The 'Luchs' petrol injection system has been developed and proved over a number of years to give added engine performance, combined with reliability and increased economy over the conventional carburetter system.

Fundamentally the system differs very little from that outlined in publication No. 1780 'Developments in Petrol Injection Equipment', which should be referred to for general information purposes. Modifications incorporated in the current system include a permanent magnet motor in place of the wound field type shown in the brochure, the addition of a thermal relay, and a manual control. The relay is mounted on the dashboard and incorporates a warning light and resetting button. It has been designed to switch the pump off, after approximately 30 seconds, should the ignition be left on and the engine not started in that time. This prevents unnecessary drain on the battery. The manual control has been introduced to assist cold starting conditions. This also is mounted on the dashboard.

In addition to the theory given in publication No. 1780 the following fault finding notes, outlining the procedure to be adopted when servicing petrol injection equipment, will enable you to determine and rectify faults which may occur in service.

The following test equipment is needed to carry out a systematic check:-

0 - 30 amp	D.C. Ammeter
0 - 20 volt	D.C. Voltmeter
0 - 150 p.s.i.	Pressure Gauge
	Torque Spanner

FAULT DIAGNOSIS WITH P.I. EQUIPMENT

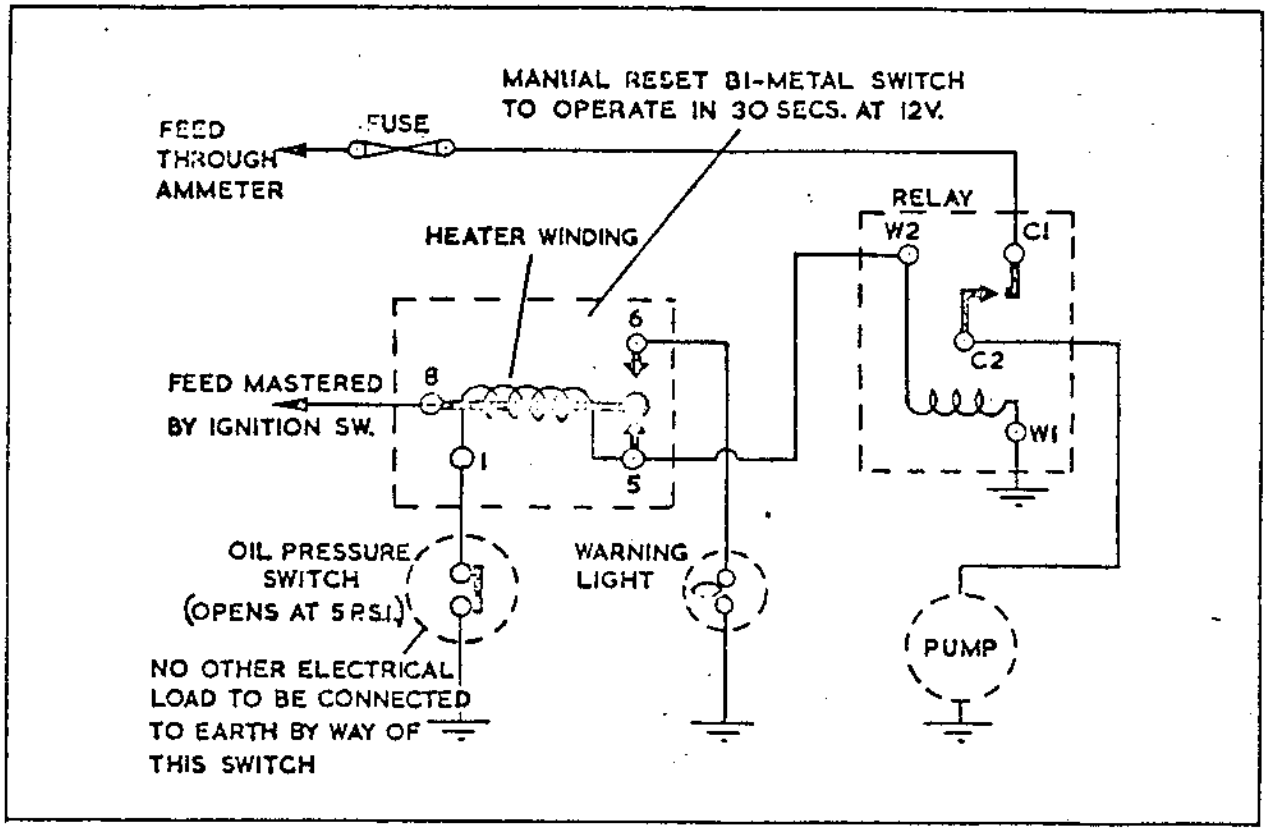
Faults on P.I. Equipment have been categorised under 'FAULT' headings. In the introductory paragraph to each fault, reference has been given to causes outside those of P.I. Equipment which could present the same symptoms. It will be assumed that preliminary checks on such causes, in accordance with recognised procedure, will have been carried out before commencing with a P.I. diagnosis. Reference is first given to the P.I. Electrical circuitry, and a circuit diagram included. Intricate fault finding procedure on the electrical side has been excluded, but a generalised pattern given if the fault is found to be an electrical one.

THE ELECTRICAL CIRCUIT

The pump is fed via the panel ammeter, a fuse and the contacts of a 65RA relay. The relay winding is fed from the ignition switch via a thermal switch, which is designed to open in 30 seconds if the ignition is left on, and the engine not started in that time.

The thermal relay contacts will open should the engine oil pressure be below 5 p.s.i., and a warning light is illuminated. The warning light is built into a manually operated resetting button mounted on the dashboard. This button should be pressed to reset, approximately 15 seconds after tripping.

Manual over-riding of the thermal relay is possible, by holding the button in the depressed position.



Servicing Notes

The following servicing instructions must be carefully followed particularly when removing units from the vehicle and fitting replacements.

Metering Distributor/Control Unit

1. If the exterior of the unit is dirty, clean it before unscrewing any pipe connections.

2. As pipe connections are unscrewed, immediately fit blanking caps or plugs both to the pipe and the unit inlet to prevent entry of dirt. Similarly ensure that blanking caps and plugs are left in position until immediately before the pipe connections are to be re-made.

3. When refitting a metering distributor/control unit to an engine, ensure that the flange faces of the distributor and the engine timing case are clean and undamaged. Take care to fit the heat insulating plate, with a gasket on either side.

   The timing mark on the end of the metering distributor drive shaft must coincide with the timing mark on the engine drive. It will be found best to rotate both the metering distributor shaft and the engine until these timing marks are at 6 o'clock, for correct alignment.

4. Ensure that all solid pipes are correctly formed to shape and lie correctly in the plane of the clamps before these are tightened. The clamps are provided to support the pipes, not to distort them into position; undue strain on the pipes may result in breakage.

5. Check that all pipe unions are undamaged before connecting them to the unit, and tighten the unions to the following torque figures:-

   7/16 in. UNF unions - 16 lb.ft.
   3/8 in. UNF unions - 10 lb.ft.

   Excessive tightening will damage the pipe entrances.

6. After fitting a replacement unit, remove the protective tape from air filter and extra orifices.

7. Before initially running a new or replacement unit, fill the oil pump cam box on the metering distributor with clean engine oil. Access to the cam box is obtained by removing the screwed plug (using ½ in. A/F box spanner) at the rear of the oil pump.

8. Ensure that when the cold starting control on the dash is fully home, the overfuel lever on the control unit is hard against its stop.

9. If any O-rings are removed during examination of the banjo connections, new rings must be fitted. It is essential to use only the correct recommended Lucas spares, as these are of a special approved grade of material.

10. Each banjo connection must be refitted in the location from which it was removed. This is important since on some installations banjos of unequal lengths are used.

Primary Pump

11. All electrical connections in the pump circuit must be kept clean and tight, particularly the snap connectors at the pump. Never disconnect these snap connectors without first ensuring that the ignition switch is OFF.

12. The BLACK cable on the pump is the POSITIVE connection, irrespective of whether the electrical system is of positive or negative earth polarity.

13. If the pump is mounted below the level of the fuel, the fuel tank must be drained before any pipes are disconnected from the pump. This applies also if the pump filter bowl is to be removed.

14. Unless there is adequate space for working and inspection, the pump should be removed from the vehicle when renewal of the filter element becomes necessary.

Maintain the unit with the motor uppermost until the filter bow has been completely drained of fuel. This will prevent sediment from the filter bowl entering the pump inlet.

When replacing the filter ensure that the upper end of the element, complete with its 'O' ring, is centralised in the pump inlet chamfer before inserting the conical rubber seal and refitting the filter bowl.

When a filter element is removed, and the same element refitted, a new top 'O' ring must be fitted as the original will have swollen due to prolonged immersion in petrol.

Ensure that the rubber sealing washer on the rim of the filter bowl is undamaged.

N.B. 'O' rings can be obtained from C.A.V. - Part No. 5855-30T, in packets of 10.

An incorrectly fitted filter unit will permit unfiltered fuel to pass into the pump and subsequently into the remainder of the equipment.

The filter assembly tool illustrated can easily be made and should always be used when fitting a filter assembly. This is done in the following manner:-

(i) Insert the end of the tool into the lower end of the filter, that is, the end that does not have an 'O' ring.

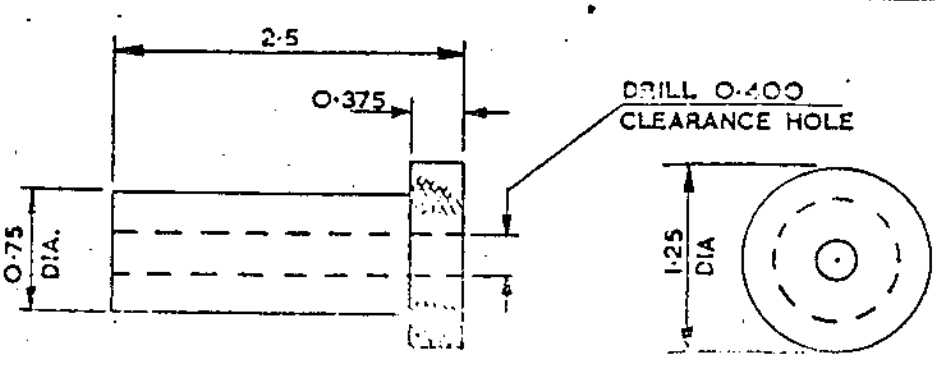
(ii) Slide the filter over the shaft, 'O' ring end first, press firmly and hold in that position.

(iii) Remove assembly tool with free hand and refit conical rubber seal.

(iv) Refit spring washer, spring and filter bowl etc.

'O' Ring Replacement

Improved sealing is obtained with Lucas 'O' ring, part number 54731428, when fitted in place of C.A.V. 'O' ring, part number 5855-30T, on the upper face of the filter element. Accordingly, the Lucas unit only should be used henceforth, Replacement filter elements will incorporate C.A.V. 'O' rings and these should be changed for Lucas units before fitment.



MILD STEEL
DIMENSIONS IN INCHES

Injector Nozzles

15. Take precautions against entry of dirt by fitting blanking caps to injector and pipe when an injector is removed from the engine.

16. New nozzles are protected by dust caps on both ends. Ensure that these caps remain in position until immediately before use.

17. The precautions given in 4 and 5 regarding the forming of pipes and tightness of unions must be followed.

18. See that the O-ring on the heat insulating block is in good condition.

19. Tighten the screws or nuts firmly to secure the heat insulating block to the manifold, but do not apply excessive force, or the moulding may split. Note that the seal is formed by the O-ring, not by the tightness of the heat insulating block.

20. When fitting nozzles into the heat insulating blocks, take care not to over-tighten, as the heat insulating blocks are made of bakelite and excessive force could strip the thread.

INDEX OF FAULTS

FAULT A! ENGINE WILL NOT START

Assuming that there is sufficient fuel in the tank, that the ignition system is in order, and that the starter will crank the engine, the following diagnosis is recommended:-

N.B. If the fault is found to exist in any category after A.5, then after rectifying and ensuring the engine fuctions correctly, RECONNECT the lead from the thermal switch to the oil pressure switch.

TEST	METHOD
A.1. Pulsations at Metering Distributor	Switch ON the Ignition. RESET manual button, as necessary, and maintain in this position. CRANK the engine, and progressively press firmly with finger on the non-return valves in the outlet ports on the Metering Distributor. A distinct pulsation should be felt as injection takes place. Alternatively, the injection pipe unions at these ports may be slackened, and a flow of fuel should occur from each union in turn as the engine is rotated.

ACTION

a) If pulsations are felt, proceed to A.12 via A.5.
b) If NO pulsations are felt, proceed to A.2.

A.2. Fuel pump running

Locate the pump at the rear of the car and on eliminating extraneous noises, the pump should be heard running.

ACTION

a) If the pump is heard to be running proceed to A.9. via A.5.
b) If the pump is NOT running proceed to A.3.

A.3. Operation of Safety Switching Circuit

RELEASE the manual reset button, and the warning light should be illuminated.

ACTION

a) If the warning light illuminates proceed to A.4.
b) If the warning light does NOT illuminate check the wiring, especially the supply from the ignition switch to terminal 8 on the thermal switch.

A.4. Current taken by pump motor

OBSERVE the reading on panel ammeter.
Switch OFF the ignition.
ALLOW approx. 15 seconds to elapse before RESETTING the manual switch.
Switch ON the ignition, and again OBSERVE the reading on the panel ammeter.
If the pump is functioning correctly it should consume approximately 5 amperes.

ACTION

a) If NO change is indicated proceed to A.6. via A.5.
b) If the change in readings is high (full scale deflection) proceed to A.7. via A.5.

A.5. To exclude reset-circuit from subsequent tests.

Switch OFF the ignition. DISCONNECT, at the oil pressure switch, the lead from the thermal switch, and insulate the free end of the wire. RESET the manual switch. This need NOT now be maintained in this position for subsequent tests.

A.6. Blown Fuse

Check Fuse.

ACTION

a) If fuse has blown, proceed to A7.
b) If fuse has NOT blown, proceed to A.3.

A.7. Current taken by pump motor. (external supply)

DISCONNECT the motor at the snap connectors, and reconnect the motor to an external, REMOTE 12v, D.C. supply, via a 0 - 30 ampere D.C. ammeter, retaining the original polarity and making the final connection at the supply. The black lea should be connected to the supply positive terminal. The white/purple lead should be connected to the supply negative terminal.

CAUTION: NO SPARKS SHOULD OCCUR NEAR PETROL ENCLOSURES.

The pump should consume approximately 5 amperes.

ACTION

a) If the pump functions satisfactorily, taking approximately 5 amperes, check wiring, particularly for short circuits. Fit replacement fuse after rectifying circuit.
b) If the pump takes a high current (20 amperes), it has stalled. A replacement should be fitted, together with a fuse.

A.8. Voltage at motor

CONNECT a 0 - 20 v D.C. voltmeter between the feed snap connectors to the motor. Switch ON the ignition.

ACTION

a) If voltage is present (the pump still not operating), the motor will be open circuit. A replacement is necessary.
b) If NO voltage is present a wiring check should be made.

A.9. Pressure and Current

1. RECHECK there is sufficient fuel in the tank.

ACTION

1. Refill as necessary. N.B. when starting the engine after re-filling an empty tank, the system will need time in which to prime itself before a successful start is ensured (30-40 seconds).

METHOD

2. DISCONNECT the fuel inlet pipe from the filter at the Metering Distributor, taking care to fit a blank on the filter union, and connect the pipe to any reliable pressure gauge of minimum reading 150 p.s.i. CONNECT a 0 - 30 ampere D.C. ammeter in series with the motor.
CAUTION: NO SPARKS SHOULD OCCUR NEAR PETROL ENCLOSURES.
Switch on the igniton.
CHECK gauge reading is correct at 100 p.s.i.
CHECK ammeter reading is approximately 5 amperes.

ACTION

2.a) Gauge and ammeter give correct readings, proceed to A.10.

b) Gauge reading LOW (around 80 p.s.i.) and ammeter reading HIGH (10 amperes). This indicates a tight pump. A replacement pump should be fitted.

A.10. Pressure and current while cranking with starter

ALLOW starter to crank engine.
OBSERVE gauge and ammeter readings.

ACTION

a) Gauge and ammeter readings remain correct. Remove the apparatus and restore original connections. Proceed to A.11.

b) Gauge and ammeter readings fall to either:- (i) around 80 p.s.i. and 3 amps. (ii) both zero and pump stops. In either case the battery should be recharged.

A.11. Faulty Metering Distributor

Swith OFF the ignition. DISCONNECT one of the injector pipes from its banjo on the Metering Distributor, after ensuring that the exterior of the unit is clean. By removing the banjo bolt from the unit, a view is obtained of the rotor. If this is seen to remain stationary when the engine is turned, loss of rotor drive is indicated. To determine whether the failure is of the drive to the metering unit, or of the coupling between the drive shaft and the rotor, remove the top cover of the Metering Distributor oil-pump, again after ensuring that the exterior is clean. Rotate the engine and observe whether the oil pump piston is moving, by holding the fingers across the springs on the oil-pump piston.

ACTION

a) If the oil-pump is operating, then the coupling between the drive shaft and rotor will have sheared. The complete unit should be removed, after disconnecting all oil, fuel and vacuum pipes from the complete Metering/Control Unit, taking care to fit blanks as pipes are removed. A new Metering/Control Unit should then be fitted.

b) If the oil pump piston is found NOT to move, then failure is in the engine drive to the unit. Proceed as (a) to remove the complete Metering/Control Unit from the engine, and check for rotation of the drive from the engine timing case.

A.12. Faulty Control Unit	(i) CHECK that the overfuel lever outside the control unit, operates over its full range when the starting lever on the dashboard is operated. REMOVE the air filter cover-plate from the control unit, after removing the four retaining screws. Below this will be seen the cover-plate which is retained by three screws. When this is removed, the linkage is exposed. (ii) CHECK that the overfuel lever in the control unit moves in accordance with the starting lever on the dashboard. With the pump RUNNING, the resultant fuel pressure should maintain the cam follower in contact with the fuel cam, and the latter in contact with the overfuel lever throughout its excess fuel range. N.B. Metering Units and Control Units are accurately calibrated as one unit, and MUST NOT BE SEPARATED ACTION a) If the pump and Metering/Control Unit are functioning correctly and the engine still fails to start, proceed to A.13. b) If a fault is found on the Control Unit, the action taken should be as follows:- (i) Rectify if necessary. (ii) If any of these faults are found on the Control Unit, then the complete Metering/Control Unit should be removed as described in A.11 (a) and a replacement fitted.
A.13. Incorrect Ignition/timing	A recheck, in accordance with recognised procedure, should be adopted to correct this fault.

FAULT B:- ENGINE FIRES, BUT WILL NOT RUN (COLD)

Assuming there is sufficient fuel in the tank, and that the ignition/timing has been checked as being in order.
N.B. If the Method or Action involves following the procedure of A.5 (Fault A), then at the end of the diagnosis, RECONNECT the lead from the thermal switch to the oil-pressure switch.

TEST	METHOD
B.1. Pulsations at Metering Distributor	Proceed to Fault A, and follow through to the end of Method A.1. ACTION a) If pulsations are felt at each non-return valve proceed to B.2.

b) If no pulsations are felt at each non-return valve, proceed to 'Engine will not start' (Fault A) ref. A.5 and hence A.9 to A.11 inclusive.
c) If pulsations are felt at only two (4-cylinder engines), three (6-cylinder engines) or six (8-cylinder engines), a nozzle stuck closed should be suspected. REMOVE the injectors where NO pulsations are felt and blow through them with compressed air in excess of 60 p.s.i. This should ascertain the faulty nozzle. Exchange for new nozzle.

B.2. Faulty Control Unit

Proceed to fault A ref. A.5 and hence to Method A.12.

ACTION

a) If control unit is found to function satisfactorily proceed to B3.
b) If a fault is found on the Control Unit, proceed in accordance with Action A.12 (b).

B.3. Faulty Metering Distributor

The fault may be a sheared drive to the Metering Distributor rotor, causing the rotor to run out of phase, or intermittently. Proceed to Fault A, directly to method A.11, and by prolonged observation of the Metering Distributor rotor, the fault may become apparent as intermittent rotation of the rotor.

ACTION

a) Proceed as Action A.11 (a) to remove the Metering/ Control Unit. A replacement should then be fitted.

FAULT C: UNEVEN IDLING, MISFIRING OR LOSS OF POWER

Assuming there is sufficient fuel in the tank, and that the ignition/timing system is in order, a Petrol Injection fault may be revealed during this preliminary diagnosis. An 'oily' plug indicates leaking 'O' rings at the Metering Distributor banjo (ignition system being in order). If this evidence is present, remove the corresponding banjo/banjo-bolt and fit replacement 'O' rings immediately adjacent to the bolt-thread. Without such evidence, proceed directly to C.I.

TEST	METHOD
C.1. Stuck Injector Nozzles	This can take one of two forms - stuck open or stuck closed. The former is by far the most likely to be met in service, probably due to a particle of dirt between the nozzle valve and the seat. Should the fault be a nozzle stuck closed, the idling will be very bad, because 2 cylinders will be out of action for 4 or 8 cylinder engines, or 3 cylinders

out for 6 cylinder engines. With the engine running SHORT-CIRCUIT each sparking-plug in turn to the engine with the aid of a screwdriver, and the one(s) which does not affect the running should have the associated nozzle(s) checked. Should only ONE nozzle appear affected then it should be suspected of being stuck open. Should TWO (4 or 8 cylinder engines), THREE (6 cylinder engines) nozzles appear affected, then one nozzle stuck closed should be suspected.
N.B. It is NOT possible to dismantle a P.I. nozzle for cleaning.

ACTION

a) If the nozzles appear satisfactory, proceed to C.2.
b) Should evidence point to stuck injector nozzle(s) REMOVE any which appear affected. Compressed air in excess of 60 p.s.i. should clear a nozzle stuck open, or ascertain a nozzle stuck closed. Should this not prove conclusive, exchange any which appear affected.

C.2. External leak at banjo

Switch OFF the ignition. Examine banjo area on Metering Distributor for leakage.

ACTION

a) If there is no leakage, proceed to C.3.
b) If there is evidence of leakage, ascertain if (i) around circlip in banjo-bolt. (ii) at banjo/banjo-bolt matings. If at (i) A REPLACEMENT banjo-bolt should be fitted. If at (ii) REMOVE banjo-bolt and fit REPLACEMENT 'O' ring(s).

C.3. Slackened Unions

Check all unions visually, for cleanliness. Any slackened unions should be revealed by accompanying leakage.

ACTION

a) If the unions are satisfactory, proceed to C.4.
b) If any unions have become slackened, correct by TIGHTENING.

C.4. Cracked lines

Check all lines visually, for cleanliness. Remember to inspect those portions of the pipes which are normally enclosed by clamping brackets. Any cracks should be revealed by accompanying leakage.

ACTION

a) If the lines are satisfactory, proceed to C.5.
b) If cracks are present, the affected lines should be replaced. CARE should be taken to ensure that

the pipe is well supported and prevented from twisting, when tightening or slackening unions. When fitting pipes, it is desirable that they should be properly aligned before tightening the unions. The union nuts must NOT be used for drawing pipes into position. It should be remembered that the function of the clamping bracket is to support, not distort, the pipes.

C.5. Faulty Control Unit

(i) Proceed as 'Engine Will Not Start' (Fault A) Method A.5 and hence A.12.

(ii) In addition to this procedure, the barometric datum wedge may have stuck in the out position, and insufficient fuel quantities are being injected into the cylinders. This condition will be found to improve when the excess fuel lever is moved slightly towards the excess fuel position.

(iii) A further possible cause is a stuck piston in the Control Unit.
MANIPULATING the connecting link between the fuel cam and the control piston axially, with the ignition switched OFF, should ascertain this fault.

N.B. If the lead from the thermal switch to the oil-pressure switch is disconnected (A5) during the test, remember to RECONNECT on completion of the diagnosis.

ACTION

a) If the Control Unit appears satisfactory, proceed to C.6.

b) Should a fault be found in section:- (i) Proceed as 'Engine Will Not Start' (Fault A) ref. A.12 (b), (ii) or (iii) A replacement Metering/control Unit should be fitted.

C.6. Faulty Metering Distributor

The fault is probably a sheared drive to the Metering Distributor rotor, causing the rotor to run 'out of phase' or intermittently. Proceed to Fault A, directly to Method A.11, and by prolonged visual observation of the Metering Unit rotor, the fault may become apparent as intermittent rotation.

ACTION

a) If the Metering Distributor is functioning satisfactorily and the diagnosis has not revealed the cause, then an additonal probable cause is leaking 'O' rings at the banjo-bolt, allowing unmetered fuel to be injected. This is an internal fault, and no external evidence of leakage should be apparent. A progressive analysis will reveal the faulty 'O' ring(s) otherwise a complete refitment of new 'O' ring(s) immediately adjacent to each banjo-bolt thread, must be carried out.

b) If a fault is found proceed as A.11(a) to remove the complete Metering/Control Unit. A replacement should then be fitted.

FAULT D: ENGINE STARTS, BUT STOPS AFTER 30 SECONDS AND WARNING LIGHT COMES ON

The oil pressure switch has not opened, allowing the thermal switch to trip the pump supply after 30 seconds and cause the engine to stop.

TEST	METHOD
D.1. Engine oil pressure	OBSERVE the oil-pressure gauge reading on the dashboard is above 5 p.s.i. ACTION a) If pressure gauge is reading correctly, proceed to D.2. b) If no pressure is indicated check oil level with the 'dip-stick' and refill if required. If oil is found to be present, the engine oil pump should be checked.
D.2. Electrical Fault	CHECK the lead from the thermal switch to the oil-pressure switch, and the corresponding terminals for possible 'earths'. ACTION a) If no electrical fault is found, proceed to D.3. b) If an electrical fault is found, rectify as necessary.
D.3. Oil-pressure switch stuck closed	RESET the manual switch on the dashboard, after the required 15 seconds delay, and again attempt starting. ACTION a) If the fault recurs then the oil-pressure switch has stuck closed and a replacement is necessary.

FAULT E: DIFFICULTY IN STARTING A WARM ENGINE

The probable cause of this is either leaking injector nozzles, or leaking non-return valves on the Metering Unit.
This will result in the injector pipe becoming unprimed, so that when a starting attempt is made, the Metering Unit has initially to prime the pipe before fuel can be injected into the manifold.

TEST	METHOD
E.1. Leaking Injector nozzle(s)	With the ignition switched ON, progressively press firmly with finger on the non-return valves in the outlet ports of the Metering Distributor, during a starting attempt, and during the first few seconds of running. Feel for pulsations as injection takes place. ACTION a) If no pulsations occur at one or more non-return valves fit replacement injector nozzle(s) in the associated pipe line. If poor hot-starting is still experienced, proceed to E.2.
E.2. Leaking non-return valves	ACTION a) Replacement banjo bolts(s) at which no pulsations occur, should be fitted to the Metering Distributor. N.B. It must be remembered that no improvement in starting will be shown by the first start, after carrying out any work which involves disturbing any part of an injector line. This is because the affected lines have to be given time in which to become primed with fuel.