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WORKSHOP INSTRUCTIONS

CONTROL BOXES

MODELS RB310 and RB311

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LUCAS WORKSHOP INSTRUCTIONS

CONTROL BOXES

MODELS RB310 and RB311

1. GENERAL

Models RB310 and RB311 are current-voltage control boxes containing a cut-out relay and two regulators, one to control the voltage of the charging system and the other the current. Model RB311 contains, in addition, a filter circuit consisting of two feed-through capacitors and a choke which, together with a screening sectionalised box of aluminium sand cast construction, suppresses this unit against interference with radio communication over a frequency range of at least 0.2 to 200 megacycles per second.

All electrical and mechanical settings are accurately adjusted during manufacture and it should seldom be necessary to remove a control box cover in service.

(a) CUT-OUT RELAY

The cut-out relay (usually referred to as 'The Cut-Out') is an electro-magnetic switch having its contacts connected between the generator and battery. Two coils, one having a high resistance winding and the other a low resistance winding, are carried on the cut-out bobbin. The high resistance coil is connected in shunt with the generator. When the generator is accelerated from rest, this coil is energised and causes the contacts to close when the generator voltage is high enough to charge the battery. The second coil, connected in series with the generator, carries the charging current and its magnetic effect on the cut-out armature assists that of the shunt coil in keeping the contacts closed. When the generator voltage falls below that of the battery, e.g. when the engine is slowing down or is stationary, the neutralising effect of the resulting discharge or reverse current flowing through the generator windings and the cut-out series coil reduces the magnetic pull on the cut-out armature, so that the contacts open and isolate the generator from the battery.

(b) VOLTAGE REGULATOR

The voltage regulator has two coils, one being a high resistance main coil and the other a low resistance frequency (or 'bucking') coil. The main coil is connected in shunt with the generator and so makes this regulator responsive only to changes in the system voltage.

The operating frequency of the regulator is largely determined by the inductance of the generator field system and also of the regulator itself. The purpose of the frequency coil is to increase the rate of vibration of

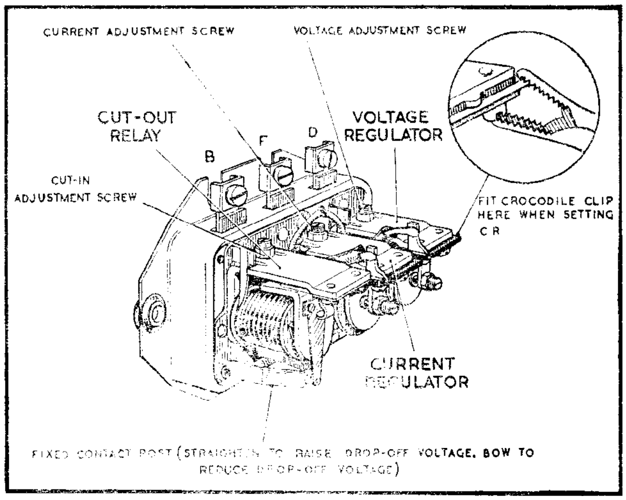

Fig. 1
Control Box model RB310 with cover removed

the regulator armature (see also below, under 'OPERATION'). The coil carries the generator field current and, magnetically, assists the main coil to attract the voltage regulator armature to the bobbin core when both the voltage regulator and current regulator contacts are closed. Immediately either pair of contacts opens, the frequency coil is de-energised and its contribution to the magnetic pull on the armature removed. In this way, the vibration frequency of the armature is increased, resulting in a steadier charging current.

(c) CURRENT REGULATOR

The current regulator has a single low resistance coil which carries the generator output. This unit is therefore responsive only to changes in the charging current.

(d) OPERATION

The generator (which must be a shunt wound machine) has its field coils energised via the regulator contacts, these being normally closed and connected in series with the frequency coil. An alternative circuit is formed by a field current resistor (referred to as the 'contacts resistor') connected in parallel with the contacts and frequency coil.

As the generator speed is increased from rest, the field coils are energised and the open circuit voltage rises. When a predetermined voltage is reached, the cut-out relay contacts close and connect the generator to the battery.

Further increase of speed causes the generator voltage to continue rising until, under conditions of light load and a well charged battery, the operating setting of the voltage regulator is reached. At this point, the magnetic attraction of the voltage regulator armature towards the bobbin core causes the contacts to open. The contacts resistor, now in circuit, reduces the field current and causes the generator voltage to fall. This results in a reduced magnetic pull on the regulator armature, so that the contacts reclose and the field strength again increases. This cycle is repeated many times per second and the generator voltage is thus limited to the preset value.

However, if the generator voltage fails to reach the operating setting of the voltage regulator, due to a discharged battery or a large electrical loading, an auxiliary means of limiting the generator output to a safe value is necessary and this is the purpose of the current regulator. When the current output of the generator reaches its maximum rated value, the electro-magnetic effect of this current, flowing through the current regulator coil, causes its armature to be attracted to the bobbin core and its contacts to open and the resistor to be inserted in the field circuit. Consequently, the current regulator armature is now set into vibration and a safe limit is imposed on the generator output.

(At one time, regulators designed to control the larger generator model C47 with its higher value of field inductance had a second contacts resistor. This was connected across the current regulator contacts and formed a parallel circuit with the first resistor when the current regulator contacts opened. This arrangement was later abandoned and a field-parallel resistor introduced).

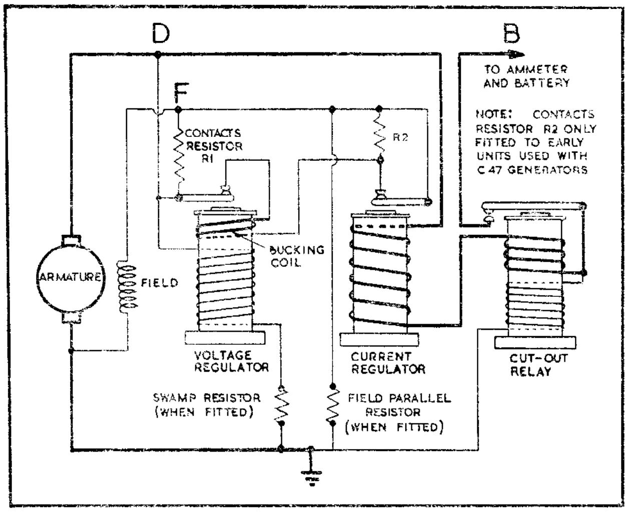

Fig. 2
Control Box model RB310 and generator, internal connections

On beginning to charge a flat battery, the voltage of the system is too low for the voltage regulator to operate. Consequently, the current regulator permits the full rated output of the generator to pass to the battery. This continues until the battery approaches a charged condition, when the voltage of the system rises sufficiently to initiate operation of the voltage regulator, the current falls and the current regulator becomes inoperative. In practice, a changeover period often exists when both regulators are in action.

(e) TEMPERATURE COMPENSATION

The main coils of the cut-out and voltage regulator consist of many turns of fine copper wire and, consequently, the ohmic resistance of these coils rises and falls as the temperature rises and falls—due in part to ambient working conditions and in part to the normal passage of current. In turn, this causes the operating current and therefore the magnetic pull on the armature to vary inversely with changes in temperature. Thus, to maintain the necessarily close operating limits expected of these units, some form of compensation is required.

The method adopted with cut-outs and all voltage regulators other than 24-volt units is to utilise a bi-metal strip either to supplement or to take the place of the armature tension spring—the hinge spring being of steel, copper coated in cut-outs and blue in voltage regulators. The effect of the bi-metal is to cause the spring force on the armature to reduce with rises in temperature and to increase with falls in temperature. This method also compensates for variations in battery voltage with temperature—a higher operating voltage being provided in cold weather.

With 24-volt units, it is customary to employ a wire wound series (or 'swamp') resistor in the voltage regulator shunt coil circuit to minimise the effects of temperature fluctuation—the resistor being of higher ohmic value than the coil and having a low temperature coefficient.

Current regulators are not compensated, the resistance of the operating coil being too low to vary significantly with changes in temperature.

(f) 'HOT-SETTING'

During manufacture, the majority of control boxes are heat-soaked at 70°C. before electrical settings of the voltage regulators are made. Then, while at this temperature, the regulators are set on open circuit to very close limits (14.1$\pm$0.2 volt, for 12-volt units). This method, known as 'hot-setting', ensures that accurate, stable settings obtain at normal working temperatures.

On cooling to 20°C., the temperature compensation device causes units to regulate at higher voltages and

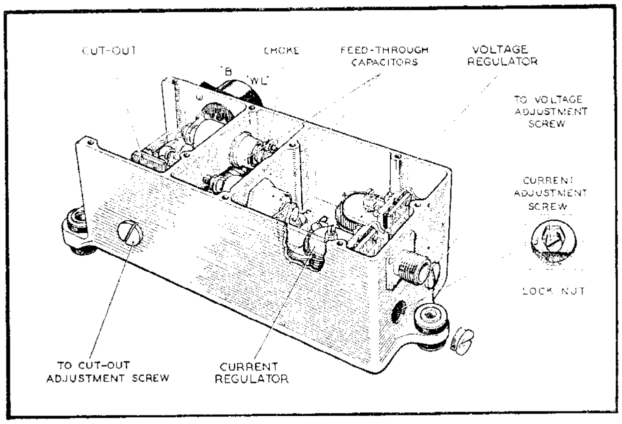

Fig. 3
Control Box model RB311 with cover removed

between slightly wider limits (15.2±0.6 volt, with 12-volt 'hot-set' units.)

As specified in para. 2 (a) (i), closer limits are necessary when service settings are made at the lower temperature in order to ensure correct regulation at the higher.

2. DESIGN DATA

(a) ELECTRICAL SETTING OF VOLTAGE REGULATOR

(i) *Open Circuit Voltages*

6-volt units	*12-volt units**	*24-volt units*
8.0—8.4	14.9—15.5	28.4—28.9

(ii) *Conditions for Voltage Measurement*

When checking or making settings to the above limits, the following conditions should obtain:

The control box should be connected to its usual generator or to another having the same Service Number.

The generator should be driven at 3,000 r.p.m.*

The control box should be mounted so that the plane of its contacts is vertical and the terminals point upwards. (See also page 5 col. 2 line 8, et seq.)

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

The ambient temperature and that of the control box windings should be at approximately 20°C. (68°F.). If not, a temperature correction factor must be applied to the above limits.*

(iii) *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 from the 6-volt limits
0.2-volt from the 12-volt limits
0.3-volt from the 24-volt limits

Conversely, the same corrections must be **added** for every 10°C. **below** 20°C.

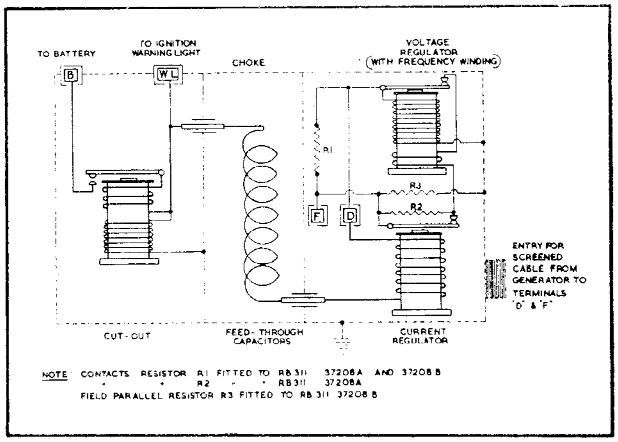

Fig. 4
Control Box model RB311, internal connections

(b) ELECTRICAL SETTING OF CURRENT REGULATOR

The current regulator must be set to operate at a current value equal to the maximum rated output of the generator it controls. The relevant values for Lucas generators are given in Section A-2 of this manual. The equivalent values for C.A.V. generators are 19 amperes for generator D5LF24B (control box number 37213) and 15 amperes for generator GH4524 (control box number 37266).

(c) ELECTRICAL SETTING OF CUT-OUT RELAY

	Cut-in voltage	*Drop-off voltage*
6-volt units:	6.3—6.7	4.8— 5.5
12-volt units:	12.7—13.3	9.5—11.0
24-volt units:	27.0—27.5	19.0—23.0

Note: By means of the bi-metal compensation device, cut-out settings remain substantially constant over a wide range of temperatures. Any small variations in setting due to changes in temperature result merely in proportionately small increases or decreases in the generator cutting-in speed. No temperature correction factors need therefore be applied to the above settings.

* *Except units controlling C47 generators which should be set to* 14.5—14.8 *volts at* 1500 *generator r.p.m. and all normal ambient temperatures*

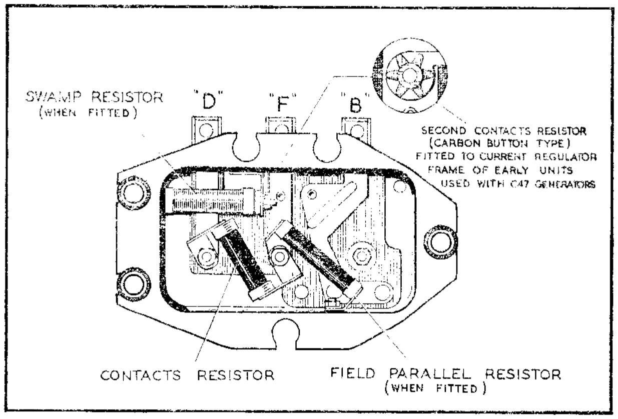

Fig. 5
Underside view of Control Box model RB310 showing positions of resistors

(d) RESISTOR VALUES

(i) *Contacts Resistor*

6-volt units: 50 ± 4 ohms.
12-volt units: $63\pm{}^{12}_{8}$ ohms (except earlier units used with C47 generators which were fitted with two contacts resistors, R1 150 ± 15 ohms, across the VR contacts, and R2 110 ± 10 ohms, across the CR contacts).
24-volt units: 240 ± 24 ohms.

(ii) *Field Parallel Resistor*

12-volt units: $38\pm{}^{7}_{2}$ ohms.
24-volt units: 60 ± 6 ohms

(iii) *Voltage Regulator Swamp Resistor*

24-volt units: 120 ± 6 ohms

(e) RESISTANCE OF SHUNT WINDINGS AT 20°C.

	Voltage Regulator	*Cut-out Relay*
6-volt units:	26— 30 ohms	18·5— 21 ohms
12-volt units:	103—115 ohms	58 — 65 ohms
24-volt units:	45— 51 ohms	240 — 260 ohms

(f) REPOLARISATION

When necessary, a control box originally intended for use with a positive earth generator can be repolarised for use with a negative earth generator (or vice versa) by applying a d.c. supply of appropriate voltage between terminal 'D' and base for five seconds. The connection to the base must be of the required earth polarity. Repolarising voltages are 10, 20 or 40 volts, for 6-volt, 12-volt and 24-volt units, respectively.

3. SERVICING

(a) FAULT DIAGNOSIS

Symptom	*Probable Causes*
No output from generator.	Generator driving belt broken. Loose connection or broken cable in charging circuit. Defective generator, control box or ammeter.
Intermittent or low output.	Generator driving belt slipping. Loose connection in charging circuit. Defective generator, control box or ammeter.
Normal output but battery under-charged.	Low mileage. Defective battery.
High initial output, quickly falling to a low value.	Loose or corroded earth connection. Electrical or mechanical settings of control box incorrect. Sulphated battery plates.
High output and battery over-charged.	Electrical or mechanical settings of control box incorrect.

Note: The circuit resistance between the regulator and battery should be of the following order: 6-volt installations, 0.012 ohm; 12-volt installations, 0.02 ohm; 24-volt installations, 0.02 to 0.03 ohm.

(b) ADJUSTMENT OF ELECTRICAL SETTINGS

(i) *Preliminary Checking of Charging Circuit*

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

Check the battery by substitution or with an hydrometer and a heavy discharge tester.

Inspect the generator driving belt.

Check the generator by substitution or by linking terminals 'D' and 'F' and connecting a voltmeter between this link and earth and running the generator up to about 1,000 r.p.m., when a rising voltage should be shown.

Inspect the wiring of the charging circuit and carry out continuity tests between the generator, control box, and when fitted, the ammeter.

Check earth connections, particularly of the control box.

If the generator is run at a fixed speed but the ammeter pointer swings more than the permitted amount to each side of the mean maximum value, the contacts of the voltage regulator or current regulator 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.

(ii) *Voltage Regulator Open Circuit Setting*

Disconnect control box terminal 'B' (marked 'A' on early models).

Connect a first-grade moving coil voltmeter between terminal 'D' and earth, using a 0—10 instrument for 6-volt units, 0—20 for 12-volt units and 0—40 for 24-volt units. In the case of model RB311, the voltmeter can be connected to terminal 'B' to avoid removing the cover at this stage.

Start the engine and run the generator at 3,000 r.p.m., when the open circuit voltage reading should lie between the appropriate limits given in para. 2 (a)—unless a non-standard setting is specified, when it should agree with the special limits quoted in Section F-1 Part A.

If the reading occurs outside the appropriate limits (and a correction for temperature has, when applicable, been made) it will be necessary to stop the engine and make an adjustment.

Access to the adjustment screw is gained by removing the cover of model RB310 control boxes and by unscrewing the righthand plug from the end of model RB311.

Restart the engine and again run the generator at 3,000 r.p.m.

Slacken the locknut of the voltage adjustment screw, turn the screw (clockwise to raise the setting or anti-clockwise to lower it) until the correct setting is obtained, and retighten the locknut. Check the setting by switching off and then raising the speed again to 3,000 r.p.m.

(iii) *Current Regulator On-Load Setting*

On the vehicle:

When setting the current regulator on the vehicle, the generator must be made to develop its maximum rated output, whatever the state of charge of the battery might be at the time of setting. The voltage regulator must therefore be rendered inoperative. To do this, the voltage regulator contacts should be short-circuited with a clip large enough to bridge the outer armature assembly securing screw and the insulated fixed contact bracket, as shown in Figs. 1 and 6.

Disconnect the cable from control box terminal 'B' and connect a first-grade moving coil 0—40 ammeter between this cable and terminal 'B'. Switch on all lamps and accessories. This will prevent the voltage of the system rising when the engine is started.

With the generator running at approximately 4,000 r.p.m., the ammeter needle should be steady and indicate a current equal to the maximum rated output of the generator. If it does not, the unit must be adjusted in a manner similar to that described for the voltage regulator.

Re-make the original connections.

On the bench:

When setting the current regulator away from the vehicle, a test generator and an artificial load is needed. The load circuit should comprise a 51 ampere-hour battery, a 0—40 ammeter and rheostat capable of carrying up to 35 amperes. The connections are shown in Fig. 6. The control box, it will be noted, is shown with its terminals pointing vertically upwards. This is the position in which electrical settings are made during production and is the mounting position recommended to vehicle manufacturers. However, since settings can be affected by change of position, bench settings should be made with the control box mounted as on the vehicle. Adjust the rheostat until ammeter A1 indicates a current slightly in excess of the maximum rated output of the generator normally controlled by the regulator. Run the test generator at approximately 4,000 r.p.m. and adjust the current regulator until the required setting is indicated by ammeter A2.

The permissible tolerances on current regulator settings are $\pm$ 1 ampere for generators of up to 25 amperes maximum output and $\pm$ $1\frac{1}{2}$ amperes for generators of up to 35 amperes maximum output.

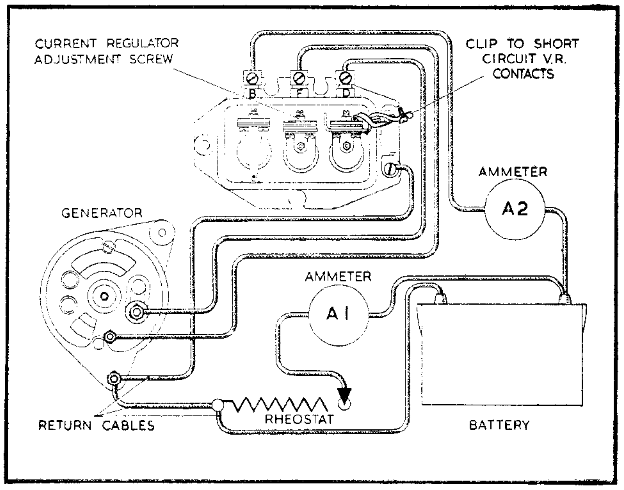

Fig .6
Connections for bench testing of current regulator

(iv) *Cut-out Relay Electrical Settings*

Cut-in voltage:

Connect a first-grade moving coil voltmeter between control box terminal 'D' and earth. Switch on an electrical load, such as the headlamps, and slowly increase the engine speed from zero. Closure of the contacts, indicated by a slight drop in the voltmeter reading, should occur between the limits given in para. 2 (c). If it does not, the unit must be adjusted in a manner similar to that described for the voltage regulator.

Note: When setting the cut-in voltage at a test bench, a suitable load resistor capable of passing about 6 amperes without over-heating should be connected between control box terminal 'B' and earth. This will cause the voltmeter needle to flick at the instant of contact closure.

Drop-off voltage:

Disconnect the cable from control box terminal 'B'. Connect a first-grade moving coil voltmeter between this terminal and earth. Run the engine up to speed and then slowly decelerate, noting the instant when the voltmeter reading drops to zero. This should occur between the limits given in para. 2(c). If it does not, the spring force exerted by the moving contact blade must be adjusted by altering the height of the fixed contact. To do this, carefully straighten the legs of the fixed contact post to raise the drop-off voltage or bow them to reduce it. Repeat the test and, if necessary, re-adjust until the armature releases at the voltage specified.

As with voltage regulators, the electrical settings of cut-outs should be completed as quickly as possible to avoid errors due to heating.

(c) CLEANING CONTACTS

When cleaning the voltage or current regulator contacts, use fine carborundum stone or silicon carbide paper, followed by methylated spirits (denatured alcohol).

When cleaning the cut-out contacts, use a strip of fine glass paper—never carborundum stone or emery cloth.

(d) CHECKING INTERNAL CONTINUITY OF CONTROL BOX

Single overall continuity checks of the internal connections, windings and resistors can be made by measuring the resistance between certain terminals of the control box. The resistance values quoted below apply for an ambient temperature of 20°C., with all external terminal connections removed.

However, it should be noted that, except for the first of the terminals 'D'–to–'F' checks, these measurements involve parallel circuits having branches of differing resistance values. An overall ohmic reading which falls within the correct limits does not therefore necessarily indicate a good unit. On the other hand, a reading which falls outside the appropriate limits can be assumed to indicate some defect of continuity or resistance, such as open or short circuits and high resistance joints or contacts.

(i) *Units with one contacts resistor*

	6-volt units	*12-volt units*
Terminal 'D' to base:	10—13 ohms	36—42 ohms
Terminal 'D' to terminal 'F' with VR or CR contacts open:	46—54 ohms	60—75 ohms (nominally 63 ohms)

(ii) *Units with two contacts resistors*

	12-volt units
Terminal 'D' to base:	36—42 ohms
Terminal 'D' to terminal 'F' with CR contacts open:	57—70 ohms

(iii) *Units with contacts resistor and field parallel resistor*

	12-volt units
Terminal 'D' to base with VR or CR contacts open:	26—31 ohms

(iv) *Units with contacts resistor, field parallel resistor and VR swamp resistor*

	24-volt units
Terminal 'D' to base with VR or CR contacts open:	70—80 ohms

(e) ADJUSTMENT OF AIR GAP SETTINGS

(i) *Gauge Thicknesses*

Air gap settings are accurately adjusted during assembly and should require no further attention. If, however, an armature is removed for any reason, care must be taken to obtain the correct setting on re-assembly. When setting an armature-to-bobbin core air gap, the correct size of gauge required is determined by the thickness of the non-magnetic separation used in the gap and also, in the case of voltage regulators, on the thickness of the bi-metal spring located behind the tensioning spring of the armature.

The above variable features are easy to identify and are as follows:

0.015″ separation is by means of a disc of copper.*

0.009″ separation is by means of a square of copper.

0.012″ bi-metal springs are bright and unplated.

0.010″ bi-metal springs are copper plated.

**Alternatively, two parallel copper wires were used in some units during 1956/7.*

A flat steel gauge of 0.015″, 0.018″ or 0.021″ is used as follows:

Voltage Regulators:
Use a 0.015″ gauge for units fitted with a 0.015″ disc of copper* and a bi-metal spring of either 0.010″ or 0.012″ thickness.
Use a 0.018″ gauge for units fitted with a 0.009″ square of copper and a bi-metal spring of 0.012″ thickness.
Use a 0.021″ gauge for units fitted with a 0.009″ square of copper and a bi-metal spring of 0.010″ thickness.

Current Regulators:
Use a 0.015″ gauge for units fitted with a 0.015″ disc of copper.*
Use a 0.018″ gauge for units fitted with a 0.009″ square of copper.

*See *footnote, col. 2, page 6.*

(ii) *Voltage and Current Regulator Mechanical Settings*

Slacken the two armature assembly securing screws so that the armature is loosely attached to the regulator frame.

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

Slacken the voltage (or current) adjustment screw locking nut and unscrew the adjustment screw until it is well clear of the armature tension spring.

Using a flat steel gauge of appropriate thickness (see para. 4(e) (i) opposite) and wide enough to cover the bobbin core, insert the gauge between the underside of the armature and the copper disc* or square. Take care not to turn up or damage the edge of the disc* or square.

Press the armature down squarely against the gauge

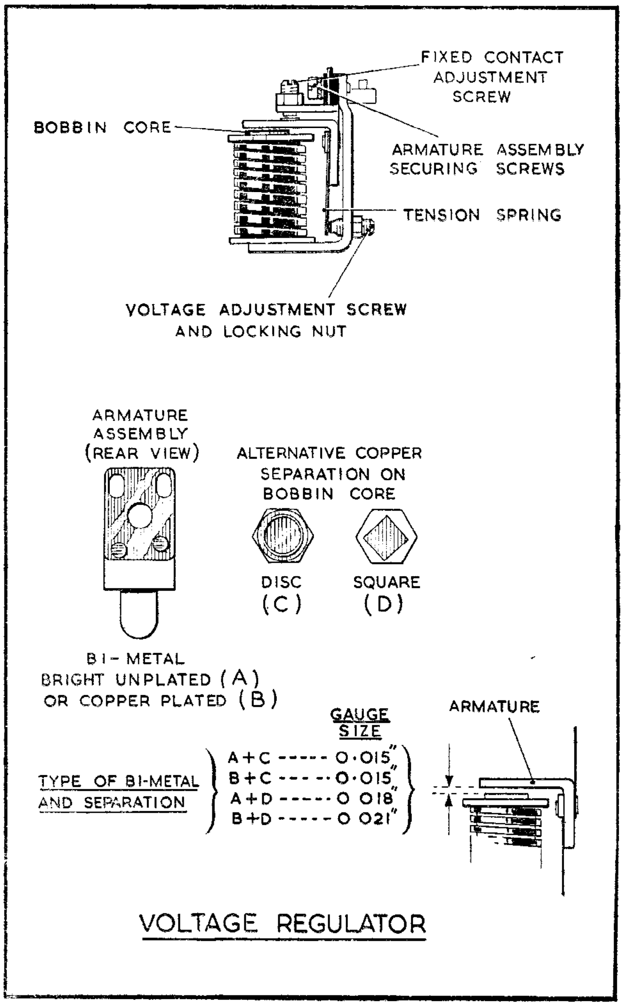

Fig. 7
Mechanical setting of voltage regulator

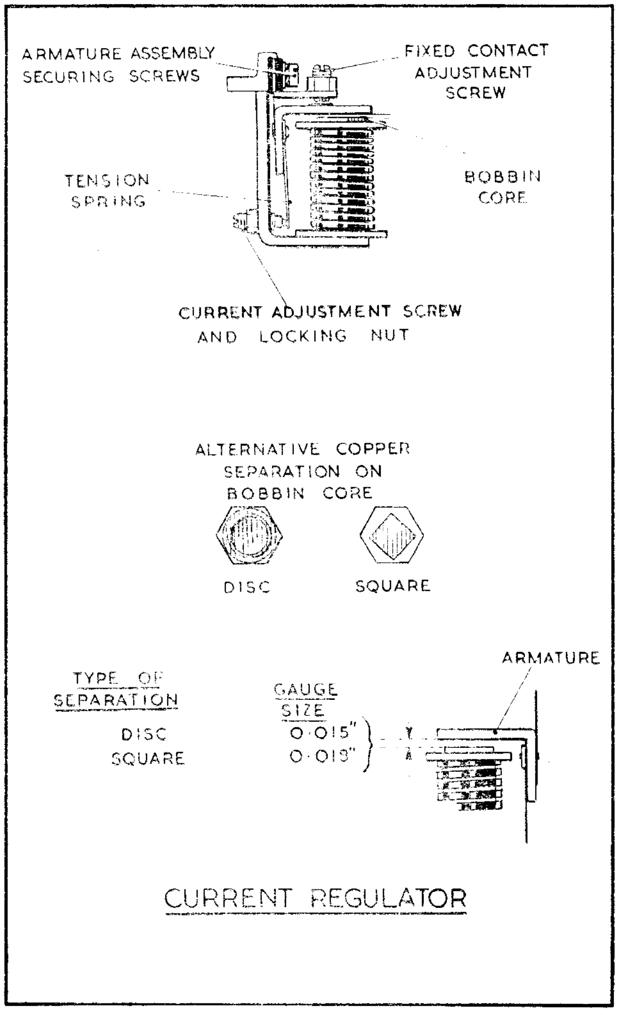

Fig. 8
Mechanical setting of current regulator

and re-tighten the two armature assembly securing screws.

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

Carry out the electrical settings as given in para. 3(b) (ii) and (iii).

(iii) *Cut-out Relay Mechanical Settings*

Slacken the two armature assembly securing screws so that the armature is loosely attached to the cut-out frame. Slacken the adjustment screw locking nut and unscrew the adjustment screw until it is well clear of the armature tension spring.

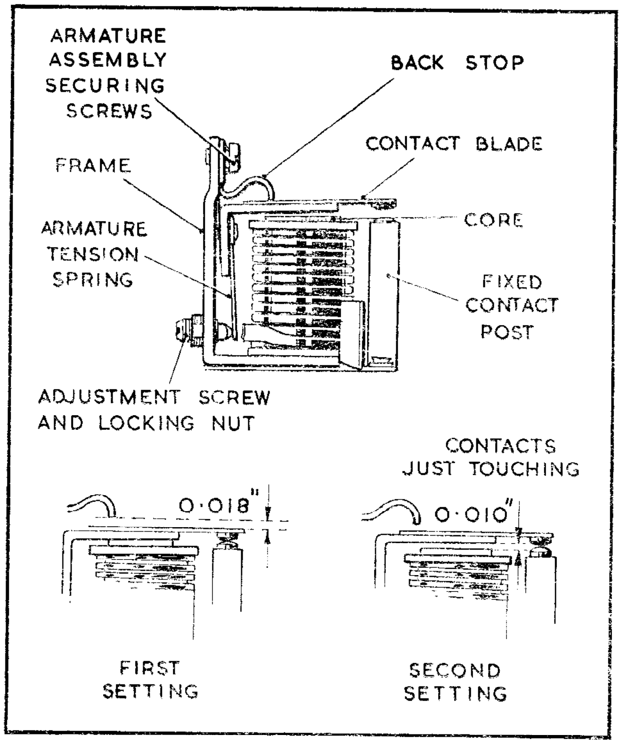

Fig. 9
Mechanical settings of cut-out relay

Press the armature down squarely against the core face (copper sprayed in earlier units or fitted with a square of copper in later units) and re-tighten the two armature assembly securing screws. No gauge is necessary.

Press the armature down against the core face and adjust the armature back stop so that a 0.018″ gap is obtained between the tip of the back stop and the contact blade.

Insert a 0.010″ thick flat steel gauge between the underside of the armature and the copper separation. The gauge should be inserted from the side of the core nearest the fixed contact post. The leading edge of the gauge should not be inserted beyond the centre line of the core face. Press the armature down against the gauge and check the cut-out contacts. These should be just touching.

If necessary, adjust the height of the fixed contact by carefully straightening or bowing the legs of the fixed contact post.

Carry out the electrical setting as given in para. 3(b) (iv).

4. RADIO INTERFERENCE SUPPRESSION

Interference with car radio originating at the control box can be recognized by periods of continuous crackling and is caused by normal regulator action. This interference can only be eliminated or reduced by electrical filtering and no attempt should ever be made to remedy it by the indiscriminate fitting of capacitors or by tampering with the regulator contacts. The remedy to be adopted depends on the type of radio equipment carried by the vehicle.

Interference with normal car radio can be cured by fitting a suppressor unit, model WS14. This unit incorporates a filter circuit comprising a choke and two capacitors and is designed for direct attachment to terminals 'D' and 'F' of model RB310 control boxes.

Interference with two-way radio communication equipment requires the higher order of suppression afforded by control box model RB311, referred to on page 1. It is essential that this unit is adequately bonded to its associated generator (usually model C47) by running the interconnecting cables 'D' and 'F' through fully screened cabling, properly connected and earthed at each end.

Warning: Under no circumstances should capacitors be connected to control box terminal 'F', or to the generator field terminal, or in parallel with the regulator contacts. Attempts to correct regulator interference in this way can affect the proper functioning of the charging system and may cause damage to the regulators.

If replacement of an existing suppressor unit becomes necessary, it is important to use only authorised spares. The electrical values of filter components are critical, both with respect to regulator performance and to the frequency ranges over which suppression is required.