers 2b on the basis of volume V1 of chamber 70; pressures p2, p1 existing in chamber 70 and containers 2b respectively when they are fluidly isolated from one another; and equalizing pressure pT existing in both chamber 70 and container 2b when they are fluidly connected with one another.

[0059] For the sake of clarity, pressures p1, p2 and pT sensed by sensor 73 in each of the step shown in Figures 1 to 10 are indicated inside the schematic representation of control unit 60b.

[0060] In the embodiment shown, control unit 60b estimates volume Vb2 on the basis of the following formula:

$$Vb2 = V1 * \frac{p1-pT}{pT-p2} \quad (1)$$

[0061] This formula can be justified by assuming that the aeriform inside container 2b and chamber 70 behaves as a perfect gas and that it undergoes an isothermal transformation, as it will be evident from the foregoing of the present description.

[0062] In the embodiment shown, pressure p2 is the pressure existing in both chamber 70 and container 2b due to the previous not-shown operations, and pressure p1 is the pressure existing inside tank 13. Pressure p1 is higher than pressure p2 and equalizing pressure pT is lower than pressure p1 and higher than pressure p2.

[0063] Preferably, pressure p1 is identical or really close to the pressure inside tank 13 and pressure p2 is identical or really close to the pressure inside discharge collector 41.

[0064] In greater detail, control unit 60b is programmed to subsequently:

- set valve 71 in the open position and valve 22 in the closed position, so as to generate same pressure p2 in chamber 70, filling mouth 14 and container 2b (see Figure 1) ;
- set valve 71 in the closed position and valve 22 in the open position, so as to fluidly connect tank 13 with chamber 70 and generate pressure p1 greater than pressure p2 in chamber 70 while leaving pressure p2 inside container 2b and filling mouth 14 (Figure 2); and
- set valve 71 in the open position and valve 22 in the closed position, so as to generate equalizing pressure pT in chamber 70, filling mouth 14 and container 2b (see Figure 3).

[0065] In particular, in the condition of Figure 3 the following formula is valid:

$$pT * (V1 + Vb2) = (n1 + n2) * RT \quad (2)$$

where n1 and n2 are the number of moles inside chamber 70 and container 2b, R is the ideal constant gas and T is the temperature inside chamber 70 and container 2b.

[0066] Under isothermal conditions, n1 and n2 can be derived by the following formulas which apply to conditions of Figures 1 and 2:

$$p2 * (Vb2) = (n2) * RT \quad (3) ;$$

and

$$p1 * V1 = (n1) * RT \quad (4) .$$

[0067] Formula (3) can be derived by the fact that container 2a, 2b remains at pressure p2 when valve 22 is set in the closed position by control unit 60b (Figure 1).

[0068] Formula (4) can be derived by the fact chamber 70 is pressurized at pressure p1 when valve 22 is set in the open position by control unit 60a (Figure 2).

[0069] By substituting (3) and (4) in (2), formula (1) is obtained.

[0070] Control unit 60b is also programmed to subsequently:

- set valves 71 and 22 in the open position while keeping shutter 15 in the closed position, so as to pressurize container 2b (Figure 4); and
- set shutter 15 in the open position, so as to fill container 2b with the pourable product and to allow the return of the aeriform contained in container 2b towards tank 13 (Figure 5).

[0071] As it will be evident from the following of the present description, control unit 60b is programmed to set shutter 15 of filling device 1b in the closed position after a time interval Δt has lapsed.

[0072] Control unit 60b is also programmed to set valves 22 and 71 in the closed position and valve 42 in the open position (Figure 7).

[0073] In this way, chamber 70 is pressurized again at pressure p1 existing in tank 13 and the aeriform contained in empty portion of container 2b is discharged in collector 41, thus de-pressurizing for a first time container 2b itself. The pressure inside container 2b equals pressure p2.

[0074] After depressurization of container 2b control unit 60b sets valve 71 in the open position and valve 42 in the closed position, so as to generate equalizing pressure pT in chamber 70, filling mouth 14 and empty volume of container 2b (see Figure 8). Pressure pT is sensed by sensor 73.

[0075] Control unit 60b is also programmed to set valve 42 in the open position, so as to completely de-pressurize empty portion of container 2b and discharge the aeriform contained in chamber 70 and empty portion of container 2b

in collector 41 and to reduce the pressure in chamber 70 and empty portion of container 2b up to value p_2 (Figure 9) . Pressure p_2 is sensed by sensor 73.

[0076] In the embodiment shown, control unit 60b estimates volume V_{bres} of empty portion of container 2b on the basis of the following formula:

$$V_{bres} = V_1 * \frac{p_1 - p_T}{p_T - p_2} \quad (5)$$

[0077] This formula can be justified by assuming that the aeriform inside empty portion of container 2b and chamber 70 behaves a perfect gas and that it undergoes an isothermal transformation, as it will be evident from the foregoing of the present description.

[0078] In particular, in the condition of Figure 8 the following formula is valid:

$$p_T * (V_1 + V_{bres}) = (n_1 + n_2) * RT \quad (6)$$

where n_1 and n_2 are the number of moles inside chamber 70 and empty portion of container 2b, R is the ideal constant gas and T is the temperature inside chamber 70 and empty space of container 2b.

[0079] Under isothermal conditions, n_1 and n_2 can be derived by the following formulas which apply to conditions of Figures 9 and 7:

$$p_2 * (V_{bres}) = (n_2) * RT; \quad (7);$$

and

$$p_1 * V_1 = (n_1) * RT \quad (8) .$$

[0080] Formula (7) can be derived by the fact that container 2b is de-pressurized at pressure p_2 when valves 42, 71 are set in the open position by control unit 60b (Figure 9).

[0081] Formula (8) can be derived by the fact chamber 70 is pressurized at pressure p_1 when valve 22 is set in the open position by control unit 60b (Figure 7 and 8). Thus, chamber 70 remains at pressure p_1 when it is fluidly isolated from tank 13 and empty volume of container 2b.

[0082] By substituting (7) and (8) in (6), formula (1) is obtained.

[0083] Finally, control unit 60b is programmed to set valves 22, 71, 42, 52 in the respective closed position and to release filled container 2b.

[0084] Furthermore, control unit 60b of filling device 1b is programmed to keep shutter 15 in the open position for time interval Δt .

[0085] In this way, differently from shutter 15 of filling device 1a, shutter 15 of filling device 1b is controlled not on the basis of a given flow Q but on basis of a given time interval Δt .

[0086] Control unit 60b is programmed to store a current value of time interval Δt , to store a value desired amount of pourable product, and to keep shutter 15 in the open position for time interval Δt during the filling of container 2b.

[0087] Advantageously, control unit 60b is programmed for updating the current value of time interval Δt on the basis of the difference between the actual filling volume and the desired filling volume of container 2b, after the filling of container 2b itself.

[0088] In the embodiment shown, control unit 60b is also programmed for updating the current value of time interval Δt , every time filling device 1b fills a new container 2b.

[0089] In the embodiment shown, control unit 60b is programmed for setting an initial value of current time interval Δt , on the basis of the time required to actually fill volume of container 2a with a desired volume and measured by a flowmeter 45 of filling device 1a.

[0090] In other words, filling device 1a acts as a "master" filling device while filling device 1b acts as a "slave" filling device.

[0091] Furthermore, time interval Δt is updated every time a new container 2b has been filled up to when the difference between the actual filling volume and the desired filling volume of container 2b is less than a threshold value

[0092] To this end, control unit 60b is programmed, every time new container 2b is processed by filling device 1b, to:

- estimate empty volume V_{b2} of container 2b to be filled before the filling thereof;
- estimate volume of empty portion V_{bres2} of filled container 2b after the filling of container 2b; and
- estimate actual filling volume V_{2bact} as a difference between V_{2b} and V_{2bres} .

5 **[0093]** Filling device 1a is shown in Figure 31 and will be described hereinafter only as far as it differs from filling device 1b; corresponding or equivalent parts of filling devices 1a, 1b will be indicated where possible by the same reference numbers.

[0094] In particular, filling device 1a differs from filling device 1b for not comprising chamber 70 and valve 71.

10 **[0095]** Furthermore, filling device 1a differs from filling device 1b for comprising flowmeter 45 arranged along fluidic line 11 and operatively connected to control unit 60a.

[0096] In particular, control unit 60a is programmed for displacing shutter 15 from the closed to the open position after flowmeter 45 has detected that a desired amount of pourable product has filled container 2a.

[0097] Control unit 60a is also programmed for transmitting to control unit 60b a signal associate to the time interval along which shutter 15 has been kept in the open position.

15 **[0098]** Supports 20 are driven in rotation by carousel, receive relative empty containers 2a, 2b at an inlet station (not-shown), convey relative containers 2a, 2b along an arc-shaped trajectory, and output filled containers 2a at an outlet station (not-shown).

[0099] In particular, each support 20 is arranged in the relative rest position at inlet station and at the outlet station, and moves from the relative rest position to the lowered position and vice-versa along the arc-shaped trajectory.

20 **[0100]** Filling station 100 further single collectors 41, 51 for all filling devices 1a, 1b.

[0101] The operation of the station 100 will be described with reference to filling device 1a and only one filling device 1b and to relative containers 2a, 2b.

[0102] The operation of filling device 1a, 1b is in the following of the present description described separately only for the sake of clarity, being it clear that filling device 1a, 1b operate substantially simultaneously on relative containers 2a, 2b.

25 **[0103]** In greater detail, filling device 1a acting as "master" filling device fills container 2a with a desired volume and control unit 60a generates a control signal for control units 60b of filling devices 1b which acts therefore as "slave" filling device (Figure 32).

[0104] Very briefly, the operation of filling device 1a can be summarized in this way:

- 30
- container 2a is pressurized with the aeriform contained in tank 13 up to reach the pressure of the pourable product inside tank 13;
 - control unit 60 sets shutter 15 in the open position and container 2a is filled with the pourable product while the aeriform contained in container 2a returns back in tank 13 (Figure 31);
 - when flow-meter 45 has sensed that container 2a, has been filled an amount of pourable product equals to a desired
- 35
- value, control unit 60 sets shutter in the closed position, thus interrupting the filling of container 2a;
 - container 2a is de-pressurized; and
 - filled container 2a is discharged.

[0105] Very briefly, the operation of filling device 1b can be summarized in this way:

- 40
- on the basis of the format of container 2b, control unit 60b memorizes a set-point value Q for the amount of pourable product to be filled in container 2b and sets shutter 15 in the closed position;
 - control unit 60b estimates volume V_{b2} of container 2b and corrects set-point Q on the basis of volume V_{b2} (Figure 3) ;
 - container 2b is pressurized with the aeriform contained in tank 13 up to reach the pressure of the pourable product
- 45
- inside tank 13 (Figure 4);
 - control unit 60b sets shutter 15 in the open position and container 2b is filled with the pourable product while the aeriform contained in container 2b returns back in tank 13 (Figures 5 and 31);
 - when control unit 60b has detected that a current time interval Δt is lapsed, it sets shutter 15 in the closed position, thus interrupting the filling of container 2b (Figure 6);
- 50
- container 2b is de-pressurized for a first time (Figure 7);
 - control unit 60b estimates empty volume V_{bres} and the de-pressurization of container 2b is completed (Figures 8 and 9); and
 - filled container 2b is discharged (Figure 10).

55 **[0106]** In detail, as of the condition of Figure 1, support 20 is in the operative position and mouth 3 of empty container 2b is tight-fluid contact with opening 14 and body 10.

[0107] Furthermore, control unit 60a sets shutter 15, 22, 42, 52 in the closed position and valve 71 in the open position.

[0108] The pressure inside chamber 70 is pressure p_2 , which corresponds to the pressure from the previous operations

of filling device.

[0109] Thanks to the fact that valve 71 is set in the open position, pressure p2 is generated also in container 2b and sensed by sensor 73.

[0110] With reference to Figure 2, control unit 60b sets valve 22 in the open position and valve 71 in the closed position. Thus, chamber 70 is fluidly connected to tank 13 and pressurized at pressure p1 while container 2b is fluidly isolated from chamber 70 and remains at pressure p2.

[0111] In this condition, sensor 73 senses pressure p1 inside chamber 70.

[0112] With reference to figure 3, control unit 60b sets valve 22 in the closed position and valve 71 in the open position. Thus, chamber 70 is fluidly connected to container 2b. Chamber 70 and container 2b reach an equalization pressure pT which is sensed by sensor 73.

[0113] Control unit 60b estimates volume Vb2 of container 2b on the basis of volume V1 of chamber 70, pressures p1, p2 and equalizing pressure pT.

[0114] In detail, control unit 60b estimates actual volume Va2 of container 2a by means of the following formula (1):

$$Vb2 = V1 * \frac{p1 - pT}{pT - p2}$$

[0115] At this stage (Figure 4), control unit 60b sets also valve 22 in the open position. Thus, the gas contained in tank 13 at pressure p1 flows along fluidic line 21 and pressurizes container 2b.

[0116] Finally, control unit 60b sets also shutter 15 in the open position (Figure 5). Thus, the pourable product contained in tank 13 flows along fluidic line 11 inside container 2b, up to when flow-meter 45 detects that the corrected amount of pourable product has filled container 2a.

[0117] In the meanwhile, the gas contained inside container 2b returns back in tank 13 along fluidic line 19.

[0118] At this stage, control unit 60b sets shutter 15 in the closed position (Figure 6) and the filling of container 2b is completed.

[0119] Afterwards, control unit 60b sets valves 22, 71 in the respective closed positions (Figure 7) and sets valve 42 in the open position.

[0120] Accordingly, pressure p1 is generated in chamber 70 while the pressure in empty volume of container 2b decreases. Sensor 73 senses pressure p1.

[0121] Furthermore, container 2b is depressurized for a first time at pressure p2.

[0122] Control unit 60b then sets valve 71 in the open position and sets valve 42b in the closed position.

[0123] Thus, chamber 70 is fluidly connected to empty volume of container 2b. Chamber 70 and container 2a are isolated from tank 13 and collectors 41, 51 and reach an equalization pressure pT which is sensed by sensor 73 (Figure 8).

[0124] At this stage, control unit 60a sets valve 42 in the open position. In this way, pressure p2 is generated inside chamber 70 and empty volume of container 2b (Figure 9).

[0125] Thus, the aeriform contained inside empty volume of container 2b flows towards collector 41 and the depressurization of empty volume of container 2b is completed.

[0126] In the meanwhile, control unit 60b estimates volume Vbres of empty volume of empty portion of container 2b on the basis of volume V1 of chamber 70, pressures p1, p2 and equalizing pressure pT.

[0127] In detail, control unit 60b estimates actual volume Vbres of empty portion of container 2b by means of the following formula (5):

$$Vbres2 = V1 * \frac{p1 - pT}{pT - p2}$$

[0128] It is important to point out that pressure p2 inside container 2b is sensed in the condition of Figure 9, but is substantially identical to pressure p2 inside container 2a in the condition of Figure 6.

[0129] Control unit 60b estimates actual volume of pourable product inside containers 2b as Vb2-Vbres2 (Figure 32).

[0130] Furthermore, control unit 60b memorizes a desired value of the volume of pourable product to be filled in container 2b and keeps open shutter 15 during the filling step (Figure 5) for current time interval Δt.

[0131] More precisely, control unit 60b sets an initial value for time interval Δt on the basis of the time interval needed to filling device 1a to fill containers 2a with the desired volume and provided by control unit 60a.

[0132] Furthermore, every time filling device 1b fills a container 2b, control unit 60b estimates the actual volume Vb2 of container 2b (Figures 4 and 32) and the actual volume Vbres of empty portion of container 2b (Figures 9 and 32).

[0133] Control unit 60b also estimates the actual volume of pourable product inside container 2b as the difference Vb2-Vbres and updates time interval Δt in case the difference between actual volume and the desired volume of pourable product to be filled inside container 2b is smaller than a threshold value.

[0134] After the filling of some containers 2b, the difference between the desired and the actual volume of pourable product inside container 2b is below the threshold value.

[0135] It is important to point out that the method in accordance to the present invention assumes that the actual volumes of containers 2a, 2b processed by filling station 100 are identical to one another.

[0136] With reference to figures 11 to 20, 1b' indicates, as a whole, a filling device according to a second embodiment of the present invention. The filling device 1b' is similar to filling device 1 and will be described hereinafter only as far as it differs therefrom; corresponding or equivalent parts of filling devices 1b and 1b' will be indicated where possible by the same reference numbers.

[0137] In particular, filling device 1b' differs from filling device 1b in that sensor 73 is configured to detect the pressure at filling mouth 14 and, therefore, inside container 2b. In particular, sensor 73 is arranged on body 10 and has a sensible element fluidly connected to filling mouth 14.

[0138] Furthermore, the operation of filling device 1b' differs from the operation of filling device 1b in that pressure p1 is sensed by sensor 73 during the pressurization step (Figure 14) and, therefore, volume Vb2 is estimated by control unit 60b respectively during pressurization step (Figure 14) and after chamber 70 and container 2b have reached an equalization pressure pT.

[0139] In this respect, it is important to point out that chamber 70 is at the same pressure p1:

- when control unit 60b sets valve 22 in the open position and valve 70 in the closed position (Figure 12); and
- when control unit 60b sets both valves 22, 70 in the respective open positions (Figure 14).

[0140] With reference to Figures 21 to 30, 1b" indicates, as a whole, a filling device according to a second embodiment of the present invention. Filling device 1b" is similar to filling device 1b and will be described hereinafter only as far as it differs therefrom; corresponding or equivalent parts of filling devices 1b" and 1b will be indicated where possible by the same reference numbers.

[0141] Filling device 1b" differs from filling device 1b in that sensor 73 is configured to detect the pressure at filling mouth 14 and, therefore, inside container 2b. In particular, sensor 73 is arranged on body 10 and has a sensible element fluidly connected to filling mouth 14.

[0142] Furthermore, filling device 1b" differs from filling device 1a, 1b in that chamber 70" is arranged along fluidic line 40 between opening 14 and valve 42, and for comprising a valve 80" interposed between opening 14 and chamber 70", and for not comprising valve 71.

[0143] Filling device 1b" also differs from filling device 1b in that control unit 60b is programmed to:

- keep shutter 15 in the closed position;
- set valves 22, 42 in the closed position and valve 80" in the open position, so as to generate same pressure p2 in chamber 70", filling mouth 14 and container 2a, 2b (see Figure 21);
- set valve 22 in the open position and valve 80" in the closed position, so as to fluidly connect tank 13 with filling mouth 14 and container 2b and generate pressure p1 greater than pressure p2 in container 2a, 2b and filling mouth 14 while leaving pressure p1 inside chamber 70" (Figure 22);
- set valve 80" in the open position, so as to generate equalizing pressure pT in chamber 70, filling mouth 14 and container 2a, 2b (see Figure 23).

[0144] Control unit 60b is also programmed to subsequently:

- set valve 22 in the open position, so as to pressurize container 2b at the pressure of pourable product contained in tank 13 (Figure 24); and
- set shutter 15 in the open position, so as to fill container 2b with the pourable product and to allow the return of the aeriform contained in container in tank 13 (Figure 25).

[0145] In the embodiment shown in Figures 21 to 25, control unit 60b is programmed to estimate volume Vb2 on the basis of the following formula:

$$Vb2 = V1 * \frac{pT - p2}{p1 - pT} \quad (9)$$

[0146] The formula (9) can be justified in the following way.

[0147] In the conditions of Figure 23, the following relation is valid:

$$pT * (V1 + Vb2) = (n1 + n2) * RT \quad (10)$$

where n1 and n2 are the number of moles inside chamber 70 and container 2b, R is the ideal constant gas and T is the temperature inside chamber 70 and container 2b.

[0148] Under isothermal conditions, n1 and n2 can be derived by the following formulas which apply to conditions of Figures 21 and 22:

$$p2 * V1 = (n1) * RT \quad (11) ;$$

and

$$p1 * Vb2 = (n2) * RT \quad (12) .$$

[0149] By substituting (11) and (12) in (10), formula (9) is obtained.

[0150] Furthermore, control unit 60b is programmed to subsequently:

- set valves 22, 80" in the respective open positions, valve 42 in the closed position and shutter 15 in the closed position, so as to end the filling of container 2a, 2b and arrange empty portion of container 2a, 2b and chamber 70" at pressure p1 (Figure 26);
- set valves 22, 80" in the respective closed positions and valve 42 in the open position (Figure 27), so as to depressurize chamber 70" at pressure p2 and to keep the empty volume of container 2b at pressure p1;
- set valve 80" in the open position and valve 42 in the closed position (Figure 28), so as to equalize at value pT the pressure inside empty volume of container 2a, 2b and inside chamber 70" ;
- set valve 42 in the open position (Figure 29), so as to complete the de-pressurization of the empty volume of container 2a, 2b; and
- estimate empty volume Vbres by means of the formula:

$$Vbres = V1 * \frac{pT - p2}{p1 - pT} \quad (13) .$$

[0151] The formula (13) can be justified in the following way.

[0152] In the conditions of Figure 28 the following relation is valid:

$$pT * (V1 + Vares) = (n1 + n2) * RT$$

$$pT * (V1 + Vbres2) = (n1 + n2) * RT \quad (10)$$

where n1 and n2 are the number of moles inside chamber 70 and container 2b, R is the ideal constant gas and T is the temperature inside chamber 70 and container 2b.

[0153] Under isothermal conditions, n1 and n2 can be derived by the following formulas which apply to conditions of Figures 26 and 27:

$$p2 * V1 = (n1) * RT \quad (11) ;$$

and

$$p1 * Vbres = (n2) * RT \quad (12) .$$

[0154] By substituting (11) and (12) in (10), formula (9) is obtained.

[0155] The operation of filling device 1b" differs from that of filling device 1b for the steps carried out by control unit 60b" to estimate volume Vb2 of container 2b.

[0156] In greater detail and with reference to the condition shown in Figure 21, control unit 60b" sets valves 22, 42 and shutter 15 in the closed position and sets valve 80" in the open position.

[0157] In this way, the pressure inside container 2b and chamber 70 is pressure p2, which corresponds to the pressure from the previous operations of filling device.

[0158] Then, control unit, 60b" sets valve 22 in the open position and valve 80" in the closed position (Figure 22). Thus, container 2b is fluidly connected to tank 13.

[0159] In this way, a pressure p1 greater than pressure p2 is generated inside container 2b while chamber 70" remains at pressure p1.

[0160] With reference to Figure 23, control unit 60b" sets valve 22 in the closed position and valve 80" in the open position.

[0161] In this way, equalizing pressure pT is generated in both container 2b and chamber 70" .

[0162] In the meanwhile, control unit 60b" estimates volume Vb2 of container 2b by means of the formula:

$$Vb2 = V1 * \frac{pT - p2}{p1 - pT} \quad (9) .$$

[0163] With reference to Figure 24, control unit 60b" sets valve 22 in the open position, so as to pressurize container 2b at the pressure of pourable product contained inside tank 13.

[0164] Then, with reference to Figure 25, control unit 60b" sets valve 22 in the closed position and shutter 15 in the open position, so as to fill container 2b with the pourable product.

[0165] With reference to Figure 26, control unit, 60b" sets shutter 15 in the closed position, so as to end the filling of container 2b.

[0166] The operation of filling device, 1b" also differs from that of filling device 1b for the steps carried out by control unit 60b" to estimate volume Vbres of empty portions of containers 2b.

[0167] In greater detail, after the completion of filling of container 2b, control unit 60b" sets valves 22, 80" in the respective open positions and valve 42 in the open position (Figure 27).

[0168] In this condition, empty portion of container 2b and chamber 70" are fluidly isolated from one another and sensor 73 senses pressure p1 inside empty portion of container 2a.

[0169] Then, control unit 60b" sets valve 80" in the open position and valve 42 in the closed position (Figure 28).

[0170] In this condition, empty portion of container 2b and chamber 70" are fluidly connected with one another and sensor 73 sense equalizing pressure pT inside both empty portion of container 2b and chamber 70" .

[0171] Afterwards, control unit 60b" sets valve 42 in the open position (Figure 29), so as to discharge the empty portion of container 2b.

[0172] In the meanwhile, sensor 73 senses pressure p2 inside empty portion of container 2b and chamber 70" both connected to collector 41. It is important to point out that pressure p2 sensed by sensor 73 inside chamber 70" in the condition of Figure 28 is identical to the one existing in chamber 70" in the condition of Figure 27.

[0173] In this condition, control unit 60b estimates volume of empty portions Vbres of filled containers 2b by means of formula (13):

$$Vbres = V1 * \frac{pT - p2}{p1 - pT}$$

[0174] Finally, control unit 60b" sets valves 42, 80" in respective closed position and container 2b is discharged.

[0175] In a further not-shown embodiment, also filling device 1a, 1a', 1a" do not comprise any flow-meter 45 and are identical to filling device 1b, 1b', 1b".

[0176] In this case, the initial value of time interval Δt for all filling device 1b, 1b', 1b" is determined on the basis of historical or presumed loss of head along fluidic line 11.

[0177] The advantages of filling device 1b; 1b', 1b" and the filling method according to the present invention will be clear from the above description.

[0178] In particular, the current value of time interval Δt is updated every time filling device 1b, 1b', 1b" fills a new container 2b on the basis of the difference between the actual filling volume and the desired filling volume of container 2b.

[0179] In other words, every time a new container 2b is filled, its actual filling Vb2-Vbres2 volume is estimated and used for updating time interval Δt for which shutter 15 of filling device 1b is kept in the open position.

[0180] Thus, after the filling of some containers 2b, the difference between desired and the actual volume of pourable

product inside container 2b is below the threshold value.

[0181] In this way, it is possible to achieve a relevant degree of precision and repeatability in the amount of pourable product actually filled inside container 2b, even without using any flow-meter in filling device 1b itself.

[0182] Thus, a substantial reduction in overall costs of manufacturing and maintaining filling device 1b, 1b', 1b" is achieved.

[0183] Furthermore, filling device 1b; 1b'; 1b" reaches this technical effect without requiring to substantially redesign the known filling device. It is therefore only required to add a chamber 70, 70" to known filling device and to selectively fluidly connect/isolate it with/from the inner volume of container 2b so as to generate pressure p1, p2 and equalizing pressure pT.

[0184] Filling device 1b; 1b'; 1b" advantageously makes use of the aeriform in tank 13 to generate pressure p1 inside chamber 70 or container 2b, when volume V2b of container 2b and residual volume Vbres is estimated. Thus, there is no need for an additional hydraulic circuits to generate pressure p2 inside chamber 70 or container 2b.

[0185] Chamber 70" of filling device 1b" is fed with aeriform escaping from container 2a, 2b when valve 80" is set in the open position to generate equalizing pressure pT in container 2b and chamber 70" .

[0186] In one embodiment, initial value of time interval Δt is set on the basis of the time interval needed to fill container 2a by means of filling device 1a, 1a', 1a" with the desired value. In this embodiment, filling device 1a, 1a', 1a" acts as a "master" filling device and filling device 1b, 1b', 1b" acts a "slave" filling device only when the first container 2b is filled.

[0187] Thus, it is possible to set initial value of time interval Δt with a good precision by mounting only one flow-meter 45 on respective only one filling device 1a of filling station 100.

[0188] In another embodiment, initial value of time interval Δt is set on the basis of historical or presumed loss of head along said first fluidic line 11.

[0189] Thus, filling station 100 can be made without any flow-meter 45.

[0190] Thanks to the fact that the pressure p1 higher than equalizing pressure pT is generated in a volume defined by container 2b which is then depressurized at equalizing pressure pT in a little higher volume defined by chamber 70" and container 2b, the isothermal assumption on the behavior of the aeriform is particularly plausible.

[0191] Finally, it is apparent that modifications and variants not departing from the scope of protection of the claims may be made to filling device 1b, 1b'. 1b" and method disclosed herein.

Claims

1. A method for contact filling at least one first article (2b) with a pourable product, comprising the steps of:

i) arranging a first mouth (3) of said first article (2b) in contact with a first filling body (10) of a first filling device (1b, 1b', 1b"); said first filling body (10) defining a respective first fluidic line (11) for said pourable product and comprising a first shutter (15) which can be selectively set in an open position in which it allows the flow of said pourable product along said first fluidic line (11) and towards said first article (2b) and a closed position in which it prevents said flow;

ii) filling said first article (2b) by setting said first shutter (15) in said open position for a current time interval (Δt);

characterized by comprising the step iii) of updating said current value of said time interval (Δt), on the basis of the difference between an estimated actual filling volume and a desired filling volume of said first article (2b) after said step ii).

2. The method of claim 1, **characterized in that** said step iii) comprises the steps of cyclically:

iv) estimating a first quantity (Vb2) associated to the volume of said empty first article (2b) to be filled before said step ii);

v) estimating a second quantity (Vbres) associated to the volume of an empty portion of said first filled article (2b) after said step iii); and

vi) estimating said actual filling volume on the basis of the difference between said first quantity (Vb2) and second quantity (Vbres).

3. The method of claim 2, **characterized in that** at least one of steps iv) and v) comprise the steps of:

vii) fluidly isolating said first article (2b) and a chamber (70, 70") having a given volume (V1);

viii) generating a first pressure (p2; p1) inside said article (2b) and a second pressure (p1; p2) inside said chamber (70, 70") ;

ix) fluidly connecting said article (2b) and said chamber (70, 70"), so as to generate a third equalizing pressure (pT) inside both said article (2b) and said chamber (70, 70"), by fluidly connecting said article (2b) and said chamber (70, 70"); and
 x) estimating said first quantity (Va2, Vb2) and second quantity (Vbres) on the basis of:

- a third quantity associated to said given volume (V1) ;
- a fourth quantity associated to said first pressure (p2; p1) ;
- a fifth quantity associated to said second pressure (p1; p2); and
- a sixth quantity associated to said third equalizing pressure (pT).

4. The method of claim 3, **characterized in that** said step iv) comprises the steps of subsequently:

xi) fluidly connecting said chamber (70, 70") and said first article (2b) , so as to generate in both of them the lower (p2) of said first pressure (p2; p1) and second pressure (p1; p2) before said step vi);

said step viii) comprising the step xii) of increasing the pressure in one of said chamber (70, 70") and said first article (2b), so as to generate in it the higher (p1) of said first pressure (p2; p1) and second pressure (p1; p2).

5. The method of claim 4, **characterized by** comprising a step xiii) of pressurizing said first article (2b) with an aeriform contained in a tank (13) at said higher (p1) of said first and second pressure (p2; p1) by connecting along a second fluidic line (19) said tank (13) and said first article (2b); said step xiii) being carried out before said step ii); said step xiii) comprising the step xiv) of feeding said one of said chamber (70, 70") and said first article (2b) with an aeriform by means of said second fluidic line (19).

6. The method of claim 4 or 5, **characterized in that** said step xii) comprises the step xv) of increasing the pressure inside said chamber (70), so as to generate therein said second pressure (p1); said step viii) comprising the step xvi) of conveying said aeriform from said chamber (70) to said article (2).

7. The method of claim 6, **characterized in that** said step xvi) comprises the steps of:

- xvii) fluidly isolating said chamber (70) from said tank (13) during said step x); and
- xviii) fluidly connecting said chamber (70) to said tank (13), so as to generate said higher (p1) of said first and second pressure (p1, p2) inside said chamber (70) before said step viii).

8. The method of claim 6, **characterized in that** said step xii) comprises the step xix) of increasing the pressure inside said first article (2b), so as to generate therein said higher (p1) of said first and second pressure (p1); said step viii) comprising the step xx) of conveying said aeriform from said first article (2b) to said chamber (70) ;

9. The method of any one of claims 2 to 8, **characterized in that** said step v) comprises the steps of:

- xxi) generating said higher (p1) of said first and second pressure (p1, p2) in both of said empty portion of said article (2b) and said chamber (70, 70");
- xxii) fluidly isolating said empty portion of said article (2b) and said chamber (70, 70") ;
- xxiii) generating said lower (p2) of said first and second pressure (p1, p2) in one of said empty portion of said article (2b) and said chamber (70, 70"); and
- xxiv) fluidly connecting said empty portion of said article (2b) and said chamber (70, 70"), so as to create said equalizing pressure (pT) in both of said empty portion of said first article (2b).

10. The method of claim 9, **characterized by** comprising a step xxv) of de-pressurizing said empty volume of said first article (2b) after said step ii) by connecting said empty portion of said first article (2b) to a discharge collector (41) by means of a third fluidic line (40); said step xxv) comprising the step xxvi) of discharging said aeriform contained inside said one of said chamber (70, 70") and said first article (2b) inside said collector (41) and by means of said third fluidic line (40).

11. The method of any one of the foregoing claims, **characterized by** comprising the step xxvii) of setting said initial value of said time interval (At) on the basis of historical or presumed loss of head along said first fluidic line (11).

12. The method according to any one of claims 1 to 10, **characterized by** comprising the steps of:

xxviii) arranging a first mouth (3) of a second article (2a) in contact with a first filling body (10) of a second filling device (1a); said first filling body (10) defining a respective first fluidic line (11) for said pourable product and comprising a second shutter (15) which can be selectively set in an open position in which it allows the flow of said pourable product along said respective first fluidic line (11) and towards said second article (2a) and a closed position in which it prevents said flow;

xxix) filling said second article (2a) by setting said second shutter (15) in said open position;

xxx) measuring the amount of pourable product flowing along said first fluidic line (11) of said second filling device (1a) by means of a flow-meter (45); and

xxxi) interrupting the filling of said second article (2a) by setting said second shutter (15) in respective said closed position, when the amount of pourable product measured by said flow-meter (45) equals a given set-point;

said method further comprising a step xxxii) of setting an initial value of said time interval (A_t) on the basis of the amount of pourable product measured by said flow-meter (45) during said step xxviii).

13. A filling device (1b) for contact filling at least one first article (2b) with a pourable product, comprising:

- a body (10), which defines a first fluidic line (11) for said pourable product; said first fluidic line (11) having a filling mouth (14) adapted to be set, in use, in tight-fluid contact against said first article (2b);

- a first shutter (15), which can be selectively set either in a first position in which it allows said pourable product to flow from said fluidic line (11) up to said filling mouth (14) so as to fill said first article (2b) with said pourable product, or in a second position, in which it prevents said pourable product from flowing from said fluidic line (11) up to said filling mouth (14) inside said first article (2b);

- a first control unit (60b, 60b', 60b'') programmed to keep said first shutter (15) in said open position for a current value of a time interval (A_t) and to memorize a desired filling volume of said first article (2b);

characterized in that said first control unit (60b, 60b', 60b'') is configured for updating said current value of said time interval (A_t) on the basis of the difference between the actual filling volume and the desired filling volume of said first article (2b).

14. The filling device of claim 13, **characterized in that** said control unit (60b, 60b', 60b'') is programmed to:

- estimate a first quantity (V_{2b}) associated to the volume of said empty first article (2b), in use, before the filling thereof; and

- estimate a second quantity (V_{bres}) associated to the volume of an empty portion of said first filled first article (2b), in use, after the filling thereof.

15. The filling device of claim 14, **characterized by** comprising:

- a chamber (70, 70'') having a given volume (V_I); and

- first valve means (71, 80''), which can be selectively set either in an open position or in a closed position; said valve means (71, 80'') establishing, in use, a fluid connection between said chamber (70, 70'') and said filling mouth (14) when set in said open position, and interrupting, in use, said fluid connection when set in said closed position;

said control unit (60b, 60b', 60b'') being programmed to:

- set said first valve means (71, 80'') in said closed position, so as to fluidly isolate said chamber (70, 70'') and said filling mouth (14), when a first pressure (p_2 ; p_1) is generated, in use, inside said filling mouth and a second pressure (p_1 ; p_2) is generated, in use, inside said chamber (70, 70'') ;

- set said first valve means (71, 80'') in said open position, so as to generate, in use, a third equalizing pressure (p_T) inside both said filling mouth (14) and said chamber (70, 70''), by fluidly connecting said filling mouth (14) and said chamber (70, 70''); and

- estimate at least one of said first quantity (V_{2b}) or said second quantity (V_{2res}) on the basis at least of:

- a third quantity associated to said volume (V_I);

- a fourth quantity associated to said first pressure (p_2 ; p_1);

- a fifth quantity associated to said second pressure (p_1 ; p_2); and

- a sixth quantity associated to said third pressure (p_T).

16. The filling device of claim 15, **characterized by** comprising:

- a tank (13) fillable, in use, with an aeriform at the higher (p1) of said first and second pressure (p1, p2; p2, p1); and
- second valve means (22) interposed between said tank (13) said chamber (70);

said second valve means (22) being selectively settable by said control unit (60) either in a closed position in which it prevents said aeriform from flowing from said tank (13) to said one of said chamber (70) filling mouth (14) or in an open position in which it allows said flow of said aeriform; said first valve means (71) being interposed between said chamber (70) and said filling mouth (14).

17. The filling device of claim 15, characterized by comprising:

- a discharge (41);
- a third fluidic line (40) which extends between said filling mouth (14) and said discharge (41), and is adapted to depressurize said filled first article (2b) when said shutter (15) is, in use, in said second position;
- fourth valve means (42), which are arranged along said third fluidic line (40) and may be selectively settable either in a closed position in which they prevent said aeriform from flowing from said filling mouth (14) to said discharge (41) or in an open position in which they allow said flow of said aeriform;

said chamber (70") and said first valve means (80") being arranged along said third fluidic line (50) a in a position interposed between said filling mouth (14) and said discharge (41).

18. The filling device of any one of claims 13 to 17 characterized by comprising a pressure sensor (73), which is configured to sense, the pressure, existing in said chamber (70, 70") or in said filling mouth (14).

19. The filling device of any one of claims 13 to 18, characterized in that said first control unit (60b, 60b', 60b") is programmed for generating an initial value of said time interval (At) on the basis of historical or presumed loss of head along said first fluidic line (11).

20. A filling station (100) comprising:

- at least one first filling device (1b) according to any one of claims 13 to 19; and
- a second filling device (1a) for contact filling at least one second article (2a) with a pourable product; said second filling device (1a) comprising:
 - a second body (10), which defines a first fluidic line (11) for said pourable product; said first fluidic line (11) having a second filling mouth (14) adapted to be set, in use, in tight-fluid contact against said second article (2a) ;
 - a second shutter (15), which can be selectively set either in a first position in which it allows said pourable product to flow from said first fluidic line (11) up to said filling mouth (14) so as to fill said second article (2a) with said pourable product, or in a second position, in which it prevents said pourable product from flowing from said fluidic line (11) up to said filling mouth (14) inside said second article (2a);
 - a flow-meter (45), which is adapted to measure the amount of pourable product flowing along said first fluidic line (11) and filling said second article (2a); and
 - a second control unit (60a, 60a', 60a"), which is programmed for displacing said second shutter (15) in said second position when the amount of pourable product flowing along first fluidic line (11) measured by said flow-meter (45) equals a given set-point (Q);

said first control unit (60b, 60b', 60b") being programmed for generating an initial value of said time interval (At) on the basis of the amount of pourable product measured by said flow-meter (45) and flowing along said first fluidic line (11) of said second filling device (1a) .

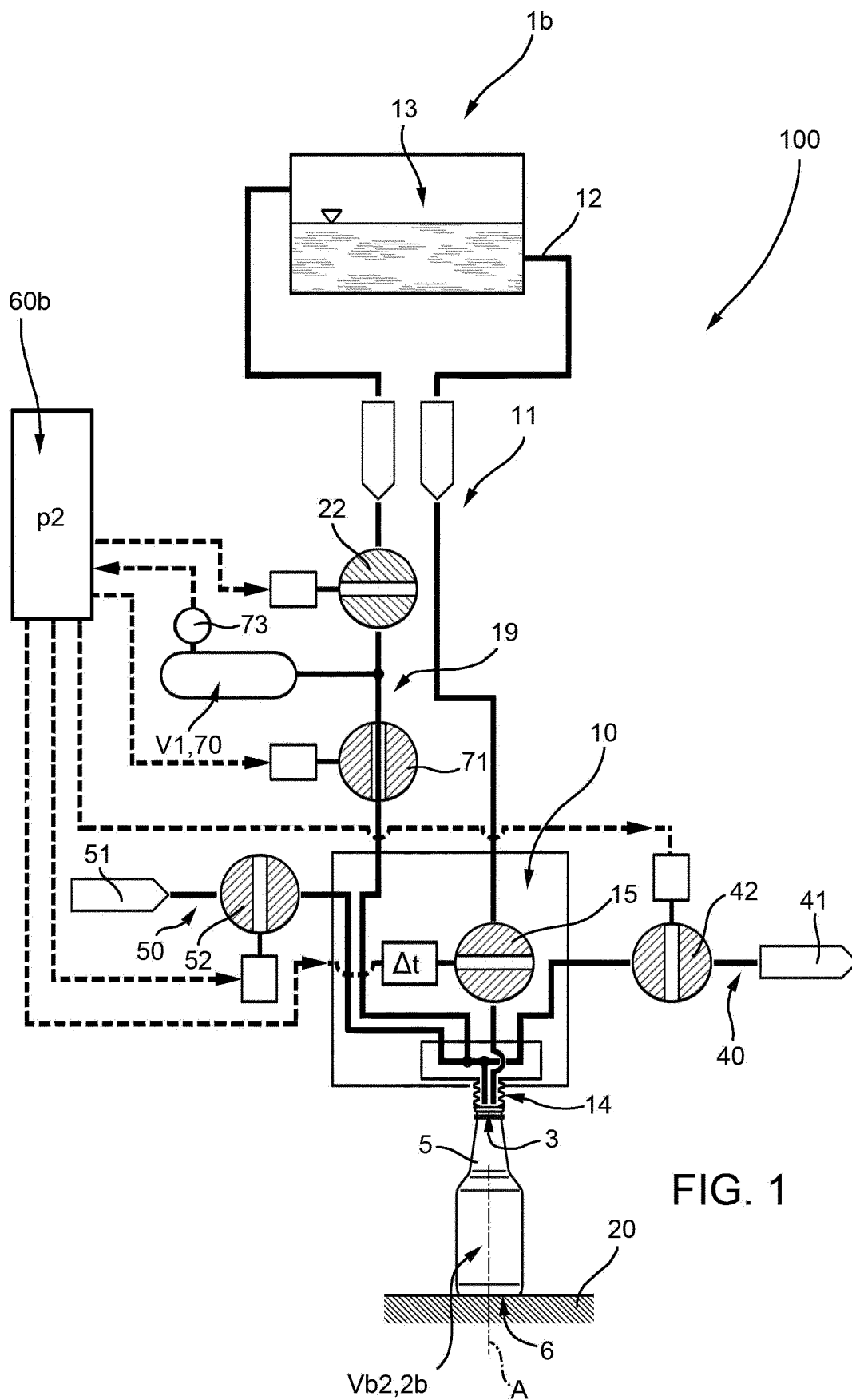
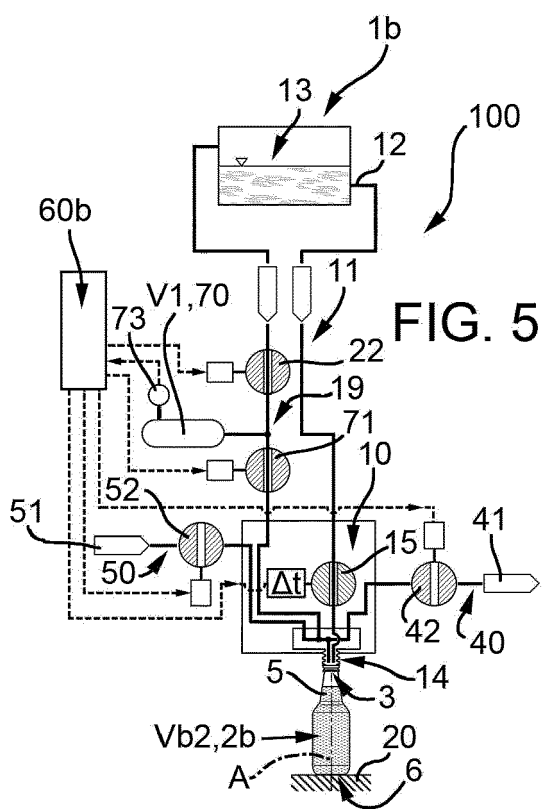
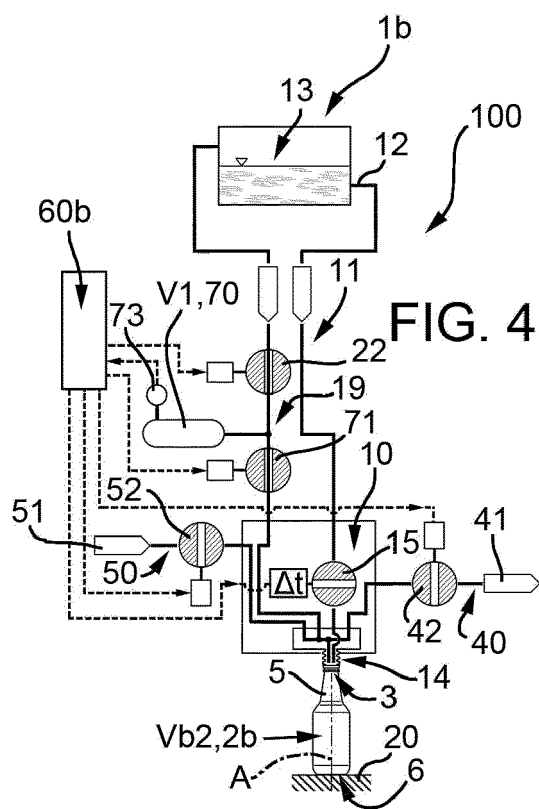
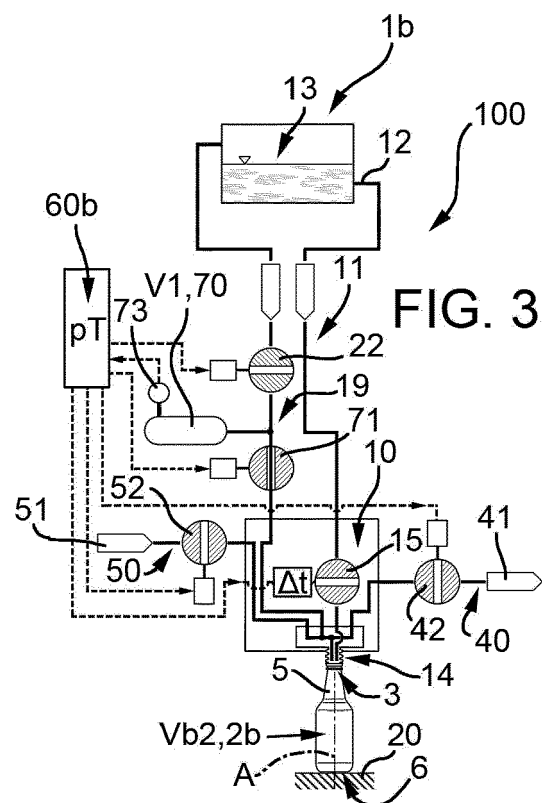
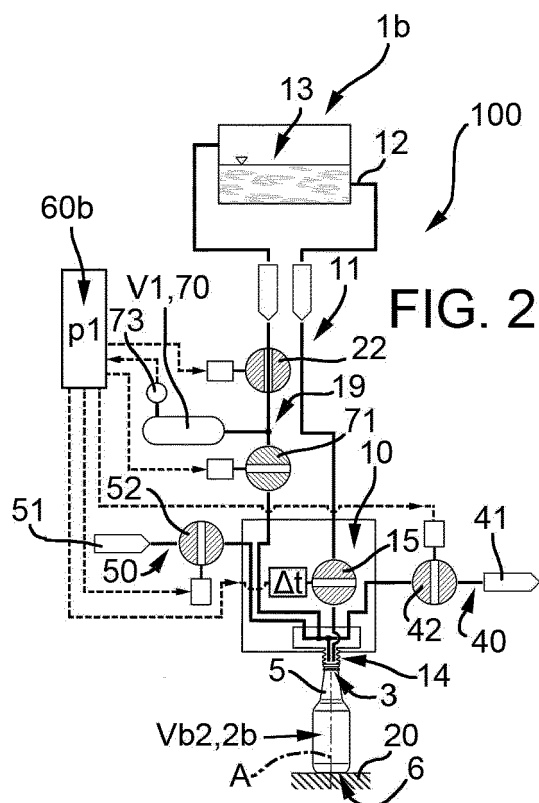
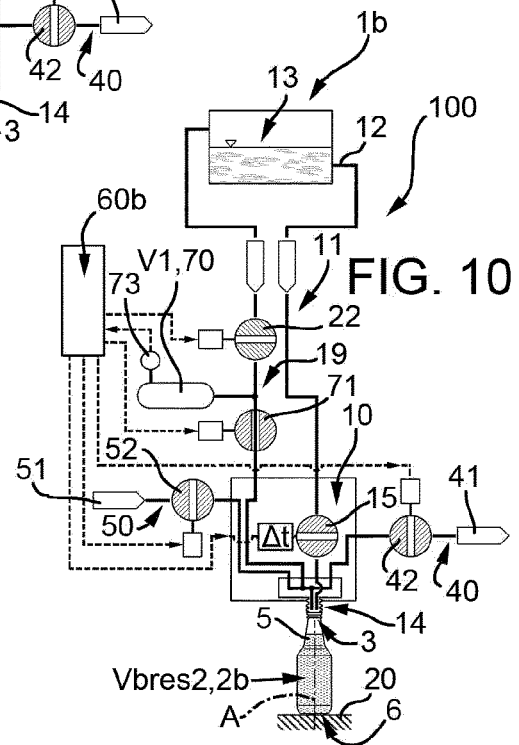
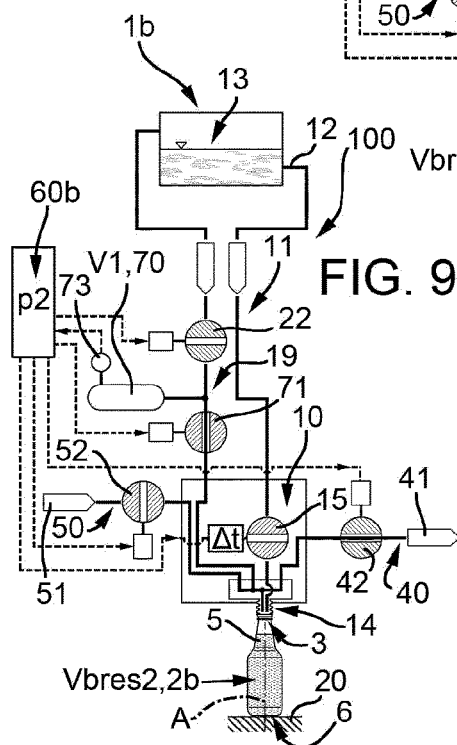
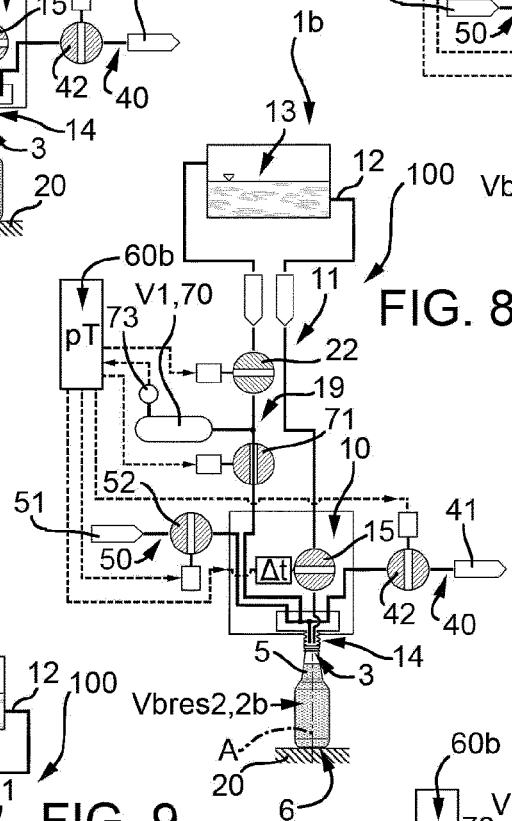
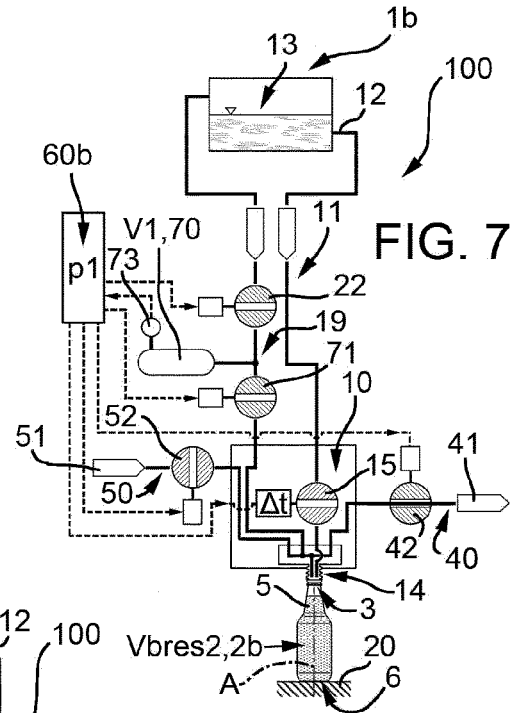
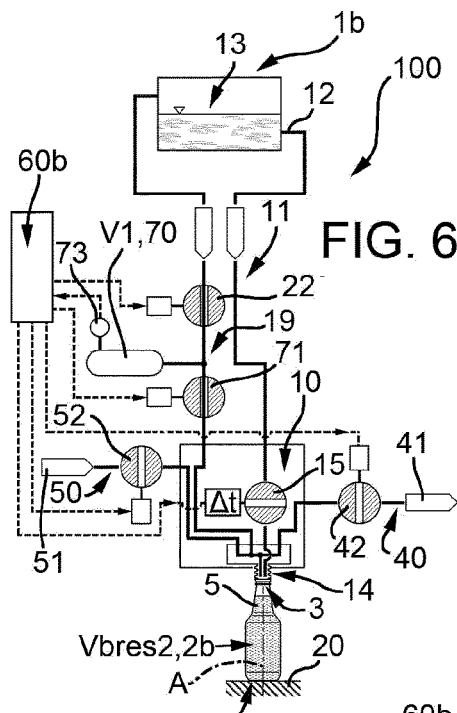


FIG. 1





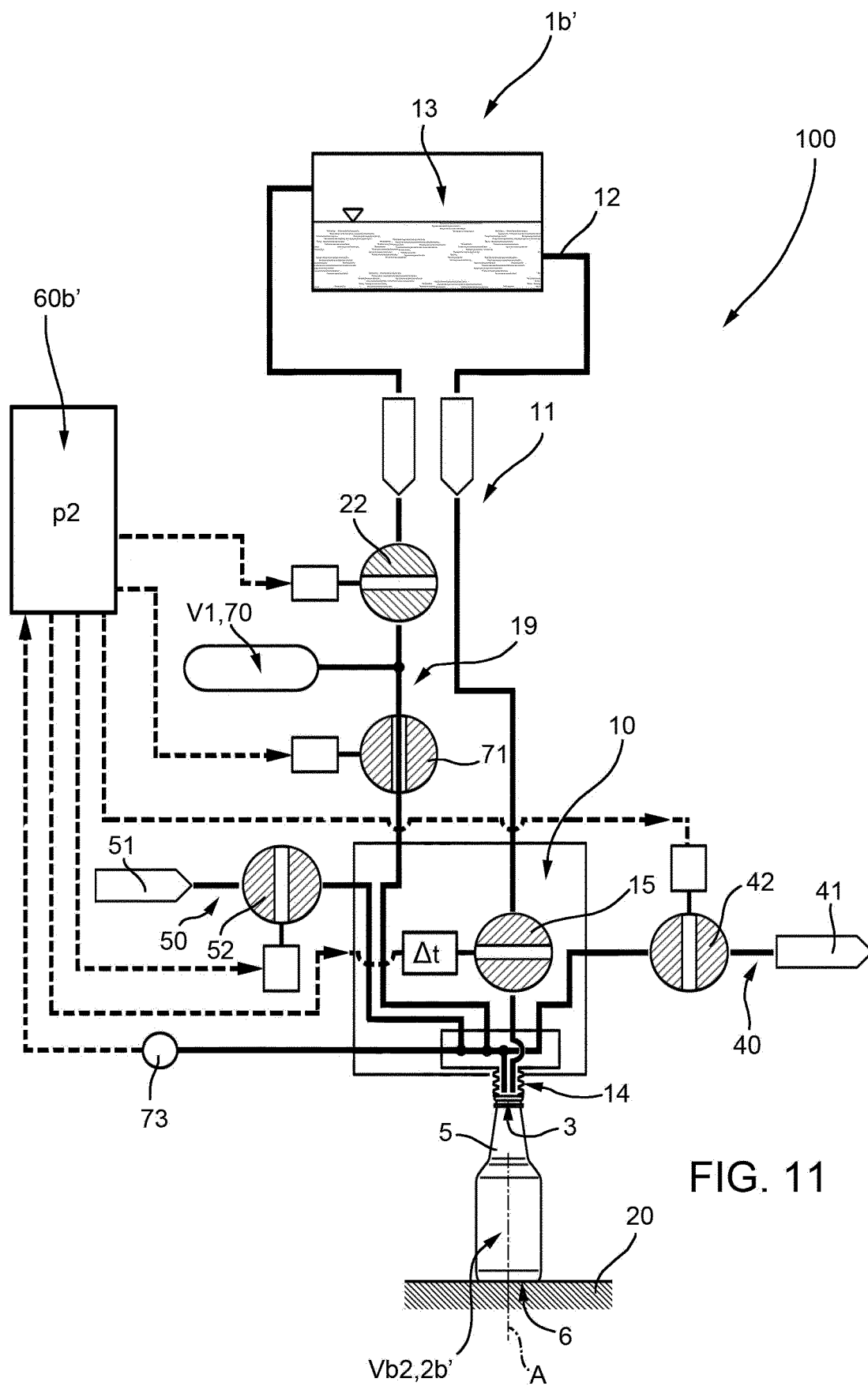
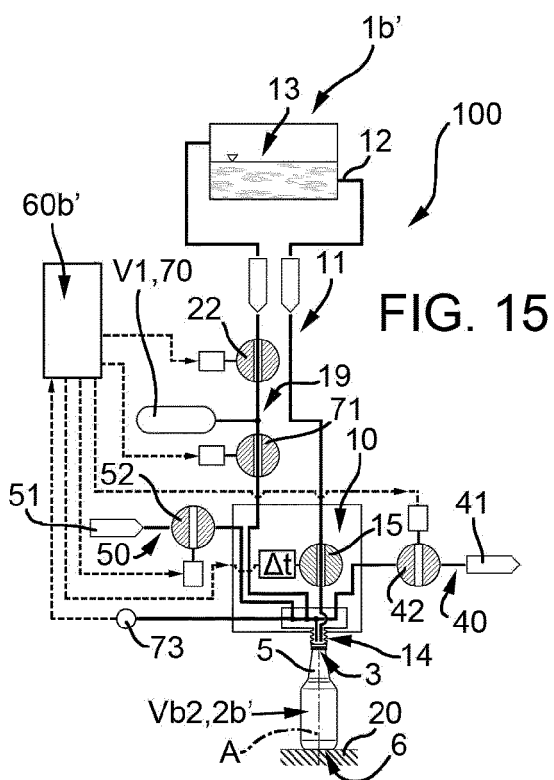
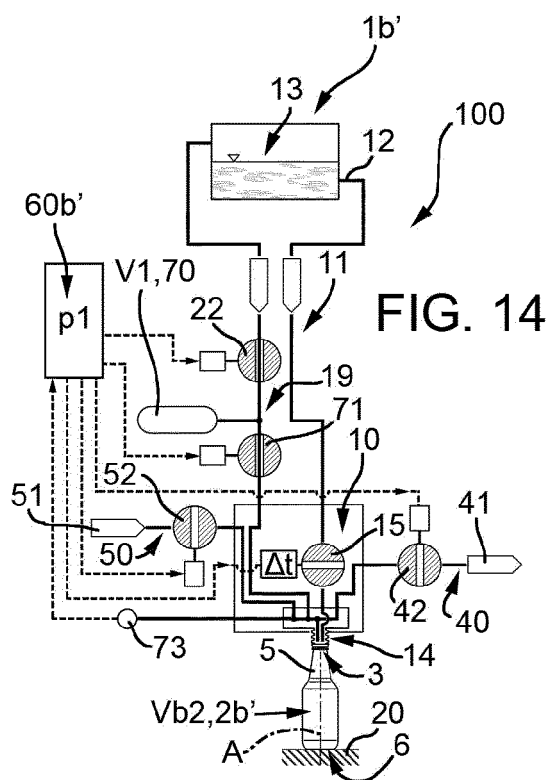
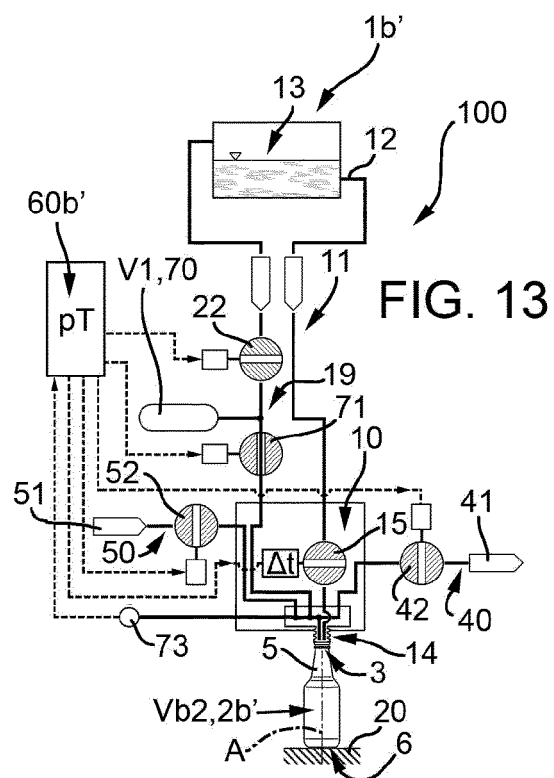
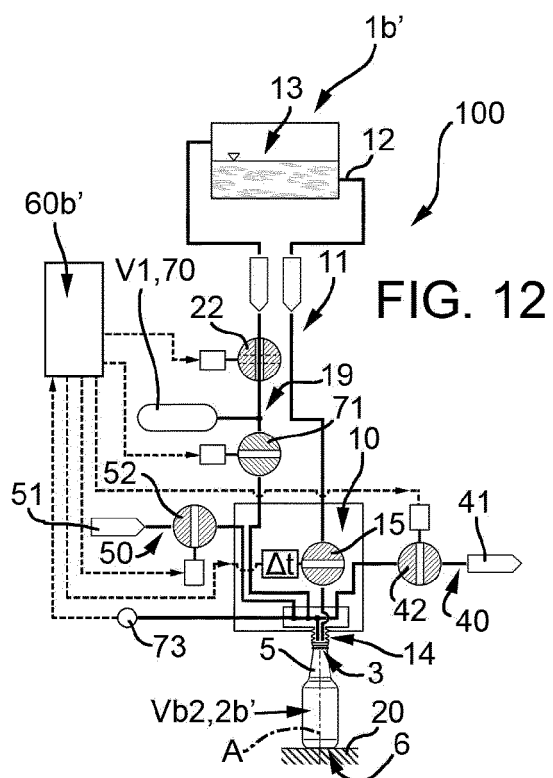
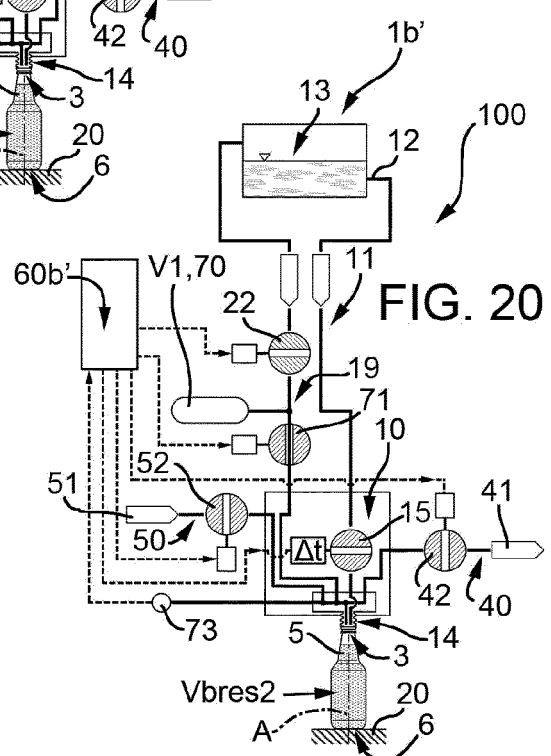
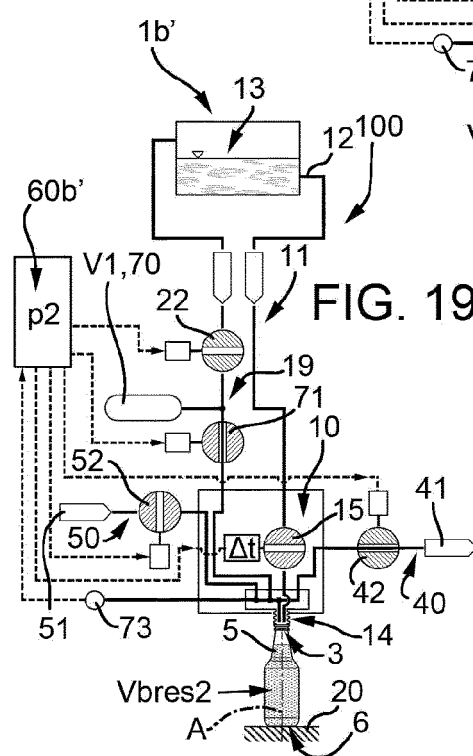
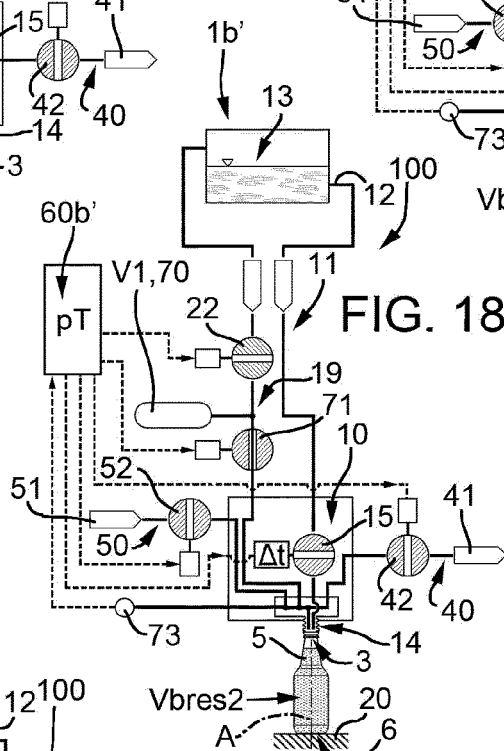
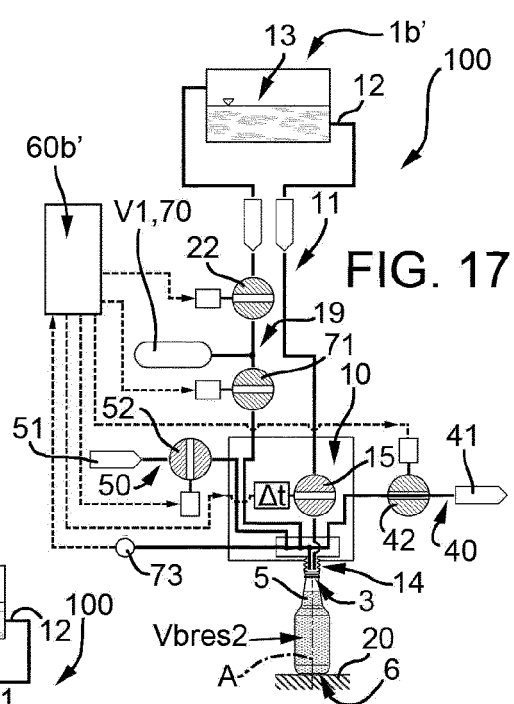
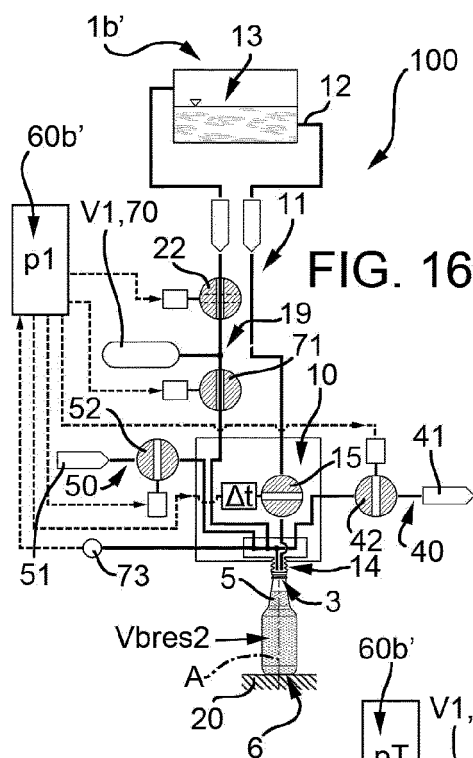


FIG. 11





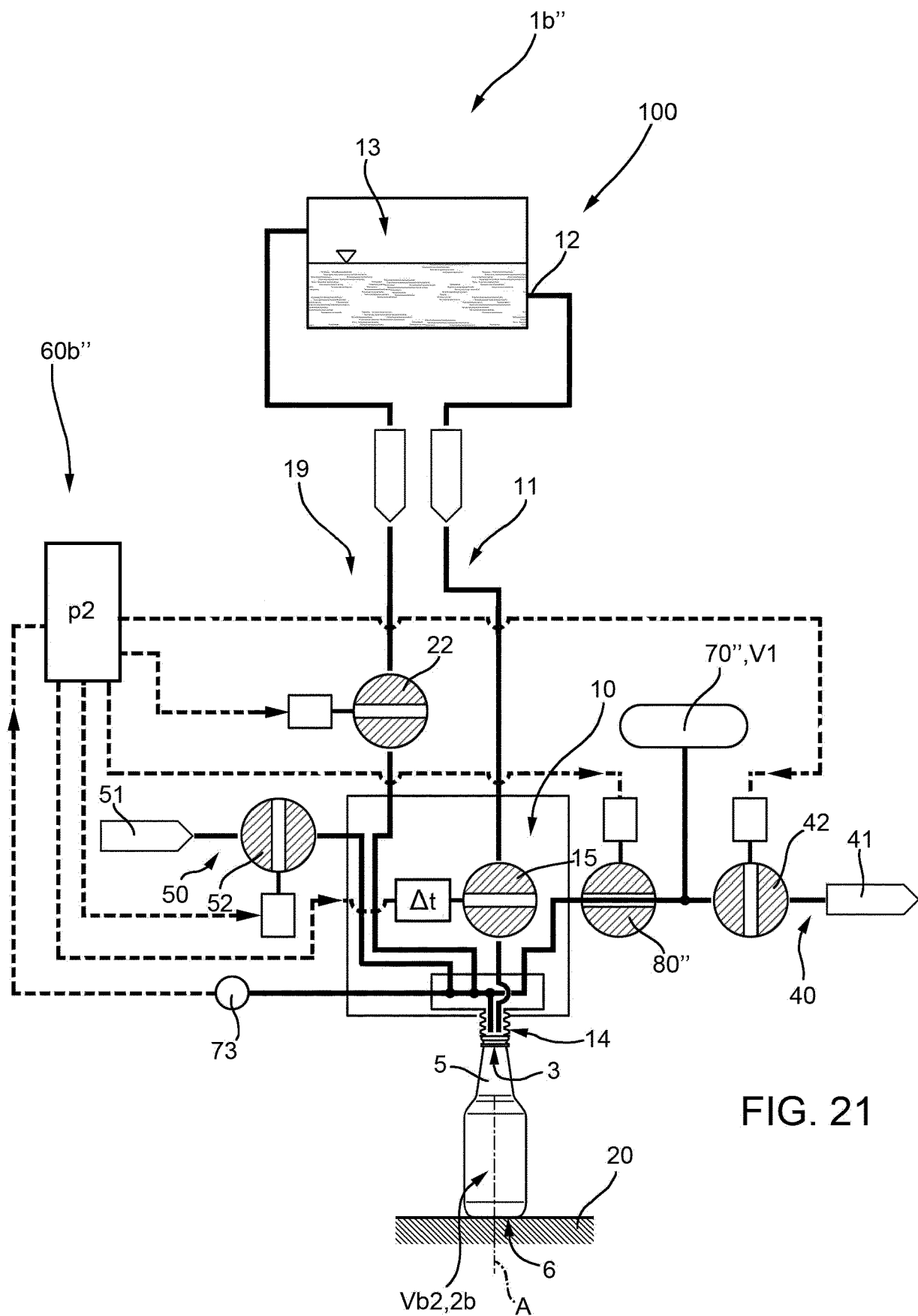
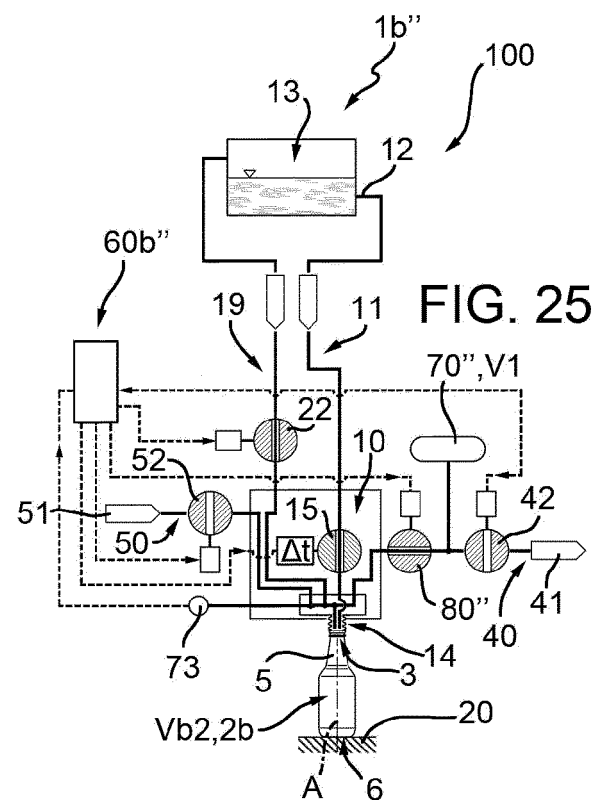
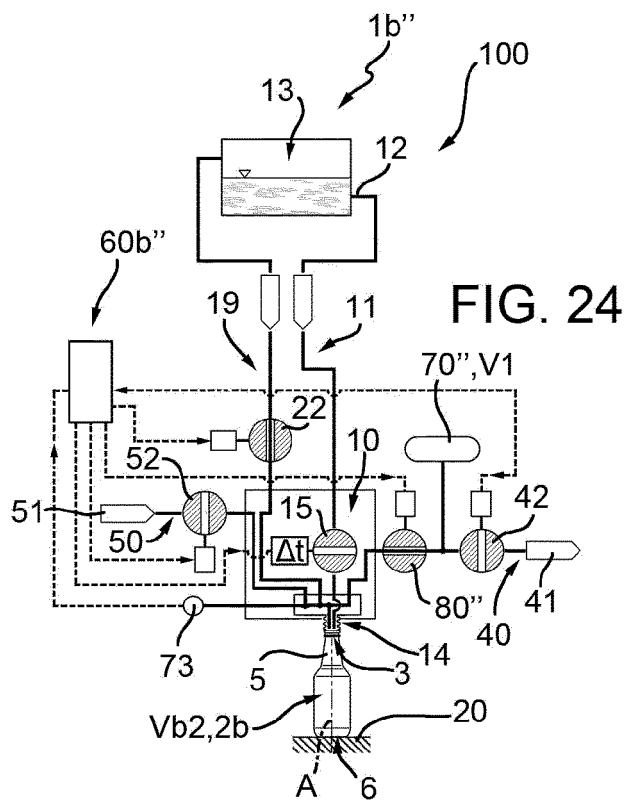
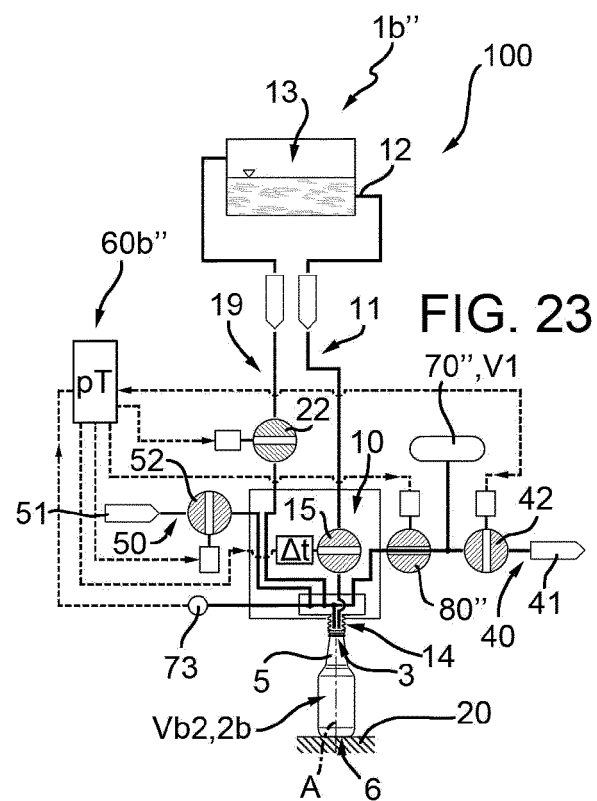
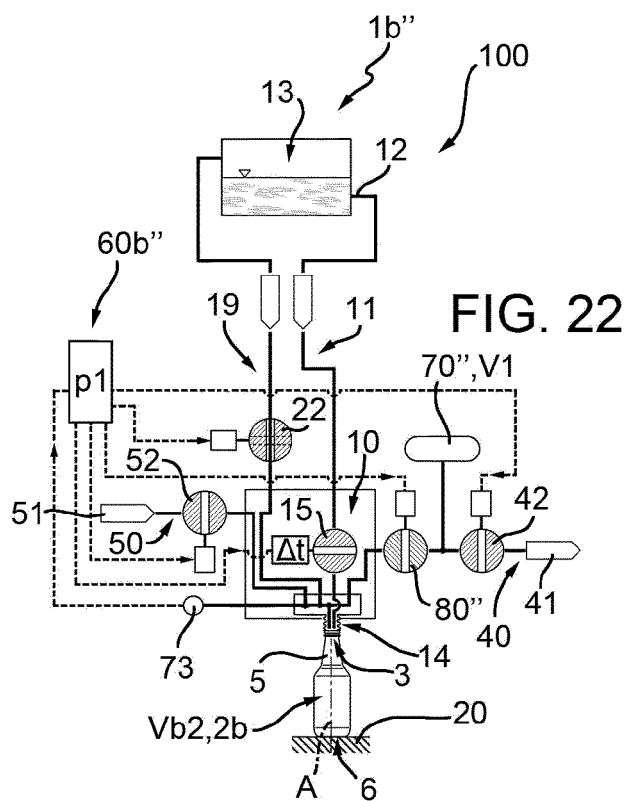
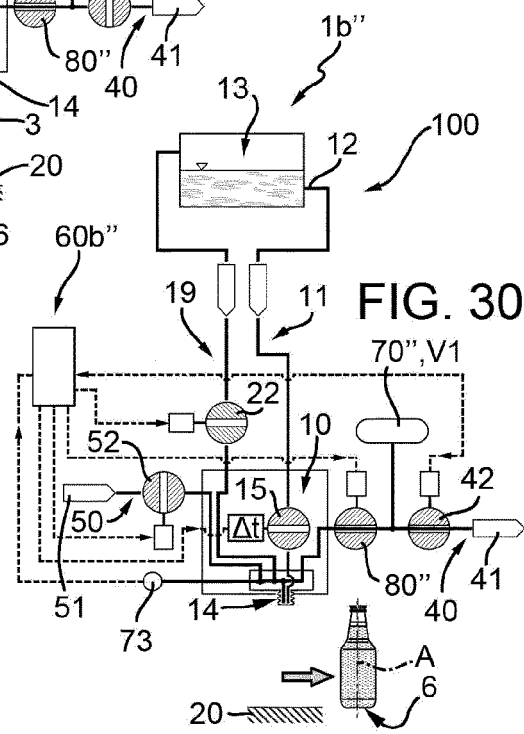
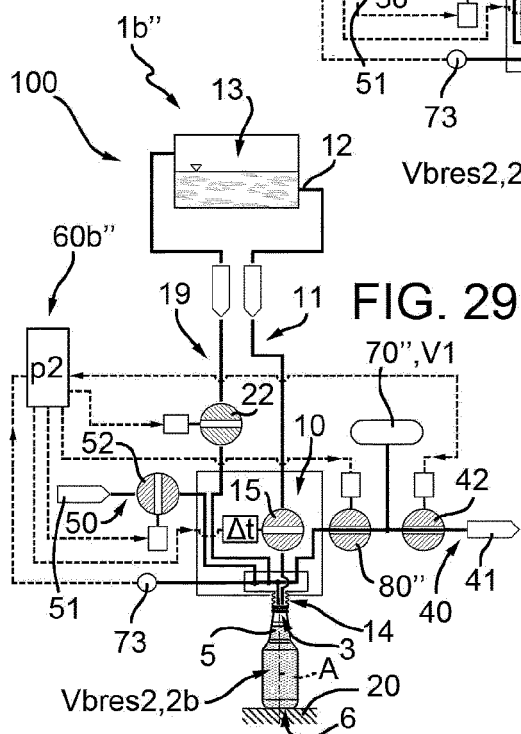
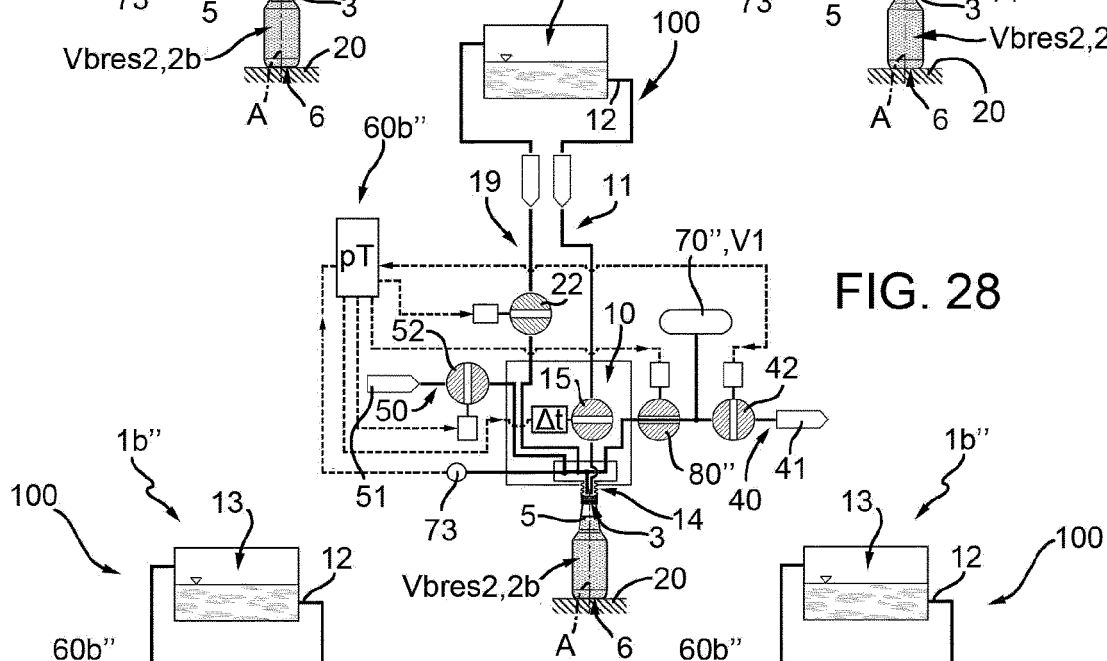
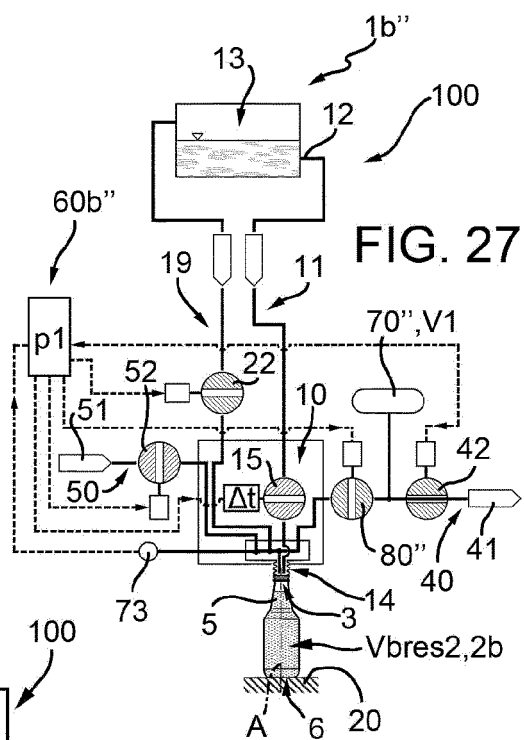
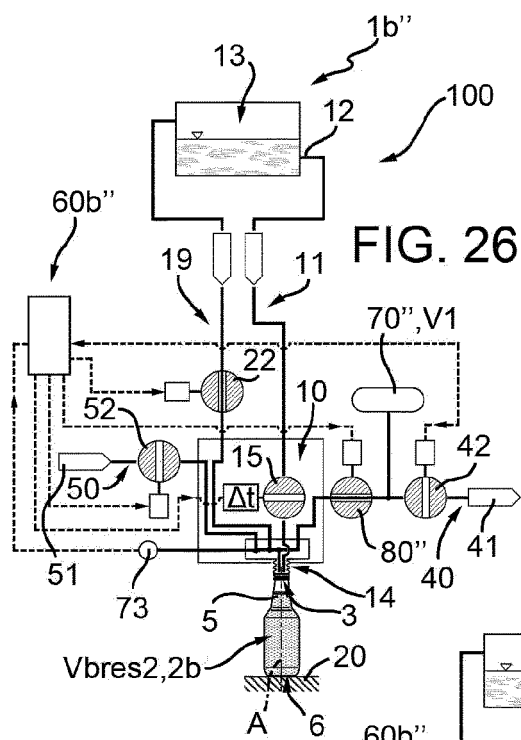


FIG. 21





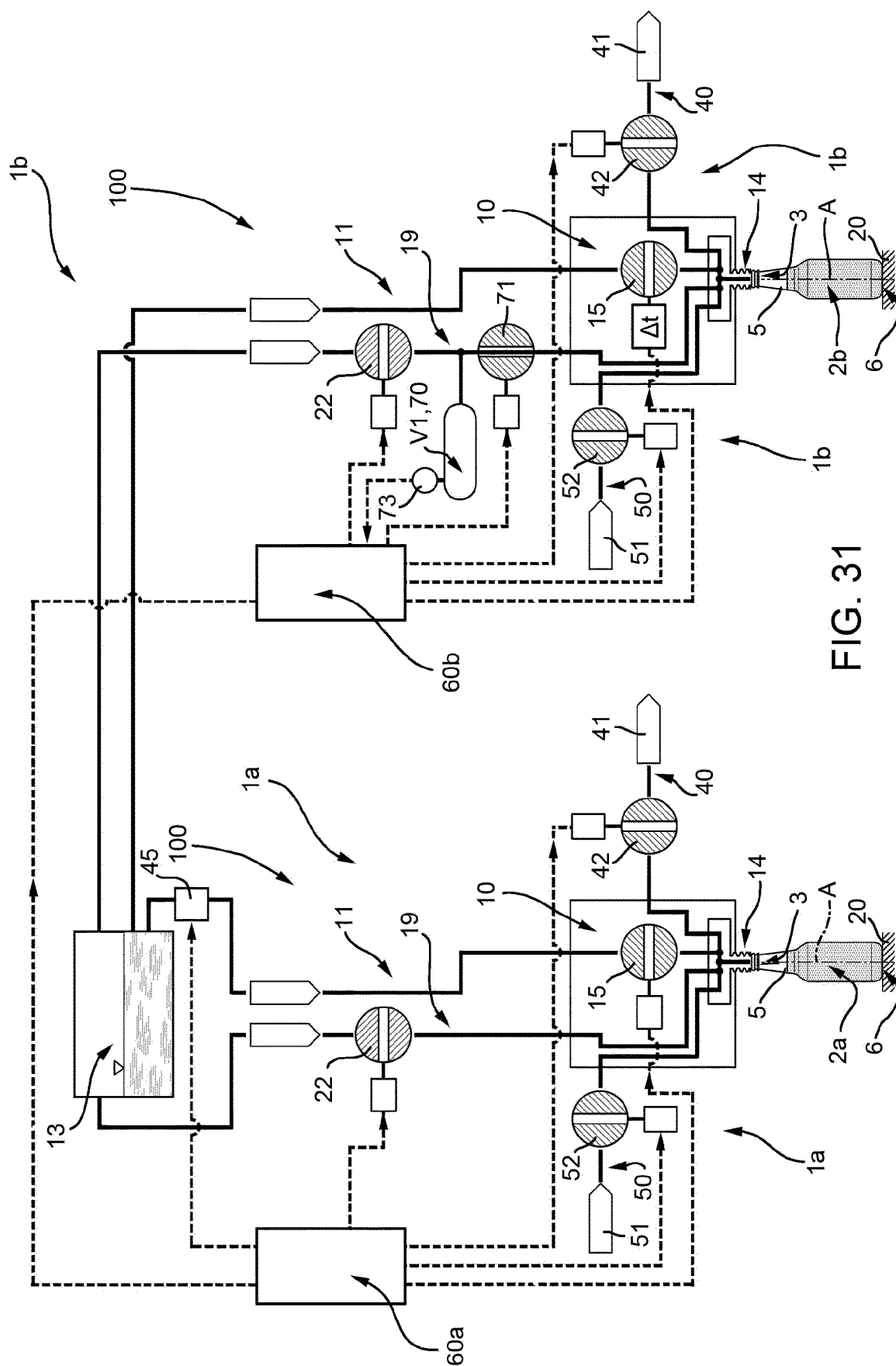


FIG. 31

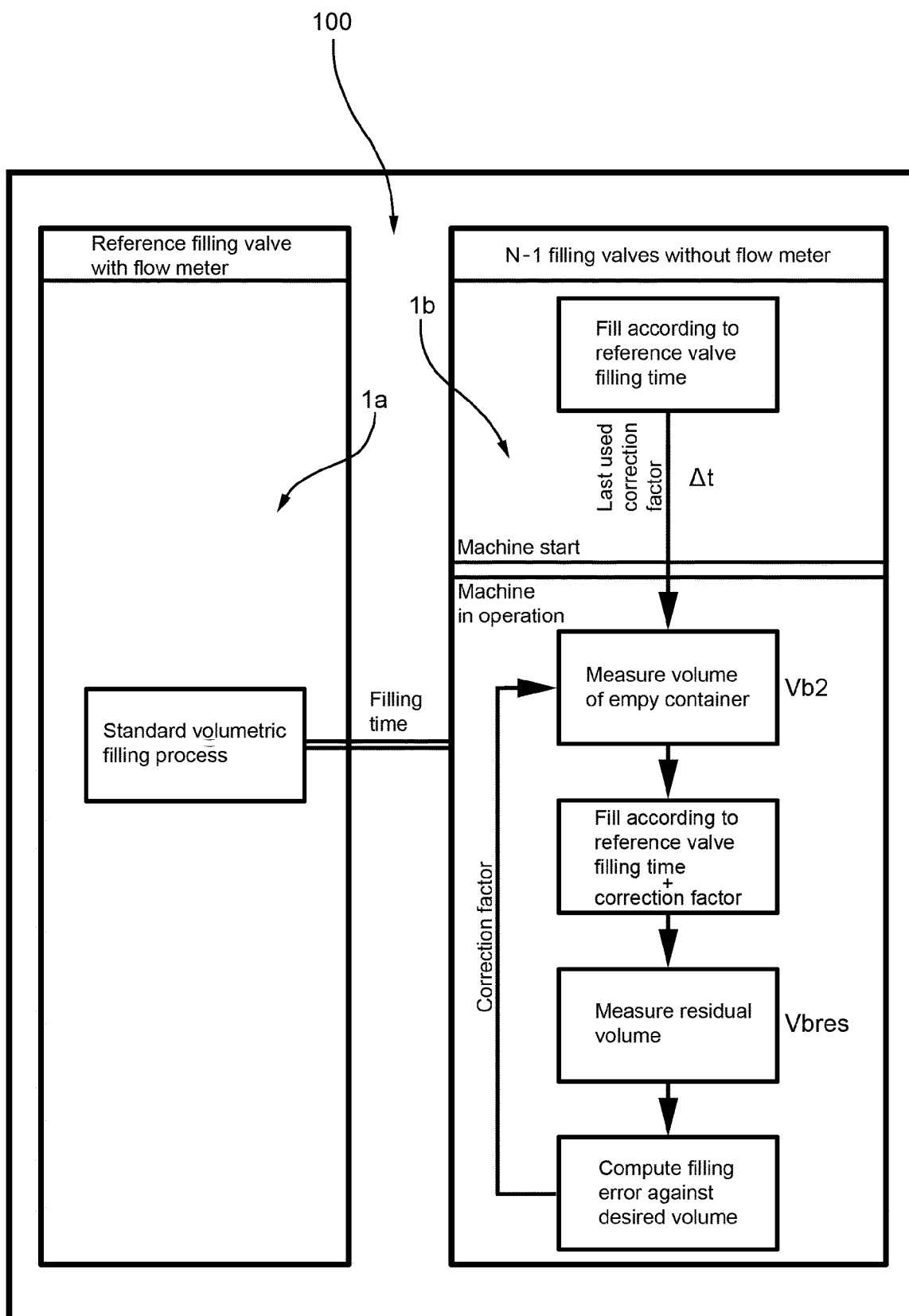


FIG. 32



EUROPEAN SEARCH REPORT

Application Number
EP 16 30 6552

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			B67C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 24 May 2017	Examiner Wartenhorst, Frank
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04C01)

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