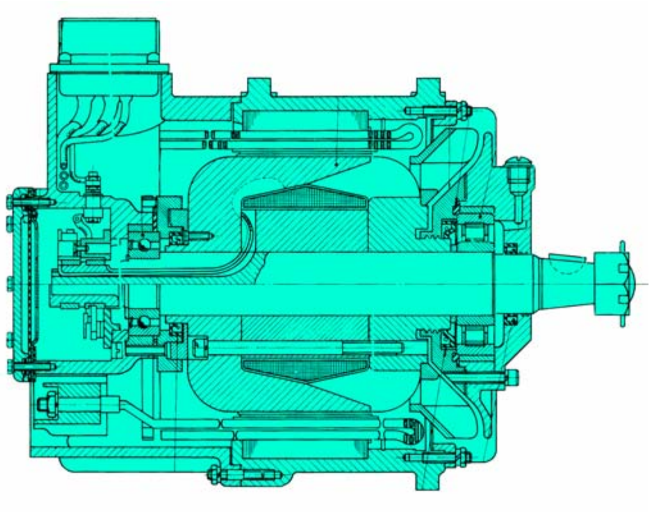
ALL CHARGED UP!



Clive Elliott continues his series on military alternators by giving some hints for fault finding in the 90-amp 24-volt system so widely used in post-war British vehicles.

This article is intended to help those who want to carry out electrical tests on the Generator No.10 and the associated Generator Panel No.9. This is the fourth article in the series about British Army charging systems, some aspects of this 90-amp system were described in *Windscreen* numbers 101, 103 and 127. Although it is helpful to have read the earlier articles I need to cover a little bit of the ground again so that this article is not dependant on constant cross referencing. I have simplified all of the circuit diagrams using colours to help illustrate how things function and introduced many photos that are now in colour. I have tried to minimise technical terminology and some explanations may seem rather simplistic. I have mixed the descriptions of function with the fault finding, as this is more likely to lead to a successful diagnosis.

The current version of this article is a major upgrade to what was originally published. It now includes coverage of the shunt box arrangements but the biggest change is an expansion of the generator testing section. If some of it seems a bit out of your depth, don't give up please just skip onto another section. I have gone into more detail than is essential in the section dealing with generator diode types. There is information there that will not be readily found by online searches and I couldn't resist including it, skipping this will have little disadvantage for fault finding as such. I have tried to avoid tests that rely on elaborate test equipment; these tests are aimed at a 'bloke in his shed' environment.

It is assumed that the reader is able to use a multimeter. A lot can be ascertained with even a quite basic instrument. Although many of us may posses a digital multimeter it should be used with caution. These instruments have an annoying habit of displaying gibberish, particularly on the most sensitive ranges even when the test prods are making no contact to the circuit under test! This happens whether you are trying to measure voltage, current or resistance, when there is nothing definitive to measure the display 'hunts' and throws up random numbers on the display. Not so much a problem when you know there is a particular voltage or resistance there to measure and want a precise reading. But not so good if you have an intermittent fault and unsure that there is actually something there to be measured.

Measuring resistance

Modern digital multimeters can read very high resistances, but that can be tiresome if it is autoranging. Sometimes you are measuring a resistor that has failed yet you still get a reading of say 10, but it is not ohms because the meter has hopped through kilohms and into megohms and you are measuring leakage from somewhere along the circuit. At least with an old fashioned moving coil (analogue) meter you can decide with the range selection what magnitude of resistance you are expecting to measure.

Many regard a *Megger* type of instrument (megohmmeter) as the definitive way to measure very high resistance and detect leakage of current through what is meant to be an insulating material i.e. testing leakage between wires in the interconnecting cable or insulation of components from earth. These instruments generate several hundred volts and need to be used with caution in circuits where semiconductors are employed. For tests around diodes and capacitors the test voltage should not exceed 100 volts, for tests on cabling then 500 volts can be used. For those with a Megger I have included readings for various items.

For those not familiar with a Megger it is worth considering obtaining one or at least befriending someone with one! REME Inspection Standards will often quote that that an insulation resistance should not be below 5 megohms at a given voltage. When you consider this generating circuitry is operating at no more than about 30 volts, the 'short circuiting' effect of 1 megohm or even 1 kilohm is negligible.

So why should this drop in insulating properties matter? Although an ohmmeter will tell you when a short circuit has occurred, a Megger will warn you of impending failures in a deteriorating system.

The insulation on the covering of cables in systems like these will be adequate and may well have a resistance as high as 200 megohms testing with 100 volts. Consider the cables below showing various degrees of damage to the insulating sheath.

These might all seem to just show relatively minor damage, which would have no effect of the system functionality. But Megger readings would show a progressive reduction in resistance of the insulating sheath, a point may be reached when some of the high voltage transients produced by an inductive load break through the remaining insulation then this will be followed by overt failure.

This failure can now be detected with an ohmmeter, but clearly it would have been better to have avoided failure by detecting a weakness in the system at earlier stage by the use of a Megger type instrument. If the damage has got this far it is likely to have brought with it the failure of three diodes.

Meggers were originally powered by a hand cranked generator to produce the high DC voltage. Although there was no reliance on batteries it was sometimes a little awkward to use with one hand holding the instrument steady whilst cranking with the other hand.

The development of transistor inverters meant that a high voltage could be available at the touch of a button.

The inverter models originally used a moving coil but there are now digital ones that perform well. Although the high voltage invertors have to be activated by a push-button, great caution needs to be exercised to ensure the button is not triggered in error or pushed into the 'lock-on' position. A cautious person might feel more at ease with a handle activated Megger, on the basis that you have to start winding the handle to deliver an electric shock to yourself!

Measuring current

There are some tests that require an ammeter, although multimeters can measure current usually their maximum range is 10 amps. This is not going to be of much use in testing the charging system where an ammeter with a range of up to 100 amps would be useful.

If you are fortunate enough to have a multimeter such as an Avo 12 you can read up to 36 amps directly or with an external shunt up to 360 amps. The Avo 12 was used in military service and was designed specifically for automotive use.

An ex-REME Avo 12 seen here with its shunt in the foreground. The DC voltage ranges (3.6, 9, 18 and 36 DC volts) make it ideal for vehicle use. Furthermore having a low sensitivity of 200 ohms per volt DC means that a small load is inevitably placed on the circuit under test. Not much good for electronic circuits where something like 20,000 ohms per volt is considered the lowest acceptable sensitivity. In an automotive environment I find it reassuring to measure a voltage and know that this is something more than a token voltage only available to deliver a few microamps. A digital meter presents virtually no load on the circuit and I find this is not always helpful.

Despite my enthusiasm for meters such as the Avo 12, I have to acknowledge that it is inconvenient and potentially hazardous to cut into a circuit and measure the current flowing directly through it. But there is gadget that has considerable merit for automotive work and is not yet widely used amongst enthusiasts. It is called a digital clamp meter and requires no disconnections or cutting of wires. It is a meter that has spring loaded jaws to clamp over a single wire to measure the current flow. Traditionally these meters could only use the clamp facility to measure AC current, but now DC clamp meters are also available. I bought new for about £35, although you can pay considerably more.

It is very convenient for measuring the current in any wire from as little as 0.1 amps up to 400 amps. It is useful for checking the output from the generator, the rate of charge to a battery, the drain from particular equipment or even the current drawn by the starter motor, provided a *single* cable can be identified and placed within the jaws of the instrument. A bonus is that these instruments are multimeters as well. For those who are committed to testing all the electrical components in this equipment, there are also dedicated meters around that can measure inductance (L), capacity (C) and resistance (R) up to 2,000 megohms.

Digital clamp meter *L, C & R meter*

Measuring resistance in diodes

Caution needs to be exercised when testing diodes. All the readings that are quoted here are based on the sort of readings you could expect using an analogue (moving coil) multimeter such as an Avo 7 or Avo 8 on the 10,000 ohm range.

If you have a digital multimeter be aware that on the ohms ranges there will only be a voltage in the order of 0.3 volts. This is insufficient to forward bias a silicon diode into conduction, so a perfectly functional diode may seem defective if it reads several megohms in forward and reverse directions. A silicon diode needs about 0.7 volts to conduct, so some digital multimeters have a diode test facility that will forward bias the diode. The meter then reads the voltage drop across the conducting diode; this should be less than 1 volt. In the reverse direction there will be no reading. The clamp meter above does have a diode facility but the LCR meter does not.

Where the tests specify the polarity of prods this refers to an analogue meter. Confusingly the way the ohmmeter works means that the –ve prod actually has the +ve voltage and the +ve prod has the –ve voltage! If you are using a digital meter the polarity of the prods must be reversed!

Fault finding

If the fault finding sequence in the last article was followed, sooner or later the fault can be laid at the feet of either the generator or generator panel and detailed fault finding can proceed on the defective unit. But I've learnt since I wrote the articles that for various reasons people tend not to stick to the diagnostic flow. The generator is often tackled first as it is less scary than the generator panel and there is often the erroneous belief that if the generator doesn't work it must be a fault in the generator itself.

Even if a strict diagnostic logic has not been applied, it is quite legitimate to test by the substitution of another unit. It is important to have confidence that the replacement unit has no faults either! So I have tried to incorporate tests that can be applied directly to the generator and generator panel without being installed into the system.

Definitions

For those not feeling too confident, some basic terminology:
Generator in military parlance can refer to either a dynamo or an alternator.
Dynamo generates Direct Current (DC) & requires no rectification.
Alternator generates Alternating Current (AC) & requires rectification to convert it into DC.
Generator panel regulates the generator output, provides RF filtering & switches the batteries to charge.
Armature or Rotor is the rotating part of the alternator incorporating the field winding.
Field winding provides the magnetic field for the alternator.

Slipring (of which there is a pair) is a conducting collar on the rotor making contact with a carbon brush for the field supply.
Stator is the non-rotating part of the alternator.
Stator windings are the main output windings.
Rectifier a device for converting AC into DC. This may be a discrete item or made up of individual rectifier diodes.
Multimeter a multi-purpose meter for measuring voltage (**voltmeter**), current in amps (**ammeter**) and resistance in ohms, kilohms (1,000 ohms) & megohms (1,000,000 ohms) (**ohmmeter**)

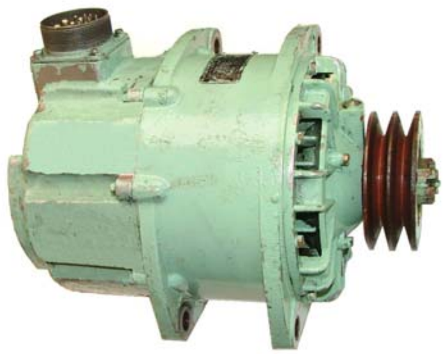
Background

In this instance the Generator No.9 is an alternator that was installed predominantly in Fitted For Radio (FFR) Rovers. The first AC charging system was introduced in 1961 to convert GS Rovers into a FFW role and was still being fitted to the early Rover 8 and 9 models. The limitation of this system was that it could only deliver 40 amps output and needed special provision for cooling the selenium rectifier.

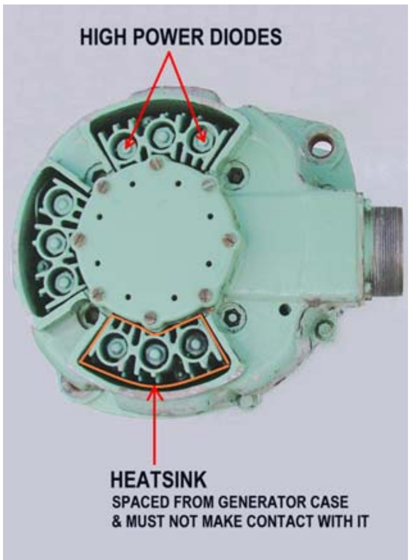
This rectifier had integral cooling fins and to maximise cooling efficiency in later vehicles the rectifier was mounted in an area created by an extended radiator grill, often nicknamed a “toast rack grill”.

The design of the system was limited, not by constraints of alternator design, but by the rectification system that would fail above 80 degrees C. This is why early AC systems could not be accommodated in armoured vehicles.

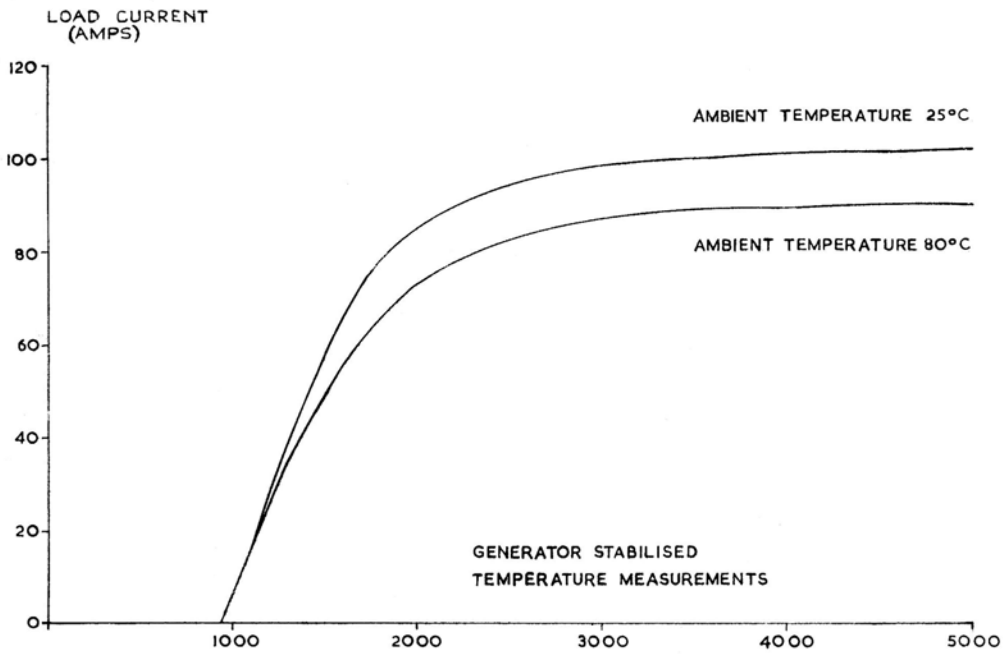
90-Amp Generators



Advances in semiconductor technology have meant that silicon diode rectifiers could perform more efficiently and at temperatures of even up to 200 degrees C. They can handle much higher currents yet generate less heat. Furthermore their construction meant they could be bolted directly to heat sinks that were fashioned into the design of the alternator.



Silicon diodes are still affected by heat and this poses a limit on the output achievable. A nominally 90-amp system in low temperatures can deliver about 100 amps. But the temperature of an engine bay will not stay low for very long. Attempting to draw more current from a diode than it was designed to carry will destroy it. Failure of a diode may not be spectacular, it will simply cease to be a semiconductor and become a conductor. In other words a functional diode tested with an ohmmeter will have a high resistance measured in one direction and a low resistance in the other direction. When the diode has failed the ohmmeter will read low in both directions.



ALTERNATOR No 10 Mk II
PERFORMANCE OF GENERATOR AT 27·5 VOLTS

Types of AC

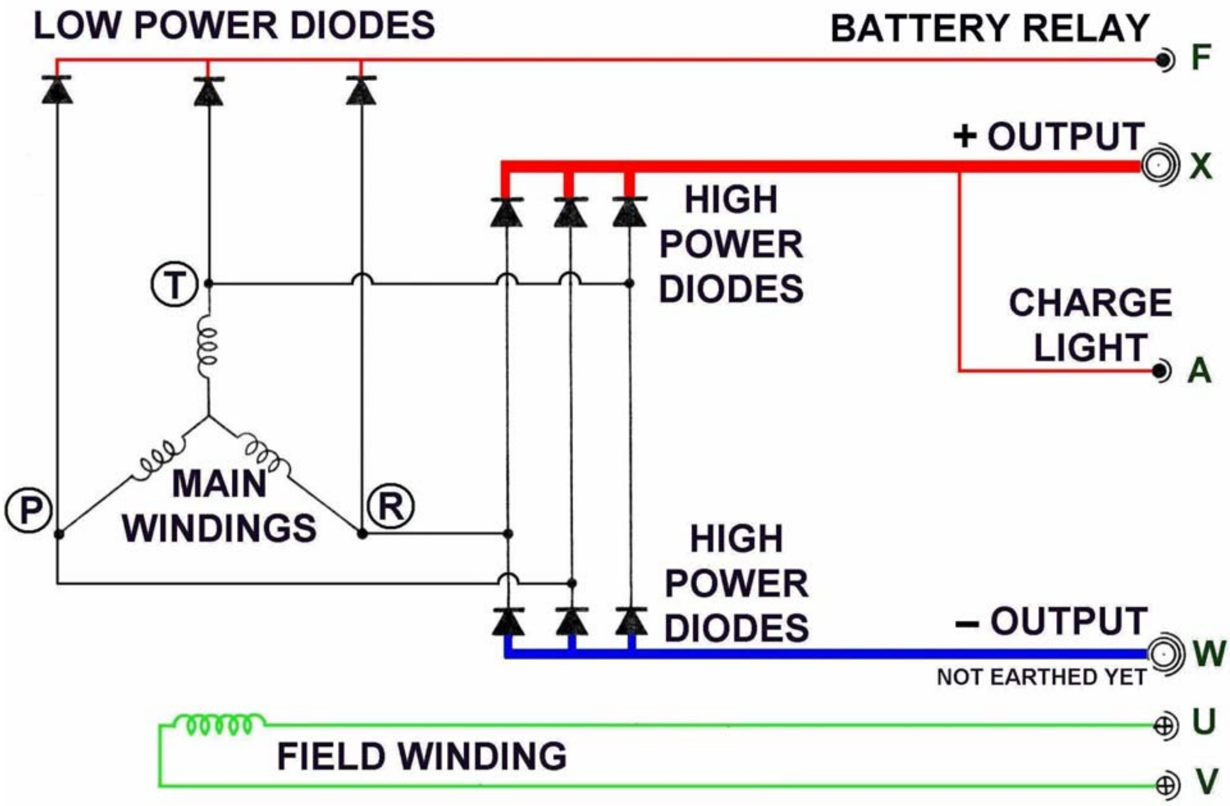
The National Grid generates and supplies AC power in the form of three-phase electricity i.e. AC power that is fed from three points. One can observe that high voltage power lines are always in groups of three. At a domestic level the power is converted for distribution through a two cable supply. This is single-phase AC and allows for simpler designs of domestic appliances, although some French cars with low electrical demands have used a single-phase alternator. Just as the designers of the National Grid knew that AC can be generated more efficiently if it is three-phase, it is not surprising that modern vehicle alternators should be three-phase as well.

This is why there are three coils or windings and three pairs of diodes in a modern alternator. Failure of some of these diodes would clearly reduce the available DC power and at the same time the failed diodes, now acting as conductors, would allow some AC content into the power output as well.

How it works in practice

Electricity is generated by revolving an electromagnet on a shaft inside these three windings. This electromagnet is energised by the 'field winding' and is supplied by current that is transferred to contacts on the shaft via lightly sprung carbon brushes. Adjusting the strength of the current in the field winding provides a means of regulating the output of the alternator.

The primary purpose of the Generator Panel No.9 is to regulate the output voltage by adjusting the voltage to the field winding. The generator will not perform properly by itself if the generator panel is not connected and indeed should not be run in this state as high voltage transients can destroy the silicon diodes.



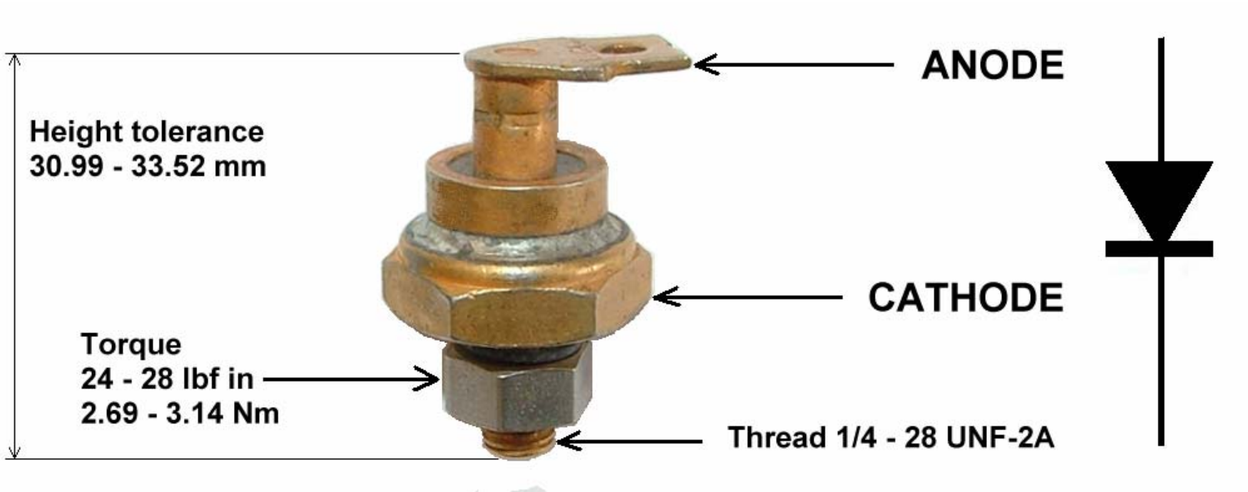
Looking at the circuit diagram, it can be seen how each of the three main windings feed into their respective diode pair. As the field winding rotates on the shaft, each of the main windings in turn receives the maximum magnetic change. Each winding in turn will deliver a single-phase AC output but with a degree of time overlap between maximum outputs from each coil, when these sources are added together the generator delivers a three-phase AC output.

With a ready source of AC power it is tempting to wonder whether some tools could be powered directly from the alternator. In fact there was provision for this by taking the AC supply directly to pins P, T & R of the main connector. This power tool facility required a special transformer unit and was only provided in the APGP (Air Portable General Purpose) Rover and some early Mk 1 Stalwarts. The Mk 3 generator differed from earlier Mks by the omission of these connections. There is no point in re-instating the connections P, T, & R to the socket for diagnostic purposes as these test points can be obtained directly from each of the three heat sinks.

High power diodes

The three windings represent three separate alternators with each winding supplying a pair of diodes. In each diode pair, one is connected the opposite way round from its partner. This means the sine wave of the AC is cut in half so the +ve portion is allowed through one diode and blocked by the other diode. As the wave moves into its –ve portion that is allowed to pass through the other diode whilst the +ve supplying diode now acts as a block. The outputs from the diodes are joined together with their neighbours to produce a combined DC output.

The studs that hold the diodes onto the metal heat sink provide one of the electrical contacts to the diode; the other contact is the top terminal. Although all six diodes have exactly the same electrical properties they are constructed in two forms, one being the electrical mirror image of the other. This means that a diode pair of opposite polarities (i.e. one that has the cathode on the stud and the other with the anode on the stud) can share the same metal heat sink by being directly bolted to it. The diodes used were Lucas type DD716 and the mirror image DD716A. The suffix 'A' signifies that the stud is the anode connection.



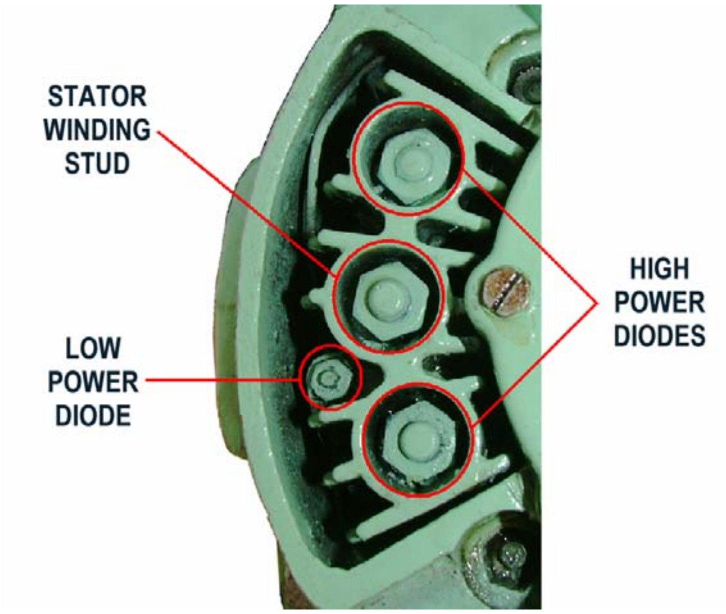
For maximum heat conduction the thread of the diode should be smeared with silicone grease and the stud set to the correct torque. Even so once the temperature of the DD716 increases above 135 deg C the current handling of the diode plummets in a linear fashion so that it will no longer function at all at 175 deg C. However at 155 deg C it can still handle 18 amps so a diode trio can still provide an overall output of 54 amps.

It should be noted that these heat sinks need to be insulated from the main metalwork of the generator. That includes the –ve rail, as although this generator is for a –ve earth vehicle, the –ve supply is isolated from earth not just in the generator but in the generator panel as well. It does not get earthed until after it leaves the generator panel. Although in the Generator Panel No.9 Mk 4 the –ve line is earthed internally.

Low power diodes

It will be seen that in addition to the six high power diodes, there are three low power diodes. The purpose of these diodes is to provide an independent supply to the relay in the generator panel. This heavy duty relay connects not only the +ve terminals of the radio and vehicle batteries together but it feeds them with the +ve output from the generator. In the later transistorised generator panel this supplemental supply powers not just the main relay but provides excitation to the field winding and to the charge light.

One of these three diodes is mounted in each of the three heat sinks for the high power diode pairs.

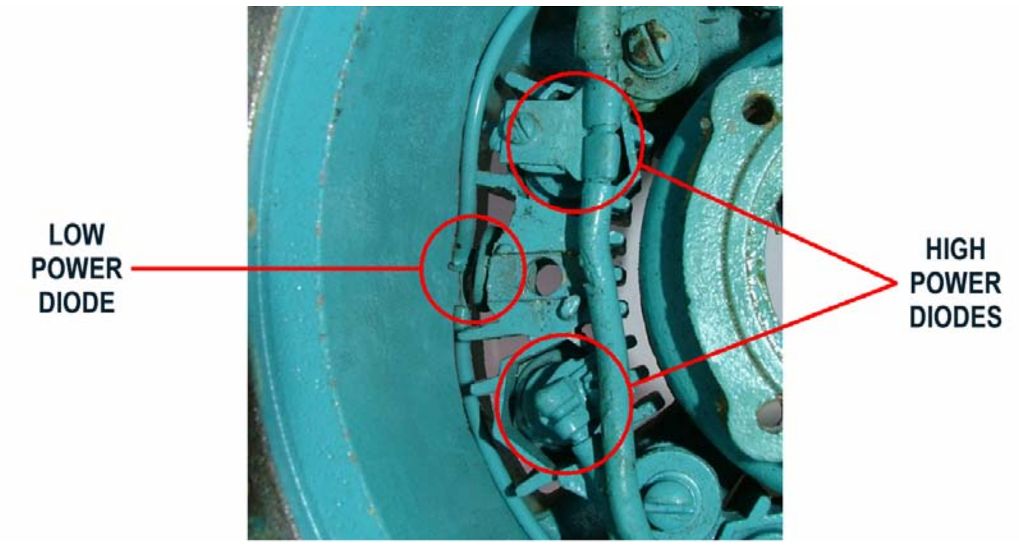


By having the relay operated by an independent supply it means that when the generator output falls the relay disconnects the two pairs of batteries from each other and from the generator output. If the relay was operated from the main generator output, once the relay closed and generator voltage fell, it would continue be held closed as it would now be powered by the batteries themselves. The independence of this supply is established by having its own three diodes that block the flow of any power from the batteries.

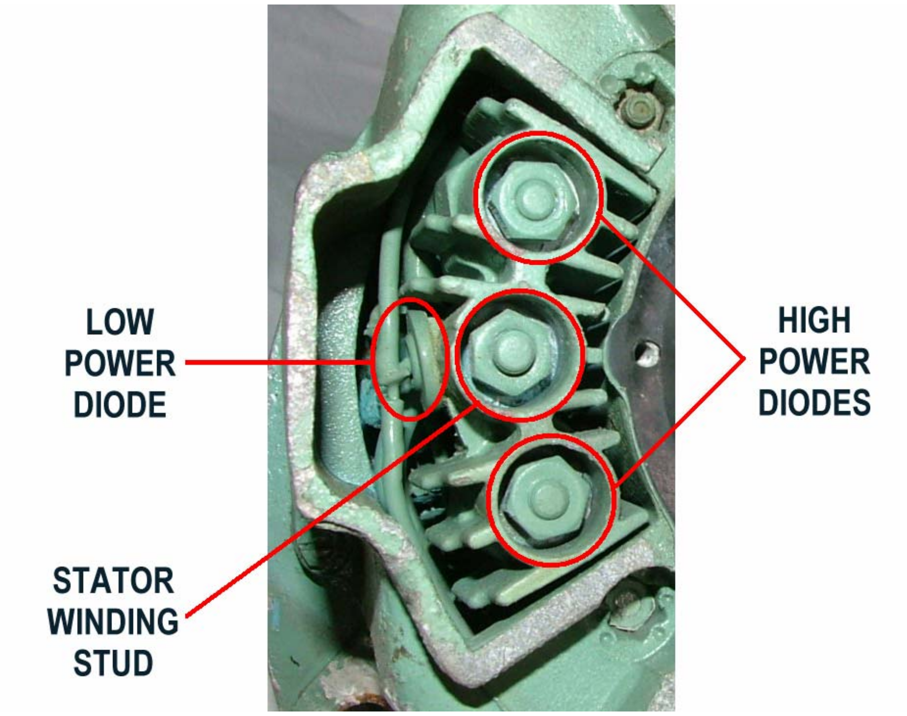
When you look at the three diode packs each has three large studs. The studs at each end of the trio are the high power diodes. They are functionally identical to each other although one in each pair is the reverse polarity of its partner.

The central stud of the three large studs is not a diode, it is the stud attached to the stator winding. The smaller low power diodes (Lucas DD3026A) have the anode to the stud connecting directly to each heat sink, the cathodes are wired together to give the +ve supply for the battery relay winding. It can be confusing appreciating the polarity of diodes because although electrons flow from –ve to +ve, the current flow is actually in the opposite direction! This was the arrangement of the low power diodes in the Generator No.10 Mk 2 and earlier models.

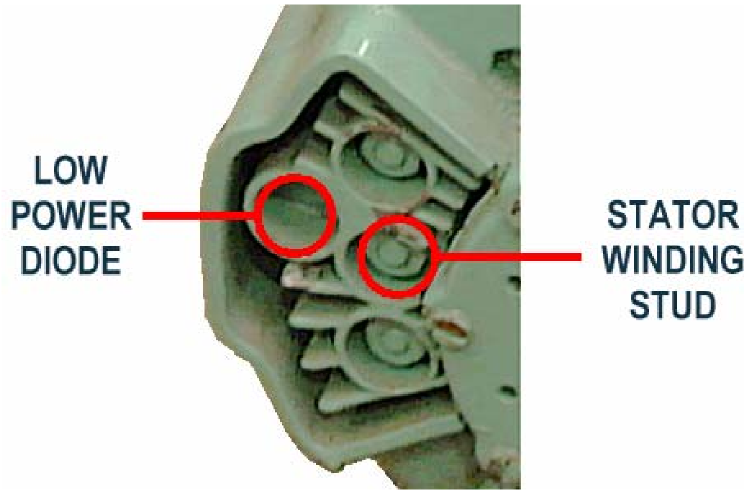
The Mk 3 used different rather stubby diodes that were accommodated laterally to the central stator studs. Mounting them here gave very little room for access, necessitating removal of the heat sink to replace the diode. In the view below the low power diode can best be seen from inside the slipring end shield.



Later versions of the Mk 3 are characterised by an enlargement of the slipring end shield, which gives much better access.



A further development was yet another heat sink now incorporating the low power diode in the same axis as the high power diodes. Indeed the new diode is of similar dimensions as the high power diodes.



The retaining nut for the low power diode, although deeply recessed, is blanked over presumably to protect it from being undone in mistake for the stator winding nut.

Charge warning light supply

When the ignition circuit is turned on a +ve feed is connected to the charge warning light. The 'earthy' end of this light is fed through the generator panel and on to the main output of the generator where it is fed through the main diodes and their connections to the –ve rail. Once the generator output rises to equal the voltage applied to the ignition side of the light, it is extinguished.

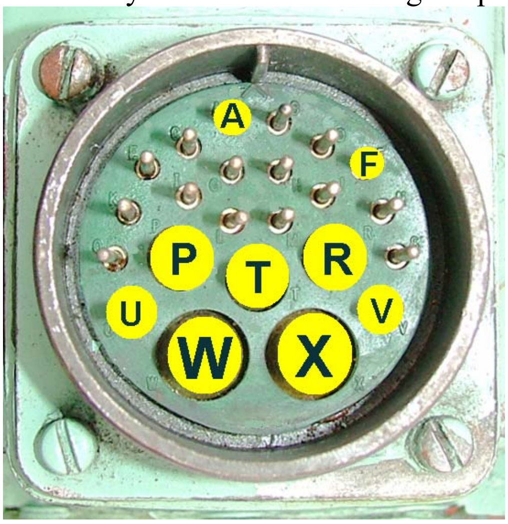
The reason that the warning light has an independent supply directly from the generator is to have as stable a voltage as possible. It minimises the fluctuations that may occur when heavy currents are drawn through the main wiring and the filter chokes resulting in a voltage drop.

Differences in Generators No.10

The generator was developed by C.A.V. and designated AC90/2. Apart from a change in diode types, there is only one major difference between the Mk A, Mk 1, Mk 2 and Mk 3 generators. The earlier generators had a three-phase output to run power tools but the wiring for this was omitted in the Mk 3 generator. Unless you have an APGP Rover or an early Stalwart and want to run power tools then the Mk of generator does not matter. However the current demands of the supplementary output from Pin F are greater when using the Generator Panel No.9 Mk 4 than with earlier panels. The Mk 3 generator has low power diodes that can cope with these demands. It would seem unwise to rely on using an earlier generator with its lower power diodes on installations with the Mk 4 panel.

Tests on Generator No.10

Disconnect the generator to generator panel cable. Identify the pins on the generator socket. The use of ready made small jumper cables can be very useful for connecting the prods from the multimeter.



Testing the field winding

With the meter on the low ohms range measure the resistance between pin U and pin V. Take the average of three readings each time turning the generator pulley a little it should be about 15 ohms. If there is no reading the most likely cause is that the carbon brushes are worn down and need replacing. If the reading goes erratically above 20 ohms means the copper sliprings are significantly dirty or grooved. This will require inspection by dismantling the generator cover plate, which is very easy to do.

Testing diodes with a multimeter

The following tests relate to the use of an analogue meter. If you try to use a digital meter to measure diode resistance there will not be enough voltage to forward bias the diode to conduct. This means when using a digital multimeter as on ohmmeter it will give very high readings in both directions across a diode. If the digital meter has a diode test facility this can be used but the polarity of the test prods must be reversed compared to an analogue meter.

There can be quite large differences in readings between different types of analogue meter. This depends on not only on the sensitivity of the meter but how much voltage a particular meter provides when measuring resistance and this will affect how hard it drives a diode into conduction. Readings are given for the Avo Model 7 and Model 8 with both instruments set on the 10,000 ohms range.

The difference between readings for the two models of Avo may seem great, but they are really only measuring the flow of current in a diode rather than taking an actual measurement of resistance. If you are using an Avo 12 on the x 1 ohms range you can expect readings to be about half that as for the Avo 7. The important point is that there is dramatic difference in conduction when the test prods are reversed on the diode under test.

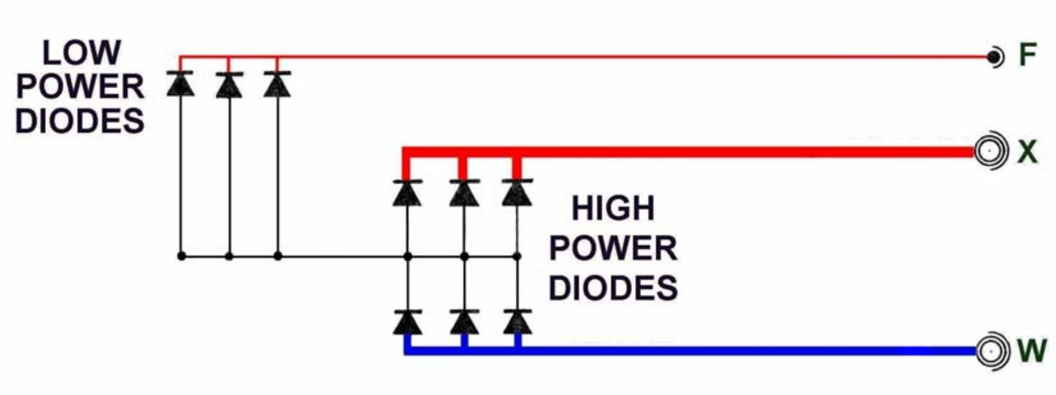
Testing diodes in generator Mk 2 or earlier

Pins P, T & R are connected to the main windings for the three-phase output. This is convenient as it allows testing to be done with the generator mounted in the vehicle. This will not be possible if the generator has been mounted with the main connector facing downwards so proceed as if it was a Mk 3 generator.

Testing diodes in generator Mk 3

The heat sinks provide the access to the equivalent of points P, T & R as this is where the main windings are bolted to each diode trio in their heat sink. It is only necessary to scratch off a little bit of paint anywhere on each heat sink or on the exposed nuts to gain electrical access to the main windings. For convenience I will continue to refer to these junctions as P, T & R.

By using points P, T & R in turn it might seem that each low and high power diode can be individually tested. Sadly this is not the case, when the generator is not running then both types of diodes see only the very low resistance of the windings that link them together. So with the generator at rest each diode is in effect in parallel with the other two of the trio and will be tested simultaneously. For testing purposes they are in effect behaving like this:



A short circuit in one diode will short circuit the other diodes in the trio. An open circuit in one (or two) diodes would be masked by the conduction of the survivor(s). Running all of the P, T & R tests is not a waste of time as it validates the continuity of the main windings, although it doesn't indicate whether the windings are working correctly or have a short circuit.

Testing the high power diodes

Put the –ve prod to pin W and the +ve in turn to points P, T & R, each time it should read 24–30 ohms on an Avo 7 or 650-670 ohms on an Avo 8. Reverse the prods and repeat the readings which should be in excess of 10,000 ohms (10 kilohms). A low reading indicates a failed diode or indeed several.

Put the +ve prod to pin X and the -ve in turn to pins P, T & R each time it should read 24–30 ohms on an Avo 7 or 650-670 ohms on an Avo 8. Reverse the prods and repeat the readings which should be in excess of 10,000 ohms (10 kilohms).

To test all six main diodes as a group, put the –ve probe to pin W and +ve to X it should read 35-100 ohms on an Avo 7 or 1,700-2,000 ohms on an Avo 8. Reverse the prods and it should read in excess of 10,000 ohms.

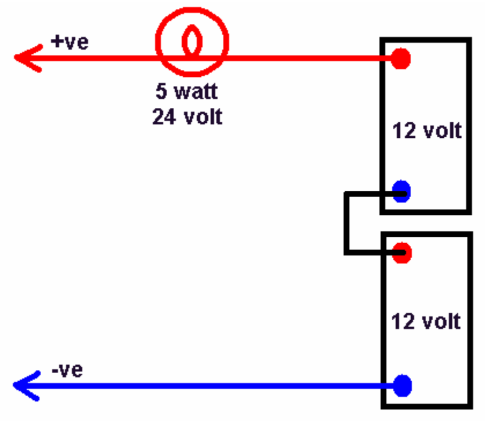
Testing the low power diodes

Similarly the low power diodes can be tested. Put the +ve to pin F and the negative in turn to points P, T & R, each time it should read 25–30 ohms on an Avo 7 or 500-600 ohms on an Avo 8. Reverse the prods and repeat the readings which should be in excess of 10,000 ohms (10 kilohms).

To test the low power diodes (and inevitably half of the main diodes again) put the –ve probe to pin W and +ve to F, it should read 110-140 ohms on an Avo 7 or 2,250-2,380 ohms on an Avo 8. Reverse the prods and it should read in excess of 10,000 ohms.

Testing the diodes without a meter

This can be done for any Mk of generator and is a powered way of measuring diode group function. It requires a 24-volt battery connected in series with a 5-watt 24-volt bulb and two test prods.



Each of the three heat sinks supports a pair of high power diodes of opposing polarities and one low power diode. It is necessary to scratch a little paint of each heat sink to allow contact for the probe.

Put -ve prod to pin X and the +ve prod to each heat sink in turn, the bulb should light up. Reverse the prods and repeat the test, the bulb should not light up.

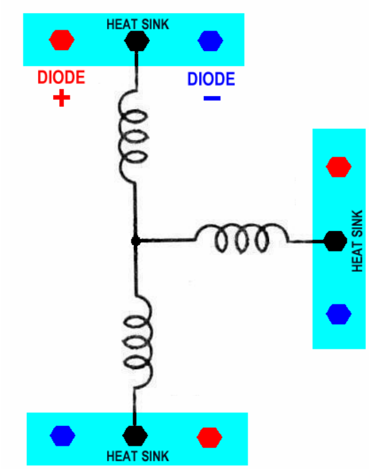
Put +ve prod to pin W and the -ve prod to each heat sink in turn, the bulb should light up. Reverse the prods and repeat the test, the bulb should not light up.

Those two tests evaluate the main diodes. The next test is for the low power diodes. Put -ve prod to pin F and the +ve prod to each heat sink in turn, the bulb should light up. Reverse the prods and repeat the test, the bulb should not light up.

Remember that all those tests with a multimeter or with a lamp are testing a diode trio. The only way to test an individual diode of either type is to partly dismantle the generator and unsolder the top terminal on each diode in turn.

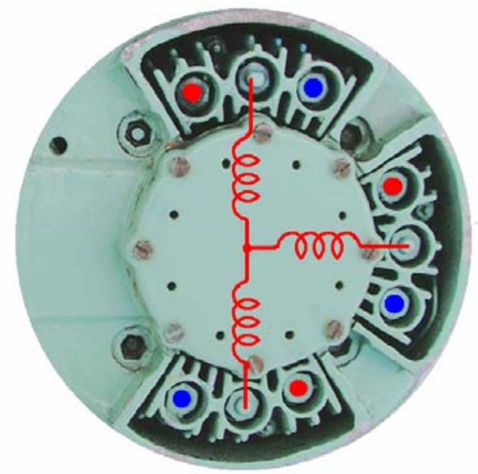
Testing the main windings

The main windings are of very low resistance and it is not practical to attempt to measure this directly. Passing a significant current through the windings produces a voltage drop across them. Knowing the current flow and the voltage drop by the resistance can be calculated. Unfortunately the common junction of the windings is not accessible so two windings have to be tested at the same time. Three readings will be needed that will include two windings in series for each set of readings.



Even if you have an early generator it might seem that you could test the main windings from pins P, T & R. But to eliminate the resistance of these leads it is imperative in the following high current tests that the main windings are accessed directly at the heat sinks. For this is where each of the three main windings connect with a high power diode anode and a high power diode cathode. Note that although I have marked the polarity of the diodes on the diagram above and below, these diode pairs are connected together. To test the diodes directly the generator needs to be dismantled.

Whatever Mk of generator you have you need to scratch off some paint from the heat sinks in order to make a bare metal surface for attaching bulldog or crocodile clips. It is tempting to consider undoing central winding retaining nut and bolt an 'O' terminal for the test wires. This would ensure a tight and low resistance contact whilst give a more secure fixing than a clip. Unfortunately there is insufficient space to do this, given that the 7/16 socket will only just fit inside the heat sink casting.



According to the EMER, passing a current of 40 amps should produce a voltage drop of 1.8-1.9 volts across any pair of the three terminals. By using Ohms Law (Resistance in Ohms = Voltage divided by Current in Amps) it can be calculated that the readings should lie be between 0.045 to 0.0475 Ohms. Clearly not a value one could expect to measure directly with an ohmmeter.

This measured resistance is of course the resistance of any two windings in series; an individual winding should have a resistance of half this i.e. 0.0225 to 0.0237 ohms. As long as the temperature remains constant the resistance will remain the same, it is not necessary to calculate the actual resistance. All that is necessary is to know for a given current flow what the voltage drop is.

All three readings should be in close agreement. In the event of an open circuit on one winding then two sets of readings would be open circuit, no current would be drawn, so the voltage measured would be that of the battery. In the event of one winding having shorted turns then two readings will have higher current and voltage values, obviously the winding that was common to the these two tests is the culprit.

If there is a difference in readings it is worth repeating the tests. The readings will be influenced by the state of charge of the battery, the inevitable resistance of the wires used to connect this all up and the heat generated in all this will affect the total resistance of the circuit. Although the battery may go down the ratio of voltage to current will remain the same as this is equal to the resistance of the windings under test.

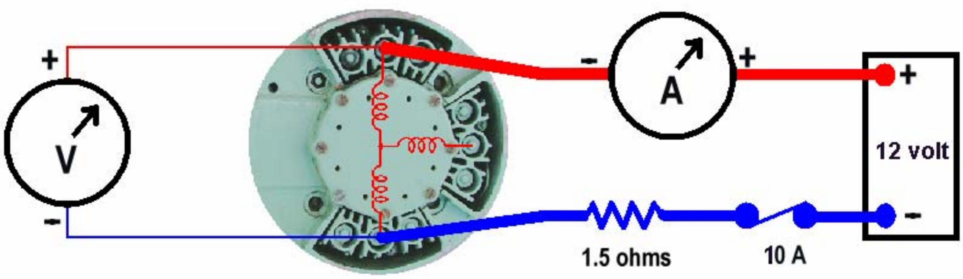
It is unlikely that many of us will have the facility of a power supply unit that could deliver 40 amps. Of course batteries could be arranged to deliver this sort of current, but other than by using a DC clampmeter few of us are likely to have an ammeter that can measure this current. Most good quality multimeters such as the Avo 8 have a maximum current range of 10 amps.

In order to get a battery to deliver the selected current it is necessary to provide a dropper resistance in the circuit. The problem is that the higher the test current selected the lower will be the required resistance.

With that comes the difficulty of obtaining a resistance of less than 1 ohm at reasonable cost and one sufficiently rated to withstand the heat that it generates.

The most readily available high power resistor is the ballast resistor used in some civilian ignition circuits. These usually have a resistance of 1.5 ohms and typical of this is the Lucas 47725A. It would normally be used in a 12-volt system in series with a 6-volt coil, the resistance of the coil matching that of the ballast resistor. In such an arrangement the heat dissipated by the resistor will be 24 watts, although this will be intermittent as the points open and close, it will get very hot, which is why the resistor winding is embedded in ceramic.

Such a resistor can be wired in series with a 12-volt battery to test the main windings by allowing a restricted current to flow and measuring the voltage drop across the windings. This means the current drawn will be less than 10 amps although the voltage drop across the windings will be more like 0.3 volts. This makes testing far more practical for the average enthusiast and without noticeably detracting from the accuracy of the high current test.



The exact value of 1.5 ohms for the ballast resistor is not too important as long as it is of that order which is sufficient to limit the current flow to below 10 amps. Too much resistance will produce quite a small voltage drop which will be difficult to measure with accuracy.

It is advisable to incorporate a safety fuse in the order of 10 amps and to mount this near to one of the battery terminals. Heavy duty wires should be used to minimise the resistance of the wire, this additional resistance will reduce the voltage available at the alternator windings. Furthermore this will generate heat which could become a fire risk. When wiring up the circuit one battery terminal should remain disconnected. An ammeter or multimeter should be switched to the DC 10-amp range before connecting to the battery otherwise internal arcing could damage the meter switch. Alternatively a DC clamp meter can be used.

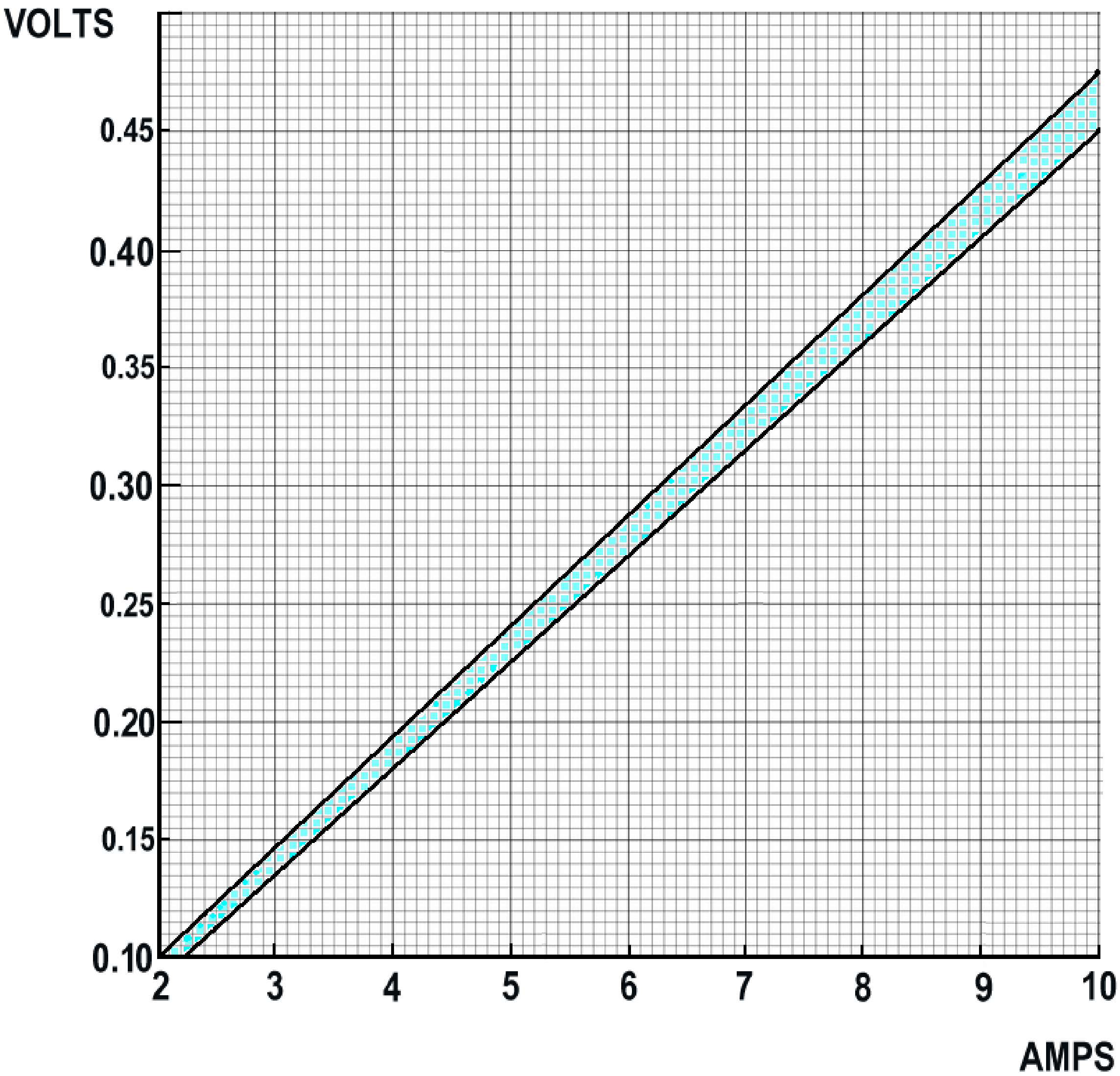
Sturdy crocodile or bulldog clips with strong springs should be attached to any two of the three heat sinks on an area that has been scraped clean of paint. It is important that the clips to not touch the alternator case. Although this is isolated from the internal wiring, the test will be invalidated if the other clip contacts the case.

A voltmeter set on its lowest range, which usually is 3 or 10 volts, is connected with small clips to the large clips already on the heat sinks. No appreciable current is carried to the voltmeter so the normal test leads may be used. It is important that the voltage is measured directly at the heat sinks; measuring the voltage anywhere else on the circuit will introduce errors due to the voltage drop in the wires feeding the main windings.

Both the voltmeter and ammeter should be positioned so that they can be easily read from where the operator would stand to connect the battery terminal to turn the circuit on. The test should not take longer than a few seconds because the ballast resistor will be carrying double the current it was designed to handle. Not only could this risk damaging the resistor but could, if the connection was prolonged, become a fire hazard. Anything other than a very short test could cause the wire and the test wings to heat up which will cause the resistance of the components to change.

For each of the three readings it is important that the ammeter and voltmeter readings are observed simultaneously. Once a pair of readings is obtained, one of the heavy duty clips is moved to the other heat sink and the test repeated with the voltmeter re-attached to the new pair under test. Then finally the other clip is moved to the other heat sink.

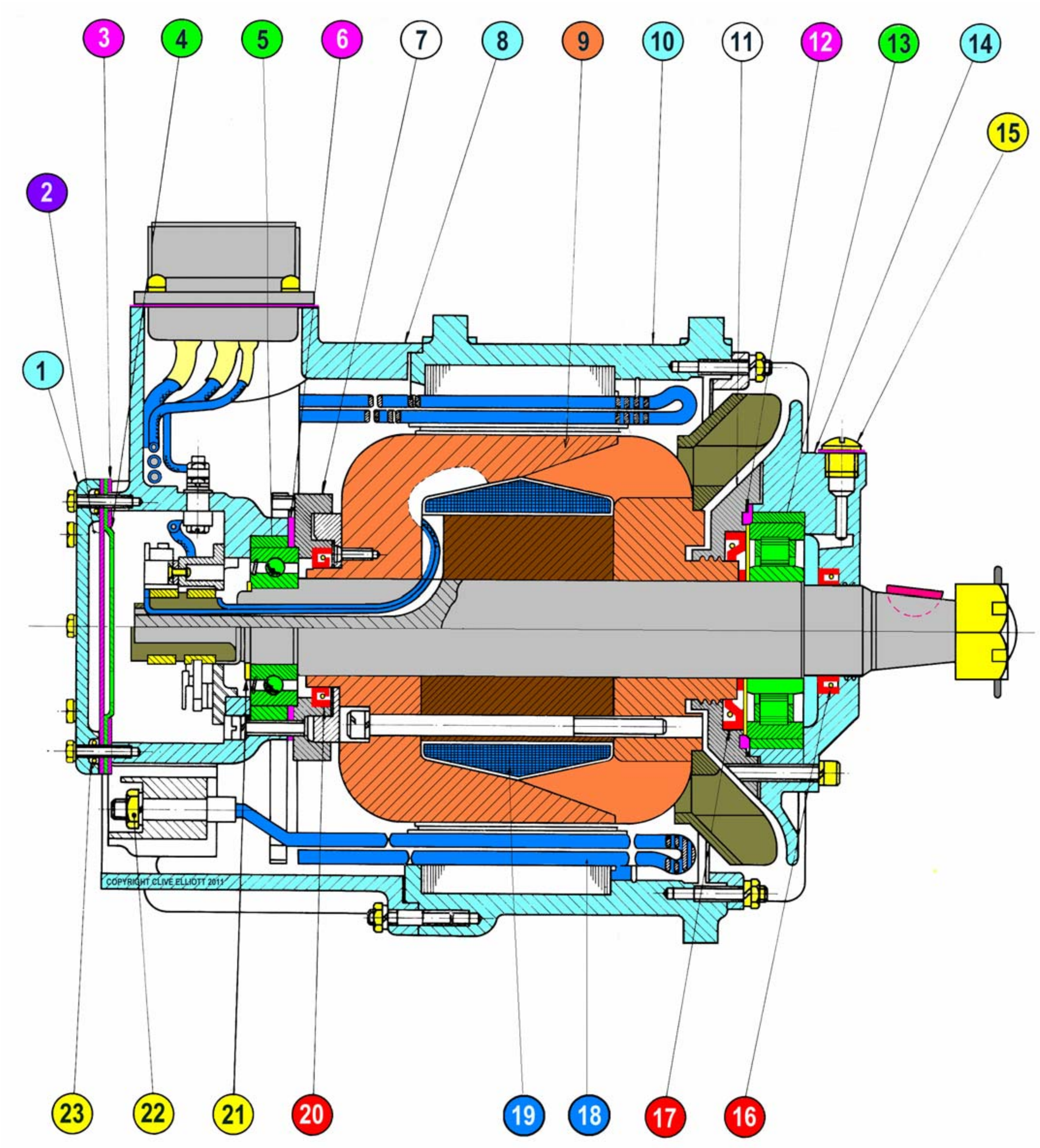
Inevitably the battery will lose some of its charge during the tests, so the final pair of readings may be a little lower than the first. This does not matter as it is the ratio of the two readings that is important. Compare the readings with the graph that depicts a range of likely readings. It is probably easiest to identify the current reading first then where it intersects with the blue portion of acceptability then read across expected voltage and compare it with your voltage reading. The blue area indicates the tolerance of acceptability; this is a percentage of the readings. The lines of tolerance are convergent as the value of the readings decrease although the tolerance as a percentage remains constant.



Provided the diodes are not defective they will have no appreciable effect on the outcome of the tests if the generator has not been dismantled. Dismantling does make it easier to gain access to the main windings, test the diodes individually and test leakage of the diode packs and main windings in isolation.

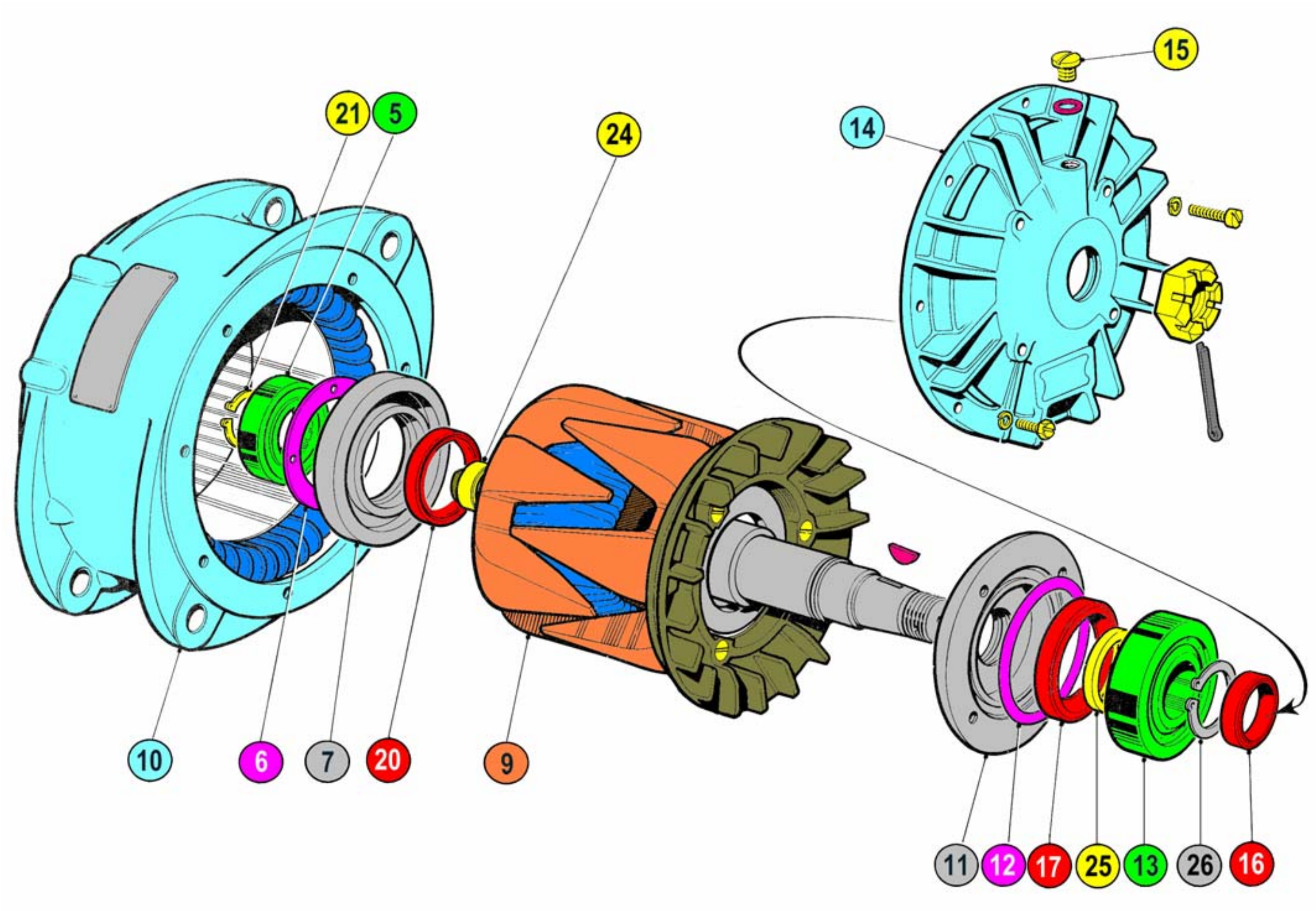
Generator construction

Before starting to dismantle the generator it is worthwhile spending a little time studying its construction. The diagram below is based on the drawing at the start of the article, which hopefully is more meaningful by the use of various colours.



1. Cover plate
2. Diaphragm
3. Gasket
4. Stop plate
5. Ball bearing
6. Gasket
7. Bearing clamp plate
8. Slipring end shield
9. Rotor casting
10. Stator
11. Bearing clamp
12. 'O' ring
13. Roller bearing
14. Drive end shield

15. Lubrication plug
16. Oil seal
17. Oil seal
18. Stator winding
19. Field winding
20. Oil seal
21. Circlip (replaced retaining ring)
22. Stator connection nut
23. Sealing ring
24. Slipring
25. Washer
26. Circlip (replaced retaining ring)
27. Rotor



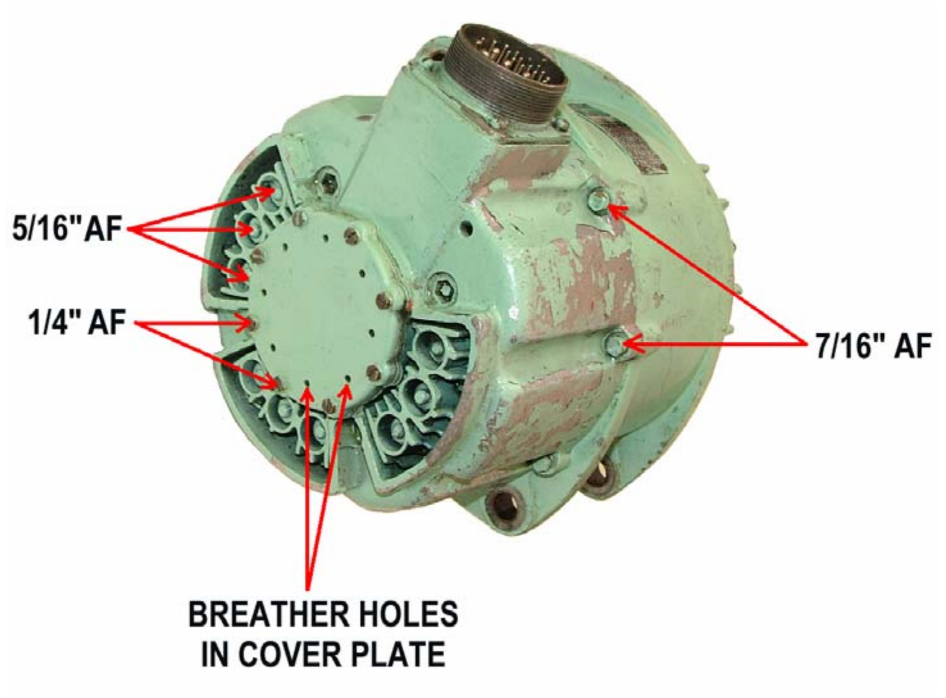
Modification record plate generator Mk 2

Mod No.1 – Additional bearing seal on slipring end in addition to Item 20

Mod No.2 – Circlip at drive end bearing (Item 26) replaced a retaining ring

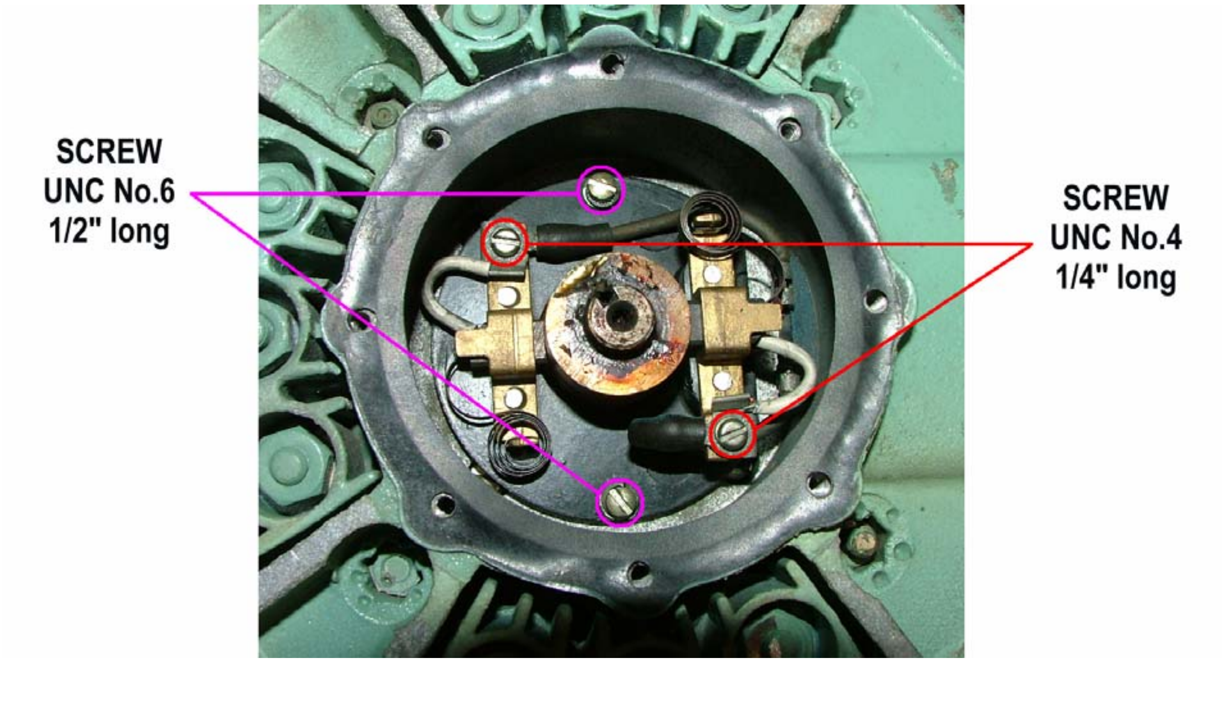
Dismantling the generator

You will need a ¼" drive and extension with sockets for ¼"AF, 5/16"AF and 7/16"AF. In order to inspect or replace any of the diodes the generator needs to be partially dismantled. The first step is to gain access to the cover plate that encloses the brushes. The cover plate is retained by eight ¼" AF screws; although they have slotted heads the initial loosening and final tightening should be done with a socket or spanner. They are quite tight as the plate retains a waterproof gasket and a diaphragm as the generator is designed to withstand submersion. It might seem curious that there are eight breather holes in the cover plate in something that is meant to be waterproof. These holes are to allow water to ingress and so that the diaphragm can absorb internal air pressure variations that might come about by a temperature change such as being suddenly immersed in water. The diaphragm is supported internally with a breather plate.

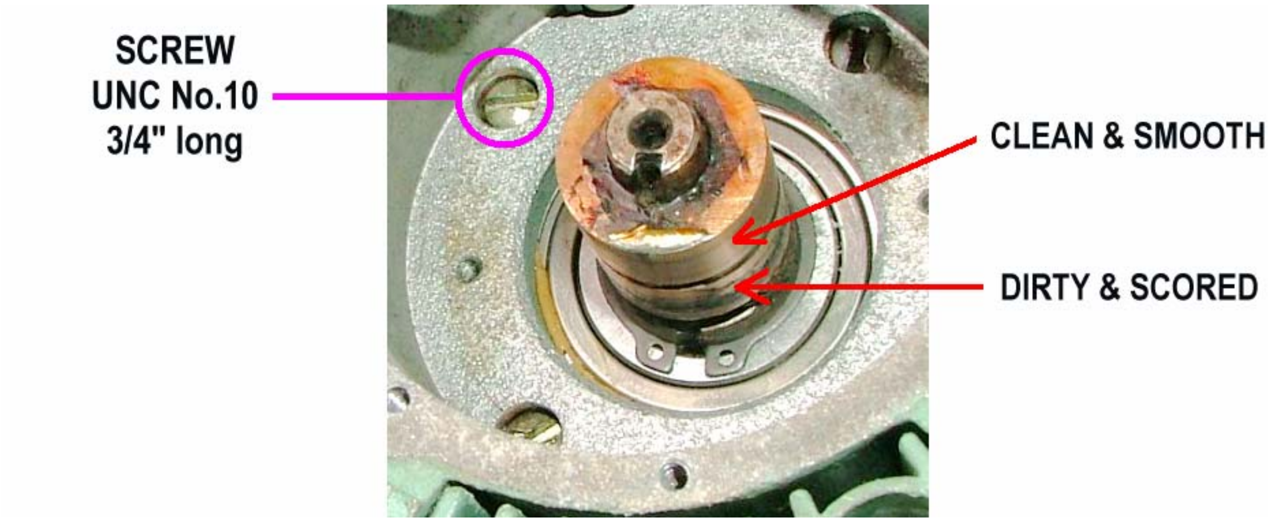


DIAPHRAGM BREATHER PLATE

The brush retaining mechanism can now be seen.



Here is the reason why the field resistance readings were so erratic ranging from 20 to 200 ohms as the shaft was rotated.

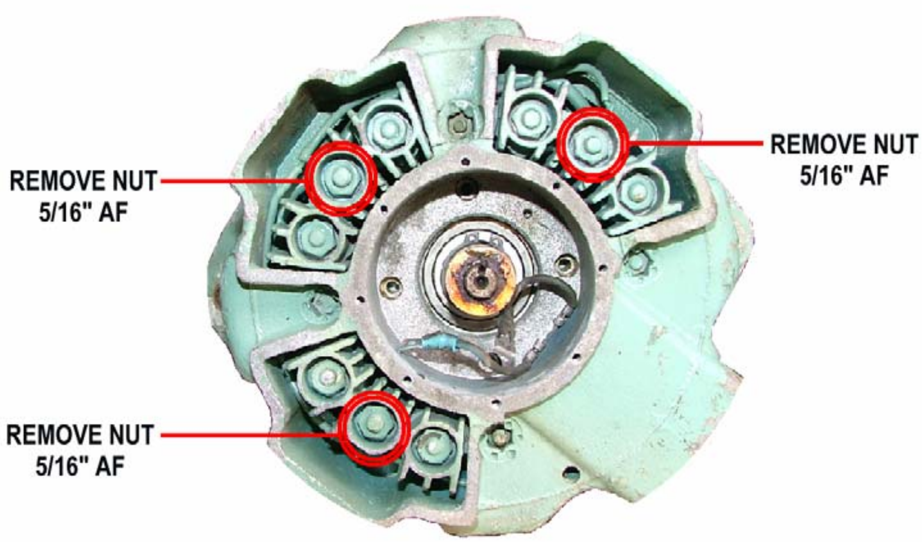


Once the rings were cleaned and the brush mechanism reassembled, the resistance reading was 15 ohms on all points of rotation. The normal resistance should lie between 14.5 – 15.5 ohms, increases above this will have a serious effect on the magnetic field that can be created and hence reduce the output of the generator. This is the most common electrical problem effecting generators like this, the opportunity should be taken to measure the brush length and the slipring diameters.

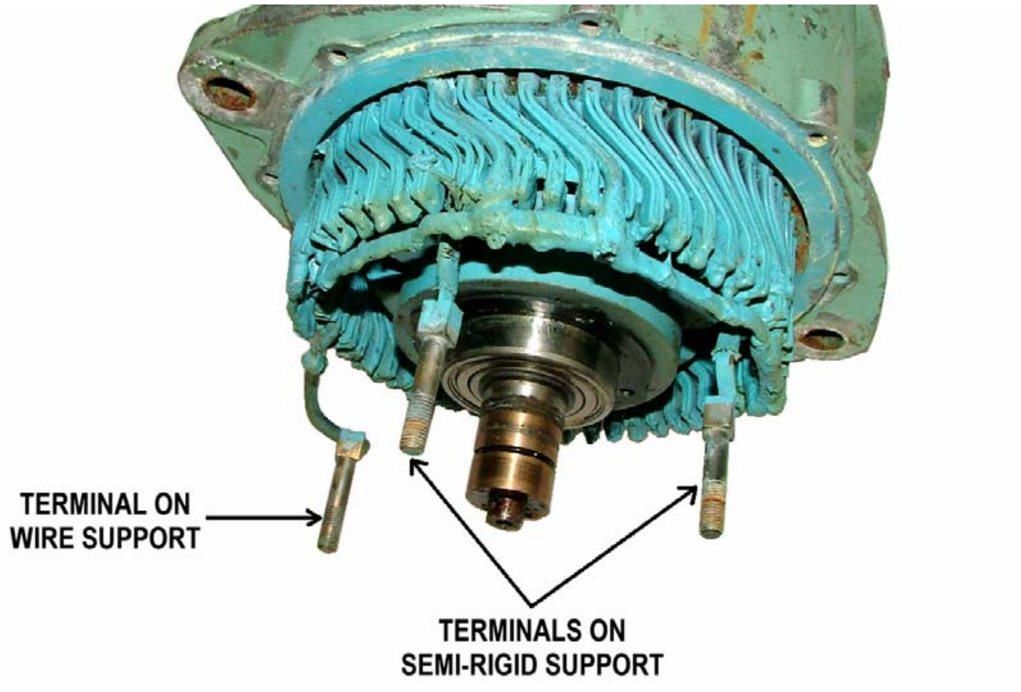
Slipring minimum diameter: 0.875 in
Brush minimum length: 0.3125 in

If the diode assemblies or the main winding need to be inspected, the slipring end shield must be removed. There is no need to remove the Circlip on the shaft, just remove the four UNC No.10 screws in the brush holder chamber.

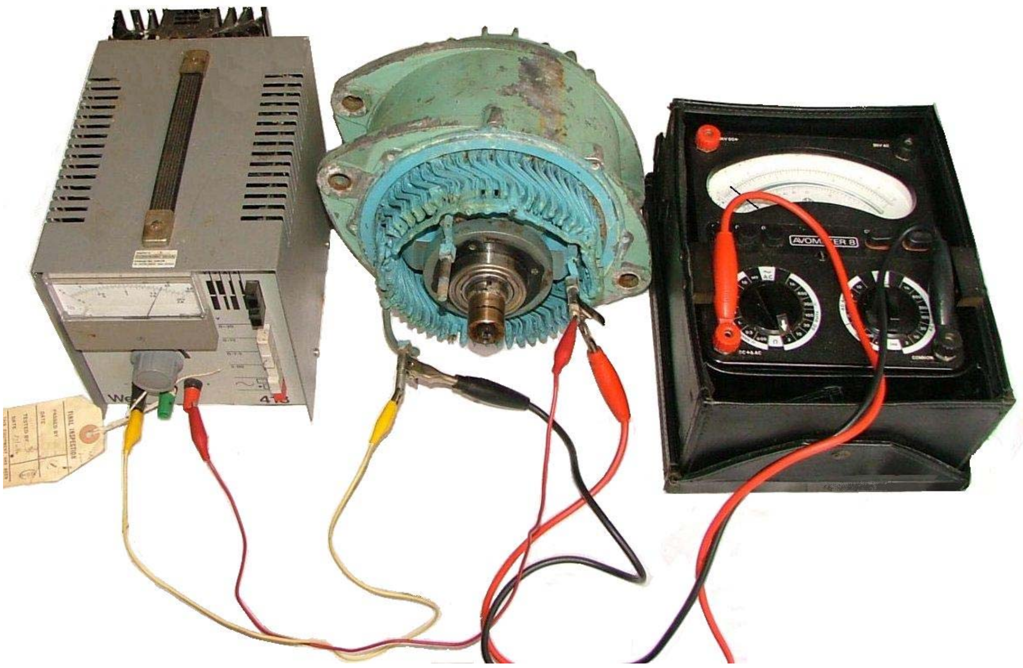
Then remove the three 5/16” AF nuts that are the centre nuts in each heat sink assembly. Once removed do not attempt to push down on the studs that protrude, two of these are rigidly wired to the main winding. Keeping them in position will aid reassembly.



Then remove the eight UNF 7/16" AF screws around the edge of the shield casting, this is where the ¼" drive extension is needed! Gradually separate the slipring end shield from the rest of the generator. Modest blows with a hide hammer combined with gentle levering will help separate these assemblies. It will be noted that one lead from the main winding is flexible but the other two leads are fairly rigid, try to keep them in position for later assembly.



If for any reason the diodes or the main windings were suspect there is now the opportunity to test the main windings independent of any other components. This can be done as before with a 12-volt battery and the ballast resistor. If you happen to have a variable power supply this can be used instead. Although this one only managed to deliver 5 amps with rather flimsy jump leads, it still gave an adequate current allowing a meaningful voltage drop to be measured across the windings.



It is also a useful opportunity to do an insulation test to establish that there is no undue leakage from the main windings to the case or from the three heat sinks to the case of the end shield. Then if there was leakage after reassembly it could be seen not to be due to the windings themselves.

Insulation leakage tests

With a Megger set to 100 volts the insulation resistance to earth must not be less than 5 megohms for the sliprings, main windings, heat sinks and plug pins. There is no danger of damaging the diodes as 100 volts is well below their voltage rating.

The conundrum of different diode types!

I have drawn this information from a range of parts catalogues, EMERs, AESPs, several NSN resources, Joint Service Products Lists, CV Register of Valves and numerous old semiconductor data books. I have tried to marry these up to the parts lists, which often give quite different part numbers for the same generator type. Furthermore there are examples where a diode has up to five different NATO Stock Numbers (NSNs). I have included all the designations I can find in the hope that it may assist identification when these are spotted for sale.

High power diodes

These stud mounted diodes are rated at 400 PIV. This seemingly high Peak Inverse Voltage allows for the high voltage transients that can be associated with inductive devices. Particularly high transients will be produced if the generator is run with no load i.e. without the batteries connected. In addition diodes can be destroyed by the use of an arc welder and an instruction in a 1967 EMER was to disconnect the batteries before welding. However this did not give adequate protection and the instruction was amended in 1976 to require the disconnection of the batteries, generator and control panel. Were it not for protective circuitry in the later generator panels the diodes could be destroyed by reversed battery polarity.

The diodes are each rated at 35 amps. As this is from a 3-phase supply, the combined capability is just over 100 amps at 25°C. In order to maintain this output it assumes that the diodes are firmly secured to their heat sinks and that the heat sinks can radiate their heat properly without being clogged up with mud and debris.

DD716 (cathode stud) in its various guises - Mk 2 generator & earlier

This was the most powerful of the fifty or so silicon power diodes in the Lucas range and indeed the most powerful of the diodes available in even 1970. There is great confusion between the DD716 and DD716A as several catalogues swap the FV codes, several swap the CV code, several swap the NSN and some swap all three! Below is the ‘best guess’ assumption to the equivalent designations.

DD716 (Lucas)
6019-319 (CAV Ltd) Sometimes CAV Ltd diodes are prefixed by ‘CB’
CV8870 (Technical Valve Committee)
FV543302 (FVRDE) Some books quote this for DD716A
LV6/MT4/CB6019/451 (Vocabulary of Army Ordnance Stores (VAOS) that predates NSN)
LV6/MT4/5960-99-881-2996 (pre-January 1967)
LV6/MT4/5961-99-881-2996 (post-January 1967)
Z42/5960-99-037-4158 (pre-January 1967)
Z42/5961-99-037-4158 (post-January 1967)

In VAOS Sections LV6/MT1 to LV6/MT15,‘CB’ is the manufacturer’s code for CAV Ltd . The nice thing about VAOS is that the part number was usually constructed from the manufacturer’s own part number, unlike the NSN that has no such helpful relationship. The two main NSN pairs are intriguing as it might suggest two different diode types that could do the same job perhaps, or where an early type had become obsolete, or it may be simply an error where duplication of NSNs has occurred. It is easy to see how this might have happened. Looking at the pre-codification item, the VAOS Subsection LV6/MT4 identifies it as an electrical MT component. After codification this was transferred as the Domestic

Management Code (DMC) to prefix the NSN. The NSN incorporates the NATO Supply Class (NSC) 5960 identifying it as an electronic tube i.e. in English meaning a thermionic valve and indeed the CV allocation means Common Valve (i.e. common between the Services). Semiconductor devices were included in the CV classification whilst the NSC 5961 indicates a special Class created for semiconductors which was applied in January 1967. A different DMC allocated as Z42, indicates a miscellaneous electrical or electronic component rather than specifically a MT electrical item. Although it could suggest it was a new device as it was an entirely different NSN.

If it was exactly the same item then the new NSN could comprise just the new NSC 5961 prefixing the old NIIN (NATO Identification Number) of 99-881-2998. One might be tempted to think this NIIN could not be used because the NSN it forms might have been already allocated. But it should be remembered that the NIIN is unique whether it is prefixed with a NSC or not. This is why some stores items are marked just with a NIIN or even just the last seven digits (IIN) without the Nation Code (being 99 for the UK) as it will still be unique within that country.

CV numbers allocated before 1961 were predominantly codified by the digits of the CV number forming the final part of the NIIN (the last seven digits of the NSN). For example:

CV1234 is 5960-99-000-1234

The method only applied to blocks in the ranges CV1-CV4099, CV4501-CV4520 and CV5001-CV5175. CV numbers from CV5176 and above were allocated in blocks starting from 5960-99-037-2000. Sometimes CV items were not codified if there was no defence requirement but it was used by some other Government Department e.g. the GPO.

These examples with the NSC 5960 could be a thermionic valve or a semiconductor, in the parts catalogues a diode would be identified as a *'Valve, electric'*. However after January 1967 the NSC 5960 would mean it was a valve and a semiconductor was classed as 5961. Apart from the tweaking of the NSC there are only two fundamentally different NSNs. So it seems likely that during the mass codification of valves and diodes it was not realised that there was an existing code.

It has to be remembered that this was not the Army at work but several other organizations. The Technical Valve Committee (TVC) was under the Joint Electronics Standardization Committee (JESC) which was under the authority of the Ministry of Aviation (MoA) which of course is quite a different body from the RAF. The MoA was responsible for research, development and procurement of not just the most obvious air based projects but also for electronic equipment for the fighting services.

The codification was the responsibility of the National Codification Bureau, subsequently becoming the Defence Codification Agency. Before issuing a NSN, their role was to check existing NSNs to ensure there was no duplication. But of course this would depend on how an item was described and as codification was only fully implemented in 1965, it is easy to see how some items could have slipped through the net.

The CV registration became less used with the abolition of the TVC in 1969, although it was still being amended up to 1971. Quality approval then became the remit of the UK Electronic Valves Quality Products List Authority. This came under the authority of the Ministry of Technology that had already assumed the responsibilities of the MoA in 1967. Despite this the last published reference I can find to a CV diode in a generator parts list is 1982.

DD716A (anode stud) in its various guises - Mk 2 generator & earlier

DD716A (Lucas)
6019-451 (CAV Ltd)
CV8871 (Technical Valve Committee)

FV510819 (FVRDE) Some books quote this for DD716
LV6/MT4/CB6019/451 (Vocabulary of Army Ordnance Stores (VAOS) that predates NSN)
LV6/MT4/5960-99-881-2998 (pre-January 1967)
LV6/MT4/5961-99-881-2998 (post-January 1967)
Z42/5960-99-037-4157 (pre-January 1967)
Z42/5961-99-037-4157 (post-January 1967)

The arguments about the NSN change are the same as its partner diode and one can compare the later NSN for each and see they were codified at the same time. However there are further complications as DD716A was issued with another CV number and that in turn with another NSN!

CV8776 (Technical Valve Committee)
Z42/5961-99-037-4042 (post-January 1967). I can find no comparable CV allocation for DD716.

High power diodes - Mk 3 generator

There are less cross references for these later diodes. Although the EMER and AESP emphasise the change in the low power diodes, no mention is made of the change of high power diodes. The change can only be noted from the checking the parts lists that now give the replacement diodes and cross reference to:

LV6/MT4/5961-99-833-9958
FV636048
6019-798 (CAV Ltd)
Y043 063 12 (Foden)

I assume that there was no CV allocation as the diode post-dated the dissolution of the TVC. So it escaped codification in the NIIN sequence starting 99-037-2000.

I assume this is the replacement for the DD716A as the diode is “painted red”. This must surely mean that the body, rather than the terminal, is red i.e. the stud is the anode.

It follows that the DD716 replacement is:
LV6/MT4/5961-99-833-9959
6019-628 (CAV Ltd)
Y043 062 01 (Foden)

Note that a Lucas number is no longer given for any of the diodes in the Mk 3 generator. In 1926 Lucas bought the company CAV that was formed by Charles Anthony Vandervell in 1904 and became CAV Ltd in 1939. So it seems curious that Lucas and CAV Ltd both produced part numbers for the same items. I can only assume the later use of just the CAV Ltd part numbers emphasised the company’s focus on industrial automotive components whereas the Lucas focus was on the domestic car industry when the company became Lucas CAV in 1978.

The electrical business was sold to Prestolite Electric in 1998. The later CAV diode numbers can be prefixed with ‘Y’ to translate them into Prestolite numbers e.g. Y6019-628

Low power diodes - Mk 2 generator & earlier

The original low power diodes were DD3026A, although some catalogues do not identify the diode as a demandable item. All three diodes were of the same configuration with ‘A’ suffix indicating that the stud is the anode. It is rather curious that some catalogues also quote particulars for DD3026 which is the cathode stud version with a consecutive NSN; such diodes have no application in this generator.

DD3026A (Lucas)
6208-23A (CAV Ltd)
CV8706 (Technical Valve Committee)
LV6/MT4/CB6208/23A (Vocabulary of Army Ordnance Stores)
LV6/MT4/5960-99-881-2992 (pre-January 1967)
Z42/5961-99-037-3977 (post-January 1967)

Low power diodes –Mk 3 generator (early)

The distinguishing feature of the Mk 3 generator was the provision of new diode type with a higher current rating to fulfil the extra demands of its matching Generator Panel No.9 Mk 4. These new diodes could not be directly fitted as replacements to the Mk 2 generator as they were wider and mounted adjacent to and at right angles to the stator winding bolts. Note that early Mk 3 generators still had the same shape of casting in the vicinity of the diodes.

Curiously parts catalogues do not identify the lower power diodes as demandable items although the two types of high power diode are identified. The only way to renew the low power diodes was to install the three heat sinks complete with diodes and leads as one unit. The single complete assembly being:

LV6/MT4/5961-99-833-9960
FV636017
6019-788 (CAV Ltd) Sometimes CAV Ltd diodes are prefixed by 'CB'
X6019-788 (Prestolite)

Low power diodes –Mk 3 generator (late)

Presumably the earlier diodes became obsolete or were withdrawn because of failure due to overheating. I have been unable to find any documents that reveal the identity of the larger replacement diode.

As the CAV design passed to Prestolite I contacted their technical support team. Unfortunately they were unable to confirm the data I held on any of the earlier diodes. However the drawings that they do hold show that the final low power diode was identical to the type used as the main diodes. This follows the practice of using identical diodes in all the current Prestolite alternators. So that would be the DD716A successor and this would be running very conservatively in just providing the auxiliary supply for the field winding.

Finding replacement high power diodes

From time to time the proper diodes do turn up on the surplus market, but not as 'off the shelf' items, more likely as diodes for which the seller knows little about. I have even seen heat sinks complete with diodes offered for sale. Unfortunately if the dealer knows the particular application for such a diode the pricing may make it unrealistic to fit replacements. However a suitable replacement would be the 1N1188 and the reverse connection 1N1188R, these are also silicon diodes rated at 35A 400PIV.

Note that the new diodes are classified by the JEDEC system where '1N' indicates a diode followed by a serial number and if the connections are reversed suffixed by 'R'. This is a bit confusing as the system adopted by Lucas was that a reversed connection diode was suffixed by 'A'.

It gets even more confusing if a higher rated diode is chosen. Such a diode rated at 40A 400PIV is the 1N1188A, this not the reverse connection of a 1N1188 but simply a beefier diode. The reverse connection of the 1N1188A is the 1N1188RA.

Both groups of diodes are in a DO-5 casing. The stud is the same size but the top terminal is not the right-angled blade termination that is on the original Lucas diodes. It should be easy enough to fashion a small angle piece to bolt to the feed cable at one end and to the diode at the other. The joints can then be soldered. These joints need to be mechanically rigid; they should not be made solely by soldering.

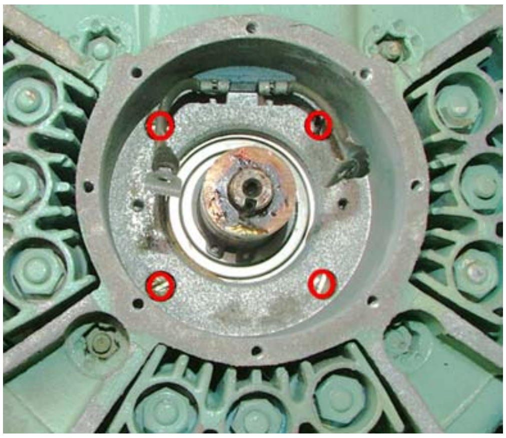
Finding replacement low power diodes
There is nothing special about this diode, the DD3026A is just a silicon diode rated at 1.5 amps 400 PIV. In order to dissipate heat from these early diodes they had to be bolted to a heat sink. Modern diodes are more robust and with greater power handling are often designed to require no heat sink at all. Looking for an easily obtainable substitute, the Maplins catalogue lists a diode type P600J rated at 6 amps 600 PIV. This gives a good operating margin provided it doesn't get hotter than 150 deg. C. It can just be wired in to a solder tag attached to a small bolt in the hole vacated by the defective diode. Not only will the new diode generate less heat in operation but it can tolerate a greater degree of overload in the event of temporary wiring fault compared to the original lower current diodes. Even if only one of these diodes has failed it is advisable to replace all three at the same time.

So the three new the low power diodes should be capable of a combined output of 18 amps. One would think this should be adequate for even the Mk 3 generators. However if the Mk 3 generator is being regulated by the Mk 4 generator panel a much higher current is being drawn so these diodes may not be adequate unless they can be effectively cooled. One has to bear in mind that at various stages three types low power diodes have been used culminating in the low power diodes finally being of the same rating as the high power diodes. So if you have a late version of a Mk 3 generator the 1N1188R or 1N1188RA would be a suitable substitute. Without modifying the heat sink it would not fit a Mk 2 generator and neither would it fit laterally into an early Mk 3 generator. However later versions with the enlarged casing in this area could probably accommodate the new diode.

Waterproofing
The generator is intended to work when submerged as the field winding brushes are in a waterproof chamber. To retain the waterproof properties and resist corrosion it is important to re-assemble the components carefully.

If the rotor shaft has been removed, molybdenum grease should be applied to the inner lips of the three oil seals. All bearings should be packed 2/3 full with general purpose grease. The grease should also be packed in the spaces between the bearings and the oil seals and labyrinths.

Duralac DTD369B sealing compound should be applied to the threads of the four screws attaching the slipring and bearing clamp plate. *Duralac* is used as it inhibits corrosion between dissimilar metals.



Painting is important not just for general preservation but to provide a coating of insulation, this is not just for wading but for general protection in damp conditions. Any break in the integrity of the paintwork is not just an opportunity for corrosion and long term failure, but in the short term allows leakage of current in a damp environment. To that end any area where work had been undertaken should have all loose material removed and then paint stripper applied to the remaining painted surfaces. When this is washed away and thoroughly dried then the area should be covered in black heat-resisting paint. This is at variance to the bright blue paint applied internally at manufacture or remanufacture.

The gaskets and seals should be carefully assembled using the appropriate sealing compound on both sides of the diaphragm. The original sealing compound was *Bostick C* then in 1977 it changed to *Hylomar SQ32M*. This seems to be no longer available but *Hylomar* technical support advised that *Hylomar Universal Blue* is perfectly adequate.

The black paint was a REME Field and Base Repair requirement, which after assembly extended to painting the whole generator black. This too is at variance to the heat-resisting Sky Blue paint with which we are so familiar. The example below shows a generator that has gone through this workshop repair.
The chipping black paint shows bare metal indicating that this generator has gone through the full process of paint stripping followed by black paint. This together with the workshop engravings indicates an official repair rather than a previous owner over painting it in black.

<u>Testing the generator cable</u>
It is important to test the continuity of each wire within the cable from plug to plug. Although there are 23 pins only 7 of these are used A, F, G, U, V, W & X. It is also important to check there is no leakage between individual cables themselves and the metal sheath. For those with a Megger leakage should be not less than 5 megohms at 500 volts but even for those with just an ohmmeter should use it on the highest range and rule out the more obvious faults.

The cable above passed continuity tests. Even so it is worth inspecting the right angled plug that connects to the generator. Considerable straining can occur to the narrow wires so that wires can break within the pins or poorly soldered joints can break free.

Some gentle tugging revealed defective joints, despite passing continuity tests.

Generator Panel No.9

The Generator No.10 is intended to function with a Generator Panel No.9. However the pin configuration of the Mk A generator permits it to be used in an uncommon configuration with the Generator Panel No.8 Mk 1. This is a panel with a carbon pile regulator primarily intended to be used with Generator No.9 Mk 1. This is the 100-amp alternator fitted to Mk 1 FV432, Hornet FV1620 and some early Mk 1 Stalwarts.

The functions of the Generator Panel No.9 are:

1. To regulate the generator output by controlling the voltage to the field winding. This determines the degree of magnetism within the generator and so controls the output voltage.
2. To connect the vehicle and radio batteries together and to the generator when the output voltage is adequate and to break these contacts when the output voltage falls.
3. To provide suppression of radio interference from the generator and the voltage regulator.
4. To facilitate a charge warning light.

There were five Mks of generator panel that all provide the same basic functions. It is worth trying to understand the principles of operation to appreciate how improvements were achieved. I have drawn all these circuit diagrams in a similar way so that comparisons can be easily made. To understand how the panels operate I have avoided trying to match up the theoretical operation with the physical layout. I have included all the suppression chokes but avoided cluttering up the diagram with the filtering capacitors.

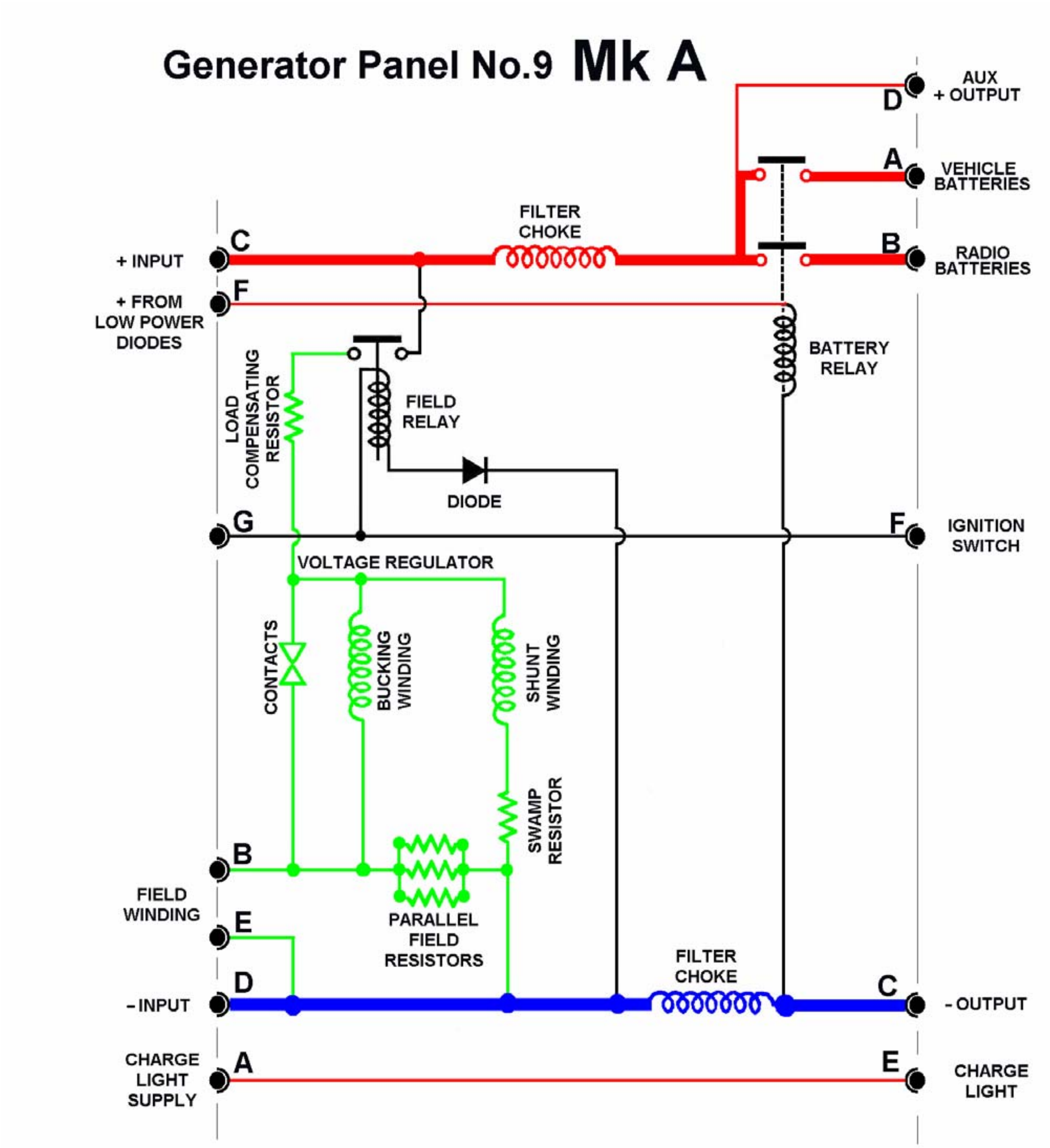
Although official circuit diagrams in their various forms include these capacitors, on some of them there are omissions compared with the panels themselves and the relevant parts catalogues. Whatever type of generator panel you have it is worth reading through it all. Not just to see how these panels evolved with time but because there are many common items that are described along the way.

Generator Panel No.9 Mk A

Mk A was fitted to the Rover (APGP) which is largely remembered because it has the facility for floatation. It was also distinctive not only because it was the first Rover with a 1-Ton rating, but it was the first airportable Rover, not the Lightweight I'm afraid. A less known feature was the provision for running power tools from the three-phase output from the generator. The generator cable is plugged into a junction box giving two configurations.

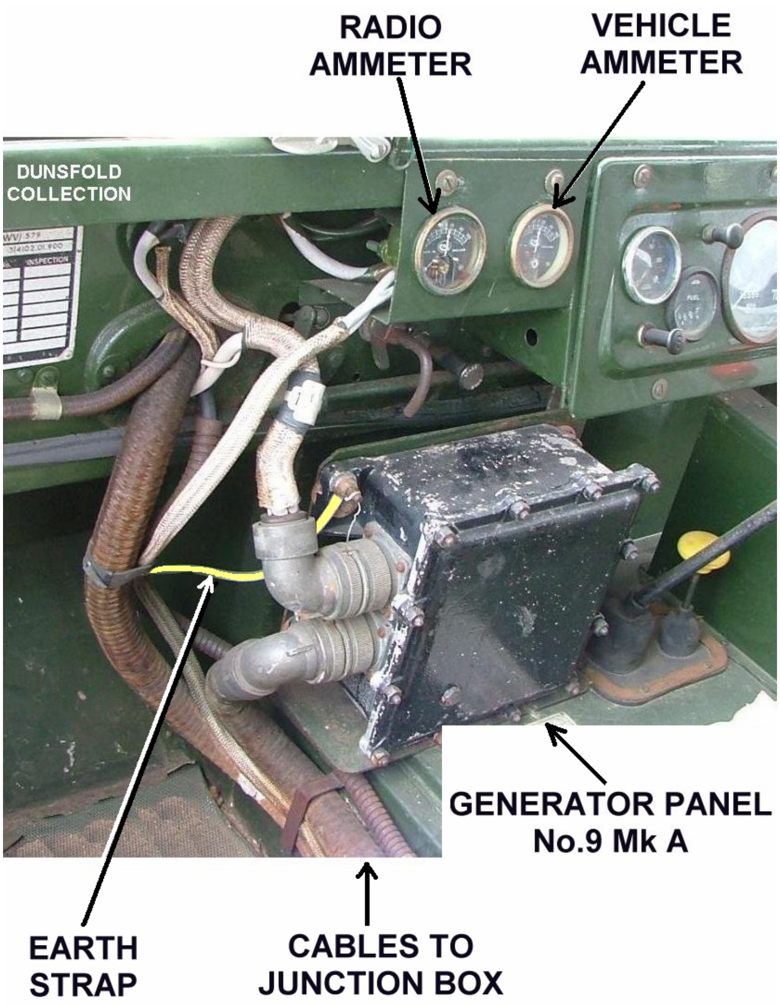
For normal driving the cable from the generator panel cable is plugged into the junction box. For the operation of power tools the cable from the generator panel cable was unplugged and a further cable supplying a transformer unit plugged in. This unit contains a three-phase transformer with two windings. One winding for 208 volts for the power tool and further winding for 24 volts that is rectified and regulated for vehicle and radio battery charging.

The Mk A generator panel can only be operated with its junction box. Although it is very similar to the Mk 2, it is not interchangeable as the input plug is different from the later generator panels which is why the pin designations differ.



Power from the ignition switch energises a CAV Type L10 relay, which permits the output of the generator to supply the field winding in a process of 'self-excitation'. The initial process is reliant of some residual magnetism in the generator and as the voltage rises, so does the field voltage that builds the magnetic field, this in turn increases the generator output. The relay together with a blocking diode is protection against damage by the batteries being accidentally reversed.

The battery relay is a CAV Type BCK 96, which is operated from an independent supply from the generator as the voltage increases. This connects vehicle and radio batteries together and to the main generator output. Although it was rarely used, Pin D provides the facility for an unswitched 1-amp supply directly from the alternator. Once the –ve supply lead leaves via pin C it is earthed and is depicted in yellow in this picture of an APGP installation.



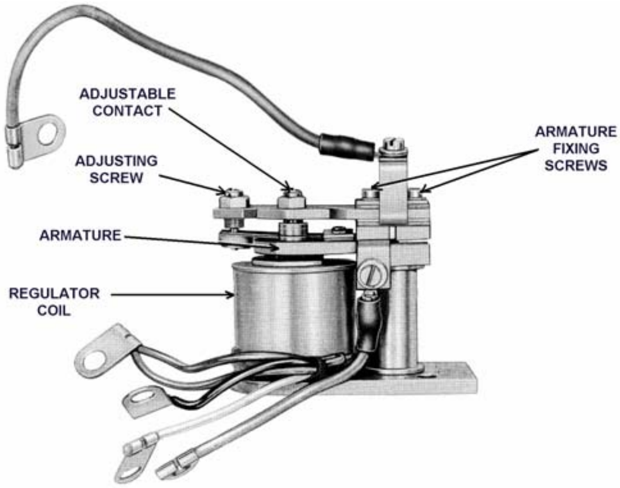
In later panels the earthing is via the ammeter shunt box, in this application the ammeters are of a direct reading type and require no shunts. The difficulty with this is that there is a voltage drop in the leads to the ammeters on the dash. For this reason the generator panel is mounted close to the ammeters to keep the cable length to a minimum, rather than behind the driver in the later shunted systems.

Action of regulator

The supply for the field winding is fed through a vibrating contact CAV 'N' type regulator. This is essentially a relay that switches resistance into the field supply when the output voltage reaches 28.25-28.75 volts. The voltage then falls so triggering the regulator to reduce the resistance. The cycle is repeated rapidly so that the regulator will literally be buzzing away when the voltage reaches the regulator cut-in voltage. It will remain quiet once the charging above this voltage has been maintained.

Dynamo systems need both voltage and current regulation, but here current output is self-limiting and any excess demands can only be met by the battery.

The regulator has two windings. The main winding is called the shunt winding, which is connected by a swamp resistor to the -ve line, this resistor nullifies the effect of temperature on the shunt winding. The bucking winding is connected across the regulator's points, as these open the winding is energised. It is wound in the opposite sense to the shunt winding creating an opposing magnetic field that assists in breaking the contacts as rapidly as possible to minimise arcing at the points.



The three parallel field resistors are connected across the supply to the field winding. This resistance helps absorb the voltage induced by the inductance of the coil and the reduces arcing by loading the circuit with resistance against the inductance of the coil. The reason that there are three resistors is a matter of convenience, rather than have one bulky 360 ohm 18 watt resistor the same effect is achieved by three 120 ohm 6 watt resistors in parallel. It is easier to fit these three resistors into the confined space of the regulator panel and no doubt were easier items to source as replacements.

Interference suppression

The very rapid switching by the regulator contacts generates a degree of sparking, similar to a spark gap transmitter, not a welcome feature for a vehicle with radios. For this reason the electrical 'dirty' components are screened off in a separate compartment within the generator panel to minimise the interference *radiated* to the subsequent wiring. Two types of suppression are employed to minimise interference that is *conducted* through the wiring by the use of chokes and capacitors.

Filter chokes are closely wound coils that tend to oppose the flow of AC in the form of 'ripple' on the DC supply from the generator and radio frequency interference from the regulator. The more turns of wire on the coil, the more it will 'choke' off a wide range of radio frequencies. The problem is that the more turns of wire, the greater the resistance, so a thicker wire is chosen where current demands are high. This becomes a physical issue and the main 90-amp chokes each consist of two windings wound together to halve the resistance. It is in effect two chokes wired in parallel. The effectiveness of the choke is dramatically increased by the addition of a central ferrite core. Ferrite is a powered and compressed magnetic material widely used with coils to enhance their inductance.

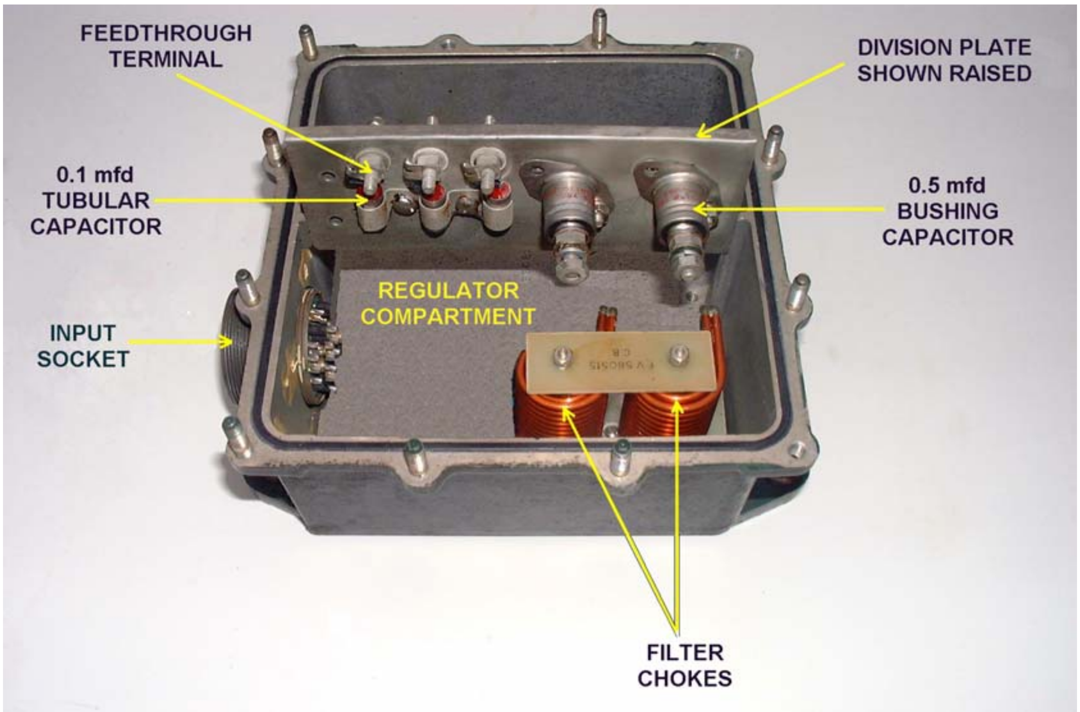
It should be noted that by keeping –ve line isolated from earth that filters have been included in the –ve line as well as the +ve line.

Capacitors behave in quite a different way to chokes. Rather than inhibit the flow of AC, capacitors allow AC to pass, but block the flow of DC. This can be utilised to allow capacitors to let unwanted AC voltages flow to earth and be lost. Quite low value capacitors can bypass VHF energy, but for lower frequencies higher value capacitors are needed. It might seem straight forward to wire in small value capacitors for VHF suppression, but at these sort of frequencies and higher, the wire on the earthy side can represent significant inductance, behaving as if it was part of a coil.

To overcome this, capacitors can be manufactured that are 'metal clad' so that the casing forms the earthy connection and can be bolted directly to earth. A row of three such capacitors can be seen fixed to the division plate in the regulator panel.

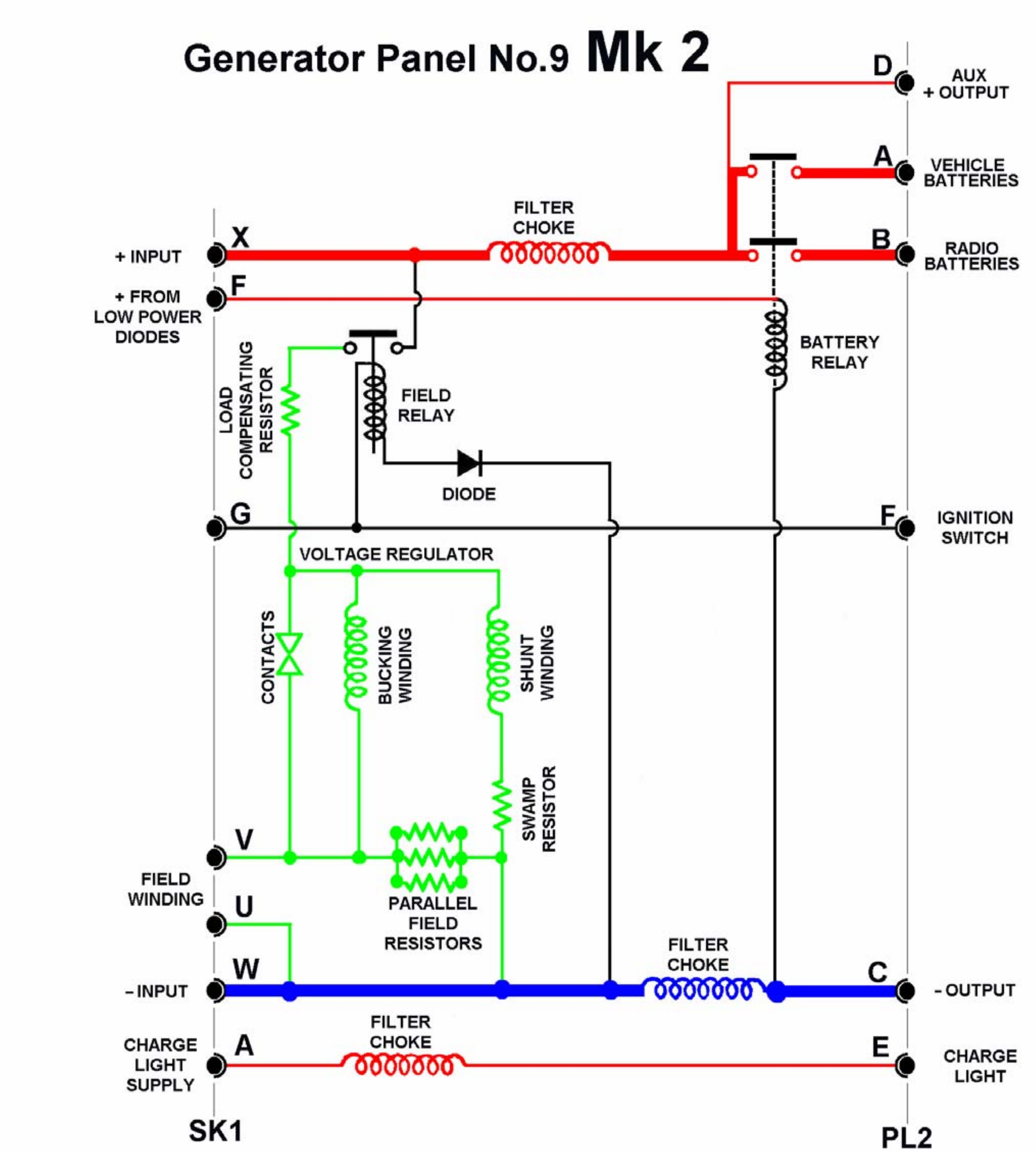
Bushing or feed through capacitors are metal clad capacitors that allow connections between circuits that are deliberately separated by screening by having a common terminal at each end. In this installation they also provide rigidity for the attached circuitry.

Here they are quite large as they have a fairly high capacity and this offers good suppression at low frequencies together with their feed through construction makes them effective up into the UHF spectrum.

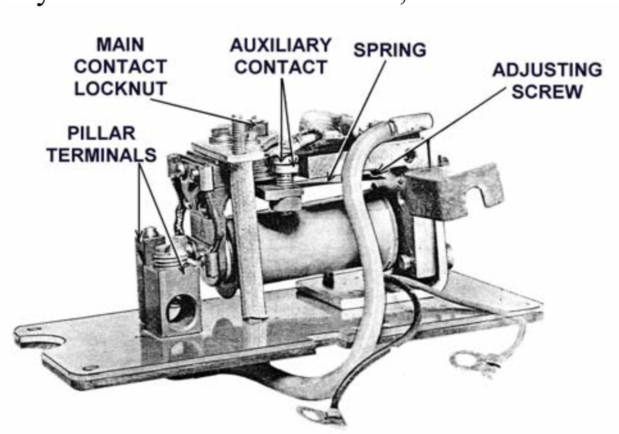


Generator Panel No.9 Mk 1
This panel was intended to be used with Generator No.10 Mk 1 fitted to some early Mk 1 Stalwarts, but not Rovers.

Generator Panel No.9 Mk 2
This generator panel is very similar to the Mark A but adopted a different plug and socket configuration that was continued for all the later Mks. The Mk 2 panel seems not to have been routinely fitted to Rovers, but was fitted to some Mk 1 Stalwarts in 1966 and was soon superseded by the Mk 3 panel a year later.



The Mk 2 panel used the same regulator and battery relay as the Mk A, but underwent several modifications in service. There was a change in the regulator base, interchange of output leads ‘A’ and ‘B’ and a change of battery relay from BCK 96 to BCK 104, which is shown below.



The N66 Type vibrating contact regulator is common to all the generator panels except Mk 4. The resistance readings for the shunt coil are about 35 ohms and for the bucking coil 300 ohms with the regulator contacts held open. The field isolating relay is about 240 ohms. To test this relay and its diode place -ve prod on SK1 pin G and the +ve prod on PL2 pin W. The resistance should be about 400 ohms and with the prods reversed in the order of 2,000-10,000 ohms. Getting the low reading in both directions means the diode has failed, but getting no reading in either direction means either the diode or the relay has burnt out.

All other readings will be similar to those obtained on the Mk 3 panel described later, although the readings will be different around the battery relay terminals because of the diodes that are wired to pins A and B.

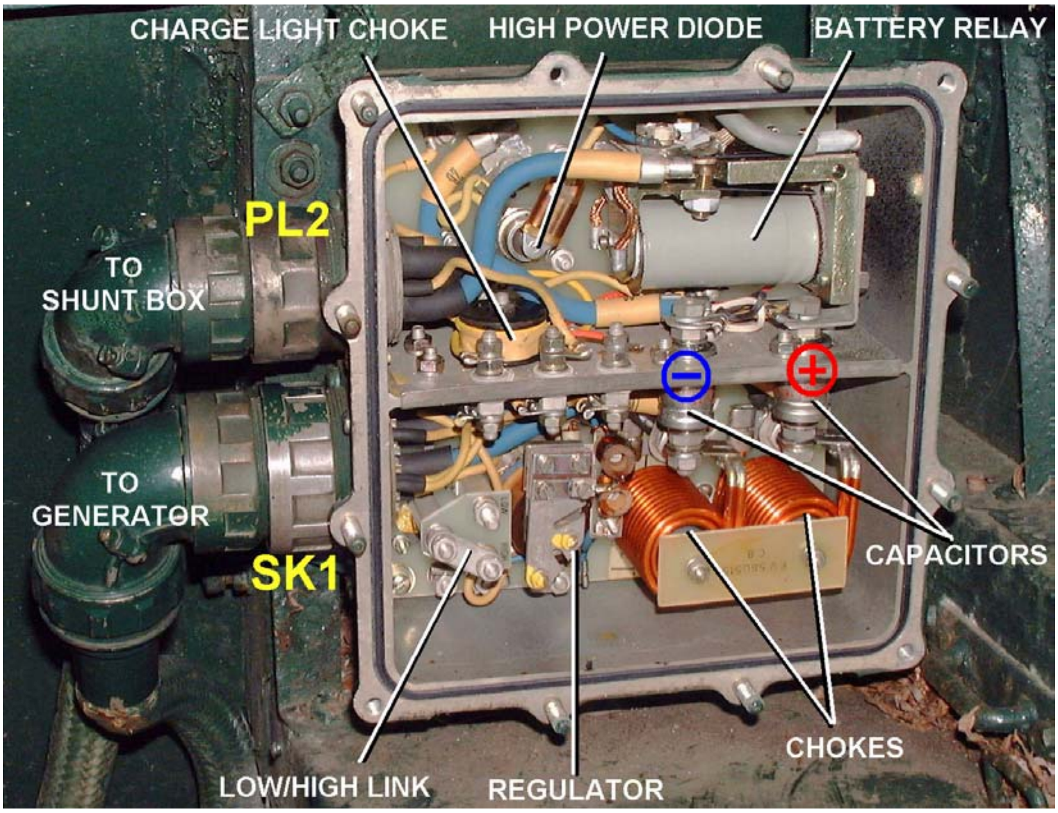
Modification record plate

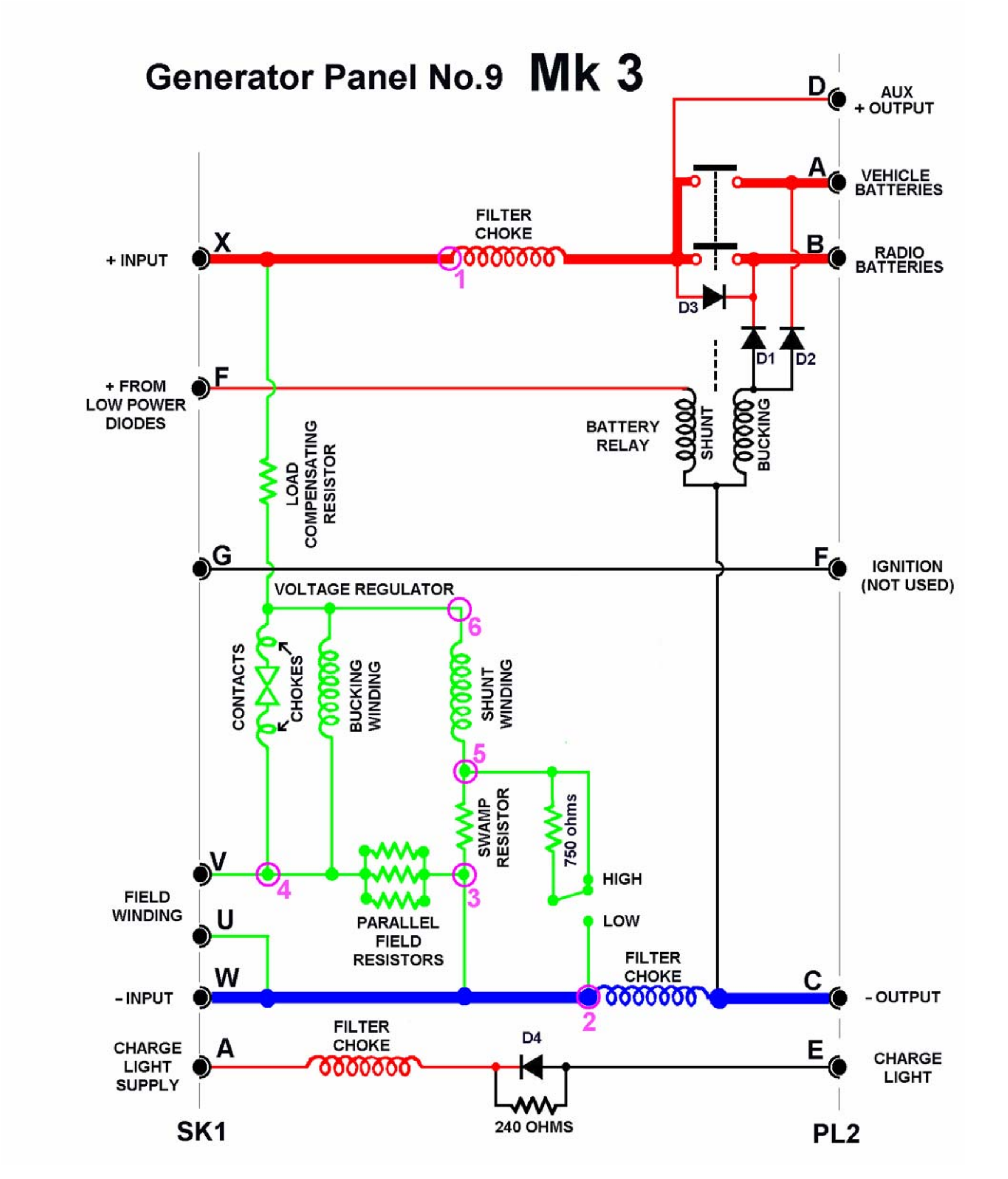
1. Regulator base.
2. Battery relay change.
3. Leads from pins A & B interchanged on connector PL2.

Generator Panel No.9 Mk 3

I have given the greatest coverage to this panel as it is the most widely encountered panel and therefore deserves greatest attention. Some aspects will be common to the other Mks of panel, particularly the previous Mks. The Mk 3 panel appeared in 1967 and was fitted to Mk 2 Stalwarts and all new FFR Rovers of the time. There were two significant advances with this version of panel, a new type of battery relay that eliminated the need for a separate relay in the field supply and the provision of a HIGH/LOW setting for rate of charge.

In common with the previous panels, early installations in Rover 9 (1720-0762) despite being fitted with the Mk 3 panel still relied on direct reading ammeters. With the panel mounted behind the driver the voltage drop on the ammeter cables to the dashboard and back was significant. The introduction of a shunt box avoided this power loss and provided an earthing point for the –ve line.





New battery relay

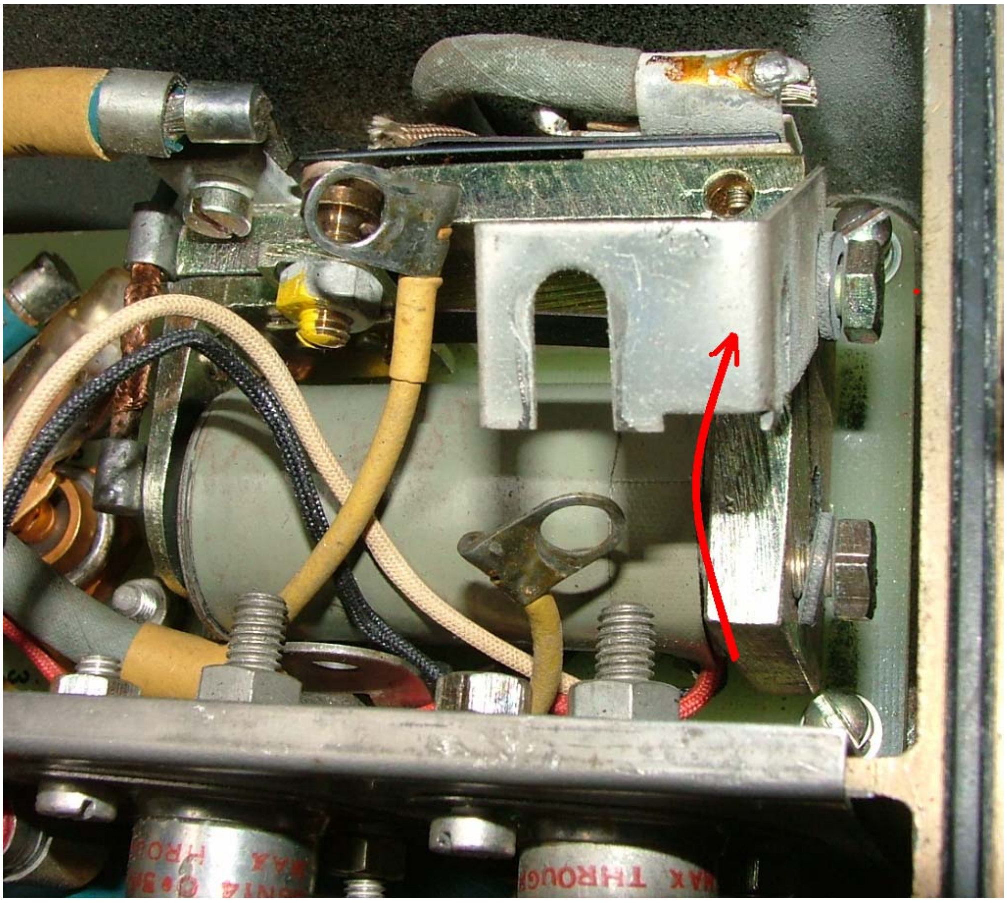
The battery isolating relay changed to a CAV Type BCK 102 relay, which has two windings. One winding energises the relay in the normal way but the other winding is wound in the opposite direction. The second winding is not normally used; it is only operated if the batteries are connected the wrong way round. If this happens with either battery, what is normally a blocking diode for each battery allows this reverse current to flow. This energises this second winding on the relay to overcome the magnetism created by the first winding allowing the relay to open thereby isolating both batteries and the generator output from each other. There is then no need for a separate field relay, although the technical descriptions in many manuals fail to take account of this change and still describe the field relay as being present. Caution needs to be exercised as some parts catalogues are riddled with errors particularly the labelling of smaller items and many items that are labelled are not listed at all.

HIGH/LOW switch
There is now a facility for setting the charge rate to a lower level in hot climates. This provides for a reduced output to avoid batteries ‘gassing’ by being over charged when they are too hot.

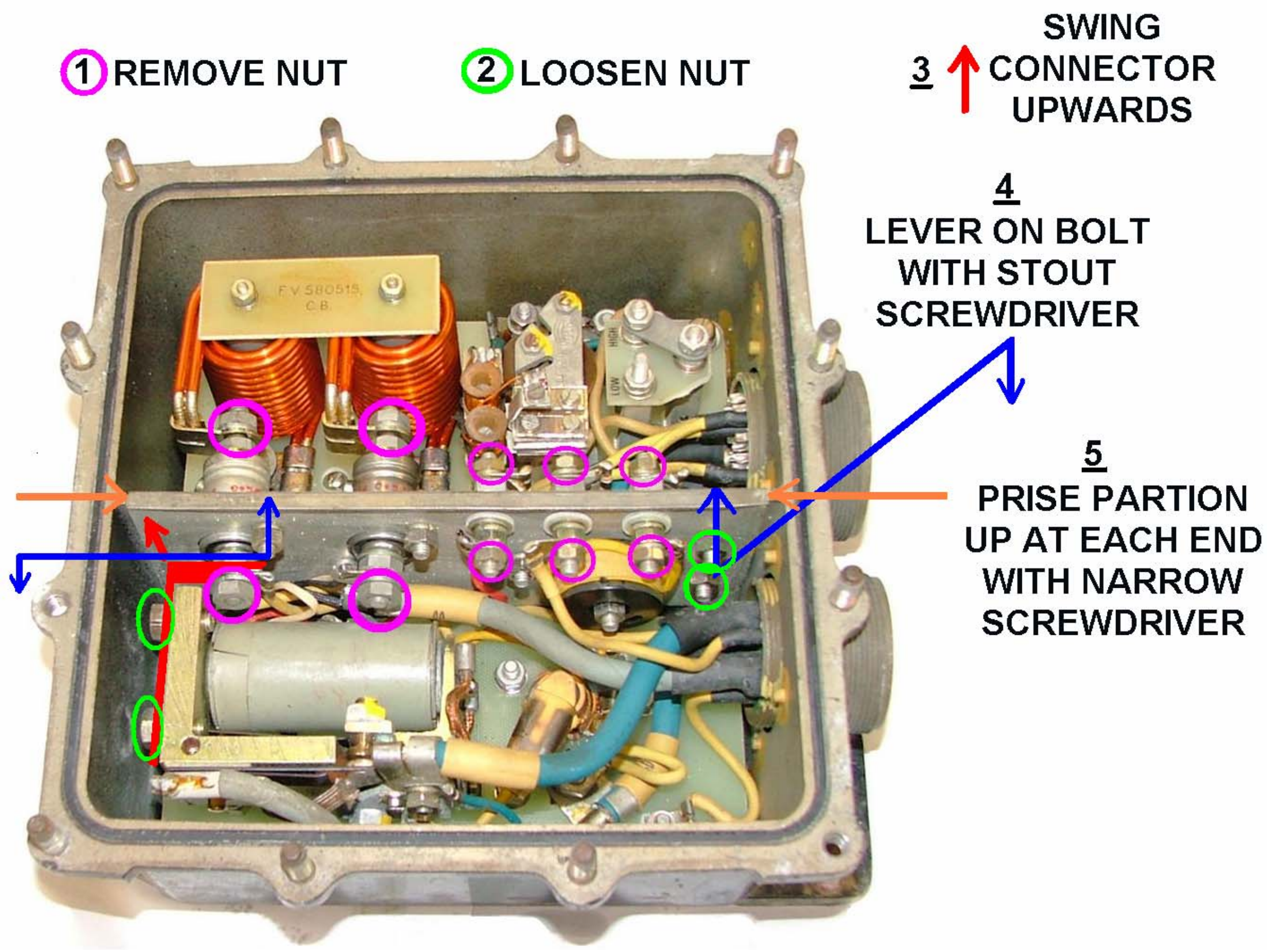
Dismantling the generator panel
Certain components are hidden underneath the relay and regulator boards. If either board is to be investigated the dismantling process is the same. It is important to draw a sketch of the panel and record the identity of each wire as it is dismantled. Most wires are identified on a yellow band at the end of the wire although several leads in the relay compartment are not. Most wires and particularly the thick ones have a very obvious relationship to their terminals, but there is some ambiguity with some of the thinner wires.

Although there are a number of UNF and UNC fasteners, most of the ones you will need to undo are BA threads. Few of us will be equipped with BA spanners and although BA sockets are not uncommon, limited access requires the use of spanners. As an expedient Imperial open ended spanners can be used although they are a little slack.
0 BA use 7/16 AF
2 BA use 5/16 AF or 8 mm

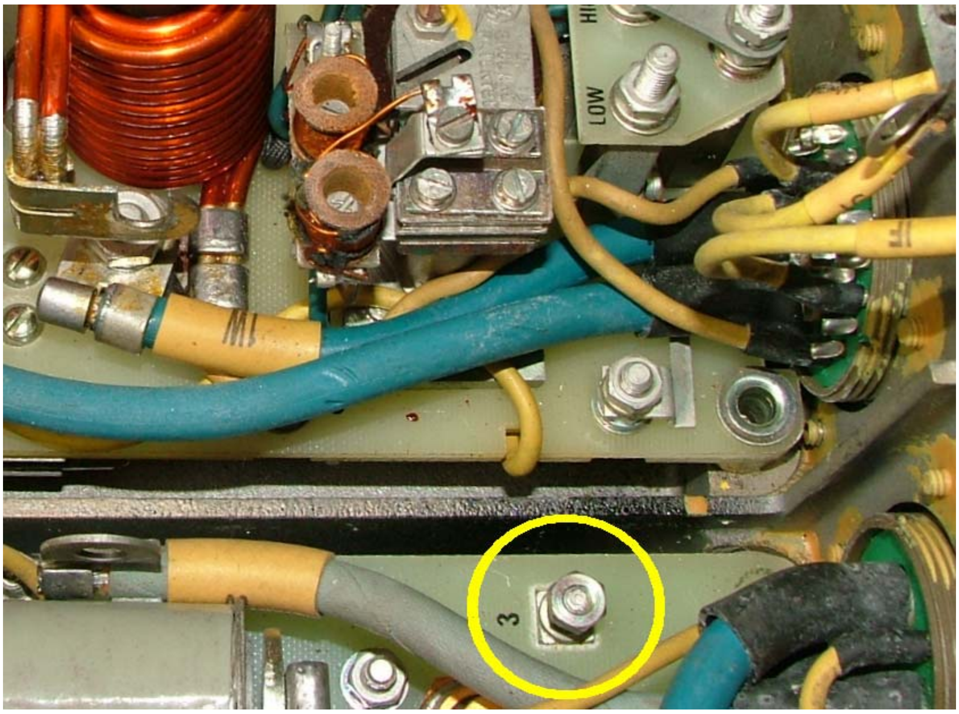
It is essential to loosen the bolts on the connector from the +ve supply to the battery relay and then swing it up clear of the partition.



Do not attempt to use a screwdriver to loosen the two bolts on dividing partition, this will not work as the partition is double-skinned and encloses a hidden nut. It is not possible or necessary to access the lower bolt on the far bushing capacitor. When starting to move the partition by levering do not lever on the bushing capacitor, only on its upper retaining bolt and the bolt at the other end of the partition. Once there is a little bit of movement a narrow screwdriver can applied in the gap between the two walls that lever up the partition.

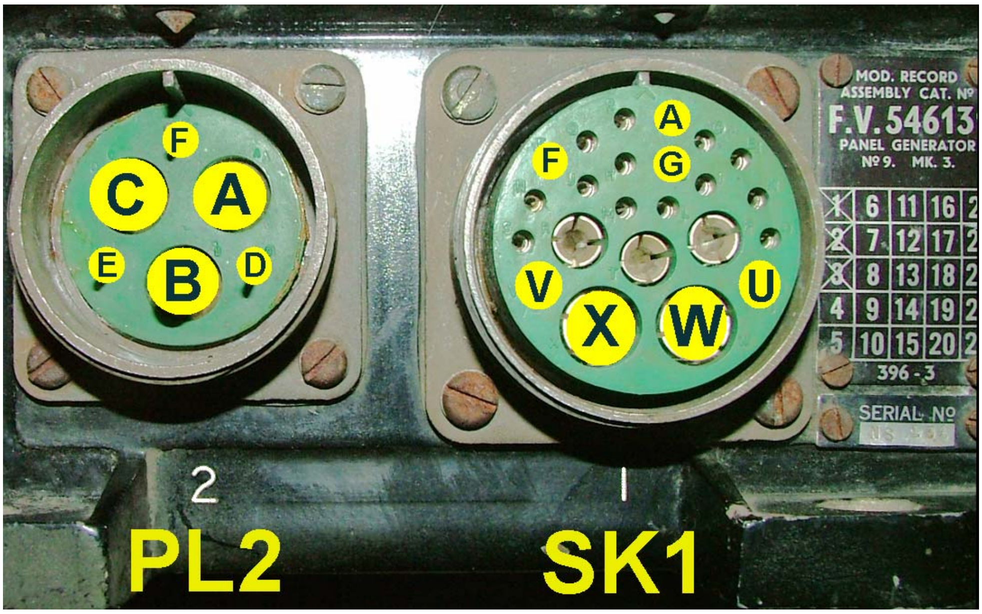


Once the partition is lifted free then the lead for the ignition warning light choke can be detached from terminal 3 on the relay board. On reassembly it is imperative that this is reinstated before inserting the partition, otherwise it will become inaccessible!



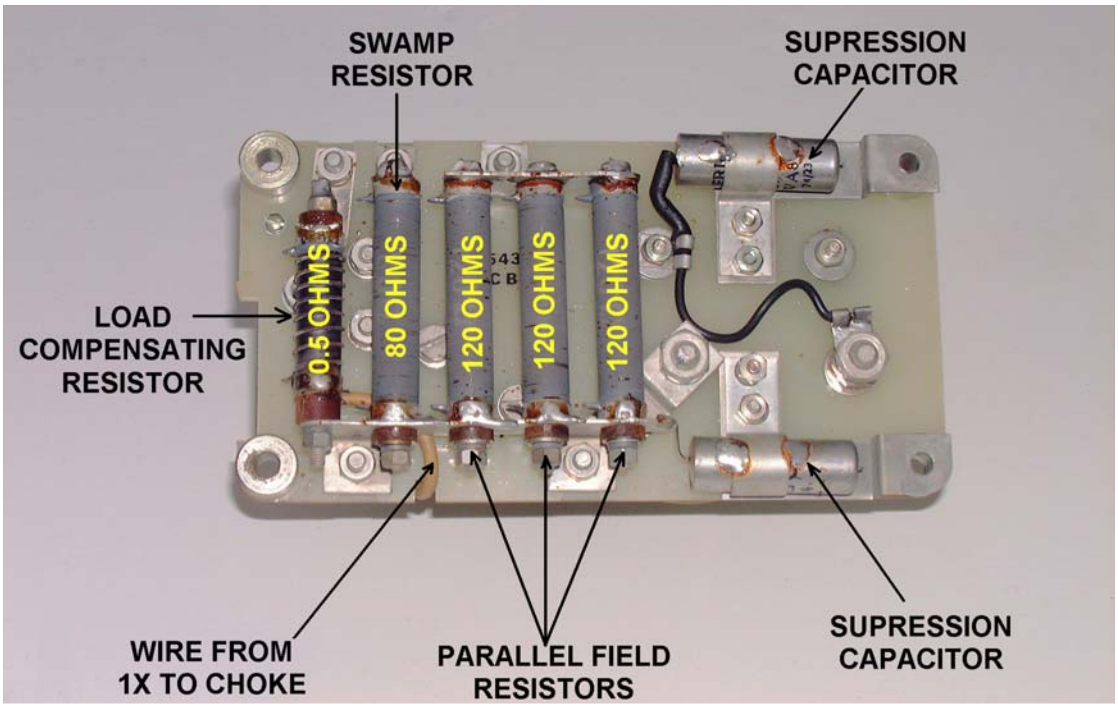
Most leads are identified by a yellow collar marked with the pin letter and the connector, e.g. lead 1A comes from pin A on SKI and lead 2F comes from pin F on PL2. SK1 is the input connector with socket

fittings and PL2 is the output connector fitted with plug fittings. Those that are not marked with a collar are the three leads from the relay, the charge light choke and the large protection diode.
The following tests will give a good indication of a fault and can be conducted without removing the box lid once both panel plugs are disconnected. A bright light and possibly a magnifying glass may be needed. Approximate resistance readings should be as follows. Note ‘zero ohms’ means there is continuity, not ‘no reading’.

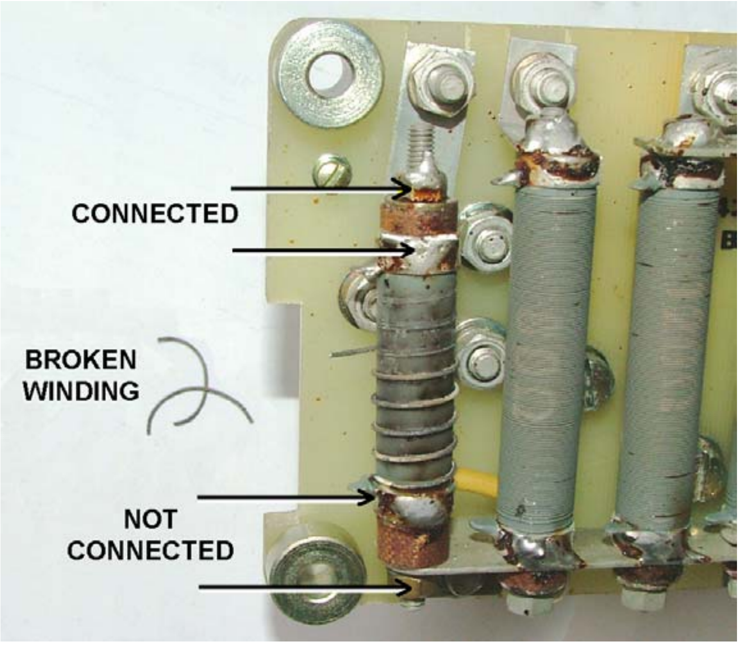


Test: SK1 Pin V & SK1 Pin X – 0.5 ohms (Resistor problem)
If there is no reading at all, the only cause for failure is the ‘swamp load resistor’ having burnt out. This resistor provides the only voltage feed to the regulator for the field winding. It causes a voltage drop that helps the regulator keep the contacts closed for longer, which is the ‘at rest’ state for the regulator. Under heavy load this voltage drop will be at its greatest helping to maintain the maximum voltage to the field winding. Under a light load the effect of this resistance on the regulator is minimal.

Unfortunately this resistor is mounted on the underside of the regulator panel.

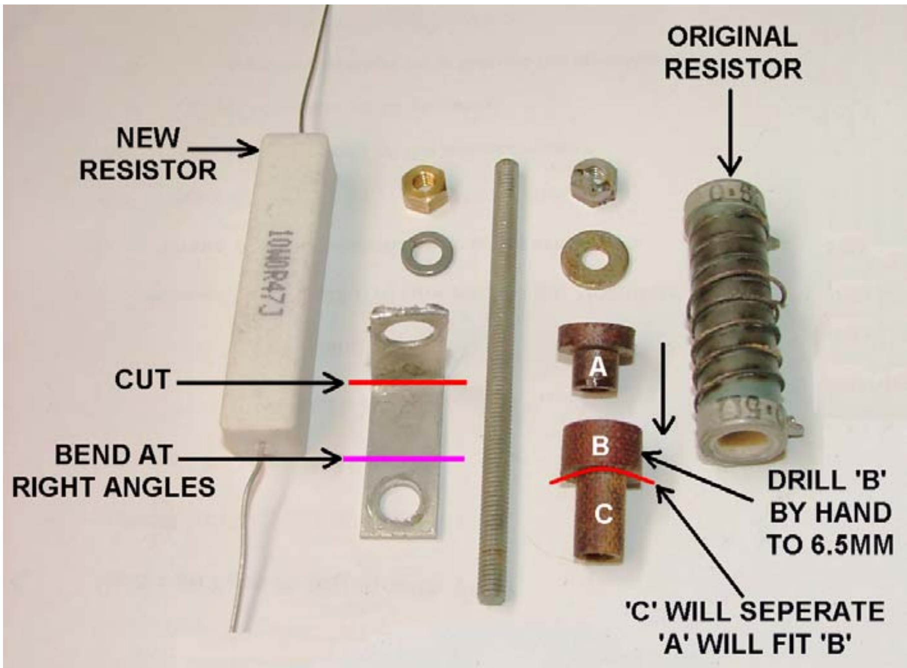


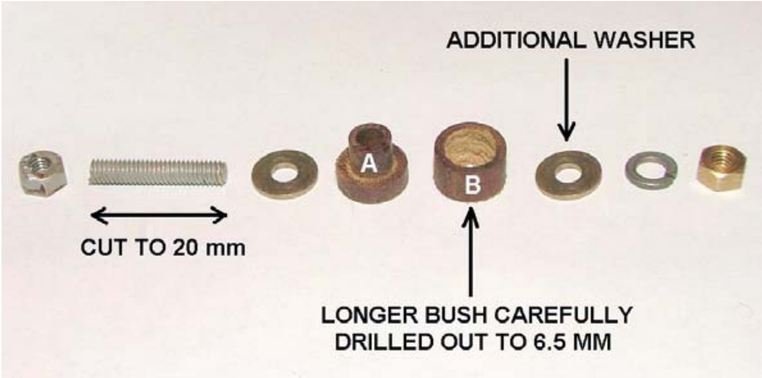
It is worth checking the integrity of all soldered joints, the security of the retaining nuts and measuring the resistance of the resistors. The load compensating resistor is only 0.5 ohms and rated at 4 watts but will often show signs of intense heat. Under normal circumstances 4 watts is quite adequate but will be inadequate if there has been a short circuit in the field winding or the regulator circuitry. As a consequence the resistor winding can become very brittle with time and can fail.

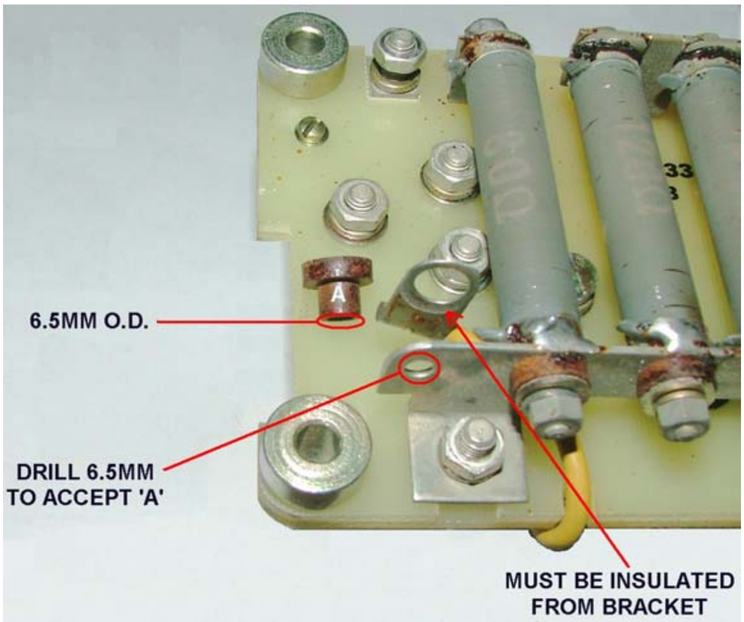


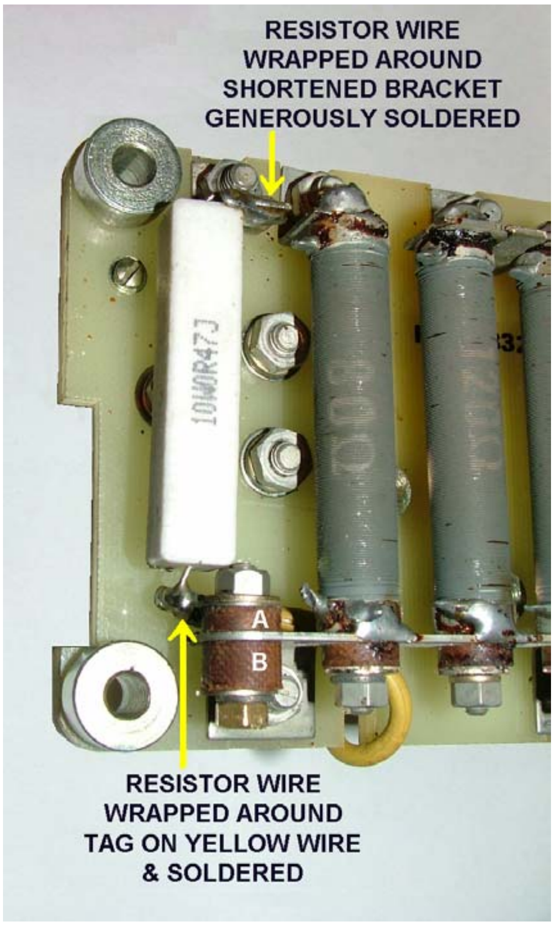
Replacing this resistor is not straightforward. It is not a standard component that can be easily obtained and whatever substitute is used it needs to be supported rigidly but at the same time insulated from the bracket to which the other four resistors are terminated.

The first thing was to obtain a substitute resistor and see how much room was required. Although 0.5 ohms is not a 'preferred value' the nearest is 0.47 ohms, which is perfectly adequate. I wanted to use a higher wattage resistor in the hope that it would be more reliable, the largest that could possibly fit in was one rated at 10 watts. This also benefited by being enclosed in a sort of ceramic body and cost only 48p from Maplins. The next challenge was to see how the old supporting components could be utilised to provide an insulated support.




ADDITIONAL WASHER
A
B
CUT TO 20 mm
LONGER BUSH CAREFULLY
DRILLED OUT TO 6.5 MM

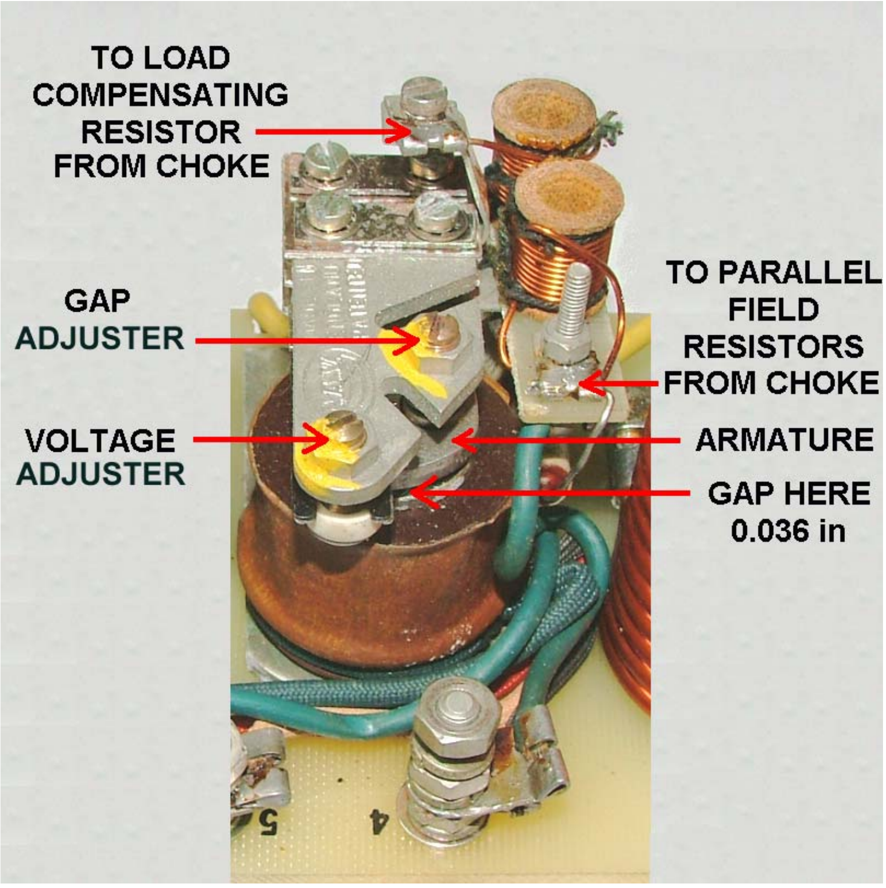

A
6.5MM O.D.
DRILL 6.5MM
TO ACCEPT 'A'
MUST BE INSULATED
FROM BRACKET


RESISTOR WIRE
WRAPPED AROUND
SHORTENED BRACKET
GENEROUSLY SOLDERED
10WR47J
A
B
RESISTOR WIRE
WRAPPED AROUND
TAG ON YELLOW WIRE
& SOLDERED

Test: SK1 Pin V & SK1 Pin X – 0.5 ohms (Regulator problem)

At rest the regulator contacts should be closed. If they are making good contact then a reading of 0.5 ohms should be obtained. If the reading is 100 ohms then regulator contacts are open. This may be because they are severely worn or need adjusting. If the yellow paint on the adjustment screws is damaged then the screws may have worked loose or more likely someone has been tinkering. Readings of less than 100 ohms but above 0.5 ohms may indicate just dirty contacts, if pressing the contacts together decreases the reading. If the regulator has not been used for a while the contacts may clean up with use, but if in recent usage then cleaning and gap checking is required.

The normal rest position is with the contacts closed, to clean the contacts press down fully on the armature to contact the metal core of the coil. It is worthwhile gently wiping the contacts with very fine 'wet and dry' paper but used dry, and then wiping the dust away with a clean cloth. The gap should then be checked with a feeler gauge. Note that this is not the gap between the contacts when open; it is the gap between the armature and the core of the coil with the contacts closed. It should read 0.036 in. on the outer tip of the armature. If this reading is not obtained then the gap must be adjusted by freeing the locking screw, which should normally be painted yellow and then adjusting the screw for correct depth, then locking it with the nut.



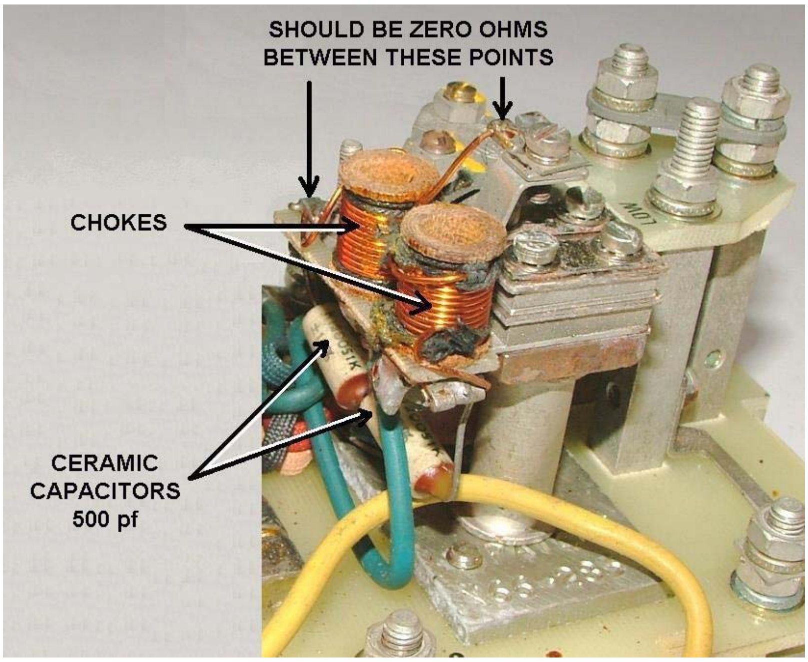
The voltage adjuster should also be painted yellow and is located at the end of the contact carrier. The adjuster determines the tension in the return spring for the armature and sets the regulator voltage. It can only be set up under running conditions.

It is not practical for an enthusiast to set up a test bench installation that would have been available in a REME workshop. For practical purposes the regulator can be set up with everything installed again in the vehicle.

1. Check that the HIGH/LOW link is set to HIGH.
2. Run the engine to 2,000 rpm. In order to promote a significant a load, turn on the headlights with that comes the load of the side lights. That will give a load of about 5 amps
3. Measure the voltage between the two main chokes on the bushing capacitors. This should be 28.5-29.0 volts. If not switch off, slightly slacken the nut on the voltage adjuster.

4. Start up again run to 2,000 rpm with all lights on and adjust the screw with an insulated screwdriver. Turning the screw anti-clockwise to increase the voltage.
5. Rev the engine up and down, returning to 2,000 rpm the voltage should still read as before.
6. Switch off. Lock the adjuster with the nut. Set the link to LOW repeat the test a reading of 26.5-27.0 volts should be obtained. Then return the setting to HIGH.
7. Initial setting of the voltage should be done with some haste before the temperature of the regulator coil rises.
8. Running the engine under load at maximum speed should not cause the voltage to exceed 29.5 volts.

This N66 regulator differs only from earlier panels in that there is some suppression around the contacts. This is in the form of a small choke feeding each contact and a 500 pf ceramic capacitor in parallel with each choke and across the points.



If there is any doubt about the integrity of the load compensating resistor, the contacts can be checked continuity with an ohmmeter should record zero ohms at the choke terminals.

SK1 Pin F & PL2 Pin C – 230 to 260 ohms
This tests the shunt winding of the BCK battery relay.

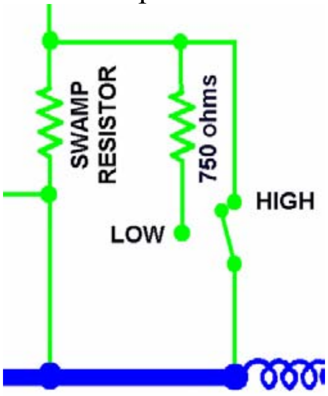
Test: SK1 Pin V & SK1 Pin W – 30 ohms
This tests the parallel field resistors, the swamp resistor and the shunt winding. The parallel field resistor consists of three 120 ohm resistors in parallel, which give an effective resistance of 40 ohms. This a higher figure than will be measured at the test points, the reason for this is with the points closed the bucking winding is shorted out but the points connect the shunt winding (35 ohms) in series with the swamp resistor (80 ohms) then in parallel with the parallel field resistors. The resultant effective resistance is 30 ohms.

This assumes the regulator contacts are actually making proper contact. With the contacts open through a fault or deliberately pressing down on the armature, the resistance measured at the pins will rise to 36 ohms. The position of the HIGH/LOW link has a negligible effect on this reading.

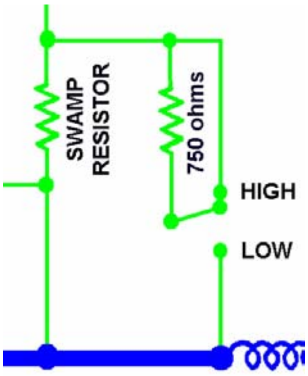
Test: SK1 Pin V & SK1 Pin U – 30 ohms
As above but if the reading is intermittent or in previous test is intermittent check the security of the nut at the base of the –ve choke that joins the thin wire 1U and the thick wire 1W to the choke.

Test: Swamp and HIGH/LOW resistors

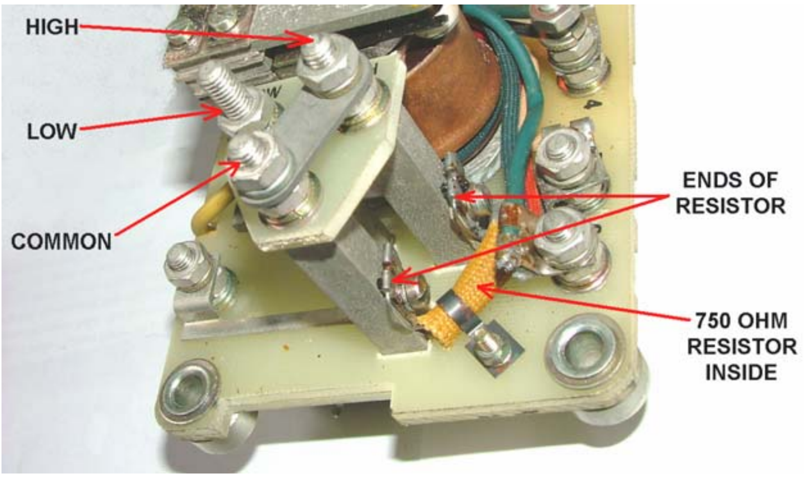
The vast majority of official circuit diagrams wrongly depict the action of the adjustable link. They show the link common terminal coming from the –ve line and when in the LOW setting switches a 750 ohm resistor in parallel with the swamp resistor and in the HIGH setting the resistor is disconnected.



That is incorrect; in fact the 750 ohm resistor is in circuit all the time and the link in the HIGH setting short circuits the resistor. With the link in the LOW setting the action of the resistor is reinstated and it is the LOW terminal that is connected to the –ve line.



To test this resistor simply remove the link and measure between the common terminal and HIGH. With the link still removed or on HIGH setting, the swamp resistor (80 ohms) can be measured by measuring the resistance between terminals HIGH and LOW. It should read 65 ohms with the armature pressed down and 38 ohms at rest with the contacts closed. If you are unsure as to whether the contacts are making a good contact simply connect a small jump lead across the choke to the regulator coil during this measurement.



Test: SK1 Pin X & PL2 Pin D – zero ohms

This is the auxiliary output that is not controlled by the battery relay. It is rarely used but continuity here at least means the main +ve feed is reaching the BCK relay.

Test: SK1 Pin W & PL2 Pin C – zero ohms
This checks the main –ve feed through its main choke. If there is no reading or intermittency then check the tension on the nuts for the bushing capacitor and the base of the coke.

Test: SKI Pin G & PL2 Pin F – zero ohms
I have only included this test for completeness as the link between the connectors still exists and indeed does have a bypass capacitor. Pin F is linked to the ignition switch but no longer serves any obvious purpose as pin G has no connection to the generator. In the earlier panels pin F was used to supply the field relay but a field relay is not fitted to this Mk of panel.

Test: SK1 Pin X & PL2 Pin A – zero ohms (battery relay depressed)
Use +ve prod on X and –ve prod on A. This tests the main +ve feed to the vehicle batteries. It is important that this is zero ohms; because of the high current that can be drawn even a fraction of an ohm could cause a significant voltage drop.

Test: SK1 Pin X & PL2 Pin B – zero ohms (battery relay depressed)
Use +ve prod on X and –ve prod on A. This is the same as the previous test but for the radio batteries.

Test: SK1 Pin A & PL2 Pin E
Use +ve prod on A and –ve prod on E should read about 38 ohms. Prods reversed should read 240-260 ohms. This tests the charge light diode D4, its parallel resistor and the choke.

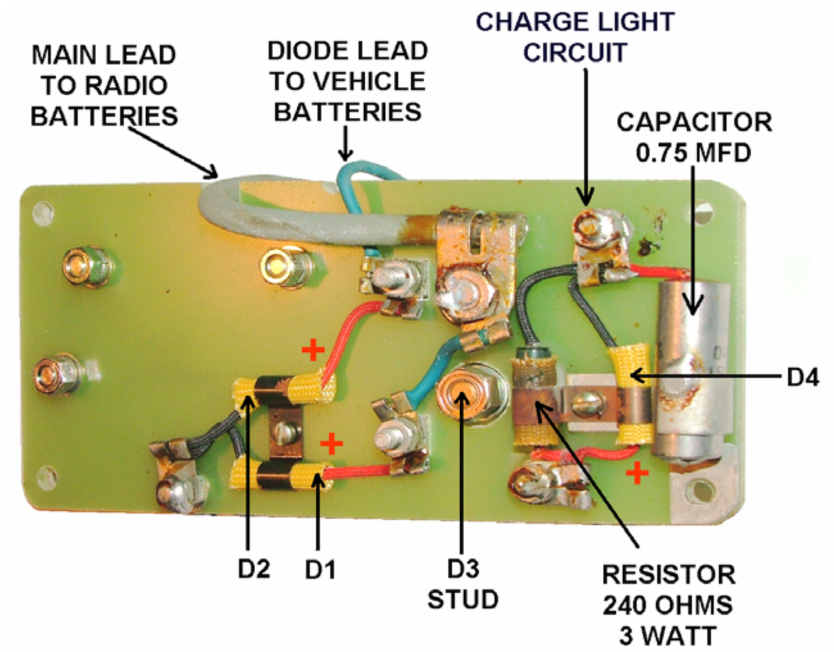
Test: PL2 Pin C & PL2 Pin A
Use –ve prod on C and +ve prod on A should read 700-800 ohms. Prods reversed should read more than 2,000 ohms. This tests the reverse battery protection diode D2 for the vehicle batteries.

Test: PL2 Pin C & PL2 Pin B
Use –ve prod on C and +ve prod on A should read 700-800 ohms. Prods reversed should read more than 2,000 ohms. This tests the reverse battery protection diode D1 for the radio batteries.

Test: SK1 Pin X & PL2 Pin B
Use –ve prod on X and +ve prod on B should read 700-800 ohms. Prods reversed should read more than 2,000 ohms. This tests the reverse battery protection diode D3 for the radio batteries that would cause the safety fuse in the shunt box to blow.

Access to diodes
The only visible diode (D3) on the regulator panel is the large stud mounted diode. It serves to protect the generator from damage as the result of having the radio batteries connected the wrong way round and serves no purpose in the normal functioning of the system.

This diode was not originally fitted to early panels and was an EMER upgrade. Later panels received the diode during manufacture. The other diodes are smaller and hidden beneath the regulator panel although they can be tested by indirect means, they may need to be replaced.

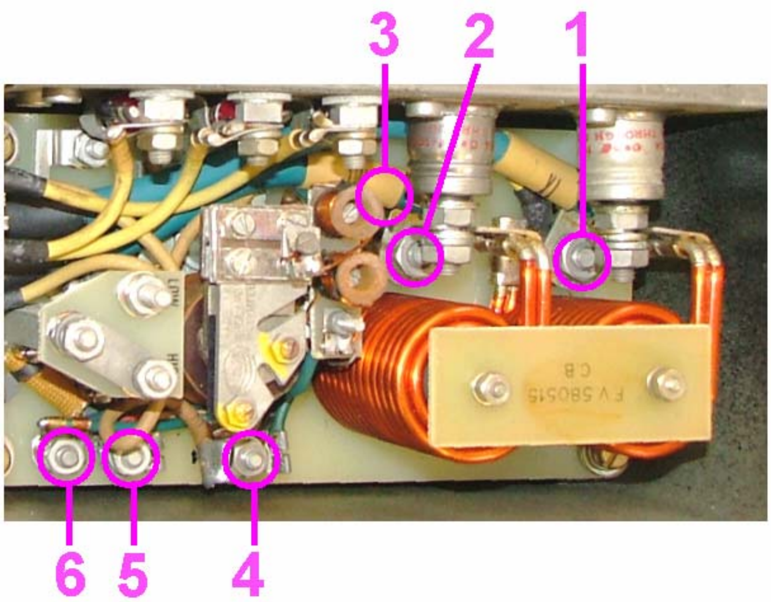


Replacement may not be easy; D3 is given as Z42/5961-99-118-1987 which is obsolete. The other diodes are all the same and given as LV6MT4/2920-99-881-9925 in the parts book which again is obsolete. The EMER quotes CV5694, which although obsolete can be obtained on the surplus market and anyway it is only a silicon diode rated at 50 volt 0.5 amps.

Voltage readings

It will be noticed that terminals on the relay board are marked 1-3 and on the regulator board marked 1-6, these are for identification purposes when assembling the boards. They are not formal test points and indeed some of the markings are not easily seen once the boards are fully installed. However some of them can be used as test points for voltage readings, which I hope might be of particular use around the regulator. There are many interactions of coil windings and resistors that give fairly low resistance readings sometimes looking at the voltage can be more helpful.

As some of the terminal markings can be seen I have used the same designations that are used on the regulator board and related them to the circuit diagram so you can see which points are being measured.



These voltage readings are taken with the connectors removed from SK1 and PL2. In this state with the generator disconnected do not run the engine otherwise the generator diodes could be destroyed without a load attached. These measurements need to be taken with the battery relay depressed or if the tests are being performed on a spare panel this is not necessary as the supply can be connected directly to the bushing capacitors above the marked terminals i.e. –ve above point 2 and +ve above point 1.
With the meter –ve prod connected to point 2 and with a nominal 25 volt supply, these are average ballpark figures derived from three examples of panels known to work. Apply +ve prod to:

1	25 volts
2	0 volts
3	0 volts
4	24.5 volts (regulator contacts closed)
4	3 volts (regulator contacts open by pressing armature down)
5	18 volts
6	24.5 volts

Disconnect the plug from generator and at other end of cable screw on connector to SK1. Apply voltage or press battery relay down. Measure 24 volts or so on the generator connector with –ve prod on U and +ve prod on V. This would establish that the field winding supply is being delivered down the cable to the generator connector. Pressing the armature down will reduce the field voltage down to 3 volts or so.

Unless the batteries are on float charge, there will be a drop in voltage during the tests as the regulator and its resistors are drawing current. It is worth repeating the readings to check that the relationship in readings is much the same as before. There will be no such problems if the batteries are on float charge, however the battery could well be above the regulator cut in voltage and the contacts are held open. Although this will only affect the readings on points 5 and 6 a little, the reading on point 4 needs to be taken by holding the contacts closed. A finger nail held underneath the armature is a convenient way to do this.

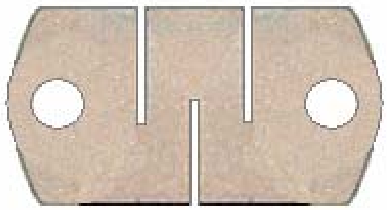
Modification record plate

1. Choke added in charge light circuit.
2. Capacitor added in charge light circuit.
3. Diode added across relays contact for radio batteries.

Shunt box type 466-3

The early generator panels worked in conjunction with two ammeters, one for monitoring the vehicle batteries and the other for the radio batteries. These ammeters were direct reading instruments mounted on the dash that necessitated the entire current drawn to be passed through them. In the case of the APGP the voltage drop was minimised by the generator panel being mounted near the foot well. Repositioning the generator panel behind the driver's seat represented an unacceptable voltage drop and risk fire from long high current cable runs. Mk 2 and even some early Mk 3 panel installations (early Rover 9) were like this. However the majority of installations were provided with a shunt box to overcome these problems.

A shunt is a precision resistor able to pass the majority of the current leaving a small proportion to flow through a very sensitive ammeter. Where the current is high, the resistance of the shunt is low. In this application the resistance is so low that the shunt is reduced to a metal strip with precision cuts that determine the exact resistance.

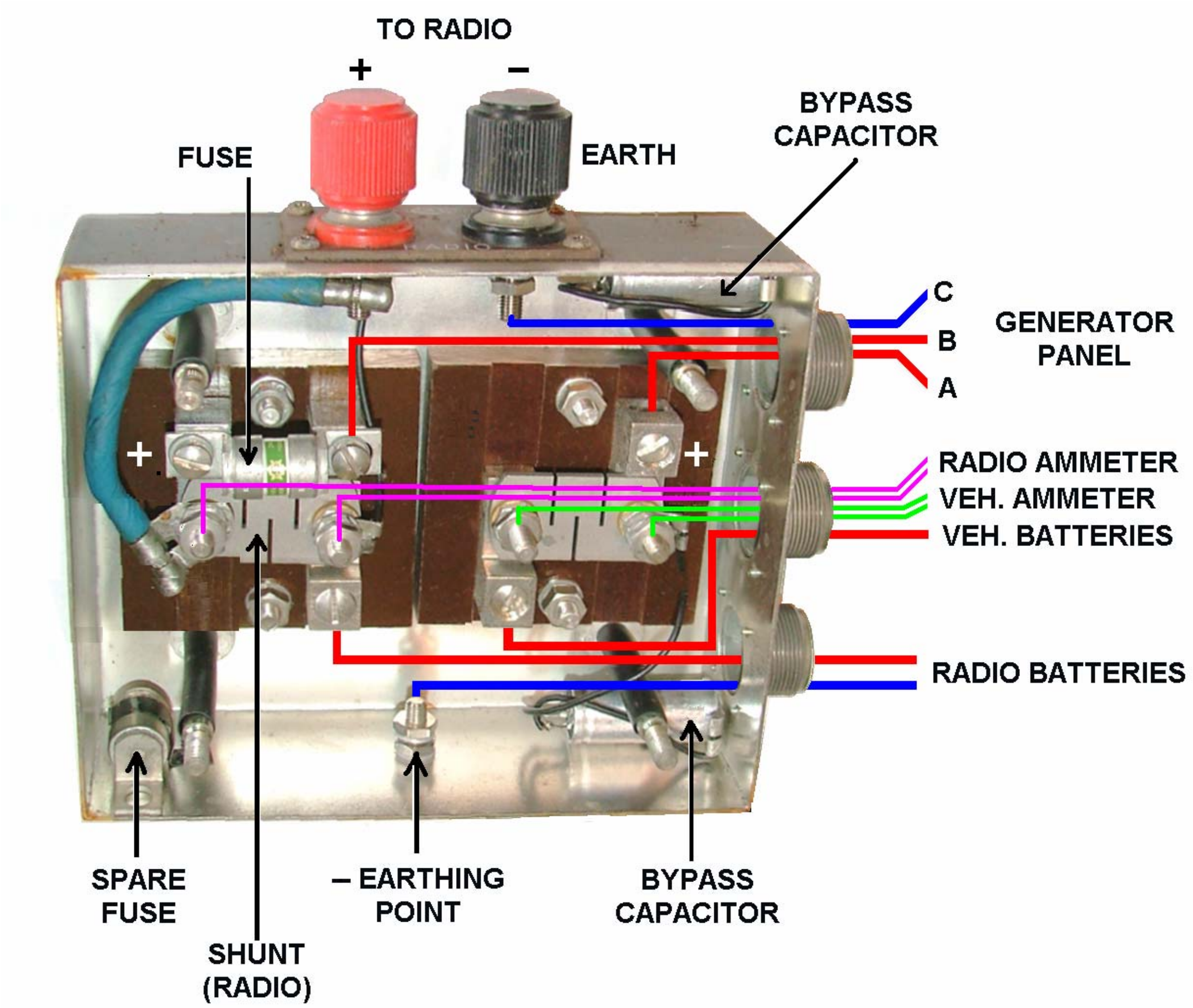


The ammeter can be mounted at some distance without suffering any voltage drop and because of the tiny currents carried it allows standard wires to be used. The calibration of such a meter is only valid for a specific shunt that it was designed for. This can be seen on the meter front.

The shunt box also forms a convenient power distribution point. The generator panel feeds into it and it is here that the –ve supply is actually earthed. It is clearly imperative that the box is properly bonded to earth as there no –ve lead for the vehicle batteries, it is done through the earth return. The two +ve supplies for each set of batteries are connected to their shunts and terminals on the top are the supply points for the radio.

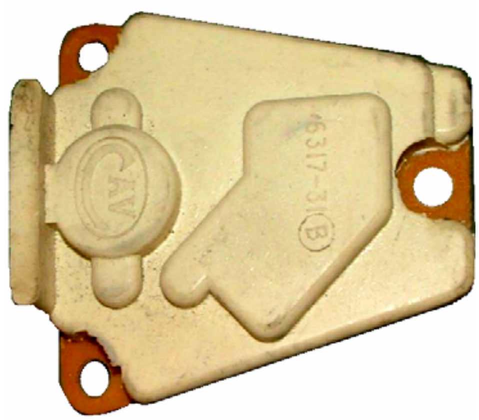
There is already protection against the battery polarities being accidentally reversed in the form of the additional reverse winding on the BCK battery relay; however this proved not to be rapid enough. Such a connecting error is most likely to occur with the radio batteries, the modification to the generator panel was the addition of a high power diode connected to the radio batteries +ve supply and to the –ve line. Reversal of the batteries would cause a short circuit to earth; this would cause the 150-amp fast-blow fuse inside the shunt box to blow. The original panels were not fused and the inclusion of a fuse indicates the companion panel had the additional diode fitted.

A spare fuse is carried inside the box. There is no fuse to the vehicle shunt but both shunts are fitted with filter capacitors to earth, although early boxes only used one capacitor.



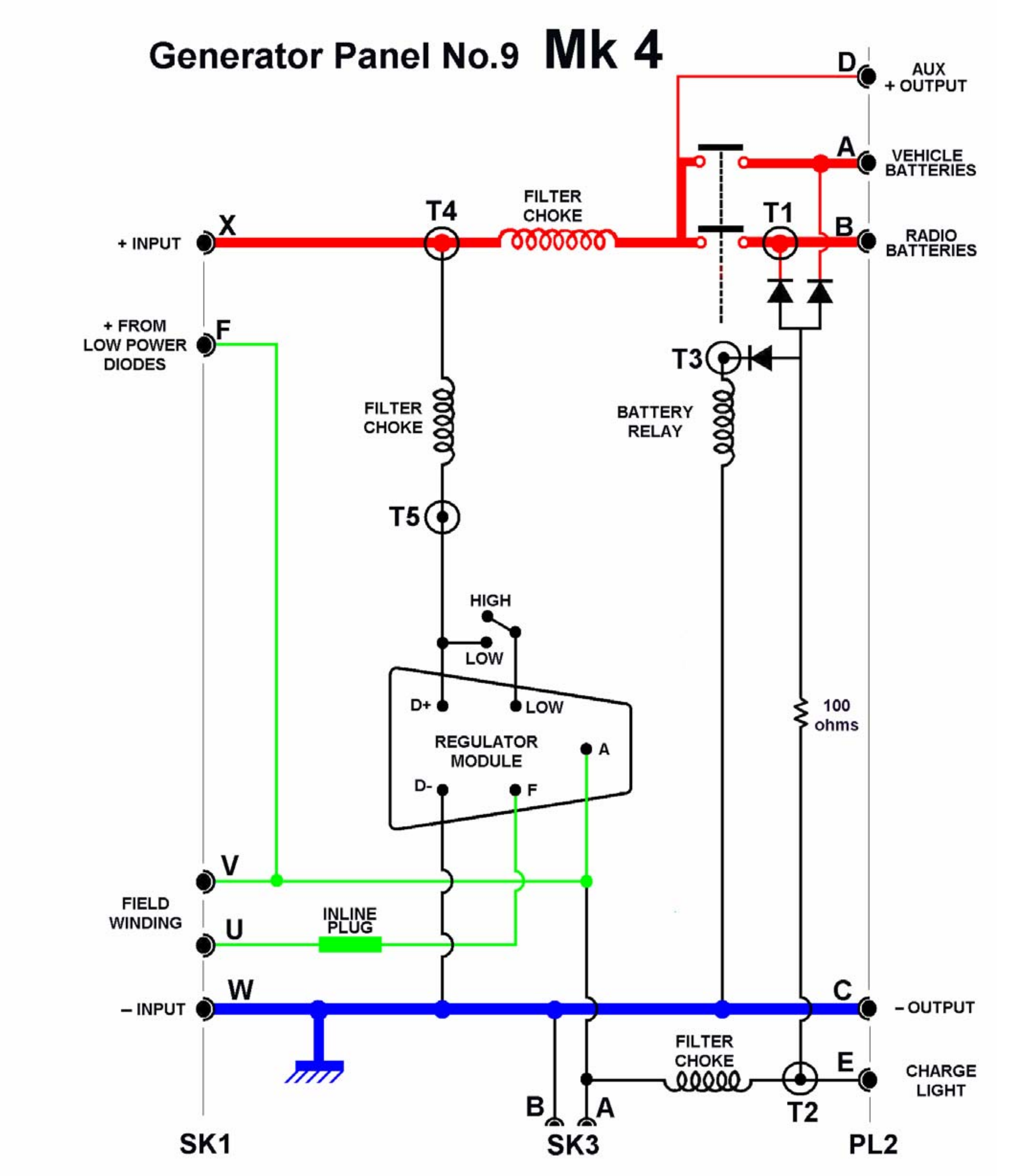
On some installations the wiring through the lower and middle fittings are reversed.

<u>Generator Panel No.9 Mk 4</u>
The most significant change was the introduction of a transistorised regulator. In a sense it was more reliable than the vibrating contact regulator as there were no contacts to stick, corrode or be tinkered with. But therein lies the catch, no amount of ingenuity in the field can bring to life a solid state regulator that has failed. The old regulators can often be brought to life and give satisfying signs of activity as the contacts buzz away, in clear contrast to the solid state replacement gives no obvious clue as to its status unless the plastic of the module has actually melted!



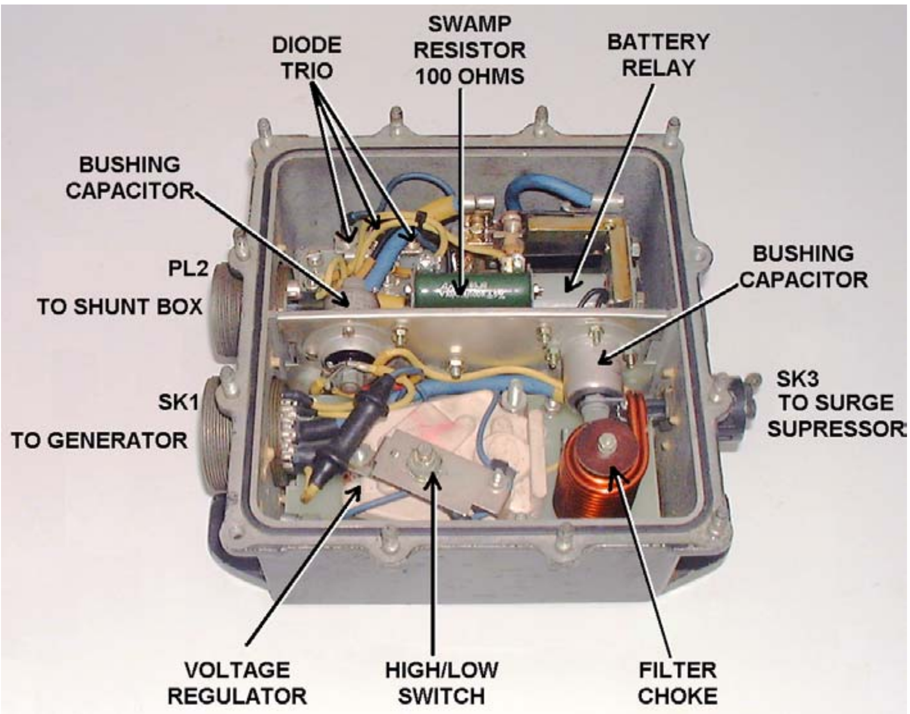
C.A.V. Type W6317-31B transistorised regulator module

The regulator module contains a switching transistor which does not radiate interference like a vibrating contact regulator. It does need to be fed with a +ve supply that is delivered via its own filter choke. The main +ve supply passes through a ferrite loaded choke. In official circuit diagrams two chokes are depicted, although this is correct, it is depicting the double winding used in earlier panels and is an identical component. There is no filter choke in the –ve line as the input lead from pin W is immediately earthed to the box mounting.

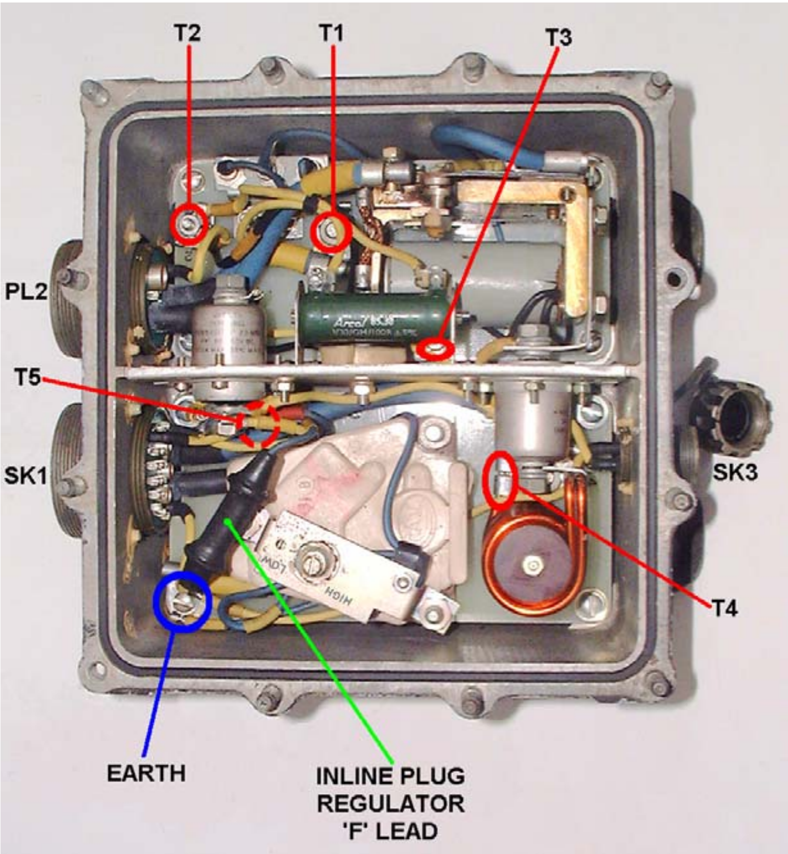


There is a change of battery relay yet again to a BCK108 (incorrectly described as BCK10 in some manuals) this is similar to the BCK 102 but has no bucking winding. Instead a protection diode is wired to the main winding so that in the event either the radio or vehicle batteries being connected in reverse, then the relay will immediately be de-energised and disconnect the batteries. Again each battery feed has a blocking diode so that they behave in isolation to each other when the relay is open.

The path of the charge warning light circuit that provides field tickling is different from earlier panels that use SK1 pin A. Here the charge warning light is fed directly to the field winding through SK1 pin V. This is why earlier panels should not be used as a replacement in Mk 4 installations. The previous pointless connection between SK1 pin G and PL2 pin F is now omitted. Some manuals refer to the main generator socket as PL1. As the connector is based on socket elements its proper designation is SK1 rather than PL1 that would refer to a plug based connector.



The tests that can be performed are more limited. Terminals (T1 –T5) act as test points for voltage readings. Some are not easily accessible as can be seen below. These should all read the nominal 28 volts, but T1 only with the relay closed.



This is the only panel that has an integral earthing point, with all other panels the –ve supply is earthed at the shunt box. The inline plug in the regulator lead F, seems rather elaborate and has no special diagnostic purpose. I can only assume that it is to allow easy dismantling of the panels without the need for any unsoldering and besides the leads provided on the regulator module are rather short.

Continuity testing
The following should measure zero ohms.
SK1 Pin F – SK1 Pin V. Tests field supply interconnection
SK1 Pin F – PL2 Pin E. Tests charge light circuit & its choke
SK1 Pin X – PL2 Pin D. Tests main filter choke connections
SK1 Pin X – PL2 PinA. Tests vehicle relay contacts with contacts closed
SK1 Pin X – PL2 Pin B. Tests radio relay contacts with contacts closed
SK1 Pin W – Panel casing. Tests the earthing of the –ve supply
SK1 Pin W – PL2 Pin C. Tests –ve supply line. This is important as the cable wire sheathing must not be relied upon to pass high currents.

Test: T4 & T5 – 2 ohms
This tests the filter choke supplying the regulator module. It is the same component used in the charge light supply of Mk 3 panels and is located in a similar position. However in the Mk 4 panel the choke for the charge light circuit is mounted on the underside of the regulator board. It must be a reliable component as spares are 'not provisioned' and it has no NSN.

Test: PL2 Pin E & PL2 Pin A -appx 1,000 ohms
Reversing the polarity of test prods should read not less than 100,000 ohms. This tests the 100 ohm swamp resistor and the integrity of the blocking diode for the vehicle battery supply. The swamp resistor loads the circuit with resistance and helps offset the inductance of the relay winding.

Test: PL2 Pin E & PL2 Pin B -appx 1,000 ohms
Reversing the polarity of test prods should read not less than 100,000 ohms. This tests the 100 ohm swamp resistor and the integrity of the blocking diode for the radio battery supply.

Test: Test prod –ve lead on T3 & +ve prod to earth – 100 ohms
This tests the battery relay winding.

Test: Regulator performance
To provide a load for the generator, run the engine and turn on all lights. This will give a load of about 5 amps. Set the voltage selector to HIGH and run the engine at 2,000 rpm then measure the generator output which should be between 28.2-28.8 volts.

Turn off the engine set the voltage selector to LOW and repeat the process. The output voltage should be between 26.2-26.8 volts.

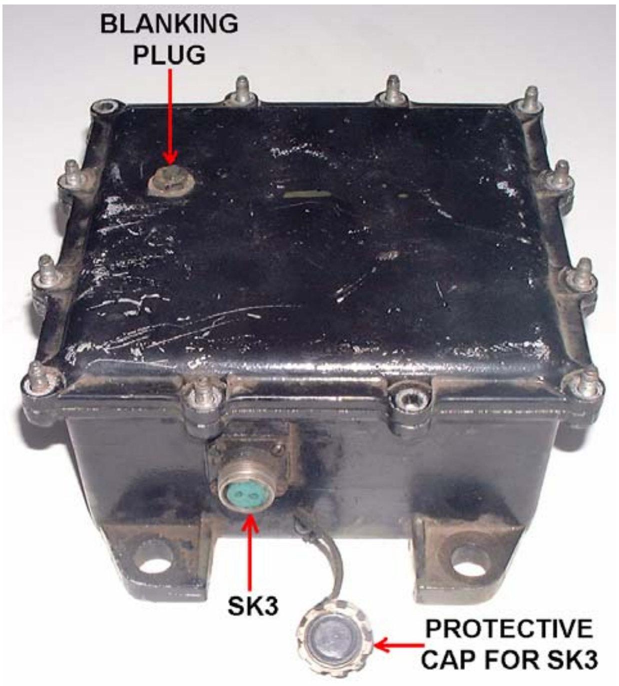
Turn off the engine return the voltage selector to HIGH. Repeat the process but rev to 9,200 rpm and check the voltage does not exceed 29.0 volts.

Attach a load to either the radio or vehicle batteries so that the total load from the generator is 66 amps at 1,800 rpm the output voltage should not drop below 27.5 volts. Repeat this with an 88 amp total load at 2,800 rpm again the output voltage should not drop below 27.5 volts.

Now that the generator and panel are hot, repeat the very first test and ensure that the output voltage is between 28.3-28.7 volts. If these values are not obtained there is nothing that can be done other than by changing the regulator module or the panel itself. Using a Megger on 100 volts check the insulation between PL2 pins A and B and earth is not less than 5 megohms

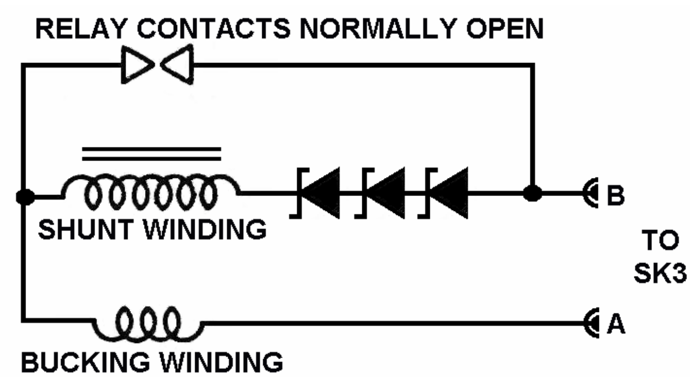
Surge Protection Unit No.1 Mk 1

SK3 is a two-pin socket mounted on the opposite wall to the main power sockets. It provides for plugging in a screened cable to feed a surge suppressor designated Surge Protection Unit No.1 Mk 1. The purpose of this is to protect sensitive electronic equipment from voltage surges from the generator. I have never seen one of these units nor have I ever found a description of one. It is clearly a specialist item and the lack of it will have no effect on the normal performance of the charging system.



For the sake of completeness I will make an attempt to describe its function by extrapolating a similar arrangement built into the Generator Panel No.12 used in CVR(T)s. In both types of panel the suppressor relies on an earth connection and a connection to the field winding. The basis of all these panels is the regulation of the output by controlling the field winding voltage.

A surge is an unexpected large voltage and is particularly likely to happen in circuits with inductive loads such as motors, compressors etc. With such inductive loads not only would sensitive electronic equipment be at risk but even the transistor regulator itself. If the generator was to produce a voltage surge it could be detected and used to instantaneously cut the voltage to the field winding, which in turn pulls down the generated voltage to a safe level. As this voltage falls, so does the clipping effect on the field supply and normal voltage output is reinstated.



In the arrangement above three Zener diodes rated for instance at 12 volts are wired in series with a relay with two windings. When connected to the generator panel, B is earthed and A is connected to the subsidiary generator output via SK1 pin F. With the normal generator output no current can flow through the Zener diodes.

With a surge voltage in excess of 36 volts the diodes will conduct and energise the relay closing the contacts thus preventing an excessive current destroying the diodes. This cuts the voltage to the field winding causing the generator output voltage to fall; at this point the diodes cease to conduct although the relay contacts will remain closed for a moment. The presence of the bucking winding wound in the opposite sense to the shunt winding creates an opposing magnetic field and causes the relay contacts to open rapidly.

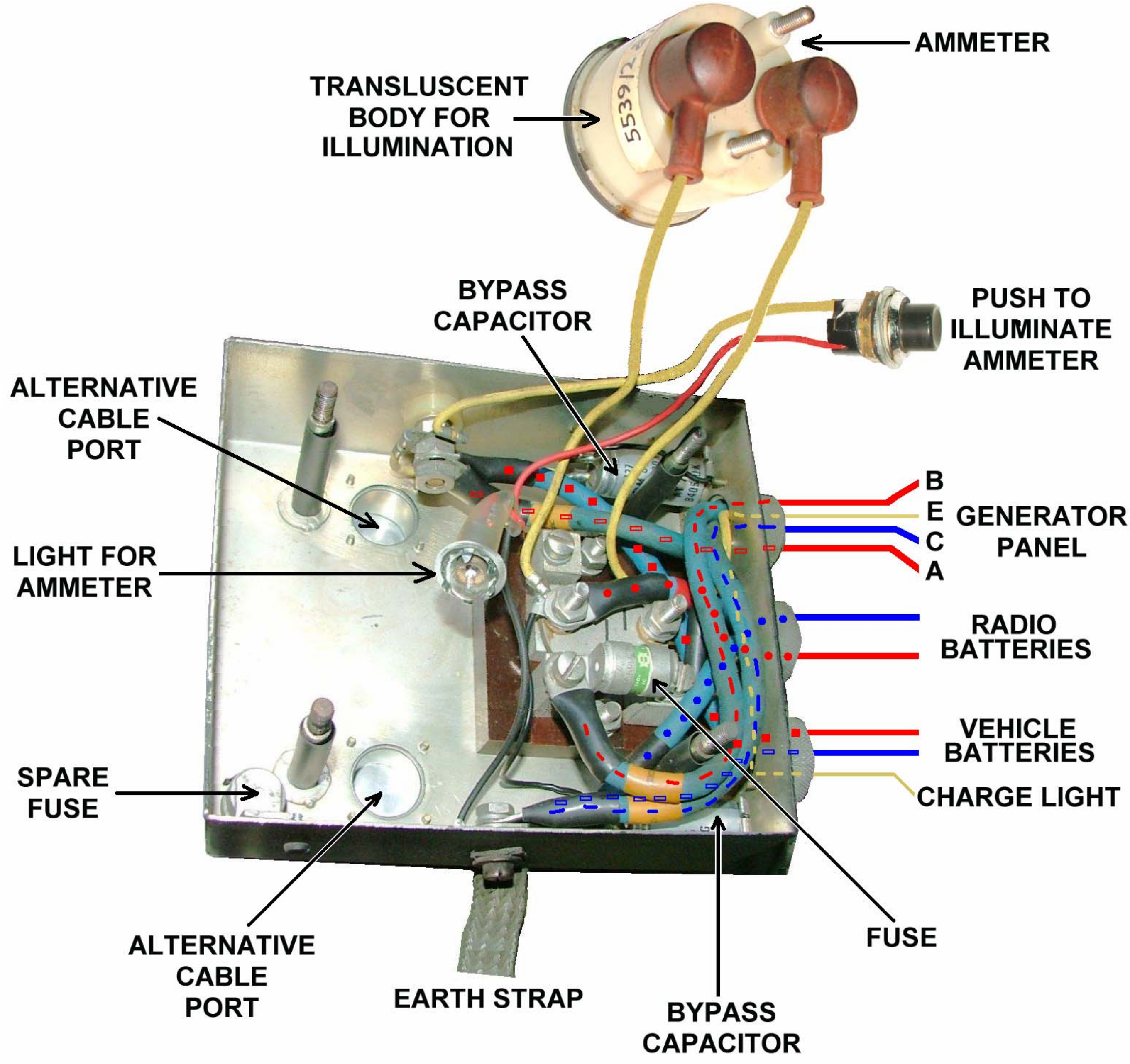
But for most applications surge suppression will not be required and SK3 will be protected with a waterproof protective cap. The lid encloses a blanking plug which is common to all Mks of panel. The purpose of this is to facilitate the fitting of an adaptor for an air pump for waterproof testing. There are special protective caps that are fitted to SK1 and PL2. With the lid firmly secured the panel is immersed in water and pressurised to 6 psi. After one minute no bubbles should emerge.

Shunt box – single ammeter

Installations with the Mk 4 panel generally have a single ammeter shunt box mounted between the two front seats of a Rover. A push button provides illumination of the ammeter dial. The bulb is powered from the vehicle battery supply which is already present in the box as it acts as a distribution point not just for the radio batteries.

This single ammeter only monitors the rate of charge to the radio batteries unlike the earlier arrangement where it was able monitor the discharge as well. In other words this is a single ammeter reading 0-100 amps wired into the generator feed to the radio batteries. Whereas the previous centre reading ammeter measured 100-0-100 amps and was wired in the supply to the radio batteries. It was no longer felt necessary to monitor the charge to the vehicle batteries.

There is obviously only one shunt and is of exactly the same type as before. Again a fuse is provided just in the supply to the radio batteries and two filter capacitors. The shunt box has no terminals for the radio batteries; the supply is passed through one of the three outlets to the rear of the vehicle to a terminal bracket. A feature of this type of shunt box is that there are two additional outlets in the base of the box allowing for various mounting configurations.



<u>Final thoughts</u>

When fault finding it is sometimes difficult to stick to a logical approach and one can be tempted to dive in and start pulling things apart. This can be based on a prejudice against a particular part of the system or because someone else that had “the same problem”. A good medical tenet is “No treatment without a diagnosis” and the same should apply to automotive repairs, otherwise more damage may be done or at the very least it might add confusion to the original symptoms.

<u>Acknowledgements</u>

Many thanks to Darren Parsons for the providing the items to be photographed also to Dale Prior, Richard Farrant, Philip Bashall, Cliff Rice and Wayne Fisher for additional references.