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(54) Filling unit of a container filling machine, having improved communication capability

(57) A filling unit (10) of a filling machine (1) engages at least one container (2) to carry out filling thereof with a filling product, and is provided with an electronic control module (20), integrating a computing unit (22), and a communication interface (28), coupled to a communication bus (32) for communication with a central control unit (30). The computing unit (22) autonomously and independently initiates communication with the central control unit (30) over the communication bus (32), and asynchronously issues one or more interrupts (INT) over the communication bus (32) in order to communicate with the central control unit (30).

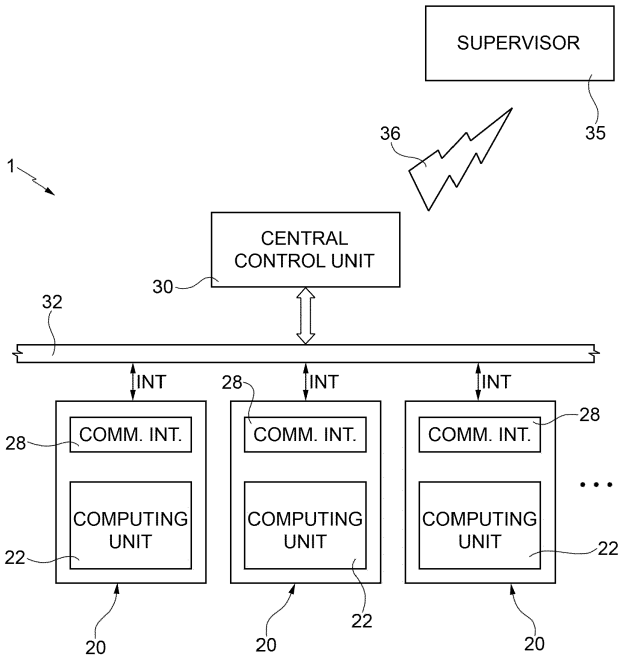

FIG. 4

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Description

[0001] The present invention relates to a filling unit of a filling machine, designed for filling containers with a product, for example a carbonated liquid. In particular, the present invention relates to a filling unit having improved communication capability.

[0002] In the field of bottling of carbonated products, such as beer, in containers, like glass bottles or aluminum cans, a system is known comprising a feed line for feeding a succession of empty bottles to a filling machine, in turn comprising a filling rotating wheel (so called "carousel") carrying a number of filling units. The filling units are mounted to rotate continuously about a longitudinal axis, receive the empty bottles, feed pressurized gas into the bottles, fill the bottles with the product, decompress the filled bottles, and then feed the bottles to a capping machine, which is connected to the filling machine by at least one transfer wheel and closes the bottles with respective caps.

[0003] The Applicant has realized that known filling machines may suffer from some drawbacks concerning faults and failure events occurring during the filling operations.

[0004] In particular, a failure event that may occur during filling operations is the burst of the container being filled, e.g. due to pre-existing defects; this event may occur, for example, during filling of glass or PET bottles with a carbonated fluid product, such as beer (and it may even be more likely in case of returnable glass bottles or bottles having reduced wall thickness).

[0005] If proper actions are not carried out in the filling machine in a sufficiently short time after the burst of the container occurs, serious problems may arise, such as contamination or damages; in general, cleaning and/or stopping of the filling machine should be performed at the earliest possible time after burst of the bottle occurs.

[0006] In known filling machines, it may be difficult to reliably and promptly react to the occurrence of such failure events.

[0007] A solution that has been proposed to detect a burst event envisages the use of a flow-meter, arranged to measure the flow rate of the filling fluid flowing into the container to be filled; in case of bursting of the container, a sudden variation of the measured flow occurs, which may be used as an indication of the failure condition. However, use of a flow-meter is not possible in some operating conditions, such as in the case where glass bottles are to be filled.

[0008] Another solution, which has been proposed, envisages the use of suitable sensors coupled to the rotating wheel of the filling machine, which are designed to monitor the movement of, and/or the weight carried by, a supporting plate, configured to support the containers during filling by a respective filling unit; the output from the sensors undergoes a steep variation in case of bursting of the container, which once again may indicate the occurrence of a failure.

[0009] However, known solutions may not prove to be fully satisfactory, due to a certain amount of delay in the detection of the failure events and in the communication of the same failure events to a machine central control unit, which is then to initiate suitable control actions to react to the failure.

[0010] In this respect, standard means of data communications between the filling units and the central control unit are based on infrared technology, according to which a filling unit is able to transmit or receive data only at predetermined communication points during rotation of the carousel.

[0011] In other known solutions, the filling units are queried by the central control unit at predetermined times, and are then able to answers to the queries.

[0012] The aim of the present invention is to solve, at least in part, the problems previously highlighted and to provide a more reliable solution able to cope with faults and failures occurring during the filling operations.

[0013] According to the present invention, a filling unit of a filling machine, and a related filling machine, are thus provided, as defined in the appended claims.

[0014] For a better understanding of the present invention, preferred embodiments thereof are now described, purely by way of a non-limiting example, with reference to the attached drawings, wherein:

- Figure 1 is a schematic view of a filling machine;
- Figure 2 is a schematic block diagram of a filling unit of the filling machine of Figure 1;
- Figure 3 is a schematic block diagram of a control module of the filling unit of Figure 2, according to an embodiment of the present solution; and
- Figure 4 is a schematic block diagram of a digital communication system in the filling machine.

[0015] Figure 1 schematically shows a filling machine 1, for filling containers 2, for example glass bottles or aluminum cans, with a carbonated product.

[0016] Filling machine 1 comprises a conveying device, including a carousel 4, which is mounted to rotate continuously (anticlockwise in Figure 1) about a substantially vertical longitudinal axis A.

[0017] The carousel 4 receives a succession of empty containers 2 from an input wheel 5, which is coupled to carousel 4 at a first transfer station 6 and is mounted to rotate continuously about a respective vertical longitudinal axis B, parallel to axis A.

[0018] The carousel 4 releases a succession of filled containers 2 to an output wheel 8, which is coupled to carousel 4 at a second transfer station 9 and is mounted to rotate continuously about a respective vertical longitudinal axis C, parallel to axes A and B.

[0019] Filling machine 1 comprises a number of filling units 10, which are equally spaced about axis A, are mounted along a peripheral edge of carousel 4, and are moved by the same carousel 4 along a path P extending about axis A and through transfer stations 6 and 9.

[0020] Each filling unit 10 is designed to receive at least one container 2 to be filled, and to perform, during its rotation along path P, a number of filling operations according to a filling "recipe", to fill the container 2 with a fluid (e.g. a carbonated liquid).

[0021] As also shown in Figure 2, the filling unit 10 is configured to engage the container 2, at an opening of a neck 2' thereof, and includes one or more fluidic conduits, which are designed to selectively couple the container 2 to one or more feed devices (here not shown), e.g. a first feed device, designed to supply the liquid that is to fill the container 2, from a first feed tank; a second feed device, designed to supply a gas, such as carbon dioxide, from a second feed tank (not shown); and an air-suction device (e.g. including a vacuum pump), providing a suction action to extract gases from the bottle during a vacuum phase.

[0022] Each filling unit 10 comprises at least one flow regulator device 14, designed to define one or more filling passages 15 (only one of which is schematically shown in Figure 2) communicating with the opening at the neck 2' of the container 2, and including a valve group 16, operable to selectively couple one or more of the first feed device, second feed device and/or air-suction device with the one or more filling passages 15, during filling of the container 2.

[0023] Each filling unit 10 may be integrally provided with a sensor element 17, which is arranged so as to be fluidically coupled to the filling passage 15, during filling of the container 2, thereby being able to monitor parameters and quantities associated to the environment within the same container 2; for example, sensor element 17 may be arranged within the filling passage 15, or so as to be in fluidic communication with the same filling passage 15.

[0024] According to an aspect of the present solution, which will now be discussed in connection also with Figure 3, the filling unit 10 is provided with electronic intelligence, including suitable electronic circuitry in an electronic board of a related control module 20. It is to be noted that some (at least one), or all, of the filling units 10 of the filling machine 1 may be made as it will now be discussed.

[0025] In particular, control module 20 includes:

- a computing unit 22, including a microcontroller, or any other processing unit;
- a sensor interface module 25, coupled to the computing unit 22, configured to acquire the electrical signals from the sensor element 17, to process the same electrical signals (in case it is required, e.g. via an analog to digital conversion), and to provide the same signals to the computing unit 22. Sensor interface module 25 may acquire the sensed signals at a preset sampling period;
- an actuator interface module 26, coupled to the computing unit 22 and to actuator elements of the flow regulator device 14, configured to transmit to the same actuator elements commands generated by the computing unit 22, based on the operations to be performed according to the filling recipe; and
- a communication interface module 28, coupled to the computing unit 22, operable to receive and transmit data from/to the external environment, in particular, as will be detailed in the following, to a central control unit (here not shown) of the filling machine 1, which may be able to further process the data, e.g. in order to diagnose faults and failures.

[0026] Computing unit 22 may also be configured (e.g. via suitable software and program instructions) to process in real time the operating data, in order e.g. to detect a fault of the flow regulator device 14, or a serious failure event, such as bursting of the container 2 being filled.

[0027] In general, the intelligence on-board the filling unit 10 allows to more reliably and promptly identify and react to any problem or anomaly occurring in the filling machine 1.

[0028] According to an aspect of the present solution, which will now be discussed with reference to Figure 4, the control modules 20 of a number of filling units 10 communicate with a master (or central) control unit 30 of the filling machine 1 over a communication bus 32. In particular, the filling units 10 may act as slave units with respect to the master (or central) control unit 30.

[0029] In a possible embodiment, central control unit 30 includes an industrial programmable controller (PLC), and communication bus 32 is a digital communication bus, transferring digital information, signals and commands; for example, communication bus 32 is a CAN bus.

[0030] The control modules 20 communicate with the communication bus 32, and thereby with the central control unit 30, via the respective communication interface modules 28 coupled to the respective computing unit 22.

[0031] The central control unit 30 is coupled to the communication bus 32 and may also be coupled with a supervisor unit 35, e.g. located remotely with respect to the filling machine 1, via a remote wireless link 36.

[0032] The central control unit 30 is able to receive operating data from the various filling units 10, in real time during execution of the filling recipe, and/or after the same filling recipe has been completed.

[0033] The communication bus 32 also allows the master control unit 30 to transmit to the various control modules 20 data relating to the operating condition of the filling machine 1 and data regarding the operations to be performed, in order to assist execution of the filling recipe; for example, these data may include pressure values in the feed tanks, relating to the pressure of the filling fluid and/or gas within the same feed tanks (these data may be used by the slave units to control the filling operations and even diagnose possible faults and anomalies).

[0034] The central control unit 30 is also provided with suitable software and program instructions in order to

process the received operating data, either in real time or as post-processing operations.

[0035] According to a particular aspect of the present embodiment, the filling units 10 are able to autonomously, independently and asynchronously initiate communication with the central control unit 30 over the communication bus 32, without having been previously queried by the same central control unit 30, or without predetermined external events being required.

[0036] In particular, communication over the communication bus 32 by the various control modules 20 and the central control unit 30 is executed based on interrupts, issued by the filling units 10 and received by the central control unit 30.

[0037] Accordingly, whenever a filling unit 10 requires to communicate with the central control unit 30, the respective control module 20 issues an asynchronous interrupt INT on the communication bus 32, and then sends data packets on the same communication bus 32.

[0038] Communication priorities on the communication bus 32 may be based e.g. on the time interrupts INT have been generated and received, and the nature of the same interrupts INT.

[0039] A priority level may be assigned to the various interrupts INT, e.g. based on the control module 20 that has generated it, or the content and actions due upon receipt of the same interrupts INT (a highest priority may be e.g. assigned to an interrupt associated to detection of the burst of a container 2 by a respective control module 20).

[0040] Use of an interrupt-based communication allows the various filling units 10 to promptly and asynchronously communicate with the central control unit 30, e. g. as soon as a failure or an anomaly is detected, such as burst of a container 2. Interrupts may be autonomously generated by each of the filling units 10, which may communicate with the central control unit 30, as soon as the need arises.

[0041] Therefore, suitable actions may be promptly performed in the filling machine 1, following interrupt generation; for example, cleaning operations may be timely started, or operation of the filling machine 1 stopped.

[0042] According to a further aspect of the present solution, sensor element 17 of filling unit 10 includes a pressure sensor, which is configured to monitor the pressure (or vacuum condition) within the container 2 during each step of the filling recipe; the presence of the sensor element 17 allows to collect relevant diagnostic information for the control and monitoring of the filling operations, and also to perform control actions and adjustments in real time during the same filling operations.

[0043] In particular, the presence of sensor element 17 allows to perform a number of control actions, among which:

- detecting pressure values during all the steps of the recipe;
- monitoring the occurrence of failures, such as burst of the container 2, during execution of the recipe steps, e.g. by checking if the sensed pressure values overcome a preset absolute maximum pressure threshold Th_1, or a preset differential pressure threshold Th_2, relating to the difference of pressure between the container 2 and a respective feed tank. In case any one of the absolute or differential pressure thresholds Th_1, Th_2, is overcome (this being indicative of a possible failure), suitable actions may be performed in order to safeguard the filling machine 1. As an alternative, a sudden variation of the sensed pressure associated with burst of the container 2 may be detected by monitoring the pattern of the derivative of the sensed pressure signal;
- monitoring the correctness of the vacuum level during the recipe steps envisaging vacuum within the containers 2, in particular with respect to glass bottles;
- monitoring the correct depressurization of the containers 2 during the recipe steps envisaging depressurization (e.g. during a snift operation). In this case, the sensed pressure values are compared to a decompression pressure threshold Th_3, and decompression is considered successful only if the sensed pressure is found to be below the decompression pressure threshold Th_3 at the end of the recipe step.

[0044] Moreover, the presence of sensor element 17 proves useful also in different operating conditions of the filling machine 1, e.g. during a cleaning/sterilization operation, when dummy containers (e.g. dummy bottles) are placed in the filling machine 1 and a cleaning fluid is introduced. Monitoring pressure values allows in this case to check the correct passage of the cleaning fluid through the flow regulator devices 14 into the dummy bottles (and this is particularly useful in case no flowmeters are present at the openings of the containers 2).

[0045] The sensor element 17 may further include a temperature sensor, which may for example be integrated with the pressure sensor, in order to detect the temperature of the filling fluid during filling operations, and/or of the cleaning fluid during cleaning operations.

[0046] Also in this case, monitoring of the temperature values within the containers 2 allows to perform controls and adjustments in real time during execution of the operations of the filling machine 1, e.g. during filling or recirculation of the filling fluid, or during cleaning/sanitizing of the flow regulator devices 14, in general providing important diagnostic information to be used in real time or at a later stage (during a post-processing stage) to control the filling machine 1.

[0047] The advantages that the described solution allows to achieve are clear from the foregoing description.

[0048] In particular, the provision of intelligence and improved communication capability in the filling units 10 allows to more reliably and promptly react to any failure or anomalous event occurring during the filling operations, to diagnose faults in the filling machine 1, in par-

ticular based on data sensed at the same filling units, and to improve transmission of data that may be collected during the filling operations.

[0049] Interrupt-based communication on digital communication bus 32 allows to improve communication between the various filling units 10 and the central control unit 30, and to promptly manage alarms and execute proper control and safety actions.

[0050] In particular, this kind of communication is clearly advantageous over standard means of data communications, such as those based on infrared technology, or those envisaging replies by the filling units in response to queries issued by the central control unit.

[0051] Finally it is clear that modifications and variations may be applied to the solution described and shown, without departing from the scope of the appended claims.

[0052] For example, it is clear that the improved communication solution may be used to achieve timely intervention for solving any kind of problem or failure occurring during the filling operations (in addition to the burst of the containers being filled). In this respect, the filling units may include any kind of sensing element, or other input units, in order to allow detection of the occurrence of the problem or failure.

[0053] The digital communication bus may differ from the CAN bus previously discussed, e.g. being a Ethernet-based field bus.

[0054] Moreover, each intelligent filling unit 10 may be configured to control filling of more than one container (e.g. having a corresponding number of flow regulator devices 14 and filling means).

Claims

1. A filling unit (10) of a filling machine (1), designed to engage at least one container (2) to carry out filling thereof with a product, the filling unit (10) being provided with an electronic control module (20), integrating a computing unit (22), and a communication interface (28) configured to be coupled to a communication bus (32) for communication with a central control unit (30) of the filling machine (1),
wherein the computing unit (22) is configured to initiate communication with the central control unit (30) over the communication bus (32).

2. The filling unit according to claim 1, wherein the communication bus (32) is a digital communication bus.

3. The filling unit according to claim 2, wherein the communication bus (32) is a CAN bus.

4. The filling unit according to any of the preceding claims, wherein the computing unit (22) is configured to autonomously and independently initiate communication with the central control unit (30) over the communication bus (32).

5. The filling unit according to any of the preceding claims, wherein the computing unit (22) is configured to asynchronously issue one or more interrupts (INT) over the communication bus (32), in order to communicate with the central control unit (30).

6. The filling unit according to claim 5, wherein a priority level is designed to be associated to the interrupts (INT).

7. The filling unit according to any of the preceding claims, being integrally provided with a sensor element (17) configured to detect at least one operating parameter related to the filling operations, during the filling operations.

8. The filling unit according to claim 7, wherein the sensor element (17) includes a pressure sensor arranged so as to be fluidically coupled with the internal environment of the container (2) during the filling operations, thereby detecting the pressure within the same container (2).

9. The filling unit according to claim 7 or 8, wherein the sensor element (17) is further configured to detect a temperature within the container (2) being filled, during the filling operations.

10. The filling unit according to any of the preceding claims, wherein the computing unit (22) is configured to detect the occurrence of a failure in the filling of the container (2), and to communicate this occurrence to the central control unit (30) over the communication bus (32).

11. The filling unit according to claim 10, wherein the computing unit (22) and/or central control unit (30) are configured to activate protection actions, when the occurrence of the failure is detected.

12. The filling unit according to claim 10 or 11, wherein the failure includes the burst of the container (2) being filled.

13. The filling unit according to any of the preceding claims, including at least one flow regulator device (14) to regulate flow of the filling fluid within the container (2) during filling operations.

14. A filling machine (1), including: a number of filling units (10), according to any one of the preceding claims; a central control unit (30); and a communication bus (32); wherein the filling units (10) are configured to communicate with the central control unit (30) over the communication bus (32), via an interrupt-based communication.

15. The filling machine according to claim 14, wherein a

priority level is designed to be associated to interrupts (INT) issued by the filling units (10) to the central control unit (30) over the communication bus (32).

16. The filling machine according to claim 14 or 15, including a conveyor element (4), which is mounted to rotate about a longitudinal axis (A), and carries the filling units (10) at its periphery, the filling units (10) being designed to be moved along a path (P) by the rotation of the conveyor element (4); wherein the filling units (10) are configured to fill one or more containers (2) with a carbonated product.

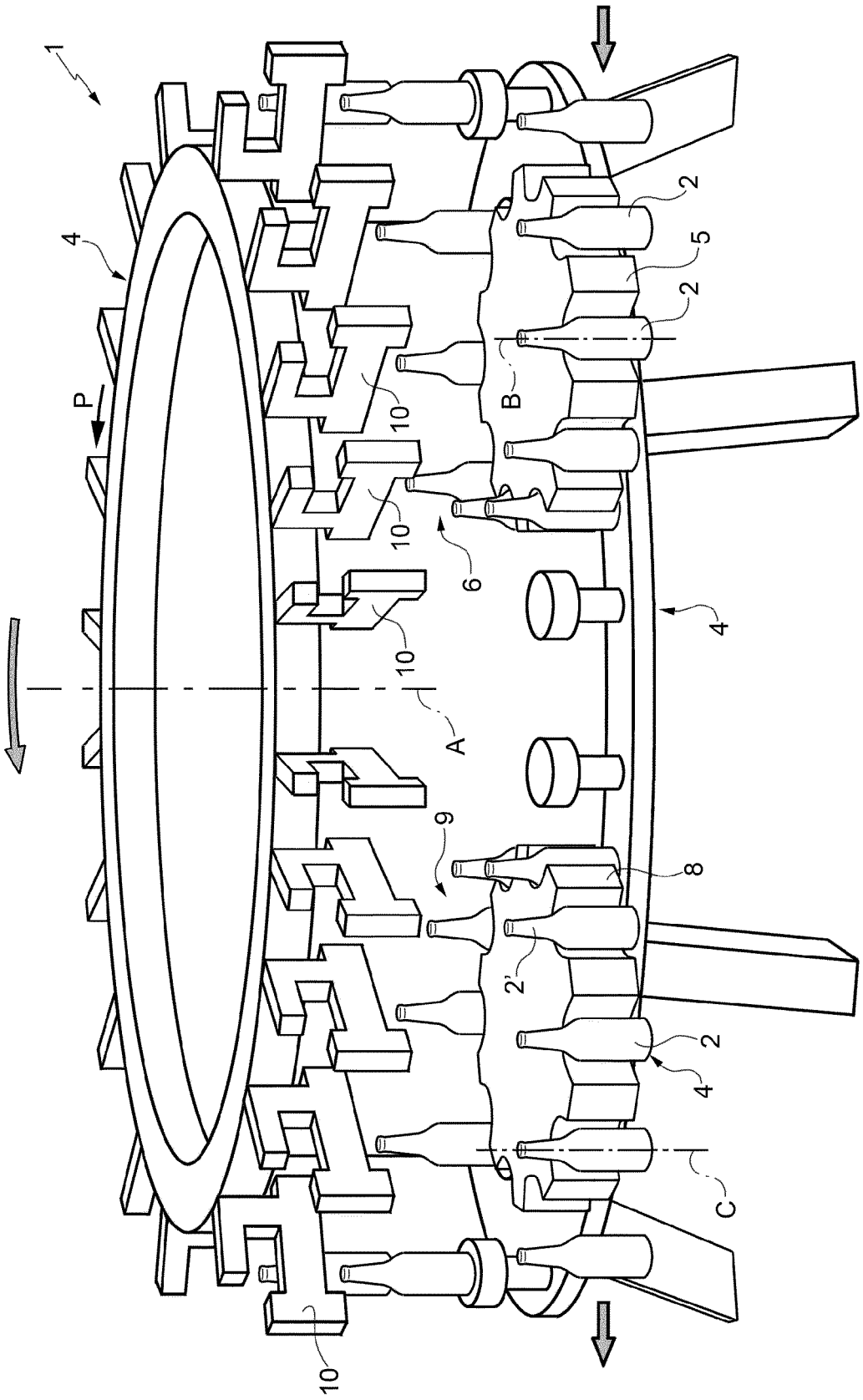
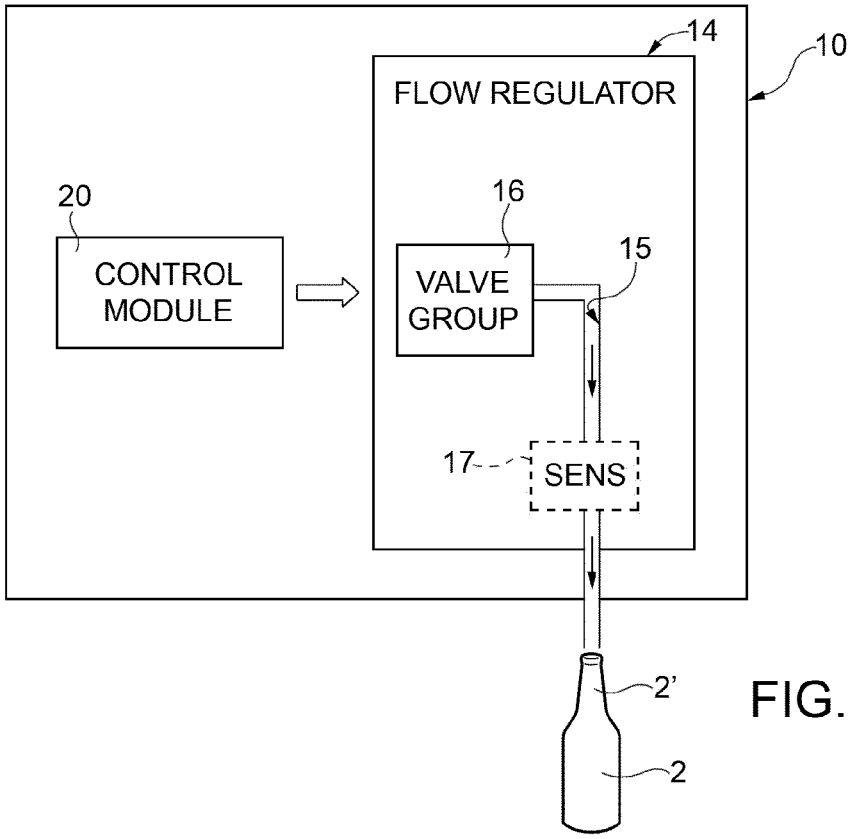


FIG. 1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20
16
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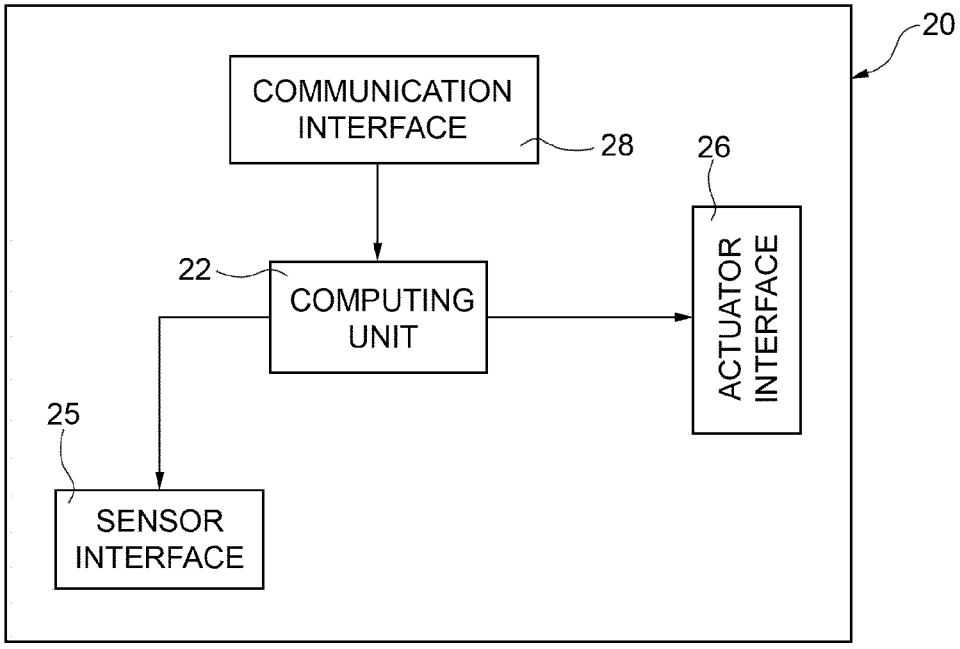
VALVE GROUP
15
17
SENS
2'
2

FIG. 2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COMPUTING UNIT
ACTUATOR INTERFACE
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SENSOR INTERFACE

FIG. 3

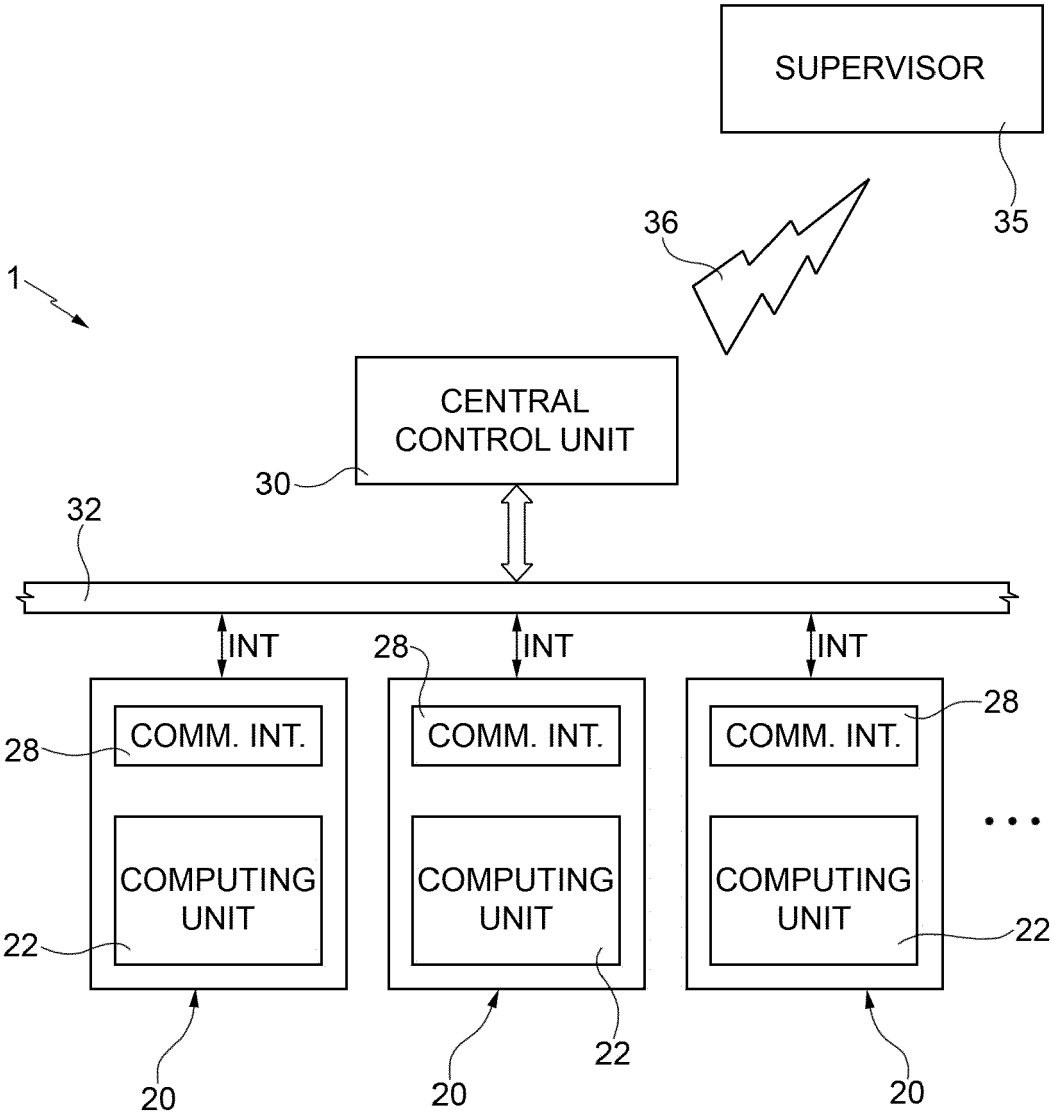
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FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 14 00 1724

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B67C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 September 2014	Wartenhorst, Frank

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