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(71) Applicant: **Baumer A/S**
8230 Abyhoj (DK)

(72) Inventors:
- **Simmons, Bo Wellejus**
8220 Brabrand (DK)
- **Hansen, Thomas**
8240 Risskov (DK)
- **Möller Jensen, Kurt**
8700 Horsens (DK)

(74) Representative: **Strauss, Steffen**
Baumer Innotec AG
Hummelstrasse 17
Group Intellectual Property
8501 Frauenfeld (CH)

(54) **Display for sensors**

(57) It is an object of the invention to facilitate monitoring prescribed parameter ranges of industrial sensors. For this purpose, the invention provides a display device for displaying measurement values of sensors, the display device comprising at least one electrical connector for connecting to a sensor output a housing with a display, a multicolour backlight and a processing device wherein said display is being luminated by said multicolour backlight and adapted to display at least measurement values, wherein said processing device is suitable to read said measurement values from the electrical connector, to calculate the values to be displayed and being set up to compare said measurement values to at least one prescribed limit value limiting a normal operation range and to change the illumination of said multicolour backlight if said comparison yields that the measurement value is not within said normal operation range.

A method of control the display device is also provided.

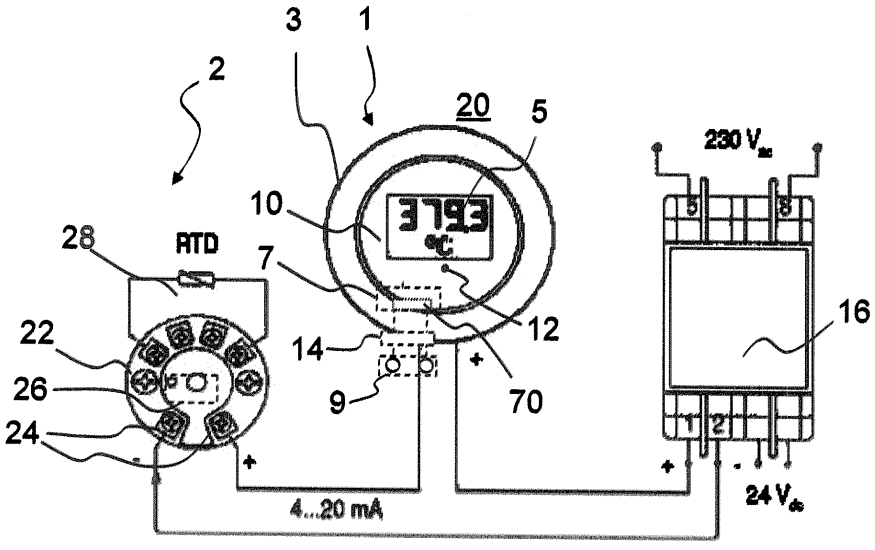

Fig. 1

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Description

[0001] The invention generally relates to the field of sensor systems. More specifically, the invention relates to sensor devices with displays for displaying sensor measurement values.

[0002] Sensors are widely used for automatic process control and supervision of process parameters in industrial fabrication processes. For example, the pressure or temperature within a vessel or conduit is measured by a sensor and the measurement values are used by a process control device to maintain the operation parameters within a predefined range.

[0003] However, the predefined parameter range may eventually be exceeded for a couple of reasons. For example, ambient values may influence the process so that the parameter range cannot be maintained. As well, malfunction of components of the system may result in instabilities of the process. A supervisor of an industrial fabrication process often needs to monitor measurement values of different sensors. As the characteristics of the sensors and the threshold values for normal operation may be different, it is often not evident at first glance that a threshold value has been exceeded or underrun.

[0004] It is therefore an object of the invention to facilitate monitoring prescribed parameter ranges of industrial sensors. This object is solved by the subject matter of the independent claims. Advantageous embodiments and refinements of the invention are defined in the dependent claims.

[0005] Accordingly, a display device is provided for displaying measurement values of sensors, the display device comprising a housing with a display, whereby the display is adapted to display measurement values. The measurement values are preferably displayed as digits. The display device further comprises at least one electrical connector for connecting to a sensor output.

[0006] The housing accommodates a display, a multicolour backlight and a processing device. The display is being luminated by said multicolour backlight and adapted to display at least measurement values. The processing device is suitable to read said measurement values from the electrical connector, to calculate the values to be displayed and being set up to compare said measurement values to at least one prescribed limit value limiting a normal operation range and to change the illumination of said multicolour backlight if said comparison yields that the measurement value is not within said normal operation range.

[0007] Thus, according to the invention, the display is not accommodated in the sensor itself but rather in a separate housing which can be attached to a sensor housing so as to read out the sensor data and obtain a response via the multicolour backlight, whether the component to be supervised by the sensor is in normal operation. Thus, the invention also provides a method for displaying measurement values of sensors at a display device, the method comprising the steps of:

- a processing device reads measurement values from at least one electrical connector of said display device
- said processing device calculates the values to be displayed
- said processing device is set up to compare said measurement values to at least one prescribed limit value limiting a normal operation range
- said processing device controls a multicolour backlight wherein said multicolour backlight is designed to laminate said display
- said processing device changes the illumination of said multicolour backlight if said comparison yields that the measurement value is not within said normal operation range.

[0008] Further a sensor assembly comprising a sensor housing which accommodates sensor circuitry. At least one electrical connector is arranged at the sensor housing for output of measurement values by the sensor circuitry. The sensor assembly further comprises a display device as described above. The housing of the display device is detachably attached to the sensor housing, so that the electrical connector arranged at the sensor housing is electrically connected to the electrical connector of the display device so that the sensor measurement data can be transmitted to the display device.

[0009] As the display device is accommodated into a separate housing and collects the measurement variables via an electrical connector, it can be easily attached to various sensors. In particular, the display device can be fixed on a sensor or a sensor circuitry by simply plugging the display device thereon so that the electrical connector of the display device connects to the sensor output.

[0010] The stored prescribed limit value or normal operation range, respectively, and the change of the multicolour backlight and with that the colour of the display due to a deviation of normal operation parameters alerts a user to an alarm situation without having detailed or any knowledge about the normal range of the respective measurement variable which is actually monitored.

[0011] According to a preferred refinement of the invention, a pixel display is used. A pixel display can be flexibly configured so that it does not only display the measurement value as a digit but, e.g., also gives information which kind of measurement is actually monitored. This facilitates adapting the display device to different sensor types such as pressure, level, conductivity and temperature sensors.

[0012] According to a preferred embodiment, the sensor is configurable so that, e.g., the type of sensor, such as a pressure sensor, temperature sensor or conductivity sensor can be selected by the user. Further parameters which may be configured are the limit values, or normal operation ranges, respectively.

[0013] In particular, user input for configuration of the display device may be set via a display which is set up

as a touch-screen, which accordingly forms a user interface. Thus, according to this refinement of the invention, the processing device is set up to read configuration data from user input via the touch-screen.

[0014] According to one embodiment, the processing device is adapted to read current or voltage values from the electrical connector and to assign sensor measurement values to measured currents, or voltages, respectively. Accordingly, the display device is set up to process analogue input values.

[0015] In this regard, it is advantageous if the range of the output measurement value of the sensor is standardised. This way, the processing device can easily detect whether a measurement value lies within the prescribed range of operation without the need to ascertain which type of sensor is actually attached to the display device. However, in general it is advantageous if the user can select the type of sensor which is to be monitored. According to a refinement of this embodiment, the processing device is adapted to assign a current of between 4 mA and 20 mA to a normal operation range. The processing device further changes the colour of the multicolour backlight and with that the illumination of the display if the current is less than 4 mA and/or if a current of 20 mA is exceeded.

[0016] According to a further embodiment, the display device is set up to process digital input data. For this purpose, the processing device comprises a digital communication interface connected to the electrical connector and is set up to process digital sensor measurement values transmitted from a sensor via the electrical connector.

[0017] In particular, the display device may be set up to process both analogue and digital measurement variables. The electrical connector for the digital communication interface may be the same as the electrical connector for the analogue input. Alternatively, two separate electrical connectors for digital and analogue input may be provided.

[0018] Furthermore, the display device may also be configurable via the digital communication input. More specifically, the digital communication input may be used to transmit configuration parameters to the processing device which then configures the display accordingly. At least one of following configuration parameter may be read from the digital communication input:

- at least one limit value delimiting a normal operation range,
- a sensor type,
- the measurement unit of the measurement values,
- a linearization table,
- an assignment of a type of illumination to a prescribed limit value.

[0019] Additionally or alternatively, these parameters may be entered via a user interface such as a touch-screen.

[0020] A linearization table is particularly useful if the displayed measurement variable differs from the variable measured by the sensor. For example, this is the case if a volumetric measurement is displayed but the sensor measures the hydrostatic pressure in an asymmetric container.

[0021] Generally, without restriction to the above described embodiment, the display device may advantageously be configurable to calculate a second measurement variable from a first measurement variable measured by the sensor.

[0022] The multicolour backlight may advantageously controlled by the processing device as follows: If the comparison of the actual measurement value to the prescribed limit yields that the measurement value is not within normal operation range, a flashing illumination may be established. Additional or alternatively, the colour of the multicolour backlight may be changed and with that the colour of the display. For example, the colour of the multicolour backlight for normal operation measurement values may be white. If the normal operation range of the measurement value is exceeded or underrun, the colour of the multicolour backlight may change to another colour such as red or green.

[0023] In the following, the invention is described in more detail with respect to specific embodiments and with reference to the accompanying drawings.

Brief description of the drawings:

[0024]

Fig. 1 shows components of a sensor assembly and the wiring of the components;

Fig. 2 shows a perspective view of a sensor assembly and

Fig. 3 shows a graph representing a linearization table.

[0025] Fig. 1 shows the wiring of a sensor assembly 20 comprising a display device 1 according to the invention. The main components of the sensor assembly 20 are the sensor 2 and the display device 1. The sensor 2 comprises a sensor element 28 such as a resistance temperature detector (RTD) connected to or accommodated in the sensor housing 22. The sensor housing 22 further accommodates sensor circuitry 26 for processing, e.g. amplifying the measurement values.

[0026] Similarly, the display device 1 comprises a housing 3 which accommodates the circuitry forming a processing device 7. Housing 3 may be fabricated from plastics. In particular, polycarbonate housing is suitable to ensure high resistance to moisture even under hard environmental conditions. As both the processing device 7 and the sensor circuitry 26 are accommodated within housings 3 and 22, respectively and thus are not visible

from outside. These components 7, 26 are drawn in dashed lines.

[0027] Sensor 2 and display device 1 are electrically interconnected via electrical connectors 9, 24. Electrical connector 24 of sensor 2 forms the sensor output.

[0028] The sensor 2 of this embodiment is adapted to control a current which represents the measurement variable. In this particular embodiment, the measurement variable is a current which represents the temperature.

[0029] Specifically, the display device 1 and the sensor 2 are connected in series so that the current controlled by the sensor flows through a current measuring element 70 of the data processing device 7. The current sensed by current measuring element 70 is then assigned to a corresponding temperature by the processing device 7.

[0030] A power supply 16 is wired to the sensor assembly 20 to provide a supply voltage. In the example shown in Fig. 1, the supply voltage is 24 Volts. According to an advantageous embodiment of the invention, and as shown in Fig. 1, the supply voltage is applied on the electrical lines through which the measurement current flows. This way, advantageously, the number of required electrical connections is reduced. However, the display device 1 may also have a separate power supply. For example, the display device 1 may be battery powered.

[0031] The measurement values are shown as digits 10 on a display 5. The digits are shown in contrasting colour or illumination with respect to the multicolour backlight 12 of the display 5.

[0032] According to one exemplary embodiment, the normal operation range of the sensor 2 is assigned to currents between 4 to 20 mA. Thus, the current values of 4 and 20 mA are prescribed limit values limiting the normal operation range.

[0033] If a current value within this upper and lower limit is measured by the current measuring element 70, a first illumination of the background of the display is selected by the processing device. For example, a white background colour may be illuminated by the multicolour backlight 12.

[0034] If, however, the current value is less than 4 mA or exceeds 20 mA, i.e., if the comparison of the measured current with the prescribed limits yields that the measurement value is not within the normal operation range, the background illumination of the display from the multicolour backlight is changed so as to obtain a visual signal for paying attention to the measurement. For example, according to one embodiment of the invention, the colour of the display appears white for normal operation and is changed to red or blue colour if the current value lies below the lower limit, e.g., between 3.0 mA to 3,5 mA. Thereby, the minimum current of 3.0 mA is consumed for operation of the sensor circuitry 26.

[0035] Furthermore, not only the colour of the background illumination may be changed. To obtain a particular alerting effect, the background may be illuminated continuously if the current is within the prescribed limit values of 4 mA to 20 mA, but may be changed to a flashing background illumination if the measured current falls below, or exceeds the prescribed limit values.

[0036] The prescribed limit values may be fixed, e.g., may be 4 mA and 20 mA so that the processing device 7 changes the multicolour backlight 12 and thus the colour of the display 5 independent from the sensor type attached.

[0037] According to an alternative or additional embodiment, the display 5 may be configured by the user via a user interface. This configuration may in particular include:

- a choice between pre-loaded parameters of various sensor types or engineering units, respectively,
- the setting of one or more limit values,
- a selection of a specific type of backlight illumination (e.g. no illumination, flashing illumination, background colour) to a limit value and/or the normal operation range,
- the measurement unit of the measurement values.

[0038] The choice between pre-loaded parameters of various sensor types and/or of the measurement unit of the measurement values via the user interface may advantageously include a choice between various layouts of the display 5. These layouts are designed to indicate the measurement values in terms of the corresponding measurement unit such as pressure, temperature, weight and conductivity. For example, in the embodiment as shown in Fig. 1, a user selects a display layout for temperature measurement. Then, the sensor output values (i.e. the current values) are assigned to respective temperature values by the processing device 7 and are displayed as a temperature. In the example of Fig. 1, the actual current value has been assigned to a temperature value of 379.3°C which is displayed as digits 10 on the display 5.

[0039] The input and/or the choice of configuration parameters as described above is particularly convenient, if the display 5 is a touch-screen. The choice of the parameters may advantageously be provided by a set of menus through which the user navigates to select the appropriate configuration. The processing device 7 then reads configuration data from user input via the touch-screen and stores the configuration parameter.

[0040] In this regard, it is further advantageous, if the display 5 is a pixel display which allows for a flexible arrangement of the elements to be displayed on the screen, depending on the selected configuration.

[0041] According to a further refinement of the invention, the display device 1 provides a user-interface which allows the user to set up a user-specified display design and display parameters such as the assignment of displayed values to measured variables and the corresponding measurement unit. Again, this user-interface may be provided by the touch-screen. To facilitate a complex set-up, it may also be advantageous to exchange the parameters via a digital communications interface

14. This way, the sensor 2 may also be connected to a computer and configured by software running on the computer.

[0042] Generally, for the purposes described above, the display device 1 may advantageously comprise the digital communication interface 14. In the embodiment shown in Fig. 1, the digital communication interface 14 is connected to the electrical connector 9. Thus, in this case, both analogue and digital data are entered via connector 9. However, it is possible as well, to provide a separate electrical connector for digital communication interface 14. The digital communication interface 14 reads digital sensor measurement values from appropriate sensors with digital output from electrical connector 9. The measurement values are then processed by the processing device 7 to be displayed on the display 5. According to a refinement of this embodiment, the processing device 7 automatically detects the type of sensor and uploads actual menus relevant for the attached sensor if a connection of display device 1 and sensor 2 is established.

[0043] For illustrative purposes, the sensor 2 and the display device 1 are shown separately in Fig. 1. However, the display device 1 is preferably designed to be attached directly to the sensor 2. In other words, the housing 3 of display device 1 may be detachably attached to the sensor housing 22, with the electrical connector 24 arranged at the sensor housing 22 being electrically connected to the electrical connector 9 of the display device 1.

[0044] Fig. 2 shows a perspective view of an embodiment of a sensor assembly 20 with housings 3, 22 of sensor 2 and display device 1 directly attached and mutually fixed. In this exemplary embodiment, sensor 2 is a pressure sensor measuring the pressure of a fluid within access opening 29. Generally, without restriction to the exemplary embodiment shown in Fig. 2, the display device 1 may be mounted to the sensor housing 22 by means of a snap lock.

[0045] Of course, the display device 1 may also be mounted separate to the sensor 2. In this case, an intermediate cable may be used to electrically interconnect connectors 9, 24

[0046] According to a refinement of the invention, the connectors 9, 24 are positioned on the housings 3, 22 so that an electrical connection between the connectors 9, 24 is established upon attachment and fixation of the display device 1 on the sensor housing 22.

[0047] Fig. 3 shows an exemplary embodiment of a linearization table 30 and limit values which delimit the normal operation range. In Fig. 3, the linearization table 30 is represented as a graph. As described above, the linearization table 30 may be entered via a touch-screen or via the digital communication interface 14 of the display device 1.

[0048] For example, the linearization table 30 assigns the current values representing a pressure value to a volumetric charging level. Although the hydrostatic pressure measured by the sensor 2 depends linearly to the charging level. This does not hold for the volumetric charging level in terms of percentage of the volumetric capacity of a container. This parameter depends on the shape of the container. For example, the graph of linearization table 30 shown in Fig. 3 links the hydrostatic pressure measured by a pressure sensor and translated into the output current to a volumetric charging level of a horizontally mounted cylindrical container. The user interface of the display device 1 enables the user to set critical values as limit values 18, 19 which are adapted to the particular nonlinear dependency of the measurement variable to be monitored.

[0049] In the above example, critical values of the measurement variable which indicate that the container is almost empty (5% of the overall capacity) or almost filled (95% of the overall capacity) are closer together as it would be the case with a linear dependency. In other words, the normal operation range of the current values is narrower for the illustrated example, ranging from 6 to 11 mA. It is therefore advantageous if the user can configure the limit values and/or the normal operation range. Further, in this example, the upper limit value may be more critical as exceeding this value may easily result in an overflow of the container. To address the relevance of the limit values, it is therefore generally advantageous if different background illuminations for different limit values can be configured and assigned by the user. For example, a colour change may of the multicolour backlight 12 be assigned for an underrun of lower limit value 18. If the upper limit value 19 is exceeded, additionally a flashing background illumination may be assigned to alert a supervisor.

List of reference signs

[0050]

1	display device
2	sensor
3	housing
5	display
7	processing device
9, 24	electrical connector
10	digit
12	multicolour backlight
14	digital communication interface
16	power supply
18	lower limit value

19	upper limit value
20	Sensor assembly
22	sensor housing
26	sensor circuitry
28	sensor element
29	access opening
30	linearization table
70	current measuring element

Claims

1. A display device for displaying measurement values of sensors, said display device comprising at least one electrical connector for connecting to a sensor output
a housing with

- a display
- a multicolour backlight and
- a processing device

wherein said display is being luminated by said multicolour backlight and adapted to display at least measurement values,
wherein said processing device is suitable to read said measurement values from the electrical connector,
to calculate the values to be displayed and
being set up to compare said measurement values to at least one prescribed limit value limiting a normal operation range and
to change the illumination of said multicolour backlight if said comparison yields that the measurement value is not within said normal operation range.

2. A display device in accordance with claim 1, wherein said processing device is adapted to read current or voltage values from said electrical connector and to assign sensor measurement values to measured currents or voltages, respectively preferably said colour display is a pixel display.

3. A display device according to the preceding claim, wherein said processing device is adapted to assign a current of between 4 mA and 20 mA to a normal operation range, and wherein said processing device is set up to change colour of illumination of said backlight an with that the colour of the display if said current is less than 4 mA and/or if a current of 20 mA is exceeded.

4. A display device according to one of the preceding claims, wherein said processing device comprises a digital communication interface connected to said electrical connector, the processing device further being set up to process digital sensor measurement values transmitted via said electrical connector.

5. A display device according to the preceding claim, wherein said processing device is set-up to automatically detect the type of sensor and preferably to upload actual menus relevant for the attached sensor upon establishment of the connection of said display device to a sensor.

6. The display device according one of the preceding claims, **characterised in that** said processing device is set up to configure the colour of the multicolour backlight in response to at least one of following configuration parameter read from a digital communication input or entered via a user interface:

- at least one limit value delimiting a normal operation range and / or
- a sensor type.

7. The display device according to one of the preceding claims, wherein said colour display is a touch screen, and whereby said processing device is set up to read configuration data from user input via said touchscreen.

8. The display device according to one of the preceding claims, wherein the display device comprises a user interface for choosing between various display layouts with indication of the measurement values in terms of the corresponding measurement unit.

9. The display device according to one of the preceding claims, wherein at least two sensors are connected to said display device within a network or with wireless distribution, wherein said processing device is designed to automatically upload the measurement values of the sensor, which measurement values are not in said normal operating range and
to change the multicolour backlight so that a changing background illumination or preferably a flashing illumination is shown.

10. A method for displaying measurement values of sensors at a display device, the method comprising the steps of:

- a processing device reads measurement values from at least one electrical connector of said display device
- said processing device calculates the values to be displayed
- said processing device is set up to compare

said measurement values to at least one prescribed limit value (18, 19) limiting a normal operation range

- said processing device controls a multicolour backlight wherein said multicolour backlight is designed to laminate said display
- said processing device changes the illumination of said multicolour backlight if said comparison yields that the measurement value is not within said normal operation range.

11. A method in accordance with claim 10, wherein said processing device is adapted to assign a current of between 4 mA and 20 mA to defined a normal operation range, and wherein said processing device controls the multicolour backlight to change the illumination an with that the colour of the display if said current is less than 4 mA and/or if a current of 20 mA is exceeded.

12. A method in accordance with claims 10 or 11, wherein said processing device automatically detects the type of sensor and preferably uploads actual menus relevant for the attached sensor upon establishment of the connection of said display device to a sensor.

13. A method in accordance with claims 10 to 12, wherein said said processing device sets up to configure the colour of the multicolour backlight in response to at least one of following configuration parameter read from a digital communication input or entered via a user interface:

- at least one limit value delimiting a normal operation range and / or
- a sensor type.

14. A sensor assembly comprising a sensor housing which accommodates sensor circuitry, at least one electrical connector being arranged at said sensor housing for output of measurement values by said sensor circuitry, the sensor assembly further comprising a display device according to one of the preceding claims, the housing of said display device being detachably attached to said sensor housing, so that said electrical connector arranged at said sensor housing is connected to said electrical connector of said display device to transmit sensor measurement data to said display device.

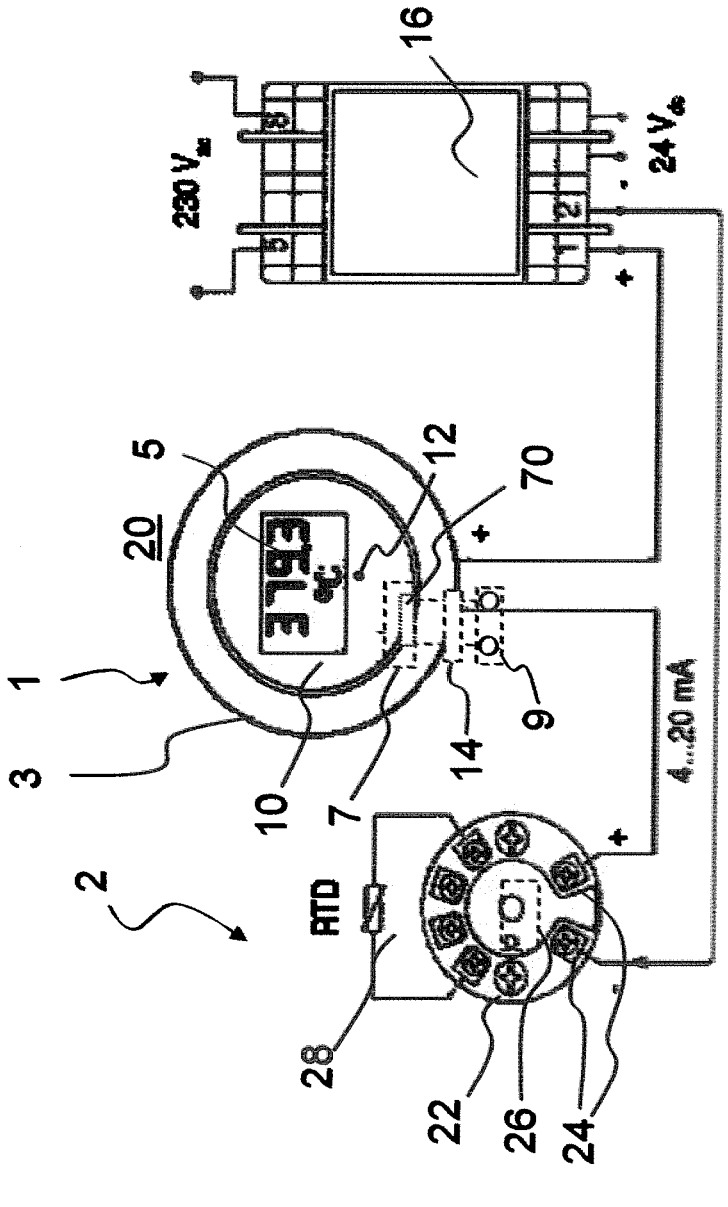

Fig. 1

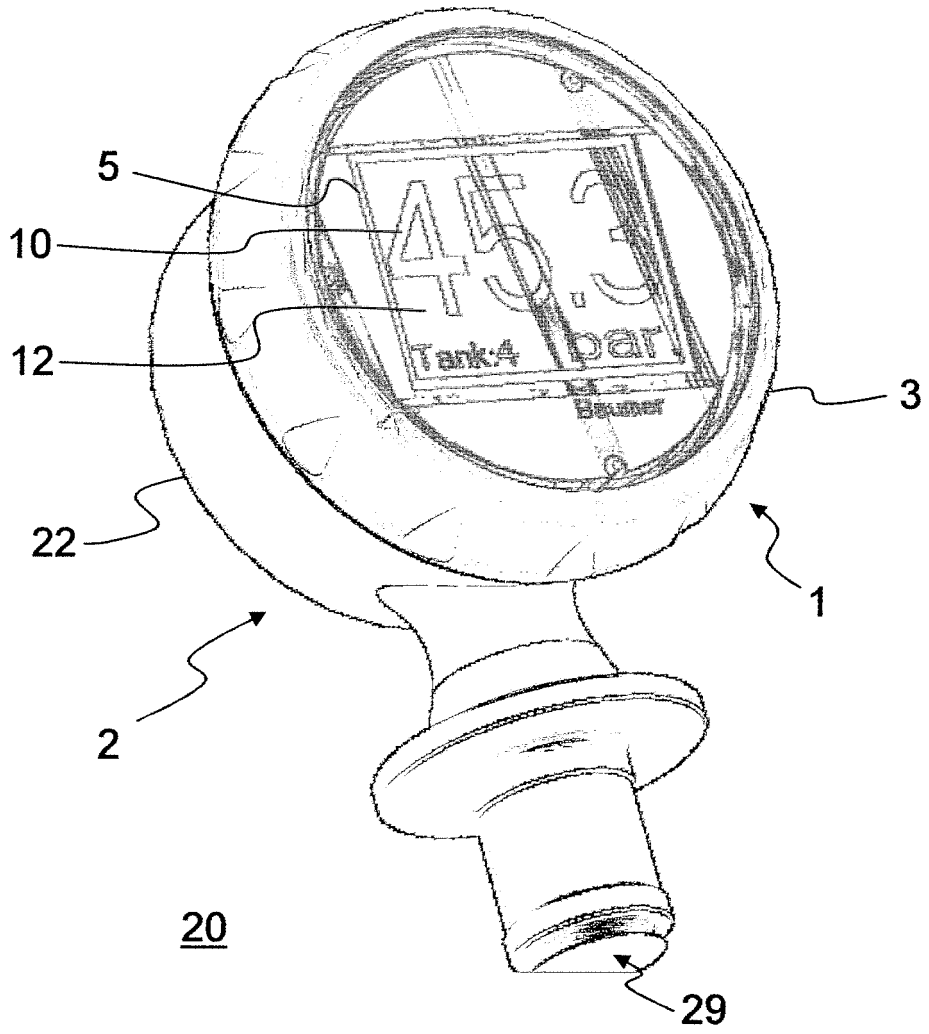

Fig. 2

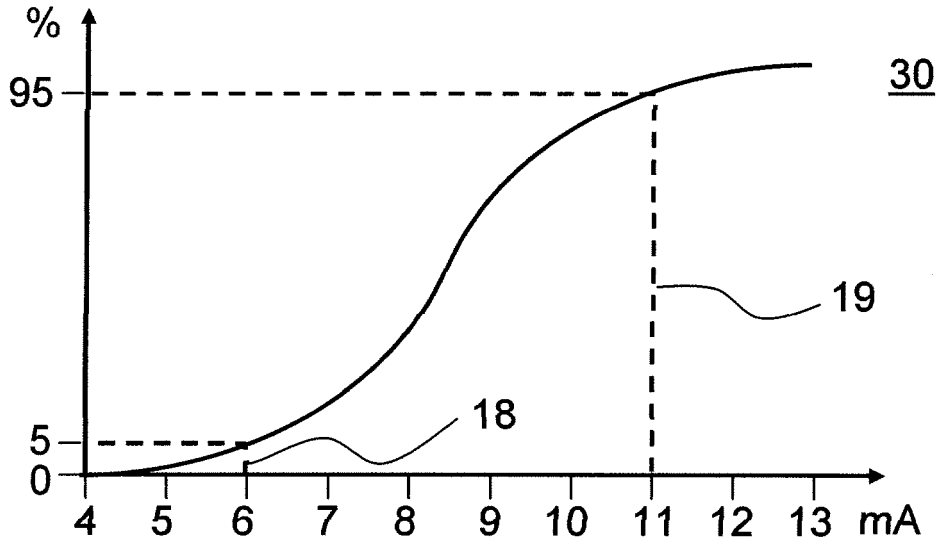

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 4263

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 November 2011	Köck, Arno

CATEGORY OF CITED DOCUMENTS

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