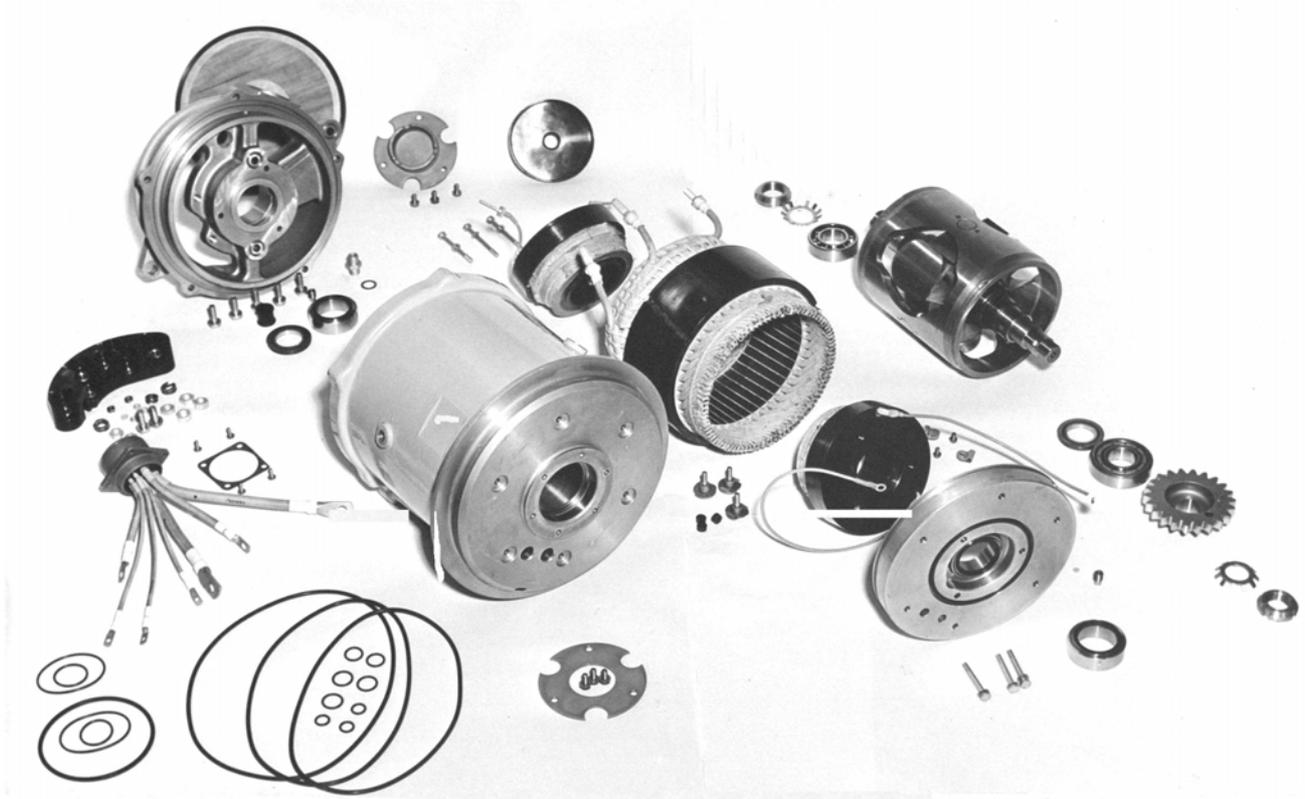


# ALL CHARGED UP!



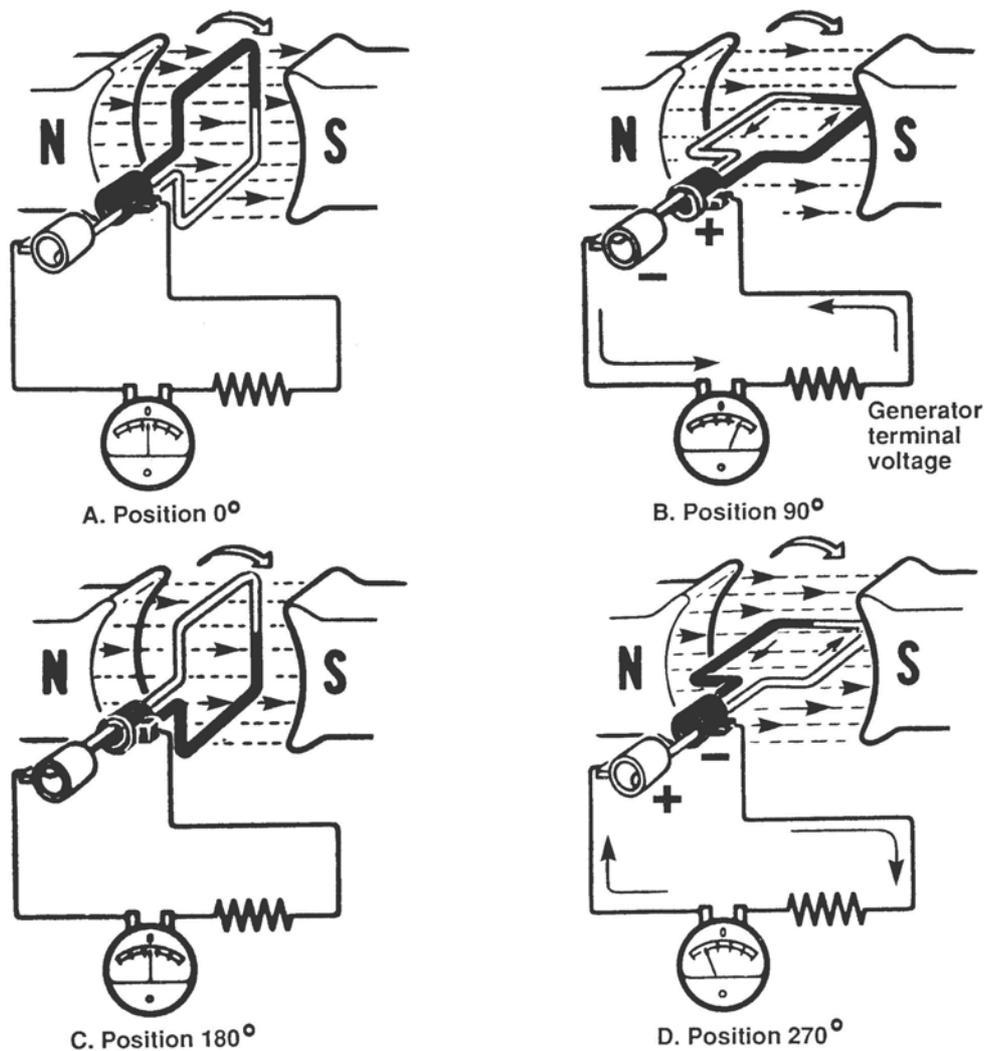
*Clive Elliott takes a look inside some of the AC charging systems that have been used in British Army vehicles.*

Civilian books on vehicle electrics will have sections that deal with direct current (DC) charging systems i.e. those systems that use dynamos. Often these books can give information that is equally applicable to systems used in the less sophisticated military vehicles. But as far as alternating current (AC) systems go they are of little help in explaining the complexities of military systems and they are of even less help when something goes wrong. In this first part I will describe the basic principles of AC charging systems, then how they were developed for military service and then a more detailed description of the more common systems. Further articles will give details of fault finding. Please note there is a glossary at the end of this article.

## **Basic Charging Systems**

An AC generator is known as an alternator and a DC generator as a dynamo. In British Army terminology although a dynamo is always described as a generator, an alternator is sometimes classed either as an alternator or as a generator. It should be remembered that dynamos and alternators are only part of a charging system that is dependent on additional control circuitry to regulate the output to within safe limits.

It is helpful to start by considering the basic principles of a dynamo and an alternator, as they are very similar. In 1834 Michael Faraday discovered that when an electric conductor moves relative to a magnetic field then a voltage is produced in the conductor. The magnetic field can be provided by either a magnet or be created by passing a current through a coil. In an alternator or a dynamo the magnetic field is created by passing an electric current through a coil called the field winding. By placing another coil that is able to rotate relative to the field winding a voltage is produced in the second coil. Unfortunately each time the rotating coil moves through 180 degrees the polarity of the output voltage changes and an alternating current is produced. At the in-between positions of 90 degrees, there is no voltage output.



*The action of a simple generator*

Generating a voltage by rotating a coil in a magnetic field is the basis of both a dynamo and an alternator; the devices differ in how the AC output is managed. In a dynamo the rotating inner assembly consists of a coil (the armature) that feeds its output through copper segments (the commutator). The output voltage in a dynamo is taken from spring mounted carbon brushes that are stationary and rub against the rotating commutator. The wiring of the armature and the segments of the commutator are so arranged that the circuitry is switched as rotation takes place. This switching is a mechanical form of rectification and means that a DC output is obtained. The problem is that, particularly at high speeds, arcing takes place at the commutator, this adds to wear, power loss through heat generation and there is radio interference. Apart from the brush problems, the switching of current in the armature coupled with the mechanical limitations of its construction means that a dynamo cannot be designed to cope with a wide range of speeds.

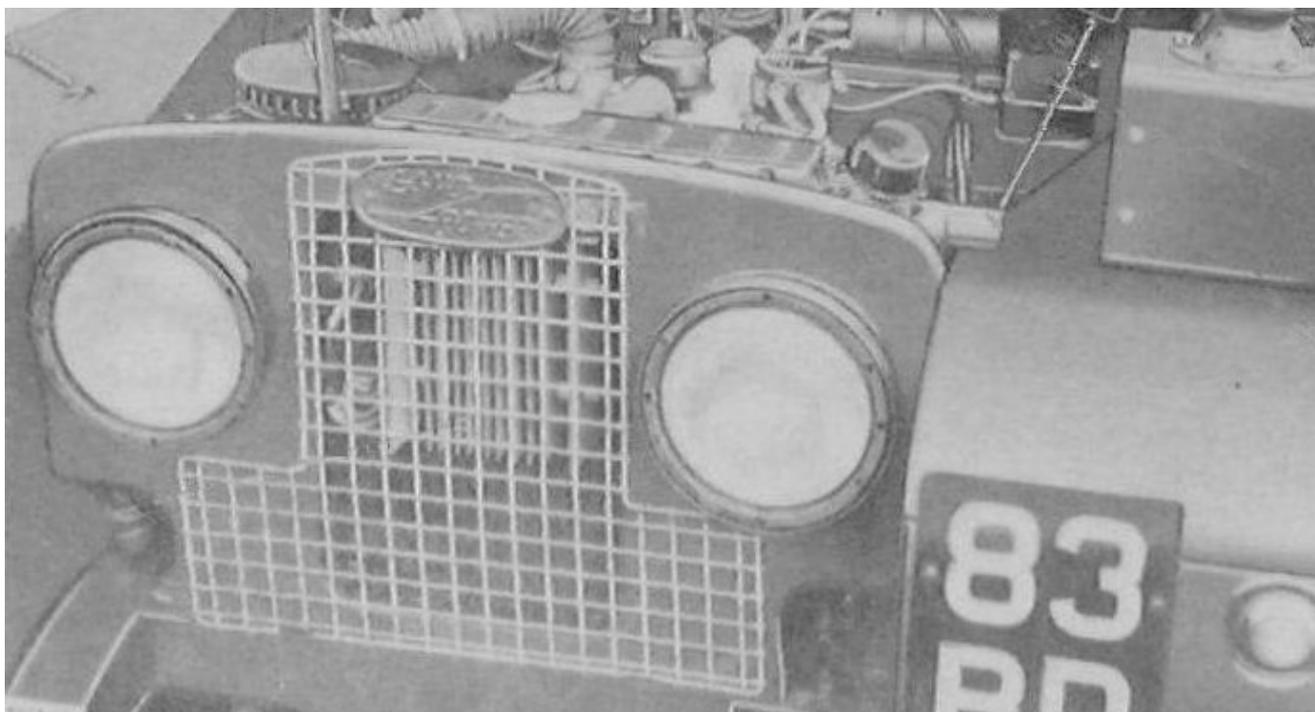
In an alternator rectification is provided by electronic means. By replacing the commutator of a dynamo with an electronic rectifier it becomes a very basic alternator. By making the field winding rotate instead of the armature coils, the generator has been turned inside out. This means that the relatively low current required for the field winding causes less wear, less power loss and less heat at the brushes which are now in contact continuously with slip rings without the sparking that would occur in a dynamo. The smaller size of the rotating windings (the field coil) means the mechanics of the moving components can be made smaller. Alternator output power is proportional to the number of turns in the output winding and their magnetic flux. Although the flux is dependant on the amount of associated iron, it can be compensated for by increasing the windings still further allowing reductions to be made in the iron content. This means that an alternator for a given output will be about half the size of a dynamo of similar power.

## Military Requirements

The majority of military 'B' vehicles use charging systems that are common with commercial vehicles and they will not be described here. I will confine the descriptions to systems used in AFVs and 'B' vehicles that have a Fitted For Radio role (FFR) and are invariably operating nominally at 24 volts. Military vehicles have been increasingly required to provide more electrical power for ever more electrical equipment. There are size and weight limits as to how large a dynamo can be accommodated in a vehicle. In addition the development of vehicles with higher engine speeds means that the generating systems must cope with this increased speed yet be capable of supplying power for long periods when the vehicle is static but with the engine idling.

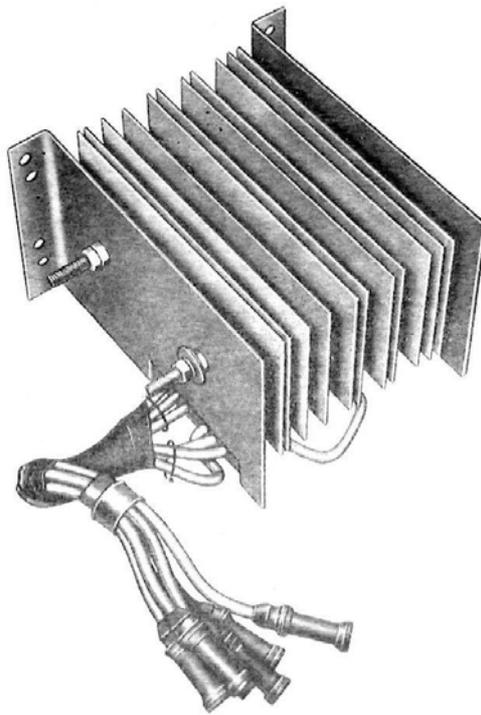
One way of coping with the problem of generating power at low engine revs was the introduction of a two-speed dynamo. During the 1950s a range of vehicles using Rolls Royce 'B' Series engines were introduced using a dynamo that had an internal gearbox to speed up the dynamo as the engine speed fell. The Generator No.2 was used in the Champ, Ferret, Humber, Saracen and Saladin. Pulley speeds above 2,000 rpm drive the armature at 1.545 times the pulley speed but when the pulley speed falls to below 2,000 rpm a clutch mechanism introduces a gearing that increases the dynamo armature speed by 4.37 times the pulley speed. Despite this ingenuity the Generator No. 2 only had a maximum output of 25 amps at 26 volts. This was not adequate for many applications of the time, even a fitted for wireless Humber Pig required an auxiliary generator mounted on the wing and the Humber Hornet had to be fitted with the alternator from a FV432. Saladin had additional electrical demands due to the drain from an electrical gun firing mechanism. In the later Mk 2 Saladins these demands were met by Generator No.4, which again was a two-speed generator but was capable of 75 amps output. This was really at the limit of what could be achieved from a dynamo in practical terms. Both versions of two-speed generator required the internal gearbox to be fed with oil from the engine.

So the search was on for a more practical system based on an alternator. By 1961 modification kits were available to fit Land Rovers with alternators capable of 24-volt output at about 40 amps. The FFW Rovers Mk 3 and Mk 5 were fitted with CAV Alternator Type AC7/24/1. The current output was limited by the reliance on a selenium rectifier. A feature of such a vehicle was the rather bulky rectifier, with its cooling fins mounted immediately behind the radiator grill. This was to maximise cooling and prevent rectifier failure, which would occur above 80 degrees centigrade.



*Note the selenium rectifier mounted behind the upper part of the radiator grill. It is mounted vertically to achieve maximum cooling.*

The limitation of early rectifiers was not just their low current rating but their limited temperature range. This is why early alternators were not used in AFVs where temperatures could reach 100 degrees centigrade.



*The bulky air-cooled selenium rectifier. About 8 inches high, it contains the equivalent of nine diodes.*

By the 1970s the temperature specification for military alternators required the ability to function at 140 degrees centigrade. As rectifiers will perform effectively at any speed, the top speed of an alternator of say 15,000 rpm is only influenced by mechanical limitations such as wear. So it was not until the development of silicon diodes that the full potential of the alternator could be realised. Silicon can handle higher currents, higher peak inverse voltages and can function up to a maximum temperature of 200 degrees Centigrade. The silicon diodes being smaller can be mounted closer to the alternator fan and make the system better suited to vehicle wading.



*A single silicon diode. About an inch high usually arranged as a group of 6 diodes.*

It is far easier to waterproof an alternator than a dynamo, which has commutator and brushes susceptible to dirt and moisture. Cooling is more efficient in an alternator as the hottest parts are the output windings as they are within the outer body of the generator rather than the dynamo, which has the output windings in the revolving armature. In applications where there is switching of high inductance loads there can be quite high voltage surges. The selenium rectifier could only handle a peak inverse voltage of 42 volts, but a typical silicon diode can handle 400 volts.

### **Alternator Types**

There was much experimentation in alternator design during the 1950s and 1960s. Of particular importance was the design of the field winding and its poles. The possibilities of five types of design were considered:

#### **Permanent magnet type**

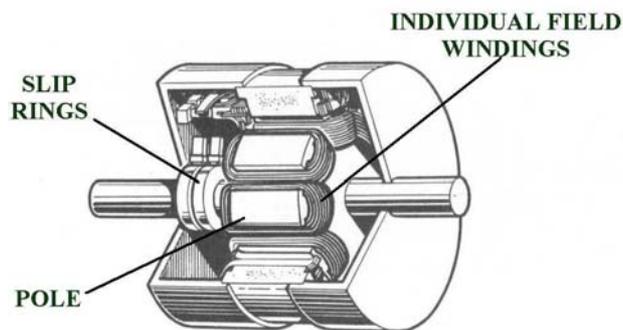
It would be possible to make an alternator with no field winding. A rotating permanent magnet could be used but there would be no easy way to regulate the alternator output. The normal practice is to adjust the field winding voltage to produce the desired output. But with a permanent magnet this form of regulation could not be used and the concept was rejected.

### Inductor type

Rather than have permanent magnet, metal pieces mounted on the rotor could be magnetised by an external inductor. Such an inductor would make the alternator twice the size of the other alternators under consideration, so the concept was rejected.

### Salient pole type

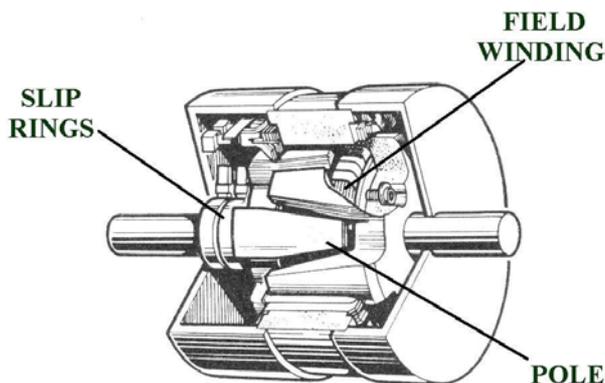
In this design a series of poles were individually energised by their own field winding to produce the magnetic field. The first type of military alternator was of the salient pole type and was scaled down from industrial applications. They were developed in the USA but were produced under licence in the UK by CAV. The main advantage was the flexibility in design size. They could be made long and thin or short and wide for a given output. The disadvantage was that a high current was needed for the field windings and that required a relatively bulky and expensive regulator.



*The rotor of the salient pole type, the AC output winding is not shown.*

### Imbricated pole type

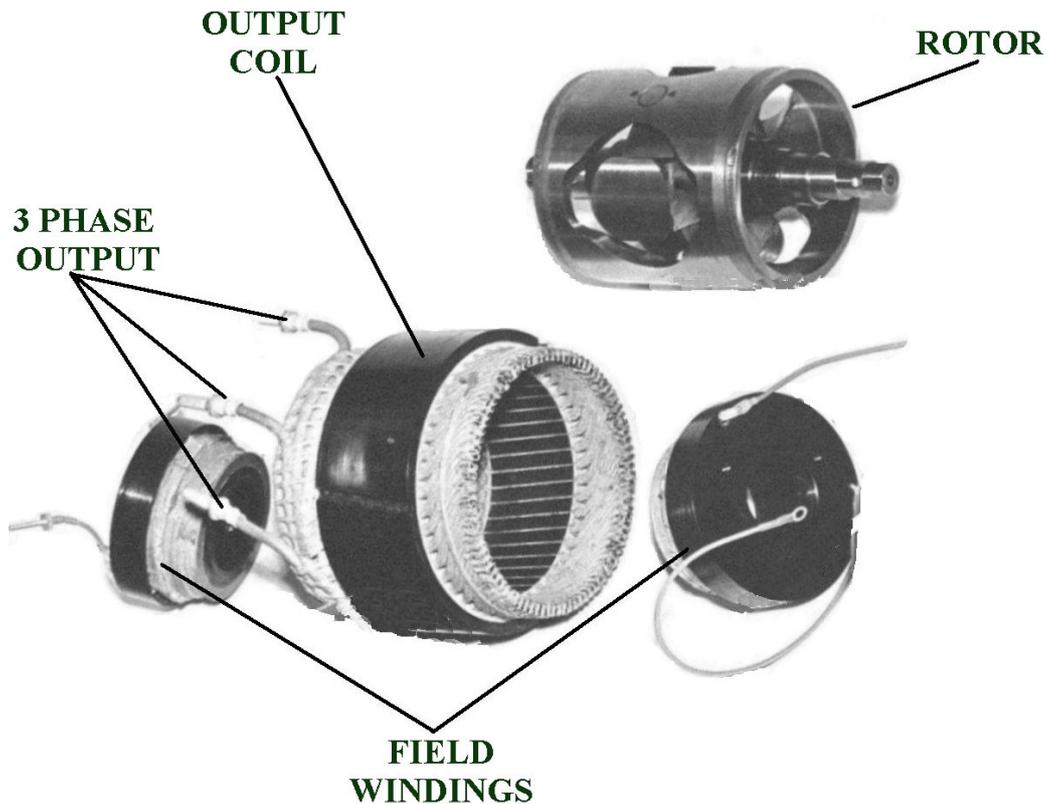
The design of the imbricated pole used a single field winding wound around the rotor core, which energised a series of poles equally. Unfortunately the design meant that the rotor had to be short but wide and that gave a higher moment of inertia than a comparable salient pole type or even a dynamo. CAV found that manufacturing costs for imbricated pole alternators was less than for salient pole alternators. When CAV started to manufacture military alternators to their own design it was of the imbricated pole type. In the motor industry it is sometimes known as a claw-pole alternator.



*The rotor of the imbricated type, note that only one field winding is required.*

### Brushless alternators

A drawback of alternator design was the need for brushes and slip rings to provide current for the rotating field winding. The 1958 Farnborough Air Show saw the display of brushless alternators from English Electric and Rotax Ltd. In addition Joseph Lucas (G.T.E.) Ltd was displaying a hydraulic drive motor coupled to a Rotax brushless alternator. These two companies were later to combine forces to develop charging systems for the FV430 Series and Chieftain. The Rotax idea was to have two fixed field coils that acted upon a rotor which was a magnetic tube with six areas cut out. The protrusions of the metal that remained formed magnetic poles of one polarity. The rotor shaft accommodates six spokes that radiate outwards that provide poles of the opposite polarity.



*The Rotax brushless rotor arrangement.*

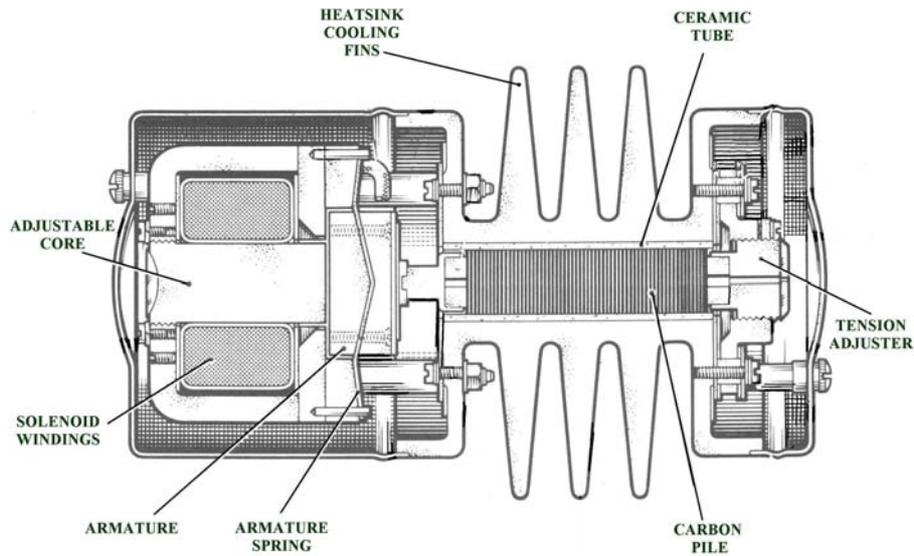
### **The complete charging system**

The alternator is only part of a charging system; there are two other elements, the rectifiers and the regulator. By definition an alternator produces AC this must be changed by the rectifiers to DC to be able to charge batteries. Some French cars used to have single-phase alternators as they were relatively cheap but they gave low output. Modern cars and in particular military vehicles have heavy electrical demands and invariably the alternator output is three-phase AC. In smaller alternators the rectifier diodes are mounted within the alternator, but in larger alternators the rectifiers are in a separate unit. This has several advantages:

1. The rectifiers are removed from the heat of the engine area and the heat from the alternator, which itself needs to be cooled by its own fan or oil cooled from the engine.
2. It makes it easier to develop a reliable alternator that is suitable for wading.
3. It is easier to service and repair the rectifiers if they are not built into the alternator, which would otherwise need to be removed.
4. It is easier to tap off a three-phase supply for power tools that are used on some AFVs.

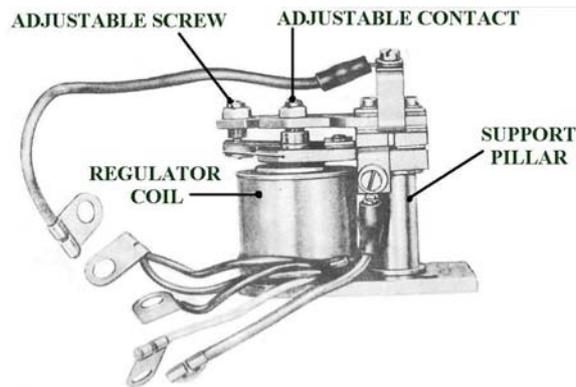
A regulator is needed to reduce the output from the alternator as the batteries become charged. This is achieved by reducing the voltage to the field winding and so reducing the magnetic field, which causes a fall in output voltage. This can be achieved by:

1. Carbon pile regulators, which are a stack of carbon discs held inside a ceramic tube within a casting formed into a finned heatsink. The discs are held in compression by a spring controlled by a solenoid with its winding linked to the alternator output. The carbon discs are wired in series with the field winding. As the alternator output rises it causes the solenoid to release some of the pressure on the carbon discs, their resistance increases which in turn cause the voltage to the field winding to decrease causing the alternator output to fall. Carbon pile regulators get quite hot and must be positioned to allow a good airflow. They were used mainly for high current regulation before transistors were developed capable of handling such currents.



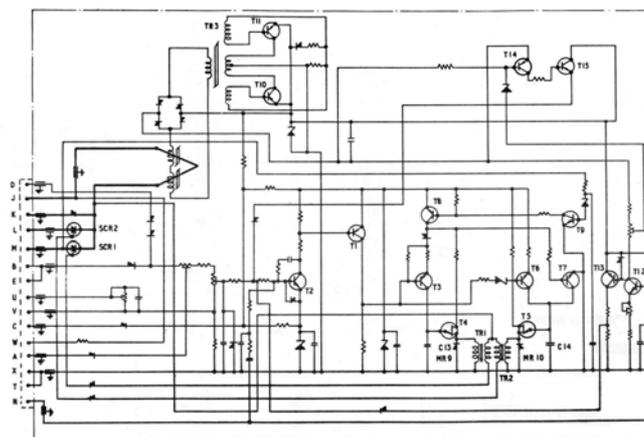
*A typical carbon pile regulator*

- Electromagnetic regulation was the most common form of regulation. In essence it consists of a relay tensioned so that at a pre-set voltage the contacts would open bringing a resistance into the field winding. Designed to operate very rapidly the relay is known as a vibrating contact regulator. Unfortunately this is a source of radio interference.



*Vibrating contact regulator type N66 made by CAV*

- Transistorised regulation provides a smoother way of controlling the voltage to the field winding. Although a basic car regulator can be made from a couple of transistors, military systems are far more complicated. There need to be systems to protect the electronics from excess heat, voltage surges/spikes and reverse voltage. There is much less radio interference than the vibrating contact type.

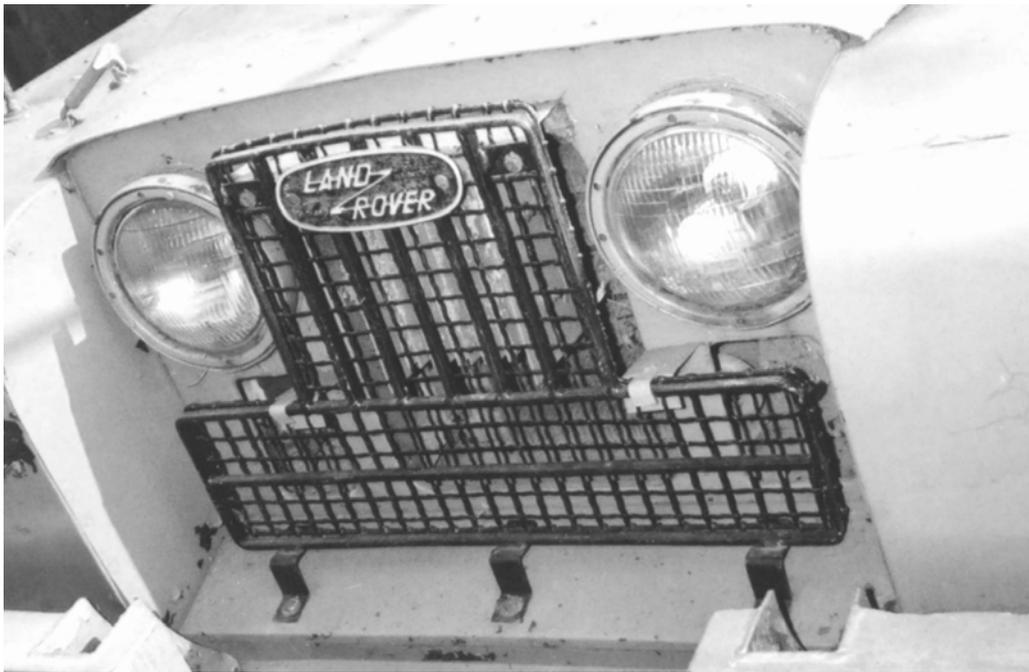


*The complexities of voltage regulator FV342587 used with Alternator No.1, Mk 1.*

### 40-Amp System

The CAV Type AC724/1 generator was the first alternator to see widespread service in the British Army. Unusually a military designation was not used; official literature and the generator itself use only the manufacturer's designation. It was introduced in 1961 as a modification kit to be fitted to the ¼ Ton Rover Mk 3 and Mk 5. The change from 12 to 24 volts necessitated replacing a number of components and repositioning others to accommodate the new equipment.

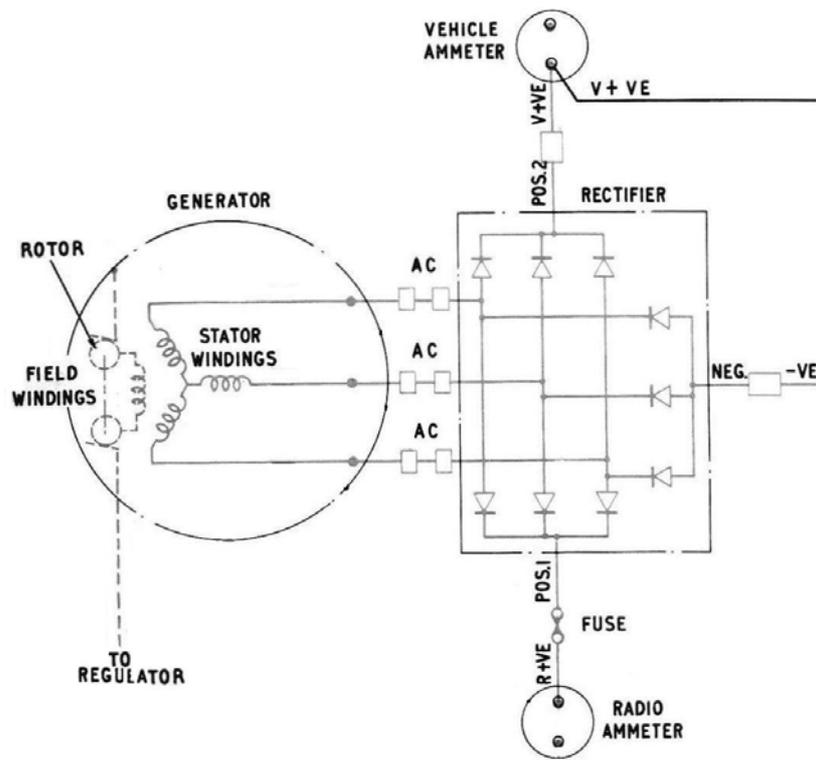
A picture of a Rover modified in this way can be seen earlier in this article. It should be noted that the limitation in the design was the fairly low current handling of the selenium rectifier, which was dependent on not exceeding 80 degrees Centigrade. Unfortunately even mounting the rectifier immediately behind the grill did not give adequate air circulation for the cooling fins particularly when static. In the production FFR Rovers improved rectifier cooling was achieved by making the radiator grill protrude a couple of inches. A substantial frame fitted over the original radiator grill gave it improved protection, often referred to as a 'toast-rack' grill. If a winch was fitted, the mid portion of the lower part of the grill had to be cut away.



*A 'toast-rack' grill. (Photo – Depot 37)*

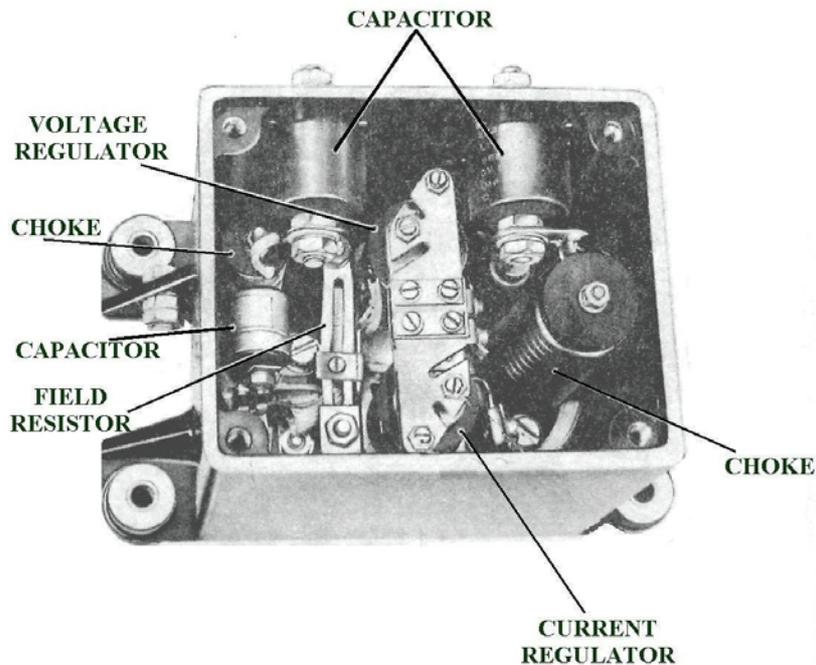
This system was also fitted to early versions of ¼ Ton FFR Rover 8 and ¾ Ton FFR Rover 9 but was superseded by a 90-amp system within a few years. The selenium rectifier contains the equivalent of nine rectifiers, unlike the later alternators that have six rectifier diodes. Apart from acting as a rectifier for the alternator output, it blocks the current flow between the vehicle batteries and the radio batteries. This prevents a faulty or discharged battery from draining power from the other set of batteries. Whichever set of batteries is at a lower charge will receive a higher proportion of output from the alternator. This is different from later systems that use a relay to switch in circuit the radio batteries when the alternator is functioning.

The selenium rectifier was thought to block the flow of battery discharge and there was seen to be no need for an isolating relay as in later systems. Unfortunately the rectifiers do permit a slight leakage and will discharge the batteries. It was recommended that the vehicle be run every two to three weeks to keep the batteries fully charged.



*40-amp generator and selenium rectifier with three groups of three rectifiers.*

The CAV control board was Type 323-2; again no military designation was used. The unit contains two vibrating contact regulators, one for current and one for voltage. In normal use the voltage regulator controls the alternator voltage. In the event of a current of more than 40 amps being drawn the current regulator operates to reduce the voltage. With this protection built in it was realised that the fuse in the radio battery supply was unnecessary and it was later omitted. Within the control panel box are chokes and capacitors to reduce radio interference. Unlike later systems there was no provision to pre-set the charging rate to a lower level for use in the tropics where heat may precipitate gassing from the batteries. As the gas given off is hydrogen, this was important!



*Control board showing regulators and suppression components.*

### Generator CAV Type AC724/1.

Three-phase alternator of imbricated pole design

Alternator : Engine speed 1.8 : 1  
Cutting in speed (24 volts) 840 rpm (engine speed 466 rpm)  
Maximum output (40 amps) 1,330 rpm. (engine speed 739 rpm)  
Field resistance 16 ohms  
Field current 1 amp (fed via brushes & slip rings)  
EMER POWER W100/14 – W109/14

### Rectifier CAV Type RUS-3

Air cooled three-phase full-wave with selenium elements

Forward resistance 10 ohms  
Reverse resistance 1,000 ohms  
EMER POWER W120/3 – W129/3

### Control Board CAV Type 323-2

CAV 'N' type regulator (vibrating contact)  
Voltage setting 28.75-29.25 volts (open circuit)  
Current setting 39.0-41.0 amps  
EMER POWER W110/3 – W119/3

### Ammeters CAV Type W5539/23E

60-0-60 amps (direct reading, they do not operate through a shunt)

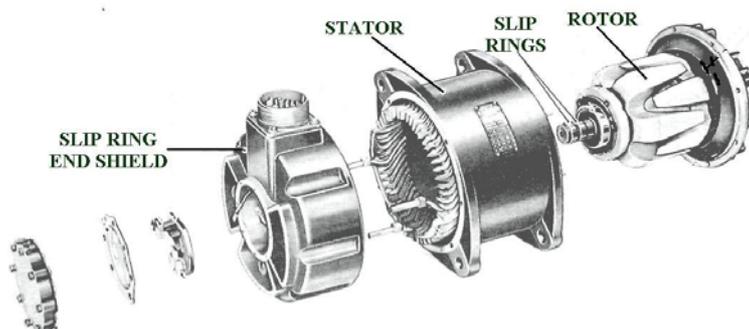
## 90-Amp System

The advent of silicon diode rectifiers allowed alternators to be more powerful, more efficient and more reliable. The new breed of alternators could operate at higher temperatures and were better suited to wading. They produce less electrical interference than a vibrating contact regulator, which is continuously sparking, something that is important in a FFR vehicle.

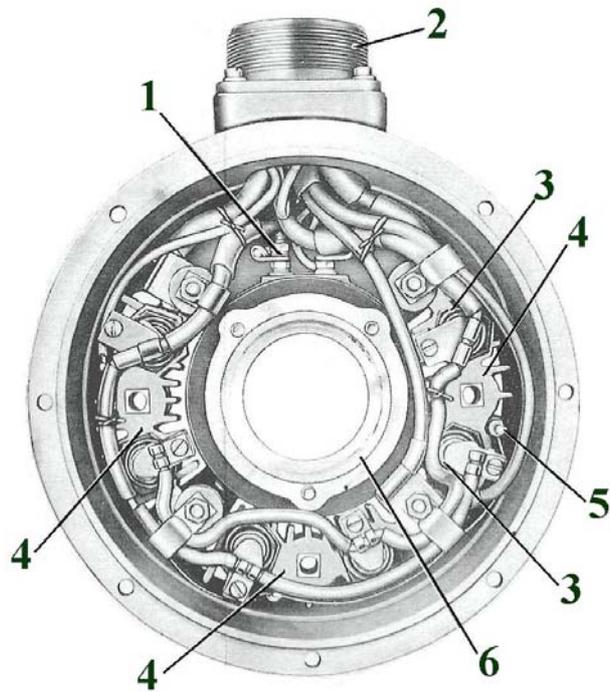
The most widely used 90-amp system was the Generator No.10 and its associated Generator Panel No.9. The system, made by CAV, appeared in the early 1960's and was used extensively in FFR Land Rovers but also found its way into Stalwart, AEC recovery vehicles and BV202E. Some Ferrets and Saracens were modified in an upgrading programme although after five years this was abandoned in Saracens due to "acute shortages" of alternators. The most common set up was Generator No.10 Mk 2 used with Generator Panel No.9 Mk 3. I will describe this system first then at the end outline the main differences with other versions.

### The Generator No.10 Mk 2

This is a 3-phase alternator of the imbricated pole type. It therefore requires brush and slipring contacts to energise the rotating field coil, as this is only at a current of about 1 amp there is usually not much wear on it. The nine silicon diodes are stud mounted on heat sinks which, are insulated from, but in thermal contact with the aluminium casting that forms an end cover over the slip rings. There are six high power diodes that rectify the main generator output and three that are low current and operate the relay in the generator panel. There are three high power diodes DP716 and three DP716A, one type has reverse connections to the other which facilitates direct bolting to the heat sinks. The three low power diodes are DD3026A or CV8871.

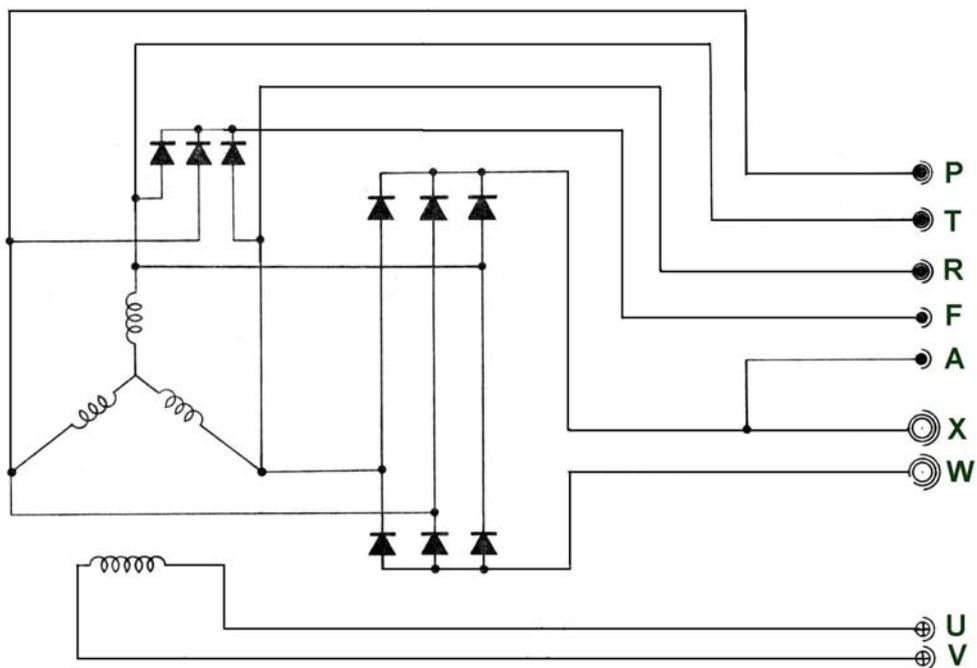


*The rotor shows imbricated poles, which form a 12-pole system.*



Inside the slip ring end shield.

- 1 Terminal
- 2 Plug
- 3 High current diode
- 4 Heat sink
- 5 Low current diode
- 6 Bearing housing



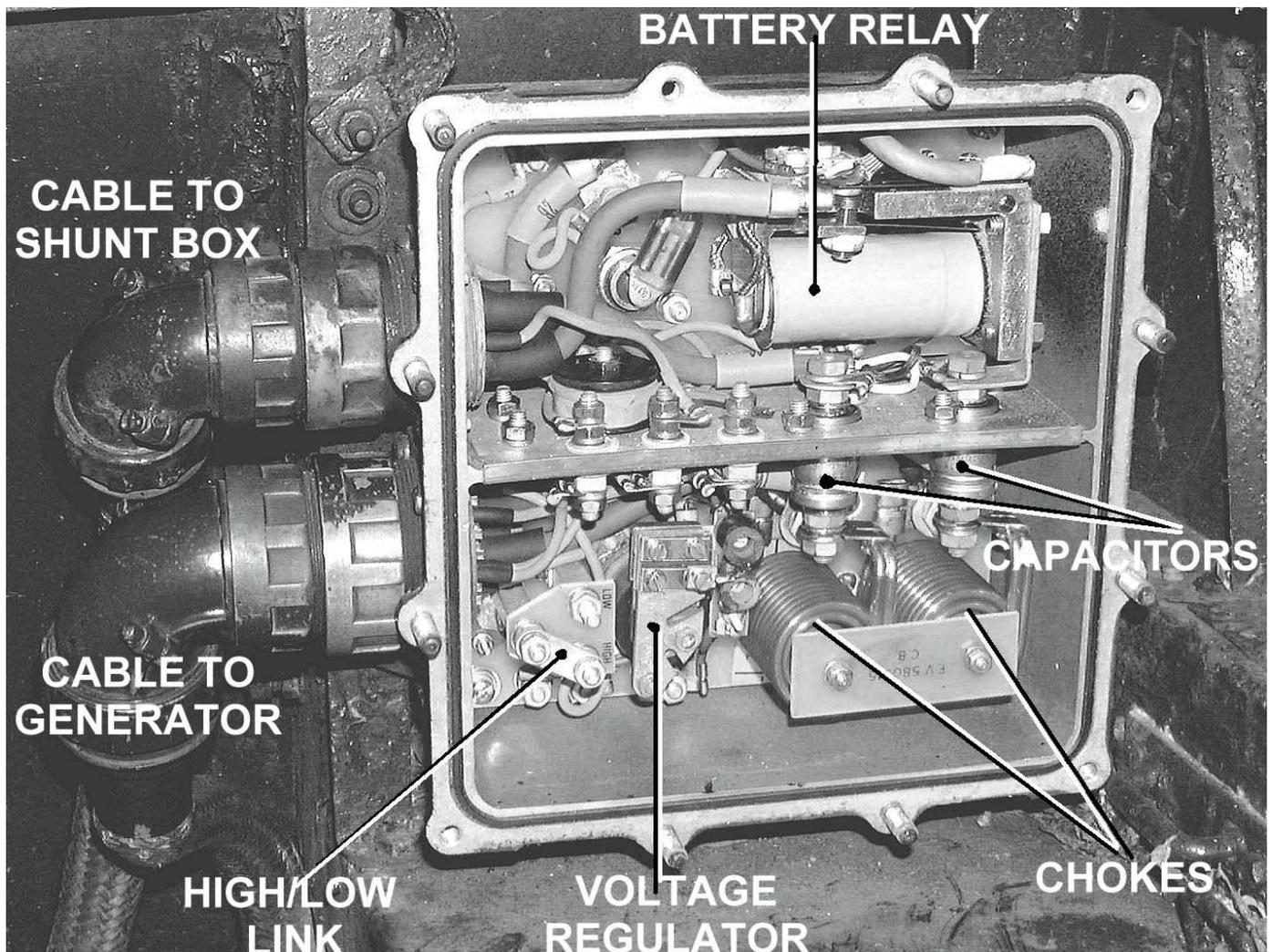
Wiring diagram Generator No.10 Mk 2:

- P-T-R 3-phase AC output
- F +ve DC out to relay
- X +ve DC out 90 amps
- W -ve DC out 90 amps
- U-V Field winding

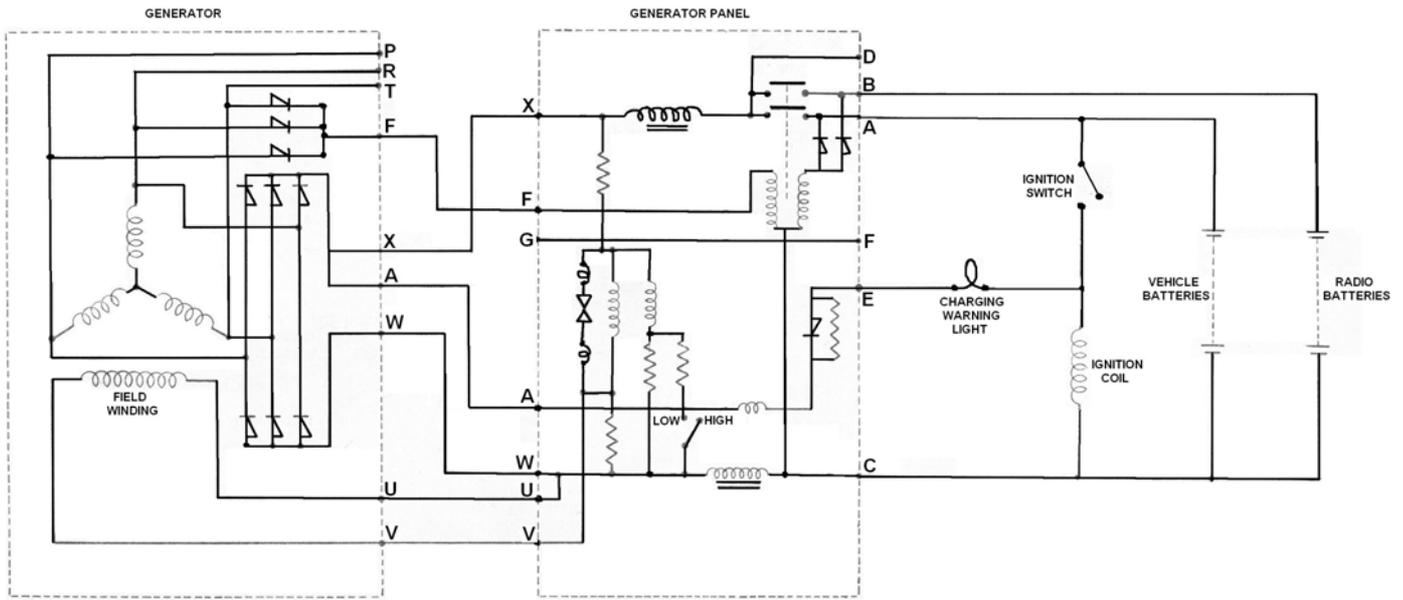
### Generator Panel No.9 Mk 3

This panel is of cast aluminium and divided by a removable partition. It contains:

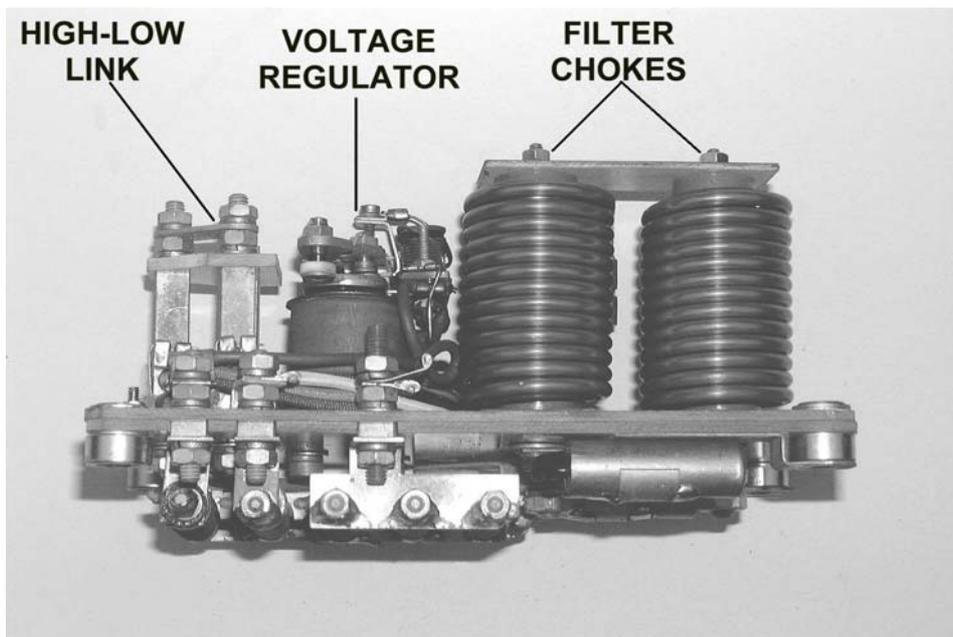
1. A vibrating contact regulator that rapidly switches a resistance into the field winding to maintain a constant voltage.
2. A link to select HIGH or LOW rates of charge, depending on ambient temperature. In high temperatures there is a danger of batteries gassing and a LOW charge rate should be selected. This brings into circuit additional resistance into the field winding.
3. CAV battery relay type BCK102, which has two separate contacts to switch the two sets of batteries on line during charging. The coil is energised from the generator via the three low power diodes from pin 'F' of the generator.
4. Interference filtering circuitry. This comprises a screened compartment, chokes and capacitors. Chokes are coils that impede the flow of radio frequency (RF) energy. Capacitors permit the flow of RF and are used to bypass RF energy to earth. Capacitors that incorporate stud mountings are used as they offer a more effective path to earth at VHF than the more usual wire ended type. In addition they form rigid points to terminate leads.
5. Protective diodes to prevent damage in the event of batteries being connected with reversed polarity.
6. Resistors that effect, load and temperature compensation and charging rate.
7. Connections to the shunt box which in turn supply the ammeters.



*Generator Panel No.9 Mk 3 installed in a Rover 1.*



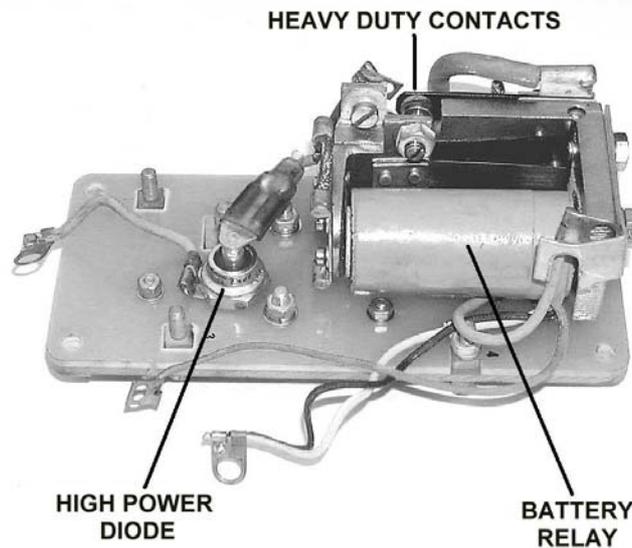
*Generator No.10 Mk 2 & Generator Panel No.9 Mk 3, for the sake of clarity redrawn without capacitors.*



*The regulator board with resistor group underneath.*

Apart from the main generator output an additional output is provided by three low power diodes and fed from pin 'F' to operate the battery relay. There are two contacts on the relay that connect the generator output to the two sets of batteries. When there is no generator output the vehicle and radio batteries are isolated from each other and from drain by the voltage regulator.

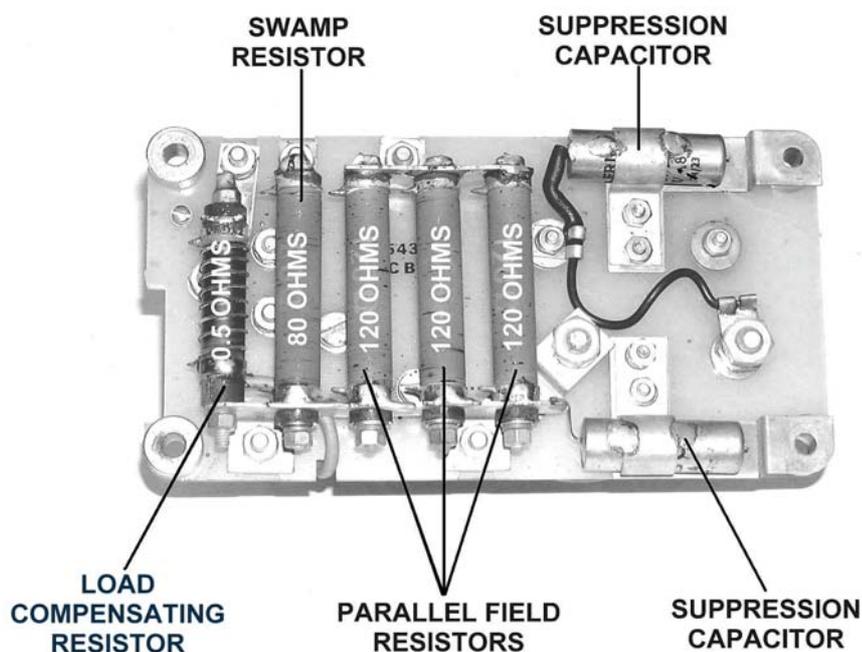
There was a risk that if the radio batteries were not connected that the battery leads could short out. Consequently there was a modification to fit a high power diode across the battery relay terminals and a fast acting fuse in the shunt box. From 1974 when the modification was done in manufacture or in the field the figure '3' was struck off the modification plate.



*The board with CAV Relay Type BCK102 and modified with the protection diode.*

There are three sets of resistors mounted under the regulator board:

1. The 'swamp' resistor (80 ohms 6 watt) in series with the regulator coil offsets the effects of temperature changes on the regulator coil.
2. The 'load compensating' resistor (0.5 ohms 4 watt) is connected across the field winding and in series with the regulator coil. Under heavy load there is a voltage drop across the resistor which keeps the regulator contacts closed and gives a stronger field current needed for heavy charging loads. It is usual to see evidence of this resistor having got extremely hot!
3. The 'parallel field' resistors are each 120 ohms 6 watt and wired in parallel they give a resistance of 40 ohms rated at 18 watt. They are wired across the voltage regulator contacts. With the contacts open the resistors are in circuit and limit the current to the field winding, as the generated voltage falls the regulator contacts close shorting out the resistors and applying a higher voltage to the field and thus increases output.
4. The 'HIGH/LOW' resistor is 750 ohms 1.5 watt and is mounted on the top surface of the board close to the high/low link. With the link set to 'LOW' the resistor is wired in parallel with the 'parallel field' resistors to give an effective resistance of 38 ohms. This limits the charging rate in hot climates where there would be a risk of gassing from the batteries.



*The resistor board mounted rather inaccessibly under the regulator board.*

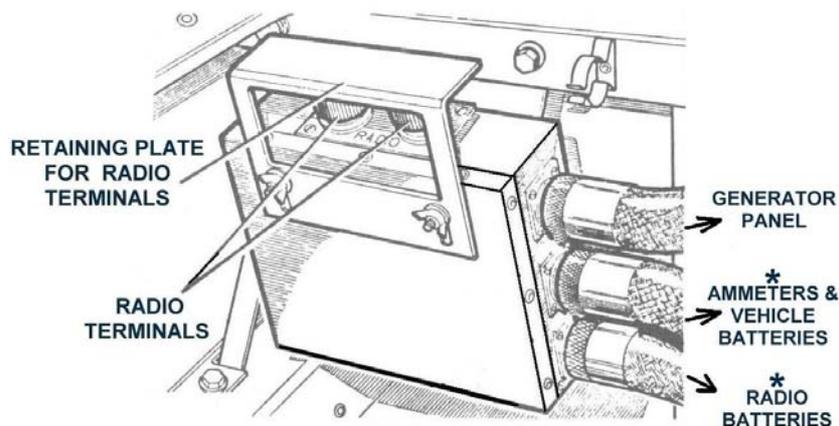
## Shunt Box for double ammeters

Its purpose is to:

1. Accommodate shunts for ammeters to monitor the charging rates in both vehicle and radio batteries.
2. Distribute power to the vehicle and radio batteries.
3. Provide a power point for the radio installation.
4. In later versions to accommodate a quick blow fuse.

It is useful to monitor the rate of charge and discharge for both the vehicle and radio batteries. This is achieved by ammeters mounted in the vicinity of the dashboard. In the old 40-amp system the ammeters were fed by the whole power system, requiring thick cables to minimise voltage drop. With the early 90-amp system even thicker cables were required which still caused a voltage drop under heavy loads.

Voltage drop can be minimised with a meter shunt. A shunt is a precision resistor that carries most of the current and allows a microammeter to only receive a small current but in proportion to the current flow in the shunt. The two shunts Type Z5913/30 are mounted in Shunt Box Type 466-3 in the rear of the vehicle whilst the ammeters can be mounted where they can be read easily and fed with more modest wires. The ammeters are calibrated 100-0-100 amps i.e. they can measure rate of charge in one direction and when there is battery discharge the needle moves in the opposite direction. The terminals for connecting the radio equipment were mounted on an insulating plate at the top of the box. Unfortunately the plate was retained by round head screws which risked short-circuiting when several leads were connected. They were later changed to countersunk screws. The other problem was that the terminal thread proved to be a bit short; this was corrected by assembling the insulating washers in a different way.



\* ON SOME INSTALLATIONS CABLE POSITIONS ARE INTERPOSED

*The CAV shunt box which contains two shunts.*



*The centre reading microammeter which must always be used with its shunt.*

### Generator No.10 – other Mk3

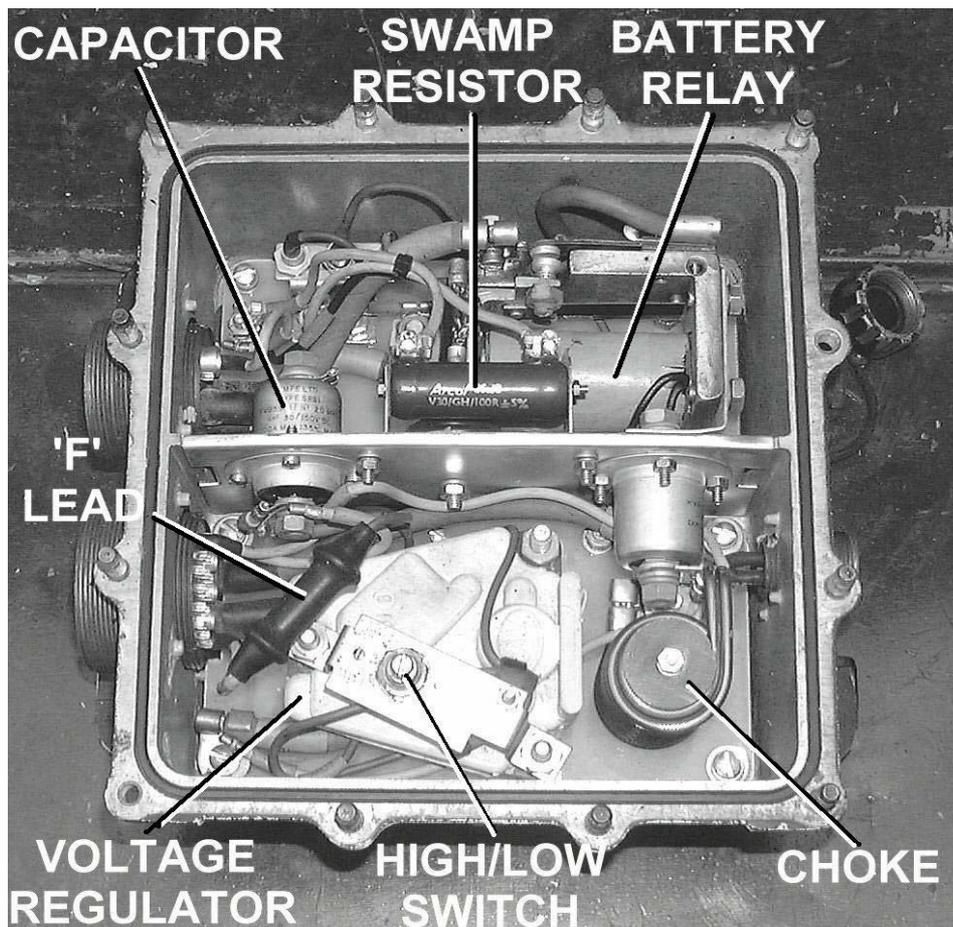
The next most common generator is the Mk 3, although physically similar to the Mk 2, there are two significant differences. Firstly there is no provision for an AC output, so pins P, T and R are not connected. Secondly the three diodes for the auxiliary supply are of a much higher current rating in the Mk 3 generator. Indeed there were at least two versions of diode type that had been used in this role to withstand the demands placed on them by the newer Mk 4 generator panel.

The Mk 2 generator, like the earlier versions Mk A and Mk 1, had a three-phase AC output for power tools. Very early Stalwarts are quoted as sometimes having both Mk A and Mk 1 types fitted but they never seemed to make use of the AC facility. The only application I can find equipped for this AC facility is the Truck, 1 Ton, Air Portable General Purpose, 4x4, Rover (APGP).

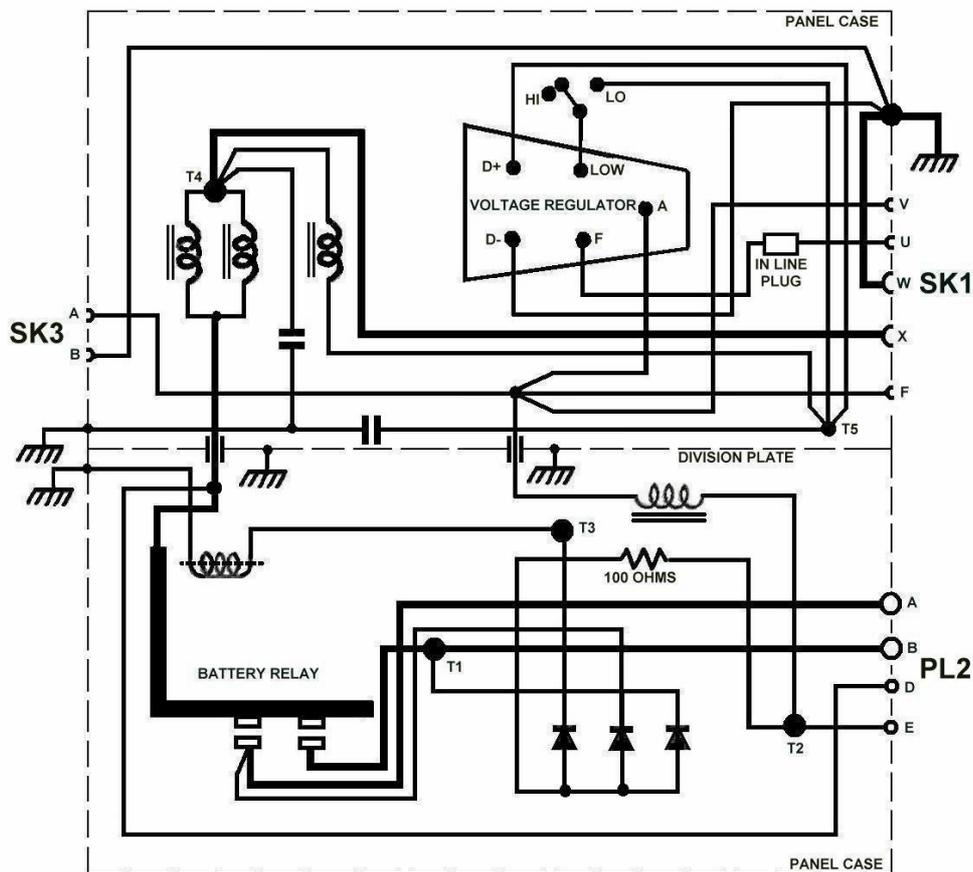
### Generator Panel No.9 Mk4

The differences in the Mk 4 panel are:

1. It uses an encapsulated voltage regulator instead of the vibrating contact type of earlier versions. The Type W6317-31B regulator is based on switching transistors.
2. The battery relay was replaced by CAV Type DR24 (or BCK10).
3. Pin 'W' (GEN -ve) is earthed via an external stud, so good earth bonding to chassis is essential.
4. The charge warning light (field tickling) is different, in SK1 pin 'A' is not used.
5. The HIGH/LOW selection is by a switch to the regulator module rather than a link to a resistor.
6. There is only one resistor, a 'swamp' resistor of 100 ohms.
7. There is an additional socket SK3 to permit connection to Surge Protection Unit No.1 Mk 1 for the protection of sensitive electronic equipment. In installations where this is not needed the hole is blanked off with a protective cap.



*Generator Panel No.9 Mk 4.*



*Wiring diagram Generator Panel No.9 Mk 4, T1-T5 are terminals.*



*Generator Panel No.9 Mk 4 looking much like earlier panels except the additional two-pin socket.*

### **Shunt Box for single ammeter**

The shunt box for the transistorised panel only needs one shunt for the single ammeter, which is contained in the unit itself. As the ammeter dial must be seen easily, the shunt box is usually installed between the two front seats. The ammeter only measures the charge to the radio batteries and can be illuminated internally by pressing a push button on the front of the box. The ammeter reads 0-100 amps i.e. it can only read rate of charge, it cannot measure discharge. Like the centre reading ammeters of the earlier systems it is used in conjunction with an identical shunt Type Z5913/30. The shunt box also acts as a distribution point for cables to the vehicle and radio batteries. For protection against short circuiting of the radio battery leads when disconnected, a fast blow cartridge fuse is fitted together with a spare fuse. The charge warning light is routed through the shunt box, being connected to PL2 pin 'E' on the generator panel.



*The shunt box for the transistorised regulator.*

### **Generator Panel No.9 Mk 2**

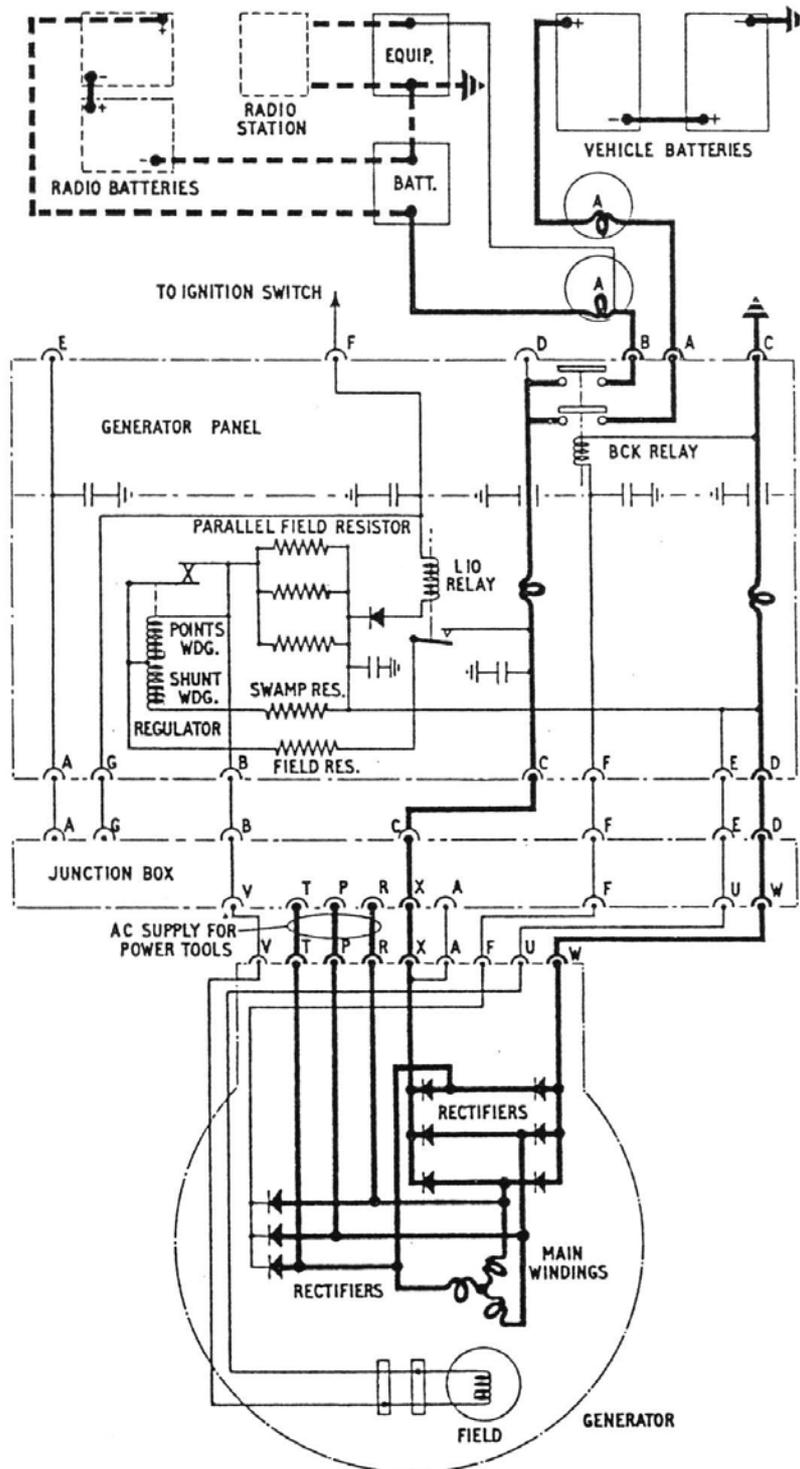
The Mk 2 panel differed from later panels by:

1. An isolating relay in the field winding wired to the ignition switch through a silicon diode. In the event of reversal of the battery leads it will protect the generator diodes. Relay CAV Type L10 and diode DD3026.
2. A battery relay with pillar terminals and grub screw retention rather than leads from relay being wired directly to the plug. Type unknown but it replaced the CAV BCK96 used on Mk A.
3. No provision for HIGH/LOW charging adjustment.
4. Compatibility, via a junction box, to accommodate three-phase AC output provided by the earlier generators for power tools.
5. Later versions of Mk 2 had plug PL2 pins 'A' and 'B' reversed.
6. The lid was sealed with *Bostick C*, which proved unreliable as it was an adhesive and needed re-application after opening the lid. Later panels used a sealing compound.

### **Generator Panel No.9 Mk A & Mk 1**

Both Mk A and Mk 1 are listed amongst several types of charging system used on early Stalwarts. The only other vehicle I can find that used the Mk A was the Truck, 1 Ton, Air Portable General Purpose, 4x4, Rover. This rather underrated Land Rover has been a source of fascination for its facility to float with airbags. I think it is more notably in that it was the first airportable Land Rover and the first 1 Ton Land Rover.

A further feature is that it seems to have been the only 'B' vehicle to have had an AC power tool facility. An installation for power tool operation needs a junction box between the generator and generator panel. The junction box merely acts as a convenient place for the generator leads. For power tool operation the generator lead is removed from the junction box and plugged into a Power Tool Transformer Unit.



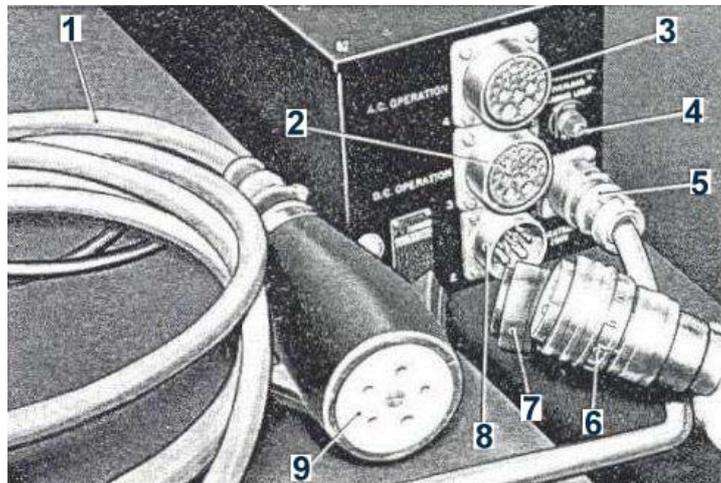
*Generator No.10 Mk A and Generator Panel No.9 Mk A with power tool facility.*

The transformer unit provides 208 volts 400 Hz three-phase AC for the power tools and at the same time 28.5 volts for battery charging. To obtain the required output the generator must be run at 4,000 rpm, which means the engine must be run at 2,250 rpm, which is maintained by a governor. The transformer has three windings:

1. The primary winding is connected to the AC output from the generator.
2. The main secondary is connected to the power tool socket.
3. The second secondary is connected to a bridge rectifier to provide a DC output of up to 30 amps. This is fed to the generator panel for charging in the normal way.

With power tool use it is important that the charging rate does not exceed 30 amps otherwise there will be damage to the rectifier diodes. It might seem surprising that if the engine speed is too low that there will also be overheating. This is because a voltage of too low a frequency will cause heating in a transformer designed for a higher frequency.

To protect the unit a thermal switch is fitted adjacent to the diodes and another by the transformer. Both thermal switches are connected to a relay, which will break the circuit in the field winding. When the relay is tripped a warning light will glow in the 'Press to Test' button. If power tool operation is likely to be needed again it is not necessary to disconnect the Power Tool Transformer Unit as a through connection is provided so that generator is connected to the generator panel without transferring connections to the junction box. The unit is supplied with a twenty-foot extension cable for the power tool.



#### *Power Tool Transformer Unit*

- 1 *Extension cable for power tool*
- 2 *Generator socket for DC operation*
- 3 *Generator socket for AC operation*
- 4 *Warning light*
- 5 *Extension cable plug*
- 6 *Generator harness*
- 7 *Generator panel harness*
- 8 *Generator panel plug*
- 9 *Power tool socket*

#### **Complete Installations**

The two most common installations of generator and generator panel are:

- Generator No.10 Mk 2 used with Generator Panel No.9 Mk 3 (two ammeters, non-transistorised)
- Generator No.10 Mk 3 used with Generator Panel No.9 Mk 4 (one ammeter, transistorised)

The impression given is that the Mk of generator must match the Mk of the generator panel. This is because they were introduced together and when described in User Handbooks it seems as if they are inseparable. The main difference in the generators is that the Mk 2 has a three-phase output but this facility is rarely used and the Mk 3 merely has those connections missing.

It seems therefore possible to use either generator with either generator panel. If a Mk 3 installation is replaced with a Mk 4 panel it will for the time being work normally, but the other way round the charge warning light won't work although the system would still charge.

It should be borne in mind that the auxiliary output from the Mk 2 generator has only to power the winding of the main BCK relay and no great demands are placed on the auxiliary diodes by the Mk 3 generator panel. However the demands on the auxiliary supply for the Mk 4 generator are much greater as this supplies regulation for the field supply. Consequently the auxiliary diodes of the Mk 3 generator are of a higher power rating of than those in the Mk 2 generator. So much so that at least two types of diode were used to increase their power rating.

A keen eye can be used to identify an early Mk of generator from a Mk 3 and indeed the three versions of Mk 3 depending on the diode size, position and the shape of the generator case.

I have never found any EMERs on the transistorised panel, although there is basic diagram in some User Handbooks. It seems the data was only published as an AESP supplement and I have only been able to find it as a FAESP i.e. on microfiche. The circuit diagram that I have produced for the transistorised panel was derived by a rather lengthy process. The microfiche reader produces distortion, the illumination density is quite varied over the screen, and there are the inevitable specks and scratches on the reader and the fiche. I took a digital picture, then inverted the black/white ratio, gradually stretched the image horizontally and vertically to get a linear image. No amount of processing would make up for the poor contrast and blurring. So I had to gradually redraw the whole image, which took about eight hours! Curiously all the EMERs on the 40-amp system were still listed as demandable publications even until 1984.

For further details of the 90-amp system see All Charged Up 3 which includes a fault finding flow chart. More comprehensive descriptions and detailed fault finding can be found in All Charged Up 4.

### **Glossary**

**Armature** – The rotating part of a generator usually in relation to a dynamo.

**Brushes** – Spring-loaded contacts, usually of carbon, that make contact to the armature/rotor through the commutator or slip rings.

**Commutator** – The rotating switch on the armature that changes the direction of current flow in a dynamo.

**Field windings** – The coil producing the magnetic field.

**Generator** – A rotating machine to produce electricity. Alternator for AC. Dynamo for DC.

**Pole** – One end of a magnet that is created around a metal core that is energised by the field winding.

**Rotor** – The rotating part of a generator usually in relation to an alternator.

**Shunt** – A precision low-value resistor wired across the terminal of an ammeter to extend its range.

**Slip rings** – The rotating contacts on the rotor that make continuous contact with the output windings in an alternator.

**Stator** – The non-rotating parts of a generator.

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