Chapter 4

EXPLOSION PROTECTION SYSTEM

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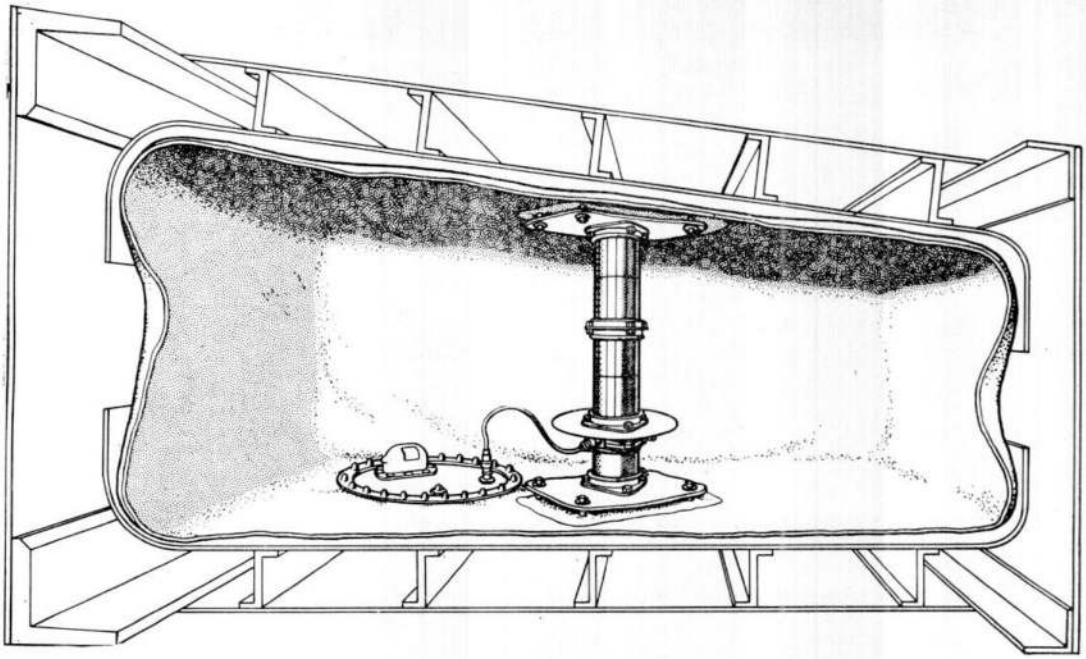

Fig. 1. Typical fuel tank installation

Introduction

1. The Graviner Explosion Protection System is designed to prevent an explosion in an aircraft fuel tank when it is in its most vulnerable condition, i.e., when partially empty and containing a highly explosive mixture of fuel/air vapour above the fuel.

2. The system operates on the principle that there is a time interval between the introduction of a flame into the explosive mixture in the fuel tank and the development of the maximum explosive force. During the first 15 milliseconds the pressure inside the tank rises at a comparatively slow rate, and, if detected during this time, an explosion can be suppressed before it progresses beyond control.

3. In this system a photo-electric detector is used to detect visually the presence of a flame within the tank and to emit an electrical pulse to an explosive detonator. The pulse causes the detonator to explode, thereby rupturing a suppressor tube containing a suppressing agent which is then dispersed, in mist form, rendering the unburnt vapours inert and so arresting the incipient explosion.

4. This chapter deals with the system as a whole, giving brief details only of the individual components. For comprehensive details of these components and their installation, reference should be made to A.P.4343E, Vol. 1, Sect. 15, and to A.P.957C, Vol. 1, 2nd Edn., Part 1, Sect. 2.

DESCRIPTION

General

5. The system consists essentially of the following components :—

(1) Detector unit

(2) Power pack

(3) Over voltage unit

(4) Suppressor unit

The detector unit and suppressor unit are fitted at the fuel tank itself, the suppressor being fitted completely within the tank, whilst the detector is flange-mounted on the tank access panel with the electrical connections outside the tank itself. Also mounted on the tank access panel are a test lamp, an indicator fuse, a co-axial bulkhead fitting, and a test coupler socket. The installation location of the remaining components varies with different aircraft, and the appropriate aircraft handbook should be referred to if these are required.

Detector unit

6. The detector unit (*fig.* 2) comprises a highly sensitive photo-electric cell combined with a firing circuit in a pressed steel casing. The casing has a window which, when the unit is installed, allows the photo cell to view the tank interior. Light falling upon the photo cell causes a voltage to be applied to the triggering electrode of a cold cathode valve which forms part of the detector firing circuit

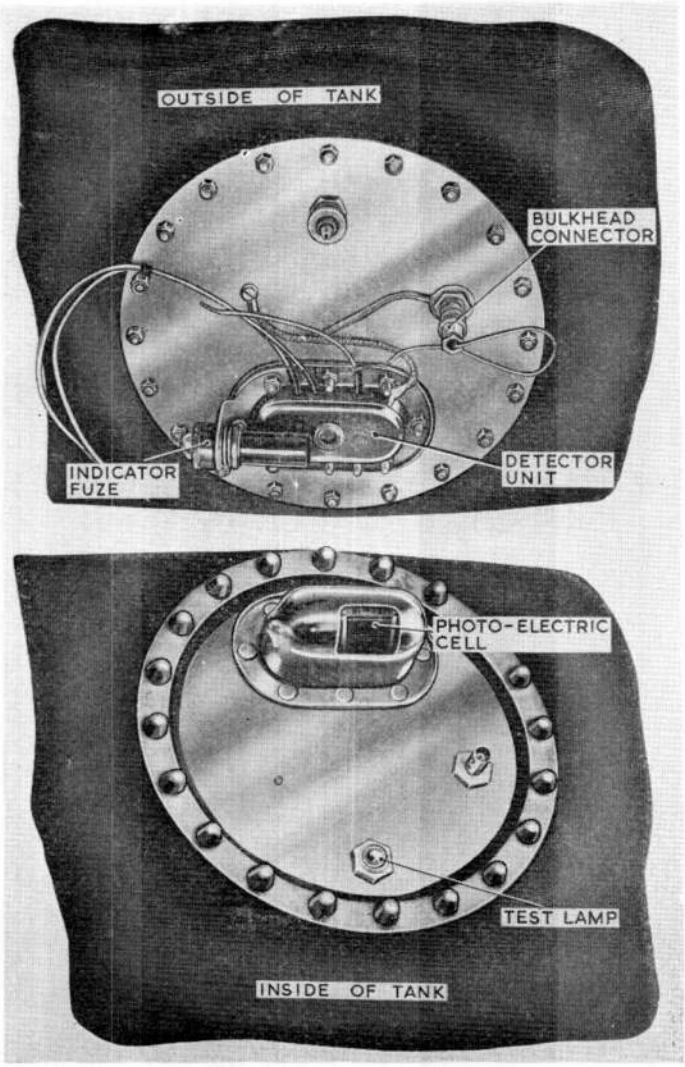

Fig. 2. Detector unit installed on tank access panel

7. The firing circuit comprises the cold cathode valve, capacitors, and resistors, and is designed to fail to safety if external wiring is open or short circuited.

Note . . .

(1) *Care must be taken to ensure that the connections to the detector unit are correct when installing, since irreparable damage may be caused if the detector unit is wrongly connected in circuit.*

(2) *Detector unit window must be kept blanked off from the light until finally installed in the tank, to prevent deterioration of the photo cell.*

Power pack

◀**8.** The power pack (*fig.* 3) converts the 115-volt, 400 c/s aircraft supply into the two voltage levels required in the system, namely, +142 volts and —500 volts. The unit also incorporates a double-wound relay which automatically trips if the supply is interrupted for any reason or if the voltage level on the 142-volt side exceeds 159 volts. One plug and three sockets provide connections to the other units employed in the system.▶

Over voltage unit

9. This unit is in effect an electronic relay which operates to trip the power pack relay in the event of the power pack voltage exceeding the desired limit. This unit is also used for circuit matching, the output current of the power pack being maintained reasonably within the desired limits by interconnection of the resistors within the unit.

Note . . .

When replacing an over voltage unit in an aircraft, it is most important that the interconnection of the output leads should be as shown in the respective aircraft handbook.

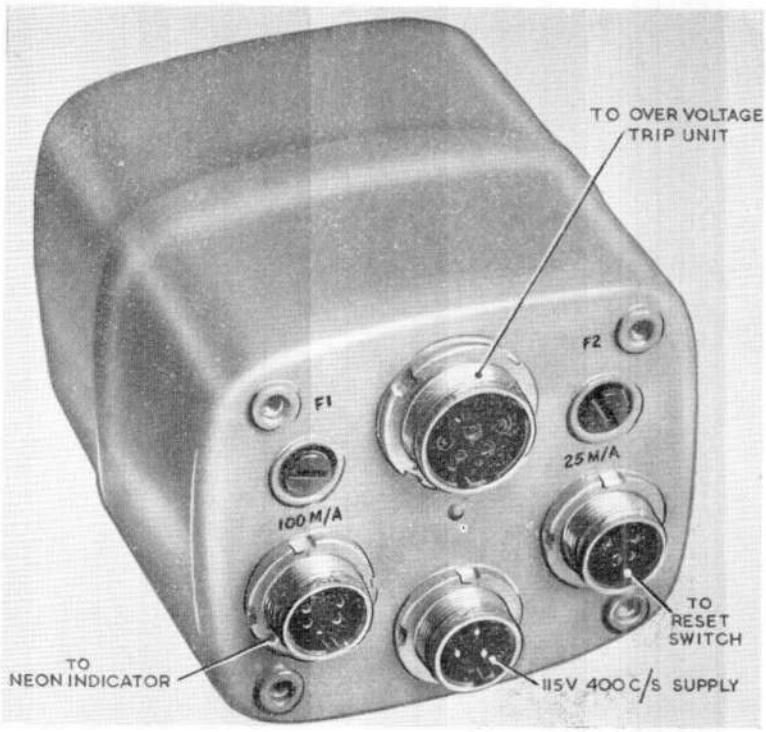

Fig. 3. Power pack

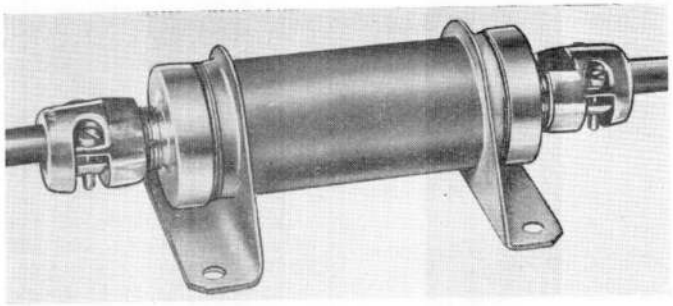

Fig. 4. Over voltage unit

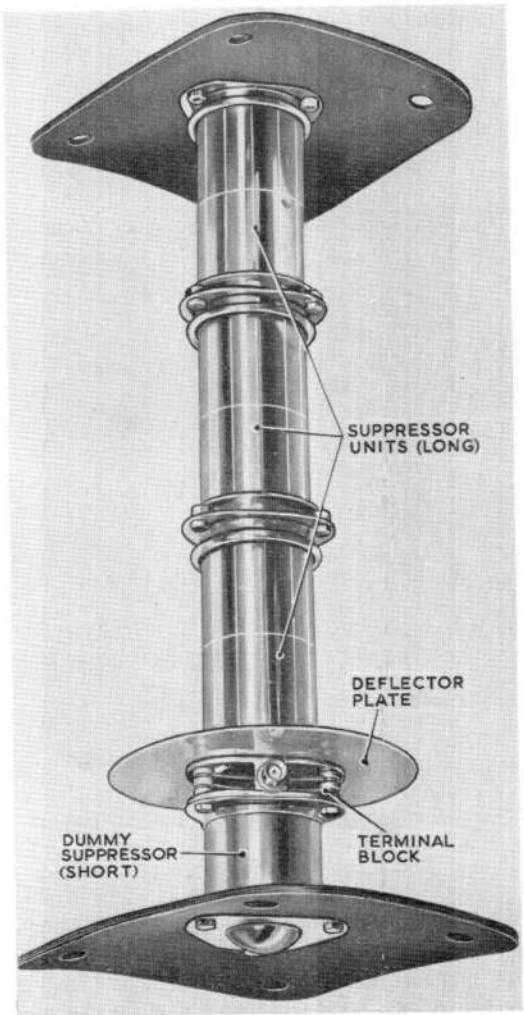

Fig. 5 Typical column of suppressors

Suppressors

10. The suppressor unit contains the suppressing agent to be dispersed within the tank in the event of the detector viewing a flame. The unit is basically a metal cylinder externally scored both longitudinally and circumferentially and containing the suppressing agent and a detonator. On detonation the scoring pattern enables the walls of the cylinder to fold back, rather like the petals of a flower, about the unscored ends, thus effectively distributing the suppressing agent.

11. In most installations several suppressors are joined together forming a suppressor column (*fig.* 5), electrical continuity between the detonators being provided to ensure that all the detonators in the column are fired simultaneously when a firing pulse is received from the detector unit.

12. The suppressor column is mounted on a terminal block (*fig.* 6), which is itself mounted upon a spacer tube attached to the tank access door. This terminal block provides connection to the detonator by means of a centrally-mounted pin which mates with the corresponding socket in one end of the detonator. Two co-axial sockets on the terminal block provide for both the lead from the bulkhead connector and a parallel connection to any other column(s) mounted in the tank.

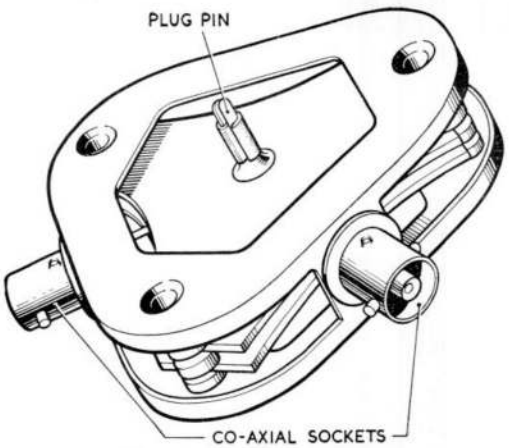

Fig. 6. Terminal block

Detonators

13. Two standard lengths of detonators, $4\frac{1}{2}$ in. and 3 in., are employed in this system for use in the two standard lengths of suppressors. They are basically thin plastic tubes containing explosive, with an incandescing wire bridged between a plug pin at one end of the tube and a socket at the other end, passing through the centre of the detonator. The detonator fits into the centre of the suppressor, and the pin and socket enable the suppressor column to be built up with the detonators connected in series.

Dummy suppressors and conductors

14. To enable a long suppressor column to be built up for a fuel tank of small capacity where less suppressant and a lower total detonator force are required, dummy suppressors and conductors of the two standard lengths are provided. The dummy suppressors differ in appearance to the suppressors proper only in the fact that no longitudinal scoring exists on the walls. The conductors which provide electrical continuity through the dummy suppressors may be identified by reference to the table below:–

15. In later installations the detonators may be distinguished from the conductors by their colourings ; the detonators are coated with pink varnish and the 116 Mk. 1, which is superceding the 110 Mk. 1, has a coating of lemon varnish around the base of the shoulder.

Note . . .

These detonators are explosive and must be handled with reasonable care. They should be kept away from heat applications, electrical leads, sockets, and batteries, and not exposed to severe blows or undue force when fitting.

TABLE 1

Detonators and Conductors

Part No.	*Type*	*Length*	*Identification*	*Resistance (ohms)*
110 Mk. 1	Detonator	$4\frac{1}{2}$ in.	Metal band on shoulders stamped with Type No.	10—16
116 Mk. 1	Detonator	$4\frac{1}{2}$ in.	Metal band on shoulder stamped with Type No.	10—16
115 Mk. 1	Detonator	3 in.	No shoulder—Type No. etched around edge of pin	10—16
E228	Conductor	$4\frac{1}{2}$ in.	Single groove around shoulder—no metal band	—
E627	Conductor	$2\frac{3}{4}$ in.	Plain shoulder	—

(The resistance valve should be checked with a safety ohmmeter, 13 milliamp max. current).

Indicator fuse

16. In order to have a permanent visual indication that the suppressors in the tank have been fired, an indicator fuse is included in the circuit. This fuse also eliminates the possibility of a spark occurring in the tank after an explosion has been suppressed.

17. The fuse and fuse housing are illustrated in fig. 7. The replaceable fuse consists of a matchhead fuse surrounded by a red oxide powder, above which is a small piston. When the matchhead is ignited, the red oxide is spread over an integral window in the fuse

head, thus leaving a permanent indication of operation.

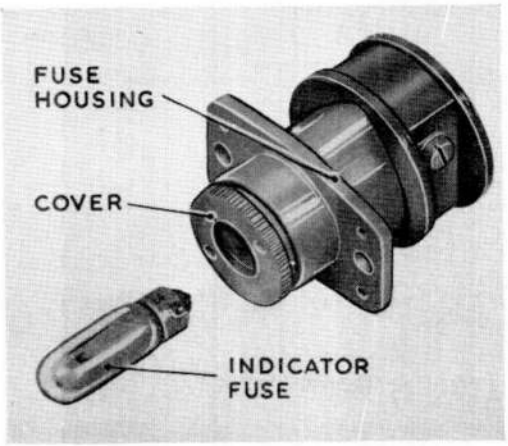

Fig. 7. Fuse and fuse housing

18. A shunt resistor is also incorporated in the fuse to ensure that the current passing through the fuse never exceeds the current consumed by the detonators in one column of suppressors. Without this safeguard it is possible that, where more than one column is employed, the fuse could sever before the detonators fire. It is therefore most important that the correct indicator fuse for the appropriate circuit is employed. The correct fuses for the varying tank installations are given below.

19. In early installations a Mk. 1 fuse housing is fitted on a bracket attached to the base plate of the detector (*fig.* 2). In later installations the fuse housing is a Mk. 2 (*fig.* 7) fitted in the aircraft skin near the fuel tank concerned. The Mk. 2 fuse holder has a flat window which comes flush with the aircraft skin.

Test lamp

20. To enable a source of light to be deliberately introduced into the tank to excite the photo-electric cell of the detector for test purposes, a 28-volt test lamp is fitted in the tank within the field of view of the detector.

21. When the test is performed, a cable unit coupling connector is unplugged from a panel mounting (usually mounted on a bracket on the tank access door) ; this isolates the detonators from the detector output. In place of the cable unit, a test set such as that indicated in fig. 9 may be plugged into the socket. The test set incorporates a battery to light the test lamp, neon indicators to show detector output, and connections for a safety ohmmeter which enable resistance and continuity tests to be made through the suppressor column(s).

TABLE 2
Indicator Fuses

Fuse Part No.	*Identification on brass holder*	*Number of columns in circuit*	*Resistance (ohms)*
E301	one groove	one	10—16
E302	two grooves	two	5·2–7·2
E303	three grooves	three	3·5–4·8
E304	four grooves	four	2·6–3·4

(The resistance value should be checked with a safety ohmmeter, 13 milliamp max. current).

OPERATION

22. The circuit diagram of a typical explosion protection system is illustrated in fig. 8, where a tank contains one detector and two suppressor columns.

Reset switch depressed

23. The reset switch is biassed to one position, and contacts 1 and 2 are closed and 4 and 6 are open when the switch is in its normal position. When the switch is depressed, however, contacts 4 and 6 are closed and 1 and 2 are open.

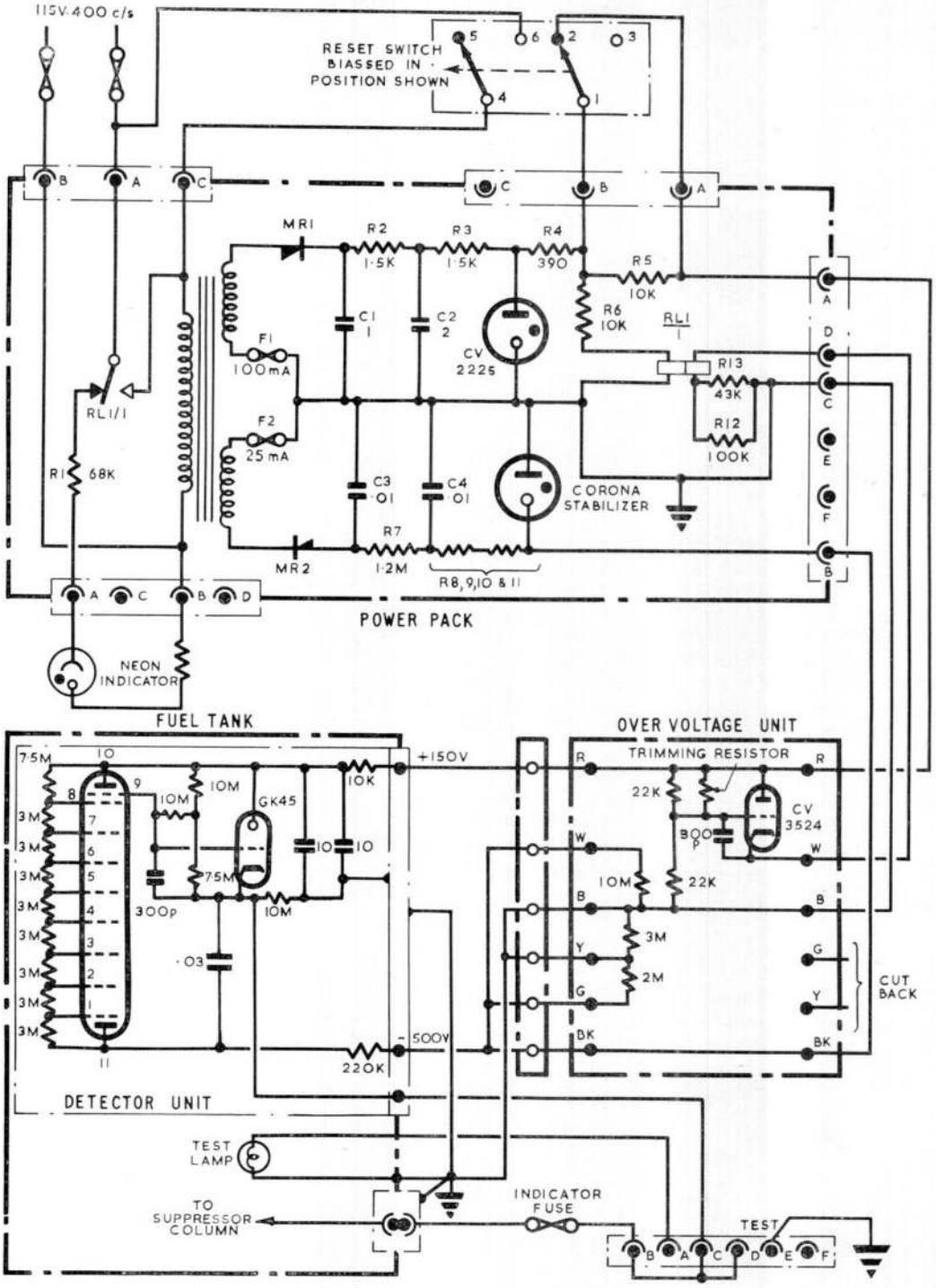

Fig. 8. Circuit diagram of typical installation

24. Contacts 4 and 6, when closed, complete the supply to the primary of the power pack transformer via poles B and C of the three-pole supply plug. The opening of contacts 1 and 2 removes the link between poles A and B of the three-pole socket on the power pack. This causes the 10K resistor R5 to be inserted in the +142 volts output circuit of the power pack. This resistor prevents the sudden surge of current which would otherwise result when switched on, due to initial low impedance of the two 10 μF capacitors in the detector unit.

25. The outputs of the two secondary windings have a common earth connection and are rectified, smoothed, and stabilized to give outputs of +142 volts and —500 volts across poles A and C, and B and C respectively of the six-pole socket.

26. The relay RL1 operates immediately the output circuits of the power pack are energised, one of its coils being energised by the +142-volt circuit via the 10K resistor R6. Contacts RL1 change over to their operated position, thus providing a direct supply to the primary winding of the transformer ; this enables the reset switch to be released and so return to its biased position.

27. The changing over of the relay contacts RL1/1 breaks the supply to a neon indicator lamp which otherwise glows to indicate that the 115-volt, 400 c/s supply is switched on but the system needs resetting.

28. The output lines from poles A, B and C of the power pack are taken, via the over voltage unit, to the detector unit at the aircraft fuel tank. There the +142 volts and —500 volts are combined at one point to give a total voltage of 642 volts across the photo cell. The firing circuit of the detector utilizes the +142 volts d.c. only.

Operation of detector unit

29. When no light exists in the tank the current passing through the photo cell is restricted to approximately 0·1 μA, and the voltage applied to the trigger electrode of the cold cathode valve is insufficient to allow the valve to conduct. When the photo cell views a light within the tank, however, the current increases to 2 μA or above, which provides sufficient potential to the trigger electrode to enable the cold cathode valve to strike and start conducting.

30. The two 10 μF capacitors in the detector unit, which have stored up a charge, due to being connected across the +142-volt circuit, now discharge through the cold cathode. This discharge is sufficient to operate the detonators without causing a sudden surge of current through the power pack.

31. The discharge from the capacitors is applied, via the indicator fuse, to the detonators which fire, rupture the suppressor columns and disperse the suppressing agent and thereby arrest the explosion. The indicator fuse blows almost simultaneously, thus disconnecting the suppressor terminal block from the detector unit and also giving a permanent visual indication of operation. As the suppressing agent does not contaminate the fuel in any way when dispersed, the remaining fuel can still be used.

High voltage surges

32. The possibility of a high voltage surge overloading the power pack or causing inadvertent operation of the detector is obviated by the over voltage unit. This unit, as already mentioned, is connected in the output lines of the power pack and provides straight through connection for the +142V, —500V and common earth output lines (poles A, B and C of the six-pole output socket on the power pack).

33. Two 22K resistors in series are connected across the +142V and earth lines in the over voltage unit and constitute a potential divider, the mid-point of which is connected to the trigger grid of the cold cathode valve. The anode of this valve is connected to the +142V line, whilst the cathode is connected to the line from pole D of the power pack output socket.

34. If the output voltage from the power pack exceeds 159 ± 3 volts the potential of the cold cathode trigger grid is sufficient to enable the valve to strike and start conducting, thus causing a current to pass through the second coil of the relay RL1 in the power pack.

35. The effect of this current flowing through this relay coil is to neutralize the effect of the current already passing through the first coil of the relay (*para.* 26), and so cause the relay to return to the de-energized position, thus breaking the supply to the primary winding of the power pack transformer. This isolates the whole circuit and necessitates the operation of the reset switch to reset the system.

TESTING

Warning

The attention of all concerned is drawn to the risk of injury to personnel by the accidental firing of detonators while they are being installed or tested. The detonators appear to be innocuous but they contain plastic explosive and should be handled with extreme care. Circuits should always be opened before columns of suppressors are fitted, and only approved types of test equipment should be used.

Detector test kit

36. Using the Graviner detector test kit in conjunction with a safety ohmmeter (maximum current 13mA) makes it possible to carry out a functional test of the detector unit and a continuity check on the suppressor and indicator fuse.

Method of testing

Resistance of suppressor columns

37. Disconnect the co-axial bulkhead connector located near the detector unit and, using the safety ohmmeter, check the resistance between the centre pin of the connector and earth. This should agree with the resistance specified on the data sheet on the tank access plate or in the aircraft log book.

Functional test of detector

38. With the 115V, 400 c/s supply switched on and the reset switch operated, disconnect the cable unit coupling connector fitted adjacent to the detector, and plug in the detector test kit cable. The circuit diagram of the detector test kit is given in fig. 9, and a full description will be found in A.P.4343S, Vol. 1, Sect. 17.

39. Depression of the test switch on the front panel of the test kit applies 30 volts d.c. to the test lamp mounted inside the tank, via pole A of the cable unit coupling socket. The presence of light within the tank should cause the firing circuit of the detector to operate, thus causing operation of the neon indicator.

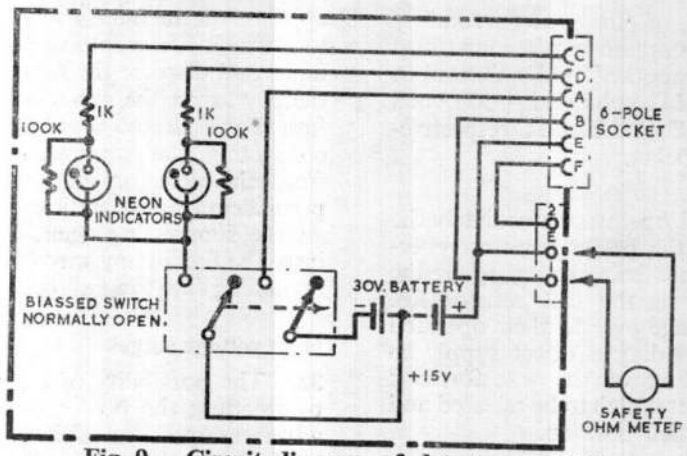

Fig. 9. Circuit diagram of detector test kit

40. The resistance of the detonator and indicator fuse may be tested with the test kit plugged into the coupler unit by connecting the safety ohmmeter to the relevant connector on the side of the test kit. Should the resistance be other than that expected, each item should be separately checked, commencing with the fuse, and then the columns. Part(s) found faulty should be renewed.

Comprehensive test kit

41. A Graviner test kit which enables each unit to be tested accurately, both in situ and in the servicing bay, in addition to enabling a serviceability test of the complete system to be made, is obtainable. This test kit and its method of use will be found in A.P.4343S, Vol. 1, Sect. 17.

Note . . .

An insulation resistance tester should NOT be used on any leads or components in the system.

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