CHAPTER 8

IGNITION HARNESS AND SPARKING PLUGS

Objectives

1. This Chapter is a continuation of Chapter 7 and the aim is to satisfy the remainder of the relevant Skills and Knowledge Specifications (SAKS) contained in the Engine Ignition Systems. When you have studied this Chapter, you will be able to:

a. State the purpose of an ignition harness, the servicing required and the insulation and bonding tests which are necessary.

b. Describe the tests required to test a Mk 2 HT Ignition Tester.

c. Describe the precautions to be taken when handling sparking plugs, how they are serviced, including cleaning and testing, and the equipment used during the various processes.

Ignition Leads and Harness (HT)

2. The HT leads that connect the magnetos to the plugs are made of single cored, heavily insulated cable, capable of carrying high voltages in excess of 12 000 volts and of withstanding the ill-effects of oil and fuel contamination and the engine temperature. The single core is made of twisted strands of either tinned copper or stainless steel, and the rubberised insulation is generally protected by an outer covering of varnished fabric. In certain instances, a further covering of braided metal wire is added. LT cable used for wiring the switch into the magneto circuit is of similar construction but not quite as robust.

3. **Ignition harness.** On multi-cylinder engines, it is usual to enclose the HT leads, as far as possible, in a metal conduit or harness. The advantages to be gained from this arrangement are:

a. Positive screening with less weight.

b. Quicker servicing, because all HT leads can be assembled to the engine as one unit.

c. Greater access to other engine components for servicing.

d. Protection of the leads from damage.

e. Sealing of the leads against moisture.

4. In practice, an ignition harness consists of one or more rigid metal conduits to which are attached two large diameter flexible conduits leading to the magneto distributors, and a number of smaller flexible conduits connecting to the individual sparking plugs. The complete assembly is secured to the engine by attachment lugs on the rigid conduit. Each HT lead passes from the magneto distributor block, through a large bore flexible conduit and around the inside of the rigid conduit to the small flexible conduit leading to its sparking plug. Each lead has an identification sleeve at each end. An ignition harness is illustrated at Fig 1.8.1.

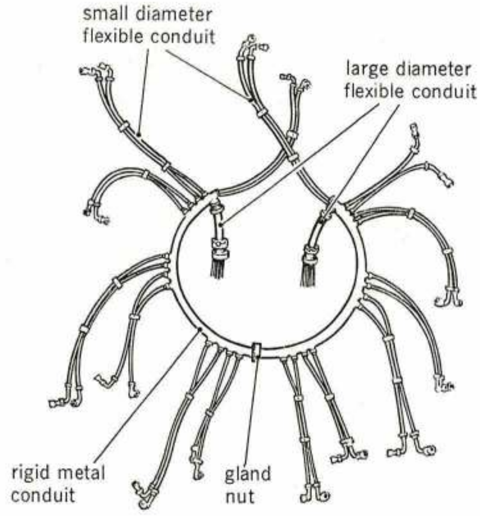

Fig 1.8.1 An ignition harness

5. **Screening.** The sudden variations in current flow and the arcing that takes place in the HT windings, leads, distributors and sparking plugs during normal operation produce unwanted signals that, unless suppressed, interfere with the aircraft radio reception. Reduction of such signals is prevented by enclosing all the components of the ignition system in a non-magnetic metal screen.

6. The magnetos are screened by the metal body of the magneto and the fitting of cover plates over the contact breaker and distributor block. HT leads are screened either by enclosing them in metal conduit (ignition harness) or by the use of metal braided cables. Screening is effective in eliminating any such interference only where all screening is electrically connected or *bonded* to the airframe structure.

Servicing and Testing Ignition Leads (HT)

7. Before any servicing is started on aero-engines it is vitally important to ensure that the magneto switches are in the OFF position. All magneto switches are installed in a standard manner. There are two switches for each engine: a left hand switch for the port side magneto and a right hand switch for the starboard side magneto. These switches short out the magneto primary circuit contact breaker; no current interruption and subsequent spark can thus be produced should the magneto system be operated. When the switch is in the 'UP' position, the magneto is 'ON' because the switch is no longer shorting out the contact breaker in the magneto primary circuit and the system is now 'LIVE' and capable of producing an HT spark. IF THE SWITCH LEADS TO THE MAGNETOS ARE REMOVED, OR IF THE CONTACT BREAKER COVERS ARE REMOVED, THE MAGNETOS ARE LIVE BECAUSE THE PRIMARY CIRCUIT CONTACTS ARE NOT SHORT CIRCUITED. The HT leads to the plugs should be removed,

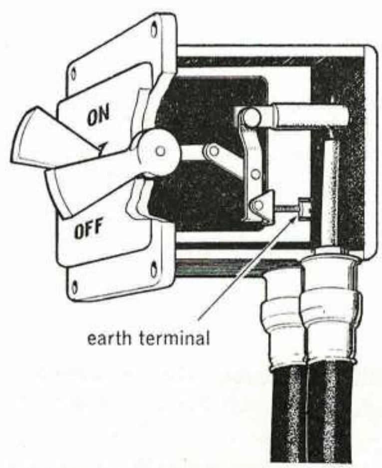

Fig 1.8.2 Engine ignition switch

or a sparking plug removed from each cylinder should the switch leads be disconnected. When the switch is in the 'DOWN' position, the magneto is 'OFF'. At routine servicing, the ignition switches are to be examined for insecurity and external damage. An illustration of an ignition switch is shown at Fig 1.8.2.

8. **Servicing of ignition harness.** Servicing of an ignition harness consists of a visual inspection, a continuity test and an insulation test. Faults to look for during visual examination include:

a. Loose cables and sleeves at sparking plugs and distributor blocks.

b. Insecurity of attachment bolts.

c. Perished insulation of cables. This is indicated by hardening of the insulation and the formation of surface cracks when the lead is bent into a tight loop.

d. Damage to the metal braiding or rigid conduit.

e. Oil sodden insulation, which is indicated by swelling and softening of the rubber insulation and bursting of the fabric binding.

9. **Bonding.** All metal parts of an aircraft must be in good electrical contact one to another so that all have the same electrical charge or potential. Unless this is done, any intermittent contact that causes arcing between parts at different potentials produces radio interference and also increases the danger of fire.

10. In practice, pipelines, metal braided leads, metal conduit, and other components that are not in constant metallic contact with the airframe are all 'bonded' to the airframe structure with special metal clips or wires. Positive contact at these points is checked with a lamp and battery.

11. **Continuity test.** The purpose of the continuity test is to ensure that there is a good electrical contact throughout a lead and its distributor connection. Since a poor electrical contact forms a resistance to current flow, a low resistance must indicate good electrical continuity, and this can easily be checked by trying to pass a current from a low voltage supply. A convenient way to do this is to use a magneto synchronizer lamp and battery previously mentioned in an earlier paragraph.

12. To check a lead in a harness for continuity, the lead is disconnected from its sparking plug, and the distributor block is removed from the magneto. The two leads from the lamp and battery are held together and the brilliance of the lamp is noted. One of the leads from the lamp and battery is then connected to the sparking plug end of the HT lead to be tested, and the second lead is connected to the appropriate distributor segment. If the lamp lights with the former brilliance then there is no appreciable resistance and continuity is positive through both the lead and the lead/distributor connection. On some types of harness a resistor is fitted in the HT lead at the sparking plug end sleeve; this resistor must be removed before the test.

13. **Insulation test.** The purpose of this test is to check the efficiency of the lead insulation. To do this, a high voltage, well in excess of the normal working load, is applied to one end of the core and a check is made for any electrical leakage.

14. The high voltage required for the test is supplied by a Mk 2 High Tension Ingition Tester, illustrated at Fig 1.8.3, for which the servicing is described in the next paragraph. To

test a lead in a harness, the lead is disconnected from the sparking plug, and the distributor block is detached from the magneto. One lead from the HT tester is connected to the core of the lead under test, and the second lead from the the tester is clipped to the metal harness. The handle of the tester is then turned slowly (hand starting magneto); any sparking that may be seen or heard, or hunting of the meter, indicates a breakdown in the insulation. If none of these signs are noticed, the turning speed is increased, the push button on the tester is depressed, and the meter reading noted. Only if the pointer positions itself on the *green* sector of the scale, can the insulation be considered serviceable.

Note: The push button safeguards against the meter being overloaded when there is a short circuit or earth fault in the circuit under test.

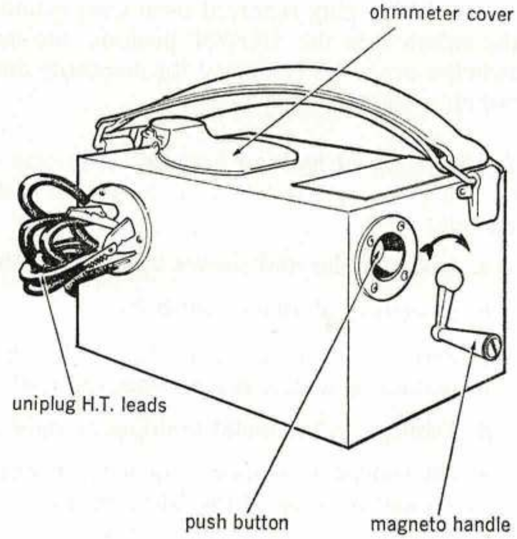

Fig 1.8.3 High tension ignition tester

15. **Servicing the Mk 2 HT igition tester.** This instrument is sealed and the internal parts are *not* to be touched. The leads, however, should be examined to ensure that they are in good condition. The terminals should be kept clean and lightly smeared with grease PX7.

16. **Testing.** The meter fitted in the Mk 2 tester is calibrated on a magneto output of 11 200 to 12 500 volts, and any variation in the output voltage, such as would result from a failure through breakdown or open circuit of the capacitor connected across the magneto primary circuit, would cause inaccurate meter readings. If the voltage of the tester is suspected of being incorrect for any reason (such as the apparent rejection of a series of HT cables or the passing of an obviously unserviceable cable as serviceable), the voltage is tested as described below.

17. Connect the earth lead of the instrument to the earthed side of a standard ball test gap and the HT side to the insulated electrode of the gap. The test handle must now be turned at approximately 300 rev/min. Regular sparks should be maintained across the gap when the gap setting is 2·95 mm (11 200 volts) and when this setting is increased to 3·40 mm (12 500 volts), the spark should be maintained or become intermittent. When the gap is increased to 3·8 mm there should be no sparking at all. THE PUSH BUTTON MUST NOT BE DEPRESSED DURING THIS TEST.

Renewing an HT Lead

18. When a harness on an aircraft is found to contain unserviceable HT leads, the faulty leads are to be renewed. Whether this is done *in situ* or after removing the complete harness depends on the particular installation and the number of faulty leads. In general, if there are *more than two* faulty leads the harness is removed from the engine. The engine Air Publication, Volume 6 should be consulted.

19. To renew an HT lead in an installed harness, proceed as follows:

a. Disconnect the lead at the magneto distributor and remove the terminal sleeve.

b. Bare the end of the new length of lead, twist the end to that of the faulty lead and solder firmly together. (Use phosphoric acid as a flux for stainless steel cored cable.)

c. Remove any jagged ends from the soldered joint and coat the new cable, covering liberally with french chalk.

d. Remove any securing clips from the flexible conduit that will take out any sharp bends in the lay of the faulty cable.

e. Pull out the old lead from the sparking plug end, and at the same time feed the new cable until it is in place.

f. Cut away the soldered joint completely and cut the new lead to length. Attach the end fittings and connect the lead to the distributor block. Refit securing clips.

g. Test the lead for continuity and insulation.

Low Tension (LT) Leads

20. Metal braided leads are used between the magneto contact breaker and the ignition switches, the screening metal braiding forming part of the return circuit to the magneto. As with HT leads, LT leads are tested for continuity and insulation but, since LT leads carry a relatively low voltage, the insulation test is not as searching.

21. **Continuity.** The continuity of LT ignition leads is checked by attaching one lead from a lamp and battery to the magneto end of the switch lead core and the second lead to the outer metal braiding. The lamp should light with the ignition switch at 'OFF', and go out when the ignition switch is moved to 'ON'.

22. **Insulation.** The insulation of LT ignition leads is checked with a loading of 500 volts. This loading is applied by a 'megger', which is basically a hand driven electrical generator and a meter in a sealed casing. One lead is connected to the magneto end of the switch lead core, and the second lead is attached to the metal braiding. The ignition switch is moved to the 'ON' position and the handle of the megger turned at a steady speed. The resistance of the insulation is then read off the meter. A serviceable LT gives a reading of at least 10 megohms.

Sparking Plugs

23. As stated previously, the sparking plug is secured into the cylinder head, where it is required to produce a spark at the proper time, and it has to continue this function for several hours and remain untouched for quite a long time. A sparking plug has two poles—a POSITIVE one and a NEGATIVE one. One is referred to as the central electrode and the other as the earth electrode. Each is insulated from the other. These electrodes terminate at the mouth of the plug in close proximity to each other, and the space between them is called 'the sparking plug gap'. Across this gap, the spark is discharged from the HT lead terminal attached to the sparking plug.

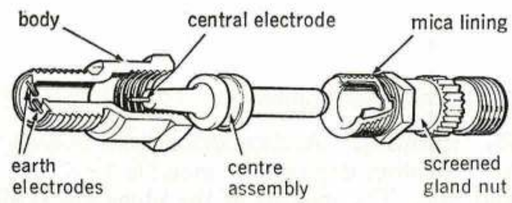

Fig 1.8.4 A sparking plug

24. A sparking plug is subjected to intense heat, highly corrosive gases and high voltages. Because it has to withstand these combined stresses, and also to nullify the effects of the varying expansions, the centre core, forming the current conductor, is not built in one piece. Some plugs have resistors fitted; the resistor, which is built into the centre assembly, reduces erosion caused by arcing at the electrodes. This type of plug has a suffix 'R' after the plug type marking, *eg* RZ4/2R. The lower section of the centre core, and sometimes the earth electrodes, are

made of nickel alloy. The wire electrodes fitted to the majority of aero-engine plugs are made of platinum. The insulation may be mica, but is more generally a ceramic. An example of a sparking plug is illustrated at Fig 1.8.4.

25. Sparking plugs are classified as 'detachable' or 'non-detachable', as illustrated at Fig 1.8.5. A detachable plug has a screen sleeve which may be removed for cleaning, whilst the central assembly still remains secure. *It is emphasized that the screen sleeves, where applicable, are the only parts of the sparking plug which may be removed for cleaning.* When a plug has been removed for bay servicing, it has to be degreased and cleaned, the gap checked and the plug tested. Before commencing this servicing, it should be emphasized that safety precautions must be obeyed and that reference should always be made to the Servicing Procedures (SP).

26. **Degreasing.** The approved degreasing agent is white spirit. Mica-lined sleeves must be blanked off for protection, and the plugs are then immersed in the liquid. The plugs are agitated to remove loostened deposits. After removal and draining, surface corrosion and deposits must be removed and the plugs dried. The insides of the screen sleeves are cleaned with a soft brush moistened with white spirit and again dried. An air blast must NOT be used to dry mica-lined screen sleeves. All obviously damaged sparking plugs must be rejected at this stage.

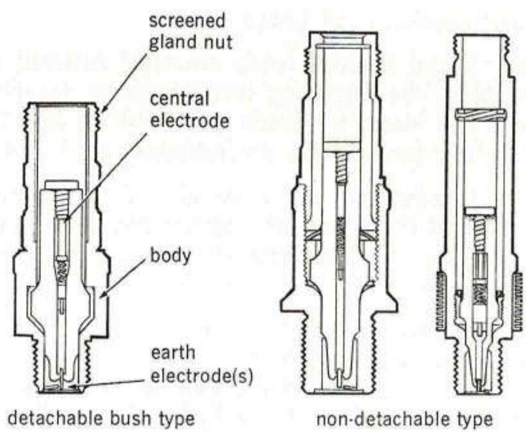

Fig 1.8.5 Detachable and non-detachable plugs

27. The following safety precautions are to be taken during this operation:

a. The extractor fan must be running whilst the degreasing bath is in use.

b. Fire extinguishers must be readily available.

An example of a degreasing bath is illustrated at Fig 1.8.6.

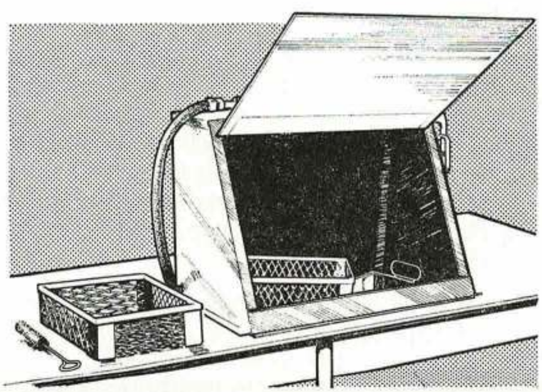

Fig 1.8.6 A degreasing bath

28. The degreasing bath is of the cabinet type and is designed for bench mounting. It is three inches deep and a drain cock is fitted at its lowest point. Fumes are removed from the cabinet by a pneumatically driven metal fan, and the fumes are exhausted through trunking to an outlet which must be outside the building. A fire extinguisher, mounted at the side of the cabinet, is connected to a spray nozzle in its interior.

29. **Cleaning.** A chemical cleaner is used for removing deposits of metallic lead and lead salts. The mouths of the plugs are subjected to a jet of hot cleaning solution, and this is followed by an air blast which brings away loosened particles including carbon deposits. Whenever possible, the plugs should be cleaned in batches of 36, all of which should have the same thread diameter and reach. The thread diameter of a plug is expressed in mm—*eg* 12mm or 14mm, and the reach is commonly expressed as 'short reach' or 'long reach'. This, basically,

is the length of the threaded portion of the plug which is screwed into the cylinder head—the cylinder head being designed to accommodate a specific type of plug.

30. To clean the plugs, proceeds as follows:

a. Ensure that the cleaning fluid is at the correct level.

b. Switch on the main and heater switches.

c. Check that the neoprene grommets on the top plate are of the correct thread size and reach for the plugs that are being cleaned.

d. Feed the plugs into the top plate and position the earth electrodes so that the fluid jet has an unobstructed path into the mouth of the sparking plug.

e. Blank off vacant spaces, if any, and fit the top plate to the cleaner.

f. When the heater light goes out, indicating that the working temperature has been reached, switch the pump motor 'ON'.

g. After 10–15 minutes, switch the pump motor 'OFF', open the air control valve and leave the air blast on for not less than 30 seconds; then close the air control valve.

h. Remove and invert the top plate; examine all the plugs for satisfactory removal of deposits. Repeat the cleaning operation if unsatisfactory.

j. If satisfactory, thoroughly dry the threads and the interior of each plug, then remove them from the top plate.

31. After cleaning, an examination of the plugs should be made. Any which have the insulation cracked or any electrodes which are loose or are eroded outside the limits laid down for the cross-sectional area, or any of those with signs of the mica flaking, should be rejected. An example of cracking and erosion is illustrated at Fig 1.8.7.

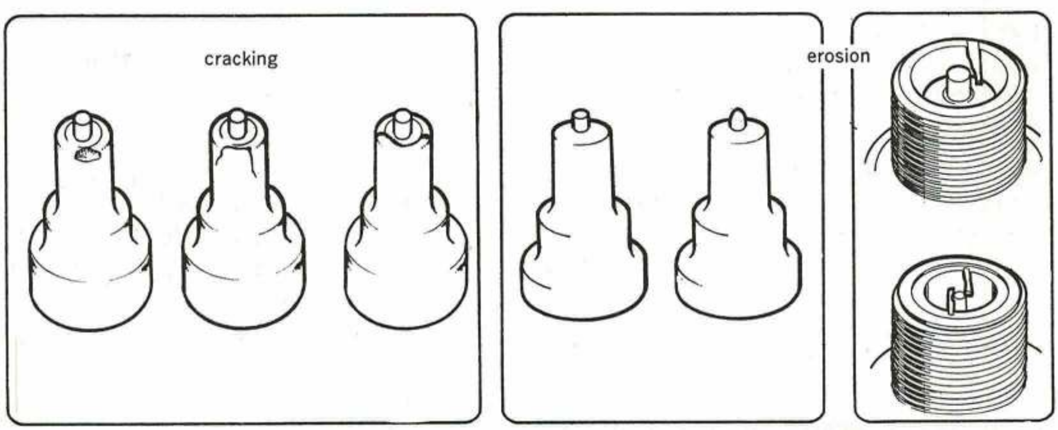

Fig 1.8.7 Cracking and erosion of plugs

32. **Gap setting.** The gap between the central electrode and each earth electrode must be set towards the low limit of the standard setting for any particular type of plug as laid down by Engineering Instructions. Under no circumstances should any attempt be made to bend the central electrode; all adjustments are made by bending the earth electrodes. When resetting the gaps of plugs having fine wire earth electrodes, the wire should be slowly bent to close the gap,

then slowly opened up until the correct setting is reached. This ensures that the gap will decrease if the fine wire has any tendency to recover after bending. Measurement of the gaps is made with a special gauge consisting of a metal holder carrying two wires; one wire diameter is the low setting and the other the high setting, *eg* 0·012 in and 0·015 in. After the gaps have been checked and/or adjusted, the sparking plug must be tested for sparking and gas leakage. An example of a sparking plug gap gauge is illustrated at Fig 1.8.8.

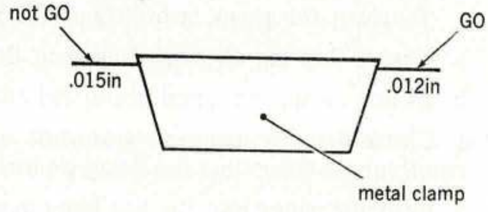

Fig 1.8.8 Sparking plug gap gauge

Testing of Sparking Plugs

33. Two tests are required to be passed satisfactorily before a sparking plug can be considered to be serviceable. The first is known as the insulation test and is designed to test the insulation surrounding the central electrode. The second test is designed to check the gas tightness of the central electrode and centre assembly. *No leakage is permissible.*

34. **Insulation test.** The sparking plug tester is designed to test both Class 1 and Class 2 sparking plugs. *The test voltage for Class 1 sparking plugs is 12kV and for Class 2, 14kV.* These voltages are obtained by the variation of the setting of the standard ball spark gap fitted to the tester (*see* 1.8.9). Having set the required gap and tested the machine, proceed as follows:

a. Fit the sparking plug into the retaining plate, and raise the carrier into position by hand. Slowly apply air pressure until the carrier is retained by the pressure and the sparking plug is sealed.

b. Press the switch and check that sparking occurs at the electrodes; this checks that the electrical connections are correctly made.

c. Continue to admit air pressure until sparking occurs at both the electrodes and the ball gap; then increase pressure slowly until sparking is suppressed at the electrodes.

d. Sparking at either the electrodes or the ball gap must be regular; any irregularity indicates a faulty plug.

e. If sparking occurs over the nose of the insulator, this indicates a dirty plug. If audible or visible 'shorting' occurs, through or over the screen insulation, dirty or punctured screen insulation is indicated. If audible or visible shorting occurs through the insulator to the plug body, the centre assembly insulation is punctured, cracked or broken.

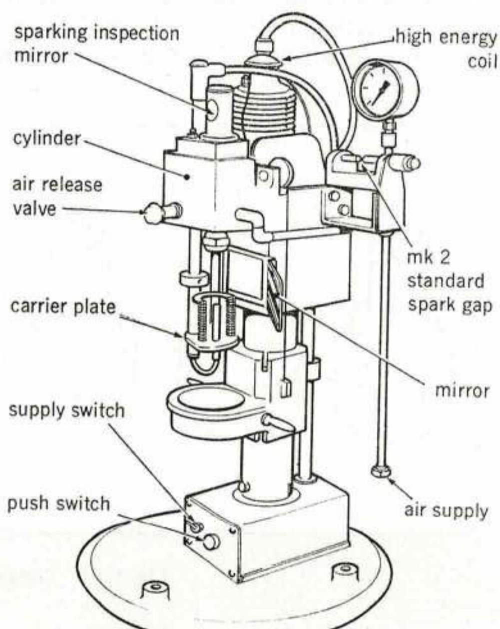

Fig 1.8.9 Spark and leak tester

35. A spark and leak tester for sparking plugs is illustrated at Fig 1.8.9.

36. **Gas leakage test.** If the plug is sparking satisfactorily, leave it in the tester and adjust the air pressure to 100 psi (6·895 bars). Fill a glass jar with white spirit to ¾ in of the top and place it on the holder. Raise the holder so that the sparking plug is immersed to half-way up the body hexagon. Bubbles appearing from any part of the plug that is immersed indicates leakage and the plug must be rejected. To remove the sparking plug from the machine, press the air pressure release valve; the carrier will then drop and the plug can be lifted out.

Storage of Sparking Plugs

37. Plugs that have been satisfactorily serviced and tested, but are not to be put into immediate use, should have the external body threads lightly smeared with the approved grade and make of anti-seize compound. Screen and body threads should be fitted with bakelite protection caps. They are then placed in plug trays and put into a storage cupboard which is electrically heated, the temperature inside the cupboard being thermostatically controlled at 5° to 10°F above normal room temperature. Storage under these conditions ensures freedom from condensation. A storage cupboard is illustrated at Fig 1.8.10.

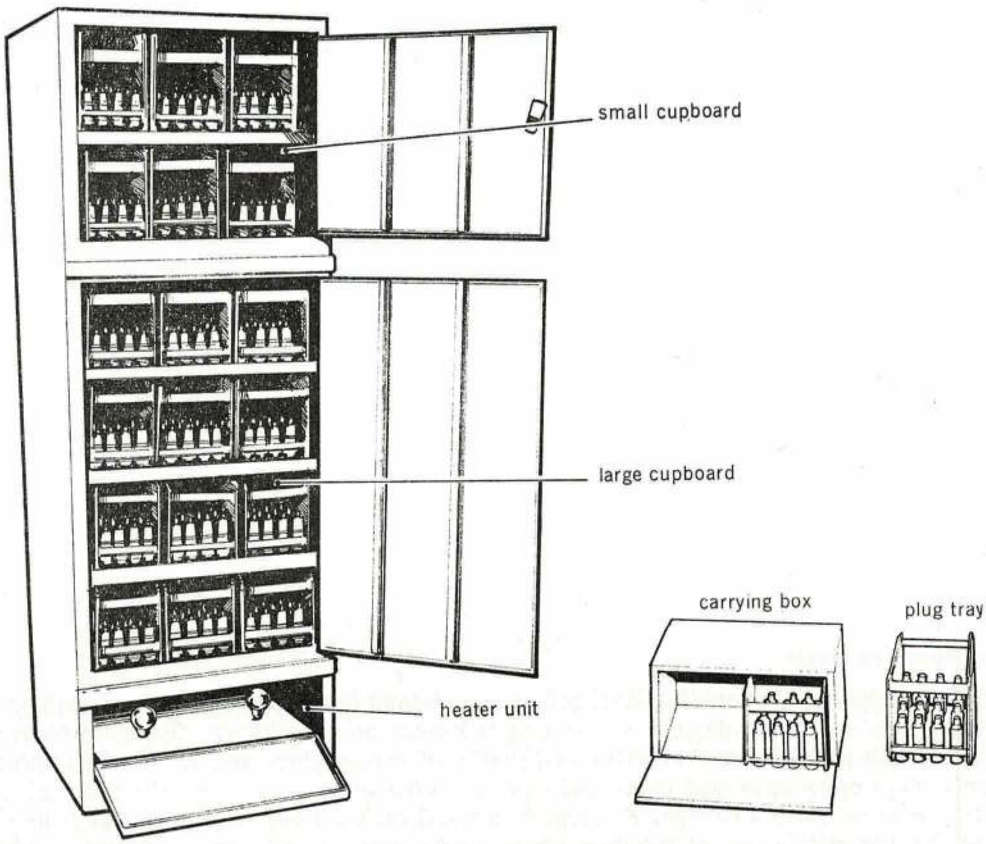

Fig 1.8.10 A storage cupboard

Typical Layout of a Sparking Plug Servicing Bay

38. A typical layout of a servicing bay is illustrated at Fig 1.8.11.

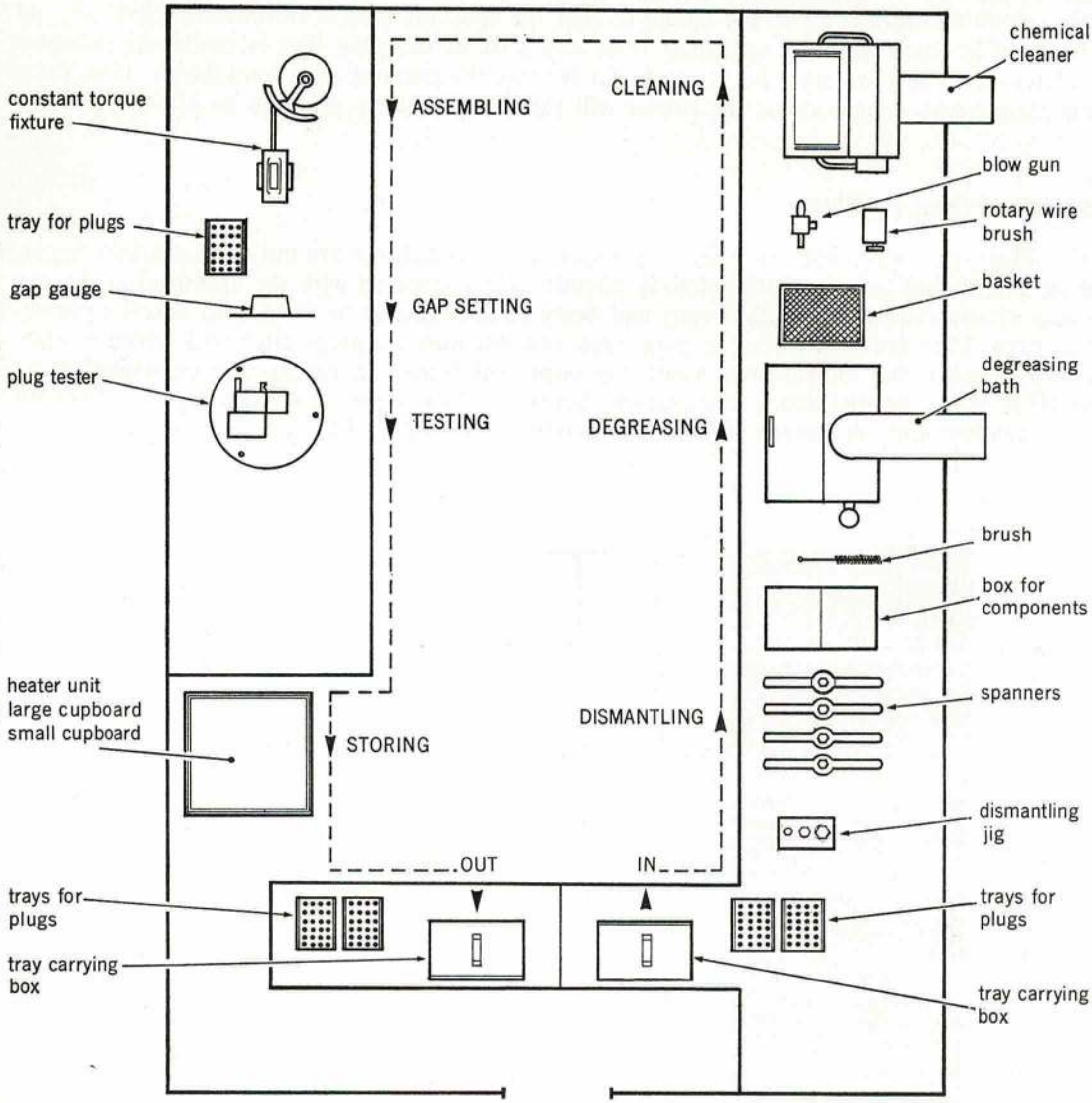

Fig 1.8.11 Layout of servicing bay

Fitting Sparking Plugs

39. Engines should be allowed to cool before any attempt is made to remove or install sparking plugs. This will avoid damage to the plug adapters or wire inserts. Sparking plugs are designed to suit particular makes, types and marks of aero-engines and it is most important that *only plugs of an approved make and type are fitted to an engine*. All the plugs of a set must be the same make and type. The type is marked on the body of the plug and the sizes refer to the diameter in mm of the thread that screws into the cylinder, *eg* 12mm or 14mm. When fitting sparking plugs check that a new or serviceable external sealing washer is fitted

and that the external body threads have been lightly lubricated, and check that the electrodes and the mouth of the plug are clean. Start and screw in the plug finger tight and then, to ensure the correct torque loading, use the approved sparking plug spanner.

40. If a sparking plug is allowed to fall to the ground or is in any way mishandled it must not be fitted to an engine until it has been degreased, the gaps re-checked and has satisfactorily passed the insulation and gas leakage tests.

41. Some *'do's'* and *'dont's'* regarding sparking plug maintenance are illustrated at Fig 1.8.12.

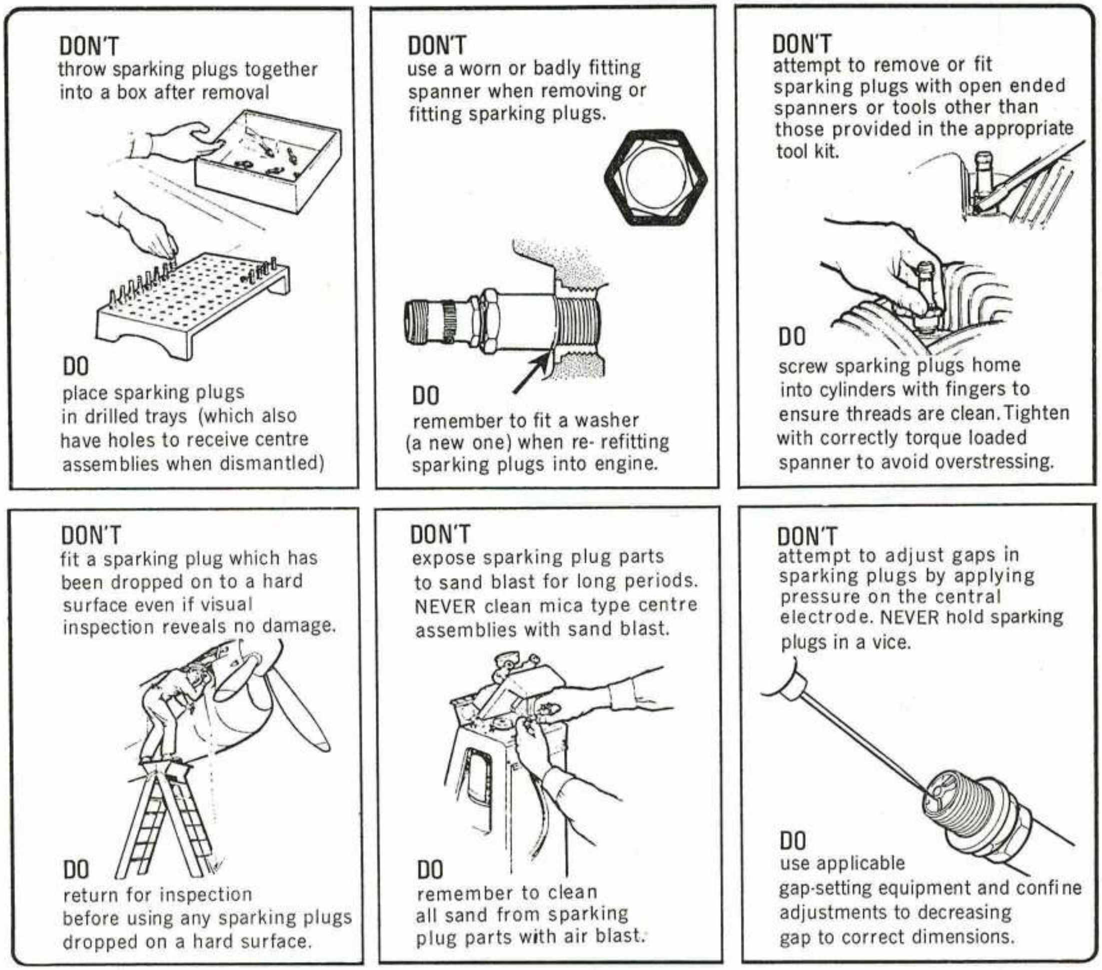

Fig 1.8.12 'Do's' and 'Dont's' regarding sparking plug maintenance

References

42. AP120L-0506-1 gives information on servicing equipment which is used on sparking plugs during dismantling, degreasing, assembly and storage. AP120L-0105-1 describes the chemical cleaning plant Mk 2, and the servicing of aero-engine sparking plugs is contained in AP113L-0500-1.