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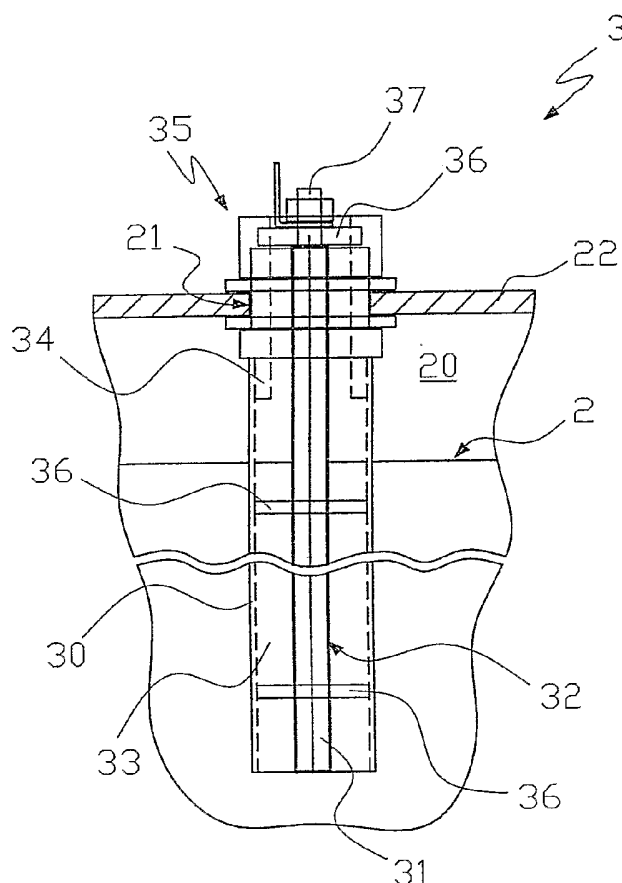
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(54) Title: AGRICULTURAL SPRAY VEHICLE HAVING ONE OR MORE CAPACITIVE LIQUID LEVEL PROBES



(57) Abstract: A spray tanker for an active liquid, comprising a tank (20) for containing said liquid, and a system (1) for measuring the quantity of liquid contained in said tank (20); said measuring system (1) comprising a capacitive sensor (3, 40) for generating an electric signal proportional to the level (2) of active liquid in the tank (20), a logic control unit (4) for processing said electric signal, and a device (5) for indicating the quantity of liquid contained in the tank (20).

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations* AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB,

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DESCRIPTION

AGRICULTURAL SPRAY VEHICLE HAVING ONE OR MORE CAPACITIVE LIQUID LEVEL PROBES

TECHNICAL FIELD

- 5 The present invention relates to a spray tanker for use in agriculture, particularly but not exclusively for spraying crops with active liquids such as herbicides or fertilizers.

BACKGROUND ART

- 10 A spray tanker is known to comprise generally a tank for containing one of said active liquids and means for delivery the active liquid; depending on the crop dimensions and requirements, said tank and delivery means are provided with conveying members or are mounted on a truck for their movement.
- 15 Although said spray tankers have been used for a considerable time, they still present certain problems due in particular to the difficulty of checking and controlling the active liquid quantity present in the tank.
- In this respect, checking is generally done manually by an operator using graduated rods to be inserted into the tank, or simply by visual inspection
- 20 through transparent branch pipes associated directly with the tank wall.
- In this manner, the information obtained is approximate and sometimes unreliable, and in any event not suitable for rational use of the spray
- tanker, because the complex shape of the tank does not enable a simple and immediate relationship to be established between the liquid level and
- 25 its volume; moreover said information is always much influenced by the inclination of the tank.

This gives rise to a series of problems affecting the entire operation of the spray tanker, from the tank filling stage to the spraying stage.

For example, with traditional tankers, sudden interruptions can occur during spraying due to inadequate tank filling, or due to excessive

5 uncontrolled consumption of active liquid; it is also difficult, if not impossible, to precisely plan the quantities of active substance to be sprayed onto the different crops for effective use of the substance.

Said problems result in a consequent increase in downtime during the various operative stages, non-optimized use of resources, and finally an
10 increase in the operating costs of the entire crop spraying process.

Another deeply felt problem of known spray tankers is the measurement of the liquid quantity distributed by the delivery means.

This measurement is generally done by mounting mechanical flow indicators upstream of the delivery means, which besides making the
15 spray tanker more complicated from the plant aspect, require considerable maintenance because they usually become clogged, to compromise the operation of the spray tanker and hence the reliability of the measurement.

The object of the present invention is to overcome the said problems
20 within the framework of simple, rational and low-cost solution.

DISCLOSURE OF THE INVENTION

This object is attained by a spray tanker comprising a tank for containing an active liquid, and a system for measuring the quantity of liquid
25 contained in said tank; said measuring system comprising a capacitive sensor for generating an electric signal proportional to the level of active

liquid in the tank, a logic control unit for processing said electric signal, and a device for indicating the quantity of liquid contained in the tank.

By virtue of this arrangement, immediate continuously updated precise information is obtained regarding the liquid quantity in the tank; moreover

5 as the information is transformed into an electric signal, it can be easily manipulated and consequently utilized to automatically control other devices and equipment for controlling the active liquid.

In particular, according to a preferred embodiment of the invention, the measuring system is able to measure and indicate at each instant the

10 liquid volume contained in the tank.

Alternatively, said measuring system can directly measure and indicate the height of the active liquid level.

In a preferred embodiment of the invention, the capacitive sensor comprises a capacitive probe having an electrical capacitance which

15 varies with the active liquid level, and a transducer device, preferably a capacitance/frequency converter, arranged to generate an electrical signal proportional to said electrical capacitance; said capacitive probe consists substantially of a cylindrical capacitor which, as it is partially immersed in the active liquid, has as its dielectric the liquid itself, so that its electrical
20 capacitance depends on the liquid level.

In this manner the sensor is of simple construction and hence of low cost.

According to a further preferred embodiment of the invention, an algorithm is implemented within the logic control unit to calculate both the volume of active liquid delivered by the spray tanker, so advantageously avoiding the
25 installation of mechanical flow indicators and overcoming all the problems arising from their presence, and the liquid flow rate. Said logic control unit

can also be programmed to dialogue with peripheral units and to operate the devices controlling the active liquid in the tank.

From the constructional viewpoint, in the preferred embodiment of the invention the logic control unit and the sensor transducer device, both of which are electronic components, are formed on the same electronic card
5 connected to the capacitive probe, to the indicating device and to all the peripherals.

Finally, according to the invention, to obviate any measurement errors due to tank inclination during the use of the spray tanker, the measuring
10 system comprises three capacitive sensors having their respective capacitive probes vertical and equidistant inside the tank.

In this manner, if the tank is inclined, the logic control unit processes the different electrical signals generated by the sensors (substantially taking their average), to provide a result which is indicative, with excellent
15 approximation, of the quantity of active liquid actually contained in the tank.

The dependent claims define preferred and particularly advantageous embodiments of the spray tanker according to the invention.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Further characteristics and advantages of the invention will become apparent on reading the ensuing description provided by way of non-limiting example, with the aid of the figures shown in the accompanying drawings, in which:

25 Figure 1 shows schematically a measuring system for spray tankers, according to the invention;

Figure 2 is a detailed view of the capacitive sensor of the measuring system of Figure 1;

Figure 3 is a block diagram representing the operation of the measuring system.

5

BEST MODE FOR CARRYING OUT THE INVENTION

Said figures show a system 1 for measuring the quantity of an active liquid, such as a fertilizer or herbicide, contained in a tank 20 of a spray tanker (not visible in the figures).

- 10 Said measuring system 1 comprises (see Figure 1): a capacitive probe 3, the electrical capacitance of which varies as a function of the level 2 of the liquid contained in the tank 20; an electronic card 4 connected to said probe 3 to produce and process an electric signal the frequency of which is proportional to said electrical capacitance of the probe 3; and an
- 15 indicating device 5 connected to the electronic card 4 and provided with a plurality of LEDs 50 which light in a number proportional to the frequency of said electric signal, to indicate the liquid volume in the tank 20.

- In detail (see Figure 2), the capacitive probe 3 comprises a cylindrical tubular element 30 of stainless steel located in the tank 20, and within
- 20 which a central cylindrical rod 31 of oxidized aluminium, completely coated with an insulating paint layer 32, extends coaxially along its entire length; as can be seen from the figure, the diameter of said central rod 31 is less than the inner diameter of the tubular element 30, so that an air gap 33 of an annular cross-section remains defined between said two components.
- 25 A threaded bush 34 associated with one end of the tubular element is inserted through a hole 21 provided in a top wall of the tank 20, to which

the tubular element 30 is then fixed by usual connection means, said connection means being specifically able to electrically isolate the tubular element 30 from the tank 20, if this latter is of conductive material.

The central rod 31 is fixed to the tubular element 30 by plastic connection means making it electrically isolated, and is provided with a pin 37, not
5 coated with the insulating layer 32, which projects from that edge of the threaded bush lying outside the tank 20, to allow it to be connected to the electronic card 4 (see Figures 1 and 2).

As can be seen from the figures (see Figure 2 in particular), said tubular
10 element 30 and central rod 31 form the conductive electrodes of a cylindrical capacitor, the capacitance of which depends generally on the dielectric constant of the substance occupying the air gap 33.

Said conductive electrodes are immersed in the active liquid contained in the tank 20 by a length depending on its level (see Figure 2),
15 consequently the air gap is occupied for said length by the active liquid, and for the remainder by air.

Generally, said active liquid is a very dilute aqueous solution, and for this reason its behaviour, and in particular its dielectric constant, is substantially equal to that of water; consequently, as said dielectric
20 constant is about 80 times higher than that of air, the capacitance of the capacitor formed by the probe 3 is not constant, but varies as the level 2 reached by the active liquid in the tank 20 varies.

The electronic card 4 is provided with integrated circuits which, as will be apparent from the block diagram of Figure 3, form a
25 capacitance/frequency converter 40, for example an oscillator, which converts the electrical capacitance expressed by the capacitive probe 3

into an electric signal having its frequency proportional to said capacitance, and a logic control unit 41 for processing this signal.

The capacitance/frequency converter 40 and the capacitive probe 3 together form a capacitance sensor generating an electric signal

5 proportional to the active liquid level, the logic control unit 41 being programmed to create a correspondence between said electric signal and the volume of active liquid contained in the tank 20. In addition, according to a preferred embodiment of the invention, an algorithm is implemented within said logic unit 41 able to calculate the volume of active liquid

10 delivered by the spray tanker delivery means (not shown) and its flow rate. Preferably, the entire programming of the logic control unit 41 is achieved by connecting the electronic card 4, and hence the unit 41 itself, to a personal computer 6 which, if connected to the internet, makes it possible to remotely control the overall measuring system 1 (see Figure 3).

15 Specifically, the logic control unit 41 (see Figure 3) is arranged to operate the devices for controlling the active liquid (e.g. alarm systems, discharge valves, etc.), to interface with peripheral units, and in particular to control the indicating device 5 so that it lights a number of LEDs 50 proportional to the liquid volume in the tank 20.

20 To make all this possible (see Figures 1 and 3), the electronic card 4 is provided with a plurality of electrical connections 9 for connecting it to the probe 3, to the indicating device 5, and to said peripherals which, depending on particular requirements, can comprise an additional display unit, a data storage unit, or a two-threshold module 11 for setting the
25 threshold values (maximum, minimum) of the electric signal frequency

range, and hence of the liquid volume, which values are used as the basis for operating the control equipment 7.

Finally, it should be noted that the indicating device 5 (see Figures 1 and 3), consisting in this case of a display unit provided with a plurality of LEDs 50, can assume different graphical forms, be replaced by a display of digital or other known type, or be replaced by a vocal or acoustic indicator, without on this account leaving the scope of the invention.

From the foregoing, for the measuring system 1 to be able to measure the volume of active liquid contained in the tank 20, the logic control unit 41 must be programmed to create a correspondence between the frequency of the electric signal (proportional to the level 2) and the volume of active liquid contained in the tank 20.

Said correspondence depends on the doubly unambiguous relationship existing between the level 2 reached by the liquid in the tank 20 and its volume, which depends on the shape of the tank 20; however as the shape of the tank 20 can often be very complicated, said relationship is difficult to achieve theoretically.

For this reason, during the manufacture of the spray tanker the measuring system 1 has to be calibrated, this consisting essentially of determining and memorizing in the logic control unit 41 the relationship between the frequency of the electric signal generated by the capacitive sensor and the liquid volume in the tank 20.

Said calibration procedure need be carried out only during manufacture of the first spray tanker; for subsequent identical spray tankers the results of the measuring system calibration procedure on said first spray tanker need merely be memorized in their logic control units 41.

In detail, the calibration procedure involves connecting the logic control unit 41 to a suitably programmed personal computer 6, and using for filling the tank 20 a pipe delivering a water jet of known constant flow rate; in this manner the logic control unit 41 is able to effect a self-learning
5 procedure on the frequency-volume relationship which begins when the water in the tank 20 reaches the lower end of the probe 3.

In this respect, at regular time intervals established by a program loaded into the personal computer 6, the system stores in the memory of the logic control unit 41 both the frequency of the signal corresponding to the level
10 reached at that moment, and the liquid volume delivered up to that moment by the pipe; said volume can be obtained simply by means of an algorithm which multiplies the constant value of the flow rate by the time which has passed.

The calibration procedure terminates when the liquid level reaches the top
15 of the probe 3, after measuring approximately one hundred significant points of the relationship between signal frequency and liquid volume.

CLAIMS

1. A spray tanker for an active liquid, comprising a tank (20) for containing said active liquid, and a system (1) for measuring the quantity of active liquid contained in the tank (20), characterised in that said
5 measuring system (1) comprises
at least one capacitive sensor (3, 40) for generating an electric signal proportional to the level (2) of active liquid in the tank (20);
a logic control unit (4) for processing said electric signal to determine the quantity of active liquid contained in the tank (20);
10 and an indicating device (5) for indicating said quantity of liquid contained in the tank (20).
2. A spray tanker as claimed in claim 1, characterised in that said quantity of active liquid, measured by the measuring system (1), is the volume of said active liquid contained in the tank (20).
- 15 3. A spray tanker as claimed in claim 1, characterised in that said quantity of active liquid, measured by the measuring system (1), is the level reached by said active liquid in the tank (20).
4. A spray tanker as claimed in claim 1, characterised in that said capacitive sensor comprises a capacitive probe (3), the electrical
20 capacitance of which varies as a function of the active liquid level (2), and a transducer device (40) generating an electric signal proportional to the electrical capacitance of the capacitive probe (3).
5. A spray tanker as claimed in claim 4, characterised in that said capacitive probe comprises:
25 a cylindrical tubular element (30) made of conductive material;

a central rod (31), also of conductive material, coated with an insulating layer (32) and disposed coaxially within said cylindrical tubular element (31), in such a manner as to define an air gap (33) of annular cross-section;

- 5 means (36) for connecting said central rod to the tubular element, and means (35) for connecting this latter to the tank;
said connecting means (35, 36) being correspondingly arranged to electrically isolate the tubular element (30) from the tank (20) and the central rod (31) from the tubular element (30), so that these latter form the
10 conductive electrodes of a cylindrical capacitor.

6. A spray tanker as claimed in claim 4, characterised in that said transducer device consists of a capacitance/frequency converter (40) for generating an electric signal of frequency proportional to the electrical capacitance of the capacitive probe (3).

- 15 7. A spray tanker as claimed in claim 1, characterised in that said logic control unit (41) is programmable to create a correspondence between the active liquid quantity present in the tank (20) and the electric signal generated by the capacitive sensor (3, 40).

8. A spray tanker as claimed in claim 1, characterised in that an
20 algorithm for calculating the volume of delivered liquid is implemented within said logic control unit (41).

9. A spray tanker as claimed in claim 1, characterised in that an algorithm for calculating the flow rate of the delivered liquid is implemented within said logic control unit (41).

- 25 10. A spray tanker as claimed in claim 1, characterised in that said logic control unit (41) operates devices (7) for controlling the active liquid.

11. A spray tanker as claimed in claim 1, characterised in that said logic control unit (41) is arranged to dialogue with peripheral units.

12. A spray tanker as claimed in claim 11, characterised in that said peripheral units are chosen from the group comprising: a display unit, a
5 data storage unit, a two-threshold module (11).

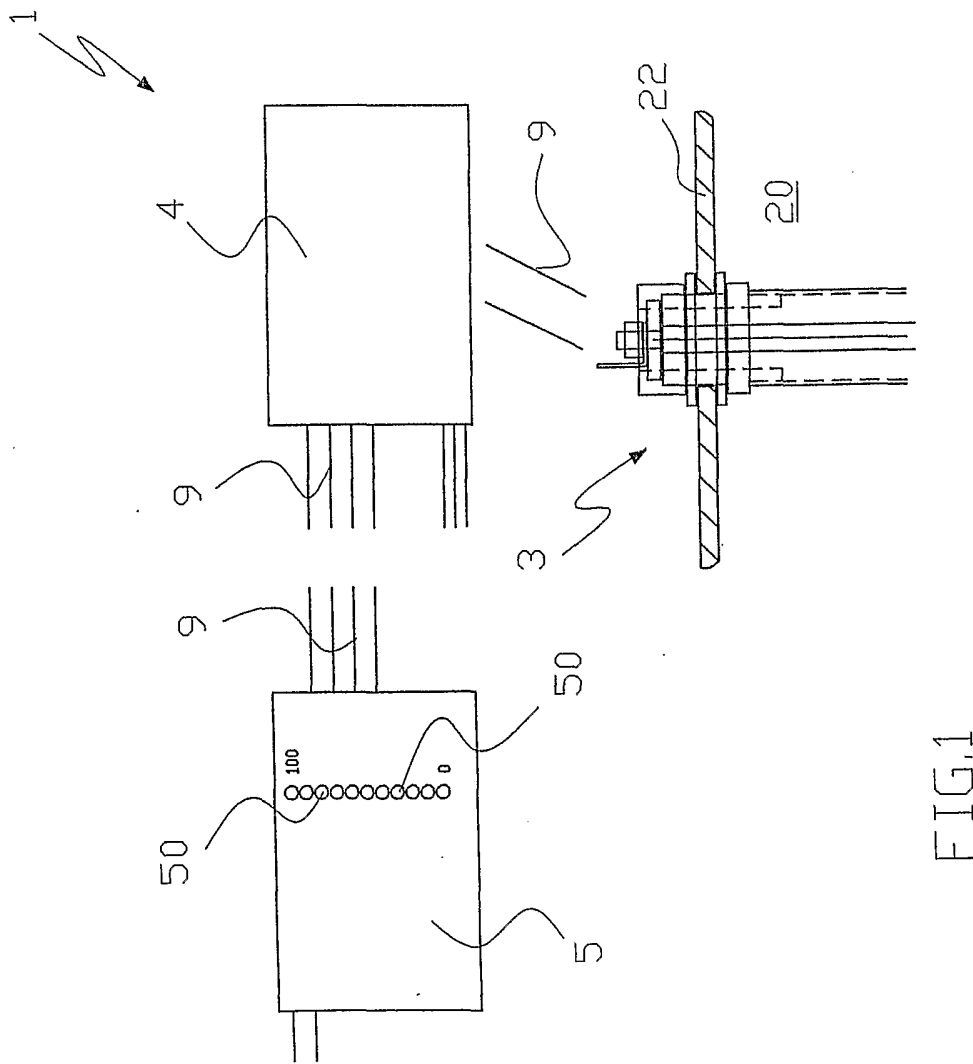
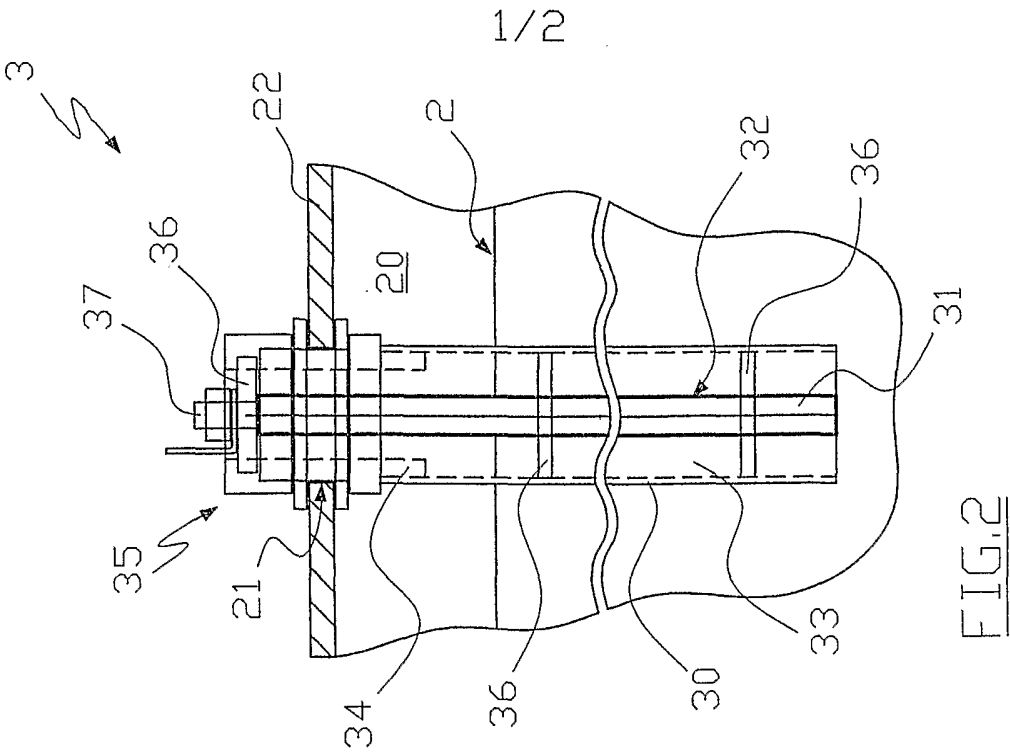
13. A spray tanker as claimed in claim 7, characterised in that said logic control unit (41) is programmed by a personal computer (6).

14. A spray tanker as claimed in claim 4, characterised in that said logic control unit (41) and said transducer device (40) are formed on a single
10 electronic card (4).

15. A spray tanker as claimed in claim 1, characterised in that said indicating device (5) is a display unit provided with a plurality of LEDs (50).

16. A spray tanker as claimed in claim 1, characterised in that said indicating device (5) is a digital display.

15 17. A spray tanker as claimed in claim 1, characterised in that said measuring system (1) comprises three capacitive sensors (3, 4) having their respective capacitive probes disposed vertically and mutually equidistant within the tank (20).



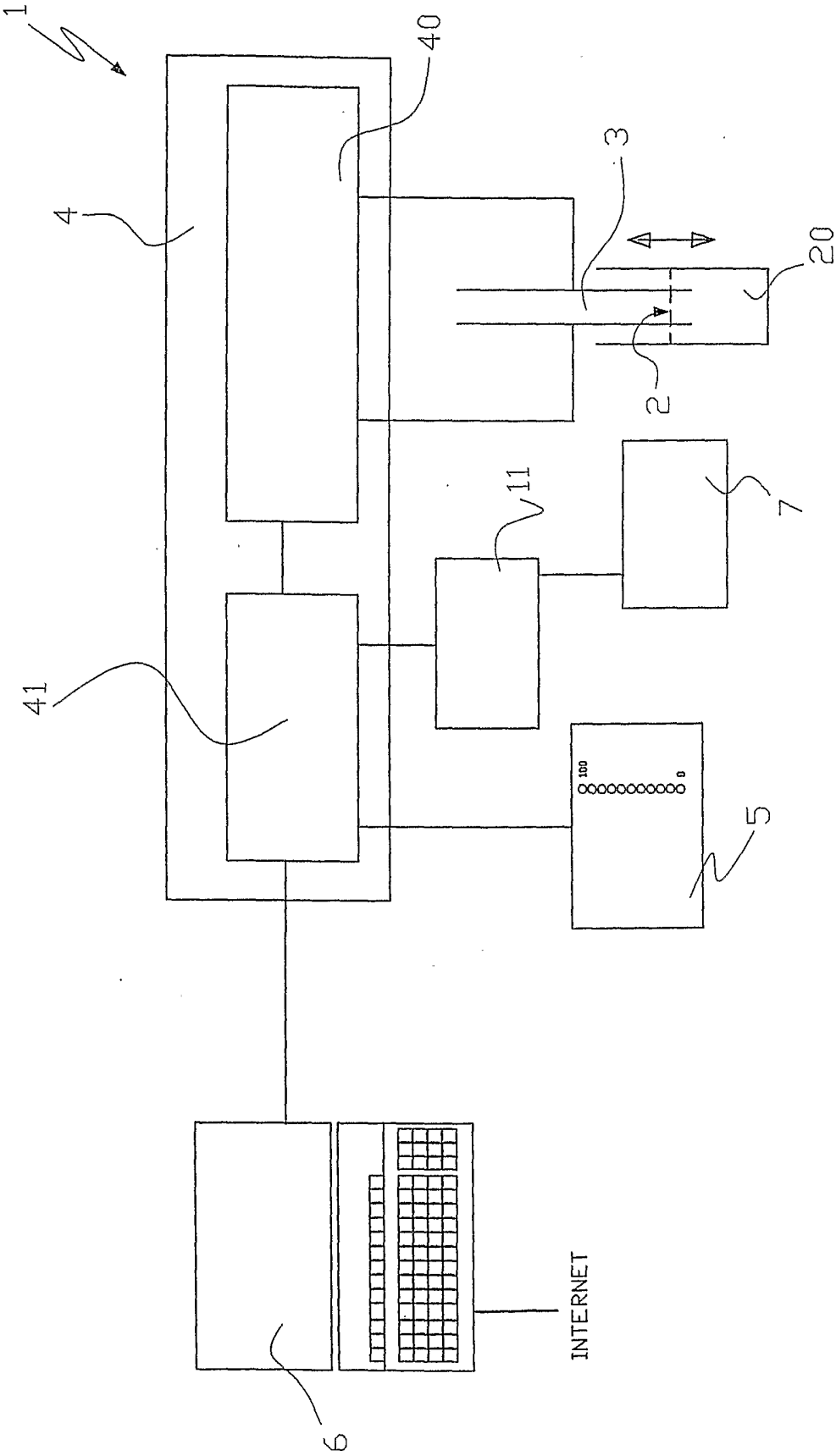


FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER		
G01F23/26	A01M7/00	A01C23/00 A01M21/04 A01G25/09
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
G01F A01M A01C A01G B05B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☒ Further documents are listed in the continuation of box C. ☒ Patent family members are listed in annex.		
* Special categories of cited documents : *A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *&* document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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