LUCAS PETROL INJECTION EQUIPMENT

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1. Introduction

On a petrol injection engine, the carburetter is replaced by a pressurised fuel system which meters accurate charges of fuel to each cylinder in turn. The fuel is injected in the form of finely atomised spray into the intake air at a point in the manifold close to the inlet valve. The mixture is then compressed and spark-ignited in the usual manner.

The accurate control possible over the amount of fuel supplied to each cylinder under all operating conditions gives increased economy and greater flexibility to a petrol injection engine. In addition, the removal of the carburetter choke and the absence of the exhaust-heated hot spot permit an increased air charge to the engine, resulting in increased power output.

2. Application

The equipment as at present developed is intended as an improved fuel system for 6 and 8 cylinder high performance engines on which multiple carburetters are both complicated and expensive. It is precision-made equipment and therefore costly to produce, so that its use would seem to be limited to the more expensive high performance car models.

The advantages in performance offered by petrol injection equipment would be extremely useful on the normal ranges of popular cars, but such an application is unlikely with the present system on economic grounds.

Because of the specialised nature of this equipment, its application will need to be considered jointly in detail by Lucas and the Engine Manufacturers.

3. Description

The system is illustrated schematically in Fig. 1. A motor-driven primary pump, mounted on the chassis adjacent to the fuel tank, supplies filtered fuel at a pressure of 100 p.s.i. to the combined metering distributor and mixture control unit mounted on, and driven by, the engine. From the metering distributor, accurately timed and metered quantities of fuel are delivered at each injector in turn.

The Fuel Pump

The fuel pump (Fig. 2) comprises a simple gear pump driven by a permanent magnet motor operating at battery voltage, and incorporates a filter element in the main fuel supply. A relief valve returns excess fuel to the tank and maintains the line pressure at 100 p.s.i. There is no possibility of vapour lock with the Lucas Petrol Injection system.

Electrically, the pump is under the control of the ignition switch, while a thermal relay is provided to switch off the pump after a short period should the car be left with ignition on and engine not running, thus preventing unnecessary drain on the battery.

The Metering Distributor

The Principle of Shuttle Metering

The principle of shuttle metering is illustrated in Fig. 3 which shows an arrangement suitable for a three cylinder engine. An engine-driven rotor, having three radial ports leading to a bore in its centre, fits in a sleeve containing fuel inlet and outlet ports. The bore of the rotor contains two small shuttles capable of moving axially between two stops, one fixed and the other adjustable.

As the rotor turns within the sleeve, the rotor port at the fixed stop end becomes coincident with the fuel inlet port in the sleeve, as shown in the upper diagram. Fuel from the pump now enters at pressure and drives both shuttles towards the control stop end of the rotor bore, displacing fuel which is discharged through the ports in the rotor and sleeve at that end, then through the connecting pipework to an injector. Rotation of the rotor by 120° will result in the position shown in the middle illustration. Fuel now enters through the inlet port in the centre of the rotor, the right-hand shuttle is forced to the fixed stop end of the rotor, and the fuel thereby displaced is fed to the second injector. Similarly, after a further 120° rotation of the rotor, the left-hand shuttle is moved to the right and fuel is displaced to the third injector.

In this way, the shuttles move to and fro between the stops as the rotor is driven round, and at each movement an accurately metered amount of fuel is displaced and injected into the appropriate cylinder. The quantity of fuel is the product of the area of the shuttle bore and the distance of shuttle travel, the latter being determined by the setting of the control stop.

By incorporating two bores in the rotor, each with two shuttles and suitable fuel inlet and outlet ports, a metering distributor for a six-cylinder engine is obtained. For an eight-cylinder engine a similar arrangement but having only a single moving shuttle in each rotor bore is employed.

Construction of Metering Distributor

Fig. 4 shows the constructional features of the six-cylinder metering distributor. Two three-cylinder units are combined in the rotor which is driven at ¼ times engine speed. Inlet and outlet ports are arranged so that each cylinder receives one injection of fuel per intake stroke, the shuttles in the two bores being phased to begin injection at intervals of 120° (engine).

The control stops, by means of which the fuel quantity is adjustable, abut against a face in the mixture control unit described below.

A constant-pressure pump, operated by a small eccentric on the drive shaft, pumps engine oil at about 105 p.s.i. which is used for preventing leakage of petrol from the rotor ends and for lubricating the control stop faces. From the pump, oil is filtered and fed to a longitudinal drilling in the sleeve, from which cross drillings lead to two oil grooves, one at each end of the rotor. At the control stop end, drillings in the rotor groove lead to the stops, feeding oil through the centres of the stops to the rubbing faces.

The hardened steel sleeve, complete with rotor and shuttle assembly, is floated in rubber sealing rings in the aluminium body casting, while between the driving shaft and the rotor driving plate there is a self-aligning coupling which allows for any slight misalignment of the rotor and sleeve assembly on its rubber mounting.

The Mixture Control Unit

This unit is secured to the end flange of the metering distributor (Fig. 4) and its purpose is to provide complete control of the quantity of fuel according to load under normal running conditions, with appropriate corrections for changes in barometric pressure. In addition, it incorporates a manual control for cold starting and warm-up conditions.

Control is achieved by adjustment of the position of the control stops which determine the length of shuttle stroke and hence the quantity of fuel delivered. Fig. 5 shows a simplified schematic arrangement of the control mechanism. A cam follower has an abutment face against which the control stops in the metering distributor are forced by fuel pressure, while at the other end of the follower a small roller bears against a fuel cam of predetermined slope. The hydraulic loading of fuel pressure is offset by a balance spring surrounding the follower, resulting in only light pressure between the roller and fuel cam. Thus, movement of the fuel cam is reflected in movement of the control stops. The fuel cam has a roller at each end, and is connected through a pivoted link to the main control piston which is backed by calibrated springs. One of these two rollers runs on a reference surface in the body of the control unit, and the other on the track of the excess fuel lever, of which more is said later. The space at the back of the piston is connected to the engine downstream of the throttle so that, as manifold pressure changes, the position of the control piston alters; this varies the fuel cam position, so causing the cam follower and control stops to take up a new setting to maintain the required fuel-air ratio.

Since operation is by the difference in pressure across the throttle, the same full throttle stroke will be provided irrespective of the barometric pressure. Thus as the air becomes less dense, the mixture ratio applied to the engine would become progressively richer unless the fuel delivery were reduced proportionately. In the control unit, this is achieved by the use of a capsule responsive to changes in barometric pressure. The capsule carries a wedge which controls the final setting of the excess fuel lever in its warmed-up position, and so determines the inclination of the fuel cam track.

For cold starting, additional fuel and air are required to overcome the friction of a cold engine and permit it to run at a fast idle; as the engine warms up, both require to be reduced in step. It must also be possible to drive the engine under any load during this period. A manual control is therefore provided which controls simultaneously the positions of the excess fuel lever and also a plate-type air valve. With the control set to the 'start' position, (see Fig. 5 inset) the excess fuel lever takes up a position in which up to 300% excess fuel is possible, and extra air is admitted to the engine manifold through the opened air valve. As soon as the engine fires, the manual control lever is returned to the halfway position, while the depression in the manifold lifts the control piston to reduce fuel in accordance with load in the usual way. When the engine is warmed-up, the manual lever, is returned to the fully home position, in which the air valve plate apertures are closed. The excess fuel lever now takes up its position for normal running, with its free end pressing against the datum wedge of the barometric capsule and its edge providing the track for the fuel cam roller. The mixture is now correct for the prevailing barometric condition.

The Injector Nozzles

The performance of the petrol injection system is dependent to a considerable extent on good atomisation of the fuel. This is achieved by means of the characteristics of the nozzles employed, which are illustrated in Fig. 6.

4. Performance

The performance of a petrol injection engine is characterised by the following advantages:-

(i) Greater flexibility in handling. Smoother running at very low speeds and improved engine pickup.

(ii) Reduced fuel consumption.

(iii) Improvement in engine torque curve.

The actual values of (ii) and (iii) will, of course, be dependent on the characteristics of the engine to which the equipment is fitted.

5. Mounting Details

Because of the specialised nature of this equipment, its application will need to be considered jointly in detail by Lucas and the engine manufacturer.

6. Weights

6-cylinder Metering Distributor/Control Unit :9¾ lb.

Fuel Pump :9½ lb.

Injector Nozzles (6) :1 lb.

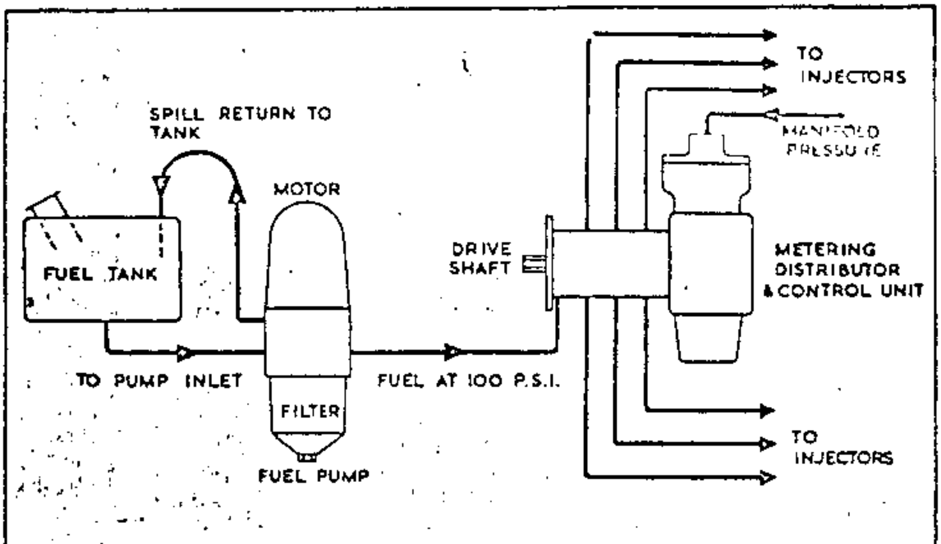

FIG I. SCHEMATIC ARRANGEMENT OF PETROL INJECTION SYSTEM.

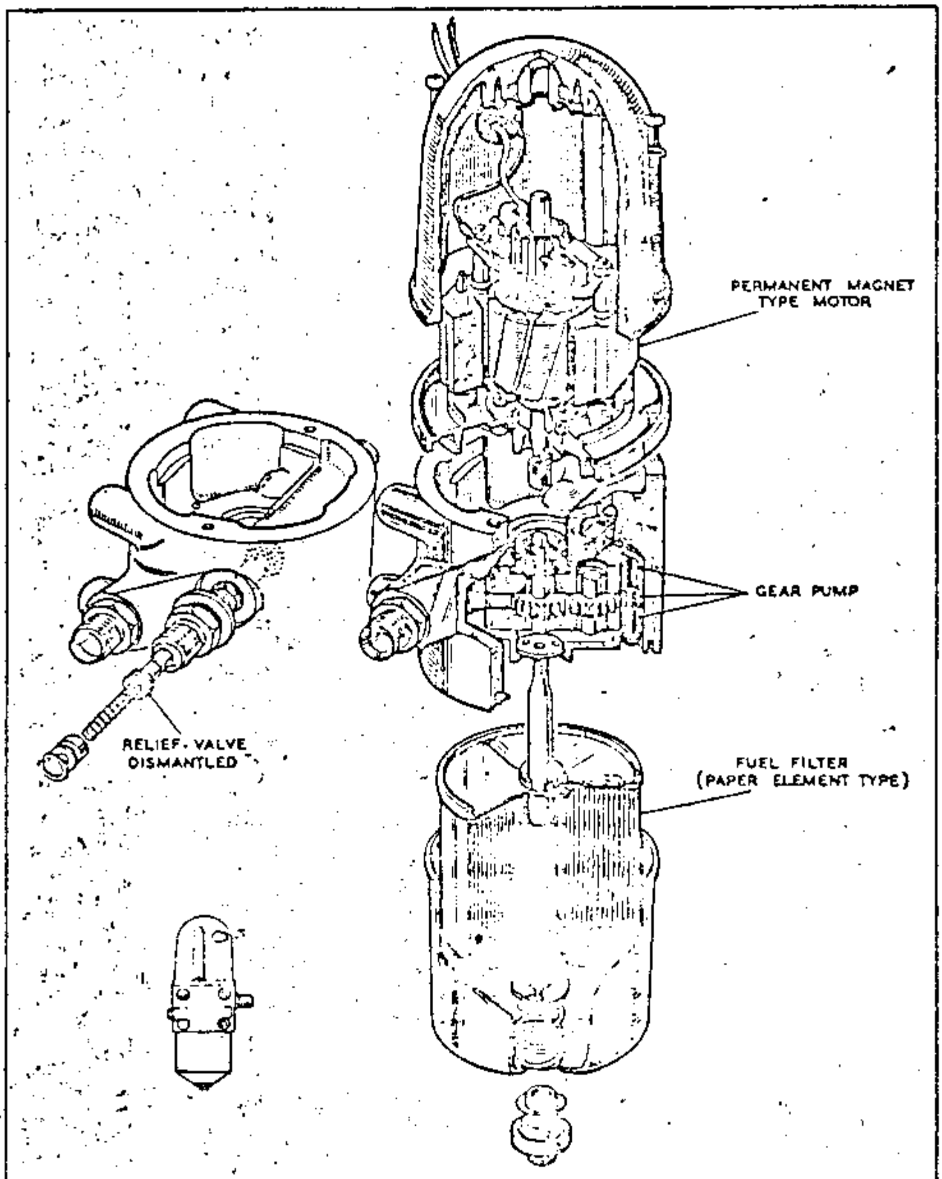

FIG 2 ELECTRIC MOTOR-DRIVEN FUEL PUMP

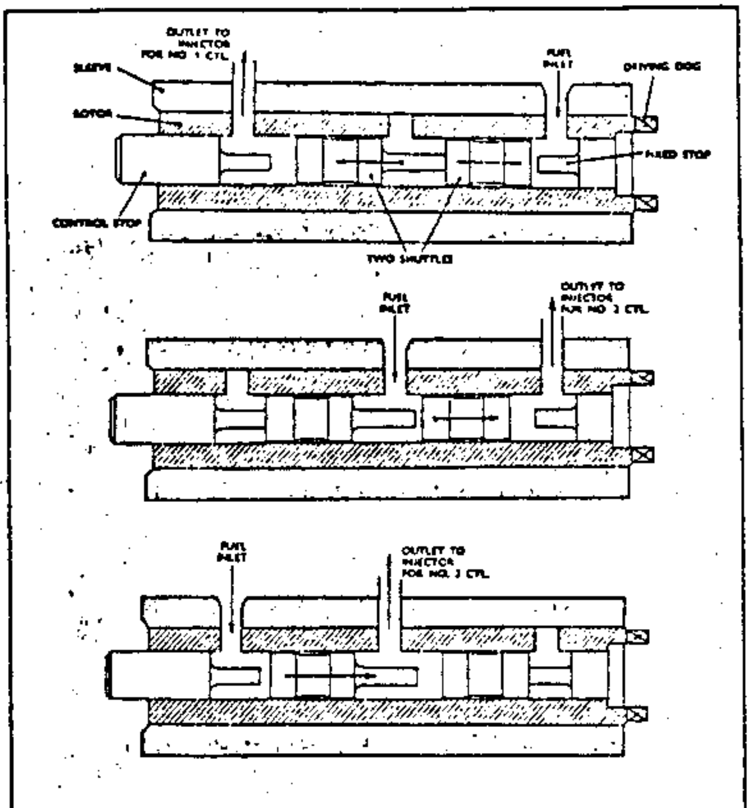

FIG 3. PRINCIPLE OF SHUTTLE METERING DISTRIBUTOR

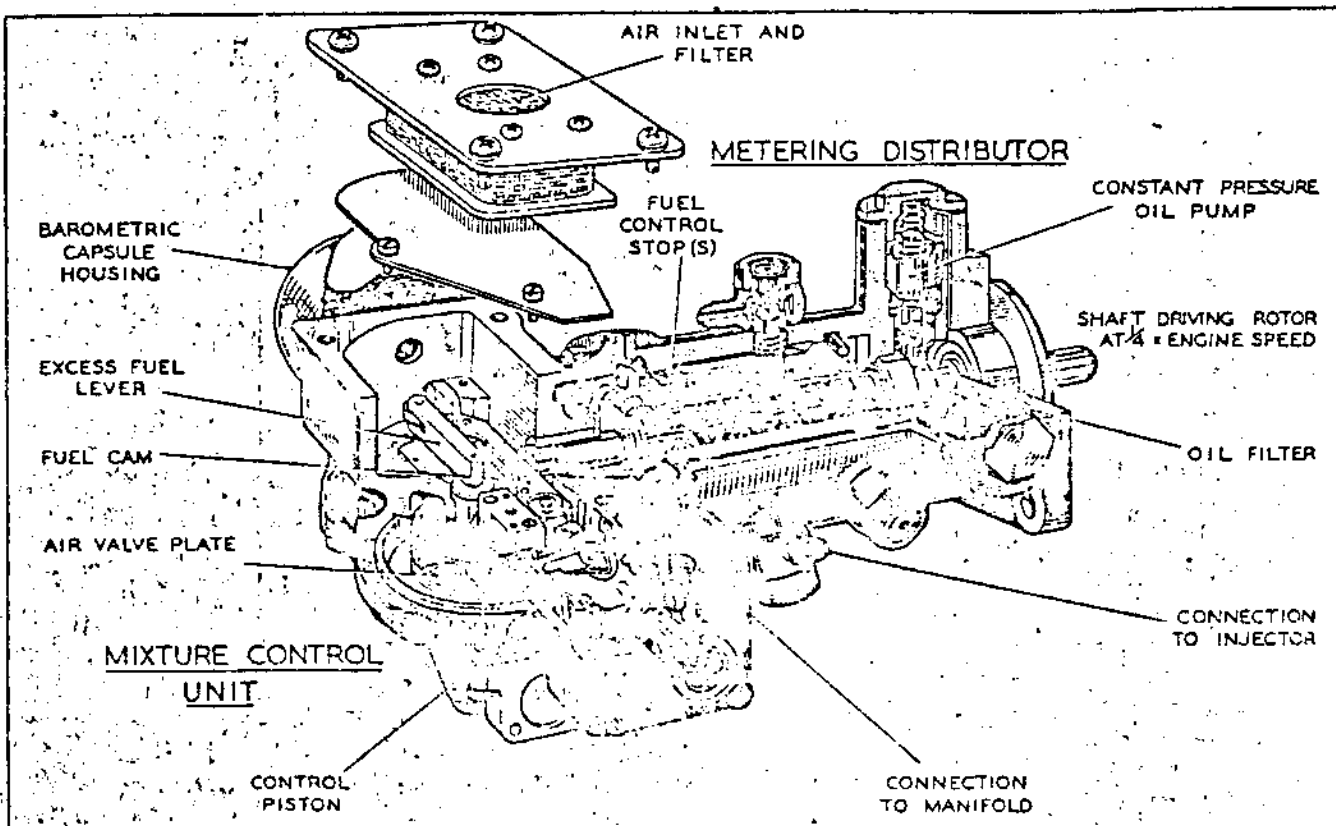

FIG. 4 COMBINED METERING DISTRIBUTOR AND MIXTURE CONTROL UNIT

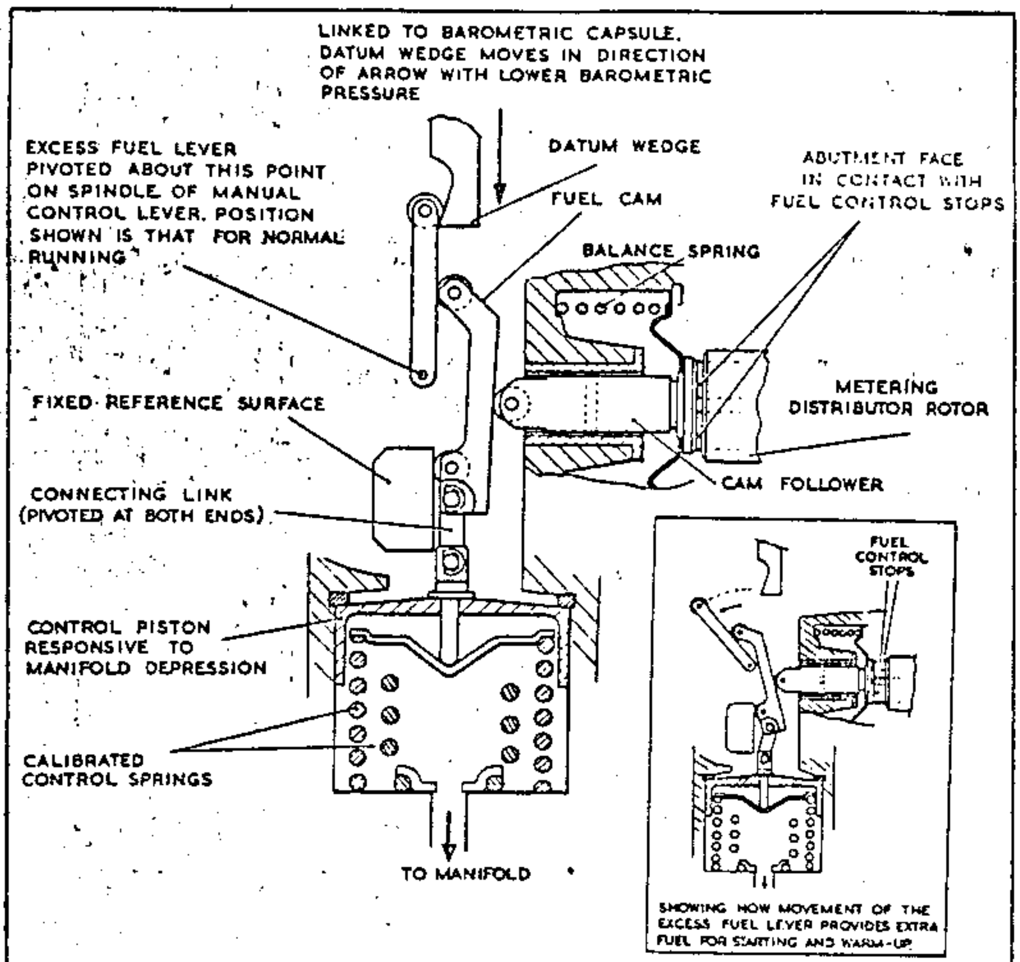

FIG. 5 SCHEMATIC DIAGRAM OF MIXTURE CONTROL UNIT

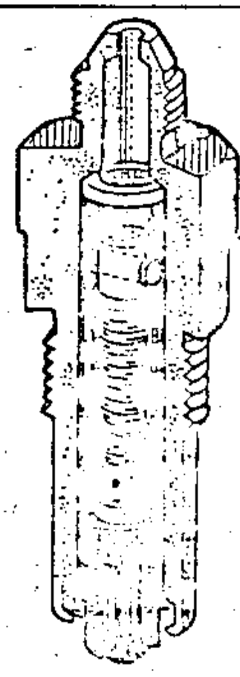

FIG. 6 POPPET VALVE INJECTOR

THE LUCAS PETROL INJECTION SYSTEM

The 'Lucas' 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 6SRA 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.