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Monitorozórendszer csővezetékekben lévő hibahelyek észlelésére

Az európai szabadalom ellen, megadásának az Európai Szabadalmi Közlönyben való meghirdetésétől számított kilenc hónapon belül, felszólalást lehet benyújtani az Európai Szabadalmi Hivatalnál. (Európai Szabadalmi Egyezmény 99. cikk(1))

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MONITORING SYSTEM FOR THE DETECTION OF FAULTS IN PIPELINES

The invention relates to a monitoring system for determining the location of a pipe burst of a pipeline filled with a transport medium, the pipeline comprising an exterior plastic pipe with an interior metal pipe surrounded by insulation material, wherein at least a first measuring line and a second measuring line are provided in the insulation material and wherein the monitoring system exhibits a measuring device which is connected to a first end of the first measuring line and a first end of the second measuring line and, by applying a supply voltage and measuring a measuring voltage on the measuring lines, is configured for determining the location of the pipe burst of the pipeline. Such a pipe burst constitutes a flaw and may occur both in the pipeline filled with the transport medium or, respectively, in the medium pipe and in the exterior plastic pipe or, respectively, in the casing pipe.

Document EP 1 031 826 A2 discloses a method of determining the location of a pipe burst of a pipeline filled with a transport medium by means of measuring lines laid along the pipeline. In doing so, two measuring lines based on resistance wires are introduced into the insulation material between the interior metal pipe containing the medium and the exterior plastic pipe. Such pipelines are used, for example, in long-distance heating pipeline systems. If a pipe burst occurs in such a pipeline system or in a similar one, it must be identified promptly and the location of the pipe burst must be located.

Furthermore, it is known to a person skilled in the art that, for determining the location of a pipe burst, an earthed diode must be located in the reverse direction at the end of each measuring line, wherein, by means of said diode and by applying appropriate supply voltages as well as by measuring corresponding measuring voltages on the respective measuring lines, the occurrence of a pipe burst and/or the occurrence of a wire break can be detected. If moisture enters the insulation space from outside or, respectively, from inside for example as a result of the plastic pipe and/or the metal pipe sustaining damage, an electrically conducting connection will form between the measuring line and the earthed metal pipe, which connection can be detected by means of a measuring device. If a defect (insulation fault, wire break, pipe burst) is detected, the measuring voltages arising between the first and the second ends of the measuring line as well as between the first end of the measuring line and the metal pipe will be determined by applying a supply voltage to one of the measuring lines. In case of a pipe burst, the location of the pipe burst is determined from the measured values via the voltage divider adjusting itself at the pipe burst and with the aid of the lengths of the measuring line and the metal pipe.

It has turned out to be a disadvantage of the known method that a permanent monitoring and a prompt identification of a possible wire break and/or a pipe burst as well as of the location associated therewith cannot be combined, automatized and performed continuously and, therefore, are extremely time and resource consuming.

Documents DE4003788A1 and US2009/0277252A1 disclose further devices known from the prior art for the detection of leakages and the detection of a wire break.

The invention is based on the object of providing a monitoring system for detecting flaws, wherein the above-mentioned disadvantages do not occur and wherein the pipeline can be monitored in a fully automated way and defects which might possibly occur (insulation fault, wire break, pipe burst) can be identified and lo-

cated promptly.

According to the invention, this problem is solved in that a limit reversing switch is connected to a second end of the first measuring line and to a second end of the second measuring line and, being controlled by the measuring device, is switchable between a first switch position and a second switch position, wherein the second ends of the measuring lines in the first switch position are connected for determining the location of the pipe burst and wherein each of the second ends of the measuring lines in the second switch position is connected via a diode poled in the reverse direction to the interior metal pipe or the earth potential, respectively.

As a result, the advantage is achieved that a pipeline is checked permanently and regularly at selectable intervals for the occurrence of a wire break and/or a pipe burst. In case a pipe burst actually occurs, the location of the pipe burst is then located – again while being controlled by the measuring device. Consequently, the pipe burst can subsequently be fixed promptly and in a resource-saving manner.

A further advantage of the monitoring system is that very long pipelines or, respectively, all pipelines of a widely branched and vast pipeline system – such as, for example, in case of a long-distance heating pipeline system – can also be monitored in a fully automated way. In such pipeline systems, the monitoring system according to the invention makes sure that at least one intermediate reversing switch (also: “connection side-switch”) is switched into the measuring lines between the measuring device and the limit reversing switch (also: “connection endswitch”), the intermediate reversing switch also being switchable while being controlled by the measuring device. In doing so, the intermediate reversing switch basically has the same technical possibilities as the limit reversing switch, with the additional option of disconnecting the measuring lines downstream to it from the part of the monitoring system upstream to it. Per switching unit, up to four wires can be connected and monitored. In case of long-distance heating pipes, said wires are provided by the pipelines of the supply lines (also: “feed line (VL)”) or, respectively, the pipelines of the discharge lines (also: “return line (RL)”).

Providing an intermediate reversing switch has the advantage that the length of the pipeline to be measured is reduced, which in turn reduces the inaccuracy of the determination of the location of the pipe burst – in this case, the distance of the pipe burst from the measuring device. This results from the fact that the absolute size of the inaccuracy of the determination of the location of the pipe burst depends on the total length of the pipeline and, with a constant ratio, increases roughly linearly as the total length increases.

In the concrete case of a long-distance heating pipeline system, the invention offers the advantage that the pipeline can be isolated metrologically from the combined heat and power station into an individual house service connection in order to detect and locate a possible pipe burst on said connection. The monitoring system allows to monitor the pipelines of the supply lines as well as the pipelines of the discharge lines in a fully automated way and to use each of the existing measuring lines as a means of control. Moreover, any number of connection units, for example, in each house, can be installed, which allow the connection of a measuring instrument and/or further measuring lines to the measuring lines of the monitoring system.

Further advantageous embodiments of the monitoring system according to the invention are illustrated below in further detail on the basis of the figures.

Fig. 1 schematically shows a cross section of a pipeline, with two measuring lines introduced into an insulation material between an interior metal pipe and an exterior plastic pipe.

Fig. 2 shows a scheme and a block diagram of a monitoring system for detecting a pipe burst according to a first exemplary embodiment of the invention.

- Fig. 3 shows a scheme and a block diagram of a monitoring system for detecting a pipe burst according to a first exemplary embodiment of the invention.
- Fig. 4 shows a scheme and a block diagram of a monitoring system for detecting a pipe burst according to a further exemplary embodiment of the invention.
- Fig. 5 shows a table illustrating resistance values for a copper wire 1.5 mm² in diameter as a function of the wire temperature.
- Fig. 6 shows a block diagram of a monitoring system for detecting a pipe burst according to a further exemplary embodiment of the invention.

Fig. 1 schematically shows a cross section of a pipeline R, with a first measuring line 1 and a second measuring line 2 introduced into an insulation material 3 between an interior metal pipe 5 containing a transport medium 4 and an exterior plastic pipe 6. Such pipelines R are used, for example, in long-distance heating pipeline systems 7 (illustrated herein, in Fig. 4, in a further exemplary embodiment of the invention).

Figures 2 and 3 schematically show a monitoring system 8 according to an exemplary embodiment of the invention which is configured such that a pipeline R filled with the transport medium 4 is monitored automatically and a pipe burst 9 which might possibly occur is identified and located promptly. The monitoring system 8 comprises a measuring device 10 which is connected to a limit reversing switch 11 via a second end 22 of the first measuring line 1 and a second end 23 of the second measuring line 2. The limit reversing switch 11 comprises two earthed blocking diodes 12, wherein it connects, in its first switch position 13, the first measuring line 1 at the second end 22 thereof to the second measuring line 2 at the second end 23 thereof (Fig. 3) and, in its second switch position 14, connects the first measuring line 1 at the second end 22 thereof as well as the second measuring line 2 at the second end 23 thereof to one of the blocking diodes 12, respectively (Fig. 2). In doing so, the limit reversing switch 11 is being controlled by the measuring device 10 via the first measuring line 1 and/or the second measuring line 2.

In the present invention, the monitoring of the pipeline R happens advantageously in that it is possible, in case of the second switch position 14 of the limit reversing switch 11 according to Fig. 2, to switch in a fully automated and controlled manner between a voltage 15 actuating the blocking diodes 12 in the reverse direction, preferably a direct current voltage of 48 volts, for detecting the pipe burst 9, and an oppositely poled voltage 16 actuating the blocking diodes 12 in the conducting direction for detecting a wire break, thereby measuring the respective current which is flowing. From the measured current, the resistance is determined via Ohm's law and the associated calculation formula $R = U/I$, wherein R represents the resistance, I represents the measured current and U represents the actuating voltage 15. A corresponding detection is based on the fact that, for detecting the pipe burst 9, a threshold resistance on the first measuring line 1 and/or the second measuring line 2 is fallen short of, and, for detecting a wire break, a threshold resistance on the measuring line 1 and/or the measuring line 2 is exceeded.

In doing so, the pipe burst 9 is detected in that moisture enters into the insulation material 3 from outside or, respectively, from inside as a result of the plastic pipe 6 and/or the metal pipe 5 sustaining damage, and an electrically conducting connection forms between the first measuring line 1 and/or the second measuring line 2 and the earthed metal pipe 5.

In order to determine the location of the pipe burst 9, the limit reversing switch 11 is driven into its first switch position 13, and the first measuring line 1 is thereby connected to the second measuring line 2 at the

second ends 22 and 23 thereof. The respective block diagram is illustrated in Fig. 3. By applying a supply voltage 17, which preferably is smaller than 48 volts, to the first measuring line 1 and the second measuring line 2, a measuring voltage 18 arises between a first end 19 of the first measuring line 1 and the metal pipe 5, and a measuring voltage 20 arises between a first end 21 of the second measuring line 2 and the metal pipe 5. From the measuring voltage 18 and the measuring voltage 20, the location of the pipe burst 9, i.e., the distance of the pipe burst 9 from the measuring device 10, is then determined via the voltage divider adjusting itself at the pipe burst 9 and with the aid of the lengths of the first measuring line 1, the second measuring line 2 and the metal pipe 5. Said distance corresponds to the length portion L of the measuring line 1 from its first end 19 to the location of the pipe burst 9 and is proportional to the measuring voltage 18 which arises. The remaining length portion from the location of the pipe burst 9 to the second end of the first measuring line 22 as well as the length of the second measuring line 2 correspond to the measuring voltage 20 which arises. The arising current may have 5 amperes, for example. The accuracy of this distance detection for determining the location of the pipe burst 9 is essentially three percent of the total length of the measuring lines used for the measurement.

Fig. 4 shows the monitoring system 8 according to a further exemplary embodiment, wherein, in addition to the measuring device 10 and the limit reversing switch 11, two intermediate reversing switches 24 are provided along the pipeline R filled with the transport medium 4, wherein the intermediate reversing switches are also always controlled by the measuring device 10 and are switchable between a first switch position 25 and a second switch position 26. Thereby, each of the intermediate reversing switches 24 in the first switch position 25 connects all the measuring lines coming from the measuring device 10 or from another intermediate reversing switch 24 always to the limit reversing switch 11 and, in the second switch position 26, short-circuits at least two measuring lines coming from the measuring device 10 or from another intermediate reversing switch 24.

This is a crucial advantage since the precise determination of the location of the pipe burst 9 is difficult in widely branched and/or vast long-distance heating pipeline systems 7. In order to determine the location of the pipe burst 9 as precisely as possible, the measuring lines are opened successively at each intermediate reversing switch 24 in the first switch position 25, this being controlled by the measuring device 10, and the detection of the pipe burst is effected, wherein, at first, the test is performed via the limit reversing switch 11, then via the intermediate reversing switch 24 with the greatest spatial distance from the measuring device 10, then via the intermediate reversing switch 24 next closer to the measuring device 10, etc.. If the intermediate reversing switch 24 located closest to the measuring device 10 until to which the pipe burst 9 is still detectable is identified, it is driven into its second switch position 26 in order to locate the location of the pipe burst 9. Since the accuracy of this distance detection for determining the location of the pipe burst 9 is essentially three percent of the total length of the measuring lines used for the measurement, the size of the error of measurement can thus be reduced substantially, since the total length of the measuring lines used for the measurement is reduced.

If the pipe burst 9 is located, for example, in the area of a branching supply line or discharge line to a house, the associated pipeline R is isolated by controlling and switching the respective intermediate reversing switch 24, and only in this way it is rendered possible to identify and locate the pipe burst 9. In this connection, Fig. 6 shows a further exemplary embodiment of the invention, wherein, in the concrete case of a long-distance heating pipeline system 7, the monitoring system 8 allows to monitor the first measuring line 1 and the second measuring line 2 of the pipelines R of the supply lines as well as a third measuring line 27 and a fourth measuring line 28 of the pipelines R of the discharge lines in a fully automated way and at selectable time intervals -

preferably of, e.g., 120 seconds - and to use each of those measuring lines as a means of control. Moreover, any number of connection units 29, for example, in each house, can be installed, which allow the connection of a measuring instrument and/or at least two continuative measuring lines on at least two of the measuring lines 1 to 2 or 27 to 28 of the monitoring system 8.

In order to precisely determine the location of the pipe burst, a distance detection is performed in each case from both sides of the presumed location of the pipe burst 9, i.e., for example, from the measuring device 10 and from the connection unit 29 located closest to the measuring device 10, using a portable measuring apparatus, e.g., a measuring kit. The measuring voltages 18 thereby arising in each case always correspond to the length portion L from the location of the pipe burst 9 to the portable measuring apparatus. The measurement is performed with a positive and, respectively, a negative polarity of the supply voltage 17. A positive polarity or, respectively, a negative polarity of the supply voltage 17 is provided if the first end 19 of the first measuring line 1 is configured as a positive pole or, respectively, a negative pole and the first end 21 of the second measuring line 2 is configured as a negative pole or, respectively, a positive pole. In case of a positive polarity or, respectively, a negative polarity of the supply voltage 17, a voltage $U1^+$ or, respectively, a voltage $U1^-$ arises between the first end 19 of the first measuring line 1 and the metal pipe 5. The voltage $U1^+$ or, respectively, the voltage $U1^-$ thus corresponds to the measuring voltage 18 with a positive polarity or, respectively, a negative polarity of the supply voltage 17. By means of the calculation formula measuring voltage $18 = (U1^+ + U1^-)/2$, an "external voltage correction" of the measuring voltage 18 is carried out. Furthermore, a "fault resistance correction" of the measuring voltages 18 arising in each case is carried out in respect of the internal resistance of the pipeline. Finally, the measuring voltages 18 arising in each case are corrected with regard to the wire temperature of the measuring line 1 or the measuring line 2. A respective table illustrating resistance values for a copper wire 1.5 mm² in diameter as a function of the wire temperature is depicted in Fig. 5.

The monitoring system 8 and, respectively, a detection performed therewith in case of a pipe burst 9 can be summarized as follows:

1. Wire break monitoring: The limit reversing switch 11 is in its second switch position 14, the blocking diodes 12 are connected to the earth potential, and the oppositely poled voltage 16 actuating the blocking diodes 12 in the conducting direction is applied.
2. Monitoring the insulation resistance in terms of the penetration of moisture or, respectively, a pipe burst 9: The limit reversing switch 11 is in its first switch position 13, and the voltage 15 actuating the blocking diodes 12 in the reverse direction is applied.
3. Pre-detection of the leak with error correction methods or, respectively, determining the location of the pipe burst 9, according to previously described exemplary embodiments with an error accuracy of essentially ± 3 percent.
4. Fine detection of the leak or, respectively, determining the location of the pipe burst 9 by means of the portable measuring apparatus and error correction methods, with a measurement engineer being present at the nearest connection unit 29, according to previously described exemplary embodiments with an error accuracy of essentially ± 1 percent.

It may be mentioned that the monitoring system according to the invention may also be used for monitoring other pipelines. In this connection, pipelines of a cooling system or of an oil or gas line might, for example, be monitored. Furthermore, it would be possible to provide also more than only two measuring lines in one

pipeline.

Monitorozórendszer csővezetékekben lévő hibahelyek észlelésére

Szabadalmi igénypontok

1. Monitorozórendszer (8) szállítóközeggel (4) töltött csővezeték (R) csőtörése (9) helyének meghatározására, amely csővezeték (R) szigetelőanyaggal (3) körülvetett belső fémcsővel (5) rendelkező külső műanyagcsövet (6) tartalmaz, ahol a szigetelőanyagban (3) legalább egy első mérővezeték (1) és második mérővezeték (2) van elrendezve, és ahol a monitorozórendszer (8) olyan mérőberendezést (10) tartalmaz, amely az első mérővezeték (1) első végével (19) és a második mérővezeték (2) első végével (21) van összekötve, továbbá a mérővezetékekre (1, 2) tápfeszültséget (17) kapcsolva és a mérővezetékeken mérőfeszültséget (18, 20) mérve a csővezeték (R) csőtörése (9) helyének meghatározására alkalmasan van kiképezve,

azzal jellemezve, hogy

az első mérővezeték (1) második végéhez (22) és a második mérővezeték (2) második végéhez (23) végkapcsoló (11) van csatlakoztatva, amely a mérőberendezéssel (10) vezérelve első kapcsolóhelyzet (13) és második kapcsolóhelyzet (14) között kapcsolható át, ahol a csőtörés (9) helyének meghatározásához az első kapcsolóhelyzetben (13) a mérővezetékek (1,2) második végei (22, 23) össze vannak kötve, továbbá ahol a második kapcsolóhelyzetben (14) a mérővezetékek (1, 2) második végeinek (22, 23) mindegyike záróirányban polarizált diódán (12) keresztül a belső fémcsővel (5) van összekötve, illetve földpotenciálra van kapcsolva.

2. Az 1. igénypont szerinti monitorozórendszer (8), **azzal jellemezve, hogy** a második kapcsolóhelyzetébe (14) vezérelt végkapcsolónál (11), a mérőberendezés (10) csőtörés (9) észleléséhez az első mérővezeték (1) és/vagy a második mérővezeték (2) első végére (19, 21) egy a diódát (12) záróirányban vezérlő első feszültség (15) rákapcsolására, továbbá az első mérővezeték (1) és/vagy második mérővezeték (2) huzaltörése észleléséhez az első mérővezeték (1) és/vagy második mérővezeték (2) első végére (19, 21) egy, a diódát (12) vezetőirányban vezérlő második feszültség (16) rákapcsolására alkalmasan van kiképezve.

3. A 2. igénypont szerinti monitorozórendszer (8), **azzal jellemezve, hogy** a második kapcsolóhelyzetébe (14) vezérelt végkapcsolónál (11), a mérőberendezés (10) a csőtörés (9) észlelésére alkalmasan van kiképezve, ha a rákapcsolt első feszültségnél (15) az első mérővezetékbeli (1) és/vagy a második mérővezetékbeli (2) küszöbáram túllépésre kerül.

4. A 2. igénypont szerinti monitorozórendszer (8), **azzal jellemezve, hogy** a második kapcsolóhelyzetébe (14) vezérelt végkapcsolónál (11), a mérőberendezés (10) huzaltörés észlelésére alkalmasan van kiképezve, ha a rákapcsolt második feszültségnél (16) az első mérővezetékbeli (1) és/vagy a második mérővezetékbeli (2) küszöbáram nem került túllépésre.

5. Az előző igénypontok bármelyike szerinti monitorozórendszer (8), **azzal jellemezve**, hogy a mérőberendezés (10) és a végkapcsoló (11) között az első mérővezetékbe (1) és a második mérővezetékbe (2) beiktatott legalább egy közbenső kapcsoló (24) van elrendezve, amely közbenső kapcsoló (24) a mérőberendezéssel (10) vezérelve első kapcsolóhelyzet (25) és második kapcsolóhelyzet (26) között kapcsolható át, ahol az első kapcsolóhelyzetben (25) az első mérővezeték (1) és a második mérővezeték (2) rendre a mérőberendezés (10) és a végkapcsoló (11) között vannak összekötve, továbbá ahol a második kapcsolóhelyzetben (26) a mérőberendezésből (10) jövő első mérővezeték (1) a mérőberendezésből (10) jövő második mérővezetékkel (2) van összekötve.

6. Az 5. igénypont szerinti monitorozórendszer (8), **azzal jellemezve**, hogy a második kapcsolóhelyzetébe (14) vezérelt végkapcsolónál (11) és az első kapcsolóhelyzetébe (25) vezérelt közbenső kapcsolónál (24), a mérőberendezés (10) a mérőberendezéstől (10) legtávolabbi közbenső kapcsolót (24) az első mérővezetéken (1) csőtörés (9) észlelése esetén a második kapcsolóhelyzetébe (26) vezérlőn van kiképezve, továbbá ahol a mérőberendezés (10) az első kapcsolóhelyzetébe (25) vezérelt legtávolabbi közbenső kapcsolót (24) az első mérővezetéken (1) újabb csőtörés (9) észlelése esetén a második kapcsolóhelyzetébe (26) vezérlőn van kiképezve.

7. Az előző igénypontok bármelyike szerinti monitorozórendszer (8), **azzal jellemezve**, hogy a csővezeték (R) távhő-vezetékrendszernek (7) része, továbbá felmelegített szállítóközeg (4) hőerőműből bevezető vezetékeken keresztül házakhoz történő szállítására és lehűlt szállítóközegnek (4) a házból elvezető vezetékeken keresztül hőerőműhöz történő szállítására szolgál, ahol a mérőberendezés (10) a bevezető vezeték első mérővezetékéhez (1) és második mérővezetékéhez (2), továbbá az elvezető vezeték harmadik mérővezetékéhez (27) és negyedik mérővezetékéhez (28) van csatlakoztatva.

8. A 7. igénypont szerinti monitorozórendszer (8), **azzal jellemezve**, hogy a mérőberendezés (10) a négy mérővezeték (1, 2; 27, 28) egyikén észlelt csőtörés (R) esetén, a csőtörés (R) helyének meghatározásához a maradék mérővezetékek (1, 2; 27, 28) egyike kiválasztására alkalmasan van kiképezve.

9. A 7. vagy a 8. igénypont szerinti monitorozórendszer (8), **azzal jellemezve**, hogy legalább egy házban legalább az első mérővezetéken (1) és a második mérővezetéken (2) csatlakozóegység (29) van elrendezve, amelynél a négy mérővezeték legalább egyikéhez külső mérőeszköz és/vagy külső mérővezeték csatlakoztatható.

10. Az előző igénypontok bármelyike szerinti monitorozórendszer (8), **azzal jellemezve**, hogy a mérőberendezés (10) választható időintervallumoknál, előnyösen 120 másodperces intervallumoknál, választhatón vagy egyetlen meghatározott mérővezeték (1, 2; 27, 28) vagy valamennyi mérővezeték (1, 2; 27, 28) rendszeres ellenőrzésére alkalmasan van kiképezve.

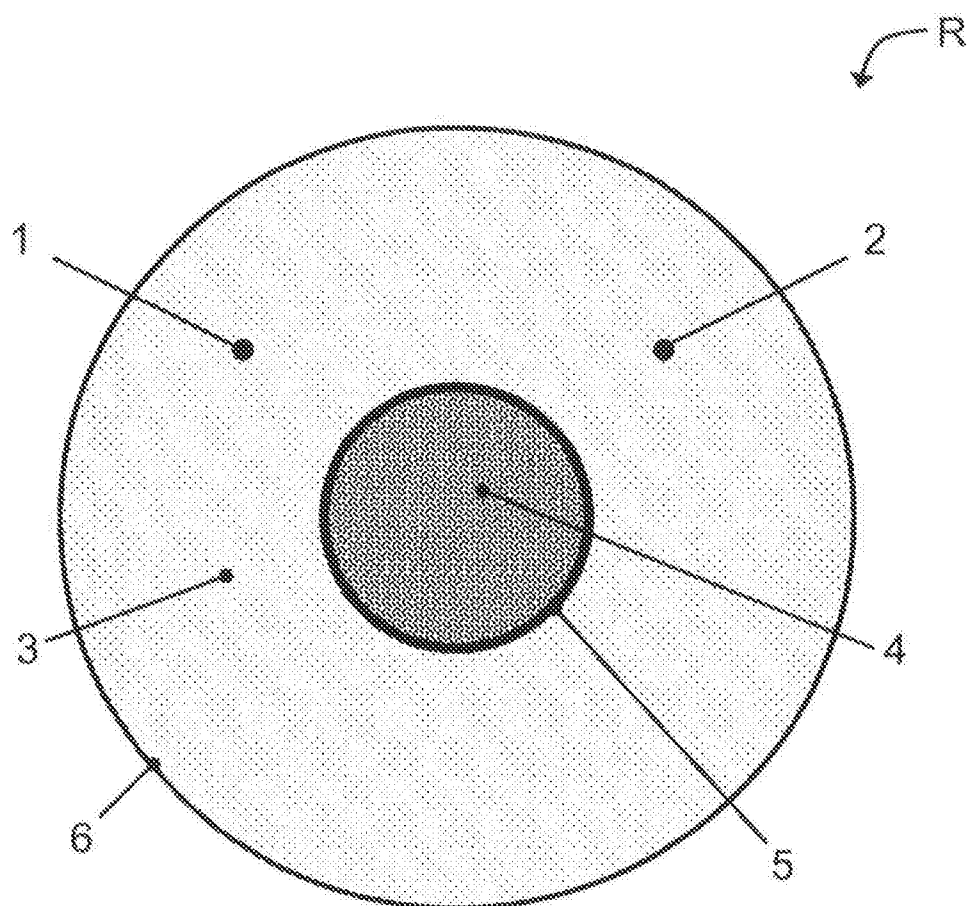


FIG. 1

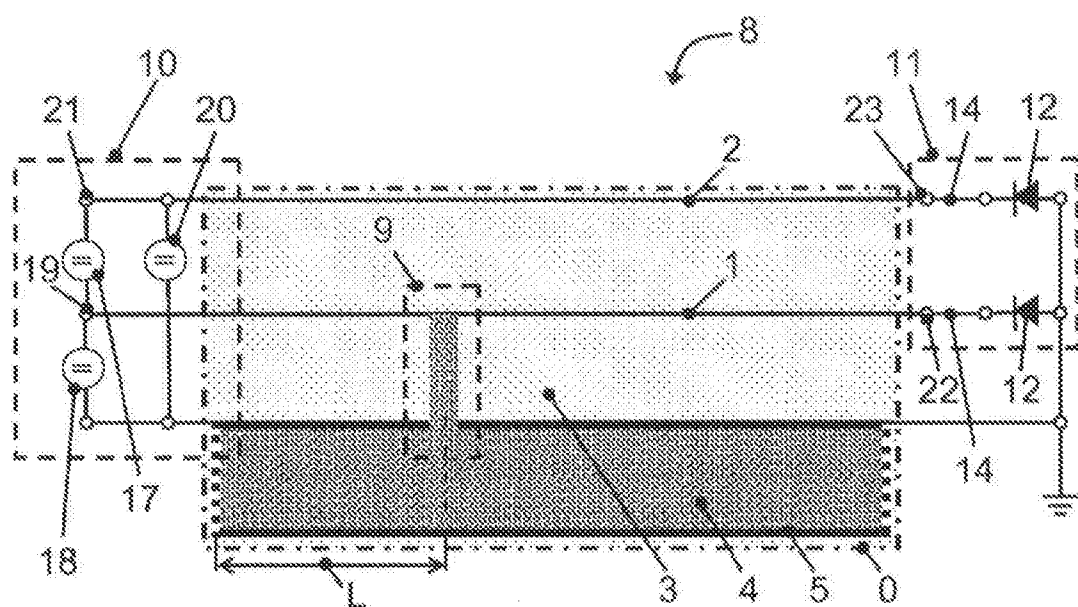


FIG. 2

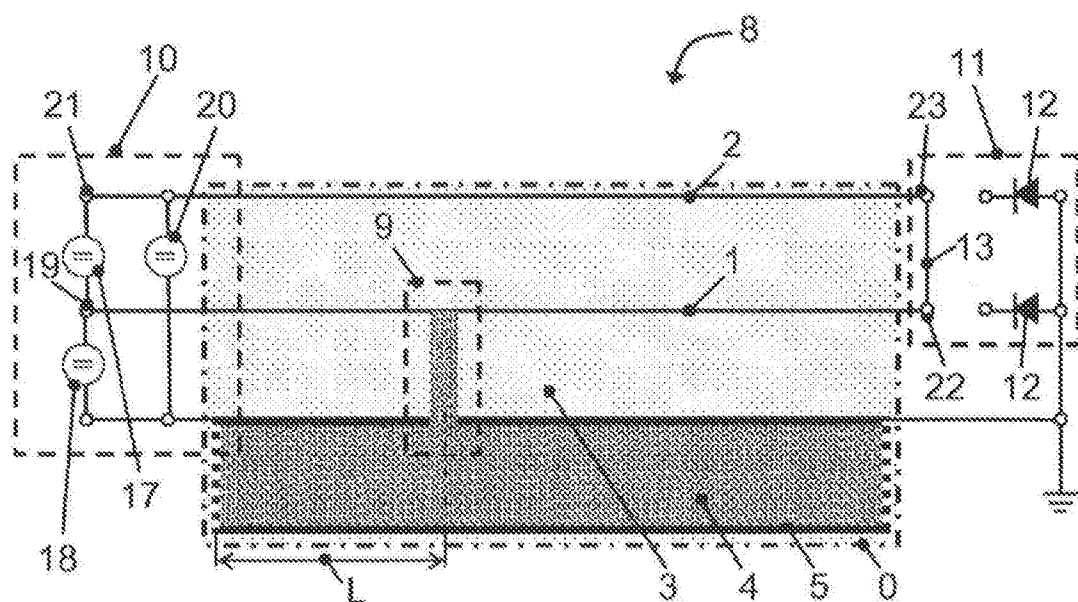


FIG. 3

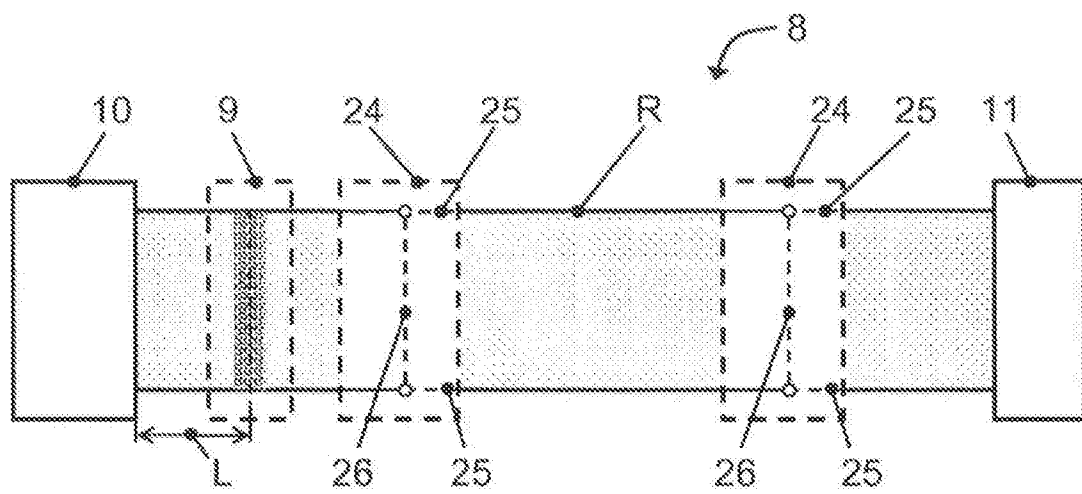


FIG. 4

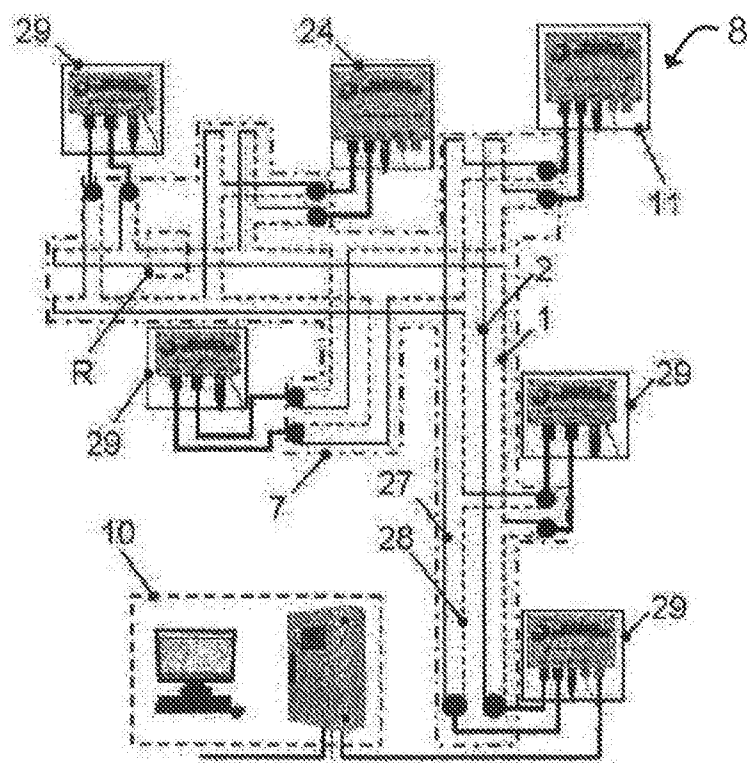


FIG. 6

Resistance values 1.5 mm ² Cu wire (as a function of the temperature)							
Temp. (°C)	Ohm/100m	Ohm/m	%	Temp. (°C)	Ohm/100m	Ohm/m	%
0	1.095	0.01095	91.0	50	1.333	0.01333	113.8
1	1.100	0.01100	91.4	51	1.338	0.01338	113.8
2	1.105	0.01105	91.8	52	1.343	0.01343	113.8
3	1.110	0.01110	92.2	53	1.348	0.01348	113.8
4	1.114	0.01114	92.6	54	1.353	0.01353	113.8
5	1.118	0.01118	93.0	55	1.357	0.01357	114.0
6	1.124	0.01124	93.4	56	1.362	0.01362	114.4
7	1.128	0.01128	93.8	57	1.367	0.01367	114.8
8	1.133	0.01133	94.2	58	1.371	0.01371	115.2
9	1.138	0.01138	94.6	59	1.376	0.01376	115.6
10	1.143	0.01143	95.0	60	1.381	0.01381	116.0
11	1.148	0.01148	95.4	61	1.386	0.01386	116.4
12	1.154	0.01154	95.8	62	1.390	0.01390	116.8
13	1.157	0.01157	96.2	63	1.395	0.01395	117.2
14	1.162	0.01162	96.6	64	1.400	0.01400	117.6
15	1.167	0.01167	97.0	65	1.405	0.01405	118.0
16	1.171	0.01171	97.4	66	1.410	0.01410	118.4
17	1.176	0.01176	97.8	67	1.414	0.01414	118.8
18	1.181	0.01181	98.2	68	1.419	0.01419	119.2
19	1.186	0.01186	98.6	69	1.424	0.01424	119.6
20	1.190	0.01190	99.0	70	1.428	0.01428	120.0
21	1.195	0.01195	99.4	71	1.433	0.01433	120.4
22	1.200	0.01200	99.8	72	1.438	0.01438	120.8
23	1.205	0.01205	100.2	73	1.443	0.01443	121.2
24	1.210	0.01210	100.6	74	1.448	0.01448	121.6
25	1.214	0.01214	101.0	75	1.452	0.01452	122.0
26	1.219	0.01219	101.4	76	1.457	0.01457	122.4
27	1.224	0.01224	101.8	77	1.462	0.01462	122.8
28	1.229	0.01229	102.2	78	1.467	0.01467	123.2
29	1.233	0.01233	102.6	79	1.471	0.01471	123.6
30	1.238	0.01238	103.0	80	1.476	0.01476	124.0
31	1.243	0.01243	103.4	81	1.481	0.01481	124.4
32	1.248	0.01248	103.8	82	1.486	0.01486	124.8
33	1.252	0.01252	104.2	83	1.490	0.01490	125.2
34	1.257	0.01257	104.6	84	1.495	0.01495	125.6
35	1.262	0.01262	105.0	85	1.500	0.01500	126.0
36	1.267	0.01267	105.4	86	1.505	0.01505	126.4
37	1.271	0.01271	105.8	87	1.510	0.01510	126.8
38	1.276	0.01276	106.2	88	1.514	0.01514	127.2
39	1.281	0.01281	106.6	89	1.519	0.01519	127.6
40	1.286	0.01286	107.0	90	1.524	0.01524	128.0
41	1.290	0.01290	107.4	91	1.529	0.01529	128.4
42	1.295	0.01295	107.8	92	1.533	0.01533	128.8
43	1.300	0.01300	108.2	93	1.538	0.01538	129.2
44	1.305	0.01305	108.6	94	1.543	0.01543	129.6
45	1.310	0.01310	109.0	95	1.548	0.01548	130.0
46	1.314	0.01314	109.4	96	1.553	0.01553	130.4
47	1.319	0.01319	109.8	97	1.557	0.01557	130.8
48	1.324	0.01324	110.2	98	1.562	0.01562	131.2
49	1.329	0.01329	110.6	99	1.567	0.01567	131.6
50	1.333	0.01333	111.0	100	1.571	0.01571	132.0

FIG. 5