Oct. 26, 1954 A. G. B. METCALF 2,692,982

FIRE DETECTION APPARATUS

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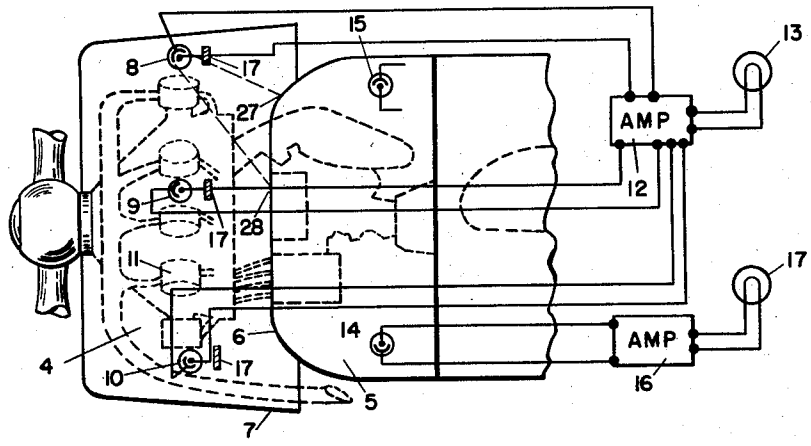


Fig. 1.

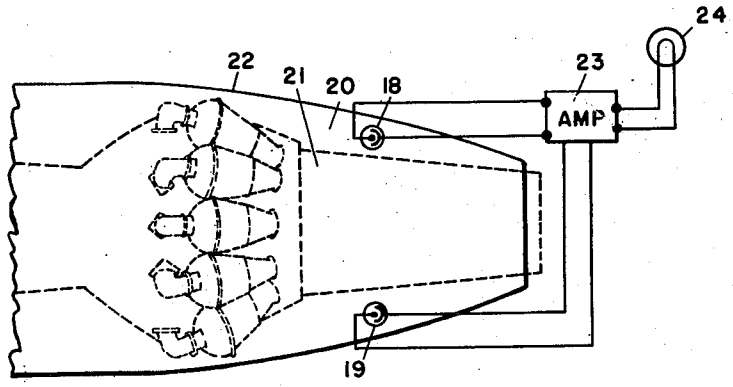


Fig. 2.

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FIRE DETECTION APPARATUS

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3 Claims. (Cl. 340—227)

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This invention relates to fire detection and prevention in vehicles, particularly in aircraft.

The airplane is not only inherently subject to fire hazards not common to other vehicles, but, in addition, peculiarly vulnerable to fire. The very factors which promote flying efficiency, for example, lightness of structure, reduction in the weight and frontal area of the power plant, the use of light metals, which have poor heat resistance, and improvement in the volatility of fuels, necessarily increase the danger of fire. High altitude flying has introduced new hazards, such as arcing in electrical systems, and inadequacy of cooling in air-cooled engines, and has given rise to the requirement for supercharging and oxygen supply systems which are in themselves potential sources of fire.

The modern airplane is a complex assembly often powered by several engines, and equipped with a vast number of intricate electrical, hydraulic and mechanical devices for performing the various indicating, control, and communication functions necessary for operation and navigation of the craft. Stringent space requirements dictate that large quantities of high octane gasoline be carried in wing tanks, in proximity to the engine nacelles. While considerable research and effort has been directed toward minimizing fire hazards in the design and arrangement of electrical and hydraulic systems and toward the development of fireproof fuel tanks, it is inevitable that increasing complexity of any mechanism which utilizes highly combustible fuels should result in an increasing probability of fire. The hazard is aggravated in the case of the military airplane by the carrying of explosives and exposure to enemy gunfire.

As a result of extensive investigation by military and civilian authorities, both in this country and abroad, it has been determined that the fires most disastrous and difficult to control, that is, fires occurring in flight, usually start in the engine, and that such fires can be extinguished in flight without serious damage to the airplane if the pilot is warned of the fire and applies the proper fire-fighting measures in time. The need for quick action and especially for quick detection has been dramatically illustrated in several known instances where fire in an engine nacelle has caused wing failure in less than a minute after the fire started and before the pilot was aware that his engine was on fire. In short, one of the major conclusions to be drawn from such investigations is that the virtual elimination of serious accidents due to fire in flight, with the resulting incalculable saving in lives and property, can be achieved, and at present requires only the development of a reliable alarm system capable of instantly detecting the outbreak of fire. In such a device, reliability is as important as quick action. The usual fire fighting procedures involve shutting down the engine, which may necessitate a forced landing. It can be readily appreciated that one or two such experiences as a result of false alarms may lead pilots to disregard the fire warning system.

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Experiments have been made with a variety of fire alarm devices and several types are currently used on aircraft. The detecting elements may be generally classified as thermocouples, thermal expansion switches, and fusible elements. The fundamental disadvantage of such elements for fire detection purposes is that they are temperature-responsive, rather than flame-responsive and therefore subject to an inherent time delay which may vary considerably, depending on the distance of the element from the flame and on local conditions affecting heat transmission. To ensure reasonably quick operation, temperature-responsive elements must be placed in the engine so as to be downwind from and fairly close to the possible sources of fire, and, for this reason, the elements themselves are usually destroyed when fire occurs. Care must be taken, also, to ensure that detecting elements are not so located as to be cooled by air currents, as, under such conditions, these devices have failed to give warning of a serious fire burning only a short distance away. This difficulty can be minimized only by exhaustive experimentation with each new type of engine installation to determine the proper location of detecting elements, and the use of a large number of detecting elements. The thermocouple types of detectors and some of the thermal expansion types require frequent, delicate adjustment and must be used with sensitive circuits which are unstable in operation. Being essentially mechanical switching devices, they are susceptible to vibration and acceleration. The fusible type is additionally objectionable because it is destroyed on operation and must be replaced, and does not permit checking of the system. In order to provide anything approaching complete fire protection, a large number of such elements, spaced not more than a few inches apart, would be required all around each engine. An alternative, the continuous strip element of the fusible type, is now considered by aircraft authorities to be obsolete because of many inherent drawbacks in its use. Since the weight of the elements themselves and the wiring for such complete protection would be prohibitive, the present fire detection systems on aircraft necessarily represent a compromise between weight and safety considerations.

Furthermore, the development of jet propulsion for aircraft has given rise to a fire detection problem for which the thermally operated systems are wholly inadequate. In comparison to a reciprocating engine of comparable power, the potential danger area of a jet engine is considerably greater, and the normal ambient temperature in the engine nacelle is considerably higher. Moreover,

excessive cooling of the jet pipe is to be avoided, as efficiency is dependent on maintaining a jet temperature as high as the internal metal parts will withstand. Insulation between the engine and the surrounding structure is ordinarily provided only by a relatively narrow air-gap between the engine itself and a conical metal shroud. It is apparent that, with such an arrangement, the occurrence of fire, upon failure of a high pressure fuel line or turbine blade, for example, is likely to be so rapid and localized that even very closely spaced thermal detectors would fail to respond in time to prevent severe damage to the airplane. Difficulty from false alarms are also encountered because of the rapid temperature fluctuations and the small differential between normal operating and excessive temperature.

It is accordingly the object of this invention to provide a fire detection system, especially suitable for aircraft, which, although light in weight as compared to systems now in use for the purpose, is reliable and stable in operation, which responds instantly, which affords complete coverage of the danger area on all types of airplane engines, including many locations inaccessible for thermal detectors, which is substantially unaffected by local temperatures and air currents, which responds to flame at a considerable distance from the detecting elements, so that the elements need not be located in the flame, which is impervious to vibration and acceleration effects, which is capable of performing functions beyond the scope of many of the present devices, and which can be readily adapted to any engine installation.

This invention comprises generally an element, which undergoes an electrical change when subjected to radiation from a flame, connected to a suitable amplifier, the output current of which actuates the desired control devices. Between the detecting element and the flame may be interposed a filter, designed to pass a selected band of frequencies and to filter out extraneous radiation.

The many advantages and novel features of this device are more fully explained in the following description with reference to the accompanying drawings, of which:

Fig. 1 is a diagrammatic side view of a typical aircraft engine with the fire alarm device installed; and

Fig. 2 is a diagrammatic side view of a turbo-jet engine (the turbine section broken away for convenience), with the fire alarm device installed to supervise the combustion chamber and jet pipe area.

According to this invention, a detecting element sensitive to the frequencies radiated by flame is mounted in the engine nacelle in a suitable location so as to receive direct radiation from a flame occurring within the space to be supervised. The detecting element is connected to an electronic amplifier of any of the suitable types known in the art, so that the change in conductivity of the element under the influence of radiation is amplified, and the resulting current may be used to operate a control or alarm device. Examples of suitable detecting elements include present commercial types of caesium-oxide-on-silver photocells, bolometers, and selenium cells, which have good sensitivity in the visible red and infrared region, lead sulphide semi-conductors which have sensitivity extending well into the infrared, and special types of sodium and other photocells which are sensitive to ultra violet. If the cell is to be mounted in a location where it is subject to extraneous light, it is preferably enclosed in a housing provided with an optical filter, which has good transmission in a selected non-visible region but cuts out part or all of the visible spectrum. The frequency band selected for transmission should correspond, wherever possible, to the region of peak sensitivity of the detecting element. It has been found that a caesium oxide photocell or lead sulphide semi-conductor used in conjunction with a filter which passes infrared, but shuts out substantially all the visible spectrum, will detect a small flame at considerable distance against the normal daylight background. Either type of cell responds instantaneously to the flame radiation, the sensitivity of the flame detector system being determined by the degree of amplification.

In an aircraft radial engine installation as illustrated in Fig. 1, the space occupied by the cylinders is ordinarily referred to as the "power zone," and that occupied by the fuel pump, oil pump and other engine accessories, as the "accessory zone." The two zones, here generally indicated by the numerals 4 and 5, are divided by a fire wall 6, which serves to retard the spread of fire from one zone to another. A reasonably small fire in the power zone can ordinarily be "blown out" when detected, by proper measures such as stopping the engine, thus stopping the supply of fuel which might feed the fire, feathering the propeller, and opening the cowling, if adjustable, to increase ventilation. Prompt detection is imperative, however, if the fire is to be successively extinguished, before great damage is done to the engine and surrounding structure. A fire originating in the accessory zone, if promptly detected, can be readily extinguished by a standard aircraft type of chemical extinguisher.

According to Fig. 1, fire detection in the power zone is provided by a photocell 8 mounted approximately in the plane of the cylinders 11 and facing slightly inward and toward the rear of the cowling 7. The field of vision of the photocell cathode is preferably so chosen as to exclude direct rays of the sun which might enter the rear of the cowling in certain attitudes of flight. Since flame occurring in the power zone will be blown toward the rear, this disposition of the photocell is suitable for covering one quadrant of the space in this zone. Three other photocells 9, 10 and another, not shown, are similarly mounted at 90° intervals around the engine and connected to amplifier 12. Radiation impinging on any of the photocells from a source within its optical field lowers the impedance of the cell. This change in conductivity is amplified and the resulting current output from amplifier 12 is used to operate a signal lamp 13 on the instrument panel of the airplane. It is, of course, understood that the output current of amplifier 12 may operate any other electrical control or indicating device. Since zone 4 is ordinarily open to daylight through the rear edge of the cowling, the photocells in this area are preferably enclosed and provided with optical filters, schematically indicated by 17 which shut out the visible spectrum. According to well-known methods, the detecting photocells may be connected either in parallel or to separate amplification channels feeding into a common output circuit.

In zone 5, two photocells 14 and 15 placed on opposite sides near the outer edge of the accessory compartment are ordinarily adequate to supervise the entire region. These photocells are connected to amplifier 16 which actuates a signal light 13' or other control or indicating device.

It will be noted that in both the power zone and

accessory zone installations, the proper location of detecting elements can be simply determined by optical alignment, that is, full coverage of a zone requires only that the parts of the area blocked from the view of one photocell be within the view of another. Thus, installation of this device on a new type of engine presents no obstacle comparable to the lengthy experimental determinations of local temperatures and air currents required for effective use of the thermally operated fire alarm systems hitherto used.

In Fig. 2, two photocells **18** and **19** are shown mounted in the air space **20** between jet engine **21** and the shroud **22**. Flame occurring anywhere inside the shroud will illuminate at least one of the photocells. The resulting change in conductivity of the cell is amplified by amplifier **23** and the output current of amplifier **23** operates a signal or control device which may, for example, be a signal lamp **24** mounted on the instrument panel of the airplane. As for the reciprocating engine installation of Fig. 1, the proper location of the detecting elements is simply determined by optical considerations. An optical filter may be used where necessary to shut out extraneous visible light.

Any of the systems shown gives a "fire out" indication, that is, the signal light goes out, when the photocell returns to its dark, high impedance, condition. Tests have established that these detectors, if properly installed, are able to survive successive fires without failure even in cases where the engine or other structure has failed under repeated fire tests. A false "fire out" indication cannot occur, however, as it may with thermal detectors when the fire moves away from the detecting elements, because a photocell will be subject to radiation as long as any flame exists in the supervised space. Furthermore, this device operates instantly upon cessation of flame, whereas a thermal element will operate only after a considerable and unpredictable delay because of persisting high temperature in the surrounding parts. The photoelectric detector is ready to operate as before if fire should again break out. This repeat action is important because, under emergency conditions, the pilot may be forced to start the engine again after the fire is extinguished, and there is the possibility of recurrence of fire in the damaged engine.

The advantages of this system in both illustrations will be at once apparent. The alarm operates immediately upon outbreak of fire, so that the pilot has a maximum time to apply fire fighting measures before serious damage occurs. Furthermore, since the detecting element is excited by radiated rather than conducted heat, false alarms due to ambient temperature fluctuations, and failures due to cooling by local air currents, are eliminated. The small number of elements required to supervise a given volume represent a considerable saving in weight, for example, in Fig. 1, two photocells **14** and **15** provide more complete protection in the accessory zone, where unpredictable fire draft conditions make the problem of locating thermal elements particularly difficult, than was formerly obtainable with from ten to fifteen thermal elements. Another advantage is the ease with which the system may be checked. The condition of some types of thermal elements can be checked only roughly, and the fusible type cannot be checked at all. This system can be operated for inspection purposes by exposing the cells to light from a small incandescant lamp, for example, a test lamp permanently installed inside the nacelle. A further advantage is the insensitivity of the detecting elements to mechanical vibration and acceleration.

Since certain changes may be made in the above-mentioned article and different embodiments of the invention are possible 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 is:

1. A fire detection system for aircraft adapted to detect fire in aircraft engine nacelles, including a photoelectric detecting element adapted to undergo an electrical change upon exposure to infrared frequencies radiated by a flame, means for mounting said element in a fixed position to supervise a selected space within its optical field, optical filter means adapted to transmit said infrared frequencies to said element and reject substantially all visible radiations, means for amplifying said electrical change, and means actuated by said amplifying means for effecting a response upon occurrence of said electrical change.

2. A fire detection system for aircraft adapted to detect fire in aircraft engine nacelles, including a plurality of photoelectric detecting elements adapted to undergo an electrical change upon exposure to infrared frequencies radiated by a flame, means for mounting said elements in fixed positions to supervise a selected space, optical filter means adapted to transmit said infrared frequencies to said elements and reject substantially all visible radiations, means for amplifying said electrical change, and means actuated by said amplifying means for effecting a response upon occurrence of said electrical change.

3. A fire detection system for aircraft adapted to detect fire in aircraft engine nacelles, including a plurality of photoelectric detecting elements adapted to undergo an electrical change upon exposure to infrared frequencies radiated by flame, optical filter means adapted to transmit said infrared frequencies to said elements and reject substantially all visible radiations, means for mounting and aligning said elements in fixed positions within an aircraft engine nacelle about the circumference of said nacelle to supervise substantially the entire nacelle so that flame occurring within said nacelle will illuminate at least one of said detecting elements, means for amplifying said electrical change, and means actuated by said amplifying means for effecting a response upon occurrence of said electrical change.

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