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FIRE WARNING DEVICE

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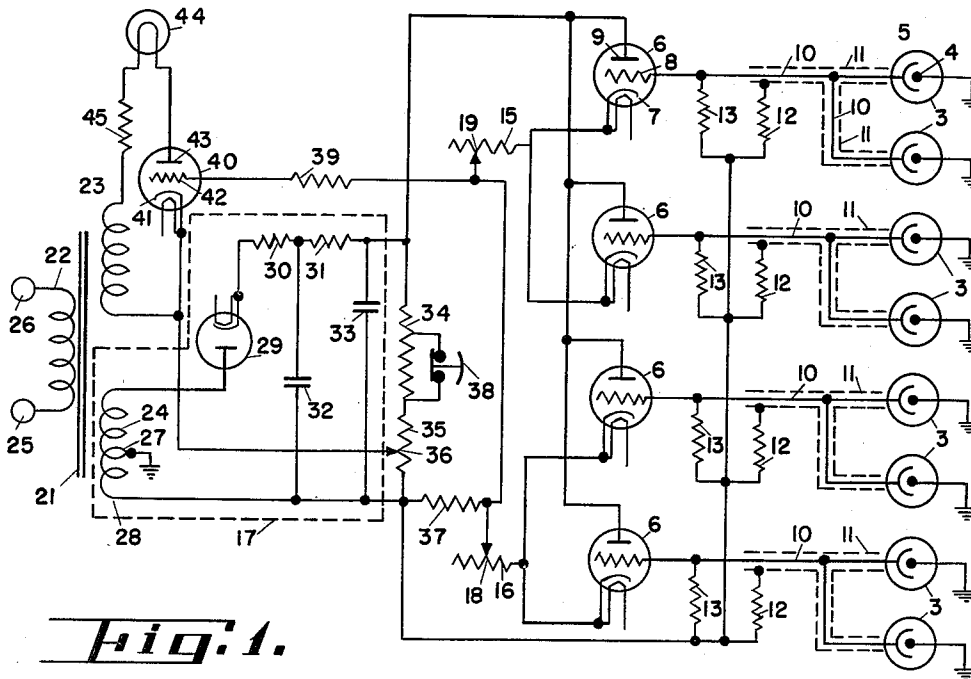


**Fig. 1.**

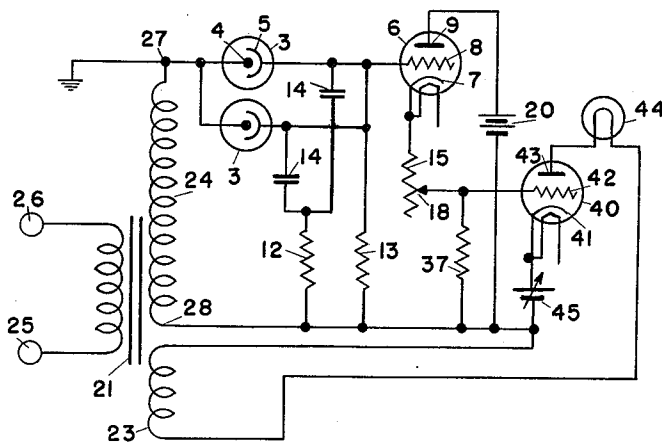


**Fig. 2.**

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## UNITED STATES PATENT OFFICE

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## FIRE WARNING DEVICE

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5 Claims. (Cl. 177-311)

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This invention relates to fire detection and, in particular, to fire alarm devices suitable for use on vehicles, such as aircraft.

The problem of fire protection in vehicles, particularly in aircraft, involves many factors not present in stationary fire alarm installations. A fire in an airplane engine, for example, is likely to result in total destruction of the craft unless the proper fire fighting measures are quickly applied. Instant operation of the fire alarm system upon the first occurrence of flame is, therefore, imperative. Exceptional reliability is required in such a system, because, on the one hand, its failure to operate may result in loss of the airplane and the personnel aboard, and, on the other hand, a false alarm may necessitate a forced landing. To insure reliability, it is essential to eliminate the possibility of false operation due to vibration or to ambient temperature fluctuations, and to construct the system so that failure or destruction of one of the detecting elements, a number of which are ordinarily located in the danger region, neither affects the operation of the remainder of the system nor results in a false alarm. Considerations of weight and space are also of primary importance.

The fire alarm system used heretofore in aircraft have depended on thermally operated switching devices or fusible elements for flame detection. Since devices which depend on secondary heating effects for their operation are subject to inherent delay and are influenced by local conditions of heat transmission, it has been found that radiation sensitive devices, such as the photoelectric cell, or the lead sulphide semiconductor, which are excited directly by radiation from the flame, offer a far more satisfactory solution to the essentially three-dimensional problem of fire detection. A radiation sensitive device of this type is used in conjunction with an amplifier circuit which operates an electrical control or indicator in response to excitation of the device. For use in aircraft, such a circuit, in addition to providing the necessary operational characteristics, must be relatively simple, and stable in operation. If a number of detecting elements are connected to a common amplifier, it may be necessary to adjust the sensitivity of the detecting channels independently, to allow for different ambient light levels at the various detecting stations.

The object of this invention is to provide an electrical fire alarm system, employing radiation sensitive detecting elements, which is fast and reliable in operation, which is insensitive to vibration, ambient temperature, and line voltage

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fluctuations, which is unaffected by damage resulting in either short or open circuit in a detecting element or its connecting cable, which allows for independent sensitivity adjustment of the various detecting channels to compensate for difference in ambient light conditions, and which requires a minimum number of electrical components.

These and other objects, advantages and features will be apparent from the description with reference to the drawings, in which:

Fig. 1 is an electrical diagram of the circuit for a complete fire protection system according to the invention; and

Fig. 2 is a simplified diagram illustrating one of the detecting channels of Fig. 1.

Referring to Fig. 1, a number of phototubes 3 may be located in the space to be supervised, for example, in the engine nacelle of the aircraft, so as to receive radiation from flame arising anywhere within a selected region. Two or more phototubes may be connected in parallel and located remotely from the remaining circuit components. Each phototube shown in the drawing is connected by a cable 10 to the grid 8 of an amplifier tube 6 which is employed as a cathode follower. The cable 10 is surrounded by conductive shield 11 which is connected in series with resistance 12. The cable 10 and resistances 12 and 13 together form an input network to grid 8 similar to the network comprising resistance 12, capacitance 14 and resistance 13 in Fig. 2. The system is supplied with alternating current at terminals 25 and 26, across which is connected primary 22 of transformer 21.

In Fig. 1 the cathode follower tubes 6 are shown connected in parallel in pairs, the upper pair being connected to the cathode follower resistor 15, and the lower pair to cathode follower resistor 16. A direct plate voltage is supplied to tubes 6 by a conventional direct current power supply, generally indicated as 17, energized by secondary 24 and comprising rectifier tube 29, and a filter network consisting of condensers 32 and 33, and resistors 30 and 31. The direct current output is applied across load resistances 34 and 35 which are connected in the plate circuits of tubes 6.

A tube 40, which is preferably of the hot cathode gas discharge type, is supplied with an alternating plate potential by secondary 23. The control grid 42 of tube 40 is connected through limiting resistance 39 to one end of resistance 37, which acts as an input resistance to tube 40. An initial negative bias is applied to the grid 42

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by the section of resistance 35 between its lower end and tap 36.

The operation of the circuit can best be understood with reference to Fig. 2, which illustrates a single detecting channel. In Fig. 2, for the purpose of simplifying the explanation of the circuit, power supply 17 of Fig. 1 may be considered as replaced by a battery 20, and the section of resistance 35 between its lower end and tap 36, which provides the initial negative bias on the grid of tube 40, as replaced by a variable bias battery 45. In this circuit when the phototubes 3 are dark, no current flows across the input network consisting of resistances 12 and 13, and capacitance 14 which represents the cable capacitance between cables 10 and shields 11, and the bias on grid 8 is entirely supplied by cathode follower resistors 15 and 37. The small initial current which flows through tube 6 under this condition is stabilized by the presence of the cathode follower resistors which apply a compensating bias change to grid 8 when changes in the plate current of tube 6 occur. The adjustable tap 18 is so positioned that the positive bias applied by resistance 37 to grid 42 is not sufficient to overcome the bias applied by battery 45. Tube 40 is non-conductive and signal lamp 44 or other load device, which is connected in the output circuit of tube 40 is, therefore, not energized.

If the phototubes 3 are subjected to ambient light, current flows through them on alternate half cycles charging capacitances 14 so as to apply a positive bias to grid 8. The initial current, through tube 6 under these conditions, is larger than when the phototubes are dark, but remains stable because of the cathode follower connection. Tap 18 can be adjusted so as simultaneously to increase the load resistance in the plate circuit of tube 6, thereby cutting down the plate current, and to reduce the proportion of the output applied as bias to grid 42, so that tube 40 can be maintained in the non-conductive state with a reasonable normal level of illumination at the phototubes. If the excitation of one of the phototubes is suddenly increased, as by the outbreak of flame within the supervised area, the charge on the associated capacitance 14 is considerably increased, raising the potential of grid 8. The cable capacitance for normal lengths is relatively small so that the full charge is built up within less than a second. The D. C. signal which is applied across load resistance 37 then raises the potential of grid 42 sufficiently to make tube 40 conductive on alternate half cycles and signal lamp 44 is illuminated. The lamp, therefore, gives an indication of the presence of flame in the space supervised by either or both of the phototubes 3. If one of the phototubes should become open-circuited, that detecting branch drops out of action, but the other phototube may impress a signal on the system in the normal manner upon occurrence of flame. If the phototubes are short-circuited or bridged by a leakage resistance which is low in comparison to the dark impedance of a phototube, alternating current flows across capacitance 14 so that no charge is built up. The alternating potential across resistance 13 gives rise to an intermittent current in the plate circuit of tube 6. As will be seen from the arrangement of secondaries 23 and 24, however, the resulting potential across load resistance 37 is 180° out of phase with the plate voltage of tube 40 and tube 40 therefore remains non-conductive. A short circuit across a capacitance 14, which is equivalent to a short-circuit between the cable 10 and

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its shield 11, results in a similar intermittent current across resistance 37.

The circuit as shown in Fig. 2 has two independent adjustments for the sensitivity of tube 40. For example, the initial bias can be adjusted by means of battery 45, and the potential applied by load resistance 37 can be adjusted by moving tap 18.

Referring back to Fig. 1, it will be seen that the sensitivity of the upper branch of the circuit, comprising the upper pair of cathode follower tubes 8, connected to resistance 15, can be adjusted by tap 19, and the sensitivity of the lower branch, comprising the pair of cathode follower tubes 6 connected to resistance 16, can be independently adjusted by tap 18.

From the description of operation with respect to Fig. 2, it will be apparent, therefore, that in Fig. 1 any defect or failure in one of the detecting branches results only in loss of signal from the defective branch. The operation of the remainder of the detecting elements being unaffected, the strength of the signal applied to grid 42 for a given light by any one of the four lower phototubes depends upon the adjustment of tap 18, while the strength of the signal applied to the grid tube 42 for a given light intensity of any one of the 4 upper phototubes 3 may be adjusted independently by tap 19. The circuit shown, therefore, has two independently adjustable sensitivity levels. Any desired number of detecting branches may be added in each sensitivity level, and any desired number of sensitivity levels may be added, by connections similar to those shown. Regardless of the number of detecting channels used in the system, no current will flow through tube 40 unless one or more of the phototubes is illuminated and its associated circuit is in proper operating condition.

In the circuit of Fig. 1, adjustment of the initial negative bias on tube 40 is provided by tap 36 on the power supply output resistance 35. A normally closed push-button 38 shunts out part of resistance 34. If the push-button is temporarily depressed, the resistance of the power supply output circuit is increased and a decrease in output current results. The bias applied by tap 36 to grid 42 is, therefore, decreased. In setting one of the taps 18, 19 to compensate for the ambient light level at the phototubes, the push button 38 is depressed and the tap 18 (or 19) adjusted until signal light 44 just goes out. When the push button 38 is released, a fixed amount of additional negative bias is applied to grid 42, so as to give a predetermined safety margin which must be overcome before the tube 40 will respond to increased excitation of one of the phototubes. Reliability of the system is thus greatly increased by eliminating false alarms due to slight fluctuations in ambient light at the phototubes.

Reliability of the system regardless of appreciable line voltage fluctuations is insured by the stabilizing effect of tap 36. If the line voltage increases, the output current of the power supply increases and the corresponding increase in the negative bias applied by tap 36 to grid 42 compensates for the rise in plate voltage across tube 40 and prevents the tube from conducting.

From the foregoing description, it is apparent that a device constructed according to this invention provides substantially instantaneous detection of fire, and is reliable and stable to a high degree under severe operating conditions. The system contains no moving parts and so is not subject to vibration effects. Since a relatively small number of electrical components, them-

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selves negligible in size and weight, is adequate for supervision of a large space, the device is ideally suited for use on aircraft or other vehicles. The fact that the system continues to operate as long as one detecting channel remains intact is of crucial importance in aircraft, as the system will continue to provide a considerable measure of fire protection in spite of severe damage from engine failure, previous fire, enemy action, or other causes.

Since certain changes may be made in the above described article and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative only and not in a limiting sense.

**What is claimed:**

1. A fire detection device comprising: a plurality of detecting branches, each of which comprises an electron discharge device having an anode, cathode, and control electrode, a direct current source connected between said anode and cathode, a capacitance connected between said cathode and control electrode, and connected in series with said capacitance, a first alternating current source and a radiation sensitive element adapted to pass a rectified current when exposed to radiation; an electronic amplifier tube having input and output terminals; a common load resistance connected in the anode-to-cathode circuits of all said discharge devices and also connected to the input terminals of said amplifier tube; and, connected between said output terminals, an electrical signalling device and a second

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alternating current source, the phase of which is substantially opposite to that of said first alternating current source.

2. A device according to claim 1 wherein said direct current source comprises, in series connection, an alternating current source, a rectifier tube, and means for applying an initial negative bias to said input terminals.

3. A device according to claim 1 wherein said direct current source comprises, in series connection, an alternating current source, a rectifier tube, means for applying an initial negative bias to said input terminals, and a resistance shunted by a normally closed switch.

4. A device according to claim 1, each of said detecting branches including a cathode follower resistance in its cathode circuit.

5. A device according to claim 4 having means for independently varying the magnitude of each of said cathode follower resistances.

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