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(54) **Temperature monitoring systems.**

(57) A temperature monitoring system, useful for example for detecting fires, comprises a cable (10) having at least two conductors (16, 18) separated by elongate temperature-sensitive means. The shunt impedance (or a component thereof, for example the resistance Rs) between the conductors (16, 18) is monitored to monitor the cable temperature. The impedance (or a component thereof, such as the resistance) between the ends of a series circuit comprising at least one of the conductors (18, 20) is also monitored. The latter impedance (or component) varies in accordance with the temperatures of the associated conductor or conductors (18, 20) and thus indicates the ambient temperature.

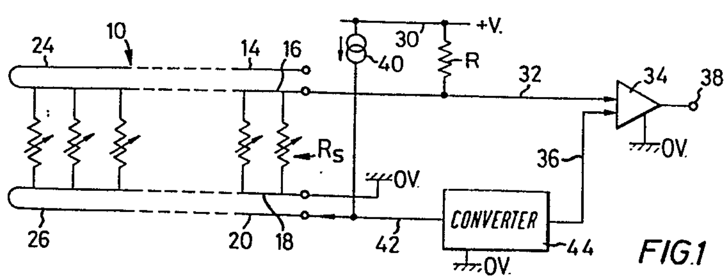

FIG.1

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TEMPERATURE MONITORING SYSTEMS

This invention relates to temperature monitoring systems.

A known type of temperature monitoring system, particularly (but not exclusively) useful for detecting fires, includes a cable arrangement comprising at least two conductors, two at least of the conductors being separated by elongate temperature-sensitive means, and detection means for monitoring the shunt impedance (or a component thereof) between the conductors separated by the temperature-sensitive means. Such systems may be of two types, depending upon whether the cable arrangement comprises what is known in the art as a "digital cable" or what is known in the art as an "analogue cable". In a digital cable, the temperature-sensitive means comprises an electrically insulative material that melts (liquifies or softens) in the event of a fire or other overheat situation to allow contact of the conductors, whereby the above-mentioned impedance is subjected to a large abrupt change from one value to another in response to the overheat. In an analogue cable, the temperature-sensitive means has an impedance that varies in an analogue manner with temperature whereby monitoring of the impedance can produce a signal that is representative of the temperature of the cable arrangement.

As is known to those skilled in the art, the ambient temperature of the cable arrangement generally has a significant effect on the operation of the system and it is thus often desirable reliably to monitor the ambient temperature, e.g. to provide a continuous indication of such temperature or to indicate to supervisory or operating personnel and/or equipment that the temperature has gone beyond a predetermined limit or limits. Reliable monitoring of the ambient temperature may be difficult, bearing in mind in particular that it may vary along the length of the cable arrangement.

According to the present invention there is provided a temperature monitoring system comprising:

a cable arrangement having at least two conductors, two at least of said conductors being separated by elongate temperature-sensitive means; and means for monitoring the shunt impedance (or a component thereof) between the conductors separated by the temperature-sensitive means;

the system being characterised by means for monitoring the impedance (or a component thereof) between the ends of a series circuit comprising at least one of the conductors of the cable arrangement, said impedance (or component) varying in accordance with the temperature of said at least one conductor and thus being indicative of the ambient temperature.

Thus, with a system in accordance with the invention, the ambient temperature can be monitored by using the cable arrangement itself as a sensor. The ambient temperature can thus be monitored reliably and accurately, in contrast for example to the case in which one or more point measurements are relied upon.

The second-mentioned means for monitoring is preferably operative to monitor - wholly or predominantly - the resistance between the ends of the series circuit. An advantage of this feature is that, since the resistance of the conductor material can be considered equivalent to the sum of a plurality of incremental resistors arranged in series, any ambient temperature variations are effectively integrated in real time, the total resistance being effectively representative of a mean or average ambient temperature value.

The second-mentioned monitoring means may be operative to monitor, at one end of the cable arrangement, the series resistance of a series circuit comprising two conductors connected together at the other end of the cable arrangement to form a looped conductor. Alternatively, the second-mentioned monitoring means may be operative to monitor the resistance of a series circuit comprising one conductor and an earth return.

In one embodiment of the invention described below, in which a digital cable arrangement is employed, the first-mentioned monitoring means is operative to indicate a fire or other overheat situation and the second-mentioned monitoring means is operative separately to indicate when the ambient temperature exceeds a value - e.g. a permitted maximum ambient - somewhat less than the value necessary to cause the first-mentioned monitoring means to indicate a fire or other overheat. In other embodiments described below, in which an analogue cable arrangement is emplyed, the detection and monitoring means use output signals that are employed interactively.

In known analogue systems, the means for monitoring the shunt impedance (or a component thereof) is generally operative to provide an output signal if the impedance of the temperature sensitive means achieves a threshold value indicative of the cable being at a predetermined temperature. The elongate temperature-sensitive means may for example comprise polyvinyl chloride (PVC) which has a negative temperature coefficient such that at room temperature it acts as an insulator and such that its impedance drops with increasing temperature in a known manner. The impedance between the conductors, for a given length of cable, will decrease as the temperature increases. Looking at the matter in another way, the impedance between the conductors, for a given temperature, will decrease as the length of the cable increases. Thus, the impedance of a short piece of cable at a given temperature is the same as that of a longer piece of cable at a lower temperature. This leads to the following problem. Suppose, for the sake of argument, that the system is designed to provide an output signal (hereinafter also referred to as 'an alarm') if the impedance is such that any one metre length of the cable is at 100^{0}C, for example due to the cable being heated by a fire. Obviously, a rise in the ambient temperature of the whole cable or a part thereof substantially longer than one metre to a value of less than 100^{0}C will also give rise to an alarm. As the length of the cable is increased, there will come a point when a rise in the ambient temperature to a value which might reasonably be expected to occur will cause a spurious alarm to be produced. Thus, a practical limit is imposed on the maximum length of cable that can be employed. The limit could in principle be increased by making the monitoring means respond to a lower threshold shunt impedance, e.g. to provide an alarm only if one metre of the cable is heated to an operating or trip temperature of greater than 100^{0}C. However, increasing the limit in this way is not acceptable since to do so to any substantial extent would mean that the temperature value to which a short length of the cable has to be heated to cause an alarm would be unacceptably high. Thus, in summary, there is a maximum limit on the length of the cable that can be employed in the known system if both spurious alarms due to ambient temperature rises and an unacceptably high operating or trip temperature for heating of a short length of the cable are to be avoided. In more concise terms, the maximum length of cable that can be employed is dictated by the differential between the required operating or trip temperature and the maximum ambient temperature. Thus, for example, in a particular application where a particular length of cable must be used, it might be necessary to split that length into several sub-lengths each provided with its own detection means and associated circuitry thereby increasing cost and complexity. Looking at matters in another way, in a conventional system a trade-off or compromise must be made between the maximum length of cable that can be employed and the differential between the maximum ambient temperature and the operating or trip temperature.

According to an embodiment of the present invention, the elongate temperature-sensitive means has an impedance that varies with temperature, and the system comprises:

means for generating a first signal representing said shunt impedance (or a component thereof) between the conductors separated by the temperature-sensitive means and thus varying with local or general variations in the temperature of the cable arrangement;

means for generating a second signal representing said impedance (or a component thereof) measured between the ends of said series circuit comprising at least one of the conductors of the cable arrangement;

means responsive to a predetermined relationship between the first signal and a reference value to provide an output signal indicating that the temperature of at least part of the cable arrangement has exceeded a predetermined value; and

compensation means responsive to the value of the second signal to alter said reference value in a sense at least partially to compensate for changes in the ambient temperature of the cable arrangement.

The at least partial compensation for ambient temperature changes provided by such a system relaxes the above-described constraint on the maximum cable length in that the differential between the ambient temperature and the operating or trip temperature is constrained and is in fact preferably held constant at least over a certain range of ambient temperatures. This advantage is achieved in essence by monitoring and suitably compensating for the ambient temperature by monitoring the impedance (or a component thereof) of the series circuit comprising the at least one conductor. As will be appreciated, with such an arrangement the ambient temperature is measured reliably and accurately, in marked contrast to what might be the case if, for example, an attempt was made to provide compensation for ambient temperature changes by means of one or more point measurements of ambient temperature.

The second signal is preferably wholly or predominantly representative of the resistance of the conductor or conductors concerned. An advantage of this feature - additional to that mentioned above - is that, since the resistance of the conductor material can be considered equivalent to the sum of a plurality of incremental resistors arranged in series, then while the overall resistance varies with a general ambient temperature change it varies little with a local change in resistance caused by local overheating (e.g. due to a fire) because a local change in resistance will cause little change in the overall resistance. In this connection, it will be appreciated that the second signal thus reacts in a totally different way to local heating than does the first signal, in that the first signal is representative of the shunt impedance (or a component thereof) between the conductors separated by the temperature-sensitive means and will thus vary markedly in response to local overheating since local overheating can be considered to change markedly the impedance of what can be considered to be one of a plurality of incremental impedors connected in parallel. That is to say, the second signal can be considered, at least approximately, to vary only with general heating of the cable arrangement due to ambient changes, taking little or no notice of local changes due to a localised fire or the like, whereby the second signal provided in such a case is very well suited to compensate for ambient temperature changes.

The above-mentioned compensation means may include means operative to vary the relationship between the second signal and the reference value in a sense complementary to that in which the first signal varies with temperature, assuming that both such signals do not vary with temperature in the same way. For instance, if the first signal varies antilogarithmically with temperature, then the compensation means may comprise a converter that provides a generally logarithmic transfer function between the second signal and the reference value.

It is conceivable that, in some instances, for example in the case of a fire building up slowly and not producing a very large amount of local heating of the cable, the ambient temperature of the cable arrangement could rise gradually to a dangerous value. In this case, in the absence of some feature to recognise and respond appropriately to these circumstances, the temperature monitoring system could conceivably not respond at all to the fire but instead treat the slowly rising temperature as a slowly rising permissible ambient temperature and do nothing to provide an output signal. (In this connection, it should be appreciated that preferred systems described below are in essence operative to provide the desired ambient compensation by preserving a fixed differential between the ambient temperature and the temperature at which an alarm is generated.) In a preferred embodiment of the invention described below, this possibility is avoided by imposing a limit on the extent to which the reference value can be varied. That is to say, compensation for changes in ambient temperature is stopped - i.e. the differential is allowed to decrease - once the ambient temperature exceeds a predetermined value.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which like reference numerals designate like items throughout, and in which;

Figure 1 is a circuit diagram - partially in block diagram form - of a first temperature monitoring system embodying the invention, the system using an analogue cable;

Figure 2 is a cross-section through wires of a cable forming part of the system of Figure 1;

Figure 3 is a graph showing the approximate relationship of the resistance (R_S) with temperature (T) of an insulating material of the wires of Figure 2;

Figure 4 is a circuit diagram - partially in block diagram form - of a modified temperature monitoring system embodying the present invention, also using an analogue cable; and

Figure 5 is a circuit diagram - partially in block diagram form - of another temperature monitoring system embodying the invention, this system using a digital cable.

The temperature monitoring system shown in Figure 1 includes an "analogue" temperature monitoring cable 10 comprising four wires 12 that are twisted together and, preferably, enclosed within a sheath (not shown). (The cable 10 could however be of coaxial construction). The cable 10 is disposed in proximity to an object or an area whose temperature is to be monitored, e.g. above a conveyor belt or on a ceiling, in particular to detect a fire.

The wires 12 comprise respective conductors 14, 16, 18 and 20 having respective sheaths 22. The sheaths 22 are of a material of which the impedance (or a component thereof) has a temperature coefficient, for example a negative temperature coefficient. The material can be silicone rubber or a form of rubber known in the art as "EP rubber". Preferably, however, the material is polyvinyl chloride (PVC), which may or may not be doped with a material that enhances its conductivity. As is known to those skilled in the art, the resistance of PVC, whether doped or undoped, drops from a very high value at room temperature, in a substantially logarithmic value, as its temperature increases.

The wires 12 having the conductors 14,16 are joined at one end of the cable 10 (the left hand end as shown in Figure 1) - or comprise a single wire folded back on itself - thereby to form a single looped conductor 24 whose ends are accessible at the other end of the cable 10. Similarly, the wires 12 having the conductors 18,20 are joined - or integral - at the left hand end of the cable 10 as shown in Figure 1 to form another looped conductor 26. The looped conductors 24, 26 are useful for a number of reasons, especially in that they enable the continuity of the wiring to be checked by checking that the loops are not broken. However, at least one of the loops is used for a further purpose, the nature of which will be explained below.

The wires 12 are shown in Figure 2 as being so arranged that the conductors forming each of the looped conductors 24, 26 are diagonally opposite each other. They could instead be arranged with such conductors adjacent each other.

As will be appreciated from an inspection of Figures 1 and 2, the looped conductors 24 and 26 are separated by the temperature-sensitive material constituting the sheaths 22. For convenience of representation, the distributed shunt impedance of the sheaths 22 between the conductors 24 and 26 is shown in Figure 1 as comprising a plurality of discrete resistors connected in parallel, the total resistance thereof as viewed at the ends of the cable being R_s. As will be appreciated, Figure 1 should, strictly speaking, show further discrete resistors connected between the conductors 14 and 18 and the conductors 16 and 20. However, for convenience, these are omitted.

A resistor R is connected between a +V rail 30 and the looped conductor 24. An 0V rail is connected to the conductor 26. Thus, the resistor R and the resistance R_s are connected in series across a d.c. voltage source +V whereby the voltage on a line 32 connected to the junction of the resistor R and the resistance R_s constitutes a signal representing the value of the shunt resistance R_s. This voltage is applied to one input of a comparator 34. A reference value or signal is applied on a line 36 to another input of the comparator 34 and the comparator 34 is operative to produce an output signal on an output terminal 38 when the resistance R_s drops to a value indicating that the temperature of the cable 10 has exceeded a predetermined trip or threshold value. Note that, because the resistance R_s can be considered as being constituted by a multiplicity of incremental resistance elements connected in parallel, the resistance R_s could drop to the value causing the generation of an output signal either by general heating of the whole cable 10 or by more intense localised heating of a part of the cable 10.

A current source 40 is connected as shown to the looped conductor 26 and to the +V rail 30 and OV rail such that a predetermined d.c. current is sent through the looped conductor 26. (The current source 40 could be a constant current source, but preferably comprises simply a resistor whose resistance is high with respect to that of the looped conductor 26 whereby the predetermined d.c.current is substantially unaffected by changes in the resistance of the conductor 26). The looped conductor 26 is of a material whose resistance changes in known manner with temperature. The material may for example be copper, whose resistance changes by approximately 0.4% per deg C and in fact increases by a factor of only about two between normal ambient temperature and its melting point. Consequently, it will be appreciated that the voltage (with respect to the OV rail) on a line 42 will be representative of the resistance of the looped conductor 26. That is to say, such voltage will vary with changes in the ambient temperature of the cable 10. Note, however, that since the resistance of the loop 26 can be considered to be the series combination of a multiplicity of incremental resistance elements, the overall resistance of the looped conductor 26 will be subjected only to a small change if the cable 10 is subject to intense local heating as a result of a localised fire.

The resistance/temperature characteristic of a typical sheath material 22, that is to say the value of the resistance R_s, is represented in Figure 3. As will be seen, below a value typically equal to about 60°C, on a logarithmic scale, the relationship between R_s and temperature is approximately linear, there being typically a 17 deg C change in temperature per decade of resistance or, in other words, a doubling or halving of resistance for a change in temperature typically of about 5 deg C. It will be appreciated that the magnitude of the signal on the line 32 representing the parameter R_s will vary in similar manner, though not in exactly the same manner because R_s forms a potential divider chain with the resistor R. The signal on the line 42, which represents the series resistance of the looped conductor, is processed by a converter or amplifier 44 which has a logarithmic characteristic or transfer function such as to produce from the signal on the line 42 a modified (reference) signal on the line 36 which varies with temperature in similar manner to that on the line 32. Thus, the signal on the line 36 provides a degree of ambient temperature compensation for the signal on the line 32, in that both signals vary in a similar manner with changes in the ambient temperature of the cable 10, but does not preclude the generation of an output signal on the terminal 38 in the event of a fire situation in that the reference signal on the line 36, unlike that on the line 32, does not respond substantially to localised heating, for the reasons explained above.

If, in the above-described arrangement, the voltage +V is continually applied to the resistance R_s and the constant current is sent continuously through the looped conductor 26, there is a possibility that the output signals on the lines 32 and 42 might mutually interfere. This could be avoided by energising these different parts of the cable 10 at different times. If this is done, sample and hold units may be incorporated in the converter 44 and in the line 32 to sample the lines 42 and 32 at the appropriate times.

In the above-described arrangement, <u>d.c.</u> energisation of both the resistance R_s and the conductor 26 is employed. However, it is within the scope of the invention to instead use <u>a.c.</u> energisation. Further, a form of pulse energisation described below may also be used.

With the circuit as described above, a fixed differential (e.g. say 5 deg C) is maintained, as the ambient temperature varies, between the ambient temperature and the temperature at which an alarm will be generated. There is therefore some risk that a gradual rise in temperature of the cable 10 to a dangerous value, e.g. in the event of an adjacent but not contiguous fire, could be ignored if it is sufficiently gradual. This can be avoided by limiting the extent to which the reference value on the line 36 (representing ambient temperature) can be altered. In other words, the converter 44 can be arranged so that it does not continue to alter the reference value if the signal on the line 42 goes beyond a value equivalent to a limit temperature value of, say, 32 deg C greater than a predetermined temperature value equal, for example, to a normal ambient temperature value. Looking at the matter another way, the converter 44 causes the system to cease to preserve the fixed differential between the ambient temperature and alarm temperature - i.e. to stop the alarm temperature tracking the ambient temperature - once the ambient temperature exceeds said limit temperature value.

The converter 44 may in fact be designed so that it does not provide a continuously varying output but instead provides an output which can adopt only one of (say) eight discrete values each corresponding to the signal on the line 42 indicating a respective step in temperature of (say) 4 deg C above said predetermined temperature value (e.g. normal ambient temperature value). Such a feature can readily be accomplished, essentially by sensing the magnitude of the input signal on the line 42 and allocating one of eight particular values to the reference signal on the line 36, the reference values being related in logarithmic manner to the input threshold values whereby the desired logarithmic transfer function of the converter 44 is obtained.

A modified temperature monitoring system embodying the invention will now be described with reference to Figure 4. The system of Figure 4 is closely based upon that of Figure 1 and will only be described in so far as it differs therefrom. The system of Figure 4 incudes a feature, more fully described in our co-pending UK Patent Application No. 8205338 and in our co-pending European patent application of even date herewith, which avoids certain disadvantages that may be incurred if the resistance R_S is energised with direct current. In the system of Figure 4, an electronic switch arrangement 50 is provided. The switch arrangement 50, schematically represented for simplicity of comprehension as a pair of change-over switches, is operative so that the current sent through the resistance R_s is periodically reversed at a frequency corresponding to the frequency of switching thereby to reduce the net d.c.current, preferably to zero. In theory, operation of the switching arrangement 50 would have no affect on the signal on the line 32. In practice, however, bearing in mind that the cable 10 has considerable capacitance, there is in fact a spike on the signal on the line 32 each time the current is reversed due to the capacitance of the cable being charged. The resultant waveform on the line 32 is as shown in Figure 4. To ensure that the signal reliably represents the value of the resistance R_s, the switching frequency of the switching arrangement 50, which is determined by control logic 52 driven by a clock 54, is chosen to be sufficiently slow that the cable capacitance charges in good time for the signal on the line 32 to reach a steady state value before the next current reversal. The necessary frequency will of course vary with different materials and different applications, though a typical frequency will be about 1/6 or 1/7 Hz, that is to say the period of the waveform will about 6 or 7 seconds in such a typical application. A sample and hold unit 56, the operation of which is synchronised by the control logic 52, is provided in the line 32 to sample the waveform during each 'plateau' portion, i.e. after the end of each spike.

The control logic 52 also controls and synchronises a gate 58 such that current is sent through the looped conductor 26 towards the end of each plateau of the waveform on the line 32, i.e. shortly before the next spike. The converter 44 will include a sample and hold unit or the like to sample the resultant voltage on the line 42 at the appropriate times, but may otherwise be of the same construction decribed above. The circuit of Figure 4 in fact operates in much the same manner as that of Figure 1, as regards the feature of temperature compensation, the only substantial difference being that, as mentioned above, the resistance R_s is periodically energised by d.c. of opposite polarity whereby problems associated with continuous energisation with the same polarity can be avoided or at least reduced. Such reduction can be maximised (i.e. the problems can be minimised) if the net d.c. current through the resistance R_s is reduced to zero, e.g. if the applied d.c. voltage and its duration are identical in the two portions of the switch arrangement 50. The voltages are kept identical by using the common voltage source +V and ensuring that the switches making up the arrangement 50 have negligible "on" resistance. The durations are kept identical by suitable design of the control logic 52. To this end, the control logic 52 may comprise an edge-triggered counter/divider driven by the clock 54 to produce an output switching waveform whose two halves are of exactly equal time span.

The invention can of course be embodied in various different ways than those described above by way of example. As mentioned above, a.c. energisation can in principle be used instead of d.c. energisation. In this case, instead of measuring R_s, the parameter measured might be the impedance of the sheaths 22. Over a large range of frequencies the impedance would in fact be largely or predominately resistive, in particular if the PVC is doped with a conductivity-enhancing material. However, the capacitive component may have some affect at high frequencies, in particular if undoped PVC is used.

Another temperature monitoring system embodying the invention is shown in Figure 5. The system of Figure 5 resembles that of Figure 1 to some extent and will therefore be described only in so far as it differs therefrom. The system of Figure 5 includes a cable 10' which, for convenience, is illustrated as having a like configuration to the cable 10, though it should be appreciated that - as explained below - other forms of cable can readily be employed. The cable 10' differs from the cable 10 in that it is a digital rather than an analogue cable. More specifically, the material of the wire sheaths 22, represented by the resistance R_s, does not necessarily have a temperature coefficient of resistance, since in this embodiment the arrangement is such that, in the event of a fire or the like, the material melts (liquefies or softens) to allow contact of the at least one of the conductors 14, 16 with at least one of the conductors 18, 20, the resultant short circuit resulting in R_s dropping from a very high to a low value.

Means is provided to provide an alarm output signal on the output terminal 38 when the resistance R_s drops to a low value as a result of a fire or the like. For example, as shown, the resistance R_s and the resistor R are connected in series as a potential divider across the +V d.c. supply and their junction is connected to an input of a trigger circuit 60, the circuit 60 being operative to provide an alarm output signal when it detects that the voltage on the line 32 has dropped from a relatively high level to a relatively low level as a result of the resistance R_s having done likewise.

In the embodiment of Figure 5, as in the embodiment of Figure 1, the signal on the line 42 is representative (in an analogue sense) of the resistance of the looped conductor 26 and therefore of the ambient temperature of the cable 10'. Such signal is applied to an input of a trigger circuit 62 set to switch and provide a warning output signal on an output terminal 64 if the ambient temperature exceeds a predetermined value, e.g. maximum permitted value.

In all of the foregoing embodiments it is contemplated that the parameter of the loop 26 that is monitored may not be its resistance. It is contemplated that a cable might be provided in which the inductance of the loop 26 might vary with temperature, in which case the inductance could be monitored and used to provide an indication of the ambient temperature.

As should be evident to those skilled in the art from a perusal of the foregoing, various different forms of cable than those specifically described above could be used within the scope of the invention. For example, though the cables 10, 10' happen to have two looped conductors 24, 26, it should readily be apparent that for present purposes the looped conductor 24 is not needed. Furthermore, the looped conductor 26 does not, as is the case in the cables 10 and 10', have to be common with one of those conductors between which the resistance R_s is monitored. The looped conductor 26 could in fact be wholly separate and need not even be sheathed by temperature-sensitive material. It is in fact possible for the conductors associated with the resistance R_s and those forming the loop to be separate cables laid together or least reasonably close to one another to form a common cable arrangement.

It is not in fact essential in any of the above embodiments to use a looped conductor. It is instead feasible to feed the current from the source 40 into a single, non-looped conductor having a good earth connection at its end remote from the source 40, whereby the voltage of the conductor with respect to earth could be measured to determine its resistance. (If the remote earth potential were different to that at the monitoring system, the difference could be trimmed out). In this case, it is the resistance between two ends of a non-looped conductor (rather than between the two ends of a looped conductor formed by a series circuit of two conductors) that is monitored. In general, one can monitor the impedance (or a component thereof) between the ends of a series circuit comprising at least one of the conductors. The invention can in fact be carried into effect with a cable having only two conductors.

It is within the scope of the invention to connect a device having a different characteristic for positive and negative polarities (e.g. a diode) between that end of the conductors separated by the temperature-sensitive means that is remote from the detecting means. This can enable different properties of the cable arrangement to be measured by reversing the polarity of energisation. For example, if the device is a diode then the shunt-impedance detection means in effect monitors the shunt impedance (or a component thereof) between the two conductors when the polarity is such that the diode does not conduct. With the opposite polarity, the diode is forward-biased whereby the diode effectively short-circuits the remote ends of the conductors together and enables their continuity to be checked by measuring the resistance presented to the detection means. If the conductors monitored by the shunt-impedance detection means and the series-circuit impedance monitoring means are common, e.g. if there are only two conductors, the continuity check can be carried out by the monitoring means monitoring the impedance (e.g. resistance) of the two conductors. That is to say, the impedance of the temperature-sensitive means is monitored when the energisation is of one polarity (e.g. during half-cycles of an alternating supply of one polarity) and the conductor continuity and the series circuit impedance representing ambient temperature are monitored when the energisation is of the other polarity (e.g. during half-cycles of the opposite polarity).

CLAIMS

1. A temperature monitoring system comprising:

a cable arrangement having at least two conductors, two at least of said conductors (16, 18) being separated by elongate temperature-sensitive means; and

means for monitoring the shunt impedance (or a component (Rs) thereof) between the conductors (16, 18) separated by the temperature-sensitive means;

the system being characterised by means for monitoring the impedance (or a component thereof) between the ends of a series circuit comprising at least one of the conductors (18, 20) of the cable arrangement, said impedance (or component) varying in accordance with the temperature of said at least one conductor (18, 20) and thus being indicative of the ambient temperature.

2. A system according to claim 1, wherein the second-mentioned means for monitoring is operative to monitor - wholly or predominantly - the resistance between the ends of the series circuit.

3. A system according to claim 1 or claim 2, wherein the first-mentioned means for monitoring (+V, R, 60) is operative to indicate a fire or other overheat situation and the second-mentioned means for monitoring (40, 62) is operative separately to indicate when the ambient temperature exceeds a value less than a value necessary to cause the first-mentioned means for monitoring (+V, R, 60) to indicate a fire or other overheat.

4. A system according to claim 1, wherein the elongate temperature-sensitive means has an impedance that varies with temperature, the system comprising:

means (+V, R) for generating a first signal representing said shunt impedance (or a component thereof) between the conductors (16, 18) separated by the temperature-sensitive means and thus varying with local or general variations in the temperature of the cable arrangement;

means (40) for generating a second signal representing said impedance (or a component thereof) measured between the ends of said series circuit comprising at least one of the conductors (18, 20) of the cable arrangement;

means (34) responsive to a predetermined relationship between the first signal and a reference value to provide an output signal indicating that the temperature of at least part of the cable arrangement has exceeded a predetermined value; and

compensation means (44) responsive to the value of the second signal to alter said reference value in a sense at least partially to compensate for changes in the ambient temperature of the cable arrangement.

5. A system according to claim 4, wherein the second signal is wholly or predominantly representative of the resistance of the series circuit.

6. A system according to claim 4 or claim 5, wherein the compensation means (44) is operative to vary the relationship between the second signal and the reference value in a sense complementary to that in which the first signal varies with temperature.

7. A system according to claim 6, wherein the first signal varies substantially antilogarithmically with the temperature and the compensation means (44) provides a generally logarithmic transfer function between the second signal and the reference value.

8. A system according to any one of claims 4 to 7, wherein the compensation means (44) is operative not to alter the reference value if the second signal exceeds a predetermined limit value.

9. A system according to any one of claims 4 to 8, wherein the compensation means is operative to alter the reference value between a plurality of predetermined discrete values in response to variation in the value of the second signal.

10. A system according to any one of claims 4 to 9, wherein
the means for generating the first signal comprises

energisation means (+V, R) operative to send d.c. current through a circuit network including the temperature sensitive means, thereby to generate the first signal in the form of a d.c. signal representative of the resistance (Rs) of the temperature-sensitive means, and

switch means (50) operative periodically to reverse the connection of the temperature-sensitive means into the circuit network and therefore to reverse the direction of current flow through the temperature-sensitive means, the frequency of operation of the switch means being sufficiently low that, after a change in the first signal that will take place upon each said reversal due to reactance of the temperature-sensitive means, the first signal will revert substantially to a steady value before the next reversal,

and wherein the means (34) providing said output signal is responsive to said predetermined relationship between said steady value of the first signal and the reference value.

11. A system according to any one of the preceding claims, wherein said series circuit comprises a pair of conductors (18, 20) that are connected together or integral with one another at one end of the cable arrangement and are connected to the compensation means (44) at the other end of the cable arrangement.

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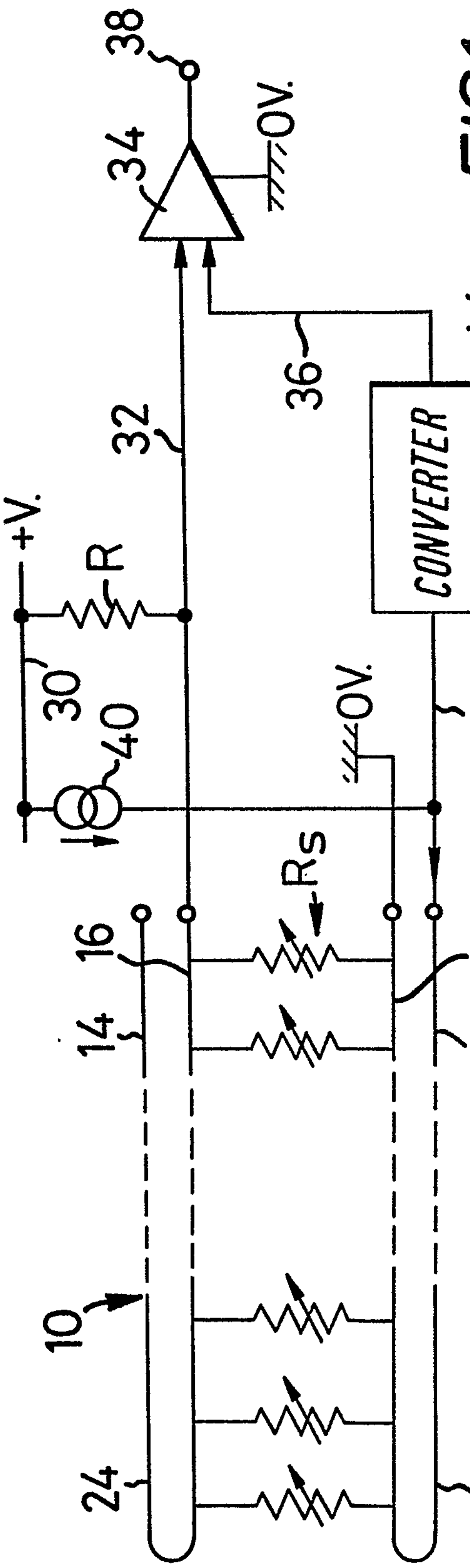

FIG.1

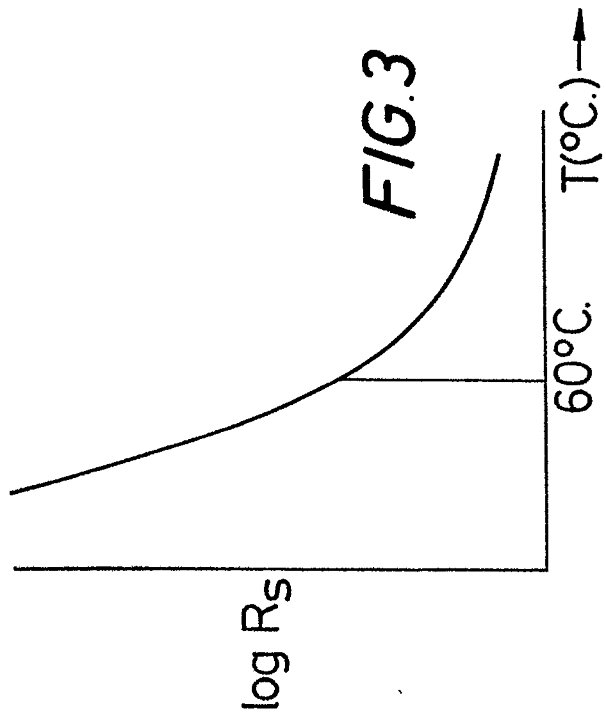

FIG.3

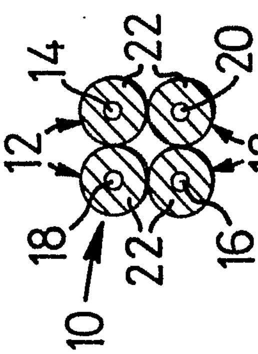

FIG.2

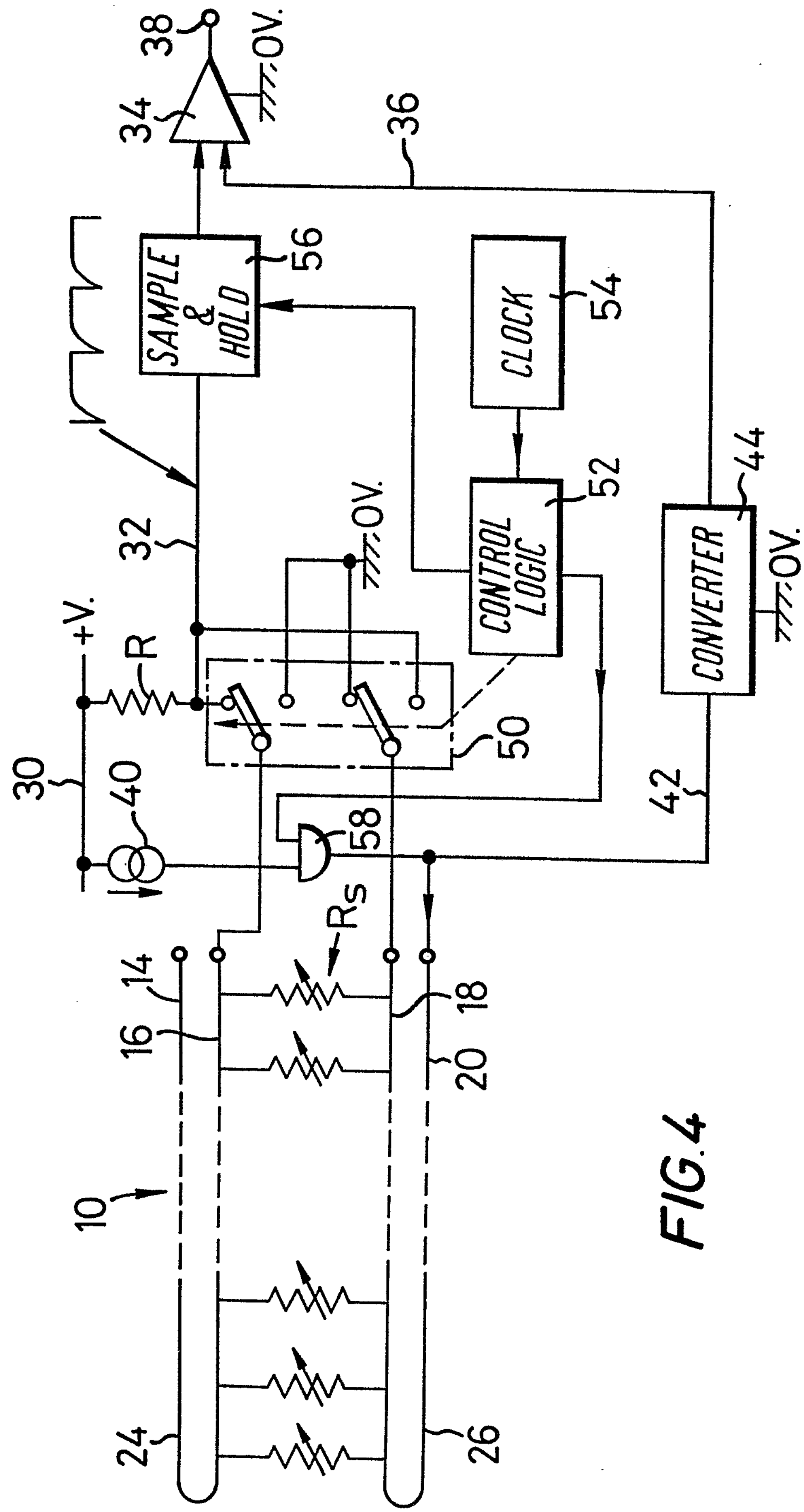
38
0V.
34
36
56
SAMPLE & HOLD
CLOCK
54
52
CONTROL LOGIC
44
CONVERTER
0V.
32
0V.
+V.
R
50
30
40
I
58
42
Rs
14
16
18
20
10
24
26

FIG.4

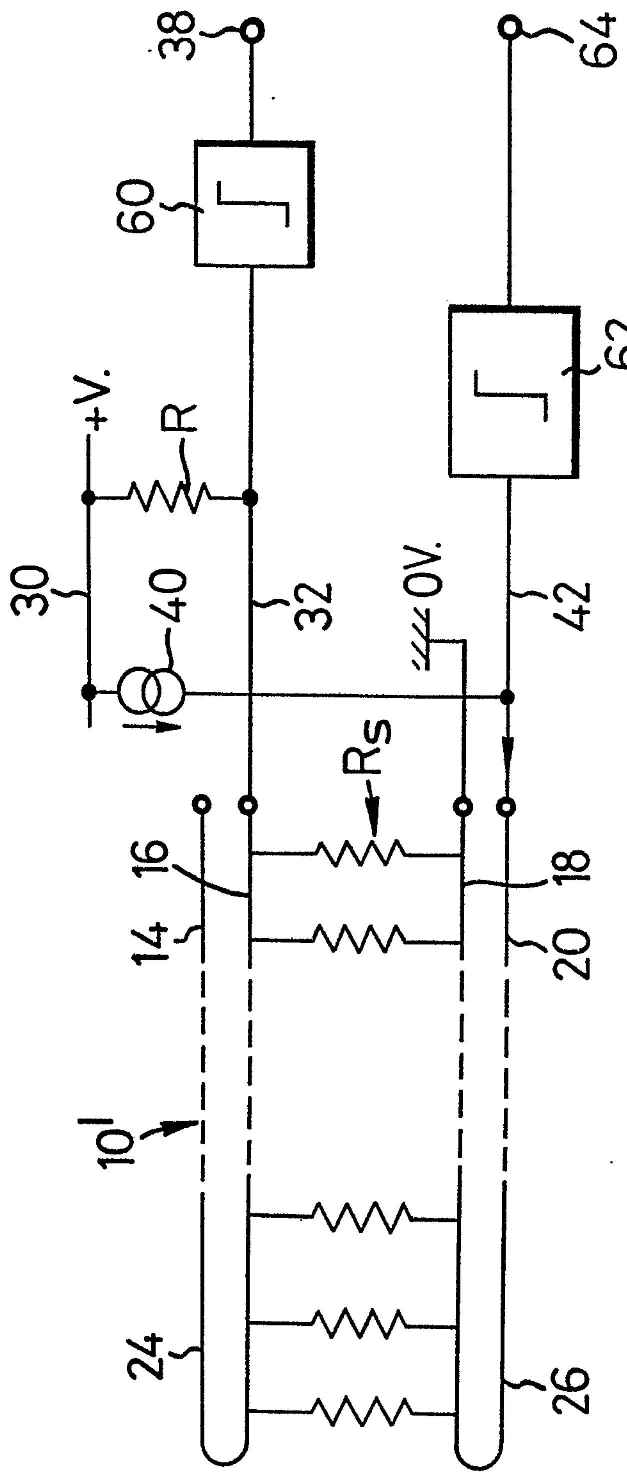

FIG.5