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[Continued on next page]

(54) Title: TEMPERATURE MEASUREMENT SYSTEM AND METHOD FOR A TEMPERATURE MEASUREMENT SYSTEM COMPRISING AT LEAST ONE THERMOCOUPLE

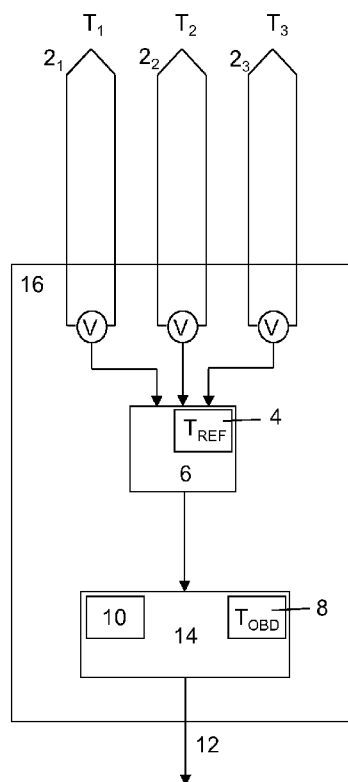


FIG. 1

(57) Abstract: Temperature measurement system comprising at least one thermocouple with a measuring portion (2) and a reference portion (4) which presents a reference temperature TREF for the thermocouple, which system comprises a temperature measurement circuit (6) adapted to determining the temperature difference between the measuring portion and the reference portion and to determining on the basis thereof the temperature for the measuring portion. The system comprises, a temperature sensor (8) situated close to the reference portion and adapted to measuring a spot temperature T_{OBD}, and the system further comprises a calculation unit (10) adapted to calculating $\Delta T = T_{REF} - T_{OBD}$, to comparing the absolute value of ΔT with one or more predetermined threshold levels (T_{TH1}, T_{TH2}) and to generating a diagnosis signal (12) according to the result of the comparison.



TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, **Published:**

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,

LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,

SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,

GW, ML, MR, NE, SN, TD, TG).

— *with international search report (Art. 21(3))*

Title

Temperature measurement system and method for a temperature measurement system comprising at least one thermocouple.

5 Field of the invention

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

Background to the invention

10 An EU standard introduced in 1996 which applies from 2000 to all vehicles with petrol engines and also from 2003 to diesel-engined vehicles requires inter alia that all sensors relevant to emissions be diagnosable for errors. New requirements within the performance field also require that small errors of sensors be detectable. This is done by what is known as “on board diagnosis” (OBD).

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As the term indicates, OBD is used to investigate the status of a vehicle. The electrical socket used has 16 poles and has to be readily accessible from the driving seat. When some form of reading unit is connected, any error codes can be read and service lamps be switched off. Real-time data may also be read.

20

Ensuring that legal requirements about emissions are complied with involves inter alia measuring the temperature in the exhaust system of a vehicle, e.g. a bus or truck. A type of temperature sensor used is so-called thermocouples.

25 A thermocouple is a type of temperature sensor consisting of two mutually insulated metal wires made of different materials. At one end, the measuring point (often called “hot junction”), the two wires are joined together so that they have electrical contact with one another. At the other end they are connected to an instrument for measurement of electrical voltage.

30

When a metal wire passes through a temperature difference, a thermoelectric voltage (Seebeck voltage) occurs across it. Its hot and cold ends will then acquire different

electrical potentials depending on the temperature difference but also partly on the absolute temperatures at the two ends. Different materials produce different voltages.

Taking two wires of different materials and joining them together at the measuring point (at which they thus assume the same potential) therefore results in a potential difference

- 5 between the two ends which is measurable by the measuring instrument. If the temperature in the measuring instrument (often called “cold junction”) is known and the relationship between temperature difference and voltage for the two materials is known, it is possible to use a formula to calculate the temperature at the measuring point, a calculation which is catered for by the measuring instrument.

10

The voltage from a thermocouple is small (typically a few thousand microvolts per degree of temperature difference) so the measuring instrument needs to be sensitive.

Thermocouples are made of various standard materials. In many cases the material characteristics are so good that it is possible to assume a simple linear relationship

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between voltage and temperature. This relationship is usually called the Seebeck coefficient.

The most commonly used type of thermocouple is the type K wire thermocouple which comprises two conductors, viz. chromel (a nickel-chrome alloy) and alumel (a nickel-aluminium alloy). At around room temperature the electromotive voltage for the chromel/alumel combination is about $41 \mu\text{V}/^\circ\text{C}$.

20

Thermocouples generally provide an accurate temperature measurement, are robust and have a quick response time.

- 25 There are various different ways of determining the temperature in the measuring instrument, i.e. at the cold junction. One way is to use a thermistor, i.e. a temperature-dependent resistor, placed close to the cold junction. Another way is described in EP 1,087,217, in which a temperature-sensitive transistor is used instead.

US 3,911,745 describes a thermocouple which comprises a resistor with a temperature-dependent resistance which is used to compensate for temperature changes at the cold junction.

There are thus various different ways of measuring the temperature at the cold junction
5 and compensating for any temperature changes at the cold junction.

As the thermocouple's temperature measurement is based on the temperature difference between the hot and cold junctions, the reliability of the measurement depends inter alia on how accurate the measurement of the temperature at the cold junction is. The prior art described above indicates various different methods for determining the temperature at the
10 cold junction which all have the disadvantage that if an incorrect temperature value for the cold junction has been measured, e.g. because the temperature sensor is faulty or damaged, the thermocouple will deliver an incorrect temperature.

The object of the present invention is to indicate a system and a method which give an indication if there is such an error.

15 Summary of the invention

The above object is achieved by the invention defined by the independent claims.

Preferred embodiments are defined by the dependent claims.

The invention thus covers a temperature measurement system comprising at least one thermocouple with a measuring portion and a reference portion which presents a reference
20 temperature T_{REF} for the thermocouple. The system comprises also a temperature measurement circuit adapted to determining the temperature difference between the measuring portion and the reference portion and to determining on the basis thereof the temperature for the measuring portion. In addition, a temperature sensor situated close to the reference portion is adapted to measuring a spot temperature T_{OBD} , and the system
25 further comprises a calculation unit adapted to calculating $\Delta T = T_{REF} - T_{OBD}$, to comparing the absolute value of ΔT with one or more predetermined threshold levels and to generating a diagnosis signal according to the result of the comparison.

The invention covers also a method for a temperature measurement system which comprises at least one thermocouple with a measuring portion and a reference portion which presents a reference temperature T_{REF} for the thermocouple.

The method comprises:

- 5 determining the reference temperature T_{REF} for the thermocouple;
determining a spot temperature T_{OBD} by means of a temperature sensor situated close to the reference portion;
calculating $\Delta T = T_{REF} - T_{OBD}$;
comparing the absolute value of ΔT with one or more predetermined threshold levels, and
- 10 generating a diagnosis signal according to the result of the comparison.

An advantage of the present invention is that components already present may be used for diagnosis without having to incorporate new components in the system.

Brief description of the drawings

Figure 1 is a schematic block diagram of the temperature measurement system according to the present invention.

Figure 2 is a schematic block diagram of a temperature measurement circuit according to the present invention.

Figure 3 is a flowchart illustrating the method according to the present invention.

Detailed description of preferred embodiments of the invention

20 The invention is described below in more detail with reference to the drawings.

Figure 1 is a schematic block diagram of the temperature measurement system according to the present invention which comprises at least one thermocouple with a measuring portion 2 and a reference portion 4 which presents a reference temperature T_{REF} for the thermocouple. The system further comprises a temperature measurement circuit 6 adapted to determining the temperature difference between the measuring portion and the reference portion and to determining on the basis thereof the temperature for the measuring portion.

A temperature sensor 8 is provided close to the reference portion and is adapted to measuring a spot temperature T_{OBD} , and the system further comprises a calculation unit 10

adapted to calculating $\Delta T = T_{\text{REF}} - T_{\text{OBD}}$, to comparing the absolute value of ΔT with one or more predetermined threshold levels T_{TH1} , T_{TH2} (not depicted in Figure 1) and to generating a diagnosis signal 12 according to the result of the comparison. The temperature sensor may for example take the form of a thermistor, e.g. of NTC type.

- 5 According to a preferred embodiment, the system is adapted to being situated close to a vehicle's exhaust system. The system preferably comprises three thermocouples which share a common reference portion. Within the scope of the concept of the invention, more or fewer thermocouples may be provided depending on the particular application. In the preferred case, the three measuring portions are situated along the vehicle's exhaust
- 10 pipe, e.g. close to the vehicle's catalyst. Providing three measuring portions and doing measurements between pairs of them results in a simple indication as to whether any of them deliver deviating values, i.e. an indication that the respective measuring portion functions correctly. In this application, the temperature may range between -40 and 800°C, and more specifically between 150 and 600°C.
- 15 The temperature sensor 8 and the calculation unit 10 are preferably located in a microprocessor 14 situated close to the temperature measurement circuit 6. The microprocessor thus receives measurement signals from the temperature measurement circuit 6 and does any further processing of the signals before delivering measured data to a general bus system (not depicted).
- 20 The temperature measurement circuit 6, the reference portion 4 and the microprocessor with the temperature sensor 8 and the calculation unit 10 are located, according to a preferred embodiment, on an assembly unit 16 with a maximum dimension of the order of 50 mm. The assembly unit takes the form of an enclosed unit adapted to being fitted close to the vehicle's exhaust system. Embodiments whose maximum dimension exceeds
- 25 50mm are of course also possible within the scope of the concept of the invention indicated in the claims. For example, the assembly unit may be of elongate shape with a length exceeding 50 mm to suit the particular space in which it is to be fitted.

The measurement to validate the thermocouple may be done partly at vehicle start-up when the exhaust temperature is relatively low and the microprocessor has not yet been

warmed by its own energy consumption. It is also possible to perform measurements during normal operation, in which case the energy consumption of the microprocessor and the heat generated by it have to be taken into account. However, this makes no substantial difference to the measurement, as the temperature measurement system provides reliable
5 diagnosis signals even in that case.

An embodiment of the invention is described below with reference to Figure 2, which is a schematic block diagram of a microprocessor according to the present invention.

According to this embodiment, two threshold levels T_{TH1} , T_{TH2} are applied. If the absolute value for ΔT exceeds the lower threshold level T_{TH1} , a first diagnosis signal indicating a
10 minor deviation between the temperatures T_{REF} and T_{OBD} is generated, and if the absolute value for ΔT exceeds the larger threshold level T_{TH2} , a second diagnosis signal indicating a major deviation between the temperatures T_{REF} and T_{OBD} is generated.

For example, T_{TH1} may be set between +10 and + 40°C, e.g. at 20° C.

For example, T_{TH2} may be set between +80 and + 200°C, e.g. at 120° C.

15 The threshold levels may of course be set elsewhere within the above ranges, depending on the preferred application for measurement of exhaust temperatures.

More than two threshold levels may also be used. Alternatively, the diagnosis signal may depend directly on the absolute value of ΔT , e.g. ΔT may be indicated directly by the diagnosis signal.

20 The invention also covers a method for a temperature measurement system which comprises at least one thermocouple with a measuring portion 2 and a reference portion 4 which presents a reference temperature T_{REF} for the thermocouple. The method will now be described with reference to Figure 3.

The method comprises:

- 25 determining the reference temperature T_{REF} for the thermocouple;
determining a spot temperature T_{OBD} by means of a temperature sensor situated close to the reference portion;
calculating $\Delta T = T_{REF} - T_{OBD}$;
comparing the absolute value of ΔT with one or more predetermined threshold levels T_{TH} ,

and

generating a diagnosis signal according to the result of the comparison. If the absolute value for ΔT is smaller than the threshold level T_{TH} , the measurement is deemed correct, i.e. the reference temperature is correctly stated.

- 5 The method further comprises determining the temperature difference between the measuring portion and reference portion and determining on the basis thereof the temperature for the measuring portion.

- According to a further embodiment, the method comprises using two threshold levels (T_{TH1} , T_{TH2}) and if the absolute value for ΔT exceeds the lower threshold level T_{TH1} , a first
10 diagnosis signal indicating a minor deviation between the temperatures T_{REF} and T_{OBD} is generated, and if the absolute value for ΔT exceeds the larger threshold level T_{TH2} , a second diagnosis signal indicating a major deviation between the temperatures T_{REF} and T_{OBD} is generated.

The present invention is not confined to the preferred embodiments described above.

- 15 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 temperature measurement system comprising at least one thermocouple with a measuring portion (2) and a reference portion (4) which presents a reference temperature T_{REF} for the thermocouple, which system further comprises a temperature measurement circuit (6) adapted to determining the temperature difference between the measuring portion and the reference portion and to determining on the basis thereof the temperature for the measuring portion,
c h a r a c t e r i s e d in that the system comprises a temperature sensor (8) situated close to the reference portion and adapted to measuring a spot temperature T_{OBD} , and the system further comprises a calculation unit (10) adapted to calculating $\Delta T = T_{REF} - T_{OBD}$, to comparing the absolute value of ΔT with one or more predetermined threshold levels (T_{TH} , T_{TH1} , T_{TH2}) and to generating a diagnosis signal (12) according to the result of the comparison.
2. A temperature measurement system according to claim 1, in which the temperature sensor (8) and the calculation unit (10) are located in a microprocessor (14).
3. A temperature measurement system according to claim 1 or 2, which system comprises three thermocouples with a shared reference portion.
4. A temperature measurement system according to any one of the foregoing claims, which system is adapted to being situated close to a vehicle's exhaust system.
5. A temperature measurement system according to any one of the foregoing claims, in which the temperature measurement circuit (6), the reference portion (4) and the temperature sensor (8) are located on an assembly unit (16) whose maximum dimension is 50 mm.
6. A temperature measurement system according to any one of the foregoing claims, in which the temperature sensor is a thermistor.
7. A temperature measurement system according to claim 6, in which the thermistor is of NTC type.

8. A temperature measurement system according to any one of the foregoing claims, in which two threshold levels (T_{TH1} , T_{TH2}) are applied and if the absolute value for ΔT exceeds the lower threshold level T_{TH1} , a first diagnosis signal indicating a minor deviation between the temperatures T_{REF} and T_{OBD} is generated, and if the absolute value for ΔT exceeds the larger threshold level T_{TH2} , a second diagnosis signal indicating a major deviation between the temperatures T_{REF} and T_{OBD} is generated.

9. A method for a temperature measurement system comprising at least one thermocouple with a measuring portion (2) and a reference portion (4) which presents a reference temperature T_{REF} for the thermocouple, characterised in that the method comprises:
determining the reference temperature T_{REF} for the thermocouple;
determining a spot temperature T_{OBD} by means of a temperature sensor situated close to the reference portion;
15 calculating $\Delta T = T_{REF} - T_{OBD}$;
comparing the absolute value of ΔT with one or more predetermined threshold levels, and generating a diagnosis signal (12) according to the result of the comparison.

10. A method according to claim 9, which method comprises:
determining the temperature difference between the measuring portion and the reference portion and determining on the basis thereof the temperature for the measuring portion.

11. A method according to either of claims 9 and 10, which method comprises:
using two threshold levels (T_{TH1} , T_{TH2}) and if the absolute value of ΔT exceeds the lower threshold level T_{TH1} , a first diagnosis signal indicating a minor deviation between the temperatures T_{REF} and T_{OBD} is generated, and if the absolute value for ΔT exceeds the larger threshold level T_{TH2} , a second diagnosis signal indicating a major deviation between the temperatures T_{REF} and T_{OBD} is generated.

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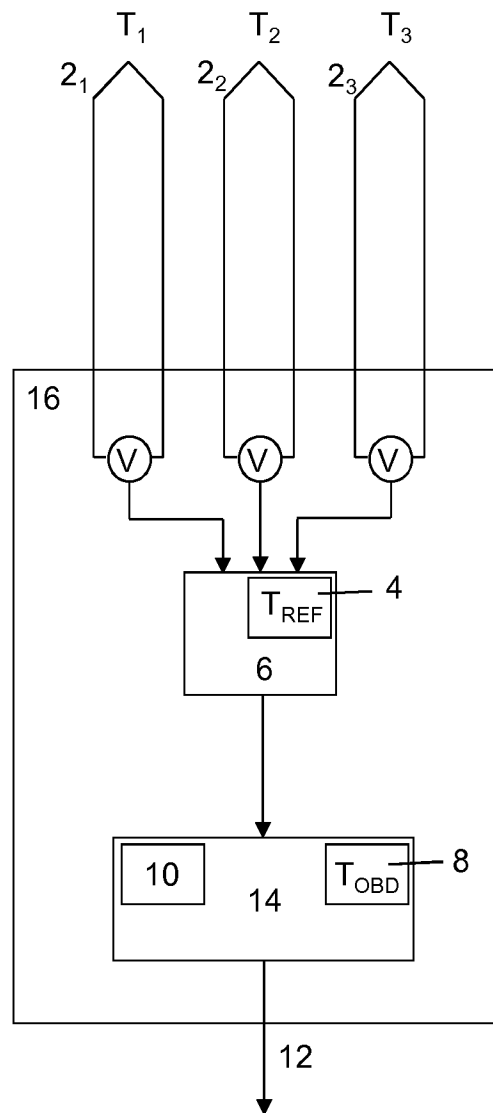


FIG. 1

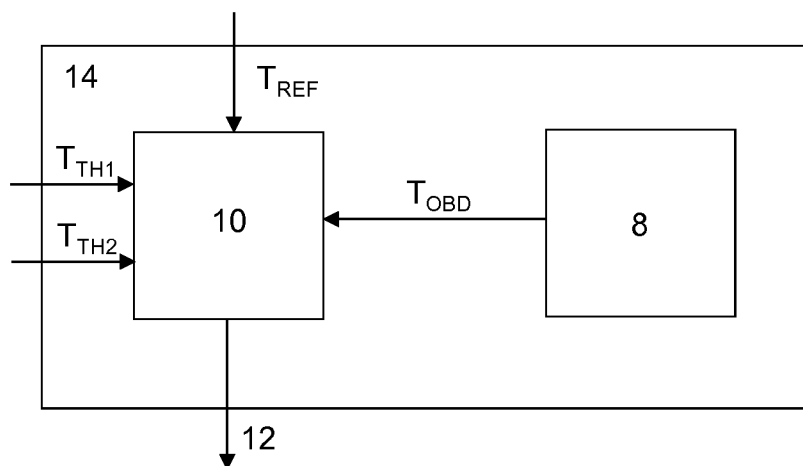


FIG. 2

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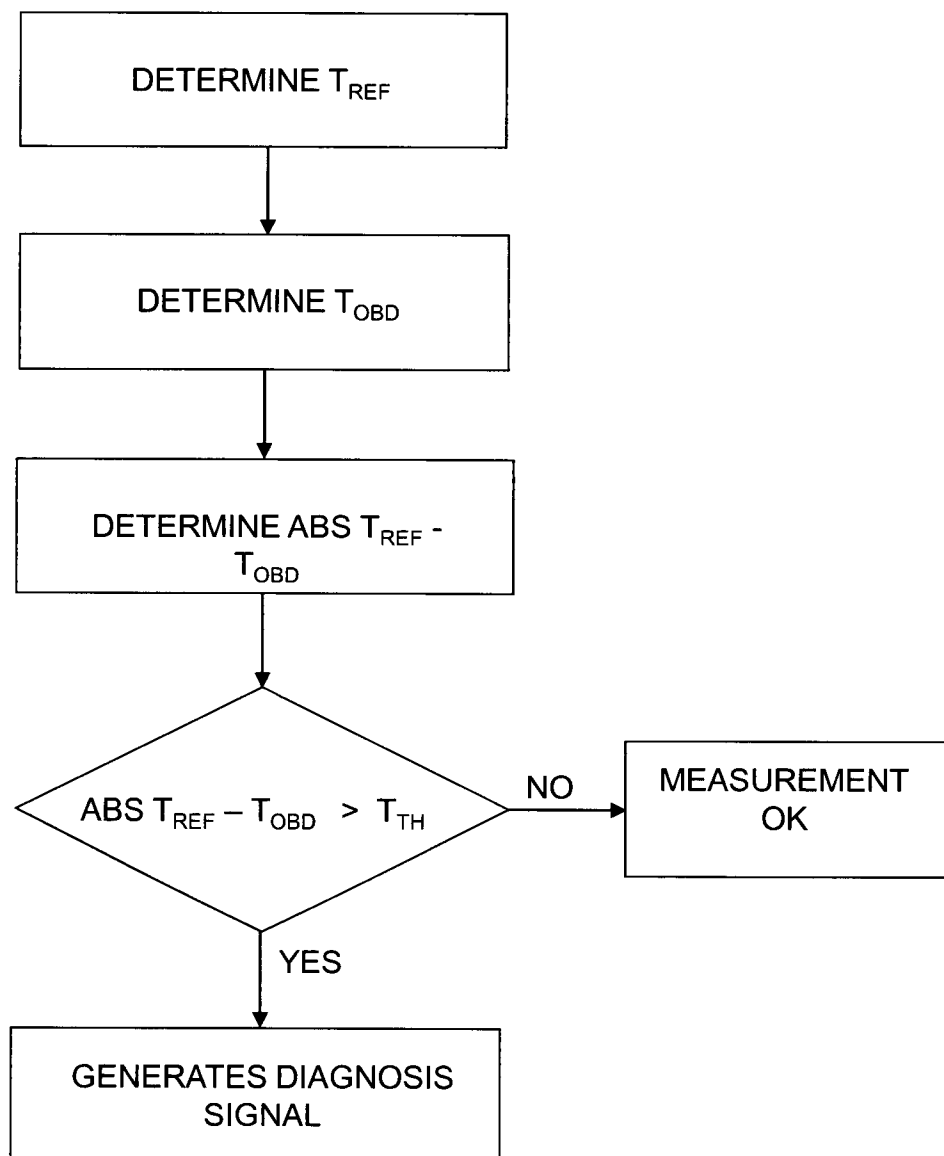


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2011/050655

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: F01N, F02D, G01K

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	US 4590472 A1 (BENSON MICHAEL R ET AL), 20 May 1986 (1986-05-20); abstract --	1-11
A	US 4588308 A1 (SAITO HIDEYUKI), 13 May 1986 (1986-05-13); abstract --	1-11
A	US 5611624 A1 (TORNARE JEAN-MARC), 18 March 1997 (1997-03-18); abstract --	1-11
A	EP 0686835 A1 (FLUKE CORP), 13 December 1995 (1995-12-13); abstract --	1-11



Further documents are listed in the continuation of Box C.



See patent family annex.

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“&” document member of the same patent family

Date of the actual completion of the international search

18-08-2011

Date of mailing of the international search report

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Name and mailing address of the ISA/SE

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INTERNATIONAL SEARCH REPORTInternational application No.
PCT/SE2011/050655

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4157663 A1 (IHLENFELDT EUGENE T ET AL), 12 June 1979 (1979-06-12); abstract -- -----	1-11

Continuation of: second sheet

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Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SE2011/050655

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