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# LUCAS

## TECHNICAL SERVICE

### OVERSEAS TECHNICAL CORRESPONDENCE COURSE

#### Section 4 GENERATORS



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# INTRODUCTION

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Electrical generators are almost as commonplace as batteries and similarly are specially developed and adapted for different purposes.

They range from the enormous 60,000 Kilowatt Turbo Alternator Generator down to the small toy generator which we 'gave Bobby for his Birthday.' In principle they are all the same. A magnetic field is created generally by electro magnets and within this field, conductors mainly of copper, are moved through it. The cutting of the lines of force of the magnetic field cause current to be induced in the conductors or armature windings, which is collected by slip rings in the case of the alternator, or a commutator in the case of the direct current generator. One of the most common characteristics of generators is that they run at a constant speed, although a limited number of special applications necessitate variable speed, amongst these being automobile generators.

For automobile work D.C. or Direct Current has been used for many years, but more recently alternating current equipment has been developed for general use on motor cycles and whilst this rapidly advancing form of current supply offers numerous attractions, it will inevitably create many problems if and when applied to automobiles.

So far, the voltage of the supply for vehicle work has been limited to 6, 12 and 24 volts, and, as previously discussed, there are sound reasons for recommending that 12 volts is the most suitable for light vehicles, and 24 volts for heavy vehicles, particularly for passenger transport work.

A feature of the low voltage D.C. generator as applied to the modern light or heavy vehicle is its ability to operate and control the amount of current necessary, through an average speed range of 600—6,000 r.p.m.; also at any given moment sufficient current for battery charging, lighting, etc.

The amount of current needed at a given time will of course vary between one vehicle and another, as for example the requirements of a vehicle which may be in service anywhere between the equator and the antarctic.

The problem of obtaining a reasonably uniform current supply over a wide speed range was solved originally by what was known as the 'Leitner third brush system of dynamo control' and for the limited requirements of those early motor vehicles, was moderately satisfactory. The system has one serious limitation however, that of not being able to easily regulate the current supply to accommodate changes in 'demand.' This led to the development of multiple position charging switches which incorporated the use of resistances. Furthermore, the tendency of the generator to overheat, strictly limited the amount of current which could be made available from a reasonable size machine.

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A major development has been the Constant Potential or Constant Voltage System of battery charging, which, suitably adapted, was applied with success to the larger vehicles for some time before it became widely used on light vehicles and finally on motor cycles.

The principal features of this system as applied to vehicle work are :

That it provides a source of supply at an approximate constant voltage over a wide range of generator speeds. Also, having fixed the voltage of this supply at a suitable figure it is then possible to provide, by virtue of the difference in terminal voltage between a 'charged' or 'discharged' battery, a charge rate which will automatically adjust itself to the state of the battery, i.e., a heavy charge, when the battery is low and a progressively smaller charge as the battery comes up. This is commonly referred to as a 'tapering charge.' Furthermore, if an additional load is applied to the circuit by switching on some or all of the lights, the generator will put out sufficient additional current to provide for this load without drawing from the battery as the original equipment supplied on the vehicle is properly balanced to achieve this. Therefore some caution is necessary in installing additional equipment which might, for example, result in a partial or constant state of discharge of the battery, with consequent short battery life on the one hand, or persistent overloading of the generator on the other.

One feature about what is now called the 'Compensated Voltage Control System' and which should be very clearly realised is that the generator and its combined voltage control and cut-out unit are 'A PAIR' on any particular vehicle and the control box cannot be exchanged haphazardly even for one of the same general type as the original. This is because the compensating series or load windings on the voltage regulator vary to suit the overall requirements of each different vehicle. Unless such exchanges are made by reference to an interchangeability list, unsatisfactory performance in service will result.

As you proceed with your study of generators you will be impressed with the extreme simplicity both as to their construction and to the small range necessary to equip the large number of makes and models of vehicles to which they are applied.

To-day's generators provide many thousands of miles of running with little or no attention whatsoever in whatever territories or conditions the vehicles may be used. This is a first-class testimony not only to modern production methods but more particularly to the Design and Development people without whose prolonged and unremitting work such results could not be obtained.

Close and carefully maintained tolerances, careful selection of the correct materials, extensive endurance tests for all conditions of running, followed by similar tests in various territories, add up to precision built components and the average motor engineer who values the goodwill of his clients, may think very seriously before departing from the original manufacturers component parts for service fitment.

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## STUDENT'S QUERY PAPER

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# Working Principles

## THE GENERATOR.

Electrical machines can be divided into two broad groups: machines which convert electrical energy into mechanical energy, such as the starter motor, and machines which convert mechanical energy into electrical energy.

The generator or dynamo falls into this second group; it is driven from the engine by a belt or gears and produces electric current for charging the vehicle battery and supplying the various circuits.

We shall now discuss the principles upon which its operation depends.

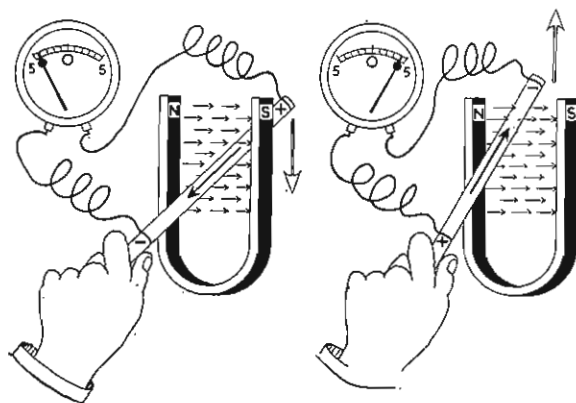
## CREATION OF AN E.M.F.

As we have said, we start with mechanical energy. A simple experiment such as the one we show you here will illustrate the fundamental principle involved.

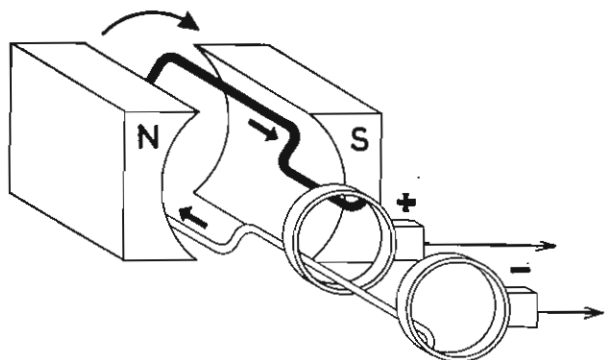
When a conductor is moved in a magnetic field, a force called an 'electro-motive force' or 'e.m.f.' is induced into it. If the conductor forms a closed circuit, an electric current will flow which will register on a sensitive meter.

You will notice that when the direction of the mechanical movement is reversed, the current flow is also in the reverse direction.

The conductor is cutting the lines of force of the magnetic field which exists between the North and South poles of the horseshoe magnet.



THE GENERATION OF AN E.M.F.



## ROTATION OF WIRE LOOP IN MAGNETIC FIELD.

Carrying this principle a stage further, we can introduce a single loop of wire free to rotate in a magnetic field. If both ends of the loop are attached

to metal rings, called 'slip-rings,' electric current can be collected from the loop by means of brushes making contact with the rotating rings.

Voltages are induced into the conductor when, due to its rotation, magnetic lines of force are cut.

The magnitude of these induced e.m.f.'s, which can be measured in volts, will depend on these factors:

- (1) The intensity of the magnetic field.
- (2) The speed at which the conductor cuts the lines of force.
- (3) The angle at which these lines of force are cut.

Maximum voltage is induced when the conductor cuts the lines at right angles; no voltage is induced when the conductor moves parallel with the lines of force. The next picture illustrates this last point more clearly.

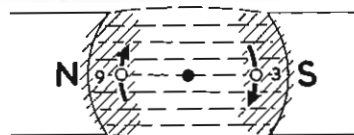
## MAXIMUM AND MINIMUM INDUCTION.

The top illustration shows the areas where maximum induction occurs. You will notice that these are shaded opposite the North and South poles at 9 o'clock and 3 o'clock respectively. When travelling through these areas, the conductors will be cutting directly across the lines of force of the magnetic field.

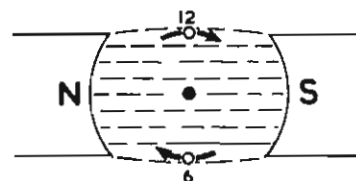
In the lower illustration, however, we show the conductors travelling parallel with the lines of force.

Here, little or no induction takes place, the areas around 12 and 6 o'clock normally being termed 'neutral.'

These neutral points are of importance and will be cropping up again in connection with brush positioning.



MAXIMUM INDUCTION



MINIMUM INDUCTION

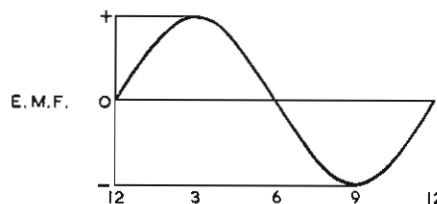
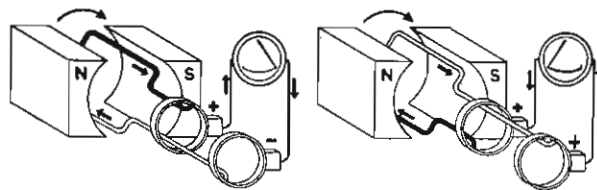
## SINGLE LOOP GENERATOR — WITH SLIP RINGS.

Now if we follow one complete revolution of this loop, which we mentioned previously, looking at the shaded conductor in the left-hand sketch, we shall see that the latter, moving clockwise, will first be cutting lines of force in one direction; and then completing its cycle as in the right-hand picture, it will be cutting them in the reverse direction. Stated simply, it is first travelling downwards through the magnetic field and then upwards. Thus the voltages induced will alter in polarity and the current flow in the external circuit, as shown here by the two meters, will 'alternate' in direction. In other words, we have produced an 'alternating current.' The small arrows indicate the direction of this current in the circuit.

In the left-hand sketch, current leaves the shaded conductor, making the slip ring contacting it through the slip ring positive (+). Current flows round the external circuit, positive to negative and thus back into the loop.

In the right-hand sketch, however, current leaves the loop via the slip-ring attached to the *non*-shaded conductor, making this brush positive. Current therefore flows round the external circuit in the opposite direction. The current flow must therefore reverse in this circuit every time the non-shaded conductor commences to move downwards.

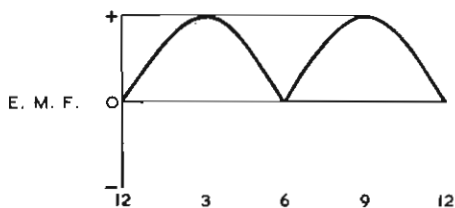
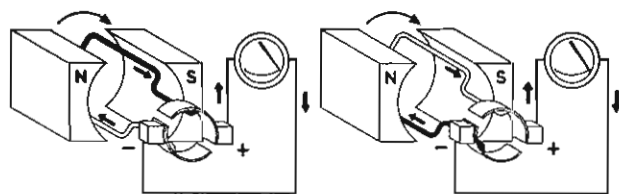
From this graph you can see that the induced e.m.f. and therefore the current, builds up to a maximum in both directions; the maximum points occurring



SINGLE LOOP GENERATOR WITH SLIP RINGS

at 3 o'clock and 9 o'clock, that is when the lines of force are being cut at right angles. As the conductor turns either to 6 o'clock or back to 12, so the e.m.f. is reduced in value, the conductor then travelling parallel with the lines of force.

The bottom diagram thus represents the alternating output obtained from one revolution of the loop and shows the 'Positive Half Wave' above the horizontal line with the 'Negative Half Wave' below the line.



SINGLE LOOP GENERATOR WITH COMMUTATOR

## SINGLE LOOP GENERATOR — WITH COMMUTATOR.

But as we know, alternating current is no good for battery charging; to charge our vehicle battery we must have a *direct* current source.

In order to use our generator then, we must provide some means of reversing the connections to the external circuit of the generator, so as to make the current flow one way only in that circuit. This is the function of the commutator; and in the simple illustration we have chosen, our commutator would consist of a metal ring divided into two halves or segments.

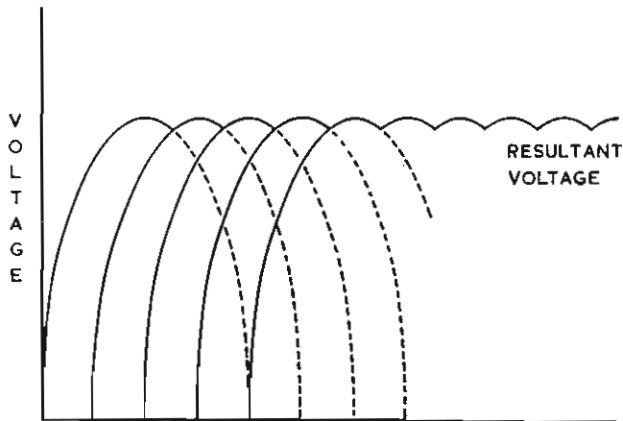
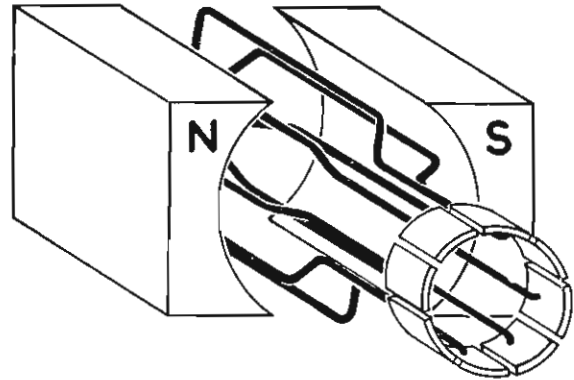
It will be seen that each conductor as it is moving downwards in a clockwise direction, will be connected to the positive brush. Similarly, the upwards moving conductor is always connected to the negative brush. The current in the external part of the circuit will therefore always flow in the same direction — from the positive to the negative brush. The meter now indicates current in one direction only.

You can see from the graph that the effect of the commutator, so far as the external circuit is concerned, is to transfer the negative half-wave to the positive side. The commutator in no way affects the points at which maximum current is induced, these still being at 3 and 9.

## THE PRODUCTION OF PULSATING D.C.

The current output obtained from this single loop generator, although being unidirectional or 'Direct,' will of course fluctuate badly. It will rise to a maximum, fall to zero, and then rise again with the second half of the revolution. So, instead of using one loop, we employ several. We must of course still connect each end of every wire loop to a commutator segment, so that the current in our external circuit will always remain unidirectional.

With this arrangement, the induced voltage never has a chance to fall to zero before the next loop is moving through the areas of maximum induction and passing current. Thus an output which is relatively steady and always at a maximum can be taken from the machine.



## RESULTANT VOLTAGE.

The output from the generator would appear like this in graph form.

The graph shows the series of induced pulses which become superimposed one upon the other. The wavy line on the right represents the effective voltage level at the generator brushes.

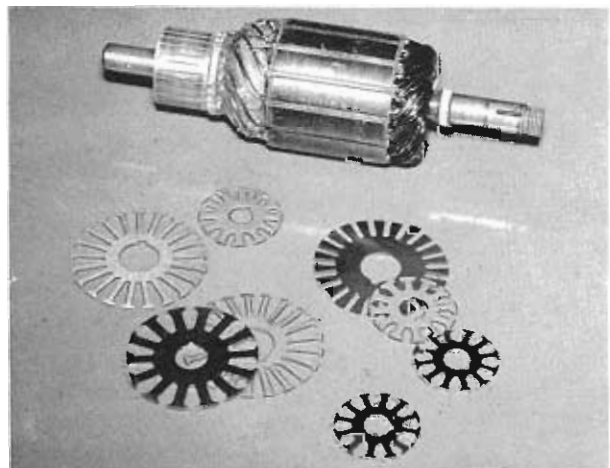
Thus the output we use for battery charging is virtually steady D.C.

## THE ARMATURE.

In practice, the armature assumes the form shown here. It is built round a solid steel shaft. Laminations are added, forming an iron core. The wire conductors pass through the slots in the laminations, the ends of each coil being soldered to separate segments of the commutator. The laminations shown are a selection of the various types.

In the right-hand end of the shaft you can see a keyway, by means of which the generator driving pulley or gear is keyed onto the shaft.

Thus, in effect, we have many loops of wire which we can rotate in a magnetic field.



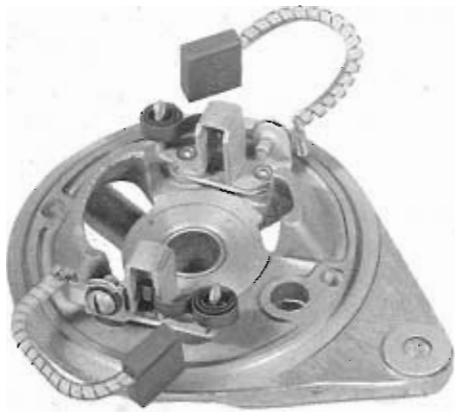
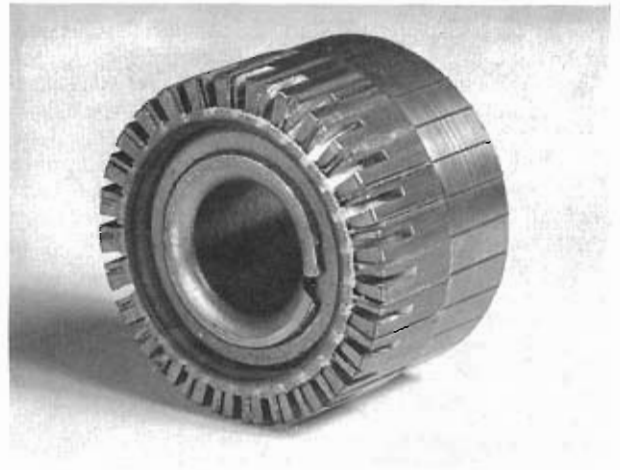


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## THE COMMUTATOR.

This picture of a typical commutator shows the slots into which the ends of the armature coils are soldered. The segments are insulated from one another by strips of micanite.

The commutator is machined to the required size and the insulators are under-cut so that they do not protrude above the level of the segments and so spoil the smooth surface on which the brushes run.



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## THE BRUSHES.

The charging current is collected from the armature via the commutator by means of two carbon brushes which are positioned on the end-bracket of the machine.

One brush is earthed directly to the metal of the end-bracket ; whilst the other is insulated.

Both brushes are spring-loaded and shaped so that they make good electrical contact with the rotating commutator.

These brushes are positioned so that they make contact with those coils passing through areas where maximum induction occurs.

We shall be referring to the brush positioning more fully later on.

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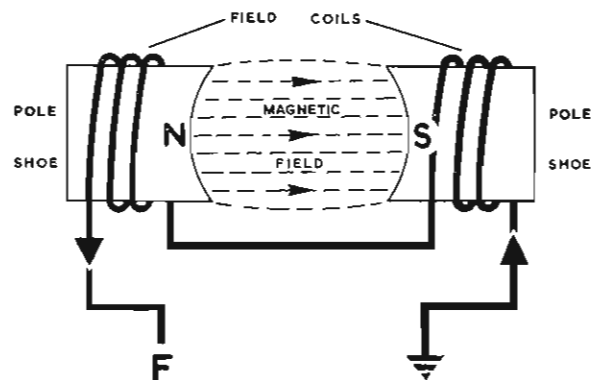
## THE FORMATION OF THE MAGNETIC FIELD POLES.

Having shown you how the armature is built up, we can now consider the formation of the magnetic field in which this armature rotates.

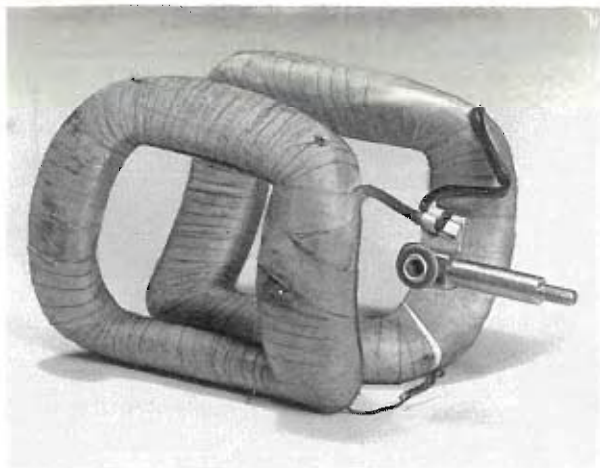
Two coils called ' Field Coils ' are placed in position round two soft-iron blocks called pole pieces or Pole Shoes. They are so wound, that when current passes through them, unlike magnetic poles are produced, North on the left, South on the right.

The current flowing round the field coils is actually part of the current generated by the armature windings. You will notice that one end of the field coil winding is earthed and that the other is connected to a terminal marked ' F ' — the ' Field Terminal ' of the generator.

The armature rotates in the magnetic field existing between these two poles.







### THE FIELD COILS.

In practice we use a pair of field coils such as we show you here. These are two windings linked together and the ends brought out at an external terminal assembly.

One end of the winding is taken to an earth tag, insulated from the rest of the terminal but earthed by a rivet to the yoke of the generator. The other end of the winding goes to the insulated terminal 'F.'



### POSITIONING THE FIELD COILS.

Here you see the field coils and pole-pieces being placed inside the generator yoke. Each coil is insulated by taping and held by one pole-shoe fixing screw. The countersunk hole in the yoke is visible on the left.

### THE YOKE.

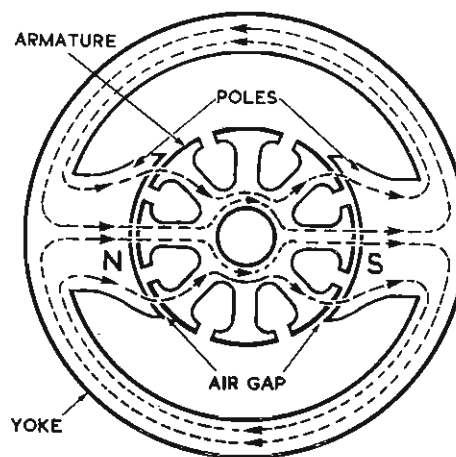
The yoke itself forms part of the magnetic circuit between the two opposing magnetic poles of the field coils.

Lines of force circle round from the North Pole across the air gap, through the laminated iron core of the armature; then across the air gap at the other side to the South Pole. The soft-iron yoke then completes the magnetic circuit back to the North Pole.

You can see that two distinct paths exist between the North and South Poles.

The yoke, then, plays a vital part in the magnetic circuit. You will realise from this how important the air gaps are to the correct operation of the machine. Too large a gap will considerably reduce the efficiency. The pole-shoes too must be properly fitted: they must seat correctly on the inside of the yoke and they must be held tightly by the fixing screws. If the poles are not seating properly, the magnetic flux transference between yoke and pole-shoe will be poor, resulting in low output. Ill-fitting field poles can quite easily foul the armature, resulting in binding and possible damage to the windings.

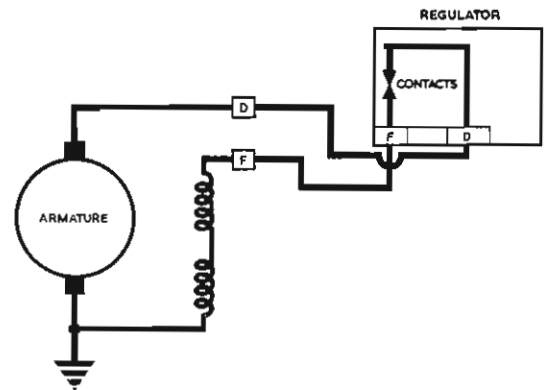
Our next picture shows how the armature and field circuits are interconnected.



## THE ARMATURE AND FIELD CONNECTIONS.

The induced current leaves the armature by means of two brushes. One brush is connected to earth; the other to an external terminal, 'D.' You can see that one end of the field winding is also earthed; whilst the other end is brought out to an external terminal, 'F.' Thus the armature and field windings are connected in Parallel (Shunt connected), the machine being termed 'Shunt-Wound.' For the generator to build up a voltage suitable for battery charging, the circuit between terminals D and F must be closed externally. In practice this is done through a pair of contacts in the voltage regulator.

When D and F are joined and the armature rotates, the induced armature current is able to flow through the field coils, thus energising the pole-pieces and producing the North and South poles of the magnetic field.



THE ARMATURE AND FIELD CONNECTIONS

## RESIDUAL MAGNETISM.

You may ask how the soft-iron pole-pieces are initially magnetised to North and South polarity — that is, before the machine charges and the field coils are energised. Each generator is 'Motored' on leaving the production line, the fields being energised by an external current source. Afterwards, as we have seen, the machine is 'Self-excited': that is, it is able to energise itself by virtue of the magnetism remaining in the pole pieces.

After the machine has once charged, sufficient magnetism remains in the pole-pieces to create a weak magnetic field. Thus when the armature begins to

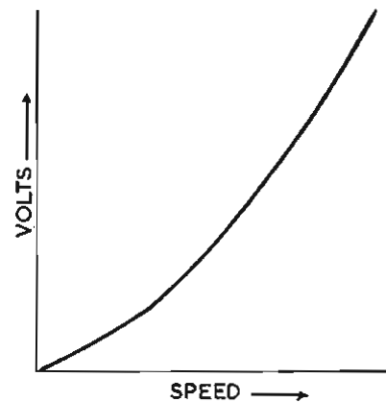
rotate, a weak current is induced into the armature windings. As these windings are in parallel with the field coils, current will also flow through the field. The magnetic flux existing between the North and South poles will therefore be rapidly increased, resulting in increased induced voltage and hence greater output.

You can see then just how important this 'residual magnetism' in the pole-shoes is. Without it, there would be no generation of current. You may bear this in mind for when we come to the testing of the generator.

## CHARACTERISTICS OF THE SHUNT-WOUND GENERATOR.

The generator we have described — the shunt-wound type — quickly reaches its charging speed. The generated voltage then continues to rise as the driving speed increases. You can see from the graph that the output curve is practically a straight line; that is, the voltage rises in direct proportion to the speed.

You will realise why this is so when you recall that earlier we mentioned that the magnitude of the voltage induced in the rotating armature windings depended upon the speed at which the conductors cut across the lines of force. The greater the speed, the greater the induction.



Output to speed characteristics' of a plain shunt wound generator

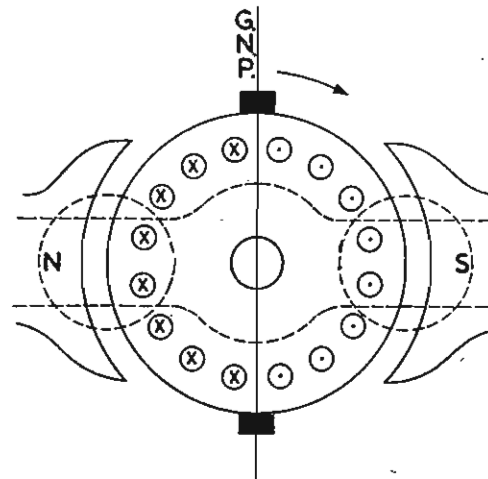
## THE GEOMETRICAL NEUTRAL PLANE.

A further word about the positioning of the brushes. You will remember that we mentioned earlier that the brushes in a generator are so arranged as to contact each commutator segment just as the relative coils are passing maximum current. This means that the coils in question are at that time opposite the pole-shoes, that is, at 3 o'clock and 9 o'clock.

Logically, therefore, there is no reason why the brushes too should not be positioned at these points. But, you will notice that they are drawn here at 12 and 6 o'clock, i.e., at the points of minimum induction or neutral points.

Generally speaking, the armature is so wound that, although the conductors in question are passing through areas where maximum induction takes place, the ends of each coil group are brought out to segments under the brushes at the neutral points.

There is a good practical reason for this: positioning the brushes in what is termed the 'Geometrical Neutral Plane' would in theory prevent sparking when commutation has occurred and the segment in question is leaving the brush.



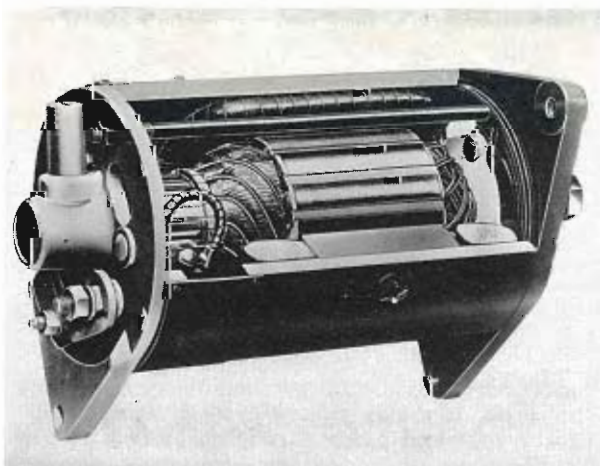
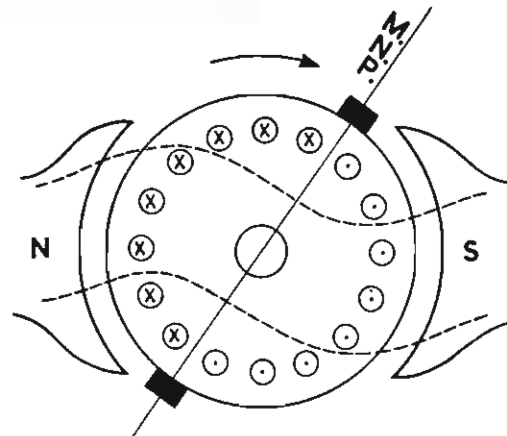
But in practice a complication arises: what is geometrically the neutral plane is magnetically not so.

Because the armature windings are passing current, they produce their own magnetic field, as we have indicated by the dotted rings. This armature field distorts the main North-South field of the pole-shoes — which we shall show in the next picture.

## THE MAGNETIC NEUTRAL PLANE.

Here you see the resultant field. Notice how the neutral plane has been swung round in the direction of rotation. It is now marked M.N.P., i.e., Magnetic Neutral Plane. So as to keep the brushes at the neutral points to avoid sparking, the brush position too has to be off-set in the direction of rotation.

For the record, this phenomenon of the armature producing its own magnetic field is known as 'Armature Reaction.'



## BRUSH POSITIONING IN PRACTICE.

When we come to the actual production machine however, we find that an apparent contradiction arises. The brushes of Lucas generators are positioned almost in line with the pole-shoes, so that the ends of the coils have to be twisted through an angle necessary to bring them from the neutral plane to the brushes.

We stress, however, that the reason for so positioning the brushes is purely constructional — the through bolts in this case prevent the brushes from being placed in what would theoretically be their true position.

However, from an electrical point of view, the theory of the brushes being positioned in the neutral plane to prevent sparking still holds good. They are displaced physically, merely for the convenience of construction.

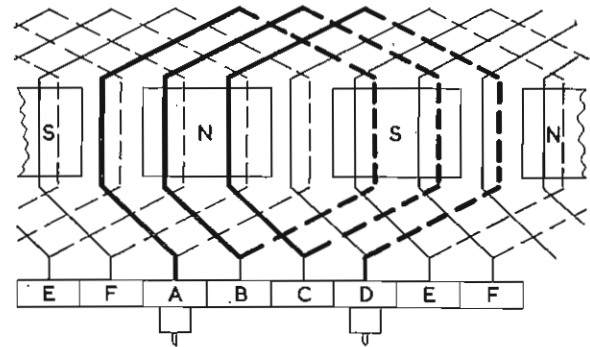


## THE LAP WOUND ARMATURE.

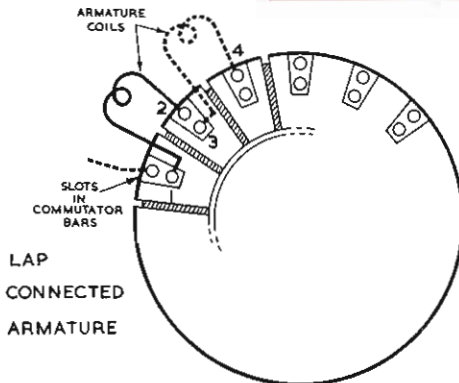
There are two main methods of winding armatures : 'wave winding' and 'lap winding.' The difference lies in the actual armature coil to commutator segment arrangement.

As all our modern production generators are 'Lap Wound,' we shall show you this method only. You can see what we mean by the term if you imagine the commutator and the coils flattened out.

The end of one coil is connected to the same segment as the beginning of the next coil. Follow the coil from segment 'A' round to segment 'B,' and then from 'B' to 'C' and so on. The coils are thus connected between adjacent segments. The current path, however, is from the brush on segment 'A,' through the series of the coil windings to the other brush on segment 'D.' In other words, the output we collect at the brushes is all the current flowing in coils 'A' to 'D.'



LAP WOUND ARMATURE CIRCUIT

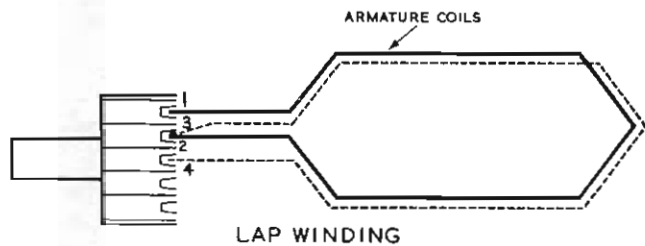


## ARMATURE COIL INTERCONNECTION.

This picture will give you a further insight into the method of interconnecting the coils.

The ends of each coil winding are brought out to the correct commutator segment. Follow the numbers from 1 to 4 and you will see how one coil is joined via the segment to the next coil.

The winding continues in this manner round the commutator, two coil ends being soldered in the slots of every commutator segment.



A more practical illustration indicates how the coils lie round the armature.

Each coil may consist of seven to ten turns, depending upon the type of machine the armature is intended for. You can see that we have just shown one turn of each coil for the sake of simplicity.

The number of coils varies with the type of generator, but the present-day C45 machines for instance possess 14 coils, each one consisting of two windings.

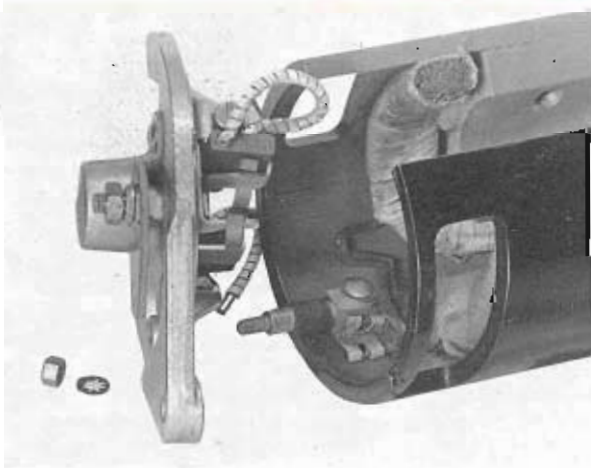
This means that there are 14 slots in the armature core and 28 commutator segments.

## GENERATOR INTERNAL CONNECTIONS.

From this picture you can obtain a good idea of the absolute simplicity of the modern vehicle generator in its practical form.

Here we are pointing out the electrical connections, showing the disposition of the field coils and the field terminal, together with the commutator end-bracket complete with two Brush Boxes. One of these Brush Boxes is earthed to the metal end-bracket, the other is insulated, the external 'D' terminal being connected directly to it. The Brushes themselves have flexible leads or 'Pigtails' which carry the current to the D terminal and earth respectively via the Brush Boxes.

The Field terminal assembly is rivetted to the generator yoke and passes through a bushed hole in the end-bracket.

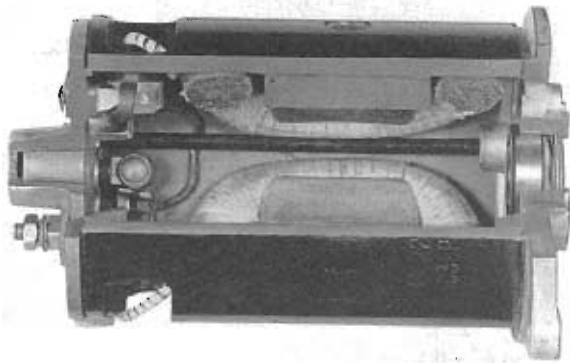
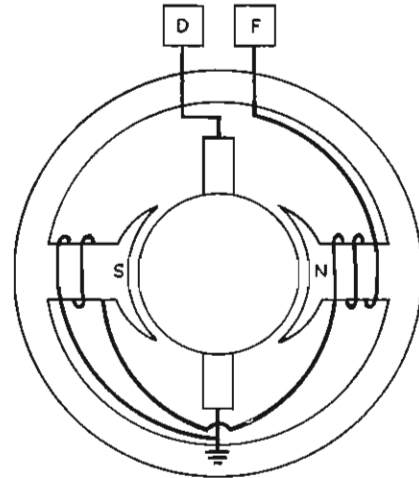




### THE GENERATOR-DIAGRAMMATIC.

The generator is diagrammatically represented in the manner shown in this picture.

The external terminals D and F are indicated, together with their connections to the insulated brush and field coils respectively. The earth brush and the earthed end of the field coils are connected to the yoke direct.



### THE GENERATOR BEARINGS.

The generator armature is carried in a heavy ball bearing at the driving end, and for all ordinary applications, a porous bronze bush is sufficient at the commutator end. For special applications however, ball or roller bearings are used.

The ball or roller races are packed with grease on the assembly line, requiring no further attention during service. An oil-hole or grease filler is provided for lubricating the bearing bush. (Refer to end of Part 2 — 'Lubrication.')

### VENTILATION.

One further point must be mentioned in connection with the construction of generators, and that is, ventilation.

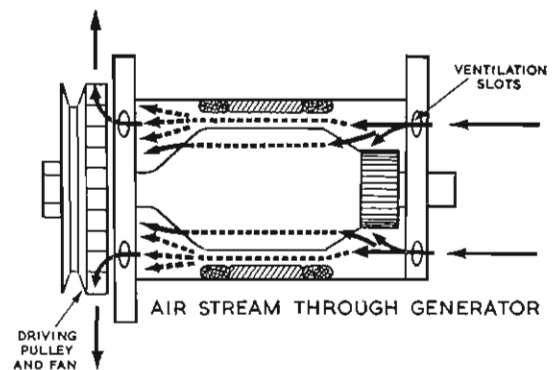
When the machine is generating current, it is doing work and producing heat in the armature windings. If the machine is to work efficiently, giving its full output, this heat must be dissipated.

To this end, ventilation slots are provided in both end-brackets of the machine and a special type of extractor fan is fitted at the back of the driving pulley. This draws air through the generator; in via the slots in the commutator end-bracket and out via those in the driving end-bracket.

The latest machines have specially designed slots in the C.E. bracket which deflect the air stream straight on to the commutator and the armature windings.

In this way, the cooling is greatly improved, resulting in a higher output being obtainable.

Where operating conditions are such that ventilation is impossible — for instance when generators are used on agricultural and marine equipment — a completely enclosed machine is employed to prevent the entry of dirt and water. This enclosure causes



the running temperature to be rather high, so that only a moderate continuous output may be taken from the machine. The use of a special voltage regulator is necessary to control the output so that it never exceeds the rated maximum. The generator is thus protected against overheating, avoiding damage to the insulation of the windings.

# Generator types, applications, symbols, maintenance

## STANDARD GENERATORS TYPES C39, C45 AND RA5.

We can now consider modern production generators, that is, the series of standardised generators which are fitted to practically all British cars, light com-

mercials and tractors now being produced for both Home and Overseas markets.

There are three main types : C39, C45 and RA.5. These basic types comprise of 6 and 12 volt models, fully enclosed or ventilated.

## GENERATOR SYMBOLS.

But first, a word about the identification symbols. You can see that the letter — prefixes refer either to the positioning of the armature or to the shape of the machine yoke. The numerals 39, 45, etc., as in the case with starter motors, again refer to the diameter of the yoke.

Suffixes following the numerals, as you will see later, refer essentially to variations of the original basic type.

These suffixes may be followed by numbers 2, 3, 4, etc., which denote internal design modifications.

The symbols illustrated should be carefully studied as they are of great assistance when handling the units.

## DYNAMO SYMBOLS

### THE PREFIX

C = CONCENTRICALLY MOUNTED ARMATURE  
RA = RECTANGULAR LAMINATED YOKE WITH  
DIE-CAST C.E. BRACKET

### THE NUMERALS

39 = 3.9" DIA. YOKE  
45 = 4.5" " "  
5 = 5" " "

### THE SUFFIXES

P = LONG 2 POLE TYPE  
V = VENTILATED TYPE  
S = SPECIAL EQUIPMENT

## DESIGN FEATURES.

There are several points applicable to all our generators.

- (1) They are designed to fit in with the overall electrical load of different cars. It is this load which dictates the type and size of the generator fitted to a particular vehicle.
- (2) The driving speeds are generally arranged to enable the maximum output of the machine to be available at an equivalent of approximately 20 miles per hour in top gear.
- (3) Each generator is designed to work with a particular regulator or control box.
- (4) All types are generally 'swung-mounted,' with nut and bolt adjustment for tensioning the driving belt.
- (5) The 'cutting-in' speed — that is, the speed at which charging of the battery commences — generally lies between 950—1,200 r.p.m. The maximum safe turning speed for all types is 8,500 r.p.m. The machines are generally run at approximately one and a quarter times engine speed.
- (6) ELECTRICALLY, they are all PLAIN SHUNT, TWO pole machines with Lap Wound armatures.

## THE C39 SERIES OF GENERATORS.

The C39 groups of generators made for 6 and 12 volt working may be either fully enclosed or ventilated. They comprise four machines, the C39P and P2, the C39PV and PV2.

The fully enclosed or non-ventilated types shown here, of which there are two, the C39P and the C39P2, are used mainly for Tractor and Marine work and for any other applications where conditions of excessive dirt and moisture may be present. In this form, these generators which have a cutting-in speed of between 1,050 and 1,200 r.p.m. for the 12 volt models and 950—1,050 r.p.m. for the 6 volt models, produce maximum outputs of 11 amperes for the 12 volt and 13 amperes for the 6 volt, both at 1,600 r.p.m. They will be used for installations where the overall electrical load on the vehicle does not exceed 9 amperes.

*continued*





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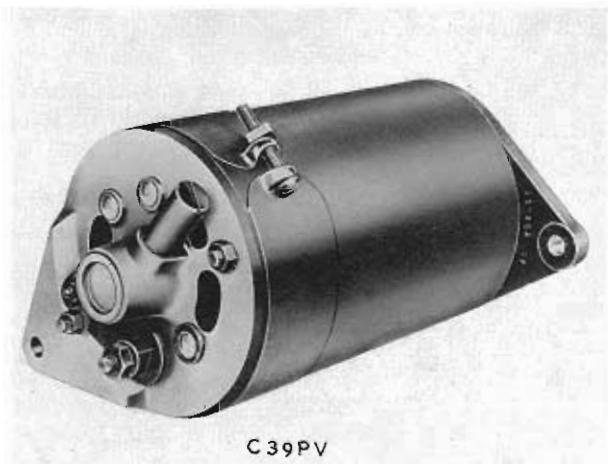
### THE C39 SERIES OF GENERATORS. *continued*

The illustration shows the similarity in appearance of the two machines; the difference between them is that the C39P2 model, which incidentally supersedes the C39, has an armature with a larger commutator and also larger end-brackets.

These machines are interchangeable in Service but it may be found necessary to fit a longer Belt Tension-

ing link where the P2 is used as a replacement for the P model.

The correct Control Boxes for use with these enclosed generators are the RF97 or the later RB107, both of which are fully sealed against the ingress of dirt and moisture, together with special electrical characteristics with which we shall deal at a later stage.



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### THE C39PV SERIES OF GENERATORS.

These are the ventilated models of the C39P Series which we have just described and are basically similar both as to design and general dimensions.

By providing vents in the end-brackets and incorporating an extractor fan with the Driving Pulley it is possible to reduce the running temperature of the machines and obtain higher output. This is the principal difference between the two types.

The illustration shows the C39PV model which is designed for use on vehicles with a continuous electrical load not exceeding 14 amperes. The 12 volt model with a cutting-in speed of 1,050—1,200 r.p.m. has a maximum output of 17 amperes at approximately 2,000 r.p.m. The 6 volt model has a cutting-in speed of 950—1,050 r.p.m. and a maximum output of 21 amperes at 2,000 r.p.m.

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### THE C39PV2.

The generator shown on the left — the PV2 — illustrates a further advance in the ventilating technique.

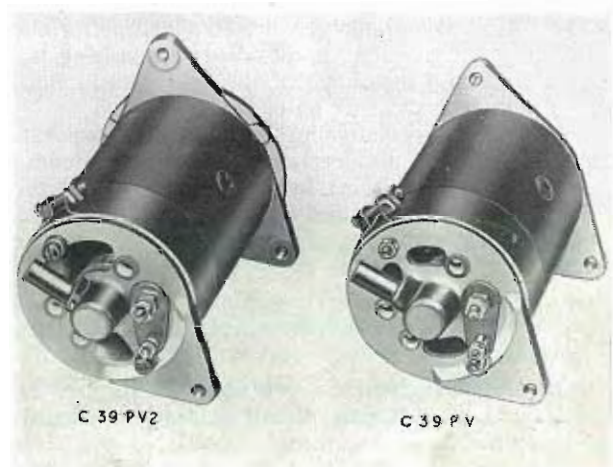
It incorporates an armature with a larger diameter commutator. 'Ducts' in the end-brackets direct the air straight on to the commutator and through the windings. The difference from the earlier PV model is clearly visible in the picture.

The increased ventilation enables a still higher output to be obtained at a safe temperature.

The unit provides for a maximum vehicle load of 16 amperes. The 12 volt model has a cutting-in speed of 1,050—1,200 r.p.m. with a maximum output of 19 amperes at 2,000 r.p.m. The 6 volt model has a cutting-in speed of 900—1,050 and a maximum output of 23 amperes at 2,000 r.p.m.

The Control Boxes for use with the PV2 model are the RF95 and the RB106 as specified.

If this PV2 generator is used as a replacement for a PV model, the correct Control Box must also be used and this subject will be dealt with in the next part of the Course — 'Generator Output Control.'



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## THE C45 SERIES OF GENERATORS.

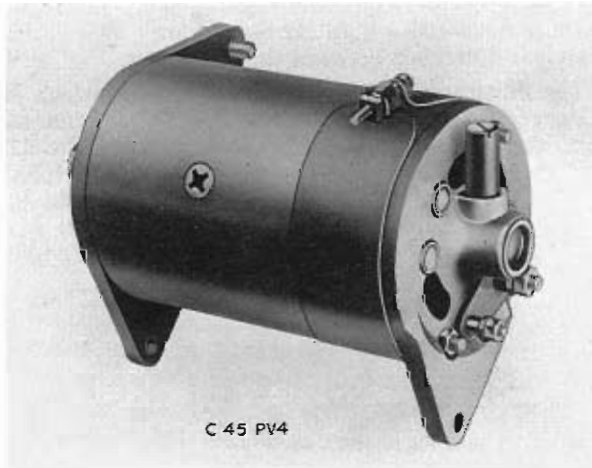
At the present time there are four types of this generator in general use. The enclosed models: the C45P4 and P5 and two ventilated models C45PV4 and P5.

The principal differences between this series of larger size generators and those we have just reviewed are: firstly, higher outputs and, secondly, lower cutting-in speeds.

We show here two of the fully enclosed types which are widely used for Tractor and Marine work.

The difference between the two machines is that the P5 model has larger end-brackets. Made generally for 12 volt working, the enclosed models, with a cutting-in speed of 900 to 1,050 r.p.m. produce a maximum output of 13 amperes at 1,350 r.p.m.

The Control Boxes for use with these two machines are the RF97 or the RB107 to the type specified.



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## THE C45 PV4 GENERATORS.

In general construction this machine is similar to the other ventilated models but has been designed for applications where the driving ratios do not conform to those of the C39PV models.

For use where the vehicle load does not exceed 17 amperes, it has a cutting-in speed of 900 to 1,050 r.p.m. and a maximum output of 20 amperes at 1,650 r.p.m.

The Control Boxes are the RF95 or RB106 to specification.

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## THE C45PV5 AND PVS5.

The C45PV5 is similar to the PV4 except for the provision of additional ventilation by increasing the size and altering the shape of the apertures in both the commutator and driving end-brackets.

The PVS5 is a specially finished machine incorporating Ball Bearings and certain minor design refinements. The Yoke is machined and plated and the End Brackets are of natural finish aluminium. It has generally been applied to High Speed Sports and other special cars.

On these models a very high air extraction rate of approximately 18 cu. ft. per minute at 6,000 r.p.m. is maintained.

Both of these generators are intended for use on vehicles with a continuous circuit loading not exceeding 17 amperes. The cutting-in speed is 900—1,050 r.p.m. with maximum output of 20 amperes at 1,650 r.p.m.

The Control Boxes are again the RF95 and RB106 to specification.





## THE RA5 GENERATOR.

The last of the three main groups of Lucas generators is the RA5. It is the largest of our car generators and came into general use during 1949. It is a very highly finished machine, originally fitted to Rolls-Royce and Bentley cars.

The yoke is black finished and the end covers natural aluminium.

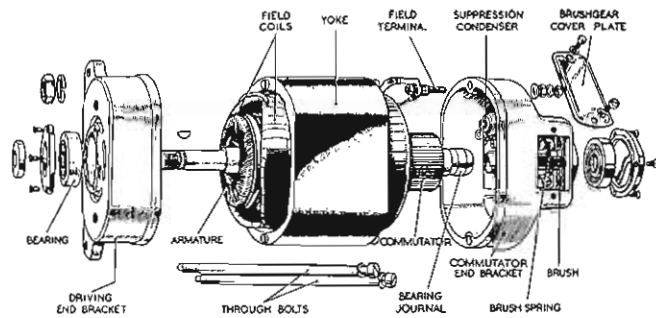
You will notice that the machine is rectangular in construction.

## THE EXPLODED VIEW RA5.

This exploded view shows the special type end-brackets that are fitted and also the suppression condenser in the comm. end-bracket on the right.

There is a ball race at the D.E. and roller bearings at the C.E. of the armature shaft.

Ventilation is provided by a fan at the D.E. and ducts in the end covers.



R A 5 GENERATOR

Like the other generators we have shown you, it is a two pole machine designed for compensated voltage control working and either the RF96 or the RB106/1 control box may be used.

The RA5 has a cutting-in speed of 800—850 r.p.m. and a maximum output of 24 amperes at 1,500 r.p.m.

## GENERATOR SERVICE AND MAINTENANCE.

Service and maintenance is concerned with :

- (a) Commutator and Brushes.
- (b) Commutator End Bearing Lubrication.

Commutators and Brushes on all our generators require only the very minimum of maintenance to obtain entirely trouble-free running. The average brush life on the modern C.V.C. generator is in the region of 60,000 miles or more under normal conditions.

The commutators themselves are very highly finished with diamond tools and the insulators between the commutator segments are under-cut to a depth of approximately one thirty-second of an inch. To obtain the longest satisfactory service it is essential to :

- (a) Use the correct grade of brush. That is, the brush originally installed in the machine.
- (b) Periodically examine the brush movement to prevent sticking in the boxes, which causes sparking and damage to the commutator.

- (c) Occasionally clean the commutator surface, using a soft cloth moistened in petrol. Fine glass paper may be used to polish the commutator if brush sticking and sparking has already occurred.

- (d) Lastly, attend to the lubrication.

As already stated, the driving end bearing is packed with grease and only requires renewal when the generator is completely overhauled.

A porous bronze bush at the commutator end is charged with lubricant when installed. Increasing temperature subsequently releases an adequate amount of lubricant. Adequate, but not excessive lubrication at this point is of some importance. Excessive lubrication will cause oil to be thrown out on to the commutator and for this reason no oil hole is present in these bushes.

Such little attention as is required should be carried out at mileages ranging from 6 to 12,000 as specified in the following pictures.



## LUBRICATION.

If a lubricator is fitted to the commutator end-bracket, it should be half-filled with high melting-point grease every 12,000 miles.

Don't forget to replace the felt pad and spring.

Ball bearing races are pre-packed with H.M.P. grease and need no further attention.

And, remember, porous bronze bushes are pre-soaked.

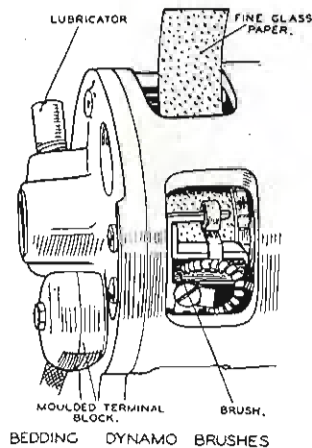
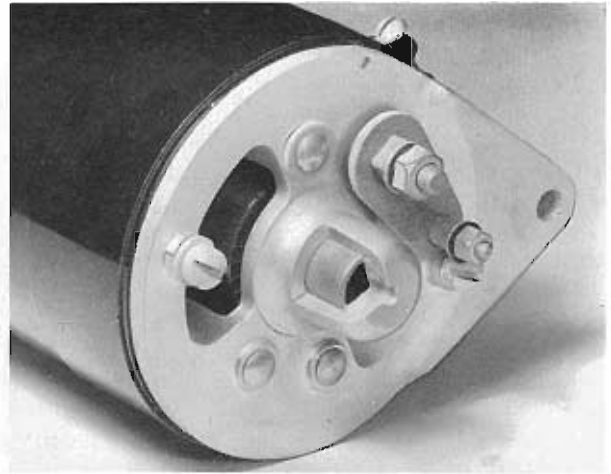
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### THE LATEST OILING ARRANGEMENT.

On the latest C39 and C45 generators, however, the grease lubricator for the C.E. bearing has been replaced.

An inlet hole is now cut in the end of the bearing housing for oiling. A felt washer absorbs the oil, thus acting as a reservoir. In addition, an aluminium washer is located immediately next to the bush to prevent any dirt from entering the bearing.

The oil chamber should be filled every 6,000 miles with a high-quality, medium viscosity engine oil (S.A.E.30).



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### BEDDING BRUSHES TO THE COMMUTATOR.

If new brushes have been fitted, they must be "bedded" to the commutator.

First lift the brushes and pass a thin strip of fine glass paper between the brush boxes and commutator, following the direction of rotation and with the abrasive surface towards the brush faces. Drop the brushes and turn the armature by hand for a few minutes in its normal direction of rotation. Lift the brushes again before removing the paper, and blow out the dust with compressed air, still turning the armature.

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### GENERAL.

You will observe in describing the range of generators we have emphasised three points. The cutting-in speed — the maximum outputs and speeds and the type of control box used.

With any specified driving ratio, the cutting-in speed of the generator will determine the lowest road speed at which the battery will receive a charge, and thus cutting-in speed is largely influenced by the air gaps between armature and pole-shoes.

It follows that the correct clearances should always be maintained and therefore skimming the armature would seriously upset the characteristics of the

generator; the same would also apply to a 'Pattern Part Makers' product which may, or may not, be to the correct dimensions.

Again, given correct air gaps, the maximum outputs will depend upon the gauge of wire used and full number of turns in both field and armature windings.

The significance of the Control Box specifications is in the number of series turns on the bobbin which will affect the ampere outputs obtainable from the Generator. This latter point we will discuss when studying 'Generator Output Control.'

# Testing the Generator

## TEST INSTRUMENTS.

Some time and thought has gone into the development of simple routine Test procedures for general Checking and Fault Finding on vehicles which is both quick and effective and, because of its methodical approach, avoids the possibility of important incidental causes of failure being overlooked.

We have applied such a procedure to generators, so that we can pin down a particular fault to a particular cause. We may then say with all reasonable confidence: 'There's the trouble.'

In order to make our test Routine as widely applicable as possible, the only equipment necessary is a suitably Calibrated Moving Coil Voltmeter and Ammeter: no other equipment is required.

The voltmeter should be a good quality, moving coil, portable instrument scaled from 0—20 volts and a similar ammeter scaled 5—0—25 amperes.

Failure of a generator to charge can be caused by any of the following faults:

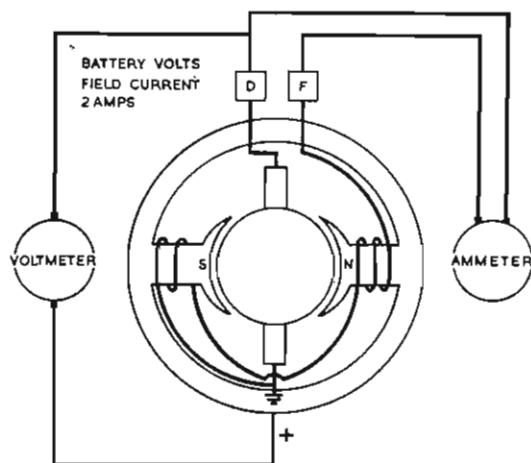
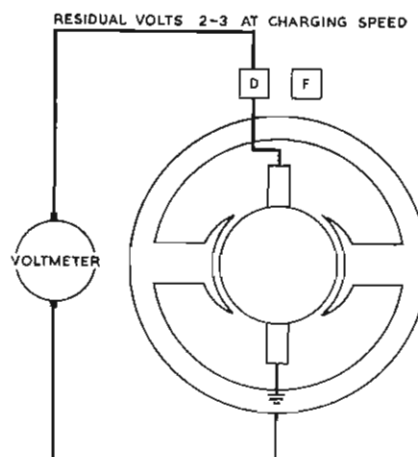
- (a) Slipping or defective belt drive.
- (b) Loose or earthed external connections.
- (c) Sticking brushes.
- (d) Short-circuited, open-circuited or earthed-armature windings.
- (e) One field coil shorted out.
- (f) Both field coils earthed.
- (g) Broken field coil lead, i.e., open-circuited.

## THE GENERATOR ARMATURE CIRCUIT.

For test purposes we may consider that the generator contains TWO internal circuits: the Armature Circuit and the Field Circuit.

THE ARMATURE CIRCUIT which, when the generator is assembled, may be regarded as the armature itself, the Brushes which bear on the commutator, the Earthed Brush Box and the insulated Brush Box which connects to the 'D' terminal.

If run at a good speed, the generator, with Field disconnected, is capable of developing a pressure of between 2 and 3 volts by virtue of Residual magnetism alone, providing that the armature windings are sound and the Brushes properly bearing on the commutator, and provided that these components are free from any EARTH, OPEN CIRCUIT or SHORTING FAULTS.



## THE FIELD CIRCUIT.

If we close the field circuit by connecting our ammeter between the D and F terminals, still leaving the voltmeter between D and earth, and increase the generator speed slowly until the nominal battery voltage of the system is reached (i.e., 6 or 12 volt), the ammeter should then register 2 amperes.

This reading of 2 amperes at either 6 or 12 volts is a fair measure of the resistance of our two field coils in series, providing that no earth, open-circuit or shorting fault exists on the field coils themselves or on the connecting leads. We shall shortly be showing you how this may be applied in practice when testing a generator on a vehicle.

Before we do this, we must consider if the machine is being driven correctly — this step will be the first to take.

Do let us formulate this complete test in a Routine of operations.



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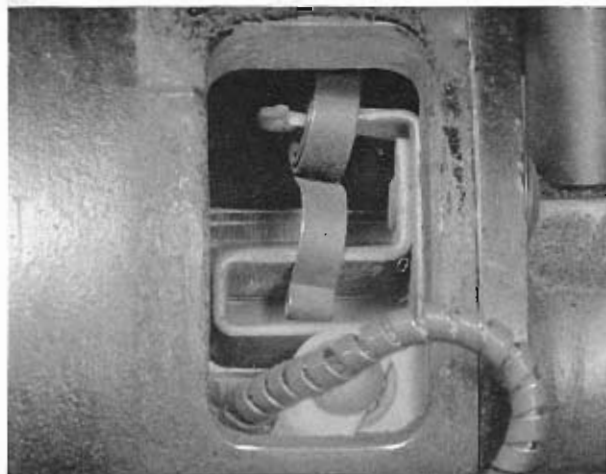
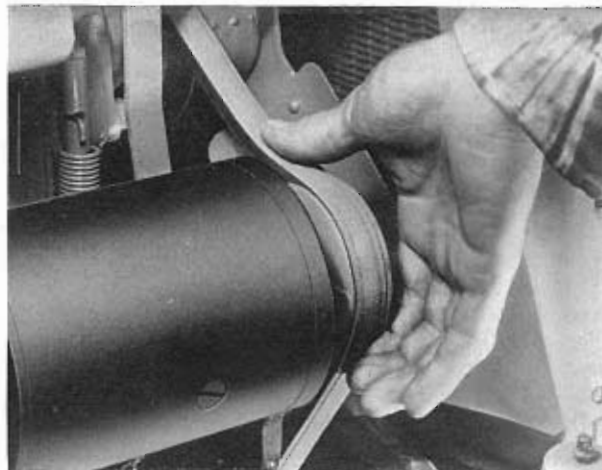
## CHECK THE DRIVING BELT. OPERATION 1.

There should be about half an inch to an inch movement in the belt, tested at this point. And remember that a belt that is excessively tight not only strains the generator bearings, but is also liable to damage the water pump gland.

Make sure too that the belt is not frayed or oily, as this will cause slip when the generator is under any appreciable load. One last point: the 'V' belt must *not* be bottoming in the pulley. If it is, either the pulley or the belt is worn or both.

A check should also be made at this stage for side play or end float in the bearings. Make sure too that the generator leads are securely connected at the terminals.

This rather obvious fault could well be the cause of the trouble.



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## VISUAL CHECK OF BRUSHES AND COMMUTATOR.

### OPERATION 2.

The brushes should next be checked to see that they are free in their holders and under spring tension.

At the same time, the commutator can be inspected for signs of over-heating, which often results in solder being thrown from the risers. The commutator surface should appear smooth, but not glazed.

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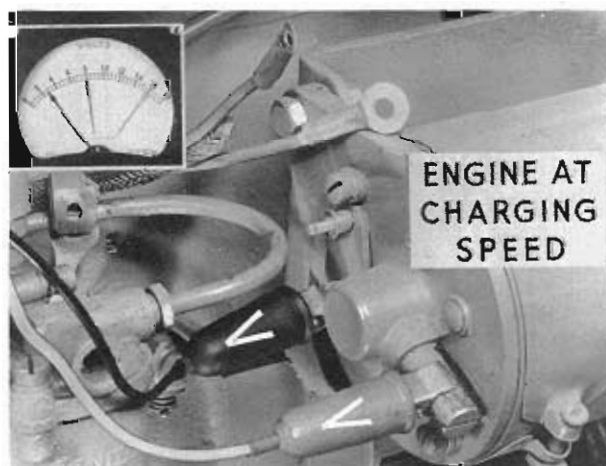
## TESTING THE ARMATURE.

### OPERATION 3.

Our first electrical test, i.e., to measure the residual voltage — applies the theory we have already discussed.

The generator leads must be removed as you can see, and a voltmeter connected between the main generator 'D' terminal and earth. The engine should then be run at charging speed, that is, at approximately 1,200—1,500 r.p.m. when a reading of between 2 and 3 volt should be registered on the meter. This reading is applicable to both 6 and 12 volt machines.

The earth lead of the voltmeter can be attached to any convenient good earthing point.



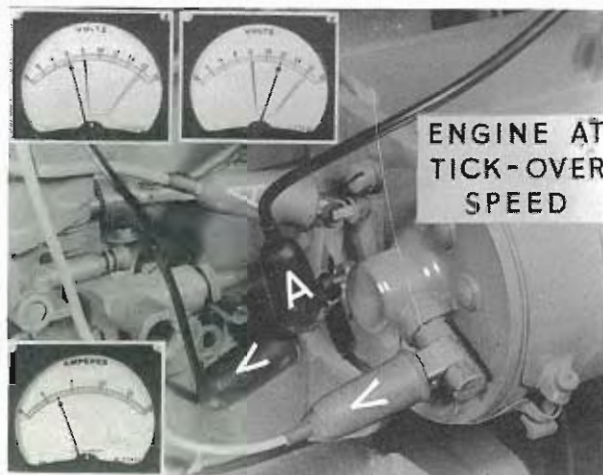


## TESTING THE FIELDS. OPERATION 4.

The next step is to connect an ammeter between the 'D' and 'F' terminals, still leaving the voltmeter connected as in the previous test. Increase the engine-speed slowly, until the reading on the voltmeter is either 6 or 12 volts, i.e., the nominal battery voltage of the vehicle system. At this point the ammeter should read no more than 2 amps.

Our picture shows two voltmeters at the top ; the one on the left reading 6 for the 6 volt system, that on the right 12 for the 12 volt system. The ammeter reading should be the same for either systems.

Suppose the ammeter had registered 3 or 4 amps. instead of 2 amps. This reading could be caused by either an internal short or an earth on the field coils, which reduces the resistance of the field circuit and hence increases the current flowing in it.



The inspection operations followed by the two simple Electrical Tests are all that is necessary to prove the serviceability of the generator.

This test routine is applicable to any type of Lucas Plain Shunt C.V.C. generator and although not by any means as comprehensive as a Full Scale Bench Test, or even proof against 'Flying Shorts' it will be found most effective for everyday 'Trouble Shooting' work.