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WORKSHOP INSTRUCTIONS

CONTROL BOX

MODEL 2TR

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CONTROL BOX
MODEL 2TR

1. GENERAL

This control box houses a vibrating-contact voltage regulator which is arranged to work in conjunction with the alternator Model 2AC, described in SECTION A–5. A transistor, mounted on an aluminium heat sink, is included in the circuit to assist the vibrating contacts, and is protected by an air-cooled surge quench diode.

No cut-out is required, since the diodes incorporated in the alternator prevent reverse currents flowing. No current regulator is required as the inherent self-regulating properties of the alternator effectively limit the output current to a safe value.

The regulator setting is accurately adjusted during manufacture, and the cover should not be removed unnecessarily.

Some form of switching device is needed in the circuit between the main alternator output terminal and the control box terminal 'IG', to disconnect the alternator field and voltage regulator windings from the battery when the engine is at rest. This is achieved by a relay having its operating coil energised on closure of the ignition switch.

The control box is polarised to suit a specific earth polarity. Earthing the wrong battery terminal will damage the regulator and the diodes in the alternator. These control boxes must only be connected to alternators of like polarity. Fig. 1 shows the general arrangement.

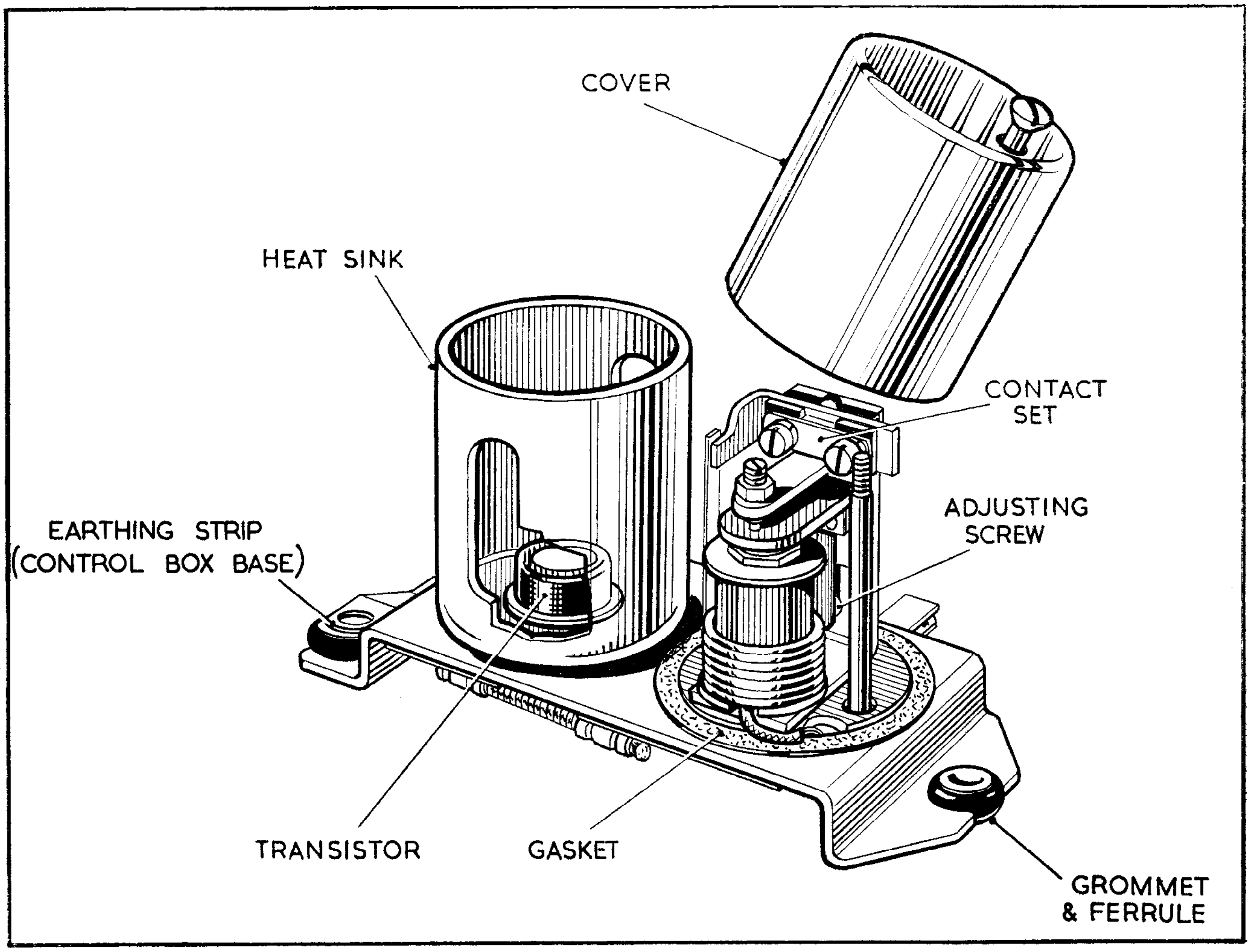

Fig. 1. General arrangement of Control Box, Model 2TR

OPERATION

The regulator has its operating coil connected across the D.C. output terminals of the alternator stator, and has a pair of normally closed contacts in the base circuit of the transistor. The alternator field winding forms part of the transistor output circuit (see Figs. 2 and 3).

Operation of the ignition switch causes the field relay to close. The battery voltage is impressed upon the regulator shunt winding and transistor.

Positive Earth System (Fig. 2)

Current flows from earth, through emitter 'E' and base 'B', base resistor, regulator contacts and frame, returning to the battery via terminal 'IG' and the relay contacts.

By normal transistor action, this base current allows the full alternator field current to flow from emitter 'E', through collector 'C', frequency coil and terminal 'F' to the alternator rotor winding, through the rotor winding to terminal 'IG' and to the battery by way of the relay contacts.

Negative Earth System (Fig. 3)

Current flows from the battery via the relay contacts to terminal 'IG', through emitter 'E' and base 'B', base resistor, regulator contacts and frame to earth. By normal transistor action, this base current allows the full alternator field current to flow from emitter 'E', through collector 'C', frequency coil and terminal 'F' to the alternator rotor winding, and through the rotor winding to earth.

On starting the engine, the alternator output voltage rises until the regulator contacts open, due to the increasing electromagnetic pull on the regulator armature. Opening of the contacts interrupts the base circuit current and, again through transistor action, the field current is reduced to a negligible value. The alternator voltage therefore falls and allows the regulator contacts to re-close. This cycle is repeated many times per second—the rate of vibration being augmented by the frequency coil to ensure an adequately smooth and steady charging current.

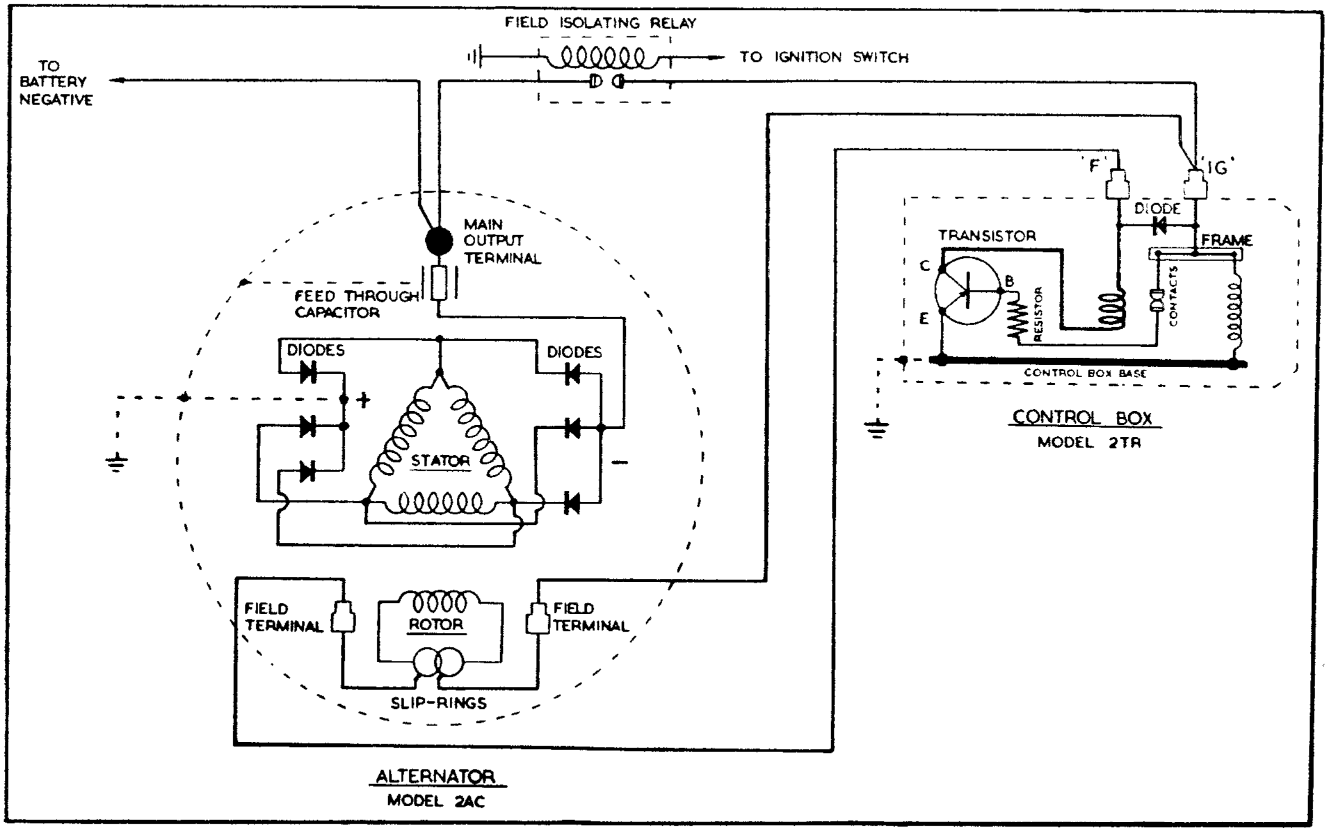

Fig. 2
Internal connections of charging system (positive earth)

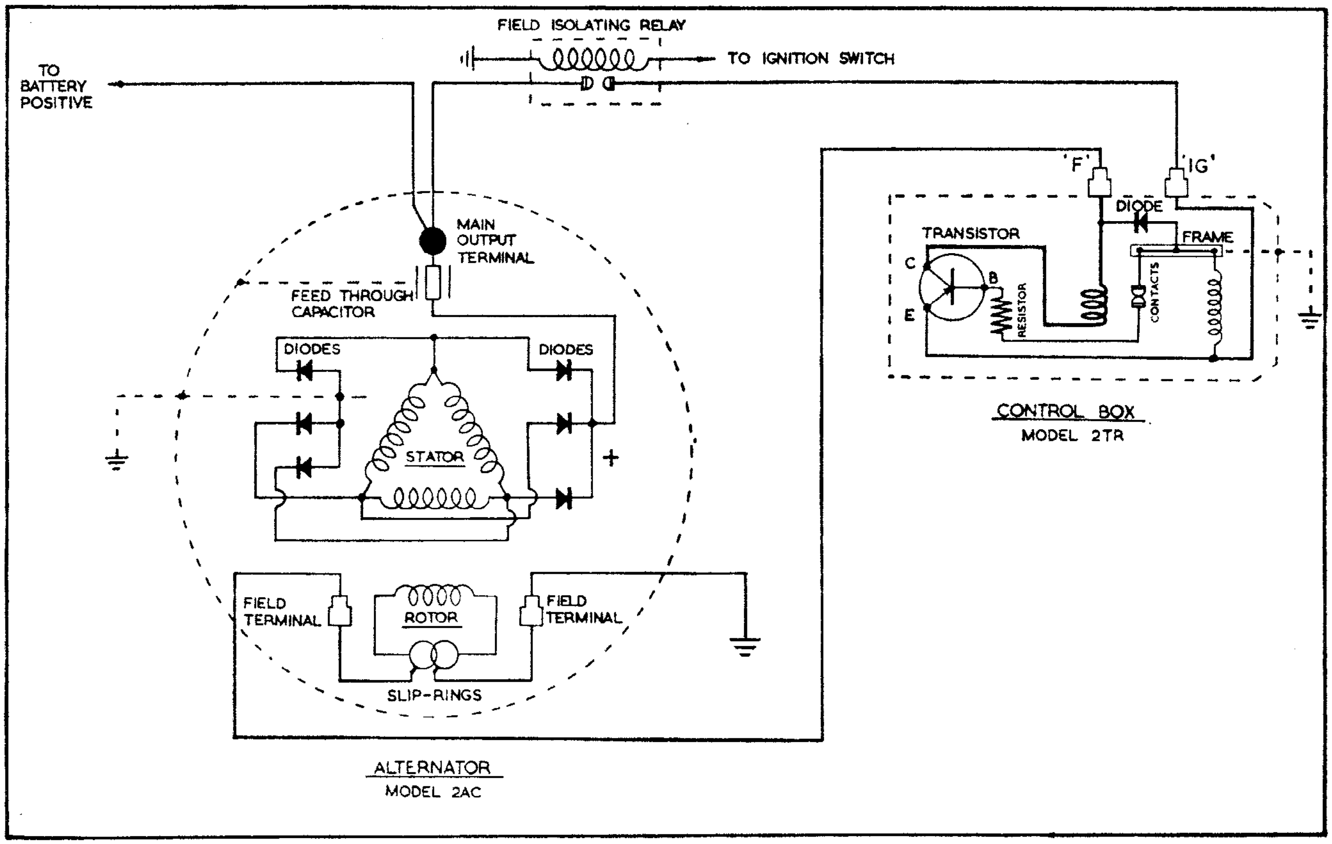

Fig. 3. Internal connections of charging system (negative earth)

2. DESIGN DATA

(a) ELECTRICAL SETTING OF VOLTAGE REGULATOR

(i) *Open Circuit Voltage Setting*

14.4—14.8 volts at 20°C. (68°F.).

When checking or making adjustment of electrical setting, the following conditions should exist:

The control box should be connected to its usual alternator or to another having the same Service Number and hence same earthing polarity.

The alternator should be driven at 3,000 r.p.m. The control box should be mounted with its base in the vertical plane and the terminals pointing upwards.

Checking and setting should be completed as rapidly as possible to avoid heating errors.

The limits quoted are for an ambient temperature, and that of the control box windings, of approximately 20°C. (68°F.). For other temperatures, a correction factor must be applied.

(ii) *Temperature Correction Factor*

Corrections to be made to the above voltage limits when checking or making settings at temperatures other than 20°C. are as follows:

For every 10°C. (18°F.) **above** 20°C. **subtract** 0.1 volt.

For every 10°C. (18°F.) **below** 20°C. **add** 0.1 volt.

(b) TRANSISTOR BASE RESISTOR

30 ±3 ohms

(c) RESISTANCE OF SHUNT WINDING AT 20°C. (68°F.)

103—115 ohms

(d) SEMI-CONDUCTOR COMPONENTS

The control box incorporates two semi-conductor devices, namely, a diode and a transistor. The transistor has been incorporated due to the abnormally inductive nature of the alternator field circuit ; any direct making and breaking of this circuit by means of vibrating contacts would involve problems of contact burning and transference. By using a transistor, the regulator contacts handle only a small pilot current (the transistor base current) while control of the main field current is exercised in the transistor. The transistor is protected from inductive surge voltages by the diode, through which the stored energy of the field system is diverted. Special precautions are necessary when semi-conductor devices are employed (see Para. 4).

3. SERVICING

(a) FAULT DIAGNOSIS

Symptom	*Probable Causes*
No output from alternator	Generator driving belt broken. Loose connection or broken cable in charging circuit. Defective alternator, field isolating relay, control box or ammeter (where fitted).
Intermittent or low output:	Generator driving belt slipping. Loose connection in charging circuit, or bad earths. Defective alternator, field isolating relay, control box or ammeter (where fitted).
Normal output but battery under-charged:	Low mileage with excessive use of electrical load. Defective battery.
High initial output, quickly falling to a low value:	Loose or corroded earth connection. Electrical or mechanical setting of control box incorrect. Sulphated battery plates.
High output and battery over-charged:	Electrical or mechanical setting of control box incorrect. Open-circuited shunt winding.

(b) PRELIMINARY CHECKING OF CHARGING CIRCUIT

Before disturbing any electrical settings, ensure that the fault does not lie outside the control box, as follows:

(i) Check the battery by substitution or with a hydrometer and a heavy discharge tester.

(ii) Inspect the alternator driving belt, and adjust if necessary.

(iii) Check the alternator by substitution or by the method described in SECTION A–5, Para. 4 (a).

(iv) If, when the alternator is run at a fixed speed, the ammeter pointer swings appreciably to each side of its mean value, the regulator contacts may need cleaning, or a piece of ferrous swarf or other foreign matter may be affecting the operation, or, if a mechanical setting has been disturbed, the air gap measurement may be incorrect.

(c) ADJUSTMENT OF OPEN-CIRCUIT VOLTAGE SETTING

(i) Disconnect battery earth lead.

(ii) Disconnect the battery cable from the main terminal of the alternator, leaving in position the smaller cable which connects to the relay. Take care not to short the battery lead to earth. Connect a good quality moving coil D.C. voltmeter, scale 0—20 volts, between the main output terminal of the alternator and earth.

(iii) Re-connect battery earth lead.

(iv) Switch on the ignition and start the engine.

(v) Raise the engine speed momentarily to half throttle or more to achieve self-excitation, then slowly reduce the alternator speed to approximately 3,000 r.p.m., when the open circuit voltage reading should lie between the appropriate limits, given in Para. 2—unless a non-standard setting is specified.

(vi) If the voltage reading lies outside the appropriate limits, it will be necessary to stop the engine, and remove the voltage regulator cover to gain access to the adjustment screw.

(vii) Restart the engine and again run the alternator at 3,000 r.p.m. Turn the adjusting screw clockwise to increase the voltage, or anticlockwise to decrease the voltage.

(viii) Check the setting by switching off and then raising the speed to 4,500 r.p.m.—when the setting must not exceed 15·8 volts.

Note : Adjustments should be made as quickly as possible, otherwise heating of the regulator winding may cause an inaccurate setting.

(ix) Switch off engine and remove battery earth lead, replace cover and re-connect the main cable to the main output terminal of the alternator.

(x) Re-connect battery earth lead.

(d) CLEANING CONTACTS

To clean the regulator contacts, use fine carborundum stone or silicon carbide paper, followed by methylated spirits (denatured alcohol).

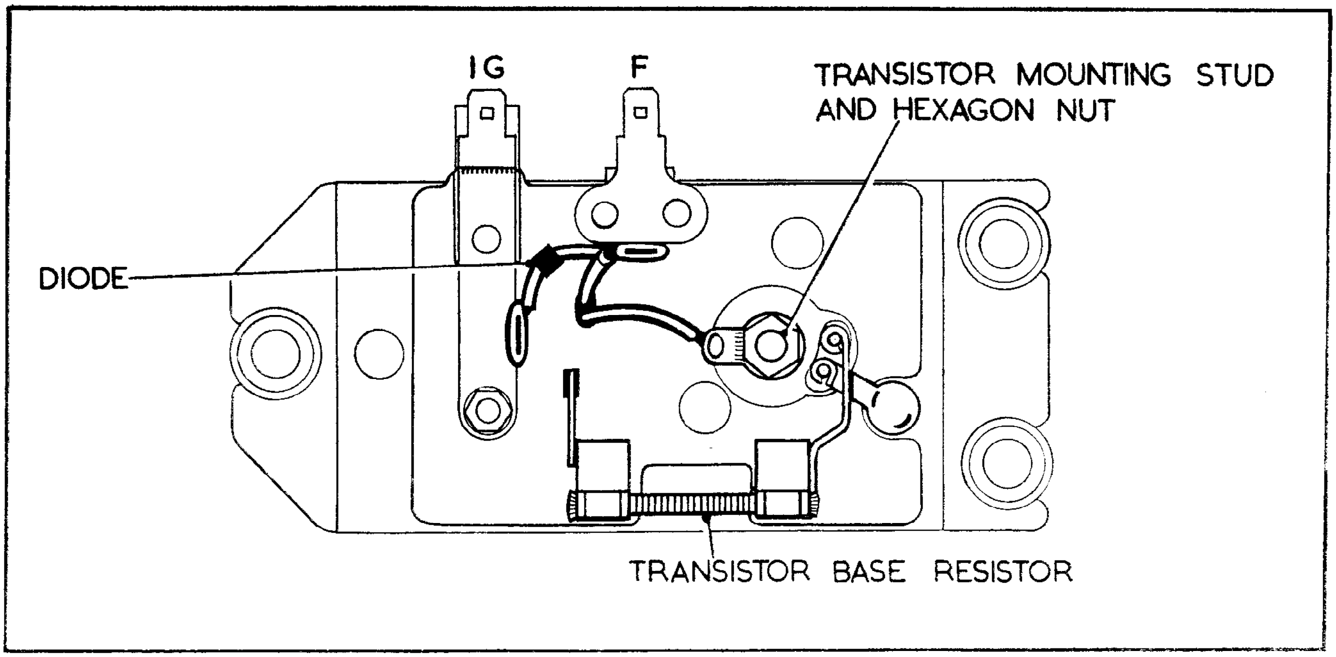

Fig. 4.
Base layout for positive earth model

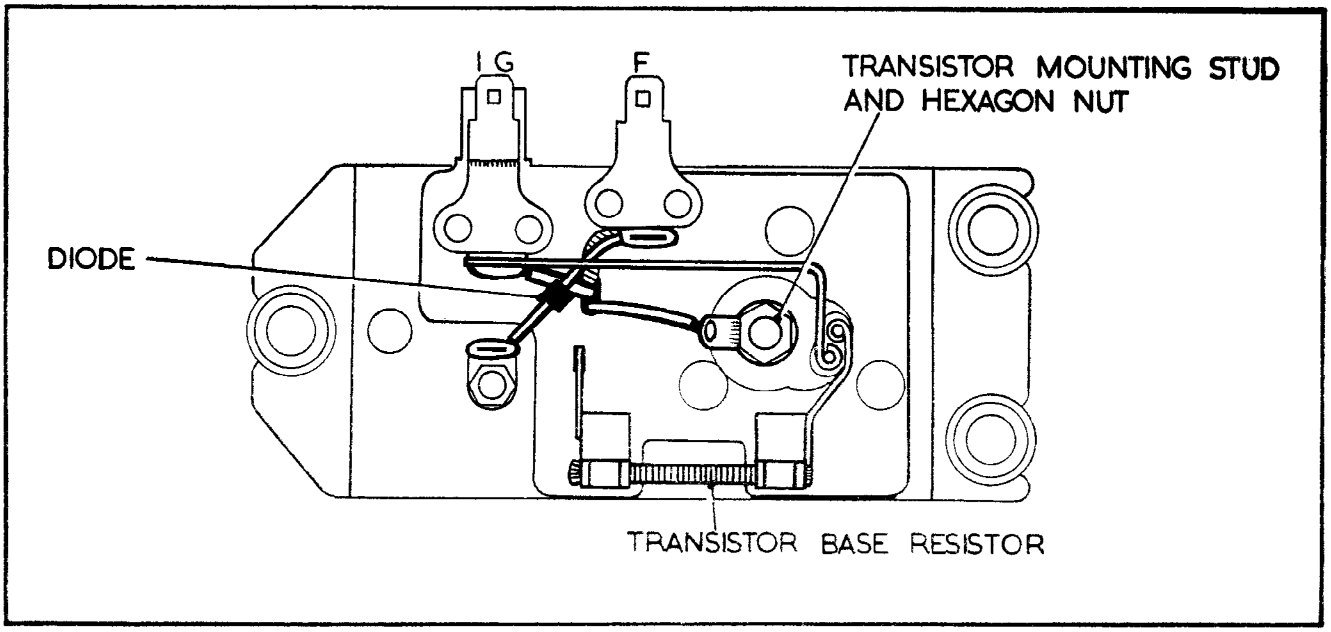

Fig. 5.
Base layout for negative earth model

(e) CHECKING INTERNAL CONTINUITY OF CONTROL BOX

(i) Ascertain that the hexagon nut securing the transistor to its heat sink is secure (see Figs. 4 and 5). If retightening is required, the nut should be tightened until a torque of 1 lb.-ft. is being applied. Application of a torque in excess of this figure is liable to cause external, and possibly internal, mechanical damage. (1 lb.-ft.=0.138 kg.-m.).

(ii) Visually examine all soldered connections on the underside of the unit. Should it be thought necessary to resolder any connectors or leads to their respective terminals, the precautions given in Para. 4 must be followed.

Important: The transistor must remain secured to its heat sink during soldering.

(iii) *Simple Test for Diode Checking*

In order to bench test the diode, it will be necessary to isolate it from the circuit by unsoldering that end of the diode remote from terminal 'F' on the control box. This applies to both positive and negative earth units. The unsoldering operation must be carried out observing all the necessary precautions concerning the effects of excessive heat upon semi-conductor devices (see Para. 4). With a test circuit comprising a 12-volt battery and two test leads, one lead having a 12-volt 1.5 watt test lamp (Lucas L.E.S. Bulb No. 280) in series with it, connect one test probe to terminal 'F' on the control box and the other to the isolated end of the diode.

Reverse the probes and observe the effect. Current should flow in one direction only. The bulb should therefore only light for one of the two positions tested.

The above test is adequate for service purposes. Any accurate measurement of diode resistance necessitates the use of factory equipment. Since the forward resistance of a diode varies with the voltage applied, no realistic readings can be obtained from battery-operated ohmmeters. However, if a battery-operated ohmmeter is used, a good diode will yield "Infinity" in one direction only and some indefinite, but much lower reading in the other.

Warning: Ohmmeters of the type incorporating a hand-driven generator must never be used for checking diodes.

If the diode is functioning correctly, as indicated by either of the tests described, then the isolated end should be resoldered to its original terminal whilst observing the necessary precautions of Para. 4. Proceed to Para. 3 (e) (iv).

A defective diode which yields "Infinity" in both directions on an ohmmeter, or results in the bulb not lighting when reversing the probes in the alternative test, is open-circuited. Its function as a protective device is lost, and the possibility of the transistor having become defective is present. A defective diode which yields less than "Infinity" in both directions on an ohmmeter, or results in the bulb remaining on when reversing the probes in the alternative test, is short-circuited. A diode in this condition has shorted out the alternator field and, therefore, besides resulting in zero output has allowed the transistor to carry a very high current which will almost certainly have led to the transistor becoming defective. Before disturbing the circuit to replace the diode, it is therefore advisable to test the transistor and its associated circuit as described below.

(iv) Place a strip of insulation between the contacts. Measure the resistance of the shunt coil with the aid of an ohmmeter, by placing the test leads at terminal 'IG' and the base of the control box. The resistance should lie between 103 and 115 ohms at 20°C. Measure the resistance of the resistor used for limiting the transistor base current. This value should be 30 ohms ±3. Ensure there is continuity between the transistor stud and terminal 'F'. If any of the above components are defective, the control box must be replaced.

(v) *Simple Test for Transistor Checking*

Depending upon the polarity of the control box, make the connections shown in Fig. 6 or 7. The 12-volt battery should be in a suitable state of charge to supply 12.0 to 13.5 volts to the circuit. A good quality moving-coil multi-scale voltmeter

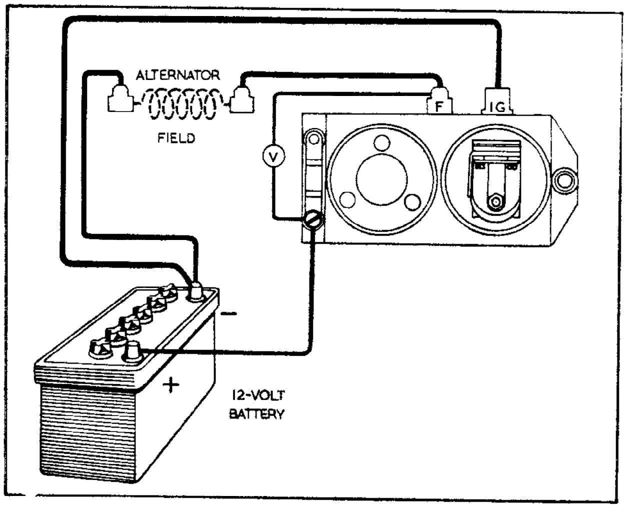

Fig. 6. Connections for testing transistor (positive earth)

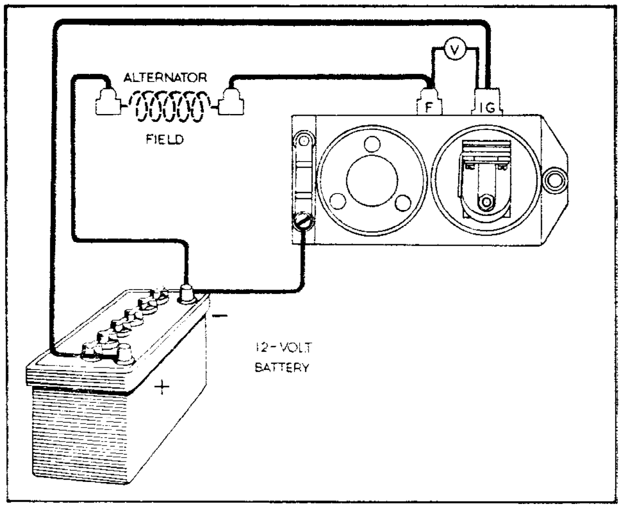

Fig. 7. Connections for testing transistor (negative earth)

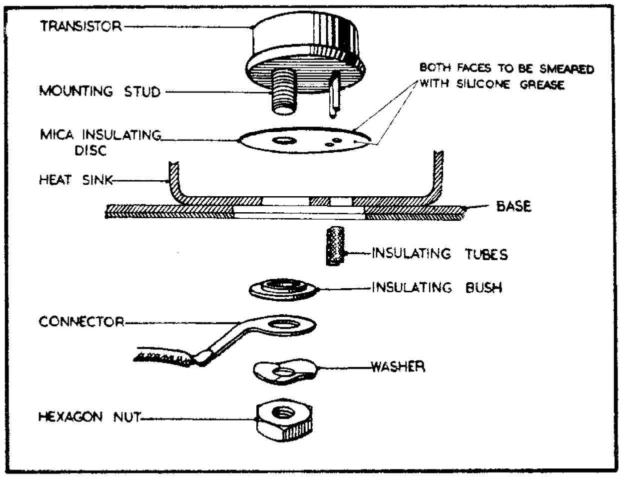

Fig. 8. Transistor assembly

(V) capable of accurate readings up to 15 volts is required. Using the alternator field as load, connect the negative terminal of the voltmeter to terminal 'F' on the control box ; connect the positive terminal of the voltmeter to the control box base (positive earth units) or terminal 'IG' (negative earth units).

With the insulation between the contacts note the voltmeter reading carefully. Then use the voltmeter to measure the supply voltage. If the first reading is more than 0.1 volt below the supply voltage, a replacement transistor must be fitted.

If the reading is within the required limits, remove the insulation from between the contacts, and put the voltmeter (connected as before) on to a lower full-scale reading. The voltmeter should register less than 1.0 volt. If the voltmeter registers 1.0 volt or more, a replacement transistor must be fitted.

(vi) *To Fit a Replacement Diode*

Precautions necessary when using a soldering iron on, or near, semi-conductor devices (see Para. 4) need not apply when **removing** the defective diode. Remove the diode lead from the remaining terminal 'F'. Remove the insulating tubing from the defective component. The ends of the leads from the replacement diode should be tinned prior to assembly. Grip the lead between the diode and the area to be soldered with the jaws of a pair of pliers. Ensure the area to be soldered is clean. Use an instrument-type soldering iron and resin-cored solder. Having tinned the diode leads, fit the insulating tubing before soldering each wire to its respective terminal. The wire associated with the end of the diode marked in red should be soldered to Lucar connector 'F'. The remaining lead should be soldered to the Lucar connector 'IG' (positive earth units) or to the connector associated with the bobbin mounting stud (negative earth units), ensuring that it passes **under** the copper connecting bar passing across its path.

(vii) *To Fit a Replacement Transistor* (see Fig. 8)

Unscrew and remove the hexagon nut on the transistor fixing stud. Remove the crinkle washer (not used on early production units) and connector. Remove the insulating bush. Unsolder the transistor leads and remove from the terminal stubs. Remove the tubing from the two leads. The replacement transistor will be found to contain a mica insulating plate, fitted to its underside. Lightly smear silicone grease between the transistor and this plate and press the two surfaces together. Grip each transistor lead in turn between the jaws of a pair of pliers, at a point between the transistor and the area to be soldered. Using an instrument-type soldering iron and resin-cored solder, tin the ends of the two wires for approximately $\frac{1}{8}''$. Soldering time should be a minimum. Ensure that the area of the heat sink upon which the transistor will lie is clean, before smearing it with silicone grease. Smear the underside of the mica insulating disc with silicone grease, before fitting the transistor into its location in the heat sink. ($\frac{1}{8}''=3.2$ mm.).

Fit the two insulating tubes, before locating the transistor leads in their correct terminal stubs. Fit the insulating bush, connector, crinkle washer and hexagon nut. Ensure that the transistor will make good thermal contact with the heat sink by making sure that the insulating tubes do not become trapped when tightening the hexagon nut.

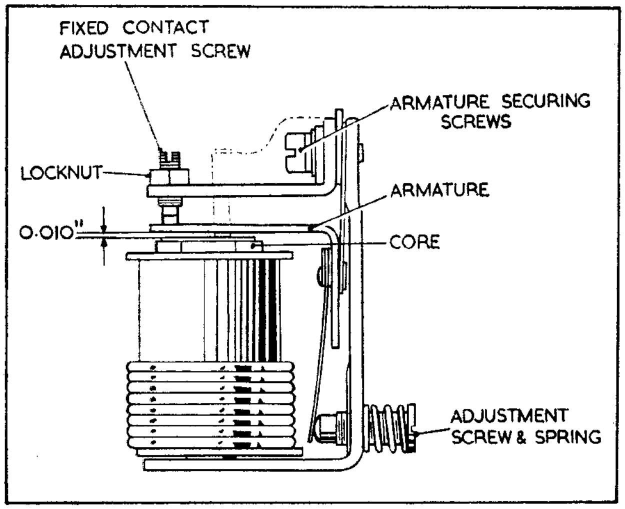

Fig. 9. Mechanical setting of airgap

Tighten the nut until a torque of 1 lb.-ft. is being applied. With an instrument-type soldering iron and resin-cored solder, solder each wire to its respective stub. Soldering time should be a minimum. (1 lb.-ft.=0.138 kg.-m.).

(f) MECHANICAL SETTING OF AIR-GAP (see Fig. 9)

The air-gap setting is accurately adjusted before the units leave the factory and should require no further attention. If, however, an armature is removed for any reason, care must be taken to obtain the correct air-gap setting on re-assembly. This can be obtained as follows:

(i) Slacken the fixed contact locking nut and unscrew the fixed contact adjustment screw until it is well clear of the armature moving contact.

(ii) Slacken the spring-loaded adjustment screw until it is well clear of the armature tension spring.

(iii) Insert a 0.010″ thick flat steel gauge, wide enough to cover completely the core face, between the underside of the armature and the copper disc. Take care not to turn up or damage the edge of this disc. (0.010″=0.3 mm.).

(iv) Press the armature squarely down against the gauge and re-tighten the two armature assembly securing screws.

(v) With the gauge still in position, screw in the fixed contact adjustment screw until it just touches the armature moving contact. Tighten the locking nut.

(vi) Carry out the electrical settings as given in Para. 3 (c).

(g) CHANGING THE CONTACTS (see Fig. 10)

The life of the contacts should be long, since they handle only the small base current. Should it be thought necessary to change the contacts, the following procedure should be adopted:

(i) Slacken the locknut on the fixed contact adjusting screw and remove the screw and locknut.

(ii) Slacken the spring-loaded adjustment screw in the main bracket until it is well clear of the armature tension spring.

(iii) Remove the two armature assembly securing screws together with the clamp plate and insulating plate.

(iv) Remove the moulded plate and armature assembly.

(v) Assemble the replacement contact set in the original order, and screw in the securing screws but do not tighten.

(vi) Proceed in accordance with Para. 3 (f) (iii)–(v) inclusive to set the air gap, using the replacement fixed contact adjustment screw and locknut.

(vii) Carry out the electrical settings as given in Para. 3 (c).

4. SPECIAL PRECAUTIONS FOR SEMI-CONDUCTOR DEVICES

When checking, removing or installing semi-conductor devices, or when utilising any circuitry which incorporates semi-conductor devices, the following important points should be noted:

Semi-conductor devices, particularly germanium units of which the transistor employed in Model 2TR is an example, are affected by temperature. Excessive temperatures during operation or storage can permanently damage the device. Manufacturers usually quote an upper temperature limit above which a deterioration in the characteristics of the device occurs and, over a period of time, this may result in permanent damage to the device. For Model 2TR, the transistor stud temperature (which is the collector electrode temperature) should not exceed 75°C. (167°F.) when working. For safety, the control box should not be operated in an ambient temperature above 58°C. (136°F.) and a position should be found for it where there is good air circulation.

The semi-conductor devices of Model 2TR are operated well within their characteristics ; the transistor is mounted on a generously dimensioned heat sink to ensure adequate heat dissipation. It is important that the transistor remains in firm contact with the heat sink, and must leave it only if a replacement transistor is being fitted.

The soldering of semi-conductor devices involves a source of heat over which careful control must be exercised. An instrument-type soldering iron must be used, and the bit placed in contact with the wires to be soldered for the minimum of time. The solder must be resin-cored and there must be no separate fluxing of the joint or bit. When tinning the wires to the transistor or diode, prior to their insertion through the protective insulating tubing, grip an area of the wire between the device and the part to be soldered with the jaws of a pair of pliers. This will limit undue heat from being conducted along the wire to the semi-conductor device. Ensure that the terminals to which wires from semi-conductor devices are to be soldered are tinned prior to the joining process.

Ensure that the connections and polarities of circuitry incorporating semi-conductor devices are correct before switching on the supply. The control box is polarised to suit a specific earth polarity which is clearly labelled on the heat-sink. Earthing the wrong battery terminal will damage the regulator.

Ensure that any battery test supplies are switched off when inserting or replacing semi-conductor devices.

Simple tests have been devised for testing both the diode and transistor after first removing the control box from the vehicle. These tests are quite adequate for service purposes, and form part of the systematic fault-finding diagnosis in Para. 3. It is important that the tests are carried out in the order stated.

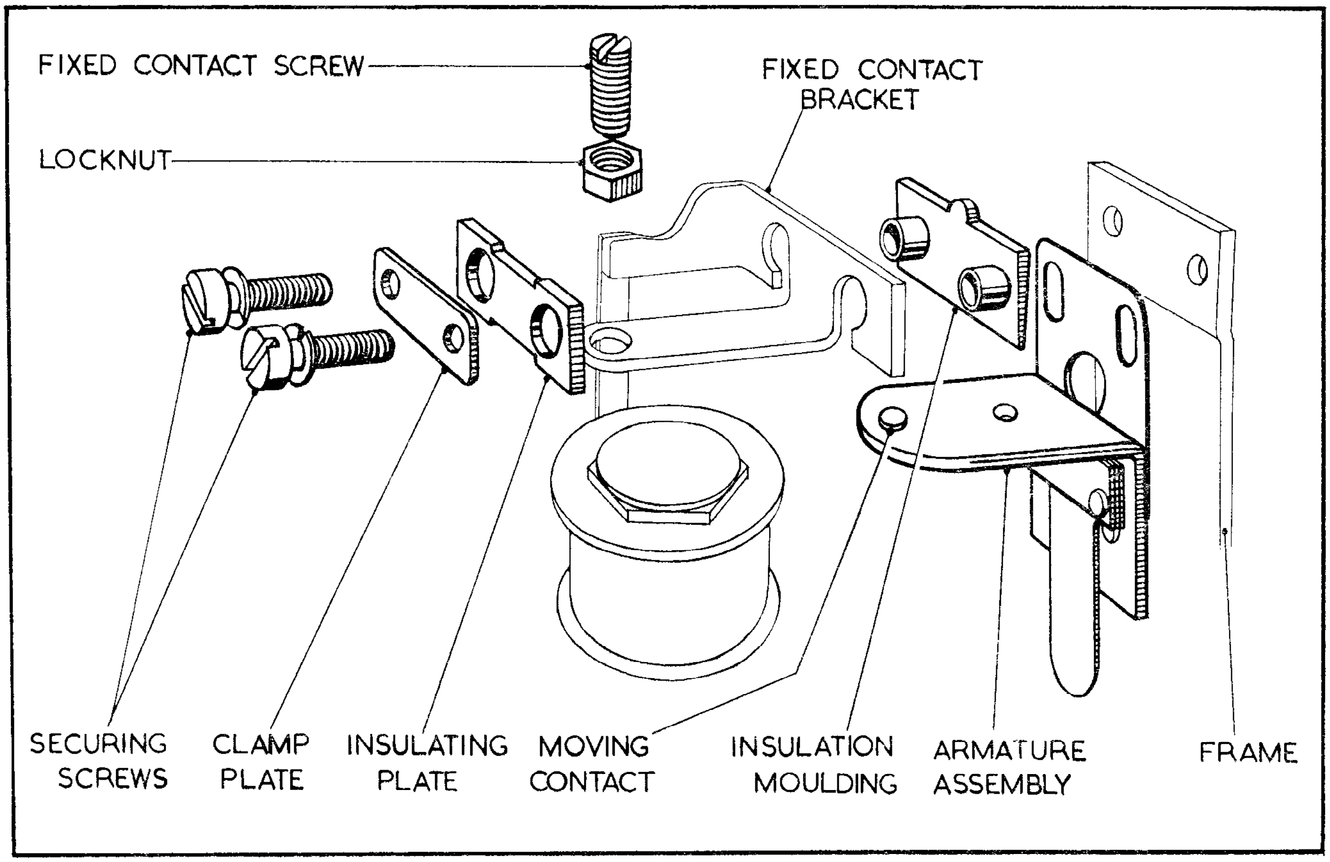

Fig. 10.
Details of contact set assembly