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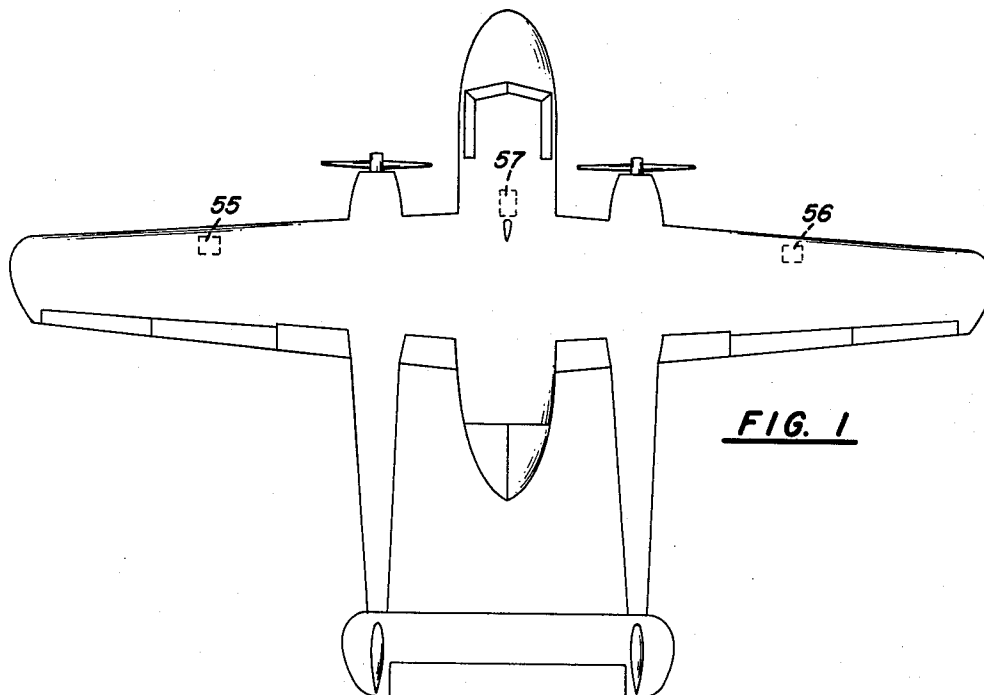
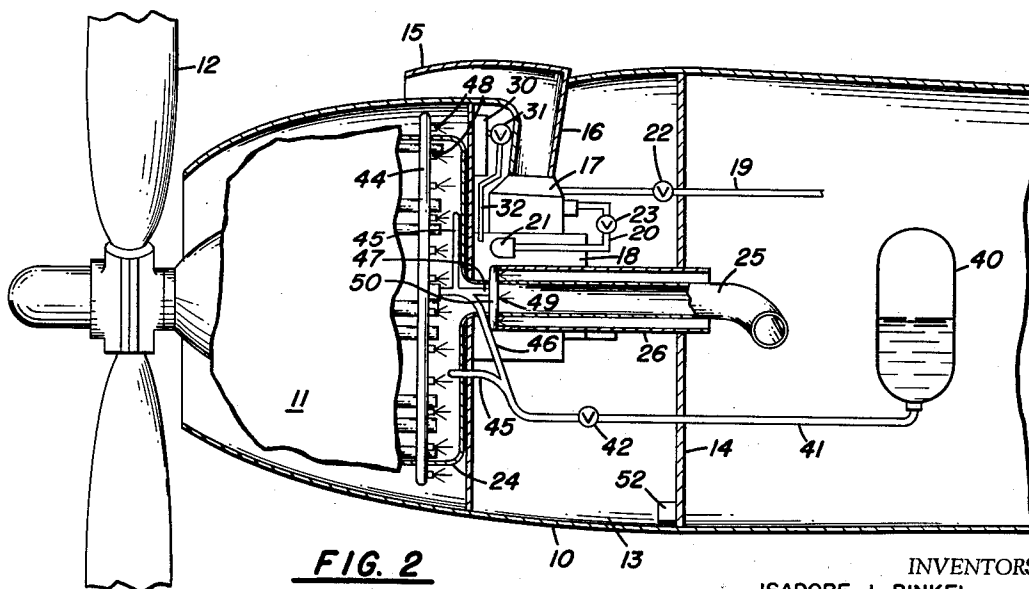
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2,737,249

CRASH-FIRE IGNITION SOURCE INERTING SYSTEM

Filed May 14, 1954

2 Sheets-Sheet 1

FIG. 1FIG. 2

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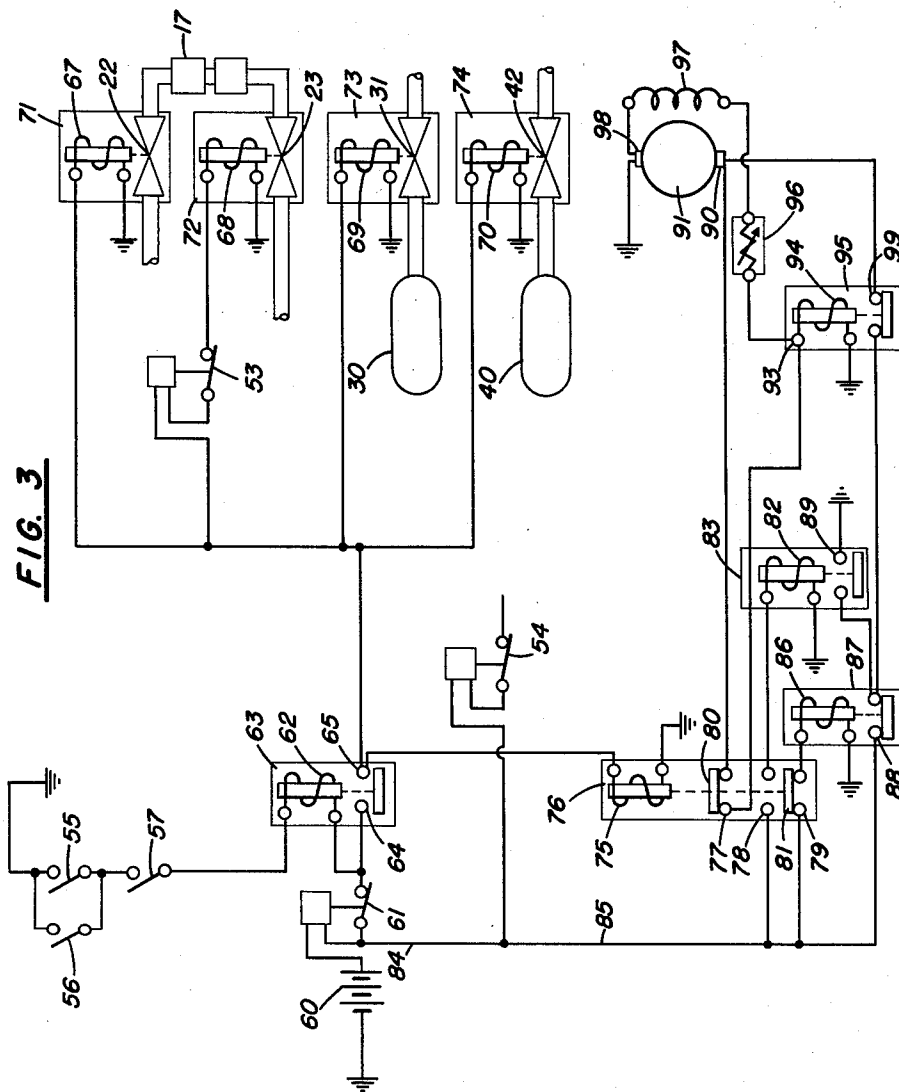
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CRASH-FIRE IGNITION SOURCE INERTING SYSTEM

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Application May 14, 1954, Serial No. 430,002

11 Claims. (Cl. 169—2)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to a crash fire preventing system having general application to all mobile apparatus and particular application to aircraft, to which the description will be confined.

The fire hazard of aircraft is well known, this being due to inherent susceptibility to crash and necessity of use of highly inflammable fuels. Crash studies have developed the information that fuel ignition is due to several causes, the most important of which are the heated exhaust ducts and appliances, the internal engine flames appearing at fuel induction and exhaust ports and disruption of the electrical system producing electric arcs, short circuits and exposed hot wires. The resulting fires may be practically instantaneous with crash or they may ignite as late as twenty minutes or longer afterwards.

It is an important object of this invention to provide a crash fire prevention system which is effective for an extended time interval after crash.

An object also is to provide such a system which insures fire protection not only in the nacelle but also in the engine exhaust region external to the nacelle, including the exhaust tail pipe and heat exchangers.

An additional object is to provide a fire protective system which as a sequence of step actions progressively reduces fire hazard after crash.

Further objects are to provide a fire protective system which operates successfully when exposed to high speed air flow, which both cools and blankets the heated elements with inert gases and which functions only on excessive craft deceleration and ground contact.

Other objects and features of the invention will appear on consideration of the following detailed description of an embodiment of the invention, reference being made in this connection to the accompanying drawings in which:

Fig. 1 is a plan view of an aircraft showing location of crash switches;

Fig. 2 is a view, partly in section, showing the engine nacelle unit including the power unit and elements of the engine exhaust system; and

Fig. 3 is a schematic diagram of the various electrically actuated components of the fire protective system.

Reference is first made to Fig. 2 where is illustrated the nacelle casing 10 of an airplane powered with reciprocating engines, the power unit being indicated at 11 with connections to the propeller 12. Rearward of the engines is the engine accessory section, terminated by fire wall 14. The air intake 15 directs air to the engine cylinders through tube 16, carburetor 17 and supercharger 18, the fuel carried by inlet pipe 19 being first metered by carburetor 17 and then directly injected at the supercharger 18 as indicated by tube 20 and tube heading 21. For a purpose to be explained

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later shut-off valves are placed in fuel tube 19 at 22, just forward of fire wall 14, and in tube 20 at 23. The engine block is provided with an engine exhaust collector manifold 24 from which leads the exhaust pipe 25, this pipe being encased by a heat exchanger unit 26 for cabin heating.

In order to suppress flame development and propagation use is made of a fire extinguishing agent preventing fuel oxidation. In the specific example of the disclosure, this agent is carbon dioxide which is tanked at 30 and conducted through valve 31 and pipe 32 to the supercharger 18 for direct mixing with air by the action of the impeller. The volume of carbon dioxide should be such as to reduce the partial pressure of the incoming air to a point below combustion and, to this end, the volume of inert gas should be at least equal to the volume of ingested air. The air volume is computed on the basis that the engine is operating at maximum power, which is often the case when the airplane is being maneuvered to avoid crash.

For cooling the highly heated exhaust disposal system both within and without the nacelle, as well as for supplying these parts with a flame blanketing agent, use is made of a forced spray system immediately operative on crash. Water was selected as the spray agent for two reasons: because of its low molecular weight the volume of steam generated to form an inert blanket per pound of fluid is greater than that from other known usable fluids; and similarly, the heat of vaporization is pronouncedly higher than that of most other fluids affording a most effective cooling agent.

To apply water to the heated surfaces, it is stored in a reservoir 40 rearward of the firewall 14. A conduit 41 is provided to apply the liquid to the heated engine parts, this conduit leading from the reservoir through valve 42 to four points of application: by branch 46 to the annular distribution manifold 44 surrounding the exhaust collector manifold, by branches 45 to the interior of the exhaust manifold 24 and by branch 47 to the interior of the heat exchanger. Distribution manifold 44 is provided with side nozzles 48 to spray liquid over the exposed exhaust disposal system and, similarly, ring 50 is provided with side nozzles 49 to spray liquid over the heat exchanger 26. It is noted that the nozzles 48 and 49 are leeward of the normal air flow in relation to the distributing manifold 44 and ring 50 and close to the hot exhaust system surfaces so that high speed air, moving over the surfaces early in the crash, does not sweep away the protective fluid before it can form an inert blanket on these surfaces.

During normal aircraft operation the various valves of the crash fire protective system are held in opened or closed position, as the case may be, to render the system ineffective. However, on crash, these valves should each function not only to open or close, but also to take this action at a predetermined sequence of time intervals so as to lessen fire hazards as will be explained hereinafter. Electrical switches 55 and 56 (Fig. 1) are located on the main spar of each wing and each is constructed to close the electrical circuit on a deceleration of the wing in the plane thereof equal to twice that of gravity. Primary switch 57 is located on the lowest section of fuselage skin and is of the wipe-off type, the switch closing on contact of the underbelly of the fuselage with the ground in the event of landing gear failure or wheels-up crash.

In Fig. 3 is illustrated the electrical circuit for actuating the valve system on closure of crash switch 57 and either one of switches 55 and 56. At least two of these switches, including switch 57, is required. The battery 60 supplies direct current electricity for operating the electrical system. One end of the battery is grounded. The other

battery end is connected to ground through the time delay switch 61, solenoid 62 of solenoid switch 63 and series connected crash switches 55 and 56. Energization of solenoid 62 closes the circuit between circuit terminals 64 and 65, thus applying electric power to the solenoids 67, 68, 69 and 70 of solenoid valve units 71, 72, 73 and 74 and to the solenoid 75 of solenoid switch 76. Solenoid switch 76 includes three pairs of contacts 77, 78 and 79, contacts 77 being normally closed by armature 80, but movable to open position on solenoid energization, contacts 78 being normally open but closed by armature 81 on solenoid energization, and contacts 79 being normally closed by armature 81 but opened on solenoid energization. Contacts 78 are interposed between the grounded solenoid 82 of solenoid switch 83 and a point 84 between the battery 60 and time delay switch 61, through connecting line 85. This line 85, also, has connection to ground through contacts 79 of switch 76 and the solenoid 86 of solenoid switch 87. Line 85 also leads through normally closed contacts 88 of switch 87 and normally open contacts 89 to ground.

Normally closed contacts 77, of switch 76, are connected on the one hand between a terminal 90 of the electric generator 91, the other terminal 92 of which is grounded, and, on the other hand, to a terminal 93 of the grounded solenoid 94 of solenoid switch 95. Terminal 93 is also connected through the field rheostat 96 and generator field coil 97 to the generator terminal 98; and generator terminal 90 is also connected through contacts 99 of switch 95 to the contacts 88 of switch 87.

Solenoid valve 71 contains valve 22 in the fuel line of inlet 19, solenoid valve 72 contains valve 23 in the fuel line between carburetor 17 and supercharger 18; solenoid valve 73 contains valve 31 in the pipe between tank 30 and supercharger 18; solenoid valve 74 contains valve 42 in pipe 41 connecting the water reservoir 40 to the exhaust disposal system.

The operation of the crash system may now be described. On crash such as will bring about closure of switch 57 and at least one of switches 55 and 56, the electrical circuit of battery 60 is closed through solenoid switch 63, time delay switch 61 being timed for opening in one-half second after actuation of switch 63. Closure of contacts 64-65 energizes solenoid 75 of solenoid switch 76 causing upward movement of armatures 80 and 81 with the opening of contacts 77 in the airplane generator circuit and closure of the circuit to solenoid 82 of switch 83. Thereupon, a ground circuit of the power lines is formed through contacts 89. Also contacts 79 of switch 76 are opened, opening the main battery circuit to the generator through opening of contacts 88 of switch 87. Solenoid 94 of switch 95 is also deenergized, opening contacts 99 to disconnect the generator from the airplane power lines.

Actuation of switch 63 also operates the various valves in the following manner. Valve 22 in the inlet fuel line is closed instantaneously (less than 0.1 second) to stop the flow of fuel to the engine carburetor. Valve 23 closes in less than 0.4 second to shut off flow of fuel from the carburetor to the supercharger, the greater time interval being permitted in order to burn the carburetor line fuel residue between valve 22 and the supercharger. A time delay switch 53 may be used to secure the proper timing. Valve 31 opens in less than 0.1 second in order to discharge contents of fire extinguishing agent bottle 30 to make inert the fuel-air mixture present in the engine before fuel valve 23 is fully closed. Valve 42 is opened in less than 0.1 second in the inert cooling fluid line 41 in order to make the blanketing and cooling fluid immediately effective on the highly heated exhaust system. It is apparent that because of the method of fire prevention used, employing inert blanketing and cooling agents, it is unnecessary to open the ignition circuit. However, if ignition shut-off is used as an added precaution, this should be adjusted to succeed the closing of valve 23 by

at least 0.8 second in order to insure that, in the event of malfunctioning of the fire extinguishing agent discharge system at the engine inlet or slow closure of the fuel shut-off valve, the fuel that passes through the engine burns in the normal manner within the engine cylinder. This is desirable since, if the fuel burns in the normal manner, the tail pipe gas exhaust is sufficiently inert and cool to avoid ignition of fuel, as gasoline, spilled at this point. However, if the engine fuel is not burned internally, it is ignited by the hot internal exhaust structure and issues as a flame at the tail pipe, igniting the spilled gasoline. If ignition cut-off is employed, a mechanical time delay 54 initiated by the crash solenoid circuit, is desirable. For example, an off center spring element may be used working against a collapsible air chamber having a leak aperture.

The ignition opening switch as well as other switches for miscellaneous electrical equipment are located at a convenient point, as at 52, on the forward face of fire wall 14. Solenoid and time delay switches, similar to those shown in Fig. 3, and subsidiary to main switch 63, may be used, to operate these switches.

The time sequence of the equipment should approximate to the following values:

Crash switches 55, 56	close in 0.1 second
Water switch 42	close in 0.1 second
CO ₂ switch 31	close in 0.1 second
Fuel valve 22	close in 0.1 second
Fuel valve 23	close in 0.4 second
Battery circuit 52	open in 0.1 second
Ignition switch 54	open in 0.8 second

The time periods of fluid and crash system actuating current flow approximate the following values:

	Seconds
Electricity	0.5
Carbon dioxide	3.0
Water	15.0

In order to secure rapid fluid application in the water spray system, nitrogen pressurized to 300 pounds per square inch or higher is included in the reservoir 40, the pressure depending on the desired rate of flow. Since the heat capacity of the engine exhaust system is not large, a few gallons is adequate to secure in 15 seconds' flow a temperature drop from 1300° F. to 400° F., the latter temperature being below the ignition temperature for the fuel, oil and most of the hydraulic fluids now in use on aircraft. It would be possible to use a pyrotechnic charge in place of the nitrogen, the charge discharging on crash into the reservoir 40 to expel the liquid. The water of reservoir 40 may also form part of the standard flight fire prevention system, but ordinarily this should not include the crash distribution system, and preferably these systems should be independent.

It is apparent that modifications and variations of the disclosure may be made and hence it should be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as described.

We claim:

1. A method of preventing crash-fire in vehicles employing internal combustion engines including a fuel induction system, an exhaust system and an ignition system, comprising the steps of stopping the supply of fuel to said induction system, injecting an inert quench gas into said induction system, and disabling the ignition system, the disabling of the ignition system succeeding the cut-off of fuel supply by a time interval of about eight-tenths second sufficient to burn combustible fuel mixtures in said engine.

2. A method of preventing crash-fire in vehicles employing internal combustion engines including a fuel induction system, an exhaust system and an ignition system, comprising the steps of stopping the supply of fuel to said induction system, injecting an inert quench gas into said

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induction system, and simultaneously cooling the heated areas of said exhaust system while blanketing said exhaust system with a flame quenching medium.

3. The method of preventing crash fires in vehicles as defined in claim 2, the time period of cooling and blanketing of said exhaust system being about fifteen seconds after crash.

4. A crash-fire prevention system for vehicles employing an internal combustion engine including a fuel induction system having a carburetor, an exhaust system and an ignition system comprising a pipe line for supplying fuel to said carburetor, a crash sensitive valve for closing said pipe line on crash impact of said vehicle, means for actuating said valve on vehicle crash, a source of inert gas, means for injecting said inert gas into said carburetor, a switch in said ignition system, and means for opening said switch a time interval after said valve closes, whereby combustible fuel in said engine after said valve closes is burned.

5. A crash-fire prevention system for vehicles employing an internal combustion engine including a fuel induction system having a carburetor, an exhaust system and an ignition system comprising a pipe line for supplying fuel to said carburetor, a crash sensitive valve for closing said pipe line on crash impact of said vehicle, means for actuating said valve on vehicle crash, a source of inert gas, means for injecting said inert gas into said carburetor, and means for blanketing both the inside and outside of exposed and normally heated areas of said exhaust system with flame quenching and cooling fluid.

6. A crash-fire prevention system for vehicles employing an internal combustion engine including a fuel induction system and an exhaust system, an exhaust manifold in said exhaust system, a coolant source mounted on said vehicle, a connection between said source and the interior of said manifold, and valve means operative to open on vehicle crash included in said connection.

7. The crash-fire prevention system as defined in claim 6, and pressure means at said coolant source for produc-

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ing a pressurized coolant flow into said exhaust manifold for at least fifteen seconds.

8. The crash-fire prevention system as defined in claim 6 and an orificed coolant distribution manifold adjacent said exhaust manifold connected through said valve to said coolant source, whereby coolant under pressure is applied simultaneously to the inside and outside wall of said exhaust manifold.

9. The crash-fire prevention system as defined in claim 6 including additionally an orificed distribution ring adjacent the exhaust pipe line external to said engine, and a connection from said ring to said source through said valve, whereby coolant is supplied simultaneously to the inside and outside surfaces of the wall of said pipe line.

10. The crash-fire prevention system as defined in claim 8 with said distribution manifold being placed in front of said exhaust manifold and closely adjacent said engine, and the orifices of said distribution manifold being placed leeward thereof, whereby coolant may be blanketed over said exhaust manifold irrespective of the forward speed of said engine and vehicle.

11. A crash-fire prevention system for vehicles employing an internal combustion engine including a fuel induction system and an exhaust system, an exhaust manifold in said exhaust system, a source of fire quench medium on said vehicle, a fire quench distribution manifold, a pipe connection between said quench medium source and distribution manifold, a valve in said connection, and means operative on vehicle crash to open said valve, said distribution manifold being placed in close juxtaposition to said engine and forward of said exhaust manifold and having discharge orifices on the leeward side thereof, whereby a fire quenching medium may be blanketed and retained adjacent said exhaust manifold during forward movement of said vehicle.

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