

March 24, 1953

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2,632,885

FIRE DETECTION APPARATUS

Filed July 7, 1949

3 Sheets-Sheet 1

Fig. 2

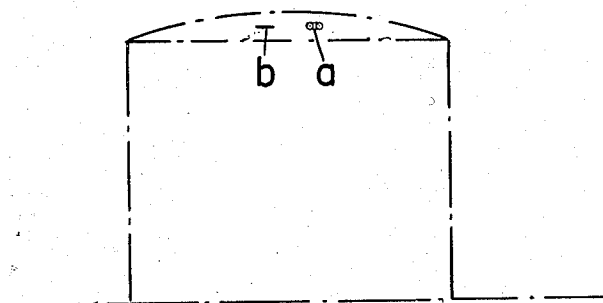
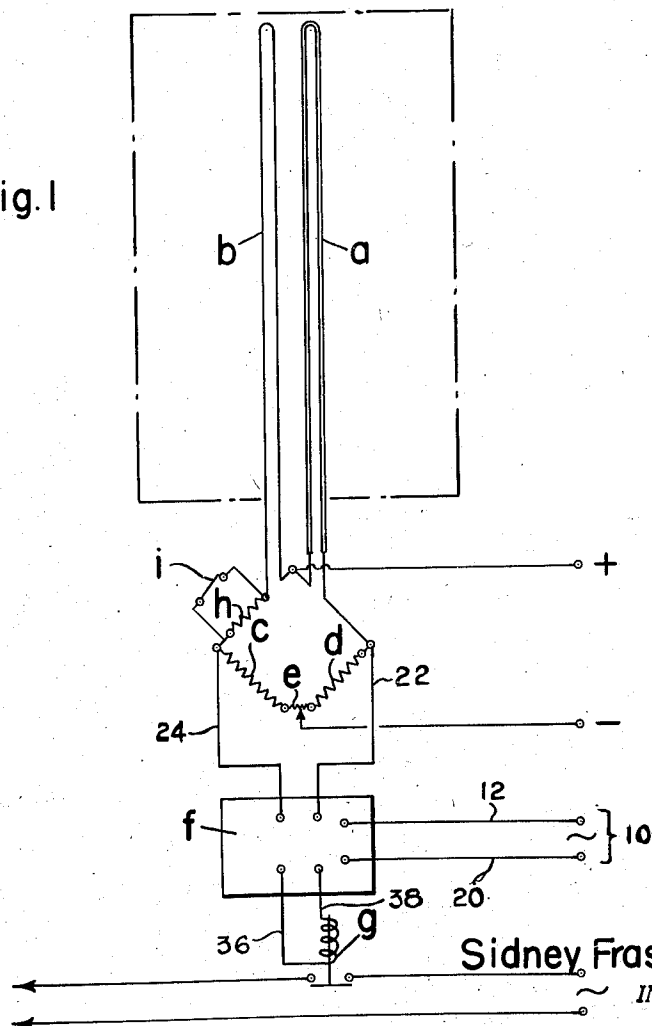


Fig. 1



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Fig. 4

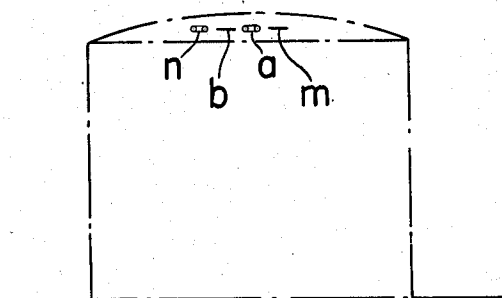
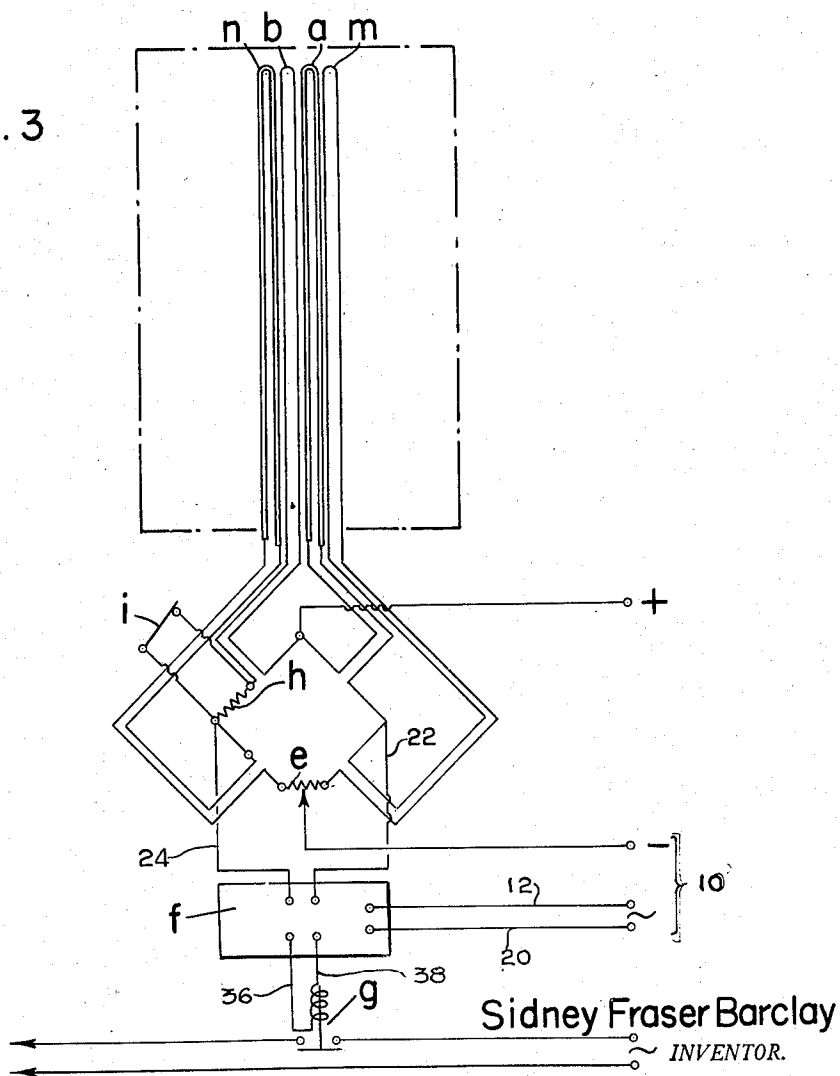


Fig. 3



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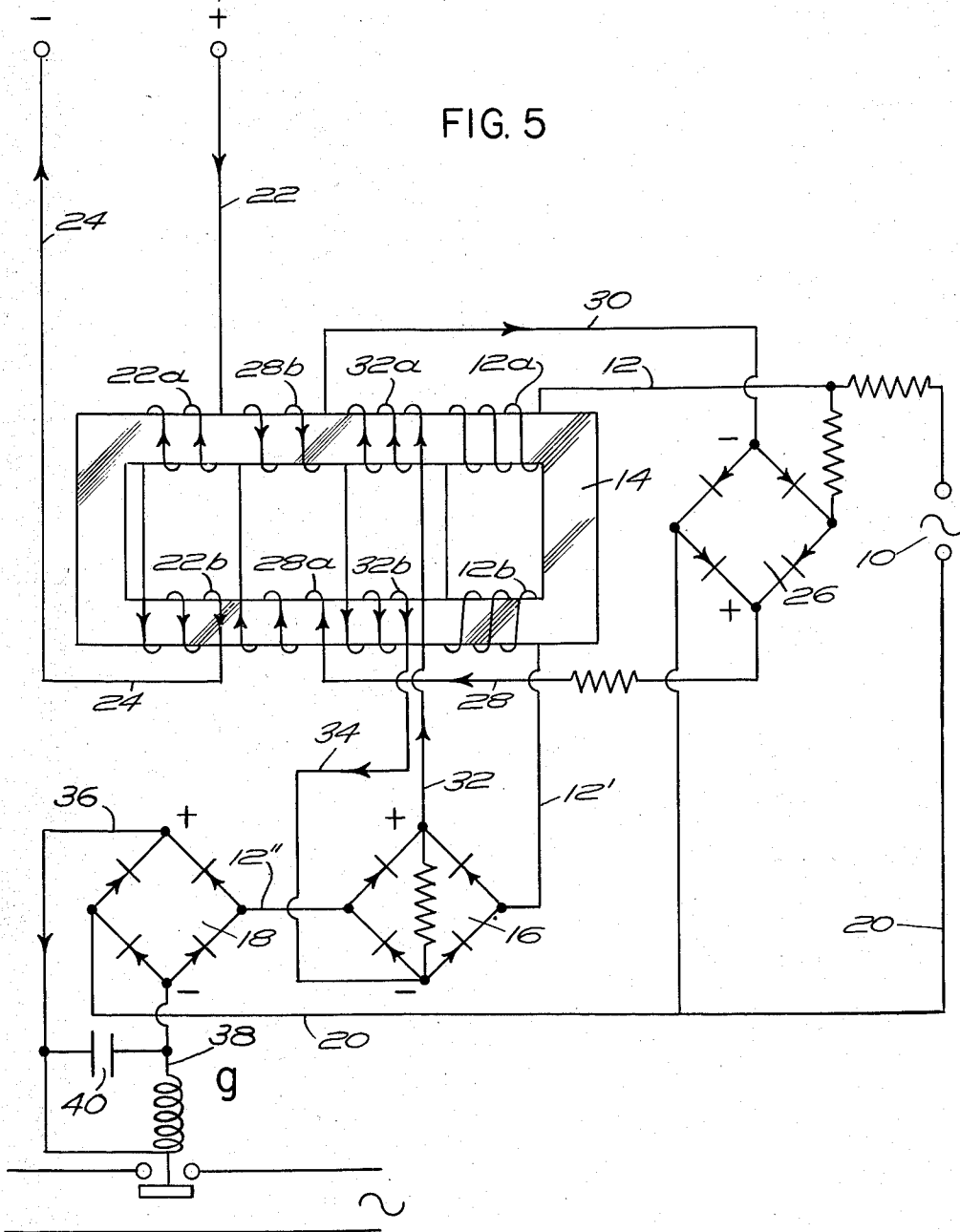
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FIG. 5



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FIRE DETECTION APPARATUS

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In Great Britain July 21, 1948

1 Claim. (Cl. 340—233)

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This invention relates to an improved fire detection apparatus, more particularly for the operation of so-called deluge systems for fire extinguishing, and has for its object to provide a simple and reliable apparatus which will detect an outbreak of fire rapidly and may readily be extended to cover a large area without complication.

A further object of the invention is to provide a fire detection apparatus having a temperature detecting element of a simple and robust nature without electrical contacts or moving parts of any kind, which obviates the necessity for mounting complicated heat-sensitive devices at the roofs of buildings where they are often inaccessible and may be required in large numbers.

The arrangement according to the invention comprises two electrical conductors, one being covered with heat-insulating material and the other bare, or coated with a heat absorbent material, which are mounted in a position in which they are equally exposed to heat from an outbreak of fire, the conductors being connected to an electrical power source and to means for detecting a predetermined increase in the resistance of the bare conductor relatively to the covered conductor and for operating an extinguisher system or an alarm in accordance with such relative increase in resistance.

The conductors conveniently take the form of flexible stranded wires and are made of the same material having the same temperature coefficient of electrical resistance which preferably has a high value. The wires preferably have the same cross section and length.

According to further feature of the invention, the wires form two arms of a Wheatstone bridge, with the out-of-balance current of the bridge which results from an increase of the resistance of the bare wire relatively to the covered wire being utilised for operating an alarm or extinguisher system, when the out-of-balance current attains a predetermined value.

Referring to the accompanying explanatory drawings:

Figure 1 is a circuit diagram of one form of the invention, indicating the manner in which it is installed in a building.

Figure 2 shows diagrammatically the arrangement in the roof of a building.

Figures 3 and 4 are similar diagrams for another form of the invention.

Figure 5 is a diagrammatic showing of the circuits in a polarized magnetic amplifier.

In the form of the invention, shown in Figures

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1 and 2, two stranded copper wires *a*, *b*, of the same length and cross section, the wire *a* being covered with an insulation in common use for electrical purposes while the wire *b* is bare, are mounted in a building to be protected, such as an aircraft hangar and extend along the building under the centre of the roof, which is the highest part. In the case of a large hangar having several bays, a separate installation may be provided for each bay: in the case of very long bays, these may be sub-divided lengthwise into sections, with a separate installation for each section.

The ends of the wires *a*, *b* are connected in two arms of a Wheatstone bridge, two equal fixed resistances *c*, *d*, form the ratio arms of the bridge. A direct-current electric power supply is connected across the bridge and a small variable resistance *e* is included in the bridge to allow for accurate zero setting.

Should a fire break out in the building the wires will be heated at different rates as a consequence of the insulation of the wire *a*. The resistance of the bare wire will increase relatively to the covered wire and the balance of the Wheatstone bridge will be disturbed. When this occurs, a current will flow through *f*, a magnetic amplifier which is connected across the bridge, and when the current attains a predetermined value, a relay *g* will operate a circuit to a solenoid which trips the main valve of a deluge system. The Type MAE 3 magnetic amplifier put out by Electro Methods, Ltd., of London, England, has been found satisfactory since it can be polarised so that it can operate only when the bridge is unbalanced under the conditions described and not if it should be unbalanced as a consequence of the bare wire being at a lower temperature than the covered wire.

In general magnetic amplifiers make use of the fact that coils wrapped around an iron core present an impedance to an A. C. current flowing in the coils, which impedance may be varied by changing a D. C. control current flowing in a separate coil wrapped about the same core. Within a limited range the change in the A. C. output current is proportional to the change in the D. C. control current. Outside of this limited range, however, a change in the D. C. control current has little or no effect on the A. C. output current. A polarized magnetic amplifier is one designed to operate close by one end of the limited range, referred to above, so that when the D. C. control current flows in one direction it has substantially no effect on the A. C. output

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current, whereas when the D. C. control current flows in the opposite direction the A. C. output current is changed materially.

In such a polarized magnetic amplifier, the circuits of which are shown diagrammatically in Fig. 5, current to operate the relay *g* is drawn from an A. C. source 10 through a circuit loop comprising a conductor 12, coils 12*a* and 12*b* wrapped about a core 14, conductor 12', rectifier 16, conductor 12'', a rectifier 18 and return conductor 20. The coils 12*a* and 12*b* are so wrapped about core 14 that the lines of magnetic flux produced therein by the A. C. current cancel each other. However, these coils 12*a* and 12*b* present an impedance to the A. C. current flowing in the circuit loop, above described, connected with the source 10.

When the Wheatstone bridge (see Figs. 1 and 3) is unbalanced by a rapid increase in temperature in the loop *b*, extending within the protected area, a small D. C. control current flows from the Wheatstone bridge along a second circuit loop comprising a conductor 22, coils 22*a* and 22*b* and a return conductor 24. The direction of flow of the D. C. control current is indicated by the arrows, and the coils 22*a* and 22*b* are so wrapped about core 14 that the lines of magnetic flux produced by each coil are added to one another. The impedance which coils 12*a* and 12*b* offer the A. C. current from supply 10 is altered by the presence of these lines of magnetic flux produced by the D. C. control current flowing along coils 22*a* and 22*b*.

A full wave rectifier 26 is connected between conductors 12 and 20 and provides a rectified A. C. current (in effect, a D. C. current) which flows in a third circuit loop comprising a conductor 28, coils 28*a* and 28*b*, also wrapped around core 14, and a return conductor 30. These coils 28*a* and 28*b* are so wrapped about the core that the magnetic lines of force produced by the current flow in each coil are added to one another. The purpose of rectifier 26 is to produce the proper degree of core saturation so that when no D. C. control current is flowing from the Wheatstone bridge through coils 22*a* and 22*b*, the magnetic amplifier is operating close by one end of the limited range in which the change in A. C. output current is substantially proportional to the change in D. C. control current flowing in coils 28*a* and 28*b*. In other words, rectifier 26 provides a core saturation bias.

Rectifier 16 in series with coils 12*a* and 12*b* in the circuit loop connected with source 10 produces a rectified A. C. current in a fourth circuit loop comprising conductor 32, coils 32*a* and 32*b* wrapped around core 14, and return conductor 34. This rectified A. C. current is in the nature of a feed back and will amplify the effect of the D. C. control current if coils 32*a* and 32*b* are so wrapped that the lines of magnetic flux produced by the rectified A. C. current therein are added to the lines of magnetic flux produced by the D. C. control current in coils 22*a* and 22*b*. Rectifier 18 is connected in series with the rectifier 16 and in turn is also connected by wires 36 and 38 with the relay *g*. Thus the rectified A. C. current which is filtered by a condenser 40 connected across the wires 36 and 38, operates the relay *g*.

A resistance *h* is connected in series with the bare wire *b* and is normally short-circuited by a switch *i*. When the switch *i* is opened the bridge becomes unbalanced to the same extent as when the bare wire is heated under a fire condi-

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tion, and the equipment can therefore easily be tested by opening the switch.

The arrangement shown in Figures 3 and 4 has additional bare and covered wires *m*, *n* which are included in the bridge in place of the resistances *c*, *d*.

The bridge circuit may be supplied with alternating instead of direct current, in which case a rectifier for the out-of-balance current will be required. The rectifier is so connected that it yields current to the amplifier only when the out-of-balance current results from the bare wire being at a higher temperature than the covered wire. A convenient value for the current in the bridge circuit is 3 amperes, each of the wires *a*, *b* (and *m*, *n* when used) taking 1.5 amperes.

According to my invention the wires can be and preferably are of considerable cross section in order to realise mechanical strength and reliability. In the particular form of the invention I describe, the detectors consist of three strands of copper wire each 0.029 inch diameter.

When a building is sub-divided into a number of sections, as previously mentioned, each with its own installation, I may use a single magnetic amplifier having as many signal input circuits as there are sections. The advantage of this arrangement is a gain in sensitivity of the response to a fire condition for the reason that the multiple signal inputs to the amplifier are additive.

It will be seen that under the slow temperature variations from normal causes, there will not be sufficient temperature difference between the wires to upset the balance of the Wheatstone bridge in a degree necessary to bring about closure of the relay contacts, and the equipment is equally suitable for use in hot and cold climates. Under a fire condition however, the bare wire rises in temperature and resistance more quickly than does the insulated wire and a considerable difference in the relative resistance of the wires results.

In a building having a curved roof, hot gases tend to accumulate along the centre line of the building, whatever the location of the fire, and therefore the best location for the wires is along the centre line of the building or bay and the bare and covered wires should be mounted close together. With a flat roof, the location of the wires is of little importance and the wires need not be close spaced. With a saw-tooth roof, the wires may be run along each bay, or along some of the bays, according to size, with close spacing of the wires. In the case of a small room, it may be necessary to arrange the wires in the form of a very open grid under the ceiling, in order to obtain the desirable length. Short wires would be effective, electrically, but would need to be of fine diameter and so lack robustness.

It will be appreciated that an installation in accordance with our invention may be given any desired rate of response to fire by varying the value of the current flowing in the roof wires and/or by varying the amplification of the signal current taken from the bridge. A highly sensitive response is usually desired so that the installation will operate when the outbreak of fire has caused the temperature of the bare wire to be increased by only a few degrees Fahrenheit, as compared with the covered wire. It is therefore obvious that if doors or windows of a heated building are opened, an inrush of cold air could quickly cool the bare wire to such an extent as

to cause the generation of a signal current from the bridge of sufficient amplitude to bring the installation into operation, in the absence of any provision to the contrary. Such a happening would be intolerable and it is an essential feature of our invention that the installation operates only when the bare wire is heated and not when it is cooled, relatively to the covered wire. As explained previously herein the means we adopt to detect and utilise the change in resistance is polarised so that the relay contacts close only when the bare wire is heated relatively to the covered wire and not when it is cooled.

Although we prefer to connect the bare and covered wires to constitute two arms of a Wheatstone bridge, and prefer to employ a magnetic amplifier for amplifying the signal from the bridge, our invention can be put into effect in other ways.

For example, we may use a sensitive relay for direct operation from the bridge signal without amplification of the signal or we may amplify the signal in known manner by the use of thermionic valves. Alternatively, we may dispense with the bridge and use a polarised differential magnetic amplifier with the opposing coils connected in series with the bare and covered wires: normally, the current in the two coils would be substantially the same but in the event of fire it would be appreciably different on account of the increased resistance of the bare wire bringing about a reduction in the current flowing through it. In another alternative, when we dispense with the bridge, we employ a sensitive polarised differential relay, with the opposing coils connected in series with the bare and covered wires.

In particularly corrosive situations we may apply a thin coating of varnish or enamel to the member we herein call the bare wire, in order to protect it against corrosion during such times as the installation may not be in commission. We find from actual tests that the resistance to heat flow of a thin coating of varnish or enamel is largely or wholly offset by the improved heat absorption, as compared with a bright metal surface, so that a varnished or enamelled wire can be as effective for our purpose as a bare wire.

The constant consumption of electricity which the device requires is small and has the important advantage that there is a gentle warming of the roof wires and associated equipment which tends to prevent condensation and corrosion and to preserve the electrical insulation in good condition.

The invention is applicable in all cases where it is desirable for the rate of response to an outbreak of fire to be in proportion to the rate of increase of temperature and not to the absolute temperature attained.

In large buildings the fire detection apparatus

and deluge may be installed in sections in order to avoid unnecessary water discharge, in the event of a small outbreak of fire.

Many buildings, e. g aircraft hangars, are very high, and a fire at floor level results in a fairly wide-spread temperature increase in the roof or at ceiling level without any large rise in temperature at one point. An advantage of the fire detection apparatus according to this invention is that the wires are dispersed over a large area and will respond to a general through small rise in temperature whereas known devices will respond only to a concentration of heat. Nevertheless, the fire-detection apparatus described herein responds equally rapidly when only a short length of the wires is affected by a concentrated outbreak of fire.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

A fire detection apparatus comprising two wires forming a pair of parallel loops extending throughout an area to be protected in positions in which the said loops are equally exposed to heat resulting from the outbreak of fire, one of said loops being capable of being heated more rapidly than the other and thereby changing the relative resistance of the two loops and the relative flow of current through them; a Wheatstone bridge having one of its arms interconnected with and embracing one of said loops and having another of its arms interconnected with and embracing the other of said loops; said bridge being connected to an electrical power source and to means for detecting a predetermined decrease in the current flow in one loop; the last said means including a differential polarized magnetic amplifier from which a predetermined output energizes a relay to close a circuit to a solenoid and thereby effect the giving of an alarm; the said predetermined output being produced by a change in the impedance of said amplifier occasioned by the change in current flow in the said loop which is more rapidly heated.

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