

Aug. 7, 1956

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2,758,294

HEAT RESPONSIVE CONDUCTIVE CABLE

Filed Jan. 25, 1954

3 Sheets-Sheet 1

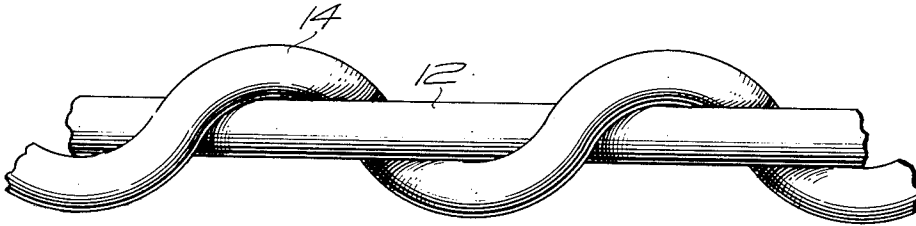


FIG. 1

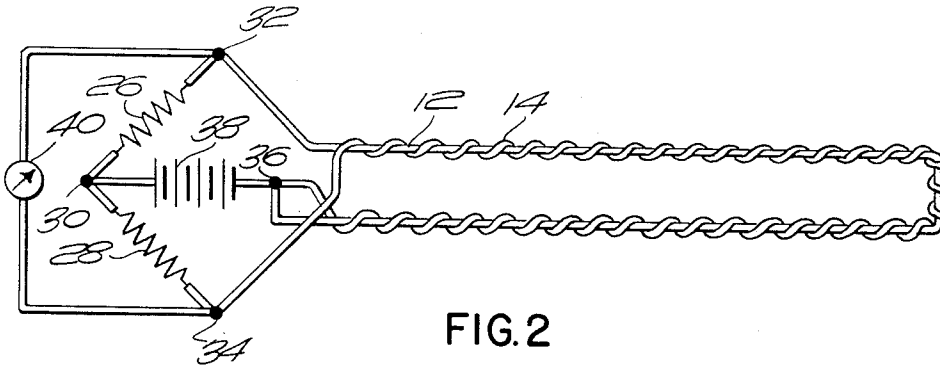


FIG. 2

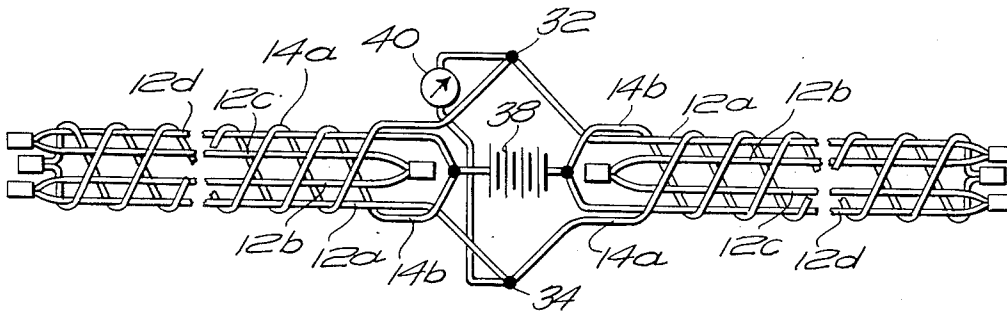


FIG. 8

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3 Sheets-Sheet 2

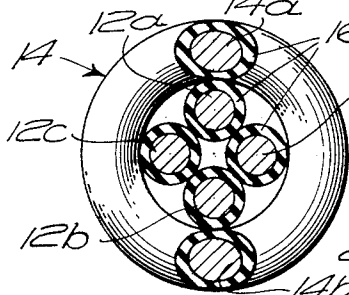
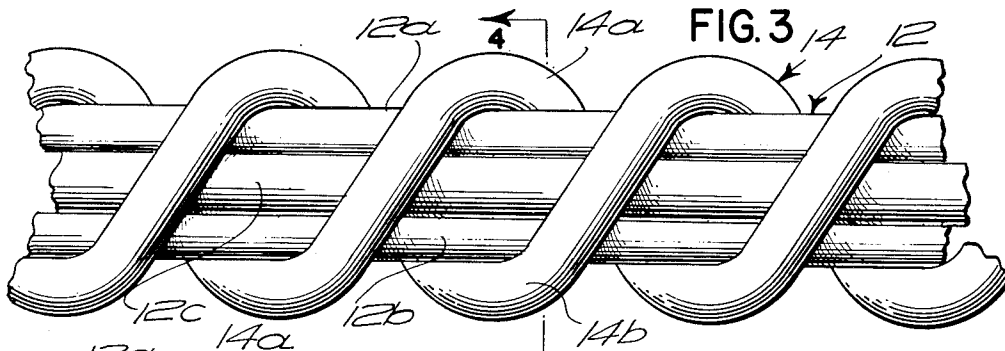


FIG. 4

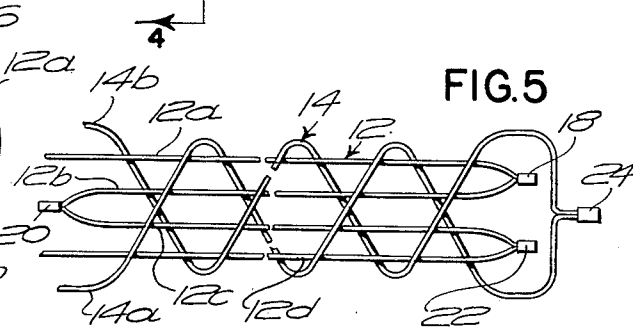


FIG. 5

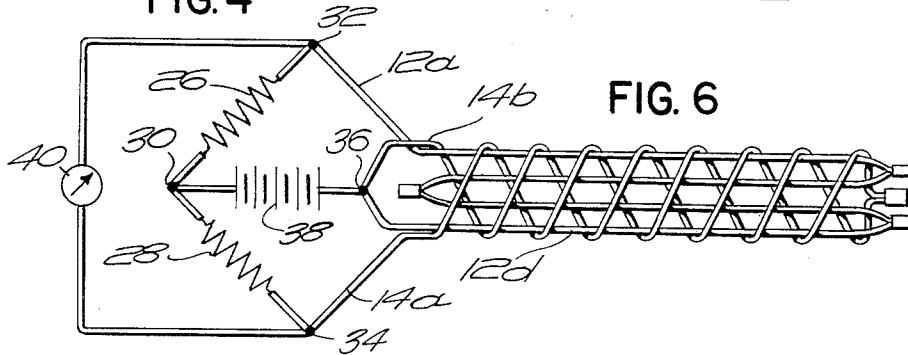


FIG. 6

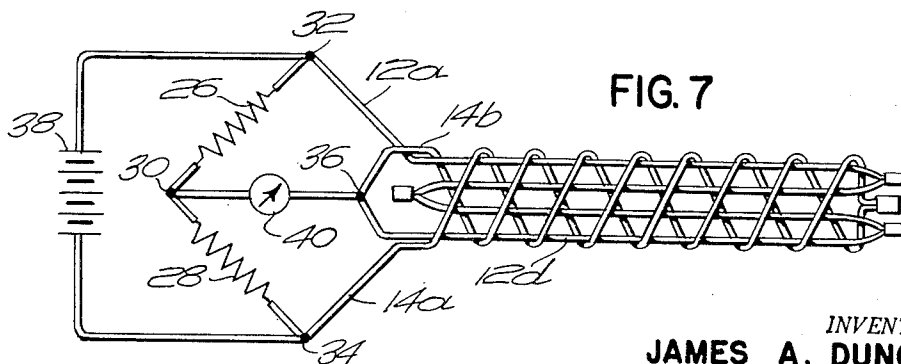


FIG. 7

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3 Sheets-Sheet 3

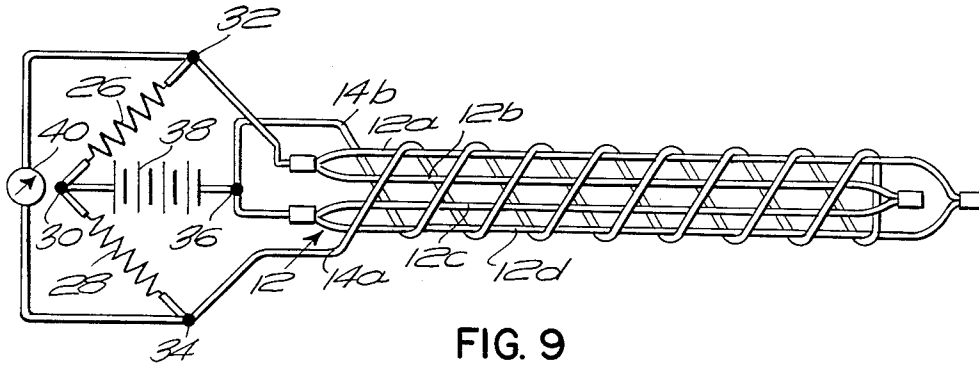


FIG. 9

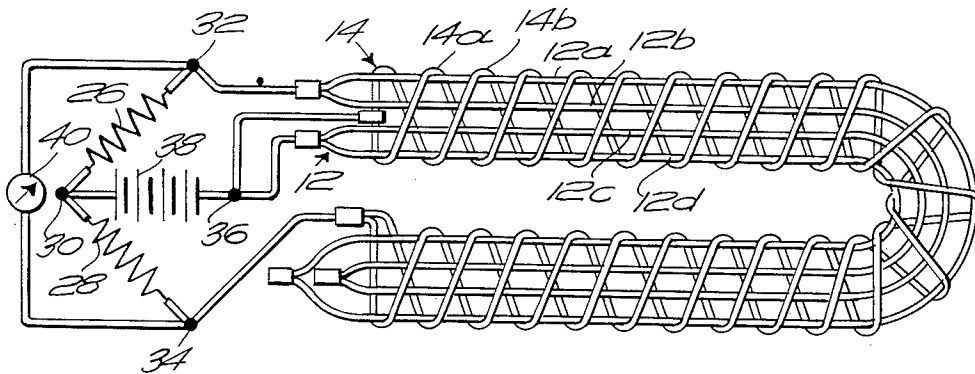


FIG. 10

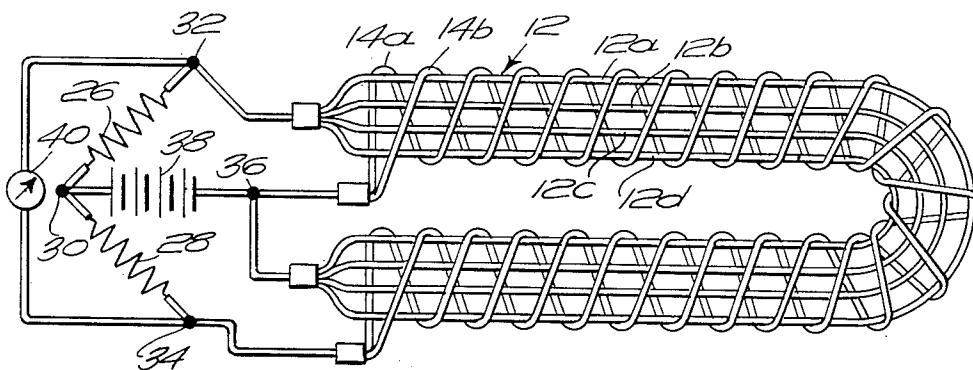


FIG. 11

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2,758,294

HEAT RESPONSIVE CONDUCTIVE CABLE

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Application January 25, 1954, Serial No. 405,837

17 Claims. (Cl. 340—233)

This invention relates to improvements in cables. More especially it has to do with cables particularly suitable for use in an electrical rate-of-rise fire protective system which responds to heat from a fire and actuates an alarm or sets in operation fire extinguishing agencies.

One of the desirable features of a rate-of-rise fire protective system is that it is unaffected by slow variations of the ambient temperature of the air in the enclosure in which it is installed and responds only to rates of increase in that ambient temperature which exceed a predetermined rate. This feature is desirable because it has been found that while space heating equipment and industrial equipment and even sunlight can achieve very high temperatures within the enclosure, they usually cannot effect a rate of temperature increase which approaches that produced by a fire.

The rapid increase in air temperature typically produced by a fire can be utilized in rate-of-rise systems by exposing to it two electrical, current-carrying conductors which are distributed in the enclosure and are so designed that their temperatures, and hence their resistances, are increased at different rates by the increase in air temperature. A circuit which includes these conductors, together with other elements, and which is in electrical balance when the air temperature is not changing, can be arranged so that this difference in the rates of resistance change in the two conductors results in the flow of an unbalance current in certain of these other elements to actuate an alarm device. Rates of temperature increase which are produced by the normal operation of such equipment or by sunlight will also cause the flow of unbalance currents, but when the circuit is properly adjusted these are not large enough to give an alarm.

Heretofore the conductors have been installed in the enclosure to be protected in spaced relationship or simply twisted together so that both were equally exposed to a rising temperature and attained unbalance by having diverse thermal properties by reason of dissimilar materials, sizes or degrees of insulation. My invention resides in the assembly of the conductors into a cable in which they are so disposed that one thermally shields the other and the shielded one shields itself, to an extent needed to produce the sensitivity desired.

The conductors forming the cable may conveniently be identical in size, material and insulation. My invention, however, is not limited to this advantage but has others as will be pointed out later.

When the circuit of a rate-of-rise system is adjusted so that the rates of air temperature increase which will give alarms are relatively low and approach those rates produced by the operation of space heating equipment or sunlight, the system is said to be very sensitive. In other words if a fire should start a signal would be given while the fire was still very small. Sensitivity, as thus defined, is very desirable, but there is a limit to the degree of sensitivity which can be successfully employed. Thus, while it is important that the circuit be sufficiently

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unbalanced to produce an alarm when the rate of air temperature increase indicates the occurrence of a small fire, it is equally important that the circuit balance be restored quickly after the termination of air temperature increases which are not caused by a fire and accordingly do not produce signals individually. If such restoration is not made quickly it might be found that a series of air temperature increases will build up a circuit signal condition even though any one of these increases is insufficient for that purpose. A rate-of-rise system is said to lack stability when circuit balance is not quickly restored.

I have discovered that when the different rates of temperature and resistance change in the two distributed conductors are at least partially achieved by so forming these conductors into a cable that they are close together and one shields the other from changes in air temperature, system stability for any given degree of sensitivity is unusually good.

I have further discovered that stability for any given degree of sensitivity is improved by compactly associating the distributed conductors so that heat can be readily exchanged between them.

I have also discovered that system stability for any given degree of sensitivity is still further improved when, in addition to having one conductor shield the other in a cable comprising both, the shielded conductor is arranged so that it partially shields itself from air temperature changes and thereby contributes to the achievement of the different rates of temperature and resistance change in the conductors.

I have also discovered that system stability for any given degree of sensitivity is even further improved when the distributed conductors comprising a cable have the same thermal capacity, and the entire difference in rates of temperature and resistance change therein is achieved in each instance by the shielding of one conductor by the other or by the other and by itself.

In addition to having good stability, it is desirable that rate-of-rise systems employ distributed conductors which are as free as possible from variations throughout their lengths. Such variations can be troublesome because they may either exaggerate the difference in the rates of conductor temperature and resistance change and cause a signal to be given when the air temperature increase is not caused by a fire, or they may detract from such difference and delay the giving of a signal when the air temperature increase is caused by a fire.

I have discovered that when the entire difference in rates of conductor temperature and resistance change is achieved in each instance by the shielding of one conductor by the other or by the other and by itself, the conductors may be formed of identical wires with the result that variations throughout the conductor lengths are kept at a minimum.

I have further discovered that the undesirable effects of those conductor variations which do exist are minimized when the conductors are so arranged in a cable that they are doubled back therein one or more times, and if each such conductor is doubled back an odd number of times this arrangement has the additional advantage that currents induced in the conductor by external magnetic fields cancel out and cannot unbalance the system.

In rate-of-rise systems of the kind under consideration it is desirable to employ for the distributed conductors wires which have low thermal capacities, because the temperatures and resistances of such wires are quickly changed by air temperature increases, and a signal which should be given is given at the earliest moment. In general wires of small size have low thermal capacities and therefore I prefer to employ them for the distributed

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conductors. Such wires, however, will not individually withstand rough treatment by installers.

I have discovered that when the small size conductor wires are formed into a cable these wires are not easily broken or otherwise damaged with rough treatment.

I have further discovered that when a cable is provided in which the conductors are doubled back one or more times the various strands of each conductor may be connected together at the ends of the cable to cause some or all of these strands to be in parallel with each other. This is advantageous because the resistance of the cable as a whole may be varied by such selective connections to suit particular cable length requirements without having to alter the cable construction but merely by changing the cable end connections.

Having made the above-noted discoveries with respect to the distributed conductors of rate-of-rise systems, one object of my invention is to achieve the different rates of temperature and resistance change in these two conductors by so forming them into a cable that they are close together and one shields the other from changes in the temperature of the fluid surrounding the cable.

Another object of my invention is to achieve the different rates of temperature and resistance change in these two conductors by so forming them into a cable in which each conductor constitutes a branch in an electric circuit that one of the branches is substantially interposed between the fluid and the other branch and is therefore more freely exposed to convection currents in the fluid surrounding the cable than said other branch.

Another object of the invention is to provide a rate-of-rise cable comprising the distributed conductors in which these conductors are compactly associated with each other so as to permit the ready exchange of heat therebetween.

Another object of the invention is to provide a rate-of-rise cable comprising the distributed conductors in which one conductor will be disposed so as to partially shield itself from changes in air temperature.

Another object of the invention is to provide a rate-of-rise cable comprising the distributed conductors in which these conductors have substantially the same thermal capacity.

Another object of the invention is to provide a rate-of-rise cable comprising the distributed conductors in which these conductors are formed of identical wires.

Another object of the invention is to provide a rate-of-rise cable comprising the distributed conductors in which these conductors are doubled back one or more times.

Another object of the invention is to provide a rate-of-rise cable in which the distributed conductors are doubled back one or more times to provide a plurality of strands of each conductor in any given section of the cable and in which some or all of these strands in the same conductor are connected at the ends of the cable so as to be in series with each other.

Another object of the invention is to provide a rate-of-rise cable in which there is a plurality of strands of each conductor in any given section of the cable and in which some or all of these strands in the same conductor are connected at the ends of the cable so as to be in parallel with each other.

Another object of the invention is to provide a rate-of-rise cable of the type described in which the strands of a conductor therein are connected at the ends of the cable so as to be in series-parallel combinations.

Still another object of the invention is to provide a rate-of-rise cable comprising the distributed conductors in which each conductor is doubled back an odd number of times.

And still another object of the invention is to provide a rate-of-rise cable comprising the distributed conductors which is easily and quickly installed and will withstand rough treatment without being injured.

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Another object of the present invention is to provide a rate-of-rise cable comprising the distributed conductors wherein all of the conductors are insulated so as to prevent corrosion and resulting change in resistance which might lead to false alarms.

The best mode in which it has been contemplated to apply the principles of my improvements is shown in the accompanying drawings but these are to be deemed primarily illustrative because it is intended that the patent shall cover by suitable expression in the appended claims whatever features of patentable novelty exist in the invention disclosed. For example, while specific reference is made to use of this invention in fire protective systems wherein temperature increases are involved, it is obvious that the cable can be used in other types of systems wherein it might be desired to detect temperature decreases.

In the drawings:

Figure 1 is a side elevation view of a portion of a form of my improved cable;

Figure 2 is a diagrammatic view showing the cable of Fig. 1 connected to other elements of a satisfactory circuit;

Figure 3 is a side elevation view of a portion of the preferred form of my improved cable;

Figure 4 is a cross sectional view of the cable taken as on line 4—4 of Fig. 3;

Figure 5 is a diagrammatic view showing how the various strands which form the two conductors of the preferred form of my cable may be connected at the ends of the cable;

Figure 6 shows the preferred form of my cable connected to the other elements of a circuit like that shown in Fig. 2;

Figures 7 and 8 show other ways of connecting my preferred form of the cable into satisfactory circuits;

Figure 9 is a diagrammatic view of another form of my improved cable shown with a portion of a circuit similar to that of Fig. 2 to which it is connected;

Figure 10 is a diagrammatic view, similar to that of Fig. 9, showing still another form of my improved cable; and

Figure 11 is a diagrammatic view similar to that of Fig. 9, showing yet another form of my improved cable.

Referring now more particularly to the drawings, the preferred form of my cable shown in Figs. 3 to 8 comprises what may be termed a core and a helical wrapping. The core consists of four wire strands 12a, 12b, 12c and 12d. As a practical matter each of these strands of the core may come from a different wire spool when the cable is being made (though I prefer to use wire from the same spool), but when a particular length of cable is installed in a rate-of-rise circuit some of the ends of the strands are so connected together that the core as a whole constitutes a single conductor which, in effect, has been doubled back along itself three times. The outer wrapping 14 consists of two strands 14a and 14b whose ends are connected together at one end of the cable so that the wrapping also constitutes one conductor which, in effect, has been wrapped along the core and then wrapped back in the spaces of the first wrap.

Preferably all the wires are of the same size and material and are covered uniformly with the same insulation 16. The core strands 12a, 12b, 12c and 12d (hereinafter when reference numerals of the several wire strands are used they are to be taken as referring to the wire plus its insulating covering) are laid parallel, although it is within the scope of my invention to twist them somewhat along the axis of the cable about one another if desired. The strands 14a and 14b of the wrapping wire 14 are wound helically around the core with sufficient tightness thereagainst to give appreciable firmness to the cable. Nevertheless, the latter can be bent readily around and laid along such uneven supports as may be encountered where it is installed.

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The cable can be made up in one section or, if additional length is required, in several sections by connecting the corresponding strands of one such section to those of another. However, when a cable of proper length has been selected or made up from several shorter sections, it is necessary in my preferred arrangement, as has been previously indicated, to so connect the ends of certain strands that the cable as a whole constitutes two conductors 12 and 14. This manner of connection is shown in Fig. 5.

The left end of strand 12a of the core 12 is shown free and its right end connected by a suitable connector 18 to the right end of strand 12b. The left end of the latter strand is joined with the left end of strand 12c by another connector 20. The right end of strand 12c is connected by a connector 22 to the right end of strand 12d, and the left end of the latter is shown free. Thus the strands of the core, though perhaps made up in the cable from different spools, when connected as just described provide a single conductor from the left end of strand 12a to the left end of strand 12d.

Similarly the left end of helical strand 14b is shown free and its other, or right, end is connected by a connector 24 to the right end of strand 14a. Thus these two strands also provide a single conductor from the left end of strand 14a to the left end of strand 14b.

There are undoubtedly a considerable number of circuits with which my improved cable may be associated to form a rate-of-rise system. I have found none, however, which are more satisfactory than those which operate on the principle of the Wheatstone bridge, and accordingly I have shown the preferred form of my cable in three such bridge circuits in Figs. 6, 7 and 8.

Referring now particularly to Fig. 6, the bridge circuit shown there has for two of its arms fixed resistors 26 and 28 connected together at a junction point 30. The remaining end of fixed resistor 26 is connected to core strand 12a of my cable at a junction point 32, and similarly the remaining end of fixed resistor 28 is connected to wrapped strand 14a of the cable at a junction point 34. The cable's core strand 12d and wrapped strand 14d have their free ends connected together at a junction point 36. A battery 38 or other source of electromotive force is connected between junction points 30 and 36 and a galvanometer relay 40 which can be adjusted to respond to a current therethrough of any particular magnitude is connected between junction points 32 and 34.

It will be seen from the daigrammatic showing of the cable in Fig. 6 that the core 12 constitutes a bridge arm connected between junction points 32 and 36, and the wrapping 14 also constitutes a bridge arm connected between junction points 34 and 36. As has been noted, the cable is distributed throughout the enclosure to be protected from fire. The remaining circuit elements are customarily housed, as, for example, in a wall box.

When the rate-of-rise system shown in Fig. 6 is installed it is set for normal, or what may be called standby, conditions under which the bridge circuit is in balance. This balance condition is attained by adjusting the resistance of one or more arms until no current is flowing in the galvanometer 40. Thereafter if the air temperature increases in the neighborhood of the cable the bridge will become electrically unbalanced and current will flow through the galvanometer. The higher the rate of air temperature increase the larger the galvanometer current, and the galvanometer is adjusted to respond and give a signal when the magnitude of current through it indicates that the air temperature increase is caused by a fire.

An increase in air temperature results in a galvanometer current because there is exposed to fluid currents a greater proportion of the external surface area of the wrapping conductor 14 than of the core conductor 12 thus causing the temperature of the former to increase at a faster

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rate than the rate of temperature increase of the latter. Stated another way the temperature, and hence the resistance, in the core conductor follows but lags behind the increasing temperature in the wrapping conductor. As a result the ratio of resistances of these two bridge arms which existed in the balance condition is changed by the air temperature increase, and if this ratio is changed enough, as it would be with a rapid air temperature increase caused by a fire, the galvanometer current is large enough to give a signal.

The disposition of the core strands so that the conductor, in effect, partially shields itself contributes to the difference in rates of temperature increase in the two conductors for a given rate of air temperature increase.

Since the shielding of the core conductor by the wrapping conductor and the shielding of the core conductor by itself are sufficient to achieve the different rates of temperature increase in the two conductors, I am not required to use wire in one conductor which has a different thermal capacity than the wire in the other conductor in order to achieve these different rates. In fact, I prefer to use for the two conductors wires which have substantially the same thermal capacity, and, accordingly, I find that wires of the same material and size and having the same insulation are very satisfactory in my cable.

In addition to having substantially the same thermal capacity, I prefer that the two conductors in my cable have substantially the same resistance for any given length of the cable itself. One reason for this preference is that I have found that the auxiliary circuits (not shown) usually associated with the main Wheatstone bridge circuit are simple and inexpensive when the distributed conductors have the same resistances. As a practical matter these auxiliary circuits are necessary to give trouble signals in the event of broken wires, power failures and other mishaps. Furthermore, when the two distributed conductors have the same resistance it is possible to obtain properly paired commercial resistors for the two fixed bridge arms 26 and 28.

In the preferred form of my cable I make the resistances of the two distributed conductors equal by using therefor wires identical in every respect and by so choosing the number of wrapping strands and the number of turns made thereby for a given number of core strands that in any selected section or in all of the cable the total length of the wrapping strands will be approximately the same as the total length of the core strands.

Figs. 7 and 8 illustrate additional Wheatstone bridge arrangements employing my improved cable. Fig. 7 is identical to Fig. 6 except that the battery and galvanometer have been interchanged. Fig. 8 is identical to Fig. 6 except that another length of my improved cable has been substituted for the fixed resistances 26 and 28.

Although it has been pointed out in the foregoing description of the preferred form of my cable that the use of identical wires is desirable, that the provision of a cable in which the two conductors have the same length is also desirable and that doubling back of the conductors within the cable has advantages, it will be appreciated that the shielding of one conductor by the other may be achieved in other arrangements, the most simple of which is shown in Figs. 1 and 2. In these latter figures the cable comprises a single strand core conductor 12 around which there is disposed by helical wrapping another single strand conductor 14.

Operation

Consider now the operation of the preferred form of my cable. Good practice in the installation of electrical rate-of-rise systems dictates the proper lengths of the conductors which are to be distributed in a protected enclosure of any particular size. Assume, as an example, that such practice is observed when 400 feet of the preferred form of my cable is uniformly distributed in a given enclosure.

Assume, further, that this cable is located in the enclosure where electrical rate-of-rise conductors are usually located, that is, near the ceiling. If the cable is then connected into a bridge circuit such as that shown in Fig. 4 and the bridge is balanced the system is ready to detect fires.

When a fire starts somewhere in the enclosure the air in the immediate vicinity of this fire is heated well above the normal room temperature, and convection currents promptly carry this heated air to other parts of the room including the parts where the cable is located. As would be expected with the cable uniformly distributed, the heated air does not arrive at all sections of the cable at the same instant, but instead first reaches only a small portion of the total length of 400 feet. At this portion heat from the heated air initially flows into the wrapping conductor and into the core conductor through the spaces between the turns of the wrapping conductor strands. Since the two conductors have substantially the same thermal capacity in this preferred form of my cable, the fact that the wrapping conductor is more exposed to the heated air than the core conductor obviously causes its temperature and resistance to increase faster than the temperature and resistance, respectively, of the core conductor.

Though the conductor temperatures and resistances are thus increased at different rates only over the portion of the cable encountered by the heated air, an alarm will be given if the difference in these rates at this portion results in a sufficient difference in the total conductor resistances for the entire cable.

One advantage of the structure of the preferred form of my cable is that the various strands of the two distributed conductors therein may be connected at the ends of the cable to achieve parallel arrangements of these strands rather than the series arrangement of the preferred form. Several such parallel arrangements are possible including those illustrated in Figs. 9, 10 and 11 and generally have the advantage that they enable me to provide longer cable lengths for a given circuit. This is because the parallel connection of the strands makes the total resistances of conductors for a unit length of cable less than the corresponding resistances in the series connection of the preferred form. These parallel arrangements may result in a decrease in sensitivity of the system, but in many installations the sensitivity afforded by the use of the parallel arrangements, is entirely satisfactory.

Referring particularly to the parallel arrangement of Fig. 9, the left ends of strands 12a and 12b are shown connected together and to the junction point 32. Similarly the left ends of strands 12c and 12d are connected together and to the junction point 36. At the right end of the cable of Fig. 9 strands 12a and 12d are connected together as are the remaining core strands 12b and 12c. As to the wrapping conductor, the strands 14a and 14b thereof are connected in series at the right end of the cable as in the preferred form.

In Fig. 10 the strands of the core conductor 12 are connected as in Fig. 9, but the wrapping conductor strands 14a and 14b are connected in parallel. In this latter manner of connection it is convenient to so dispose the cable in the protected area that both ends of the cable terminate at the wall box or other mounting for the remaining elements of the circuit. Thus in Fig. 10 the cable itself is shown with its "remote" end returned to these elements so that the parallel strands 14a and 14b are connected directly to the junction point 34.

In Fig. 11 the arrangement is the same as in Fig. 10 as far as conductor 14 is concerned, the strands thereof being in parallel, and in addition all of the strands of core conductor 12 are likewise in parallel. In this arrangement it is again convenient to locate the cable in the protected area so that the "remote" end is returned to the other circuit elements, because with this disposition the

parallel strands 12a, 12b, 12c and 12d may be directly connected to junction point 36.

In any of the arrangements herein disclosed of a cable embodying my inventive features extended lead-in wires may of course be used to connect the cable conductors to the other circuit elements. When such extension lead-ins are employed their resistances should be small relative to the resistances of the cable conductors.

Having particularly described my invention in its preferred form and the operation thereof, I now direct attention to the advantages achieved by the fulfillment of the objects earlier stated herein.

One advantage is that system stability for any given degree of sensitivity is very good when the distributed conductors are so arranged that they are close together and one shields the other from air temperature changes. Formation of the conductors into a cable wherein one conductor is exteriorly disposed and the other is interiorly disposed results in such shielding. By such close relationship of the distributed conductors with respect to each other heat exchange therebetween is facilitated to the extent that greater stability results for any given degree of sensitivity. The conductors need not have the same thermal capacity or comprise wires identical in all respects to realize this advantage if the conductor wires actually chosen operate properly with respect to each other and the other parts of the rate-of-rise system circuit when formed into a cable as above.

Another advantage is that system stability for any given degree of sensitivity is still further improved when, the shielded conductor is arranged so that it partially shields itself from air temperature changes. Doubling back of the shielded conductor along itself within the cable results in such an arrangement.

Another advantage is that system stability for any given sensitivity is even further improved when the wires selected for the conductors have substantially the same thermal capacity, such wire selection being made possible by the fact that the entire difference in rates of conductor temperature and resistance change in the presence of an air temperature increase may be achieved by the shielding of one conductor by the other or by the other and by itself.

Another advantage is that by forming the conductors into a cable installation is simplified and there is little likelihood that the individual conductor strands will be broken by rough treatment.

Because the wires employed for the two conductors in my improved cable can have the same thermal capacity they can be identical in every respect. It is an advantage to employ such wires because they can be taken from the same spool and as a practical matter the chances of there being serious variations in the temperature coefficient of resistance at points therealong attributable to manufacturing errors are smaller when the wire employed for both conductors has been drawn through the same wire-making die. The variations above-mentioned which usually take the form of non-uniformity in wire diameter, and undesirable because they may result in the giving of a signal where no signal should be given or in the delay of a signal which ought to be given. Thus it may happen that a portion of one of the conductors has a wire diameter slightly greater than the wire diameter of the remainder of that conductor. At the same time it may happen that the corresponding portion of the other conductor has a wire diameter slightly smaller than the wire diameter of the remainder of that conductor. It would follow that along these portions the ratio of resistances of the two conductors in the balance condition would differ from the ratio of the total resistance of the conductors. Depending on whether this difference were in a direction to exaggerate or detract from the effects of heated air reaching these portions simultaneously, a signal might be given where no signal was warranted or a proper signal might be delayed.

Another advantage of my invention is that when the

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conductors are doubled back along themselves a number of times the undesirable effects of any variations along the wires thereof are further minimized. Both conductors may be doubled back along themselves in the cable. The larger the number of times each is so doubled back the more likely the variations will cancel each other out. If each conductor is doubled back an odd number of times (so that there are an even number of strands of each conductor in any portion of the cable), there is the additional advantage that any current induced in one strand of a conductor by external magnetic fields is cancelled out by an equal opposite current induced in another strand of that conductor. Consequently, the danger of false alarms caused by currents being induced in the distributed conductors is reduced.

A further advantage of that form of my invention wherein a plurality of strands of each conductor are employed is that these strands may be variously connected at the ends of the cable in series or parallel arrangements or in a combination of these to achieve different characteristics without effecting the structure of the cable itself.

It will be understood, of course, that while the cable arrangements particularly described hereinbefore have had certain definite numbers of strands for each conductor, larger or smaller numbers of such strands obviously may be provided without departing from the spirit of my invention.

The following are values of exemplary system that has been found very satisfactory using the preferred cable arrangement in the circuit of Fig. 6 in a system in which the fluid surrounding the cable is air, it being understood, of course, that such values are merely illustrative and in no way are meant to limit the scope of the invention:

1. Cable length—400 feet.
2. Conductor wire size, material and insulation—No. 22 pure electrolytic copper with $\frac{1}{64}$ inch vinyl plastic insulation.
3. Voltage on system of Fig. 6—25 volts.
4. Current through cable—1.0 amperes.
5. Resistors 26 and 28 of Fig. 6—25 ohms each.

With this arrangement resistance of each distributed conductor is approximately 25 ohms.

I claim:

1. For an electrical rate-of-rise fire detecting system which employs the elements of a Wheatstone bridge circuit, a cable for distribution in a region in which fires are to be detected by said system, said cable comprising individually insulated wires which form the core of said cable and additional individually insulated wires wrapped firmly around and shielding said core, the wrapped and core wires each being of an electric current conducting metal which has a substantial temperature coefficient of resistance, the wires of said core being interconnected in series to constitute a single conductor to form one arm of said Wheatstone bridge circuit and the wrapped wires likewise being interconnected in series to constitute another single conductor to form a different arm of said bridge circuit, and said wrapped wires having the exterior surfaces of the insulation thereon more exposed to the air in the region than the exterior surfaces of said core wire insulation, said difference in exposure causing the temperatures of said conductors, and hence their resistances, to change at different rates for each change in air temperature in said region.

2. In an electric circuit, heat responsive, conducting cable comprising a plurality of individually electrically insulated wires, some of said wires being interconnected in series to form a single conductor which constitutes a first current-carrying branch of the circuit, and the remaining of said wires being interconnected in series to form a single conductor which constitutes a second current-carrying branch of the circuit, each of the wires of both branches being of an electric current conducting metal which has a substantial temperature coefficient of

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resistance, the wires of the first branch being laid against each other to form the center portion of the cable, and the wires of the second branch being laid against the wires of the first branch to form the outside portion of the cable substantially shielding the center portion, said shielding alone causing the temperature of the first branch to change less rapidly than the temperature of the second branch for each rate of change in the temperature of the air around the cable.

3. In an electric circuit, a heat responsive, conducting cable as defined in claim 2 in which all of the wires have substantially identical thermal capacities.

4. In an electric circuit, a heat responsive conducting cable comprising a plurality of individually electrically insulated wires, some of said wires being interconnected to form a single conductor which constitutes a first current-carrying branch of the circuit, the remaining of said wires being interconnected to form another single conductor which constitutes a second current-carrying branch of the circuit, each of the wires of both branches being of an electric current conducting metal which has a substantial temperature coefficient of resistance, the wires of the first branch being laid against each other in a tight cluster, and the wires of the second branch being disposed against said cluster in separated relation with respect to each other to partially shield the wires of the first branch from changes in the temperature of the air around the cable, said partial shielding alone causing the temperatures of the branches to change at different rates for each rate of change in the air temperature, and the wires of the first branch at least partially shielding each other from the air temperature changes to contribute to the said difference in said rates.

5. In an electric circuit, a heat responsive conducting cable as defined in claim 4 in which each branch has an even number of wires.

6. For an electrical rate-of-rise fire detecting system which employs the elements of a Wheatstone bridge circuit and has means responsive to electrical unbalancing of said circuit of predetermined magnitude, a cable for distribution in a region in which fires are to be detected by said system, said cable comprising a group of individually electrically insulated wires which form the core of said cable and are interconnected in series so as to constitute a single conductor, additional individually electrically insulated wires wound helically about said core in firm contact therewith, said additional wires likewise being interconnected in series so as to constitute another single conductor, said core wires and said additional wires having the same size and insulation and being of an electric current conducting metal which has a substantial temperature coefficient of resistance, the total length of core wires in said first-mentioned single conductor being equal to the total length of additional wires in said second-mentioned single conductor, said first-mentioned single conductor being adapted to form one arm in said Wheatstone bridge circuit and said second-mentioned single conductor being adapted to form a different arm in said bridge circuit, and said additional wires partially shielding said core wires so that for a gradual change in temperature in said region the unbalancing of said circuit due to the dissimilar changes in the resistances of said single conductors will fail to achieve said predetermined magnitude, but for a rapid change in temperature in said region the unbalancing of said circuit due to dissimilar changes in the resistances of said single conductors will achieve said predetermined magnitude.

7. For an electrical rate-of-rise fire detecting circuit which has first and second current-carrying branches and which is in electrical balance when the resistance ratio of said branches has a predetermined value, a heat responsive, conducting cable comprising a plurality of individually electrically insulated wires having substantially identical thermal capacities, a number of said wires being connected in series at the ends of the cable to form

a single conductor which constitutes the first branch, a smaller number of said wires being connected in series at the ends of the cable to form a single conductor which constitutes the second branch, all of the wires being of the same electric current conducting metal which has a substantial temperature coefficient of resistance, the wires of the first branch being laid against each other in a tight cluster to form the center portion of the cable and the wires of the second branch being laid against and wrapped helically around said cluster in separated relation with respect to each other and at such a uniform pitch that the total lengths of the conductors are substantially the same, said wires of the first branch partially thermally shielding each other and being partially thermally shielded by the wires of the second branch, and said shielding relation causing the temperatures of the branches to change at different rates for each rate of change in the temperature of the air around the cable to effect a change in the predetermined branch resistance ratio.

8. For an electrical rate-of-rise fire detecting circuit which has first and second current-carrying branches and which is in electrical balance when the resistance ratio of said branches has a predetermined value, a heat responsive, conducting cable comprising six individually electrically insulated wires having substantially identical thermal capacities, four of said wires being connected in series at the ends of the cable forming a single conductor to constitute the first branch, the remaining two wires being connected in series at the ends of the cable forming a single conductor to constitute the second branch, the wires of the first branch being laid substantially parallel to and against each other in a tight cluster which form the center portion of the cable and the wires of the second branch being laid against and wrapped helically around said cluster parallel to each other and in separated relation with respect to each other and at such a uniform pitch that the total lengths of the conductors are substantially the same, the said four wires of the first branch partially thermally shielding each other from changes in the temperature of the air around the cable and being partially thermally shielded by the two wires of the second branch from said air temperature changes, and said shielding relation combined alone causing the temperatures of the branches to change at sufficiently different rates for each change in the temperature of the air around the cable to effect a change in the predetermined branch resistance ratio.

9. For an electric circuit, a heat responsive conducting cable for distribution in a fluid subject to temperature changes, said cable comprising a pair of individually electrically insulated wires, one of said wires being adapted to constitute a first current-carrying branch of the circuit, and the other of said wires being adapted to constitute a second current-carrying branch of the circuit, each of the wires being of an electricity conducting metal which has a substantial temperature coefficient of resistance the wire of the second branch being wrapped closely about the wire of the first branch to form the outside portion of the cable, the wrapped wire of the second branch shielding the wire of the first branch from fluid temperature changes to a greater extent than the wrapped wire is in turn so shielded by the wire of the first branch, said difference in extent of thermal shielding causing the temperatures of the branches to change at different rates for each rate of change in the temperature of the fluid around the cable, and the said close wrapping causing that difference in the temperatures of the branches which results from the said different rates to be quickly reduced at the termination of each fluid temperature change.

10. In an electrical rate-of-rise fire detecting system which employs the elements of a Wheatstone bridge circuit, a cable for distribution in a region in which abnormal changes in temperature are to be detected by said

system, said cable comprising individually electrically insulated wires which form the core of said cable and additional wires wrapped around said core, each of the wires being of an electricity conducting metal which has a substantial temperature coefficient of resistance the wires of said core being interconnected in parallel at the ends of the cable to form one arm of said Wheatstone bridge circuit and the wrapped wires being interconnected in series to constitute a different arm of said bridge circuit, and said wrapped wires being more exposed than said core wires so that a change in temperature in said region causes the temperatures of said conductors, and hence their resistances, to change at different rates.

11. In an electrical rate-of-rise fire detecting system which employs the elements of a Wheatstone bridge circuit, a cable for distribution in a region in which abnormal rates of change in temperature are to be detected by said system, said cable comprising individually electrically insulated wires which form the core of said cable and additional wires wrapped around said core, each of the wires being of an electricity conducting metal which has a substantial temperature coefficient of resistance, the wires of said core being interconnected in parallel at the ends of the cable and doubled back to form one arm of said Wheatstone bridge circuit and the wrapped wires being interconnected in parallel at the ends of the cable to constitute a different arm of said bridge circuit, and said wrapped wires substantially shielding said core wires from temperature changes in said region so that when an abnormal change in temperature occurs therein the temperatures of said conductors, and hence their resistances change at substantially different rates.

12. In an electrical rate-of-rise fire detecting system which employs the elements of a Wheatstone bridge circuit, a cable for distribution in a region in which abnormal changes in temperature are to be detected by said system, said cable comprising individually electrically insulated wires which form the core of said cable and additional wires wrapped around said core, each of the wires being of an electricity conducting metal which has a substantial temperature coefficient of resistance, the wires of said core being interconnected in parallel at the ends of the cable to form one arm of said Wheatstone bridge circuit and the wrapped wires being interconnected in parallel at the ends of the cable to constitute a different arm of said bridge circuit, and said wrapped wires substantially shielding said core wires from temperature changes in said region so that when an abnormal change in temperature occurs therein the temperatures of said conductors, and hence their resistances, change at substantially different rates.

13. For a rate-of-rise electric circuit which has two electric current carrying branches distributable in a fluid subject to temperature changes and which responds to a predetermined difference in the rates of change of electrical resistances of the branches, a heat responsive cable for distribution in the fluid, said cable comprising a plurality of strands which form the branches, each of said strands carrying an electric current and being in non-electricity-conducting relationship with one another at all times, each of the strands being of an electric current conducting material which has a substantial temperature coefficient of resistance, each strand of one branch substantially thermally shielding a strand of the other branch from the fluid temperature changes, and said shielding relation alone producing in the branches a substantial portion of said predetermined difference in the resistances for each rate of said fluid temperature change.

14. For a rate-of-rise electric circuit which has two electric current carrying branches distributable in a fluid subject to temperature changes and which responds to a predetermined difference in electrical resistances of the branches, a heat responsive cable for distribution in the fluid, said cable comprising a plurality of strands which form the branches, each of said strands carrying an elec-

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tric current and being in non-electricity-conducting relationship with one another at all times, each of the strands being of an electric current conducting material which has a substantial temperature coefficient of resistance, the strands of one branch partially thermally shielding the strands of the other branch to a greater extent than the strands of the one branch are partially shielded by the strands of the other branch, the strands of the other branch partially thermally shielding each other to a substantially greater extent than the strands of the one branch partially shield each other, and the combined shielding relations producing in the branches a substantial portion of said predetermined difference in said resistances for each rate of said fluid temperature change.

15. For a rate-of-rise electric circuit which has two electric current carrying branches distributable in a fluid subject to temperature changes and which responds to a predetermined difference in the electrical resistances of the branches, a heat responsive cable for distribution in the fluid, said cable comprising a plurality of strands which form the branches, each of the strands carrying electric current at all times and being of an electric current conducting metal which has a substantial temperature coefficient of resistance, the strands of one branch being disposed at the interior of the cable and being individually covered with electrical insulation which electrically insulates them at all times from each other and from the strands of the other branch between the ends of the cable, the strands of the other branch being disposed at the exterior of the cable substantially thermally shielding the interior strands, said shielding relation causing the proportion of the interior strand surfaces which is exposed to fluid temperature changes to be smaller than the proportion of exterior strand surfaces so exposed, and said shielding relation alone thereby producing in the branches a substantial portion of said predetermined difference in the resistances for each rate of said fluid temperature change.

16. For a rate-of-rise electric circuit which has two electric current carrying branches distributable in a fluid subject to temperature changes and which responds to a predetermined difference in the electrical resistances of the branches, a heat responsive cable for distribution in the fluid, said cable comprising a plurality of strands which form the branches, each of the strands carrying electric current at all times and being of an electric current conducting metal which has a substantial temperature coefficient of resistance, the strands of one branch being individually electrically insulated and being clustered at the interior of the cable partially thermally shielding each

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other from fluid temperature changes, the strands of the other branch being wrapped around the clustered interior strands and thereby partially shielding the interior strands from fluid temperature changes, said shielding relations combined causing the proportion of interior strand surfaces which is exposed to fluid temperature changes to be smaller than the proportion of wrapped strand surfaces so exposed, and said combined shielding relations alone thereby producing in the branches a substantial portion of said predetermined difference in said resistances for each rate of said fluid temperature change.

17. For a rate-of-rise fire detecting electric circuit which has two electric current carrying branches distributable in that portion of a protected area where the occurrence of a fire produces air temperature changes and which responds to a predetermined difference in the electrical resistances of the branches, a heat responsive cable for distribution in said portion of the protected area, said cable comprising wires clustered together forming the cable core and additional wires wrapped firmly around said core, the clustered and wrapped wires each being of an electric current conducting metal which has a substantial temperature coefficient of resistance and each having an individual electricity insulating coating which has electricity insulating properties substantially unaffected by temperature changes, the clustered wires being interconnected at the cable ends to constitute a single electric current carrying conductor which forms one of the branches, the wrapped wires likewise being interconnected at the cable ends to constitute a single electric current carrying conductor which forms the other branch, and the wrapped wires substantially thermally shielding the clustered wires from changes in air temperature adjacent the cable, said shielding relation causing that proportion of surface area of the clustered wire coatings which is exposed to air temperature changes to be smaller than the proportion of surface area of the wrapped wire coatings so exposed, and said shielding relation alone thereby producing in the branches a substantial portion of said predetermined difference in said resistances for each rate of said air temperature change.

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