



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.05.2022 Bulletin 2022/19

(51) International Patent Classification (IPC):
B67C 3/00 *(2006.01)* **B67C 3/28** *(2006.01)*

(21) Application number: **20206564.5**

(52) Cooperative Patent Classification (CPC):
B67C 3/007; B67C 3/287

(22) Date of filing: **10.11.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
 Designated Extension States:
BA ME
 Designated Validation States:
KH MA MD TN

(71) Applicant: **Sidel Participations**
76930 Octeville-sur-Mer (FR)

(72) Inventor: **D'ERRICO, Stefano**
43126 Parma (IT)

(74) Representative: **Sidel Group**
c/o Sidel Participations
Avenue de la Patrouille de France
76930 Octeville-sur-mer (FR)

(54) **METHOD FOR CONTROLLING A FILLING DEVICE DURING A FILLING OPERATION AND FILLING DEVICE FOR FILLING RECEPTACLES WITH A POURABLE PRODUCT**

(57) It is described a method for filling a plurality of containers by means of a filling device (1) and during a sequence of respective filling operations, which method allows the filling device (1) to have a reduction of the mechanical complexity and to have the ability of improving the precision and/or the accuracy of the automatic control of subsequent filling operations carried out by the same device (1).

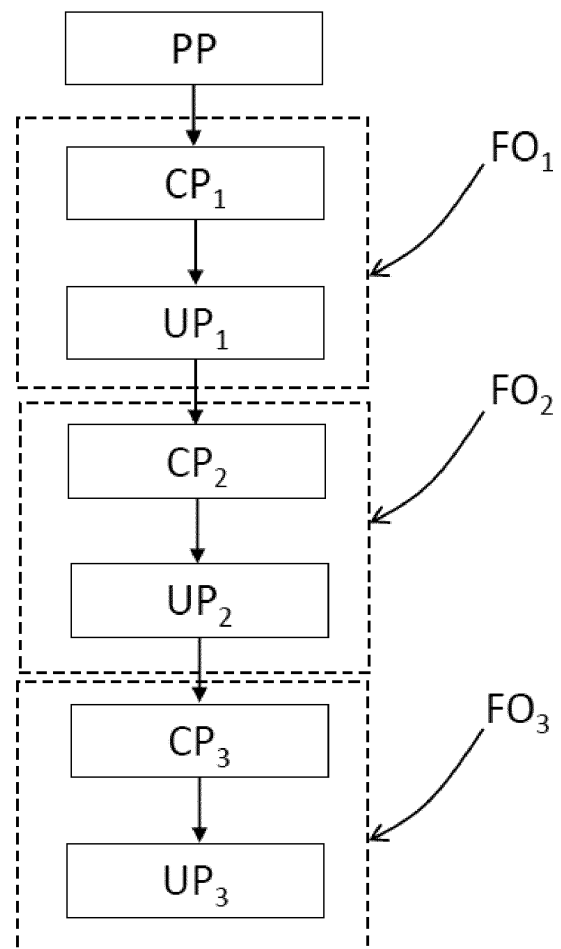


Fig. 2

Description

TECHNICAL FIELD

[0001] The present invention relates to a method for filling a plurality of containers by means of a flow of pourable product occurring through a filling device.

[0002] The present invention also relates to a filling device configured for carrying out the method.

BACKGROUND ART

[0003] Filling devices are known for filling containers with a pourable product. A type of filling device comprises a flow channel for guiding a flow of pourable product. The filling device comprises a valve element which can adopt a variable position with respect to said flow channel. The filling device is configured so that by controlling said position the flow rate of said flow can be influenced. The filling device comprises an electromagnetic or magnetic actuator for controlling said position by means of an electrical quantity. The filling device comprises a flowmeter for measuring the flow rate. The filling device comprises a position sensor for detecting said position.

[0004] The filling device is configured so that the flow rate can be influenced by sending a control value of the electrical quantity to the electromagnetic or magnetic actuator, said control value being dependent on the measured actual flow rate and upon the measured actual position. The position sensor increases the mechanical complexity of the filling device.

DISCLOSURE OF INVENTION

[0005] A filling method according to any of the appended method claims or according to present description allows for the filling device used for carrying out the method, to improve automatically the precision and/or accuracy of the flow rate automatic control of subsequent filling operations which are carried out for filling subsequently a plurality of respective containers by means of the same filling device.

[0006] A filling method according to any of the appended method claims or according to present description does not require, for the purpose of flow rate automatic control, to carry out any closed loop control of the position of the valve element, thereby obtaining a reduction in the mechanical complexity of the filling device used for carrying out the method.

[0007] A filling device according to any of the appended device claims or according to present description is configured for carrying out a method according to any of the appended method claims or according to present description.

[0008] The following brief description of the drawings and detailed description of the invention will be referred to a possible example embodiment of a filling method according to present description and a possible example

embodiment of a filling device according to present description.

[0009] In the following brief description of the drawings and detailed description of the invention, the example embodiment of the filling method will be defined for the sake of convenience as "method". In the following brief description of the drawings and detailed description of the invention, the example embodiment of the filling device will be defined for the sake of convenience as "device".

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The following detailed description will be referred to the accompanying drawings, in which:

Figure 1 is a schematic, partially sectioned side view, with parts removed for clarity, of the device; and Figure 2 is a flow diagram showing the method;

Figure 3 is a flow diagram showing a preliminary phase of the method;

Figure 4 is a graph for explaining a step of the preliminary phase of Figure 3;

Figure 5 is a table for explaining another step of the preliminary phase of Figure 3;

Figure 6 is a flow diagram showing a generic filling operation of the method;

Figure 7 is a flow diagram showing a controlling phase of the generic filling operation of Figure 6;

Figure 8 is a flow diagram of an operative sequence associated to a generic instant of the controlling phase of Figure 7;

Figure 9 is a flow diagram showing an updating phase of the generic filling operation of Figure 6;

Figure 10 is a graph for explaining some steps of the operative sequence of Figure 8;

Figure 11 is a graph for explaining other steps of the operative sequence of Figure 8 and a step of the updating phase of Figure 9;

Figure 12 is a graph for explaining another step of the updating phase of Figure 9.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The method is for filling a plurality of containers by means of a flow of pourable product, which flow occurs through the device 1. The device 1 is indicated in Figure 1.

[0012] The pourable product can be for example a pourable food product such as water, juice, milk, beer, carbonated soft drinks, or the like. The pourable product can be alternatively a pourable product which is not a food product.

[0013] The containers of said plurality are to be considered different from each other in the sense that each container is a different instance or specimen of the same type of container. Therefore, all the containers of said plurality are of the same type.

[0014] The method comprises a preliminary phase PP

and, after the preliminary phase PP, a temporally ordered sequence of filling operations. During each filling operation, a respective container is filled by means of the device 1. The plurality of filling operations can comprise any number of filling operations.

[0015] In Figure 2, box PP represents the preliminary phase. In Figure 2, each of the dashed boxes FO₁, FO₂, FO₃, represents a different filling operation. In Figure 2, the plurality of filling operations comprises a first filling operation FO₁, a second filling operation FO₂, and a third filling operation FO₃. The number of filling operations can be 1. The number of filling operations can be greater than 1. The enclosed Figures are referred to a case in which the number of filling operations is 3.

[0016] The preliminary phase PP comprises setting a preliminary curve PC. In Figure 3, box M1 represents the step of setting the preliminary curve PP. Figure 4 shows an example of preliminary curve, which is indicated with PC. The preliminary curve PC correlates a flow rate F of said flow with an electrical physical quantity EQ. The device 1 is configured so that said flow rate can be influenced by means of the electrical quantity EQ. The preliminary curve PC corresponds to a mathematical relationship correlating the flow rate F with the electrical quantity EQ.

[0017] The step of setting M1 the preliminary curve PC is carried out experimentally.

[0018] The preliminary phase PP comprises setting a control curve. Figure 4 shows an example of control curve, which is indicated with CC. The control curve CC correlates said flow rate F with said electrical physical quantity EQ. The control curve CC corresponds to a mathematical relationship correlating the flow rate F with the electrical quantity EQ.

[0019] In Figure 3, box M2 represents the step of setting the control curve CC. The step of setting M2 the control curve CC is carried out so that control curve CC is set equal to the preliminary curve PC. In Figure 4, it can be seen, that the control curve CC, during the preliminary phase PP, is set equal to preliminary curve PC.

[0020] Preliminary phase PP comprises setting a table. In Figure 3, box M3 represents the setting of the table.

[0021] The table associates at least one time instant to a respective desired value of the flow rate. The desired value is the value of flow rate which is desired to be obtained at the respective instant. Figure 5 shows an example of the table, which is indicated with T. In the example of Figure 5, a first time instant t₁ is associated to a first desired value D1, a second time instant t₂ is associated to a second desired value D2, and a third time instant t₃ is associated to a third desired value D3. Therefore at the first time instant t₁ it is desired to obtain the first desired value D1 of the flow rate, at the second time instant t₂ it is desired to obtain the second desired value D2 of the flow rate, and at the third time instant t₃ it is desired to obtain the third desired value D3 of the flow rate.

[0022] In the example of Figure 5, table T associates

each instant of a plurality of time instants to a respective desired value of said flow rate, said desired value being desired to be obtained at the respective instant. In the example of Figure 5, the plurality of time instants comprises the first instant t₁, the second instant t₂, and the third instant t₃.

[0023] The plurality of time instants can comprise any number of time instants. The number of time instants can be 1. The number of time instants can be greater than 1. The enclosed Figures are referred to the case in which the number of time instants is three.

[0024] The step of setting M3 the table T can be carried out before or after or at least partially simultaneously with respect to the step of setting M1 the preliminary curve PC and/or with respect to the step of setting M2 the control curve CC.

[0025] Each filling operation comprises a respective controlling phase and a respective updating phase. Figure 6 shows a generic filling operation FO. The filling operation FO can correspond to any one of the first filling operation FO₁, second filling operation FO₂, and third filling operation FO₃. In Figure 6, box CP represents the controlling phase of the generic filling operation FO. In Figure 6, box UP represents the updating phase of the generic filling operation FO. More specifically, in Figure 2, box CP₁ represents the controlling phase of the first filling operation FO₁, box CP₂ represents the controlling phase of the second filling operation FO₂, and box CP₃ represents the controlling phase of the third filling operation FO₃. More specifically, in Figure 2, box UP₁ represents the updating phase of the first filling operation FO₁, box UP₂ represents the updating phase of the second filling operation FO₂, and box UP₃ represents the updating phase of the third filling operation FO₃.

[0026] For each filling operation FO, the controlling phase CP comprises, for each time instant of the table T, a respective operative sequence associated to the instant. In Figure 7, box OS₁ represents a first operative sequence which is associated to first instant t₁, box OS₂ represents a second operative sequence which is associated to second instant t₂, and box OS₃ represents a third operative sequence which is associated to third instant t₃. In Figure 8, operative sequence OS can correspond to any one of first operative sequence OS₁, second operative sequence OS₂, and third operative sequence OS₃.

[0027] The operative sequence OS comprises a step of obtaining the desired value associated to the respective instant. The step of obtaining the desired value is carried out based on the table T. In Figure 8, box S1 represents the step of obtaining the desired value.

[0028] During the first operative sequence OS₁, the first desired value D1 is obtained based on the table T. During the second operative sequence OS₂, the second desired value D2 is obtained based on the table T. During the third operative sequence OS₃, the third desired value D3 is obtained based on the table T.

[0029] The operative sequence OS comprises a step

of determining a control value of the electrical quantity EQ. The step of determining the control value is carried out by applying said control curve CC to the obtained desired value. In Figure 8, box S2 represents the step of determining the control value. The determined control value is therefore associated to the obtained desired value through the control curve CC.

[0030] In Figure 10, C1 is a first control value. The first control value C1 is the control value determined during the first operative sequence OS₁. First control value C1 is determined by applying control curve CC to the obtained first desired value D1. In Figure 10, C2 is a second control value. The second control value C2 is the control value determined during the second operative sequence OS₂. Second control value C2 is determined by applying control curve CC to the obtained second desired value D2. In Figure 10, C3 is a third control value. The third control value C3 is the control value determined during the third operative sequence OS₃. Third control value C3 is determined by applying control curve CC to the obtained third desired value D3.

[0031] The operative sequence OS comprises a step of influencing said flow rate. The step of influencing the flow rate is carried out by means of the determined control value. In Figure 8, box S3 represents the step of influencing the flow rate.

[0032] During the first operative sequence OS₁, the step of influencing S3 the flow rate is carried out by means of the determined first control value C1. During the second operative sequence OS₂, the step of influencing the flow rate S3 is carried out by means of the determined second control value C2. During the third operative sequence OS₃, the step of influencing the flow rate is carried out by means of the determined third control value C3.

[0033] Operative sequence OS comprises, after said step of influencing S3, a step of measuring an actual value of said flow rate. In Figure 8, box S5 represents the step of measuring the actual value of the flow rate.

[0034] In Figure 11, A1 is a first actual value. The first actual value A1 is the actual value measured during the first operative sequence OS₁. In Figure 11, A2 is a second actual value. The second actual value A2 is the actual value measured during the second operative sequence OS₂. In Figure 11, A3 is a third actual value. The third actual value A3 is the actual value measured during the third operative sequence OS₃.

[0035] The operative sequence OS comprises a step of determining a preliminary value of said flow rate. The step of determining the preliminary value is carried out by applying the preliminary curve PC to the determined control value. In Figure 8, box S4 represents the step of determining the preliminary value. The determined preliminary value is therefore associated to the determined control value through the preliminary curve PC.

[0036] In Figure 11, P1 is a first preliminary value. The first preliminary value P1 is the preliminary value determined during the first operative sequence OS₁. First preliminary value P1 is determined by applying preliminary

curve PC to the determined first control value C1. In Figure 11, P2 is a second preliminary value. The second preliminary value P2 is the preliminary value determined during the second operative sequence OS₂. Second preliminary value P2 is determined by applying preliminary curve PC to the determined second control value C2. In Figure 11, P3 is a third preliminary value. The third preliminary value P3 is the preliminary value determined during the third operative sequence OS₃. Third preliminary value P3 is determined by applying preliminary curve PC to the determined third control value C3.

[0037] The step S4 of determining the preliminary value and the step of influencing S3 can be carried out in any temporal order, and/or at least partially simultaneously with each other. In Figure 8, the step S4 of determining the preliminary value is shown for example after the step of influencing S3.

[0038] The step of determining S4 the preliminary value and the step of measuring S5 can be carried out in any temporal order, and/or at least partially simultaneously with each other. In Figure 8, the step S4 of determining the preliminary value is shown for example before the step S5 of measuring. However, the step S4 of determining the preliminary value can be carried out after the step S5 of measuring.

[0039] The operative sequence OS comprises determining an error value. The error value is the deviation between the measured actual value and the determined preliminary value. In Figure 8, box S6 represents the step of determining the error value.

[0040] In Figure 11, E1 is a first error value. The first error value E1 is the error value determined during the first operative sequence OS₁. First error value E1 is the deviation of the measured first actual value A1 with respect to the determined first preliminary value P1. In Figure 11, E2 is a second error value. The second error value E2 is the error value determined during the second operative sequence OS₂. Second error value E2 is the deviation of the measured second actual value A2 with respect to the determined second preliminary value P2. In Figure 11, E3 is a third error value. The third error value E3 is the error value determined during the third operative sequence OS₃. Third error value E3 is the deviation of the measured third actual value A3 with respect to the determined third preliminary value P3.

[0041] The operative sequence OS comprises associating the determined error value with or to the determined control value. In Figure 8, box S7 represents the step of associating.

[0042] During the first operative sequence OS₁, the first error value E1 is associated to the first control value C1. During the second operative sequence OS₂, the second error value E2 is associated to the second control value C2. During the third operative sequence OS₃, the third error value E3 is associated to the third control value C3.

[0043] For each filling operation FO, the updating phase UP comprises a step of determining an error curve

correlating the error with said electrical quantity EQ. In Figure 9, box J1 represents the step of determining the error curve. Figure 11 shows an example of error curve, which is indicated with EC. The error curve EC corresponds to a mathematical relationship correlating the error E with the electrical quantity EQ. The error E corresponds to the deviation between the preliminary value and the actual flow rate. The step of determining the error curve EC is carried out by means of at least one determined error value E1 or E2 or E3, and by means of the associated at least one determined control value C1 or C2 or C3. In the case the number of time instants is greater than one, the step of determining J1 the error curve can be carried out by means of the determined error values E1, E2, E3, and by means of the respective associated and determined control values C1, C2 and C3.

[0044] The updating phase comprises a step of reinitializing the control curve CC. In Figure 9, box J2 represents the step of reinitializing the control curve CC. The step of reinitializing J2 the control curve CC is carried out by means of the determined error curve EC and the preliminary curve PC. Figure 12 shows an example of reinitialized control curve, which is indicated with CC. Control curve CC of Figure 12 is for example obtained by adding error curve EC of Figure 11 to control curve CC of Figure 11. Error values E1, E2, E3 of Figure 11 are to be considered negative values, for simplicity of illustration and for the sake of convenience.

[0045] Therefore the reinitialized control curve CC is obtained by means of the determined error curve EC and the preliminary curve PC. The step of reinitializing is carried out by adding the determined error curve EC to the preliminary curve PC. Therefore the reinitialized control curve CC is obtained by adding the error curve EC to the preliminary curve PC. The reinitialized control curve CC (Figure 12) is equal to the sum of the preliminary curve PC (Figure 4, 10 and 11) and the determined error curve EC (Figure 11). The preliminary curve PC remains constant and is kept the same for all the filling operations of the filling method, as can be derived from Figure 12, while the control curve CC can vary from one filling operation to another filling operation of the same filling method.

[0046] In this way, the control curve CC is updated or reinitialized during each of the filling operation. In particular, the control curve CC used during the controlling phase CP₂ of the second filling operation FO₂, corresponds to the control curve CC which has been reinitialized during the updating phase UP₁ of the previous first filling operation FO₁. In the same way, the control curve CC used during the controlling phase CP₃ of the third filling operation FO₃, corresponds to the control curve CC which has been reinitialized during the updating phase UP₂ of the previous second filling operation FO₂. Therefore, the control curve CC of each filling operation occurring after the first filling operation FO₁, corresponds to the control curve CC which has been reinitialized during the updating phase UP of the previous filling operation. In this way, the automatic control of the filling oper-

ations carried out by means of the same device 1 can automatically change from one filling operation to the next one, and therefore from one container to be filled to the next one. In particular, the precision of the automatic control can be automatically increased in the passage from one filling operation to the next one, and therefore in the passage from one container to be filled to the next one.

[0047] In particular, this allows to have an automatic improvement of the automatic control performance of the device 1 in the passage from one container to the next one to be filled by the same device 1.

[0048] In particular, the automatic improvement in the precision of the automatic control of the filling operations is due to the error curve EC being constructed, for each filling operation, with: y values corresponding to error values E1, E2, E3, which are determined as deviations always with respect to the constant preliminary curve PC, and not with respect to the possibly varying control curve CC; and with x values corresponding to control values C1, C2, C3, which are in turn determined starting from respective desired values D1, D2, D3 and by means of the control curve CC.

[0049] It is to be noted that Figure 10, 11 and 12 can be referred to first filling operation FO₁ or to second filling operation FO₂ or to third filling operation FO₃. However, the control curve CC showed in Figure 10 and 11 is showed as different from preliminary curve PC, because probably during each of second filling operation FO₂ and third filling operation FO₃ the control curve CC is, already before the reinitializing step J2, different from the preliminary curve PC. However, it is to be noted that, if the control curve CC, during the preliminary phase PP, is set to be equal to the preliminary curve PC, and if Figures 10 and 11 are considered to be referred to the first filling operation FO₁, the control curve CC of Figure 10 and 11 should be equal to preliminary curve PC, as is showed in Figure 4, which is referred to a preliminary phase PP, during which the control curve CC is initially set equal to preliminary curve PC.

[0050] The device 1 comprises a flow channel 7 for guiding said flow of pourable product. The flow channel is indicated in Figure 1.

[0051] The device 1 comprises a valve element 8. The valve element 8 can adopt a variable position with respect to said flow channel 7. The device 1 is configured so that said step S3 of influencing of the flow rate is carried out by controlling said position of the valve element 8.

[0052] The device comprises an electromagnetic or magnetic actuator 19 for controlling said position.

[0053] The device 1 comprises an automatic control unit 23.

[0054] The device 1 is configured so that the step S3 of influencing is carried out by the actuator 19 receiving automatically the control value C1 or C2 or C3 from the control unit 23 and the actuator 19 controlling automatically the position of the valve element 8 as a function of the received control value C1 or C2 or C3.

[0055] The device 1 comprises a flowmeter 22 for measuring said actual value A1 or A2 or A3.

[0056] Said step S5 of measuring the actual flow rate is carried out by the control unit 23 receiving automatically a signal from the flowmeter 22.

[0057] Said step of setting M1 the preliminary curve PC is carried out by means of the flowmeter 22, the control unit 23, and the actuator 19. Said step of setting M2 the control curve CC is carried out by means of the control unit 23, for example by means of a user setting the control curve CC in the control unit 23. Said step of setting M3 the table T is carried out by means of the control unit 23, for example by means of a user setting the table T in the control unit 23.

[0058] Said preliminary phase PP is carried out by means of the control unit 23. Said step of obtaining S1 the desired value D1 or D2 or D3 is carried out automatically by means of or by the control unit 23. Said step of determining S2 the control value C1 or C2 or C3 is carried out automatically by means of or by the control unit 23. Said step of determining S4 the preliminary value P1 or P2 or P3 is carried out automatically by means of or by the control unit 23. Said step of determining S6 the error value E1 or E2 or E3 is carried out automatically by means of or by the control unit 23. Said step of associating the determined error value E1 or E2 or E3 to the determined control value C1 or C2 or C3 is carried out automatically by means of or by the control unit 23. Said updating phase UP is carried out automatically by means of or by said control unit 23.

[0059] Thanks to the influencing step S3 of an operative sequence OS being independent from the measuring step S5 of the same operative sequence OS, the controlling phase CP of the filling operation FO is less dependent on the detections of the flowmeter 22, leading to an increase in the precision of controlling the filling operation.

[0060] The magnetic and/or electromagnetic nature of the actuator 19 allows for improving the cleanliness of the device, in particular for ultraclean and aseptic filling operations.

[0061] As the position of a valve element 8 driven by a magnetic and/or electromagnetic actuator 19 is controlled by an electrical quantity EQ, the method allows to improve the precision of the automatic control of the filling operations carried out by the same device 1 provided with a magnetic and/or electromagnetic actuator 19 for controlling the position of the valve element 8, which device 1 is in particular adapted for ultraclean and aseptic filling operations.

[0062] Moreover, to automatically control the flow rate, the device 1 does not need any position sensor for detecting the position of the valve element 8 with respect to the flow channel 7. In this way a great reduction of the mechanical complexity of the device 1 is obtained. Therefore it is reduced the mechanical complexity of a device 1 provided with a magnetic and/or electromagnetic actuator 19 for controlling the position of the valve element

8, which device 1 can be in particular adapted for ultraclean and aseptic filling operations.

[0063] The electrical quantity EQ can be a Pulse-Width Modulation electric signal.

5 **[0064]** The filling device 1 does not need and therefore does not comprise any position sensor for controlling said position of the valve element 8, so that the automatic control of said flow rate is carried out without any closed loop control of said position of the valve element 8. Therefore a great reduction of complexity and cost is obtained.

10 **[0065]** The method, by reinitializing the control curve CC at each filling operation, allows for avoiding the problem related to typical actual not linear correlation between the flow rate F and the electrical quantity EQ, which would render very difficult to control the filling operations based on real time values of electrical quantity EQ and associated actual flow rates values.

15 **[0066]** The filling method comprising the plurality of filling operations can be considered a production cycle carried out by the filling device 1.

20 **[0067]** The preliminary curve PC can be considered a mathematical relationship between the flow rate F and the electrical quantity EQ. The preliminary curve PC remains the same and constant for all the filling operations of the production cycle.

25 **[0068]** Also the control curve CC can be considered a mathematical relationship between the flow rate F and the electrical quantity EQ. The control curve CC is initially set preferably equal to the preliminary curve PC and is reinitialized at each filling operation of the production cycle, based on the preliminary curve PC and the error curve EC determined during the respective filling operation.

30 **[0069]** By reinitializing the control curve CC at each filling operation FO based on the same experimentally set and constant preliminary curve PC and based on the possibly varying error curve EC, which error curve EC can change from one filling operation to the other because it is calculated by means of x-values determined as control values C1, C2, C3, which are in turn determined by means of the possibly varying control curve CC and starting from respective desired values D1, D2, and D3, and y values determined as deviations of the actual flow rate with respect to the constant preliminary curve PC, the device 1 can progressively automatically adapt, from one filling operation to the next one, the automatic control of the flow rate during the filling operation to the actual boundary conditions of the production cycle, for example in terms of temperature and/or pressure, which boundary conditions can change from one production cycle to the other.

35 **[0070]** Moreover, by reinitializing the control curve CC at each filling operation FO based on the same experimentally set and constant preliminary curve PC and based on the possibly varying error curve EC, the problem related to the not linearity of the actual correlation between the flow rate F and the electrical quantity EQ can be avoided, so that the flow rate automatic control

of the filling operation can be carried out based upon the preliminary curve PC and the control curve CC, without needing any closed loop control for controlling the position of the valve element 8, and therefore without needing any position sensor for detecting the position of the valve element 8.

[0071] The device 1 is configured for carrying out the method.

[0072] The method is for filling a plurality of containers with a pourable product, by means of the same device 1 and during a sequence of respective filling operations. The method allows the filling device 1 to have a reduction of the mechanical complexity and to have the ability of automatically improving the precision and/or the accuracy of the automatic control of subsequent filling operations carried out by the same device 1.

[0073] The type to which the containers to be filled belong can be a bottle or the like, or any other kind or type of container or receptacle.

[0074] In detail, device 1 is fluidically connected, by means of a duct 4, to a tank 3 (only partially shown) containing the pourable product.

[0075] In greater detail, device 1 is part of a well-known rotary filling machine (not shown) comprising a rotary carousel rotatable around a vertical axis, centrally carrying the tank 3 and peripherally carrying a plurality of devices 1, each connected to the tank 3 by means of one respective duct 4.

[0076] Device 1 comprises:

- a filling valve 5 for feeding the pourable product to the container 2, while the device 1 moves, in use, along a transfer path due to the rotary movement imparted by the carousel; and
- a support element (not shown) adapted to receive and hold in an upright position, below the valve 5 itself, the container 2.

[0077] The device 1 comprises a tubular body 6 defining the flow channel 7 for feeding the pourable product to the container 2 to be filled and arranged below the tubular body 6 itself, and

[0078] The valve element 8 is a shutter 8, which movably, in particular slidingly, engages tubular body 6 and is reciprocally movable inside flow channel 7 in order to open or close an outflow passage 10 of the pourable product towards the container 2.

[0079] In practice, shutter 8 is movable within flow channel 7 to selectively allow or prevent the flow of pourable product therein and towards the container 2.

[0080] To this end, tubular body 6 ends at a lower end 11 thereof with an axial outlet opening 12 fluidically communicating, in use, with an end opening 2a defined by an upper edge of the container 2 to be filled.

[0081] Flow channel 7 comprises, at an upper portion 15 thereof, a first stretch 13 having a constant section, conveniently cylindrical, and, at lower portion 11, a second stretch 14 with variable section, conveniently frusto-

conical, positioned upstream of outlet opening 12 and narrowing in the direction of the latter, up to a minimum-diameter section or narrow section 16.

[0082] Shutter 8 comprises a main portion 17 configured to cooperate in a sliding manner in contact with an internal wall of flow channel 7, preferably by means of guide portions 17a, and a shutting portion 18 configured to cooperate in contact with narrow section 16.

[0083] In particular, shutter 8 is movable at least between a closing position (Figure 1), in which shutting portion 18 closes in a fluid-tight manner narrow section 16, thereby preventing any flow of pourable product towards outlet opening 12, and an opening position (not shown), in which shutter 8 delimits together with the narrow section and the second stretch 14, an annular outflow passage fluidically communicating with outlet opening 12, so as to allow the flow of the pourable product towards the latter and into container 2.

[0084] According to this non-limiting preferred embodiment shown, filling valve 5 is of the well-known modulating type.

[0085] Accordingly, shutter 8 is movable between a maximum closing position and a maximum opening position and in a plurality of intermediate opening positions, which define with narrow section 16 respective intermediate annular outflow passages with increasing dimensions (apertures).

[0086] The actuator 19 is configured to drive the movement of shutter 8 within flow channel 7.

[0087] In detail, actuator 19 comprises a driving member, in particular a coil 20 arranged at upper portion 15 of tubular body 6 and a driven member, preferably a permanent magnet 21 carried by shutter 8, in particular arranged within main portion 17 of shutter 8.

[0088] According to a manner known and not described in detail, coil 20 is configured to be supplied with an electric current and to be magnetically coupled to permanent magnet 21, which is appropriately incorporated in shutter 8.

[0089] According to an alternative embodiment not shown, driven member could comprise a plurality of permanent magnets 21 carried by shutter 8 or shutter 8 could be made of ferromagnetic material, for example at least at its central portion 17, thereby defining the permanent magnet 21.

[0090] The advantages of the device 1 and of the method 1 will be clear from the foregoing description.

[0091] In particular, thanks to the above configuration, an efficient and simple adaptive method for controlling the filling operations, which takes into account the variability of the boundary conditions of the filling method (such as pressure, temperature or the like) for each device 1 of the filling machine. In fact, the obtained control is highly adaptive and depends on the actual filling conditions.

[0092] Furthermore, the preliminary curve PC is static and unchanged for subsequent filling operations. Control curve CC is advantageously dynamic and is recalculated

continuously at each filling operation, while at the very first filling operation is conveniently set to be the same to the preliminary curve PC.

[0093] Moreover, such adaptive control is carried out without the need for a position sensor, and therefore without the need for a closed-loop control based on a position value of shutter 8. Hence, the architecture of the device 1 is simplified and the overall costs are reduced, whilst the reliability of the system is increased.

[0094] Clearly, changes may be made to device 1 and to the method for controlling device 1 as described herein without, however, departing from the scope of protection as defined in the accompanying claims.

Claims

1. Method for filling a plurality of containers by means of a flow of pourable product, said flow occurring through a filling device (1), the method comprising a preliminary phase (PP) and, after the preliminary phase (PP), a temporally ordered sequence of filling operations (FO₁, FO₂, FO₃), each filling operation (FO₁, FO₂, FO₃) being for filling a respective container;
wherein the preliminary phase (PP) comprises:

- setting (M1) a preliminary curve (PC) correlating a flow rate (F) of said flow with an electrical physical quantity (EQ), the filling device (1) being configured so that said electrical quantity (EQ) can influence said flow rate;
- setting (M2) a control curve (CC) correlating said flow rate (F) with said physical electrical quantity (EQ);
- setting (M3) a table (T) associating at least one time instant (t₁; t₂; t₃) to a respective desired value (D₁; D₂; D₃) of said flow rate, said desired value (D₁; D₂; D₃) being desired to be obtained at the respective instant (t₁; t₂; t₃);

wherein each filling operation (FO₁; FO₂; FO₃) comprises a respective controlling phase (CP₁; CP₂; CP₃) and a respective updating phase (UP₁; UP₂; UP₃);

wherein, for each filling operation (FO₁; FO₂; FO₃), the controlling phase (CP₁; CP₂; CP₃) comprises, at least for said time instant (t₁; t₂; t₃), an operative sequence (OS₁; OS₂; OS₃), the operative sequence (OS₁; OS₂; OS₃) comprising:

- based on said table (T), obtaining (S1) the desired value (D₁; D₂; D₃) associated to the respective instant (t₁; t₂; t₃);
- by applying said control curve (CC) to said desired value (D₁; D₂; D₃), determining (S2) a control value (C₁; C₂; C₃) of the electrical quantity (EQ);

- by means of the determined control value (C₁; C₂; C₃), influencing (S3) said flow rate;
- after said influencing, measuring (S5) an actual value (A₁; A₂; A₃) of said flow rate;
- by applying said preliminary curve (PC) to the determined control value (C₁; C₂; C₃), determining (S4) a preliminary value (P₁; P₂; P₃) of said flow rate;
- determining (S6) an error value (E₁; E₂; E₃) which is a deviation between the measured actual value (A₁; A₂; A₃) and the determined preliminary value (P₁; P₂; P₃);
- associating (S7) the determined error value (E₁; E₂; E₃) to the determined control value (C₁; C₂; C₃);

wherein, for each filling operation (FO₁; FO₂; FO₃), the updating phase (UP₁; UP₂; UP₃) comprises:

- by means of at least one determined error value (E₁; E₂; E₃) and the associated at least one determined control value (C₁; C₂; C₃), determining (J1) an error curve (EC) correlating an error (E) with said electrical quantity (EQ);
- reinitializing (J2) the control curve (CC) by means of the determined error curve (EC) and the preliminary curve (PC).

2. Method according to claim 1, wherein:

- said table (T) associates each time instant (t₁; t₂; t₃) of a plurality of time instants (t₁; t₂; t₃) to a respective desired value (D₁; D₂; D₃) of said flow rate, said desired value (D₁; D₂; D₃) being desired to be obtained at the respective instant (t₁; t₂; t₃);
- for each filling operation (FO₁; FO₂; FO₃), the controlling phase (CP₁; CP₂; CP₃) comprises, for each time instant (t₁; t₂; t₃) of the table (T), a respective operative sequence (OS₁; OS₂; OS₃);
- for each filling operation (FO₁; FO₂; FO₃), the updating phase (UP₁; UP₂; UP₃) comprises determining (J1) the error curve (EC) by means of the determined error values (E₁, E₂, E₃) and the associated respective determined control values (C₁, C₂, C₃).

3. Method according to any of the previous claims, wherein said step of reinitializing (J2) is carried out by adding the determined error curve (EC) to the preliminary curve (PC), so that the reinitialized control curve (CC) is equal to the sum of the preliminary curve (PC) and the determined error curve (EC).

4. Method according to any of the previous claims, wherein the preliminary curve (PC) is set experimentally.

5. Method according to any of the previous claims, wherein, during the preliminary phase (PP), the control curve (CC) is set equal to the preliminary curve (PC).

6. Method according to any of the previous claims, wherein the electrical quantity (EQ) is a Pulse-Width Modulation electric signal.

7. Method according to any of the previous claims, wherein the filling device (1) comprises:

- a flow channel (7) for guiding said flow of pourable product;
- a valve element (8) which can adopt a variable position with respect to said flow channel (7), the filling device (1) being configured so that said step of influencing (S3) is carried out by controlling said position;
- an electromagnetic or magnetic actuator (19) for controlling said position by receiving said control value (C1; C2; C3);
- a flowmeter (22) for measuring said actual value (A1; A2; A3);
- an automatic control unit (23);

wherein:

- said step (S3) of influencing the flow rate is carried out by the actuator (19) receiving automatically the control value (C1; C2; C3) from the control unit (23) and the actuator (19) controlling automatically the position of the valve element (8) as a function of the received control value (C1; C2; C3);
- said step (S5) of measuring the actual flow rate is carried out by the control unit (23) receiving automatically a signal from the flowmeter (22);
- said step (M1) of setting the preliminary curve (PC) is carried out by means of the flowmeter (22), the control unit (23), and the actuator (19);
- said step of setting (M2) the control curve (CC) is carried out by means of the control unit (23);
- said step of setting (M3) the table (T) is carried out by means of the control unit (23);
- said step of obtaining (S1) the desired value (D1; D2; D3), said step of determining (S2) the control value (C1; C2; C3), said step of determining (S4) the preliminary value (P1; P2; P3), said step of determining (S6) the error value (E1; E2; E3), said step of associating (S7) the determined error value (E1; E2; E3) to the determined control value (C1; C2; C3), and said updating phase (UP), are carried out automatically by means of said control unit (23).

8. Filling method according to any of the previous claims, wherein the filling device (1) does not com-

prise any position sensor for controlling said position of the valve element (8), so that the automatic control of said flow rate is carried out without any closed loop control of said position of the valve element (8).

9. Filling device (1) for filling a plurality of containers by means of a flow of pourable product, said flow occurring through a filling device (1), the filling device (1) being configured for carrying out a preliminary phase (PP) and, after the preliminary phase (PP), a temporally ordered sequence of filling operations (FO₁, FO₂, FO₃), each filling operation (FO₁, FO₂, FO₃) being for filling a respective container; wherein the filling device (1) is configured so that the preliminary phase (PP) comprises:

- setting (M1) a preliminary curve (PC) correlating a flow rate (F) of said flow with an electrical physical quantity (EQ), the filling device (1) being configured so that said electrical quantity (EQ) can influence said flow rate;
- setting (M2) a control curve (CC) correlating said flow rate (F) with said physical quantity (EQ);
- setting (M3) a table (T) associating at least one time instant (t1; t2; t3) to a respective desired value (D1; D2; D3) of said flow rate, said desired value (D1; D2; D3) being desired to be obtained at the respective instant (t1; t2; t3);

wherein the filling device (1) is configured so that each filling operation (FO₁; FO₂; FO₃) comprises a respective controlling phase (CP₁; CP₂; CP₃) and a respective updating phase (UP₁; UP₂; UP₃); wherein the filling device (1) is configured so that, for each filling operation (FO₁; FO₂; FO₃), the controlling phase (CP₁; CP₂; CP₃) comprises, at least for said time instant (t₁; t₂; t₃), an operative sequence (OS₁; OS₂; OS₃); wherein the filling device (1) is configured so that the operative sequence (OS₁; OS₂; OS₃) comprises:

- based on said table (T), obtaining (S1) the desired value (D1; D2; D3) associated to the respective instant (t1; t2; t3);
- by applying said control curve (CC) to said desired value (D1; D2; D3), determining (S2) a control value (C1; C2; C3) of the electrical quantity (EQ);
- by means of the determined control value (C1; C2; C3), influencing (S3) said flow rate;
- after said influencing, measuring (S5) an actual value (A1; A2; A3) of said flow rate;
- by applying said preliminary curve (PC) to the determined control value (C1; C2; C3), determining (S6) a preliminary value (P1; P2; P3) of said flow rate;
- determining (S6) an error value (E1; E2; E3)

which is a deviation between the measured actual value (A1; A2; A3) and the determined preliminary value (P1; P2; P3);

- associating (S7) the determined error value (E1; E2; E3) to the determined control value (C1; C2; C3);

wherein the filling device (1) is configured so that, for each filling operation (FO₁; FO₂; FO₃), the updating phase (UP₁; UP₂; UP₃) comprises:

- by means of at least one determined error value (E1; E2; E3) and the associated at least one determined control value (C1; C2; C3), determining an error curve (EC) correlating an error (E) with said electrical quantity (EQ);

- reinitializing the control curve (CC) by means of the determined error curve (EC) and the preliminary curve (PC) .

10. Filling device according to claim 9, wherein the filling device (1) is configured so that:

- said table (T) associates each time instant (t1; t2; t3) of a plurality of time instants (t1; t2; t3) to a respective desired value (D1; D2; D3) of said flow rate, said desired value (D1; D2; D3) being desired to be obtained at the respective instant (t1; t2; t3);

- for each filling operation (FO₁; FO₂; FO₃), the controlling phase (CP₁; CP₂; CP₃) comprises, for each time instant (t1; t2; t3) of the table (T), a respective operative sequence (OS₁; OS₂; OS₃);

- for each filling operation (FO₁; FO₂; FO₃), the updating phase (UP₁; UP₂; UP₃) comprises determining (S6) the error curve (EC) by means of the determined error values (E1, E2, E3) and the associated respective control values (C1, C2, C3).

11. Filling device (1) according to claim 9 or 10, wherein the filling device (1) is configured so that said step of reinitializing (J2) is carried out by adding the determined error curve (EC) to the preliminary curve (PC), so that the reinitialized control curve (CC) is equal to the sum of the preliminary curve (PC) and the determined error curve (EC).

12. Filling device (1) according to any of claims from 9 to 11, wherein the filling device (1) is configured so that the preliminary curve (PC) is set experimentally.

13. Filling device (1) according to any of claims from 9 to 12, wherein the filling device (1) is configured so that, during the preliminary phase (PP), the control curve (CC) is set equal to the preliminary curve (PC).

14. Filling device (1) according to any of claims from 9 to 13, wherein the filling device (1) is configured so that the electrical quantity (EQ) is a Pulse-Width Modulation electric signal.

15. Filling device (1) according for any of claims from 9 to 14, comprising:

- a flow channel (7) for guiding said flow of pourable product;

- a valve element (8) which can adopt a variable position with respect to said flow channel (7), the filling device (1) being configured so that said step of influencing (S3) is carried out by controlling said position;

- an electromagnetic or magnetic actuator (19) for controlling said position by receiving said control value (C1; C2; C3);

- a flowmeter (22) for measuring said actual value (A1; A2; A3);

- an automatic control unit (23);

wherein the filling device is configured so that:

- said step (S3) of influencing the flow rate is carried out by the actuator (19) receiving automatically the control value (C1; C2; C3) from the control unit (23) and the actuator (19) controlling automatically the position of the valve element (8) as a function of the received control value (C1; C2; C3);

- said step (S5) of measuring the actual flow rate is carried out by the control unit (23) receiving automatically a signal from the flowmeter (22);

- said step (M1) of setting the preliminary curve (PC) is carried out by means of the flowmeter (22), the control unit (23), and the actuator (19);

- said step of setting (M2) the control curve (CC) is carried out by means of the control unit (23);

- said step of setting (M3) the table (T) is carried out by means of the control unit (23);

- said step of obtaining (S1) the desired value (D1; D2; D3), said step of determining (S2) the control value (C1; C2; C3), said step of determining (S4) the preliminary value (P1; P2; P3), said step of determining (S6) the error value (E1; E2; E3), said step of associating the determined error value (E1; E2; E3) to the determined control value (C1; C2; C3), and said updating phase (UP), are carried out automatically by means of said control unit (23).

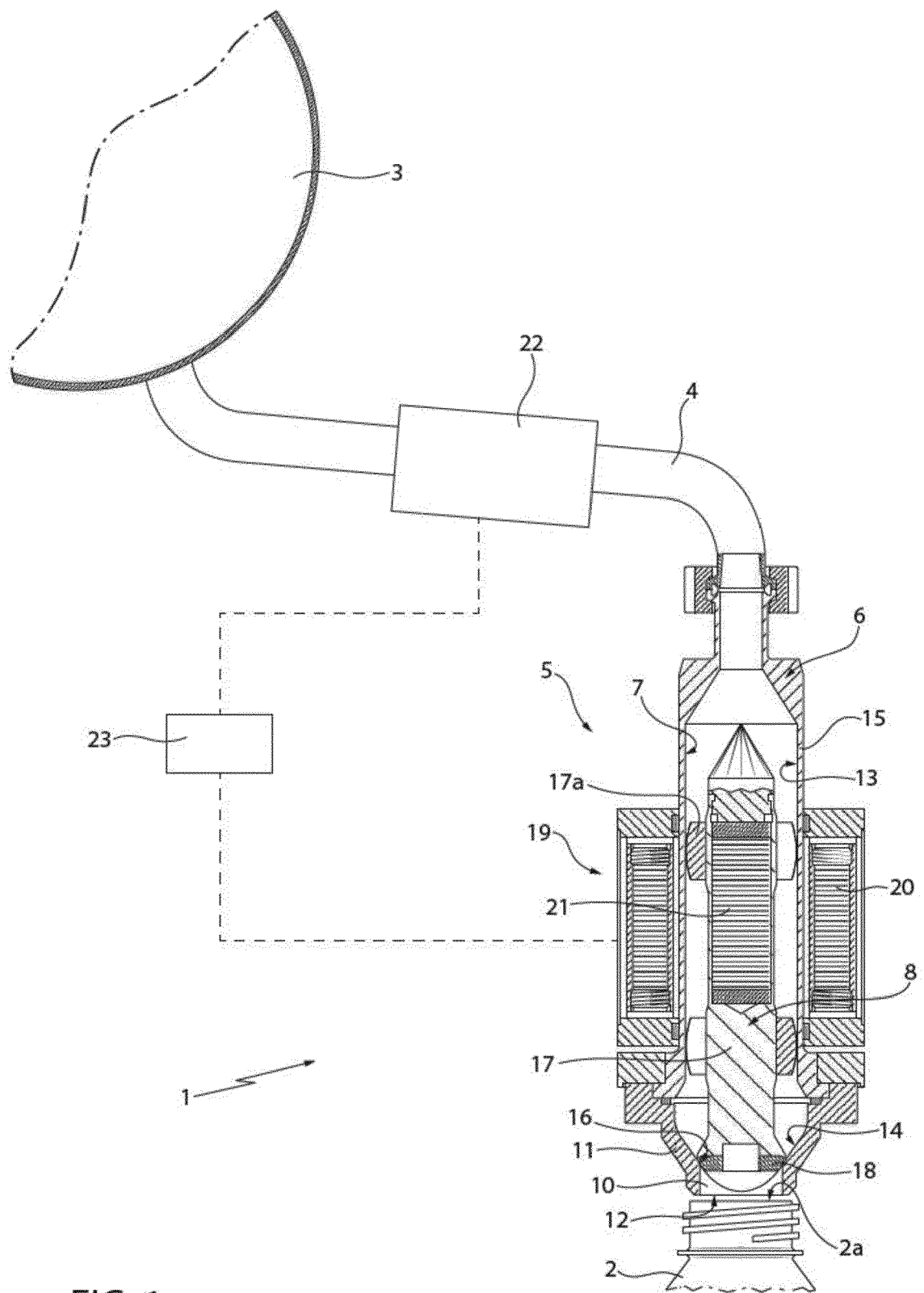


FIG. 1

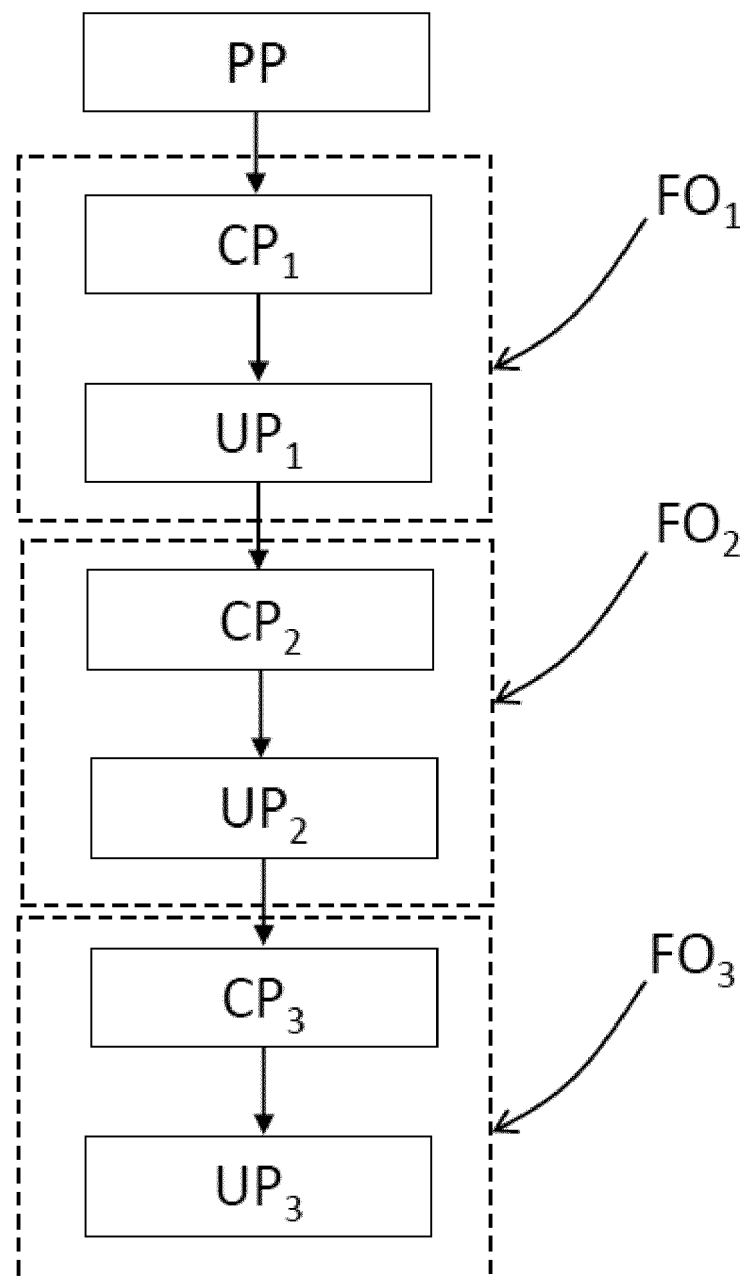


Fig. 2

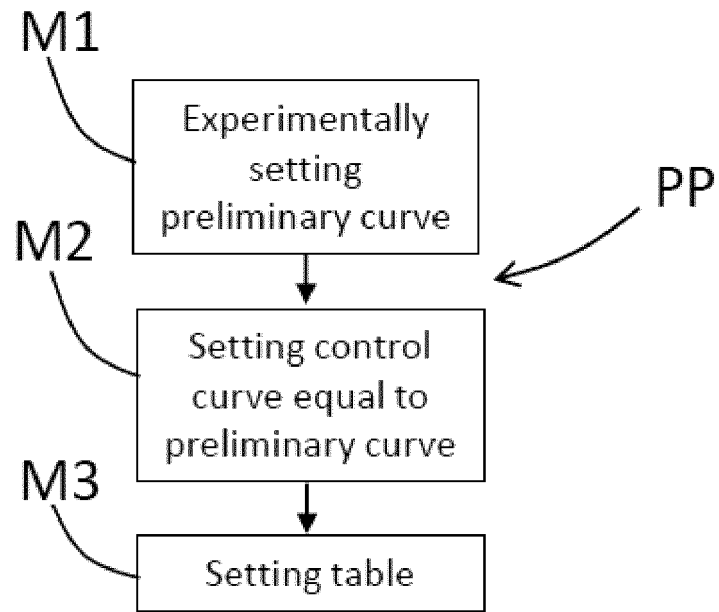


Fig. 3

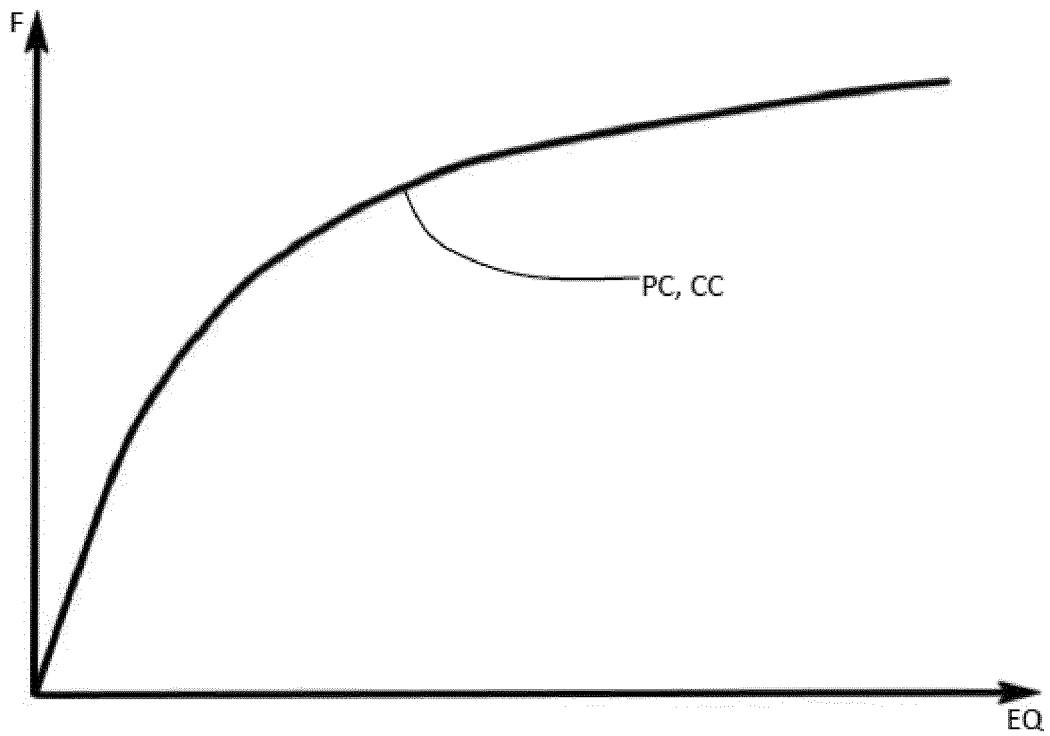


Fig. 4

t_1	D1
t_2	D2
t_3	D3

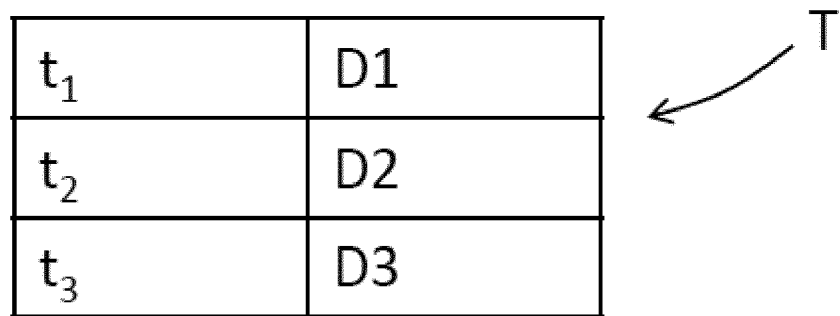


Fig. 5

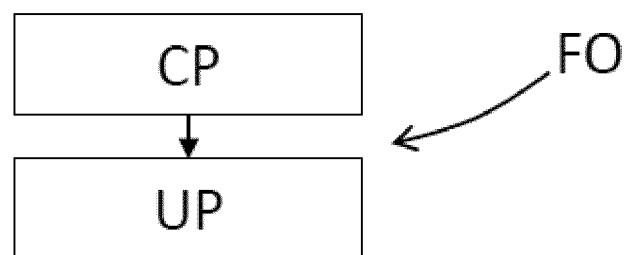


Fig. 6

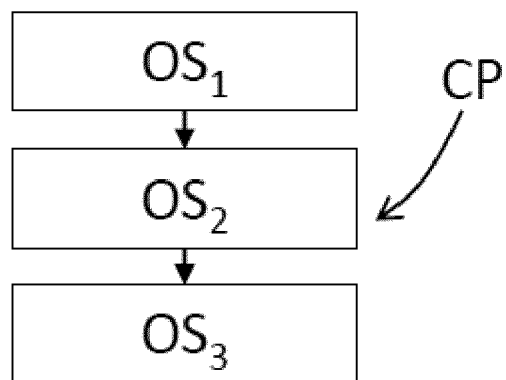


Fig. 7

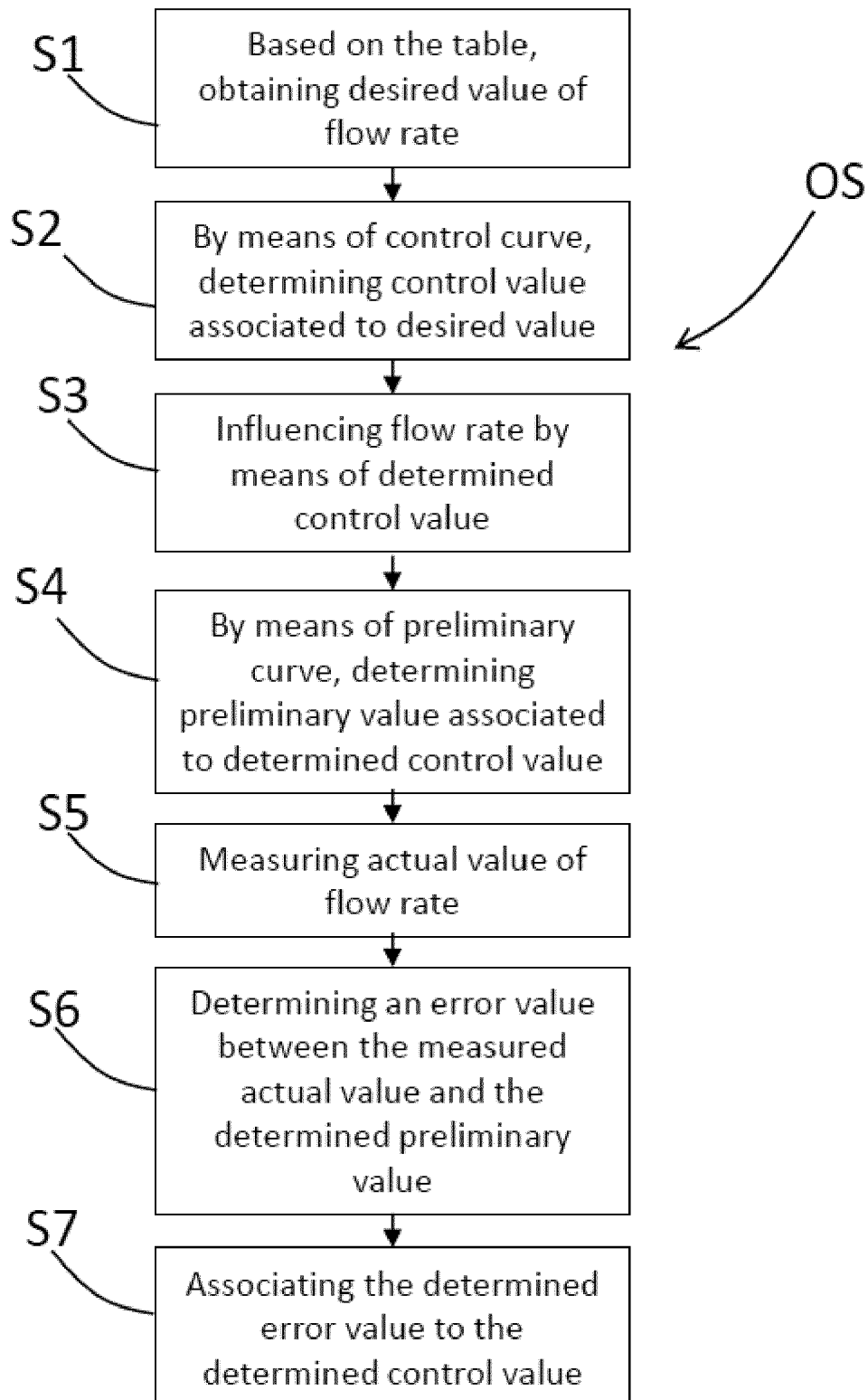


Fig. 8

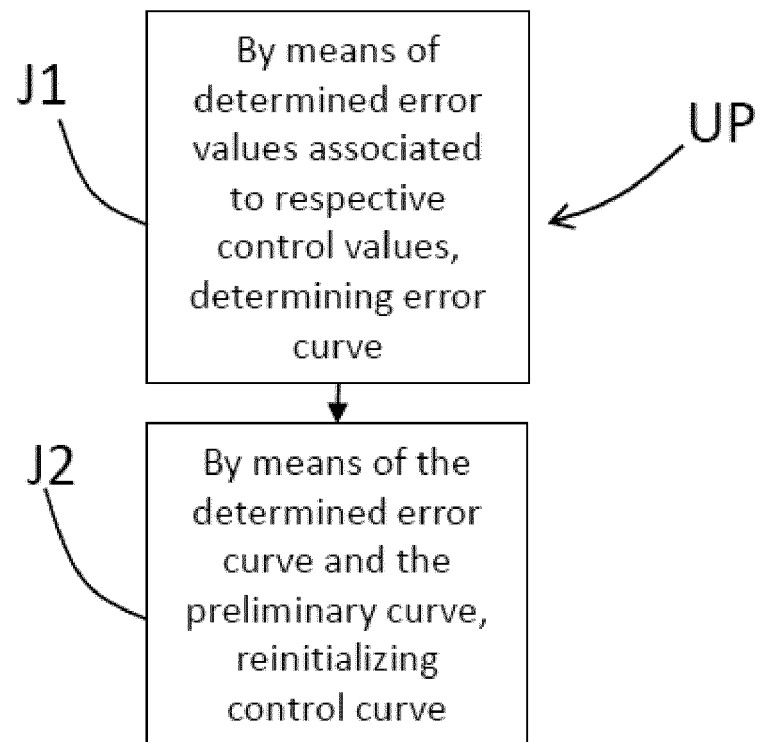


Fig. 9

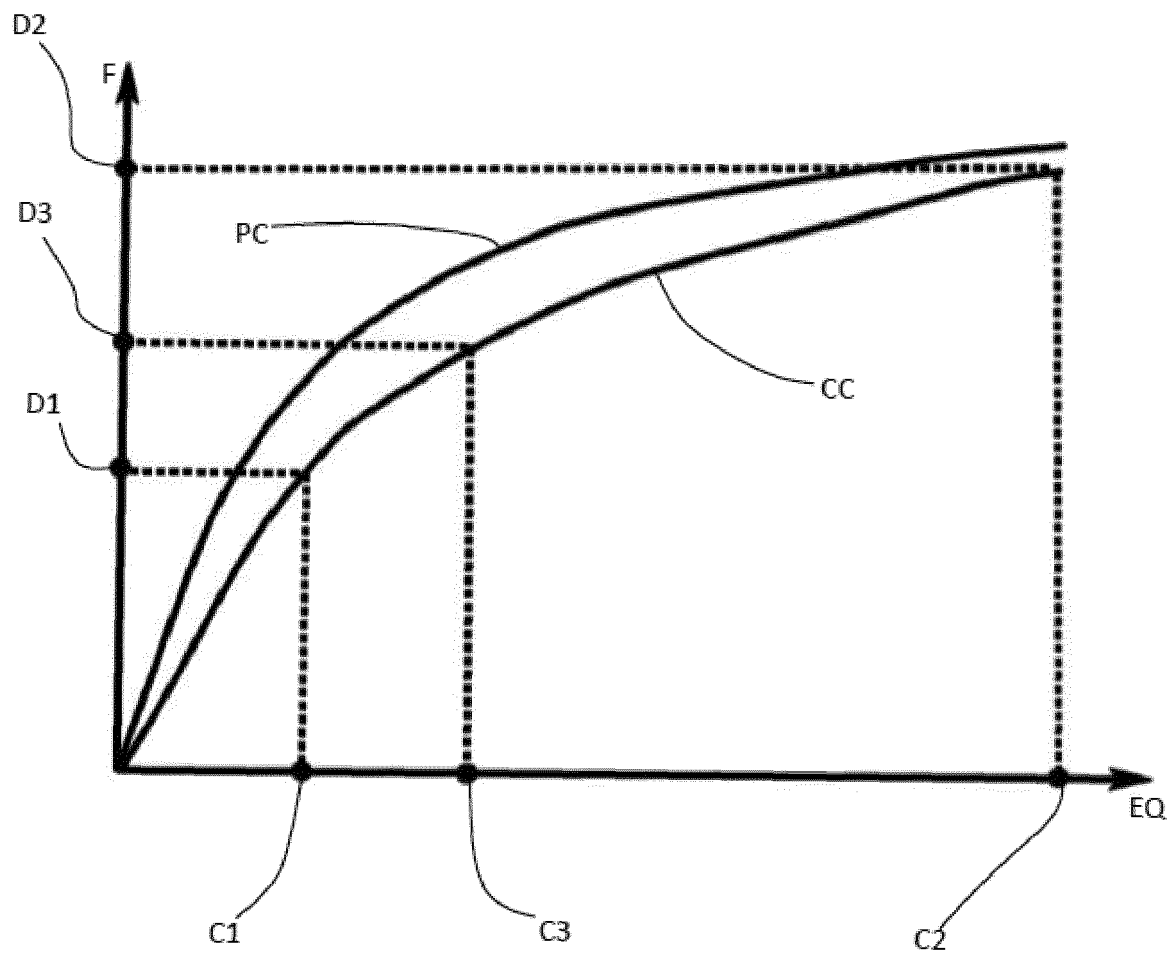


Fig. 10

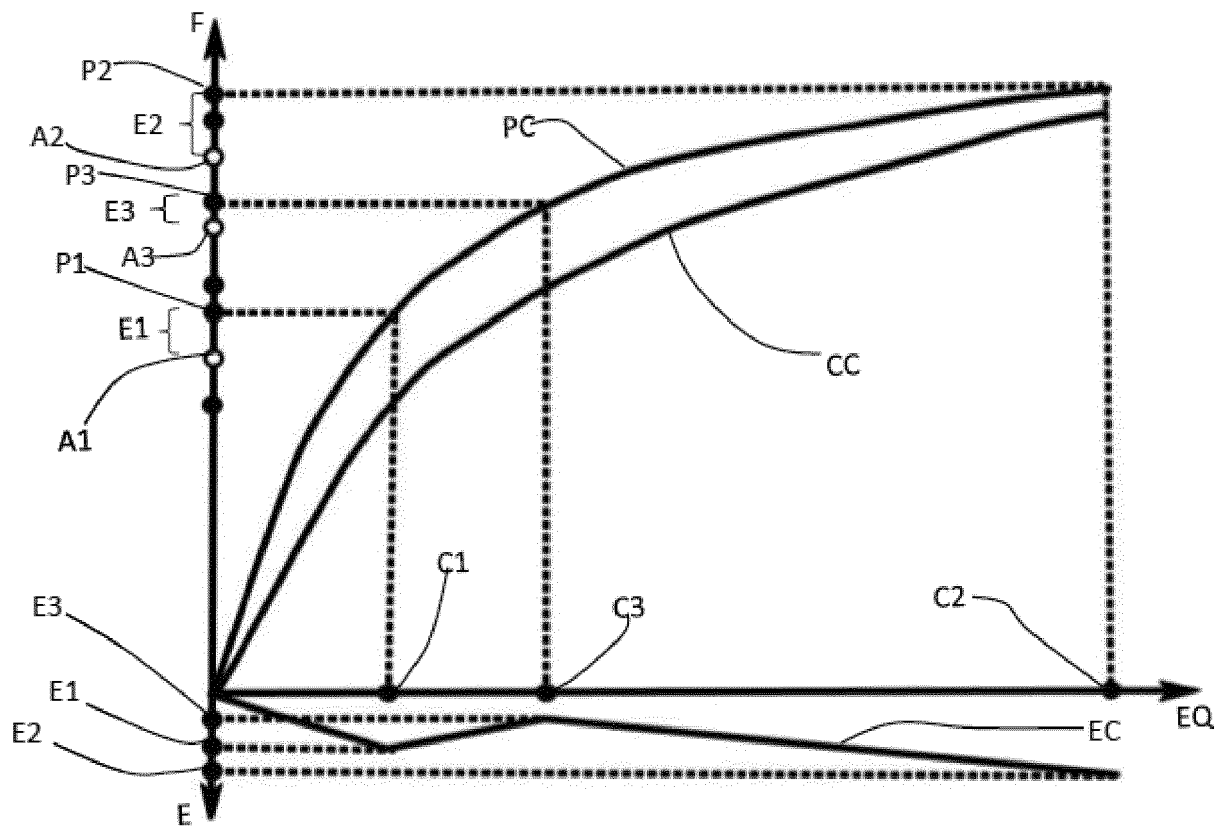


Fig. 11

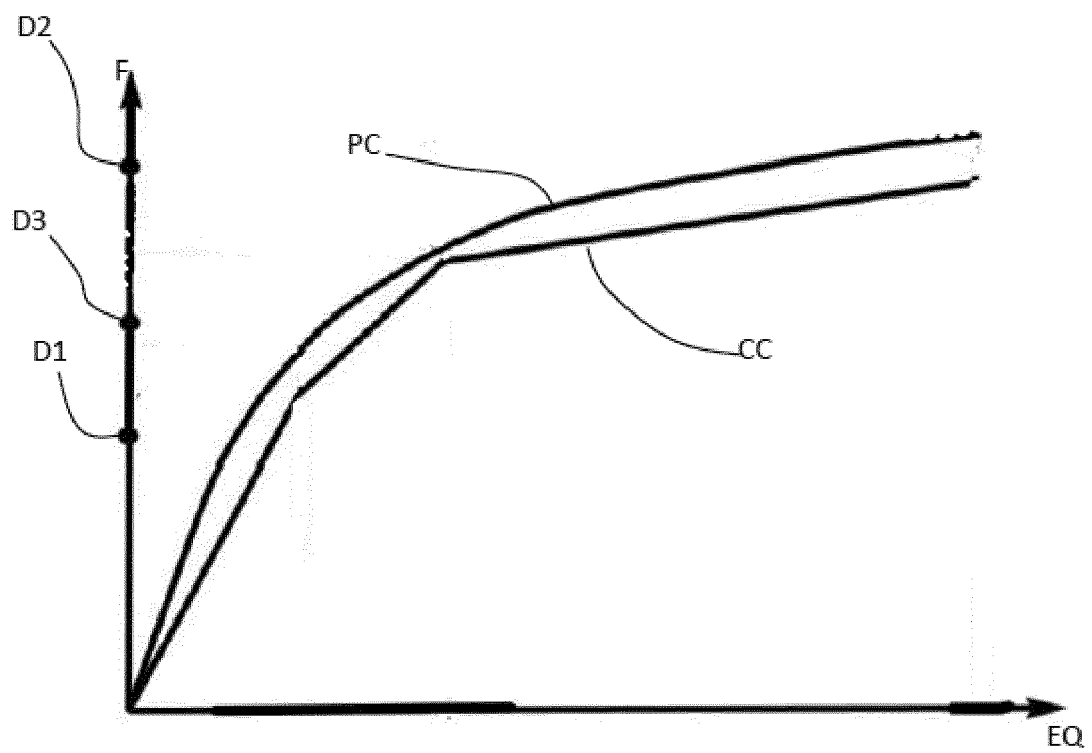


Fig. 12



EUROPEAN SEARCH REPORT

Application Number
EP 20 20 6564

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 3 728 103 A1 (SIDEL PARTICIPATIONS [FR]) 28 October 2020 (2020-10-28) * paragraphs [0052] - [0056]; figures 1,2 *	1-15	INV. B67C3/00 B67C3/28
A	EP 3 705 450 A1 (SIDEL PARTICIPATIONS [FR]) 9 September 2020 (2020-09-09) * paragraphs [0057] - [0068]; figure 2 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B67C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 19 May 2021	Examiner de Miscault, Xavier
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			

 1
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 20 6564

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-05-2021

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3728103 A1	28-10-2020	CN 111372887 A	03-07-2020
		EP 3728103 A1	28-10-2020
		US 2020346911 A1	05-11-2020
		WO 2019121151 A1	27-06-2019

EP 3705450 A1	09-09-2020	EP 3705450 A1	09-09-2020
		WO 2020182419 A1	17-09-2020

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82