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(54) **Title**: LEVEL MEASUREMENT SYSTEM AND METHOD IN A LEVEL MEASUREMENT SYSTEM

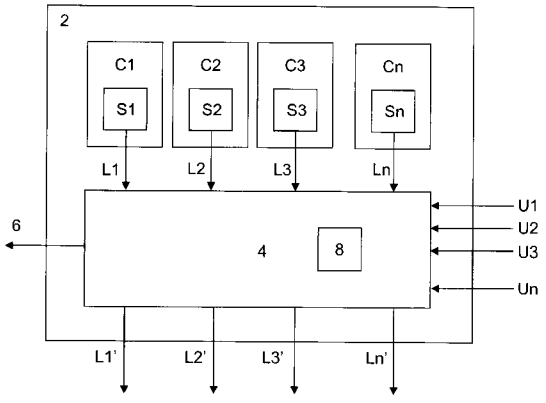

FIG. 3

(57) **Abstract**: A level measurement system (2) for a vehicle, adapted to determining the liquid level in at least one of a plurality of containers (C1, C2,...,Cn) containing liquids, each container being provided with at least one level sensor which delivers a level signal representing levels measured in the container. The level measurement system (2) comprises a calculation unit (4) adapted to receiving at least two level signals (L1, L2,...,Ln) from level signals (S1, S2,...,Sn) situated in different containers. The calculation unit (4) is adapted to receiving at least two consumption signals (U1, U2,...,Un) conveying information related to the consumption of liquid from the containers for which said level signals are received. The calculation unit (4) is further adapted to determining the vehicle's slope and generating therefrom a slope signal (6), on the basis of said at least two level signals (L1, L2,... Ln) and associated consumption signals (U1, U2,...,Un), and to determining at least one adjusted level signal (L:T, L2',...,Ln') based on said slope signal (6) and said level signals (L1, L2,...,Ln).

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Level measurement system and method in a level measurement system.

Field of the invention

The present invention relates to a level measurement system and a method in a level measurement system according to the preambles of the independent claims.

Background to the invention

Vehicles such as buses, trucks, cars etc. are provided with a plurality of containers which contain liquids and which are connected to various systems on board the vehicle. They may for example contain fuel (diesel fuel, petrol), reducing agent (urea), oil or washer liquid.

The means currently used to monitor the level of liquid in the containers is a level sensor situated in each container.

It is generally the case that a given liquid volume in a container will give different level indications depending on the vehicle's slope and acceleration, as illustrated schematically in Figures 1 and 2 depicting three different containers (C1, C2, C3) in horizontal positions (Figure 1) and with the vehicle sloping (Figure 2).

These containers are thus equipped with level sensors which measure the level in the respective containers. These levels are designated L1, L2 and L3 for the three containers (see Figure 1). When the vehicle is sloping, the sensors measure the levels as L1i, L2i and L3i in the respective containers, as illustrated in Figure 2.

Moreover, the various containers for the liquids which are to be covered by level measurement (e.g. fuel, urea, oil and washer liquid) often differ in shape, which means that the level signals will react differently to changes in the vehicle's slope (compare again the containers in Figure 1 and Figure 2).

US patent 4676102 describes a container (e.g. for fuel or gearbox oil) surrounded by an outer casing, with an intermediate space between the tank and the outer casing. The intermediate space contains a fixed amount of liquid used as a reference level when the

liquid level in the actual tank is to be determined. Such a solution certainly caters for the slope of the container when the liquid level is to be determined, but the disadvantage is that it is difficult to implement for existing systems, since it involves placing an outer casing round an existing container, which is technically complicated and also expensive.

The object of the present invention is to propose improved measurement of liquid levels in containers whereby the slope of the containers is also taken into account and no expensive reconstruction is required, since existing systems can be used.

Summary of the invention

The above objects are achieved with the invention defined by the independent claims.

Preferred embodiments are defined by the dependent claims.

The invention thus uses information about the liquid level in at least two different containers and the consumption from them to determine the slope of the vehicle. On the basis of the slope it is then possible to calculate adjusted level signals which take the slope into account and indicate a correct level for the liquid, i.e. the level at which it would have been if the vehicle was standing on a level surface. Knowing the correct level and the shape of the container makes it possible to calculate the volume of the liquid.

The present invention results in more reliable detection of liquid levels in vehicles whereby any slope of the vehicle is also taken into account.

Brief description of drawings

Figure 1 comprises cross-sections of three containers holding liquids in a horizontal state.
Figure 2 depicts the containers in Figure 1 when sloping.
Figure 3 is a block diagram schematically illustrating the present invention.
Figure 4 is a flowchart illustrating the present invention.

Detailed description of preferred embodiments of the invention

The level measurement system 2 according to the present invention will now be described with reference to the schematic block diagram in Figure 3. The invention thus relates to a level measurement system 2 for a vehicle which is adapted to determining the liquid level in at least one of a plurality of containers (C1, C2,...,Cn) containing liquids, e.g. fuel (diesel fuel, petrol), oil or reducing agent. The vehicle may for example be a truck, a bus or a car but the invention is also applicable to watercraft and generally to movable objects provided with containers for liquids.

The level measurement system 2 comprises a calculation unit 4 adapted to receiving at least two level signals (L1, L2,...,Ln) from level sensors (S1, S2,...,Sn) situated in different containers each provided with at least one level sensor which delivers level signals representing measured levels in the container.
The calculation unit is adapted to receiving at least two consumption signals (U1, U2,...,Un) conveying information related to the consumption of liquid from the containers for which said level signals are received. The calculation unit is adapted to determining the vehicle's slope, to generating a slope signal 6 based on the at least two level signals (L1, L2,...,Ln) and associated consumption signals (U1, U2,...,Un) and to determining on the basis of the slope signal and said level sensors (L1, L2,...,Ln) at least one adjusted level signal (L1', L2',...,Ln').

In one embodiment the calculation unit is adapted to receiving at least three level signals (L1, L2, L3) representing the level in at least three containers (C1, C2, C3) and to receiving at least three consumption signals (U1, U2, U3) associated with the level signals. The calculation unit is adapted to determining on the basis of the at least three level signals and associated consumption signals the vehicle's slope in three dimensions and to generating therefrom the slope signal 6.

In one embodiment the calculation unit comprises a memory unit 8 adapted to storing for each of the containers level data which relate to one or more of

- the level sensor's position in the container relative to the rotational centre of the container,
- information about the change in the liquid level at a given consumption,

- predicted changes in the liquid level over time.

In cases where the level sensor is not situated at the container's rotational centre it is necessary to take into account the horizontal distance, arrived at when the container is not sloping, between the level sensor and a vertical line through the container's rotational centre.
In the unusual cases where the level sensor is situated at the container's rotational centre, the level sensor would produce the same output signal irrespective of the container's slope.

Information about how the liquid level changes at a given consumption is important in particular where the container is of irregular shape, e.g. container C3 in figures 1 and 2.

Knowing the predicted consumption of a liquid is particularly important in the case of liquids with very low consumption, e.g. oil.

The calculation unit is preferably adapted to comparing level signals picked up from the same container at at least two different times (t1, t2), in which case the associated consumption signal will convey information about the consumption of liquid from the container between said times t1 and t2.

The invention comprises also a method in a level measurement system for a vehicle which is adapted to determining the liquid level in at least one of a plurality of containers which contain liquids. The method is illustrated schematically by the flowchart in Figure 4.

The method comprises the steps of
- receiving in a calculation unit at least two level signals from level sensors situated in different containers each provided with at least one level sensor which delivers said level signals representing measured levels in the container,
- receiving in said calculation unit at least two consumption signals conveying information related to the consumption of liquid from at least two containers for which said level signals are received,

- determining the vehicle's slope and generating therefrom a slope signal on the basis of said at least two level signals and associated consumption signals,
- determining on the basis of said slope signal and said level signals an adjusted level signal for at least one of said containers.

In one embodiment the invention comprises the steps of
- receiving in said calculation unit at least three level signals representing the level in at least three containers,
- receiving in said calculation unit at least three consumption signals associated with the level signals,
- determining on the basis of said at least three level signals and associated consumption signals the vehicle's slope in three dimensions and generating therefrom said slope signal.

As discussed above, the calculation unit comprises a memory unit adapted to storing for each of the containers level data which represent the level sensor's position in the container relative to the container's rotational centre, information about the change in the liquid level at a given consumption, and predicted changes in the liquid level over time.

The calculation unit is further adapted to comparing level signals picked up from the same container at different times (t1, t2) and to calculating the difference between them to serve as a measure of consumption.
The associated consumption signal conveys information about the consumption of liquid from the container between said times t1 and t2.

We now go on to describe an example of an application of the invention.

Let us assume that we have three containers C1, C2 and C3. Container C1 contains diesel fuel, C2 contains motor oil and C3 contains reducing agent, e.g. AdBlue®. At least one level sensor (S1, S2, S3) is situated in each container. These sensors deliver level signals (L1, L2, L3) which convey information about the liquid level in the respective containers. The level signals from the sensors at a given time t1 are designated L1t1, L2t1 and L3t1 respectively.

The level signals picked up at a later time t2 are designated L1t2, L2t2 and L3t2 respectively.

The consumption signals which convey information about the consumption, or predicted consumption, of liquid from the respective containers between times t1 and t2 are designated U1, U2 and U3.

In situations where the vehicle is on level ground, i.e. with no slope, the change in the level in container C1 will be that expected with regard to consumption of diesel fuel. The level of the motor oil in C2 will probably be unchanged, since it changes very little, and the change in the level of the reducing agent in C3 depends on the consumption, which is known.

When the vehicle is sloping, the level in container C1 will not correspond to that expected. In this case a change in the level in C2 may be relevant. The fact that the predicted consumption of motor oil is very small makes it possible to calculate the slope of the vehicle by simple trigonometry based on the known position of the level sensor in C2. The slope calculated on the basis of the information from C1 and C2 gives the slope in two dimensions.
To arrive at a value for the slope in three dimensions it is necessary to use also values from C3, assuming that the level sensors in C1, C2 and C3 are not in line with one another.

If for example the locations of the level sensors in C1, C2 and C3 are at the corners of an equilateral triangle, the result is a precise measurement of the vehicle's slope in three dimensions. When the slope of the vehicle has been arrived at, an adjusted level signal may be calculated which indicates the correct level, making it possible to calculate a correct volume for the liquid in the container.

The present invention is not restricted to the preferred embodiments described above. Sundry alternatives, modifications and equivalents may be used. The above embodiments

are therefore not to be regarded as limiting the invention's protective scope which is defined by the attached claims.

Claims

1. A level measurement system (2) for a vehicle, adapted to determining the liquid level in at least one of a plurality of containers (C1, C2,...,Cn) containing liquids, each container being provided with at least one level sensor which delivers a level signal representing levels measured in the container, which level measurement system (2) comprises a calculation unit (4) adapted to receiving at least two level signals (L1, L2,...,Ln) from level sensors (S1, S2,...,Sn) situated in different containers, c h a r a c t e r i s e d in that the calculation unit (4) is adapted to receiving at least two consumption signals (U1, U2,...,Un) conveying information related to the consumption of liquid from the containers for which said level signals are received, to determining the vehicle's slope and generating therefrom a slope signal (6), on the basis of said at least two level signals (L1, L2,... Ln) and associated consumption signals (U1, U2,...,Un), and to determining at least one adjusted level signal (L1', L2',...,Ln') based on said slope signal (6) and said level signals (L1, L2,...,Ln).

2. The level measurement system according to claim 1, in which the calculation unit is adapted to receiving at least three level signals (L1, L2, L3) representing the level in at least three containers (C1, C2, C3), to receiving at least three consumption signals (U1, U2, U3) associated with these level signals, to determining on the basis of said at least three level signals and associated consumption signals the vehicle's slope in three dimensions and to generating therefrom said slope signal (6).

3. The level measurement system according to claim 1 or 2, in which the calculation unit (4) comprises a memory unit (8) adapted to storing for each of the containers level data which relate to one or more from among the level sensor's position in the container relative to the container's rotational centre, information about the change in the liquid level at a given consumption, and predicted changes in the liquid level over time.

4. The level measurement system according to any one of claims 1-3, in which the calculation unit (4) is adapted to comparing level signals picked up from the same container at at least two different times (t1, t2), and the associated consumption signal

conveys information about the consumption of liquid from the container between said times t1 and t2.

5. A method in a level measurement system for a vehicle, adapted to determining the liquid level in at least one of a plurality of containers which contain liquids, each container being provided with at least one level sensor which delivers a level signal representing levels measured in the container, which method comprises the steps of:
- receiving in a calculation unit at least two level signals from level sensors situated in different containers,
- receiving in said calculation unit at least two consumption signals conveying information related to the consumption of liquid from at least two containers for which said level signals are received,
- determining the vehicle's slope and generating therefrom a slope signal, on the basis of said at least two level signals and associated consumption signals,
- determining on the basis of said slope signal and said level signals an adjusted level signal for at least one of said containers.

6. The method according to claim 5, further comprising the steps of
- receiving in said calculation unit at least three level signals representing the level in at least three containers,
- receiving in said calculation unit at least three consumption signals associated with these level signals,
- determining on the basis of said at least three level signals and associated consumption signals the vehicle's slope in three dimensions and generating therefrom said slope signal.

7. The method according to claim 5 or 6, in which the calculation unit comprises a memory unit adapted to storing for each of the containers level data which represent the level sensor's position in the container relative to the container's rotational centre, information about the change in the liquid level at a given consumption, and predicted changes in the liquid level over time.

8. The method according to any one of claims 1-7, in which the calculation unit is adapted to comparing level signals picked up from the same container at different times (t1, t2), and the associated consumption signal conveys information about the consumption of liquid from the container between said times t1 and t2.

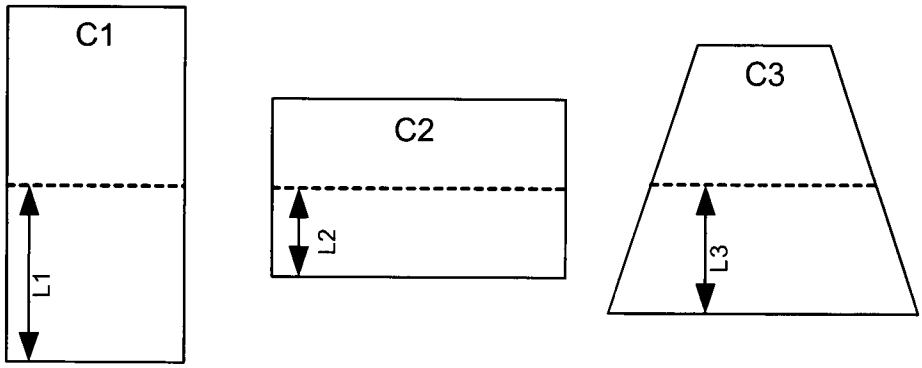

FIG. 1

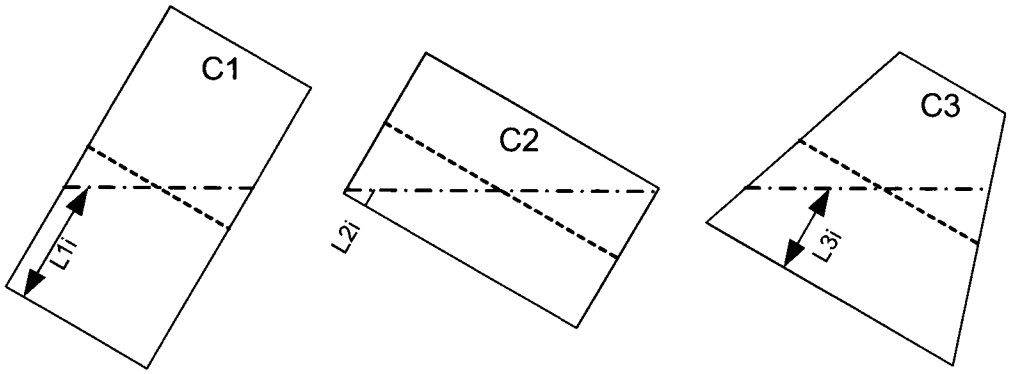

FIG. 2

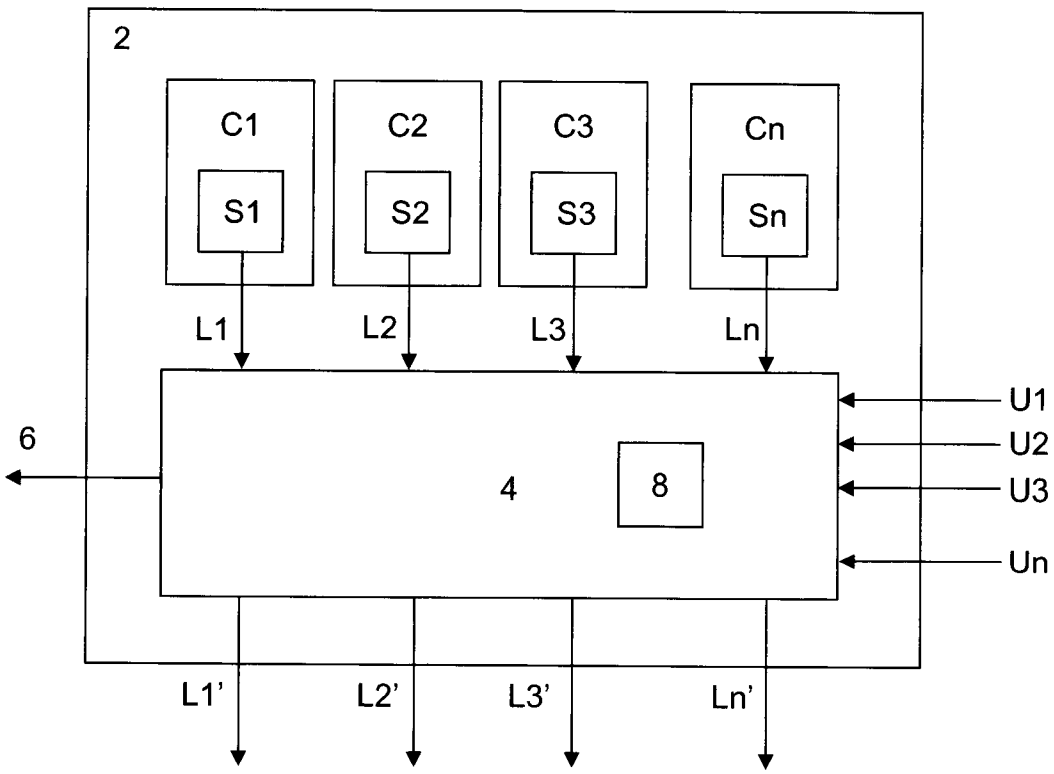

FIG. 3

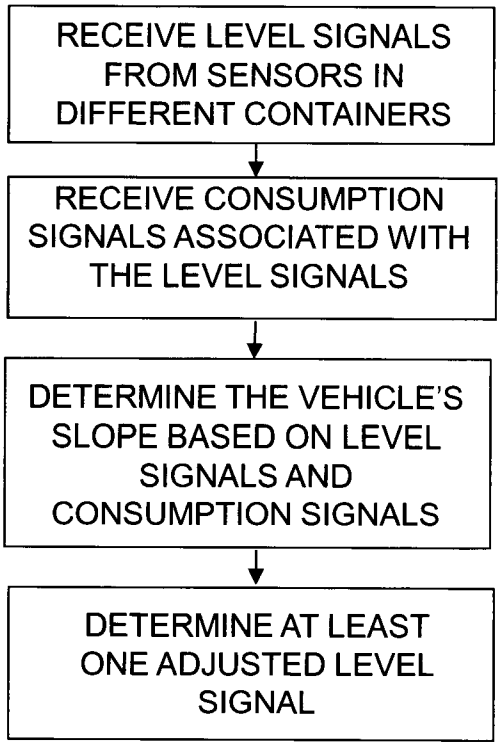
RECEIVE LEVEL SIGNALS FROM SENSORS IN DIFFERENT CONTAINERS
RECEIVE CONSUMPTION SIGNALS ASSOCIATED WITH THE LEVEL SIGNALS
DETERMINE THE VEHICLE'S SLOPE BASED ON LEVEL SIGNALS AND CONSUMPTION SIGNALS
DETERMINE AT LEAST ONE ADJUSTED LEVEL SIGNAL

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2012/051053

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: G01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2008047016 A1 (PEUGEOT CITROEN AUTOMOBILES SA ET AL), 24 April 2008 (2008-04-24); abstract; figures 1,2 --	1-8
A	US 20110010070 A1 (BOHR SCOTT ET AL), 13 January 2011 (2011-01-13); abstract; figure 2 --	1-8
A	US 4935727 A (RE FIORENTIN STEFANO ET AL), 19 June 1990 (1990-06-19); abstract; figure 1 --	1-8
A	US 5072615 A (NAWROCKI RYSZARD), 17 December 1991 (1991-12-17); abstract; figure 1 --	1-8

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
08-01-2013	08-01-2013

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Lars Jakobsson Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2012/051053

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011048579 A (RIVERWALK TRADING 535 CC ET AL), 28 April 2011 (2011-04-28); abstract; figure 1	1-8

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International application No.
PCT/SE2012/051053

Continuation of: second sheet

International Patent Classification (IPC)

G01F 23/00 (2006.01)
G01F 25/00 (2006.01)

WO	2008047016	A1	24/04/2008	FR	2907212	B1	05/12/2008
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				DE	102010026230	A1	13/01/2011
US	4935727	A	19/06/1990	BR	8803994	A	28/02/1989
				DE	3867965	D1	05/03/1992
				EP	0303874	B1	22/01/1992
				ES	2028205	T3	01/07/1992
				IT	1211347	B	18/10/1989
				JP	1138422	A	31/05/1989
US	5072615	A	17/12/1991	NONE			
WO	2011048579	A	28/04/2011	NONE			