United States Patent [19]

Johansson et al.

[11] **3,768,313**

[45] **Oct. 30, 1973**

[54] **METHOD OF DETERMINING THE RISK OF EXPLOSION OF A PREFERABLY GASEOUS MEDIUM AND APPARATUS FOR CARRYING OUT THIS METHOD**

[75] Inventors: **Stig R. Johansson,** Jonkoping; **Lars B. Johnsson,** Hovslatt; **Karl-Gustav A. Strid,** Karlstad, all of Sweden

[73] Assignee: **Industrilaboratoriet AB,** Jonkoping, Sweden

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** .... **73/432 R,** 73/35, 73/26

[51] **Int. Cl.** **G01n 25/54**

[58] **Field of Search** .... 73/35, 36, 15 R, 73/25, 26

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Primary Examiner—James J. Gill
Attorney—Cushman, Darby & Cushman

[57] **ABSTRACT**

The risk of explosion of a preferably gaseous medium is determined by measuring a parameter, which is determinative of the inflammability of the medium, by means of a probe, which comprises an ignition chamber and an ignition initiator in said chamber. A successively varied amount of energy is sequentially supplied to the ignition initiator, until the amount of energy, which is operatively therein, has reached such a level that the medium in the ignition chamber only just ignites. The actuation level, at which the medium in the ignition chamber actuated by the ignition initiator ignites, constitutes a measure of said parameter of the medium and is determined by adequate, preferably electrical means.

14 Claims, 14 Drawing Figures

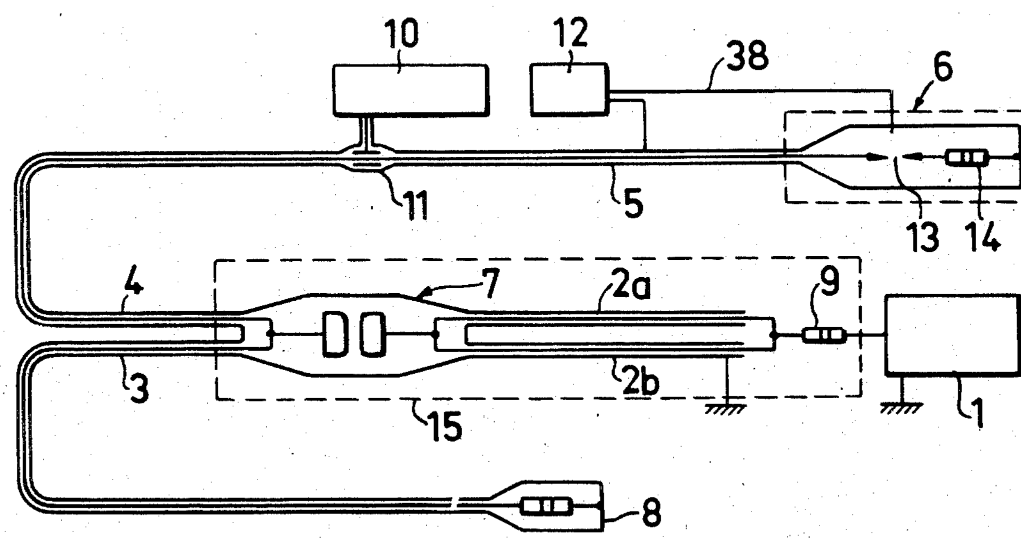


FIG.1

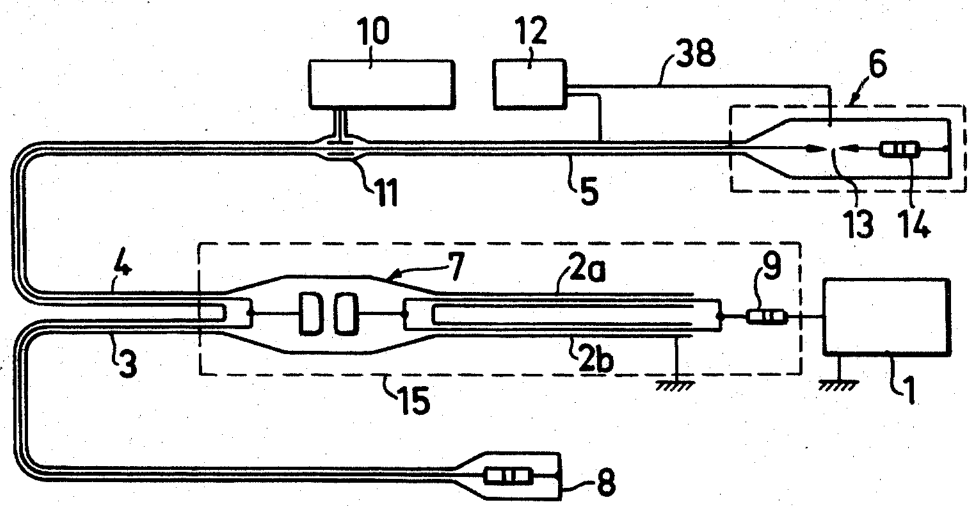


FIG.2

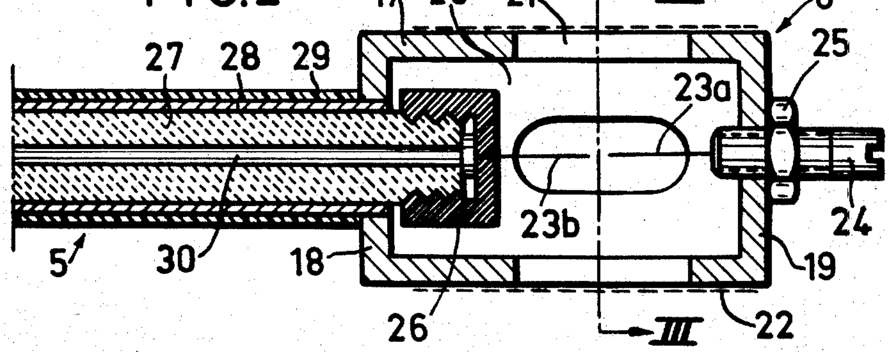


FIG.3

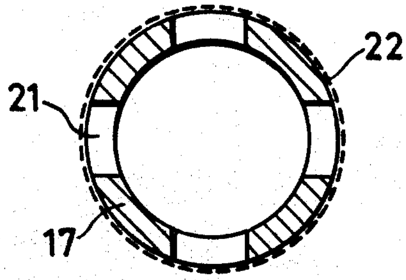
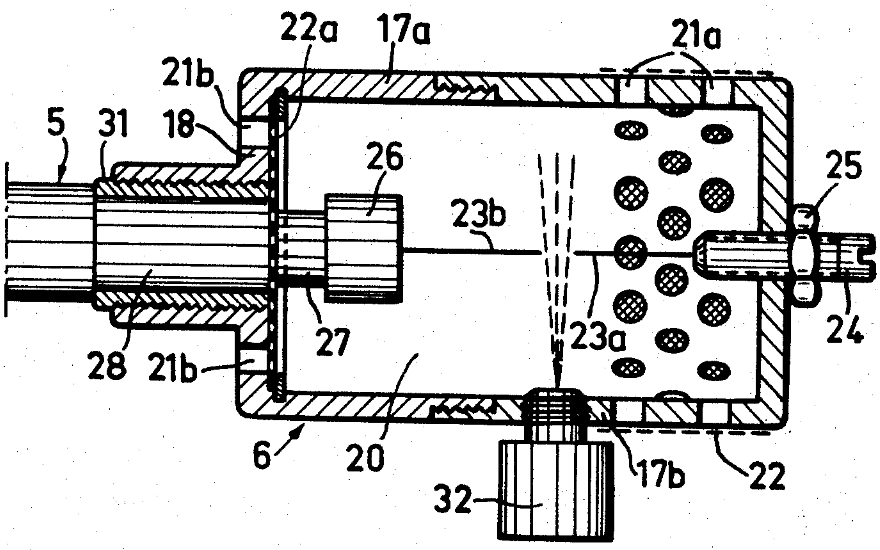


FIG.4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17a
21a
21b
5
31
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26
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23b
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6
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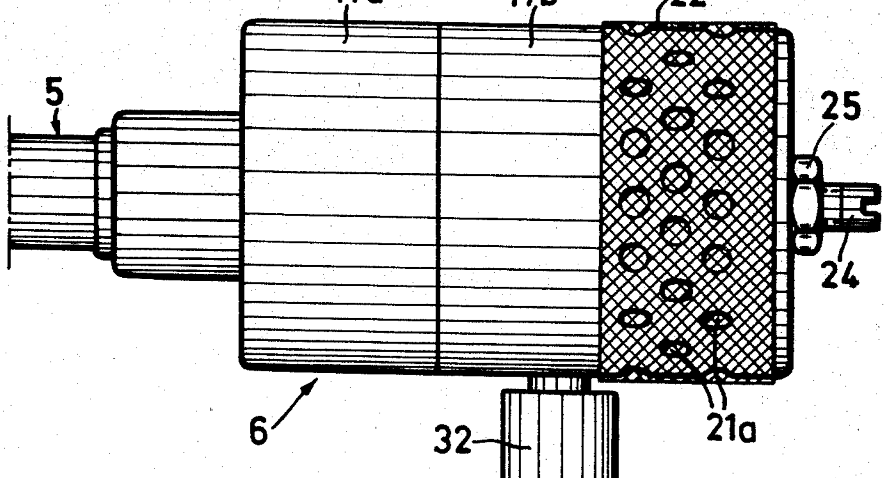
17b
22
32

FIG.5


17a
17b
22
5
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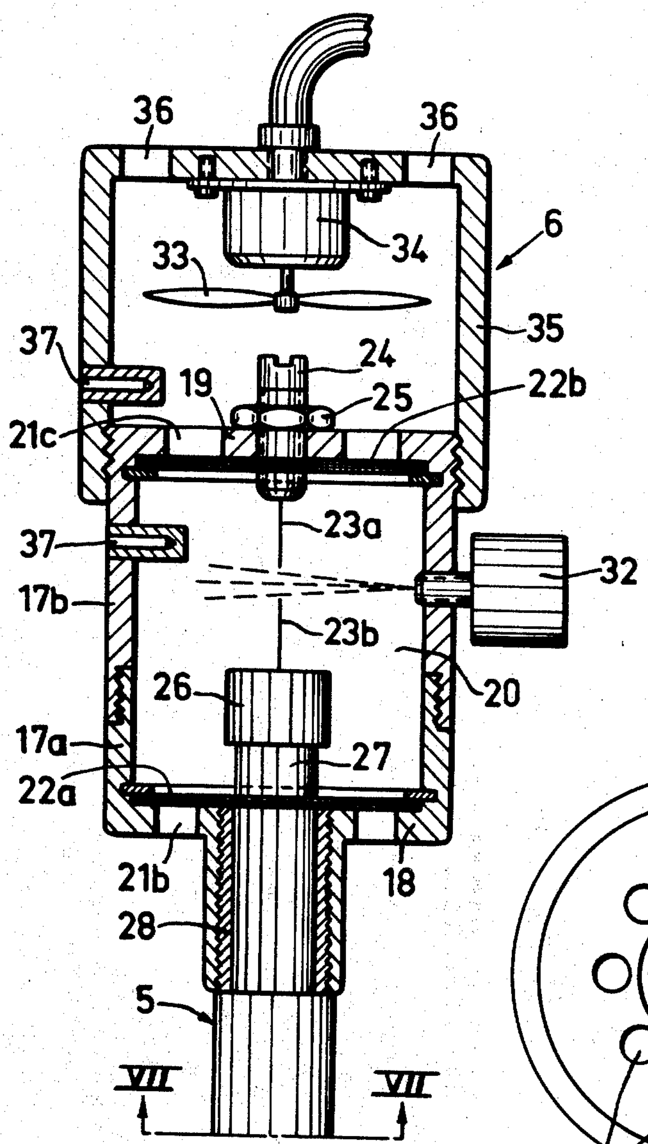
6
32
21a

FIG.6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36
6
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35
37
24
19
25
22b
21c
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32
17b
23b
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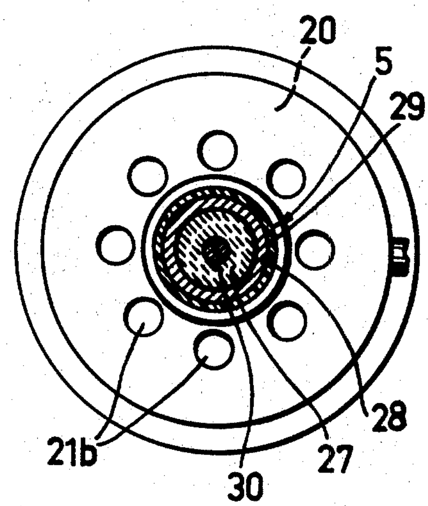
26
17a
27
22a
21b
18
28
5
VII
VII

FIG.7


20
5
29
21b
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27
30

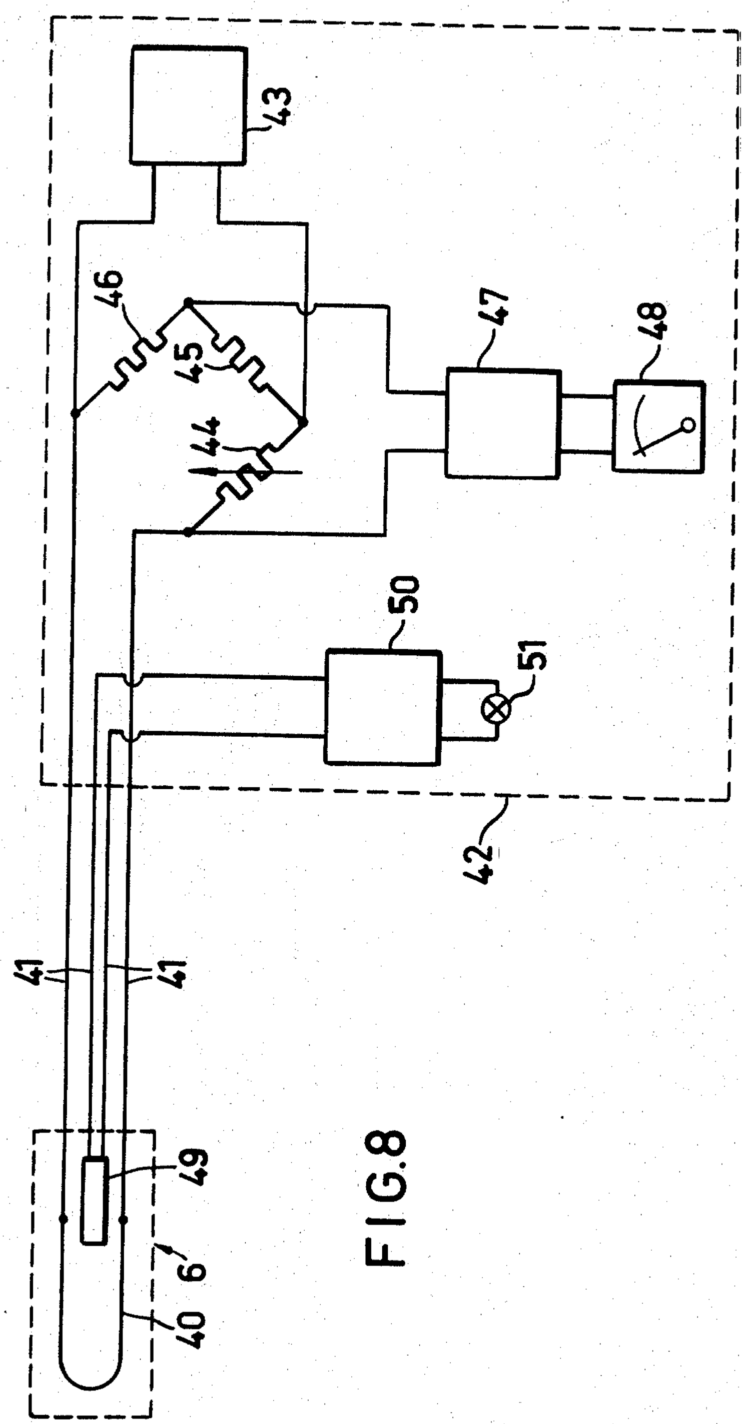


FIG.8

FIG.9

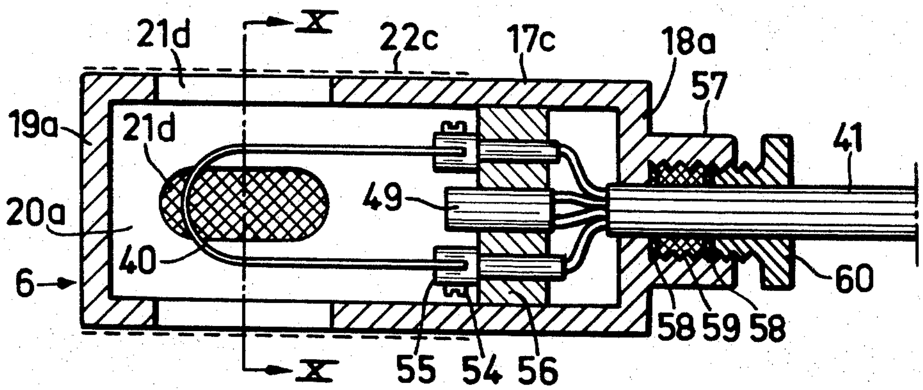


FIG.10

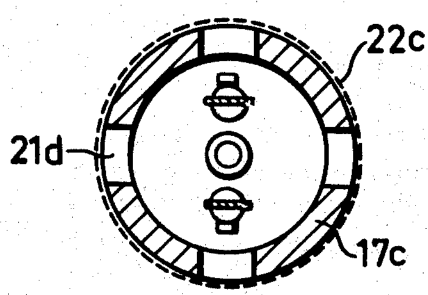


FIG.11

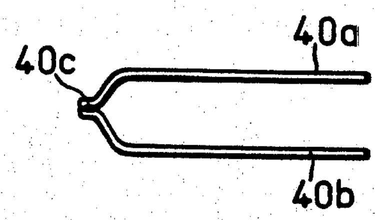
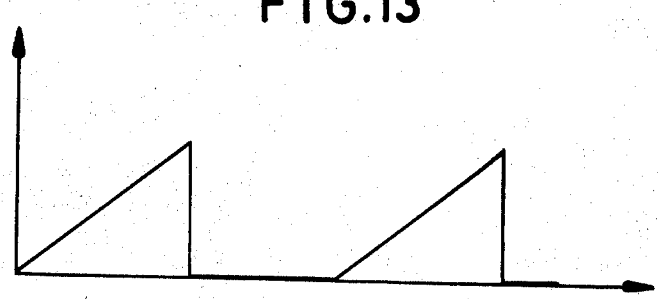


FIG.13



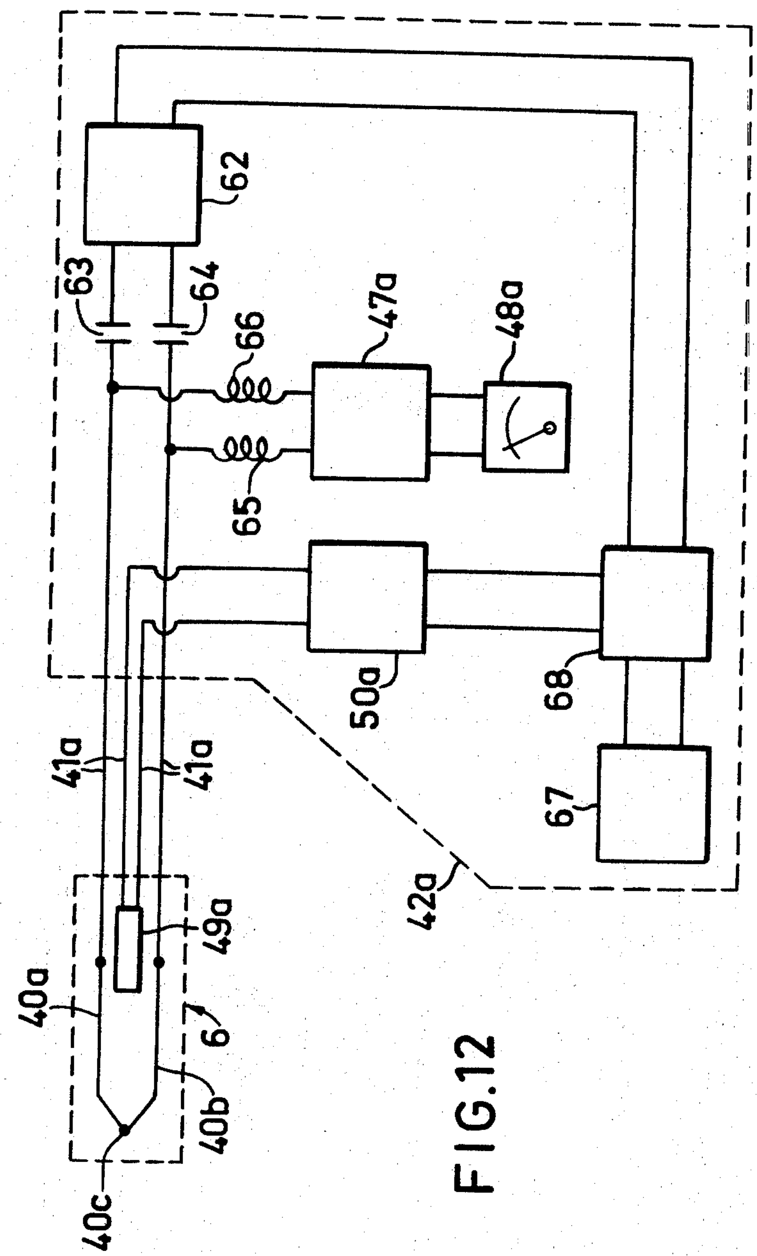
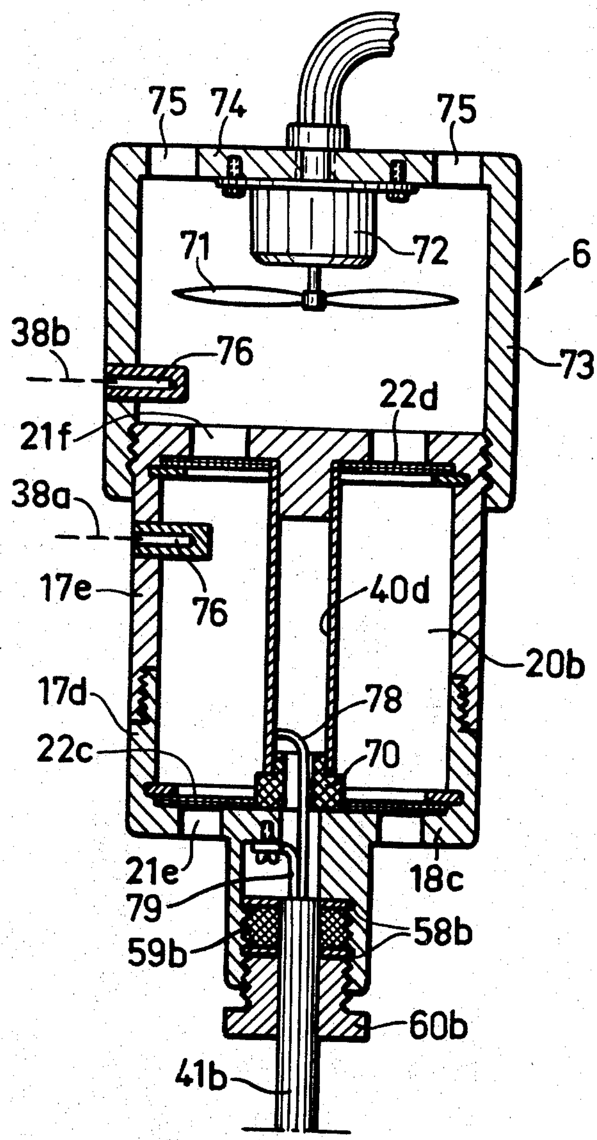


FIG.12

FIG.14


75
74
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71
72
6
38b
76
73
22d
21f
38a
17e
76
40d
20b
17d
78
22c
70
21e
18c
79
58b
59b
60b
41b

METHOD OF DETERMINING THE RISK OF EXPLOSION OF A PREFERABLY GASEOUS MEDIUM AND APPARATUS FOR CARRYING OUT THIS METHOD

This invention relates primarily to a method of determining the risk of explosion of a preferably gaseous medium and secondarily to apparatus for carrying out said method.

Accidents caused by gas and dust explosions are frequent. Besides material damages, which may be important, a sudden explosion in a usually but not necessarily gaseous medium usually also entails serious damages to persons; the number of victims of accidents of this type is comparatively great. Precautionary measures are of course essential. A necessary measure in the protective work has hitherto always consisted of the measurement of some physical or chemical property of a suspect or potentially explosive gas mixture or the like. A common method consists of the determination of the chemical composition of the gas, e.g. by means of a hot-wire instrument, after which a comparison with known data of so called explosion limits is made in order to arrive at a conclusion regarding the explosibility of the gas.

The drawback of methods such as the abovementioned one resides therein that they are indirect and therefore, unreliable. Accordingly, it would be better to measure some explosion property, such as the self-ignition temperature (T^x) or the ignition energy (E^x), but one is then faced with the difficulty of carrying out the measurement in such a way that no explosion occurs at the place in question. Furthermore, the purely experimental difficulties are considerable. Thus, there is, e.g. no simple and accurate in situ method of measuring the ignition energy, which is that property, which should be measured in this connection, in the first instance.

A primary object is this invention is to eliminate these drawbacks. This object is attained by carrying out the method and designing the apparatus according to the invention in the manner, which is set forth in the characterizing class of claims **1** and **2**, respectively. The expression "ignition initiator" herein means an incandescent or heating body, which usually should be heated to incandescence, a spark gap, over which an electric spark or discharge can be created, or equivalent means, which may be activated to such an activating level that it can ignite the medium in the ignition chamber by transferring energy thereto. In the two abovementioned cases the means for activating the ignition initiator comprises means for heating the incandescent or heating body and means for generating at least one electric impulse applied to the spark gap, respectively. In the two instances the "activation level" is represented by the (surface) temperature of the heating body and the energy contents of the impulse, respectively. Thanks to the fact that the probe is so designed that an electric spark, which bridges the spark gap, or the heated body can ignite a representative sample quantity of the medium in the ignition chamber of the probe without any possibility for an explosion to propagate into a surrounding medium, direct measurements in a possibly explosive medium, which may be gaseous, liquid or solid (pulvereous) are thus made possible. The flame generated within the probe is prevented from giving rise to an explosion in the medium surrounding the probe, thanks to the fact that the mesh

of the gauze of the probe is so minute that it is certainty smaller than the quenching distance of that or those media, in which the probe is to be utilized.

Further features and advantages of the method and the apparatus according to the invention will become apparent from the following particular description and the annexed drawings, which diagrammatically and as non-limiting examples illustrate some preferred embodiments of the invention and in which:

FIG. **1** is a simplified wiring diagram of a probe and its appurtenant apparatus for determining the risk of explosion in a given medium;

FIG. **2** is a longitudinal section of a first embodiment of a measuring probe having a spark gap;

FIG. **3** is a cross section on line III—III in FIG. **2**;

FIG. **4** is a longitudinal section of a second embodiment of a probe having a spark gap;

FIG. **5** is a side view corresponding to FIG. **4**;

FIG. **6** is a longitudinal section of still another embodiment of a measuring probe having a spark gap;

FIG. **7** is an end view of the probe according to FIG. **6** as seen in the direction of the arrows VII—VII;

FIG. **8** is a simplified wiring diagram of a probe having a heating or incandescent body as well as appurtenant equipment for determining the risk of explosion of a given medium;

FIG. **9** is a longitudinal section of a first embodiment of the probe according to FIG. **8**;

FIG. **10** is a cross section on line X—X according to FIG. **9**;

FIG. **11** illustrates a second embodiment of a detail of the probe according to FIG. **8**;

FIG. **12** is a simplified wiring diagram of a modified probe with its appurtenant equipment;

FIG. **13** is a voltage-time diagram; and

FIG. **14** is a longitudinal section of a further embodiment of the measuring probe.

In the drawings the same or similar details are designated with the same reference characters throughout.

The apparatus illustrated in FIG. **1** comprises an adjustable high-voltage source **1**, coaxial cables **2*a***, **2*b***, **3**, **4** and **5**, the measuring probe, which is generally designated **6**, a pressure spark gap, which is interconnected between the cables **2** and **3** – **4**, a terminating resistor **8**, a high-ohmic resistor **9**, the resistance of which may be of the order of 100 MΩ, an oscilloscope **10**, which is connected between the coaxial cables **4** and **5** through a capacitive voltage divider **11**, and an indicator **12**, which is in a suitable way, e.g. by means of a conductor **38**, coupled to a transducer in the probe **6** for indicating whether or not the medium, in which the probe is introduced, has been ignited by the spark traversing the spark gap **13** in the probe **6**.

The resistance of the resistor **8** is suitably approximately equal to the impedance of the coaxial cables **2** – **5**, which have the same impedance of the order of 50 Ω. A resistor **14**, which may have a resistance of the order of 0 – 10 kΩ, may be connected in series with the spark gap **13** in those instances, when it is desirable that the energy developed in the spark shall be particularly low.

The pressure spark gap **7**, the coaxial cables **2** and the resistor **9** constitute a pulse-forming net-work **15**, which together with the high-voltage source **1** operates as a pulse generator supplying high-voltage pulses of short rise-time and varying amplitude. The coaxial cables **2** are slowly charged via the resistor **9**, after which they are discharged very rapidly via the pressure spark gap 7, when that ignites. The spark gap 7 may be designed in such a way that it is ignited either on account of the fact that the voltage thereover has exceeded a certain critical level or as a consequence of a high-voltage pulse, which has been applied to an auxiliary electrode (not shown in FIG. 1). In this way two identical pulses will be formed and will propagate from the pulse-generating part, one pulse along the coaxial cable 3, where it is finally completely absorbed by the terminating resistor 8, and the other pulse along the coaxial cable 4, which may be made very long, in the order of 100 m. This pulse may be measured by the oscilloscope 10, when it passes the capacitive voltage divider 11. The pulse continues via the coaxial cable 5, which is terminated by the probe 6, where part of the energy transported by the pulse is dissipated in the spark gap 13 and in the current, limiting resistor 14, if such a resistor is utilized. That part of the energy of the incoming pulse, which is not absorbed in the probe, will be conducted back along the coaxial cables 5 and 4 in the form of a reflected pulse, which may be measured by the oscilloscope 10, when it passes the capacitive voltage divider 11. With knowledge of the shape of the incoming and reflected pulses and the resistance of the resistor 14, it is possible to estimate the energy freed in the spark gap 13. Meanwhile the pressure spark gap 7 has had time to become deionized so that it is no longer current conducting. The reflected pulse is therefore conducted directly from the coaxial cable 4 into the coaxial cable 3, where it is finally absorbed in the terminating resistor 8.

If the high-voltage source is suitably calibrated, it might be possible to dispense with the oscilloscope 10 and its capacitive voltage divider 11.

In the measurement, the object of which is to determine whether a given medium, e.g. a gas mixture, is explosive or not, a pulse is generated having so high an amplitude that a spark with certainty is obtained over the gap 13. If the medium in the probe is then ignited, which is indicated by the indicator 12, which may be located at a comparatively great distance from the probe 6, one will know that the medium is explosive. This measuring scheme may be refined thereby that a series of pulses having known, successively increased amplitude, are applied to the spark gap 13 until the spark generated therein by the pulse is sufficiently strong for igniting the medium in the probe. Since the amplitude of the igniting pulse is known, a measure of ignition energy of the medium is also obtained hereby (which in its turn gives information of the composition of the medium).

If it is possible to apply the probe 6 in such a way in a space, which is filled with the medium to be examined, e.g. a tank, a container, or the like that the probe is visible from the outside, so that it is possible to visually determine, whether or not an ignition in the probe has occured, the detector or indicator 12 may be omitted.

In FIGS. 2 and 3 a first embodiment of the probe 6 is diagrammatically illustrated, in which the resistor 14 shown in FIG. 1 is omitted to simplify the drawing. The probe comprises an ignition chamber 20, which is confined by a suitably circular-cylindrical circumferential wall 17, in which four apertures or windows 21 are provided in an angular distance of 90° from each other and two tight end walls 18, 19. The circumferential wall 17 is tightly surrounded by a fine-mesh gauze 22 having a mesh, which is with certainty smaller than the quenching distance of all media, which may become involved in connection with the probe. The spark gap located in the ignition chamber is formed by two electrodes 23*a*, 23*b*, the firstmentioned one of which is secured to a set screw 24, which permits adjustment of the electrode distance of the spark gap and with which a locking nut 25 cooperates. The electrode 23*b* has a metallic head, which is maintained in current-conducting engagement with the inner conductor 30 by being pressed against it by means of a clamping nut 26 of non-conducting material, which is threaded onto the end of the insulator 27 of the coaxial cable 5. The outer conductor 28 of the cable, which is surrounded by a plastic scheath 29, is tightly inserted into and in metallic engagement with that end wall 18 of the conducting housing of the spark chamber, which faces the cable.

FIGS. 4 and 5, in which the same reference numerals (possibly with the addition of *a*, *b* and so on) as in FIGS. 2 and 3 are utilized for designating the same or like details, illustrate a further development of the probe according to the invention.

As distinguished from the embodiment according to FIGS. 2 – 3 the circumferential wall of the ignition chamber consists of two parts 17*a*, 17*b*, which are screwed together in FIGS. 4 – 5. The apertures 21 in the circumferential wall in FIGS. 2 – 3 have been replaced firstly by three angular rows of smaller apertures 21*a* in the circumferential wall, secondly by a number of apertures 21*b* in the left hand end wall 18 of the ignition chamber 20 in the embodiment according to FIGS. 4 – 5. Inside these openings a fine-mesh gauze 22*a* or a disk of compressed steelwool or the like corresponding to the gauze 22 has been inserted, the "mesh" of which is smaller than the quenching distance. The end wall 18 is secured to the outer conductor of the coaxial cable 5 by means of a bushing 31, which is soldered to the outer conductor and has external threads, on which an extension of the end wall 18 is screwed by means of internal threads. To promote the ionization of the gas in the spark gap between the electrodes 23*a* and 23*b* and for accelerating spark break down, an ionization source 32 in the form of a container for a γ-radiating substance, e.g. cobalt-60, is inserted into the circumferential wall.

According to FIGS. 6 and 7 the probe 6 is supplemented with a blower or fan 33, which promotes the medium circulation through the spark chamber 20. The fan is driven by an encapsulated electric motor 34 and is provided in an fan housing 35, which is joined with the end wall 19 of the spark chamber by means of threads. In this wall apertures 21*c* are provided, which correspond to the apertures 21*b* and are covered by a metal-wire arrangement 22*b*, which is provided in the spark chamber and corresponds to the gauze or steelwool disk 22*a* and has a mesh, which is smaller than the quenching distance. Also in the end wall of the fan-housing ventilation openings 36 are provided so that an air stream can pass through the fan housing and the spark chamber.

Thirty-seven designates thermometer pockets, in which temperature-sensitive means, e.g. thermistors, which form a heat-sensitive transducer, are to be introduced for measuring the temperature difference between the spark chamber 20 and the fan housing 35 for indicating, whether the medium in the spark chamber is ignited or not. For the remote indication of a possible ignition, the measuring means are connected to the indicator 12 (FIG. 1), as is diagrammatically indicated by the conductor **38**.

In the embodiment according to FIGS. **8** – **13** there is utilized as an ignition initiator a heating or incandescent body, which is usually heated to incandescence, instead of the spark gap **13** formed by the electrodes **23***a*, **23***b*. On account hereof, the apparatus associated with the probe will necessarily differ somewhat from that described above.

The apparatus illustrated in FIG. **8** is comprised of a measuring probe, which is generally designated **6** and comprises a heating or incandescent body **40** and is connected by a cable, which has four wires in FIG. **8**, to apparatus **42**, which contains the elements necessary for the heating of the incandescent body **40** and for the measuring or indicating of a possible ignition. A voltage source **43**, which may be controlled externally for heating the heating body **40** feeds a Wheatstone bridge consisting of the incandescent or heating body **40** of the measuring probe and the resistors **44**, **45** and **46**, of which at least the firstmentioned one is adjustable. The unbalance voltage, which is developed over the bridge on account of the change of the resistance of the incandescent or heating body **40** due to heating is applied to an amplifier **47**, which feeds the measuring instrument **48**, which is suitably graduated in incandescent or heating body temperature. By adjustment of the adjustable resistor **44** the bridge may be balanced before the measurement commences. Ignition of the medium, in which the measuring probe **6** is introduced, is indicated by a transducer **49**, which is comprised in the probe and which by means of the amplifier **50** actuates a suitable indicator, for instance in the form of an incandescent lamp **51**, which lights, when the medium is ignited. The transducer is preferably a heat-sensitive emitter or possibly a pressure or light sensor, which is connected to a corresponding indicator. For the transfer of light from the ignition vessel of a light sensitive or photoelextric transducer it is possible to utilize fiber optics. Alternatively, some other kind of radiation sensitive or ionization sensitive transducer and a corresponding indicator may also be utilized.

Measurement is carried out in the following way: With the voltage source **43** set to supply so low a voltage that the heating of the incandescent body **40** caused thereby can be neglected, the bridge is balanced by means of the resistor **44**. After that, the voltage supplied by the voltage source **43** is increased until the lamp **5** indicates that ingition has occured; The ignition temperature T^x is then indicated on instrument **48**.

FIGS. **9** and **10** illustrate more explicitly an embodiment of the measuring probe **6** shown in FIG. **8**. This probe comprises an ignition chamber **20***a*, which is defined by a suitable circular-cylindrical circumferential wall **17***c*, in which four apertures or windows **21***d* (FIG. **10**) are provided at an angular distance of 90°, and two tight end walls **18***a*, **19***a*. The circumferential wall **17***c* is tightly surrounded by a gauze **22***c*, which covers the apertures **21***d* and the mesh of which is with certainty smaller than the quenching distance for the media, in which the probe is to be utilized. The incandescent or heating body **40**, which has the shape of a strip of resistor material, is by means of set screws **54** secured into brackets **55**, which are mounted in an insulator **56**. This also carries the transducer **49**. The cable **41** is introduced through a bushing **57**, which is secured to the end wall **18***a* and has internal threads, and is by soldering or by other means connected to the transducer **49** and the incandescent body brackets **55**. Sealing between the cable **41** and the probe casing is obtained by means of rubber packing **59**, which is surrounded by two washers **58** and is pressed against the cable **41** by a bushing **60** having external threads.

If the probe **6** can be introduced in a space filled with a medium, the explosiveness of which is to be investigated, in such a way that the probe is visible from the outside so that it is possible to see, when an ignition in the probe occurs, it is possible to omit the transducer **49**, the amplifier **50** and the indicator **51**. In a modified embodiment of the apparatus according to FIG. **8**, which is illustrated in FIG. **11**, the incandescent or heating body consists of two metal strips **40***a*, **40***b*, which are welded together at **40***c* to form a thermoelectric couple. A probe, which is provided with such an incandescent or heating body is utilized in assosiation with the apparatus **42***a* illustrated in FIG. **12**. An alternating current generator **62** supplies voltage, e.g. of the frequency 1,000 Hz, to the incandescent or heating body **40***a*, **40***b*, **40***c* through capacitors **63**, **64** and the cable **41***a* so that the incandescent or heating body is heated. The thermo-electromotive force arising in the incandescent or heating body as a consequence of its heating is extracted from the cable **41a** through blocking inductors **65**, **66**, which block the alternating current, and is applied to the amplifier **47***a*, which feeds the measuring instrument **48***a*.

In FIG. **12** there is furthermore shown a device, which permits the measurement to be carried out automatically. A function generator **67** generates a ramp-function voltage according to FIG. **13**, which is repeated with a suitable (adjustable) time interval. Electronic circuit **68** gates this voltage for actuating the alternating current generator **62** in such a way that the power given off thereby increases simultaneously as said voltage. At the start of the measurement the gate **68** is opened, the power given off by the generator **62** then causes the temperature of the incandescent or heating body **40***a*, **40***b*, **40***c* to increase in dependence of the increasing voltage.

When ignition occurs in the probe **6**, the transducer **49***a* brings about closing of the gate **68** through the amplifier **50***a*, so that the alternating current generator **62** is rendered inoperative. Suitably, the apparatus is designed in such a way that the reading of the instrument **48***a*, which indicates the self-ingition temperature T^x, remains until the next measuring period is commenced.

The probe according to FIG. **14** contains as its incandescent or heating body a thin-walled tube **40***d* of resistor material, which corresponds to the incandescent or heating wire **40** in FIGS. **9** and **10** and the incandescent or heating body **40***a*, **40***b*, **40***c* in FIG. **11** and which is directly heated by current from a pair of conductors **78**, **79** comprised in the cable in the illustrated embodiment, and is secured in an insulator **70**, which is joined to the lower end wall **18***c* of the probe **6**. As was the case in the embodiment according to FIG. **6**, the circumferential wall of the ignition chamber **20***b* in FIG. **14** consists of two parts **17***d*, **17***e*, which are joined by threads and which together with the end wall **18***c* of the probe are contempated to constitute the return lead for the current through the tube **40***d*. As is the embodiment according to FIG. **9**, the cable **41***b* is secured in the end wall 18*c*, which is provided with an abutment, by means of a rubber packing 59*b*, which is surrounded by two washers 58*b* and is compressed by means of a tightening screw 60*b*. The heating or incandescent body 40*d*, which has the shape of a thin-walled tube, may consist e.g. of tantalum and may have a length and an outer diameter, which suitably exceed about 50 mm and about 10 mm, respectively. The distance between the outer circumferential surface of the tube 40*d* and the inner surface of the circumferential wall 17*d*, 17*e* of the probe housing should suitably exceed about 20 mm. The openings 21*d* in the circumferential wall 17*c* in FIGS. 9 – 10 have been replaced, firstly by a number of apertures 21*e* in the lower end wall 18*c* of the ignition chamber 20*b*, secondly by a number of apertures 21*f* in the upper end wall 19*c* of the ignition chamber 20*b* in the embodiment according to FIG. 14. Inside each one of these sets of openings there is provided a fine-mesh gauze 22*c* and 22*d*, respectively, or a disk of compressed steelwool or the like having a "mesh," which is smaller than the quenching distance, the gauzes and the disk corresponding to the gauze 22*a* and 22*b*, respectively. A fan 71 promotes the medium flow through the ignition chamber 20*b*. The fan is driven by an encapsulated electric motor 72 and is provided in a fan housing 73, which is joined to the upper end wall 19*c* by means of threads. In the end wall 71 of the fan housing 73 ventilation apertures 75 are provided so that an air stream can pass through both the fan housing 73 and the ignition chamber 20*b*.

Thermometer pockets 76 include temperature-sensing means. e.g. thermistors, which form a heat-sensitive transducer and are introduced for measurement of the temperature difference between the ignition chamber 20b and the fan housing 73, whereby ignition of the medium in the ignition chamber is indicated. For remote indication of ignition, the measuring means are connected to an indicator, which corresponds to the indicator 51 in FIG. 8 as is diagrammatically indicated by the dash lines 38*a*, 38*b* in FIG. 14.

The embodiments described above and illustrated in the drawings are, of course, to be regarded merely as non-limiting examples and can as to their details be modified in several ways within the scope of the invention concept. Thus, the indicator may suitably be combined with or replaced by a preferably acoustical and/or optical alarm. Furthermore, new embodiments, which are also within the scope of the invention, may be created by appropriate combination of details taken from different embodiments described above.

What we claim is:

1. A method of determining the risk of explosion of a preferably gaseous medium by means of a probe, which comprises an ignition chamber, which is provided with apertures, a fine-mesh gauze covering said apertures having a mesh smaller than the quenching distance of said medium and comprising the step of measuring a parameter, which is determinative of the inflammability of the medium, particularly the ignition energy or the ignition temperature, including supplying a successively varied amount of energy to an explosion initiator, which is arranged in said ignition chamber, until the amount of energy, which is operative in the explosion initiator, has reached such a level that the medium in the ignition chamber only just ignites, and measuring the activation level, at which the medium in the ignition chamber actuated by the explosion initiator ignites, said activation level constituting a measure of said parameter of the medium.

2. Apparatus for determining the risk of explosion of a preferably gaseous medium by determining its imflammability, comprising in combination a probe, which comprises an ignition chamber, which is provided with apertures a fine-mesh gauze covering said apertures having a mesh smaller than the quenching distance of said medium, an explosion initiator which is arranged in said ignition chamber, means connected to said probe for supplying a successively varied amount of energy to the explosion initiator, until the amount of energy, which is operative in the explosion initiator, has reached such a level that the medium in the ignition chamber only just ignites, and electrical means associated with said probe for measuring the activation level, at which the medium in the ignition chamber actuated by the explosion initiator ignites, said activation level constituting a measure of the inflammability of the medium.

3. Apparatus according to claim 2, characterized in that the apparatus is designed for the measurement of the ignition energy of the medium, said ignition initiator being comprised of a spark gap and said means for supplying energy to the ignition initiator being comprised of means for generating at least one electric impulse adapted to be applied to the spark gap, said impulse generating means being connectable to the ignition initiator by means of coaxial cables.

4. Apparatus according to claim 3, characterized in that the means for measuring the ignition energy is an oscilloscope for measuring the energy contents of the impulse, said oscilloscope being connected to one of the members of the group formed by said impulse generator and said spark gap.

5. Apparatus according to claim 2, characterized in that the apparatus is designed for the measurement of the ignition temperature of the medium, and in that said ignition initiator is a heating body and the means for supplying energy to the ignition initiator is comprised of means for heating said heating body.

6. Apparatus according to claim 5, characterized in that said heating body is an incandescent body.

7. Apparatus according to claim 5, characterized in that said heating body is electrically heated.

8. Apparatus according to claim 7, characterized in that said heating body constitutes one arm of a Wheatstone bridge having an adjustable voltage source for heating the heating body connected across one of its diagonals and said means for measuring the activation level connected across its other diagonal, said measuring means being comprised of an instrument for measuring the unbalance voltage of the bridge, which is due to the alteration of the resistance of the heating body on acount of its heating through the energy supply.

9. Apparatus according to claim 7, characterized in that said heating body is a thermo-electric couple.

10. Apparatus according to claim 9, characterized by the provision of a high frequency voltage source, which is connected to said heating body through reactive means, such as a pair of capacitors, for heating said body, and a voltmeter, which is connected to said thermo-electric couple for determining the voltage thereover, which occurs at the heating thereof, said voltmeter constituting said means for measuring said actuation level.

11. Apparatus according to claim **10**, characterized in that said voltmeter is graduated in units of temperature.

12. Apparatus according to claim **7**, characterized by the provision of an adjustable voltage source for heating said heating body, a gate circuit for governing the output voltage of said voltage source and having two inputs, a transducer comprised in the probe and connected to one of the inputs of said gate circuit, and a function generator, which is connected to the other one of the inputs of said gate circuit for supplying a repetitive ramp function voltage thereto.

13. Apparatus according to claim **12**, characterized in that the ramp function voltage is of the sawtooth type.

14. Apparatus according to claim **12**, characterized in that the ramp function voltage has an adjustable repetition frequency.

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