March 6, 1962 F. K BOYD 3,024,450

FIRE DETECTION SYSTEM WITH GROUND FAULT COMPENSATING MEANS

Filed April 25, 1960 3 Sheets-Sheet 1

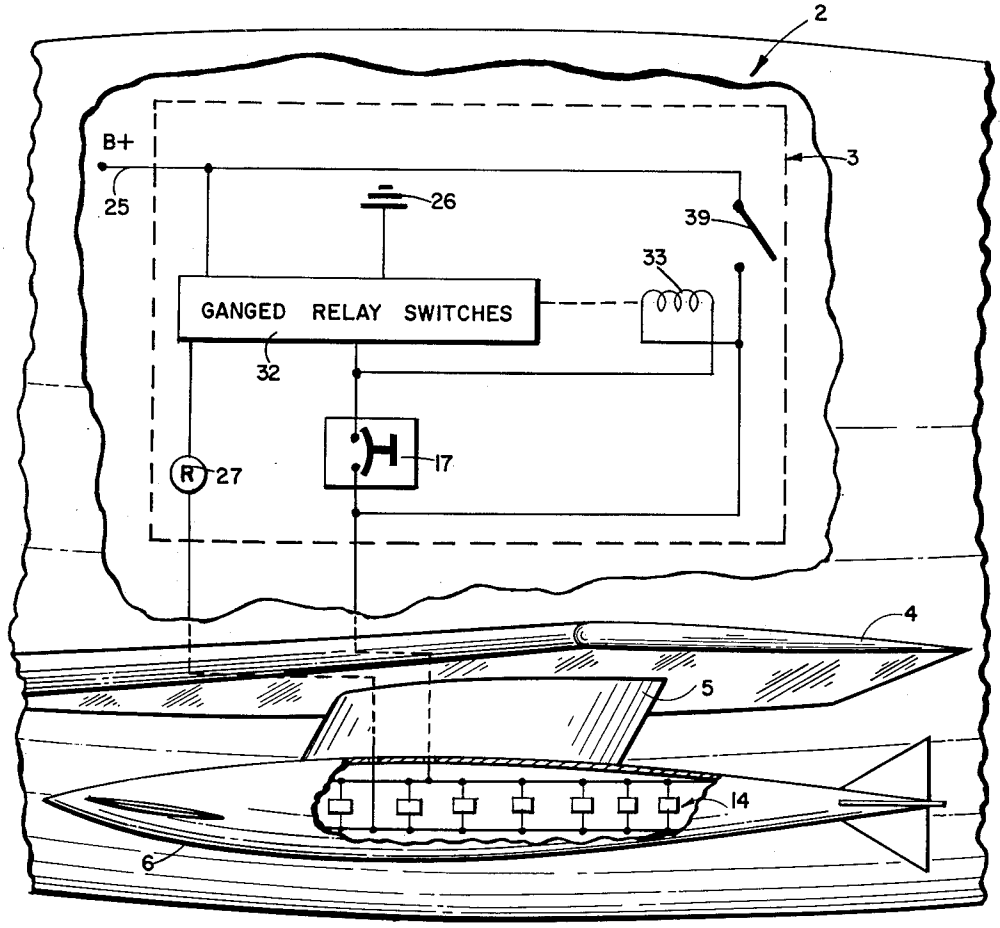


FIG. 2

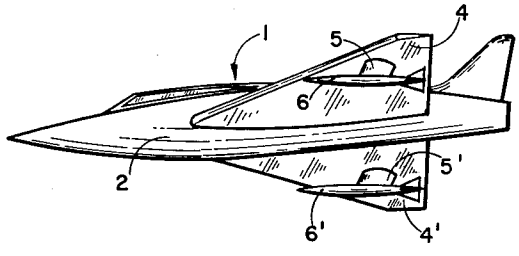


FIG. 1

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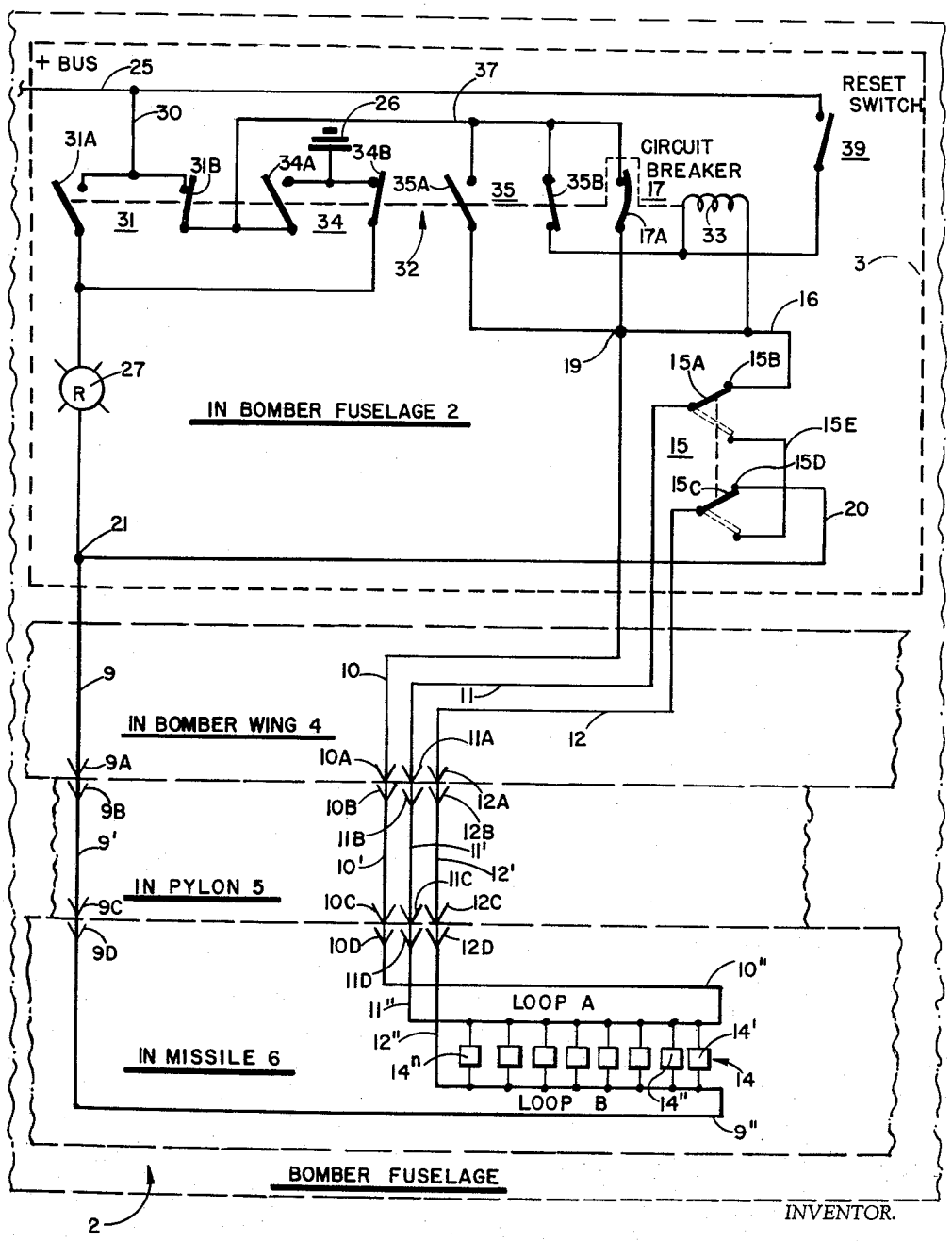


FIG. 3

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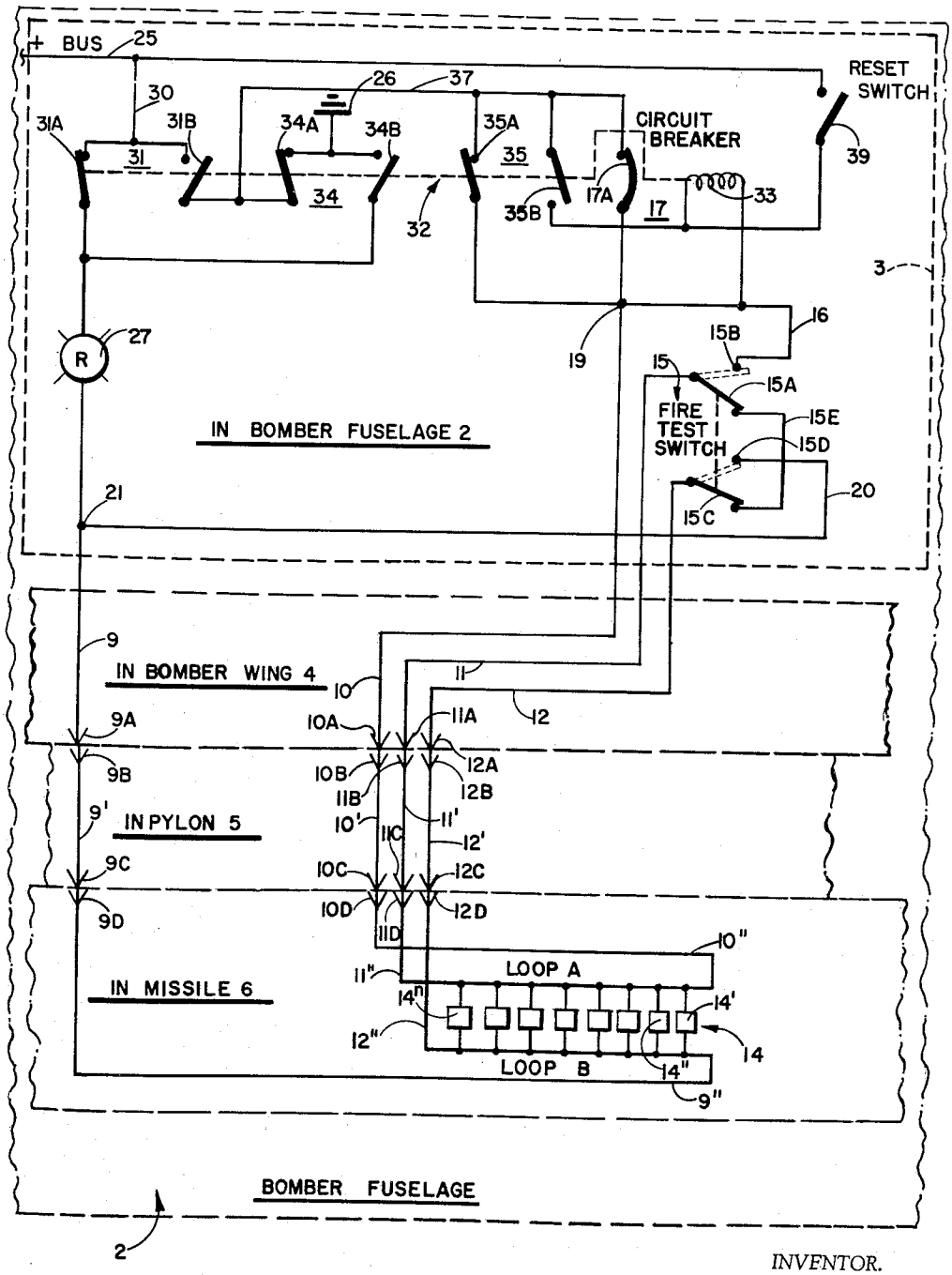


FIG. 4

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FIRE DETECTION SYSTEM WITH GROUND FAULT COMPENSATING MEANS

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5 Claims. (Cl. 340—227)

This invention relates to fire detection systems, and particularly to means for avoiding false alarms in airborne fire detection equipment.

The presence of a ground fault, productive of a false alarm signal, results immediately in transferring the alarm power from the detection loop leads on which the fault exists to another loop. If the second loop likewise indicates a fault, the probability is tremendously enhanced that the plane is actually in serious danger.

One of the major disadvantages of systems for detecting fires in previous airborne vehicles has been their lack of reliability. Pilots and crews have experienced so many false alarms caused by ground faults in the systems that the fire detection systems have tended to fall into disrepute. The system described in this disclosure prevents such false alarms by rearranging the circuitry automatically in case of a ground fault, to maintain a proper condition of readiness.

Among the disadvantages of false alarms is the fact that standard operating procedure requires a pilot in a single-engine plane to bail out as soon as a fire alarm occurs. This almost always leads to the loss of the aircraft; and if the loss is the result of an alarm given when no fire exists, it will be readily understood that the pilots are reluctant to pay attention to the warning signal on the first receipt of an alarm. In multi-engine aircraft, an improper fire warning leads to an unnecessary loss of performance, inasmuch as the particular engine near which the fire is reported by the alarm system must be immediately shut down while the supposed first is being extinguished. Another distinct disadvantage in multi-engine planes is that the crew gets so used to false alarms that they lose confidence in the system and soon ignore it completely, creating a very dangerous situation when a fire actually exists. It is not believed necessary to elaborate further on the dangers resulting from a fire in the body of a missile intended to be air-launched from the carrying plane.

The present invention eliminates these difficulties by preventing false alarms due to ground faults through the use of an alternative connection loop to the fire detection devices with a simple, reliable circuit for shifting power from one connection loop to another upon the occurrence of a ground fault in the first loop. The system must then be manually reset after the ground fault has been corrected. In the event that the fault has not been fully cleared, the system will automatically shift connections again until the abnormal condition is completely eliminated. In addition to this basic improvement, a circuit-checking system has ben devised and is included as part of the fire detection system. The pilot is able to check the condition of readiness of the fire detection circuit at any time through the use of this system, which also acts to provide an alternative current supply to the fire detection units in cases where needed, as on the breaking of a main power lead to one of the detection loops. This makes it possible to maintain the readiness condition of the fire detector units even though both main leads to these units should be broken.

The invention as described includes an arrangement of circuits such that current faults would have to occur on two separate loops supplying power to the fire detection units before a false alarm could be registered. As will be further explained hereafter, this reduces to an inconsequential figure the number of false alarms which are likely to occur due to the commonly experienced ground faults.

By suitable and obvious modifications, the invention may be utilized to indicate the presence of fire in a missile which is not associated with an airplane.

It will be obvious that a system of this sort is not limited to use with airborne equipment, but is readily applicable to any situation in which it is necessary to have a positive, reliable indication of the presence of fire. A variety of such situations exists throughout industry.

The objects of this invention will thus be seen to include providing means for determining the existence of fire, particularly in an aircraft or associated equipment;

Providing means for eliminating the effect of ground faults in the fire detection system which would be productive of false alarm signals;

Providing means for checking the condition of readiness of the fire alarm system during flight;

Providing alternative connection means supplementing the main power supply leads to the fire detection units;

Providing means for effecting the connection of an alternative power loop to the fire detection units immediately upon the occurrence of a ground fault productive of false alarms on a connection loop;

Providing means for improving fire detection systems so that plane crews will be able to rely on the warning indications supplied thereby;

Providing a fire detection system applicable to the indication of fire in a missile-carrying pylon or a missile attached thereto and suspended from an airplane; and

Providing a fire detection system applicable to any situation in which positive indications of the presence of a fire and the avoidance of false alarms is desirable.

These and other objects may be better understood by reference to the drawings, in which:

FIG. 1 is a schematic perspective diagram showing the invention as applied to a plane having pylons supporting missiles intended to be air-launched;

FIG. 2 is a schematic connection diagram for the invention as applied to the plane of FIG. 1;

FIG. 3 is a schematic circuit diagram showing the invention as applied to an alarm system for a missile carried on a pylon by a bomber, with the circuit in normal condition for operation; and

FIG. 4 is a schematic circuit diagram similar to that of FIG. 3, but showing the connections after the occurrence of a fault has resulted in the transfer of the power supply connection from the faulty first loop to an alternative second connection loop.

Referring now to FIG. 1 of the drawings, there is shown schematically a plane **1** having a fuselage section **2**, within which is disposed the instrumentation and control section, seen in greater detail at **3** in FIG. 2. To fuselage **2** are attached left and right wings **4** and **4'**, carrying therebeneath left and right pylons **5** and **5'** which may themselves be detachable if desired. Pylons **5** and **5'** act as carriers for left and right missiles **6** and **6'**. The pylons **5** and **5'** may be attached removably so that after serving as launching platforms for the missiles, they may in some circumstances be jettisoned to reduce the weight carried by the plane.

The connections from the alarm circuitry will be described hereafter for one wing, pylon and missile, but it will be understood that a corresponding system is provided for the opposite wing, pylon and missile. A similar system, not shown, may be arranged in any other part of the aircraft, such as the nose or tail sections of the fuselage, for example, in which fire might break out. Circuit connections are provided from the alarm circuitry instrumentation and controls section **3** to the remainder of the alarm circuitry. These connections extend from the

bomber fuselage section 2 to the pylons and missiles through leads 9, 10, 11, and 12, shown in FIGS. 3 and 4, and a series of releasable connectors and associated cables. Leads 9, 10, 11 and 12 connect respectively to a first series of releasable connectors 9A, 10A, 11A and 12A mounted in the lower surface of each wing. These releasable connectors are of an improved design arranged to provide a ready connect and disconnect action, but form no part of the present invention.

A corresponding first series of mating connectors 9B, 10B, 11B, and 12B is mounted in the upper surface of pylon 5. The members of the first series of mating connectors connect in turn through a first series of intermediate leads 9', 10', 11', and 12' to a second series of readily releasable connectors 9C, 10C, 11C, and 12C on the lower edge of the pylon 5.

On the upper portion of the missile 6 is mounted a second series of mating connectors 9D, 10D, 11D, and 12D cooperating with releasable connectors 9C, 10C, 11C, and 12C in the pylon 5. Within the missile, leads 9'', 10'', 11'', and 12'' extend from the mating connectors to the plurality of fire detection units, generally indicated as 14. The individual units are indicated as 14', 14'' . . . 14^n, where n=the number of detection units.

Lead 10, with its connecting leads 10' and 10'', forms the main power connection from the apparatus side of a circuit breaker 17, through a junction point 19, to a first fire detection loop A. In the normal condition of the circuit, using loop A, lead 10'' connects to the high or positive potential sides of each of the units 14', 14'' . . . 14^n. A second path to the high side of each of these units is provided through lead 11'', connectors 11D and 11C, lead 11', connectors 11B and 11A, and lead 11 to a first contact arm 15A of a double-pole double-throw test switch 15. In the normal position of switch 15, first contact arm 15A engages a contact 15B, which is connected back, by a lead 16, to the junction point 19 on the apparatus side of a circuit breaker 17, shown as being of a type actuated by current flow therethrough. Thus in the normal position of test switch 15, a path is provided from circuit breaker 17 through switch 15 and leads 11, 11', and 11'' to the fire detection units 14' . . . 14^n, parallel to that provided through the main power connection leads 10, 10', and 10''. The parallel paths, through leads 10, 10' and 10'' and through leads 11, 11' and 11'', form the loop A which is connected to supply alarm power or test power to one side of the group of indicating units 14. These parallel paths will keep the system functioning even though the main lead was to be broken.

Leads 9, 9', and 9'' similarly cooperate with leads 12, 12', and 12'' to form a loop B. When positive potential is applied to loop A, the leads 9, 9', and 9'' connect the opposite, or loop B, sides of each of the units 14', 14'' . . . 14^n, to a second contact arm 15C in test switch 15. Contact 15D in turn connects through a return lead 20 to a junction point 21 with lead 9. Thus loop B affords parallel paths from the detection units 14' . . . 14^n back to the junction point 21. The loop B could then function even though main lead 9 were to be broken.

When any one of the indicating devices 14 becomes heated in excess of a predetermined value, as by the presence of fire, it will become effective to close the circuit between loop A and loop B. As seen in FIG. 2, this allows current to flow from the positive side of the plane's power supply available on bus 25, to ground 26 through an alarm indicating device 27, which may be visual, audible, or a combination of such means.

As seen in the more detailed circuit of FIGS. 3 and 4, the positive potential on the bus 25 within the plane is delivered through a power supply connection lead 30 to a first relay switch, indicated generally as 31. Switch 31 may conveniently be one part of a multiple-member relay contact assembly generally indicated at 32 ganged to a latching relay 33 for simultaneous operation. First relay switch 31 may have two contacts and two positions, and be ganged with similar second and third relay switches 34 and 35 to be actuated simultaneously by the latching relay winding indicated generally as 33.

When the circuit breaker 17 is in closed position, as shown in FIG. 3, latching relay 33 holds contacts 31B, 34B, and 35B closed. At the same time, relay 33 holds contacts 31A, 34A, and 35A open. Thus potential from the bus 25 and power lead 30 is delivered through switch contact 31B of first relay 31, through an interconnecting power lead 37 and through contact 35B of relay 35 to the latching relay winding 33. At the same time, potential is furnished through circuit breaker contact 17A from power lead 37 and a first main power lead 10 and its associated leads and connectors as described above to loop A in the missile 6. Potential is also furnished from breaker contacts 17A through the parallel path through test switch 15 and lead 11. The circuit breaker 17 is adjusted to carry the current level resulting when one or more of the fire detecting devices 14 closes.

If an accidental short to ground occurs on loop A, the current setting of circuit breaker 17 will be exceeded, and the circuit breaker will immediately open. Because of the ganged connections between circuit breaker 17 and relay switches 31, 34, and 35, each of these switches will be actuated simultaneously so that the power supply from the bus 25 will no longer be applied to loop A, but instead will be applied to loop B, as will be further explained hereafter. Hence the alarm device 27 would not be actuated unless a fault exists simultaneously on loop B. This reduces the possibility of false alarms tremendously, since now a ground fault on loop B will have no effect until a fire alarm is registered by operation of one of the units 14, or the test switch 15 is operated.

Operation of the Test Circuit

When the pilot wishes to check the condition of the alarm circuitry in the normal position of circuit breaker 17 and its associated relays, he moves ganged switch 15 to the "test" position, shown in dotted lines in FIG. 4.

This completes, through a test shunt 15E in the switch 15, the connection through leads 11 and 12 to loops A and B, respectively. By thus shunting across the open detection units 14' . . . 14^n, the alarm device 27 may be actuated. As soon as the test switch is returned to normal position, the alarm device 27 is de-energized. If it did not function when switch 15 was moved to "test" position, the need for repair would immediately be manifest.

Effect of Overload Current

The way in which the circuit is effective to transfer the connections from the positive power supply bus 25 from loop A to loop B when an overload occurs due to a ground fault in loop A will next be considered. Unless a ground fault is also present on loop B, no false alarm will be registered.

Overload due to a ground fault in loop A will cause circuit breaker contacts 17A to open. This will immediately cause the full plane power supply potential applied from intermediate power lead 37 through contacts 35B, to be developed across the latch relay winding 33 to the faulty ground. The latch relay will operate, causing contacts 31E, 34B, and 35B to open, and closing contacts 31A, 34A, and 35A. Opening contact 35B de-energizes the latching relay, and transfers the potential from loop A to loop B. This isolates the fault in loop A, and no alarm will be given, unless there is also a fault in loop B, until a fire occurs, or until the test switch 15 is operated.

The situation after the transfer of potential from loop A to loop B is shown in FIG. 4. If one of the detector units 14 closed due to the presence of fire, a path to ground is provided as follows: from bus 25 through power lead 30 and contacts 31A of relay switch 31, thence to the alarm indicating device 27, through leads 9, 9', and 9'' to loop B, through the closed detector unit to loop A, thence through leads 10'', 10', and 10, and junction 19 to con-

tacts 35A of relay switch 35, finally through interconnecting power lead 37 and relay switch contacts 34A to ground 26. As described supra, part of this path will also be through the parallel portion of loop A formed by leads 11'', 11', and 11, test switch contacts 15A and 15B, and lead 16 back to junction 19.

The test switch 15, which was shown in normal position in FIG. 3, has been shown in test position in FIG. 4 in solid lines. The normal position is shown in FIG. 4 in dotted lines. The test procedure is the same in the situation of FIG. 4 as it is in FIG. 3. The test switch 15 provides a temporary shunt through lead 15E from loop A to loop B to actuate the alarm device 27.

However, in this case, and likewise if a fire exists and then goes out, the alarm will not cease when the test switch is released. To stop the alarm device from indicating, the circuit breaker 17 must be closed and a reset switch 39 closed momentarily. Reset switch 39 provides a connection from the positive bus 25 through the latching relay 33, relay contacts 35A, interconnecting power lead 37, and relay contacts 34A to ground 26. This will restore the latching relay 33 and all the contacts ganged thereto to their original condition.

The system is now operative as in its initial condition. If there is a fire still in existence when the circuit breaker 17 is closed, the breaker will immediately signal this condition by re-opening again.

Thus the system here disclosed provides a positive indication to the pilot when fire does exist in the airplane or missile. This enables him to have confidence in the alarm system, and will prevent the unnecessary loss of a plane when no fire exists. It will also insure that the crew will abandon ship when the situation requires this procedure.

Similarly, if applied to other types of equipment, a positive fire indication is insured, and the possibility of false alarms vastly minimized.

I claim:

1. In a system for indicating the existence of temperatures in excess of a permissible value, temperature-responsive means effective when a predetermined temperature is exceeded to actuate a warning circuit; power supply means; first loop means for connecting said power supply means to said temperature-responsive means; second loop means for alternatively connecting said power supply means to said temperature-responsive means; overload-responsive means disposed between said power supply means and said first and second loop means; said overload-responsive means being effective when current from said power supply means exceeds a predetermined value for opening said first loop means connection; and means effective on the opening of said first loop means connection for connecting said power supply means to said temperature-responsive means through said second loop means.

2. The invention of claim 1 wherein said last mentioned means comprises an electrical relay means shunted by said overload responsive means in the absence of overload currents through said overload responsive means.

3. In a system having a plurality of heat-actuable units for indicating the presence of fire, means for preventing false alarms due to accidental grounds occurring in said system, comprising: a first connection loop to said heat-actuable units; a second connection loop to said heat-actuable units; an electrical power supply; a warning device actuable by current flow; means for connecting a selected side of said power supply through said first connection loop to said units; means for connecting said second connection loop to the other side of said power supply; means, effective on flow of current in said first loop in excess of that produced by flow through said units, for switching said selected side of said power supply to said second connection loop; means for restoring said first loop to its initial condition after correction of the condition permitting flow of current in said first loop in excess of that through said units.

4. In a system for indicating the presence of fire, a power supply; a plurality of heat-sensitive units, each adapted to close a circuit therethrough when subjected to temperatures in excess of a certain value; first and second loops connecting said power supply to said units; warning means actuable by current flow through at least one of said units; and means for preventing erroneous warning signals due to an unintentional ground in said first loop, comprising: means effective on the flow of current in said first loop in excess of a predetermined value for opening the circuit between said power supply and said first loop; means effective on the opening of said circuit between said power supply and said first loop for shifting the power supply current from said first loop to said second loop; and means effective on the removal of a said unintentional ground connection for restoring said system to its original condition.

5. A system for indicating the existence of a fire, comprising: a warning circuit; means responsive to the presence of fire for actuating said warning circuit; power supply means having a grounded side and a high potential side; first loop means for connecting said high potential side of said power supply means to one side of said actuating means for actuating a warning circuit; second loop means for alternatively connecting the high potential side of said power supply means to the opposite side of said actuating means for actuating a warning circuit; means effective when current from said power supply means through said first loop means exceeds a certain value for opening the circuit to said first loop means; means operable on the opening of said circuit to said first loop means for shifting said connection from the high potential side of said power supply means to said second loop means; means for providing test switch connections from said power supply means to said means for actuating a warning circuit, connected in parallel with said first loop means and said second means, and arranged to permit alternatively testing said first loop means and second loop means; and means for restoring said circuit opening means to initial position when the condition causing said power supply current to exceed a certain value has been corrected.

References Cited in the file of this patent

UNITED STATES PATENTS

1,537,211	Wootton	May 12, 1925
2,059,510	Ekman	Nov. 3, 1936
2,695,994	Lode	Nov. 30, 1954