A NEW AUTOMATIC FIRE ALARM.*

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SO MUCH has been published in recent years in regard to the enormous annual loss from fires that nearly every one knows the magnitude of the problem and the importance of adequate fire protection. One result has been the extension of the use of sprinkler systems, and it is unquestionable that these have greatly reduced the fire losses. However, for obvious reasons there are many places where the installation of sprinkler systems is not feasible and where, nevertheless, the use of some form of fire protection is desirable. Moreover, even where the sprinkler system is in use it is important that an alarm of fire should also be given, and if this can be made automatic—so much the better.

For more than a year a very ingenious device for use as an automatic fire alarm has been the subject of considerable research work in this laboratory, and it is believed that a detailed description of it and its method of manufacture will be of interest.

GENERAL PRINCIPLE.

The fire alarm is manufactured by the General Fire Alarm Corporation, and is the invention of Mr. Eugene Garretson. It consists in the use of a thermoscope in which the active element is a substance having a negative temperature coefficient of electrical resistance. The thermoscope forms part of an electric circuit, which also contains an alarm gong and indicating device, but has such a high resistance under normal conditions that the current passing through the circuit is not sufficient to work the alarm. If, however, the temperature of the air surrounding the thermoscope rises to a certain degree the electrical resistance drops so as to permit the passage of sufficient current to give the alarm.

In Fig. 1 is shown the wiring diagram of a fire detector for two stations. The source of the current for the circuit is shown

* Communicated by the author.

at G , the alarm gong at B , and relays with drops at R_1 and R_2 , corresponding to the two stations protected with the series of thermoscopes T_1 and T_2 respectively. If the circuits are traced it is seen that they are complete only through the normally high resistance thermoscopes, and consequently the current is not sufficient to trip the relays nor to release the mechanical gong. Suppose, however, that a fire occurs in the room where the thermoscopes T_1 are installed, the resistance of one or more of these will be sufficiently lowered to permit the passage of current that will trip the relay R_1 , thus indicating where the fire is and closing absolutely the alarm gong circuit.

FIG. 1.

Fire alarm circuit.

THE THERMOSCOPE.

So far as the general principle of the invention is concerned, it is plain that a large number of substances might be used as the sensitive element of the thermoscope,—in fact, any substance with a negative temperature coefficient; but for practical purposes the substance should have other qualities than the mere possession of a negative temperature coefficient.

A thermoscope of this kind should have the following characteristics:

- (1) A very high resistance at ordinary temperatures.
- (2) A large temperature coefficient, so that a small increase in temperature produces a large decrease in resistance.

(3) Its heat capacity should be small, so that as the resistance drops the increase in current, even though a very small one, passing through the thermoscope tends to heat it, and thus greatly increases the sensitiveness of the detector as the critical temperature is approached.

(4) Its characteristics should be permanent under all conditions to which it is apt to be exposed.

One of the best of the substances which have been found for this purpose, and to which Mr. Garretson applies the general name *thermitite*, is a preparation of silver sulphide.

ELECTRICAL PROPERTIES OF THERMITITE.

Before considering the properties of *thermitite* as investigated in this laboratory it will be well to describe the thermo-

FIG. 2.

Thermoscope.

scopes as made for use in practice, as most of the tests which will be described were made with these. In Fig. 2 we have a cut showing a thermoscope, actual size. The mount is made of glazed porcelain and carries a threaded brass shell which screws into a socket just as in the case of an ordinary incandescent lamp. The *thermitite* strip has copper wires fused to its ends, and these are soldered to the contacts.

If one of these thermoscopes is put in a circuit with a small six-volt tungsten lamp and three dry cells connected in series the lamp will not light up; but if a lighted match is held under the *thermitite* the lamp almost instantly begins to glow with full candle-power. If the match is removed and the piece of *thermitite* cooled in any way the lamp is extinguished.

This, however, would not be the method when using the *thermitite* for a fire alarm, since that substance is an electrolyte, and, even though a solid, electrolytic changes might be expected were a direct current used in the circuit. That electrolysis does occur may be shown by the following experiment:

A piece of *thermitite* provided with silver electrodes was placed in a direct-current circuit for some time. Then the *ther-*

FIG. 3.

mitite was cut out of the circuit and the electrodes connected to the terminals of a sensitive galvanometer which was immediately deflected, showing the generation of a current in the opposite direction to that which had been passed through in the direct-current circuit.

The experiment clearly shows a phenomenon-like polarization in an ordinary electrolytic cell. Obviously, then, in the use of

thermitite as a thermoscope an alternating current must be used. It also indicates the necessity of using an alternating current in any attempt at making measurements of the electrical resistance of the thermoscope. The study of the behavior of silver sulphide as an electrolyte must be reserved for a future paper, as the work on it is not yet complete, for it was necessary first to develop a commercial thermoscope rather than make a complete investigation of the electrical properties of the *thermitite*.

An investigation of the change of resistance of *thermitite*

FIG. 4.

Conductance curve.

with temperature has been made with the express object of studying its action when used as a thermoscope. For this purpose a bridge was used, the current being supplied by a small induction coil and a high-resistance telephone receiver taking the place of a galvanometer. The thermoscope was immersed in an oil-bath heated by a coil of wire through which a current was passed. A rheostat was used to regulate the current so that the temperature of the oil-bath, which was kept thoroughly stirred,

could be controlled. The result of one of these experiments is given in the curves of Fig. 3 and Fig. 4, where the abscissæ are degrees Centigrade and the ordinates are mhos $\times 10^{-6}$.

Referring to Fig. 3, the curve shows the increase in conductance from 4.3×10^{-6} mhos at 21° to 143×10^{-6} mhos at 104° . Then a very abrupt change was observed, for at 105.5° the conductance was 5880×10^{-6} mhos. This sudden change is shown best in the curve of Fig. 4, which is from the same observations, but plotted on a different scale.

Now it is not pretended that the curves shown in Fig. 3 and Fig. 4 represent the true conductance of the thermoscope at the corresponding temperatures. The temperatures are those of the oil-bath and not of the *thermitite* itself, which may be higher, due to the passage of the current. The important point, considering the use of the *thermitite*, is that at a certain temperature in an electric circuit an enormous increase in its conductivity occurs.

In order to form some idea of how the thermoscope behaves when heated in air a different test is used. The circuit is similar to that shown in Fig. 1, and the thermoscope is put in an oven heated by means of a coil of nichrome wire through which a current controlled by a rheostat is passed. The temperature of the oven is raised until the alarm is given. This is found to be at approximately 80° C. It is obvious from this test that the temperature at which the alarm is given is not the temperature of the *thermitite*, but merely that of the surroundings. This may be seen from the following calculations. In order to trip the drop of the 80-ohm relay a current of 0.04 ampère is required. The e.m.f. of the circuit is 6 volts, consequently the resistance of the circuit at the moment the relay works is

$$\frac{6}{0.04} = 150 \text{ ohms,}$$

but the resistance of the relay is 80 ohms, consequently that of the thermoscope is only 70 ohms. The oil-bath test showed that at 80° the resistance of the thermoscope was 19,000 ohms, so it is plain that its temperature when the alarm is given is very much higher than that of the surrounding air. This, of course, is due to the heating effect of the current. Here we have an explanation of the great sensitiveness of the thermoscope, for it

does not simply depend upon the heating effect of the air to cause it to give the alarm. Indeed, it would be more accurate to say that the thermoscope fails to give an alarm because of the cooling effect of the surrounding air, and that when this cooling effect is removed the thermoscope becomes a good conductor and turns in an alarm.

MANUFACTURE AND TESTING.

The process of manufacturing the thermoscopes is simple. The *thermitite* is made in sheets 0.5 mm. thick, and from these oval-shaped pieces 10 mm. long and 5 mm. wide are punched out. Short pieces of No. 26 (B. and S. gauge) copper wire are fused to the ends of these oval pieces, and they are then put in the porcelain mounts.

Every batch of *thermitite* is tested by finding the oven temperature at which the thermoscopes made from it ring in the alarm. The *thermitite* is also tested in an oven heated to 65° C. to make sure that even at temperatures near the critical one it will not break down. Finally, all thermoscopes are mounted in large testing boards and kept under observation for at least one month to discover if any defects develop.

FIRE TEST.

The tests for practical work are made as follows: In a room fitted with the thermoscopes a cone made of asbestos board is moistened with about 50 c.c. of alcohol, placed on the floor under a thermoscope, and the alcohol ignited. This is quite sufficient to give the alarm, although a dial thermometer mounted beside the thermoscope fails to show more than a rise of 5 degrees C. in the temperature, nor after repeated tests has the slightest effect been observed on the varnish with which the wooden ceiling of the room is coated. No doubt, if the asbestos cone was not placed directly under the thermoscope it would be necessary to use a larger quantity of alcohol, but the test as performed shows that before the hot air about the thermoscope can even scorch varnish or cause a dial thermometer to register more than a few degrees rise in temperature the alarm is given.

PERMANENT CHARACTER.

In order to find out if the thermoscopes were permanent, some were mounted out of doors, where they would be exposed to all conditions of weather, with entirely satisfactory results. To test resistance to the action of chemicals several thermoscopes were mounted on the ceiling of our chemical laboratory where they are exposed to the acid fumes, etc., characteristic of such a room, and no deterioration has been observed.

CONCLUSION.

As a result of the study of the thermoscopes it appears that for use as a fire alarm they are highly satisfactory for several reasons. They are extremely sensitive, because the immediate cause of the heating of the *thermitite* is the electric current of the circuit, and this is prevented simply by the cooling effect of the surroundings under normal conditions. Any heating of the surroundings not only raises the temperature of the *thermitite* by the heat which these give off, but at the same time increases the flow of current and consequently increases the heating effect. When the resistance is diminished one-half the current is doubled, and, since the heating effect is proportional to the product of the square of the current and the resistance, the heating effect is doubled. In fact, the system might be described as being always in a state of unstable equilibrium.

The construction of the whole system is extremely simple, being practically equivalent to an ordinary electric bell equipment with the thermoscopes replacing the push-buttons. The thermoscopes themselves are so simple in construction that they can be treated much as are incandescent lamps. Thus, enclosed in a suitable cage they may be attached to extension cords and put in places otherwise difficult to protect, such as in the cargo stowed in the holds of ships.

The tests of the *thermitite* show its permanent character. Outside of mechanical breakage the only possibility of failure is in the direction of a lowering of the electrical resistance, which would automatically indicate that there was trouble at that point.

Finally, before closing it may be of interest to note that a new use of the thermoscope as a detector of hot bearings is at present the subject of further research.