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A FIRE DETECTOR FOR LARGE TRANSFORMER INSTALLATIONS

by

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Summary

A fire in a large transformer installation is much more readily extinguished in its early stages, and it is therefore important to detect such a fire as early as possible. It is suggested that a suitable detection system could be based on an infra-red photo-cell, and the applications of cold cathode triodes and transistors is discussed.

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Introduction

Large power transformers usually include substantial quantities of oil for cooling purposes. In the event of fire, it is the oil which is the principal fuel and the development of the fire can be very rapid.

Methods of extinguishing such a fire have been investigated (1) and it has been stressed that the fire will be most readily extinguished in its early stages before the metal and other solid parts of the installation have attained high temperatures. Rapid extinction is, of course, also desirable to reduce the damage caused by the fire. Thus a means of early detection is most desirable.

Review of possible methods

The rise in temperature caused by a fire is normally used to operate fire detectors. These detectors are, however, generally most sensitive to convected heat and to give an alarm they must be either in the flames or in the stream of hot gases from a fire. In the case of a transformer fire there is often no "ceiling" to divert the hot gases past the detector and with transformers in the open varying wind conditions would deflect the hot gases even if a false ceiling were possible. Thus to detect a small fire in a transformer using detectors sensitive to convected heat, a large number of heads are required to ensure that at least one of them will be in the flames or heated gases. This is, however, the most common system used in this country and sprinkler heads, which may be expected to operate in 15 - 30 secs. under the most favourable conditions, are used as detectors.

A particular feature of any fire involving a flammable liquid such as transformer oil is that flaming combustion will occur from the onset and give an immediate increase in radiated heat. The use of detectors sensitive to radiation would therefore seem to be a good alternative. Such detectors can give a wide angle of cover but as with an optical system, cover will only extend in the line of sight of the detectors. The limiting sensitivity in a simple system is set by the requirement that the head shall not be operated by changes in the ambient level of radiation that might be caused by the sun or by changes in the operating temperature of the transformer. Higher sensitivities can be achieved by compensating for these changes of radiation or by detecting only the flicker in flame radiation which has been found by Roeser and McCamy, to have a maximum in the frequency range 3 to 15 c/s (2), (3).

The chemical and physical nature of the gases within and above a flame zone differs from that of atmospheric air and this fact might form the basis of a detector. One detector depending on this principle employs an α particle ionisation source. The introduction, into it, of heavy smoke particles reduces the level of ionisation and hence operates an alarm. However, any systems based on these principles would suffer from the same disadvantage as a system sensitive to convected heat, since the heads would have to be in the heated gas stream.

A suggested detector

A detection system sensitive to radiation would have the advantage over the other methods discussed in that only a small number of heads would be required to protect a transformer. The radiation from a flame is greatest in the region of 1 to 5 μ and hence a lead sulphide photo-cell would be suitable.

The output of a lead sulphide cell requires amplification before it will operate a relay and the order of impedance associated with the cell makes the use of a cold cathode triode convenient. A suitable circuit is illustrated in Figure 1. The sensitivity may be controlled by the potentiometer R_3 and could be set so that the cold cathode triode will not fire at the highest levels of ambient radiation and at the highest ambient temperatures likely to be encountered in practice. Where increased sensitivities are required the resistor R_2 may be replaced by a second photo-cell with similar characteristics, both being subjected to the same levels of ambient radiation and temperature. Radiation incident only on P.C.1. will then operate the cold cathode triode.

Using a Mullard 61 SV photo-cell and a Hivac XC 18 cold cathode triode the order of sensitivity easily attained was such that a fire in a tray of petrol of surface area 12 in^2 could be detected at a range of 15 ft.

The cold cathode triode in the above circuit gives the advantage of a thyratron in that it provides a simple latching circuit and yet is much more reliable than a heated cathode electronic valve.

Whilst the impedance of the lead sulphide cell has suggested the use of a cold cathode triode a transistor is an even more reliable device. Recent technological advances, such as the development of the silicon transistor, with its low collector leakage current and ability to operate at higher voltages make the applications of transistors in this field very promising. The order of impedance associated with the recently developed indium antimonide photo-cell make it likely that this type of cell would be the most suitable for use in conjunction with transistors. It might even be, however, that a lead sulphide photo-cell would operate a relay direct from a common emitter single stage amplifier or would trigger, directly, a bistable circuit. Such possibilities are worth exploring.

Conclusion

Fires in large transformer installations can probably be most readily and economically detected by the use of infra-red sensitive photo-cells in conjunction with cold cathode triodes or transistors.

References

1. RASBASH, D. J. and STARK, G. W. V. Design of sprays for protective installations. Part II. The extinction of oil fires on banks of tubes. Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization. F. R. Note No. 303/1958.

2. LOVANT, M. Problems of Detection in aircraft engine spaces. Fire. 49, 621, March, 1957, pp 516, 548.

3. Fire detection in aircraft engine spaces. Technical News Bulletin. U.S. Bureau of Standards 1957, 41 (1) 8 - 10.

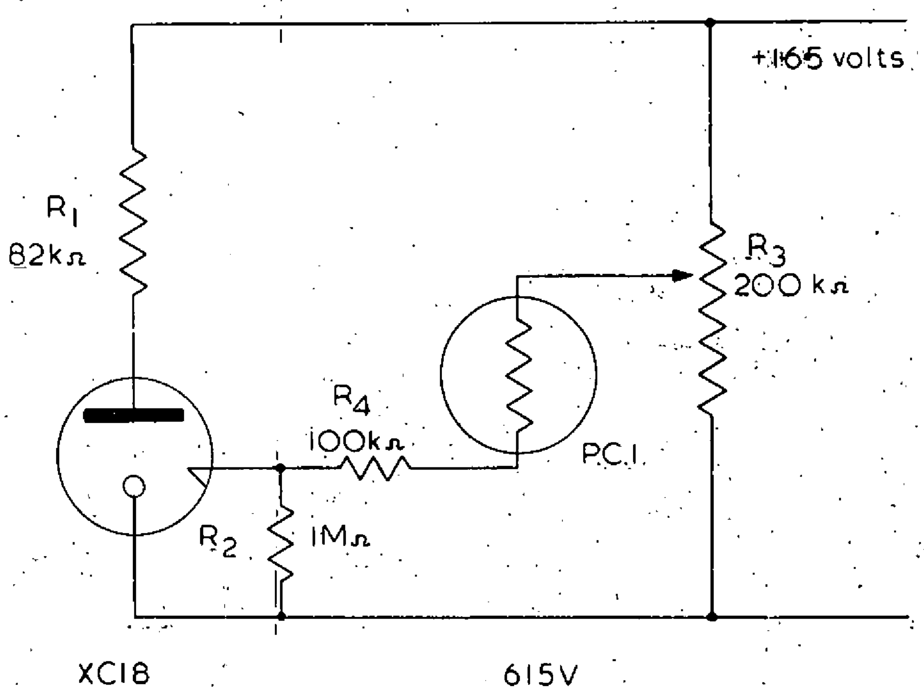

FIG. 1. CIRCUIT DIAGRAM OF DETECTOR.

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