LUCAS

TECHNICAL SERVICE

OVERSEAS
TECHNICAL CORRESPONDENCE
COURSE

GENERAL INFORMATION

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

Introduction to the Course

This educational programme has been designed to teach the Trade how to render a more complete service by increasing their technical knowledge of Lucas equipment. It aims to improve the ability of the service engineer in a review of basic principles, normal maintenance service and up-to-date testing procedure.

It aims to improve the status of the stores operator, the salesman, the representative and all the others essential to a service organisation, whether administrative or not, by promoting a means whereby they can gain technical knowledge, which is the principal function of all service operations.

Apart from its practical application, the education provided is the same as given to hundreds of traders, service managers, supervisors, electricians and garage hands who have passed through our Schools in Britain.

The Course, produced and printed in the English language only, is limited to whole-time Motor Trade personnel, for as the accompanying syllabus will show — it is directed solely to assisting the Trade towards a simple and practical approach to everyday service problems.

JOSEPH LUCAS (SALES & SERVICE) LTD., BIRMINGHAM, ENGLAND.

How the Course is Administered

ON ACCEPTANCE FOR ENROLMENT—

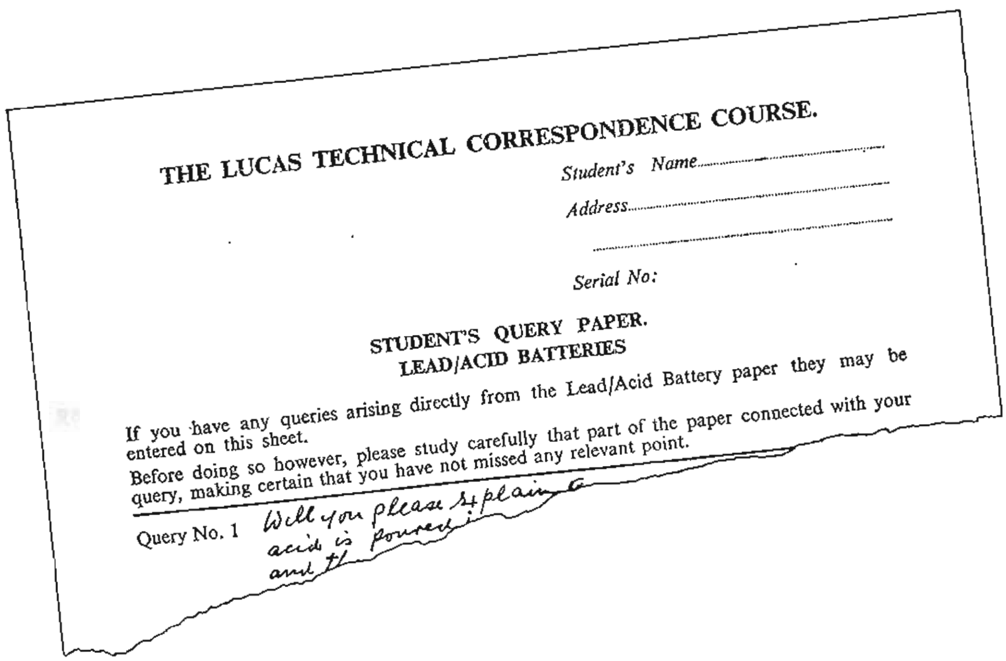
1. The student will first receive Sections 1 and 2 of the Course. Question papers, with separate answer forms will be included with each section.

2. After studying the first Section the student will give his answers to the question papers on the forms provided and return them for marking.

3. The corrected paper will then be returned to the student, together with Section 3.

This procedure will be followed throughout the Course.

Students who wish to raise any queries — which must be on subjects in the Course — should write them clearly and concisely *on the form provided.*



THE LUCAS TECHNICAL CORRESPONDENCE COURSE.

Student's Name..................

Address..................

....

Serial No:

STUDENT'S QUERY PAPER.
LEAD/ACID BATTERIES

If you have any queries arising directly from the Lead/Acid Battery paper they may be entered on this sheet.
Before doing so however, please study carefully that part of the paper connected with your query, making certain that you have not missed any relevant point.

Query No. 1 Will you please explain
acid is poured
and th

Fac-simile of Query Paper.

The Correspondence Course Syllabus

SECTIONS 1 to 9

BATTERIES	Working principles of the Lead/Acid battery. Battery types, construction and application. Putting batteries into service. Batteries in service and storage. The result of ill-treatment.
STARTERS	Principles of operation. Types of Starter Motors and their characteristics. Starter Drives. Starter Switches and Starter Circuits. Test procedure for the vehicle starting system.
COIL IGNITION	Ignition Coils — various types, their construction and function. Distributors, their function, construction and application. Auto-Advance mechanism. Maintenance and Service. Fault-finding on the vehicle.
GENERATORS	Principles of operation. Types and application. Testing of the machine on the vehicle. Service testing of generators.
GENERATOR OUTPUT CONTROL	The control of generator output. The compensated voltage regulator. Control Boxes, types and application. Test procedure for the vehicle charging system. Current/Voltage control.
VEHICLE WIRING CIRCUITS	Wiring systems — positive and negative earth. Cables, their size and application. The Lucas "Colour Code." The Starter and Battery circuit. Lighting and Auxiliary circuits. The complete vehicle wiring circuit.
LIGHTING	Lighting Circuits, lamps and the dipping system. Testing the circuits on the vehicle.
ACCESSORIES	Windscreen wipers, horns, trafficators, four lamp direction indicators and interior light circuits. Service testing and fault-finding.
ELECTRICALLY CONTROLLED OVERDRIVE	Overdrive — mechanical operation and control. Electrical components. Test procedure.

For Prospective Students

GENERAL NOTES

1. When you receive Sections 1 and 2, you should read through the whole of the first Section in order to gain a general idea of the subject matter. Not more than one hour's study at a time should be undertaken.

2. Then study the whole section again carefully, making sure you fully understand each part before proceeding to the next.

3. Answer the questions applicable to each Section. You are strongly advised to write your answers out first in pencil, in case you wish to revise them later.

4. Read through the whole Section again and then reconsider your answers.

5. When you are satisfied with the result, send in your completed answer paper excluding the Question Paper which you retain.

6. The paper will then be corrected and returned to you, recommending, when necessary, further study — together with the next Section of the Course.

7. While you are waiting for your examiner to return the corrected paper proceed with the study of the next Section ; you will thus always have one Section in hand.

8. You are urged not to undertake the Course unless you are determined to finish it ; otherwise you are wasting *YOUR TIME AND OURS.*

9. If, after full consideration of the time and effort which the Course will require, you decide to undertake it, please complete and send in the application form which you will find overleaf.

10. Upon completion of the " Full Course " a Certificate will be awarded to students who have attained the required standard.

11. All Sections of the Course remain the property of Joseph Lucas Ltd., until the Student completes his final Section. Should you for any reason fail to complete the full Course, all Sections must be returned to Joseph Lucas (Sales and Service) Ltd., Service Bulletin Department, Great Hampton Street, Birmingham, England.

LUCAS

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Section I
LEAD ACID BATTERIES

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

INTRODUCTION

Batteries in one form or another are household commodities to all of us. They are divided into two basic types, known as primary and secondary batteries. The principal difference between them is, that a primary cell is expendable, in other words, once it is discharged its useful life is finished. Whereas a secondary cell can be recharged, and for obvious reasons this is the type that we use in connection with motor vehicles, and will be the one in which we are mainly interested.

Before going into the constructional and technical details of the battery, let us consider the application of this unit from an overall point of view as it affects all branches of the trade, including commercial, technical and service aspects.

These secondary batteries generally follow highly developed basic techniques, but there are a few exceptional ones such as where both the plates and the electrolyte are basically different.

It is quite natural that in the highly commercialised world in which we live the most intensive development has been of those types which use common basic materials and are susceptible to high quantity production methods, in order that they may be produced at a cost in keeping with that of the equipment of which they form part, and this is particularly important in the vehicle field with which we are most intimately concerned.

The part played by the Battery on a vehicle has become an increasingly large and important one, until today vehicles without batteries are practically non-existent and without the battery most vehicles are wholly or at least partly immobilised. Under these conditions the battery is a large revenue earning component in all sections of the vehicle manufacturing and distributive business.

From the manufacturer, through the wholesaler, down to the wayside garage who finally fixes it to someone's vehicle, the battery plays just as important a part in the economic structure of a business as any other component that is sold. In fact, by virtue of its cost a good deal more important part than many others. Therefore, if for no other reason, it is worthy of some close attention and a reasonable degree of understanding.

Fortunately for most of us it is not necessary to be a chemist, or even to know anything much about the chemical technology of a battery to be able to manipulate it successfully in every-day service.

However, some sort of knowledge of the "How and Why" is of course both desirable and useful. Basically, what is miscellaneously known as the Secondary Battery, the Accumulator or just plain "Battery" is a box full of "Chemical Energy", which upon being connected to such components as Lamps, Starters, Ignition Coils and the like, causes an electric current to flow and so energise them to carry out their particular function.

In the following pages we shall go more deeply into the theory, construction and operation of lead-acid batteries in service, for it is felt that only by clearly understanding how a unit is made, will the operator have confidence to give the degree of service which is essential to obtain a long effective life and the purchasers satisfaction.

JOSEPH LUCAS (SALES & SERVICE) LTD., BIRMINGHAM, ENGLAND.

CONTENTS

Working Principles of the Lead-Acid Battery

THE BATTERY

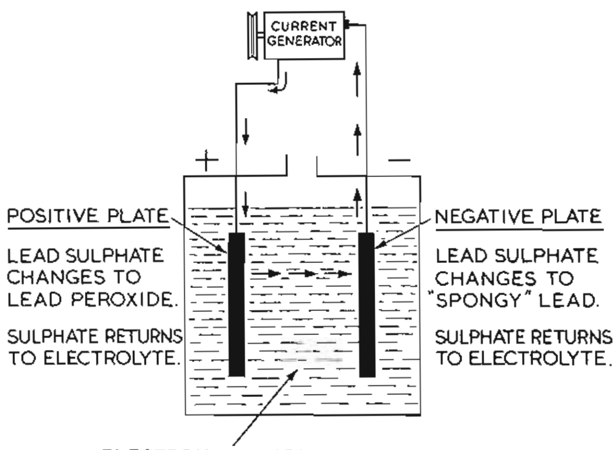
The Lead Acid Battery is simply a device for storing electrical energy in a chemical form. This energy can be released as electricity when needed.

Electrical energy is converted into chemical energy during the charging of the battery.

During discharge, the energy stored in the chemicals is released as electricity.

Let us assume that our battery is discharged. By this we mean that it is no longer capable of releasing electricity at a usable voltage or pressure. The electro-chemical energy built up in the plates of each cell during the charging process has been exhausted, and the chemicals themselves, instead of being active storers of electrical energy, have become inactive or inert.

CELL ON CHARGE



ELECTROLYTE MADE STRONGER BY THE RETURN OF SULPHATE FROM PLATES

CELL ON CHARGE

It is the function of the charging current to break down these inactive chemicals on the battery plates, converting them once more into active materials.

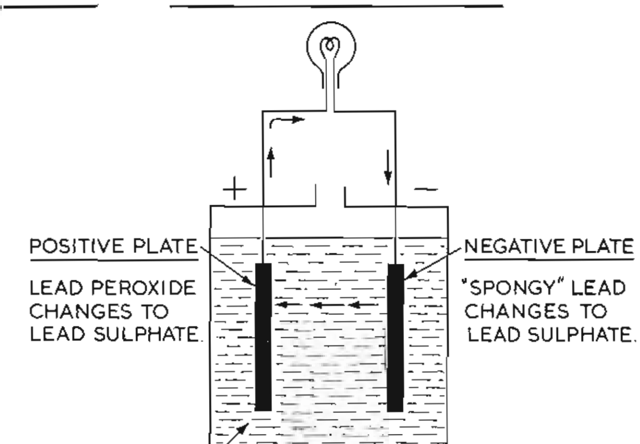
Both positive and negative plates in the discharged condition are covered by a film of Lead Sulphate. During charging this is converted, at the positive plate to active Lead Peroxide, at the negative plate to active ' spongy lead.' The chemicals in this form are once more capable of storing energy and delivering electricity. The sulphate from the Lead Sulphate compound we've just broken down, cannot just disappear of course : it combines with the electrolyte surrounding the plates, thus concentrating the dilute sulphuric acid solution.

At the same time, a mixture of gases is given off from the battery. Hydrogen gas first appears in the form of bubbles on the surface of the negative plate ; oxygen gas is attracted in the same form to the positive. The gases not used in the chemical reaction are then liberated from the battery as the plates become fully charged.

DISCHARGE OF CELL

We can now regain the energy we have just put into the plates by connecting them externally — a bulb is shown here completing the circuit. The electric current thus released flows through this circuit in the opposite direction to that of the charging current, and the active materials of both positive and negative plates gradually return to their inactive state, that is to inert lead sulphate. The sulphate part of this compound comes of course from the sulphuric acid of the electrolyte, thus leaving a weaker solution.

DISCHARGE OF CELL



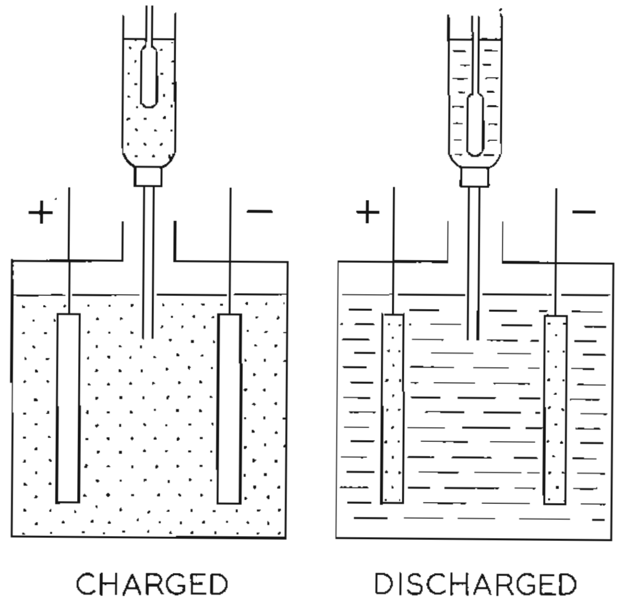
ELECTROLYTE. THE SULPHATE OF SULPHURIC ACID UNITES WITH ACTIVE MATERIALS OF PLATES, THUS LEAVING A WEAKER SOLUTION

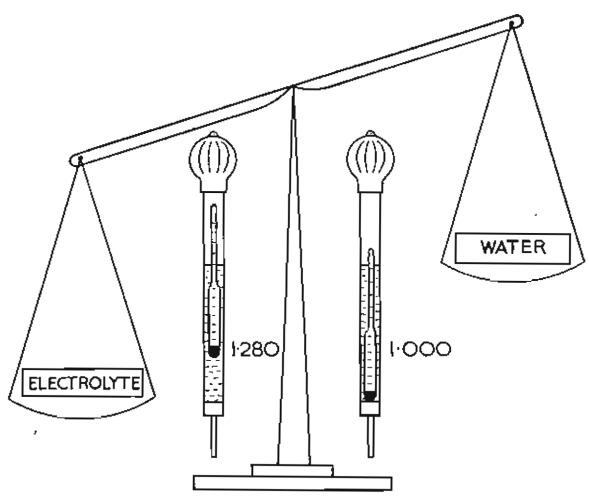
CHARGED AND DISCHARGED CONDITION.

In this diagram the sulphate group is represented by dots. You can see that in the charged condition the sulphate has disappeared from the plates and is concentrated in the electrolyte: in the discharged state the sulphate group leaves the acid, becoming concentrated in the plates.

The electrolyte, which as you know, is a solution of sulphuric acid, is thus strong when the battery is charged and weak when the battery is discharged. This gradual weakening of the electrolyte is directly proportional to the amount of electricity delivered. If now we could measure the amount of the sulphate group remaining in the electrolyte, we should be able to judge how much electrical energy is left in the cell.

The "Hydrometer" is the instrument which enables us to take this measurement, the measurement of density.





ELECTROLYTE FOR FULLY CHARGED BATTERY IS 1·28 TIMES HEAVIER THAN WATER.

DENSITY

Water is taken as the standard basic unit and given a density of 1. Thus in effect we are weighing the electrolyte acid against water. The denser or heavier the electrolyte, the higher will be the hydrometer float, and consequently the reading. Thus for a fully-charged battery, when the electrolyte is most concentrated, we shall have a hydrometer reading of approximately 1280 — this is the everyday method of saying that our acid is 1·280 times heavier than water. This density is usually referred to as the SPECIFIC GRAVITY or "S.G." of the acid. And, as the battery cell loses its energy in the form of electricity, so the hydrometer float will sink and the density reading or "S.G." fall. You can see how, in the right of the picture, the float has sunk just about as low as a float can sink.

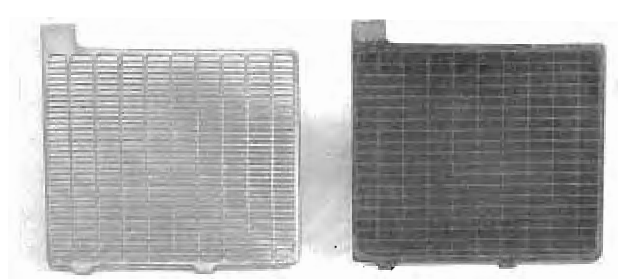
Thus the hydrometer reflects fairly accurately the state of charge of the cell, always providing that the cell is in a normal condition.

GRIDS AND PLATES

We have attempted to show you so far how the Lead-Acid Battery stores and delivers electricity and in so doing we have dealt a little with the chemical processes involved.

The basic idea of immersing two dissimilar plates in a liquid capable of conducting an electric current still remains today, but the method of constructing and assembling these plates has progressed.

We start with a lead frame work or grid, strong enough mechanically to withstand vibration ; and conductive enough electrically to offer little resistance to the passage of current. These grids are filled with the active materials, and the plates so formed, built into positive and negative groups.



GROUPS OF PLATES - SEPARATORS

The plates of the positive and negative groups are then interleaved and separators added between the plates, thus forming a complete cell unit.

These separators are an essential part of the battery, as their name implies they separate the negative from the positive plates. An effective separator must : prevent short-circuits between the plates ; offer no resistance to the electro-chemical action and what's more be reasonably immune from the corrosive effect of the acid electrolyte.

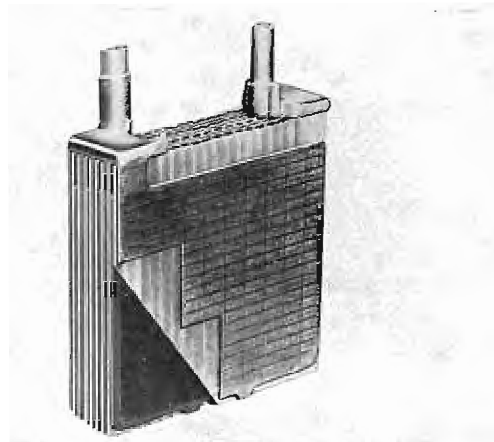
All these demands have been met adequately for many years by wood. The thin sheets used are suitably porous and sufficiently resistant to acid of normal battery strength.

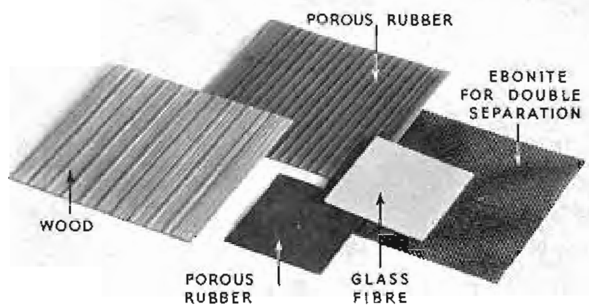
For all normal purposes, wood separators give excellent service. An alternative now being widely used is the Porous Rubber Separator as fitted in the latest models of Lucas Car and Motor Cycle Batteries.

These rubber separators have even greater mechanical strength and decrease even further the possibility of internal short circuits.

For batteries, which are at times subjected to severe vibration stresses, sheets of compressed glass fibre are now being used as a further reinforcement of the separation, in addition to the porous rubber.

Ebonite is another material used, particularly for the heavier batteries.



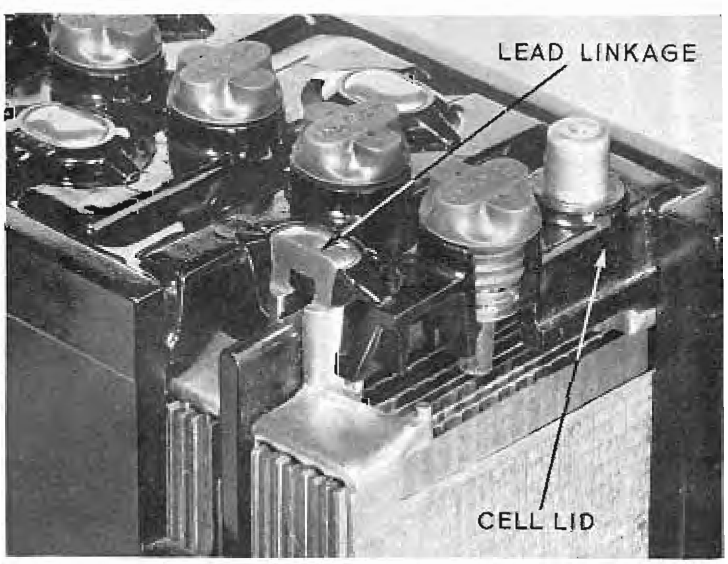


EXTERNAL FEATURES.

The Internal Construction of vehicle batteries has developed steadily "unseen" but until quite recently external features have not altered greatly until the introduction of the "Linkless" type of construction used on the GT range of batteries which are now so popular. One of the advantages in this simple and workmanlike assembly, is the saving in weight whilst retaining an ample cross section of metal to carry the maximum currents required together with perfect sealing between the cells.

In the case of the larger commercial batteries, used on heavy diesel and petrol engines, heavier intercell connectors and posts are used to offer as little resistance as possible to the extremely high currents. The lead linkages of these batteries are cored with copper.

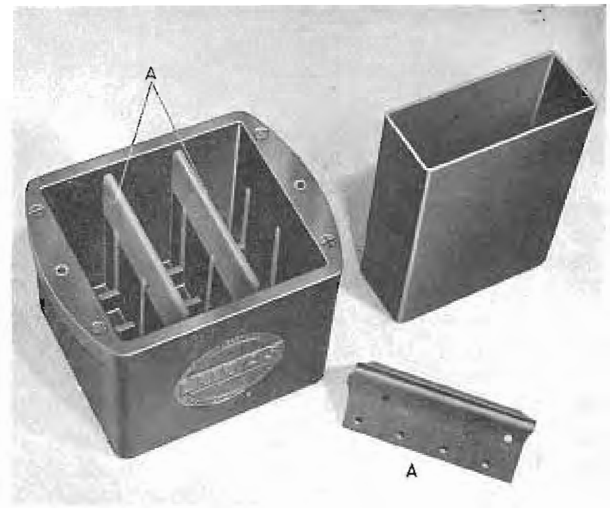
We have also made modifications to the cell lids of the car type battery. The overall result is an increase both in the life and in the efficiency of the modern battery.



CONTAINERS.

Lucas have developed a battery container with the trade-name "MILAM" (made in Lucas Acid-Proof Material). This signifies the moulded "monobloc" container you see in the illustration. You will notice that the intercell partitions are reinforced (A on illustration), a feature which lessens the chance of current leakage between cells.

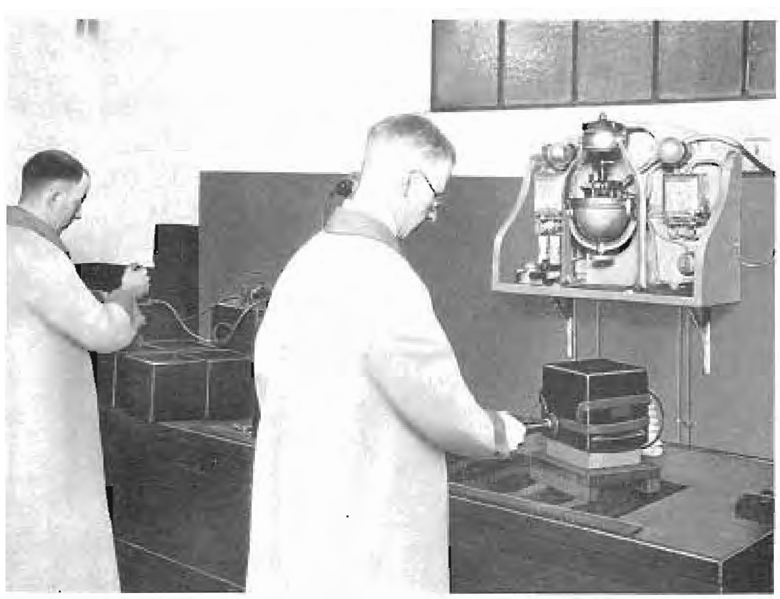
There is one further point which must be mentioned in connection with containers. The separators usually rest on ribs at the bottom of the container, thus leaving space for sediment between the bottom of the plates and the container. If this space were *not* present, sediment dislodged from the plates would fall to the bottom of the container and cause internal short circuits.



TESTING THE CONTAINERS.

In order to make sure that the "Milam" container is electrically sound, it is first given an electrical Pressure Test at 40,000 to 60,000 volts before being put into service. Any minute flaw in the walls or partitions is indicated by an electrical breakdown in the form of a flash-over which burns a visible hole or crack at the weak spot.

This is an extremely severe test which ensures that no leakage of current is possible through the container. Any container which breaks down under this test is immediately rejected.



Battery Types and Construction

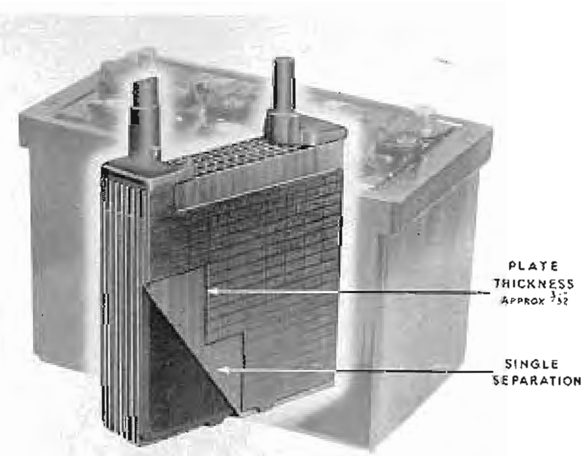
THE LUCAS BATTERY RANGE.

Having briefly outlined the working principles and external features of modern lead acid battery we can now deal with them in more detail, showing you various types, pointing out differences in construction and discussing factors which govern the selection of a battery for a given purpose.

Lucas manufacture a wide range of batteries, varying in size and shape from the small PUW5E Motor Cycle battery to the heavy "C.V."commercial type.

These batteries differ both in design and construction according to the work they will have to perform.

The Containers and Cell linkages vary. So does the material used for the separators and the Plates vary both in size, shape and thickness.



THE "T" TYPE PLATE

THE "T" TYPE PLATE.

Two of the main factors which concern us when selecting a battery for a particular purpose are :

(*a*) The thickness and number of plates per cell.

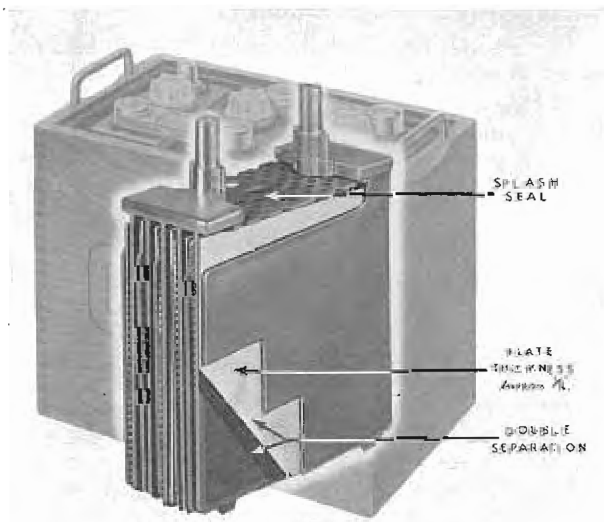
(*b*) The capacity.

We will first deal with plate thickness, upon which the durability of the battery depends, by showing a picture of our "T" type plate. This is approximately $\frac{3}{32}''$ thick and is normally standardised for use in batteries suitable for light or medium-weight petrol vehicles. You will notice that single separators are used. By that, we mean that adjacent positive and negative plates are separated by a single layer of separating material.

THE "X" TYPE PLATE.

For exceptionally heavy work on petrol vehicles where a longer life is required from the battery, thicker and therefore stronger plates are used. The illustration shows the "X" type plate, which is $\frac{1}{8}''$ thick i.e. $\frac{1}{32}''$ of an inch thicker than the "T" type plate shown above.

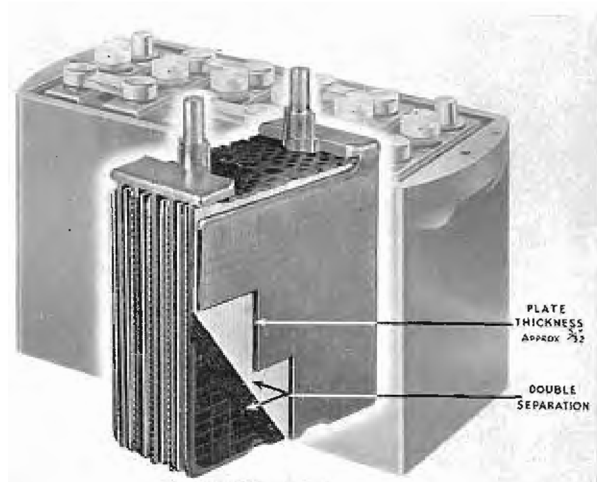
You will see that double separators are used between these plates. An additional feature not yet mentioned is the "splash seal" or "splash plate"—which, as the name implies, prevents splashing of the electrolyte from the cell. This is an additional feature of these heavy duty Lucas batteries.



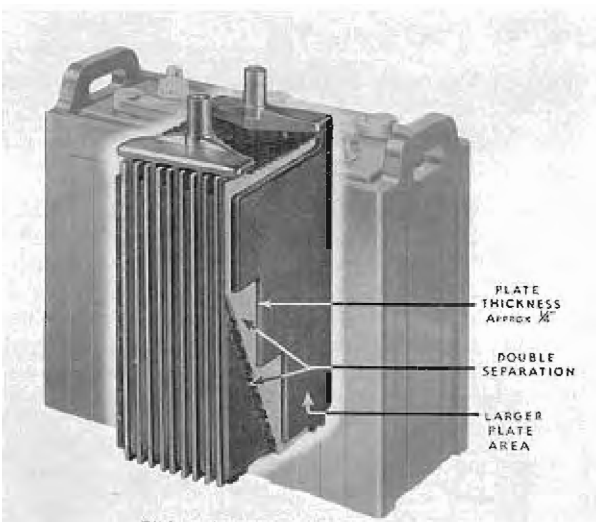
THE "X" TYPE PLATE

THE "CX" PLATE.

To obtain even longer life and still greater robustness, it is necessary to use still thicker plates. The ones you see in this photograph are $\frac{5}{32}''$ thick, and known as the "CX" plates.



THE "C X" TYPE PLATE



THE "C F" TYPE PLATE

THE "CF" TYPE PLATE.

We manufacture a further type of plate, the "CF" which is $\frac{1}{4}''$ thick. This is produced specially for passenger-carrying vehicles.

You will have gathered from the last four pictures that the idea behind all this is simple enough : the thicker the plate, the longer the life. In much the same way we get greater mileage from a heavy-duty tyre.

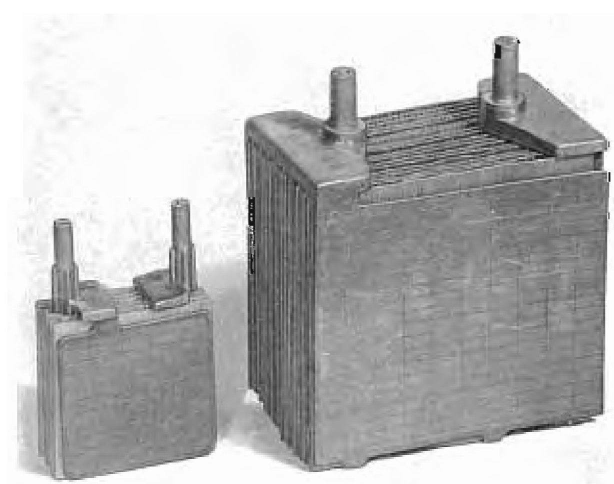
Batteries with large numbers of the thinner type of plates are capable of providing very heavy current discharges for short periods, but where continuous heavy discharges are required the Thicker Plate batteries are more suitable.

COMPARISON OF CAPACITY.

The second factor which governs battery selection is capacity.

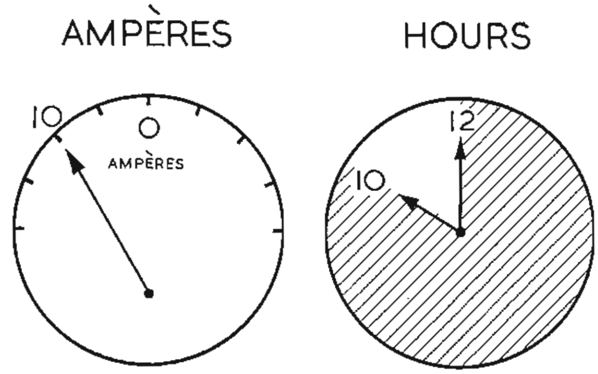
The capacity of a battery is roughly proportional to the area and thickness of the plates. It is the usual practice to get the largest surface area possible, that is the maximum capacity, by using the greatest number of thin plates per cell. This also allows easy access for the acid to the active material of the plates.

From this you can see that the capacity of the battery is also influenced by the amount of acid in each cell. It also follows that the capacity may often be increased by a more plentiful allowance of acid — that is to say, by the use of wider separation and larger containers. Thus, if some of the active material is uncovered, as when the electrolyte level falls, the extent to which chemical action takes place is obviously reduced and hence the capacity lessened. By this we mean that the ability of the battery to deliver an electric current over a given period of time is reduced.



DEFINITION OF CAPACITY.

Defining this phrase : ' the ability to deliver an electric current over a given period of time ' a little more closely, we can say that here ' current ' is expressed in amperes and ' time ' in hours. This gives us then the measurement of capacity in 'Ampere-Hours.' A battery can therefore be stated to have a certain ampere-hour capacity if it is capable of delivering a given number of amperes over a stated number of hours.



AMPÈRE – HOURS

10 AMP. DISCHARGE FOR 10 HOURS = 100 A/H. CAPACITY

The "10 HOUR" Rating

THE 10 HOUR RATING.

For the purpose of classifying batteries according to their capacity, the time in hours must be stated. A certain amount of agreement has been reached among battery manufacturers, this time being generally fixed at either 10 or 20 hours. We therefore obtain the expression ' The 10 or 20 hour rating.' In England, the most generally accepted principle is that the declared ampere-hour capacity of a car or commercial vehicle battery is : ' the total number of ampere hours obtainable in a *uniform* continuous discharge lasting 10 hours, starting from a fully charged condition and stopping at the discharged condition of 1·8 volts per cell.'

Thus the following method is normally adopted for testing the capacity of a battery which is suspect.

The battery is first fully charged. Then it is discharged at 1/10 of the rated capacity (10 hour rate) for 10 hours. At the end of this period the cell voltage should not have dropped below 1·8 volts.

If the voltage is below 1·8 volts in less than the 10 hours, the battery is not giving its stated capacity. If on the other hand the voltage remains at this or a slightly higher figure we can be sure that the battery is up to or above specification.

EXAMPLE 1. (CAPACITY).

A BATTERY IS STATED TO HAVE A CAPACITY OF 100 A.H. AT THE 10 HOUR RATE. AS SUCH, IT IS CAPABLE OF DELIVERING 10 AMPS. FOR 10 HRS. (=100) BEFORE THE TERMINAL VOLTAGE PER CELL DROPS BELOW 1·8v.

EXAMPLE 2. (CAPACITY).

THE SAME BATTERY COULD HAVE A CAPACITY RATING OF 114 A.H. AT THE 20 HOUR RATE. i.e. IT COULD BE DISCHARGED 5·7 AMPS. FOR 20 HOURS BEFORE ITS TERMINAL VOLTAGE DROPPED TO 1·8 VOLTS PER CELL.

$5{\cdot}7 \times 20 = 114$ A.H.

CAPACITY.

Example one shows you quite simply how the Amp./hr. capacity of a battery is determined.

This limiting of the minimum voltage to 1·8 volts is extremely important. From this you will realise that ' capacity ' is understood to express the USEFUL output of a battery.

The second example shows just why discharge times must be standardised and quoted when stating capacity.

Thus you will find batteries catalogued as for example :

CX13 — 116 A/H at the 10 hour rate
and 133 A/H ,, ,, 20 ,, ,,

The 10 hour rating is however the more severe test for the battery and is the one we use in the Lucas Organisation.

INFLUENCE OF ACID STRENGTH ON CAPACITY

HOW ACID STRENGTH AFFECTS CAPACITY.

We have told you that capacity is dependent on plate area and also on the volume of acid in each cell.

In addition, it has already been shown that the performance of a lead-acid battery depends as much on the acid-electrolyte as on the plates themselves, bearing in mind that the electrical output can only be maintained so long as the normal chemical reactions continue between the acid and the active materials.

It is therefore not surprising that the strength of the acid used for filling each cell also affects the output. The strength of the acid not only influences the output available, but also helps to determine what the cell voltage shall be. Within certain specific limits, both capacity and cell voltage are affected by the strength of acid.

We shall deal with the normally specified acid strengths in Part 3 of this section of the course.

THE EFFECT OF TEMPERATURE ON BATTERY OUTPUT.

Besides plate area and the volume and strength of the acid, one further factor influences the capacity and hence the output of a battery : that is, its temperature. Broadly stated :

the lower the temperature, the lower the output,

the higher the temperature, the higher the output.

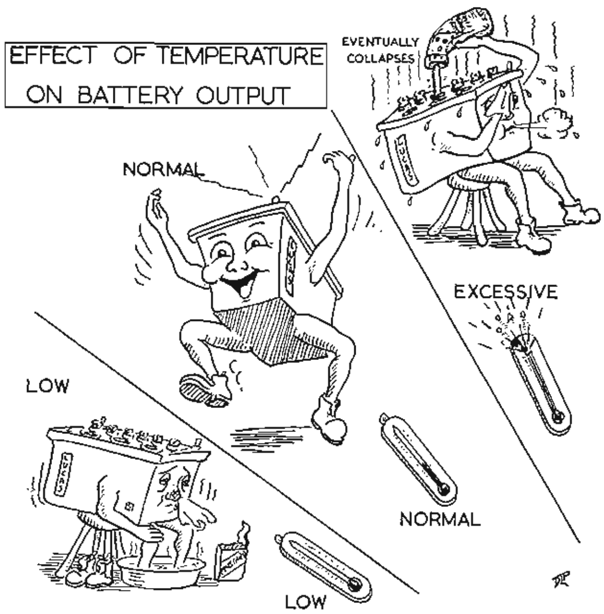
There are however limits to this rule in practice.

Let us take an actual example from discharge tests carried out on a given battery in a fully charged condition :

Temp.	Discharge current	Volts
80°F.	217 amps.	at 10V.
40°F.	178 amps.	at 10V.
10°F.	153 amps.	at 10V.

The main reason why temperature affects the output of the battery, stated simply, is that the chemical reactions are accelerated by increasing the temperature of the electrolyte. The acid is then more able to search into the pores of the plates, that is, make more immediate and intimate contact with the active materials.

In cold weather the density of acid, its viscosity if you like, increases and slows down diffusion, thus slowing down the rate of chemical action, and hence effecting the output.



Apart from this mainly chemical reason, at higher temperatures porous separators often transmit the acid more freely than at lower temperatures. This effectively decreases the internal resistance of the cell, still further improving the reaction.

Additionally, at low temperatures, the negative plate tends to lose some of its sponginess, thus restricting the action of the cell, limiting its output.

We shall now discuss further how temperature affects our battery, particularly in relation to engine starting.

STARTING CURRENTS.

In general terms, to obtain easy starting from cold minimum engine cranking speeds of about 90—110 r.p.m. are required.

To turn the engine over at this speed we must have a battery capable of delivering the required current to the starter motors down to temperatures of 20—25°F. What is more this current must be delivered at a minimum pressure of 8·5 volts on the 12 volt system or 16 volts on the 24 volt system.

The Tables shown for both systems give a fair idea of the currents required for average engines of between 2 and 4 Litres which generally use the 12 volt system, and which will require from 200—300 amperes and for engines of 4 to 8 Litres which generally use the 24 volt system.

For the larger engines, the current would rise very considerably if we did not increase the operating voltage of the vehicle system to 24 volts.

At these voltages the current drawn from the battery is generally limited to between 300 and 450 amperes.

12 Volt System

2 to 3 litre Engines
250 to 300 amps. at 8·5 volts.

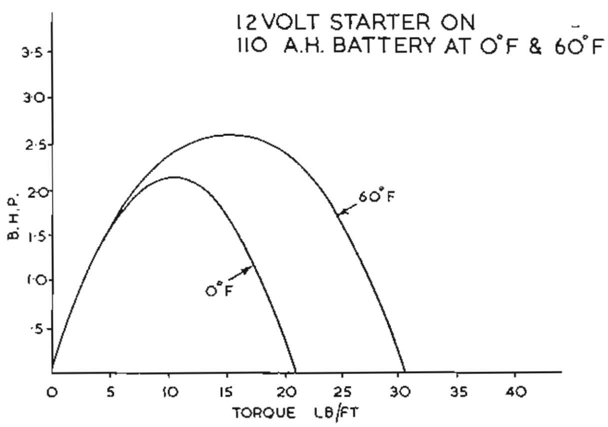
3 to 4 litre Engines
300 to 325 amps. at 8·5 volts.

24 Volt System

4 to 5 litre Engines
300 to 350 amps. at 16 volts.

6 to 8 litre Engines
350 to 400 amps. at 16 volts.

8 to 10 litre Engines
400 to 450 amps. at 16 volts.



B.H.P. AND TORQUE.

To develop full power from the starter motor down to temperature as low as 20°F. you will appreciate that the battery size and capacity must be carefully chosen. Using, for example, a 12 volt 110 A.H. battery we can obtain with a given starter motor a turning effort or torque of 30 lbs.ft. at normal temperature (approximately 60°F.).

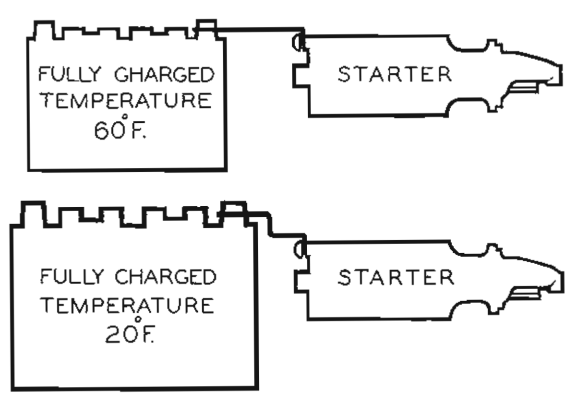
If now the same battery were used at 0°F., the current available would be seriously reduced and the maximum torque no more than 20 lbs., ft. That is, our battery is approximately one third less effective at the lower temperature.

COLD WEATHER AND THE BATTERY.

Let us consider the practical application of all this. It is a fact that in mild summer weather we can obtain the required cranking speed of 100 r.p.m. by using, say, an ordinary car-type battery for a heavy commercial vehicle. But in cold weather, this battery, with its thin plates and general light construction, would rapidly fail. Added to the effect of low temperature on the battery, there would be increased oil resistance, combustion difficulties and so on, until finally the work would be outside the scope of the car-type battery. A heavier, larger capacity battery would have to be used.

In our illustration, the top battery would be capable of cranking the engine at 60°F; but the same battery would not be big enough for the job at the low temperature of 20°F. For this application, a much larger battery would have to be used.

BATTERY CAPACITY REQUIRED

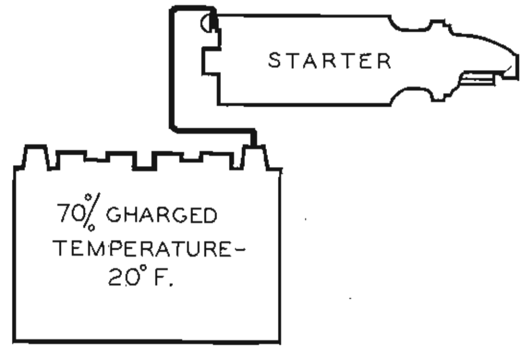


CONDITIONS FOR BATTERY SELECTION.

Do not forget that in cold weather, with early lighting-up time, the battery will seldom be fully-charged in the mornings.

It has therefore become the usual practice for vehicle manufacturers to select a battery capable of providing the required minimum cranking speed when in a 70% charged condition at approximately 20°F. You will note that this temperature is considerably lower than the freezing point of water.

BATTERY CAPACITY REQUIRED



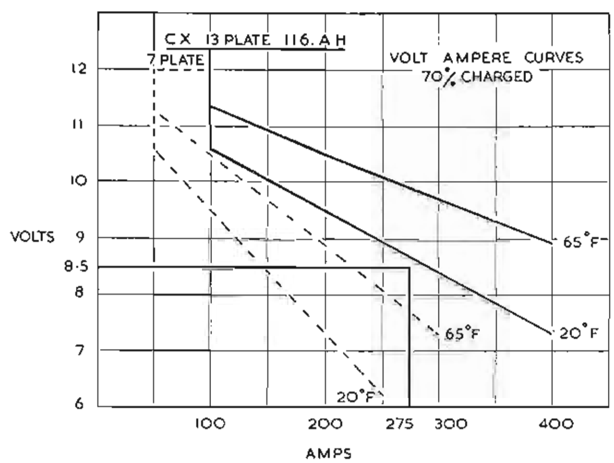
VOLT/AMP CURVES.

As a convenient and easy guide to the selection of a battery for any specified application Volt-Ampere Curves are prepared which show graphically the performance of a battery over any desired temperature range at any particular state of charge.

As will be seen from the illustration the battery voltage is plotted on the vertical ordinate and the amperes output horizontally. The "Solid" line curve shows the discharge performance of a CX 13 plate battery, 70% fully charged, and the "Broken" line curve the performance for a similar 7 plate battery. In both examples the discharge readings are plotted at temperatures of 65 and 20°F.

Now say for example that we require a starting current of 275 amperes at 8·5 volts at a temperature of 20°F.

By following the horizontal line from 8·5 volts to the point of intersection with the curve for the 13 plate battery, it will be seen that well over 275 amperes are obtainable at the minimum temperature of 20°F., whereas the comparable current from the 7 plate battery would only be about 150 amperes, as shown



at the intersection with the broken line, and whilst it might start the engine in warm weather, it would be quite unsatisfactory under colder conditions.

The specification of Amperes, Voltage and Temperature is generally decided at the design stage of the engine or vehicle and governs the type and size of battery fitted as standard equipment.

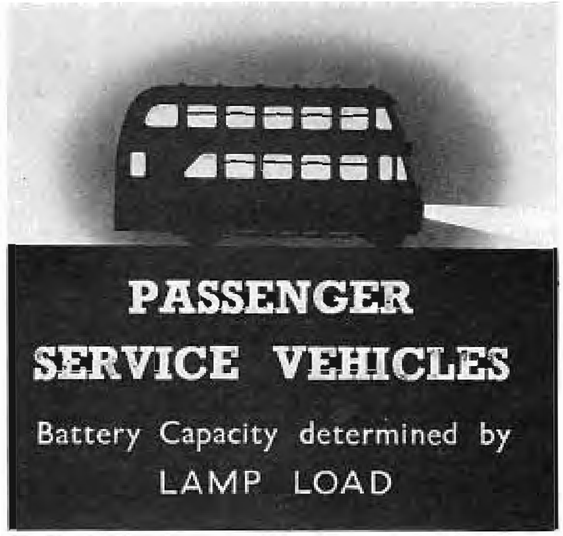
On medium and heavy goods vehicles, cold starter currents govern the capacity of batteries used.

COLD STARTING CURRENT.

Now we have seen how the capacity of a battery for a vehicle is determined by the current required for cold starting. This applies generally to all cars and commercial vehicles. In addition the lighting load when the vehicle is parked should be taken into consideration as this does, of course constitute a drain on the battery, particularly if sustained over a number of hours.

PASSENGER SERVICE VEHICLES.

Most rules however, have their exception, and in this case the exception is the "public service" or "passenger carrying" vehicle. Here the lighting-load during normal running is very heavy, and experience has shown us that the capacity for a battery under such service conditions can best be calculated by multiplying the "lighting-load" by 6. That is, for a total lighting load of 25 amps., the *minimum* satisfactory capacity would be 150 Amp./hours at the 10 hour rate. Generally this capacity would be more than sufficient to meet the starter requirements.



SUMMARY OF FACTORS GOVERNING BATTERY SELECTION

Finally we can summarise these factors with which we are concerned when selecting a battery for a particular vehicle.

The thickness of the plates — upon which the durability of our battery depends. And in this connection we must not forget the separators.

The Capacity — which determines the battery output. Remember here how the output depends on the size and number of plates, and on the strength and volume of the acid electrolyte.

The Cold Starting current — here, temperature, the type of starter and engine etc., must be taken into consideration.

Lamp Load — you will remember that this applied only to Passenger Service vehicles.

All the above factors have been taken into account by our battery technicians, and charts have been prepared which enables us, in practice, to see at a glance which battery is suitable for a particular purpose.

We also issue publications which show the interchangeability of Lucas batteries with other makes, ncluding those fitted to American vehicles.

SUMMARY

THICKNESS OF PLATES

TYPE OF SEPARATION USED

CAPACITY

COLD STARTING CURRENT

LAMP LOAD

(PASSENGER SERVICE VEHICLES)

We can further summarise this part by giving you a list of battery symbols. By referring to these symbols, a Lucas agent knows immediately the type of battery he is dealing with.

If we take for example the 'GTW9A' battery you can see what type of container and cell connectors are used ; the type and size of plates ; that it has wood separators, 9 plates per cell and a nominal voltage of 12 volts.

Symbols are used to cover the whole of Lucas battery productions. However, we have given here only those symbols commonly encountered.

LUCAS BATTERY SYMBOLS

B.	SQUARE-ENDED CASE WITH COMPLETELY SUNKEN CELL CONNECTORS.
F.	" " " WITH PROVISION FOR HOLDING RODS.
G.	" " " WITH SEMI-LINKLESS CELL CONNECTORS.
M.	MONOBLOC CONTAINER.
P.	PLATFORM MOUNTED. (MOTORCYCLF BATTERY.)
R.	ANCHORED IN RUBBER. (" ")
CX.	TYPE OF PLATE.
CF.	" " "
T.	" " "
X.	" " "
U.	" " " (FOR MOTORCYCLE USE).
L.	" " " (LOW TYPE PLATE OR LIGHTWEIGHT BATTERY)
W.	WOOD SEPARATORS.
7, 9,	11, 13 etc. NUMBER OF PLATES PER CELL.
A.	TERMINAL LAYOUT. 12 v.
E.	TERMINAL LAYOUT. 6 v.

EXAMPLE GTW9A.

LUCAS BATTERY SYMBOLS

SPECIAL BATTERIES

/F.	SPECIAL CONTAINER.
/L.	SPECIAL ASSEMBLY.
/T.	HANDLES MOULDED INTEGRAL WITH CONTAINER.
/6,/8.	SPECIAL ASSEMBLY.
FR.	FERGUSON.
Z.	DRY CHARGED.
SAY.	SPECIAL SOUTH AFRICAN.
SALY.	SUPERSEDED BY SAF. S. AFRICAN.
SFLY.	AMERICAN REPLACEMENTS.
SVFR.	AMERICAN REPLACEMENTS.
SVWT.	AMERICAN REPLACEMENTS.
SAFW.	AMERICAN REPLACEMENTS.
SVWM.	AMERICAN REPLACEMENTS.

Putting Batteries into Service

We shall assume, in this part of the course, that the batteries to be put into service have arrived in what we might term 'factory condition.' By this, we do not mean that they have luckily survived the rigours of transit, but that chemically they are conditioned to receive their initial charge.

To give you an idea of the significance of this charge, it is first essential to survey briefly the manufacturing processes and the resultant chemical changes the battery has undergone before it reaches you.

PLATE FORMATION.

We have limited the chemistry to an absolute minimum as you can see, giving only the essentials ; and you are already familiar with some of the terms from the first part of the course — the Active materials. Lead peroxide and "spongy lead" for instance. But we must start at the beginning.

Pure lead is converted into Lead oxide by combining with the oxygen of the air. This lead oxide is the essential ingredient of both positive and negative plates. During the "formation process", in which the plates are immersed in dilute sulphuric acid and an electric current passed, the chemicals on the plates are converted into their active form i.e., Lead Peroxide at the positive plate and 'spongy Lead' at the negative. At this the plates are fully charged. Normal plates are finished at this stage, dried and ready for building batteries.

Unfortunately, however, during the normal drying process, although the positive plate is unaffected, the "spongy lead" of the negative plate inevitably combines with the oxygen of the air and reverts to Lead Oxide, thus losing its charge.

Thus a battery fitted with these plates leaves the factory termed "DRY UN-CHARGED." Hence the necessity for the further charging process, known as "first" or "initial" charging.

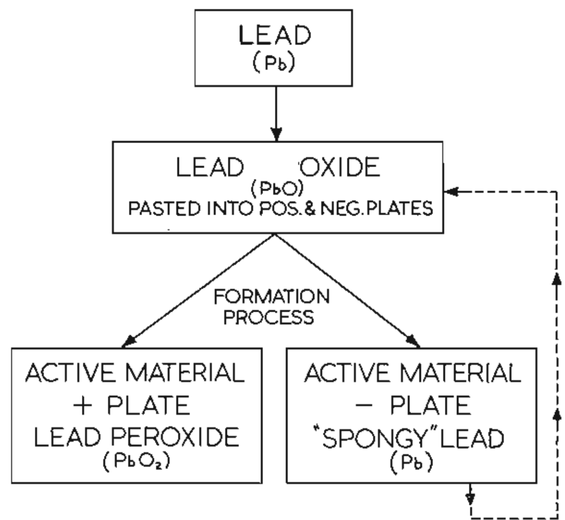


PLATE FORMATION

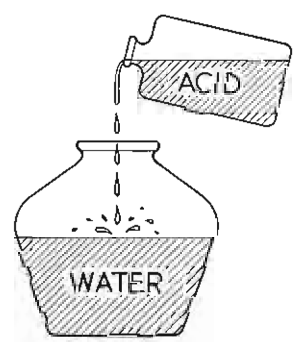
The illustration shows the progressive change which takes place during formation and how after completion the negative plates return to the lead oxide form upon being exposed to the atmosphere.

BREAKING DOWN THE ACID.

We can now set about this initial charging with a little knowledge at our finger-tips, hoping that it won't prove a dangerous thing.

If you remember that, when preparing acid for filling the battery, you dilute by adding ACID TO WATER, there will be no danger.

Start with a large earthenware, glass or lead-lined vessel ; partially fill with distilled water and pour the concentrated acid slowly into the distilled water. If, by the way, you are impulsive enough to pour quickly, we can dissuade you by saying that hot, spitting acid is not considered beneficial either to the skin or to the clothing.



ALWAYS ADD ACID TO WATER SLOWLY

MIXING PROPORTIONS.

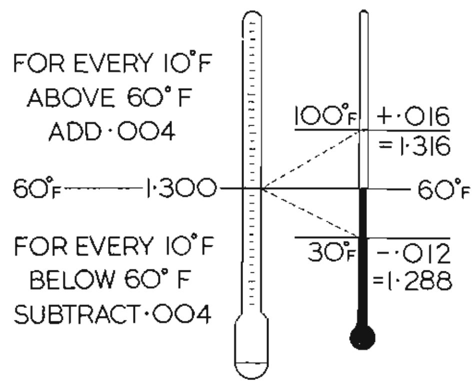
The S.G. of the concentrated sulphuric acid for commercial purposes is 1·835. The gravity of the "filling acid" varies between 1·350 to 1·215, and to get the correct electrolyte strength, the proportion of acid to water should be as shown in the figure.

TO OBTAIN SPECIFIC GRAVITY (WHEN COOLED TO 60°F.)	ADD ONE PART BY VOLUME OF ACID (1·835 S.G.) TO DISTILLED WATER BY VOLUME AS BELOW
1·215	3·9 PARTS
1·245	3·3 ,,
1·260	3·0 ,,
1·275	2·8 ,,
1·290	2·6 ,,
1·320	2·3 ,,
1·350	1·8 ,,

TEMPERATURE CORRECTION.

When using a hydrometer to test the electrolyte strength during or after mixing, it must be borne in mind that all readings are to be corrected to 60°F., as, due to expansion, the gravity varies with temperature. To correct the hydrometer reading to "true" reading, add ·004 for every 10° over 60°F. and subtract ·004 for every 10° under 60°F. If, for instance, we obtained a gravity reading of 1·300 at the mean temperature of 60°F., no correction would be necessary. However, with a temperature of 100°F., the "true" gravity reading would be 1·316 when the hydrometer indicates 1·300. Likewise at 30°F. the "true" reading would be 1·288 when the hydrometer reads 1·300.

The same temperature correction must also be observed during charging, when the battery temperature rises.



EFFECT OF TEMPERATURE ON HYDROMETER READINGS

FILLING THE BATTERY.

The specific gravity of the filling-acid varies with the type of battery, being mainly dependent on the separator used.

In the case of WET WOOD separators for instance, the electrolyte would be diluted by the moisture in the separators. In batteries where our new porous rubber separators are used, the electrolyte strength is again different from that used in batteries with wood separators.

In this respect, therefore, the instructions printed on labels attached to all Lucas batteries should be closely followed, the final electrical output of the battery being dependent on the electrolyte strength used.

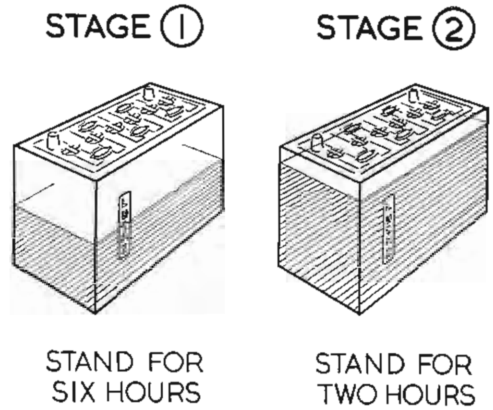
We will also point out that acid that is much too strong can quite easily char the wood of the separators, apart from shortening the life of the active materials in the plates.

SINGLE AND TWO STAGE FILLING.

Another factor too must be considered : when batteries with wet separators are filled, a great amount of heat is generated from the mixing of the acid and the water. Further heat too is generated as the result of chemical action in the negative plate. This heat is likely to cause cracks in the moulded battery container. *Thus batteries with wet separators and moulded containers* must be filled in two stages. The battery should at first be half-filled and then an interval of six hours for cooling allowed between stages. A further two hours should be allowed after the second stage.

This two-stage filling also applies to DRY-UNCHARGED batteries with porous rubber separators and moulded containers. Heat will still be generated, remember, from the negatives.

One-stage filling is however permissible for all motor cycle batteries.



TWO STAGE FILLING

Filling and Soaking Wood Crated Batteries

Specific gravity of filling acid 1320, at 60°F. Fill to top of separators in **ONE** operation. Stand for TWELVE hours before commencing first charge.

FILLING AND SOAKING FOR WOOD CRATED BATTERIES.

The cells of these batteries consist of separate ebonite jars and may be filled to the level of the separators in ONE operation.

These batteries must then be allowed to stand for TWELVE hours before commencing the initial charge.

CHARGING SYSTEMS.

There are two charging systems in use, the constant current and the constant voltage method.

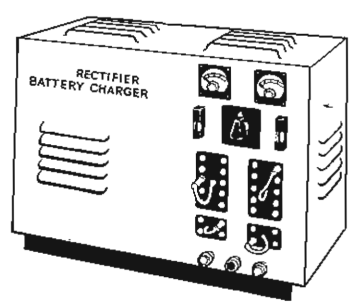
For *initial charging* we strongly recommend that only the *constant current* method be used. By this we mean that the batteries are connected in series and the current flowing through them kept constant.

If there is no alternative the "constant voltage" method may be used, but resistances and ammeters must be inserted in the circuit, so that the current flowing through *each* battery can be continuously supervised.

On no account should "Rapid Chargers" or 'Boosters" be used for initial charging.

CHARGING METHODS

Constant current or constant Voltage?



For first charging work use CONSTANT CURRENT CHARGING ONLY

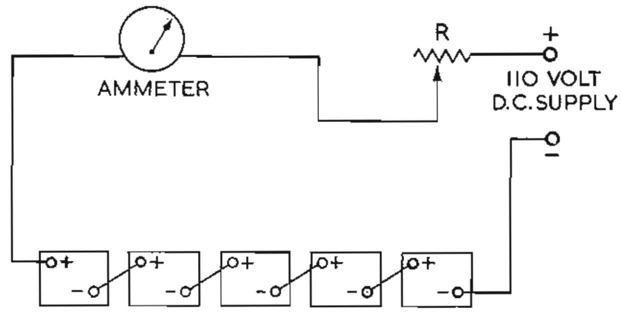
CONSTANT CURRENT CHARGING.

A maximum voltage of 110 volts has been found the most satisfactory. *We must stress here that only a DIRECT CURRENT Source can be used for battery charging.*

Whenever possible, batteries of the same capacity should be initially charged together and, for efficient work, no more than five 12 volt batteries, or ten 6 volt batteries should be in one bank. The number of banks depends of course on the current output available from the generator or supply used. Variable resistances can be employed for adjusting the current flow in each bank. The actual method of connecting the batteries in series can be seen from the illustration opposite.

Remember that a loose connection makes for an inefficient charging system and that any sparking is likely to fire the explosive gases released during charging. If a battery has to be taken off charge do *not* forget to switch off the charging current first.

Further details of charging methods will be dealt with in Part 4 of this section of the course, "Batteries in Service."



CONSTANT **CURRENT** SYSTEM

DURATION AND RATE OF INITIAL CHARGE

Our label instructions giving the duration and rate of the initial charge MUST be followed if the best performance and the longest life are to be obtained from the battery.

In general the initial charging rate of approximately 1/15 of the nominal capacity at the 10 hour rating. Charge at this constant current for 80 hours, or until voltage readings and temperature — corrected S.G. readings show no increase over five successive hourly readings. Throughout the charge, the acid must be kept level with the top of the separators in each cell by the addition of acid solution of the same gravity as the original filling-in acid. If for any reason the charge has to be continued beyond the point where S.G. and voltage readings remain constant for five consecutive hours, distilled water should be used for topping up.

As far as possible, the initial charge should not be interrupted, but if the temperature of the electrolyte in any cell reaches 100°F., the charging should be stopped and the temperature allowed to fall at least 10°F. before charging is resumed.

DURATION AND RATE OF CHARGE

Flat Plate Batteries:
up to 80 hours.

Armoured Plate Batteries:
100 hours actual.

Maximum allowable temperature when on charge.

Temperate climates 100°F.

Hot climates 110°F.

ADJUSTMENT OF ACID STRENGTH.

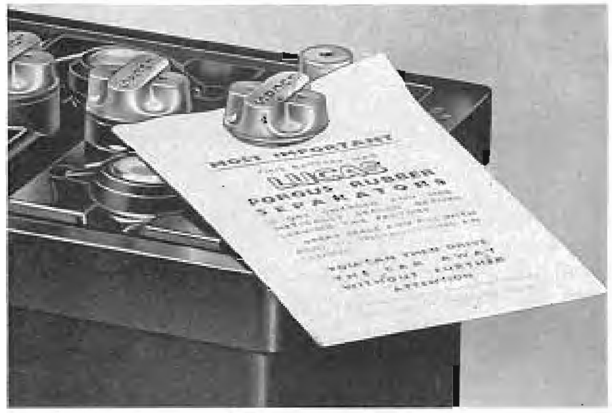
At the end of the charge, i.e. when S.G. and Voltage measurements remain substantially constant, carefully check the S.G. in each cell to ensure that it lies within the limits specified by the manufacturers' instructions. If any cell requires adjustment, some electrolyte must be syphoned off and replaced with a corresponding quantity of either acid of the strength used for the original filling or distilled water, according to whether the S.G. is too low or too high. After such adjustment, the gassing charge should be continued for one to two hours to ensure adequate mixing of the electrolyte.

THE DRY-CHARGED BATTERY.

Obviously a great amount of time and trouble would be saved if this business of initial charging were not necessary. With this thought in mind, our battery technicians set about producing a battery which could be put directly into service without initial charging.

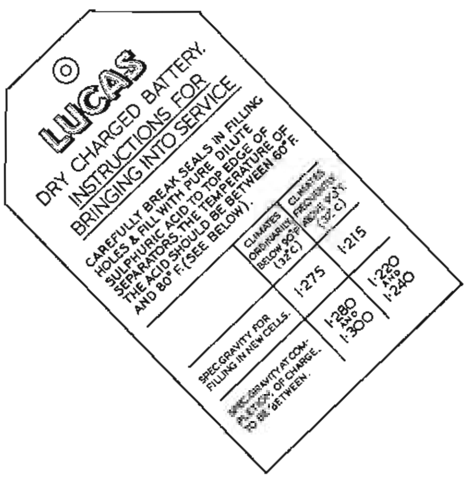
The result of their labours is the Lucas " DRY CHARGED " battery — recognisable by the RED instruction label.

In the absence of the label the Dry-Charged Batteries can always be distinguished by the letter " Z " appearing in the type symbol. For example the lettering GTZ7A will appear on one of the cell connectors — The " Former."



NO INITIAL CHARGING.

You will remember that before dealing with initial charging, we explained why this was necessary. During the normal drying process after the formation charge, the negative plate loses its charge, the " spongy lead " active material combining with the oxygen of the air. A method of drying the plates in an oxygen-free atmosphere has been perfected, the result being that both positive and negative plates remain charged. The sets of plates are then assembled, the separators inserted and the cells hermatically sealed. Thus we have a battery which can truly be termed " DRY CHARGED." This battery can be put into service immediately without initial charging.



PUTTING THE DRY CHARGED BATTERY INTO SERVICE.

After breaking the seals each cell should be filled with electrolyte of the correct S.G. The battery *MUST be filled to the top of the separators in one operation.* After this " one-stage " filling, the battery will be up to 90% charged, and may immediately be fitted to a vehicle. When time permits however, a short " freshening charge " will ensure that the battery is completely charged. Such a freshening charge should last no more than 4 *hours at the normal recharge rate of the battery.* During this charge, the electrolyte must be maintained at the level of the separators by the addition of distilled water.

Our instructions should again be referred to for electrolyte strengths and recharge rates. We emphasise here that the " dry-charged " battery can be treated in service in exactly the same manner as normal batteries.

Batteries in Service

BATTERIES IN SERVICE.

This section of the Battery Course deals mainly with practical points concerning the maintenance of batteries in service, remembering that without proper attention, even the best product is doomed to early failure.

BATTERY STOWAGE.

Let us first make a check on the installation of the battery. By this we mean the battery stowage and all metal parts in the immediate proximity of the battery, including the lugs and the earth cable or braid.

The battery should be kept clean and dry and any traces of acid spillage removed by ammonia, or hot water if this is not available. Otherwise corrosion and extensive damage to the metal work will result.

BATTERY LUG (OLD CLAMP TYPE).

Battery lug corrosion is a more serious matter than is generally realised. Heavy corrosion on the battery lugs and posts results in considerable voltage drop when a heavy current is passing, for example, when the starter is operated voltage drop will usually be noticeable by sluggish operation of the starter motor.

The rate of corrosion is dependent on two factors : The thickness of the lead covering the cast brass of the lug and the amount of acid allowed to accumulate on the battery top.

This latter is your responsibility : we, on our part, as manufacturers, produce a special alloy which is far in advance of the normal lead-coated brass lug, and reduces corrosion to an absolute minimum. This alloy lug is now used mainly for commercial vehicles, with a new diecast lead lug superseding the old clamp type on normal cars.

BATTERY LUG (DIE CAST).

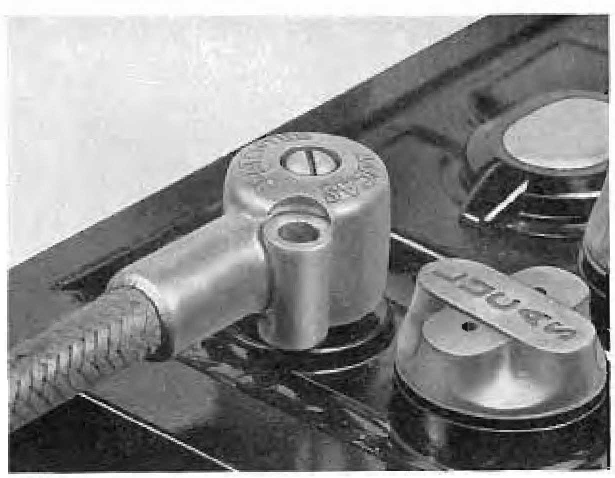
Here we give an illustration of the die-cast battery lug fitted almost exclusively on present-day British cars. This lug further reduces corrosion.

The following points should be observed when refitting these lugs.

Clean off any oxidation from the battery post and smear the post and lug with *commercial vaseline*. Grease must *not* be used for this purpose.

When fitting the lug, make sure that the two surfaces marry together properly. Insert the " Parker-Kalon " locking screw *after* pressing home the lug on to the tapered battery post.

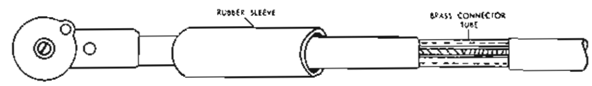
If these precautions are observed, no bad connections can develop and removal of the lug is always easy.



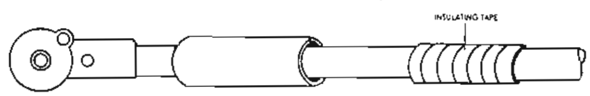
REPLACEMENT KIT.

A standard Lucas replacement kit is available for repairing either a corroded brass lug, or a damaged length of battery cable. As you can see in this photograph, the new die-cast lug is used. This, coupled with a length of starter cable, a brass connector-sleeve, a self-tapping screw, and, in the case of the insulated cable, a piece of rubber sleeving, constitutes the kit.

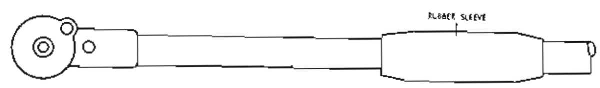
In the top picture the old battery lug has been cut off ; half an inch of the existing cable outer-covering stripped back ; the rubber sleeve pulled over the new section of cable ; the bare end of the existing cable pushed into the brass connector-sleeve, and the joint soldered.



EXISTING CABLE AFTER STRIPPING SOLDERED INTO JOINTING TUBE



JOINT BOUND WITH INSULATING TAPE



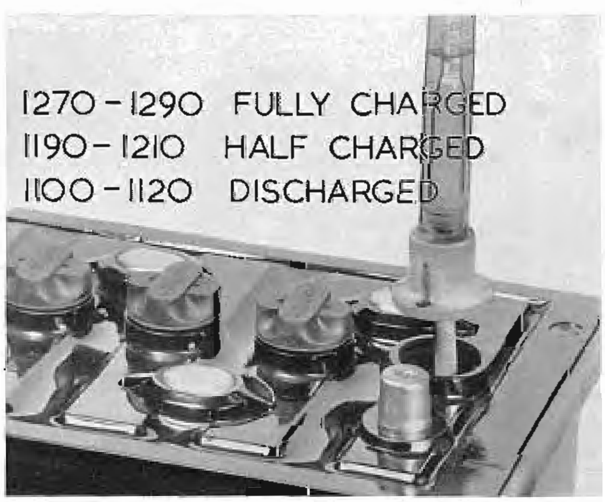
COMPLETED REPAIR RUBBER SLEEVE COVERING TAPE

INSULATING THE JOINT.

After allowing the joint to cool, it should be bound with a few turns of insulation tape and the rubber sleeving pulled over.

After smearing the battery post with commercial vaseline, the lug can be pushed firmly into position and the self-tapping screw inserted.

The replacement kit for the non-insulated battery lead, the positive earth cable on the modern car, consists of a braided earth cable with a die-cast lug, a brass connector and a self-tapping screw.



HYDROMETER TESTING.

We shall now concentrate more on the inside of the battery, dealing first with acid and voltage testing, and then with the electrolyte level.

We have already explained the meaning of specific gravity in Part 1 of this section of the course and will now merely quote approximate gravity readings for our batteries :

Fully charged	...	1270—1290
Half ,,	...	1190—1210
Discharge	...	1100—1120

THE HEAVY DISCHARGE TEST.

The hydrometer test gives us a fairly accurate account of the state of charge of each cell, but a further test must be made to make sure that each cell will supply heavy currents at the required voltage, the heavy starting currents for instance. For this purpose, we use a " heavy discharge tester " which puts an electrical load on each cell. The load, or resistance, takes at least 150 amperes from the cell in the case of a car battery, thus reproducing conditions similar to those existing when the starter motor is operated. If the hydrometer test showed the cell to be charged, and if, under these test conditions, the cell voltage remains constant at approximately 1·5 to 1·6 volts, we can be sure the cell is serviceable. A rapidly falling voltage reading indicates a weak cell. The drop tests should be held in position for about 15 seconds for each cell in the battery.

We use the same type of tester for motor cycle batteries, but a smaller load, this time of 12 amps. is adequate.

For a commercial vehicle batteries a drop tester with a load of 300 amps. must be used.

Discharged Batteries

Batteries below half charge in service should be recharged by an external supply 80% full charge minimum.

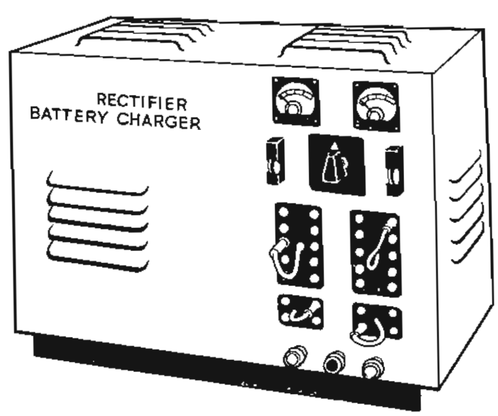
THE IMPORTANCE OF CHARGING FROM AN EXTERNAL SOURCE.

If the heavy discharge test proves the battery to be serviceable, but the gravity reading indicates that it is only half charged, i.e., between 1190—1210, the battery must be re-charged from an external source. It should not be put back into normal service until it is at least 80% charged. Care must be taken that this minimum figure is reached, particularly in wintertime when heavier currents are needed for starting.

RECHARGING IN SERVICE.

Generally, recharging presents no problems if the charging rates quoted on our instruction labels are adhered to.

The normal charging rate is usually approximately 1/10 of the Amp./Hour capacity of the battery at the 10 hour rate. The charge must be continued until voltage and specific gravity readings show no increase over three successive hourly readings.

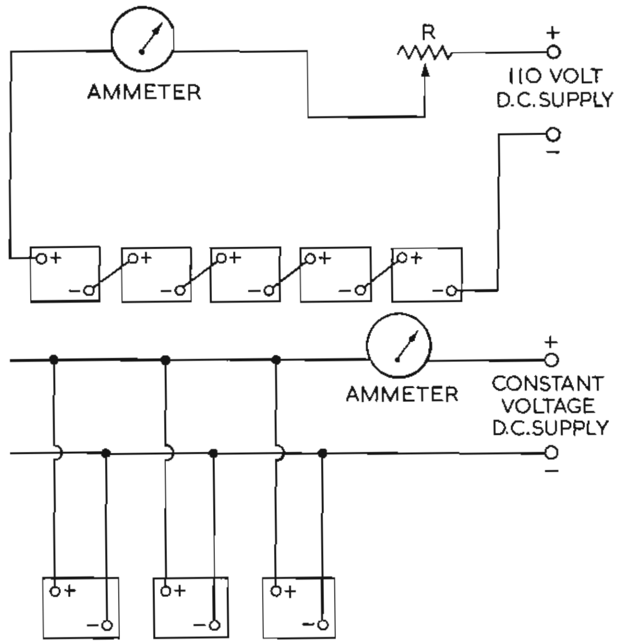


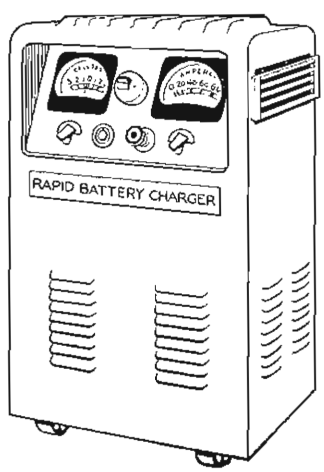
CHARGING METHODS.

Either the constant current method, which we advocated for initial charging, or the constant voltage method may be employed for recharging. In either case a DIRECT CURRENT supply must be used. The connections to be made differ with the method and can be seen from the diagram. You will see that, using the constant current method, the batteries are in series. Thus a limit is set to the number of batteries that may be charged in series, since the voltage of the batteries when fully charged must not exceed the supply voltage. It is found in practice that the most suitable arrangement is ten 6 volt batteries or five 12 volt batteries when charging from a 110 volt supply.

With the constant voltage system, the batteries are connected in parallel, usually to a low voltage motor-generator set. The number of batteries that can be charged on one generator is here limited by the rated current output of the generator, and the total of the charging currents required for all the batteries must not exceed this output.

The supply voltage can again be regulated by a rheostat, and, if necessary, a rheostat or resistance can be included in the supply line to an individual battery, where a lower charging rate is required for this battery.





BOOST CHARGING.

Rapid chargers or "boosters" should only be used for charging if there is any real urgency. They must always be supervised and should never normally be used to replace the standard charging method. No harm will be done through rapid charging if the battery is in a healthy discharged condition, although obviously rather more intelligent supervision will be needed than for ordinary charging.

A battery can be substantially recharged, i.e., to between 70%—80% of its fully-charged state, in anything between 30-60 minutes, dependent upon the state of discharge and the battery temperature.

And temperature is here the controlling factor. On no account should a temperature of 110°F. be exceeded, or the battery will be ruined.

Judge for yourselves : at 140°F. the paste starts leaving the grids.

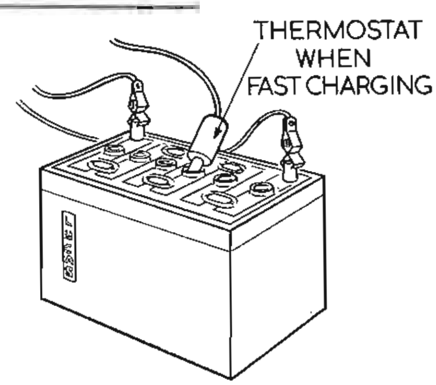
THERMOSTAT FOR TEMPERATURE CONTROL DURING BOOST CHARGING.

For the purpose of controlling temperature, a thermostat switch must be employed. This should be placed in the middle cell of 6 volt batteries, and either of the two centre cells of 12 volt batteries.

While we are discussing this subject of temperature, we will remind you once more of the necessity for temperature correction of gravity readings if variations from the mean temperature of 60°F. are encountered.

The importance of correct charging cannot be

(continued)



TEMPERATURE TO BE KEPT BELOW 110°F.

over-estimated as far as the life of the battery is concerned. If, at any time, particularly in winter, a battery should become completely discharged, it is very bad practice to leave it in the hope that it will become fully recharged by the vehicle dynamo. Unless the battery is charged by an external source, it will probably never become more than half-charged, and, even though it appears to be working satisfactorily, the plates harden and the life of the battery will be considerably shortened.

EFFECT OF TEMPERATURE ON DISCHARGED BATTERIES.

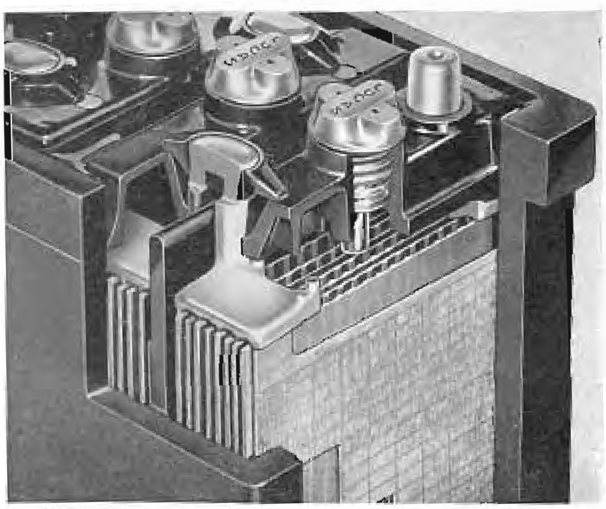
When left in a low state of charge, batteries can freeze easily. You can see from the figures given that a battery with a gravity of 1100 will freeze at 18°F., that is 14° of frost, a condition by no means impossible even in the mild climate of the British Isles.

FREEZING POINT OF WATER (i.e. 1.000)=+32°F.

FREEZING POINT OF ELECTROLYTE AT 1.100=+18°F.

FREEZING POINT OF ELECTROLYTE AT 1.200=—17°F.

FREEZING POINT OF ELECTROLYTE AT 1.300=—95°F.



THE ELECTROLYTE LEVEL.

We must deal with one further point as far as maintenance of batteries in service is concerned, that is, *topping up.*

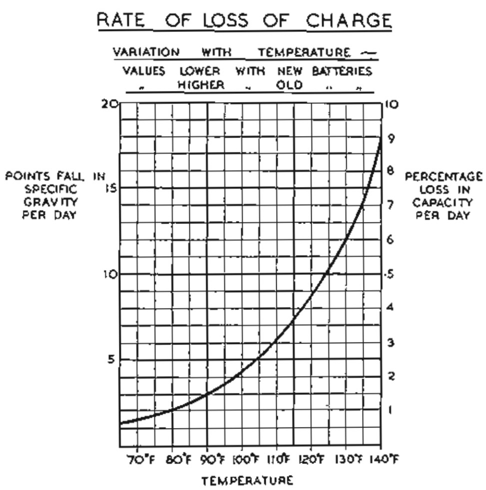
We have already touched on this subject at various times in this section of the course and will now give a short summary. The electrolyte level should be maintained at the top of the separators by topping-up *with distilled water.* Underfilling will harm the battery plates ; overfilling can only result in acid spillage, probably all over the engine compartment. Topping-up to the correct level leaves ample room for the charging gases to expand without flooding the Vent Plugs and causing external lug-corrosion and damage to surrounding metal work and upholstery.

During the normal service life of the battery it should NEVER be necessary to top up with acid electrolyte. Of course if an appreciable amount of acid has been spilled from the battery, it may be replaced by acid of the same S.G.

We also strongly disagree with the practice of changing the battery acid. It should never normally be necessary and, when the battery is turned upside down, sediment from the bottom of the container falls *between the plates, becomes wedged and inevitably causes short circuit.*

BATTERY FILLER.

This business of " topping-up " is often neglected simply because in some cases it requires a contortionist to see into the top of the battery tucked away somewhere at the back of the engine compartment. Lucas have simplified the process by patenting this battery filler. The device ensures that filling automatically ceases at the separator level.



CURRENT LOSSES.

Having set-out to discuss the maintenance of batteries in service, we must mention current losses which occur when the battery is standing.

Any charged battery that is left standing will discharge itself over a period of time. This self-discharge is inevitable, taking place even under the best conditions. The diagram shows exactly at what rate this takes place. You can see quite clearly how higher temperature increases the rate.

You will realise now why it is so important to keep the surface of the battery clean and dry and thus minimise self-discharge.

Current leakage can also occur internally between two adjacent cells, when for some reason the cell partition is defective or the sealing compound cracked.

Batteries in Storage and Service

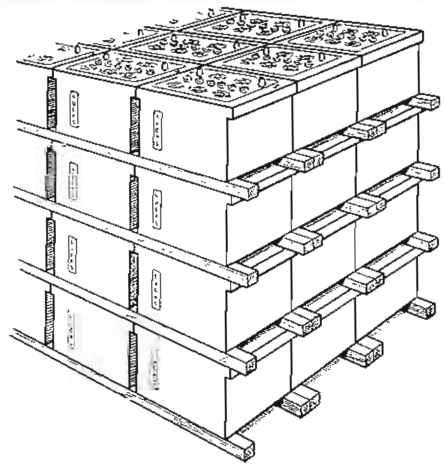
STORAGE CONDITIONS — TEMPERATURE AND STACKING.

We shall now attempt to deal with a very large Subject very briefly, in that we shall give you a clear idea of the conditions necessary for battery storage, without going into details of actual storage rooms, etc.

We shall deal separately with dry batteries, (that is with batteries that have not been filled and charged) : with charged batteries and with the latest dry-charged batteries.

All batteries, whatever their breed, should be stored in as dry an atmosphere as possible, within temperature limits of 32° and 90°F. They should be kept out of the direct rays of the sun.

Dry batteries can be stacked, provided that they are placed the correct way up and not on their sides. Car types and X and CX commercial type batteries should be stacked not more than four high, wooden spacers being placed lengthwise between layers. If the batteries are cartoned, they may be stacked six high. CV and CF types, the heavier batteries, should not be stacked more than one battery high, either in storage or transit.



TEMPERATURE 32°F TO 90°F

If the above conditions are observed dry batteries need no further supervision and, providing the cell seals are not damaged, may be stored more or less indefinitely. However, generally speaking the sooner a new battery is charged the better ; prolonged storage usually necessitates longer first charging.

STORAGE OF CHARGED BATTERIES

STORING NEW "CHARGED" BATTERIES.

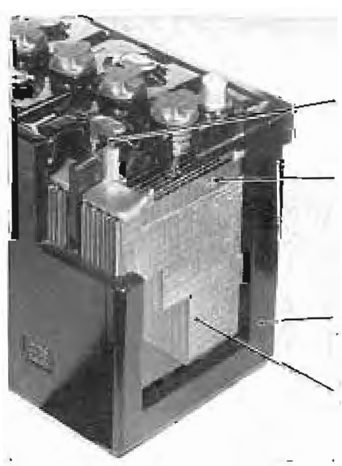
To retain new "charged" batteries in first class condition each battery should receive a "freshening charge" of four hours every month at the recommended recharge rate. Care should be taken to see that the cells are topped-up with distilled water to the level of the separators. And we repeat that the surface of the batteries must be kept clean and dry. This precaution minimises self-discharge, the reason for the "freshening-charge," of course. You remember from the graph shown on page 26 how the self-discharge increased with temperature. This is the reason why the temperature of the storage room must be controlled. Too high a temperature will mean that the freshening charge must be given more frequently than once a month.

STORING "KING OF THE ROAD" AND DRY CHARGED BATTERIES.

Our latest batteries, both the normal dry uncharged and the 'dry charged' types lend themselves ideally to storage, due to their being fitted with porous rubber separators.

In fact, in the case of the dry uncharged battery, our engineers have proved that with these new separators, the usual hermetic sealing ('flash seal') is no longer necessary.

It will be appreciated however from what we have said earlier concerning the method of production of the 'dry-charged' battery, that the sealing must still be retained. The vent plugs are provided with small plastic stoppers and then taped over.

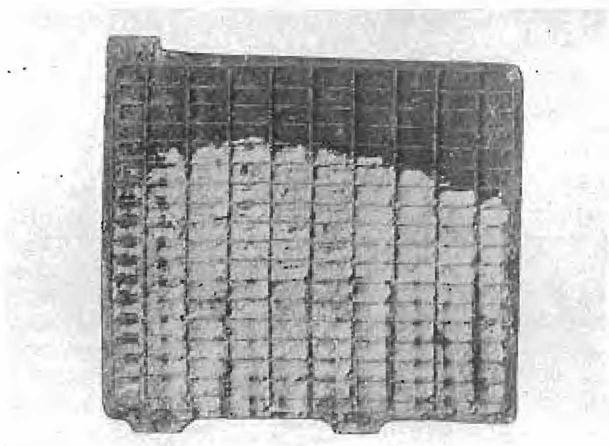


The illustrations which follow will show you just what is likely to happen to the inside and outside of a battery if it is not properly looked after.

If these batteries had been properly maintained, that is : kept clean and dry, topped-up, and correctly charged, these faults would not have occurred.

CORRODED BATTERY LUGS.

The result of neglect. Keeping the battery top dry, and the lugs clean and coated with vaseline would have avoided this. Even our new die-cast lug, although limiting corrosion to an absolute minimum, must still be efficiently maintained.



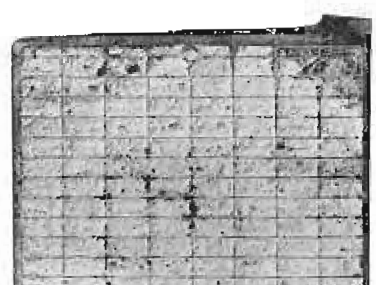
ACID LEVEL NEGLECT.

This cell had not been topped up. You can see that the acid level was only halfway up the plates instead of at the top of the separators. The plates are divided into upper and lower areas of different colour and texture. It is clear too that the battery had been standing idle in a badly discharged condition. In this photograph of the positive plate, the white of the inert Lead Sulphate is very obvious against the chocolate-coloured active lead peroxide at the top.

OVER DISCHARGED NEGATIVE PLATE.

Here we have over-discharging as it affects the negative. The paste on this negative plate is hard and light in colour — Lead Sulphate again.

This can be the result of either over-discharging, persistent undercharging, or long standing without charging.



OVERCHARGED NEGATIVE AND POSITIVE PLATES.

The result of over-charging. These negative and positive plates were taken from the same cell. The negative material was spongy and soft and you can see how, in the right hand illustration, the positive material is leaving the grid.

This lifting of the active material pellets on the positive plate could equally well have been caused by freezing when the battery was in a low state of charge.

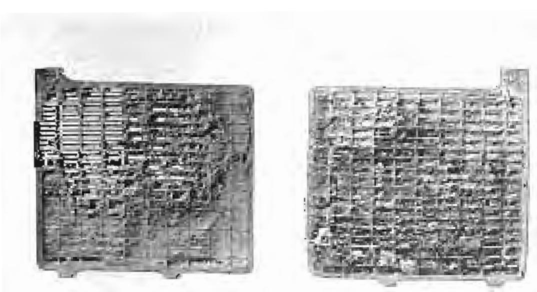
OVERCHARGED NEGATIVE & POSITIVE PLATES

OVERCHARGED NEGATIVE PLATE.

This negative plate shows even more clearly the result of overcharging. You can see that the active material surface is covered with small blisters.

MUCH OVERCHARGED NEGATIVE PLATE.

Carrying this overcharging of the battery a little further, the negative plate would have this appearance. The grid, as you can see is weak and broken, and the paste conspicuous in many places by its absence.



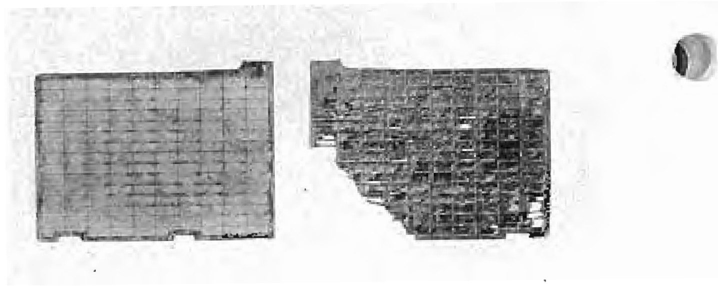
BUCKLING DUE TO OVERCHARGING.

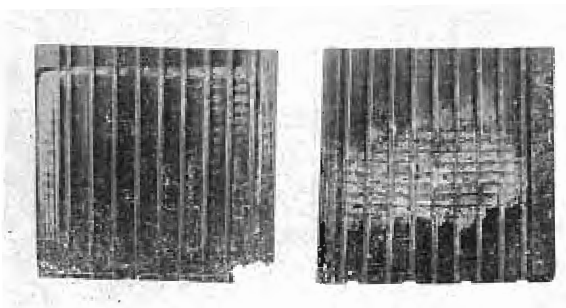
Heavy overcharging can also cause buckling of the plates. These negative and positive plates come from the same cell. The over-charging had forced the active material from the Positive plate, on the right of the illustration, and the sediment caused an internal short circuit which led to increased buckling of the positive plate and disintegration of the negative.

We hope this buckling *is* evident from the photograph. If you look closely at the two inside edges of the plates you will notice that the positive is bent away from the straight edge of the negative.

BUCKLING DUE TO OVER-DISCHARGING.

Buckling of battery plates can also be caused by a heavy over-discharge. The negative plate on the left is hard, and as you would expect, badly sulphated. The positive grid has been broken up by the buckling or expansion.





BUCKLING THE EFFECT ON SEPARATORS.

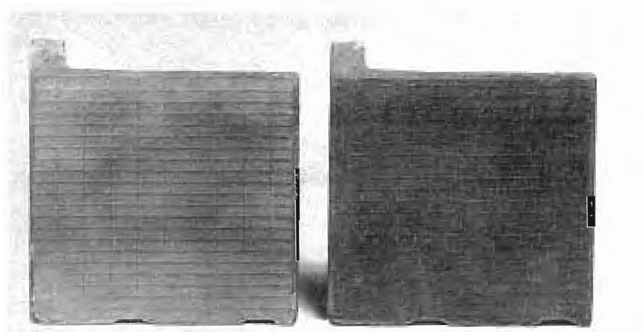
These wood separators were taken from a cell having buckled plates due to over-discharge. Note the impression of the plates, made when they were expanded and particularly the wear at the bottom and centre.

HEALTHY PLATES.

When in a healthy condition and normally charged, the negative plate should be slate grey in colour with a soft surface — soft enough to mark easily with the finger nail, but in no way " soggy " or blistered.

The positive plate should be chocolate brown with a relatively hard surface.

In both cases the grids should show no signs of wear, nor should the paste pellets be lifting.



POSTSCRIPT.

Perhaps, after studying all this information on the various phases of battery construction, repair and service, the student may have gained the impression that this is a highly complex subject. It certainly is, when considered from the manufacturing point of view, but we have given you an insight into some of the deeper technical problems merely in the hope that you will appreciate how important it is that a battery is correctly selected for its work and intelligently serviced throughout its life.

One essential fact stands out in connection with a battery that does not apply to any other electrical component, and that is — that being an electro-chemical unit — it commences its effective life from the day of its assembly, and whether it is put into active use on a vehicle or kept on a shelf in the stores, its life has started and regular maintenance in one form or another is of the utmost importance.

If the advice and instructions given in this book are understood and closely followed, we are confident that your efforts will be amply repaid in the form of satisfied customers.

LUCAS

TECHNICAL SERVICE

OVERSEAS TECHNICAL CORRESPONDENCE COURSE

Section 2
STARTING MOTORS

EPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

INTRODUCTION

The subject of Engine Starting related to Starter Motors and their service is not a difficult one if the general field of application is understood.

The basic requirements for the " Free Starting " of most classes of vehicle engines with which we have to deal are :—that in order to obtain " Free Starting " at a specified minimum temperature the engine has to be turned at a speed of round about 90 to 100 r.p.m. and this is generally referred to as the " cold cranking speed."

The equipment required to crank the engine may be regarded as a completely separate section of the electrical equipment as a whole, and will comprise simply, a Starting Motor, together with its switch, a battery of sufficient capacity to produce the current necessary to develop the " Torque " of the starting motor, and, lastly, the connecting cables.

Lucas and C.A.V. Starter Motors are available to cover a very wide range of engines from the small horse-power petrol engines, right up to the heaviest type of vehicle diesel engine, that is, the range of Starters in current production provides for the requirements of engines between 750 and 1,000 c.c. up to 8 and 10 litres capacity.

Until quite recently a number of the smaller light cars operated on the 6 volt system, but at the present time most engines up to about 4/4½ litres capacity operate on 12 volt, using Lucas Starters, and those between 4½ and 10 litres operate on 24 volt, and generally use C.A.V. Axial type starters which are outside the scope of this course.

The motors and complementary components with which we shall concern ourselves apply to engines up to about 4 litres capacity, and come within the electrical classification of " series " or " series-parallel " motors about which we shall say more at a later stage.

The outstanding characteristic of this class of motor is, that the turning power or " Torque " is at a maximum when the speed is at a minimum. This desirable feature makes it conveniently possible to produce a unit capable of turning a very cold stiff engine from the " at rest " position to whatever speed may be required to obtain " Free Starting."

At the moment the starter motor is engaged to the flywheel of a stationary engine, and the current applied, it will then exert its maximum power and also require the greatest amount of current. This may vary from approximately 250 amperes up to as much as 1,000 amperes according to the size of the engine, its temperature, the number of cylinders, compression ratio, the size of flywheel, and the general condition of stiffness, which is most prominent when it is new.

As the turning, or cranking speed of the engine increases from zero the torque required from the motor and the current required to produce it will become substantially less. So that, taking a typical example of say a 14 h.p. 4 cylinder car engine requiring current of 250 amperes to start it moving from cold, it may, when hot, turn over quite freely at more than 100 revolutions per minute with a current of 150 amperes or less.

You already know that a Battery specification is selected firstly, for its suitability to provide sufficient current for the coldest cranking condition likely to be needed for that particular engine.

Similarly a starter motor is selected to provide the maximum required torque, to crank the engine from the lowest specified temperature. Consequently, it is usual to specify, not only in regard to size but also " Lock Torque " in lbs.ft. at a definite current and voltage.

These figures are published as Workshop information and provide the necessary performance data to which all such units should be repaired if they are to be completely satisfactory when put back into service.

PINION ENGAGEMENT AND DRIVE ASSEMBLIES.

The next factor which has to be considered is the method of engaging and dis-engaging the starter motor driving pinion with the flywheel teeth, or what is more technically called the " Flywheel rack," and three methods of drive engagement are now in use for this purpose.

The first one, most commonly used on the engines of Light Cars or Trucks is the " Inertia Type " of starter pinion engagement. Secondly, for many of the heavy petrol engines and the new light diesel engines, the " Pre-Engaging " type of pinion and drive assembly is becoming increasingly popular. Thirdly, there is the " Axial Type " of electrically operated engagement so familiar in the range of C.A.V. Axial starters.

The principal component of the popular " Inertia " type Starter Drive consists of a pinion wheel assembled on to a screwed sleeve which is carried on the splined armature shaft of the motor. When the motor revolves the " Inertia " or dead weight of the pinion prevents it from turning immediately and it slides along the screwed sleeve, engaging with the flywheel teeth, the motor then " cranks " or turns the engine.

On the heavier type of pre-engaging drive the pinion is pushed into mesh manually and when fully engaged the current is automatically switched " on," when the motor commences to revolve and thus cranks the engine.

On the " Axial " type motor, the pinion forms part of a sleeve on the armature shaft. When current is switched " on " the complete armature and pinion assembly is revolved slowly and pushed forward into mesh with the flywheel. Upon completion of this engaging operation the main current supply is automatically switched " on " and engine cranking commences.

In addition to the engagement of the Starter Motor pinion the whole drive assembly must be flexible.

On the " Inertia " type drives this flexibility is obtained by adding a heavy coil spring which is compressable and thus absorbs the shocks of direct impact between Starter and Flywheel.

An alternative to this " Compression " spring is used for certain special application. This comprises a rather similar heavy spring, one end of which is anchored to the Armature Shaft and the other to the engaging pinion, thus allowing for a limited amount of flexibility by twisting of the spring. This is known as a " Torsion " Spring as used in the " Eclipse " type Drive Assembly.

On both the manually engaging and the " Axial " type drives, provision against shock load is made by inserting a spring loaded plate generally known as an Over-Run clutch, which will allow the pinion to slip when overloaded.

The standard Lucas type " Inertia " drive, by virtue of its extreme simplicity and satisfactory performance over many years will be found on the vast majority of cars and trucks, but even in this field problems occasionally arise. Very flexible engine mountings, engines with high compression ratios, advanced engine timings, ingress of swarf or grit, and other factors have necessitated the adoption of modifications to the original standard drive. These have taken the form of pinion restraining springs, rubber couplings, enclosed screw sleeve assemblies etc., until at the present time there are four main types of Lucas standard " Inertia " drives as well as the manually operated and Axial arrangement, all of which were primarily introduced to suit the engine makers particular requirements.

A proper understanding of these components is most important, and will be fully dealt with in the course of our study of " Starter Drives," together with service features such as correct pinion clearances, which have a most serious effect on flywheel wear and tooth damage

STARTER SWITCHES.

A separate section of the course deals with Starter Switches and methods of operation, of which there is a variety.

The Starter Switch itself is a compact unit with ample current carrying ability for its purpose. Numerous methods of operating the switches are provided mainly for convenience and to meet the requirements of the vehicle manufacturers.

In the case of the popular cars and light vehicles, the method most commonly adopted is the provision of a " Cable Pull," or a " Push Rod." Alternatively it may be more convenient on many layouts to incorporate an operating solenoid in the starter switch itself in order to provide Push-Button operation at any desired point inside the vehicle. In turn the solenoid starter switch itself can be mounted on the Starter Motor, or at any adjacent location such as the bulkhead. Probably the majority of starter switch troubles arise as a result of badly adjusted cable controls and Push Rods which jam, in both cases causing excessive sparking at the switch contacts with ultimate damage and failure, accompanied by unsatisfactory engine starting meanwhile.

With the manually operated pinion engaging drive, the Solenoid Starter Switch is automatically closed by means of a small push switch after the pinion engages the Flywheel, and in the case of the " Axial " type Starters the current is automatically switched on after pinion engagement, by a switch built into the motor itself.

WHY 12 VOLTS.

Some reference may be made to the effective differences when using the 6 or 12 volt systems for engine starting, bearing in mind that the 6 volt equipment is no longer produced for cars and vehicles.

In practice, a 12 volt starter will develop something approaching twice the brake horse-power of its 6 volt counterpart of the same dimensions. This is due in the main to the fact that in comparable systems of equal power, the 6-volt circuit will be required to take double the current of the 12-volt system. With this increased current, the power loss due to the constant resistance of the circuit, i.e. cables, earth return and brushgear, considerably diminishes the power available for conversion by the starting motor. These power losses are, of course, proportional to the square of the current.

Arising from the same fundamentals, another serious difficulty is present with 6 volts. Under certain engine conditions, great difficulty is experienced in keeping an inertia-engaged pinion in mesh with the flywheel for a sufficiently long time to effect a start. This is because the lower torque developed in the 6-volt starter is insufficient to accelerate the armature rapidly enough to maintain engagement with the flywheel ring as the engine fires, or even goes over compression. This difficulty can be overcome by the use of manual or pedal engagement where the pinion is physically held in mesh with the flywheel. Such systems, however, involving as they do the use of an outboard bracket, engagement mechanism and over-run clutch, necessitate considerable increase in cost, weight and complication. It might appear at first sight that a small British engine of 1·5 litres capacity would require less power to crank than an American engine of 2-3 times the capacity. Due to factors inherent in small engines, particularly the increased surface/volume ratio, that is not so. A recent test in our cold room established that at 10°F., using S.A.E.20 oil, a British 4-cylinder engine of 1·535 litres capacity required 16% more power to crank at the 90 r.p.m. necessary for a start than a 3·670 litres 6-cylinder American engine at the 50 r.p.m. it needed. This is representative of our experience.

Finally, you will note that a good deal of attention is given to Servicing and Fault Finding in our Engine Starting Studies, and this will no doubt receive close attention, because unsatisfactory performance in Service almost always arises from simple detail causes which can very easily be overcome by the requisite " Know How," rather than by any inherent fault either in the design and workmanship of the starter motor, or at the engine assembly end ; although occasionally problems do arise with starter pinions and Flywheel Rings which are concerned with the engine assembly.

In order to assist those Students who may have no knowledge of electrical matters the first section of the course deals in a simple manner with the method of operation of the Electric Motor particularly as applied to Starter Motors. If difficulty is experienced in fully understanding this Section there is no need to be in any way discouraged. Proceed with the other Sections when at a later date, particularly with increasing practical experience, it will be found that the subject will clarify itself.

CONTENTS

JOSEPH LUCAS (SALES AND SERVICE) LTD., BIRMINGHAM, 18, ENGLAND.

Working Principles

THE STARTING MOTOR

It must first be understood that energy cannot be created from nothing; it can however be converted from one form to another.

In the case of the starter motor, we employ electrical energy — the electrical current from a battery — and convert it into mechanical energy, the type of energy required to turn over the engine of a motor vehicle.

To understand how this conversion is brought about — how we can use the battery current and produce turning movement — we must consider how two magnetic fields can interact and produce such a movement. We can then go back a stage further and see how these magnetic fields are produced from the battery current.

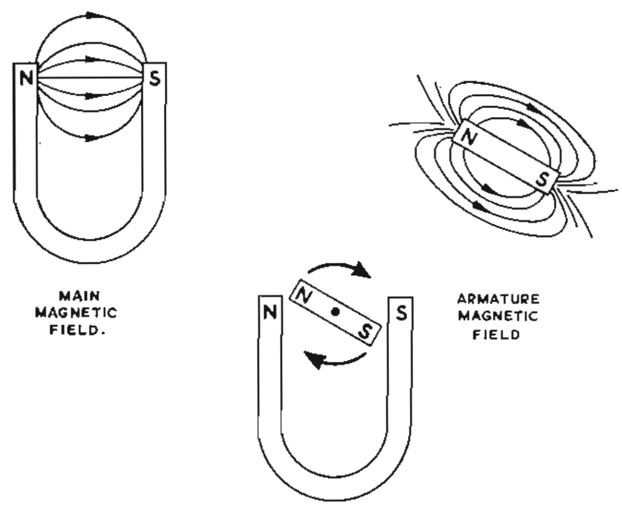
THE PRODUCTION OF TURNING MOVEMENT

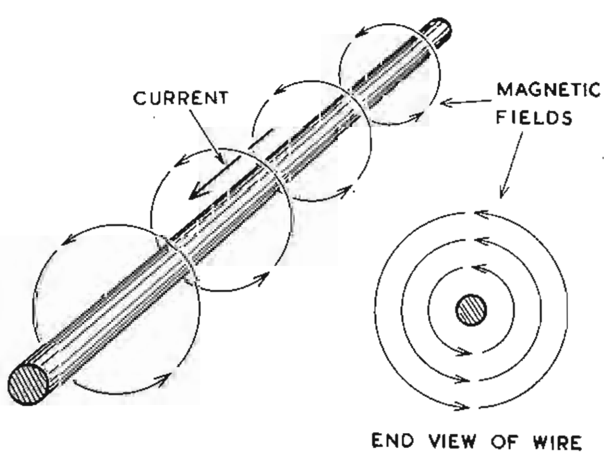
These illustrations show two magnetic fields. The main one is produced by the horseshoe magnet and the second, which we shall call the "armature magnetic field," exists around the bar magnet.

In the combined picture at the bottom, this bar magnet is pivoted at the centre.

Everytime the two magnets are brought into close proximity to each other, their fields interact, become distorted and, in trying to revert to normal, force the pivoted magnet into movement.

But the movement will be restricted: the bar magnet will turn only as long as like magnetic poles are next to one another. You can see that the two North Poles repel each other, so do the two Souths producing the turning movement. (You will remember this fundamental rule of magnetism.) But, when the magnet has rotated through half a revolution, unlike poles will be together and no further movement will occur. One way to continue the rotation would be suddenly to reverse the polarity of the bar magnet i.e. change over the North and South poles.





THE MAGNETIC EFFECT OF AN ELECTRIC CURRENT

In the build-up of our starter motors, we do not use permanent magnets to produce the two magnetic fields: we make use of the electric current from the vehicle battery.

Here we show current passing through a conductor in the direction indicated by the arrow. A magnetic field will be produced around the conductor. The lines of force of the magnetic field are formed in a definite pattern, dependent upon the direction of the current flow. In this case, the pattern is anti-clockwise in form, as we have indicated by the circular arrows. A cross-section of the wire is also shown, illustrating the circular pattern of the magnetic field.

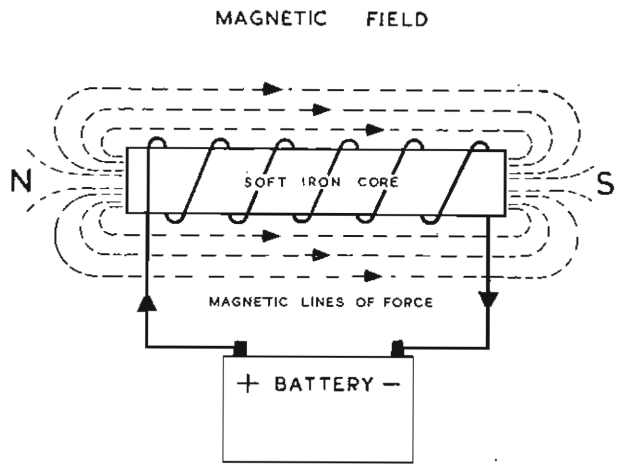
CONCENTRATING THE MAGNETIC FIELD

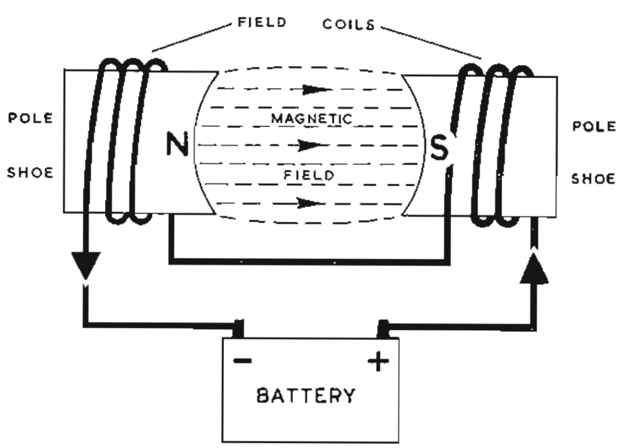
Using a coil of wire instead of a single conductor greatly increases the magnetic effect. The soft iron core adds to this by concentrating the lines of magnetic force into the coil area. The result is a powerful magnet.

The polarity of the magnetic field varies with the direction of the current flow. In this particular case the current flowing from battery positive through the coil to the negative produces a North pole on the left and a South on the right. If the battery were connected the other way round, thus reversing the current flow through the coil, the polarity of the field would also be reversed.

Having established that a magnetic field can be produced round a coil of wire, let us consider how we employ two such fields in the starter motor.

We will deal first with the main magnetic field—if you remember, this was provided by the horseshoe magnet in our original simple illustration.





PRODUCTION OF THE MAIN MAGNETIC FIELD

The main field is created by using soft iron which becomes easily magnetised by current flowing through the surrounding coils of wire. These coils are known as field coils and the blocks of soft iron, specially shaped to concentrate the magnetic strength into the gap, are called pole-pieces or pole-shoes.

All we have done in effect is to cut the soft iron of the previous illustration into two halves and shape the end of each half. In addition, the coil winding has been divided into two. The windings are so arranged that the pole-pieces are of opposite polarity.

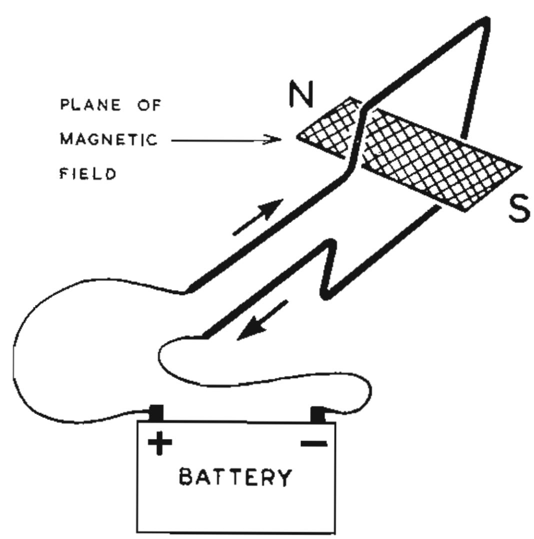
In this particular case, a north pole is formed on the left and a south on the right. The field magnets we have produced remain fixed at this polarity.

PRODUCING THE ARMATURE MAGNETIC FIELD

And now let us consider the second magnetic field, generally termed the " armature magnetic field." You will remember that this was formed by the pivoted bar magnet in our early illustration.

This loop of wire, passing battery current, produces an equivalent effect. The current flow in the wire gives rise to a magnetic field whose plane is at right angles to the loop itself — as we have indicated by the shaded area, which you can consider as representing our original bar magnet.

With the current flowing round the loop in the direction shown by the arrows, a north magnetic pole will be produced on the left, and a south on the right. If we reversed the current flow, we should also reverse these poles.

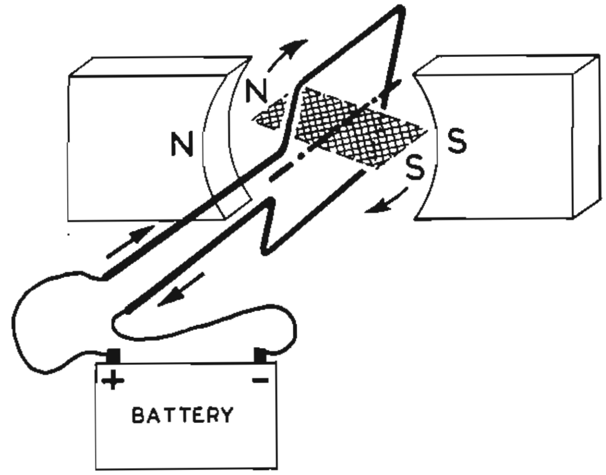


INTERACTION OF THE TWO MAGNETIC FIELDS

Here we show the armature loop in the magnetic field of the main magnet. The two fields interact, the two norths and the two souths repelling one another, thus forcing the pivoted loop into movement.

If the battery current still remains in the same direction, the loop will cease rotating after half a revolution, that is when the north and south poles line up.

However, if we could arrange matters so that as the loop turns, the pole coming round to the fixed north pole of the field magnet was itself always north ; and that approaching the fixed south pole was always south, the repelling action would invariably take place, continually impulsing the loop as it rotated.



THE PRINCIPLES OF COMMUTATION

This effect is achieved by joining the ends of the loop to two metal segments before they pick up the battery current.

Brushes actually form the contact between the battery and the segments.

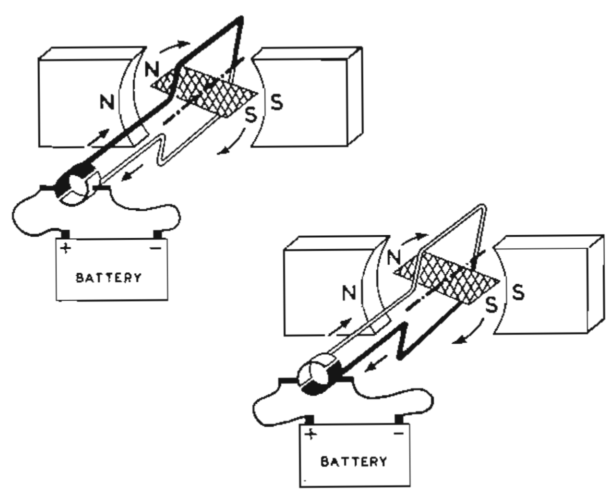
Let us consider the top left hand illustration first, where the black half of the loop is at the top, with its end connected via the segment to positive battery. In this position, the current flowing through the loop produces a north pole opposite the fixed north pole of the field magnet ; and a south opposite the fixed south pole. Repulsion occurs and the loop begins to rotate.

Now look at the bottom right-hand sketch, where you will see that the loop has moved through half a turn, so that the white section is now on top. But, you will notice that the magnetic field produced by this section is still north in polarity ; in other words it will still be repelled by the fixed north pole. Likewise, the black section of the loop which previously produced a north pole, is now producing a south as it moves opposite the fixed south pole. Repulsion will therefore occur again and the rotation will continue.

What has happened is that the direction of the current in the wire itself has changed because the segments have moved under brushes connected to opposite sides of the battery. You can see in the left-hand illustration that the black half of the wire loop is connected to positive battery ; whereas in the right hand illustration it is connected to negative battery, which means that the current flow in that section has reversed. The same can be said for the other section.

With a change in the current, comes a change in polarity. As the loop rotates, therefore, the two sections assume the polarity of the fixed poles they approach.

We shall be discussing this reversal effect, known as commutation, a little later on.



OPPOSING FIELDS

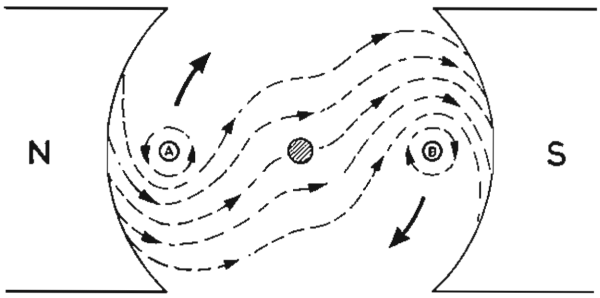
Let us examine this interaction of the two magnetic fields a little more closely, to give you a more graphic idea of how the turning movement is produced.

The illustration shows the main field produced by the north and south pole pieces. We also show, in cross-section, the magnetic lines of force surrounding the armature loop.

Imagine the current at " A " flowing through the conductor towards you. The magnetic lines of force produced around " A " in an anti-clockwise direction will interact with the lines of force of the main magnetic field between the north and south pole-pieces. The result of this interaction between the two fields is a distortion of the lines of force. A strengthening of the field occurs under the conductor at point " A."

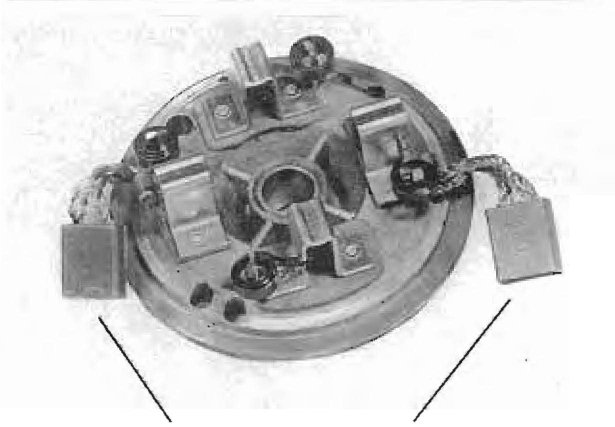
Now magnetic lines of force have elastic properties, and, if we regard these distorted lines of force as stretched elastic threads which tend to straighten themselves, we can see that a pressure will be exerted under the conductor at point " A " and the loop will be urged round in a clockwise direction.

Similarly, it can be seen that at point " B," where the current through the conductor and hence the magnetic field is in the opposite direction, that a strengthening of the field will occur above the conductor and the pressure exerted will assist the movement of the loop in a clockwise direction.



Thus by the interaction of two opposing magnetic forces, mechanical energy or more specifically turning movement has been produced from electrical energy.

We shall now consider the more practical aspects of the Starter motor, beginning with the production of the main magnetic field.



BRUSHES EARTHED TO STARTER END BRACKET

THE MAIN FIELD IN PRACTICE

The theoretical motor we have discussed so far used a main magnetic field of one North and one South pole. In practice, the majority of our machines use four pole shoes surrounded by field coils, thus producing a concentrated field with four magnetic poles.

The field coils are wound so as to produce alternate North and South poles.

The two brushes and the main terminal visible in this picture are the means by which the battery current enters and leaves these field coils.

In this particular arrangement, the four coils are wound in series, i.e. the current passes in line from one coil to the next. As this current is normally in the region of 200-300 amperes, heavy copper strip is used for the coil windings. For the same reason, two brushes are necessary, each taking half the total current consumption, to avoid electrical losses and overheating. The brushes themselves contain a high percentage of copper mixed with the carbon. We shall be referring to these two brushes from now on as the insulated brushes. You can see that the leads to them are covered by fairly heavy braiding.

EARTH BRUSHES

A corresponding pair of non-insulated or earth brushes is also used in the starter, again with the aim of passing the heavy currents without excessive losses which result in overheating.

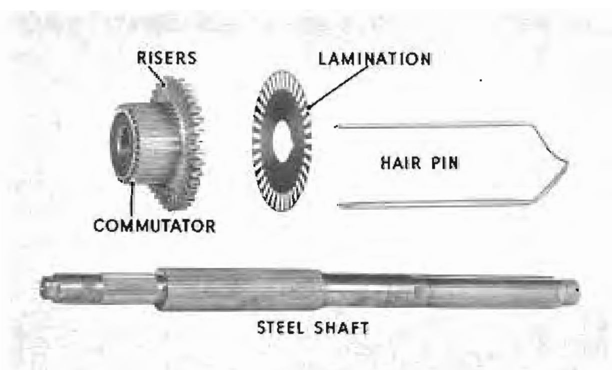
When we deal with the starter circuit, you will see exactly at what point these earth brushes fit into the picture.

THE ARMATURE

The second magnetic field in our starter motor is produced in practice by this armature which, although far removed in appearance from our simple wire loop and two segments, is essentially the same. Instead of one loop, we use many, but each end of every loop is still connected to a copper segment. All the segments are insulated from one another and rolled together to form what is called a commutator. This provides the running surface for the brushes which carry current to and from the armature windings.

The whole assembly is built round a solid steel shaft. The core, which actually carries the windings, consists of a whole series of soft iron laminations. (You will remember how iron helps to concentrate the magnetic field.) Laminations are used instead of solid metal, to reduce the heating effect of harmful electric currents known as "eddy currents" which are produced when the armature revolves in the main magnetic field. The laminations offer a sufficiently high resistance to render these currents harmless as far as heating effect is concerned.

Having shown you the complete assembly, let us examine the components more closely.



INDIVIDUAL ARMATURE COMPONENTS

Here you see the individual components. Let us commence with the steel shaft which forms the centre of the whole assembly. The short splined section on the left carries the commutator. The next splined section is larger in diameter and longer to carry the soft iron laminations of the core. The heavy splined section on the right does not concern us at this stage as it forms part of the drive assembly.

The commutator is built up of individual copper segments, with an insulating strip between adjacent segments.

The commutator "risers" provide convenient soldering points for the ends of the armature loops.

These armature loops, aptly termed "hairpins," pass through the slots in the laminations ; the ends are then twisted so as to connect with the correct commutator segment.

To continue our study of the starter motor, we must examine the method of interconnecting the individual loops in the complete armature winding.

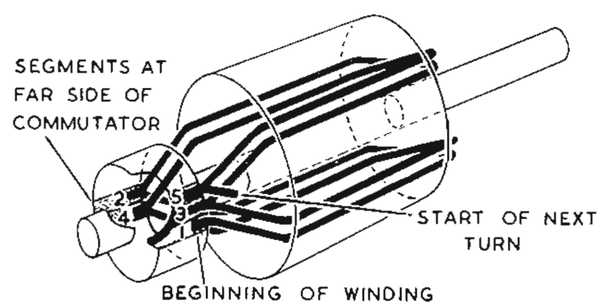
METHOD OF ARMATURE WINDING

We have reduced the number of loops in the winding so as to simplify matters, which also means of course that we reduce the number of segments in the commutator accordingly. Our aim is to illustrate the order in which each loop is connected.

If we start at segment 1, we can follow the lower loop round to the back of the commutator where it ends at segment 2. A second loop then continues the winding round to segment 3. From 3, we pass to 4 ; from 4 to 5 and so on.

You will notice that the ends of each loop are staggered to opposite sides of the commutator, being in practice always 180° apart, less one segment.

This method of winding is known as "wave winding."



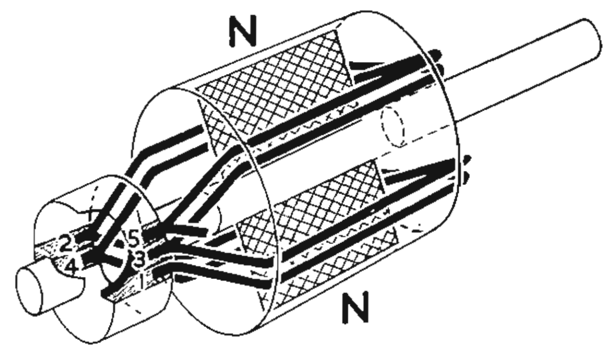
THE ARMATURE MAGNETIC POLES

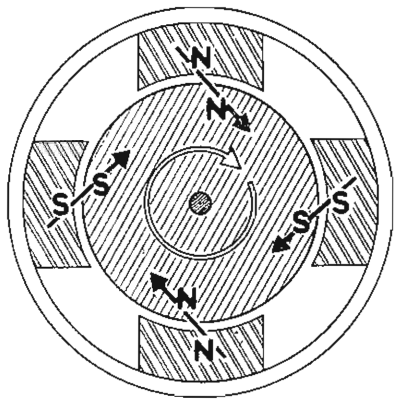
Here you see the magnetic poles produced by these windings. The current flow in them is such that two north poles are formed at the exterior of the armature and on opposite sides.

If you imagine the remainder of the windings in position round the armature, at right angles to the ones shown, the current flow in them would be arranged to produce two south poles.

The total effect would be to produce four alternate north and south poles round the exterior of the armature.

These are the four magnetic poles which oppose those of the main field of the pole-pieces.





THE OPPOSING MAGNETIC POLES

Here the illustration shows the opposing polarities of the two magnetic fields. The main field produced by the four pole pieces is shown surrounding the alternate north and south poles of the armature field.

You will remember that the poles must oppose one another for repulsion to occur and the armature to rotate.

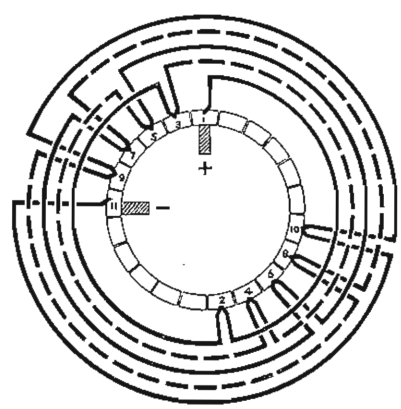
THE ARMATURE — WAVE WINDING

Although this diagram may appear complicated at first sight, it merely represents in diagrammatic form what we have already shown you — that is, the method of interconnecting the individual loops in the wave-wound armature.

We shall go a stage further and follow the path for the battery current round the armature from where it enters at one of the positive or earth brushes to the adjacent insulated or negative brush — i.e. the point at which the current leaves the armature.

Let us follow the windings, commencing from the positive brush, in position on the No. 1 segment. The first loop carries the current to the No. 2 segment at the opposite side of the commutator. You can see that the two ends of the loop are 180° opposed, less one segment. From segment 2, the winding loops round to 3 — that is the segment next to the starting point. The current path continues to segment 4 and from there to 5 ; from 5 to 6 and so on to number 11, which is the segment under the negative brush. This completes one path for the current from one positive brush to one negative.

But we have simplified matters here for the sake of clarity ; there is actually another current path from the positive brush on segment 1 round the armature in the other direction to the negative. This means that the battery current is passing through the whole of the armature windings, producing a strong magnetic field.



The magnetic effect will further be multiplied by the current flowing between the other two positive and negative brushes which we have omitted. These two are joined in parallel with the ones shown here and will be passing half the total current consumption of the starting motor.

In a production model, there are usually nine commutator segments between brushes of opposite polarity, which of course further increases the number of armature windings and accordingly the magnetic effect. Wave-winding the armature in this way, puts all the windings in circuit when the brushes are passing current.

COMMUTATION

In the last diagram, we followed the current path round the armature between one positive and one negative brush ; but we considered it in a stationary position. We must now show what happens when the armature begins to turn.

Look at the top illustration first. It shows the brushes in position on segments number 1 and number 11 — in other words the brush — segment relation is that of the previous picture. But we have dispensed with the windings not immediately concerned with the changes that take place when the armature begins to rotate. Thus segment 3 is joined directly to segment 11, instead of being looped via the intermediate segments, 5, 6, 7, 8, 9 and 10.

In the top illustration then, current enters the armature via the positive brush on number 1 segment. Here the current splits into two, one half indicated by the arrowed black line travelling clockwise via segment 2 to segment three ; then still clockwise from 3 via 4 to 11. The other half of the current would travel round an equal number of windings to the negative brush on segment 11, but in the opposite direction. The start and finish of these other windings is shown by the short arrowed white lines.

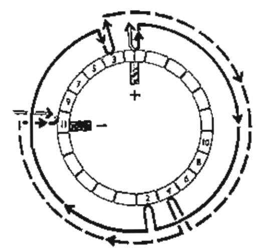
Now consider the lower illustration. The armature has rotated so that the brushes are now on segments adjacent to the previous ones — i.e. positive brush on segment 3 ; negative on segment 13.

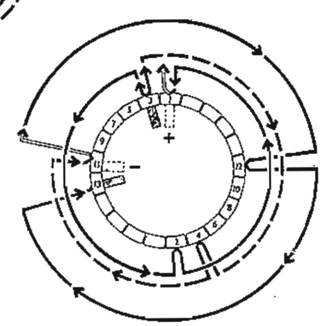
Now, you will remember from our earlier simple illustration of commutation that for the armature to continue rotating the magnetic poles produced by it must always oppose the fixed poles of the main field magnets. In other words, some change must take place to maintain this repulsion by like poles.

In the lower illustration, then, current will now flow into the armature at segment 3. It will split as before into two halves, one half continuing clockwise round the armature via segment 4 to segment 11 — i.e. in the same direction as before in this part of the winding. The current flow continues clockwise from 11 via 12 to 13 taking in an additional loop and segment.

But the other half of the current is anti-clockwise in direction from segment 3, travelling round the loop via segment 2 back to segment 1 — i.e. it opposes the previous flow in these two loops — just look at the top illustration again and see how the direction of the current has changed from clock to anti-clock.

Summing up then : while the current flow in these two loops has reversed, the overall effect is to maintain the same direction of current in all the other windings. Magnetically, this means that the original polarity of the four armature poles has not altered despite the fact that the armature itself has rotated one set of segments. If then, armature *north* poles were originally produced opposite the main *north* poles, the same condition would remain in the new position and repulsion would again occur to continue the rotation.

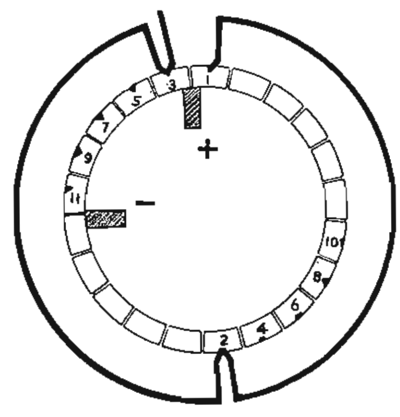




In practice, therefore, we can consider that the commutator, in reversing the current flow in two loops, ensures that the original magnetic pattern of the armature field remains constant, north poles invariably being repelled by north poles ; south poles invariably being repelled by south poles.

The exact moment at which the reversal of the current occurs in the two loops is all important to the correct running of the starter motor in service.

It is arranged to take place when two adjacent segments are making contact with the same brush. As the brushes are wide enough to cover two segments, this condition is always present no matter what the position of the armature.



Here we show the positive brush making contact with segments 3 and 1. This effectively shorts out the two loops between these segments at the moment when the current reversal is taking place. The commutation may be regarded as perfect if the reversal is completed before segment 1 is clear of the brush. On the other hand if this segment leaves the brush before the complete reversal of the current, sparking will occur between the brush and segment, which will be extremely injurious to both.

BRUSH POSITIONING

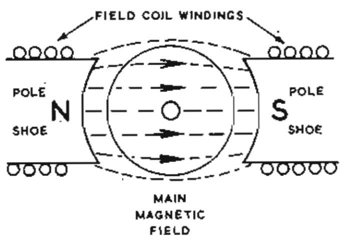
A further word now about the positioning of the brushes in relation to the magnetic fields. For the sake of clarity we shall once more revert to our early two pole example.

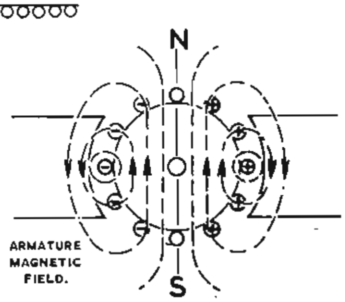
As we have seen, in the starter motor there are two fields ; the main field shown in the top picture and the armature magnetic field shown in the bottom picture. These fields are at 90° to each other, the main field running horizontal, the armature field vertical.

You will observe that in the second illustration the main concentration of the magnetic field is centered round those conductors opposite the pole shoes, leaving neutral points along the vertical line. This is normally referred to as the "Geometric Neutral Plane."

The starter brushes must be positioned in the neutral plane to prevent excessive sparking taking place when current is passing between them and the commutator segments.

But a complication arises. The two magnetic fields of the starter motor cannot possibly co-exist without some interaction. We stated right at the beginning that the turning movement was actually due to this interaction between the two fields.

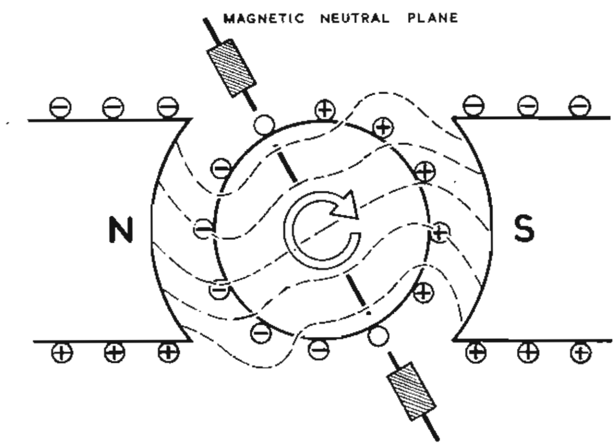




The resultant field is shown in the illustration below. You will notice immediately that the neutral plane is no longer vertical : it has moved due to the flux distortion. The neutral points, in which the brushes must be positioned, have been moved against the rotation of the armature — and, to obtain sparkless commutation the brushes must follow suit. We have indicated the correct brush position, on the new neutral plane — technically known as the "Magnetic Neutral Plane."

If the rotation of the starter were now reversed, the neutral axis would swing over to the other side and the brush position would have to be altered to correspond. This theory has a direct practical bearing.

In the production of our starter motor components, the end brackets which hold the brushes are designed with clock and anti-clock fixing holes so that the brush position may be varied according to the rotation of the machine.

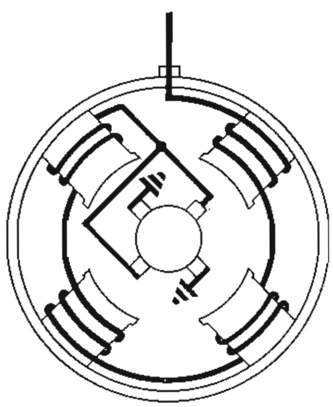


STARTER INTERNAL CIRCUIT— (SERIES FIELD)

Let us now examine the internal arrangement of a typical starter motor with a view to tracing the circuit path through the fields and armature.

You have already seen an actual photograph of the four field coils depicted here. You will remember they were wound so as to produce alternate north and south poles and that they were all in series with one another. If you start from the end of the black line at the top of the picture and follow the winding through, you will see this is the case. The pair of insulated brushes then connect with the armature commutator. The circuit continues through the armature windings to the pair of non-insulated or earthed brushes, which we showed you earlier connected to the starter end-bracket.

This means therefore that the four field coils are electrically in series with the armature windings.



Thus current flowing from the vehicle battery will at once energise the field coils and the armature, producing the necessary two opposing magnetic fields.

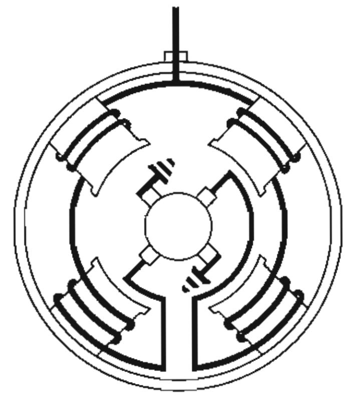
This type of starter motor is known as a "plain series motor."

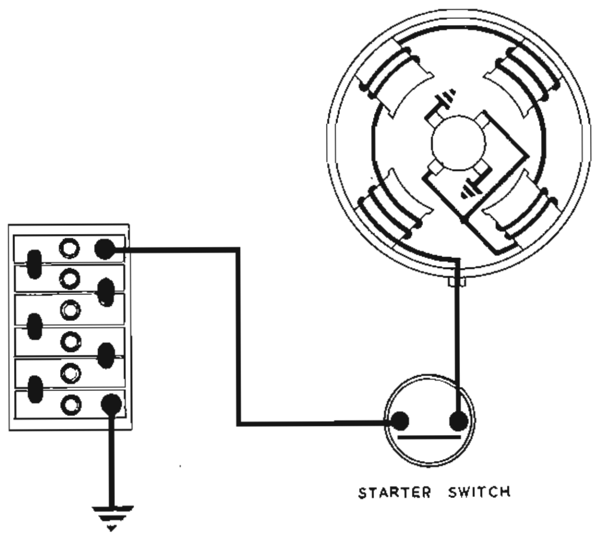
STARTER INTERNAL CIRCUIT (SERIES PARALLEL FIELD)

Another internal arrangement used in our production Starters employs a series — parallel field.

The field circuit is divided into two halves, each in parallel with the other, thus dividing the electrical load. Both halves of the circuit are, however, still in series with the armature windings, Thus this starter motor still remains a series type of machine.

By assembling the field coils in parallel, it is possible to pass a somewhat greater current and obtain an overall increase in the mechanical energy developed, or torque as it is called.





THE COMPLETE ELECTRICAL CIRCUIT

Here you see the starter motor in circuit. The external cable layout to the motor is shown, basically as it would appear on a vehicle. The two components necessary are the battery to supply the current and of course a switch to control the current supply to the starter motor.

We have used a plain series machine in this circuit, but it could be directly replaced by the series-parallel type.

Let us follow the circuit through, commencing at the battery. We shall assume that the starter switch is closed.

A heavy cable connects the battery to one side of the switch. The circuit continues across the contacts in the closed position to the starter motor. It carries on round the four field coils in series via the two insulated brushes to the armature. The pair of earth brushes complete the circuit through the metal of the starter end bracket to the body of the machine, which is bolted to the vehicle chassis or earth. This earth connects with the battery earth terminal which is also strapped to the chassis.

TORQUE

Let us now take a closer look at the expression "Torque," which is the term used to define the turning movement or effort produced by the starter motor.

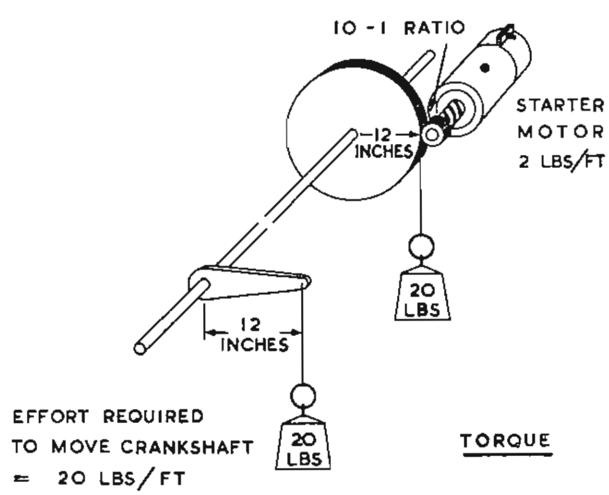
A simple illustration will suffice to acquaint you with the significance of the term.

If a force of 20 lbs. is applied to an engine crankshaft through a leverage of 12 inches, the turning effort produced would be :

$$20 \times 1 = 20\text{lbs./ft.}$$

The same unit of measurement i.e. lbs./ft. is used to express the turning effort developed by the starter motor when this effort is applied to the engine crankshaft via the flywheel.

But, to produce an equivalent 20 lbs./ft. torque at the engine crankshaft, the torque developed by the starter motor need only be 2 lbs./ft., due to the mechanical aid of gear ratio of 10 : 1 between flywheel and pinion.

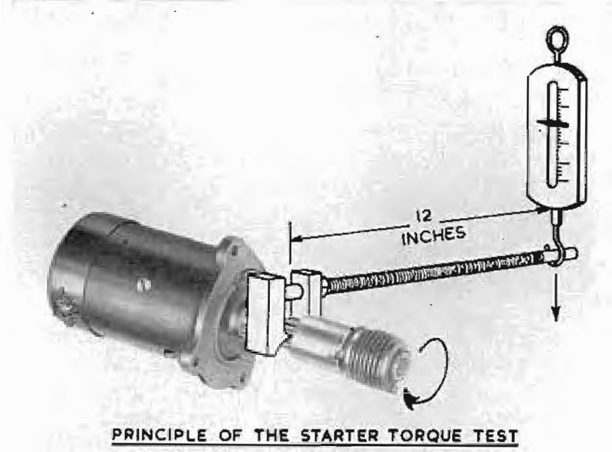


TORQUE

LOCK TORQUE TEST

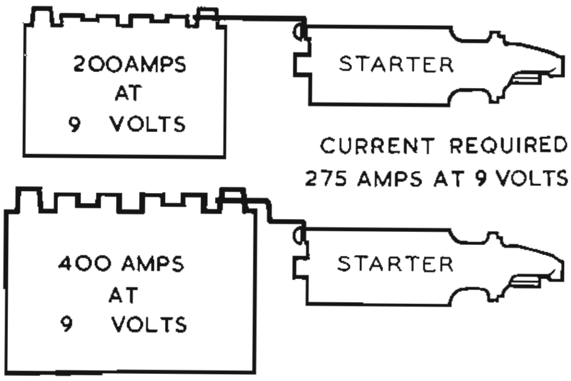
For test purposes, the torque produced by the starter motor is measured with the starter taking current, but with the armature shaft prevented from turning by a brake or clamp. The torque produced by the starter when trying to turn against this brake is termed the "Lock Torque" and the test, quite logically, the "Lock Torque Test."

The measurement can be taken directly from the armature shaft or via a test-bench flywheel.



PRINCIPLE OF THE STARTER TORQUE TEST

BATTERY CAPACITY REQUIRED



BATTERY CAPACITY — ITS IMPORTANCE IN RELATION TO ENGINE STARTING

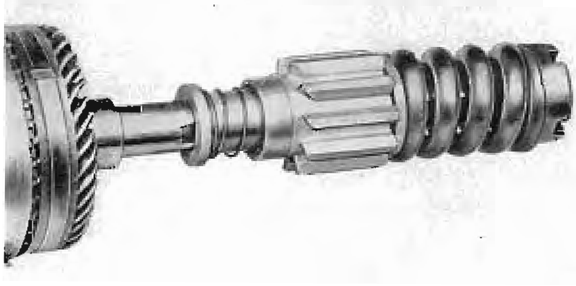
In connection with the performance of the starter motor, the importance of the battery must not be forgotten. Owing to the very heavy current taken by the starter, there is quite an appreciable drop in the battery voltage. The performance of the starter motor is therefore largely dependent upon the size of the battery employed. A battery of ample capacity is essential, otherwise the heavy discharge current will result in an excessive voltage drop which will limit the current available for the starter motor, and in turn reduce the torque developed.

In this case, you see, we need a current of 275 amps. at 9 volts. The top battery won't give us this current ; it can only supply a maximum of 200 amps at this voltage. The other, larger capacity battery will, with some to spare.

THE TRANSMISSION OF THE TURNING EFFORT

We must now show how the torque or turning movement we have produced is transmitted to the vehicle engine ; in other words how the motor we have created becomes a starter motor.

This picture shows you one of the many different types of starter drives. The pinion engages with the flywheel, thus transferring the turning movement of the starter armature shaft to the engine crankshaft.



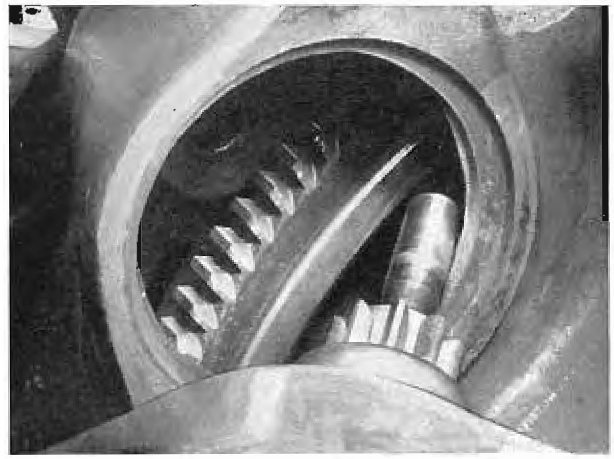
PINION AND FLYWHEEL

The pinion and flywheel can be seen from this picture.

The pinion to flywheel ratios vary usually from 9—1 to 14—1 but are generally in the order of 9 or 10 to 1 on modern vehicles.

CRANKING SPEEDS

In order to turn this flywheel at sufficient speed to start the engine, a minimum " cranking speed " of approximately 90 to a 100 r.p.m. is required. Cranking speeds are usually stated as " cold cranking speed " or " hot cranking speed." Obviously the effort required to turn over a warm engine is far less than that for a cold engine, when the oil is thick.



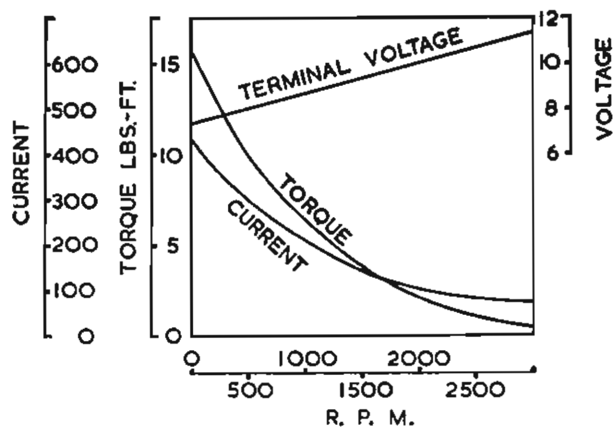
BREAKAWAY TORQUE

We must discuss one further term in connection with starter motors and engine starting in general :

" Breakaway Torque "— the torque required to move the engine from rest, that is to overcome friction, oil viscosity, compression etc.

This breakaway torque is usually of short duration, but it is evident that it represents the maximum turning effort the starter motor must produce.

Fortunately, however, the main characteristic of the series motor is that it produces its maximum torque at the beginning of the starting operation, that is when it is most needed.



TORQUE SPEED CURRENT CURVES

GRAPH — TORQUE, SPEED, CURRENT

Here we have plotted " Torque " and " Current " against speed in R.P.M. and indicated the starter terminal voltage.

You can see that the torque curve falls from the maximum as the speed of the starter increases. It is this characteristic which renders the series type of motor particularly suitable as an engine starting motor.

And furthermore, when the starter armature rotates in the magnetic field, a voltage known as a " back EMF " will be induced into the windings, which is proportional to the speed of rotation. As this induced voltage is in an opposite direction to the supply voltage, it opposes the latter. The current drawn from the battery therefore decreases as the speed of the motor increases. You can see this from the current curve. The starter terminal voltage will rise as the load decreases; and as the current drops, so the torque decreases ; in other words, the least torque is produced when the starting load is at a minimum.

One further characteristic of the series motor is that its speed varies appreciably with load variation. Particularly is this so with light loads, where the speed increases at a very rapid rate, so that under no-load conditions the motor may attain really dangerous speeds. These series motors should therefore *never* be allowed to run continuously without load.

Lucas Starters—Symbols and Model Interpretation

CURRENT PRODUCTION STARTERS

Having discussed the theory of the starter motor and explained several terms essential to the understanding of engine starting, we shall now show you the practical application of all this theory, dealing with the various types of Lucas Starters.

The power developed by our Light Car Starter Motors today may be as high as 22 lbs./ft. Lock Torque, (or the equivalent of $1\frac{1}{2}$ B.H.P. at 1000 r.p.m.) And the currents required to produce such high torques can be in the order of 400 amperes or more.

SYMBOLS

We produce three main types of starters : the M35G., the M418G. and the M45G.

The letter " M " means in all cases *starter motor :* the number refers to the diameter of the yoke, and indicates that it is either 3·5", $4\frac{1}{8}$" or 4·5" in diameter. The final letter, as you can see, usually indicates some special feature, either a particular type of end bracket, a water-proofed machine etc.

STARTER SYMBOLS

PREFIX	M	— STARTER MOTOR
	35	$3\frac{1}{2}$" DIAMETER
	418	$4\frac{1}{8}$" DIAMETER
	45	$4\frac{1}{2}$" DIAMETER
SUFFIX	A	PRESSED METAL C.E. BRACKET
	G	DIE CAST C.E. BRACKET
	L	LONG TYPE MACHINE
	W	WATERPROOFED

M 35 G STARTER

M418 G STARTER

M 45 G STARTER

THE M35G. STARTER

This machine is a 4 pole, 4 brush, series motor. It is produced either with the field coils wired in series or in series-parallel. The plain series arrangement is usually employed for the 12 volt machine, and the series-parallel for the 6 volt.

The highest torque available from these $3\frac{1}{2}$" models is approximately 9·3 lbs./ft. Lock Torque at 380 amps. for the 12 volt machine, and 6 lbs./ft. at 400 amps. for the 6 volt machine.

THE M418G. AND M45G. STARTERS

Both these starters are 4 pole, 4 brush machines with series-parallel fields. This arrangement of the field coils produces an overall increase in the torque developed. The maximum Lock Torque figures for the M418G. type are :

17 lbs./ft. at 450 amps. for the 12 volt machine and 9·25 lbs./ft. at 520 amps. for the 6 volt machine.

For the M45G. i.e. the $4\frac{1}{2}$ inch machine, the 12 volt range have a maximum Lock Torque of 22 lbs./ft. at 440 amps. and the 6 volt range of 14 lbs./ft. at 550 amperes.

In the next part we shall deal with the different types of drives used with the above range of starter motors.

Starter Drives

MAIN TYPES OF STARTER DRIVE

We have told you how the turning effort produced by the starter motor is transmitted to the engine flywheel by means of a starter drive and we shall now classify the various types, explaining the differences, both in construction and operation.

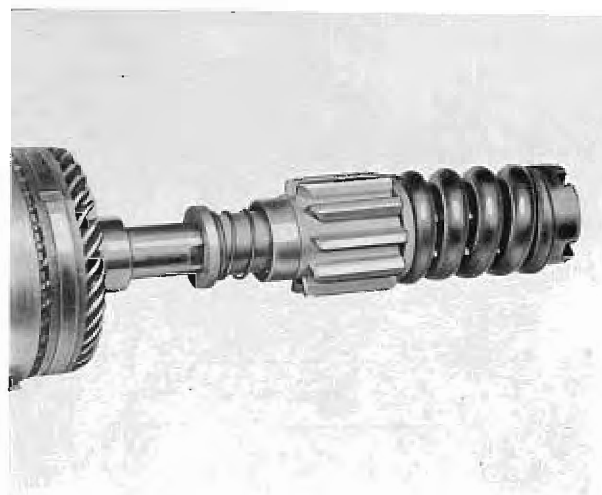
As far as the method of engagement is concerned, starter drives fall into three main groups : the inertia or " crash " type, the pre-engaged type and the axial type.

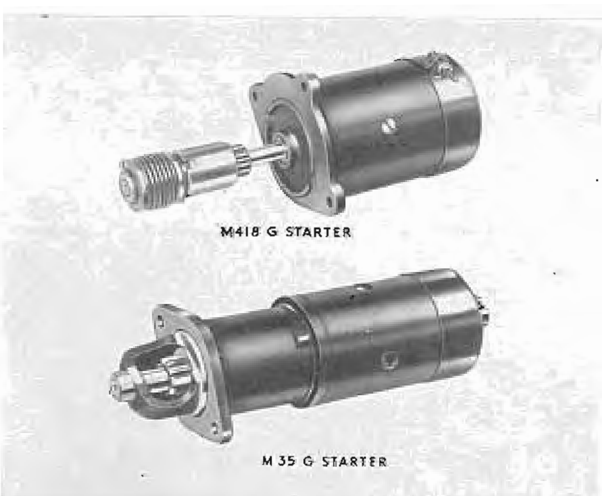
For our purposes we shall deal mainly with the inertia drive, this being the type normally employed for cars and light commercial vehicles.

THE " INERTIA " OR CRASH TYPE DRIVE

Here you see a simple " Inertia " or " Crash-Type " drive. As the starter armature rotates, quickly reaching a high speed, the pinion, lagging behind the movement due to inertia, slides along a screwed sleeve into mesh with the flywheel teeth.

The pinion and sleeve assembly is carried on splines on the armature shaft, this arrangement allowing the sleeve to move along the shaft against the action of a heavy compression spring, thus absorbing the initial shock of engagement. The pinion is thrown back into the disengaged position when the speed of the flywheel is relatively greater than that of the pinion, that is when the engine speed exceeds the motor speed.





INBOARD AND OUTBOARD OPERATION

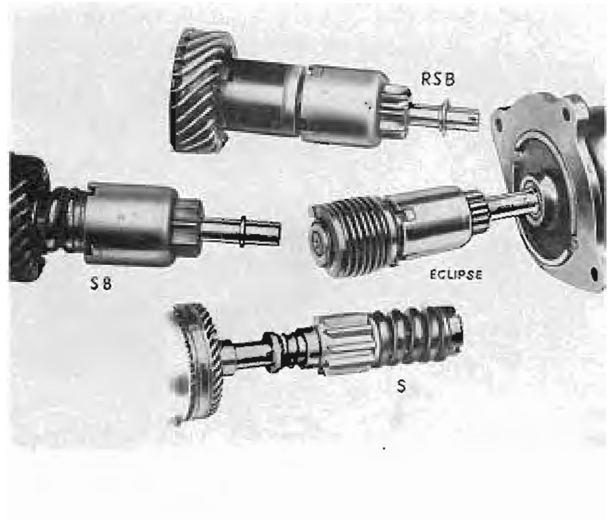
According to the method of mounting, the pinion may be arranged to move towards the starter motor to engage the flywheel or away from the motor. The former arrangement is known as the *inboard* drive — that's the one you see at the top ; the latter is the *outboard* drive.

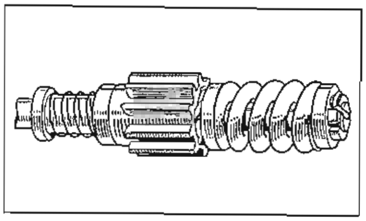
You will observe in the bottom picture that a special housing is necessary for outboard drives in order that an additional bearing can be provided to support the outer end of the shaft.

FOUR MAIN TYPES OF STARTER DRIVES

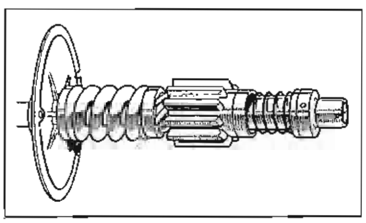
Lucas make four main types of inertia drive: the S, SB, the RSB (rubber coupling) and the Eclipse, with inboard and outboard models of each type.

We shall now examine each type individually.





Inboard Pattern



Outboard Pattern

THE "S" TYPE DRIVE

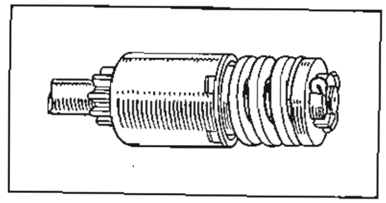
The shock load is here absorbed by the heavy compression spring. A light retaining spring prevents the pinion from being vibrated into contact with the flywheel when the engine is running.

The pinion of the inboard drive moves in towards the starter motor, that is from right to left in this picture.

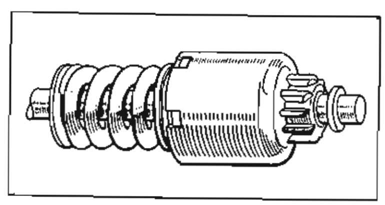
With the outboard drive the pinion moves outwards from the motor towards the end of the shaft.

THE "SB" TYPE DRIVE

This drive is a later version of the "S" type you have just seen. The pinion is here carried on a barrel type assembly which is mounted on a screwed sleeve. This sleeve is carried on splines on the armature shaft and moves along the shaft against the action of a compression spring. The pinion retaining spring is incorporated in the barrel drive.



Inboard pattern



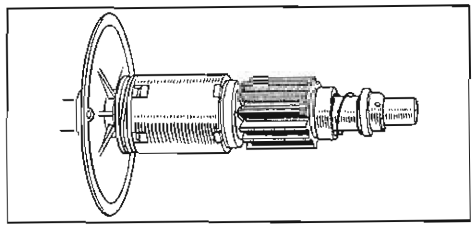
Outboard pattern

RUBBER COUPLING DRIVES

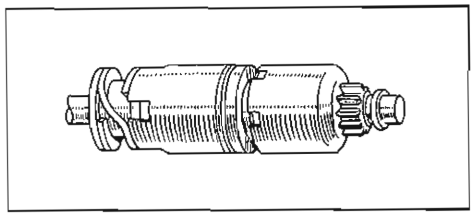
There are three models of this type, the " RS " and " RSB " being for outboard meshing, and the " RE " for inboard and outboard.

All these types of drive embody a combination of rubber torsion member and friction clutch. These control the torque transmitted from the starter to the engine flywheel and dissipate the energy developed in the rotating armature of the starter at the moment when the pinion engages with the flywheel.

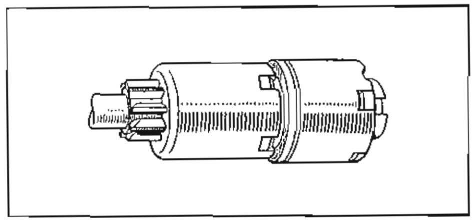
They also embody an overload release which functions in the case of extreme stress, such as may occur when the starter is inadvertently meshed into a flywheel rotating in the reverse direction.



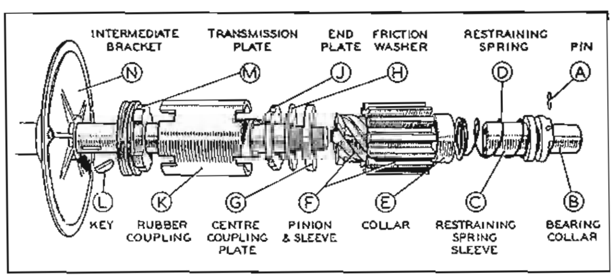
" RS " Pattern



" RSB " Pattern



" RE " Pattern



RS

THE " RS " TYPE DRIVE

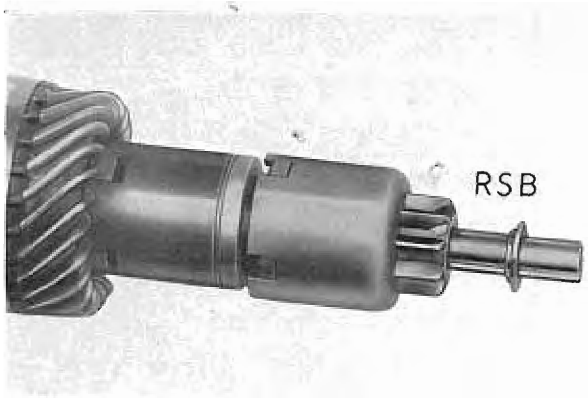
When the starter is energised, the torque is trans mitted to the pinion by two paths. One, from the transmission plate M, which is keyed on to the shaft, via the outer sleeve of the rubber coupling K and through the friction washer H to the screwed sleeve. The other path : from the transmission plate M to the outer sleeve of the rubber coupling, through the rubber to the inner sleeve and then via the centre coupling plate G to the screwed sleeve and hence to the pinion. The rubber limits the total torque which the drive transmits and, because the rubber is bonded to the inner sleeve, slipping can only occur between the rubber bush and the outer sleeve of the coupling. This slipping acts as a safety device against overload. Under normal conditions, the rubber will act as a spring and there will be no slip.

In all these drives, a pinion restraining spring D, is fitted, and this prevents the pinion from vibrating into mesh when the engine is running.

This particular drive is the RS pattern, but the principle of operation applies equally well to the other two types, the RSB and the RE.

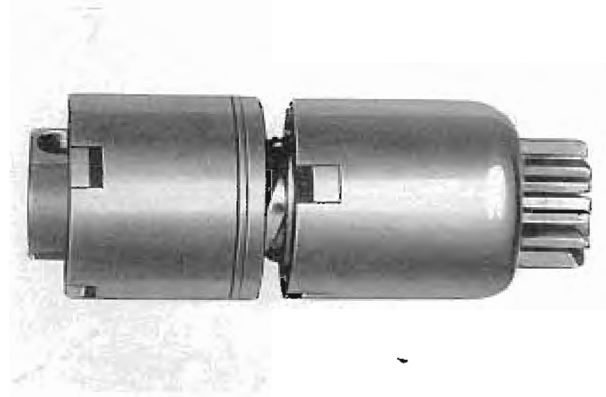
" RS " DRIVE — OUTBOARD

This is another picture of the RS drive and you'll notice that it is for outboard meshing.



" RSB " DRIVE

The RSB drive is again an outboard type. In this drive, a pinion and barrel assembly is used.



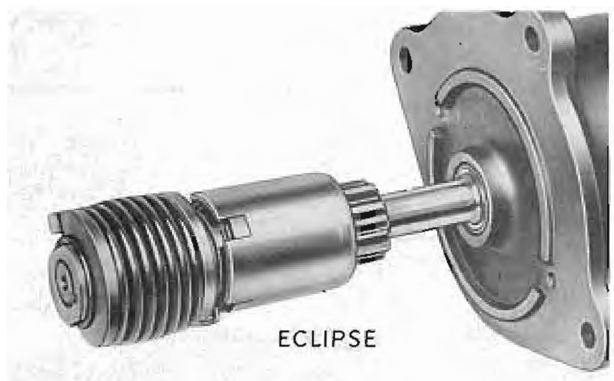
" RE " DRIVE

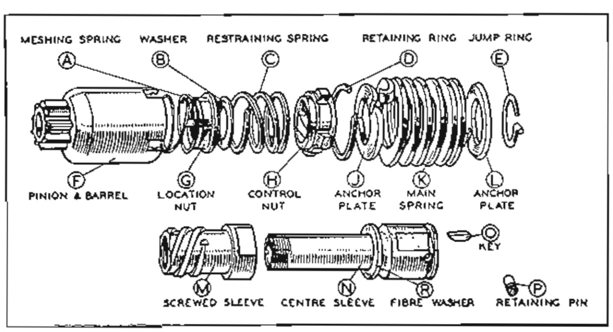
The RE drive is the only one of the rubber coupling types built for both inboard and outboard operation. Again you'll remark that the pinion and barrel assembly is used.

" ECLIPSE " DRIVE

The last main group of drives we have to deal with contains the " Eclipse " pattern. Here you have a general view of this drive, which is used for both inboard and outboard operation.

Basically it is a modified form of the " RE " drive, a main torsion spring, however, taking the place of the rubber.





" ECLIPSE " PATTERN DRIVE— EXPLODED VIEW

A meshing spring " A " (top left) and friction washer " R " (bottom centre) allow for slip under overload conditions.

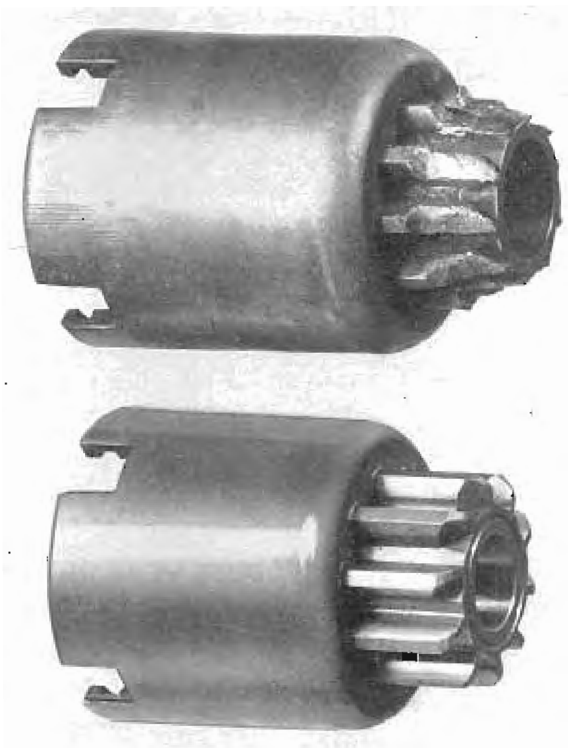
The pinion is carried on a barrel type assembly which is mounted on a screwed sleeve " M " (bottom left). This sleeve is carried on a centre sleeve " N " and is secured to the armature shaft by means of a pin and key, " P and O." The barrel assembly is so arranged that it can move along the shaft against the action of the " torsion " spring " K," to reduce the shock loading at the moment of engagement. A pinion restraining spring, " C " is incorporated in the drive.

PINION ENGAGEMENT

Before leaving the subject of starter drives, some reference should be made to the difficulties which sometimes arise with Starter engagement.

You can be assured that before any engine goes into general production, the engine manufacturer has satisfied himself that the Lucas starter which he has selected — generally in collaboration with our Sales Engineers — is suitable for that engine.

It sometimes happens however, that the assembly tolerances for instance, which finally determine the position of the leading edge of the flywheel teeth in relation to the starter motor pinion, do not work out quite as expected, resulting in starting troubles in service. The starter pinion may have to travel too far, thus developing a high speed before engaging the flywheel teeth, with the result that "milling" or "chipping" of the teeth takes place.



COMPARING A NEW AND WORN PINION

You can see in this picture how badly the teeth of one of the pinions have been damaged.

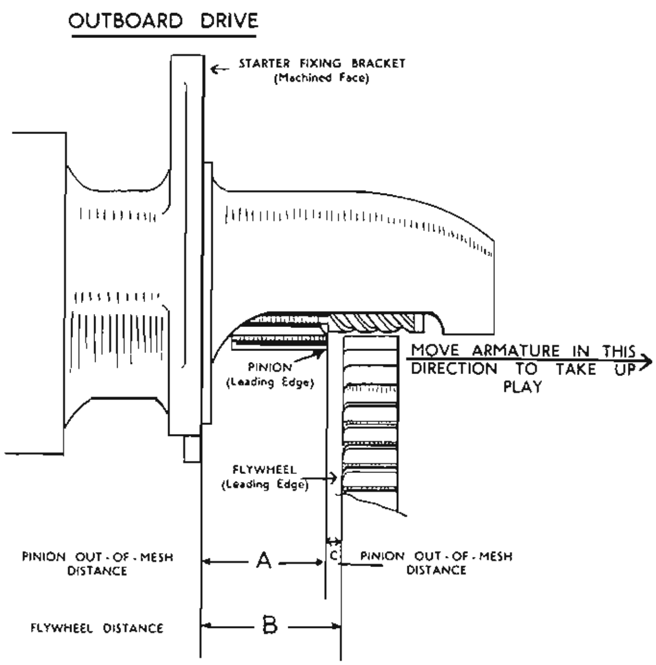
FLYWHEEL RING — NORMAL WEAR

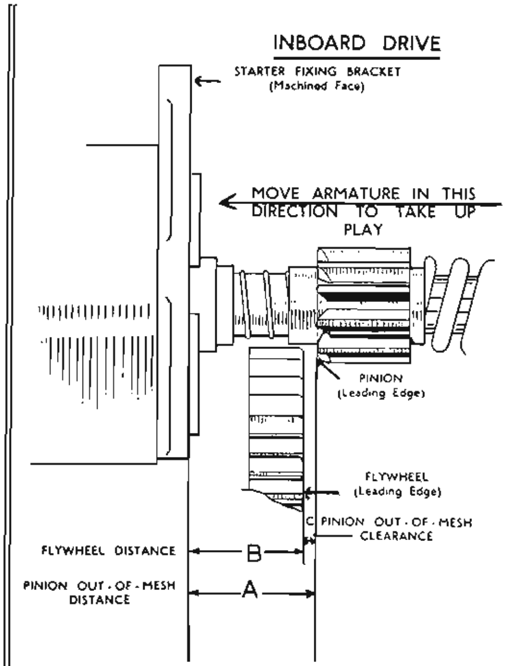
These flywheel teeth show no more than normal wear after prolonged service.

OUT OF MESH CLEARANCE

If the distance between pinion and flywheel is correct, no abnormal wear of the teeth takes place, the pinion sliding into mesh with little preliminary rotary movement. This distance, when the pinion is in the disengaged position, is called the " out-of-mesh " clearance.

We show both an outboard and inboard type arrangement here, the difference between measurement " A " and " B " being in each case the out-of-mesh clearance.





MEASURING OUT-OF-MESH CLEARANCE

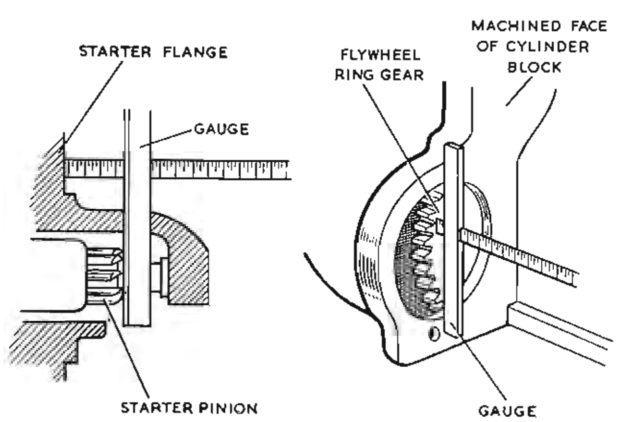
The method of measuring the clearance is shown in this illustration.

First take the dimension in the left hand picture, that is the distance between the starter — flange face and the leading edge of the pinion teeth. Then, as in the picture on the right, measure the distance from the machined face on the clutch housing to the flywheel ring gear. A properly calibrated depth gauge should be used to ensure accurate measurement.

The first measurement should then be subtracted from the second.

The correct clearances for the various types of drive are :—

Eclipse Type	$\frac{1}{16}$" to $\frac{3}{16}$"
All other types	$\frac{3}{32}$" to $\frac{5}{32}$"

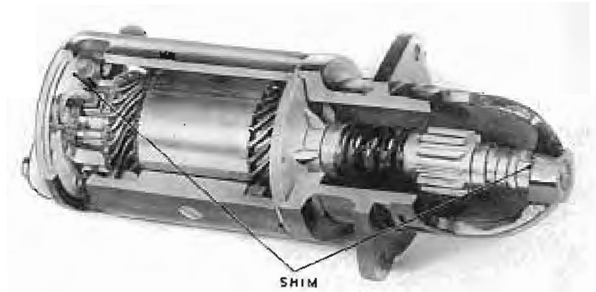


EXCESSIVE ARMATURE END FLOAT—SHIMMING

Even if the clearance was originally correct, if, in the course of service, excessive end-float is allowed to develop in the armature shaft, the out-of-mesh clearance may be sufficiently increased to cause trouble.

If noisy starter operation is experienced, the armature end-float of the starter should be checked, and if found to be excessive, shims should be inserted to take up the play. In the case of outboard starters, shims should be inserted at both the commutator and drive ends. In the case of inboard machines, the drive end only is shimmed.

Ten-thousands (·010) of an inch end float is normal, but if more than ·015, the out-of-mesh clearance may be affected, and any excess should be taken up.



FAULTY ENGAGEMENT AND DISENGAGEMENT

Faulty engagement as a general rule is the result o allowing the screwed sleeve and pinion assembly to become rusty or choked with grease or dirt and this may be easily rectified by a clean-up and re-lubrication with a light machine oil. It is particularly important to use a light machine oil under low temperature operating conditions when the motor acceleration may be reduced owing to the heavy current taken by the motor.

Other reasons for failure to engage may be broken or distorted Restraining Springs, broken or contracted main springs, faulty re-assembly of the complete drive after servicing, or incorrect out-of-mesh clearances.

As far as faulty disengagement is concerned, we will content ourselves with listing the likely causes.

Sticking of the pinion in mesh with the flywheel can be caused by :—

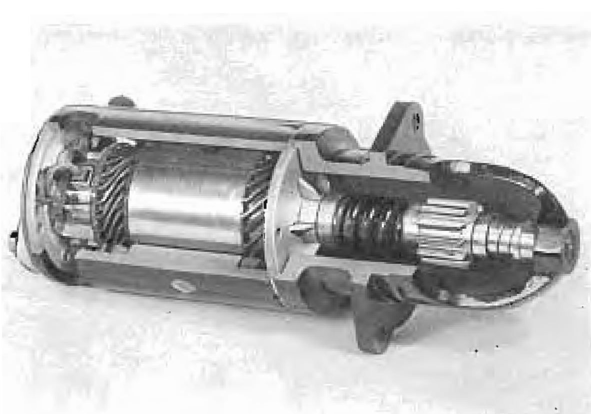
(1) Bent armature.

(2) Worn screwed sleeve, which causes the pinion to stick along the thread.

(3) Dirty or rusty condition of the sleeve and pinion.

(4) Slack drive assembly, usually due to the weakening of the compression spring.

(5) Incorrectly adjusted switch operating cable.



ASSEMBLY AND LUBRICATION OF DRIVES

These other points should not be overlooked if the mechanical side of the starting operation is in any way suspect.

First, the assembly of the drive. The unit may have been dismantled and reassembled incorrectly, in which case the best results can hardly be expected. And secondly the drive may be dry or dirty. A clean drive, lightly oiled, will give efficient operation.

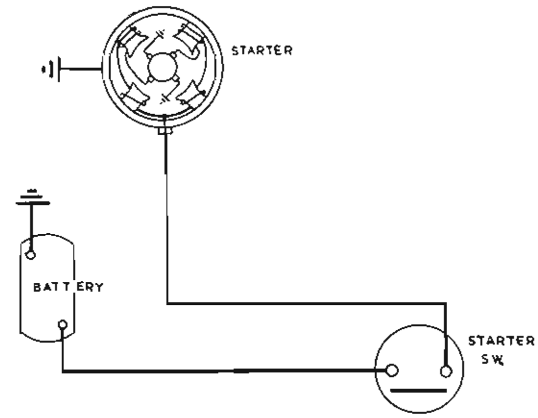
Service Testing on the Vehicle

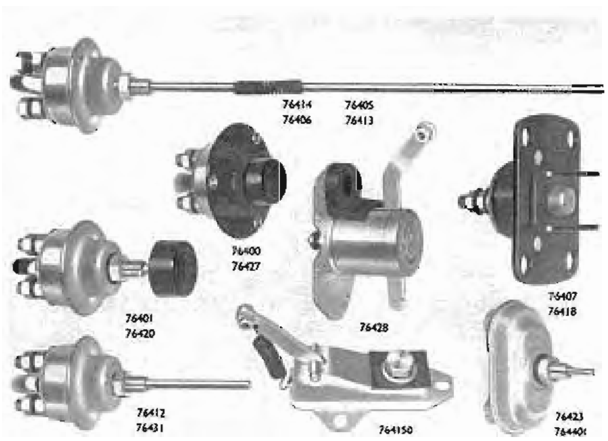
STARTER CIRCUITS

Having dealt mainly with the mechanical aspects of starting and starter motors, we shall now discuss the electrical side, showing you various starter circuits and finishing with a comprehensive series of tests for proving the electrical system.

Fundamentally the starter circuit is extremely simple as you can see, consisting of the feed wire from the battery to the starter motor, the circuit being controlled by a switch. The return path is via the chassis.

Lucas produce several types of starter switch. The one represented here is the simple manually-operated pull or push type.





MANUALLY OPERATED STARTER SWITCHES

Several examples of the manually operated switch are shown here.

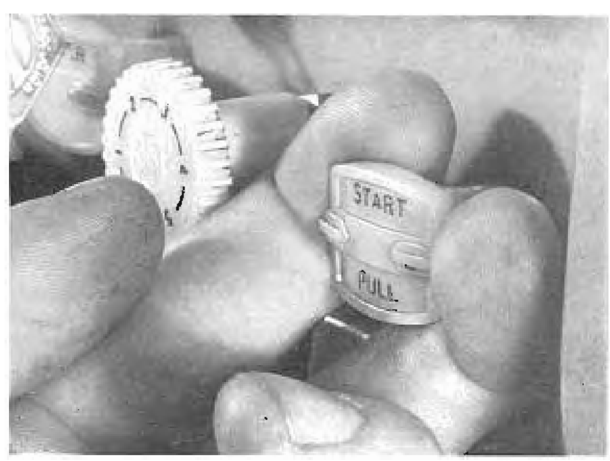
Each type, of course, is capable of passing the heavy current required by the starter motor, without voltage loss.

The effective life of any of them depends mainly on two factors: that the contact should be clean and positive; and that the break should be quick, with sufficient travel.

SWITCH ADJUSTMENT

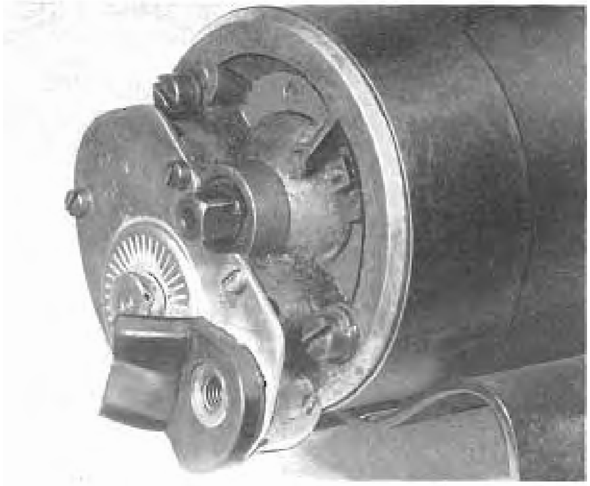
Where the switch is operated by Bowden Cable, it is extremely important that the pull is correctly adjusted. Otherwise excessive burning of the contacts takes place, with resultant loss of starter performance. There is a danger also, that with a too close adjustment of the switch contacts, the starter motor may be vibrated into operation. There should be about $\frac{1}{8}''$ free movement in the cable before the switch lever is moved.

The Push type switches are spring-loaded and require no adjustment.



" G " TYPE END BRACKET

Where this " G " type end bracket is used, the two fixed contacts must be faced to ensure correct alignment for the moving contact.



END BRACKET — BLANKING PLATE

We now mount the starter switch separately, thus enabling us to produce a standard type of end bracket. Many starters with " G " type end brackets are still, however, in service and for these a " blanking-off " plate is used which carries a disc contact to bridge the two fixed contacts.

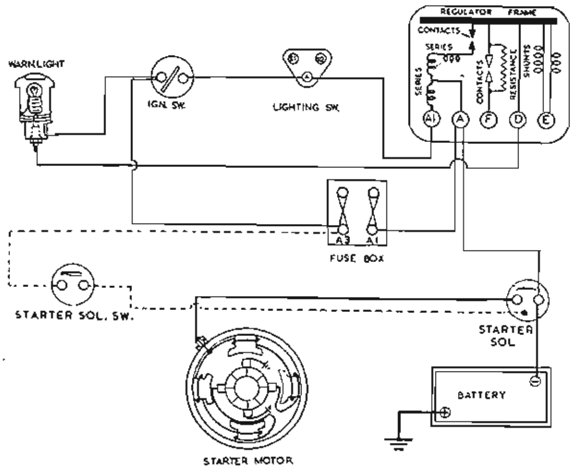
This arrangement enables the separately mounted switch, usually of the solenoid type, to be used.

STARTER SOLENOID SWITCH

The electrically operated switch or solenoid is shown here.

It contains the main starter contacts which are closed magnetically when the relay winding inside the switch is energised — that is when the starter push on the dashboard is pressed.

One end of this winding is connected to the smallest of the three terminals, and the other end to the metal case, which is earthed when the solenoid is bolted to the metalwork of the vehicle.



CIRCUIT FOR SOLENOID OPERATED STARTER

In the normal circuit, the feed to the solenoid operating push is taken effectively from the ignition switch ; A3 on the fuse board being used here only as a junction point. You'll notice there is *no* fuse in circuit. The cable from the negative of the battery is taken direct to one of the main solenoid terminals, the other main terminal being connected to the starter motor. The circuit is again completed via the starter and battery earths.

TESTING THE STARTER SYSTEM

From the earlier parts of our talk you may have gained the impression that starting troubles are mainly mechanical in origin — far from it. Trouble may often be traced to electrical causes: either to a faulty battery, a bad connection in the circuit or to a poor contact at the switch. It should never be assumed when faced with total failure or sluggish operation of a starter motor, that the fault lies necessarily with the motor itself.

It is therefore imperative that a systematic series of checks be first carried out on the electrical circuit so that the fault may be localised.

CHECKING PROCEDURE

We shall tackle the job in this order:

(1) Battery check.

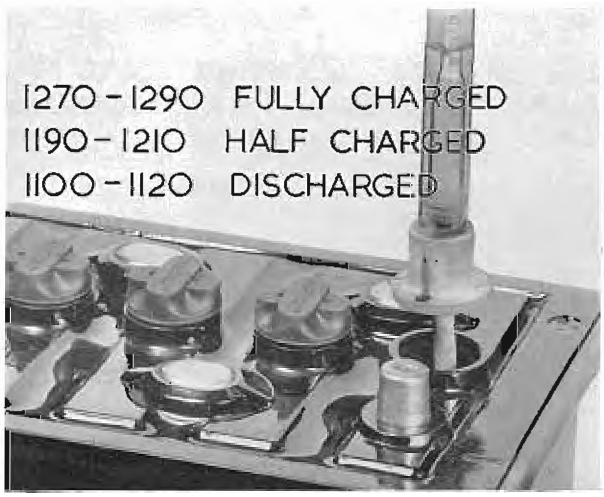
(2) Voltage at the Battery.

(3) Voltage at the Starter.

(4) Voltage drop on Main Line.

(5) Checking starter switch.

(6) Voltage drop on Earth Line.



BATTERY CHECK — HYDROMETER TEST

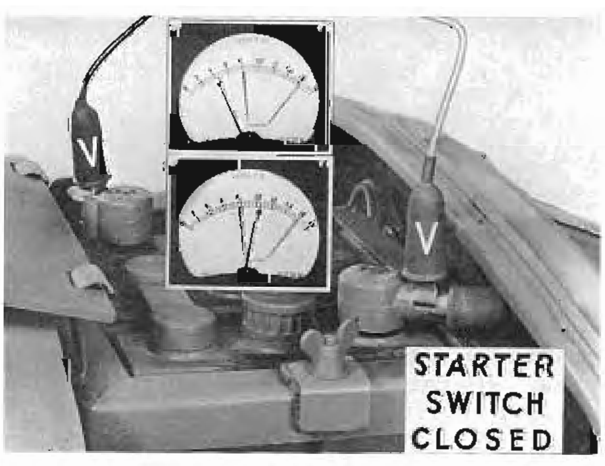
The hydrometer should show an evenly charged battery, that is, no great variation in cell readings, and *at least* a half-charged condition.

BATTERY CHECK — HEAVY DISCHARGE TEST

As a further check for the battery, a heavy discharge tester should be applied for approximately 15 seconds to each cell.

Steady readings of approximately 1·5v. per cell indicate a serviceable battery. A falling reading will be obtained from any cell which is defective.

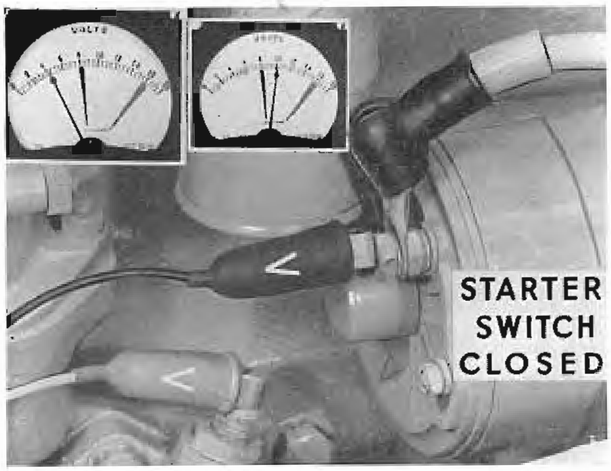
We have thus made sure that the battery is at least capable of giving the heavy current required by the starter motor.

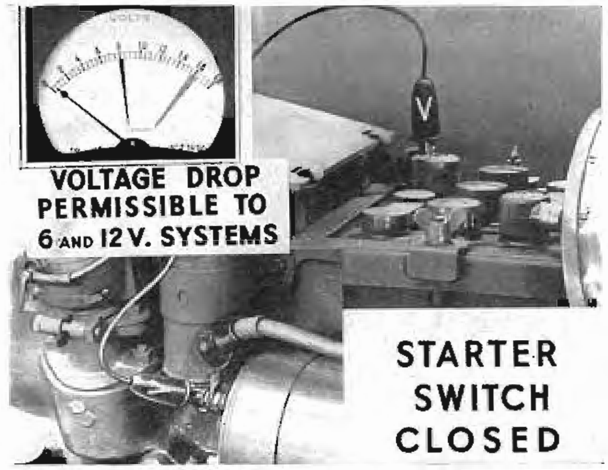


VOLTAGE AT THE BATTERY TERMINALS

And now, the rest of the circuit. The first check will give us the working voltage or pressure at the battery. The voltmeter is connected between positive and negative terminals.

When the starter is operated on a *cold engine*, the readings should not fall below 10 *volts* for the 12 volt system and 4·5*v*. for the 6v. system.





VOLTAGE AT STARTER TERMINAL

Assuming the voltage at the battery to be in order, next check the voltage at the starter terminal. This should be no more than ·5v. lower than the previous reading. *The voltmeter is connected between the starter terminal and the starter yoke.* In this photograph, the bottom voltmeter lead should NOT be connected where it is — there may be a bad connection between the engine block and the starter yoke.

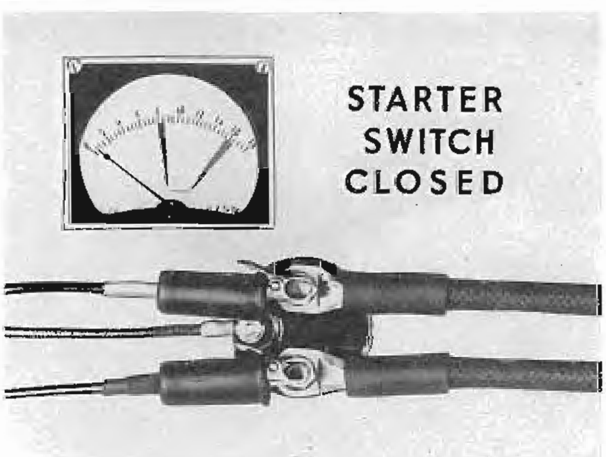
If a low reading had been obtained, both at the battery in the previous test and at the starter terminal, the motor is taking too much current, and the trouble will be found in the starter motor itself.

A good voltage at the battery and a poor voltage at the starter i.e. a considerable voltage drop, indicates a high resistance somewhere in the circuit.

VOLTAGE DROP ON THE INSULATED LINE

For our next test, we connect the voltmeter between the starter terminal and the main battery post to check the voltage drop on the insulated or feed line.

Before the starter switch is closed, battery voltage should be registered. But on closing the switch, the reading should fall to zero ; but readings of up to ·5 volt are permissible in service. If a higher voltage is registered, a high resistance point somewhere along the line is indicated. The most likely place is at the switch contacts.



CHECKING THE SWITCH CONTACTS

The contacts can be checked by connecting a voltmeter across them and closing the switch. The reading of battery voltage should fall immediately to zero or within ·5 volt of zero.

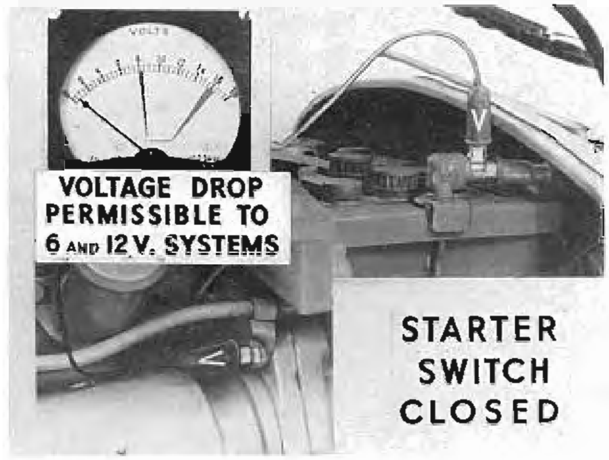
If the reading is within this limit, the high resistance deduced in the last test must be due either to a loose or corroded terminal, either at the battery or starter switch or at the starter motor. All of these points can easily be checked by a visual examination.

VOLTAGE ON EARTH LINE

In this last test, we are checking for voltage losses caused by a high resistance point on the earth return side of the circuit.

The voltmeter is connected between the battery earth terminal and the starter yoke. If the earth line is in order, the voltage drop when the starter is operated will be zero.

In service, a voltage drop of ·5 volt is permissible.



THE EARTH CONNECTION

If a substantially higher reading is obtained, all earth connections in the starter circuit must be checked.

Using the voltmeter as we have shown, each connection must be proved electrically sound.

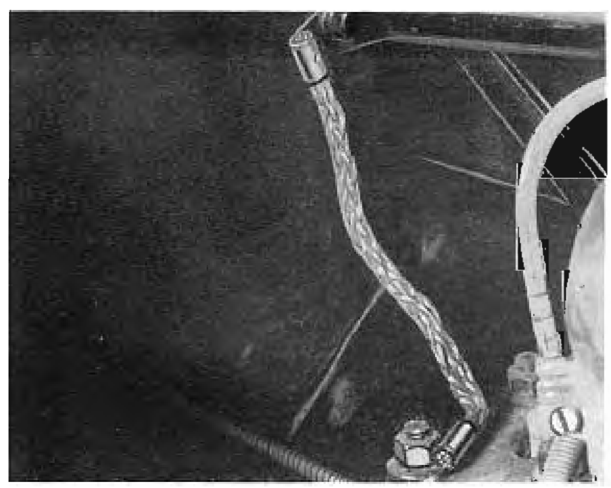
The most frequent cause of voltage drop on the earth line is a bad connection where the lug is earthed. Make sure that any such connection is clean and tight. Be particularly wary if the vehicle has just been repaired or painted ; the connection may have been disturbed.

THE BONDING STRIP

Another likely trouble spot is at the " bonding strip " between the engine block and the chassis. Remember that modern engines are rubber-mounted, the only good electrical connection to the chassis often being made by means of this strip.

Sluggish operation of the starter and sometimes complete failure can be caused by such a fault, or by a combination of minor losses at different points which produce in one circuit a sufficiently serious voltage drop to affect the performance of the starter motor.

We hope we have proved our point : don't suspect the starter before you have tested its electrical supply. Like most of us, it won't work if it's not fed properly.



The Lucas M45G Pre-engaged Starter

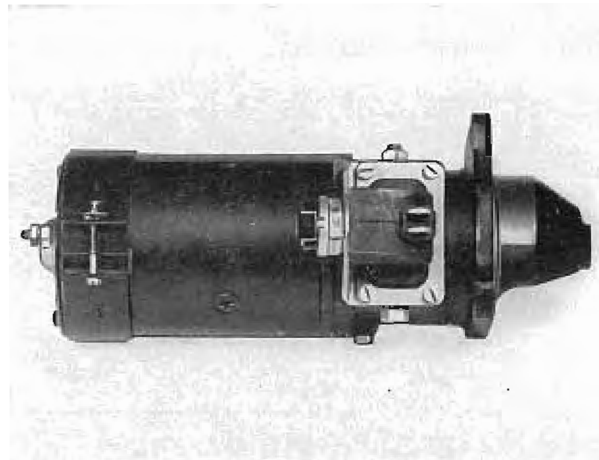
GENERAL VIEW—MANUALLY OPERATED PRE-ENGAGED STARTER

The majority of Lucas starters are equipped with the inertia or "crash-type" drive. In this arrangement, the starter motor is first energised, the revolving armature then forcing the pinion along a screwed sleeve into mesh with the engine flywheel.

The pre-engaged starter we feature here employs a different method of engagement : as its name implies, the pinion is actually in mesh with the flywheel ring gear prior to the torque being applied.

This type of engagement is more suitable for heavier engines of the diesel type, where large flywheels, high compression ratios and generally higher cranking speeds are usual. A normal inertia drive would quickly be damaged when operating under these conditions ; the meshing impact of the driven-pinion on a comparatively solid flywheel would be far too great to give an adequate service life for the starter motor.

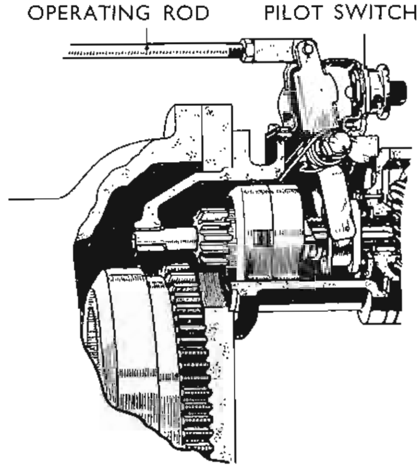
The pre-engaged starter is basically similar to the Standard M45G. motor, with a different drive assembly, and a Pilot Switch.



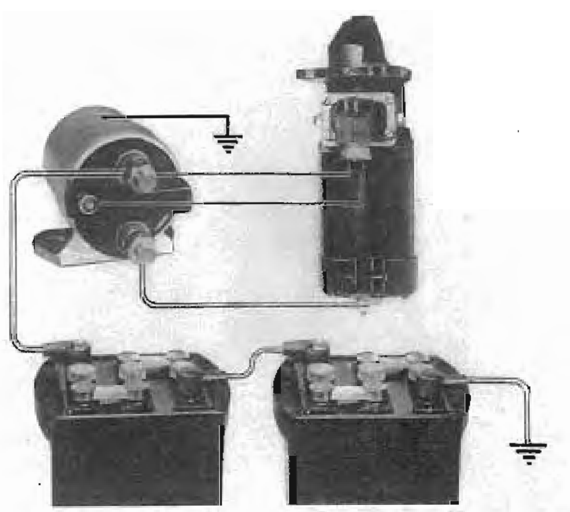
CROSS SECTION OF STARTER AND FLY-WHEEL

The position of the pilot switch in relation to the drive assembly is visible in this illustration.

When the starter operating rod is moved into the starting position, the operating lever attached to the end of it slides the pinion along the armature shaft into mesh with the flywheel ring gear. In this picture, the movement is just beginning. When the pinion has travelled the correct distance, the operating lever will close the pilot switch contacts. This completes the circuit for the energising winding of the starter solenoid, thus closing the main starter contacts. The starter armature revolves, transmitting the cranking torque via the pre-engaged pinion to the fly wheel.



SECTIONED VIEW OF STARTER AND BELL-HOUSING
Showing starter operating rod in position



THE COMPONENTS CONNECTED IN CIRCUIT

We have connected the components in circuit here to give a general idea of the layout.

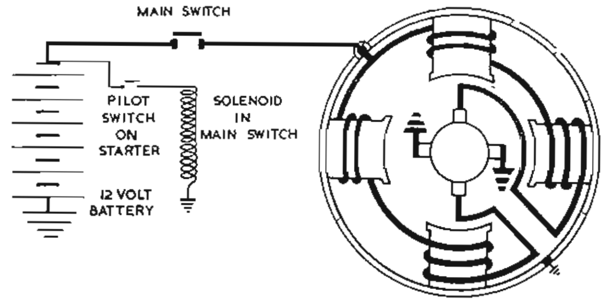
We will assume that the starter pinion has just been pushed into mesh with the flywheel. *The pilot switch contacts* will thus be made and the circuit for the energising winding of the solenoid completed. Commencing at the battery earth, this circuit is as follows :—through the two 6 volt batteries to one of the main solenoid terminals which is connected to one side of the pilot switch. Current passes across the switch contacts to the small solenoid terminal. The energising winding is connected between this terminal and the case which, as you can see, is earthed. The circuit is thus returned to the battery.

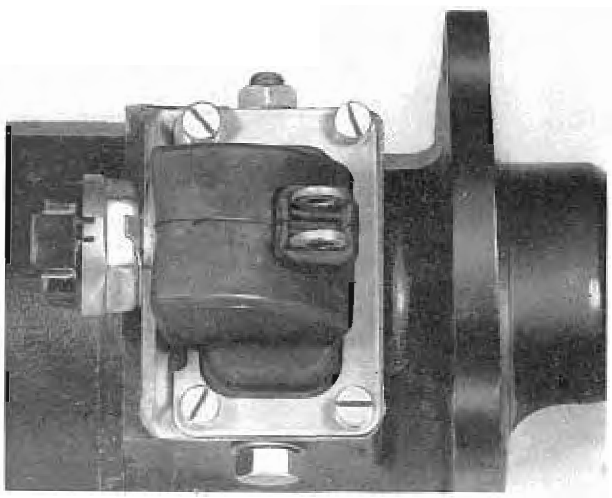
When the solenoid operates, the plunger closes the main contacts in the starter supply line, thus energising the starter in the normal way.

THE WIRING CIRCUIT

The internal and external connections can be seen from this circuit.

The study of this picture will be simplified if you divide the circuit into two : first, the relay operating circuit ; secondly, the main current circuit.





THE PILOT SWITCH AND RUBBER SHROUD

This close-up shows the pilot switch with its two grub screw connections. The switch plunger is actuated by the operating lever when the starter rod is moved.

The switch assembly is fixed to the starter body by four set screws, which also serve to fasten the water-proofing rubber shroud in position.

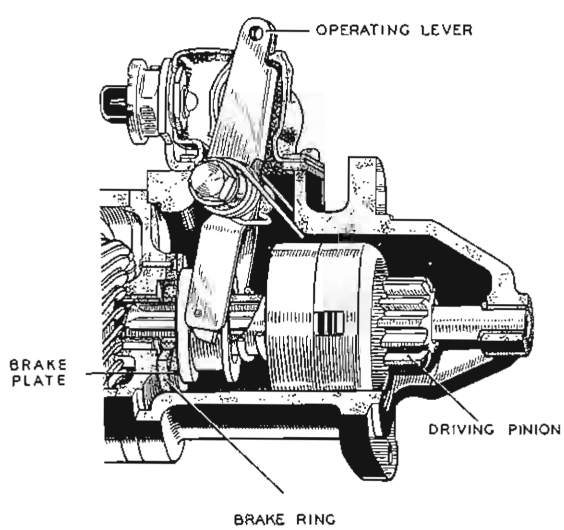
The switch bracket is slotted so as to allow adjustment of the switch in relation to the operating lever. We shall be refering to this adjustment more fully later on.

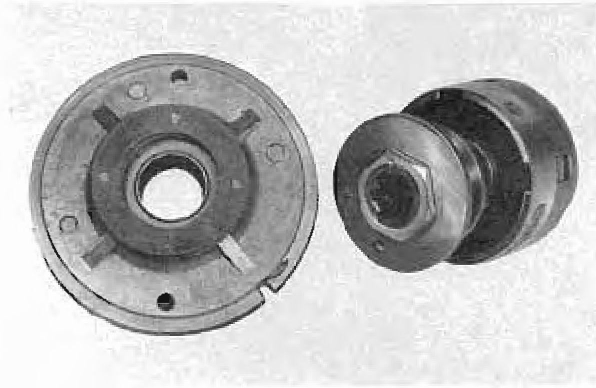
THE ARMATURE BRAKE

Let us now make a more detailed examination of the mechanical operation of this starter.

In the rest position, the bottom of the operating lever holds a brake plate hard against a brake lining. You can see the coiled springs which provide the tension. The plate is carried on the splines of the armature shaft and the brake lining rivetted to the intermediate bracket. The armature is thus prevented from rotating when the plate and lining come into contact.

Consider for instance a case where the starter is operated and the engine fires, but then stops ; the starter pinion could possibly still be revolving when it was again meshed into the flywheel. The coiled springs prevent this by returning the operating lever to the rest position and in so doing, a braking effect is applied to the armature.





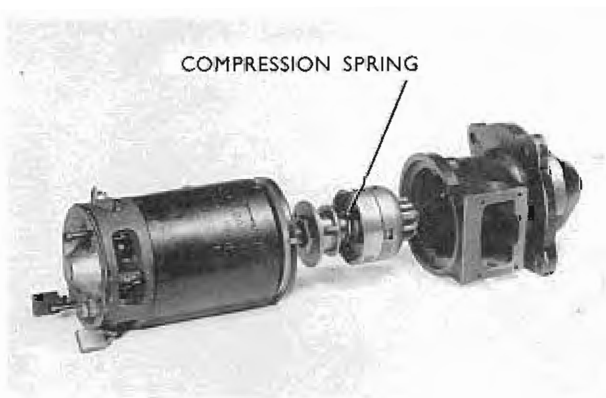
THE OPERATING LEVER

The stirrup shaped end of the operating lever is visible here so are the coiled springs holding it under tension. The two toggles actually form the bearing member on to the brake plate.

THE BRAKE LINING AND BRAKE PLATE

And here you see, on the left, the brake lining attached to the starter intermediate bracket.

On the right, we have photographed the brake plate in position at the end of the drive assembly.



THE COMPRESSION SPRING

The next feature of the drive assembly we wish to discuss is the compression spring. This is situated immediately behind the pinion and barrel assembly.

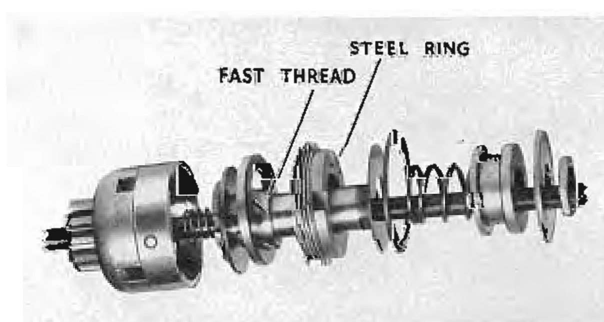
Usually, the pinion and flywheel mesh without any difficulty, the teeth being chamfered at the leading edges to ease the engagement. It can happen however that the teeth butt against one another — this is known generally as " tooth to tooth " engagement. When this occurs, the pinion will not slide into mesh but remains tight against the flywheel teeth. Increased pressure must be applied to the starter operating rod. This compresses the heavy spring behind the pinion and barrel, the compression continuing until the pilot switch contacts are closed by the operating lever. The spring can be more clearly seen in the exploded view below. The armature then begins to turn and immediately the pinion is sprung into mesh.

THE CLUTCH

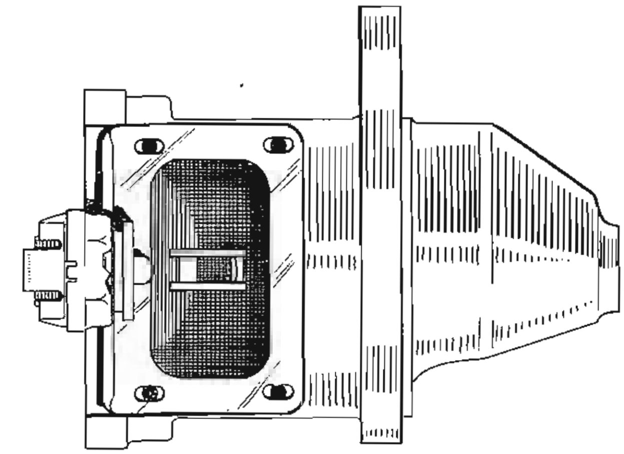
A clutch mechanism is incorporated in the drive to avoid overloading the starter. It is housed in the barrel of the pinion and barrel assembly.

Immediately the armature begins to turn, a heavy steel ring slides along a fast thread compressing the clutch plates and transmitting the drive to the pinion and barrel.

If the pinion sticks in mesh and the flywheel attempts to drive the starter motor, the steel compression ring returns along the fast thread to the rest position, leaving the clutch plates slack so that no drive can be transmitted through them.



If, to take another case, the engine load is too great, such as when the vehicle is in gear and the starter motor attempts to turn over the engine, the clutch is arranged to slip, thus relieving any abnormal strain on the motor. This slipping will also protect the starter should the engine backfire. The clutch is set during manufacture to slip in the driving direction at two to three times the normal full load torque and should never normally need re-adjustment in service.



PILOT SWITCH ADJUSTMENT

You will appreciate that the position at which the operating lever closes the switch contacts is rather critical if the pinion engagement is to be trouble free. Provision is therefore made for adjusting the position of the switch plunger with respect to this lever.

The four set screws, visible in the picture secure the cover plate and at the same time lock the adjusted switch in position.

THE ADJUSTING HOLES

This shows the elongated adjusting holes when the cover has been removed.

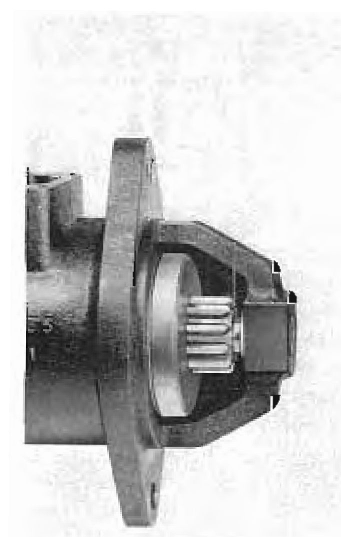
PROCEDURE FOR ADJUSTING SWITCH

In service, the adjustment of the switch should be carried out with the starter motor removed from the vehicle.

The pilot switch should then be set to make electrical contact when the leading edge of the starter pinion is from $1\frac{5}{8}''$ to $1\frac{3}{4}''$, as specified for individual vehicles, from the machined face of the drive end bracket. The switch fixing screws should be temporarily loosened and the operating lever pressed until the correct distance is reached. The switch can then be moved forward so that the plunger engages with the operating lever.

We suggest that a test lamp and battery be connected in series with the switch so as to facilitate finding the exact position at which the plunger closes the contacts.

When the motor is re-fitted, care must be taken to see that the starter operating linkage on the vehicle is correctly adjusted. There should be no slack in the movement ; on the other hand, full travel of the operating lever must be assured.



MAINTENANCE

The pre-engaged starter needs no further attention in service beyond that given to normal starter motors. An inspection of the brush gear and commutator, together with a check of the external electrical connections and cabling, should form part of the normal routine maintenance.

106.

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Section 3
COIL IGNITION

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

INTRODUCTION

It's a far cry back to the early days of coil ignition with flick contact breakers and " trembler " ignition coils. Nevertheless the principles involved have not seriously changed in any way. The high performance and absolute reliability of modern coil ignition equipment stands out as a testimony to what can be achieved by steady and persistent development.

The field of application for the modern coil ignition set now ranges from the small fractional horse power engine designed for general work right to the largest racing engines with up to 16 cylinders.

All this development has taken place at some loss to magneto Ignition, but great advances have taken place in this field and there remain extensive applications for both magnetos and flywheel ignition.

The Lucas range of ignition coils and distributors are designed to suit any type of petrol engine now in use and embody a variety of distinctive features to suit engine designers' special requirements.

The ignition coil and distributor really comprise a pair and when applied as original equipment to an engine may be accepted as the most suitable combinations for that engine, and unless subsequent change is recommended by the engine manufacturers or ourselves, there is nothing to be gained, but possibly a good deal to be lost, by haphazard exchange of ignition coils, mouldings, or other components, particularly contact breaker sets of other manufacture.

The type of ignition coil is primarily dictated by the requirements of the engine i.e. Compression Ratios, Plug Gaps, etc. To provide for the varying requirements of different engine makers, several types of ignition coils and distributors are manufactured.

Ignition coil performance will be most seriously affected by the contact breaker which operates it, particularly at the high speed end of the scale.

It is often doubtful whether the important part which the contact breaker plays in the satisfactory performance of an engine is fully realised. On a six cylinder engine running at four thousand revolutions per minute the contact breaker has to make and break at accurate pre-determined intervals, with absolute precision, some twelve thousand times per minute. At each make and break a starting current commencing at 4·0 amperes or so and falling away to about 1·5 amperes as speed increases has to pass across the points without appreciable voltage drop, if the coil is to build up a maximum spark voltage during the very brief time the contacts are closed. To achieve this a great deal of thought goes into the development of the contact breaker set.

To maintain the efficiency of the component in service only a modest amount of periodic attention is required, but this is necessary if the best results are to be consistently obtained. The racing enthusiast will give as much attention to the contact breaker as to the valves and carburation of an engine !

The original manufacturer is bound to produce a contact breaker set which will do everything that he claims for the ignition coil and distributor, and maintain this perfect condition for the longest possible time. The spurious part maker by contrast has no such responsibility, providing that his component will work reasonably well he may be satisfied.

All told the distributor comprises four distinct but complementary components each with a separate function to perform :

Firstly, the contact breaker and cam assembly which interrupts the primary winding of the ignition coil and thus produces the spark at the correct angular intervals.

Next the distributor rotor and cover which serves to distribute the spark in the correct cylinder firing order.

Thirdly, the centrifugal automatic unit which advances and retards the spark according to the requirements of varying engine speeds and fourthly a supplementary vacuum advance device. This latter being a more recent development which provides varying and additional spark advance under high speed light load conditions.

The maintenance and servicing of the whole equipment is simple and given a reasonable knowledge of the various types of units and their applications, very little specialised electrical knowledge or data is required. For this reason a study of the information contained in this book will prove most useful in the course of the day's work.

CONTENTS

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Coil Ignition Systems

Circuit Layout, Construction and Operation of the Coil

GENERAL.

In considering the Ignition System of the modern motor vehicle we are dealing with something vital to it's running.

The many refinements introduced on individual components have not disturbed the simplicity of the ignition system as a whole; in dispensing with complications reliability has been assured.

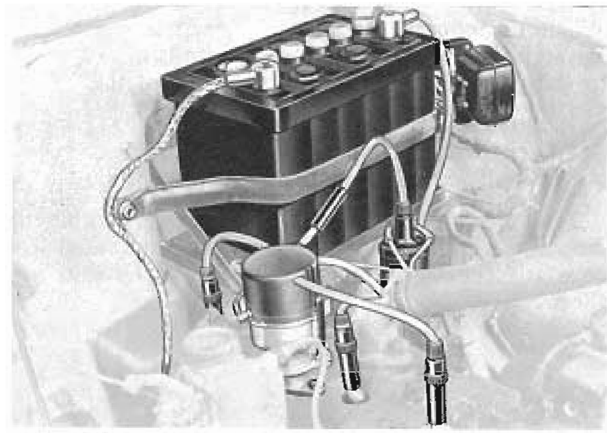
In addition, maintenance has been reduced to an absolute minimum. The average vehicle user of today is not prepared to spend a large amount of time under the bonnet, so the aim of design must be : maximum reliability with minimum maintenance.

This aim has also kept pace with the great advances which have taken place in engine design and performance, particularly as regards higher speeds, higher compression Ratios, and wide Plug Gap Settings which coupled with lean mixtures, produce greater fuel economy.

You can see then that the ignition system has a big job to do — if it doesn't do it well, even the best engine can become an ' also ran.'

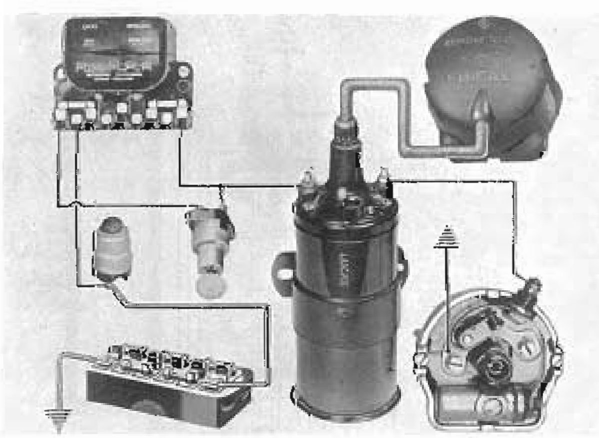
THE COIL IGNITION CIRCUIT.

Essentially, the ignition system comprises the Battery, the Coil, the Distributor, and the Spark Plugs. The Radio Suppressors shown may be optional extras.



For our purposes here, the control box on the right merely provides a convenient method of supplying the coil and distributor with current.

The general accessibility of this particular layout is most commendable, but very frequently the distributor itself is not so well placed.



PICTORIAL LAYOUT OF EQUIPMENT.

You can see from this picture how the components are connected in the circuit.

Let us start at the battery. We pass via a junction point at the starter solenoid, through terminals A and A1 of the control box to the ignition switch.

When this switch is turned to the ' ON ' position, the ignition coil is fed with current which then passes through the primary winding in the coil to the C.B. terminal. This terminal is connected to the distributor. The circuit is completed via the contact breaker points in the distributor to earth.

The high tension current for the sparking plugs is taken from the chimney of the ignition coil to the distributor cap. Then the rotor arm of the distributor conveys the spark to each of the plugs in the correct firing order.

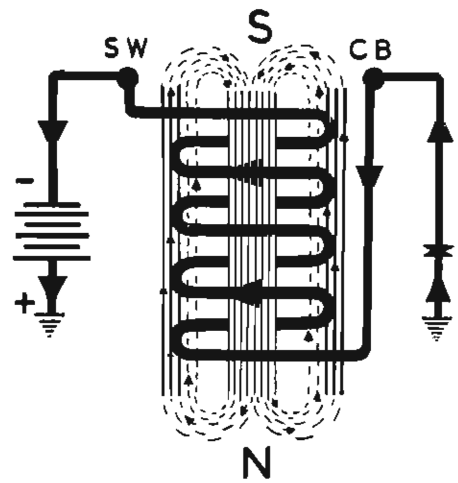
We shall now discuss the two main components of the circuit — the ignition coil and the distributor.

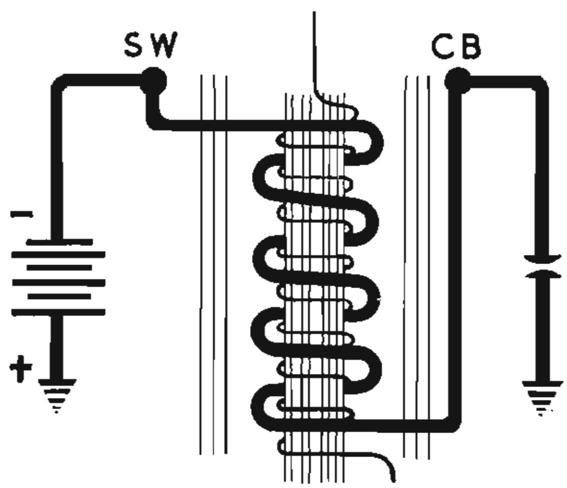
THE PRIMARY CIRCUIT.

This diagram shows the primary winding of the ignition coil with the battery connected to the S.W. terminal and a contact breaker to the C.B. terminal. When the contact breaker is closed, current flows through this primary winding and finds its way back to the positive, or ' earthed ' terminal of the battery via the engine block and chassis.

The current flowing through the winding produces a ' magnetic field ' around it, as we have illustrated.

To concentrate all the ' lines of force,' within the coil, the winding is formed round a laminated iron core and the whole assembly enclosed by thin iron sheets.





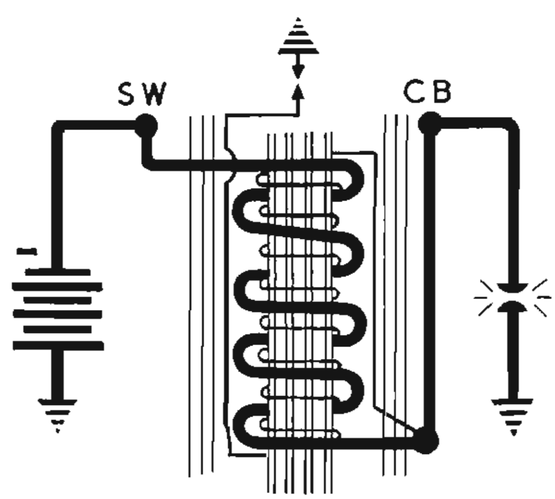
PRIMARY CIRCUIT WITH C.B. POINTS OPEN.

When the C.B. points open, the current stops flowing and the magnetic field collapses. Now if we wind a second coil of wire on to our core, about 20,000 turns of very fine wire, the collapsing magnetic field will induce a current impulse in this fine winding. This impulse can be at a pressure of 20,000 or more volts and represents the available spark plug voltage.

THE SECONDARY CIRCUIT.

One end of the fine secondary winding is connected to the primary — bottom right of the illustration — and the other end effectively to the spark plug, at the top.

The return path for this H.T. circuit is via the engine block, the chassis and the battery earth. The high voltage, therefore, causes a spark to bridge the plug gaps between the block and the insulated electrode. Additionally in this illustration, you can see that we have shown sparking across the C.B. points. And this is where a condenser comes in.

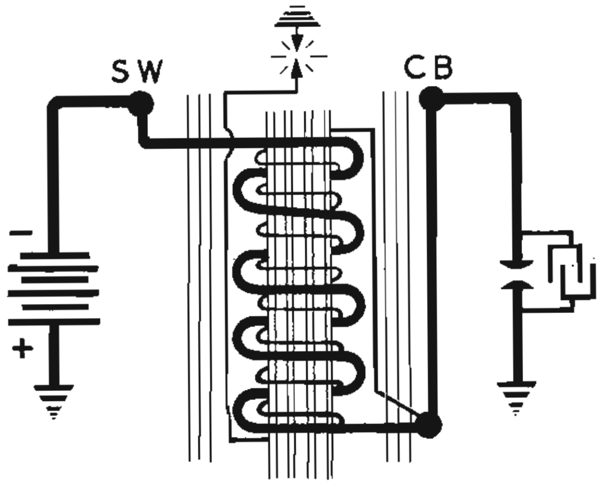


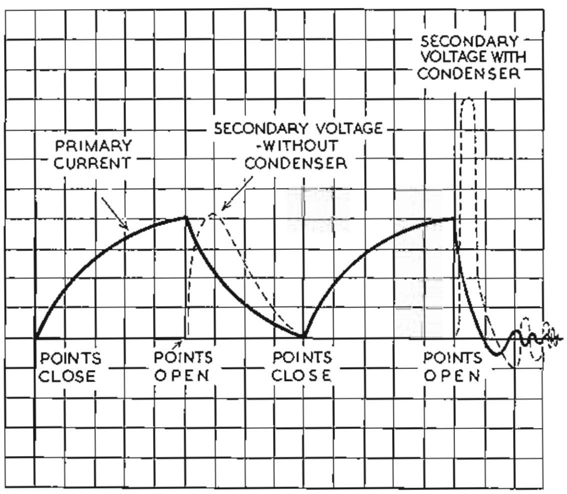
THE COIL CIRCUIT WITH CONDENSER.

We have already said that when the primary circuit is opened by the C.B. points the field collapses and a current is induced in the secondary winding.

At the same time the collapsing field also induces a new voltage in the primary which, although we are only supplying the primary winding at say 12 volts, may rise to 250 or 300 volts. This induced voltage tries to drive current round the primary circuit just as the points are opening, causing excessive arcing and sparking at great heat which would quickly destroy the C.B. points. So we place a condenser across them, the plates of which will absorb the excessive voltage and thus reduce its destructiveness.

You will see in the next illustration what effect the condenser has on the spark plug voltage.





GRAPH SHOWING EFFECT OF CONDENSER ON H.T. OUTPUT.

This graph shows how the condenser affects the H.T. output to the plug and also the arcing across the C.B. points.

Left half, without condenser. When the C.B. points close, the current builds up in the primary winding. When the points open, the current slowly collapses, arcing occurring across the C.B. points.

Only a small secondary output is obtained as shown by the dotted line.

Right half, with condenser. When the C.B. points close, the current builds up as before, but when they open, the current flow collapses almost at once, putting a very strong ' kick ' into the secondary output as shown by the broken line.

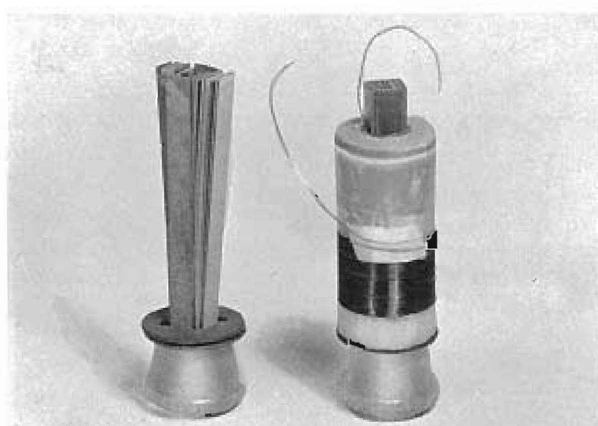
Arcing at the C.B. points is almost eliminated.

CONSTRUCTION OF THE IGNITION COIL.

Let us now see how the ignition coil is constructed.

A laminated iron core is fitted into a porcelain base-piece. The secondary or fine winding, consisting of anything from 6,000 to 20,000 turns of fine gauge enamelled wire, is then placed over the core.

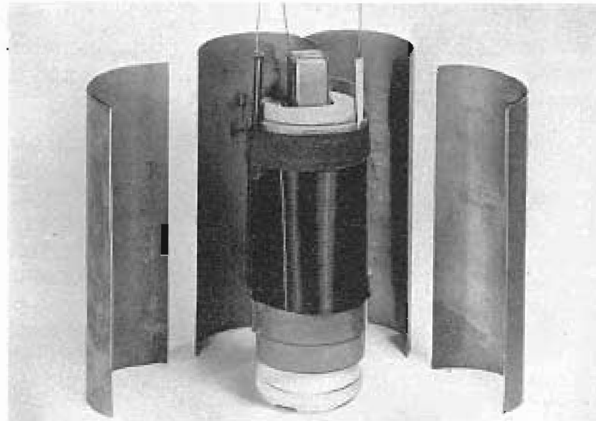
A pig-tail take-off is fastened to the end of the fine secondary wire and brought out at the top as you can see.

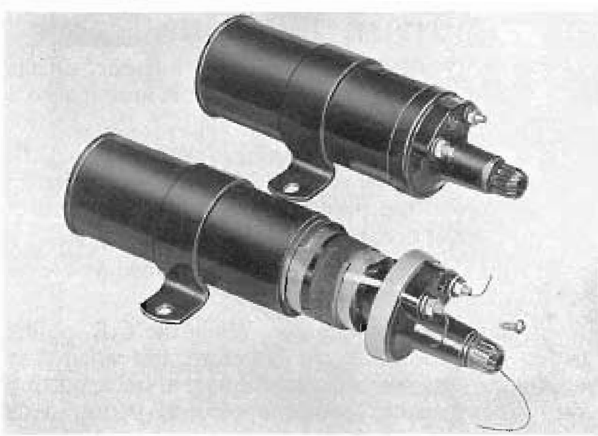


BUILDING THE COIL PRIMARY WINDING.

The primary winding, comprising about 300 turns of much heavier wire, is then wound on top of the secondary and brought out at the top. Winding the primary on top of the secondary helps to dissipate the heat and makes it easier to insulate the high tension winding from the case.

A magnetic shield of sheet iron is then placed round the complete winding.





ASSEMBLING THE COIL.

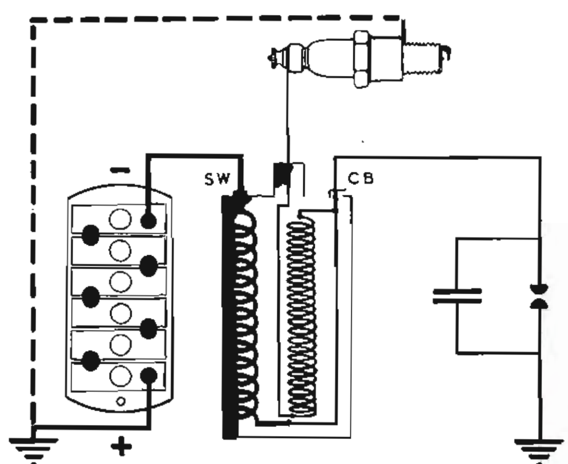
The whole assembly is then put into a steel case, the moulded top threaded over the leads, and the moulding with its metal base-ring soldered on to the case.

At this stage it is desirable to seal the whole assembly hermetically in order to prevent condensation and corrosion occurring at any subsequent stage.

For many years this very important sealing operation was done by extracting all the air and filling the case with Bitumen. More recently a fluid filling technique has become popular. Both methods are equally effective but with the fluid-filled coils a noticeable result in service is that the outer case of the fluid-filled coil is rather hot to the touch, due to the fluid filling which has a better heat conductivity than the earlier bitumen filled types. This apparent overheating should cause no concern, and is in fact an indication that the coil is working efficiently.

AUTO TRANSFORMER ACTION.

The internal circuit of the coil is of special interest. You can see that the secondary winding is in series with the primary. This improves the spark at the plug, the 300 volts induced in the primary at the contact break being added to the secondary voltage. This effect is known as auto-transformer action.

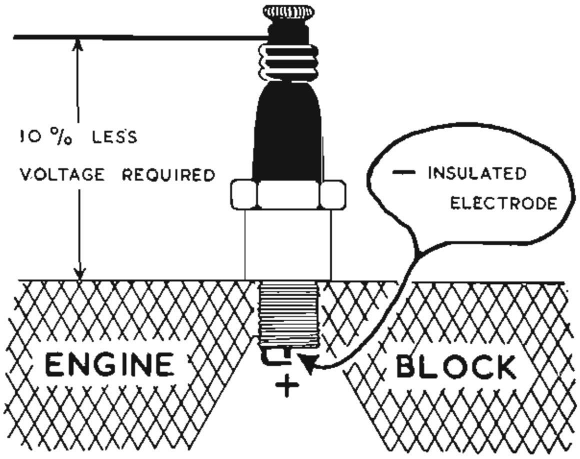


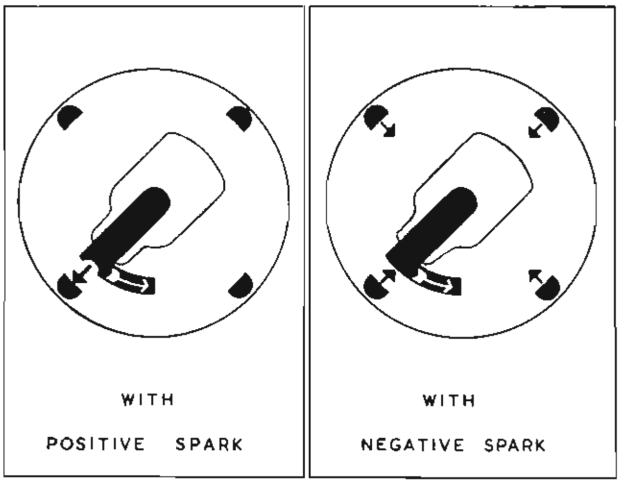
THE 'NEGATIVE SPARK.'

Coils are normally wound to give a *positive* earth spark — that is, the spark plug insulated electrode is *negative* with respect to the engine block or earth. We usually refer to this as a 'negative spark.'

Several distinct advantages are obtained. We have the same sparking efficiency at considerably lower voltages — approximately a 10% reduction in the H.T. voltage required to break down the gap. By lowering the voltage, the strain on the insulation throughout the high-tension circuit is considerably reduced — i.e. cable insulation, distributor cap and all mouldings and plugs.

We will point out that if the external connections to the SW and CB terminals of the coil are reversed, current will flow in the opposite direction through the coil, reversing the H.T. spark polarity. In addition the auto-transformer action is lost.





ROTOR WEAR.

A further advantage gained with this *negative* spark is little or no wear of the rotor arm. The picture on the left shows how metal is transferred from the rotor to the fixed electrode on each spark. With the *negative* spark on the right, the metal transference is in the opposite direction and wear is divided evenly between the four fixed electrodes.

NEGATIVE EARTH COIL.

Standard Lucas coils are all wound for use with *positive earth* battery : but special coils are available for use on negative earth systems, such coils being connected internally to give a similar spark polarity to those used with the *positive earth system.*

In emergency the negative earth coil can be used on a positive earth vehicle.

TYPES OF COILS.

We will now discuss some of the reasons why different types of coils must be produced. Factors other than the ones we have mentioned — spark polarity and supply voltage — must be taken into consideration. For instance, the work the coil has to do depends on the engine : coils for single cylinder engines need nowhere near the same spark performance as those used on 8 cylinder engines.

The ' breakdown voltage ' of the plug varies with different engines, according to the plug gap, the compression ratio, heat, etc.

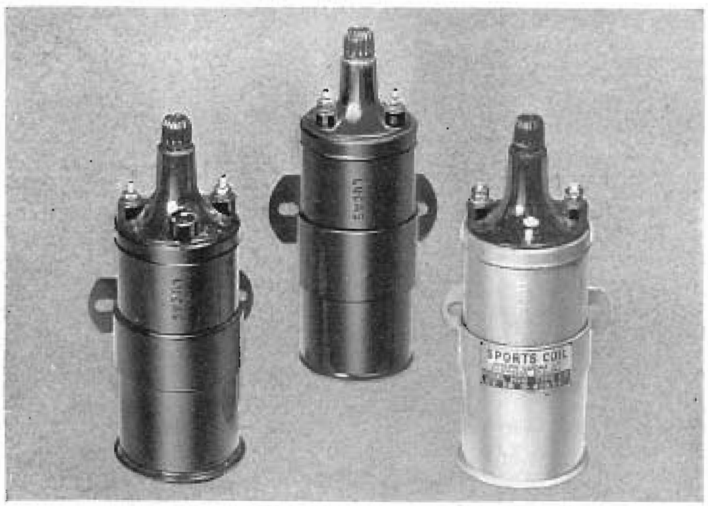
Another thing, the speed range of engines vary : one 6 cylinder engine may run up to 4,000 r.p.m. another, say, up to 6,000 r.p.m.

Our ignition coils, then, must cater for all these varying requirements. Each coil must be more than sufficient to fulfil all the operating conditions of a particular engine.

Thus we must produce a wide range of coils, varying, as far as physical make-up is concerned, in the ratio of primary to secondary turns, primary current consumption and of course size. And don't forget that this primary current has a great influence on the maintenance necessary to the contact breaker points.

The fitting of oversize or special coils can only produce an advantage in performance if accompanied by carburettor and other adjustments or modifications.

We can sum up by saying that it won't do to fit any old coil as a replacement : look up the coil recommended for the particular engine.



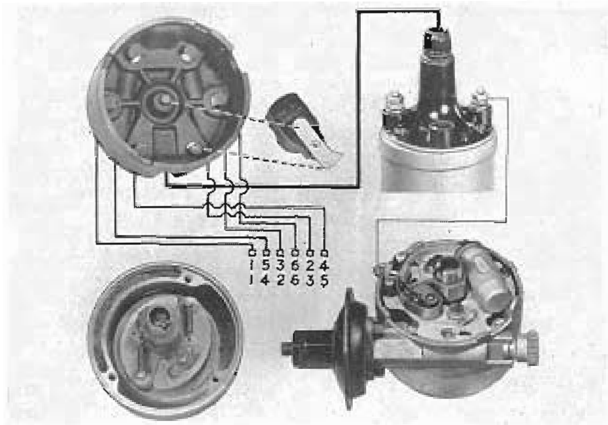
Distributors & Ignition Timing

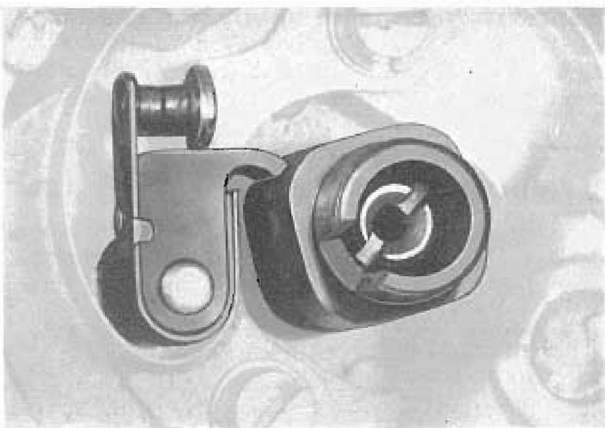
THE FOUR FUNCTIONS OF THE DISTRIBUTOR.

The four functions of the distributor are :—

1. To interrupt the primary circuit of the ignition coil and so produce the high tension spark. The contact breaker makes this possible.
2. To distribute the high tension spark to the spark plugs, in the correct firing order. The rotor and distributor cap deal with this.
3. To provide automatic regulation of the spark timing over the whole engine speed-range — the function of the auto-advance mechanism.
4. To provide means, when required — by the addition of the vacuum advance mechanism — of varying the spark timing according to the loading of the engine.

We shall now deal in turn with each of these functions.





THE CAM AND CONTACT BREAKER.

This photograph shows you the normal form of the cam and contact breaker for a four-cylinder engine.

The heel of the moving contact rides on the cam face, causing the contacts to open on each lobe of the cam, thus breaking the primary circuit of the ignition coil.

Adjustment of the contact gap is effected by moving the fixed contact. The gap is set when the contact breaker heel is on the peak of the cam lobe.

We shall deal more fully with the gap settings for the various types of cam in a later part of this book.

THE CONDENSER.

In this illustration we show the condenser, which is placed in parallel across the C.B. points.

The early types you see here consisted of two large areas of aluminium foil in strip form, separated by waxed paper.

One strip of foil is soldered to the case of the condenser, the other to a wire which is soldered to the screw terminal.

Generally speaking, if moisture, dust and foreign matter can be completely excluded at the time of manufacture, the effective life of the condenser is practically unlimited.

On the other hand if either the fixing screw or terminal nut becomes loose in service, a lot of ignition trouble will be caused due to a weak H.T. spark and burnt C.B. points.

The ignition condenser has a capacity of ·18 to ·24 M.fd. which is of considerable importance in obtaining maximum performance from the ignition coil over its full sparking range.

METALLISED-PAPER CAPACITORS.

The condensers used in the latest Lucas distributors are of further improved construction.

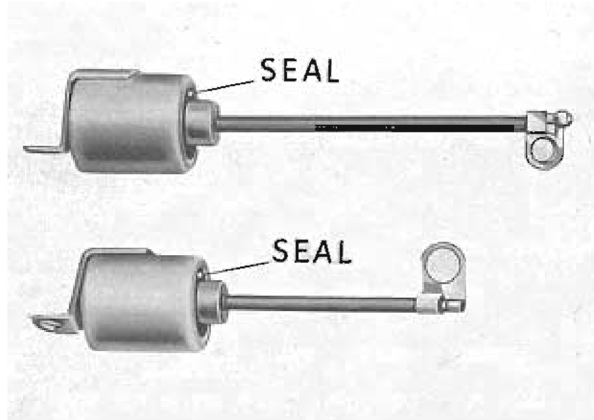
The normal foils have been replaced by an extremely thin coating of aluminium on one side of a paper tissue. A pair of these coated tissues are then wound together to form the condenser, or capacitor as we now prefer to call it.

The effect of a breakdown of the ' Dielectric ' for any reason is momentarily to produce a short circuit through which passes the high discharge current from the already charged capacitor ; a high temperature results in the immediate vicinity of the breakdown which vapourises and oxidises the aluminium and so the fault is cleared, the capacitor continuing to function normally.

The energy required to clear a fault is extremely low and the wax and paper are not damaged in the vicinity of the breakdown. Since the aluminium oxide is non-conducting, no appreciable decrease in insulation resistance is experienced, even after several hundreds of internal breakdowns have occurred under test conditions.

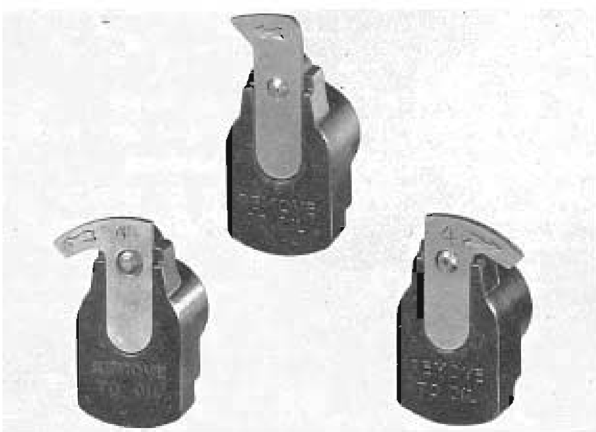
Note — the Dielectric is the separating medium — in this case, paper.

Another factor of great importance is the size of



these new type condensers : they are approximately one third the volume of the equivalent paper-foil condensers. The capacity is the same as the early types.

The sealing of the condenser has also been improved, rubber replacing the earlier bakelite end-cap. You'll notice too that the terminal nut arrangement has been replaced by a lead. This improvement avoids the strain on the end-cap which was formerly experienced when the nut was tightened.



DISTRIBUTOR ROTORS.

The most noticeable feature of our rotors is the extended electrode. Most of you know that the reason for this is to prevent back running of the engine (not backfiring).

The important point is always to have the correct lead of rotor in the distributor.

The direction of rotation of our distributors is always given *viewed from the driving end.*

Therefore the extension of the electrode must always point in the direction of rotation.

The rotors on the left and centre will both be fitted to clock distributors ; that on the right to anti-clock distributors.

DISTRIBUTOR CAPS.

A major consideration in the design of distributor caps is the avoidance of ' tracking ' of the high tension spark under extreme conditions of humidity. At the same time, adequate ventilation must be provided to allow the corrosive nitrous-oxide produced by the sparking to escape from the cap.

The cap shown here is a good example of a design which gives the maximum space between fixed electrodes. This reduces tracking of the H.T. Spark between electrodes, or to earth, to a minimum. In addition, extremely high quality bakelite is used. Distributor caps for agricultural and marine equipment are sprayed with a special anti-tracking substance.

AUTO ADVANCE AND SPARK TIMING.

Having shown you mainly constructional features of Lucas distributors, let us now delve a little more deeply into the technicalities of the subject.

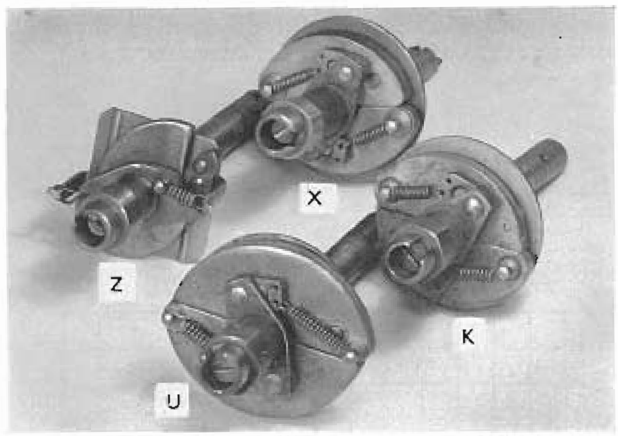
The problem of automatically varying the ignition timing to suit the running of the engine is dealt with in two ways : firstly by using centrifugal force, and secondly by using the vacuum existing in the engine inlet manifold — which of course varies with the load on the engine.

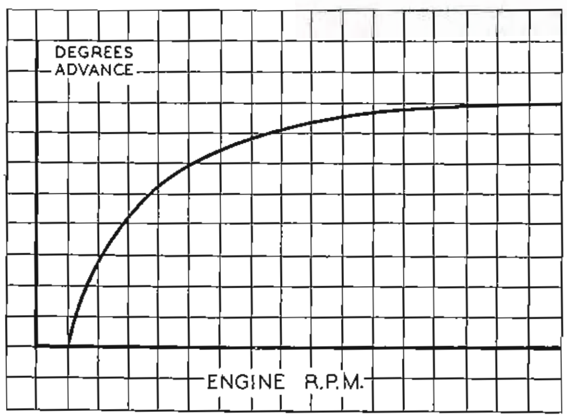
A moving weight mechanism built into the distributor and actuated by centrifugal force, in other words *governed by the speed of* the engine, is employed to give the main advance to the ignition timing.

An additional variation is provided by a vacuum advance unit tapped into the engine inlet manifold and controlled directly by the throttle position, in other words *governed by the load on the engine.*

TYPES OF ADVANCE ASSEMBLIES.

Several types of centrifugal advance mechanism have been evolved during the last few years, employing different designs for the moving weights, different spring combinations and different materials. The 'X' type unit shown here has special hardened steel weights and is designed mainly for motor-cycle work. The 'Z' indicates the so-called 'rolling weight' mechanism ; the 'U' a pressed steel assembly suitable for fitting in the larger type 6 and 8 cylinder distributors. The 'K' mechanism employs die-cast auto-advance weights.





ENGINE CURVE.

In building up the many different advance curves required by the engine manufacturers, we operate from a curve taken from the engine test which shows the degrees of advance required at different engine speeds and loads.

In general terms, an engine requires sufficient spark advance when idling to keep the plugs clean, and thereafter the advance must increase relative to speed, load, mixture, etc.

PINKING CURVE.

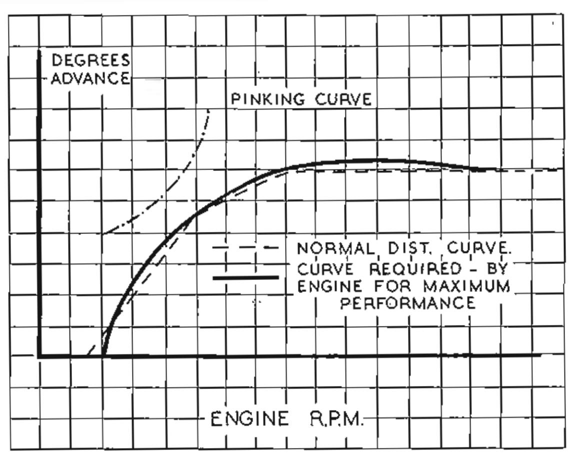
All engine tests produce a 'Pinking or Detonation Curve.'

At times, to obtain maximum power together with maximum fuel economy, the ignition advance curve will lie very close to the 'pinking' point and in many overhead valve, high compression engines, actually crosses the Pinking Curve at some point or other.

So our job is to produce an advance range in the distributor which matches the engine manufacturer's specification.

The dotted line on the diagram shows this distributor curve.

Now let's see the mechanism required to do the job.

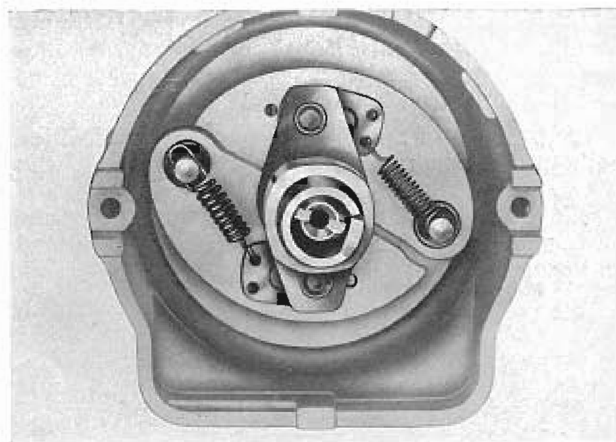


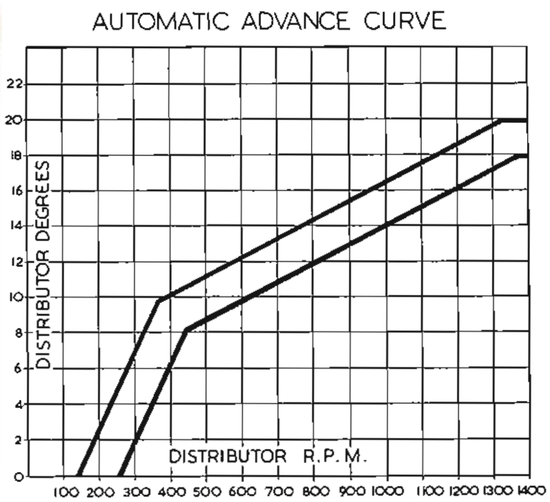
THE DIFFERENTIAL SPRING ASSEMBLY.

This is the most popular form of centrifugal advance. With increasing engine speed, the two weights are flung out, altering the position of the cam in relation to the contact breaker and thus advancing the ignition spark.

The rate of advance is controlled by the tension of the two springs. This type of mechanism employs one light spring to give a quick initial advance, and a second heavier spring to produce the main characteristic.

You will notice that there is a looped end on the heavy spring which allows free action by the light spring at the beginning of the advance movement.





DIFFERENTIAL CURVE.

This diagram shows the typical spark timing curve produced by such a differential spring assembly.

The space between the two curves represents the tolerance allowed.

You will notice the quick initial rate of advance permitted by the light spring, in this case 8-10° at 400 r.p.m.

The advance then increases more gradually to a maximum of 20° at about 1,350 r.p.m. and there is no further increase at higher revs.

It should be realised that the total advance range varies considerably for different engines. In fact at the present time there are over 300 different advance ranges in use, built up expressly to meet the engine makers' requirements.

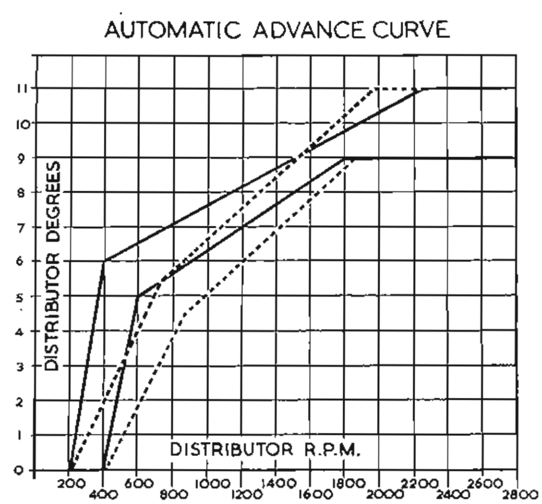
DISTORTED CURVES.

This diagram shows the result of partly closing the loop in the heavy spring.

The dotted lines represent the advance obtained when the loop is partly closed ; the continuous line, the normal advance curve.

Now, although it might appear that the engine has lost its 'pink' when revved quickly under no-load conditions, it will be sluggish when accelerating under load.

From this, you will realise that the loop is there for a purpose and must not be bent, squeezed or otherwise 'adjusted."

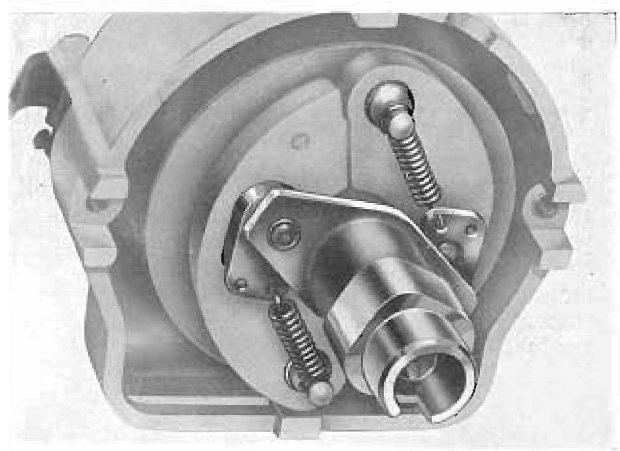


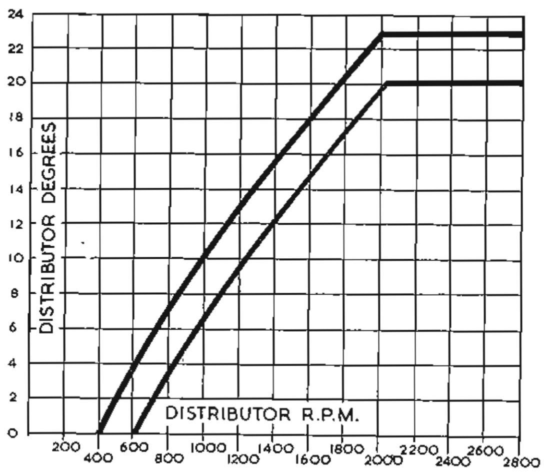
EQUAL SPRING ASSEMBLY.

The other type of auto advance in general use employs two equal springs and gives a ' straight line ' advance curve.

The spring loops are always carried by the inside holes in the toggles.

These toggles have two holes for interchange-ability purposes only.





STRAIGHT LINE ADVANCE CURVE.

The equal spring mechanism produces this form of advance curve.

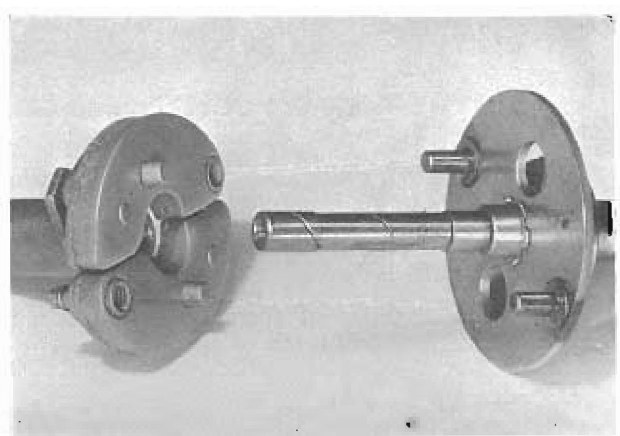
You see here that this particular advance commences at about 400 r.p.m. and progresses steadily to the maximum, which will again vary considerably with different engines.

In this case there is no quick initial advance, permitted by the weaker spring of the assembly we showed you a few pictures back.

ACTION PLATE WITH HOLES AND ADVANCE WEIGHTS WITH PINS.

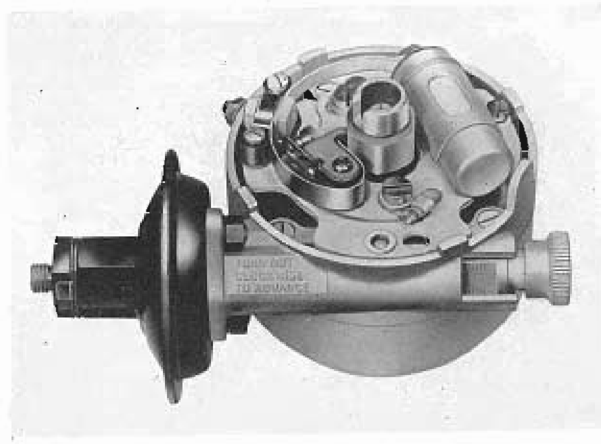
A very important point to remember with both types of advance mechanism is, that manipulation of the springs in no way affects the *total* advance given to the spark timing.

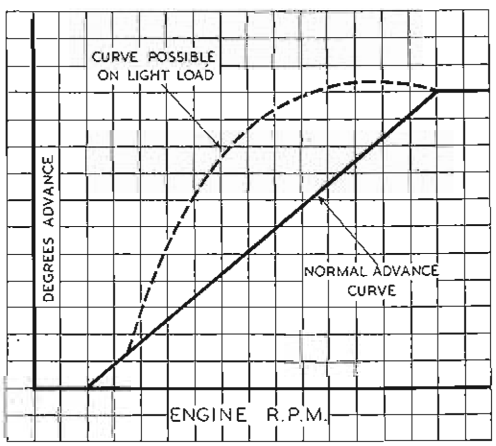
The total advance is controlled by the size of the two holes in the action plate on the right of the photograph. These limit the amount of movement of the weights.



VACUUM OPERATED TIMING CONTROL.

The advance mechanism we have discussed so far is dependent on r.p.m. alone. Additional control of the spark timing is brought about by the vacuum unit you see in this photograph. You will remember we said that, as the unit is connected to the engine inlet manifold, it's operation depends on the depression present in the manifold — that is, it's effect varies with the load on the engine.





THE SUCTION ADVANCE CURVE.

Interpreting this graph, we can say that the vacuum unit produces additional advance, as shown by the dotted line, when the engine revs are high, but the load light — that is when there is a high vacuum in the induction manifold due to the small throttle opening.

When the engine is pulling hard on full throttle, the vacuum in the manifold is low and the suction advance becomes wholly or partly inoperative. The spark timing is then solely dependent on the centrifugal advance.

The general effect of the vacuum unit is to increase the ' liveliness ' of the engine and, when economy type carburettors and wide spark plug gaps are used, a noticeable improvement in petrol consumption is possible.

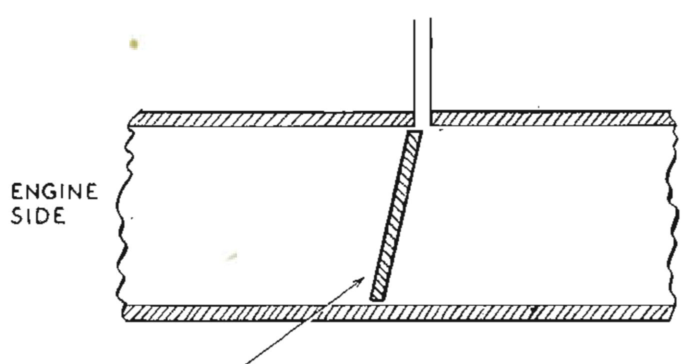
Now how and where is the pipe leading to the unit attached to the manifold ?

WHERE THE VACUUM CONTROL IS CONNECTED.

If the unit is to function correctly, the point at which it is connected to the manifold is all important.

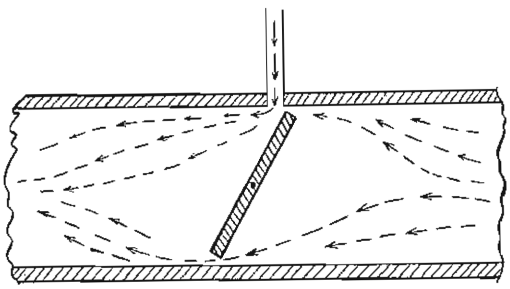
The vacuum pipe should be half sealed when the throttle butterfly is closed.

The main condition of operation is that at idling speed the vacuum unit is out of operation.



SMALL THROTTLE OPENING.

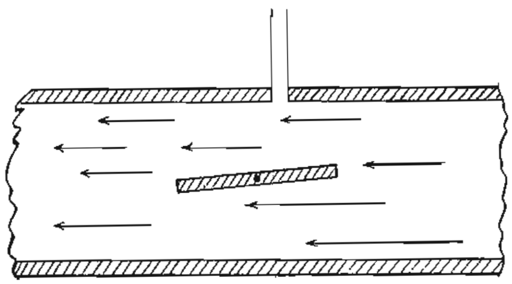
Now with small throttle opening, the vacuum at the inlet pipe is high and we have maximum permissible advance.



THROTTLE PARTLY OPEN WITH PISTON SPEED HIGH. SO MAX VACUUM ADVANCE

FULL THROTTLE OPENING.

With full throttle opening, we have a low vacuum and accordingly little or no extra advance from the suction unit.



FULL LOAD, FULL THROTTLE, LOW PISTON SPEED SO NO VACUUM ADVANCE

SECTIONED ADVANCE UNIT.

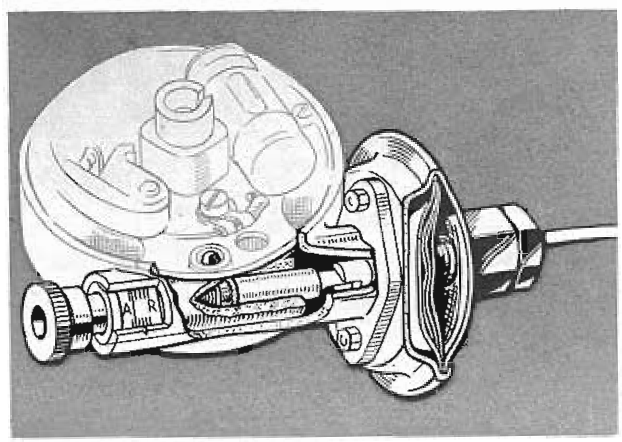
This picture shows the operation of the unit itself. You can see the plunger which moves the contact breaker plate in relation to the cam, thus altering the spark timing. A micrometer adjustment is also included.

These units are not interchangeable by the way, unless they carry the same identification number, as each unit is made up to suit a particular engine.

To check the operation of the unit in some cases, it is only necessary to run the engine at idling speed when, with changes in the throttle opening, the sliding barrel will be seen to move in and out.

A cut away distributor cap should be employed when the movement is not visible by this method.

Failure to operate is generally the result of air leaks in the pipe line, usually caused by cracked or chafed pipes or loose unions. These possibilities should be checked before suspecting a damaged diaphragm.



DISTRIBUTOR DOGS.

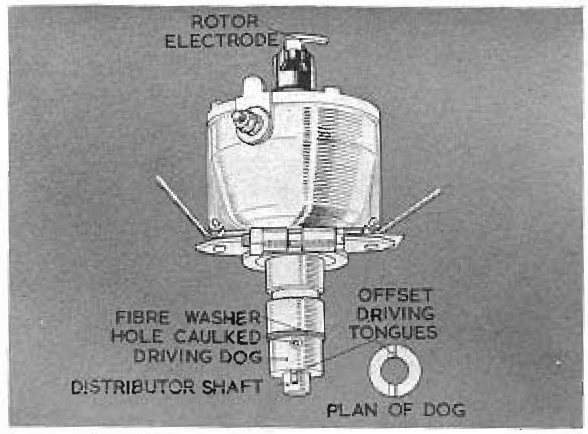
Having dealt mainly with the distributor as a separate unit and discussed the method of advancing the spark timing according to the requirements of the engine, we must now consider how a distributor should be fitted to a vehicle, from the point of view of timing, firing order and roation.

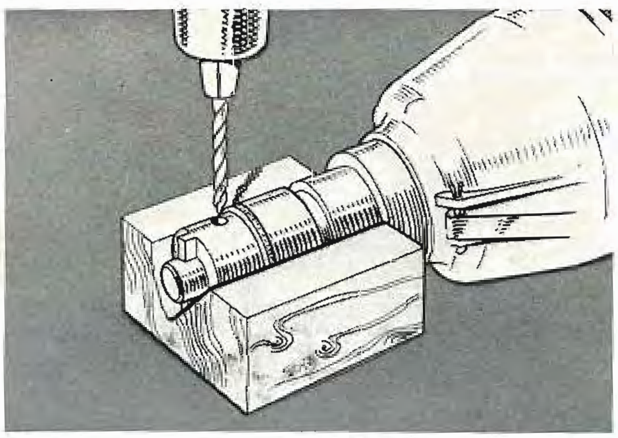
This picture shows a correctly fitted driving dog on the distributor shaft.

There are two important points to remember.

1. The driving tongues of the dog are in line with the rotor arm.
2. The driving tongues are offset with respect to the centre line of the shaft and, when viewed from the rotor electrode side, as you are seeing it now, are to the left of this line.

This guide for fitting is applicable to both clock and anti-clock distributors.





DRILLING THE DISTRIBUTOR SHAFT.

You see here the method of drilling a new distributor shaft, using the hole in the dog as a guide. To obviate shaft 'end float,' the shaft itself must be pushed down from the rotor end, with the dog hard against the fibre washer, before commencing to drill.

After fitting the pin, caulk over the holes to secure. The dog must be a tight fit on the shaft.

Driving gears are fitted in a similar manner, but then the position of the gear in relation to the rotor is immaterial.

The diameter of the drilled hole is normally $\frac{1}{8}''$; but later supplies of driving dogs for fitting to D.M. Distributors are to be drilled to take a $\frac{3}{16}'' \times \frac{7}{8}''$ Mill's grooved pin. In such cases, the diameter of the hole through the shaft must be 0·187″ to 0·188″.

INSTALLING AND TIMING A DISTRIBUTOR.

Firstly, it must always be remembered that distributors are directional, i.e. either CLOCK or ANTI-CLOCK. The correct direction of rotation is shown with the identification symbols on the body of the distributor and is always as viewed from the DRIVING END.

Additionally the letter A or C appears on the end of the distributor shaft to denote the rotation of the shaft and action plate assembly.

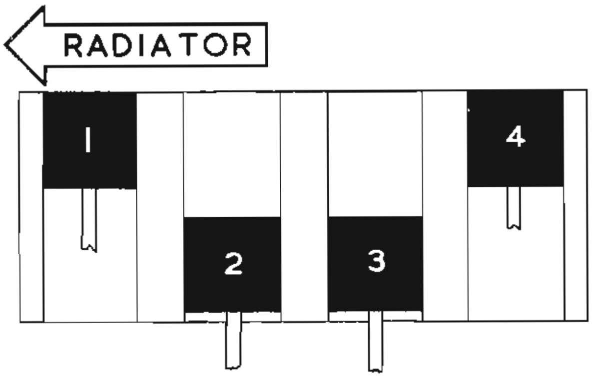
Let us take a specimen case — we have a replacement distributor to fit to an engine and we want to reset the ignition timing, as this has been accidentally disturbed. We are assuming of course that nothing is wrong with the engine valve timing.

IGNITION TIMING.

The engine should normally be timed according to the engine maker's recommendations, but timing marks are not always easily accessible or clearly visible, so we shall show you here a simple method of setting the piston in relation to the ignition spark from the distributor.

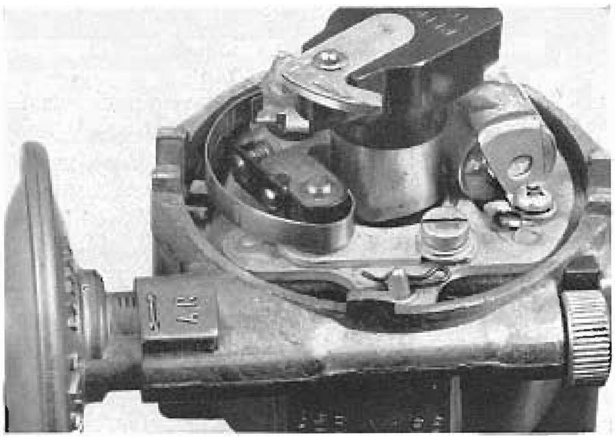
First take out the sparking plug from No. 1 cylinder — this is usually the front cylinder of the block, that is, the one nearest the radiator. Then turn the engine over slowly with the starting handle, with your thumb tight over the spark plug hole, until compression is felt.

Bring the piston slowly to the top of its stroke, using where possible a piece of wire as a final guide to the piston travel. Leave the piston set at T.D.C. on the compression stroke.



No. 1 CYLINDER

COMPRESSION STROKE T.D.C.



SETTING THE ROTOR POSITION.

Having set any micrometer advance adjuster on the distributor approximately at the half-way position, next place the distributor in position with the rotor pointing to what we can call for our purpose the No. 1 electrode in the distributor cap — that is pointing to about 7 o'clock. This is only a preliminary rough setting, being of necessity governed either by the tongues of the distributor dog-drive or by the pitch of the gears. A finer adjustment should then be made by turning the body of the distributor until the contacts are just opening, still with the rotor pointing to the No. 1 electrode. Clamp the distributor provisionally at this setting. It is not important which electrode in the cap we make No. 1. We must start from somewhere, however, and it's just a matter of convenience. What is important is that the plug lead from the cylinder we've positioned for firing, that is No. 1, is sparked from the correct electrode position in the distributor cap, that is the one in line with the rotor. For simplicity's sake, then, we'll connect No. 1 electrode in the cap to No. 1 cylinder.

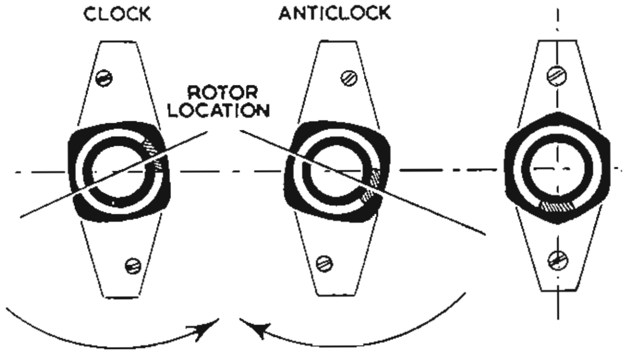
CAM AND ROTOR ASSEMBLY.

If any difficulty is experienced in obtaining this initial setting of the timing, correctly and easily, the cam should be examined.

On four cylinder distributors the cams are handed left and right, and as shown in the illustration, the most apparent difference is the position of the rotor locating slot in relation to the Cam Lobes.

Unless the rotor is correctly positioned in relation to the cam the running of the engine may be seriously affected.

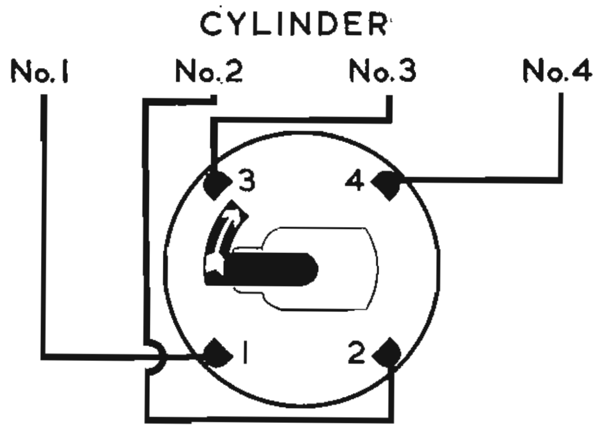
This does not apply to the 6 cylinder cam where the rotor locating slot is centrally placed in relation to the cam lobe as shown in the right-hand illustration.



ROTATION AND FIRING ORDER.

Before we can connect the remaining plug leads, we must know two things : the direction of rotation of the distributor rotor and the engine firing order. The rotation can quickly be established from the rotor itself — the extended brass electrode is usually arrowed — or the distributor body is marked. But, just to make absolutely certain, turn the starting handle just a fraction and watch the rotor. We will assume for the moment that the firing order is known, and that for the particular 4 cylinder engine it is 1, 3, 4, 2. The rotation we'll take to be as is indicated on the rotor illustrated. The plug leads can then be inserted into the distributor cap, the lead from No. 1 cylinder going to No. 1 electrode, from No. 3 cylinder to the next electrode (in the direction of rotation), No. 4 following and finally No. 2.

Connect up the vacuum advance unit if fitted and the engine should run.



LUCAS FIRING ORDER 1 3 4 2

TIMING : FINAL ADJUSTMENT.

The final adjustment of the timing is something which can only properly be dealt with during a practical demonstration. It can be set in the garage fairly accurately by vacuum gauge, but this method on its own is not accurate enough as a final adjustment. This final setting can best be carried out on the road. To obtain the best results it must be done scientifically. One engine manufacturer arrives at the best engine performance by timing the vehicle with a stop-watch over a series of test runs, conditions being identical for each run — that is, the prevailing wind must be the same, the run must be made in the same direction and the vehicle accelerated to the same m.p.h. figure.

The distributor can be moved slightly if necessary by slackening the clamp and moving the distributor body, thus varying the point at which the contacts open. The micrometer adjustment will allow an extremely fine setting to be made.

FIRING ORDER.

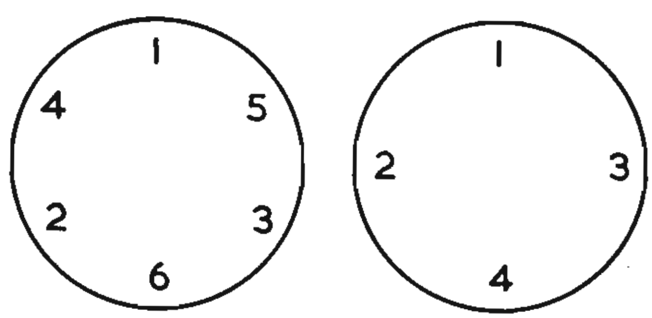
Where the firing order is not known, and cannot be found from the engine maker's instruction manual, two possible sequences exist for a four cylinder engine : 1, 3, 4, 2 or 1, 2, 4, 3.

Thus, after finding T.D.C. on the compression stroke of No. 1 cylinder, check which is the next cylinder to fire by taking out all the plugs and testing for compression on either cylinders 2 or 3. The one coming up to compression will establish which of the two possible orders it is.

The same method can be applied to a 6 cylinder engine, when once again there are only two possible firing orders, as we have indicated :—

1, 5, 3, 6, 2, 4 or 1, 4, 2, 6, 3, 5.

In every case, the method of connecting the plug leads to the distributor cap is the same : start from No. 1 cylinder to No. 1 cap electrode and continue round the cap in the cylinder firing order, NOT forgetting to follow the rotation of the distributor rotor.



SIX CYLINDER ENGINE FOUR CYLINDER ENGINE

POSSIBLE FIRING ORDER

Distributor Types & Application

Before showing you photographs of various Lucas distributors, we must consider for a moment the symbols used for identifying the different types.

TYPE SYMBOLS.

Prefix

B. Ball Bearing.
D. Distributor.
D1. 1st design.
D2. 2nd design.
D3. 3rd design.
F. Flange mounting.
H. Horizontal cable outlets.
K. Small cast iron body, with moulded contact breaker base and die-cast auto-advance weights.
KY. Die-cast body with pressed steel contact breaker base.
L. Double contact breakers.
M. Micro control.
P. Porous Bushing.
U. Large cast iron body with moulded contact breaker base.

Prefix

V. Built-in vacuum control.
X. Hardened steel auto-advance mechanism.
Z. Rolling weight auto-advance mechanism.

Numerals

1. Suitable for single cylinder engines.
2. Suitable for twin cylinder engines.
4. Suitable for four cylinder engines.
6. Suitable for six cylinder engines.
8. Suitable for eight cylinder engines.

Prefix or Suffix

*A. Fitted with automatic advance and retard.

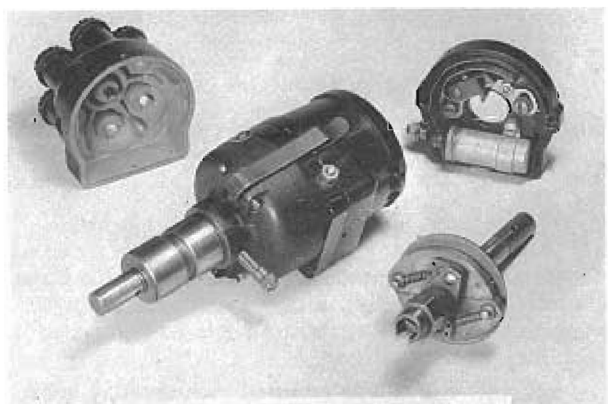
* *This symbol is omitted from latest models as they are all fitted with automatic advance mechanism.*

THE DK TYPE DISTRIBUTOR.

And now the units themselves. This picture shows the early standard DK distributor.

It has a cast-iron body, a bakelite contact-breaker base and the shaft turns in porous bronze bearing bushes.

Nowadays this type is used mainly for 'Insulated Return' circuits on Light Commercial Vehicles and Motor Cycles. When used for this latter purpose it becomes type 'DKX' (Hardened Steel Weights).



DK TYPE DISTRIBUTORS

DKZ & DKY TYPE DISTRIBUTORS

THE DKY AND DKZ DISTRIBUTOR.

These distributors are again standard types, but they are fitted with a die-cast body and metal contact-breaker base.

Die-cast or rolling weight auto-advance mechanism is used. The bearings for the shaft are still porous bronze bushes.

These types are usually applied to light cars and light commercial vehicles with medium-speed four cylinder engines.

THE DZ AND DX DISTRIBUTOR.

These types are made with a larger die-cast body. Pressed steel is used for the contact breaker base and either the hardened steel or the rolling weight auto-advance mechanism is fitted. Porous bronze bearings are again employed.

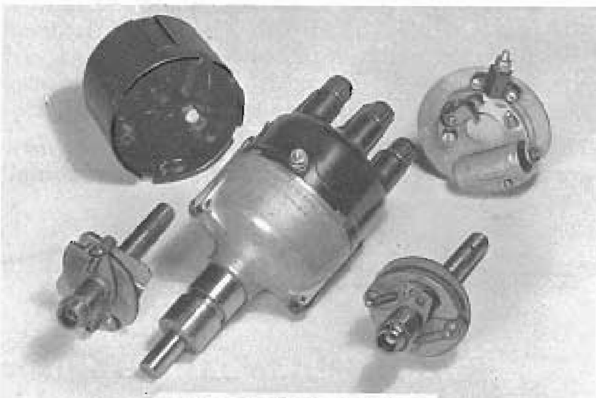
These are particularly applicable to high compression four and six cylinder engines.

THE DVZ AND DVX DISTRIBUTORS.

The main features of these distributors is the built-in vacuum advance unit. An oil well is also incorporated for lubrication.

The top bearing for the distributor shaft is a ball race, a porous bronze bush being still retained for the bottom bearing.

The DVZ and DVX distributors are applied to four and 6 cylinder engines which require vacuum advance.



DZ & DX TYPE DISTRIBUTORS

DVZ & DVX TYPE DISTRIBUTORS

THE DULF AND DU DISTRIBUTORS.

These models are standard productions with a large diameter body, usually of cast iron, except for the flange-mounted version, (bottom left in the picture) which may be die-cast.

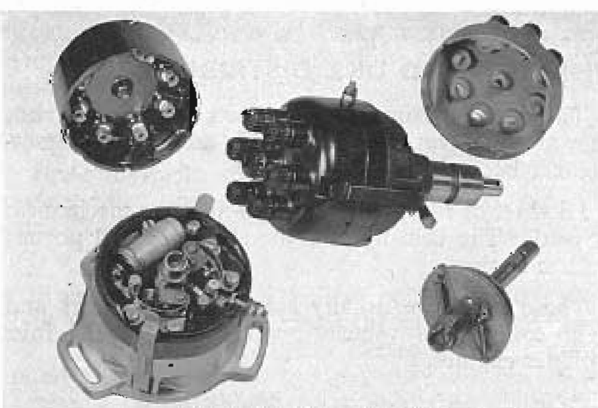
A bakelite C.B. base is fitted, which may carry single or twin contact breakers. The twin contact breaker model is generally applied to eight cylinder engines such as the FORD V8 and the ROLLS B80. Large six cylinder engines usually take the DU or DULF with a single contact breaker.

THE DM DISTRIBUTOR.

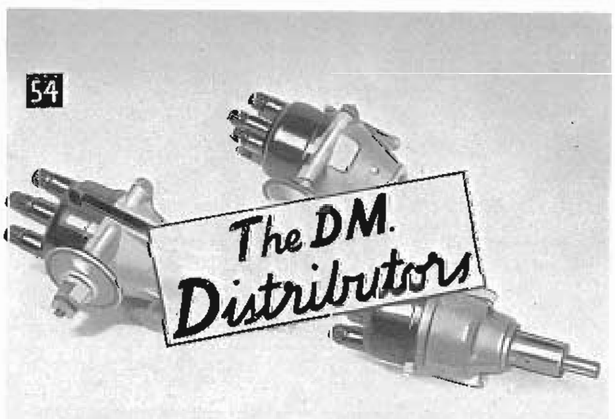
More recently a new range of distributors has been introduced and is now widely used on most British cars.

There are two main models, the DM4 and DM6, applied to high performance four and six cylinder engines. Variations of these two models fit a ball bearing.

A smaller model DM2A4 may be used for medium compression four cylinder engines together with a similar model known as the D2A4 which does not incorporate a vacuum advance unit.



DULF & DU TYPE DISTRIBUTORS



DESIGN FEATURES.

Here you see the main features of these DM distributors.

The vacuum unit is built into the distributor and incorporates a micrometer adjustment.

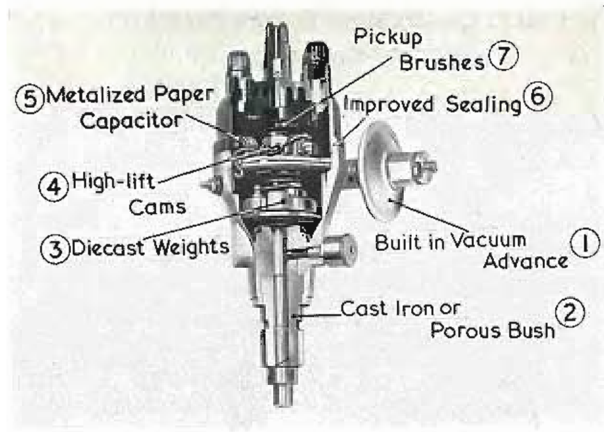
The bearings may be either cast iron or porous bronze bushes. A ball bearing is fitted, as we have mentioned, in some models.

Die-cast or rolling weight auto-advance mechanism is used.

The cam is a new design called the 'High Lift' — we shall tell you more about this in a moment.

We have already discussed the new metalised paper capacitors — you will remember their 're-healing' property if a dielectric breakdown occurs, and their comparatively small size.

The sealing of the distributor cap has been improved, rendering the unit much more dustproof — the necessary ventilation is still of course provided.



And finally the H.T. pick-up brushes are designed to act as radio suppression resistors.

But now let us examine some of these features in detail.

THE VACUUM ADVANCE UNIT.

This unit, as we have said, is built into the distributor and incorporates a fine adjustment for the spark timing.

Whilst generally similar to the earlier models, each vacuum unit is made up for a particular engine and you will remember that we stressed that *units are inter-changeable only if the numbers on the locking tabs are identical.*

BEARINGS.

Three types of shaft bearings are used. The DM6 is fitted with a long cast-iron bush.

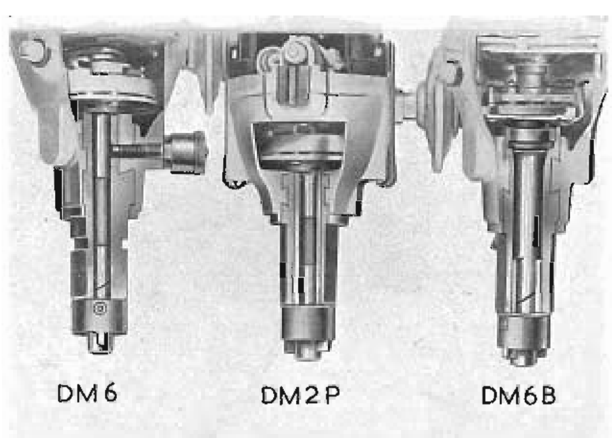
This bush is part of the shank and is not renewable. The lower part of the bearing is lubricated by oil mist from the engine and the upper part by means of a grease lubricator.

The second type of bearing consists of a single long bronze bush, shown here in the DM2P.

The bronze bushes are easily replaceable, and, as they are used in conjunction with hardened steel shafts, are expected to give extremely long service.

The lubrication is again by oil mist from the engine.

A third type of bearing consist of a porous bronze bush at the bottom with a grease packed ball bearing at the top, and no additional lubrication is required. This bearing assembly is signified by the letter 'B.'

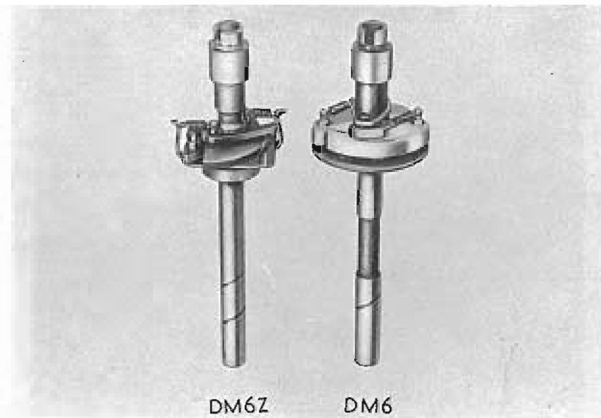


THE AUTO-ADVANCE MECHANISM.

Two types of auto-advance assembly are fitted in the D.M. distributors.

The 'rolling weight' mechanism is shown here in the left of the picture. This arrangement may employ either equal or differential springs.

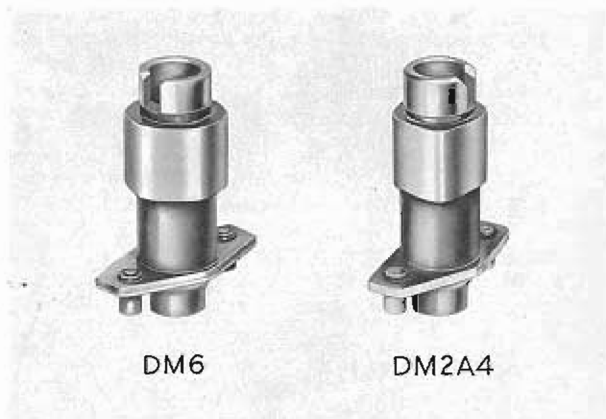
The die-cast weight assembly on the right closely follows the earlier pattern, but is much heavier in construction; also, brass toggles are used instead of steel.



THE HIGH LIFT CAM.

All D.M. distributors fit the new 'high lift' cam. This form gives a very quick break of the contacts, increased 'cam dwell' — that is a longer closed period — and generally results in increased life of the contact points.

We shall further discuss the contact setting with the 'high lift' cam in the maintenance part of this lecture, but it certainly won't hurt to say now that the contact gap should be set and maintained at ·014″ — ·016″ in service.

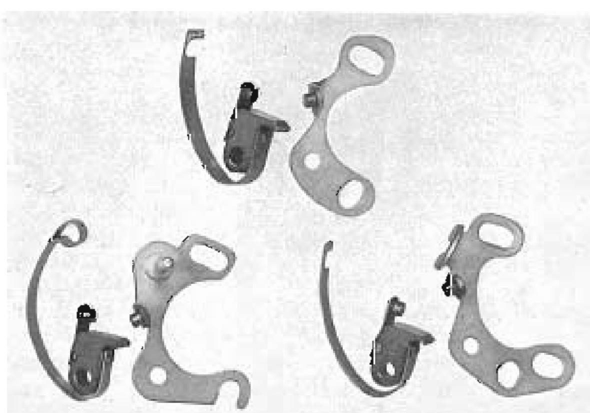


THE CONTACT SET

The contact breaker assembly used in the D.M. range of distributors has the same characteristics, a ½″ rocker arm and long stainless steel spring, as those fitted to the earlier distributors.

The spring anchorage may be slotted in the end of the spring, or alternatively, looped as shown in the left hand picture; this being the latest design which has now been standardised for all the DM range.

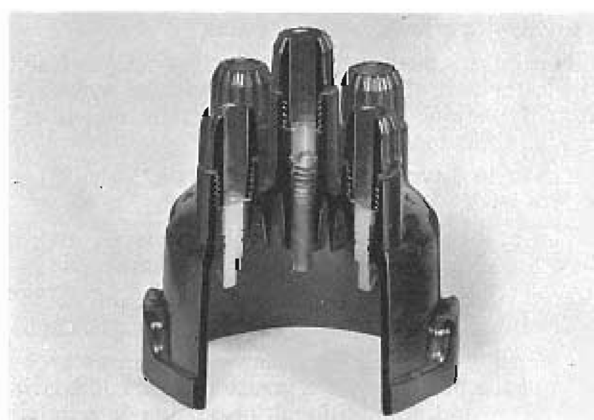
It is very simple to identify the various sets from the illustrated spares lists we supply.



THE DISTRIBUTOR CAP

This picture shows a typical cap design. Both the sealing and the ventilation have been improved. The H.T. pick-up brush contains a high percentage of resistive material and is designed to act as a radio and television suppressor. With this type of cap, no further suppressor is required in the distributor-coil H.T. cable and none should be fitted.

Caps are manufactured with both vertical and horizontal H.T. lead outlets.



Testing

The testing and servicing of coil ignition equipment can be considered from two separate standpoints.

Firstly, there is the testing and servicing of the distributor and ignition coil, this is the province of the specialist who will have a proper testing machine available together with the relevant data appertaining to the whole range of this equipment.

The more general requirement is for the Motor Engineer to be able to diagnose the cause of intermittent misfiring or complete breakdown of the ignition system in situ on the vehicle. Such preliminary diagnosis will generally precede unit testing or major overhaul. At the same time the most common faults which develop arise as the result of general neglect and can be put right at once.

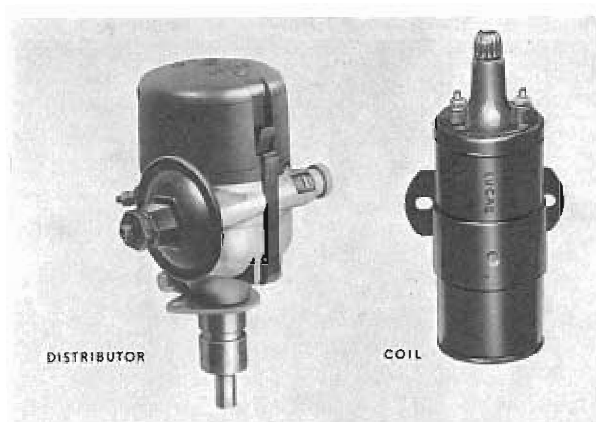
These ' service ' faults frequently involve the ignition circuit as a whole, that is the wiring, switches, etc., quite apart from the distributor and ignition coil units themselves. By the use of a simple routine test procedure any such faults can easily and quickly be located and corrected. If, at this stage satisfactory performance is not regained, it may become necessary to bench test the coil and distributor unit as a pair.

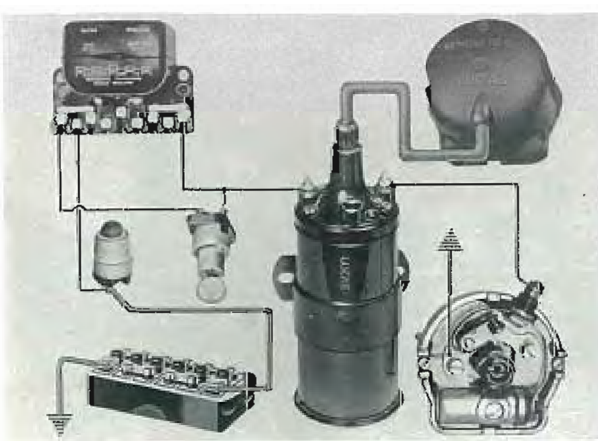
For our own purpose when setting out this routine, which can easily be memorised let us assume that we are faced with a complete failure of the ignition system on the vehicle.

In this circumstance we must first prove the current supply, i.e. the battery and then follow the current path to the ignition coil and distributor. For this purpose it is possible to completely check the low tension or PRIMARY circuit of the supply and the ignition units in FOUR operations, with a further THREE operations to check the high tension system and the condenser.

THE DISTRIBUTOR AND COILS.

Ignoring for the moment the battery, the two main components in the ignition system are the distributor and coil. Each takes its share of the blame for nearly all ignition faults.





PICTORIAL DIAGRAM OF IGNITION CIRCUIT.

However, let us see exactly how these units fit into the complete ignition circuit. Here we see a pictorial diagram of the system used on the post-war car.

The *primary circuit* : we must have a satisfactory current supply from the battery to the primary winding of the ignition coil. This current must be interrupted at the right moment by the contact-breaker points, in order to induce current in the secondary circuit and so produce the ignition spark.

The *secondary circuit* consists of the high-tension winding in the coil, the distributor rotor and cover, the high tension leads and spark plugs.

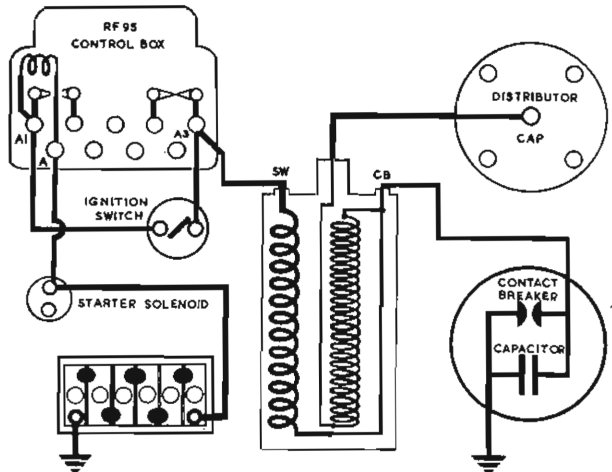
WIRING DIAGRAM OF IGNITION CIRCUIT.

A more precise idea can be obtained from this wiring diagram. Following the ignition circuit through from the battery, the feed wire is tapped off from the starter solenoid to terminal 'A' on the control box. From there it passes through the load winding of the regulator to terminal ' A1.' The circuit then continues to the ignition switch.

When the ignition is switched on, A3 of the control box is ' live.' You can follow the circuit from the other side of the ignition switch to the ' A3 ' terminal. The ' SW ' terminal of the coil is then fed from this ' A3 ' terminal. The circuit continues through the primary winding of the coil to the ' CB ' terminal, the contact breaker being connected to this terminal. The circuit is completed via the contacts to the distributor earth, and so back to the battery via the chassis.

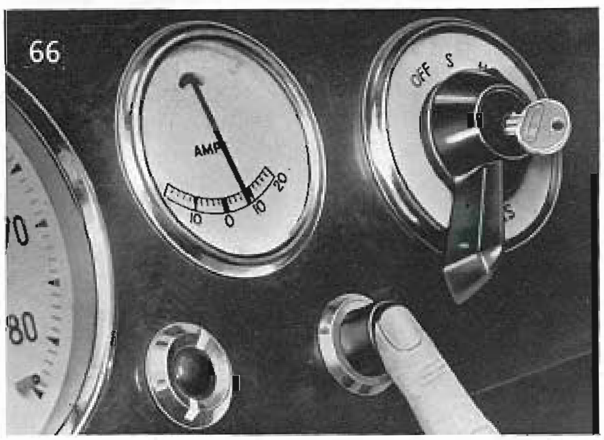
The high tension side of the system starts from the secondary winding of the coil at the chimney, through to the rotor, and then via the distributor cap to the plugs. The circuit is again completed via the chassis, in this case the block, and so back to the battery.

In the following tests, we shall prove the circuit at



IGNITION CIRCUIT.

most of the points we have mentioned, i.e. the battery, A and A1 terminals, at the A3 terminal, at the coil ' SW ' and ' CB ' terminals, finally checking the H.T. side of the circuit from the coil chimney, through the rotor, the cap and on to the spark plugs.



LAMPS SWITCHED ON.

Having given you an overall picture of the ignition system, what should be the first step when we are confronted with a complete failure? Surely the first point is to see whether there is any current available on the system at all.

The quickest method is to switch on the head-lights and operate the starter motor.

If the starter operates satisfactorily, without dimming the lights excessively, we can safely assume that the *battery is not the cause of the breakdown.*

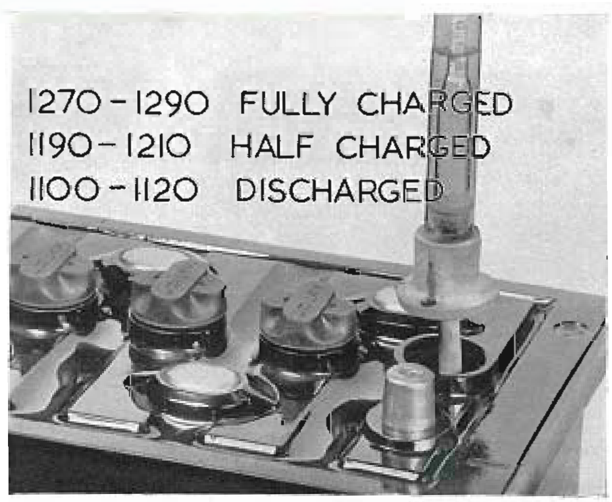
HYDROMETER TEST.

The test we have just shown you is of course a quick check for the battery.

This Hydrometer check will give a more exact idea of the state of charge of the battery.

The readings should be at least between 1·200 — 1·210, that is, about half-charged.

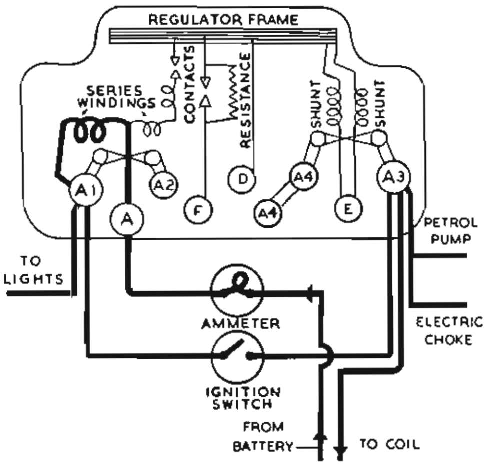
If in a very low state of charge, the voltage of the battery may be so greatly reduced when the starter is operated that the ignition coil will not spark.



HEAVY DISCHARGE TEST.

This test, which puts a heavy discharge across the battery, will complete an exact check on the condition of the cells.

The voltmeter should register approximately 1·5 volts per cell. The cell reading should remain constant throughout a 15 second application of the tester.



A1 AND A.

If we prove that the battery is serviceable and that the car lights are working satisfactorily, we have actually proved that the current supply arrives at the A1 terminal of the control box.

With the ignition ' on,' we find out next, with the voltmeter, whether the A3 terminal of the control box is ' live,' as this terminal feeds the coil and the petrol pump. In some cases this A3 terminal is located on a fuse block mounted separately from the control box.

Let us assume that there is no fault so far.

The next thing to do is to check straight through the Primary or L.T. circuit of the ignition system. From terminal A3, which we've just checked, the current should arrive at the ignition coil.

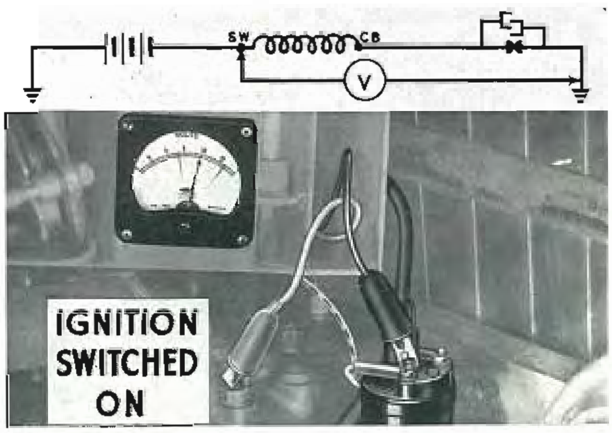
VOLTS AT ' SW ' TERMINAL OF THE COIL.

Connect the voltmeter between the ' SW ' terminal on the coil and an earthing point.

Full battery volts should be registered on the voltmeter, irrespective of whether the C.B. points are open or not, although it is preferable for them to be closed and the coil taking current. If no voltage is shown we have an open circuit in the cable between the control box A3 terminal and the coil ' SW ' terminal. This fault can soon be remedied.

But let us assume that we do get full battery volts at the ' SW ' terminal of the ignition coil. It pays to pull at the cable near the coil, thus making sure that the terminal nuts are not loose and that there is no intermittent break in the cable inside the covering.

You can see what connections we've made at the top of the picture.



VOLTS AT 'CB' TERMINAL.

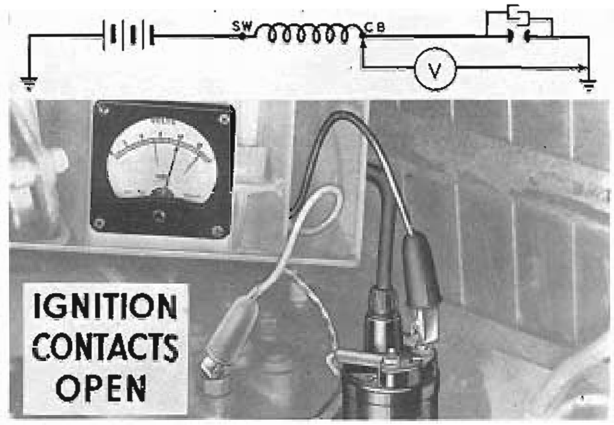
We must next see whether the circuit is intact through the coil.

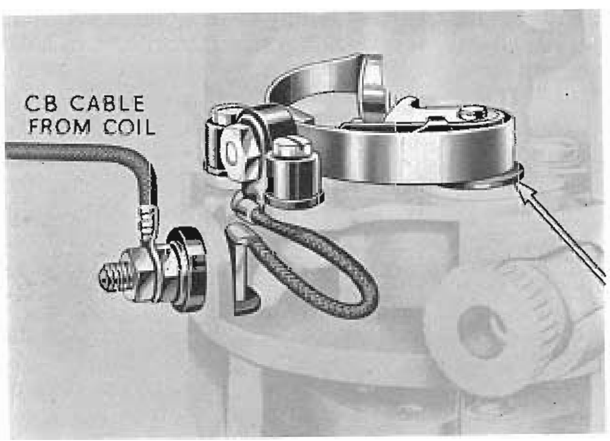
Open the CB points and, with a voltmeter connected to the 'CB' terminal of the coil, we should still get full battery volts.

If no voltage is shown at this point, there are two possibilities.

The first is an open-circuited primary in the ignition coil. The second possibility is an EARTH inside the distributor. Both points can easily be checked by disconnecting the wire from the C.B. terminal and taking another voltage reading at the coil terminal itself.

A Zero reading will then indicate a break in the primary winding, a full voltage reading, a short to earth on the distributor.





POSSIBLE EARTHING POINTS.

Such an earth can be at any of the following points :—

(a) The C.B. cable between the ignition coil and the distributor L.T. terminal — left of the picture.

(b) The flexible lead between the L.T. terminal on the distributor and the moving contact.

(c) On the moving contact itself — the insulating washer may have been omitted for instance. This washer is arrowed in the picture.

(d) Or finally at the condenser — this however is unlikely.

If none of these show up, that is, if we get *Full Battery Volts*, the next step is to CLOSE the contact breaker points.

VOLTS AT THE 'CB' TERMINAL WITH CONTACTS CLOSED.

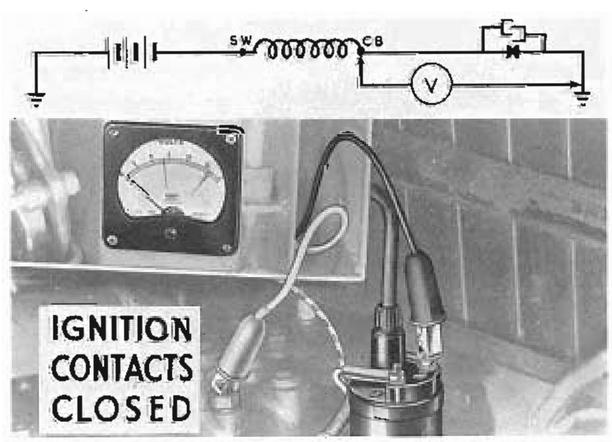
With the contact breaker points closed, we should now have a zero reading on our voltmeter.

You see, by closing the points we are shorting out the meter, providing that the distributor internal circuit is not faulty.

If any voltage reading still shows, it is probable that the points are dirty, oily or oxidised slightly, and may be cleaned up.

If heavily burned and showing grey green deposit, suspect the condenser.

Sometimes there is a bad earth between the distributor shank and the engine block and chassis. If the battery voltage does fall to zero with the contacts closed, we need only check that the cam is opening the C.B. points properly when rotating, and we have completed the check on our primary circuit.



CHECKING THE SECONDARY OR H.T. CIRCUIT.

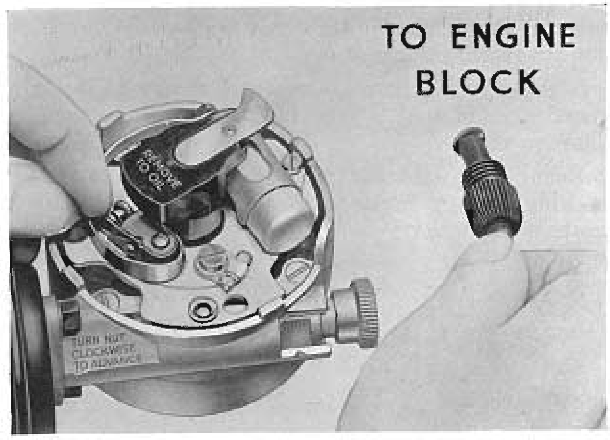
We now proceed to check the secondary or H.T. spark circuit with which we can conveniently include the condenser. The H.T. test is carried out in three operations.

The most convenient way of checking the H.T. circuit of the ignition coil is to use a short length of H.T. cable, one end of which can be pushed into the chimney of the Coil and used as a 'Jumper Lead.' The other end of the lead must be held $\frac{1}{4}''$ away from the engine block.

Our ignition switch is still 'ON' remember.

Flick the contacts from the closed position and, if the coil and condenser are good, we shall have a good spark thrown to the block at each flick of the contacts.

If NO spark is thrown, then we must have a defective H.T. winding. Remembering that we have already cleaned the points, sparking may occur even if the condenser is open circuited. The engine may run — but very roughly.



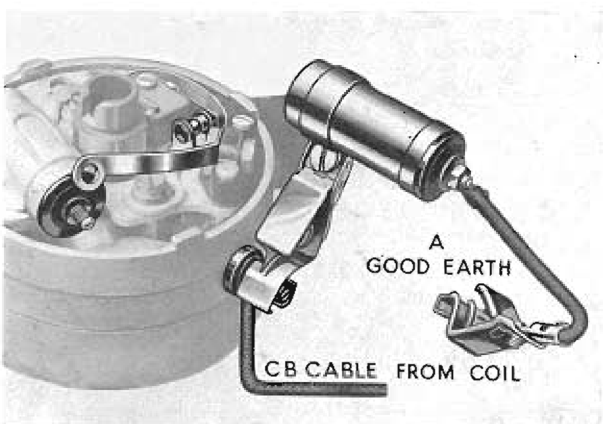
JUMPER CONDENSER.

We can easily check the position by fitting a 'jumper' or substitute condenser. After disconnecting the original condenser, the 'jumper' can be conveniently connected between the L.T. Terminal on the distributor and earth.

If we still have no spark when we flick the contacts, we know definitely that the secondary winding of the coil is faulty.

If on the other hand the spark is now improved and the engine runs much more smoothly, then the original condenser was inoperative. This might be due to the condenser screws being loose and this point should be checked first. Otherwise, the original condenser was faulty.

Assuming that this last test shows the H.T. Winding and the condenser to be in order, it remains only to test the distributor rotor and the distributor cap and H.T. cables.



CHECKING THE ROTOR.

Examine the rotor first. If this is punctured it will earth the spark on to the cam head. A tiny puncture is often invisible to the eye and we therefore test in the following manner.

Hold the piece of H.T. cable, still connected to the coil, on to the rotor electrode as shown.

If on flicking the C.B. points a spark is thrown to the rotor, then the latter is defective.

Under very damp conditions, any *faint* sparking which may be visible, will be due to static leakage and must not be confused with the true H.T. spark.

FINAL CHECK.

Our final check concerns the distributor cap and the H.T. cables.

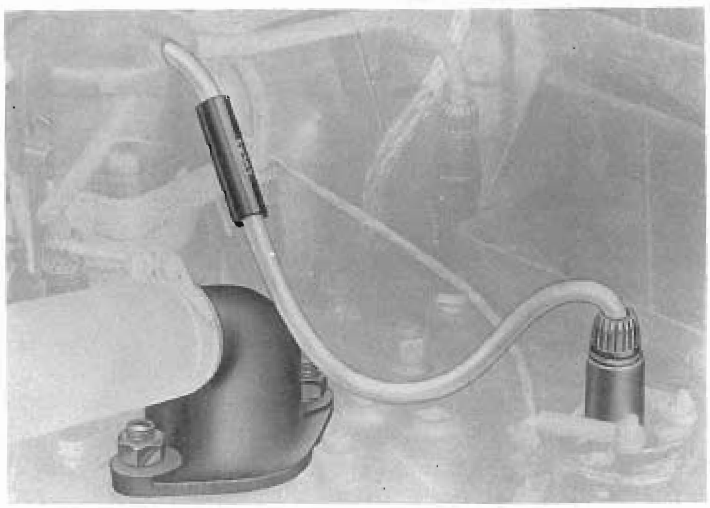
Burnt or cracked caps can easily cause misfiring but are rarely the cause of complete breakdown.

Mechanical fractures are usually easy to find by visual examination. Tracking between segments is likewise visible.

Burning around the pick-up electrodes due to a sticking pick-up brush is more elusive and may only cause misfiring.

The H.T. cables are much more likely to cause such a breakdown and all leads should be checked to see that the insulation is in good condition. In our case, with an assumed complete failure, the lead in question would be the main H.T. cable from the coil to the distributor. Any chafing at this point would of course earth the H.T. spark completely. Pay particular attention to these H.T. leads when they pass through any sort of clips or channeling, or when a suppressor is in circuit.

With this check, the testing procedure for the whole of the ignition system has been completed. There are only seven operations in all : four for the primary circuit and three for the secondary ; and the only tools we need are a voltmeter, a test condenser and a piece of H.T. cable.



Servicing

MAINTENANCE POINTS.

The maintenance necessary to obtain consistently satisfactory performance from coil ignition equipment is very small and for standard routine servicing or 'checking-over' purposes there are NINE items which require periodic Inspection. Three of these require fairly regular attention. They are: the contact breaker points and gap, the general lubrication of the bearings and auto-advance mechanism and thirdly the spark plugs.

We have listed these points in the system which require periodic attention.

1. H.T. Leads.
2. Distributor Mouldings.
3. Rotor.
4. C.B. Set.
5. Bearing Bushes.
6. Auto-advance.
7. Suction Advance.
8. Coil Connections.

THE SPARK PLUGS.

You have probably noticed that we did not list spark plugs. The importance of good, clean plugs with properly adjusted gaps cannot of course be overestimated. Set the gaps to the manufacturer's recommended setting, making sure that they are all even.

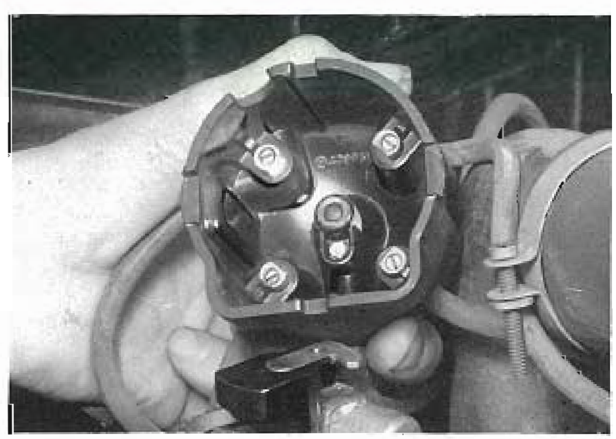
THE H.T. LEADS.

H.T. leads in a poor condition are often the cause of intermittent misfiring, even of complete breakdowns. General deterioration and cracking of the cable covering occurs with time, particularly if the leads are allowed to chafe against metal.

See that the leads are kept clean and free from oil and, as we have said, run as far as possible away from the metal parts of the engine, thus minimising wear due to vibration.

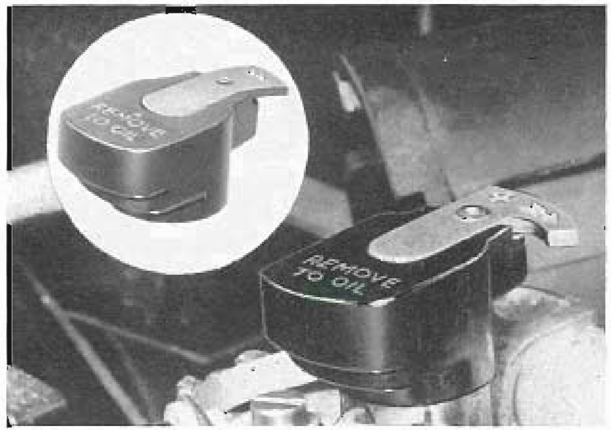
THE DISTRIBUTOR MOULDINGS.

With the increased use of high voltage ignition coils, distributor mouldings have been developed with a very open construction to prevent 'tracking.' The mouldings should be kept clean and dry inside and out, and the carbon brush checked for free movement in its holder.



THE ROTOR.

Rotors call for little or no maintenance in service. Just see that they are kept clean and dry. And remember too that rotors can't be replaced indiscriminately — make sure that the rotor is the correct one for the job, i.e. that the extended electrode points in the direction of rotation. And, by the way, there *is a difference* between a four and a six cylinder rotor. The design of the six cylinder rotor is visible in the inset.



THE CONTACT BREAKER.

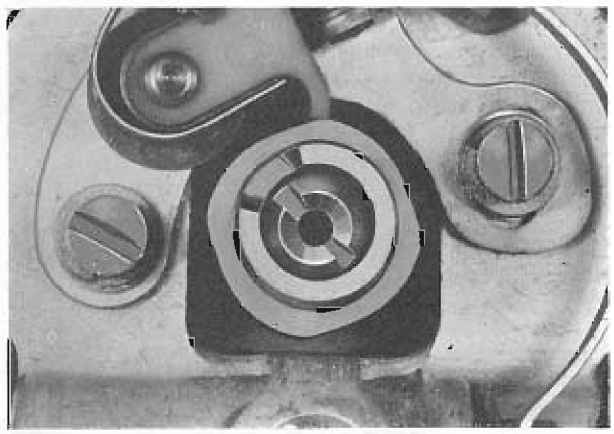
The next point for attention is the C.B. set. The C.B. points must of course be maintained in good condition, either by cleaning and facing up or by the fitting of a new set if the old points are badly burnt.

Closing-in of the C.B. points gap due to wear on the 'heel' can be practically eliminated by a little light grease applied to the cam face or the felt pad when provided.

The points setting should be maintained at a minimum of ·010″ to ·012″ to obtain full performance with all Lucas ignition coils irrespective of working conditions.

A gap setting of ·014″ to ·016″ when fitting new contacts will ensure that after the initial 'bedding-down' the final gap will not close below ·010″.

There is an exception to these settings when a distributor is fitted with the new '*high lift*' *cam. Here the contact gap should* be set and maintained at ·014″ — ·016″.



THE THREE TYPES OF CAM.

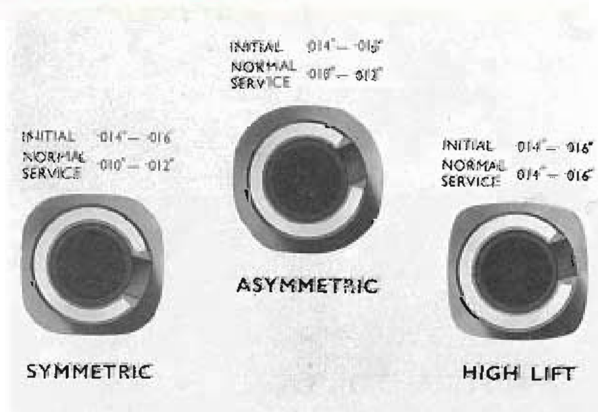
Here you can see the difference between the cam forms. The older type symmetric and asymmetric cams, as we have said, are used with a contact gap of ·010″ — ·012″, the 'High Lift' with the gap increased to ·014″ — ·016″. You can recognise the 'High Lift' cam by the much sharper form of the lobes.

You are probably wondering why there are different cam forms. Stated simply, cam development has had to keep pace with engine development. The early symmetrical cam was adequate for the ignition performance required by engines up to 1949, and gave equal open and closed periods of the contacts.

The asymmetric cam by reason of its special form helped to reduce contact breaker noise and at the same time provided a slightly increased dwell period. The contact breaker setting with this cam was somewhat critical and it was subsequently superseded by the current production 'High Lift' cam.

This cam with a sharp profile provides a very fast break, a long dwell period and is suitable for any type, high, or medium to low speed engines.

We hope that the summary will impress upon you that the contact gap must be set according to the cam form.



We'll repeat the gap settings once more :

With Symmetric and Asymmetric Cams :

New Contacts	·014″ — ·016″
In service	·010″ — ·012″

With High Lift Cams :

New Contacts	·014″ — ·016″
Maintained in Service at ...	·014″ — ·016″

DISTRIBUTOR BEARINGS.

Excessive side play at the cam head, generally caused by wear of the distributor bearings will cause uneven running and missing at speed.

Check for possible wear by putting side pressure on the cam and watching the movement at the C.B. points. *The variation in the gap should not exceed ·004″.*

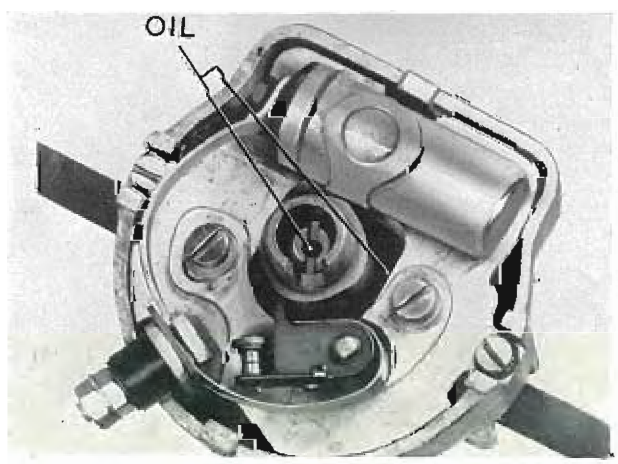
THE AUTO ADVANCE MECHANISM.

Sluggish operation or sticking of the centrifugal auto-advance mechanism will cause failure of the engine to accelerate and general erratic performance. Check the auto-advance for freedom of movement by turning the rotor heel against the spring tension.

There should be no ' back-lash ' at the start and the cam and rotor should return fully to the original position when released.

THE AUTO ADVANCE — LUBRICATION.

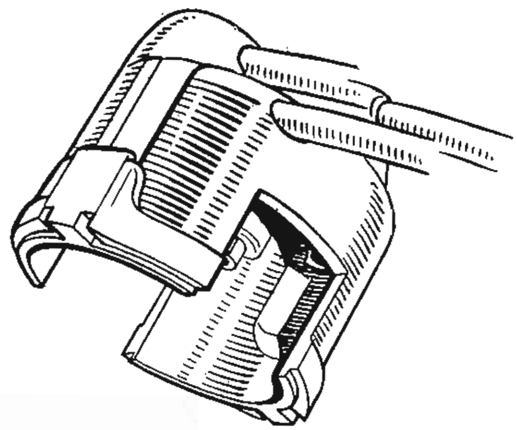
The Auto-advance should be lubricated with light machine oil at the points shown, particularly if any sticking is observed.

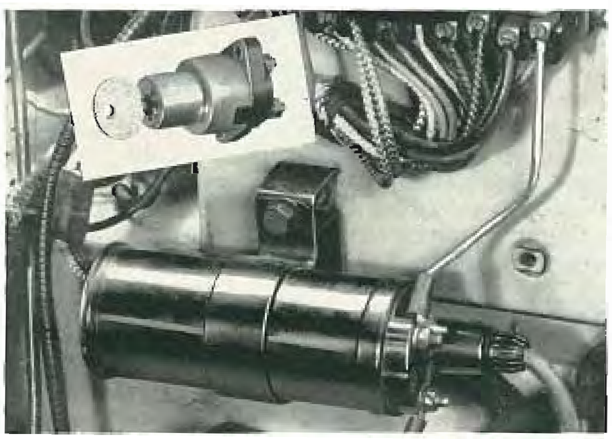


THE SUCTION ADVANCE.

Sticking or failure of the suction advance will cause poor engine acceleration, and sluggish running. An increase in the petrol consumption may also be noticed. The mechanism can be checked manually, and then observed with the engine running at varying speeds. If the suction diaphragm is working correctly, the plunger should move freely in its guide.

In some instances a cut-away distributor cap will have to be used for the movement to be seen. The picture shows how the cap should be cut away.





THE IGNITION COIL AND SWITCH CONNECTIONS.

Loose L.T. connections cause misfiring and even intermittent or total failure.

H.T. leakage at the coil chimney due to the accumulation of dirt and moisture on the moulding will frequently cause misfiring when accelerating under load.

A quick check of the L.T. circuit wiring, paying particular attention to connections at the switch and coil, plus an inspection of the coil chimney, will complete the maintenance of the ignition circuit.

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LUCAS

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Section 4
GENERATORS

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

INTRODUCTION

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 antartic.

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.

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 persistant 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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JOSEPH LUCAS (SALES & SERVICE) LTD., BIRMINGHAM, ENGLAND.

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.

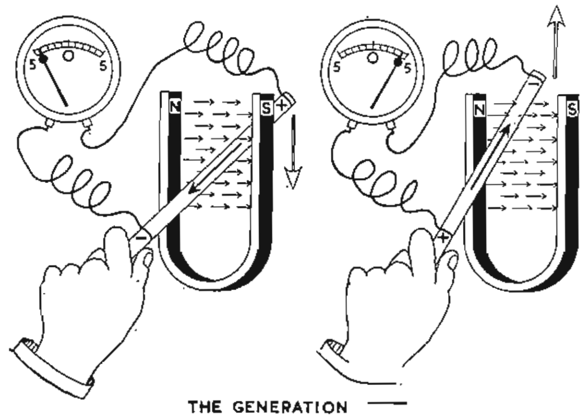
CREATION OF AN E.M.F.

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.

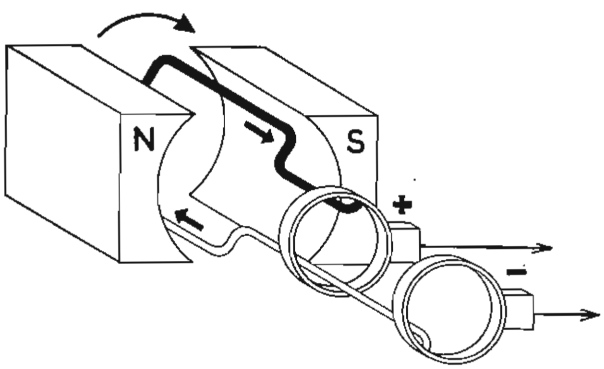
When a conductor is moved in a magnetic field, a force called an ' electro-motive force ' or ' e.m.f.' is induced into it. If the conductor forms a closed circuit, an electric current will flow which will register on a sensitive meter.

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.

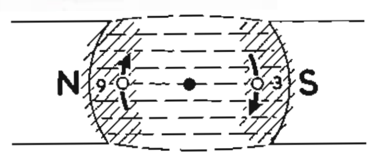
MAXIMUM AND MINIMUM INDUCTION.

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.

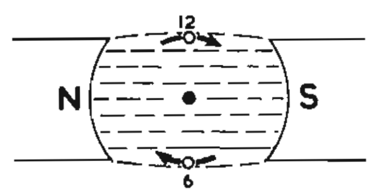
In the lower illustration, however, we show the conductors travelling parallel with the lines of force.

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.

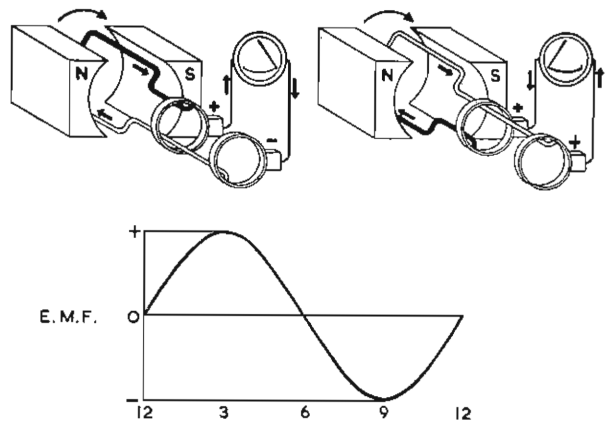
Now if we follow one complete revolution of this loop, which we mentioned previously, looking at the shaded conductor in the left-hand sketch, we shall see that the latter, moving clockwise, will first be cutting lines of force in one direction ; and then completing its cycle as in the right-hand picture, 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 brush 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 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 SLIP RINGS

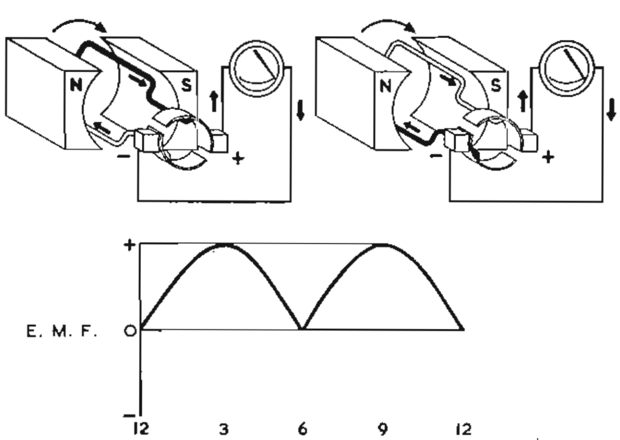
SINGLE LOOP GENERATOR—WITH COMMUTATOR.

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.

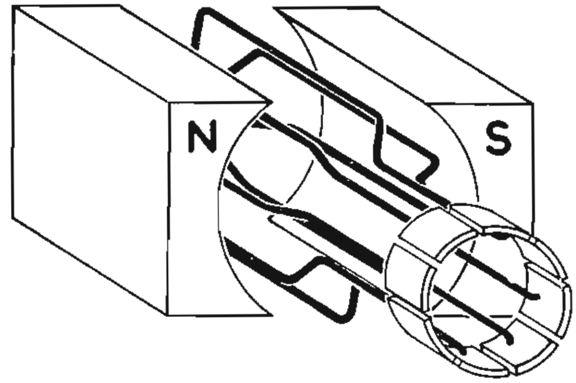


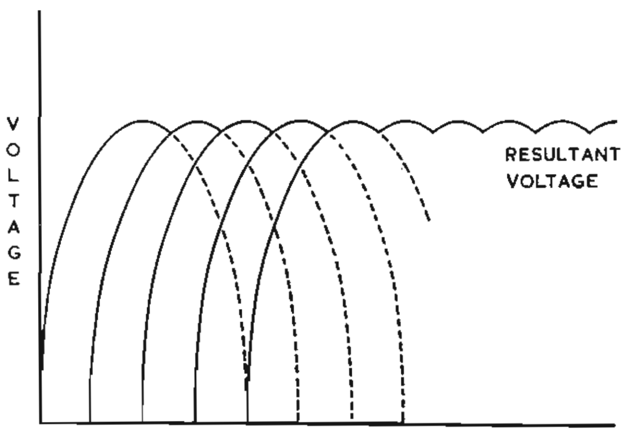
SINGLE LOOP GENERATOR WITH COMMUTATOR

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.

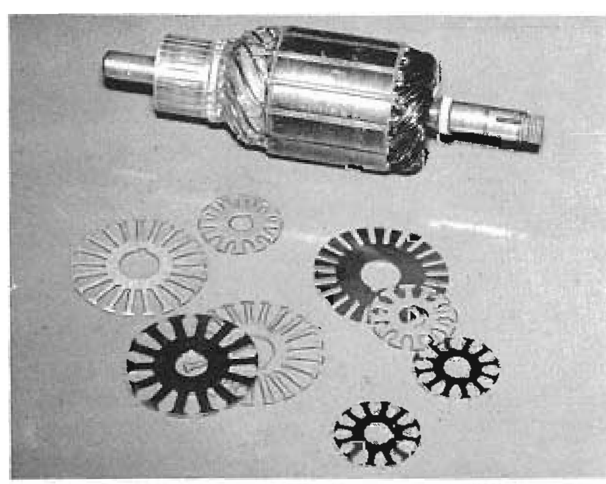
Thus the output we use for battery charging is virtually steady D.C.

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.

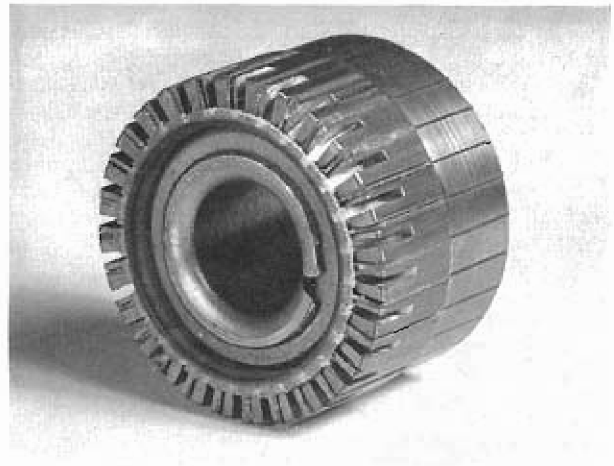
Thus, in effect, we have many loops of wire which we can rotate in a magnetic field.



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.



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.

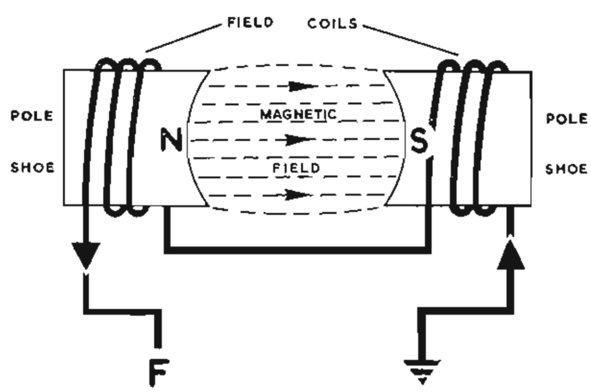
THE FORMATION OF THE MAGNETIC FIELD POLES.

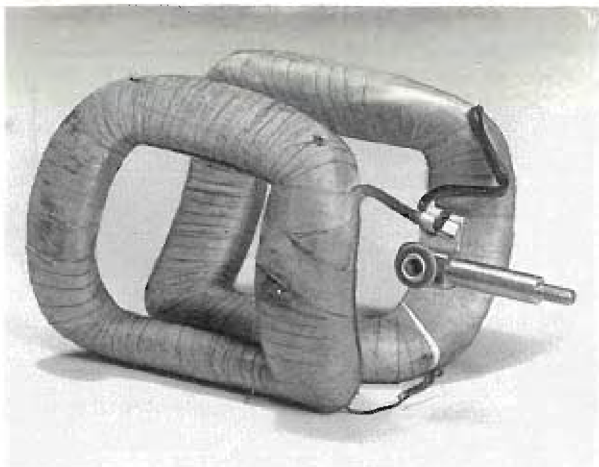
Having shown you how the armature is built up, we can now consider the formation of the magnetic field in which this armature rotates.

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.

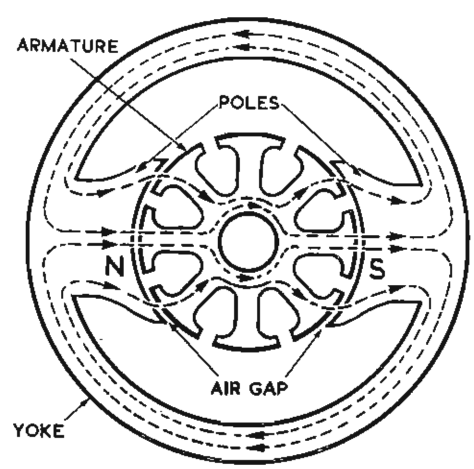
The yoke itself forms part of the magnetic circuit between the two opposing magnetic poles of the field coils.

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.

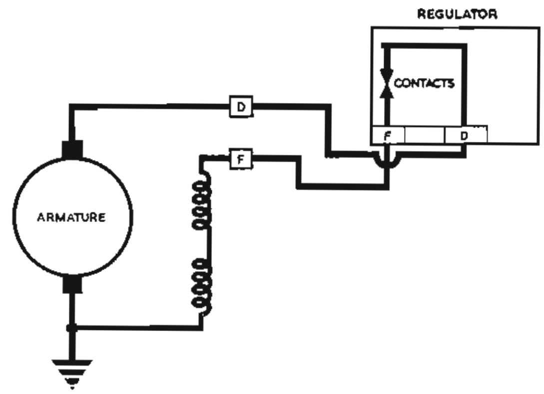
Our next picture shows how the armature and field circuits are interconnected.



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.

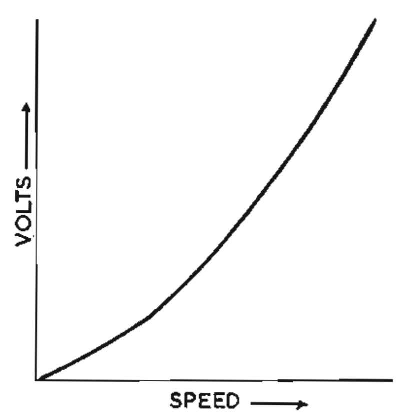
After the machine has once charged, sufficient magnetism remains in the pole-pieces to create a weak magnetic field. Thus when the armature begins to rotate, a weak current is induced into the armature windings. As these windings are in parallel with the field coils, current will also flow through the 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

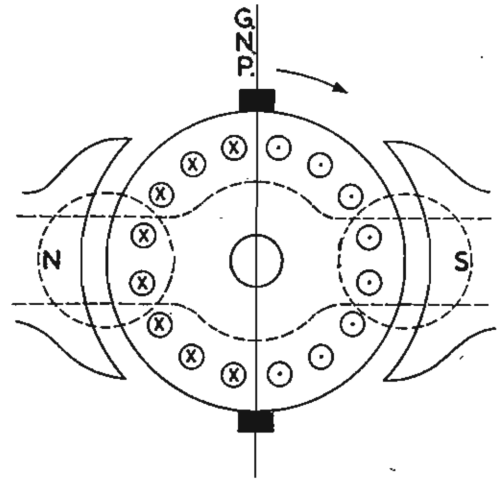
THE GEOMETRICAL NEUTRAL PLANE.

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.



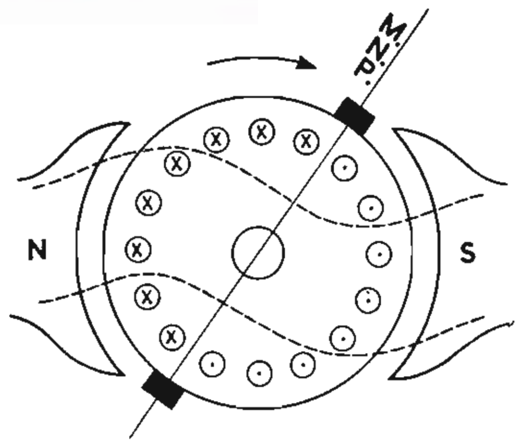
But in practice a complication arises: what is geometrically the neutral plane is magnetically not so.

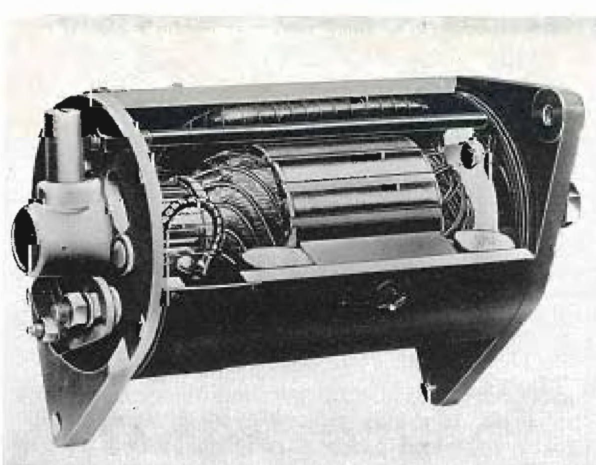
Because the armature windings are passing current, they produce their own magnetic field, as we have indicated by the dotted rings. This armature field distorts the main North-South field of the pole-shoes — which we shall show in the next picture.

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.

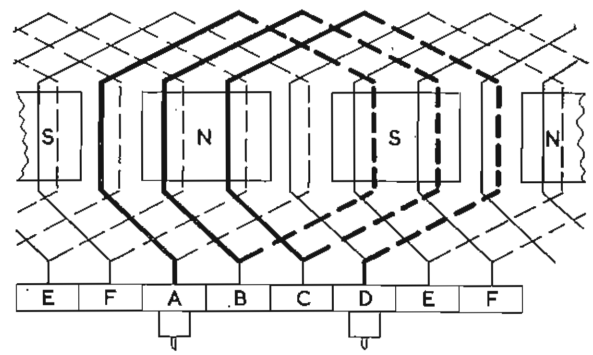
However, from an electrical point of view, the theory of the brushes being positioned in the neutral plane to prevent sparking still holds good. They are displaced physically, merely for the convenience of construction.

THE LAP WOUND ARMATURE.

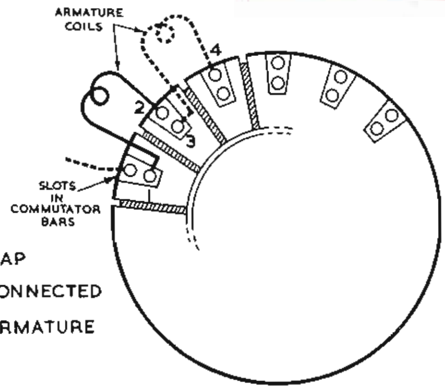
There are two main methods of winding armatures : ' wave winding ' and ' lap winding.' The difference lies in the actual armature coil to commutator segment arrangement.

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.

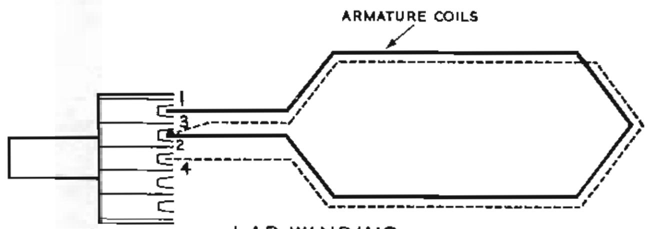
The end of one coil is connected to the same segment as the beginning of the next coil. Follow the coil from segment ' A ' round to segment ' B,' and then from ' B ' to ' C ' and so on. The coils are thus connected between adjacent segments. The current path, however, is from the brush on segment ' A,' 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



LAP CONNECTED ARMATURE



LAP WINDING

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.

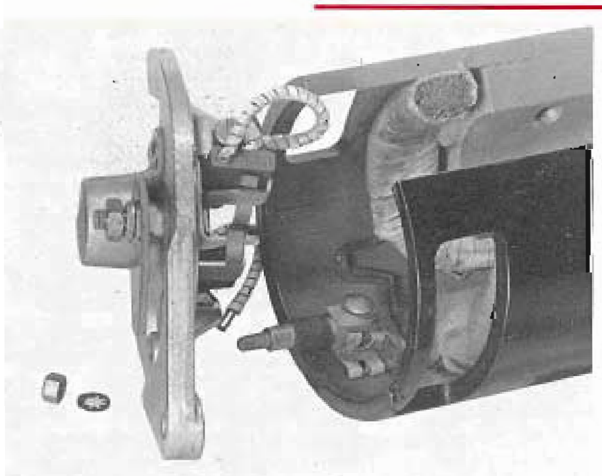
The winding continues in this manner round the commutator, two coil ends being soldered in the slots of every commutator segment.

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.

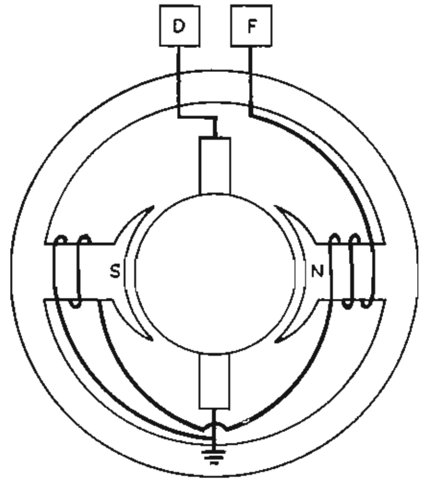
Here we are pointing out the electrical connections, showing the disposition of the field coils and the field terminal, together with the commutator end-bracket complete with two Brush Boxes. One of these Brush Boxes is earthed to the metal end-bracket, the other is insulated, the external ' D ' terminal 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.

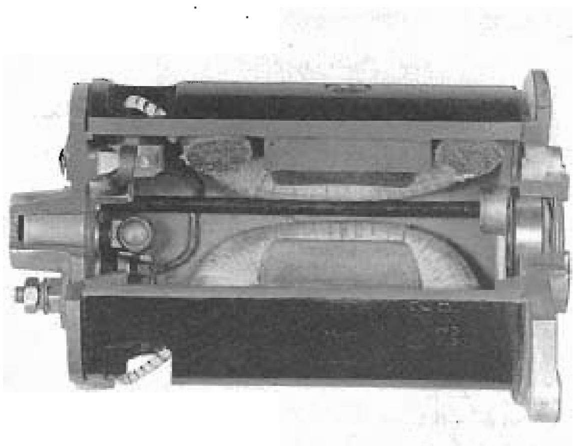
The Field terminal assembly is rivetted to the generator yoke and passes through a bushed hole in the end-bracket.

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.

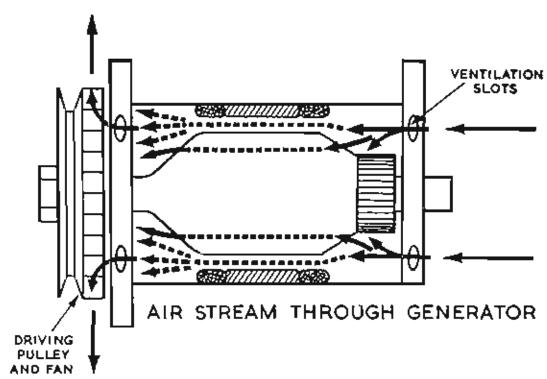
When the machine is generating current, it is doing work and producing heat in the armature windings. If the machine is to work efficiently, giving its full output, this heat must be dissipated.

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.



AIR STREAM THROUGH GENERATOR

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 commercials 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

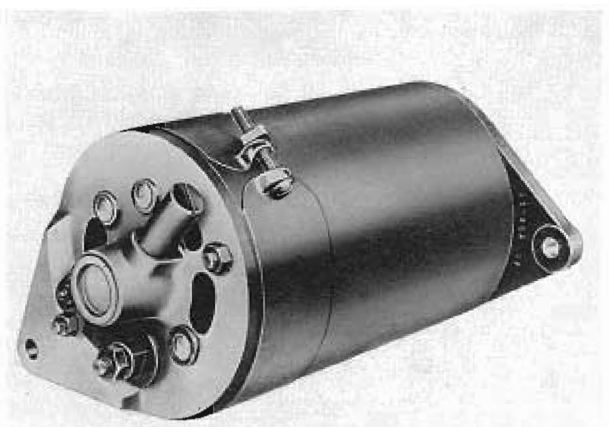
C 39 P2   C 39 P

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 Tensioning 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.



C39PV

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.

THE C39PV2.

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

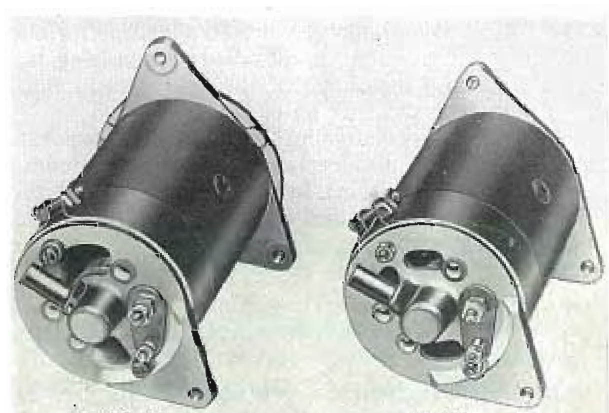
It incorporates an armature with a larger diameter commutator. ' Ducts ' in the end-brackets direct the air straight on to the commutator and through the windings. The difference from the earlier PV model is clearly visible in the picture.

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.'



C 39 PV2 C 39 PV

THE C45 SERIES OF GENERATORS.

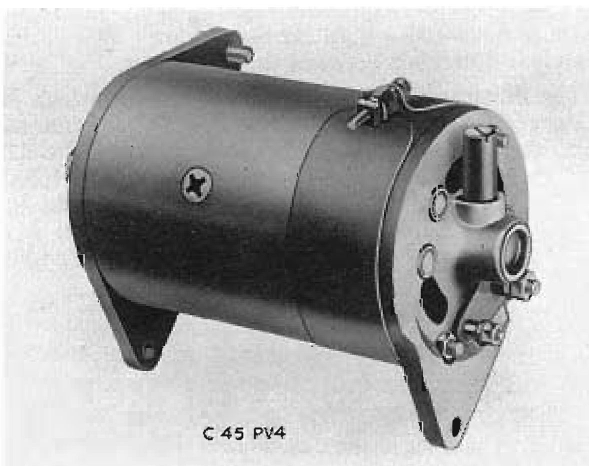
At the present time there are four types of this generator in general use. The enclosed models: the C45P4 and P5 and two ventilated models C45P4 and P5.

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.



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.

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.

TOP C45PVS5 BOTTOM C45PV5

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.

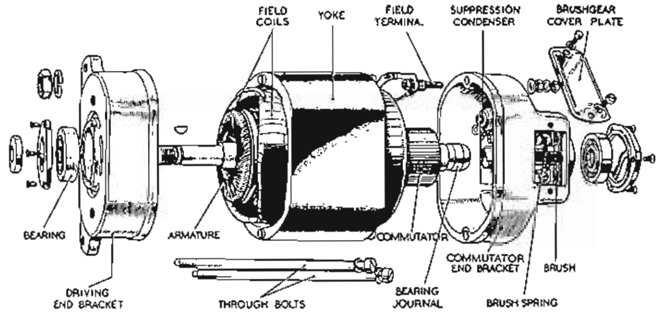
You will notice that the machine is rectangular in construction.

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.

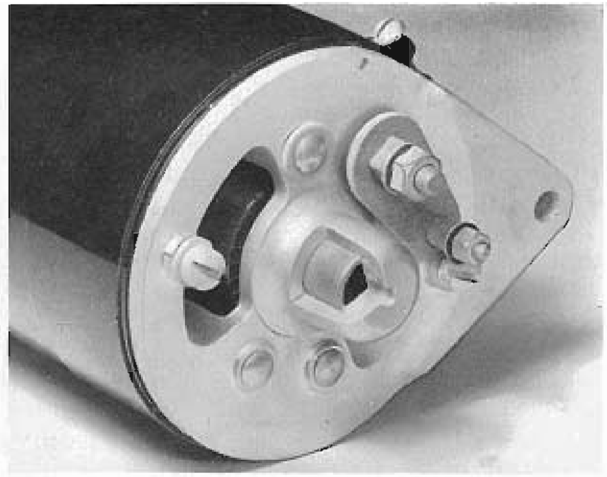
And, remember, porous bronze bushes are pre-soaked.

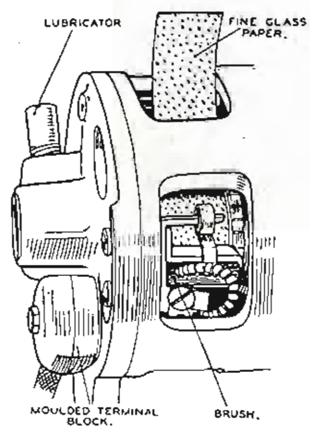
THE LATEST OILING ARRANGEMENT.

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).





BEDDING DYNAMO BRUSHES

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.

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 :

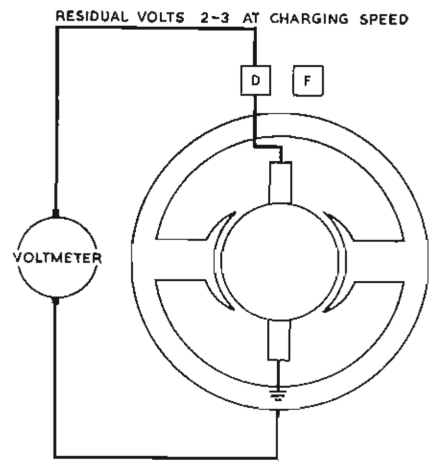
(*a*) Slipping or defective belt drive.
(*b*) Loose or earthed external connections.
(*c*) Sticking brushes.
(*d*) Short-circuited, open-circuited or earthed-armature windings.
(*e*) One field coil shorted out.
(*f*) Both field coils earthed.
(*g*) Broken field coil lead, i.e., open-circuited.

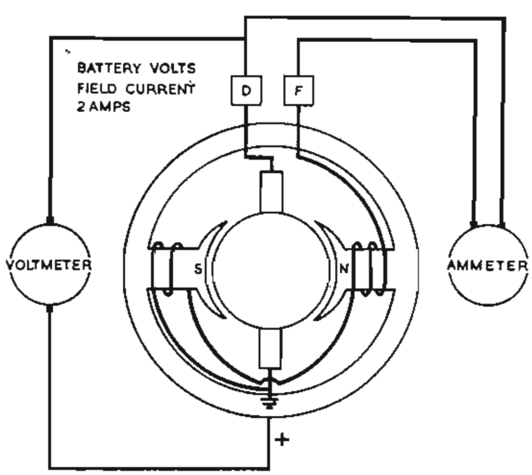
THE GENERATOR ARMATURE CIRCUIT.

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.

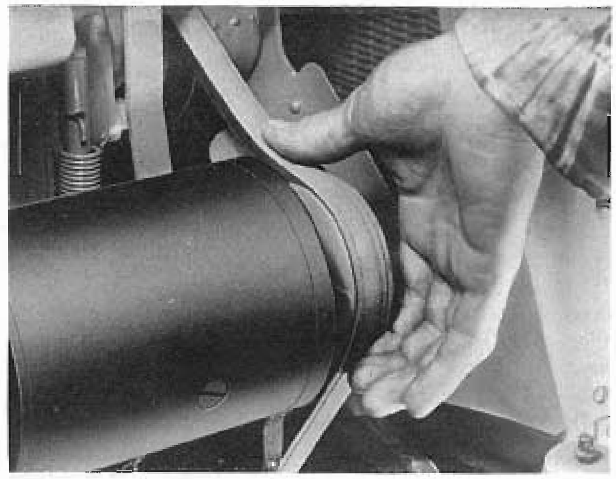
CHECK THE DRIVING BELT.
OPERATION 1.

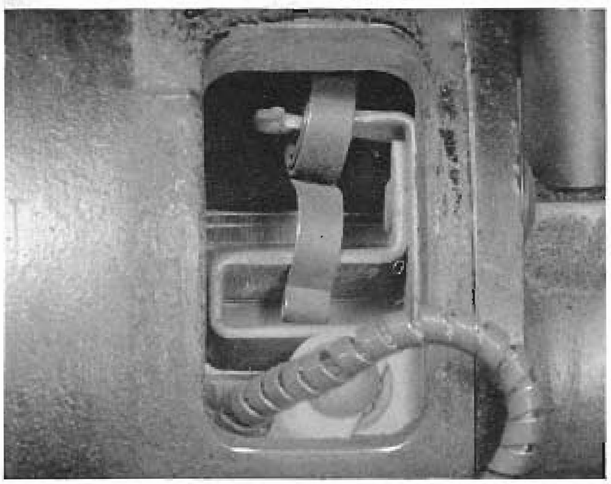
There should be about half an inch to an inch movement in the belt, tested at this point. And remember that a belt that is excessively tight not only strains the generator bearings, but is also liable to damage the water pump gland.

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.





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.

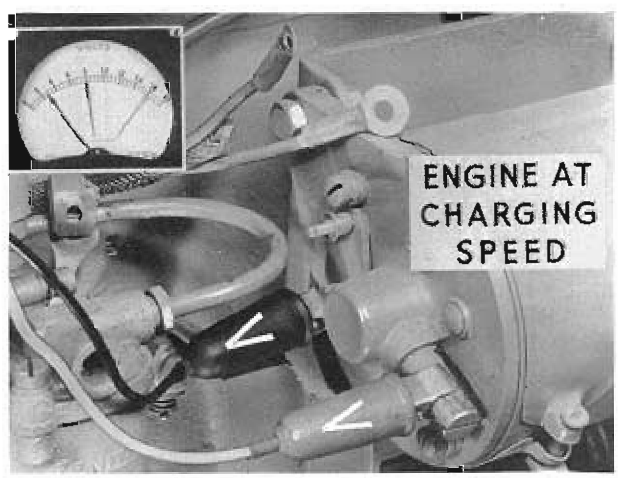
TESTING THE ARMATURE.

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.

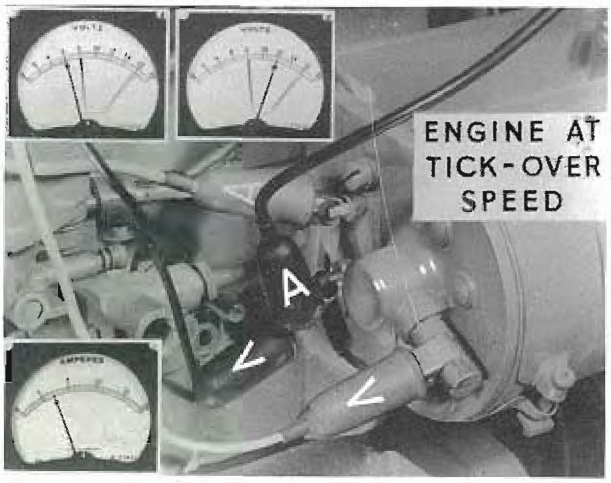


TESTING THE FIELDS.
OPERATION 4.

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.

106.

LUCAS

TECHNICAL SERVICE

OVERSEAS
TECHNICAL CORRESPONDENCE
COURSE

Section 5
GENERATOR OUTPUT CONTROL

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

INTRODUCTION

Generator Output Control would seem to be a specialised subject of interest and value only to the Technician.

This is not altogether a fact: some knowledge of what is involved will be of great assistance to the administrator and stores operator, particularly in relation to parts ordering and stock control.

If you have followed through the generator section of this course, you will realise the important part which the control unit plays. Its combined function is to control the output over the generator speed range, regulate the current input required by the battery and when necessary provide additional current to cover the full load demand of the vehicle when lights and accessories are in use. Since this control is automatic, it is evident that the control unit is of considerable importance in the scheme of things.

An iron frame or yoke secures the voltage regulator unit and the cut-out. Although combined structurally, the regulator and cut-out are electrically separate, the regulator unit being of the electro-magnetic vibrating type. When placed in the generator circuit this unit acts as the brain of the charging system and regulates the supply of current to suit the various loads which are imposed upon it.

In order to make this unit suitable for the complete range of generators and vehicles manufactured, the load windings on the regulator are varied to suit a particular vehicle's electrical specification, i.e., type of generator, lamp and accessory load, etc. For this reason the control units are NOT interchangeable as a whole. This is an important point for administrative as well as technical personnel to keep in mind. A number of the control boxes are closely akin, and our Inter-changeability List should always be referred to by the technician and the stores manager in deciding on a suitable replacement from existing stocks, as well as helping to decide what stock should be held.

The adverse effects of fitting an incorrect replacement may not be immediately apparent. A control box with too few load turns may cause the generator to persistently overheat with consequent damage to the commutator brushes and bearings, and in extreme cases a complete burn out. The fitting of a control unit with too many load turns may cause the generator output to be insufficient to cover the load and will result in permanently run down or low charged batteries, causing premature failure of the battery through hardening of the plates.

This should be borne in mind when ordering spares, such as the regulator unit assembly where the identification number on the bracket must be reconciled to the complete unit and the vehicle concerned, otherwise the results in service can be most unsatisfactory.

Efficient performance over years of service is largely dependent upon the quality of the material used in the spring blades and bi-metal strips. Great care is taken with the specification of these materials and in the quality control of supplies coming in to the works. Also a prolonged period of running is provided on all assemblies, to normalize the springs before final adjustment of the settings. This is just another reason for buying only the original maker's genuine spares.

In view of the ever increasing demand for electric current on the modern vehicle, recent developments on generator output control have led to the introduction of the Current Voltage Control System. This is a fully proved system of control which has been applied to heavy commercial vehicles over several years and is now coming into use on the larger cars with prospects for its extension to the smaller range.

Briefly, it is a Constant Voltage Regulator with the addition of a separate Current Regulator which enables the maximum output from the generator to be available for a much longer period than if the voltage regulator only is used. By this means a discharged battery is returned to a half charged state very quickly, after which the voltage regulator takes over and proceeds with a " Tapering Charge " to completion.

Both the Compensated Voltage and Current Voltage regulating systems are fully covered in the accompanying pages of this Section.

CONTENTS

JOSEPH LUCAS (SALES & SERVICE) LTD., BIRMINGHAM 18, ENGLAND.

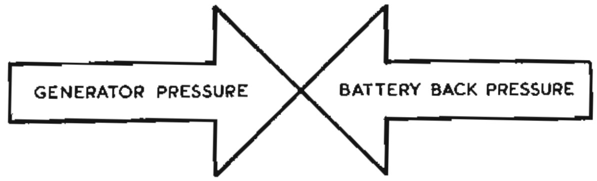
Working Principles

GENERATOR OUTPUT CONTROL

The generators we have to deal with, you will remember, are plain, shunt-wound machines. The main characteristic of these generators is that their output rises with increasing speed. Remembering that on modern vehicles the speed at which the generator is driven may be anything between 600–6,000 r.p.m. the output could quite easily rise above the safe limits of the machine. Some control of the output is therefore necessary when our generator is applied to a vehicle as the source of the battery charging current, if it is to function efficiently at all road speeds.

APPROXIMATE BATTERY VOLTAGE: DISCHARGED 12 V.
-- -- -- : FULLY CHARGED 16 V.

GENERATOR VOLTAGE CONTROLLED AT 16 V.



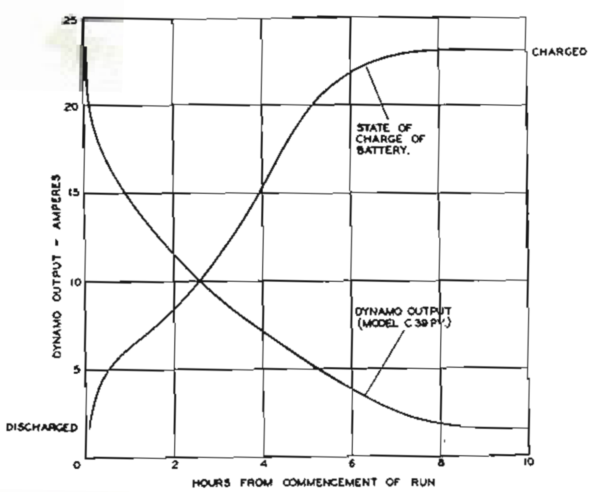
VOLTAGE CONTROL

Now on the modern vehicle how do we achieve this control of our generator output, so that at all times the battery is being correctly charged and the generator kept within its rated output? One fact really provides the key to the problem: the fact that the battery voltage varies with the state of charge. If now we could control the generator output voltage at a pre-set figure over a wide speed range, we should have a variable voltage at one end of our charging system and a constant voltage at the other. The current flowing in this charging circuit would therefore vary with the varying terminal voltage of the battery, i.e. with its state of charge. The difference between the battery terminal voltage and the generator terminal voltage would be appreciable when the battery was in a low state of charge, getting progressively less as the battery reached its fully-charged state. If the pre-determined voltage at the generator terminals has been correctly set, in theory we shall arrive at a state where the battery terminal voltage in its fully charged condition will exactly equal the generator terminal voltage. At this point, no current will flow through the charging circuit, as the back voltage of the battery will equal the pressure or voltage of the generator.

CHARGING CHARACTERISTICS

You can see from this graph how the charging rate falls as the battery reaches its fully-charged state, becoming a trickle charge, in this case of 1 or 2 amps., after 10 hours.

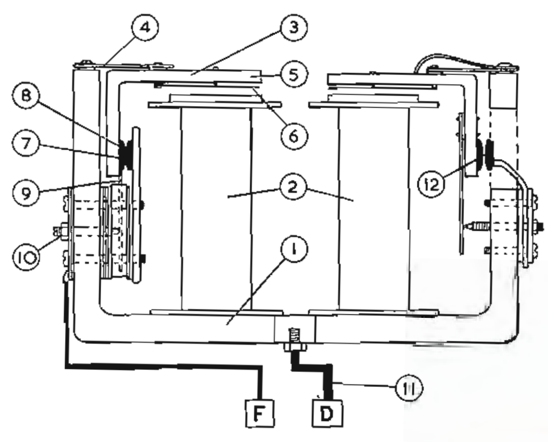
It is also clear that with this system of regulation, the " Voltage Control System " as it is called, the battery receives a high charge from the generator when it most needs it.



THE CONSTRUCTION OF THE CONTROL UNIT

As shown diagramatically in this picture the Voltage Control unit comprises an Iron Frame or " Yoke " (1) on which is mounted two Iron Bobbin Cores (2) one (left) for the Voltage Regulator and the other (right) for the Cut-out Switch.

Let us consider the Voltage Regulator units; a pivoted bracket (known as an Armature) (3) is mounted by means of a Spring Blade (4) on the top of the main bracket. The horizontal member (5) lies immediately over the bobbin core and when this core is magnetised the flat member will be drawn down to it. In order to prevent it clinging to the core by residual magnetism a brass plate (6) or a copper button prevents iron to iron contact. (*continued on next page.*)



THE CONSTRUCTION OF THE CONTROL UNIT *(continued)*

On the vertical member of this " Armature " a contact point (7) is fixed to line up with a stationary contact (8) insulated from the main bracket. Also on the vertical member of the armature is a spring blade (9) and this blade lines up with an adjusting screw (10). By means of this adjusting screw the pressure between the two contact points may be varied.

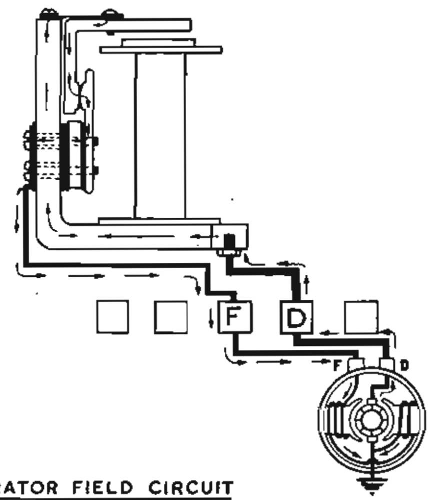
The main D terminal of the generator connects to the bracket as shown (11) and the generator Field terminal F connects to the insulated contact point (8). When at rest the two contact points will be closed, thus completing the circuit between the generator armature and field.

The contact point assembly of the automatic cut-out switch (12) is of a generally similar construction but a single opening and closing operation disconnects and connects the generator from the battery. In the normal at rest position the cut-out points are open whereas the Field Regulator points are closed.

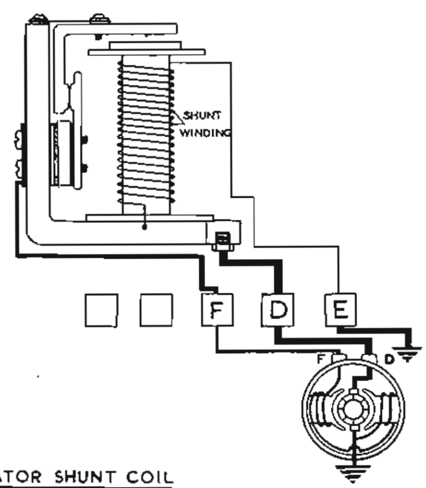
THE GENERATOR FIELD CIRCUIT

How then, in practice, do we achieve this controlled terminal voltage at the generator. Well, you know that the output of the shunt-wound generator is only obtained when the field circuit is joined in parallel with the armature circuit, i.e. when terminals D and F are connected. If we then break this D/F connection, that is, break the field circuit, the output will immediately fall off.

Here you see the regulator frame and its connection to the generator. If you follow the circuit from the generator " D " terminal, through the right-angle frame and moving contact to the fixed contact, and back to F at the generator, you can see that D is effectively joined to F through a pair of contacts. Spring tension holds the contacts together, thus keeping the D/F circuit closed.



GENERATOR FIELD CIRCUIT



REGULATOR SHUNT COIL

REGULATOR SHUNT COIL

The breaking of the contacts is controlled by an electro-magnetic relay whose winding is connected across the generator, between terminal D and earth, that is, in parallel with the generator armature. Thus, as the generator voltage rises, this shunt winding will be energised, magnetising the core, and a point will be reached when the magnetic pull of the core is strong enough to overcome the spring tension and separate the contacts.

Immediately the contacts separate, breaking the field circuit, so the output of the generator falls. In turn, the bobbin will lose its magnetic pull, release the moving contact and, with the field circuit again completed, the generator output will rise.

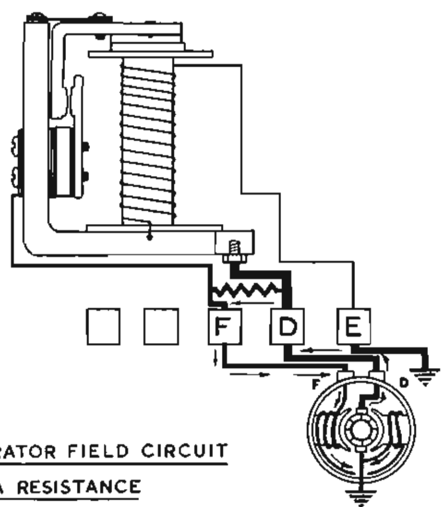
When in operation this becomes an alternate rapid opening and closing of the contacts at a frequency of between 60 and 100 times per second enabling a very fine regulation of the generator voltage to be obtained.

The voltage necessary to create sufficient magnetic effect to separate the contacts can now be controlled by the spring tension on the contacts themselves. Thus we can control our generator voltage at a pre-set figure by adjustment of the spring tension. And what is more, this control is independent of the speed at which the generator is being driven, which is what we set out to achieve.

THE REGULATOR POINTS RESISTANCE

Unfortunately, however, we cannot just break a field circuit when current is passing without causing considerable sparking across the contacts. Furthermore the generator field would be slow to collapse. A resistance must therefore be placed in parallel with the contacts to protect the points against inductive surges which would occur when the contacts open at the instant when a comparatively heavy current is flowing.

When the regulator contacts are closed, then the resistance is short circuited ; it provides however an alternative path between D and F when the contacts are open, thus quickly limiting the induced field current.



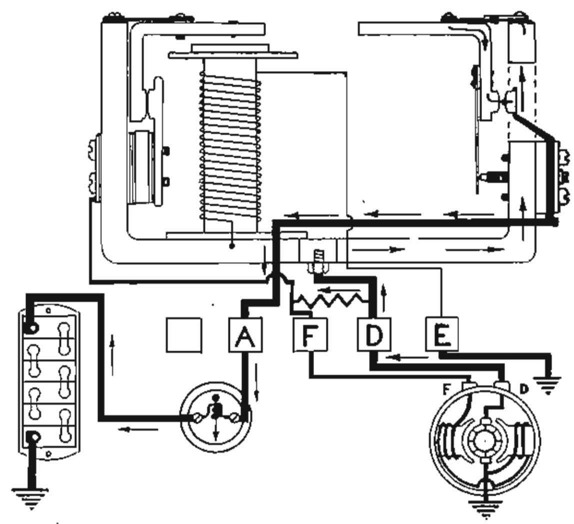
GENERATOR FIELD CIRCUIT VIA RESISTANCE

THE CHARGING CIRCUIT IN THEORY

Let us now build-up a charging circuit from what we have discussed so far. All we need is an ammeter in series with our battery, and some sort of switch to disconnect the battery from the generator when charging stops. Otherwise the battery would discharge itself through the generator windings.

We have represented this switch here by a pair of contacts on the right of the picture.

You can follow the circuit from the generator D terminal, along the extended regulator frame, through the switch and then through the ammeter to the battery. The circuit is completed via the battery and generator earths.



THE CUT-OUT

In practice of course all this switching is done automatically by another electro-magnetic relay called a " cut-out ". The winding for this cut-out is wound on a separate bobbin on the frame and connected across the generator between terminal D and earth. It is, then, a shunt winding as was the regulator shunt winding — but we stress that the regulator and cut-out are two separate units.

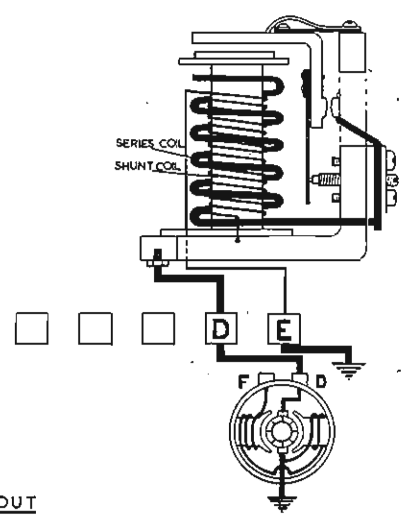
You will notice that the entire regulator frame is at dynamo potential ; in more practical terms, the connection from D of the generator is actually attached to the frame.

When the generator voltage rises sufficiently, the cut-out contacts are closed against spring tension by the magnetic pull from the cut-out bobbin and the circuit between the generator and the battery is thus closed.

When the generator speed is low or the engine stationary, the contacts will break, thus preventing current flowing back from the battery through the generator armature windings.

There is one important point to notice : all the charging current from the generator passes through the cut-out contacts and through a heavy " series " winding on the cut-out bobbin. This current assists the magnetic pull of the bobbin, preventing the cut-out contacts from chattering once they have closed.

Also, when the generator stops charging, the momentary reverse current from the battery flows through this series winding, creating a magnetic flux which opposes and cancels the existing flux, and thus quickens the opening of the contacts.

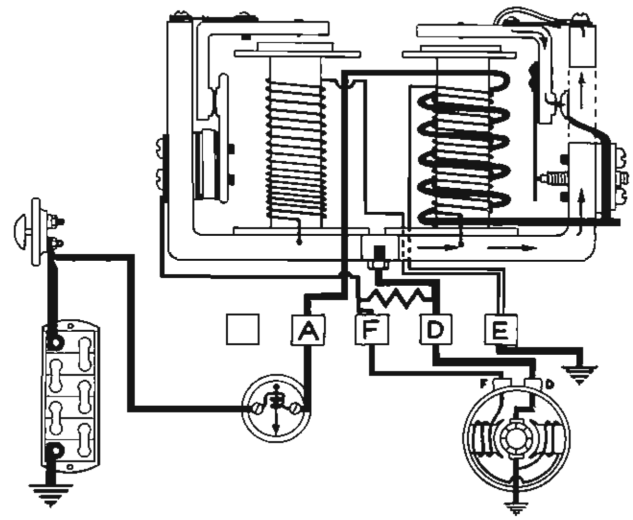


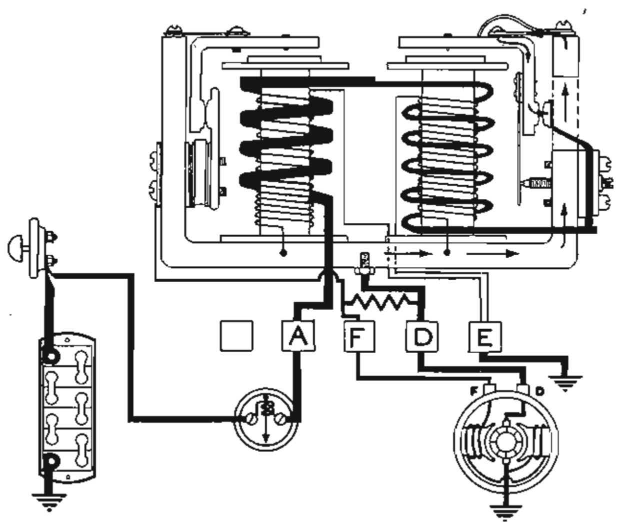
CUTOUT

CHARGING CIRCUIT: "CONSTANT VOLTAGE CONTROL"

Our regulator and cut-out assembly, that is, our control box, would now look like this. If we follow the circuit through, starting at the D terminal of the generator, we first pass to the D terminal of the box and then to the regulator frame, through the cut-out when the contacts close, through the heavy series winding on the cut-out and across to terminal A. This terminal is connected via the ammeter to the battery. The circuit is completed by the battery and generator earths.

Unfortunately, the simple "*constant voltage control*" system we have built up has one snag: it presupposes the use of a generator of very great generating capacity. If we consider the case of a battery in a low state of charge, its terminal voltage will be low. If, in addition, we put a load on the battery, switch the headlamps on for instance, the voltage will fall still lower. Under such conditions, the generator will still endeavour to maintain the pre-determined voltage set by the regulator and consequently an extremely heavy current will flow in the charging circuit, owing to the substantial difference between the battery and generator potentials. In practice this current would be sufficient to burn out the armature of a standard automobile generator.





"COMPENSATED VOLTAGE CONTROL"

The Lucas "COMPENSATED Voltage Control System" overcomes this difficulty by automatically varying the OPERATIONAL voltage setting of the regulator, so that the difference between the generator and battery terminal voltages is never great enough to cause such a heavy current to flow that the generator would be damaged.

THE REGULATOR SERIES WINDING

In practice, this variation in the operating voltage of the regulator is brought about by adding another winding to the regulator bobbin. In other words, the charging circuit now continues from the cut-out series winding, not direct to terminal A, but through an additional "Series" winding on the regulator bobbin. This winding thus carries all charging current flowing from the generator to the battery and is wound so that it assists the voltage or shunt coil of the regulator in pulling apart the regulator contacts. The heavier the current flowing, the greater will be the magnetic pull of the bobbin, and the sooner the contacts will open. Thus in effect we have lowered the voltage at which regulation occurs: our generator will then be working at an operational voltage which is varied according to the current flowing into the battery.

As the battery becomes discharged and its voltage falls the charging Circuit Voltage or "LINE VOLTAGE" will also fall. The action of the COMPENSATING or SERIES winding on the regulator is thus to limit the charging current to the maximum safe output of the generator.

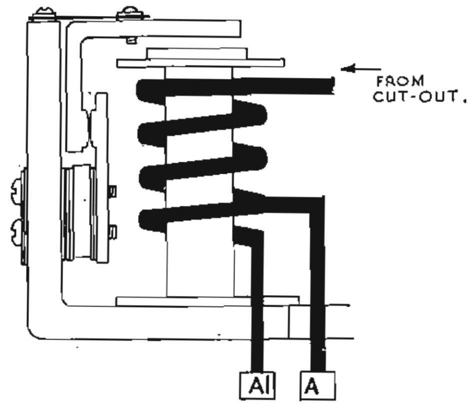
THE REGULATOR "LOAD TURNS"

If, when the battery is discharged, all the lights, etc., are switched on, a further drop in the LINE voltage will take place. To compensate for this, one or more additional turns will be added to the series winding and taken to a terminal marked A1 as shown. These are called LOAD TURNS and only become effective when the lights and any other external load are switched on.

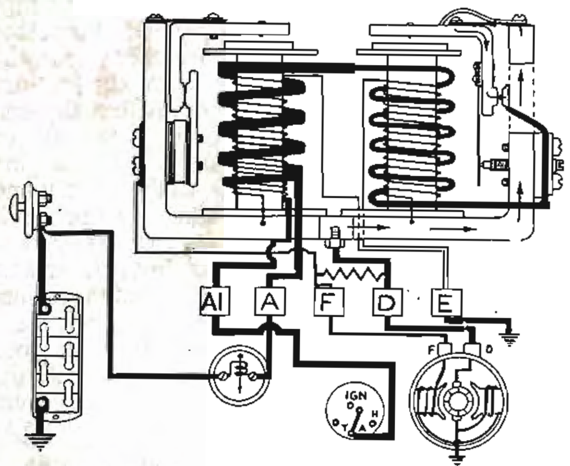
In appearance all the regulator units are similar and mechanically this is so. Also with a very few exceptions the regulator settings are the same.

So, in order to make this standard unit universally applicable to all types of generators and all models of vehicles it is necessary to vary the number of turns in the compensating and load windings. The compensator windings must be made to suit the generator and the load winding to suit the external loads, that is, the lighting, etc., for different vehicle layouts.

Thus each type of control box has an identification number which relates it to the correct generator and also the vehicle application. For this reason the control units must not be interchanged except as recommended in Lucas Interchangeability Lists.



REGULATOR SPLIT SERIES WINDING



THE MAIN CHARGING AND LOAD CIRCUITS (SHOWN IN HEAVY LINES)

CHARGING CIRCUIT: COMPENSATED VOLTAGE CONTROL

We are now in a position to study the complete charging circuit incorporating a compensated voltage control regulator. Let us trace the circuit from the generator to the battery.

We will start at the generator armature which is connected to the D terminal on the generator. This terminal is connected to the D terminal at the control box and a metal connecting strip joins the D terminal to the regulator frame, causing the frame to be at generator potential. We can follow the arrows from this point. We pass along the frame, through the moving contact, then to the fixed contact when the cut-out points close. The current is then able to flow through the series winding of the cut-out and through the main regulator series winding, being taken off at the tapping to the A terminal. The circuit then continues to the battery by way of the ammeter.

The circuit is completed through the vehicle chassis and so to the earthed brush of the generator.

You can see how the current for the load circuit is taken from the very bottom of the regulator series winding to the terminal A1 and from there to the main lighting and ignition switch.

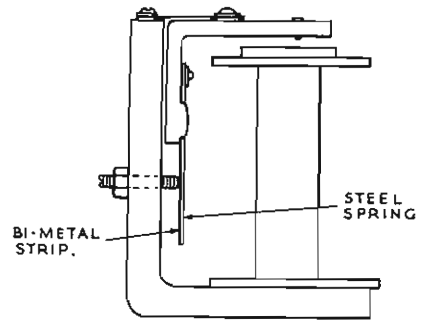
TEMPERATURE COMPENSATION

The regulators themselves, in addition to having compensating and load turns, are also TEMPERATURE compensated. This, like the regulator setting, is common to them all, but is not in any way adjustable

Put in its simplest form, this temperature compensation aims primarily to make the generator voltage-setting follow the comparative battery voltage as it rises and falls due to marked temperature changes.

As the charge proceeds, the generator will heat up quickly. The temperature compensating feature enables an extra high charge rate to be applied to the battery with a cold generator and be maintained until the generator reaches its maximum working temperature, when the generator voltage is automatically reduced by the compensator and the charge proceeds at a normal rate.

To this end, as shown in the picture, a bi-metal strip is fitted behind the contact tensioning spring. Now you know that if two strips of metal with different co-efficients of expansion are welded together and the combination heated, the differing degree of expansion will cause the combination to bend as the temperature rises and resumes its normal shape when the temperature falls. Having then applied such a combination of metals to the regulator adjusting spring, we can obtain a spring tension which will vary automatically with the temperature of the equipment. The controlling voltage of the regulator will thus be higher when it is cold than when it is hot.



BI-METAL STRIP FITTED BEHIND CONTACT TENSIONING SPRING

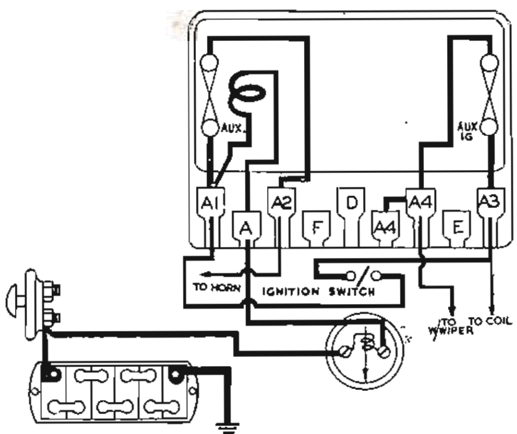
AUXILIARY CIRCUITS

We have now actually finished with the regulator itself, but there are other features of the control box which we must consider.

On some control boxes, additional terminals are provided to cater for accessories fitted on the vehicle, such as trafficators, windscreen wipers, etc.

Extra terminals on this type of box are, first : the A2 terminal. This, as you can see, is connected from the A1 terminal through a fuse marked " AUX " (auxiliary). Any accessories connected to this terminal will be fed from the battery via the ammeter through the load turns on the regulator bobbin, with a fuse in circuit.

Next, the A3 and A4 terminals. The A3 terminal is fed from the ignition switch, and is thus " live " only when the ignition switch is on. Both A4 terminals are then fed through a fuse from A3. Thus auxiliaries connected to A4 will only operate when the ignition is switched on. The feed to the ignition switch itself is from A1, i.e. through the LOAD turns.



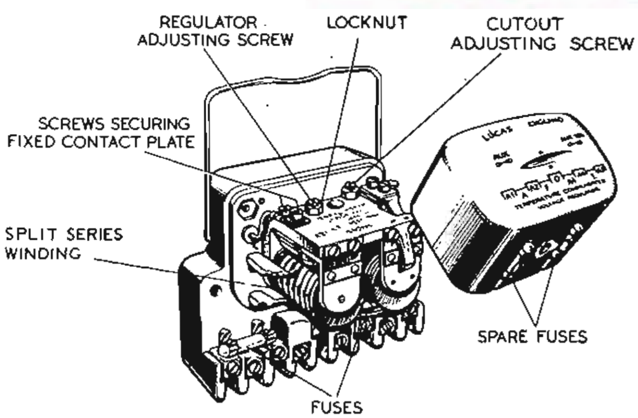
AUXILIARY IGNITION AND ACCESSORIES CIRCUIT

THE COMPLETE CONTROL BOX.

We finish this section by showing you a sketch of a complete control box.

Most of the features we have discussed are indicated. You can see the two auxiliary fuses, and the right angle bracket or yoke on which both regulator and cut-out are mounted, regulator left, cut-out right.

The regulator split-series winding is pointed out ; and the screws for adjusting the spring tension on the regulator and cut-out.



COMPENSATED VOLTAGE CONTROL REGULATOR

Control Boxes — Symbols, Types and Application

IDENTIFICATION SYMBOLS

The symbols used for identifying the different control boxes are as follows :—

R indicates " Regulator ", or " Resistance Incorporated."

F indicates " Fuse Box "

J indicates " Junction Box."

B indicates " Box."

2, 5, 7 and 9 " Type of Regulator."

1 indicates ONE Resistance.

2 indicates TWO Resistances for four pole generators.

5 indicates TWO Fuses.

6 indicates No Fuse.

7 indicates Totally enclosed " Plug-in " terminals.

X indicates partial radio suppression — may have a capacitor only.

S Full suppression, with chokes and capacitors.

RF95, 96, 97, RB107 AND RB106/1 CONTROL BOXES

We can now review the Control Boxes themselves.

We are concerned with the RF95, 96, 97 and RB107 together with RB106/1 boxes.

To begin with, what are their characteristic features? With the exception of the RB107 they all use the LRT9 regulator, with a variety of series windings, but the voltage settings are sometimes special for particular applications.

THE RF95 CONTROL BOX

This control box comprises a bakelite moulding upon which is mounted the LRT9 regulator and the cut-out assembly. The heavy series turns on the regulator are divided into the main and load compensating windings.

Two 35 amp. fuses are provided for the accessory circuits. The one fuse (right) is fed through the ignition switch. The second (left) has a direct supply through the load winding of the regulator.

The field points resistance is in the form of a cartridge placed on the underside of the base.

The terminal layout is indicated in the picture.

THE RF96 CONTROL BOX

This control box also has a moulded base assembly upon which is mounted a similar LRT9 regulator and cut-out. Again various split-series windings are employed.

The 96 is a more recent design than the 95 and is primarily intended for use with the heavier output generators, in particular the RA5.

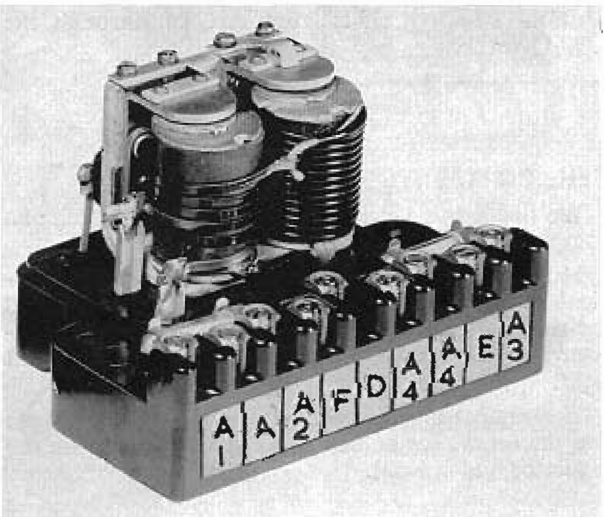
The split-series winding generally has fewer turns when used with the heavier output generators.

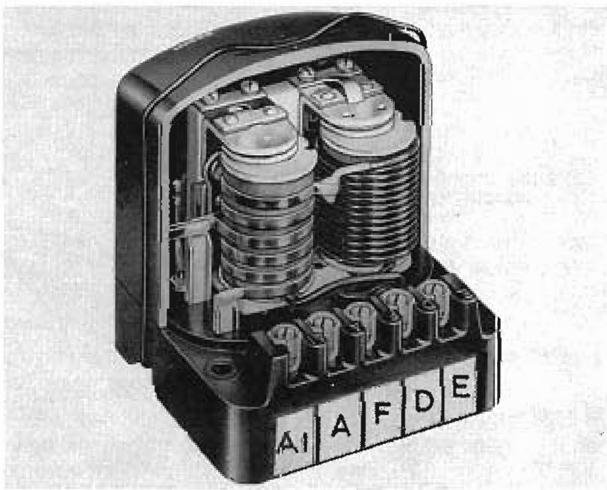
The simplified terminal board of the box is at once noticeable.

Only terminals required by the regulator and cut-out are provided ; commencing from the left.

- A1 The supply for all external load ; comes from the load turns of the split-series winding.
- A Comes from the main compensating turns of the series winding.
- F Wired to the generator field terminal.
- D Wired to the generator main terminal.
- E For the earth connection from the LRT9 assembly.

One or more independent fuse boxes can be fed from the A1 terminal according to car manufacturers' requirements.



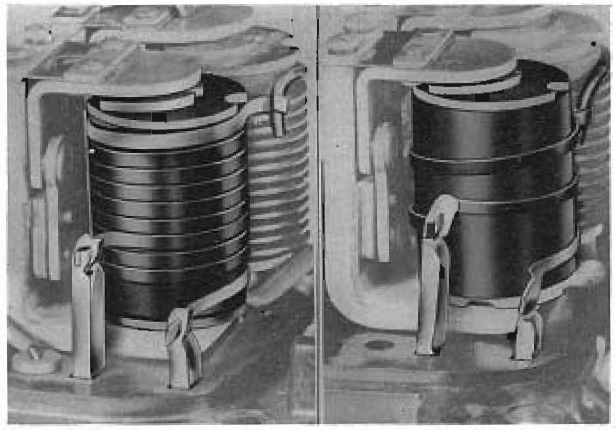


THE REGULATOR SPLIT-SERIES WINDING

You will have noticed by now that the number of series turns on the regulator bobbin varies considerably. We will sum up by saying that, generally, the higher the output rating of the generator, the fewer the series turns required. With the RA5 for instance, the high output generator used by Rolls Royce and Bentley, the regulator split-series winding has only 1 main turn, and 1 load turn.

At the other extreme, the regulator used with the fully enclosed, low output generator on the " Fordson " tractor has 6 main and three load turns.

We will stress here and now that no generator will work correctly unless it is used in conjunction with the appropriate control box.



THE RF97 CONTROL BOX

This is a fully enclosed metal box assembly, designed expressly for use in exposed working conditions. It is thus well suited for marine and tractor work.

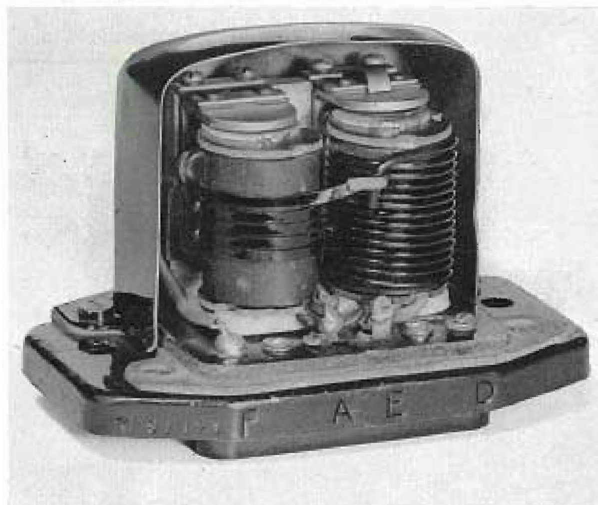
The LRT9 regulator-cut-out assembly used is fitted with a " Pellet " type resistance mounted on the back of the regulator frame and inside the box. Connections to the box are made by means of " Plug-in " terminals, thus keeping the unit watertight and dustproof.

The regulator series winding is of interest. You will notice that it is not a split winding. In other words, the box is not designed to provide compensation for a lighting and accessory load, but for use where the generator output is mostly required for charging the battery only.

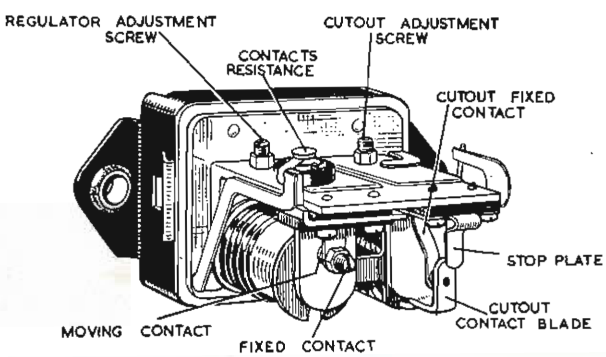
The unit is sealed by means of a Langite Gasket visible in the picture and the cover is rivetted down.

In the event of it being necessary to open the box the rivets should be drilled out and the cover re-assembled and properly re-tightened by means of 2BA or similar screws and nuts.

The change from a cartridge to a pellet type resistance was introduced to enable the resistance to be included within the sealed cover and thus prevent corrosion and damage from exposure.



The unit is produced in both 12 volt and 6 volt and mostly applied to tractors.



THE RB107 CONTROL BOX

This recent design of control box is a replacement for the RF97. It has been designed primarily to give greater ease of adjustment and maintenance and is now in production for fitting to tractors and motor cycles. It is specially applicable to marine work. It's electrical operation is the same as other compensated voltage control regulators.

You can see that the main constructional changes concern the cut-out and regulator contacts. Both have been redesigned and positioned above the bobbins.

THE RB106/1 CONTROL BOX

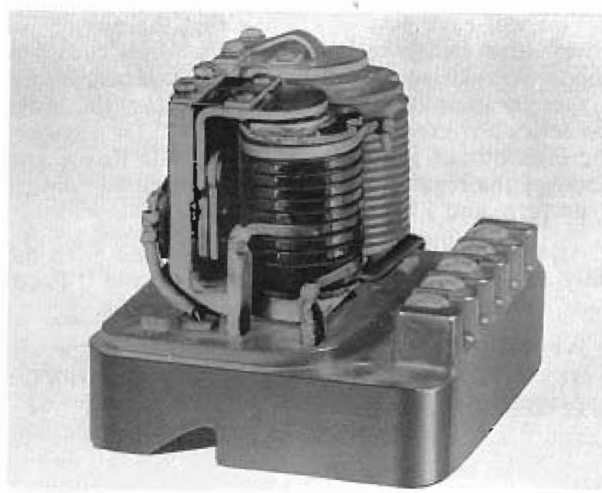
This control box is similar to the RF96, but has been designed for use with the higher output generators C45PV5 and C39PV2. It may have a series compensating winding consisting of only one main turn and one load turn.

Neither the RB106/1 nor the RF96 should be used with the lower output, fully enclosed generators, as the latter, in trying to maintain the regulation voltage with little series compensation, will be working outside their rated output and will thus over-heat.

On the other hand, if the older RF95 both with more series turns is used with the high output generators, their maximum output will never be available.

You will notice that no fuse positions are provided.

This unit is mostly used for 12 volt working but is also available for special 6 volt applications. The most recent development is the fitting of the new type regulator assembly on to the same base. This combination is known as the RB106/2.



THE MCR1 AND MCR2 CONTROL BOXES

These are two motor cycle control boxes. The later model is the one on the right, the MCR2 and it has superseded the earlier MCR1 on the left.

The standard LRT9 regulator unit with Pellet resistance is fitted in the MCR2.

Do not forget that the new RB107 box is now also being used on motor cycles and is superseding both the earlier models MCR1 and MCR2.

ADJUSTMENTS IN SERVICE

There is only a limited amount of service work possible for the motor engineer who will usually require to work with the components *in situ*.

The performance of the regulator may be affected by three factors :—

(1) Maladjustment of electrical setting, usually the result of tinkering adjustments.

(2) Oxidisation of the points due to normal usage.

(3) Incorrect air gaps invariably due to interference.

These troubles can usually be corrected quite easily.

The voltage can be set with the aid of a good Moving Coil Voltmeter as we shall detail in the next section of this course and in the following two pictures we shall show how the air gaps can be checked and the regulator points cleaned.

Checking the Charging System

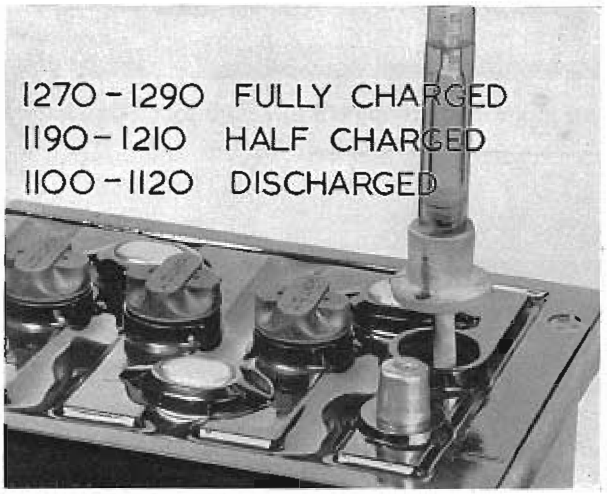
SYSTEMATIC CHECKING

In the section on generators we dealt with the electrical tests necessary for checking the machine itself. We shall now consider the whole of the charging circuit of which this forms part.

It must first be understood, however, that the circuit as a whole will not function correctly unless each of the individual units is in order, not forgetting of course the wiring between them.

In checking for a fault on the charging system, therefore, we must proceed according to a set plan ; it is no good tackling the job haphazardly. We must localise the fault to a particular section, at the same time verifying the rest of the charging circuit on the vehicle.

Let us make a start at the battery.



HYDROMETER TEST

We must first check the specific gravity of the electrolyte in each cell.

The Hydrometer readings for Lucas batteries are :—

1270–1290 fully charged.
1200–1210 half charged.
1100–1120 discharged.

The battery should normally be at least half-charged.

THE HEAVY DISCHARGE TEST

The hydrometer test gives us a fairly accurate account of the state of charge of each cell, but a further test must be made to make sure that the battery will supply heavy currents at the required voltage, the heavy starting currents for instance. For this purpose, we use a " heavy discharge tester " which puts an electrical load on each cell. The load, or resistance, takes at least 150 amperes from the cell in the case of a car battery, thus reproducing conditions similar to those existing when the starter motor is operated. If the hydrometer test showed the cell to be charged and if, under these test conditions, the voltage remains constant at approximately 1·5 to 1·6 volts, we can be sure the cell is serviceable. A rapidly falling voltage reading indicates a weak cell. The drop tester should be held in position for about 15 seconds per cell.

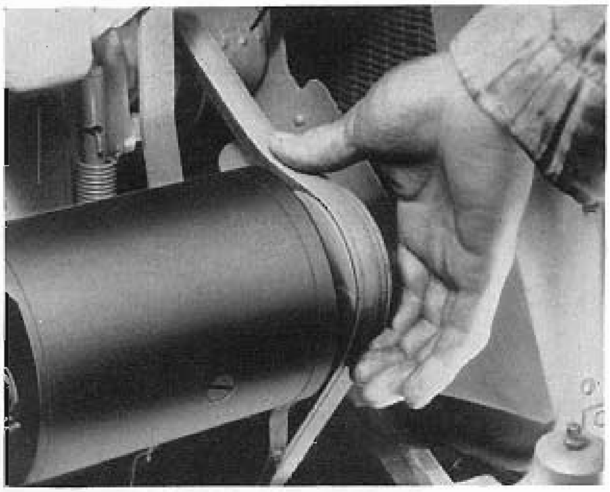
We use the same type of tester for motor cycle batteries, but a smaller load, this time of 12 amps. is adequate. A load of 300 amps. must be used for heavy commercial applications.

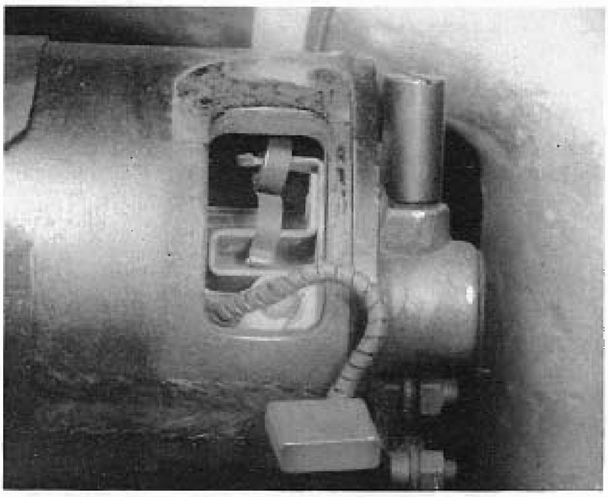
Having made certain that the battery is serviceable, let us now test the source of our charging current, the generator.

CHECKING THE DRIVING BELT AND GENERATOR BEARINGS

The next operation should always be to check the driving belt. After all the generator can hardly be expected to give of its best if it is not being driven correctly. There should be about half 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 slipping 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. 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 tight at the terminals.





VISUAL CHECK OF BRUSHES AND COMMUTATOR

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

At the same time the commutator can be inspected for glazing, roughness or overheating — the latter sometimes results in solder being thrown from the risers. The commutator surface should appear smooth but not glazed.

TESTING THE ARMATURE AND BRUSH CIRCUIT

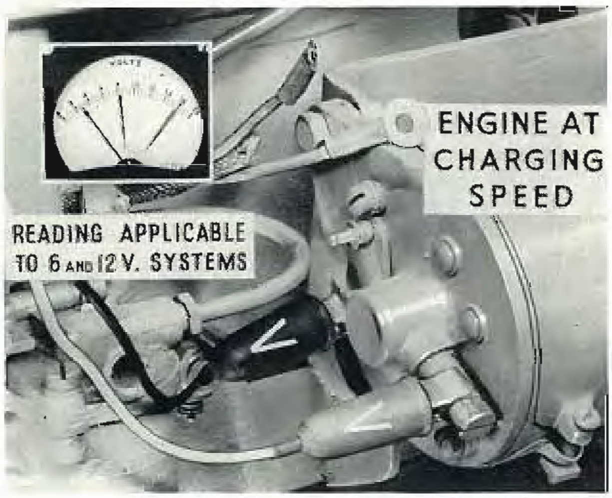
Our first electrical test will be to see that the armature is operative and the brushes properly contacting the commutator.

The generator leads must be disconnected as you can see and a voltmeter connected between the D terminal and earth.

The engine should then be run up to charging speed approximately 1500 r.p.m. when a reading of between 2 and 3 volts should register on the voltmeter.

This reading is applicable to both 12 and 6 volt units.

The earth lead can be attached at any convenient point preferably the one shown.

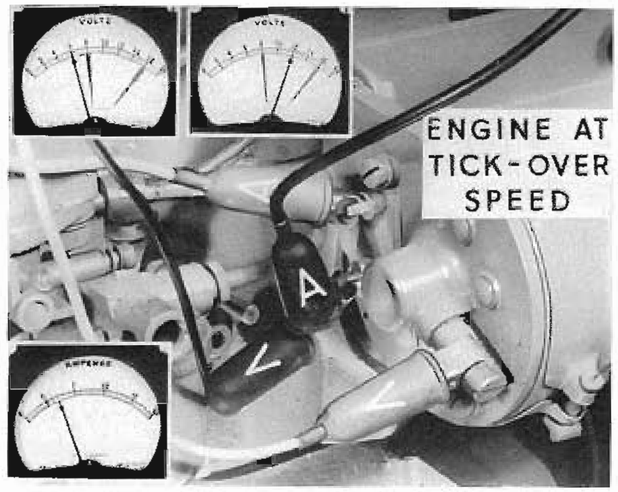


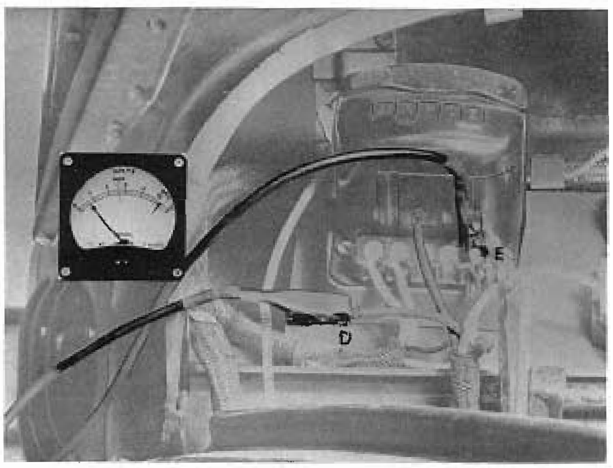
TESTING THE FIELD CIRCUIT

The next step is to ascertain that both the field coils and leads are operative and not in any way earthed, shorted or open-circuited.

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 6 or 12 volts, i.e., the normal battery voltage of the vehicle system. At this point the ammeter should not read more than 2 amps. Our picture shows two voltmeters at the top — the one on the left reading 6 for the 6 volt system and that on the right 12 for the 12 volt system.

The ammeter reading should be the same for either system. 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.





CHECKING THE GENERATOR CABLES

If the generator is in order the next step is to check the generator cables electrically, unless a complete visual examination is possible.

Repeat the last two tests to prove both the D and F cables as far as the Control Box.

First re-connect the cables at the generator and disconnect them at the control box terminals.

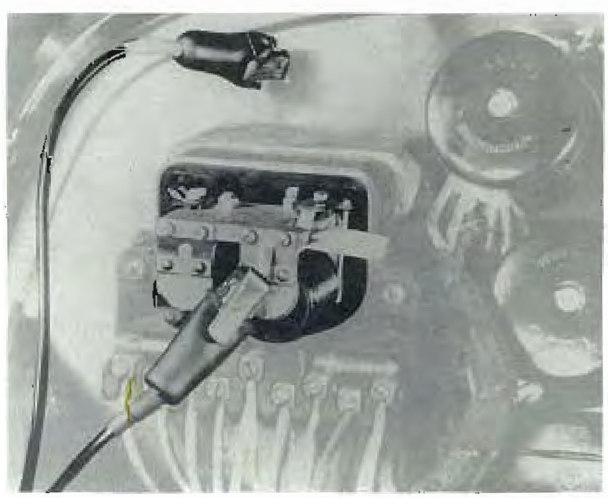
Our picture shows the first test, namely the voltmeter between D and earth. If there is any doubt as to which is the D and F cables, obviously this test will prove the point. Only one of the two leads should give a voltage reading — the D lead. It will record the armature voltage previously obtained, if the lead is intact.

We will take this opportunity of stressing, that if the D and F leads have been accidentally crossed, the regulator contacts will show very obvious signs of having passed excessive current. The points will be badly burnt and in some cases welded together. So be careful when re-connecting the leads.

CHECKING THE CONTROL BOX

We have now arrived at the control box, and our first check is to see if regulation is taking place.

The regulating point you will remember is the voltage at which the generator is controlled. The check must be made with the battery open-circuited. We therefore insert a piece of paper or card between the cut-out contacts. A voltmeter is then connected between earth and the regulator frame which you will remember is actually connected to the generator D terminal. Rev up the engine of the vehicle to about 1,500 r.p.m. The voltage reading will increase with rising speed, until the setting point of the regulator is reached, when there should be no further increase in voltage regardless of any normal increase in engine speed.



THE OPEN-CIRCUIT REGULATOR SETTING

The settings should be :—

6 volt set 7·6–8·0 volts.

12 volt set 15·6–16·2 volts.

at normal workshop temperature 68°F.

Correction must be made if prevailing temperatures are far removed from 60°–70° as shown in the accompanying table :—

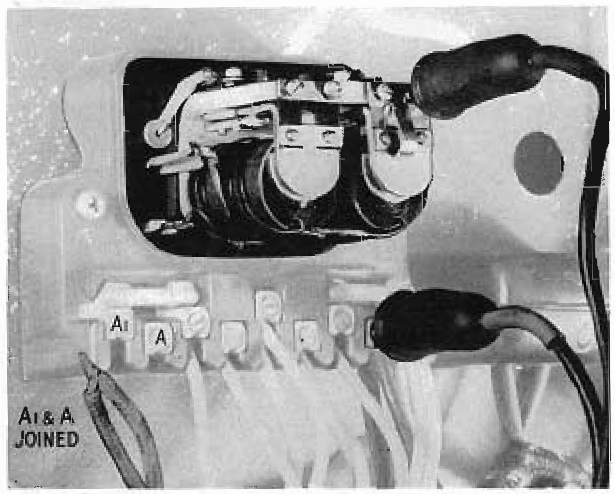
	Temperature	Setting
12 volt set ..	50°F.–10°C.	15·9–16·5 volts
12 " " ..	86°F.–30°C.	15·3–15·9 "
12 " " ..	104°F.–40°C.	15·0–15·6 "
6 " " ..	50°F.–10°C.	7·7–8·1 "
6 " " ..	86°F.–30°C.	7·5–7·9 "
6 " " ..	104°F.–40°C.	7·4–7·8 "

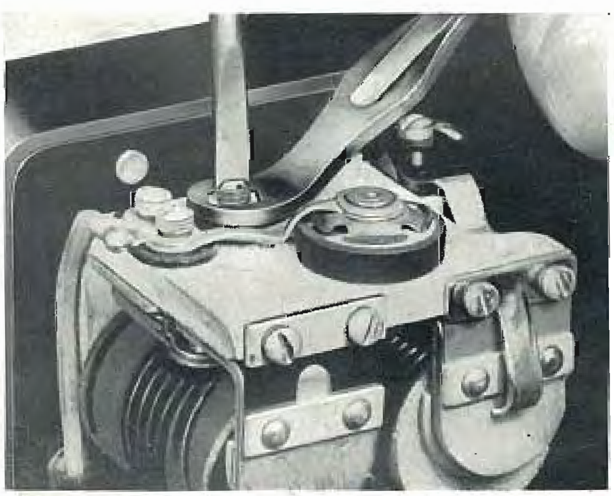
The foregoing method of open circuiting the regulator will provide an approximate idea of the setting, but in order to get a true reading the following procedure should be adopted.

TO OPEN CIRCUIT THE CONTROL UNIT — REMOVE "A" AND "A1" LEADS

The A and A1 leads should first be removed from the terminals at the control box. This does two things : it disconnects the battery from the generator and puts the regulator load winding out of circuit. In other words, as we are only making a voltage adjustment, all we want in circuit is the voltage Regulator Shunt (Voltage-Coil). The series turns would affect the voltage setting and must be out of circuit if an accurate reading of the voltage setting is to be obtained.

The A and A1 leads will have to be twisted together after detaching from the control box terminals in order to provide a feed from the battery to the ignition coil to enable the engine to be run.





ADJUSTING THE REGULATOR SETTINGS

And now that we have put the regulator on open-circuit, its adjustment is very simple.

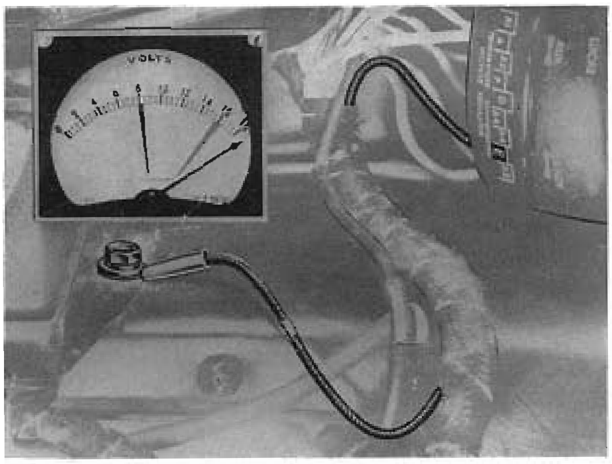
Run the engine at charging speed with the voltmeter already connected between regulator frame (Gen. D) and earth. Unlock the regulator adjusting screw (left) and turn inwards to increase the voltage, or outwards to lower it. On completion re-lock the adjusting screw. Reconnect A and A1 leads. Remove card from cut-out points.

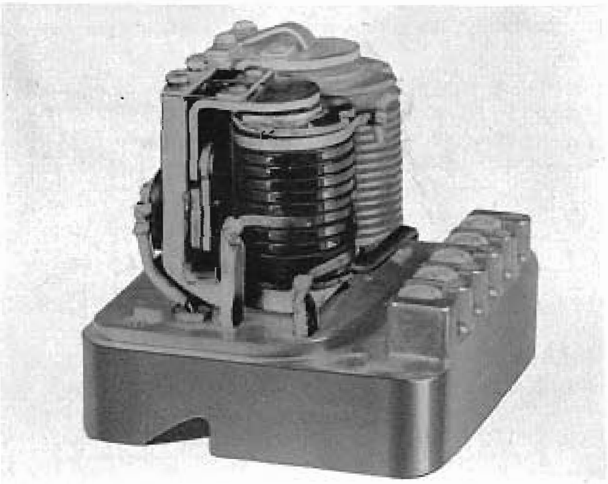
Do not allow the voltage to exceed the maximum of the tolerance given in the table of settings and temperatures.

POSSIBLE FAULTS — HIGH VOLTAGE READING

If turning the adjustment screw has no effect whatsoever on the O/C voltage and the reading is right off the scale, the most likely fault is a bad control box earth — this is the fault we show in the picture.

There are two other less likely possibilities : an open-circuit regulator shunt winding or a short between the D and F terminals. In all three cases there can be no regulation of the generator voltage. Regulation, you remember, depends on the shunt winding — and one end of this is connected to the control box earth terminal. Also, if the field and dynamo terminals are shorted at any point, neither the regulator points nor the resistance can ever be in circuit to limit the generator output voltage.





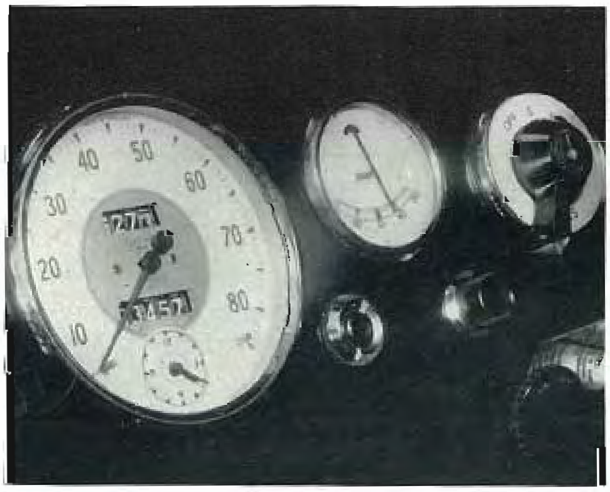
POSSIBLE FAULTS — LOW VOLTAGE READING

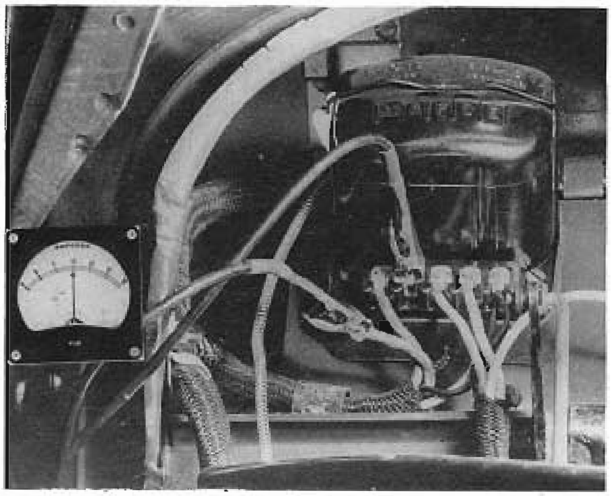
If on the other hand the regulator setting is found to be low and cannot be adjusted, take a look at the regulator contacts. In all probability they will be burnt and oxidised, thus making a good contact impossible and preventing the generator building-up it's normal voltage.

If the burning is obviously excessive check the resistance or examine for crossed D and F leads either at the control box or generator.

WARNING LIGHT AND AMMETER

Finally check the operation of the warning light, the ammeter and the cut-out. And do not forget the wiring behind the panel, make sure there are no loose connections or frayed leads. These can easily cause intermittent or complete failure of the charging system. The warning light for instance is connected directly to the control box D terminal and an earth on this cable would short circuit the generator output.





TO CHECK THE CHARGING CURRENT

If an ammeter is not fitted to the particular vehicle, the charging rate can easily be checked by connecting a test ammeter in series with the A lead. The most convenient point is at the control box.

To check the battery charging rate see that all switches are off, the charge should be approximately as shown in the guide.

Specific Gravity	*Amperes*
1270	5A or Lower
1250 or Lower	8A to 12 amps
1200 or Lower	15 to 17 amps

As a final check, switch on the full normal lighting load, i.e. Heads, Sides and Tail. With generator running at full charging speed the ammeter should lie between zero and approximately four amperes on the CHARGE side.

THE CHARGING CIRCUIT — COMPLETE

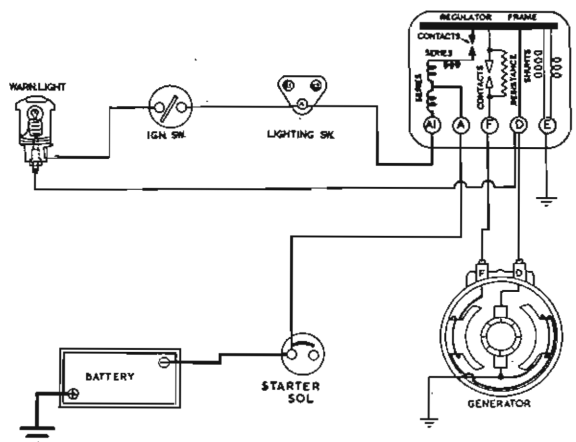
And just to remind you what we have been checking, here is a specimen charging circuit.

Our first checks, you will remember, were made at the battery : the hydrometer and high rate discharge tests.

We then checked the generator and the D and F cables from it to the control box. We made two tests : the first with a voltmeter between D and earth which checked the armature and brush circuit, and then we added an ammeter between the D and F terminals — to check the field current.

Then, at the control box, we checked the regulator open circuit settings. We showed you how to adjust this setting, with the A1 and A leads disconnected and joined together. We also made sure that the control box earth was good.

We then checked the operation of the cut-out and finally the warning light and ammeter. In this particular circuit, you can see there is no meter fitted. You remember too how we stressed the importance of good wiring and connections throughout the circuit.



CHARGING CIRCUIT

CHECKING THE CHARGING SYSTEM

BATTERY	GENERATOR	CONTROL BOX
(1) HYDROMETER TEST	(3) DRIVING BELT	(9) O/C SETTING
(2) HEAVY DISCHARGE TEST	(4) BEARINGS	(10) WARNING LIGHT & AMMETER
	(5) BRUSHES & COMMUTATOR	(11) CABLES & CONNECTIONS
	(6) ARMATURE CIRCUIT	(12) CUT-OUT OPERATION
	(7) FIELD CIRCUIT	
	(8) CABLES	

THE TEST ROUTINE

And finally, to summarise the whole business, here is a list of the operations which should be carried out in the order shown.

Current-Voltage Regulators

CURRENT-VOLTAGE CONTROL

The increasing number of electrical appliances now being fitted to the modern vehicle, many of which consume relatively heavy currents, has made necessary the introduction of a system of regulation more positive in its action than the compensated voltage system.

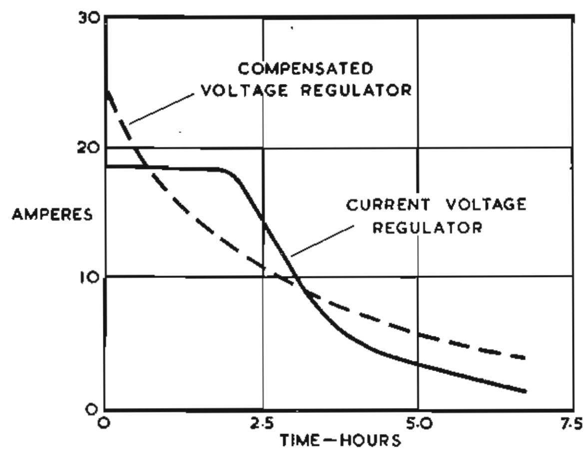
Current–voltage control of the generator *is* more positive because not only is the generator output controlled at a safe maximum, but this maximum output is used to full advantage, being available if necessary for a longer period at the beginning of the charge.

CHARGING CHARACTERISTICS

This graph will best illustrate what we mean. We assume our battery to be discharged. As shown by the broken line curve, with the Compensated Voltage Control System, charging commences at a relatively high rate, but quickly begins to taper off, after which, the charge steadily falls away as the battery voltage rises and finally becomes reduced to a "trickle charge."

With the Current-voltage Control System, however, the battery is charged at a uniform high rate, thanks to the *current regulator*, until the voltage of the circuit reaches a pre-determined figure, when the *voltage regulator* commences to operate and the charging current tapers off until finally only a trickle charge is delivered.

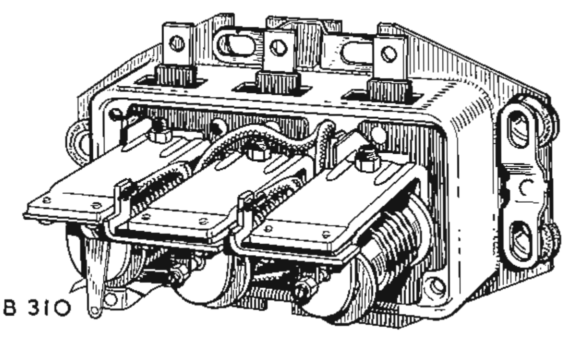
Having given you the essential differences between the two systems, let us look at one of our latest current voltage control boxes, the RB310, so that we are not attempting to explain the operation of something you may not have seen.



GRAPH COMPARING CHARGING CHARACTERISTICS — COMMENCING WITH DISCHARGED BATTERY

THE RB310 CONTROL UNIT

The complete unit consists of a normal cut-out (on the left), but has two regulators : the current regulator in the centre, and the voltage regulator on the right. It is the series-wound current regulator which controls the sustained initial charging rate and the shunt-wound voltage regulator which takes command of the system when the current flowing in the charging circuit has diminished in value.



RB 310

HOW THE CONTROL UNIT FUNCTIONS

This Control Box comprises three components :—

(a) A Cut-out Switch to connect and disconnect the generator and battery automatically.

(b) A Current Regulator which allows the generator to give its maximum continuous output for about one third of the time necessary to recharge a flat battery.

(c) A Voltage Regulator which takes over control of the output for the last two-thirds of the battery charge and thus provides a charge tapering to a finish.

Each of the items which we have mentioned has its own separate circuit in the control unit :

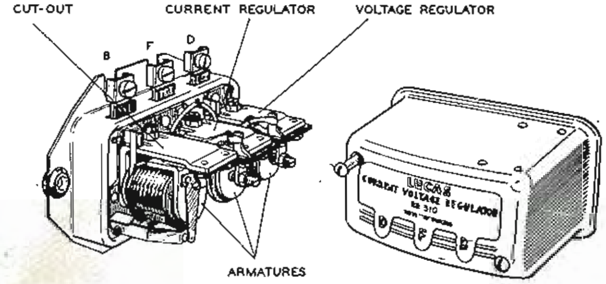
(1) The Regulator and Cut-out operating coil circuits.

(2) The main generator cut-out circuit.

(3) The Field Regulator Circuit.

We shall now study each component of the control individually after which it will be simple to follow out the overall method of operation and understand how the components combine.

First let us examine the mechanical build-up of the unit.



THE CONSTRUCTION OF THE CONTROL UNITS

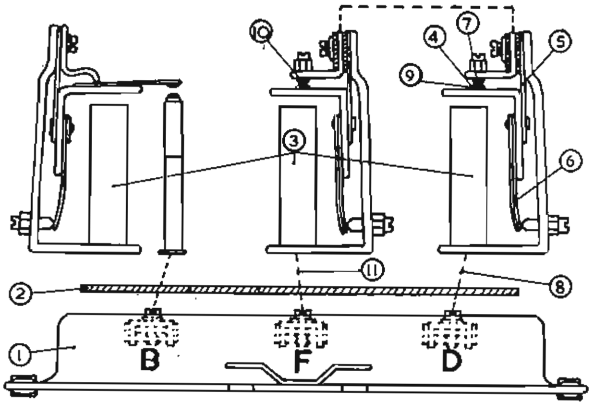
The unit is built up from a metal base (1) upon which is fixed an insulating pad (2), mounting three iron angled frames each with an iron core (3) on which will be fixed a coil winding.

Let us first consider the Voltage and Current Regulator Units (on right and centre) which are basically similar.

A pivot angle bracket (4) — the Armature — on which is fastened one contact point is mounted by means of a spring blade (5) in metallic contact with the main frame. The horizontal member of the armature lies immediately over the bobbin core. On its vertical member a spring blade (6) is fixed downwards and coincides with an adjusting screw in the back of the frame. This armature is the moving member of the contact set. The fixed contact point is screw mounted on another and smaller bracket (7) and is also fixed to, but insulated from, the top of the main frame. By means of the setting and adjusting screws the pressure between the pair of contact points may be varied to provide the requisite voltage and current settings of the regulators.

The main D (Armature) terminal of the generator connects to the frame of the Voltage Regulator (8) and thus to the moving contact point (9). The fixed point (7) is interconnected with the fixed point of the Current Regulator (10) and the current regulator frame connects directly to the F (Field) terminal of the generator.

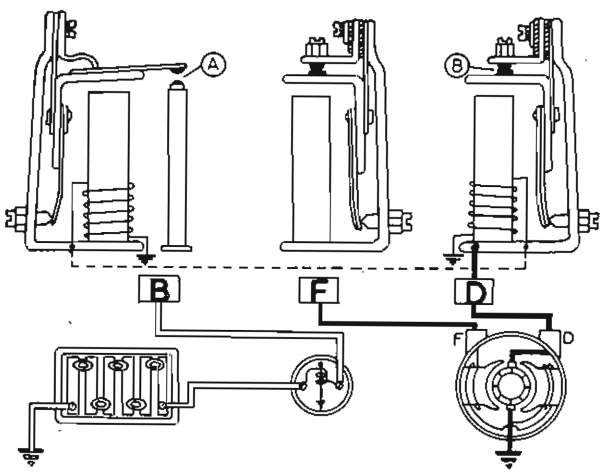
When at rest the two pairs of contacts will be closed thus completing the circuit between the generator



armature line and the " Field." In this condition the generator will charge, but immediately either of the contact pairs is opened by the magnetic pull from the Coil bobbins, the field circuit will be opened and the generator will cease to charge.

When in operation this becomes an alternate rapid opening and closing of the contacts at a frequency in the order of 60 to 100 times per second, enabling a very fine regulation of the generator Field to be obtained.

The contact point assembly of the automatic cut-out switch — left — is of general similar construction but a single opening and closing operation connects and disconnects the generator from the battery. In the " At Rest " position the cut-out points are open whereas both pairs of Regulator points are closed.



THE REGULATOR AND CUT-OUT OPERATING WINDINGS

The electro-magnetic relays which operate the cut-out switch contacts (A) and the voltage regulator contacts (B) are energised or " excited " by coils of fine enamelled wire mounted on the respective bobbins and permanently connected across the generator main circuit, i.e. " in shunt."

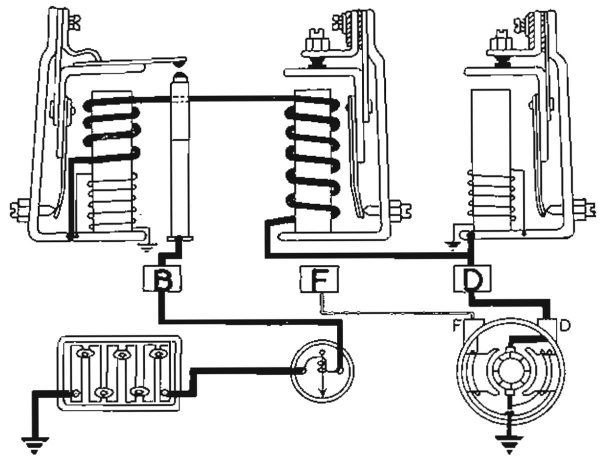
When the generator " builds " a sufficiently high voltage the current flowing in these windings induces a magnetic field in the cores of sufficient strength to pull down the armature and close the contact points, in the case of the cut-out, and separate them in the case of the voltage regulator.

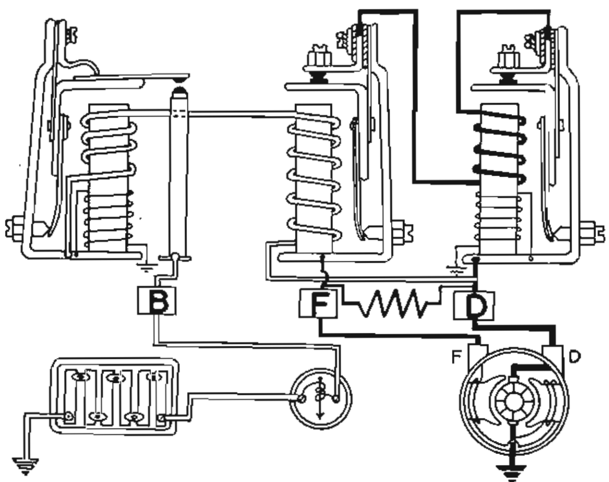
THE GENERATOR AND CUT-OUT CIRCUIT

The current path from the generator D terminal (or armature) is taken direct to the frame of the voltage regulator unit. From there a heavy gauge copper wire is taken to the current regulator and a specified number of turns of the conductor wound around the current regulator bobbin. The conductor is then taken to the cut-out bobbin where several turns are made before it connects to the moving cut-out point. From the fixed cut-out point the conductor terminates at the terminal (B) thus completing the current path from generator to battery.

The turns of this series winding on the cut-out bobbin are wound in the same direction as the previously mentioned Shunt winding and so increase the pull, thus holding the contacts together tightly. The Shunt coil closes the cut-out points at 12·7 volts on the 12 volt system and current in the series winding holds them down.

When the generator ceases to charge and the voltage falls, these points should re-open at between 9 and 10 volts. A reverse current will commence to flow back from the battery into the generator windings. This reverse current de-magnetises the core and immediately throws the armature off, thus opening the contact points.





THE GENERATOR FIELD REGULATION CIRCUIT

To make the generator " build " it is necessary to connect the Field coils to the generator main circuit, i.e. connect terminal F to D.

As shown in this picture the F terminal at the generator is connected to the frame of the current regulator. From the frame we pass to the moving contact point, from the fixed contact point through a number of turns of wire on the upper part of the voltage regulator and then to the fixed contact point of the voltage regulator. We continue from the moving contact on the voltage regulator to its frame which is the generator main connection (D). Thus the field circuit is connected through two pairs of contact points " in series " and if either is opened the field circuit will be broken or " opened." When this occurs a heavy destructive flash would take place at the contact points and quickly damage them. To prevent this, a resistance is connected between D and F as shown. This provides an alternative path for the field current, but in passing through this resistance however, it is considerably weakened.

The turns of wire shown at the top of the voltage regulator bobbin — right — form what is termed a "Bucking Coil" and simply serves to steady the action between the two sets of field points.

It can now be seen that the action of the voltage regulator is controlled by the shunt coil and the bucking winding together.

The current regulator is entirely controlled by the heavy turns of wire which carry the total current from the generator.

Finally it should be observed that in the normal rest position both pairs of regulator contacts are closed; that is, the field is fully connected.

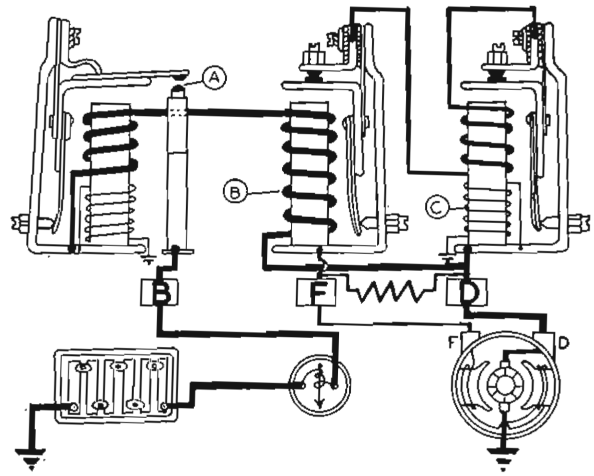
GENERAL METHOD OF OPERATION

Assuming a flat battery in circuit.

Immediately the generator is run up it builds a voltage. When this rises to 12·7 in the case of the 12 volt unit the shunt coil of the cut-out is sufficiently energised to close the cut-out points (A) against the pressure of the adjusting spring.

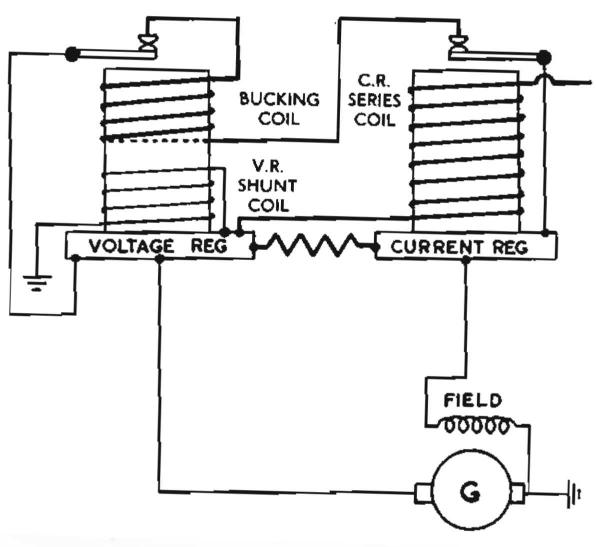
Current will then flow to the battery and increase directly with generator speed. By the time the generator output reaches the permissible maximum, the current regulator coil (B) is sufficiently energised to pull down the current regulator armature against its spring setting and so open the contact points, breaking the field circuit. The generator voltage then drops, the exciting current in the coil weakens and the regulator points close again allowing the voltage to rebuild. This opening and closing cycle continues at between 60 and 100 operations per second, thus limiting the total generator output to a safe maximum.

By the time the battery is something over one third fully charged its terminal voltage will have risen, resulting in a general rise in the line voltage, i.e. between generator and battery. When the line voltage reaches the correct value the voltage regulator coil (C) is sufficiently energised to pull down its armature against the spring setting. This set of field contacts will open and then be put into a state of vibration which will reduce and limit the generator voltage. As the battery, and consequently the line voltage, continues to rise, the field point vibration will increase in amplitude and keep the generator voltage at a safe maximum.



In this condition the difference between generator and battery voltage continues to become less and the current from the generator is finally reduced to trickle charge proportions.

From the moment that the voltage regulator points come into operation, the current from the generator is so reduced that the current regulator will no longer operate, and its contact points will remain closed.



THE BUCKING COIL

The bucking coil, as you can see, is wound in series with the two sets of contacts in the field circuit. It thus passes field current. The winding consists of a few turns of thick copper wire, so wound as to assist the shunt coil of the voltage regulator. In increasing the ampere-turns of the bobbin, it therefore influences the operation of the voltage regulator contacts, quickening the break and increasing the frequency of vibration. This serves to stabilise the operation as a whole, smoothing out and steadying the generator output.

CONNECTING POINTS AND ADJUSTMENTS

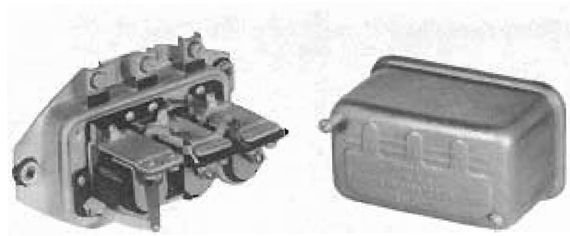
Let us now examine some of the constructional details of the RB310 current-voltage regulator. The points we shall mention also apply to the RB320 which is identical in operation and very similar in construction.

The first point to note is that there are only three terminals : D, F and B, reading from left to right in the picture. The earthing of the box is done through the fixing screws to the metal base of the assembly. The fixing holes are provided with rubber cushioning.

The cut-out is temperature-compensated by means of a bi-metal strip attached to the back of the armature tensioning spring.

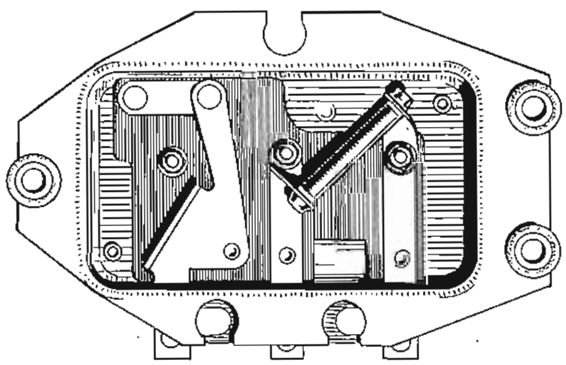
The voltage regulator is also temperature-compensated by means of a bi-metal strip.

The current regulator has no temperature-compensation.



Adjustment screws for the armature tensioning springs, that is, for adjusting the electrical settings, are located in the usual position at the back of the frames.

The mechanical settings for the two regulators are controlled by adjustment screws over the tops of the bobbins.



THE CONTACTS RESISTANCE

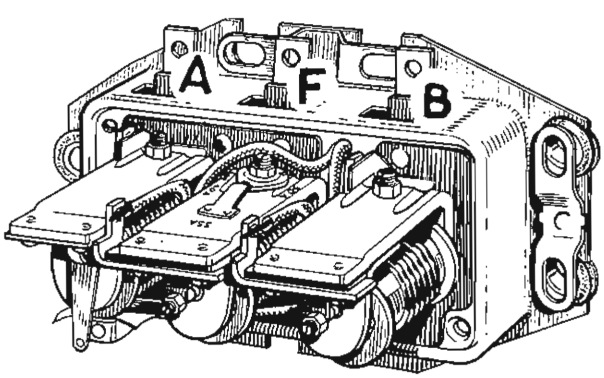
The points resistance is located under the base. It must of course be insulated from it, the latter being at earth potential.

On the 12 volt system the resistance used is a 63 ohm and on the 6 volt 50 ohms, and this rating is stamped on the body of the resistance itself.

THE RB300 CONTROL UNIT

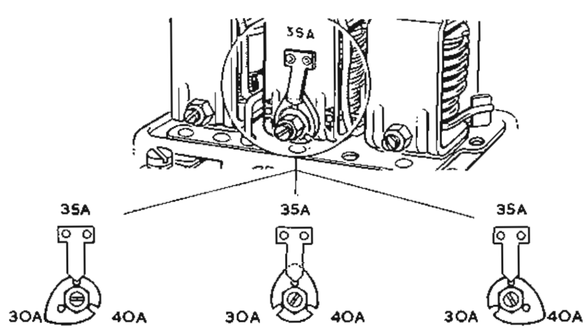
The RB300 is a current-voltage regulator, designed especially to control 6 volt automobile generators rated at 30, 35 and 40 amperes. It is directly interchangeable with Auto-Lite or Delco-Remy units of equivalent ratings, but due to different field connections is NOT a replacement for FORD units.

It is a "multi-set" regulator, having three settings for 30, 35 or 40 amperes respectively. You can see the adjustment on the back of the current regulator.



THE CURRENT ADJUSTOR

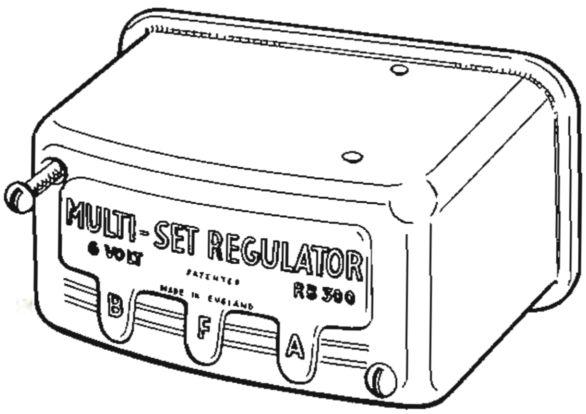
This shows you a close-up of the adjustor.



NOMINAL SETTINGS OF CURRENT REGULATOR

TERMINAL CONNECTIONS OF THE RB300

Please note the different terminal markings : "B" — battery, "F" — field, "A" — armature (i.e. normally the "D" terminal).



CHARGING TROUBLES

Unsatisfactory performance of the charging system will generally fall within the following categories :—

(1) No output.
Causes : Defective generator drive. Defective generator. Defective generator wiring or control box fault.

(2) Low output :
Causes : Defective drive, generator or control unit.

(3) Battery continually discharged.
Causes : Defective battery. Low mileage. Defective generator drive or generator. Incorrect settings at the control unit.

(4) High output to commence, with a quick "Fall Off."
Causes : Sulphated battery plates, or incorrect voltage regulator setting or high resistance connections on the line, particularly battery and other main earth connections.

CHECKING THE CURRENT VOLTAGE CONTROL REGULATORS

To check or adjust these units it is essential that a good quality moving coil voltmeter and ammeter should be available. It is also very necessary to see that these instruments are maintained in an accurate state.

Within our experience an extremely simple test set which may be made up, or purchased, as illustrated has been found the most satisfactory arrangement for use in the service garage.

In this set a $3\frac{1}{2}''$ Scale Moving Coil Ammeter calibrated 5–0–50 amperes and a similar voltmeter calibrated 0-40 volts have the correct size of very flexible leads and clips permanently connected ready for use, the assembly being accommodated in a sheet steel box with detachable cover, thus safeguarding the instruments against accidental damage in service.

Without suitable instruments NO adjustments to these control boxes should be attempted.

In every case before interfering with the Control Unit preliminary checks on the Battery, Battery Connections, Generator and Generator Driving Belt, together with an inspection of the generator and control unit cables should be made. If these are in order proceed to test, firstly the Current Regulator and secondly, the Voltage Regulator as outlined.

CHECK AND ADJUST THE CURRENT REGULATOR

Method 1.

Operation 1.

Place a crocodile clip across the contact plate to the frame of the Voltage Regulator as shown in the illustration to short out the voltage regulator contacts electrically.

Operation 2.

Disconnect the A (Battery) terminal at the Control Box and connect in the ammeter.

Operation 3.

Run the generator at full charging speed approximately 2,000 r.p.m.

Operation 4.

Check the current reading which should be as laid down in the table for the appropriate generator on the vehicle.

Operation 5.

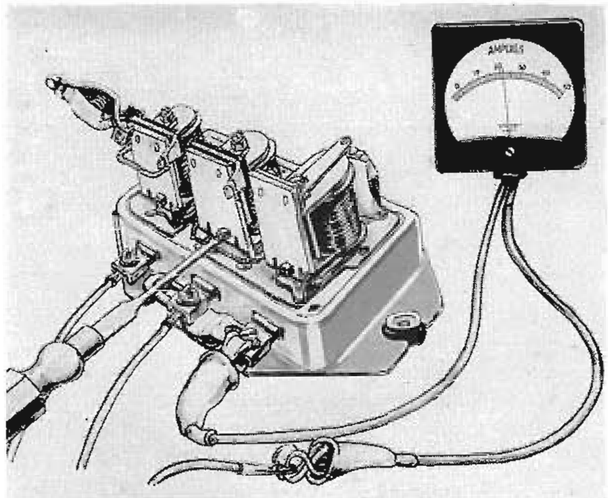
If ammeter reading is either HIGH or LOW try adjustment of the Regulator.

Unlock the adjusting screw in the back plate and screw in to increase output. Unscrew to reduce output. Observe ammeter reading carefully and re-lock the adjusting screw on completion.

If O.K. rev up generator to approximately 4,000 r.p.m. and output should remain about constant.
If O.K. reduce speed to " Tick-over."

Method 2.

If a Rheostat is available capable of carrying 35 amps without overheating, proceed as follows:



Operation 1.

Connect load Rheostat accross battery terminals.

Operation 2 to 5 : As above.

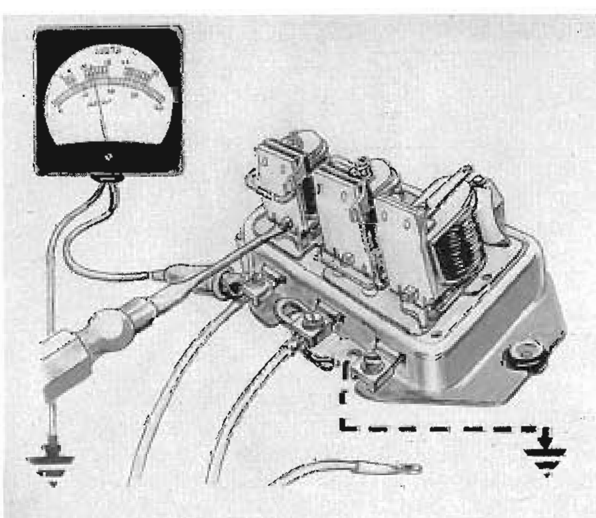
CURRENT REGULATOR ELECTRICAL SETTINGS

The current settings, for the standard generators, are as follows :—

6 volt	..	C45PV–5	..	33 amps.	± 1½ amps.
12 „	..	C45PV–5	..	22 „	± 1 amp.
12 „	..	C39PV–2	..	19 „	± 1 amp.
12 „	..	C47PV	..	30 „	± 1½ amps.

The RB300 current setting is 30, 35 and 40 amperes.

Note : The lights should NOT be switched on during this test with the voltage regulator *shorted out* and the engine running.



TO CHECK AND ADJUST THE VOLTAGE REGULATOR

Operation 1.

Remove the test ammeter and leave the A (Battery) lead disconnected. Also remove clip from under the regulator armature.

Operation 2.

Connect voltmeter between D terminal (Generator armature) and EARTH.

Operation 3.

Raise generator speed slowly to approximately 1,500 r.p.m. Voltage should rise and steady itself with a slight flick. According to temperature this reading should be as outlined in corresponding table for " Current-Voltage " Regulator settings.

Operation 4.

If any adjustment is required do not increase speed above 2,000 r.p.m. Unlock the unadjusting screw on the back plate of the bracket and screw inwards to increase voltage, outwards to lower the voltage. When corrected re-lock the adjusting screw. Reduce speed to " idling."

VOLTAGE REGULATOR ELECTRICAL SETTINGS

The standard Open Circuit Voltage setting with the *generator running at approx.* 1500 *r.p.m.* are as follows :—

Temperate	12 Volt	6 Volt
Cold Climate (50°F.)	14·5—15·1 volts	7·3—7·6 volts
Temperate Climate (68°F.)	14·2—14·8 ,,	7·2—7·5 ,,
Hot Climate (86°F.)	13·9—14·5 ,,	7·1—7·4 ,,
Equatorial Climate (104°F.)	13·6—14·2 ,,	7·0—7·3 ,,

7·0—7·3 volts @ 20°C. for 6 volt regulators for ' HOLDEN '

Setting or adjusting must be done as quickly as possible in order to preclude heating effects which would introduce errors into the setting.

When the *generator speed is raised to* 3000 *r.p.m.* the voltage *must* not rise above.

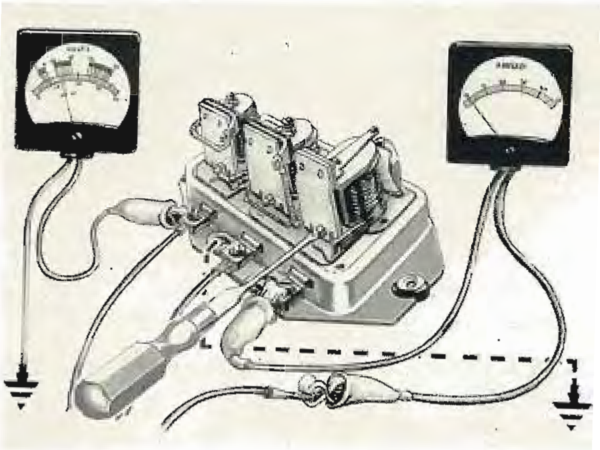
16·0 volts @ 20°C. for 12 volt regulator
8·0 volts @ 20°C. for 6 volt regulator

FINAL CHECK TEST OF THE CHARGING RATE

Leaving voltmeter connected, insert ammeter again (between terminal A (Battery)) and the " A " cable.

Steadily increase engine speed when cut-out should close at 12·7 volts and the charging rate build up with increasing speed.

Switch on full lighting load and the ammeter reading should reach the maximum rated output of the generator.



CUT-OUT SETTING

	Cut-in Voltage	*Drop-off Voltage*
12 volts ..	12·7–13·3 volts	9·5–10·5 volts
6 ,, ...	6·3–6·7 ,,	5·2–5·7 ,,

CONCLUSION

Having obtained a pretty fair idea of the various forms of generator control units and their working it may be desirable to add a note of caution.

The successful servicing of these important components does not rest entirely upon an adjustment here and there. The success of any of the servicing operations outlined depends entirely on having made an adjustment which is stable and permanent in its subsequent working. For this reason only a limited amount of work can be successfully executed in the general garage. If the control unit, for example, will not respond to the adjustments outlined an exchange should be made and the original unit subjected to bench examination in a properly equipped electrical workshop.

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LUCAS

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OVERSEAS TECHNICAL CORRESPONDENCE COURSE

Section 6
VEHICLE WIRING CIRCUITS

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

INTRODUCTION

The electrical circuit of the modern automobile can appear most complex to the uninitiated. Careful study however, of the wiring diagrams produced by the Lucas Organisation and the Vehicle Manufacturers will allow the student to study the various circuits both individually and as a whole. The study of each circuit separately before tackling the complete job, is perhaps the best method for the student to adopt, as with few exceptions the electrical system of a motor vehicle can be considered as a series of simple circuits, as for example the Lighting, Charging and Ignition circuits. Having grasped the fundamentals of these circuits it is then possible to consider as a whole the complete Wiring Harness or Wiring Loom.

Motor vehicle wiring has been, and continues to be, subject to many changes, mainly to facilitate speed and convenience on the vehicle assembly lines. With the introduction of snap connectors and separate junction boxes, cable assemblies can now be made up as subsidiaries to the main loom. This considerably assists the manufacturer, whose vehicle in these days of mass production, is often produced at separate branch works in the form of units, i.e. engine, chassis and body, before final assembly. It will be readily seen therefore, that these harness sub-assemblies play an important part both in the initial layout and later in service where rewiring of a damaged section becomes necessary.

Let us now consider the means of identification of this multiplicity of cables. As we have stated, the electrical system is a series of simple circuits, each consisting of the component, its switch and three wires, feed, switch wire and return. The Lucas colour scheme of identification for British cars is based upon this principle. Feed wires carry braiding of a main colour only, switch wires have a main colour of feed with a coloured tracer woven spirally into the braiding and return or earthing leads are black.

These then are the basic principles which will be enlarged upon in the following pages of this section of the course.

For the administrator and store keeper the sections dealing with cable sizes, their current carrying capacity, protective sleeving, rubber grommets will be found invaluable as a general guide when considering the materials to stock, particularly where the rewiring of vehicles is an essential part of the service offered.

In compiling this section on wiring circuits, as installed on modern British cars, we have reduced the technicalities of the subject to a level that should be easily understood by all students.

CONTENTS

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Wiring Principles

SIMPLE ELECTRICAL CIRCUIT

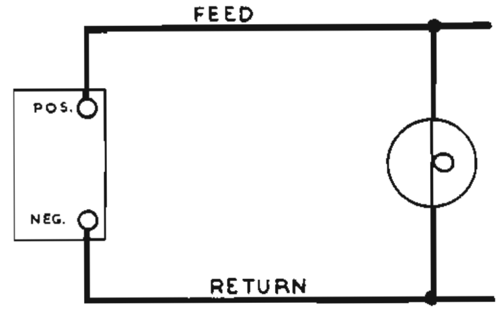
The typical electrical circuit as we know it comprises any component, such as a lamp for example, connected to a supply — which may be a battery — by two wires or cables ; a *feed-wire* and a *return.* Any electrical installation employing this arrangement is known as an *insulated return system*, and for some time the electrical equipment on vehicles followed this principle.

EARTH SYSTEM

An alternative arrangement suitable for many applications, uses an insulated cable as a feed wire to the component, the return being obtained via *earth*, which on a vehicle is of course the steel chassis.

Such an arrangement reduces both the amount of cable necessary and the complexity of the wiring circuits.

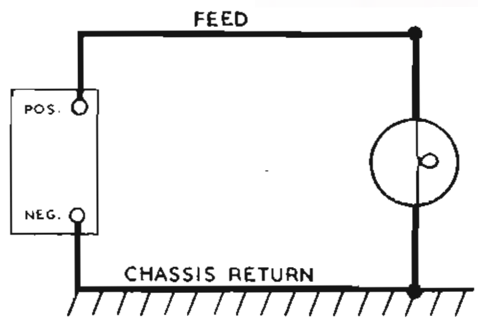
This single pole or earth return system soon became standard practice for vehicle work in general. But for many of the larger vehicles such as passenger-carrying and certain heavy commercials, which include petrol carrying vehicles, the *insulated return system* is still used.



INSULATED RETURN SYSTEM

NEGATIVE EARTH SYSTEM

With the *earth return system* the orthodox arrangement was to *earth the negative pole* of the supply, and this became known as the single pole negative earth system, which was used for vehicle work for several years — on British vehicles up to about 1936.



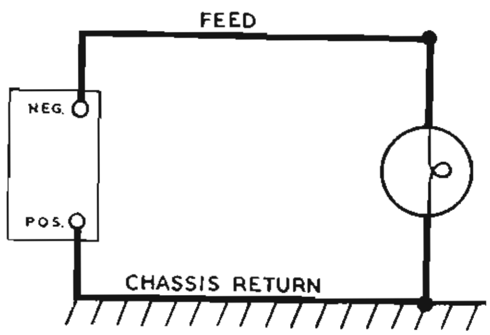
NEGATIVE EARTH SYSTEM

POSITIVE EARTH SYSTEM

It was then found that certain specific advantages were obtained by earthing the positive pole of the battery instead of the negative. Thus we had the introduction of the positive earth system, which is almost universally used to-day, except for those specialised vehicles previously mentioned.

One of the main advantages gained by earthing the positive side of the supply is that the polarity of the spark plug central electrode is made negative, which results in improved spark plug performance and longer service life of the spark plugs and the H.T. cables.

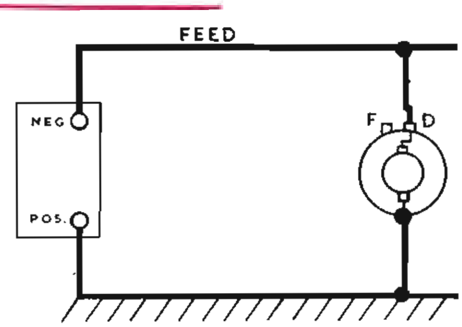
At the battery itself the formation of electrolytic sulphation at the positive lug is reduced, and also the marked tendency to electrical leakage from the cells to earth, the result of the presence of acidulated moisture. The corrosion effects at switch contacts, cable connectors, soldered joints, etc. are also reduced, especially under conditions of excessive humidity.



POSITIVE EARTH SYSTEM

CONNECTING UP AND TERMINAL MARKINGS

A point to be remembered is that this reversal of polarity makes no difference whatsoever to the working of the system or testing for faults, but it has to be borne in mind when fitting the batteries and connecting up cables. Terminals are all properly marked without reference to the polarity, as shown in our picture, i.e. the dynamo and field terminals D and F. (The D terminal being the larger of the two).



POSITIVE EARTH RETURN

METHODS OF WIRING

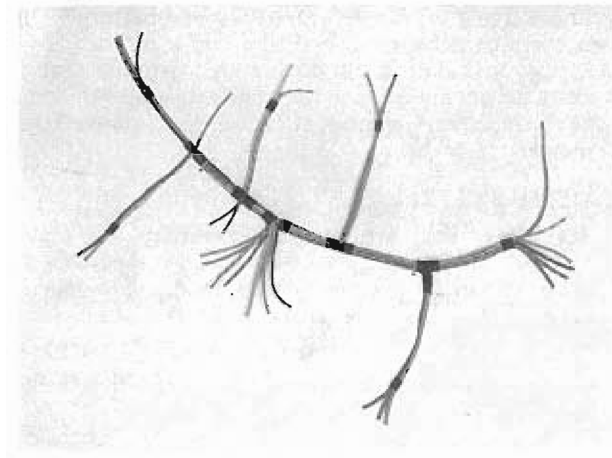
Now we come to the cables and the method of wiring which is generally by means of a harness. We shall confine ourselves to British vehicles, although most others follow the same general pattern. Our picture shows a wiring loom in course of manufacture.

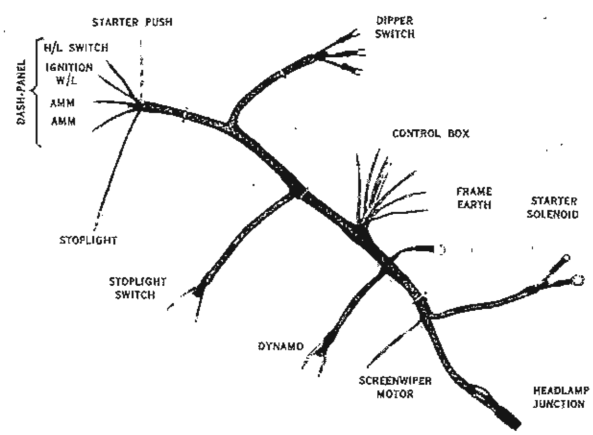
Multi-coloured cables are employed as a means of facilitating assembly both at the electrical manufacturer's works, and also on the vehicle makers' assembly lines.

Next, the cables are grouped together and braided into looms with individual conductors emerging where required, thus forming main, branch and trunk cables.

The development of this arrangement not only facilitates assembly but also provides considerable protection against chafing on metal edges and subsequent wiring faults in service.

Additionally, sub-assemblies such as the complete car body, or say a steering column may be fully assembled and wired before being positioned on the vehicle. To facilitate the fitting-up, various junction boxes and snap connectors are now widely used.





CABLE LOOM

On some vehicles one complete wiring loom may be used ; on others as many as four separate looms — one main and two or three subsidiaries are needed and these are finally connected up to the main loom by means of snap connectors or junction boxes. Altogether there is a vast variety of wiring looms made up for different makes and models.

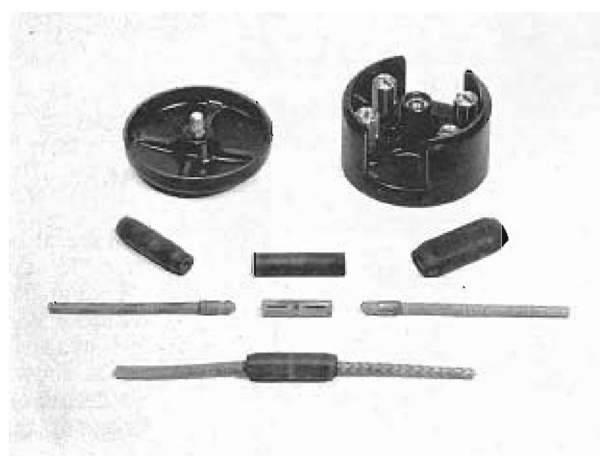
So, unless the vehicle is specially laid out, the stocking and general use of wiring looms is not practicable. For this reason the renewal of damaged wiring is more easily and economically handled in service by putting in single cables and employing either junction boxes or snap connectors to rejoin to the undamaged parts of the existing loom.

JUNCTION BOXES AND CABLE CONNECTIONS

For general purposes, a range of junction boxes and cable connectors is freely available.

The snap or spring connectors shown, greatly facilitate re-wiring and general service work. They are made in numerous combinations.

These spring connectors must be borne in mind when fault finding.



TYPES OF CABLE IN USE

Now before going into circuits and colour schemes, let us examine the types of cables which should be available before embarking on any vehicle wiring repair work.

They fall into three groups :

1. Starter cables, of which there are three sizes.
2. Car wiring cables, of which there are four popular sizes and as many colours as can be conveniently stocked by the average motor trader.
3. Ignition cables which are subdivided into two types :
   (a) High tension cable, i.e. for spark plugs, etc.
   (b) Low tension cable, for primary, or low voltage circuits.

STARTER CABLES

1. The most generally used pattern is a fairly light type of jute covered cable as shown. This comprises 37 strands of No. 20 SWG tinned copper wire.

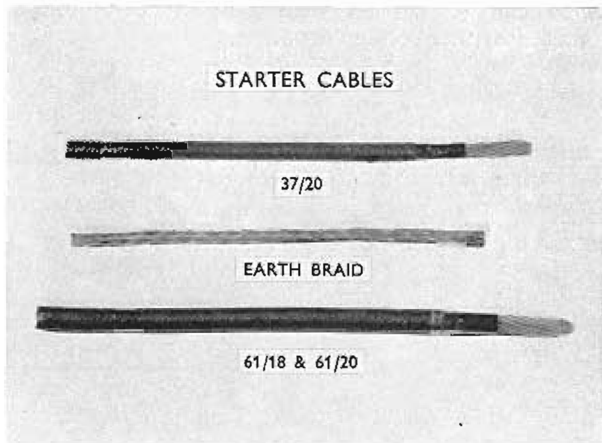
   It is suitable for most light vehicle work where the starter motor current does not exceed 400 amperes.

2. Used in conjunction with this is a similar size *earth braid* which should always be fitted between engine and chassis as a bonding strip when rubber engine mountings are used.

   This standard braid is also suitable for use as the *earth lead* from the *positive* terminal of the battery to the *earth* connection on the scuttle or chassis.

3. The two heavier starter cables are of similar construction to the light one, i.e. jute covered, but have 61 strands of No. 20 or 18 SWG, and are used for starter currents up to 700 amps.

   Where this size cable is used for the starter supply, further lengths should be made up as a bonding strip and also as the battery earthing lead.



CIRCUIT WIRING CABLES

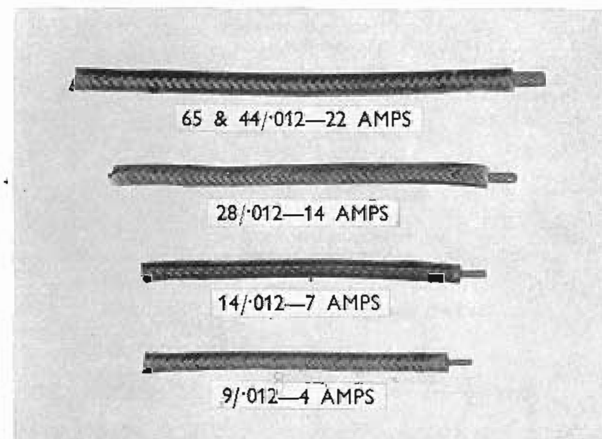
Next we come to the cables necessary for general wiring on the vehicle.

These are all special cables for the work, and comprise a number of copper strands in rubber and fabric sheaths, specially treated to be highly resistant to petrol, water and oil. Such cables are freely available on the market as auto-cable.

There are *five* sizes of cable altogether in general use on the 12 volt system, but for most purposes *three* are commonly used. These are :—

1. The battery feed circuit cable, comprising 44 strands of ·012 copper, generally described as 44/012. This cable has a current carrying capacity of approximately 22 amperes.
2. Main generator or head lamp circuit cables, comprising 28 strands of ·012 copper (28/012) with a current carrying capacity of 14 amperes. For most purposes this is adequate.
3. Side and tail lamp wiring, accessory, ignition and generator field circuits comprising 14 strands of ·012 copper (14/012) with a current carrying capacity of 7 amperes.
4. For panel lamp wiring and other incidentals a cable comprising 9 strands of ·012 copper (9/012) is the most convenient size.

It should be realised that this is only a general guide to the cables used in the different circuits. New vehicles with Lucas wiring are carefully studied to determine the correct cable sizes. Where long lengths of cable are used, a larger gauge wire may be necessary to prevent excessive voltage drop.



For example, a vehicle with an exceptionally long cable run for the battery feed, six feet or more, may be installed with an oversize cable, such as 65/012. If at any time this cable has to be renewed, a similar size replacement should be installed. This last ruling also applies to re-wiring on vehicles equipped with the 6 volt system, particularly if voltage drop trouble is encountered.

EQUIVALENT CABLES — CURRENT CARRYING CAPACITY

It may be useful to examine how the cable sizes which have been given, compare with similar cables identified by other standards of measurement. Some cable manufacturers describe their cables in terms of standard wire gauge and this illustration shows the equivalent sizes which will carry the same amount of current.

For example :—Our 44/012 will compare with 44 strands of 30 SWG wire or 100 strands of No. 36 SWG, all having the same cross sectional area of copper which determines the amount of current which can be carried with a specified minimum voltage loss, i.e. voltage drop.

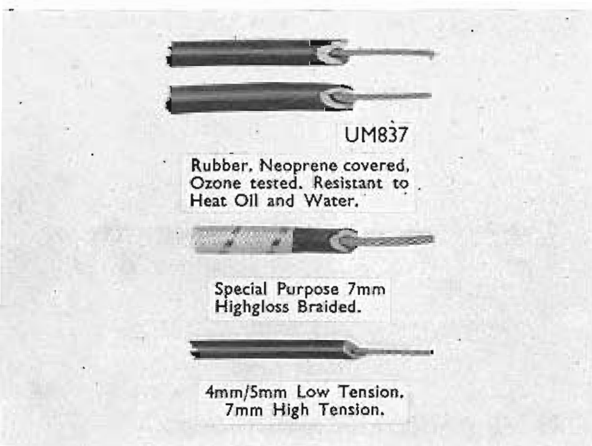
CAR TYPE CABLES

9/·012 (30 SWG) EQUIV. 23/36

14/·012 (30 SWG) EQUIV. 40/36

28/·012 (30 SWG) EQUIV. 70/36

44/·012 (30 SWG) EQUIV. 100/36



IGNITION CABLES

1. The 7 m/m high tension rubber cable is generally used for spark plugs and distributor or magneto leads.

   There are numerous grades of this widely used cable at varying prices, but it is always good policy to buy high quality in order to obtain maximum durability in service. This avoids failures as a result of deterioration and cracking, which may cause elusive and annoying misfiring or, perhaps, complete breakdown.

   The top three cables shown in the illustration are Lucas H.T. cables which all use Neoprene outer casings. This material has proved to be the best possible protection against heat, oil, petrol and water.

2. The 4 and 5 m/m low tension cables, which will carry up to about 7 amperes, are widely used for motor cycle work and are equally suitable for any exposed working conditions, where the cable is *not* subjected to oil or petrol.

We have mentioned altogether ten cables, commencing at the heavy type starter cable carrying up to 700 amperes, and finishing with the 4 and 5 m.m. mainly used on motor cycles. These ten different sized cables, together with earth braid, constitute the minimum range which should be stocked for general motor work.

Individual Wiring Circuits

THE WIRING CIRCUITS

Whilst a car wiring layout as a whole may appear complicated at first sight, the complete arrangement may be broken down into separate circuits as follows :—

1. **Battery and Starter Circuits.**
2. **The Ignition Circuit.**
3. **The Charging Circuit.**
4. **Lighting Circuits.**
5. **Accessories Circuit.**

CIRCUIT IDENTIFICATION — BATTERY, IGNITION AND CHARGING

To distinguish these circuits, a distinctive colour scheme is used.

The value of such a colour scheme on the car assembly line is obvious, and, once it is understood, it is of equal value in service fault finding. So before we discuss all the wiring circuits we must know about the colours employed.

Eight basic colours are used as follows, with an appropriate coloured tracer.

1. Plain, *brown* cable or *brown with coloured tracer* in it, is used as the current supply or feed wire to all services.
2. *White* for the ignition circuit, and all component feeds which are essential when the ignition is switched on.
3. *Yellow* or *yellow with coloured tracer* is used for the generator and field circuit.

CIRCUIT IDENTIFICATION. LIGHTING AND ACCESSORIES

4. *Red* for the side and tail lamp circuits, starting from the lighting switch.
5. *Blue* for the headlamp lighting circuit, also starting from the lighting switch.
6. *Purple* is used for the auxiliary circuits which are fed from the ammeter and protected by a fuse A2.
7. *Green* is used for the auxiliary circuits which are fed through the ignition switch and protected by a fuse, A4.
8. *Black* is used for the earth circuit. That is, if a component is not fixed directly to the chassis, a cable must be taken to a good earthing point on the chassis, and this cable will always be *black*.

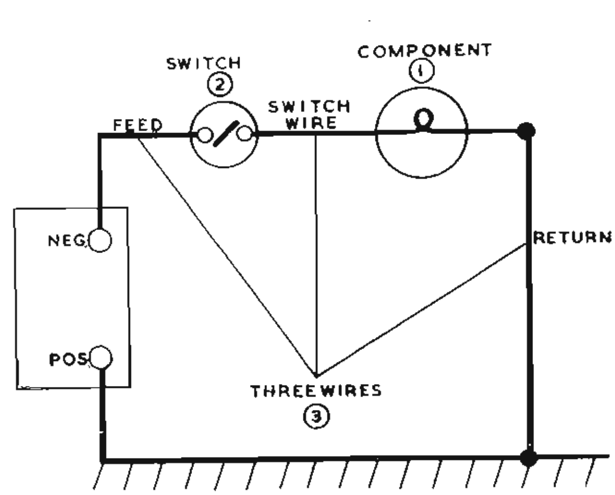
THE TYPICAL WIRING CIRCUIT

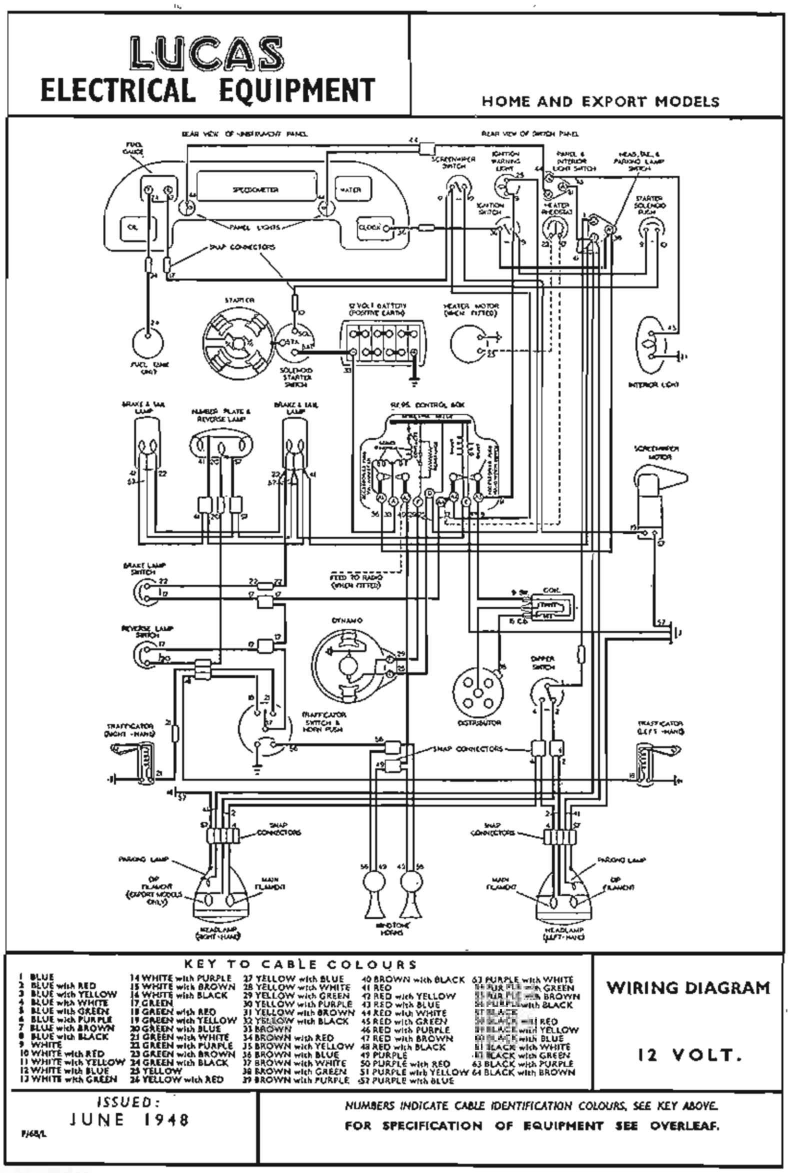
We can now deal with the wiring circuits as applied to modern vehicles.

Generally, the electrical system of a motor vehicle can be considered as a series of simple circuits, each consisting of the component (1), its switch, (2), and three wires, comprising the feed, switch wire and return (3), this return being provided by the frame of the vehicle, although, in the case of components insulated from the chassis, an earthing lead is also necessary.

Some variations are to be found, such as fuses, two-way switching and so on, but the principle of feed wire, switch wire and return remains, and it is upon this that the Lucas wiring colour scheme is based.

Feed wires carry braiding of a main colour only. Switch wires have the main colour of feed with a coloured tracer woven spirally into the braiding. The return or earthing leads are black.





THE STANDARD WIRING DIAGRAM

Here we have a typical wiring diagram of which there is one published for most models and makes of vehicles. These diagrams are of considerable value in service, but a certain amount of difficulty may be experienced by the non-specialist in following them out.

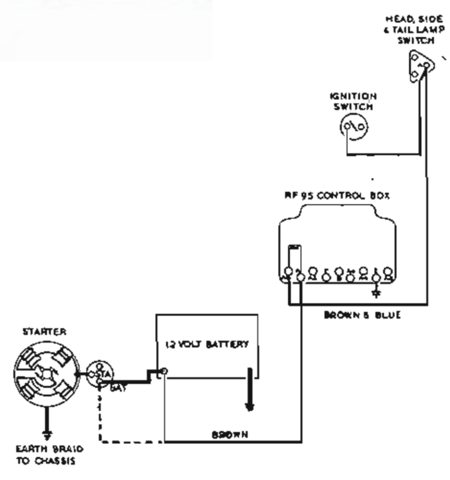
It is however, quite simple if each component circuit is considered individually which we shall proceed to do, commencing with the starter system.

COMMON BATTERY SUPPLY CIRCUIT

The current supply for all circuits on the vehicle commences either direct from the battery negative terminal, or from the battery side of the starter switch.

It comprises a *heavy brown* cable, first running from the battery to the control box 'A' terminal, and through the load windings of the regulator to the terminal 'A1.' From here a *brown and blue* cable leads to the lighting switch where it loops off to one side of the ignition switch (terminal 'A').

If an ammeter is installed, it will be placed in the brown lead between the source of supply and the control box 'A' terminal, the cable becoming *brown and white* between the ammeter and the control box.



THE BATTERY SUPPLY CIRCUIT.

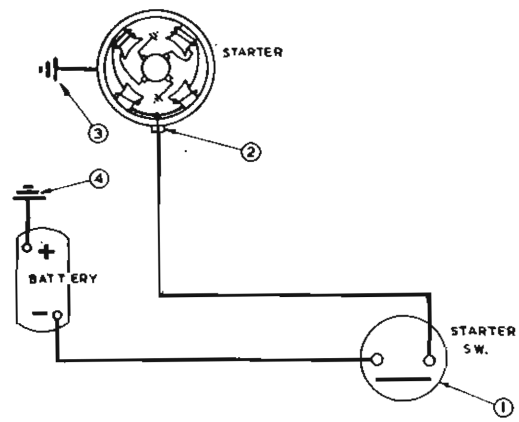
THE STARTER CIRCUIT — WITH MANUAL SWITCH

The first and most elementary circuit is that of the starter motor system. This motor can be either manually or solenoid operated.

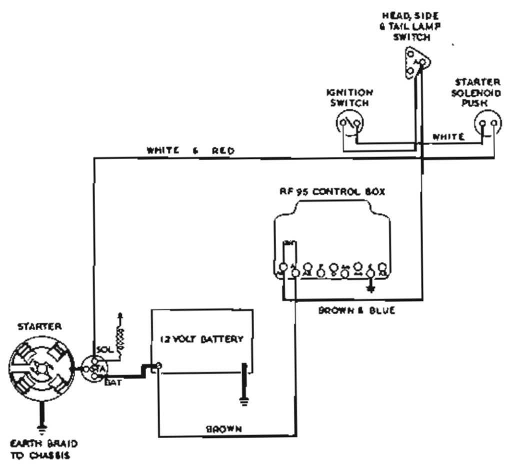
Our picture shows the manually operated starter motor circuit. The current path is from the negative terminal on the battery to the starter switch (1), across the switch contacts to the insulated terminal on the starter motor (2), through the starter to the engine block, then via the bonding strip to the chassis (3), returning to the positive terminal of the battery via the battery earth cable (4).

The earth cables 3 and 4 are most important to the successful operation of the starter, particularly under cold starting conditions and must always be well maintained.

Where a solenoid starter switch is fitted, an additional relay circuit is introduced.



STANDARD STARTER WITH MANUALLY OPERATED SWITCH



STARTER CIRCUIT

THE STARTER CIRCUIT-SOLENOID (RELAY) OPERATED

In this arrangement of the main starter circuit we have to add a solenoid operating circuit, and this is under the control of the ignition switch. That is, the starter solenoid can only be operated with the ignition switched on.

Firstly, there is the common supply from the battery to the ignition switch for all the circuits.

Our solenoid supply is taken from the other side of the ignition switch (A3) to the solenoid operating push by a white cable, and from this push to the solenoid winding by a *white and red* cable. The winding is earthed to the casing of the solenoid itself, thus completing the earth side of the circuit back to the battery earth.

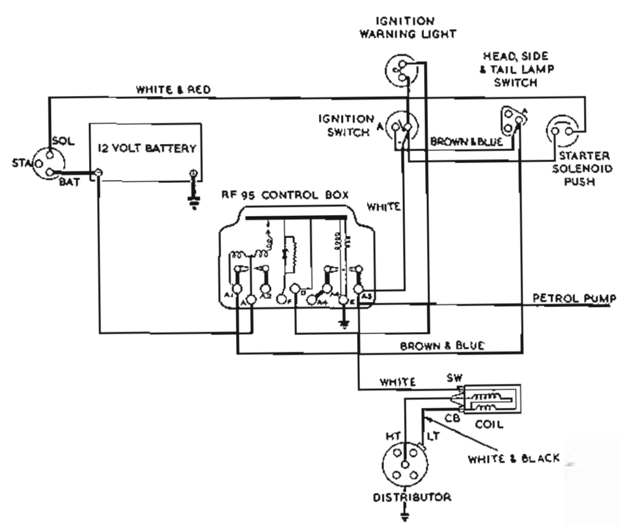
THE IGNITION L.T. CIRCUIT

A white cable, commencing at the A3 terminal of the ignition switch is taken to the A3 terminal at the control box, and provides a common supply for the ignition units (coil and distributor) together with all the ignition accessories — fused and unfused — which are under the control of the ignition switch.

Using the A3 terminal on the control box as a junction point, a *white* (28/012) cable connects directly to the SW terminal of the ignition coil. A *white and black* cable joins the CB terminal of the ignition coil to the L.T. terminal of the distributor.

The unfused accessories such as the petrol pump and automatic choke will also be supplied from the A3 control box terminal using the *white* cable as the feed wire.

The ignition warning light feedwire, also a *white* cable is taken direct from the A3 terminal of the ignition switch.



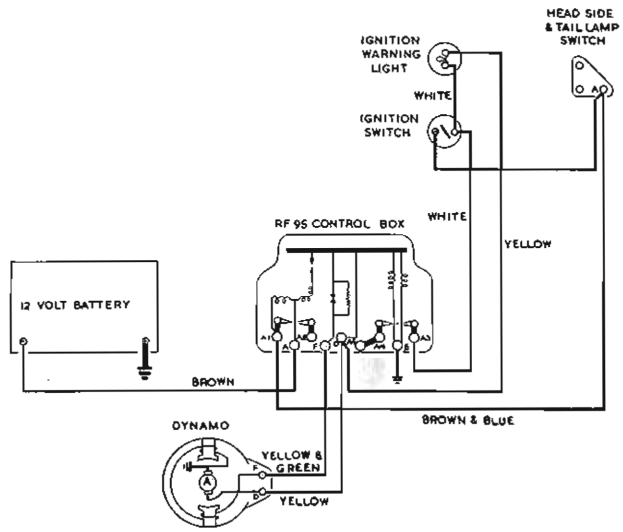
THE CHARGING CIRCUIT

The main components involved in the charging system are the generator, control box and battery.

That part of the circuit connecting the battery with the control box has already been dealt with as the *brown* battery supply circuit.

The generator circuit itself consists of a *yellow* (28/012) cable from generator 'D' terminal to control box 'D', and a *yellow green* (14/012) from generator 'F' terminal to control box 'F'.

Additionally, there is a *yellow* (14/012) cable connecting from control box 'D' to one side of the ignition warning lamp.



THE IGNITION WARNING LAMP

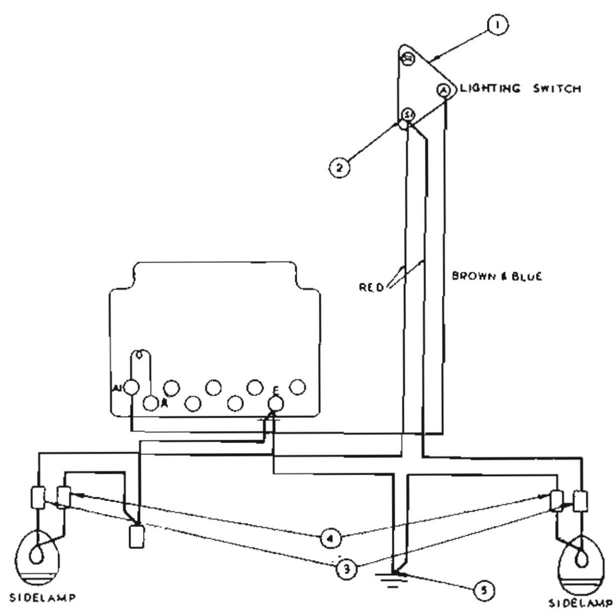
This indicator lamp performs two functions :—

1. It indicates that the battery current is switched on to the ignition and ignition-fed accessories.
2. It indicates that the generator is charging when the engine is turning at charging speed.

Follow the previous circuit through. Commencing at the A3 terminal of the ignition switch, an extension of the *white* lead is carried to one side of the warning light. From the other side, a *yellow* lead is taken direct to the 'D' terminal at the control box.

When the ignition switch is closed, current feeds from terminal A3 at the switch, through the warning lamp to the 'D' terminal of the generator, the circuit being completed through the generator winding to earth. The lamp therefore lights up.

When the engine is started, and the generator voltage builds up to 12 volts, it opposes and equalises the battery voltage previously applied to the lamp, and no current will flow through it. The light goes out, and remains so, until the generator ceases to charge, and its voltage falls. Battery current will then pass through the lamp again and it will remain alight until the ignition switch is moved to the 'off' position.



SIDELAMP CIRCUIT

SIDELAMP CIRCUIT

This picture features the sidelamp circuit.

Commencing at the lighting switch terminal S1(2), a separate *red* cable runs to each side lamp via a snap connector (3).

The return cable is *black* and you will notice that, in this case, it is a full return through snap connectors (4) to a special earthing terminal on the chassis (5).

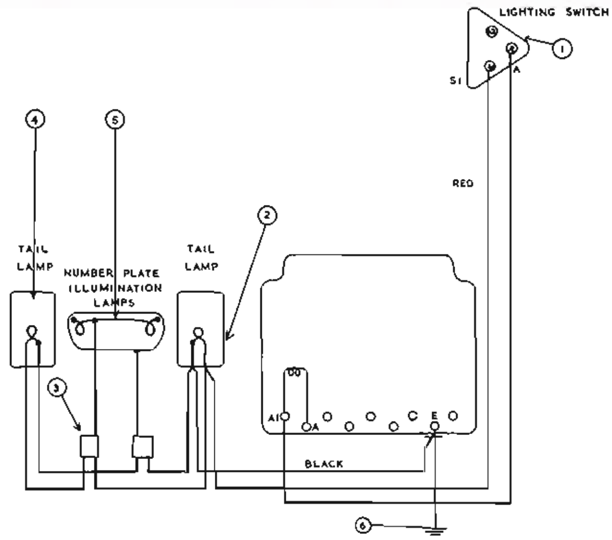
This was evidently required on this particular model to assure a good return path, and it would be very necessary to check this if any trouble were experienced with the sidelamps.

REAR ILLUMINATION

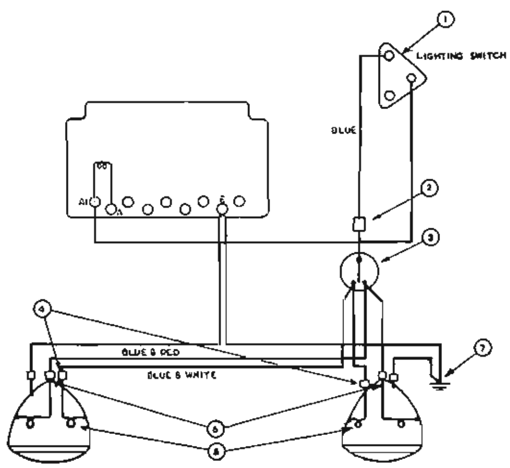
In this example the rear illumination comprises tail lamp, one on each side, and also the number plate box lighting comprising two bulbs.

Commencing at the S1 terminal on the lighting switch (1) from which the side lamp feeds are also connected, another *red* cable runs directly to the first tail lamp (2). This red cable ' loops ' out again to a snap connector located in the luggage boot (3). From this snap connector, two more red cables feed the second tail lamp (4) and the two bulbs wired in parallel in the number plate box (5).

You will notice particularly that a *black* earth wire connects from both tail lamps and the number plate box, to the earth terminal on the control box, and thence to the chassis earth (6).



REAR LIGHTING CIRCUIT



HEADLAMP CIRCUIT

THE HEAD LIGHT CIRCUIT

We have already explained that all the main lighting current passes over the load-turns on the voltage regulator to the lighting switch.

So we can commence at the S2 terminal on the lighting switch (1).

From this point, a *blue* cable runs via a snap connector (2) direct to the foot dipper switch (3).

The dipper switch is a two way switch. From one terminal two *blue* and *white* cables connect through snap connectors (4) to the *main* filament in each headlamp bulb (5).

From the other terminal on the two way switch, two *blue and red* cables run through snap connectors (6) to the dip filament in each headlamp bulb.

Here again, separate *black* earth cables are fitted to ensure a good return path for the lamps. These earth cables connect direct from the bulb holders in the lamp, via the control box earth terminal, to the common earth point on the chassis.

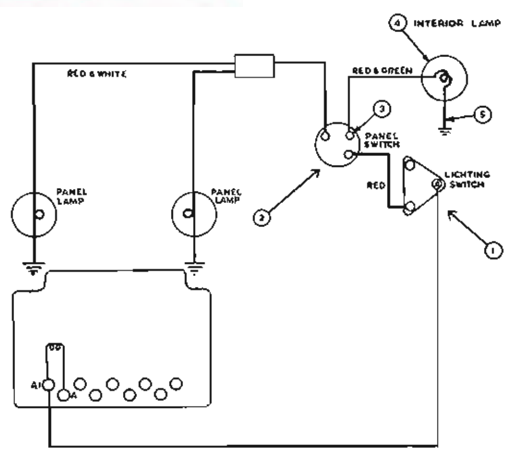
THE INSTRUMENT PANEL LIGHTING

The last item is the lighting on the instrument panel. This is generally fed from the sidelamp terminal on the lighting switch.

On this model a *red* feed cable, commencing from the lighting switch (1), supplies the panel switch (2), and this loops as a *red and white* cable to a snap connector and the individual panel lights. In this case there is no separate earth cable.

From the panel switch (2), there is a *red and green* cable (3), which feeds the interior lamp (4), and also an earth cable (5), which is a *black* cable direct to the chassis.

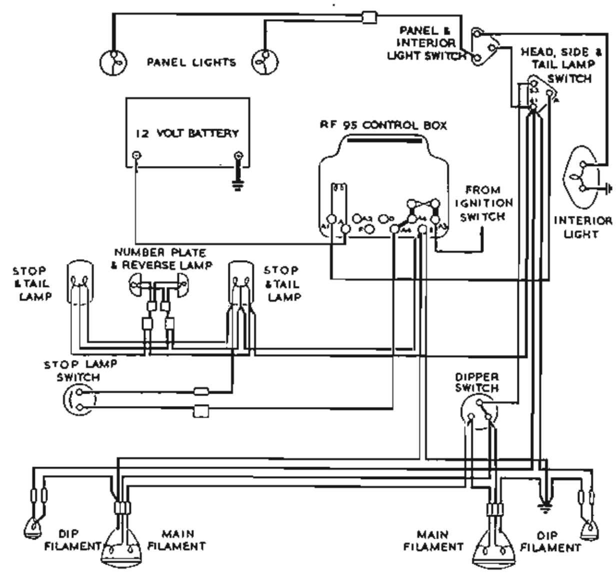
Notice that the interior light is wired directly to the panel light switch, but, generally, interior lights are fused, taking their supply from the A2 fuse.



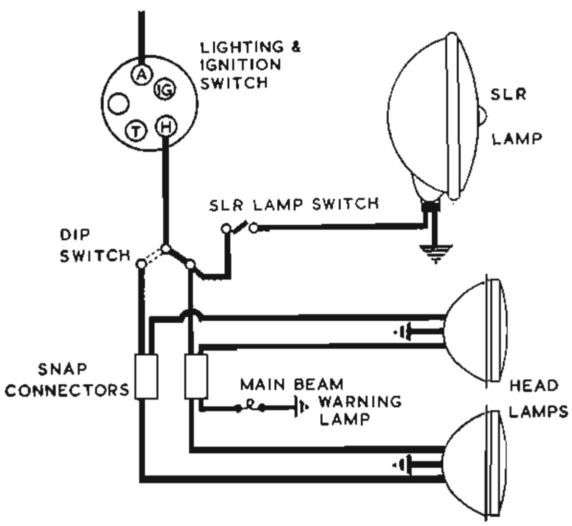
PANEL LAMP CIRCUIT

THE COMPLETE LIGHTING CIRCUIT

Here we have the wiring diagram of the complete lighting installation ; we have seen just how simple this is by breaking it up into individual circuits.



MAIN LIGHTING CIRCUIT



THE LONG RANGE DRIVING LAMP

The most satisfactory arrangement for installing this lamp is such that when the head lights are dipped the SLR lamp should automatically go out, thus avoiding the necessity for two separate operations.

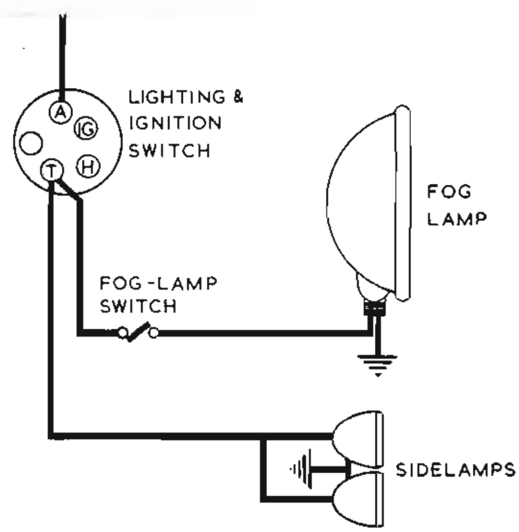
This result can be conveniently obtained by taking a *red and blue* (28/012) cable direct from the main beam terminal of the dipper switch.

An additional hand control switch may then be inserted in this feed line to enable the driver to have the SLR on with his head lamps on main beam. With this arrangement the lamp will immediately go out when the head lights are dipped.

FOG AND PASS LAMPS

When fitted as initial equipment, fog and pass lamps will usually take their current supply from the ' S ' or ' T ' terminals on the lighting switch so that they may be automatically switched off with the side lamps. If such lamps are fitted subsequently, this is still the most suitable method.

It is usual to wire these lamps by means of a *red* (28/012) cable from the lighting switch to the lamp switch, and follow with a *red and yellow* (28/012) to the lamp itself, making quite sure that the lamp has a good earth. If there is any doubt about this, a separate *black* earth wire should be installed. The relatively large size of cable is necessary if full brilliance from the lamp is to be assured.



AUXILIARIES

There are three groups of auxiliaries and accessories, which take their current supply from either the ' A3 ', ' A4 ', or ' A2 ' terminals on the control box.

Those supplied from the ' A3 ' and ' A4 ' terminals are under the master control of the ignition switch. Since they are only required when the engine or vehicle is in motion, this practice precludes the possibility of their being accidentally left on, and so running the battery down.

The *unfused* components supplied from the A3 terminal will comprise the electric petrol pump, auto choke, petrol reserve solenoids etc.

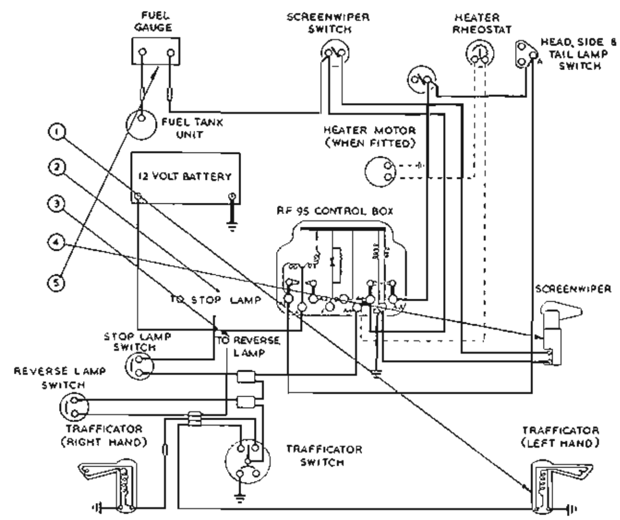
The *fused* components supplied from the A4 terminal consist of trafficators, stop lamp, reverse lamp, windscreen wiper, fuel tank unit, demister and heater motors when fitted.

The A2 terminal and its fuse takes current direct from the battery through the *load* windings of the regulator and is used for interior lights, door lights, low current horns.

The heavy-current horns, such as the wind-tone models, and also radio sets will preferably have separate fuses, the initial supply being taken from the ' A ' terminal of the control box, that is, directly from the battery and not through the load windings of the regulator.

There remain a few additional items, which, for special reasons, may take current direct from the battery. Two popular ones will be the cigar lighter, which takes a very heavy current and the inspection lamp sockets, which may be required when everything else is off.

We shall now examine all these auxiliary circuits individually commencing with the A4 fused auxiliaries under the control of the ignition switch.



A 4 CIRCUIT

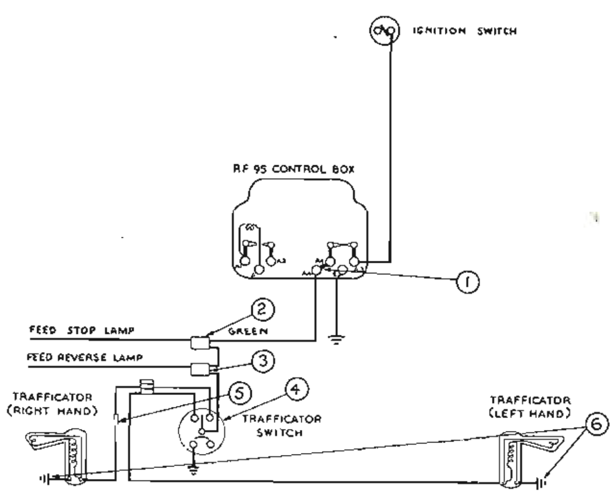
FUSED AUXILIARY CIRCUITS ON A4

Now let us examine these A4 circuits on an actual vehicle.

They are the most complicated of any, and we shall consider each one separately.

As this picture shows, there are only five altogether on this particular model, i.e.

1. **Trafficators.**
2. **Stop Lamp.**
3. **Reverse Lamp.**
4. **Windscreen Wiper.**
5. **Fuel Tank Unit.**



THE TRAFFICATOR CIRCUIT

Trafficators are supplied from the A4(1), 35 amp. fuse, local control being provided either by a self-cancelling two-way and off switch on the steering column, or alternatively by a similar type of switch on the panel.

The most usual ' run ' of this circuit is as follows :

A *green* cable (14/012) from A4 on the control box feeds to a *twin spring connector* (2).

Two leads branch from this connector, one to the stop lamp switch, the other to a further spring connector (3) located at the bottom of the steering column. From here one lead branches off to the reverse lamp switch, the other to the trafficator and horn switch at the top of the steering column (4).

Two cables *green and white*, and *green and red*, lead from this switch and connect, each to one trafficator, through an additional spring connector (5) also located at the bottom of the steering column.

In the majority of cases, a separate *black* earth lead will be run from each trafficator to an earthing point, as shown at (6).

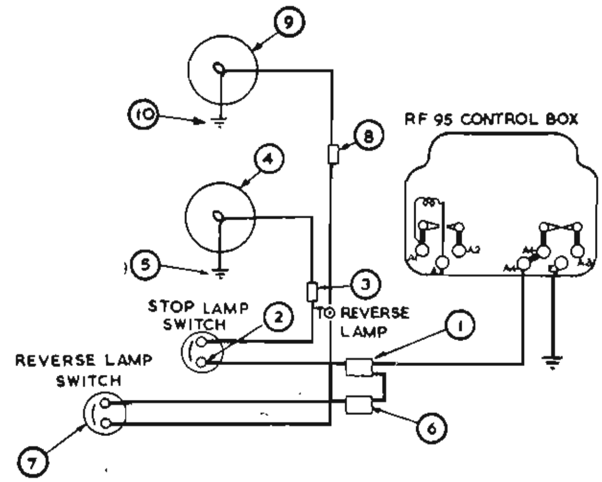
THE STOP AND REVERSE LAMP CIRCUITS

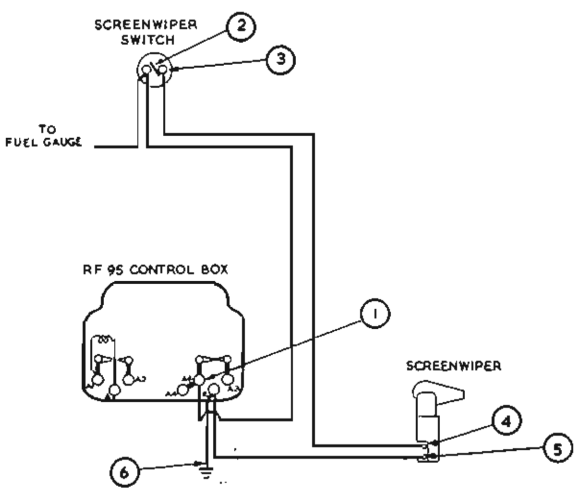
We can now examine the stop lamp and reverse lamp circuits together.

You remember the common *green* feed wire from A4 on the control box branched away, still continuing as a *green* cable from the first snap connector (1) for the stop lamp. This further *green* cable leads direct to the stop lamp switch (2), sometimes a small hydraulic switch, mounted on the master brake cylinder. From the switch, it proceeds, via a rubber-covered snap connector (3) direct to the stop lamp (4), and thence to earth (5).

In the case of the reversing lamp, the feed comes off the second snap connector (6) and proceeds still as a *green* cable to the reverse lamp switch (7) usually mounted on the side, or end of the gearbox, and actuated when the reverse gear is selected.

From the switch, the switch wire proceeds as *green and blue* via another snap connector (8) direct to the reverse lamp (9) and thence to earth (10) through the bulb.





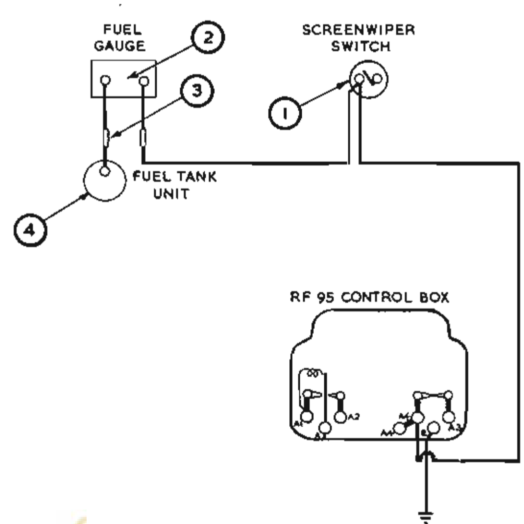
THE SCREENWIPER CIRCUIT

A second *green* feed wire from the A4 on control box (1) is used to supply the screen wiper and the petrol tank unit. This wire runs direct to one side of the screenwiper motor switch (2) which also acts as a junction point for the feed wire to the fuel tank unit. From the other side of the switch, the wire becomes *green and yellow* to one side of the screenwiper motor (4). From the other terminal on the motor (5) the cable is a *black* return to the 'E' terminal on the control box direct to a good earth on the chassis (6).

THE FUEL GAUGE AND PETROL TANK UNIT

As previously stated, the *green* feed wire for this component is junctioned off the screenwiper switch (1). From there it connects — still as a *green* cable — to the fuel gauge unit (2). From the gauge, the colour changes to *green and black* connecting through one or more snap connectors (3) to the petrol tank rheostat (4). The circuit is completed through this unit to earth.

In the event of any erratic reading on the gauge, the first thing to do would be to check the terminals for tightness, and open and remake the joints at the snap connectors, because either a loose or corroded connection will seriously affect the operation of the tank unit rheostat.

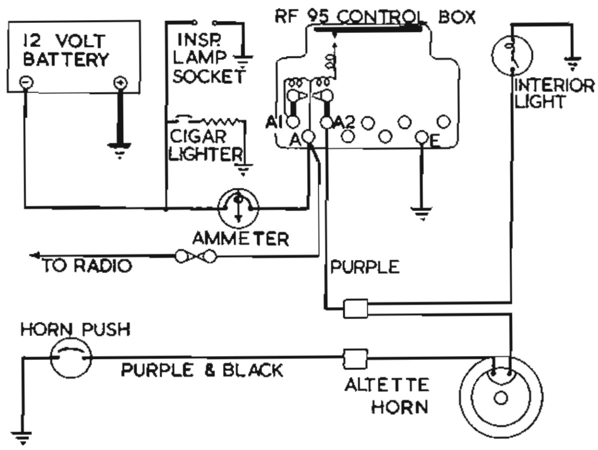


THE AUXILIARY CIRCUITS — A AND A2 ON CONTROL BOX

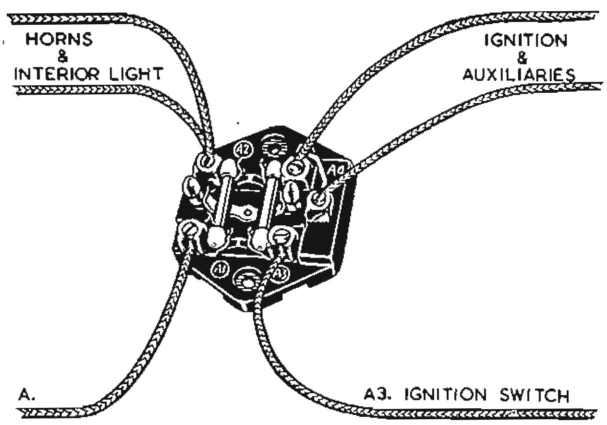
This picture shows a fairly typical layout for auxiliaries which are not under the master control of the ignition switch, and which may vary somewhat on different vehicles.

Top centre of the picture shows the inspection lamp sockets and a cigar lighter. It is usual to place these in the battery feed circuit before the ammeter. It would serve no useful purpose for the heavy current discharge from the cigar lighter to register on the ammeter ; it would merely tend to alarm the driver. Similarly if the inspection lamp is dropped, and shorts as a result of bulb breakage, this would probably damage the ammeter. On the other hand a radio set for instance, which will have its own fuse, may be left on accidentally, or it may be in circuit for prolonged periods. It is therefore desirable that the discharge should be shown on the ammeter. Similarly, with heavy-current horns such as the windtones, to connect them through the ammeter would merely register as a violent and alarming oscillation of the needle when the horn button is closed, so a separate fuse is usually supplied with them, and the supply taken direct off the battery line.

Now examine this picture in detail. Such components as interior lights, door lights, etc., which may be susceptible to wiring troubles, will be placed on the ' A2 ' fuse cable colour *purple*. Small-current horns such as the Altette horn may also be connected to this fuse. The radio set with its own fuse, however, can most conveniently be connected from the ' A ' terminal of the control box. The supply for the cigar



lighter and inspection plug sockets may be taken from the battery side of the starter switch as a matter of convenience. The supply for heavy duty horns may be taken from this point also, or, if no ammeter is installed, the windtone horn supply may be taken from the ' A ' terminal at the control box. At least one car maker who does not install an ammeter takes the windtone horn supply from the ' A2 ' fuse, thus eliminating the additional horn fuse. Since there are no other components on this fuse, there is no possibility of putting the interior lights out of action because of a fault on the horn wiring. We have covered this item in some detail as a number of exceptions to the standard recommended layout may be found on different vehicles.



THE RB106 CONTROL UNIT AND FUSE BASE

Where the RB.106 control unit is installed, a separate fuse base is used.

There are two separate current supplies to this base :—

1. From the ' A ' terminal on the control box a *brown* (44/012) cable connects to the terminal ' A1 ' on the base. The incidental accessories are connected at ' A2 ', that is, through the fuse.
2. The supply to the ' A3 ' terminal is taken from the *ignition* switch ' A3 ' by means of a *white* (28/012) cable. The ignition accessories, fused and unfused will be connected at ' A4 ' and ' A3 ' respectively.

Rewiring in Service

GENERAL

Vehicle re-wiring work properly organized is capable of producing a useful revenue, as well as providing an essential service facility which no motor engineer can really afford to neglect.

The work as a whole falls into four different categories :—

1. Incidental wiring work such as may be involved in the fitting up of accessory lamps and other components.
2. Renewing single cables within the wiring harness or external to it.
3. The re-wiring of complete sections, following damage by collision, fire, etc.
4. Complete rewires involved in major vehicle overhauls.

In this latter category it is feasible to fit a completely new wiring harness, but owing to the multiplicity of models it is not practicable to make them available as spares ; the delay involved in obtaining a special harness would be completely prohibitive.

In any of the categories mentioned, in order to carry out a good quality job on an economical and profitable basis, properly organised stocks of cables, sleeving, jointers, clips, etc. must be available and the range and quantities of these components will vary according to the amount of work anticipated.

If rewiring work is to be made a speciality, a wide range of stock controlled components will be required, otherwise the work will quickly become uneconomical as the result of delays and time lost in making-up special bits and pieces.

Within our experience, service complaints following re-wiring work can be all too frequent, and in this section of the course we shall attempt to offer some useful guidance to those undertaking it.

In every case, the fundamentals of a good quality, economical job may be assured if :—

1. The correct size and quality of cable is used.
2. Adequate stocks of the basic colours are maintained.
3. Suitable stocks of protective sleeving are available.
4. A full range of quick jointers, junction boxes and other incidentals are at hand.

Where the work is to be extensive, additional facilities in the way of guillotines, wire strippers, and other special tools for fitting up will go far in making the work more profitable.

Finally, although such work may have to be carried out by relatively inexperienced personnel, a good quick job can only be expected from an experienced electrician. At the same time, practice will soon result in increased speed and proficiency.

CABLE STOCKS SIZES AND COLOURS

The following cables constitute the minimum range necessary. Quantities can be adjusted to suit the conditions and volume of work, availability, etc.

The essentials extracted from our Catalogue No. 502F are as follows :—

Starter Cables :

1. 37/20 — for the 12 volt system.
2. 61/20 — for the 6 volt system.
3. 61/18 — for heavy C.V. work.
4. Earthing braids.

Circuit Wiring Cables :

5. 44/012 max. 22 amperes brown.
6. 28/012 max. 14 amperes yellow, blue, white, purple and black.
7. 14/012 max. 7 amperes red, green, white and yellow.

When all the coloured cables are not obtainable, short lengths of coloured sleeving will aid identification.

Ignition Cables.

8. 7 m/m. H.T. Neoprene UM.827.

For motor cycle wiring and miscellaneous purposes. } 5 m/m. Low Tension, rubber covered.

Multi-Core Cables :

An assortment of these is essential for steering column re-wiring and they are available with from *two* to *seven* cores according to requirements.

PROTECTIVE SLEEVING AND RUBBER GROMMETS

It is essential that all new wiring should be protected against chafing and exposure at vulnerable points.

For this purpose the most generally suitable material will be lengths of oil-proof plastic sleeving (PVC) which can be cut down to suit individual requirements.

The taping together of runs of cable is unsatisfactory in service, and is instantly recognisable as bad workmanship.

The following minimum range of six sizes will be required :

Sleeving :

5 m/m. dia. to carry one cable.
7 „ „ „ „ two cables.
11 „ „ „ „ three to four cables.
15 „ „ „ „ five to six cables.
18 „ „ „ „ seven to nine cables.
22 „ „ „ „ ten and over.

Rubber Grommets :

$\frac{1}{4}''$ bore to fit $\frac{1}{2}''$ hole.
$\frac{1}{2}''$ „ „ „ $\frac{3}{4}''$ hole.
$1''$ „ „ „ $1\frac{1}{4}''$ hole.

JOINTERS — SNAP CONNECTORS AND JUNCTION BOXES

The comprehensive range of connectors and junction boxes illustrated in our Cable Catalogue No. 502F will cover all requirements.

The only alternative to these connectors is twisted and soldered joints, a slow business.

In no circumstances should dry joints be permitted. These deteriorate badly in service and are visible evidence of bad workmanship.

CABLE CLIPS

A good range of cable eyelets or terminals, and also spring and screw fixing clips are other essentials to economical rewiring work, and a comprehensive range is illustrated in our catalogue No. 502F. Typical samples are as follows :—

1. Junction Boxes : These are available with 2, 4, 6 and 8 terminal positions.
2. Cable Clips : The essentials here are single and double cable clips.
3. Cable Harness Clips and Spring Clips for chassis fixing.
4. Cable Eyelets, or Terminals. $\frac{3}{16}$″, $\frac{1}{4}$″, $\frac{5}{16}$″ and $\frac{3}{8}$″ eyelets will cover all requirements.
5. Starter Cable Terminals.
6. Battery Lugs and Earth Straps.

This is the simplest form of wiring work :

WIRING UP ACCESSORY LAMPS OR RENEWING SINGLE CABLES

1. Always use the recommended size of cable and the correct basic colour, which makes for easy identification subsequently, and also enhances the appearance of the job.
2. Take great care to ‘ feed ’ the component from the correct fuse or terminal point, as we have already detailed.
3. Protect the new wire with sleeving where necessary.
4. Clip up sufficiently close to prevent sagging in service which would give a consequent untidy appearance.
5. Avoid close proximity to any ‘ Hot Spots ’ and any moving parts such as brake cables, etc.

It happens that sometimes a single cable in the harness may require renewal, and the obvious way to do this is to run a new cable of the correct size, and major colour, outside the loom. This may be clipped on to the loom at intervals. Finally cut off the old cable ends where they enter the harness.

PARTIAL REWIRES

A typical service rewiring job will be where a section of wiring has become damaged due to a smash or a fire.

In this circumstance the best and quite adequate method is to cut away all the damaged wiring, if possible at a common point. Then, using either a multi-point terminal block, a junction box or a few snap connectors, run new cables of the correct size and basic colour to the various components. In many cases it will be possible to re-use the old cable run, including the rubber grommets, clips, etc.; otherwise, fit new pieces of insulating sleeving, rubber grommets and cable clips as required.

COMPLETE REWIRES

In view of the large amount of labour involved in the re-wiring of any modern vehicle, this job merits careful consideration and a strictly methodical approach.

Job instructions may only specify a re-wire, but it is obviously futile to re-wire a vehicle to find afterwards that when the vehicle is put back into service the generator doesn't charge or the battery is flat and so on.

So, the very first thing to do is to make a general check-over of all the units, including the lamps and ascertain that they are in a serviceable condition. Proceed as follows :—

Whilst in contact with the customer make a visual check of the following :

1. The battery.
2. The distributor, leads, and ignition coil.
3. The generator, belt, commutator, brushes, bearings.
4. The control box condition.
5. The starter commutator, brushes and bearings. Listen to the engagement for undue noise.
6. The lighting — check the condition and operation where possible. Note cracked glasses, ill-fitting rims, etc.
7. The accessories : This general check-over will take about a quarter of an hour.

Remove any units which may require attention in the way of overhaul or minor repairs.

The main job of re-wiring the vehicle can then be tackled.

METHODS OF REWIRING

Where only inexperienced labour is available, the best method is to disconnect the leads from their components, and then remove the complete harness intact if possible.

During the removal of the main harness, some decision will have to be made as to whether such additional cables as trafficator leads, interior lights, etc., which are in the overhaul, require renewing. Generally this will not be necessary. On the other hand the leads passing into the steering column assembly will almost invariably need replacing. Some care should be taken over this, as such rewiring necessitates the use of the correct multi-core cable.

Lay the harness carefully on a suitable size bench and position it with a few stout nails to act as locating pins.

A complete new set of cables can now be run, using the old loom as a pattern. Tie the cables together at junctions and apply sleeving where required.

Finally, re-assemble the complete new harness on to the vehicle and re-connect to the components.

The more experienced man, who fully understands his circuits, and is thoroughly familiar with the work, will prefer to chop the old harness out piecemeal and run his new wiring direct in situ.

Whichever method may be employed, a thorough and final check is necessary when the rewire is completed in order that a clean and effective job is assured.

This final check should comprise the following operations :

1. Replace the charged battery on the vehicle, making sure that earth connections are clean and tight — leave the main battery lead off.
2. Check that oil pipes, speedometer drive, etc., are properly connected.
3. Check that ALL switches are in the 'OFF' position, and that no odd leads are left disconnected.
4. Connect the main battery lug but do not tighten — this facilitates emergency removal.
5. Switch on ignition and start engine.
6. Check the charging.
7. Check all lights in turn.
8. Check all accessories in turn.
9. If everything is in order tighten the main battery lug.

SUMMARISING

Whilst it is not possible to cover every variation in circuit arrangements that a particular vehicle manufacturer may adopt, the various circuits which have been provided in this book represent the standard layout employed for most vehicles. If these are properly understood, very little difficulty will be experienced when confronted with the wiring arrangement on occasional special models, or even on new model cars now being produced. Such arrangements will vary only in detail from the general pattern.

In the same way, satisfactory re-wiring operations cannot be covered in any great detail. Various methods may be employed which are equally satisfactory; always providing that adequate stocks of cables and components are at hand.

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Section 7
LIGHTING

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

INTRODUCTION

Vehicle lighting, particularly the lighting on production cars, receives a great deal of attention from the Design and Development Departments and also from the user and the press. Contrary to some people's professed views the standard of road illumination, both close and distant is far better to-day than it has ever been. The high concentration of motor vehicles by night in densely populated urban areas has tended to throw the matter of lighting into high relief and the motor engineer will be well advised to make himself conversant with the subject.

Most lamps, particularly side and tail lamps, are subject to fairly constant changes in design, especially as to outline, in order to meet the styling requirements and the search for individuality by the vehicle manufacturer. This may, and sometimes does work to the detriment of the engineer in service and also to the storekeeper in regard to stocking and interchangeability of such lamps; in both cases there is nothing much to be done about it.

However, as shown in the illustrations, the range of such lamps for current production cars is quite limited.

Headlamps, and the range of different sizes and patterns, inevitably give rise to a good deal of controversy both as to the changing form of the lamp body, the lens and the bulb.

Whilst there is a great deal to be said in favour of the earlier " Stem Fixing " lamps it is inevitable that with new and radically changing body styles the flush-fitting type of headlamp has come to the fore ; also the method of mounting these lamps provides a very fine directional adjustment and accessibility.

The idea that the lamp designer is one who should " never have been let out " is erroneous. His problems are many and varied. Everyone wishes to see as well at night as they can in day-light, and just as obviously, they must not be dazzled by any approaching vehicle. Also they must have visibility to drive at any speed they wish, and the light must not throw back rays from wet and shiny road surfaces.

These are only a few of the lamp designer's problems, and he might well be justified in expecting some help and support from the motor engineer in educating the user to the changing conditions, rather than the criticism which his most successful efforts frequently evoke.

According to the lamp designer his declared objective is to enable the vehicle user :—

1. To see the road direction.
2. To see that the way ahead is clear.
3. To keep his right place on the road.
4. To yield comfortable conditions and a sense of well being.

He could have added that since the vehicle user ranged from the man with his little family saloon travelling at forty m.p.h. to the high speed motorist who expected to be able to do eighty to a hundred miles an hour it wasn't going to be too easy.

However in due time a comprehensive range of headlights were evolved. Starting with an accurate and uniform method of focusing the lamp bulb, i.e. the pre-focused bulb, developing the old lamp glass into a lens, improving the reflecting surface and then assembling the components in a rigid, dust proof unit, optically correct in relationship to each other, he produced the *Light Unit*. Next came a range of lamp sizes and bulbs to suit the requirements of the vehicle, and ultimately, to obtain the very long range illumination required by the high speed driver, he introduced various cowling and reflecting devices, and special Long Range Driving Lamps.

The anti-dazzle problem is common to all, and has been largely solved by special lens design and dipping arrangements. Finally he had to face the fact that unless the whole arrangement was correctly set up and maintained on the vehicle, and also intelligently used, his efforts were seriously handicapped.

The motor engineer will do well to ponder the fact that every single detail appertaining to modern lamps and light distribution has been carefully, deliberately, and scientifically worked out to achieve its purpose.

As to the lighting circuits themselves, the simplicity of the circuits, the sizes of cables, the colouring and the great amount of economy achieved in installing the not inconsiderable number of circuits is a subject well worth careful study.

The vast majority of lighting troubles in service are concerned with the lamp bulbs themselves, or with defective earth connections. Occasionally instances of poor lights arise through voltage loss or " voltage drop " at such points as " snap connections " and switch contacts which may " weather " or corrode ; but the most frequent cause of such troubles is the renewal installation of undersized cables and the fitting of incorrect lamp bulbs.

The localising of the more obscure but infrequent wiring troubles probably calls for more electrical *horse sense* than most faults, and for this reason a full and careful study of lighting trouble diagnosis is recommended.

Lamp bulbs themselves may be regarded to some extent as " consumable," or at least their lighting efficiency falls off in the course of time and usage. The most frequent cause of premature bulb failures, however, results from excessive vibration, or else interference with the voltage regulators, particularly by raising the voltage setting when excessive brilliance is obtained only at the sacrifice of longevity.

Another point of importance with lamp bulbs is that if the correct beam of light with maximum effect and minimum dazzle is to be obtained, it is essential, firstly that the bulb filament and locating plate are correctly positioned, and also that bulbs of the correct " rating and light emission " are fitted, and this can only be assured by fitting the manufacturers' specified lamp bulbs.

As may be realised, the size, power and positioning of lamps on the modern vehicle is governed either by regulation or recommendation. Numerous efforts have been and are still being made to obtain international agreement on such matters, but, so far, only a limited amount of success has been attained in this direction, hence the variety of headlamp lenses and bulbs.

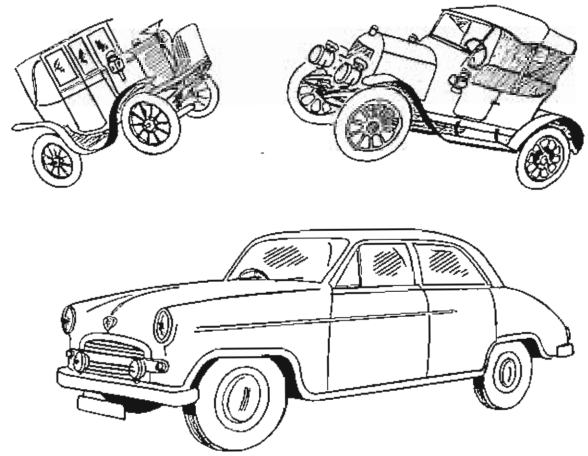
The part to be played by the motor engineer in his position as *the expert* is to see that the customer gets the best out of his lighting, and, incidentally, do what useful business he may be able, in the way of selling lamp bulbs and special purpose lamps where some useful purpose may be served by so doing.

A proper understanding of the subject is the first requisite.

CONTENTS

JOSEPH LUCAS (SALES & SERVICE) LTD., BIRMINGHAM, ENGLAND.

Obligatory Lighting



We shall not attempt to trace the history of vehicle lighting from the early days of the carriage to the modern motor vehicle. However, the distinction which existed from the very beginning, that which can be summed up as " see " and " be seen," is still prevalent to-day.

In England, the carriage lamp became the " obligatory " lamp or side-lamp ; it enabled the vehicle " to be seen." In other words it merely indicated the position on the road.

As the speed of vehicles increased, it became imperative " to see " as well as " to be seen " and so we have progressively seen the introduction of headlights, long-range driving lights, passlamps, fog lights, in fact all the additional " extras " considered so necessary to modern motoring.

For " extras " they are in the eyes of English law, and optional at that; side and rear lamps, together with rear number plate illumination still constitute the only " obligatory lighting " for vehicles in the British Isles.

It is with this lighting that we shall concern ourselves at the moment. We shall start with a review of modern side lights ; carry on with rear lighting, including stop-tail, number plate lamps, and reflectors; and then show how the circuits for this lighting appear on the average vehicle.

MODERN SIDE LIGHTS

Here you see just a few examples of modern Lucas side-lamps. There are various shapes, sizes and mountings which conform to the constructional requirements of the particular vehicle.

The 488 for instance is used on cars where stem or spigot fixing is not convenient. It is a flush fitting lamp, consisting of a strongly moulded rubber body encasing a fluted glass and chromium-plated rim. The 489 is similar in construction but with a smaller glass. The rim and glass assembly of these lamps is removable by inserting a coin or screwdriver between the rim and rubber base.

The LD109 on the other hand is of more conventional design and spigot mounted. The rim is located by a single screw to facilitate bulb replacement.

The 516 is a streamlined lamp, specially designed to match the contours of the car body.

The 545 is one of our latest side-lamps. It is provided with a bulb-holder suitable for taking a double filament bulb. One filament gives the normal side-light ; the other is used as a " flashing indicator."

The bulbs used in the above lamps are as follows :

Lamp 488 No. 361, a 12-volt, double filament bulb with a rating of 18/6 watts. The 6 watt filament serves as the side-light, whilst the 18 watt is used for many applications as a " flasher " direction indicator.

The *489* is fitted with a No. 222 bulb. This is a single contact type rated at 12 volt 4 watt.

Both the *L545* lamp and the *516* take the same bulb, No. 222. Where the L545 is used as a flasher and side-light combined, the No. 316 double filament bulb is used.

The *LD109* model employs bulb No. 207 — a 12-volt bulb rated at 6 watt.

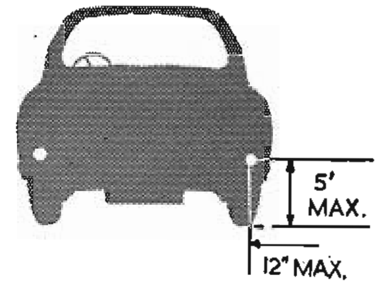
SIDE-LAMP INSTALLATION

Side-lamps are positioned on British vehicles to conform to the " Lighting Regulations " in force in Great Britain.

The regulations concerning the positioning of these lamps on cars and light-commercial vehicles state :—

1. Both lamps must be fitted at equal height and not exceeding five feet from the ground.
2. The lamps must be fixed so that no part of the vehicle or its equipment extends laterally on the same side as the lamp more than twelve inches beyond the centre line of the lamp. Mirrors and direction indicators in the operating position are excluded when making this measurement.

The maximum wattage of the bulbs should not exceed 7 watts.



Sidelamps — maximum bulb rating 7 watts.

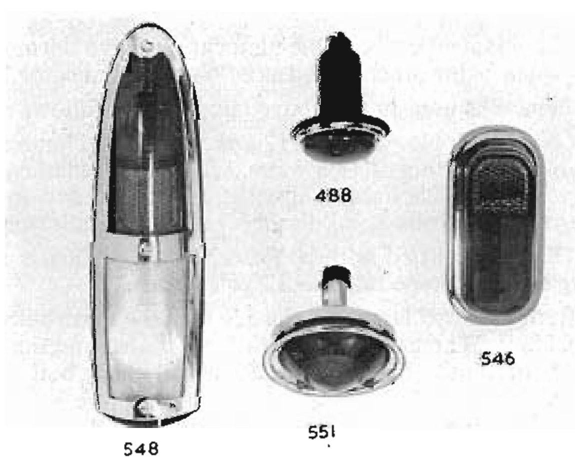
STOP TAIL LAMPS

Nearly all our car tail lamps are combined in one assembly with a stop lamp, the latter being operated by the brake pedal.

The picture shows a cross-section of the lamps we produce to-day. Let us examine their main constructional features.

The 488 is the same lamp as the side-lamp we have already shown you, but fitted with a red lens.

One of the latest developments in rear lamp design is seen in the 546 lamp. A Reflex reflector is moulded into the actual lens itself, forming the top section of the unit. The centre section houses a double filament bulb which provides the normal tail and stop lights. A " flasher " direction indicator bulb can be fitted in the bottom section. This one unit thus fulfils three functions.



The 551 lamp, too, embodies many recent design features. The moulded Diakon reflector, $1\frac{1}{2}''$ in diameter, is situated in the centre of the lens, with a clear surround. The rim is pressed onto the conical shaped lens, and the assembly fitted to a metal backplate which contains the bulbholder. To prevent the ingress of water, seating rubbers are fitted between the lens and the backplate, and also behind the backplate. A double filament bulb provides the tail and stop lamp lighting.

The 548 is the largest of our combined rear-lamps. It is approximately $11'' \times 3''$ and provides a reverse lamp in addition to the reflector and stop-tail lights.

This lamp consists of a die-cast baseplate into which are sealed two diakon windows, a red one at the top for the stop-tail light and a clear one at the bottom for the reverse lamp. The centre section contains a red reflex.

Although the clear window is provided, the reverse lamp is an optional extra, and a separate bulbholder assembly is available.

When the reverse lamp is not required, a flat steel plate is fitted over the aperture in the base plate.

The following bulbs are commonly fitted to these lamps :—

The *488 model* takes the No. 361, a 12-volt double filament bulb with a 6/18 watt rating.

The *546 lamp* is fitted with a No. 361 bulb serving as the stop-tail light and a separate " flasher " indicator bulb No. 221 12 volt 18 watt.

The *551 lamp* employs a No. 380 12 volt bulb, which contains a 21 watt flasher or stop-light filament and the normal 6 watt tail light filament.

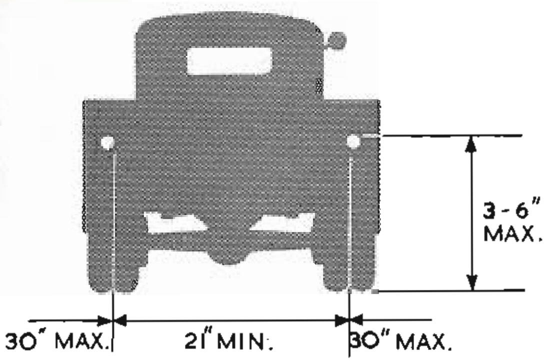
Two bulbs are used in the 548 lamp : the No. 380 rated at 6/21 watt (12 volt) and No. 382 containing a single 21 watt filament for the reverse light.

REAR LIGHT INSTALLATION

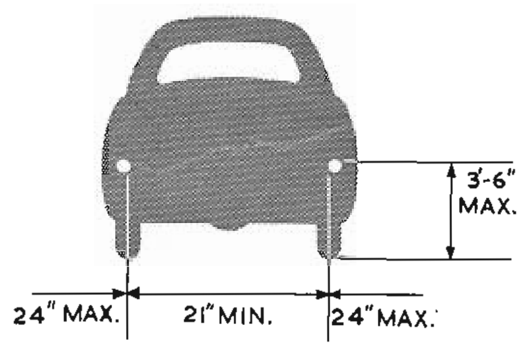
Rear lamps must be positioned on British vehicles according to the " Lighting Regulations " which are enforced in Great Britain.

The specified measurements are clearly visible in the two illustrations, and we need only add that " extreme rear " should be taken to mean the rear of the vehicle when the tail board, luggage grid or any other adjustable fixture is extended.

The bulb rating for rear-lamps should not be less than 6 watts.



Goods Vehicles (over 30 cwt.) Rear Lamps — must not be more than 3 feet 6 inches from extreme rear.



Private Cars, Goods Vehicles under 30 cwt., Three-wheel Cars and Trailers Rear Lamps — must not be more than 30 inches from the extreme rear.

REFLEX REFLECTORS

Reflectors, which in the British Isles formerly came within the category of " extras " are now legally enforced. They provide most effective supplementary rear lighting, contributing greatly to road safety.

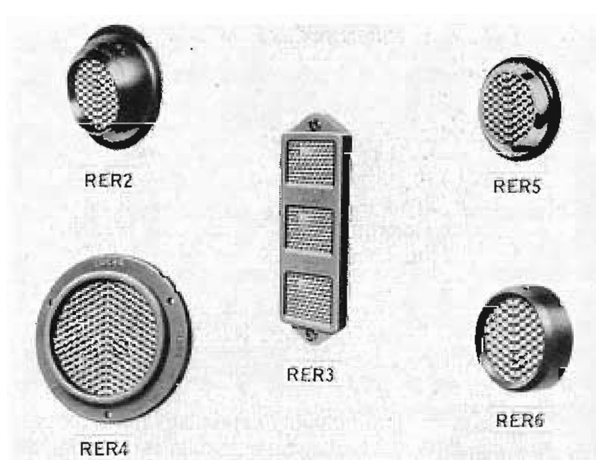
All Lucas reflectors are formed by prisms moulded in Diakon. This formation provides an extremely efficient reflecting surface, so good in fact, that tests prove that in a headlight beam, reflectors are visible at a thousand feet or more, showing up as brightly as an ordinary rear lamp.

We show you here some of the reflectors we have designed to meet the requirements of all types of vehicles.

The R.E.R.4 is a large model suitable for fitting to commercial vehicles. The strip type R.E.R.3 is also designed for this purpose. Both these models can be obtained with amber coloured reflectors for fitting to the sides of the vehicle.

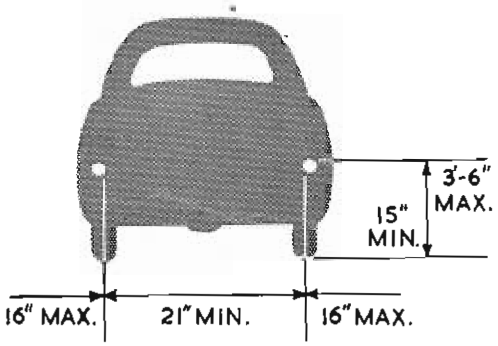
The other three types are all suitable for fitting to cars and motor-cycles. They are provided with a single self-tapping fixing screw, and designed for mounting on number plates, rear mud-wings, etc. The design of the R.E.R.2 makes it suitable for fitting to curved surfaces.

And here we must make an extremely important point concerning the positioning of all reflectors. Their fitting is controlled by the " Road Transport Lighting Regulations " and these should be carefully studied. The reflected light is cut down considerably if the reflector is not mounted in the correct position and, even more important, at the correct angle.



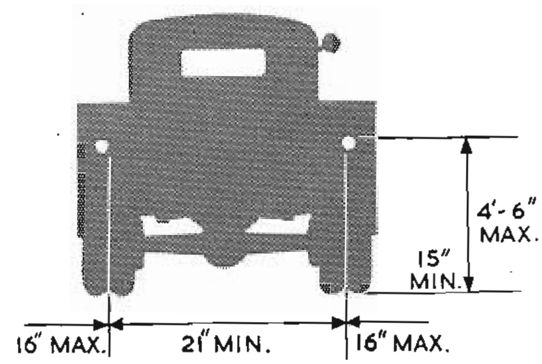
REFLECTOR INSTALLATION

These two illustrations show the specified positioning for reflectors.



Reflectors on Private Cars, Goods Vehicles under 30 cwt., Three-wheel Cars and Trailers must not be more than 30 inches from the extreme rear.

We will stress once more that to be properly effective reflectors must be fitted in the vertical plane and facing squarely to the rear.



Reflectors on Goods Vehicles over 30 cwt. must not be more than 30 inches from the extreme rear.

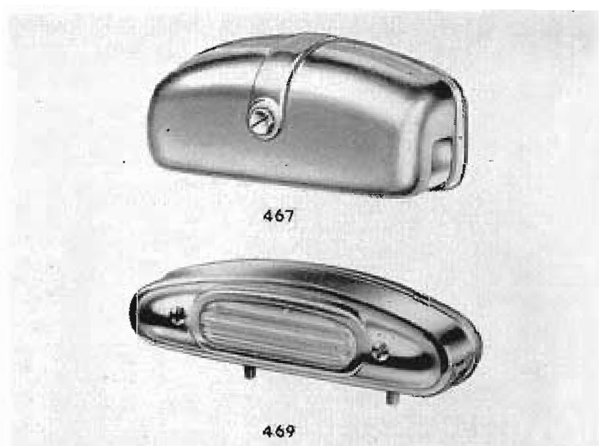
NUMBER PLATE ILLUMINATION

These are two of the most popular number plate lamps — the only remaining units in the 'obligatory' category.

The 467 is designed purely for number plate illumination and is installed with ONE, either 4 or 6 watt filament miniature bayonet cap (MBC) type bulbs.

No. 469 is intended for the larger cars. In addition to giving ample number plate illumination by two similar bulbs to those just described, this lamp also carries an 18 watt bulb which will provide a reversing light when required.

Let us now consider the circuit arrangement for the side and rear lighting.



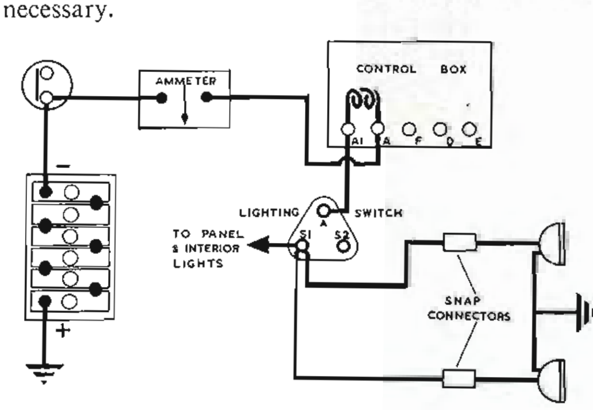
TYPICAL SIDE-LAMP CIRCUIT

On modern cars, both side lamps are fed in parallel from the S1 terminal of the main lighting switch. (Many of you will remember the earlier type combined ignition and lighting switch with this terminal marked "T").

You will notice too that the lighting switch obtains its feed via the LOAD TURNS of the voltage regulator in the control box. The complete circuit, therefore, would be as follows :—From the battery, usually via an ammeter, to terminal "A" of the control box, then through the load winding to A1, feeding the lighting switch at terminal "A". The circuit continues across the switch through both bulb filaments to earth, being completed via the vehicle chassis to the battery earth.

Notice particularly the "Snap Connectors." These are of great significance in servicing and trouble shooting work with which we shall deal later.

It will be found throughout the lighting circuits that extensive use is made of single and multiple snap connectors in order to reduce the lengths of cables necessary.

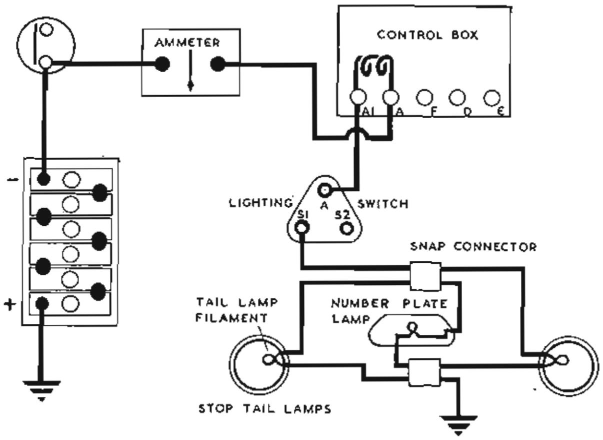


SIDE LAMPS

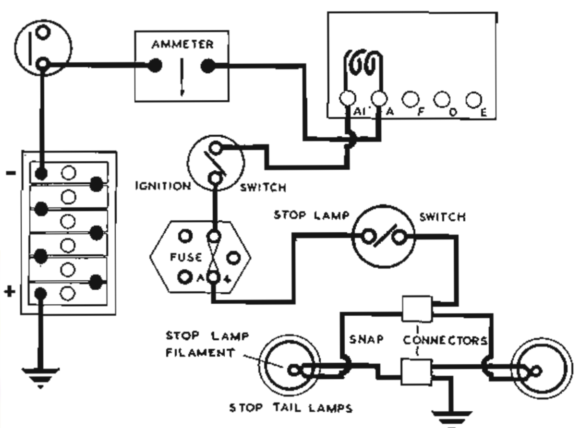
REAR LIGHTING CIRCUIT

The rear lighting is also fed from the S1 terminal of the main lighting switch. Let us follow the circuit from this point. A single cable leads direct to a double snap connector. Feed cables branch off to the tail lamp bulb filaments in the stop tail lamps and another to the number plate lamp.

Earth return cables are looped from all the lamps to one snap connector and then earthed to the chassis.



REAR LAMPS



STOP LAMPS

STOP LAMP CIRCUIT

As the stop lamps are usually part of the tail lamp assembly we have included the circuit here. These lamps usually carry double filament bulbs, one 4 or 6 watt filament for the rear light and either an 18, 21 or 24 watt filament for the stop lights with which we are concerned in this diagram.

The circuit is simple enough as you can see. The stop lamp filaments are fed from the A4 fuse via a separate stop lamp switch actuated by the brake linkage.

Feeding from the A4 circuit means that the lamps are master controlled by the ignition switch with a fuse in circuit.

In Part 2 overleaf we shall consider lighting which, while not being " obligatory " in the legal sense, is of paramount importance to all road users. We shall begin with the main headlamp lighting.

Headlamps

DAZZLE

We shall approach the subject of headlamp lighting by way of the problem it inevitable poses. In so doing, we hope to convey the sense which lies behind the development of the modern Lucas headlamp unit.

With headlamps becoming necessarily more and more powerful as the speed of vehicles increased, a problem arose which, in recent years, has been causing concern in all countries where night driving is widespread.

How do we provide adequate lighting of the road for fast driving and at the same time use this light when passing oncoming vehicles so as not to cause discomforting dazzle? What sort of *safe* compromise can we strike between poor headlights which scarcely enable the driver to see, and those which light the way brilliantly, yet blind the approaching driver? For safety depends upon *both* drivers being able to see.

DIP AND SWITCH METHOD

The only effective answer at present appears to be a really efficient dipping system.

The method we show you here, known generally as the "Dip and Switch Method," has been employed for many years on British vehicles. The off-side light, that nearest the oncoming driver is switched off, and the other "dipped" downwards and directed towards the nearside curb.

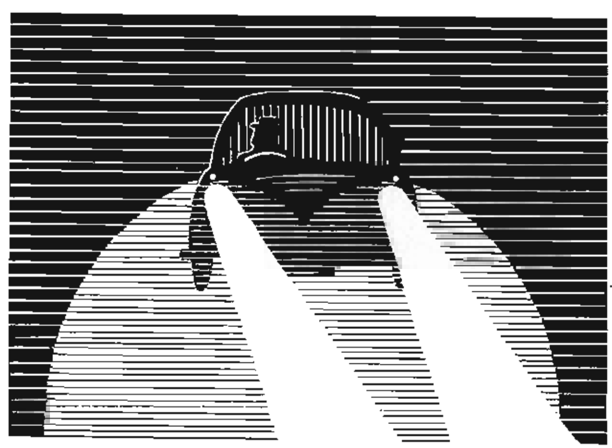
The snag in this is obvious enough: the approaching driver is safeguarded but the driver dipping his lamps is suddenly left with less than half his road lights. The difference between the main and dipped light is considerable.

DOUBLE DIPPING

The introduction of the Lucas double dipping system overcame this disadvantage. Both lights remain on, dip filaments in the headlamp bulbs providing adequate illumination of the road in the dipped position. So good is this light, that speeds of 40–50 m.p.h. can be maintained with perfect safety.

The use of PRE-FOCUS BULBS and the BLOCK PATTERN LENS reduces the dazzle of the approaching motorist to an absolute minimum.

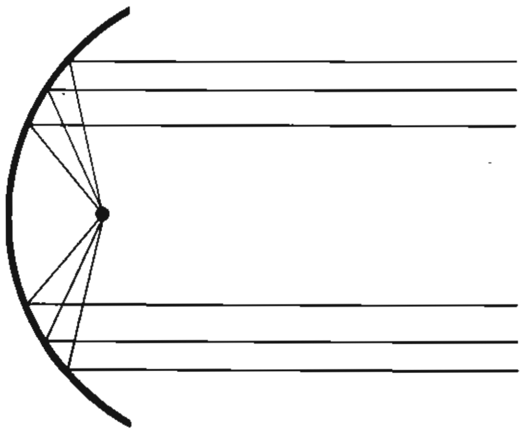
But perhaps we are going a little too quickly; some of these terms may need explaining.



OPTICAL PRINCIPLES

For you to appreciate the double dipping system fully, let us consider for a moment the optical principles involved.

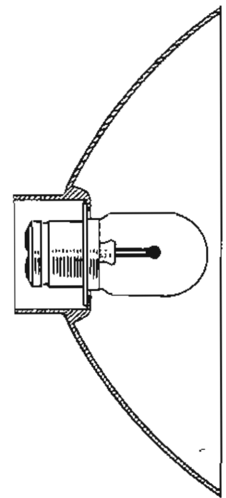
If a pin-point of light were placed at the exact focus of a parabolic reflector, in theory we should obtain a perfectly parallel beam of light. No light rays would be reflected above the horizontal.



PRE-FOCUS BULB ARRANGEMENT

But a bulb filament can never be merely a pin-point. It must have a certain substance to enable it to carry sufficient current and to make it mechanically strong.

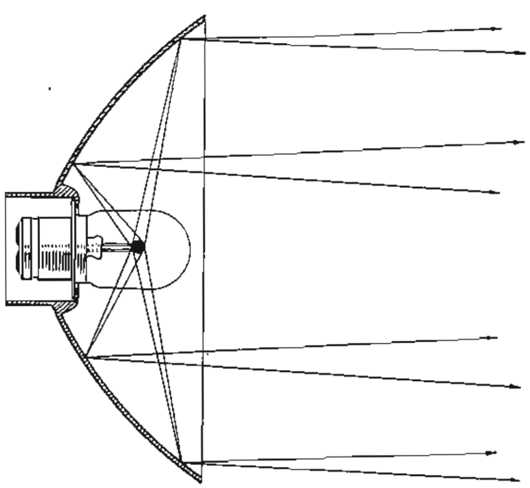
Not all the incandescent area of the filament then, can be at the exact focal point of the reflector, although by using what we call a PRE-FOCUS bulb with a locating flange we can achieve what is, for all practical purposes, an accurate positioning.



THE DAZZLE RAYS

Arising from what we have just said, the beam produced by such a bulb and reflector combination must necessarily be slightly divergent ; some light rays are reflected above the horizontal. These are the ones which cause dazzle.

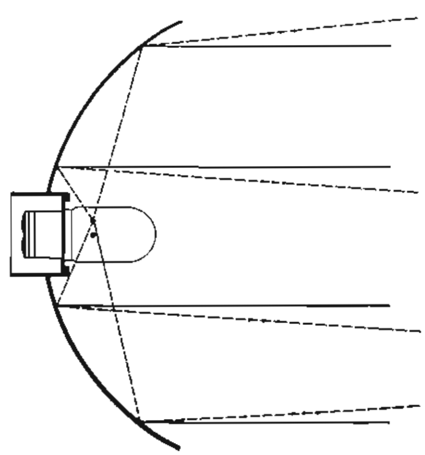
You can see from the illustration that it is not only the rays which strike the lower half of the reflector that are projected upwards ; a proportion of the light striking the upper areas is similarly affected.



DIPPED BEAM REFLECTION

A second or DIP filament situated above the filament we have so far discussed, i.e. displaced from the focus of the reflector, and actually offset from the axis of the bulb, would produce a " dipped beam " whose main concentration would fall below the horizontal.

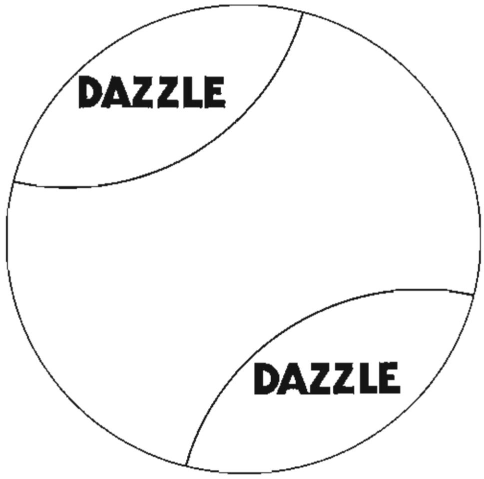
But this dip filament would still give rise to some upwards reflected light as you can see by the dotted lines at the top and bottom of the reflector. Light rays emitted from the filament, striking these upper and lower areas, will inevitably be reflected above the main concentration of the beam. This means that no matter how the dipped beam is set or directed, some light will rise, causing dazzle to the approaching driver.



DAZZLE POINTS

To re-direct these upwards reflected rays so that they are projected below the horizontal line, groups of prisms are moulded into a special glass known as a Block Lens. The dazzle points, where the two prism groups must be formed, are indicated here.

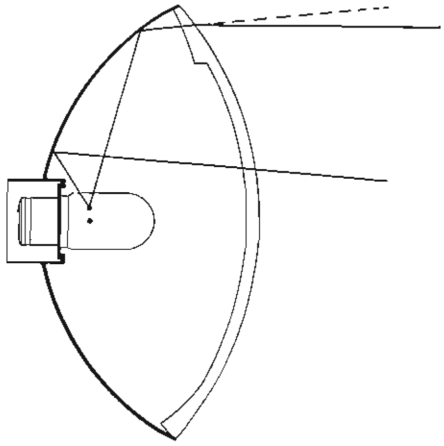
(You will see later how the actual positioning varies according to the lighting regulations of a particular country.)



PRISMATIC CONTROL — DIPPED BEAM

You can see here what the effect is as far as the Dip filament is concerned: light rays formerly rising above the horizontal are now refracted or bent downwards to the horizontal so that they fall within the main concentration of the dipped beam.

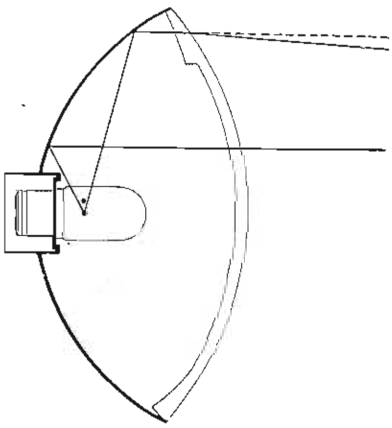
A similar group of prisms is situated in the lower area of the glass to control the other dazzle-producing rays in the same way.



PRISMATIC ACTION OF DIPPED BEAM

PRISMATIC CONTROL — MAIN BEAM

The prisms also control the light rays of the main beam — i.e. the rays emitted by our first filament at the focus of the reflector. Light which was previously projected upwards and wasted is now brought into the beam, adding to its intensity.

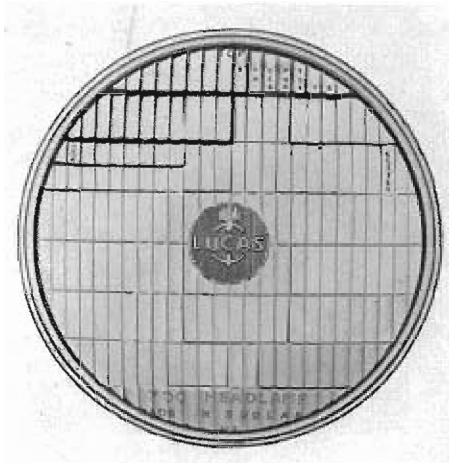


PRISMATIC ACTION OF MAIN BEAM

BLOCK LENS

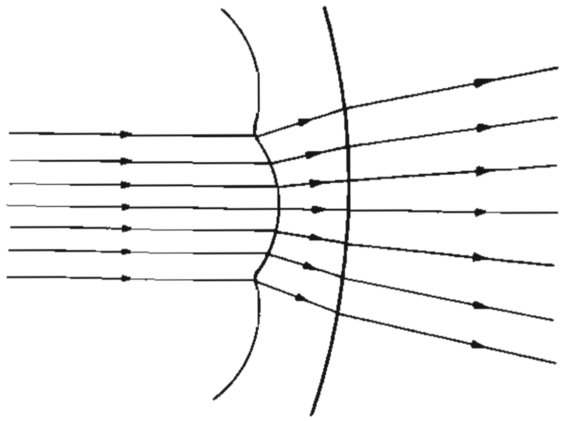
Here is a photograph of the actual lens with the grouping of the prisms clearly marked. They control the rays, then, in the vertical direction. But what about the horizontal spread of the beam ?

This is taken care of by the vertical flutes moulded into the lens.



HORIZONTAL CONTROL

Here you see the effect of these flutes. There is sufficient light-spread at good intensity to give enough light for cornering — the light intensity should be such that it is *not* the controlling factor on the speed of cornering.



A LAMP ASSEMBLY

The moulded lens containing the prism and flute combination is rolled into a dustproof assembly with the reflector. This protects the reflector surface, ensuring long life to the light unit.

The pre-focus bulb is inserted from the rear of the assembly, thus making replacement possible in service.

LIGHT IMAGE

This is the pattern of light produced by the main filament of one block lens light unit. The screen is approximately 25 feet from the lamp. Notice the intense spot in the centre of the beam ; this will give a long driving light. There is also good sidespread immediately in front of the lamp and at a little distance ahead. This ensures safe illumination of the sides of the road, enabling the driver to position himself accurately, and to pick out pedestrians and cyclists with ease.

MAIN BEAM LIGHTING

This is how the main beam lighting appears from behind the wheel. The road is illuminated for a length of over 170 yards. The brick pillars are 17 yards apart and 8 feet high. This will give you an idea too of the " low top " of the beam.

This long range light enables the driver to see the contour of the road — he can also anticipate any sudden changes in direction, a realisation which brings with it an added sense of security. The road a little distance in front of the vehicle is also brightly and evenly lit, making it possible for the driver to proceed according to the state of the surface.

This main beam lighting gives sufficient light straight ahead to enable speeds of up to 55 m.p.h. to be maintained with safety in average conditions. This limit has been set because the vast majority of drivers hardly ever exceed this speed, and, as we are necessarily working with a limited amount of light, an excess in the centre to allow faster driving might mean less at the sides of the road.

DIPPED BEAM LIGHTING

Both head lamps are now dipped, but notice that the light has relatively not decreased in intensity. These dipped beams provide adequate light for passing the oncoming vehicle with safety and comfort.

If both headlamps are correctly set, the approaching driver will be subjected to little or no dazzle.

And here we would like to make two very important points. In the first place, the approaching driver will of course be aware of two headlamps. If he happens to glance directly at them he will see two lights — but they are only sources of light : they do not dazzle. On looking directly ahead again, there is no sudden, urgent need for re-focusing of the eyes, no dangerous " black " period that we experience after the eyes have really been " dazzled."

The other point is this : you will appreciate that if both vehicles are equipped with block lens light units and the beams dipped, the whole breadth of the road surface between the vehicles is illuminated, without dazzling either of the drivers.

This avoids any possible misjudgment of the width of the vehicle.

LIGHT UNITS AND BULBS — LENS DESIGN

It may be appreciated that the desired results from double dip lighting will only be obtained if the bulb and light unit combination is correct.

Both light units and bulbs vary in accordance with the lighting regulations of different countries.

Broadly speaking, we can divide these into three distinct groups according to different areas : right-hand drive countries, left-hand drive, and continental.

The continental sphere has to be sub-divided, special lighting regulations being in force in France. In order to meet International Regulations not covered by the standard pattern lens and also to provide driving lights with special characteristics for racing work, a number of variations to the standard Block Lens are sometimes fitted. Any of those illustrated may be found on vehicles from time to time.

F700 LIGHT UNIT

This is the F700 light unit used in right-hand drive areas. It is the present standard unit fitted by British car manufacturers to vehicles for the home market.

The prism arrangement is suitable for beams dipping to the left.

CORRECT BULBS

The correct bulb is the 354 for 12 volt units with a rating of 42/36 watt (the main filament value is given first, the dip filament second). The No. 356 bulb, exactly similar in appearance, is used for 6 volt applications, its wattage being 45/35 watt.

Notice that the main filament is axial and that the dip filament is above it and to the side.

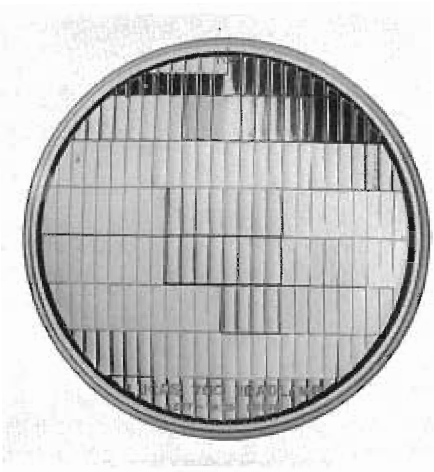
The single slot in the flange precludes the possibility of incorrect fitting.

F700 UNIT — LEFT-HAND DRIVE

The F700 unit for left-hand drive countries, including the U.S.A. has the prism groups moulded into the opposite side of the lens, i.e. top right and bottom left. Also, the dip filament in the pre-focus bulb is positioned so as to give deflection of the beam to the right.

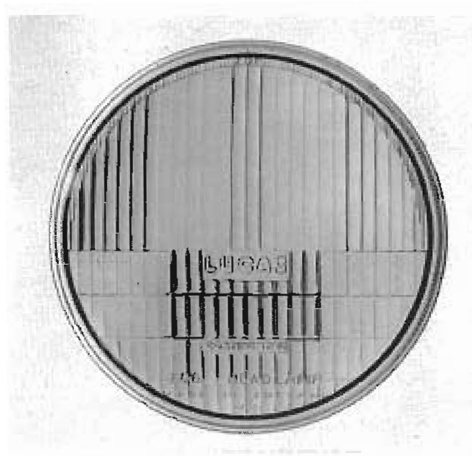
The bulb numbers are :—

12 volt	No. 355	42/36 watts.
6 volt	No. 387	45/35 watts.



F700 CONTINENTAL

This special F700 block lens light unit has been designed for use in European countries. The prisms are concentrated in the centre of the lower half of the lens, thus giving the necessary vertical dip.



BULBS FOR THE CONTINENT

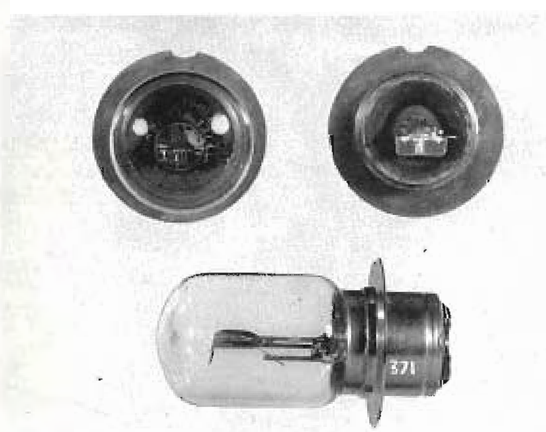
The correct bulbs for use with the continental unit are :—

12 volt	No. 370	45/40 watts.
6 volt	No. 378	45/40 watts.

Both bulbs are of the pre-focus type but with a hooded dip filament.

A similar bulb No. 371 with a yellow envelope, may also be fitted for touring in France.

This is the bulb recommended for any of the F700 light units when touring the continent.



SPECIAL UNIT FOR FRANCE

Where the visit is of a more permanent nature, both light units and bulbs must comply with the French regulations.

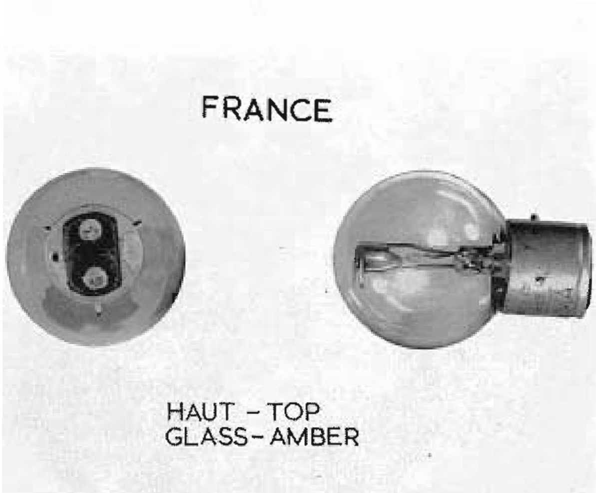
We show you here a suitable Lucas unit. The lens used is still the CONTINENTAL F700, but the reflector is fitted with the special holder to take the three pin bulb legal for France.

FRANCE

BLOCK LENS LIGHT UNIT

THE THREE PIN BULB

This bulb, No. 372, has a hooded dip filament, a yellow glass envelope and three pin fixing. The bulb must be correctly inserted in the holder and for this reason it is marked " haut " — " top."



LE MANS UNIT

This " Le Mans " light unit was specially designed for fast driving on the continent. Again you will notice the prisms are in the centre for vertical dipping.

Models of the unit are made to take either the British pre-focus bulb or the French bulb you've just seen.

P700

A later design block lens, the P700, has a clear centre, giving a longer beam. This does enable us to drive faster along the straight, but remember that with a given amount of light we can't increase the intensity of the beam centre without losing something at the sides.

Notice the hood attached to the centre piece. Apart from enhancing the appearance of the lens, this does of course serve a useful purpose. With the clear glass centre, some rays are projected upward at about 45°. These rays would tend to produce a slight glare immediately in front of the vehicle which would affect the driver, particularly in misty conditions. The driver of an approaching vehicle however would in no way be troubled. The hood suppresses this tendency to glare.

Lenses are made for right hand, left hand and continental application, the positioning of the prisms varying as in the " F " range.

The bulbs used in the previous range can also be fitted to this " P " range.

The P700 is *not* permissible at present in the U.S.A.

J700

The last light unit we have to show you is the J700. Again you'll notice the clear centre of the lens and the hood over the bulb. A lens is produced for both left and right hand drive.

The specified bulb is the No. 404, a 12-volt pre-focus type with a 60 watt main filament and a 36 watt dip filament.

This unit is *not* permissible in the U.S.A.

FOCUSING AND TRACKING

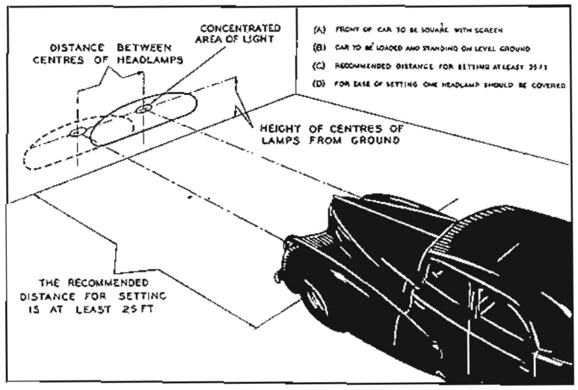
No matter how good the actual head lamps are, they will never do their job as intended unless they are correctly set. The two terms usually associated with this process are " focusing " and " tracking."

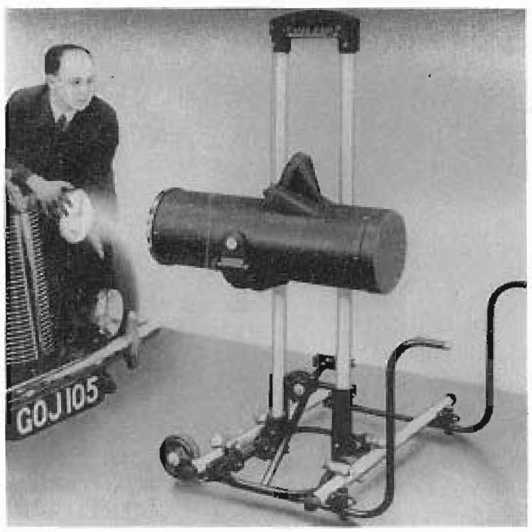
The latest bulbs, as we have said, are automatically focused in the reflector by the positioning flange and notches. Earlier types are usually adjustable in the bulb holder. In such cases, the focusing adjustment should always be carried out before the alignment or " tracking " of the lamps.

HEADLAMP SETTING

Our picture shows one method of setting lamps. A screen is used, set square to the vehicle and at least 25 feet from it. The car should be loaded and standing on level ground. Mark the lamp height and the distance between the centres on the screen. The setting operation is eased, as we suggest, by covering one headlamp. Make sure that the MAIN BEAM lighting is switched on.

Then adjust the lamps so that the beams fall on the screen as we have illustrated. Notice that just over half of the main concentration of light falls below the horizontal line.





THE BEAM SETTER

This " Beamsetter " greatly simplifies headlamp setting.

The apparatus is first positioned in accordance with the track of the vehicle wheels by means of a light ray and screen.

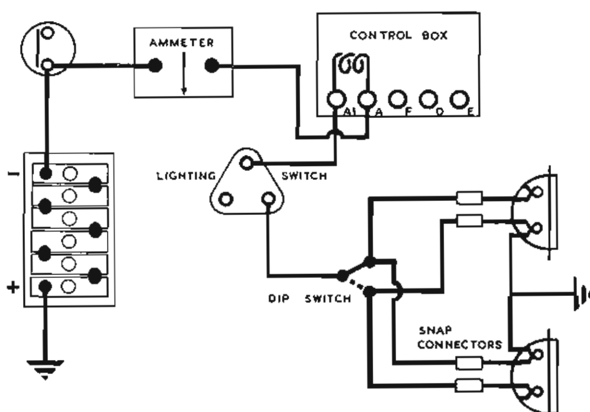
Each lamp beam is then directed in turn through the condenser lens of the apparatus and the position of maximum light intensity read off on a candle power scale. The reading is dependent on the intensity of light falling on a photo-electric cell.

HEADLAMP WIRING CIRCUIT

The headlamps are supplied with current from the lighting switch S2 terminal. The latter is connected via a cable to the dip switch, carrying battery current to either the main or dip filaments in both headlamps, depending upon the switch position.

Earth leads from each lamp are attached to any suitable point on the chassis, thus closing the circuit with the battery earth.

The circuit from the battery to the lighting switch is the same as for the side and rear lighting, current again passing via the load turns of the voltage regulator, thus compensating the headlight load.



HEADLAMPS

Auxiliary Lights

AUXILIARY LIGHTING

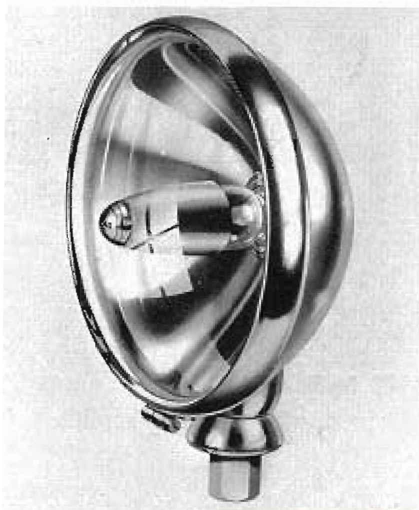
Auxiliary lights, such as long-range driving lamps, fog lamps and reversing lamps are to-day widely fitted by motorists as "extras." But the great majority of the motoring public is rapidly realising that these so-called 'extras' are well-nigh indispensable to modern motoring.

Such additional lamps afford a convenient choice of lighting to cope with any possible combination of traffic, weather and speed.

They bring added safety and comfort to night driving.

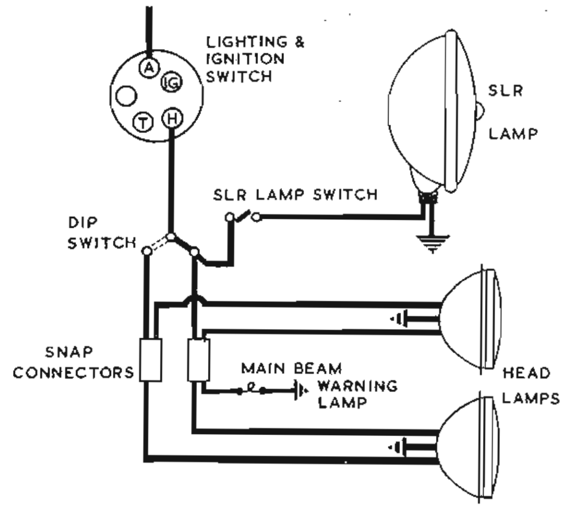
SLR700

This long-range driving lamp, the SLR700, is intended for use in conjunction with the car's normal headlamps for fast night driving. The specially designed conical bulb shield and clear lens have the effect of condensing all the light power into a thin "pencil" beam of great intensity — in fact 100,000 candle power are projected in advance of the headlamps — a searching beam which makes fast driving safe.



SLR CIRCUIT

The SLR should always be fitted as we show in this diagram. The feed is taken from the MAIN beam side of the dip switch and then via a separate switch to the lamp. Thus the SLR is only operative when the main beams are in use. On dipping the headlights, the lamp is also extinguished. This of course is done to avoid dazzling an oncoming driver.

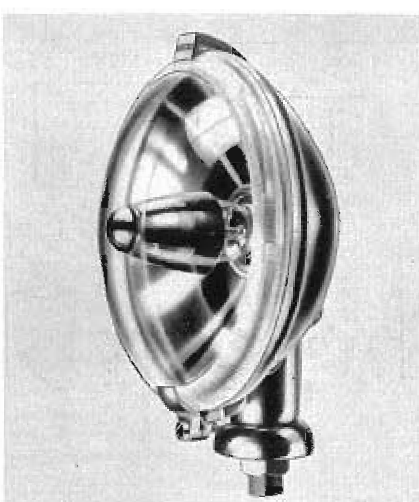


SLR 576

This SLR 576 is a development of the 700. It is much smaller in size — less than 6 inches in diameter — but is remarkably efficient, producing a long, concentrated driving beam of 80,000 candle power.

Its size and shallow body make it ideal for fitting to cars where frontal space is limited.

The 576 should also be fitted so that it is automatically extinguished when the headlamps are dipped.



SFT700

One of our most popular fog lamps, the SFT700, incorporates the block pattern lens. This lens, in conjunction with the special reflector, pre-focus bulb and bulb shield, produces a flat-topped beam with exceptionally wide side-spread and without upward or backward glare. It gives an ideal light for driving in fog.

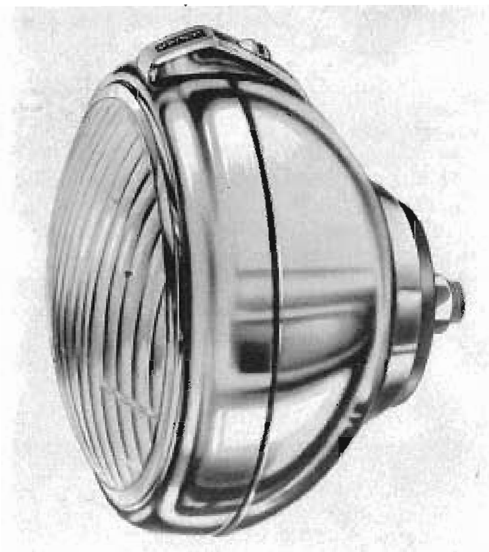
462 RANGE

The 462 models are the smallest fog lamps we make, having a diameter of 5″.

They are fitted with the block pattern lens and produce the characteristic ' flat-topped ' beam.

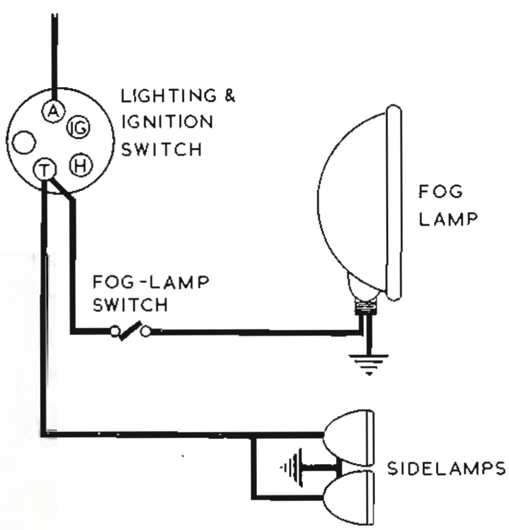
The WFT462 shown here is designed with a fixing bolt in the back of the lamp, enabling it to be mounted directly on to the front of the vehicle, or on to a vertical or suspended bracket.

The model in this range with the usual spigot fixing is the FT462.



FOGLAMP CIRCUIT

Foglamps are normally connected in the sidelamp circuit, either from snap connectors in the feed wire or as we show here direct from the lighting switch. They are of course also controlled by a separate switch.



SFT576

Another attractive foglamp, the SFT576 has been designed for use with the SLR576 long-range driving lamp. Like the larger 700 foglamp we've just shown you, it has a wide-spread beam, sharply cut off at the top — a most effective light in fog.

Fitting presents no difficulties, thanks to the shallow body and the 6″ diameter.

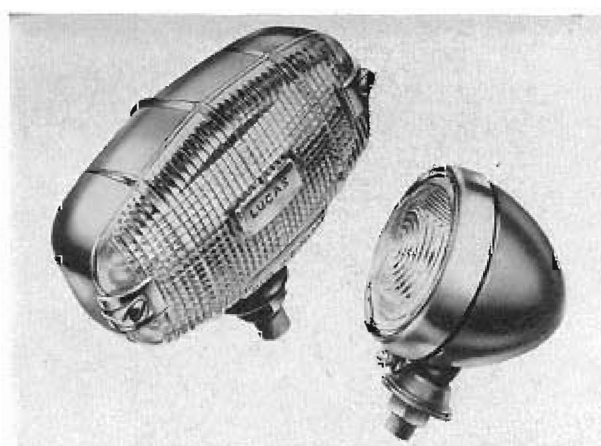
494 AND 511 REVERSE LAMP

These two auxiliary lamps have been designed expressly as reversing lights and provide ample illumination to the rear.

The model 494 on the left is roughly oval in shape and is styled to blend with the tail lines of modern cars. A wide, even distribution of light is assured by the ribbed construction of the glass.

The mounting is external, by stem and " ball-joint " fixing. The other lamp, the 511 model, is suitable for fitting to the majority of cars — it is only 3½″ in diameter and spigot mounted.

The bulb usually fitted in both these lamps is the No. 221 12 volt 18 watt or the No. 317 6 volt 18 watt. The maximum permissible bulb rating in Great Britain is 24 watt.



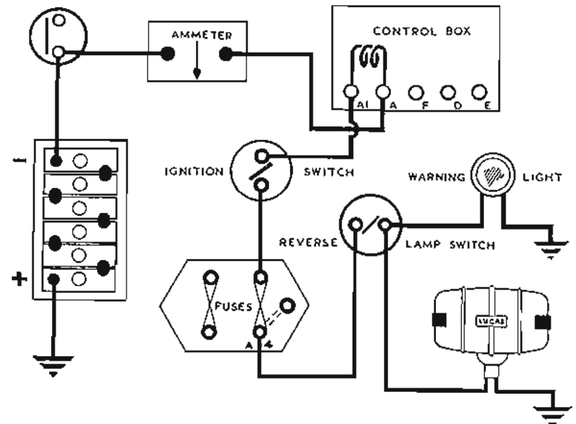
REVERSE LAMP CIRCUIT

A reverse lamp should always be fed from the A4 fuse terminal. Current passes from the battery, through the meter and then via the load turns of the voltage regulator.

Terminal A1 then feeds the ignition switch. When this is in the " ON " position, current passes through the A4 fuse to one side of the reverse lamp switch, which is normally situated near the gear box selector mechanism. When reverse gear is selected, this switch is closed and the reverse light operates.

Vehicles fitted with a reverse lamp that is not controlled by the gear change lever must have a warning light in circuit. This, as you can see, is fed from the lamp side of the reverse lamp switch.

The standard switches most suitable are models PS7 and PS15. When the 494 or 511 reverse lamps are supplied as accessory kits, either one or the other of these switches is included.



REVERSE LAMP

LIGHTING REGULATIONS

We stress once more that Regulations affecting the British Isles concerning the positioning, dimensions and bulb wattage of all lamps are contained in the latest " Road Transport Lighting Act."

They specify among other things the height of the lamps from the ground, the distance from the outer edge of the vehicle, the dimensions of the glass or lens, the type of glass, the colour of the light, etc.

It is recommended that these lighting regulations should be studied in order to understand clearly the correct positioning of all lights.

Maintenance

MAINTENANCE POINTS

1. Faulty bulbs.
2. Bad earths.
3. Bad contacts.
4. Faulty wiring.

When individual lights are poor or out of action, these points should be checked.

FAULTY BULBS

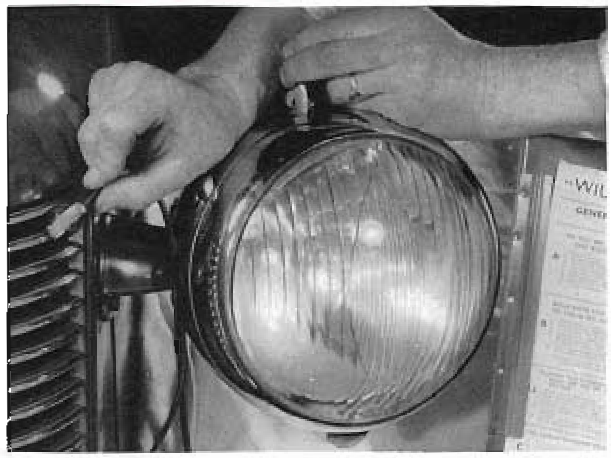
If a bulb filament is broken, make sure that the fault is due to normal wear and tear and not the result of vibration caused by a loose lamp fixing or faulty bulb holder.

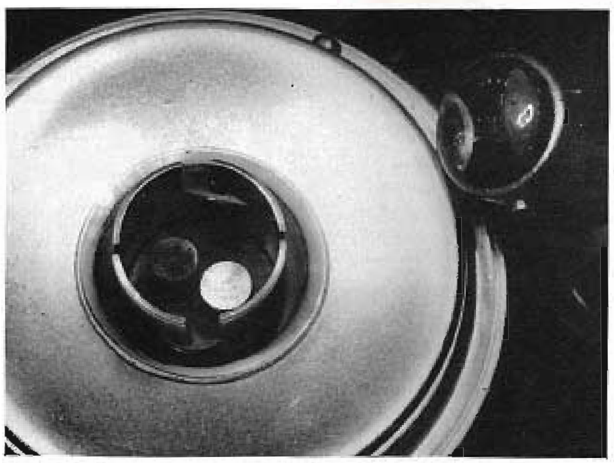
Don't forget too that in the category " faulty " we include bulbs of the incorrect type, unsuitable wattage and wrong voltage.

BAD EARTHS

Bad earths are a frequent cause of poor lights and even complete failure.

A check should be made with a voltmeter between the lamp body and a good earth on the vehicle. A voltage reading indicates a faulty earth. The voltmeter should read zero if the earth connection is good.





DIRTY CONTACTS

Dirty contacts, either at the bulb holder or the bulb will always cause trouble. Frequently, contacts are blackened by sparking between the holder and bulb contacts, due to a loosely fitting bulb. What's more, if sparking occurs, the bulb holder springs will overheat and lose their tension, thus making permanent contact impossible for instance over a rough road surface.

The only real cure if the bulb holder contacts are badly blackened or discoloured is to change the holder.

FAULTY WIRING

Our picture shows a test being made with a voltmeter to see if there is voltage at the bulb holder. No voltage reading with the lights switched on indicates a break in the feed wire.

If this is the case, the circuit should be checked with a voltmeter at every point in the feed, i.e. control box A and A1 terminals, lighting switch, dip switch and any cable junction such as a snap connector. These tests will localise the fault. A broken wire or dirty connection can then usually be found by eye when the voltage readings have been taken.

LIGHT LIFT

One of the main troubles associated with lighting in service is that of " Light Lift ". This is the term used to express the rise in the light intensity of the headlamps when the engine speed is increased quickly.

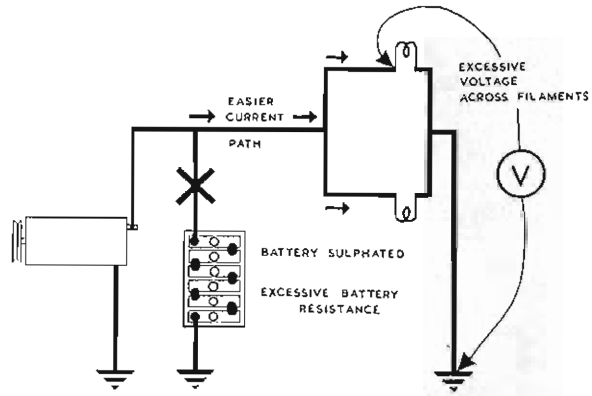
This fault is of course the exception rather than the rule, but it is one which in many cases is difficult to remedy. For this reason we intend to go into it at some length.

REASONS FOR LIGHT LIFT

The final reason for light lift is a sudden excess of voltage across the filaments of the headlamp bulbs which increases the brilliance.

Take the simple case we show you here. The battery is sulphated, that is, in a condition where its internal resistance is comparatively high. The engine is suddenly revved and the dynamo charges. But the charge will not readily be absorbed by the battery, owing to its resistance. Instead, the generator voltage will rise directly across the bulb filaments.

Admittedly, the voltage rise is limited on modern vehicles by the regulator, but it is still sufficient to cause light lift, expecially when you consider that with a bad battery the lights will be dim anyway when the engine is idling.



REASONS FOR LIGHT LIFT

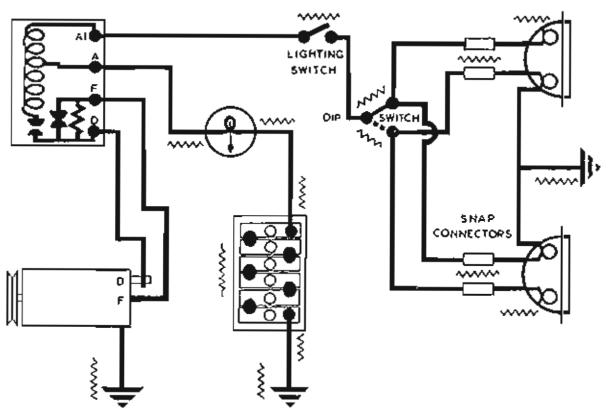
COMPLETE CIRCUIT

But the battery is by no means the only cause of light lift. Any point in the circuit where there is excessive resistance will cause a voltage drop. Consequently, with the engine idling, the lights will not be receiving their full battery voltage. There will then be a noticeable difference when the engine is revved and the full generator voltage develops.

We have indicated many of these possible high resistance points. You see that they can be anywhere in the circuit ; at terminals, at snap connectors and junction points, even in the wiring itself. There may be one main fault or a combination of minor losses which all add up to produce light lift.

We have drawn up a test procedure which will enable you to locate all the more usual faults.

To illustrate this procedure, let us take a test case. We have a vehicle with light lift, not excessive, but noticeable. How do we proceed ?

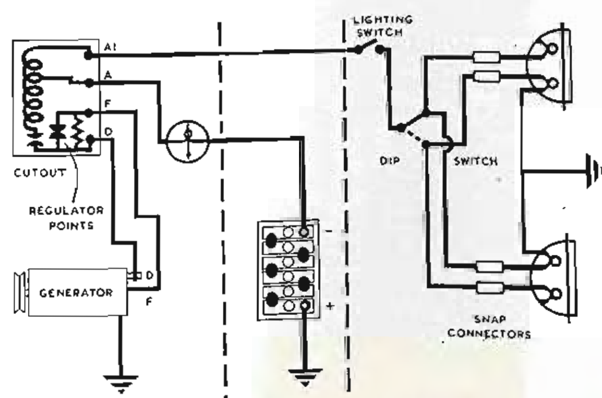


LIKELY HIGH RESISTANCE POINTS

COMPLETE CIRCUIT DIVIDED INTO THREE SECTIONS

We have divided the vehicle circuit into three sections : lights and switches ; battery ; generator and voltage regulator.

The first move is to find out just what light lift we have in terms of volts. The rise in light intensity is visible to the eye but a reading on a voltmeter gives us a more exact idea of the problem. A comparative measurement can then also be made at the end of the tests — which makes sure the fault has in fact been cleared.



COMPLETE CIRCUIT DIVIDED INTO 3 SECTIONS

LIGHTS SECTION TEST 1 AND 2

Connect a voltmeter between earth and the end of the lighting cable as close as possible to the bulb holder. Switch on the headlights (main beam) and note the reading with the engine stationary. Then make the same test with the engine running at a good charging speed.

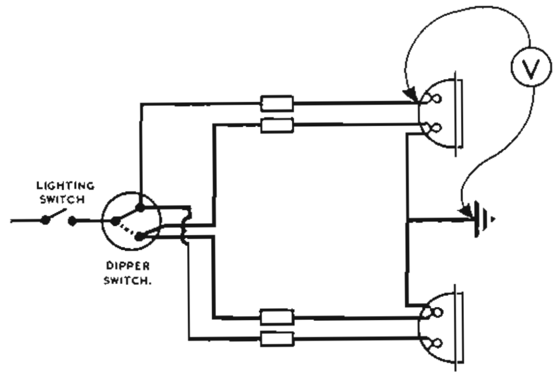
It is advisable to carry out these tests at both headlamps, just to make sure that both are affected by light lift.

Readings on our test vehicle were as follows :—

Engine stationary	11·8 volts.
Engine running	12·8 volts.

Both headlamps gave the same reading. The voltage difference, then, causing the light lift is 1 volt. For normal service purposes, 0·5 volt is considered the maximum permissible reading.

What then, in our case, is causing the higher reading ?



TEST 1 HEADLIGHTS ON — ENGINE STATIONARY
TEST 2 HEADLIGHTS ON — ENGINE RUNNING

BATTERY SECTION TEST 3

The next point in the procedure is to test the battery to ensure that no abnormal condition is affecting the circuit as a whole.

We first took S.G. readings of each cell with a hydrometer and then heavy discharge readings. Results were as follows :—

S.G. Readings : 1·230, 1·230, 1·230, 1·240, 1·240, 1·230.

Discharge voltage readings over 10 seconds : 1·6v., 1·5v., 1·5v., 1·6v., 1·6v., 1·6v.

The battery was obviously in good condition, and could not be considered as a possible cause of the trouble.

TESTS 4, 5, 6

Tests 4, 5 and 6 concern the voltage of the battery.

First use the voltmeter to check the terminal voltage with the engine stationary ; then with the engine running and finally with the engine running and full load, (i.e. engine running at charging speed).

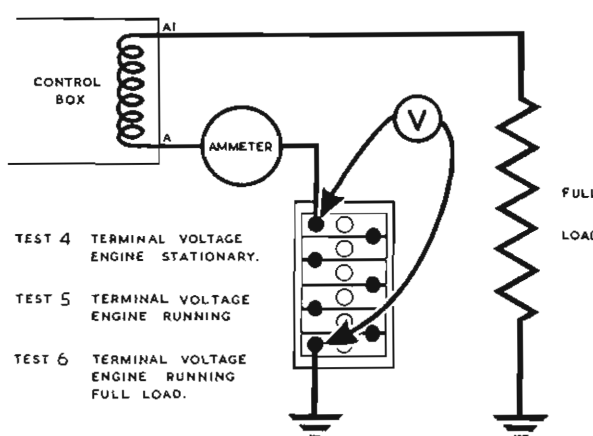
We obtained these figures :—

Test 4	12·5 volts
Test 5	13·5 volts
Test 6	12·5 volts

The load we switched on consisted of a fog lamp and long-range driving light in addition to the head, side and tail lights.

Test 5 reading should of course be higher than Test 4 for the set to be charging, but a difference in readings of much above 1 volt would suggest overcharging. In our case, with 1 volt difference, we felt that a further investigation was necessary — particularly as the battery was reasonably well charged.

Test 6 reading we considered normal — the 1 volt drop from Test 5 showed us that the load was not too great for the battery. You see, too great a load on the circuit will cause the battery terminal voltage to drop to such an extent that when charging begins, light lift will inevitably result.

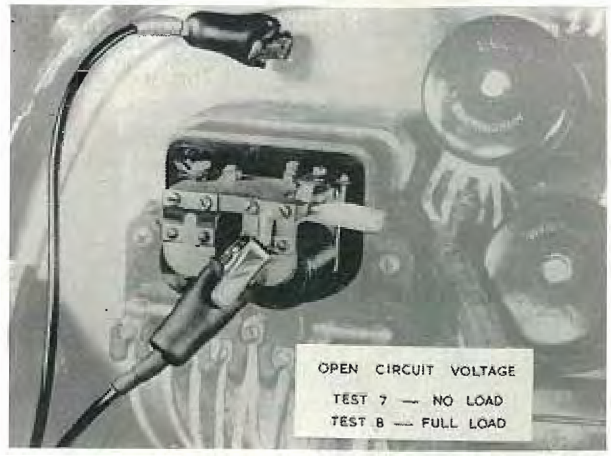


REGULATOR OPEN-CIRCUIT SETTING. TESTS 7 AND 8

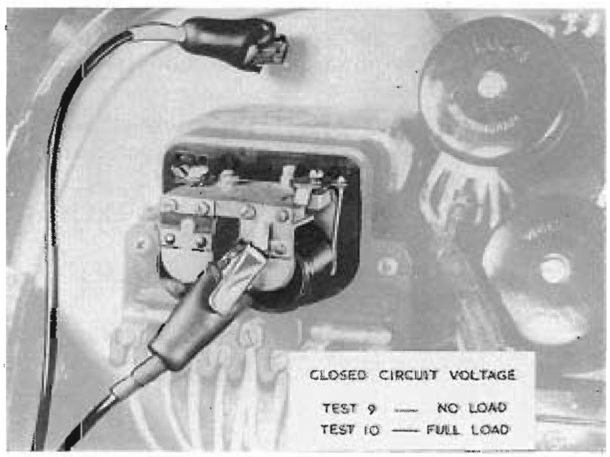
We further investigated the slightly high terminal voltage obtained in Test 5 by checking the open circuit voltage of the regulator. A voltmeter was connected between the regulator frame and earth and a piece of thin, clean paper inserted between the cut out points.

The reading as we suspected was slightly high: 16·5 volts instead of between 15·6–16·2 volts. The alteration of the setting was left until the end of the test procedure, to enable us first to trace any other faults.

We next switched on the full load of head, side and tail and two auxiliary lights. The engine was revved up to the same speed as in the previous tests and the voltmeter open circuit reading again noted: 17·5 volts. Something was obviously wrong: if the regulator is working correctly the reading with full load will be below the no-load figure. The load turns should reduce the operational voltage of the regulator when a heavy discharge current is passing to the lights.



On investigating, we found that the A and A1-leads were crossed over at the regulator. This fault too was left until all the tests had been completed.



TESTS 9 AND 10

We next removed the paper from the cut out points and switched off the load. We accelerated the engine to a good charging speed and, leaving the voltmeter still where it was, read off the closed circuit voltage.

Under these no-load conditions, the reading was 14 volts.

We then switched on the same full load as before and noted the reading: 13·8 volts.

This indicated that the generator was maintaining its closed circuit voltage under load — stated more simply, the generator was able to supply sufficient output to balance all the lighting we had switched on. It would not have been able to do this for instance if the driving belt had been slipping. If such a fault does occur, the battery gradually becomes discharged. The lights when idling are less brilliant and light lift becomes noticeable when accelerating.

TESTS 11 AND 12

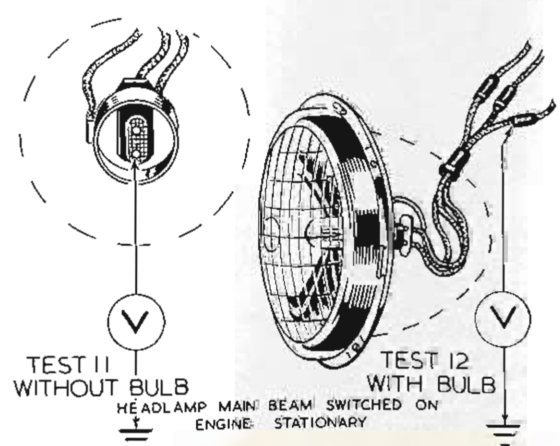
We returned then to the headlamps themselves, to make two tests at the cable ends. Both headlamp bulbs were taken out and the lighting switch moved to the " head " position (main beam). The voltage in the holder was measured with the engine stationary.

At the same time, the contacts were inspected for dirt, as this would prevent the full battery voltage from being applied to the bulbs, causing voltage drop and hence light lift.

We next inserted the bulbs and took two more voltage readings, as close as possible to the bulb contacts — in our case at the nearest snap connector.

The reading without bulbs was 12·3 volts and with the bulbs lit 11·8 volts.

This was a normal drop for the correct wattage bulbs — and this is a point we would like to stress: make sure the bulb wattage is not excessive, i.e. that specified bulbs are fitted. Bulbs with excessive wattage can easily cause light lift.



TESTS 13 AND 14. COMPLETE CIRCUIT

The final tests we made checked the wiring for voltage losses due to high resistance connections, lengths of cable of insufficient section to carry the current, bad earths, etc.

We tested the insulated line first, with a voltmeter between the generator " D " terminal and the cable ends at the headlights — with the lighting load switched on and the engine running.

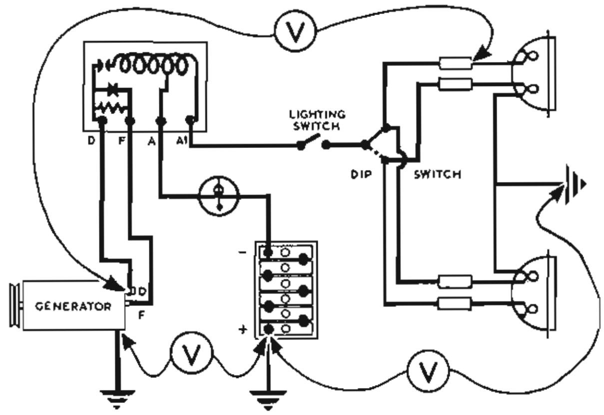
Our reading was exactly 0·5 volt, which we consider the maximum permissible voltage loss on the insulated line.

If the reading had been higher we should have had to test with the voltmeter across every connection in the line to locate the loss.

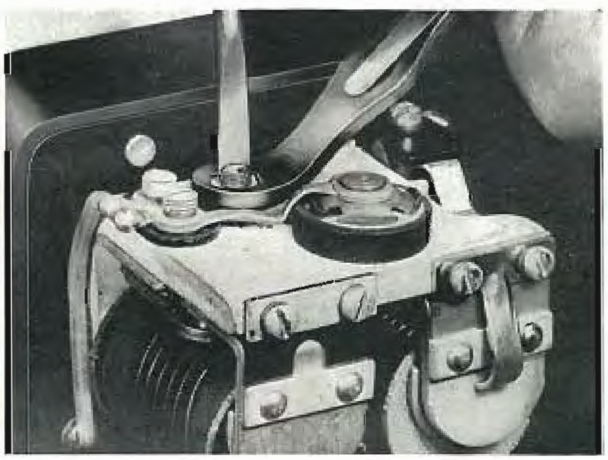
Two tests were necessary on the earth side, the first between the generator earth, that is, the body of the machine, and the battery earth post. Then from battery earth to the headlamp earth — the lights were still on in each case.

No voltage drop was recorded on our meter, proving that the earth connections were sound.

Again 0·5 volt loss is the maximum allowed.



VOLTAGE DROP TESTS WITH ENGINE RUNNING & LIGHTING LOAD ON.
TEST 13 INSULATED LINE.
TEST 14 EARTH LINE



OPEN-CIRCUIT SETTING ADJUSTMENT

Having checked the complete circuit, we corrected the faults we had found.

The regulator open-circuit setting was dropped to a mean figure of 16·0 volts and the light lift again measured as at the beginning of the procedure.

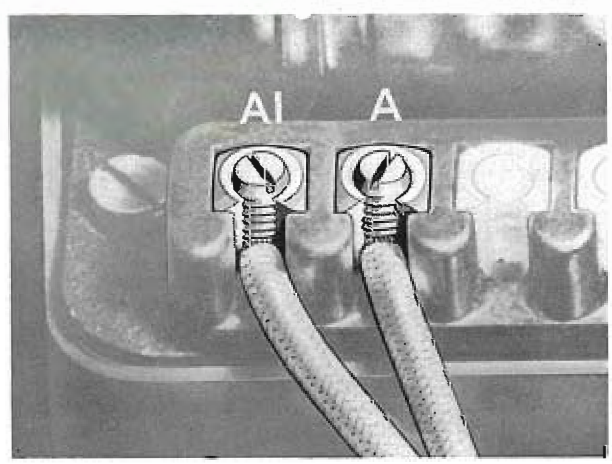
The readings were 11·75 volts with the engine stationary ; and 12·5 volts with the engine running. This worked out at 0·75 volt difference, which meant that we had slightly reduced the voltage rise causing the light lift.

RE-CONNECTING THE A AND A1 LEADS

We then changed over the A and A1 leads, connecting them correctly at the control box.

This had an appreciable effect. The difference in voltmeter readings was now only 0·25 volts, with the engine idling in the one case and revving hard in the other.

In a darkened room, the difference in the light intensity was hardly noticeable, quite within normal limits.



SUMMARY OF TESTS

This summary will give you an overall picture of the test procedure. It can be shortened with experience—for instance if a fault is found early on, rectify it and check the result.

But carrying out the whole procedure in this logical order will test the vehicle completely, ensuring that no fault is overlooked.

TEST PROCEDURE ——— LIGHT LIFT

VOLTAGE AT CABLE ENDS, WITH BULBS:
1 ENGINE STATIONARY
2 ENGINE RUNNING

3 TEST BATTERY—S.G. & H.R.D. TESTS.

BATTERY TERMINAL VOLTAGE:
4 ENGINE STATIONARY —
5 ENGINE RUNNING —
6 ENGINE RUNNING + FULL LOAD

REGULATOR O/C VOLTAGE:
7 NO LOAD —
8 FULL LOAD —

CLOSED CIRCUIT VOLTAGE:
9 NO LOAD —
10 FULL LOAD —

VOLTAGE AT CABLE ENDS, ENGINE STATIONARY:
11 WITHOUT BULBS —
12 WITH BULBS —

VOLTAGE DROP TESTS, ENGINE RUNNING:
13 INSULATED LINE —
14 EARTH LINE —

TESTS 1 & 2 SHOULD BE REPEATED AFTER EACH FAULT CORRECTION.

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Section 8

WINDSHIELD WIPERS — HORNS — SEMAPHORE AND FLASHING LIGHT DIRECTION INDICATORS — INTERIOR LIGHT CIRCUITS

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

INTRODUCTION

The electrical components on the modern vehicle, loosely described as " Accessories " are in fact " Auxiliaries " and of such importance that a vehicle may be completely inoperative if for any reason one or other of them fail to function or, at the least, some of the pleasure and refinement of driving is lost. Accessories are really those units applied as after-sales fitments such as extra Lamps, Mirrors, etc. Considered individually the auxilliary units and their associate circuits are very simple, but in view of their frequently masked and inaccessible positions on the vehicle they are not fully appreciated.

One of the auxiliaries, of outstanding importance, is the windshield wiper. On the fast modern car it is frequently subjected to very heavy loads and sustained periods of working. The body contours and construction of a vehicle often make correct and frictionless alignment of the driving mechanism difficult. Occasionally too, it is subject to distortion on the vehicle assembly line. Some detailed attention has to be given to these obscure causes of unsatisfactory operation in service.

The auxiliaries are connected through fuses in two groups, firstly those which are required only when the engine and vehicle are in motion, being supplied with current through the ignition switch ; the remainder being so connected to the current supply that they may be used when the vehicle and engine are stationary.

The reason for dividing the auxiliaries into two groups is primarily because all the components concerned with the running of the vehicle are only required when in motion, so by connecting them through the ignition switch they cannot be inadvertently left on when not required, whereas the remainder may be required at any time and consequently the supply is direct from the battery to their individual control switches.

Fuses are installed in the auxiliary circuits because, owing to their wide dispersal over the vehicle, they are more susceptible to wiring troubles than the main cable harness itself, and also because after-sales accessories are frequently wired in a haphazard manner which makes them vulnerable to short circuiting and other troubles.

All told, there is no single factor of more value in building customer goodwill, and increasing business, than that of the individual electrician, being looked upon as a competent expert by the customer. A careful study of the whole range of units covered in this book will do much to place you in this desirable category.

JOSEPH LUCAS (SALES & SERVICE) LTD., BIRMINGHAM, ENGLAND.

CONTENTS

THE CW WIPER — EXTERNAL VIEW WITH ARM AND BLADE

The type CW wiper is widely used as an accessory as well as initial equipment on certain models of vehicles.

Available in THREE models for both 12 and 6 volt working the model CW1 is supplied for top of screen mounting and the CW2 for BOTTOM screen mounting.

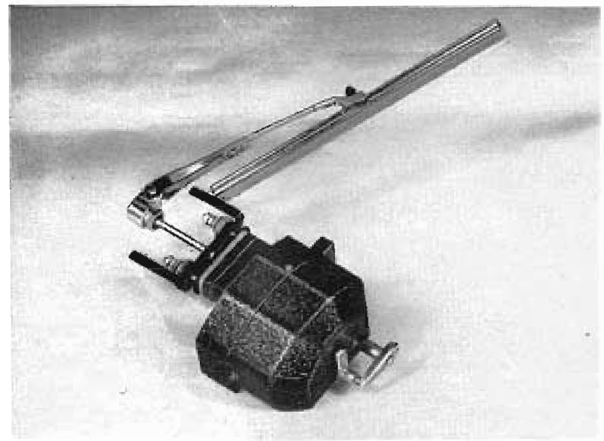
The CWX is built as a universal model for either top or bottom fixing and can be advantageously stocked as a general service replacement.

Control is obtained by means of an on-off switch and parking handle which form an integral part of the unit. Covers are designed to provide parking of the blades on either side of the screen.

The popular arrangement is a ' three ' hole fixing. The spindle emerges centrally and the motor is held by two studs one on either side.

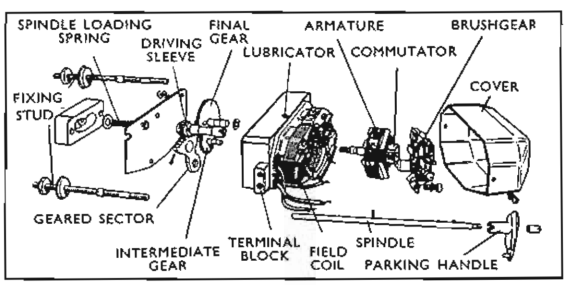
Packing pieces and adaptor blocks are available. The latter when fixed to the motor enables the assembly to become ' single ' hole fixing.

The normal wiping angle may be either 130° or 150° but models with special angles have been produced to suit vehicle makers' requirements.



The wiper arm and squeegee are fixed to the spindle by means of a quickly detachable split collet incorporated in the boss of the wiper arm.

There is a range of both arms and squeegees, the latter varying from 6″ to 9″ in length to suit different size screens.



THE CONSTRUCTION OF THE CW WIPER

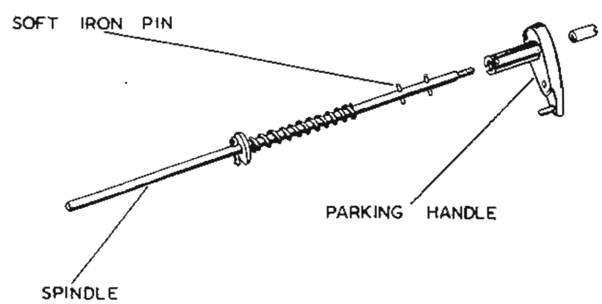
This illustration will give you an idea of the construction of the CW. The motor assembly is on the right and the gearing on the left.

We shall be examining both of these sections in greater detail later.

THE SAFETY DEVICE

One feature of the unit is not generally known, and that is that the motor is provided with a safety device against shock. A small soft-iron pin, passing through the motor spindle, forms the driving member. This pin shears if for some reason the spindle is prevented from turning with the motor still taking current. The shearing of the pin prevents the motor from burning out, or stripping some of the teeth in the gear wheels.

Now for a closer examination of the motor itself.



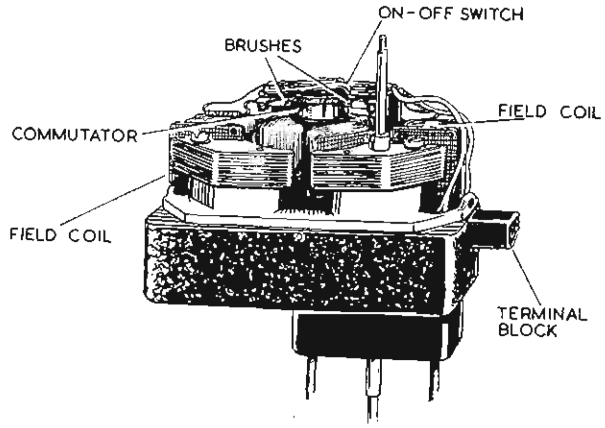
THE CW MOTOR

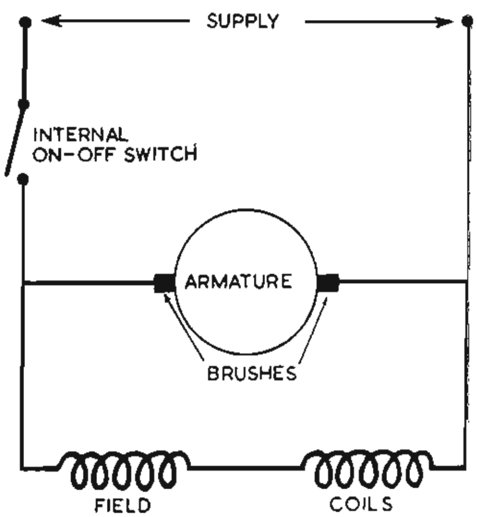
The motor consists of a three-pole armature running in a two-pole shunt wound field. The two field coils are wound on laminated iron formers and connected in series, producing two magnetic poles.

The armature comprises a laminated iron core carrying three windings, thus forming three magnetic poles.

Field and armature windings are in parallel with one another.

The ends of the windings are brought out to a terminal block on the right. The internal ON/OFF switch is built onto the brush gear, the operating lever being part of the cover assembly.





THE CW CIRCUIT

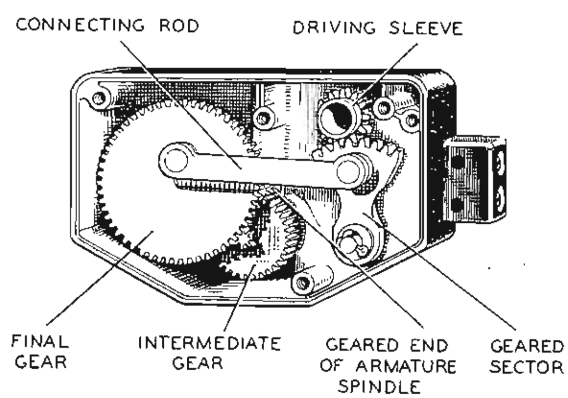
The current feed passes via this internal ON/OFF switch, through the brush gear to the commutator, round the armature windings and back to the other side of the supply. Both field coils are connected in parallel with the armature.

The supply will generally be taken from the A4 fuse to one side of the motor terminal block and from the other terminal on this block back to the E terminal at the Control Box.

THE GEARING

A small driving gear is fixed to the one end of the armature spindle. Let us now see how the drive is transmitted from this point to the wiper arm, which, in the driving position, is engaged to the driving sleeve.

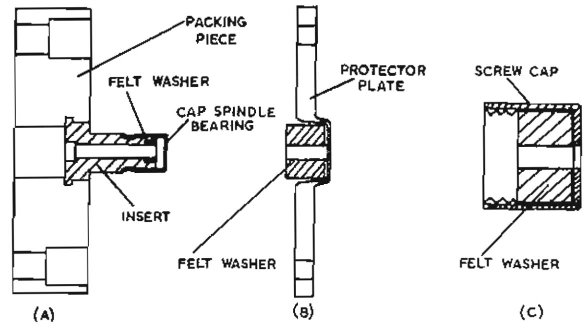
The drive is first taken up by the intermediate gear and transmitted by a pinion to the final gear. A connecting rod is pivotted eccentrically on this gear, converting the rotary movement with the help of the geared sector into the reciprocating movement necessary for the wiper arm. This drive is transmitted to the arm and blade when the parking switch is moved and the spindle engaged with the driving sleeve. The soft-iron pin we mentioned earlier is the actual engaging member.



WATERPROOFING

All wipers in the CW range are provided with adequate means for protecting the mechanism against the entry of water past the wiper spindle. The necessary felt and cork inserts are provided with the unit and must be used if the wiper is to give long and trouble free service.

We show several methods here of sealing the wiper spindle, and additional protective 'Langite' gaskets are available for waterproofing the fixing stud holes.



FITTING UP AND MAINTENANCE

No maintenance in the general sense is required in service. The gearbox is packed with Duckhams KEENAL Kg/25 grease at assembly. A spring ball lubricator is provided for the long armature bearing and a small quantity of oil may be inserted occasionally.

Care should be taken when setting up a new wiper to see that the water excluding devices are properly seated. If water should gain ingress to the gearbox the emulsified grease must be cleared out and the gear box re-packed.

Also when fitting up a new wiper the current supply should be taken from the A4 fuse, or in any earlier type of car installation, from the Ignition Switch in order that the supply is automatically cut-off when the ignition is switched off.

SERVICE FAULTS

The most common faults in service will be sheared driving pins resulting from shock load such as fouling the blade when cleaning the screen and bent spindles, causing seizing and overheating of the motor. Noisy operation usually is caused by general wear and tear.

Ingress of water causes loss of lubricant by emulsification and usually results from incorrect fitting.

Low torque will be due to worn brushes or bearings.

Normal current consumption :

12v.	..	1·8—2·5 amps.
6v.	..	3·0—4·0 „

Stall current consumption :

12v.	..	2·7—4·0 amps.
6v.	..	4·4—5·5 „

Heavy current consumption will indicate internal binding, or this fault may also be due to excessive pressure on blade to screen or spindle binding in screen aperture.

Low current reading will probably be due to worn brushes, or dirty and greasy commutator.

If ammeter test readings are unsteady suspect defective armature windings or faulty commutator.

GENERAL METHOD OF TESTING IN POSITION

Connect ammeter in circuit and switch on the wiper, take current reading.

If no current flows check A4 fuse. Using a voltmeter across the leads, check the supply from the wiper terminal block.

If voltage supply is normal but no current flowing, remove wiper for examination and service.

If no voltage at terminal block, the supply or earth return circuit is defective.

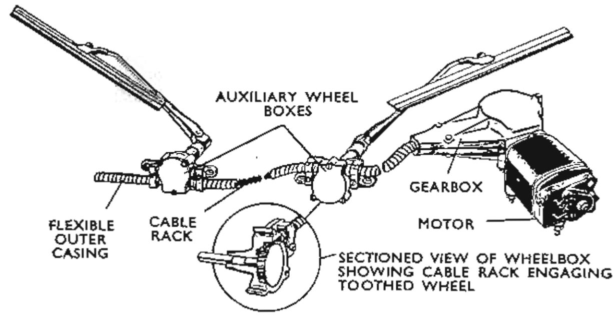
CR WIPER AND WHEELBOX ASSEMBLY

This illustration gives a general view of the CR type wiper, showing how the drive from the motor is transmitted to the wiper blades by means of a flexible rack and wheelboxes. There are two models, CR and CRT. The CR series covered by Nos. 1—7 provide a variety of wheelbox and switching assemblies together with a range of varying angles of wipe. The model CRT is similar to the CR, but incorporates a thermostatic overload switch which functions to stop the motor if, for any reason, the maximum safe working temperature is exceeded as a result of prolonged overloading.

The motor and gear box are mounted under the bonnet, whilst the wheelboxes are fitted at the bottom of the screen.

The drive to the wiper arms is obtained by means of a cable rack, comprising Bowden type cable over wound with a wire helix. This wire helix acts in the same manner as the teeth in an ordinary rack, and engages with the gear wheel attached to the wiper drive spindles mounted on the wheelboxes. The cable rack, as you can see, is enclosed in a flexible metal outer casing.

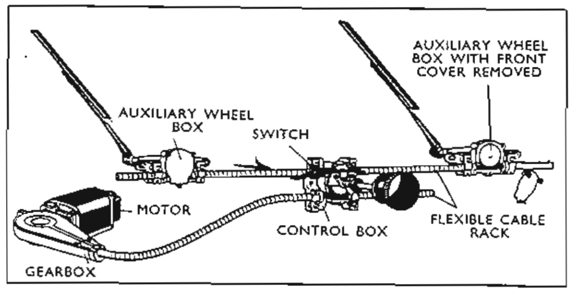
These motors are made for both 12 and 6 volt working ; the motor and its reduction gearing exerts a push of approximately 50 lbs. on the cable rack.



GENERAL ARRANGEMENT

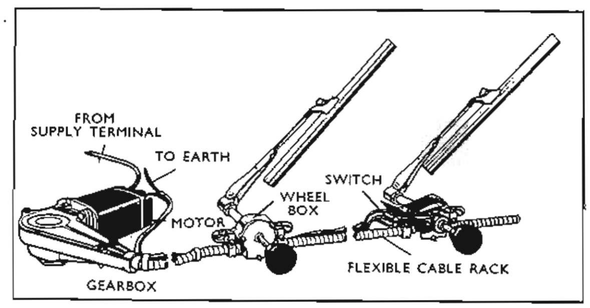
Sundry arrangements have been provided in order to fulfil the various requirements of the vehicle manufacturer.

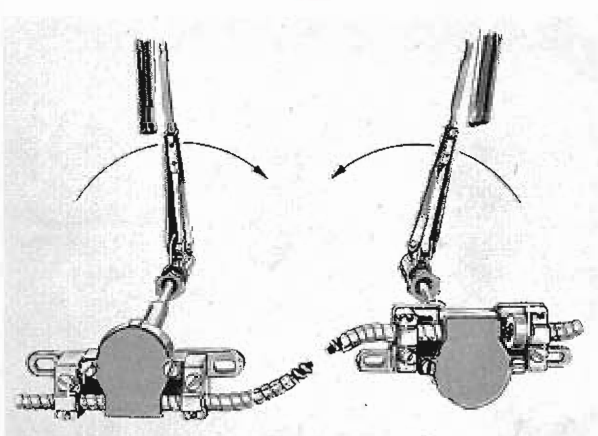
In the one illustrated the control box is mounted centrally — or may be off-set if required. It performs the dual function of simultaneously switching the motor on and off, and parking the blades at either end of the screen as may be desired.



AN ALTERNATIVE ARRANGEMENT

The arrangement illustrated in this picture provides for hand wiping and parking of either blade independently, the 'on and off' switch being incorporated in the wheelbox on the driver's side.





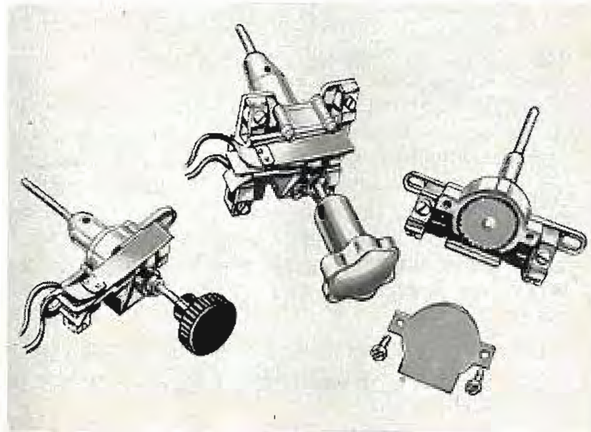
OPPOSED WIPING ARCS

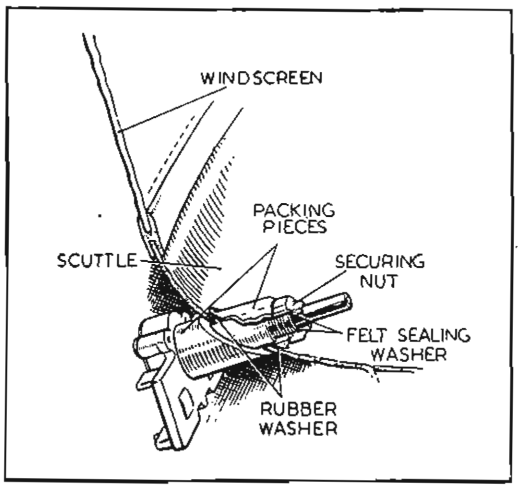
In both the above arrangements the wheelboxes are mounted over the cable rack, thus producing a parallel motion of wiper blades. If it is required to operate the arms towards each other, i.e., 'Clap Hands' arrangement, one of the wheelboxes will be mounted above the rack and the other one below it. Then, in order to obtain the desired angle of sweep it may be necessary to install a crank wheel with a different throw in the motor itself.

WHEELBOXES — ASSEMBLIES AND METHODS OF FIXING

There are one or two other features of the CR and CRT wipers which might be of interest.

This illustration shows a close-up of one of the earlier type wheelboxes used. It should be noticed that the two slotted ears are used for the fixing screws to the scuttle of the car, and two half clamps are installed to locate and hold the ends of the flexible outer casing of the cable rack.





WHEELBOX — SINGLE HOLE FIXING

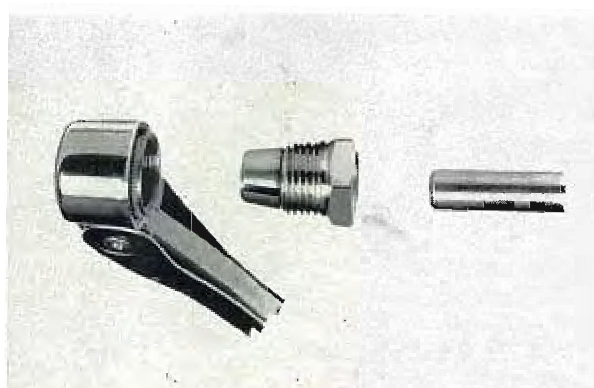
Another type of wheelbox assembly provides for single hole fixing by means of a securing nut as shown in this picture.

In order to make this arrangement adaptable to existing scuttle angles, several different sloping packing pieces and suitable rubber washers have been produced to suit individual vehicles.

WIPER ARM FIXING

This illustration shows a collet arrangement for fixing the wiper arm to the wheelbox spindle.

Several different versions of this system have been in use for many years.

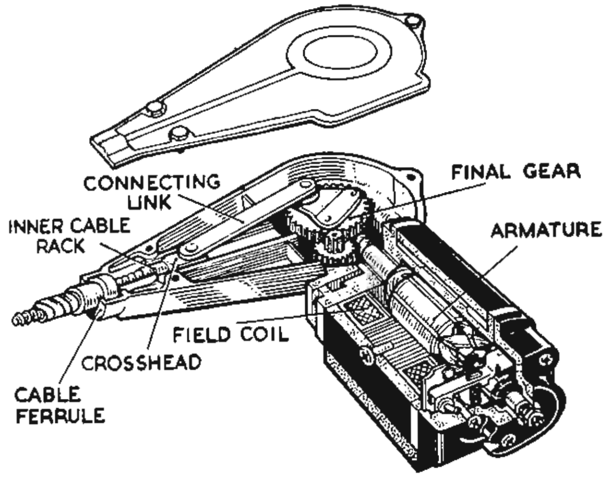


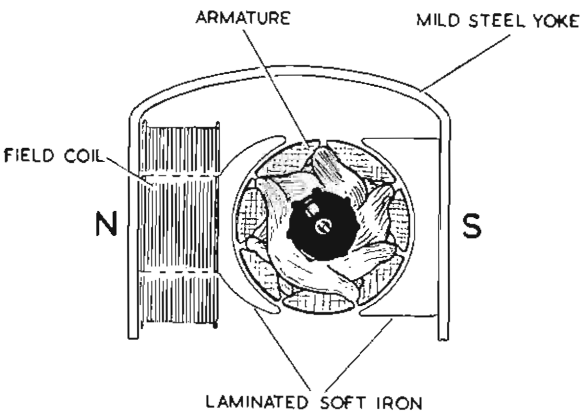
THE CR MOTOR AND GEAR BOX ASSEMBLY

The drive from the motor armature to the cable rack is obtained by means of a double reduction gear of approximately 72—1. The first stage reduction of 13 to 1 is obtained by means of a worm cut on the end of the armature spindle which engages with a worm wheel. This worm wheel is built integrally with a spur pinion ; the pinion engages with the final drive gear wheel, as shown, at a ratio of 61 to 11. A crank pin and connecting rod then transmits the drive to the crosshead on the cable rack. The number of wipes per minute will be approximately 90—100.

It should be noted that, altogether, six different wiping angles ranging from 105° to 150° are now used on the different makes of vehicles. The varying length of stroke being obtained by altering the throw of the crank. Thus to alter the angle of wipe it is necessary to change the final gear wheel in the gear box.

The silent running of this gearing can be maintained if the correct type of grease is used; that is, Duckham's Keenol KG25.





THE ECCENTRIC TYPE SHUNT MOTOR-MAGNETIC CIRCUIT

Commencing with the magnetic circuit of the motor it will be seen that the ' field ' is provided with one coil only situated on one side of the armature. The ' U ' shaped yoke of mild steel which forms part of the body of the unit completes the magnetic circuit, bringing the opposite polarity, the south pole in our illustration, to the other side of the armature.

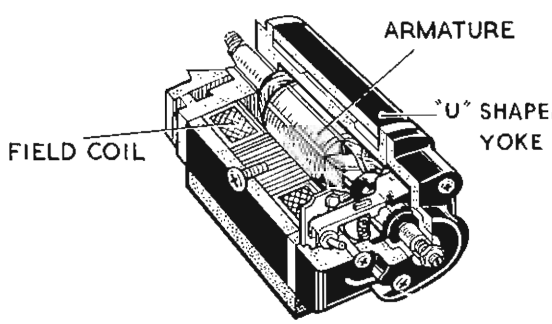
Incidentally, this type of construction is generally styled as an eccentric motor, the armature being off-set from the centre as shown.

SECTIONED MOTOR

In this cut-away section the actual layout is clearly shown.

You can see that the armature is mounted eccentrically in the body with the field coil at the side of it, and the ' U ' shaped yoke surrounding both components. Otherwise, the motor is of the plain shunt wound type, with the single field coil in parallel with the armature windings.

By contrast with the CW type wiper the ' on and off ' switch is a separate unit.

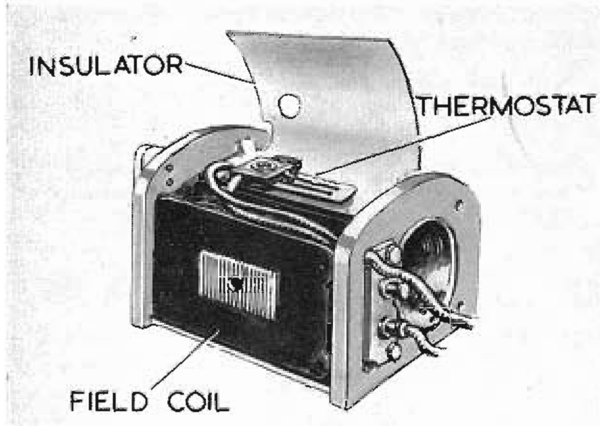


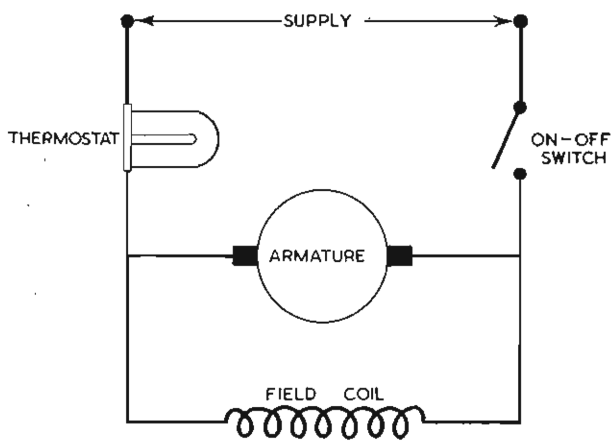
THE OVERLOAD CUT-OUT SWITCH

The CRT wiper incorporates a thermostatic cut-out switch as shown in this illustration, and this is the model now fitted to a great number of current production vehicles.

The fitting of the thermostatic switch in the original CR model was not necessary as the stall current of the motor was not so heavy. The CRT model, however, develops a much greater power with a correspondingly higher stall current.

Some form of temperature control was thus required to protect the windings against overload. Excessive current draw, with consequent overloading, can be caused by packed snow or ice on the windscreen, or by ' binding ' of the wiper spindles due to bad fitting — in fact by anything which unduly strains the motor.





THE THERMOSTATIC-CRT WIPER

The thermostatic switch is connected in the supply line to the motor and automatically breaks the circuit when the temperature rises to between 90° and 95° C., 194—203° F.

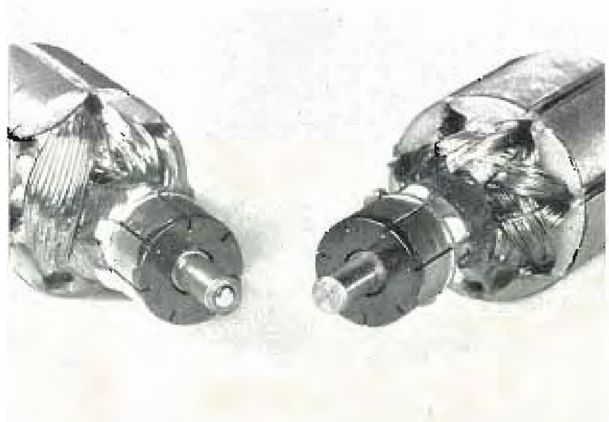
The switch will re-close automatically when the temperature of the motor falls to around 60° C. — 140° F. which is the ordinary running temperature.

Thus, operation of the thermostatic switch will stop the motor without warning and it might remain so stopped for several minutes, i.e., until the motor temperature drops, when it will re-start and continue at normal speed providing the main switch is left in the ' on ' position.

CR AND CRT ARMATURES AND FIELD COILS

The armature illustrated on the left of this picture is that used on the original CR wiper and is built with a steel thrust ball inserted in the commutator end of the spindle as shown.

The armature of the CRT model has a greater number of turns of wire in each of the seven armature slots and provision for thrust is made in a slightly different way with the result that a plain end shaft is used, as shown on the right. Therefore, these armatures are NOT interchangeable. Also, the field coils are not interchangeable.

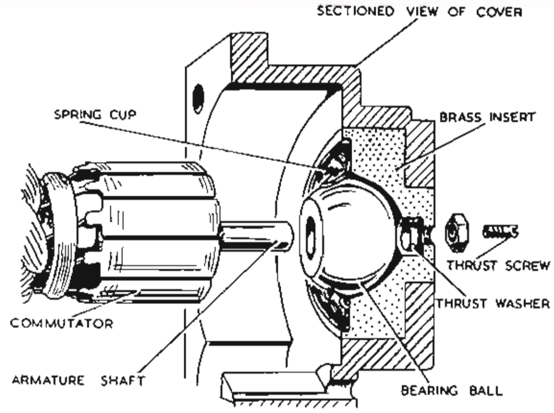


SELF ALIGNING BEARINGS

A novel feature of both the CR and CRT wiper motors is the self-aligning commutator end bearing as shown in the illustration.

The bearing itself is a ball, held in position by a spring cup as shown, thus ensuring that the armature is lined up with the front end bearing, and the thrust screw at the back.

This thrust screw is necessary by reason of the worm drive on the other end of the armature, and should be set so that the end float is just sufficient to allow the shaft to rotate freely.



WIRING CIRCUIT AND FAULT FINDING

It is general practice to wire the screenwiper circuit through the A4 fuse, thus providing master control from the Ignition Switch ; the object of this is to prevent the wiper motor being left in the ON position when the vehicle is out of use, with the consequent danger of running the battery down.

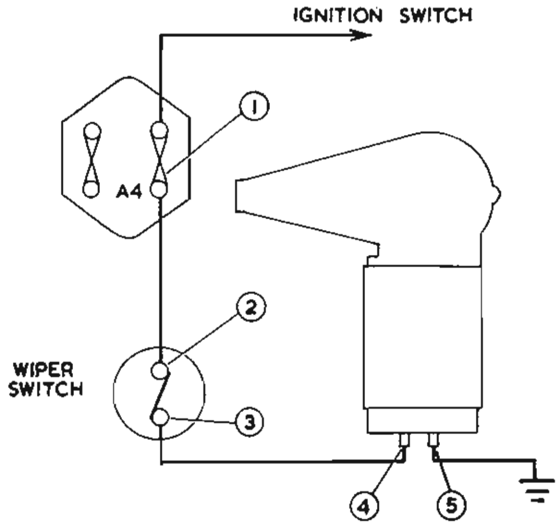
The typical circuit arrangement using a 14/·012 strand green master colour cable is shown here.

Electrical faults may be easily located by means of a voltmeter, and overloading, with consequent sluggish operation, by means of an ammeter.

In every case testing should commence with the obvious external possibilities such as defective Fuse or Fuse Clips, loose connections or defective switch, loose connections at the wiper motor and defective earth connections.

The whole systematic check should proceed in the order given.

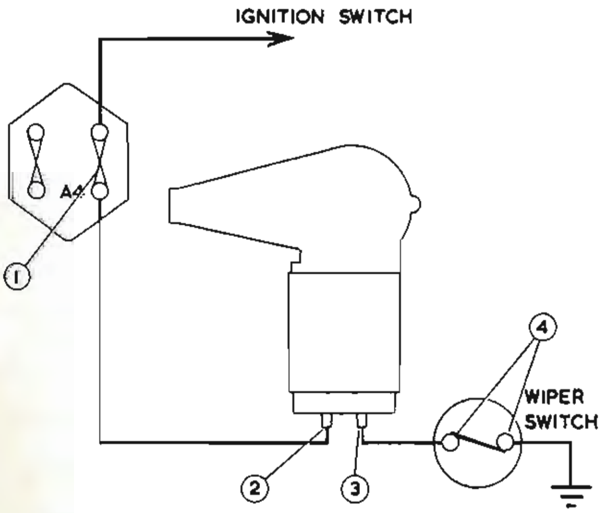
Start at point 1, the A4 fuse, one of the most likely trouble spots in the circuit. A quick check can be made by switching on first the ignition and then any other auxiliary fed from this fuse — for instance trafficators, stop lights, etc.



If none of these are operating, check the fuse. If this is intact, the supply to it can be checked with a voltmeter between the terminal and earth.

If a reading is obtained at A4, next check at the wiper switch. Voltage should be shown between either terminal and earth with the switch closed — i.e., at points 2 and 3 in our illustration.

Point 4 is the next at which a voltage reading should be shown. A zero reading should be obtained between point 5 and earth. If any reading is shown, examine the earth connection.



WIRING CIRCUIT AND FAULT FINDING (2)

In the circuit we have just examined you will notice that the switch is on the ' live ' side of the motor. Alternatively, and quite frequently, it may be installed in the earth side as shown in this picture.

The checking procedure is similar but the order of the voltage checks differs. The order in this case will be : point 1, the A4 fuse ; point 2, the motor supply terminal — at both points voltage should be registered.

With the wiper motor switched on, there should be no voltage reading between point 3 and earth ; nor between either of the switch contacts and earth.

CURRENT CONSUMPTION TEST

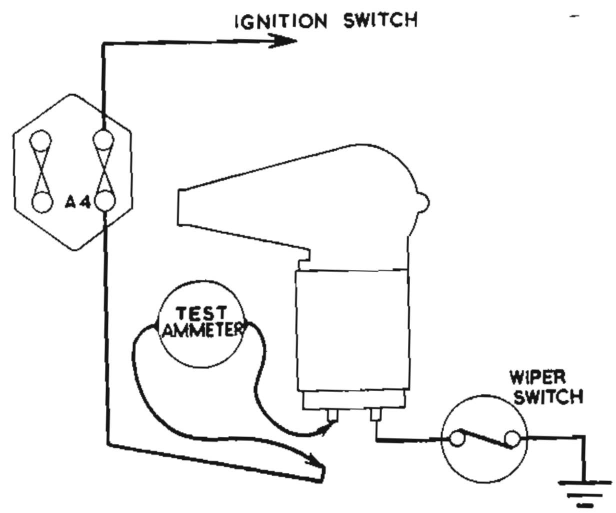
The normal running currents for these motors are a good guide to performance.

Excessive current readings will indicate that overloading exists at one of the following points :

1. Excessive blade pressure on the screen.
2. Binding at the spindles and wheel-boxes.
3. Binding at the rack or outer casing.
4. Partial seizure or other fault in the motor assembly itself.

An ammeter placed in the wiper feed as shown will give an immediate indication of any of these troubles which may then be localised, firstly, by removing the arms and blades and lastly, by disconnecting the motor assembly from the rack and trying the unit by itself.

Abnormally low current readings will, if the voltage is properly maintained, indicate that the motor brushes are either worn out or sticking, or if a heavy reading is accompanied by excessive drop in voltage, a short within the motor itself will be indicated.



NORMAL CURRENT CONSUMPTION

MOTOR COLD — DRIVING BOTH BLADES ON WET SCREEN.

	CR AMPS.	CRT AMPS.
6 VOLT.	3·5 - 6·0	4·0 - 6·5
12 VOLT.	1·75 - 3·0	2·0 - 3·25

NORMAL CURRENTS WITH COLD TEMPERATURE

The correct current readings with a cold motor driving both blades on a wet screen should be as shown in this tabulation.

Once the trouble is located to the motor assembly, an inspection can then be made, and any small faults such as dirty commutators, worn brushes, sticking brush levers or loose connections can be conveniently rectified without necessitating the exchange of any major components.

The opportunity should be taken to open the gear box cover and, if necessary, re-pack the wiper with the correct grease, Duckham's Keenol KG25.

After correction the motor should be re-tested. The current taken should then be back to normal and the specified speed of 90 to 100 oscillations per minute obtained.

MAINTENANCE POINTS

1. MOTOR & WHEELBOX FIXING
2. SPINDLE CLEARANCE
3. WIPER BLADE RUBBERS

MAINTENANCE AND FAULT FINDING

Very little maintenance is required to keep windscreen wipers in a serviceable condition.

All the moving parts are packed with grease before leaving the factory, and if periodic attention is paid to these other points, trouble-free service can be expected.

Make sure that the wiper motor fixing, and that of the wheelboxes is secure.

The next point follows from the previous one : if the wheelboxes have moved slightly, the spindles will tend to bind in the apertures, putting an undue strain on the motor.

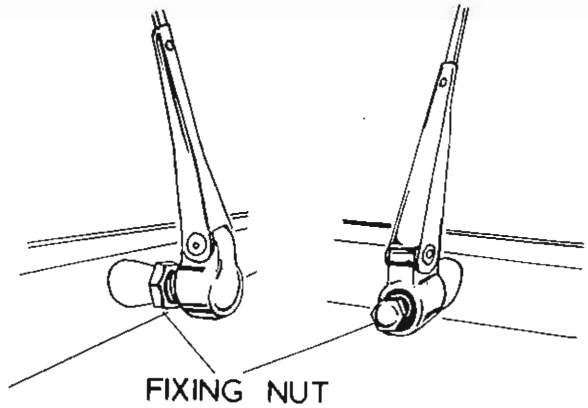
The next concerns the rubber of the wiper blades, which should be inspected occasionally, and the blades replaced after long service.

Dirt and grease tend to accumulate on the rubber and harden. This impairs the ' squeegee ' action of the blade, making clean wiping of the screen impossible.

WIPER ARM FIXING

If slipping of the wiper arm occurs, the trouble can usually be traced to the collet fixing. The hexagonal nut should be firmly tightened after the blades have been set to give the correct wiping arc on the screen.

At the same time, check that the hinge spring in the arm is not weak or broken.

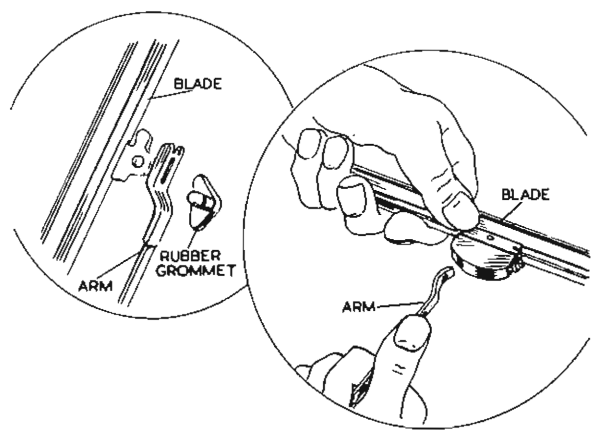


BLADE FIXING

And here are two of the usual methods in use for fitting the blades.

In the left-hand illustration, the rubber grommet secures the blade, whereas on the right it is held in position by a spring clip.

Both fixings permit side-movement or rocking of the blade, ensuring maximum contact with the screen over the full wiping angle.



THE DR1 AND DR2 WIPER MOTOR ASSEMBLIES

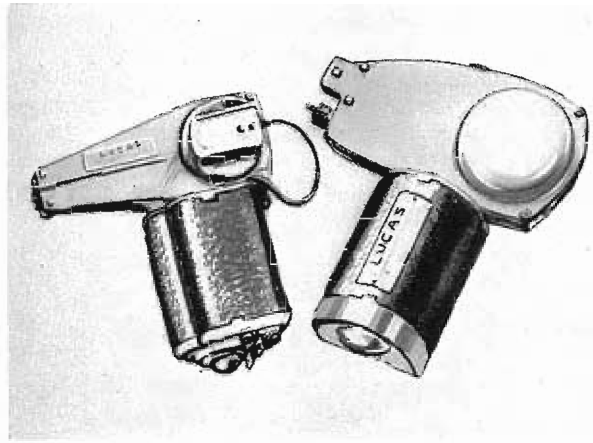
The DR series of complete Dual wiper assemblies are the latest additions to the Lucas range and are now being widely applied to current production vehicles of all makes.

There are two basic types, the DR1 which may be for either single or two speed working, and the DR2 single speed. Both models, which are made for 6, 12 or 24 volts are substantially more powerful than the earlier CR types.

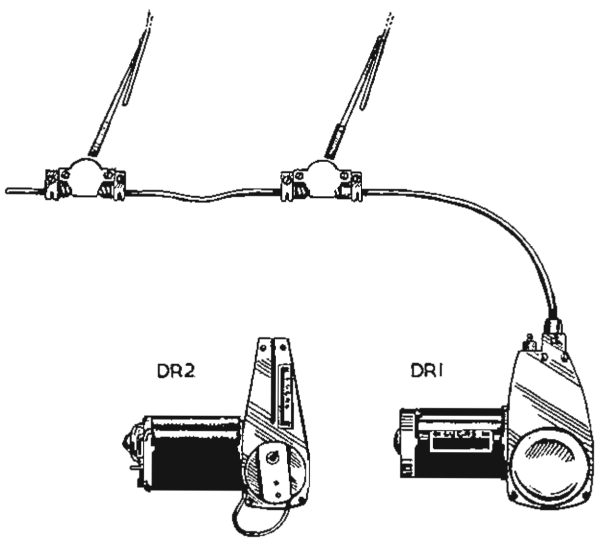
The two-speed arrangement has been developed specially for high speed vehicles which may be subjected to any conditions up to the proverbial tropical downpour.

Both of these wipers are so far arranged for automatic self-parking and are controlled by means of switches mounted on the facia panel.

The DR1 uses a rotary 3-position switch, and the DR2 a simple push and pull, 'on and off' switch.



DR2 DR1



THE DR1 AND DR2 GENERAL ASSEMBLY

The layout of cable rack, casing, wheelboxes, arms and blades follow the general pattern of the CR with certain differences.

In order to provide for the increased power it has been necessary to substitute the flexible metallic outer casings by rigid steel 'Bundy' Tubes. This is a ductile steel tube with a coppered lining and is attached to the motor and wheelboxes by 'flaring' the ends, and connecting to the motor by means of a 'union' type connection, and to the wheelboxes by means of clamp plates.

The wheelboxes themselves are cast assemblies on the DR1 model, and steel pressings on the DR2.

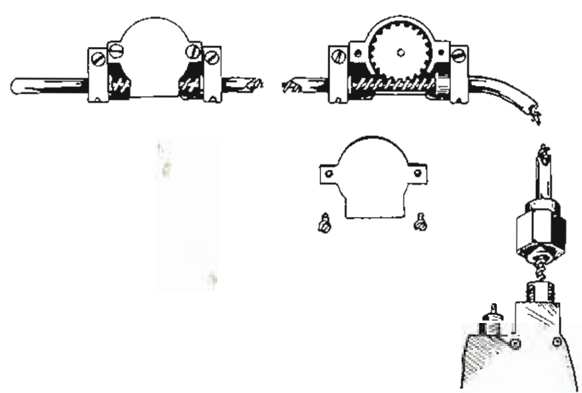
THE RACK DRIVE ASSEMBLY

A more detailed consideration of the wheelbox, motor and outer casing assembly is desirable.

Trouble free service is contingent upon the free running of the rack within the wheelboxes and the tube.

This illustration of the Bundy Tube layout will show clearly how necessary it is to have correct alignment throughout. Flattened sections or kinks in the rigid tube will cause binding and consequent overloading of the motor and care must be exercised when fixing the assembly.

Misalignment of any of the components is also liable to cause binding, the junction of the motor assembly to the Bundy tube being one of the most vulnerable points.

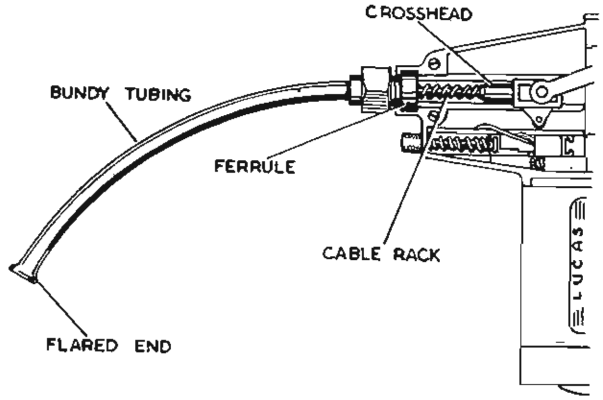


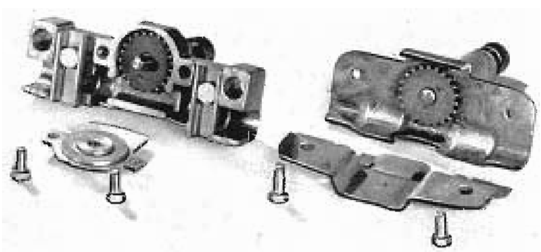
THE RACK DRIVE AND ATTACHMENT OF THE BUNDY TUBE

As seen on the left of the picture, the Bundy tube is ' flared ' for attachment by the clamp plates to the wheelboxes. The drive-end fixing centre is a ' union ' type attachment.

The flexible rack connects to the motor crank by means of the cross-head shown.

Parking adjustment is made by means of the limit switch with which we shall deal in detail at a later stage.





WHEELBOXES

Whilst following the general pattern of the CR type wheelboxes, the clamping arrangement varies in order to fix the Bundy tube properly.

The DR1 wheelbox shown on the left is of die-cast construction, and, as you can see, the flared end of the Bundy tube is located in the special recesses positioned between the rack wheel and the clamping plates.

The DR2 pressed steel wheelbox, on the other hand, uses the cover for clamping the Bundy tube in position.

The DR1 wheelboxes may be single hole fixing similar to the CR type, or may be located by means of two separate fixing screws as shown on the left.

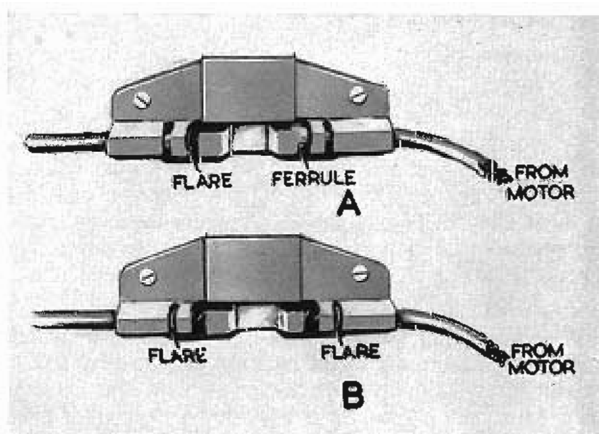
The DR2 wheelbox in the picture on the right is a one-hole fixing type only.

DR2 WHEELBOX BUNDY TUBE LOCATION

On the early production DR2's a ferrule brazed to the Bundy tube on the primary length from motor to wheelbox was arranged to locate in the space next to the rack wheel as shown at ' A ' in the illustration.

On later production the use of the ferrule was discontinued and the end of the tube ' flared out.' The correct position of the flare is then in the narrow space as shown at ' B.'

In the lower picture it can be observed that the flare on the inter-connecting section of tube may also be located in the narrow space, but this is immaterial.



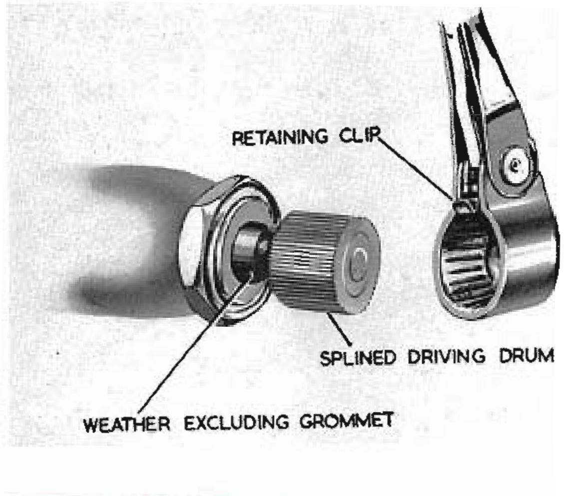
WIPER ARM FIXING

Another departure from the earlier CR arrangement is the method of locating and locking the wiper arm on to the wheelbox spindle.

In both the DR1 and DR2 a splined drum is pressed on to the wheelbox spindle, and mates with the splined hub of the wiper arm. The arm is locked by means of the retaining spring clip as shown. In order to remove the wiper arm it is only necessary to lift the spring clip by means of any small lever and withdraw the complete arm.

It should be noted that the splines are arranged at 5° intervals to enable the arm to be placed in any desired parking position.

It may also be noted that the wheelbox spindle is grease packed on assembly, and embodies a weather excluding grommet as shown.



THE DR1 MOTOR ASSEMBLY

We may now examine the DR1 motor and gearbox assembly.

To summarise the characteristics of this TWO speed arrangement.

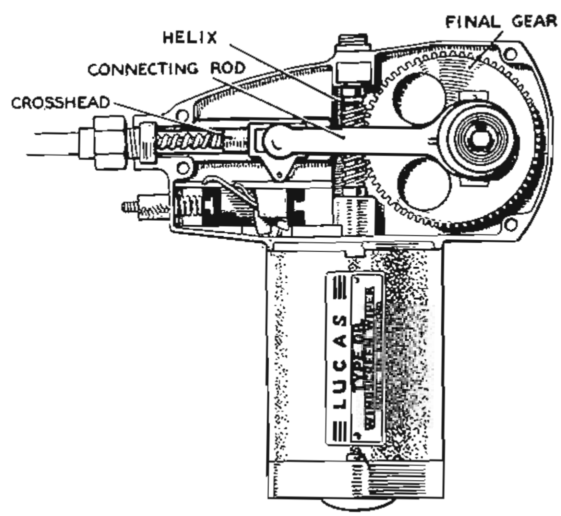
1. It is produced for 6, 12 and 24 volt working.
2. Has " NORMAL " wiping speed of 90—130 wipes per minute and in the " HIGH " speed 130—150 wipes per minute.
3. The high speed is obtained by weakening the motor field by means of a resistance inside the motor, and a combination switch mounted on the facia.
4. The angles of wipe will vary between 90° and 130° as specified by the vehicle manufacturer.
5. Parking is available at either end of the stroke as may be desired.
6. A thermostatic cut-out switch built into the motor is provided to prevent damage if persistently overloaded for any reason such as heavily packed snow or ice.

DR GEAR MECHANISM

This view of the inside of the DR1 gear box shows the gearing. In some ways it is simpler than either the CW or the CR wipers.

A worm cut on the end of the armature spindle engages with the worm wheel as shown, providing a reduction ratio of 42½ to 1. This worm wheel in turn mounts the crank pin which connects directly to the crosshead of the driving rack. A screw type adjustable Thrust Pad for the worm spindle will be seen at the top.

A self-parking switch is located at the bottom left and is adjustable for exact parking position by means of the screw and knurled nut shown on the extreme left. This parking switch is actuated by a striker fixed to the crosshead.



THE SELF-PARKING MECHANISM

Let us now make a closer examination of this self-parking device.

The requirements are that the wiper blades park automatically on whichever side of the screen may be determined by the vehicle manufacturers, and also they can be adjusted to stop at any desired position in relation to the bottom of the screen.

To do this, a simple blade type switch "A" is located in a slide as shown.

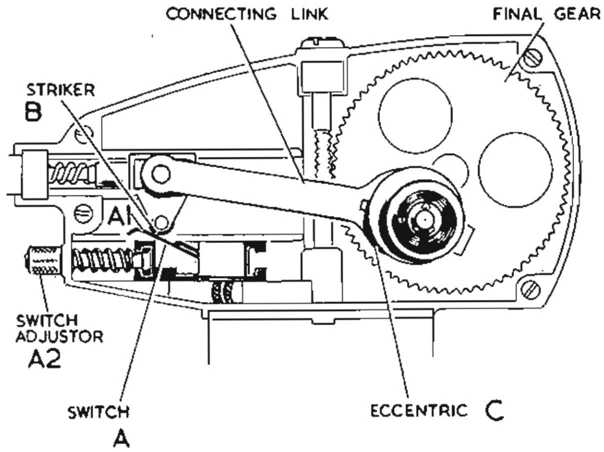
With the motor running normally the striker roller 'B' on the crosshead will NOT come into contact with the switch blade 'A1'.

To stop and park the wiper blades the first operation is to reverse the direction of the motor by means of the main switch on the facia panel inside the car.

When reversal of the motor rotation commences an eccentric cam 'C' on the crank pin causes the driving rack to move further outwards than when running normally.

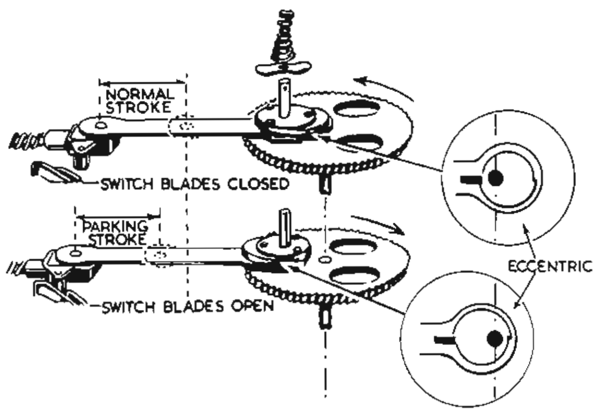
The striker roller 'B' on the crosshead then contacts the switch blade 'A1' and stops the motor. This stoppage will always take place at the end of the stroke.

The exact stopping position is determined by means



of the adjusting screw shown at 'A2' and this adjustment can be varied at any time in service.

If the wiper blades are to be parked on the opposite side of the windscreen two things are necessary. Firstly, the motor armature connections must be changed over and secondly the switch assembly 'A' must also be changed over. That is, with the blade 'A1' facing inwards towards the final gear.



THE ECCENTRIC CAM

This illustration shows in some detail the eccentric cam between the crank pin and the connecting rod.

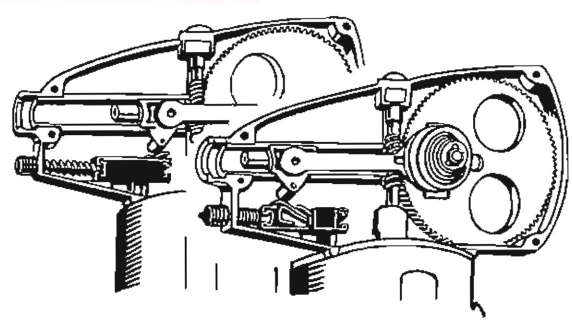
The top picture illustrates the normal stroke path of the connecting rod which is coupled to the driving rack.

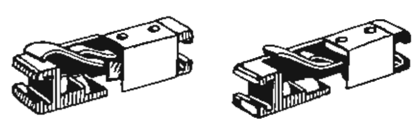
When the panel switch is moved to the 'Park' position, the direction of rotation of the motor is reversed. The eccentric cam as shown in the lower picture moves through half a revolution, and the stroke path of the connecting rod will then be moved along sufficiently for the striker on the crosshead to open the contacts of the Limit Switch and thus stop the motor.

ARRANGEMENT OF OPPOSITE PARKING POSITIONS

The top illustration clearly shows the layout of the 'PARKING' or 'LIMIT' switches for stopping the wiper either on the left or right hand side of the screen, also the knurled nut for setting the final at-rest position in relation to the bottom of the screen.

The smaller illustration gives a fair idea of the switch assembly itself, the latest model on the left having the end of the blade extended by comparison with the early type.



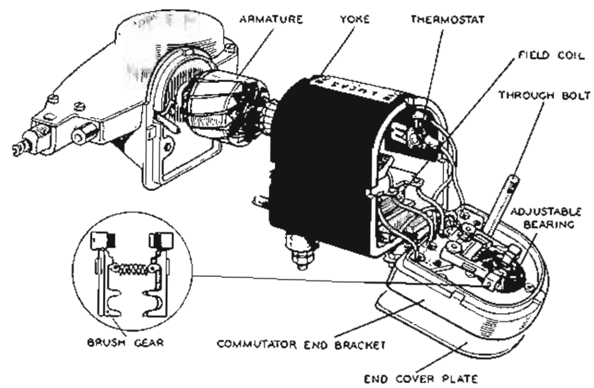


THE DR1 MOTOR

The main features of this motor, both magnetically and electrically are similar to that of the CRT model which has already been reviewed. It is an eccentric machine, the armature being offset from the centre. The field is provided with one coil only, located below the armature. The 'U' shaped yoke of mild steel, which forms part of the body of the unit completes the magnetic circuit, bringing the opposite polarity, the south pole, to the other side of the armature.

The armature itself is supported at the commutator end by a self-aligning bearing of the type used in the CR model. There is also a bearing bush between the motor and gear-box, and at the outer end of the shaft an adjustable stop is provided to control end movement.

A thermostat wired in series with the armature is mounted on the inside of the yoke near to the second pole-piece. It consists of a bi-metal strip and contacts, which open when the temperature rise becomes excessive. In this way the motor is protected against overload.



An additional component is the resistance which is connected into the field to produce the speed increase for the High Speed wipe. This is over-wound on the motor field coil, and is brought out to the terminal board on the C.E. bracket as we shall see.

THE DR WIPER MOTOR CIRCUITS

As a simple commencement to a study of the circuits of the DR1 wiper arrangement we may trace through the motor circuits only.

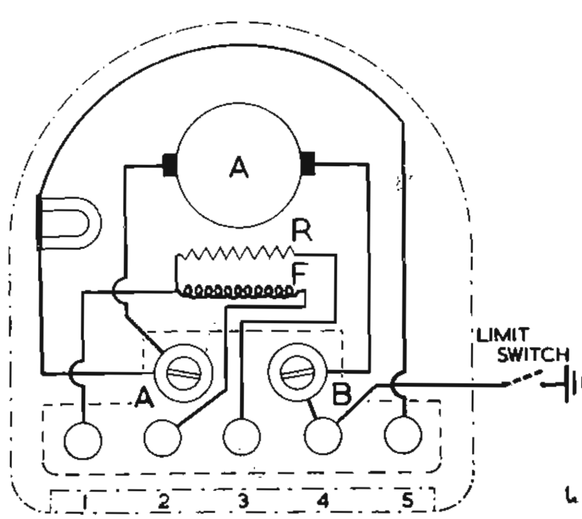
The motor itself may be considered to have four circuits: (1) The Armature Circuit; (2) The Field Circuit; (3) The Field with resistance in circuit, and (4) The Limit Switch circuit.

Commencing at the armature circuit the current path is from Terminal 5 through the thermostat switch to the brush terminal 'A', through the armature to brush terminal 'B', finishing at terminal 4.

The field circuit — from terminal 2 to one end of the Field Coil, through the field returning to terminal No. 1.

The field with resistance in circuit — from terminal 2 through the field coil to the junction point with the resistance, and from the other end of the resistance to terminal 3.

The gearbox limit switch is placed in the earth side of the motor circuit, and is as shown from terminal 4 through the switch contacts.



THE PRS5 SWITCH

A specially designed Rotary Switch arranged for single hole fixing — panel mounting — called the PRS5 provides three positions.

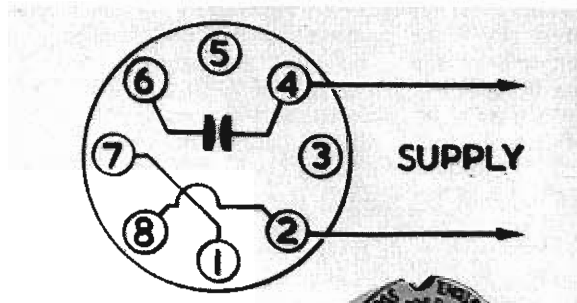
1. ' N ' — ' ON ' for normal running speed.
2. ' H ' — ' HIGH SPEED ' Wiping.
3. ' P ' — The parking position.

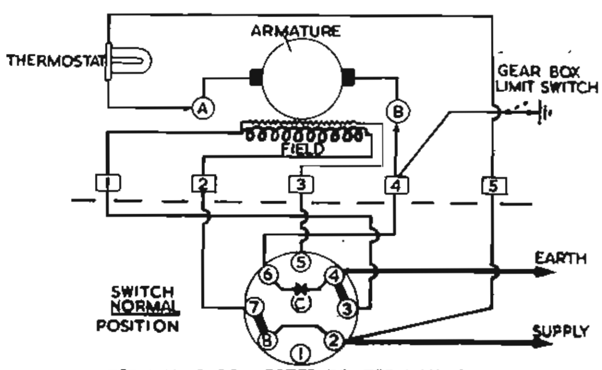
This comprises two components :

Firstly, a rotor with two contact segments which select the various running positions, and secondly a cam actuated contact breaker — a pair of points — which makes and breaks the motor earth connection for starting and stopping.

We have already stated that the motor may be considered to have FOUR internal circuits, and we can now state that the motor, the switch, and the current supply and return comprise three circuits.

1. From the supply through the switch when in the ' N ' position.
2. From the supply through a different combination of connections for the ' H ' position.
3. From the supply through a further combination of connections for parking and stopping.





TERMINAL 3 CONNECTED TO TERMINAL 4.
" 7 " " " 8.
CONTACTS Ⓒ CLOSED.

CIRCUIT No. 1 NORMAL RUNNING POSITION

Switching to the ' N ' position starts the wiper with the blades moving at normal speed.

The current supply is connected to the No. 2 terminal at the control switch. Here it divides, one path to the armature, the other to the field. Remember it is a shunt-type machine, with the two circuits in parallel.

We will deal with the armature circuit first. The supply is taken from terminal 2 of the switch to terminal 5 at the wiper motor. Then it continues via the thermostat through the brush at (A) to the armature ; the return is from the other brush at (B) to motor terminal 4, which connects to No. 6 at the switch. A pair of contacts, marked C, closed internally by the switch in the ' N ' position, completes the circuit via terminal 4, to earth.

Now the field circuit :— Starting from terminal 2 at the control switch which is permanently linked to 8, the switch rotor position for normal running connects to 7 ; the circuit path is then to No. 2 on the motor through the field to No. 1. From No. 1 then to No. 3 on the switch, across the other rotor contact to No. 4 and then to earth.

This circuit provides for screen wiping at normal speed.

HIGH SPEED POSITION

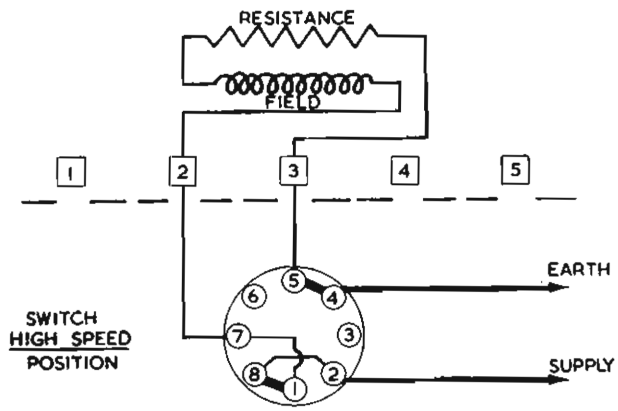
On switching to the 'H' position, high speed wiping is obtained.

This is brought about electrically by the insertion of a resistance in series with the field coil. You remember we pointed out this resistance winding on the field coil a few pages back. It has the effect of reducing the field current and hence the field strength of the motor. With the field strength reduced, the armature turns at a faster speed.

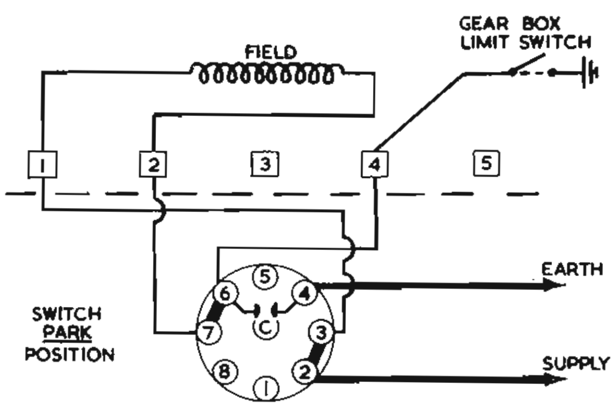
It should be realised that this increase of wiping speed is only obtained by a corresponding reduction in the motor torque. This in turn is compensated by a reduction in the wiper blade load due to the heavy flooding of the windscreen surface such as occurs in exceptionally heavy rain, tropical downpour, etc. If the high speed wipe is maintained under normal conditions of loading, the motor will eventually overheat and the thermostatic switch will finally stop it completely and it will remain stopped until the motor temperature again falls to normal.

Remembering that the armature circuit remains unchanged, now follow out the field circuit with its resistance in series.

Commence from the switch supply terminal No. 2. The current path is via the fixed link to (8), through the rotor segments to (1), through another fixed link to (7), direct to field terminal (2) on motor, through the field and its resistance to motor terminal (3). From there it passes to switch (5) through rotor segment to (4) direct to earth.



TERMINAL 8 CONNECTED TO TERMINAL 1.
" 4 " " " 5.



TERMINAL 2 CONNECTED TO TERMINAL 3
" 7 " " " 6
CONTACTS (C) OPEN

THE PARKING POSITION

This circuit shows the control switch turned to the 'P' or park position. The motor switches off, and the blades park automatically.

As far as the electrical side of the operation is concerned, the field circuit is momentarily reversed ; that is, the feed is in the opposite direction. The supply is now switched via terminal 2 and 3 of the control switch to the No. 1 terminal of the field winding, as opposed to No. 2 for 'normal' running. Current will thus flow in the reverse direction through the field circuit, reversing the rotation of the motor, but current will only flow as long as the earth side of the circuit is complete. The contacts 'C' in the control switch are open in this position, the only available earth being provided through the gearbox limit switch. You can follow this from No. 2 terminal of the field winding, through switch terminals 7 and 6 and on via terminal 4 at the motor, to the limit switch and earth.

If this switch contact is now broken, the motor will stop.

CIRCUIT TESTING—STAGE 1.

The Normal Running Position

Having examined the motor and switch circuits, we can now formulate a simple routine for testing either or both.

Assuming that our problem is an electrical one, the first thing is to localise the trouble to either the motor, the switch, or the wiring.

To do this the following procedure is recommended:

1. Check the current supply to the circuit. Commencing from the A4 fuse, this can easily be checked with the voltmeter.
2. Turn the switch to NORMAL running position. With the voltmeter, take readings at the wiper motor terminal block. We should expect to find full voltage readings between terminals 1 and 2 (Field) and terminals 4 and 5 (Armature).

This will indicate that the switch itself and its wiring to the motor is in order in the 'N' position. If a LOW voltage reading is obtained at the Armature terminals 4 and 5 it suggests that the motor is taking excessive current and will generally necessitate its removal. If 'No Voltage' is obtained from terminals 1 and 2 or 4 and 5 we can assume that an open circuit exists either in the switch, or its wiring, which can be traced by following the circuit shown in this illustration.

CIRCUIT TESTING—STAGE 2.

The High Speed Running Position

Having checked the wiring and switch for the normal running position, we can now move to the HIGH SPEED position of the switch.

For this condition we should have full voltage at terminals 2 and 3 (Field Resistance) and 4 and 5 (Armature) of the motor terminal block.

If NO VOLTAGE is obtained at either pair of terminals an open circuit exists in the switch or the wiring.

CIRCUIT TESTING—STAGE 3.

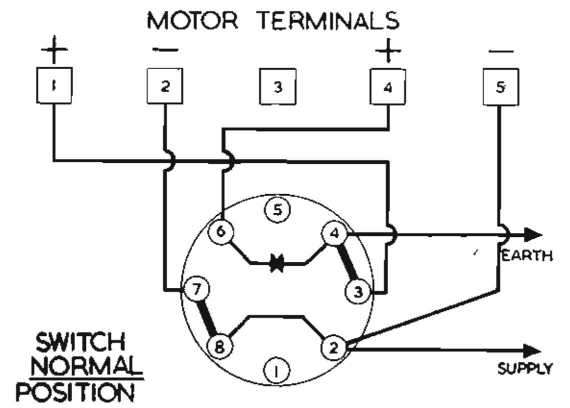
The Parking Position

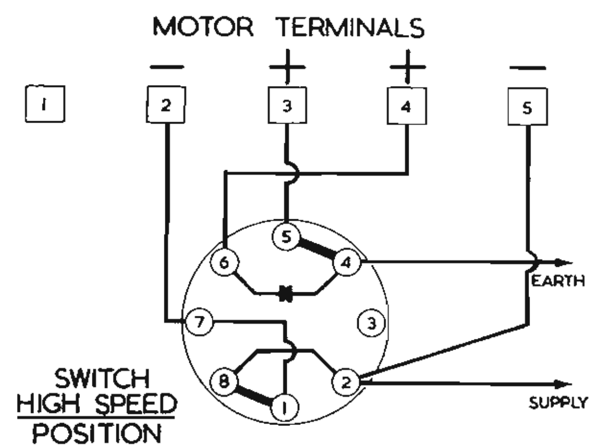
We can now check the circuit with the switch in the PARK position, which will also check the operation of the limit switch :—

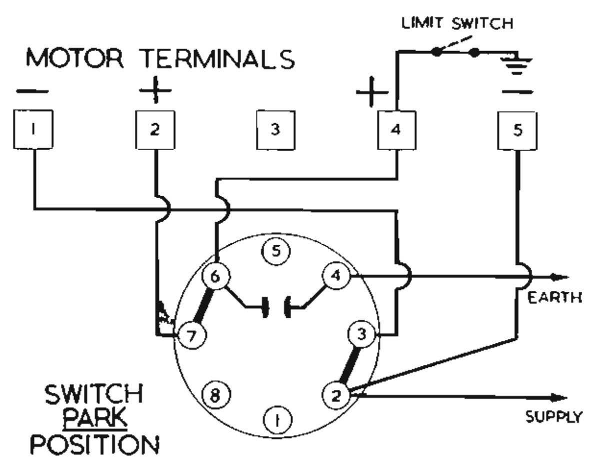
1. Connect voltmeter to terminals 1 and 2 (Field) at motor terminal block.
2. Turn switch to NORMAL position — Voltage reading sho=ld be obtained.
3. Turn switch onwards to the PARK position when polarity at terminals 1 and 2 will be reversed, the motor rotation will reverse and then the wiper will PARK at the end of the stroke.

If upon changing the switch from NORMAL to PARK the motor stops with no voltage readings at terminals 1 and 2, check the LIMIT SWITCH circuit and the EARTH to the motor body itself.

The circuits we have just examined are applicable to the DR1 wiper motor only. We can now tun to the more recent type DR2 motor and its circuit.







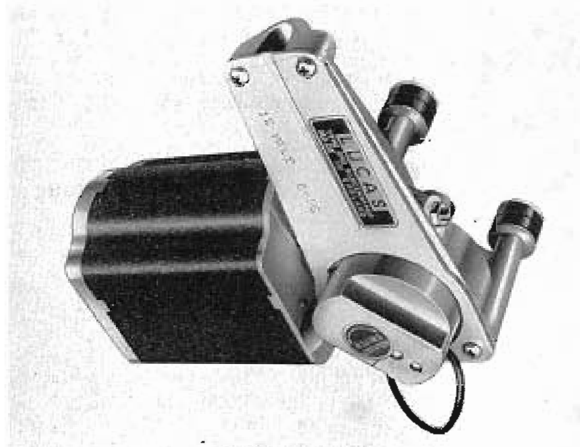
THE DR2 EXTERNAL VIEW

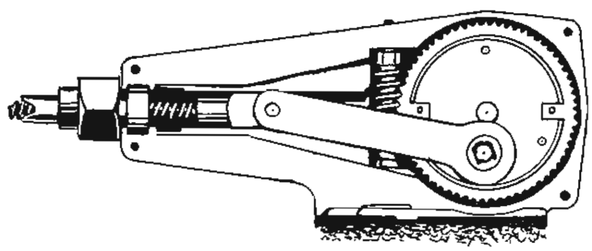
The DR2 is the new model in the DR range, being basically similar to the DR1, and designed to give approximately the same performance. It is suitable for 6, 12 and 24 volt working, with varying angles of wipe from 90° to 130°.

The models so far fitted to vehicles are constructed for single speed operation only.

The DR2 is not thermostatically controlled, since the motor is designed to withstand stall currents for a considerable time.

A different arrangement for self-parking allows a simple ON/OFF panel control switch to be used.


DR2 MOTOR

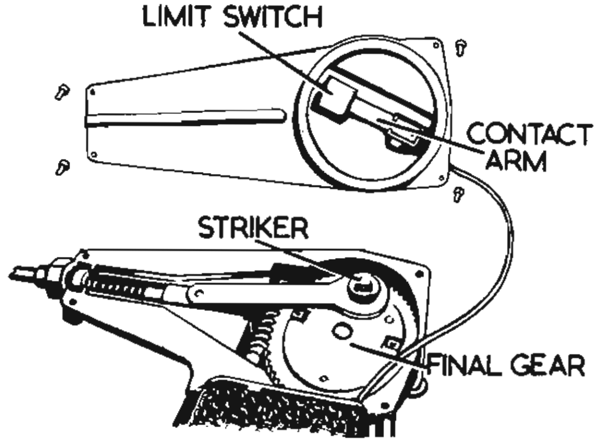


DR2 INTERNAL VIEW — VIEW GEAR BOX

Internally, the construction is very similar to the DR1. An eccentric type motor drives a single nylon final gear through a helix on the end of the armature shaft. Then the design becomes simpler than the DR1 ; there is no eccentrically mounted connecting link to give self-parking. Instead, a plain link transmits the reciprocating movement via the crosshead and cable rack to the wheelboxes. As with the DR1, the rack is housed in ' Bundy ' tubing.

SELF-PARKING ARRANGEMENT

Self-parking of the wiper blades is brought about by moving a simple panel control switch to the ' OFF ' position. With the switch in this position, the motor stops at the end of the wiper arm stroke by virtue of the limit switch shown here, which as you can see is built into the detachable cover of the gearbox. The contact arm of this switch is operated by the head of the crank pin which is an integral part of the final gear. This striker opens and closes the contacts once every complete revolution of the gearwheel.



LIMIT SWITCH CIRCUIT

This diagram will serve to illustrate the method of operation of the Parking Switch.

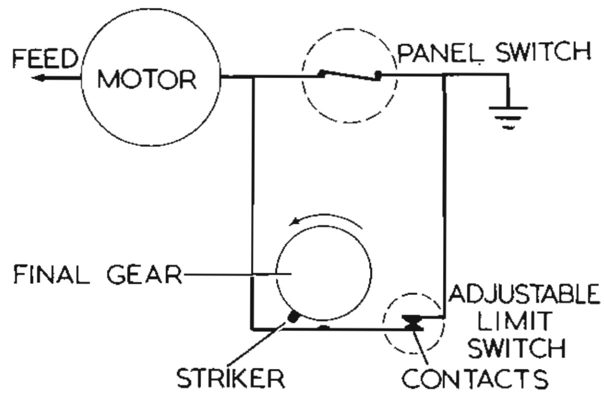
Consider the current path from the Motor to EARTH.

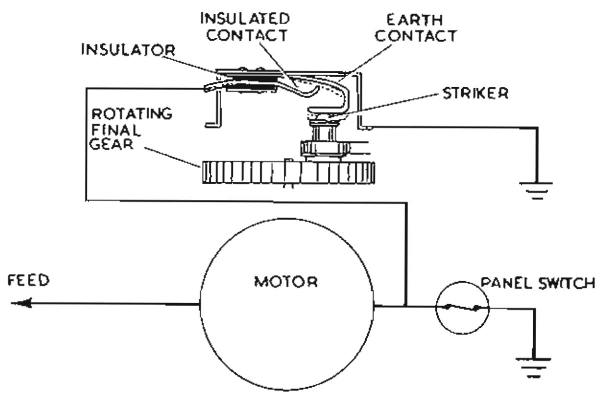
With the panel switch CLOSED the motor circuit is completed.

In order to park automatically a parallel current path and switch is placed in the circuit. To stop movement both of the switches must be open.

In order to stop the operation at any desired position of the stroke, the panel switch is first moved to the OFF position thus breaking one current path. At the end of the stroke a striker operates the blade of the limit switch, which will continue to open and close at each revolution of the crank ; this will not interfere with the operation whilst the panel switch remains in the ON position.

The panel control switch, when in the 'OFF' position, breaks the earth side of the motor circuit, the only remaining path to earth being a parallel one through the limit switch contacts. Thus the motor stops when these contacts are opened.





LIMIT SWITCH CONSTRUCTION

The construction and operation of the LIMIT switch will be apparent from this illustration.

Two spring blades are connected to the motor and the switch respectively as shown at the top, and are in contact until separated by the striker located in the head of the final drive wheel crank pin.

THE LIMIT SWITCH ADJUSTMENT

The limit switch is adjustable, enabling the correct parking position to be obtained.

The switch assembly is released by slackening off the four cover fixing screws. It should then be turned and set so that the motor switches off just after the blades have finished their downward travel and are starting the upward stroke.

It must, however, be remembered that this limit switch is correctly adjusted on the assembly line and re-adjustment should not normally be necessary.

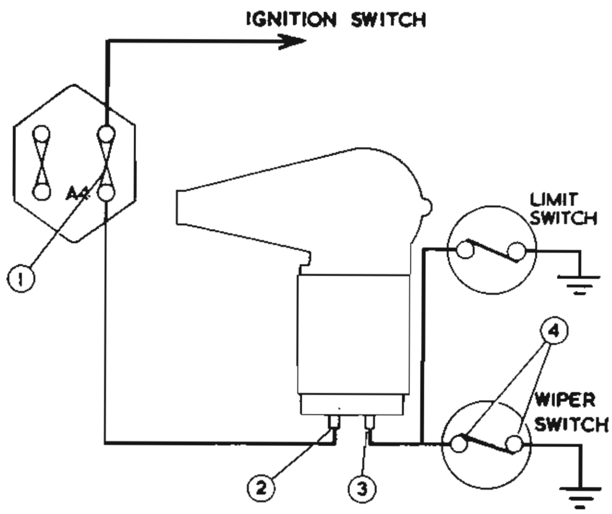
SERVICING THE DR2 WIPER

CIRCUIT TESTING — VOLTMETER TEST

Switch on the ignition and ascertain that current is available at the A4 fuse. This can be easily checked by the voltmeter. With the wiper motor switched OFF we should also have full voltage readings at the wiper motor terminals 2 and 3 in the picture. At the same time when the wiper switch (4) is moved to the ON position the voltage registered at (3) should disappear. If it does not, the wiper switch itself or the earth point is faulty.

If no voltage is registered at the points mentioned it is a simple matter to trace the open circuit by following the wiring sketch shown.

The voltage tests must be supplemented by current consumption tests as we shall now show.



NORMAL CURRENT CONSUMPTION

MOTOR COLD — DRIVING BOTH BLADES ON WET SCREEN.

	DR1 AMPS.	DR2 AMPS.
6 VOLT.	5·0 - 7·3	5·0 - 6·3
12 VOLT.	2·4 - 3·5	2·5 - 3·0
	(NORMAL RUNNING)	

THERMOSTAT SWITCH TEMPERATURES:	OPENS	135 - 150°C.
	CLOSES	80°C. MIN.

DR1 AND DR2 PERFORMANCE DATA

The correct technical data as shown above will be a very good guide in the event of any unsatisfactory performance.

For instance, any mechanical overloading will be reflected at once by abnormally heavy current consumption by the motor, with possible persistent overheating which may cause damage.

Equally, the approximately correct voltage readings are an infallible guide to defective fuses, wiring, terminals or earth connections.

To take a simple example :— Full voltage test readings, and zero, or very low current readings, would indicate at once badly bedded brushes in the motor, burnt commutator, or worn out brushes.

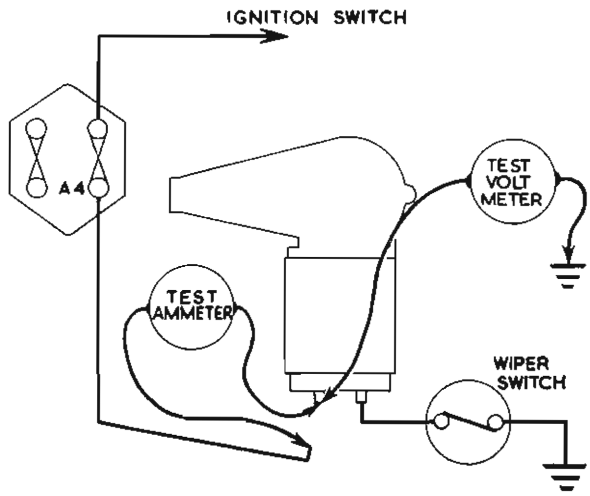
You will notice that the thermostatic switch is not fitted to the DR wiper.

On the DR1 this switch will cut out the operation if the motor temperature rises to between 135 and 150°C., and it will remain open until the motor temperature falls to 80°C., which may take several minutes according to under-bonnet and general prevailing conditions. It should be apparent that if the wiper switch is left in the ON position the motor will re-start automatically.

CIRCUIT TESTING — CURRENT CONSUMPTION

To measure the current consumption whether the motor in question is the DR1 or the DR2, an ammeter is inserted in the A4 feed (GREEN) to the wiper motor, as shown in our sketch. With the motor switched on, the reading shown will fluctuate slightly as the squeegee load varies, but a mean reading can be taken and checked against the chart already given.

It will be necessary at this stage, if the current consumption appears very high, to disconnect the rack from the motor and take a new set of figures. We shall discuss this in more detail.



SERVICING THE DR1 AND DR2 WIPER ASSEMBLIES

From the service point of view the following conditions of unsatisfactory performance may be met :—

1. Sluggish operation or complete seizure.

   Of the several possible reasons for this condition the most likely one is that of a greasy and fouled screen.

   Another is partial seizure of the driving rack resulting from misalignment of the assembly, or kinking or distortion of the Bundy tubing. Lastly, the trouble may rest in the motor and gearbox assembly itself.

In each case an excessive current will generally be taken by the motor in its effort to drive the blades at normal speed.

2. Electrical Faults :—

   True electrical faults are very infrequent but if they do occur they must obviously be either in the motor assembly, the wiring, or the switch, as distinct from the external mechanical faults to which reference has just been made and which may be sufficiently serious to damage the motor electrically if allowed to persist.

A methodical approach to fault diagnosis is essential if the CAUSE of any unsatisfactory performance is to be tracked down.

TEST PROCEDURE AND FAULT FINDING

Sluggish operation or seizure, usually indicated by excessive current consumption may be caused by :—

a. Low Voltage due to defective connections, particularly earth connections.
b. Cable Rack bind in the Bundy Tubing.
   This may result from flattening, kinking, or over sharp bends (should be 9″ minimum radius).
c. Excessive wiper blade loading due to fouled or greasy screen.
d. Wheel-box misalignment or spindles seizing in the bearing housing.
e. Mechanical or electrical faults in the motor and gearbox assembly.

To diagnose the cause of any of these troubles proceed as follows :—

1. Connect a test ammeter and voltmeter in circuit as shown in the last picture :—
   a. Connect test ammeter in series with wiper feed lead. (Green.)
   b. Connect test voltmeter across the green lead terminal of wiper and earth.
2. Switch-on the motor and check for low voltage. Should be 11.5 v. minimum. If lower, examine the fuse, re-make main and earth connections as necessary.
3. Remove both wiper arm and blade assemblies.
4. Switch on the motor and test for current consumption and speed of stroke.

	6 volt	12 volt
DR1	5·0 — 7·3 amps.	2·4 — 3·5 amps.
DR2	5·0 — 6·3 ,,	2·3 — 2·9 ,,

c.p.m.

DR1 Normal speed	90-98	(15 — 16 in 10 secs.)
High ,,	132-148	(22 — 25 ,, ,, ,,)
DR2 Normal ,,	90-100	(12 — 17 ,, ,, ,,)

   If the current take and the speed of operation is now correct the fault lies with a fouled screen. If the current reading remains excessive :—

5. Remove wiper motor gearbox cover and disconnect the driving crank from the crosshead as follows :—
   a. On DR1 Motors, remove the cotter-pin securing the connecting rod to the final gear and withdraw the connecting rod complete with eccentric coupling, conical spring and friction plate.
   b. With DR2 wipers, first remove the gearbox cover and secondly the circlip securing the connecting rod to the final gear. The connecting rod can now be lifted out.
6. With the cable driving rack now disconnected, switch on and test the motor independently, taking a current reading and also a re-count of the number of strokes of the crank pin.

   If it is then found to be correct we can safely assume the trouble to be in the Rack and Bundy tube assembly, or the wiper spindles and wheelboxes.

If the speed is still low replace the motor assembly or check following points :—

a. Armature binding due to thrust screw being out of adjustment.
b. Commutator end bearing out of alignment.
c. Short circuit on commutator due to carbon dust, etc.

TO CHECK THE BUNDY TUBE, DRIVING RACK AND WHEEL-BOX ASSEMBLIES

Sluggish operation or seizing in service is frequently caused by misalignment of the assembly or binding of the driving rack in the Bundy tube.

To test for correct cable rack clearance in the tube proceed as follows :—

If binding exists, the sections of the Bundy tube must be examined. To do this :—

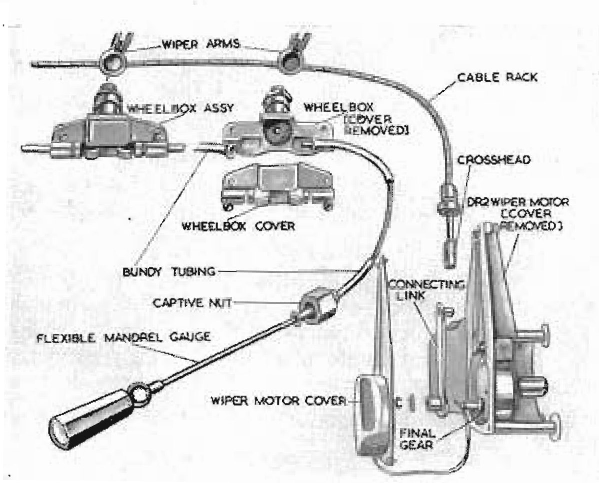
1. Remove arms and blades.
2. Remove wiper motor cover.
3. Extract connecting link between crosshead and final gear.
4. Withdraw cable rack.
5. Remove wheelbox cover.

Insert the Mandrel, which should move freely through each section of Tube.

If the bind is caused by flattening of the tube at a turn it may be possible to clear it by gently reforming the tube carefully in a vice.

If a ' kink ' exists, the complete section of tube will have to be replaced.

In some cases an *emergency repair* can be carried



out by filing away the ' kinked ' section by means of a suitable size half-round file. Care should be taken to remove frays from the cut-away edge of the bore and also to wash out all filings and lubricate all moving parts with Duckham's H.B.B. grease.

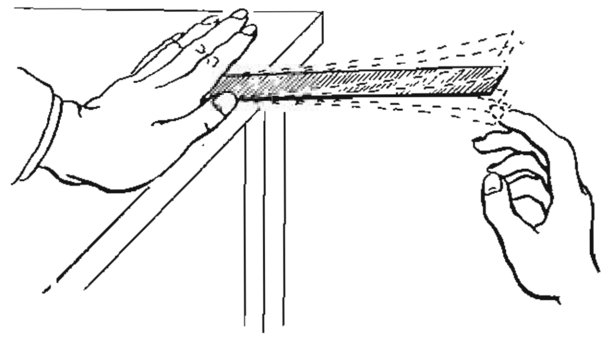
High Frequency Horns

WORKING PRINCIPLES

As the purpose of any horn is to produce an audible warning of approach, we must necessarily first spend a little time in examining the nature of sound and how it originates, before we discuss any of the modern production units.

THE PRODUCTION OF SOUND WAVES

Sound, as we know it, is the result of disturbing the air. All of you at some time must have been familiar with the effect produced by flicking a strip of metal held at one end. All that we are doing is disturbing the air, setting it in rapid motion in the immediate vicinity of the strip. The disturbance set up by such mechanical vibrations are transmitted in wave form through the air. The human ear is capable of detecting these ' sound waves ', rendering them audible.



EXAMINATION OF WAVE FORM

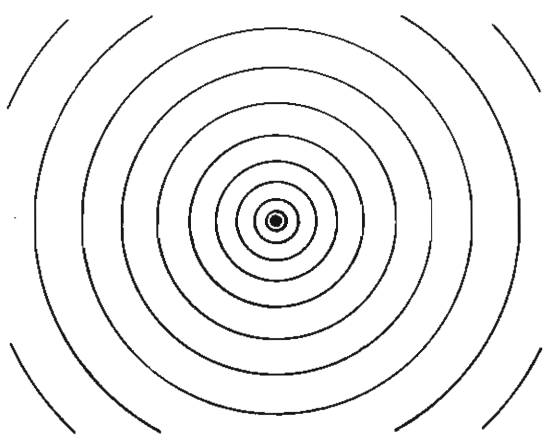
We can best illustrate how sound waves travel through the air by likening them to the waves produced on the surface of water when a stone is dropped into it.

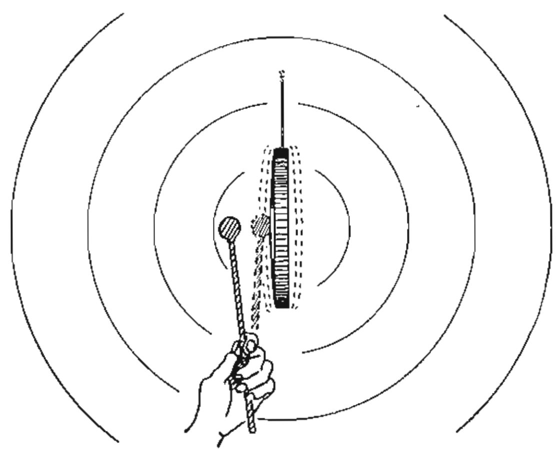
Waves or ripples travel out in a regular circular pattern from the source of disturbance, decreasing in effect as they move outwards.

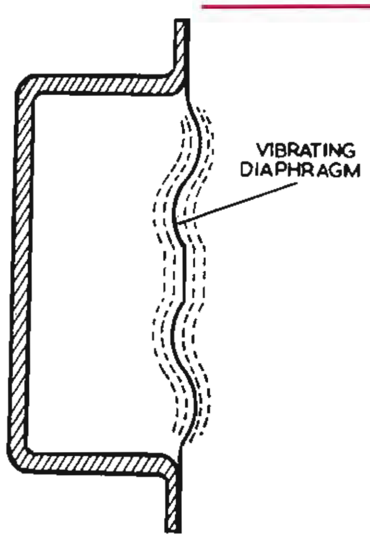
STRIKING A GONG

Similarly, when a gong is struck, the mechanical vibrations set the air in motion and the resulting sound waves travel outwards in ever-increasing circles, diminishing in intensity the further they travel.

So, to produce sound, we must produce vibrations. How do we achieve this in the case of the modern electric horn ?







THE DIAPHRAGM

In all Lucas horns, the rapid movement of a thin metal sheet or diaphragm disturbs the surrounding air, setting up sound waves which travel outwards in much the same way as they did from the gong.

The rate of vibration of the diaphragm will determine the pitch and frequency of the note, whilst its loudness or volume will depend upon the amount of movement of the diaphragm.

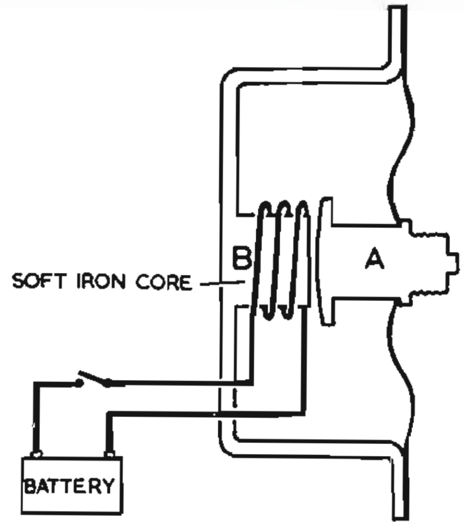
ELECTRO - MAGNETIC ATTRACTION OF THE DIAPHRAGM

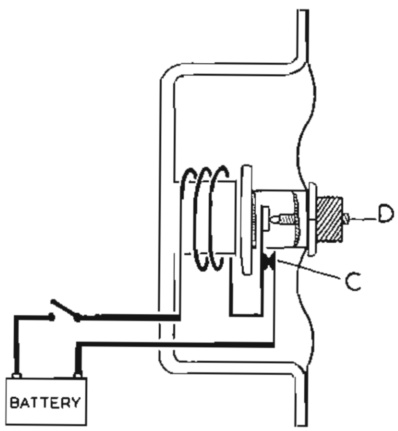
Here you see the same diaphragm, now carrying at its centre an armature A. At B, we have added a coil of wire, wound on a soft-iron core. This forms an electro-magnet which, if energised by current from a battery, will attract the armature, bringing with it the central area of the diaphragm.

The movement will continue until the armature strikes the core-face, unless it is restricted by the degree of flexibility of the diaphragm.

If the current in the coil were suddenly interrupted, causing the collapse of the magnetic field, the armature would be released.

Due to its own springiness, the diaphragm would return after a series of vibrations to its original position.





CONTACT ARRANGEMENT

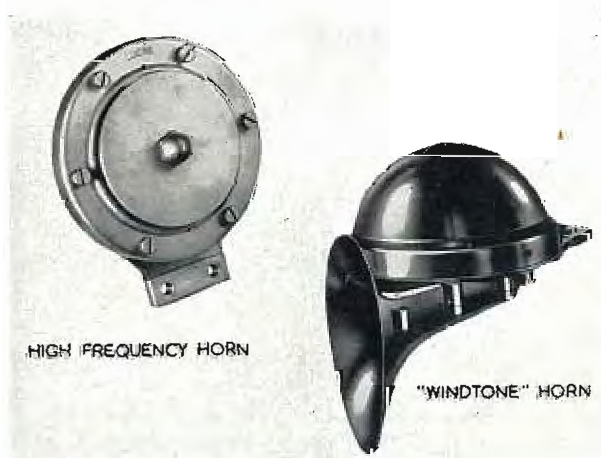
In practice the current is interrupted by a set of contacts ' C ' which are automatically opened as the diaphragm is attracted towards the core face. The point at which this happens is determined by the adjustable screw ' D '.

The pull of the electro-magnet collapses, releasing the diaphragm. As the latter returns towards its original position, the contacts will again close, re-energising the core, and once again attracting the diaphragm : thus the latter is kept in motion by a series of impulses, as long as the current supply is maintained.

This is the principle underlying all types of Lucas horns.

TWO MAIN GROUPS OF HORNS

There are two main groups of horn, the high frequency type, shown on the left of the picture, and the ' Windtone ', shown on the right. These will be familiar to you all, and we shall describe each in detail.

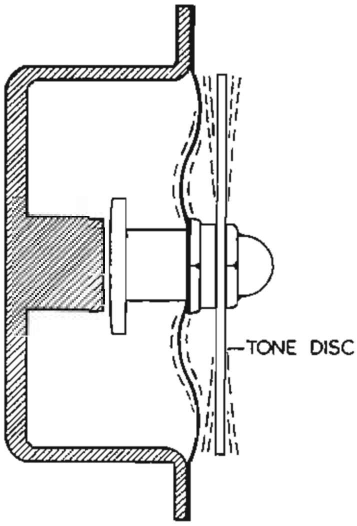


THE H.F. HORN

The high-frequency horn gives a relatively high-pitched and penetrating note. Its method of operation will be clear from the diagram.

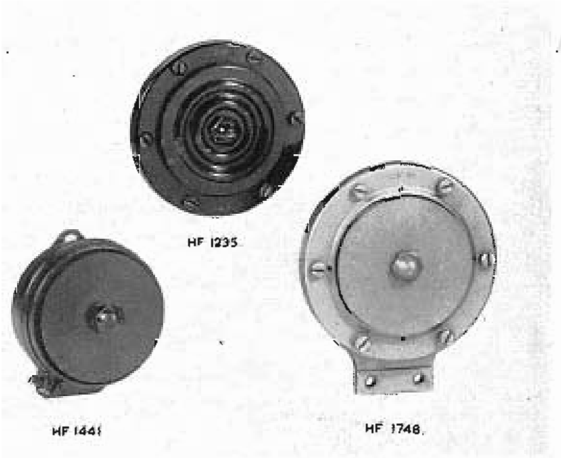
The armature is coupled to the flexible diaphragm which vibrates as we saw in our previous picture. The rate of vibration is relatively low, being in the region of 300-400 times per second. Attached to the centre of the diaphragm is a tone disc. Each impact of the armature on the core face is transferred to the centre of the disc, causing the free outer edges to vibrate at a faster rate. The rate or frequency is determined by the size, rigidity and material of the disc.

The vibrations of the diaphragm and those of the tone disc blend together, giving the horn its characteristic note.



THREE BASIC TYPES OF H.F. HORN

Here we show the three basic types of high frequency horn: on the left, the HF.1441, in the centre the HF.1235, and on the right, the HF.1748. All of these work on the principle we have just discussed, but vary in construction to cater for all specialised demands. We shall describe the main features of each of them in turn.



THE LIGHT-WEIGHT HORN.
HF.1440-1441-1444

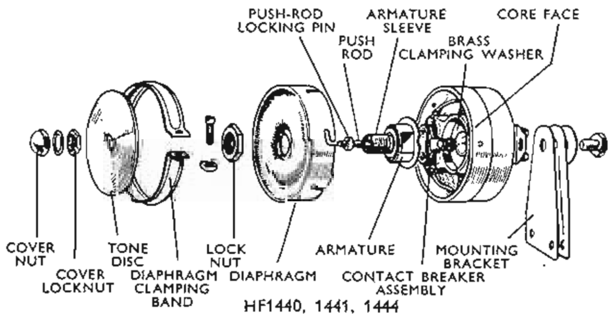
This type of horn has been fitted for several years to motor cycles, three variations of the basic model being marketed, the HF.1440, 1441 and 1444. The differences are slight and external, and in no way affect the operation. Any adjustments we give later will apply equally well to all three models.

The general construction of the unit is visible from this photograph. The features already discussed as being part and parcel of every H.F. horn are readily recognisable. The diaphragm for instance, although slightly different in shape from the theoretical one we depicted, performs exactly the same function. It is positioned in this horn by a bayonet fixing. The clamping band on the left locks this diaphragm firmly in position.

The tone disc used with this horn is not fluted in any way, as is the case with some other models, and is relatively rigid, the actual thickness of the metal being approximately $\frac{1}{8}''$. We have already mentioned how the shape, flexibility and thickness of this disc determine the final pitch of the horn note. In addition, we must consider, of course, the mounting position. As this particular horn is primarily designed for motor cycle work, it must stand up to rather rougher treatment than that to which it would be exposed under the car bonnet; a flimsy tone disc on such a horn would scarcely fill the bill, would it?

This horn, then, is generally robust in construction. The mounting bracket, too, consists of a strong yet flexible assembly of springy plates, which give a firm fixing, capable of withstanding any amount of engine or road vibration. Horn mountings really have to be good, otherwise the note will be seriously affected — but we won't labour this point here: it will be dealt with more fully when we come to 'Maintenance'.

The armature is also visible here in one of its forms and so is the core face. The function of the rest of the components, including the push rod with its locking ring, the contact breaker assembly and the various locking nuts will be more easily understood when we are discussing the adjustment of the contact gap.

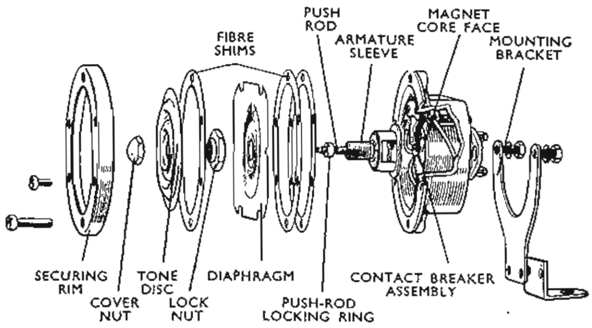


HF1440, 1441, 1444

THE ALTETTE HF.1234-1235

This horn, generally known as the 'Altette' is similar to the previous one, but of heavier construction. This diaphragm is clamped to the cast metal body by means of a securing rim held by set-screws. This rim is chromium plated on the model HF.1234, whilst that on the H.F.1235 is black finished. Early models of this horn had a flat aluminium tone disc, and a similar armature and contact arrangement to the HF.1440 type.

Recently, however, the construction has been modified somewhat and the latest type is shown in this picture. The tone disc is now of corrugated pressed steel, whilst the earlier type adjustment screw has been replaced as you can see by a push rod. Provision for adjustment of the contact breaker is made at the rear of the horn body — but more about this later in the 'Maintenance' Section.



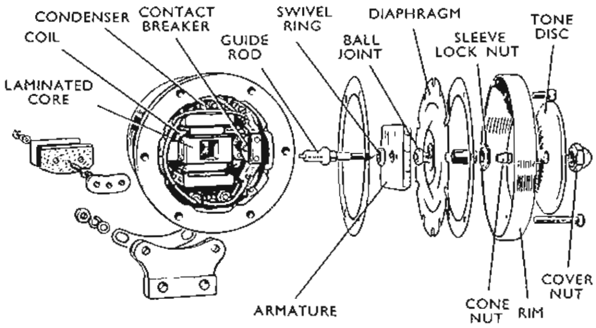
HF1234, 1235

THE HF.1746, 1747, 1748 HORNS

Again, several models of the basic type are made, catering for individual requirements, but this breakdown is generally applicable to them all.

This horn is a high performance HF. horn made in both high and low note models, suitable for fitting in matched pairs.

It is designed to give an extremely powerful, arresting and penetrating note which will be audible



HF1746, 1747, 1748

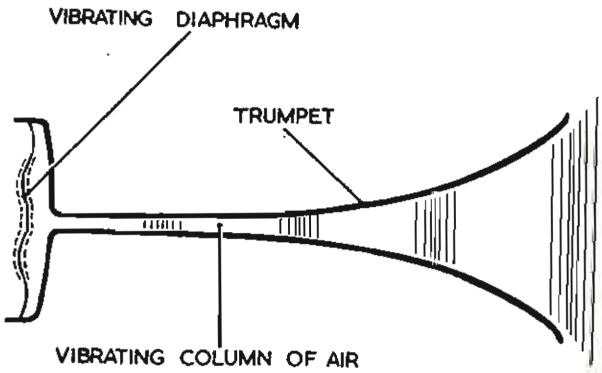
even under continental traffic conditions. The construction is very robust and the adjustment will remain constant over a wide voltage range, a particularly important characteristic of this type of horn.

Whilst the principle of operation is similar to the other HF. horns, the construction is very different. This horn is of a completely new design, having a die-cast body with a laminated core and armature. Special provision is made for the internal alignment of the armature with the core face, which explains the presence of such additional components as the swivel ring, ball joint, guide rod and core nut. These parts are machined to very fine limits to permit an extremely accurate adjustment, which is carried out on the production line and normally needs no resetting in service. As with the other types of horn, all we shall consider in the way of adjustment is the contact setting as far as normal servicing is concerned.

You will notice that a condenser is fitted in this particular horn : it is connected across the contacts to prevent excessive sparking when the horn is operating.

WINDTONE HORN — PRINCIPLE OF OPERATION

The 'Windtone' which is the other main type of Lucas horn, works on rather a different principle than the HF. type. The air is still set in motion by the electrically-produced vibrations of a diaphragm, seen here on the left of the picture, but this is now attached to one end of a trumpet. The vibrations will travel up the tube of the trumpet and, if their frequency is made to resonate with that of the tube, the sound will swell out and produce a musical note. In simple terms, the length of tube determines the pitch of the note, and its shape the overtones or quality. You will realise then, that in principle the windtone horn is similar to an orchestral wind instrument, but with the air vibrations produced electromagnetically instead of by the mouth and lips.

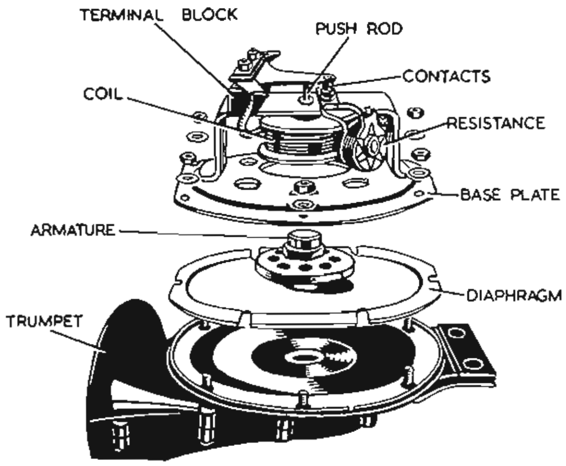


OPERATION OF THE WINDTONE HORN

This breakdown of a typical Windtone will help us to describe its operation. The actual build-up should be clear from the illustration. Two die-castings form the trumpet of the horn, at the same time providing a suitable platform for mounting the diaphragm. You can see that the latter is sandwiched between the trumpet casting and the base-plate which carries the coil, contact set and terminal block. The whole is bolted together, the six screws firmly holding the diaphragm at its edges, leaving the centre free to vibrate. Notice that the armature is attached to the centre of this diaphragm.

Imagine that we energise the coil with battery current which passes via the contacts illustrated. The armature is immediately pulled into the centre of the coil. At a set point of its travel, it strikes against the push-rod, thus opening the contacts. The current interrupted, the armature is released and the diaphragm springs back towards its original position. The contacts close again, re-energising the core, and the whole cycle is repeated, the diaphragm being set into vibration.

These electro-magnetically created air disturbances occur at the orifice of the trumpet ; the sound waves travel down the tubing, whose length is carefully calculated to coincide with the frequency of the diaphragm vibrations. This causes the note to swell out of the trumpet flare.



The pellet type resistance mounted on the contact breaker serves to damp excessive sparking which would occur at the contacts during rapid make and break.

Let us now survey the present day range of Lucas Windtone horns.

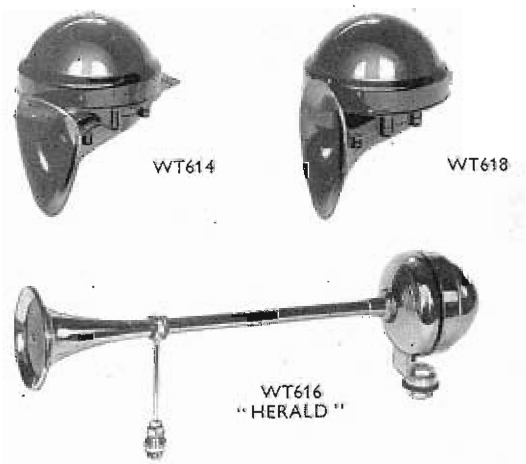
TYPES OF WINDTONE HORN

There are three types of Windtone in general use, the WT614, the WT616, and the latest addition the WT618.

The WT614 is an all black finished horn for under the bonnet mounting, and is fitted as standard equipment to most British cars. It is now replaced by the WT618. The difference between these two horns are not immediately visible from this photograph and we shall therefore leave them until we discuss each type individually.

The WT616, perhaps better known as the 'Herald,' is an exceptionally powerful horn mainly designed for overseas use. It is available in chrome finish for external mounting or in black fitting under the bonnet.

All three horns are supplied in high and low note models and are primarily designed for use in matched pairs.



THE WT614

The popular WT614, of which you see two views here, is small and compact, and gives a note which although clear and distinctive, the first requisite of any horn, is by no means raucous or unpleasant. When used in blended pairs, one high note and one low, and operated simultaneously, WT614's give a pleasantly mellow and harmonious signal.

You will notice that the horn trumpet is coiled so as to obtain the desired length in the minimum of space.

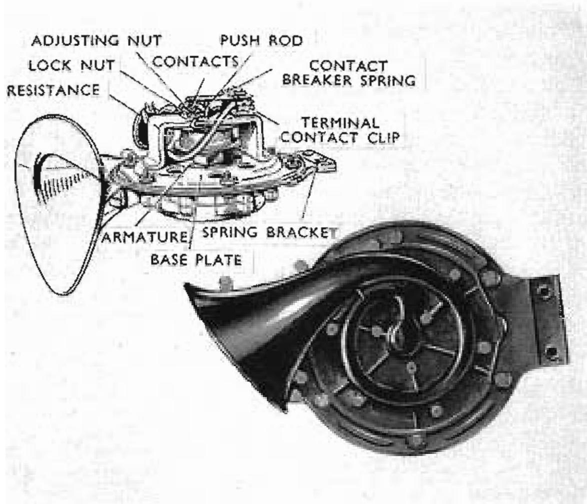
The high note model has the shorter coiled tube and the letter 'H' is imprinted inside the trumpet flare. The letter 'L' is used to distinguish the low note version.

Certain of the smaller cars fit one windtone horn only as standard equipment, usually the low note one. The high note model to make the matched pair is then available as an optional extra.

As a point of interest to the musicians among you, the notes differ in pitch by the interval of a major third.

The fixing bracket of the horn is of interest and of considerable importance: it must be firm, yet at the same time flexible. The one used here is a spring bracket formed from two sections.

The remainder of the constructional details of this horn are shown in an earlier picture — we actually used the 614 as a general example. But the accompanying illustration shows the relative positions of the components when assembled. A feature not previously pointed out is the adjusting nut for setting the contacts. The significance of this will be further discussed in the 'Maintenance' section of this book.



THE WT618

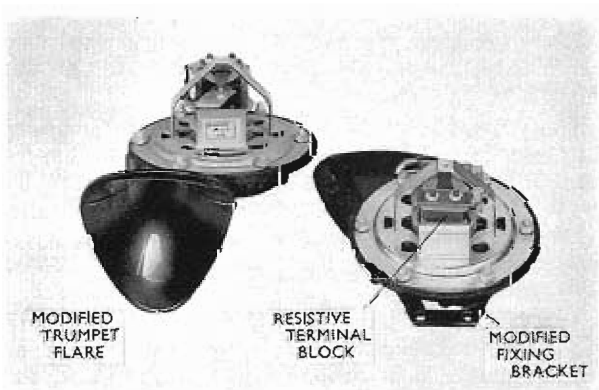
These new WT618 horns, very similar in general appearance to the WT614 model we have just shown you, have been designed to supersede the latter. They have a much louder note and will give a much more audible warning signal under heavy traffic conditions. They are intended for use in matched pairs and will normally be fitted under the bonnet. As usual, both 6 volt and 12 volt models are produced.

The external modifications are not immediately obvious: the trumpet flare has actually been redesigned and the coiling of the trumpet tube somewhat altered. This slightly changes the characteristic of the low note.

The bottom picture shows the modified spring-steel fixing bracket.

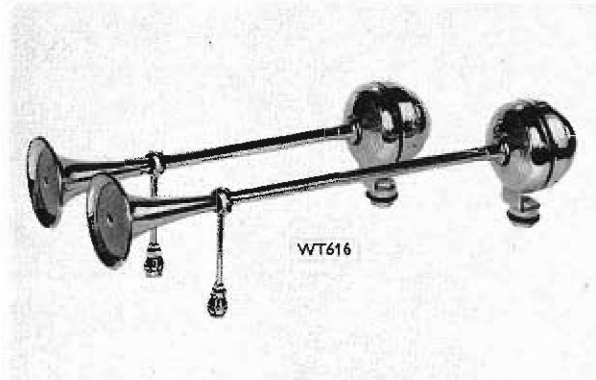
The main internal modification concerns the contact breaker assembly. The terminal block is now made of resistive material which does away with the earlier pellet type resistance used in the WT614.

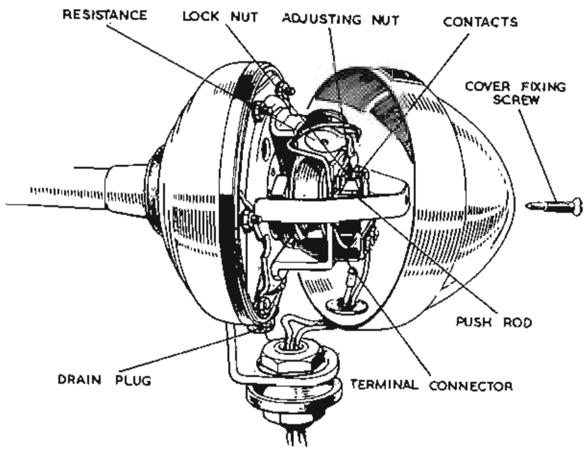
The diaphragm too has slightly different characteristics.



THE HERALD HORN

The Herald horn, the largest and loudest of the Lucas range, fits a movement which looks identical to the WT614, having the same coil and contact breaker arrangement, with a points resistance in circuit. Here the similarity ends. The Herald has a very dignified looking, chromium plated trumpet, something like the old posthorn. Blended pairs are produced, the longer trumpet giving the low note. These large horns are designed for external mounting on the larger cars and long distance coaches, although a similar model finished in black is available for interior fitting.





WT616 MECHANISM

Here you see the WT616 with the cover removed. The similarity between this mechanism and that of the WT614 is evident. The only additional feature we need point out is the drain plug. This is provided so that the horn can be drained if for any reason the interior becomes filled with water — as may happen for instance during the hosing down of the car.

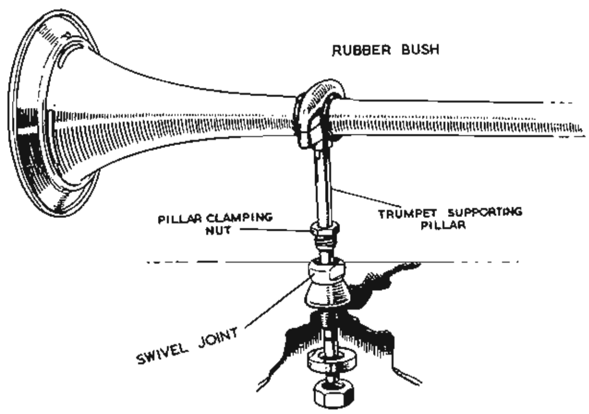
THE WT616 TRUMPET SUPPORT

The long trumpet of the Herald naturally needs supporting and here you see the type of chromium plated pillar we supply.

The pillar itself is extensible and possesses a swivel point, enabling the fixing position to be varied sufficiently to suit the contours of the car wing or bonnet, etc. This mounting facilitates fitting and avoids any strain on the trumpet.

You will notice that the trumpet clamp is rubber bushed against vibration.

We shall now discuss how the horns we have shown you are wired into the vehicle electrical circuit.

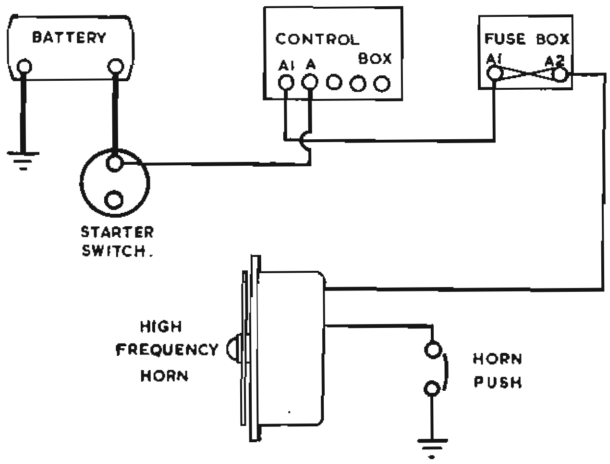


H.F. HORN CIRCUIT

This illustration shows a typical circuit used for a single H.F. horn, say of the 'Altette' type. You will notice that the horn obtains its current feed from the A2 terminal — which, as you know may be situated on a separate fuse board, or else incorporated in the control box. In either case the circuit is protected by the 35 amperes A1–A2 fuse.

The horn operating push is usually in the earth line as we have drawn it here.

There is no rigidly set supply point for a horn of this type, it could equally well be fed direct from the battery or from the battery side of the ammeter. The A2 terminal is however generally the most convenient point. The voltage drop occurring at intermediate points in the circuit between the battery and this terminal is normally negligible with a horn of this type whose current consumption is relatively low. Where two H.F. horns are used, on the other hand, we advise that they should be fed either from the battery terminal itself, or from the battery side of the starter switch or ammeter. In this case, it would also be preferable to install a separate 35 ampere fuse in the circuit.



HIGH FREQUENCY HORN CIRCUIT

WINDTONE HORN CIRCUIT

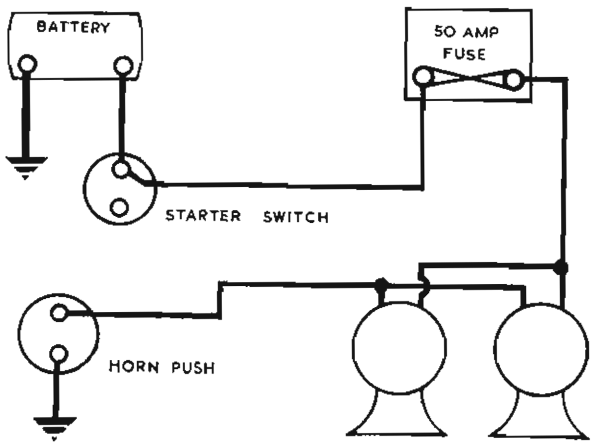
Windtone horns take much heavier currents than the H.F. type and it is normal practice to feed them direct from the battery line, either from the battery terminal, or as we show here from the battery side of the starter switch.

A separate 50 ampere fuse is recommended, though this precaution is not always taken.

The horn push is once again in the earth line.

This circuit is adequate for all cars where the cable run is not too long, especially when two 12 volt horns are installed. The voltage drop on the circuit in this case would be well within working limits. A serious voltage drop is soon noticeable, the horn note becomes rough and the power diminishes, although the pitch of the note will remain more or less the same.

Where such a heavy voltage drop would be experienced — say on some of the larger cars or light commercials, and especially when a pair of 6 volt



horns is used — a relay should be employed in the circuit.

We show this arrangment in the next picture.

TYPICAL HORN CIRCUIT WITH RELAY

Here you see a typical relay circuit, such as would be employed for the heavier current horns — the 6 volt Windtone, the 'Herald' models, etc.

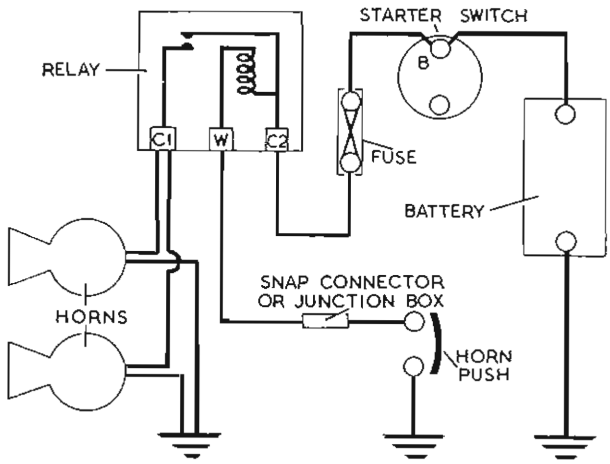
The relay possesses three terminals : C1, W and C2. The main supply cable from the battery is connected via a fuse to C2. Terminal W is joined by a cable passing up the steering column to the horn push. The other horn-contact is earthed.

When the horn push is pressed, the operating circuit for the relay is completed and battery current passes round the windings, energising the core, and thus closing the relay contacts. These contacts complete the horn operating circuit, allowing the main current to pass from the battery via terminal C2 ,through the relay contacts, then via C1 on to the horns. The circuit is completed by means of the horn and battery earths.

Continued.

This relay arrangement relieves the horn push, and the usual long run of wiring to it, of carrying the main current taken by the horns. Two purposes are thus served : the horn push contacts have a much longer life, and any voltage loss which would occur if the heavy horn operating current passed through the low capacity column wiring has been avoided. The horns therefore receive their full voltage. What is more, the main circuit wiring can now be of any reasonable length as heavier gauge cable will normally be used, the steering column which limits the cable-size having been by-passed.

This almost concludes what we have to say on the subject of horn circuits. You will have gathered that there is no hard and fast rule as to the precise method of connecting horns in circuit. The main recommendations we make are that they must be installed so that the voltage drop is absolutely at a minimum. The governing factor in this respect is the current consumption of the horn : the heavier the current, the greater will be the possibility of power losses. Very much part of this problem is the cabling itself. Certain sections of the horn circuit must of necessity be wired in cable of a low current carrying capacity : the lead inside the steering column for instance is normally part of a relatively narrow gauge multi-cored cable — no amount of persuasion can introduce a size 44/·012 cable where there is only room for a 14/·012. Hence you have seen that where a pair of heavy current windtone horns is used we employ a relay in the circuit which by-passes the column wiring and horn push, thus avoiding voltage losses. The only current carried by this section of the circuit is that necessary to operate the relay, a mere 0·5 amps for the 12 volt set and 1·5 amps for the 6 volt. The main operating current, in the order of 13 amps for the 12 volt pair and 26 amps for the 6 volt takes the direct path from battery to horn, passing through a section of the circuit where it is convenient to



install heavier cabling capable of carrying such currents without undue loss.

Another recommendation is that the horn should be fused. You saw that in the case of a simple H.F. horn, taking a low current, we used the existing A2 fuse. But where two similar horns are fitted, we recommended that they should be fed from a point nearer to the battery, with a separate fuse in circuit. The windtone horns as well should not be fed from the A2 fuse ; if they are, the car ammeter in circuit will swing violently every time the horn button is pressed.

The above considerations then should be borne in mind when studying these horn circuits, and more particularly if you are called upon to fit new or additional horns to an existing installation.

Let us now see what maintenance and servicing is necessary to keep horns in good working condition on the vehicle.

MAINTENANCE POINTS

There are very few maintenance points which apply to horns — but the few are extremely important. Each horn is correctly adjusted before it leaves the factory and will generally give long and satisfactory service with the minimum of attention.

Here you see four maintenance points. It is our experience that by checking these you will cure most of the horn troubles that occur, without the need for removing and stripping the units, so often done unnecessarily.

Let us take each in turn, starting after the normal fashion with No. 1.

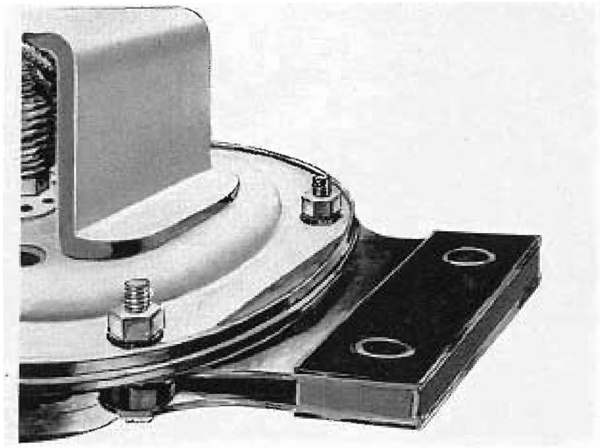
HORN MAINTENANCE POINTS

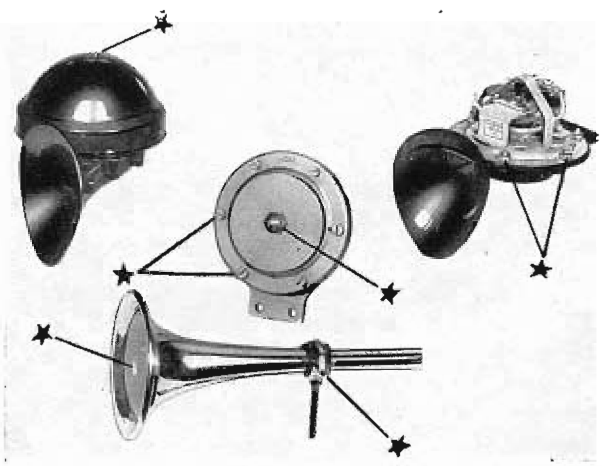
1. MOUNTING.
2. TIGHTNESS OF FLARE, TONE DISC. & DIAPHRAGM.
3. VOLTAGE DROP IN WIRING.
4. CONTACT ADJUSTMENT.

HORN MOUNTING

Horns must always be mounted on the bracket provided, and it is important that this bracket is securely bolted to a rigid part of the vehicle, one that is free from vibration. Make sure too that the horn body is not touching anything. Unless the horn is securely mounted, it will not give its true, clear note.

If at any time imperfections in the horn note become apparent, check that the fixing bolts are correctly tightened, that the bracket is not cracked and that no other unit is loose and vibrating in the immediate vicinity.





LOOSE HORN COMPONENTS

If any part of the horn itself is loose, such as the cover, the diaphragm, the tone disc, horn flare or grill, etc., the horn note will be affected.

We have indicated all the likely trouble spots in this picture.

VOLTAGE DROP TESTS FOR HORN CIRCUIT

We have stressed throughout that the horn performance will be seriously affected by voltage losses in the circuit.

To localise this fairly common cause of trouble a four-stage voltage drop test may be simply applied.

TEST 1. Battery voltage underload — engine stopped.

Switch on all lights to load the battery.

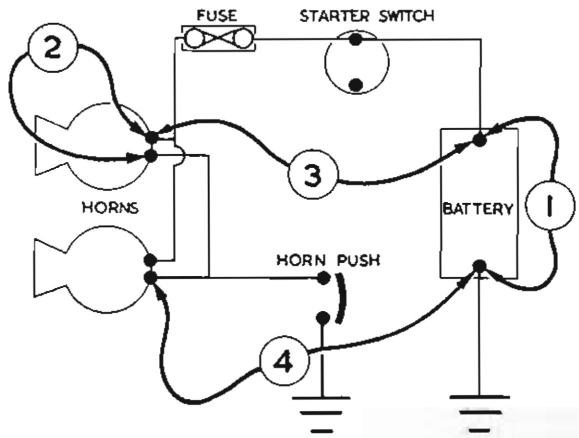
Take a battery voltage reading, which should not be less than 11 volts if the battery is in an adequate state of charge.

TEST 2. Repeat this operation at the horns.

Connect the voltmeter across the terminals of each horn in turn, press the horn push and note the reading. The voltage registered should be no more than 0·5 volts below the Test 1 reading.

TEST 3. If voltage drop is in excess of 0·5v.

Check the insulated line by connecting the meter between the insulated battery terminal and the feed terminal of one horn. Press the horn push. No voltage reading should be obtained ; if there is, check all cable connections and junction points in the feed line for loose or dirty contacts.



TEST 4. Voltage drop due to defective earth.

The final test (Test 4) will locate any voltage loss due to a bad earth contact. The meter is connected between the battery earth terminal and the horn earth terminal (i.e., terminal connected to horn push), when full battery should register. On operating the horns the voltage reading should drop to zero—or 0·5 volts is considered as the permissible maximum.

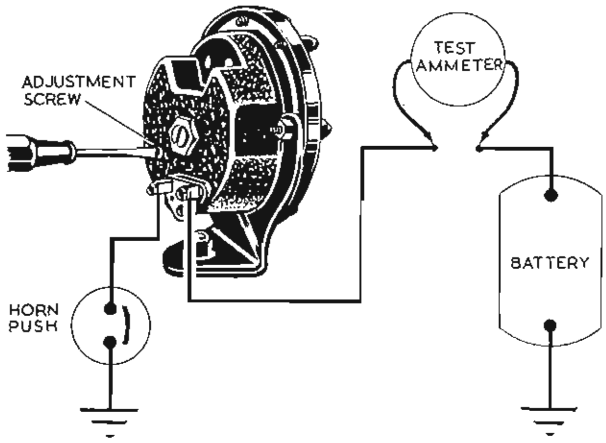
All earth connections should be examined if a reading in excess of this value is obtained.

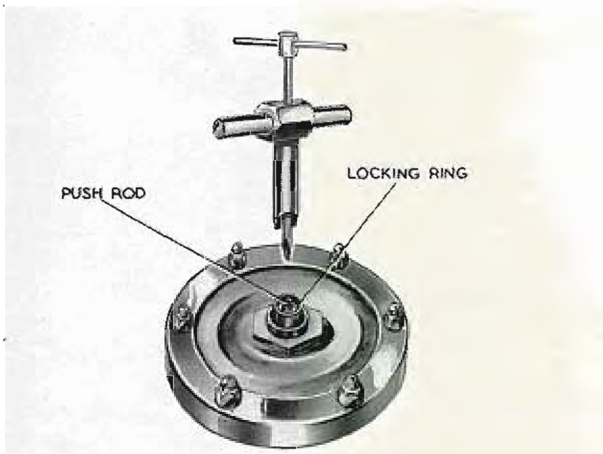
HORN CONTACT ADJUSTMENT

The only adjustment to the horns normally necessary in service is the taking up of the contact wear.

After a lengthy period of service, the horn note tends to deteriorate slightly, both in volume and in purity of tone. The cure is simple enough : every horn is provided with an adjustor which compensates the normal service wear. The actual positioning of this adjustment varies with each type of horn and we shall need to run through them in turn. One point is common to all, the contact adjustment MUST be made with an ammeter in circuit as we show here. The contacts should be adjusted until the specified current reading is obtained.

We shall state the specified value for individual horns, and the figure quoted will be at normal battery voltage. This pre-supposes that the vehicle engine is stationary and the battery well charged.





CONTACT ADJUSTMENT. THE HF.1441 TYPE

The HF.1441 type, and earlier models of the HF1234 have no fine adjustment screw at the back of the horn. To gain access to the adjustment, the cover nut must first be removed. Using a combined tool similar to the one illustrated here, which holds the locking ring while the push rod is adjusted, the slotted end of the rod may be turned until the following readings are obtained on the ammeter in circuit :—

6v. model	*12v. model*
3 amps.	2 amps.

These are average figures and slight variations may be encountered.

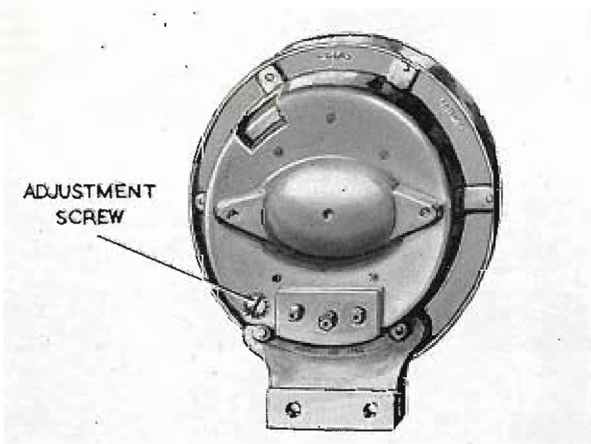
If the consumption is excessive, turn the push rod clockwise to decrease the current, or anti-clockwise to increase. Make only a small adjustment at a time, continuing until the correct setting is obtained.

CONTACT ADJUSTMENT THE HF1234, 35 AND HF.1746, 1748

These horns have a fine adjustment screw at the back of the body. With an ammeter in circuit, note the current when the horn is operated. Turn the screw in a clockwise direction to increase the current and anti-clockwise to reduce it. Adjust a quarter of a turn at a time until the reading is within the following prescribed limits and the maximum performance is obtained.

Current figures :—

	6 volt	*12 volt*
HF.1234–35 ..	3·5 amps. MAX.	2·5 amps. MAX.
HF.1746, 47, 48	5 „ „	4 „ „



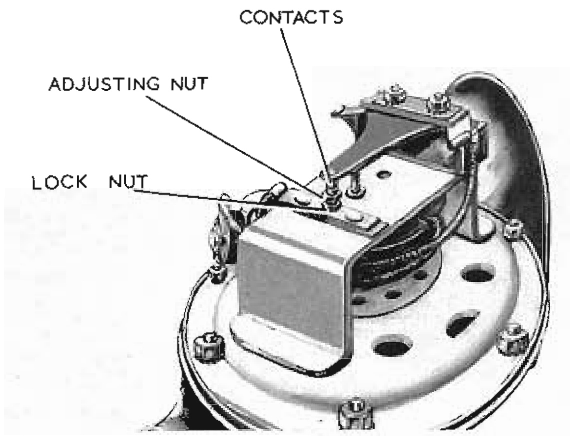
CONTACT ADJUSTMENT WT.614, 616 and 618

The following method of adjustment applies to all the present-day Windtone horns we have discussed.

First remove the cover. Then slacken the lock nut on the fixed contact and turn the adjusting nut in a clockwise direction until the contacts are just separated, as indicated by the horn failing to sound. Turn the adjusting nut *half a turn* in the opposite direction and hold it while tightening the locking nut. Check the current consumption of the horn, which must not exceed the figure quoted below. If the current is incorrect, make further very fine adjustments to the fixed contact, turning the adjusting nut clockwise to decrease and anti-clockwise to increase.

Current figures :—

		6 *volt*	12 *volt*
WT.614	..	13 amps.	6 amps.
WT.616	..	14 amps.	8 amps.
WT.618	..	—	8 amps.

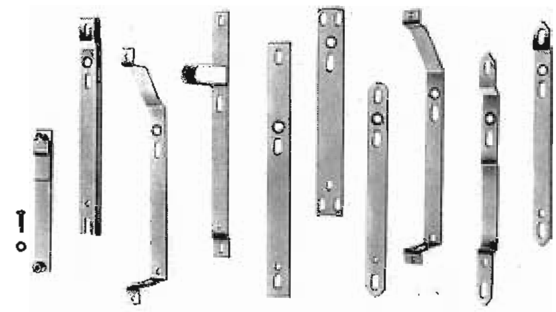


"Trafficator"—Semaphore Direction Indicators

THE CURRENT PRODUCTION SEMAPHORE INDICATOR

On current production cars TWO basic types of Trafficators, the SF80 and SE100, cover all the popular vehicles. Two other types known as the SF34 and 40, and now discontinued on new cars, have also been used in large numbers. These models are fitted on the vehicle assembly lines and are generally accommodated in recessed door pillars. For subsequent installation an external mounting unit, the SE100, is universally applicable. The same action assembly is used either for the recessed type or the box type external trafficator. The methods of switching vary, the most popular being the self-cancelling switch built in the steering-wheel hub. Another arrangement uses a self-cancelling switch mounted on the steering column and cancelled by an external cam.

A further arrangement may be a panel mounting, two-way and off switch with or without a warning light or alternatively a two-way and off switch combining a pneumatic time delay. Generally these units are for 12 volt working but are also available for 6 volt applications with a special 24 volt model for passenger carrying vehicles.



MOUNTING PLATES

For mounting on different types of vehicle bodies a range of adaptor plates are manufactured. These are attachable to the standard action assemblies and some examples are grouped together in this picture.

PRINCIPLE OF OPERATION

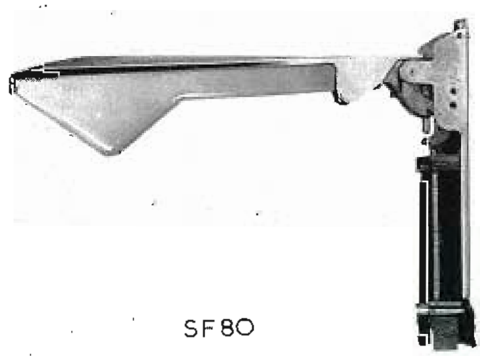
All types of trafficators follow the same principle. A solenoid is carried on a bracket and a plunger is attached to the pivoted semaphore arm. When current passes through the solenoid winding the plunger is drawn into the core thus raising the arm to the horizontal position where it will remain until the current is switched off.

A signal light in the form of a 3 watt Festoon type bulb is spring supported in the moulded arm and switched on by means of a sliding contact adjacent to the pivot part of the arm when the arm itself rises to the horizontal. Some earlier models had a continuous flexible lead to this signal.

All current production models which are made for both 6 and 12 volt working have a $7\frac{1}{4}''$ arm.

The indicator arm should return to the 'at rest' position by its own weight when the current is switched off. Wind pressure against the arm surface tends to keep it in the raised position and the top surface is given an aerodynamic contour whereby a downward thrust is produced to return the arm.

To prevent the arm being raised or 'thrown up' when not in use, a locking device is incorporated. Unless the plunger itself is moved, some force must be exerted upon the arm before the action of this device is overcome.



SF80

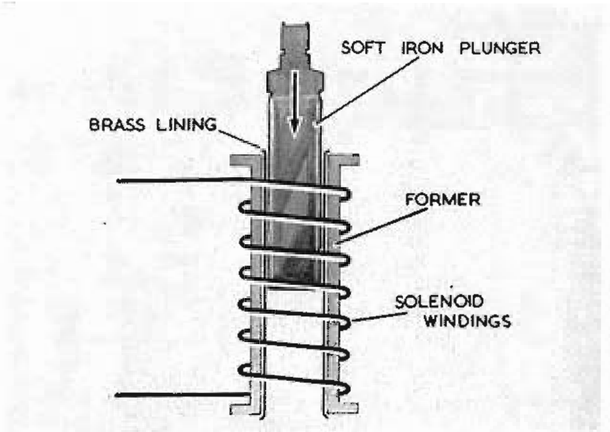
THE SOLENOID ACTION

This picture illustrates the solenoid with its hollow iron centre, around which is a winding of enamel covered wire.

A characteristic of this kind of electro-magnet is that, with the current switched on, its pulling power is at maximum when the armature is fully inserted in the core and advantage is taken of this characteristic because the pull required increases as the arm is raised from the vertical towards the horizontal position.

It may be observed that the hollow core of the solenoid has a brass lining, the object of which is to prevent 'Magnetic cling' between the surface of the plunger and the wall of the core.

The current required to operate the solenoid lies between 2 and 3 amperes.



SELF-LOCKING DEVICE

A self-locking device to hold the arm in the 'at rest' position is an essential feature of the arrangement to prevent the arm from bouncing out when the vehicle is swaying, bumping or heeling over at an acute angle. Several devices have been applied at various times and this picture shows the very simple arrangement provided on current production trafficators.

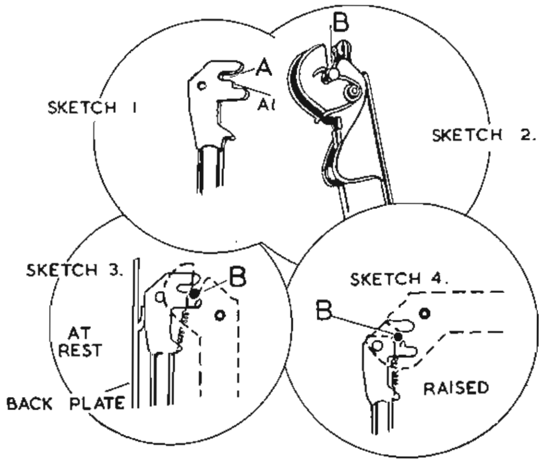
The locking device operates in the following manner :—

Sketch 1. The flattened head of the plunger is recessed to accommodate a catch pin in the positions shown at (A) when the arm is raised and (A1) when the arm is down.

Sketch 2. The plunger head fits into the slotted top of the signal arm and a catch pin (B) is located in the recess shown and retained by means of a hairpin spring.

Sketch 3. With the signal arm in the 'at rest' position, the solenoid plunger is fully raised and the catch pin (B) will be in the position shown. The plunger head then forms a block between the back plate and the pivoted arm which prevents the arm from moving outwards.

Sketch 4. When the plunger is drawn down into the solenoid, the first part of the movement releases



the lock and the continued downward movement of the plunger raises the arm into the horizontal position ; the catch pin will then be in the position shown.

Referring to sketch 2, the location of the catch pin (B) by means of the hairpin spring also acts as a safety device, allowing the pin to rise in the recess when the arm is forced up by hand, thus preventing it becoming damaged.

SF80 TRAFFICATORS

This illustration shows the current production SF80 type trafficator made for both 6 and 12 volt working, now being fitted to practically all vehicles taking trafficators as initial equipment.

This is an exceptionally compact unit and is very narrow ($\frac{3}{4}''$) and shallow ($1\frac{1}{2}''$) thus enabling it to be accommodated conveniently in restricted door pillars.

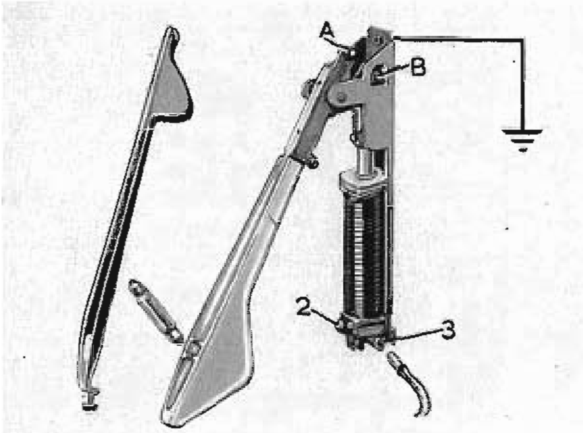
Another development is the quickly removable arm assembly, which permits a broken arm to be replaced in a few moments without taking out the assembly from the door pillar.

From the picture the following features should be noted :—

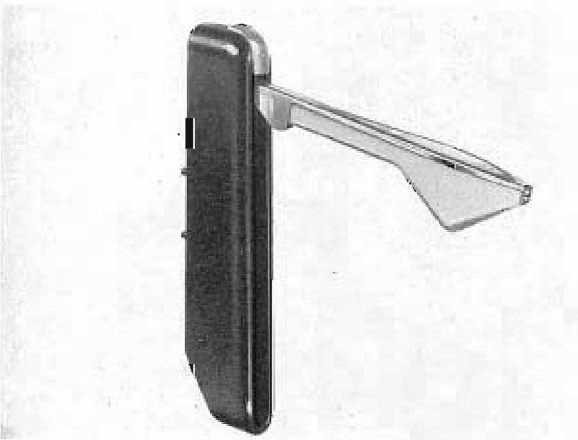
(1) The button contact 'A' for the signal light which connects with the blade 'B' when the arm is raised.

(2) The rubber buffer stop which supports the arm in the down position and prevents rattle.

(3) A thimble type of connector for the current supply at the bottom.



(4) The earth return obtained through the mounting plate and the body of the vehicle.



SE100 TRAFFICATOR FOR EXTERNAL MOUNTING

For external mounting the SF80 movement which we have just described is accommodated in a metal box as shown here.

Two holes in the back plate allow the assembly to be fastened directly on to a flat surface and a detachable right angle bracket will accommodate side fixing where required.

The unit is available for both 6 and 12 volt working. It has an exceptionally wide field of application for vans and commercial vehicles as an after-sales fitment.

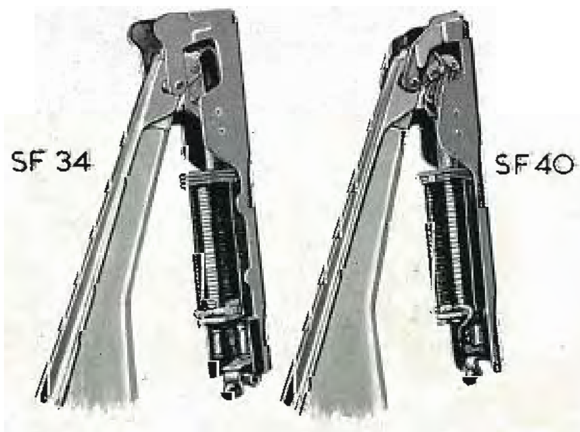
SF34 AND SF40 TRAFFICATORS

Prior to the introduction of the SF80, the two most popular trafficators in use were the SF34 and SF40 as illustrated here.

The feature of the SF 34 Trafficator was its particularly narrow construction ; it was also made with both $7\frac{1}{4}''$ and $8\frac{1}{4}''$ arm.

The leading feature of the SF40 was its extreme shallowness from back to front.

Several models of these trafficators were made with various angles of lift between 80° and 90° and others with special contacts for panel warning-light circuit arrangements.



WIRING CIRCUIT USED ON CURRENT PRODUCTION EQUIPMENT

Numerous circuit arrangements have been installed on earlier production cars to meet special requirements and at a later stage they will be included as a matter of general interest.

An extremely simple circuit is now employed for the SF80 and SE100 trafficators as shown in this picture.

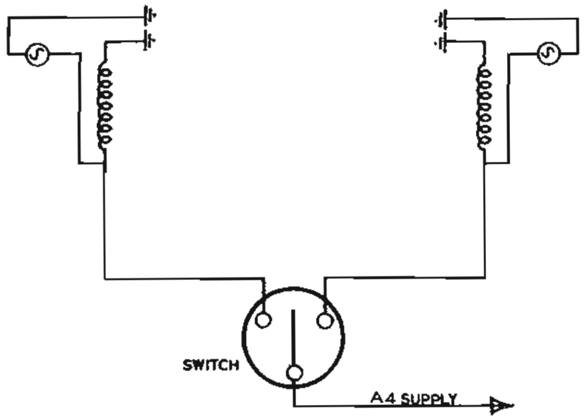
The current supply is taken from the A4 fuse by means of a GREEN cable 14/012 to the centre contact of the switch, usually via snap connector at the bottom of the steering column assembly.

GREEN and WHITE and GREEN and RED 14/012 cables are then connected, also by means of snap connectors, to each trafficator.

As shown in the diagram, it will be observed that the solenoid is connected directly to earth and the signal light forms a parallel circuit to it.

As previously mentioned, the earth return is through the frame of the trafficator to the body of the vehicle and, unless these earth connections are sound, considerable trouble may be experienced in service.

TRAFFICATOR WIRING CIRCUIT I



SERVICING TRAFFICATORS — ARM REPLACEMENT

In order to renew a broken arm on any of the early type trafficators it was necessary amongst other operations, to drill out the hinge pin. On the SF80 and SE100 models the new type, quickly-detachable arm is used.

The left-hand illustration shows how the exchange may be carried out :—

OP. 1. Remove the screw and take off the arm cover.

OP. 2. Lift out the bulb and its contact spring.

OP. 3. Loosen off the arm clamping screw and withdraw the arm moulding.

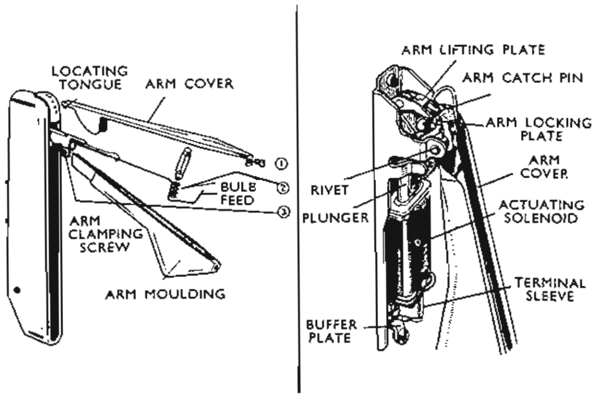
Reverse the operations and fit a new arm moulding.

On the earlier types shown on the right proceed as follows :—

Remove the trafficator from the car, take off the arm cover and remove the bulb. If the old cable and contacts are to be used, open the clip securing the cable to the arm ; otherwise slacken the screw securing the terminal assembly, remove the terminal plate and un-solder the cable, temporarily replacing the screw to hold the solenoid in position.

Drill out the rivet securing the arm.

Place the new arm in position so that the catch pin locates correctly between the lifting plate and the locking plate, and secure by fitting a new rivet. Solder



the free end of the braided cable to the tag on the terminal plate, and refit the plate in position. Before finally tightening the securing screw, fit the cable neatly between the coil and the insulating strip, so that, although held firmly, there is no danger of the insulation being damaged by sharp edges. There must be sufficient slack to allow the arm to move freely without either straining the cable or bending it sharply.

Finally, fit the bulb into the arm and replace the cover.

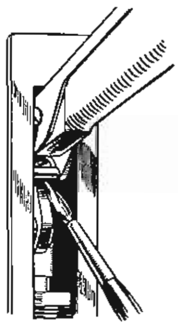
LUBRICATION AND MAINTENANCE

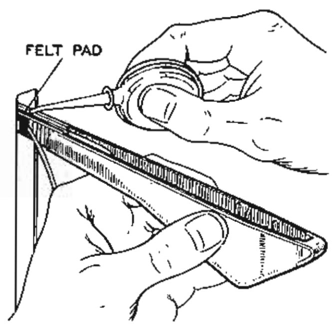
SF80 and SE100. The only lubrication required on these trafficators is *one drop* of S.A.E. 30 oil on the pivot-bearing of the arm occasionally.

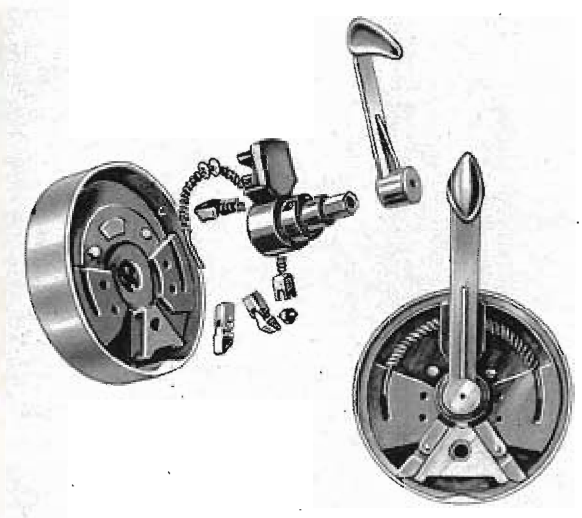
SF34 and SF40. There are two lubrication points on these trafficators, and both should be lubricated occasionally.

(a) Lift the trafficator arm and apply one drop of thin machine oil to the catch pin between arm and operating mechanism.

(b) Withdraw the screw at the end of the arm and slide off the arm cover. Move the bulb connecting lead to one side and apply a drop of thin oil to the felt lubricating pad at the top of the arm.







SWITCHING ARRANGEMENTS

A variety of switch arrangements have been developed and are available to meet the vehicle manufacturers' demands, in particular to suit the varying types of steering-column controls in general use.

The most popular arrangement on current production cars is the 'Self-cancelling' switch shown in this picture.

The self-cancelling switch assembly, built into the hub of the steering wheel, is very simple if regarded as comprising two elements : an electrical element, the switch itself, and a mechanical element, being the actuating and self-cancelling device. The operation is that the current supply is switched on by the hand lever and switched off automatically when the steering wheel is returned to the straight ahead position after a turn has been completed.

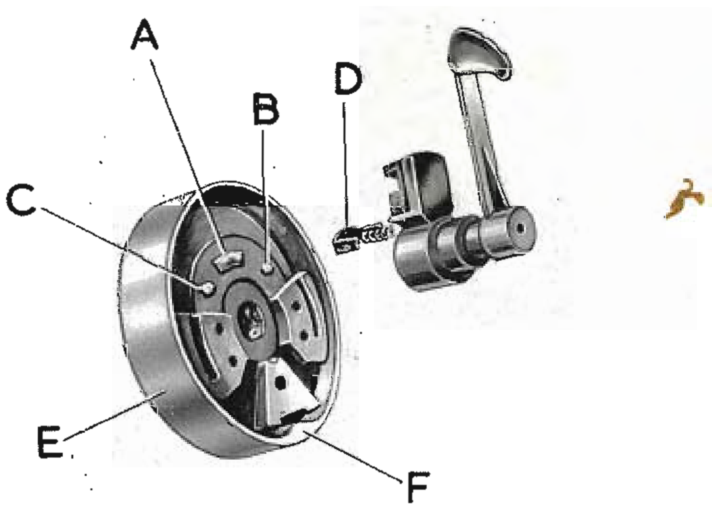
The right hand illustration in the picture shows the complete assembly as it rests in the centre of the steering wheel, that on the left shows an exploded view of the components.

THE SELF-CANCELLING SWITCH ASSEMBLY. THE SWITCH ONLY

The switch itself is of the standard TWO way type with a central OFF position. The supply contact is shown at (A) and the trafficator contacts at B and C. The rotor to which the hand lever is connected contains a spring loaded bridging contact D. Movement of the lever to the left or right connects the respective trafficator ; centralising the lever switches the current off.

The switch base, rotor and lever assembly are mounted on a stator tube and held stationary by a clamp at the bottom of the steering column.

An outer ring E with a cam F is turned with the steering wheel and actuates the self-cancelling mechanism.



THE SELF-CANCELLING ACTION

Sketch 1. The Rotor Lever (I) is centralised by means of the two coil springs (G) and is firmly held in this position by the spring loaded Roller (H), locating in the notch as shown.

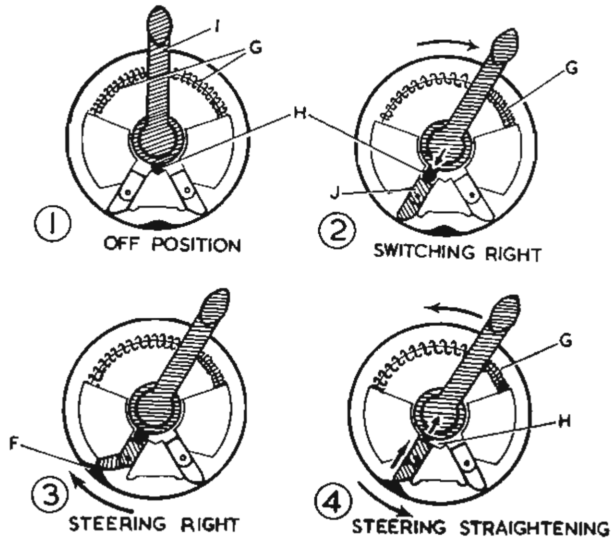
Sketch 2. Movement of the Rotor Lever — say to the right — switches on the current to the right hand trafficator and at the same time compresses the spring (G) on that side.

The Roller (H) will then be in the position shown over the pawl (J) and will hold the switch in this position.

Sketch 3. When the steering wheel is then turned in the same direction — right — the cam (F) will over-ride the pawl.

Sketch 4. When the steering wheel is moved back again to the left to straighten up after the turn has been made, the cam forces the pawl upwards, pushing the roller into the boss of the rotor lever.

The compressed spring G then returns the lever to the central position, when the roller (H) re-engaging with the notch, positions it in readiness for the next operation.



TYPICAL ARRANGEMENT WITH PANEL MOUNTING SWITCH AND WARNING LIGHT

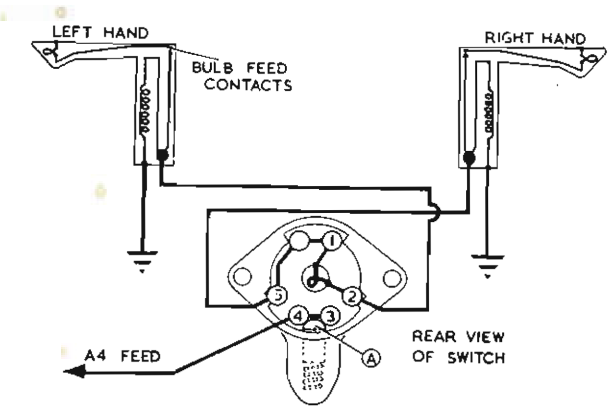
A popular type of switch for this arrangement is the type SD84 incorporating a warning light. The circuit arrangement is as shown in the illustration.

The SD84 two-way and off switch (centre picture) has a group of four main terminals, 2, 3, 4, 5, of which the centre pair 3, 4 are permanently linked. These terminals act as switch contacts and are linked in pairs by a roller on the switch arm ' A '.

Centre position of the switch is OFF and by moving the rotor to left or right, terminals 2/3 or 4/5 are linked, thus feeding current to either trafficator.

The Warning Light is connected between terminals 2 and 5 as shown.

If the switch is moved to link terminals 4 and 5, i.e., the **right-hand** trafficator, the warning lamp circuit will then be from terminal 5 through the lamp bulb filament to terminal 2 and from this point its circuit is completed through the LEFT-hand trafficator to earth. In this condition the very small current passing through the warning lamp bulb is not sufficient to cause any movement of the LEFT-hand trafficator.



If the switch is moved over to link terminals 2 and 3 to operate the LEFT-hand trafficator, the warning lamp circuit will then be completed through the RIGHT-hand trafficator.

The Warning Light is of the screw-in type, and connected between terminals 2 and 5 as shown.

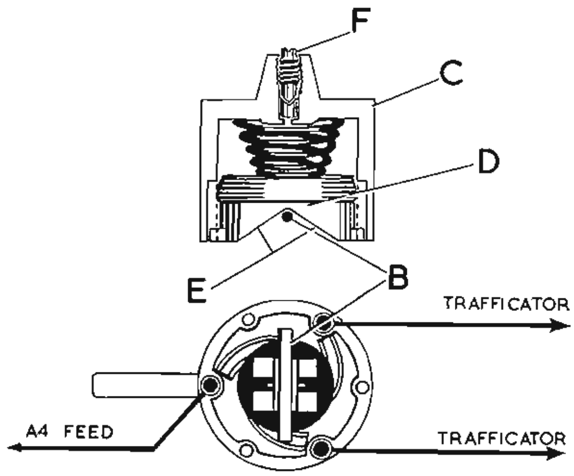
THE PNEUMATIC TIME SWITCH

An alternative to the layout we have just examined is the Pneumatic Time Switch, which will provide a self-cancelling arrangement for a vehicle not so fitted originally and which incidentally avoids the necessity for a warning light.

The switch itself is a plain TWO WAY-OFF type as generally used. The complete assembly comprises an air chamber C with a piston D on the skirt of which is formed cams E together with a loading spring and an air regulating screw F. The switch rotor is fitted with a horizontal pin B which registers with cams E and is normally held in the central or OFF position.

During the return movement of the piston, the cam face pressing on the pin B turns the switch rotor to its original central and off position.

Movement of the switch lever to right or left through about 60° switches on the current supply to the trafficator and at the same time raises the piston through the rotation of pin (B) moving over the cam face (E), the air from the cylinder escaping around the sides of the bucket piston. Since all the air has been expelled from the cylinder, the spring can only return the piston to its original position as air is allowed to re-enter the cylinder.



An adjustable air leak (F) is provided to enable this return movement to be delayed over a period of from 10 to 12 seconds. During the return movement of the piston, the cam face pressing on the pin (B) turns the switch rotor to its original central and off position.

A snap action in finally opening the switch contacts is obtained by means of a spring loaded ball in the switch rotor assembly.

TRAFFICATOR MECHANICAL TROUBLES

Trafficators occasionally get bent or damaged in service, resulting in binding or stiffness which will prevent the trafficator from rising fully or returning to the correct parked position.

If the supply line is in order the trafficator should be examined to make certain that it is not binding or sticking through faulty adjustment or lack of lubrication.

It may be necessary to remove a trafficator from the vehicle to ease or adjust it, in which case it should be tested as detailed.

The minimum voltage required to lift the trafficator arm to the horizontal should be measured at the terminals of the unit and should read as follows:— 12v unit no less than 9 volts ; 6v unit no less than 4·5 volts.

During the test, the trafficator should be tilted backwards at an angle of 5° to the vertical. The bulb should also be in circuit.

The arm must return to the locked position and not rattle when released from any position of making an angle of 60° to the vertical.

The current taken by the trafficator is :

12 volt models approx. 3 amps.
6 volt models approx. 6 amps.

SERVICE TESTING THE TRAFFICATOR SYSTEM

Where a trafficator fails to operate or is sluggish, the fault may not necessarily be confined to the trafficator movement.

Due to the unavoidably long lengths of cables and numerous connections in the circuit, high resistance may be the cause of considerable voltage loss.

The recommended cable size is 14/·012 ; voltage loss will occur if a smaller size of cable is used. Trafficators should operate efficiently down to 9 volts on the 12 volt system and 4·5 volts with 6 volt system.

A systematic series of checks may be carried out on the entire circuit to localise a fault.

After switching on the Ignition, the sequence of operations should be as follows :

1. Test the battery.
2. Operating voltage at the battery.
3. Operating voltage at the trafficator.
4. Voltage drop on the insulated line.
5. Voltage drop on the earth line.

Continued

THE BATTERY TEST 1

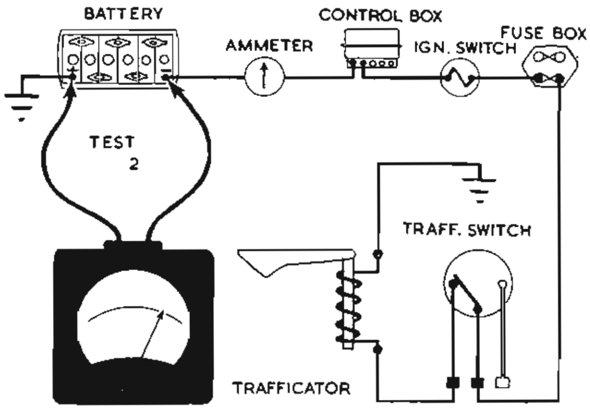
Test the battery to ensure serviceability and state of charge; this can most conveniently be carried out by switching on the Head Lights and taking a voltage reading across the battery terminals.

If the battery is serviceable and in a reasonable state of charge, apply test 2.

OPERATING VOLTAGE AT THE BATTERY. TEST 2

Connect the voltmeter between positive and negative terminals of the battery.

With ignition switched on, move the indicator switch over to supply the faulty trafficator and note the voltage reading.



TEST 3. OPERATING VOLTAGE AT THE TRAFFICATOR

Next connect the voltmeter, as shown in Test 3 between the insulated terminal and the frame of the trafficator. Check the voltage-reading.

The difference between this and the previous reading should not exceed ·5 volts. Should the difference be greater, it will indicate high resistance in the circuit.

TEST 4. TESTING THE INSULATED LINE

For the next test, connect the voltmeter to the insulated terminal of the trafficator and the negative battery lug.

When the supply is switched on the reading should not exceed ·5 volts : if a higher voltage is registered it will indicate a high resistance somewhere along the line.

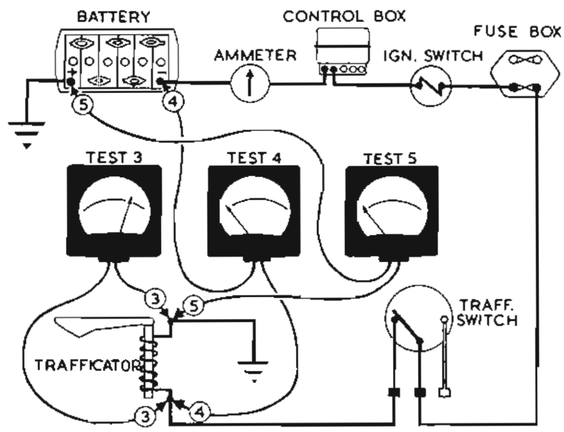
The high resistance can then be traced by testing across the snap connectors and across the indicator switch contacts. Where the switch is located at the top of the steering column, the test can most conveniently be made at the snap connectors, located at the base of the column. In all tests there should be no reading on the voltmeter.

TEST 5. VOLTAGE LOSS ON EARTH LINE

Connect the voltmeter between the frame of the trafficator and the positive battery lug and with the supply switched on, there should be no reading on the voltmeter. Any voltage reading will be due to high resistance.

One of the most likely causes will be a defective earth connection for the trafficator. Check by connecting the voltmeter between the trafficator frame and in close proximity to the earth connection.

If a reading is obtained, remake the connection and retest.



SIMPLIFIED TRAFFICATOR CIRCUIT

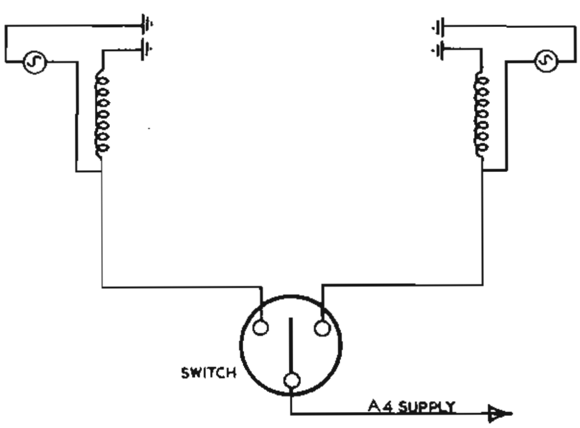
As used on current production vehicles this circuit was also used on earlier vehicles without trafficator warning light. The control is by a self-cancelling switch located on the steering column and equally suitable for facia mounted switch.

The trafficator supply is via the ignition switch and fed to control box A3, across the fuse to A4 and connected to the centre terminal of the switch.

From each of the side terminals of the switch, a wire is taken to the corresponding trafficator.

Where it is desired to incorporate a warning light on an existing installation, the assembly may be connected as shown in the following illustration.

TRAFFICATOR WIRING CIRCUIT 1



TRAFFICATOR WIRING CIRCUIT WITH WARNING LIGHT

The circuit shown here is in use where trafficators are fitted together with an indicator warning light. The supply to the indicator switch is from the A4 terminal protected by a fuse and directly controlled by the ignition switch. When installed on the vehicle, a GREEN cable is run from the A4 fuse terminal direct to the switch main terminal.

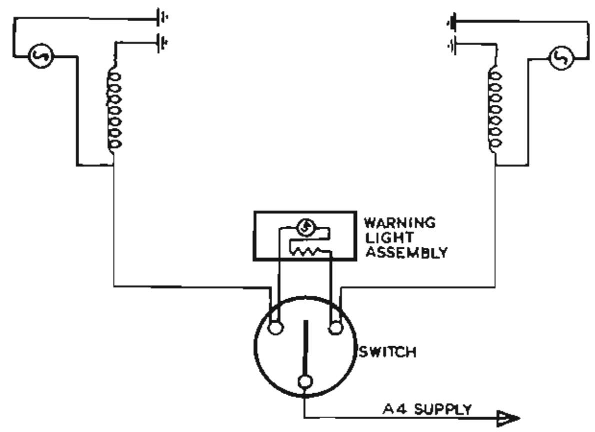
A GREEN and RED cable to the left hand, and GREEN and WHITE cable to the right hand trafficator complete the circuit.

The warning light is connected across the trafficator feed terminals of the switch.

When either trafficator is switched on, the warning light makes a parallel circuit to earth via the solenoid of the other trafficator.

The current taken by the warning light will only be small and insufficient to operate the trafficator.

TRAFFICATOR WIRING CIRCUIT II



TRAFFICATOR WIRING CIRCUIT USED ON EARLIER JAGUAR AND ROVER CARS

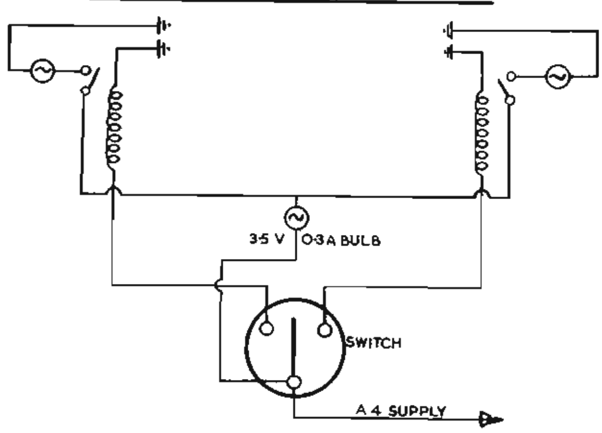
The special feature of this arrangement is the warning light circuit. This can only be completed by the switch and arm bulbs when the trafficators are in the fully raised position.

The advantage of this circuit is that with either an arm bulb fracture or the arm sluggish and not attaining the fully raised position, there would be no illumination of the warning light.

The trafficator and warning light supply wires are taken off the A4 terminal on the control box.

A BLUE and BLACK cable from the warning light is connected to an extra terminal on one trafficator, with a cross feed to the opposite trafficator.

TRAFFICATOR WIRING CIRCUIT III



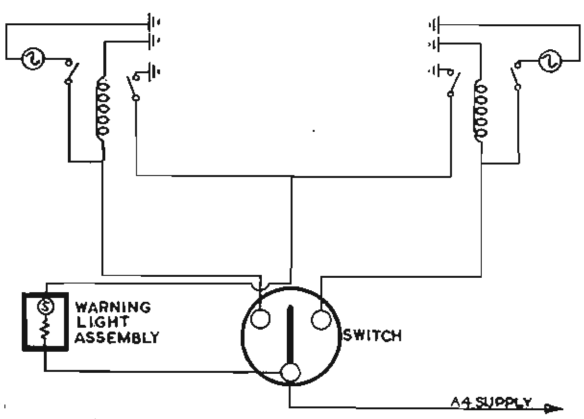
SPECIAL CIRCUIT FOR JAGUAR AND ROVER CARS

This arrangement had special features.

The trafficators incorporated two switches; the warning light circuit was only completed when the signal arm was in the fully raised position. The cable from the warning light was connected to an additional terminal on the trafficator, then to a special earthing switch built into the unit and earthing on the plunger in the fully raised position. An additional switch in the trafficator is for the arm bulb only, which completes the circuit in the fully raised position.

It will be observed that when the ignition is switched on, the supply is to the centre terminal and connected also to one side of the warning light. The other side of the assembly is connected to the earthing switch on the trafficator. This necessitates an additional cable to either trafficator.

TRAFFICATOR WIRING CIRCUIT IV



Flashing Lamp Direction Indicators

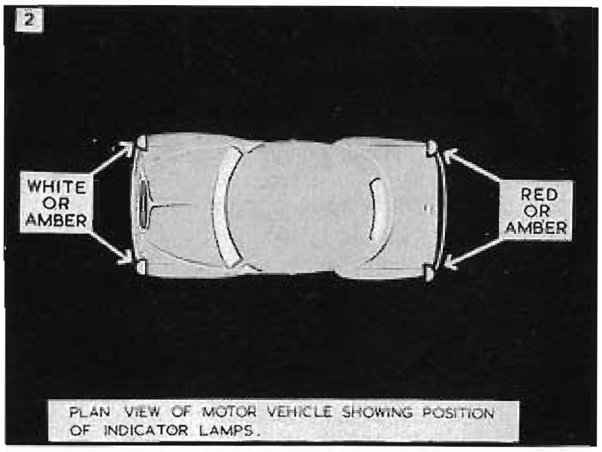
GENERAL

Four Light Direction Indicators or Flashing Light Indicators are a method of indicating change of direction widely used on American cars and now being fitted to some British cars as an alternative to the Trafficators.

The arrangement consists of a pair of lights at the front and rear of the vehicle, actuated by a switch and a flasher. Alternatively, a suitable amber coloured unit may be placed on each side of the vehicle.

The general design and lay-out of the arrangement as applied to the popular car conforms to the following principal recommendations :—

1. Two white or amber lights at the front of the vehicle and similar amber or red lights at the rear.
2. The lamps must be mounted between 17″ and 90″ from the ground and not more than 16″ inwards from the side of the vehicle.
3. They must not be less than 3½ square inches — vehicles over 2 tons 12 square inches — in area and the light shall be diffused by frosted glass or other adequate means.
4. The power of the lamp shall not be less than 15 or more than 36 watts.
5. The Flashing indicators may be combined with the vehicle's existing ' Side and Stop Tail ' lights, providing that a separate circuit and separate bulbs or bulb filaments are used.
6. The flashing rate of the lights must lie between 60 and 120 per minute.
7. The indicators shall be fitted so as to enable the driver to observe that they are operating ; or alternatively a warning light must be installed.



PLAN VIEW OF MOTOR VEHICLE SHOWING POSITION OF INDICATOR LAMPS.

VEHICLE SHOWING POSITION OF INDICATOR LAMPS

With such an indicator system we need four lamps, one at each corner of the vehicle, two facing forward and two to the rear.

All four lamps may show an amber light, or those at the front may be white and those at the rear red.

To give a visible and unmistakable signal, the lamps should show an intermittent light ; in other words they are made to flash or wink.

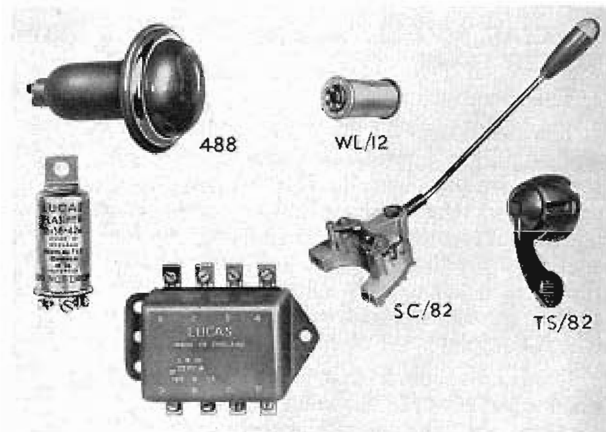
COMPONENTS OF THE "FLASHER" EQUIPMENT

Here you see the typical possible units of a flasher circuit.

In the simplest arrangement, however, only FOUR components are required :—

1. Four separate lamps (or Double Filament Bulbs in the side lamps) and separate rear lamps.
2. A Warning light mounted inside the vehicle.
3. The Flasher Unit.
4. An Indicator Switch. Two types of switch are shown, the one on the right being the SC82, a non-cancelling switch recommended for use when the Flasher Set is supplied as an accessory. The switch shown on the left is the self-cancelling type, the return being actuated by a cam on the steering column. It incorporates a warning light in the amber knob on the end of the arm.

A popular variation of this arrangement — dependent upon the choice of the vehicle manufacturer — is to use the Brake Stop Lights for the rear indicators.



This requires a ' Relay ' in addition to the other components, and incidentally complicates the wiring quite considerably.

CIRCUIT WITH INDEPENDENT REAR INDICATOR BULBS

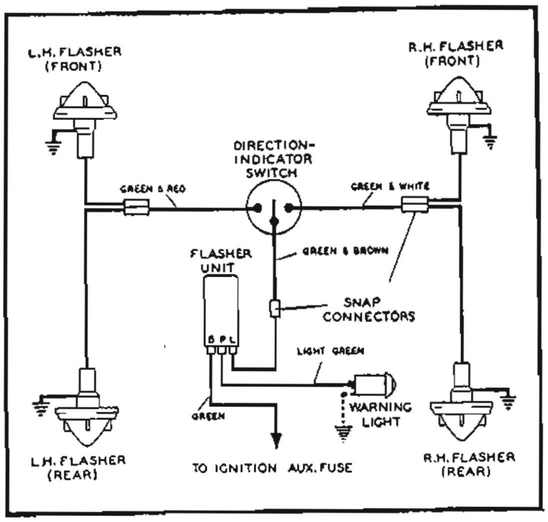
The simple layout and circuit using the side lamps at the front end and separate lamps at the rear is shown in this picture.

Looking at the lower centre, we see that the feed is taken from the ignition auxiliary fuse Terminal A4 at the Control or Fuse box directly to terminal B on the flasher unit. Current passes through the unit and out to terminal L, which is connected to the centre point of the direction indicator switch.

Here the circuit divides, leading to the left or right-hand lamps, according to the position of the switch.

Looking at one side only, say the right, we see that the front and rear lamps are connected in parallel ; the circuit to earth is completed through the lamp filaments.

The indicator warning lamp is connected between terminal P of the flasher unit and earth.



CIRCUIT EMPLOYING DB10 RELAY

If, as is frequently the case, the Brake Stop Lamps are used as Rear Indicators, this picture shows the general arrangement.

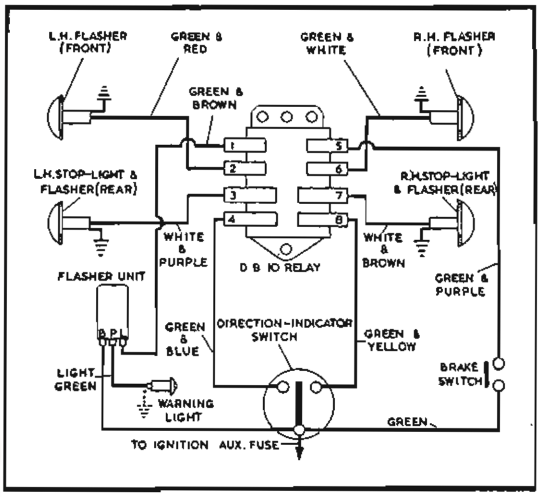
It comprises the same units as before with the addition of a Relay as shown at top centre. The sole purpose of this is to put the Brake Stop Lights out of circuit whilst it is functioning as a direction indicator.

Now to clarify this circuit, note carefully that the Indicator Switch — centre picture — is used to operate the Relay only.

The current feed from A4 terminal as before supplies separate circuits.

1. The Indicator Switch to operate the Relay.
2. The Stop Lamp Switch and then through the Relay to the Stop lamp bulb filaments.
3. A feed to the Flasher unit. From this unit to the Relay and from separate contact points in the Relay to the filaments in the Sidelamp and Stop Lamp bulbs.

Lastly, there is the Indicator Warning Light which is fed directly from the Flasher Unit — terminal P through the lamp to earth.



THE FLASHER UNIT — OPERATION OF THERMAL SWITCH

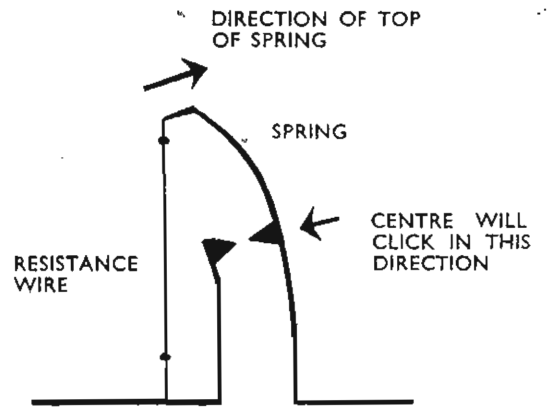
The Flasher unit is basically a Thermal switch for interrupting the current at a pre-determined rate per minute ; in other words, it switches the lamps on and off. The rate of flash is between 60 and 120 times per minute. This and the following diagrams will make the operation clear.

On the left of the picture on the next page we see a piece of resistance wire, anchored at the bottom end to the frame of the unit, and at the top to a spring, so that it is always kept under tension. The spring is a piece of thin metal, so shaped that when it is bent, a ' buckling ' or ' click ' action takes place in the centre. The centre of the spring carries one of a pair of contact points.

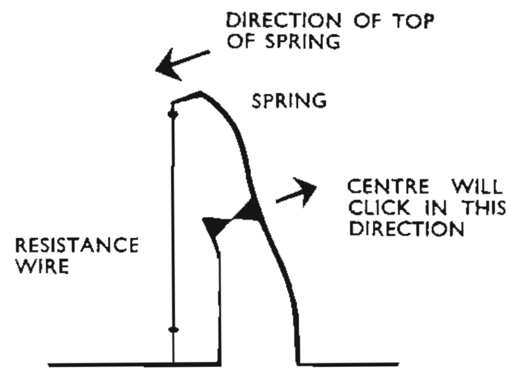
These are normally open. When current passes through the wire it will get hot and expand.

The top of the spring will move in the direction shown in the diagram. Because of the click action the centre will move in the opposite direction to the top. In practice, the points will be snapped closed when the top of the spring has travelled a pre-set distance. In simple terms this so-called " Click " action is produced by distorting a specially shaped strip of metal in the vertical plane whilst it is already under stress in the horizontal plane. This principle is widely used in the construction of micro switches. It ensures a quick positive action for a very small movement.

Continued



BASIC FLASHER UNIT—CONTACTS OPEN

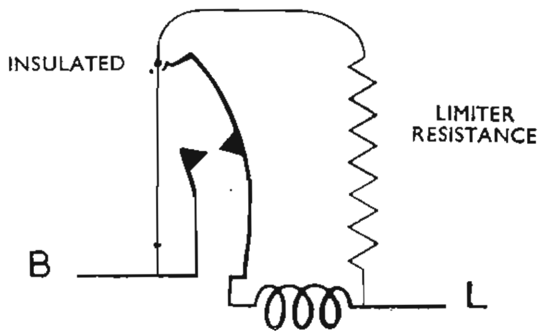


BASIC FLASHER UNIT—CONTACTS CLOSED

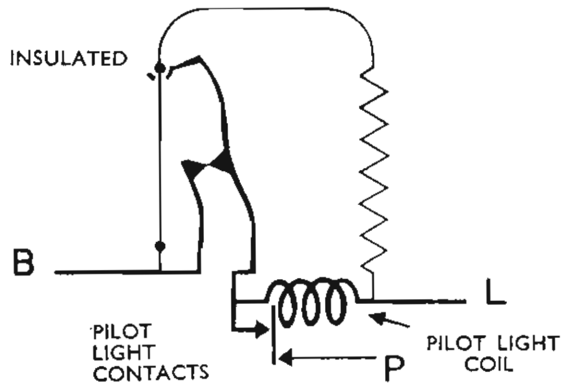
The closing of the points by-passes the hot wire and current will no longer flow through it. It immediately begins to cool, and contracts, consequently reversing the action.

As we see in the second illustration, the points are now closed, by-passing the resistance wire. The latter is thus contracting. The top of the spring will be pulled back to the left and, at a critical point, the contacts will click open. The resistance wire is again in circuit and current will pass through it ; the heat will cause it to expand and the points on the blade will ' click ' closed again.

We will point out that current will continue to pass through the resistance wire when the contacts are open, as we do not completely break the circuit — however let us look at the next picture.



FLASHER UNIT—CONTACTS OPEN



FLASHER UNIT—CONTACTS CLOSED

THE LIMITER RESISTANCE

Here we see what happens in the complete unit. Our hot-wire is shown on the left and in the centre the click spring and contacts. But we now show a resistance in series with the hot wire. This serves two purposes : it limits the amount of current passing through the flasher bulbs to below that at which they will light. It also prevents any sudden surge of current from damaging the wire when the indicators are switched on. Current passing through the wire will cause it to expand ; the spring will click over once again, and the contacts close.

OPERATION OF THE PILOT LIGHT

Having produced the Flashing light, provision has to be made for the Dashboard Warning Light. This is done by means of what is termed a ' Pilot Light Coil.'

When the main contacts close, the current to the lights, now passes through this coil. As soon as the coil is energised, it moves a small armature which closes a pair of contacts in the base of the unit. This completes the lead to the pilot lamp, causing it to flash in sympathy with the main bulbs.

However, the pilot coil is so designed that it will operate the Pilot light contacts when 36 to 40 watts are being consumed. Should less current flow, for example if one bulb failed, the contacts will not close and the pilot light will not flash, thus warning the driver that one of his direction indicators is not working.

Three leads marked ' B,' ' P ' and ' L ' are brought out to terminals in the base of the unit. The one marked ' B ' for battery will normally be connected to the A4 terminal on the control box. The centre terminal ' P ' is wired to the Pilot Lamp. The terminal marked ' L ' will feed the indicator lights, via the indicator switch or a relay if fitted.

THE FLASHER UNIT — FITTING

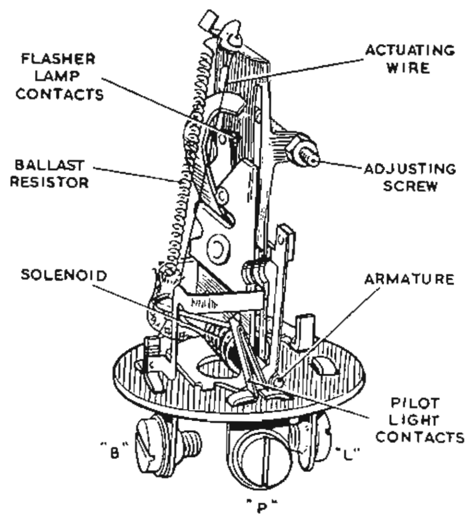
Here we have the complete Flasher with the cover removed.

As in most Thermal Switches this unit is susceptible to damage by the ingress of dust or moisture. Additionally, the temperature must be kept uniform to maintain the correct rate of Flash. For these reasons the unit is hermetically sealed by means of an aluminium cover. This of course, precludes the possibility of any adjustment in service, but in any case this is a tricky business that can only satisfactorily be done in an instrument Repair Shop.

The following precautions are necessary to ensure satisfactory performance from the flasher :

1. The mounting position must be vertical, with the terminals at the bottom. A position free from engine vibration should be chosen.
2. The correct bulbs must be used, i.e., originally TWO 18 watt, now TWO 21 watt filaments on each side.
3. Not more than 4 amps should pass through the unit at 12 volts, i.e., 48 watts. Damage may be caused if this is exceeded.
4. Less than 36 watts will not operate the Warning Light.

Testing can be carried out by applying 12 volts to the ' B ' terminal and connecting a pair of 21 watt lamp bulbs to the ' L ' terminal and a 12 volt 2·2 watt Ignition Warning bulb to the ' P ' terminal.



The Flash rate 60–120 per minute can be checked by counting the Flashes over 10 seconds and multiplying by SIX.

Care must be taken with this lightly-built unit both in Transit and Storage to prevent it becoming damaged.

THE DB10 RELAY

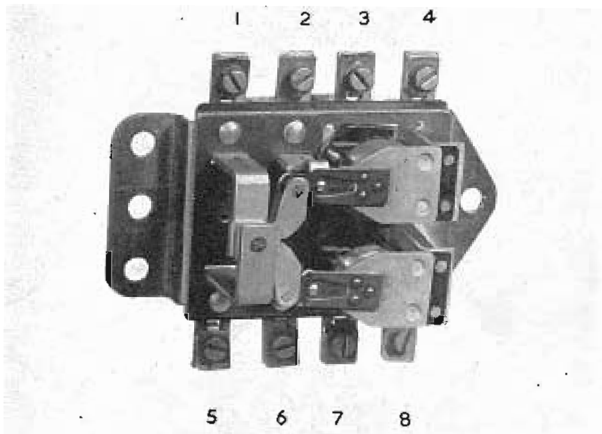
The Relay which has to be fitted when the Stop Lamps are used as direction indicators is the type DB10.

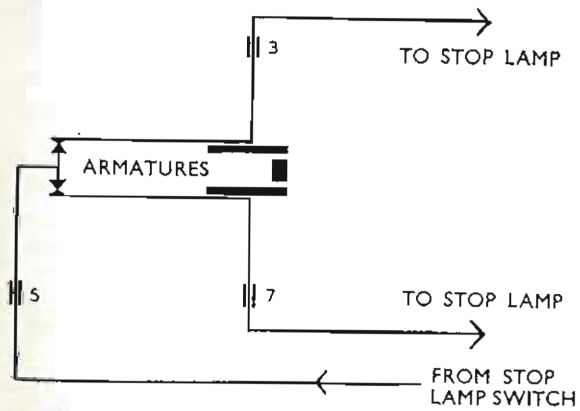
This is an EIGHT terminal Relay with the following layout :

5	Feed from Stop Lamp Switch Lead to ' L ' terminal on Flasher	1
6	To Left and Right Front Indicators	2
7	To Left and Right Rear Indicators	3
8	To Direction Indicator Switch	4

Simply connect the correct wires in this order and all will be well.

The function of this unit is to interrupt the current supply to either stop lamp when it is to be used as a direction indicator light.





DB10 RELAY SHOWING STOP LAMP CIRCUIT

THE DB10 RELAY IN THE REST POSITION

The electrical operation of this Dual Relay is quite simple if we follow it through in stages.

This diagram shows the current carrying component of the Relay when it is not being used for indicaitng purposes, i.e., at the rest position.

The two armatures — centre of picture — are then making contact with two points which are connected together left; the current feed is through terminal 5 from the Stop lamp switch.

Each armature at its fixed end is connected to a stop lamp through terminals 3 and 7.

With the relay in this position, both lamps will light when the stop lamp switch is closed by the action of the brake-pedal.

OPERATING SOLENOID AND CONTACT SETS

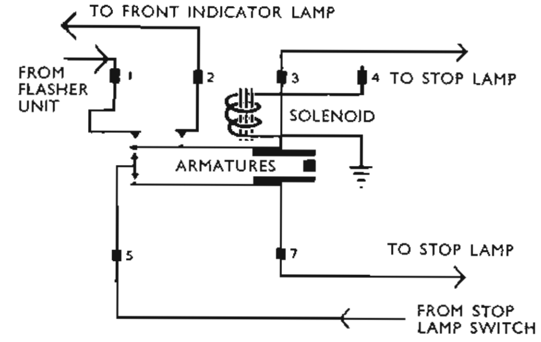
In this diagram we see that the two armatures are still at rest, and the stop lamps will operate as we described in the last figure.

We said that the unit is actually two relays mounted together, and the armatures we show form part of them.

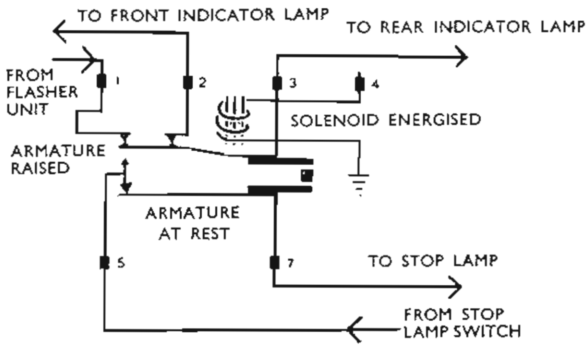
Next we have added two contacts above the top armature, which is operated by the solenoid.

One contact is connected to the flasher unit through terminal 1, whilst the other carries current to the front indicator lamp on one side of the vehicle via terminal 2.

One end of the single *operating* Solenoid shown is earthed to the frame of the relay, and the other is brought out at terminal 4. This terminal connects to one side of the indicator switch.



DB10 RELAY—'AT REST' WITH ONE PAIR OF CONTACTS ADDED



DB10 RELAY—ONE SOLENOID ENERGISED

TURNING TO THE RIGHT

When the indicator switch is moved to the right, the solenoid shown is energised. This lifts the armature and closes the pair of points.

Current then flows from the Flasher unit through terminal 1, across the armature and to the front indicator lamp via terminal 2. The rear indicator is fed via terminal 3. This lamp can no longer act as a Stop Light because the current supply from terminal 3 is now broken.

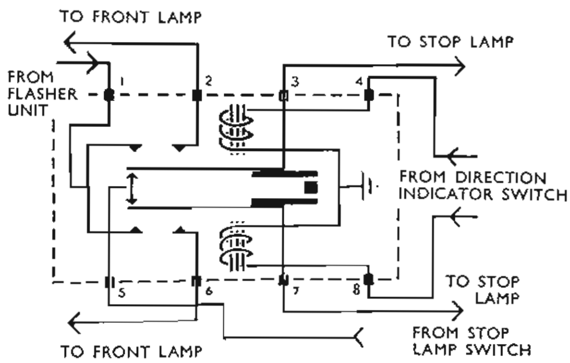
The other armature is still at rest and you will notice that the feed from the stop-lamp switch remains intact to the stop lamp. This means that the stopping signals can still be given on the left-hand side of the vehicle when the turning signals are in use on the right-hand side or vice versa.

THE COMPLETE RELAY ASSEMBLY

Here we have the complete assembly. We agree that the diagram makes this simple piece of equipment look complicated.

However, you can see that it is quite ingenious and compact.

The unit is fully sealed to prevent ingress of dirt and moisture and, even if the mechanism were easily accessible, it would be a time-wasting proposition to attempt adjustment or repair.



DB10 RELAY

THE LAMPS

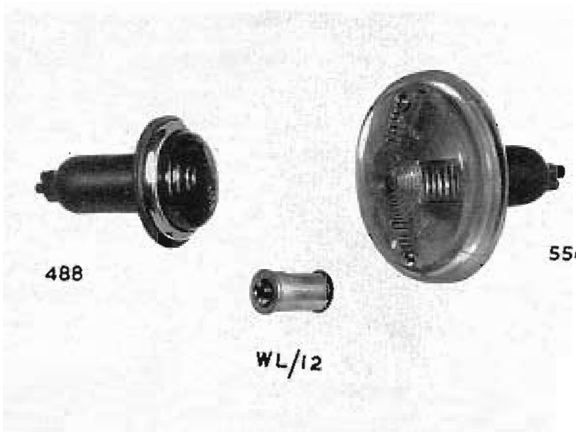
When separate lamps are fitted to a vehicle, there are two types available : the type 488 seen on the left of the picture and the 556 seen on the right.

Type 488 Lamp. This is a flush-fitting lamp consisting of a moulded rubber body holding a fluted glass and chromium plated rim. When used for direction indication it can be supplied with a white, red or amber glass, and either single or double filament bulbs (6 or 12 volt).

The models fitted with white or red glasses used for giving indication signals as well as the side or rear lighting are fitted with two pole bulb-holders having off-set slots to take a double filament bulb of the popular types No. 361 or 380.

The flasher set supplied as an accessory consists of four of these lamps with amber glasses, each having single filament 12 volt 21 watt bulbs No. 382.

Type 556 Lamp. This lamp has been specially designed for commercial vehicles. It has a moulded diakon plastic lens, amber in colour, with an area of 12 square inches. It is held in position by two screws. The body is moulded rubber fitted over a steel base-plate and a single filament bulb holder takes a 21 watt



bulb.

The WARNING LIGHT is the type WL/12, also used as a Headlamp Main Beam Warning Light. It has a die-cast body, with small amber polystyrene lens in a chrome bezel. A miniature screw type bulb is used, fitting in a standard bulb holder.

THE BULBS

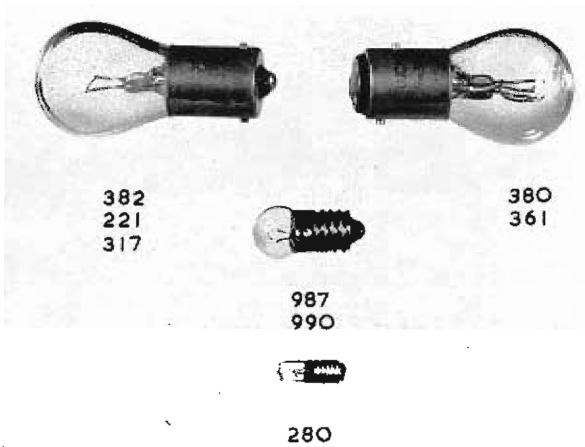
Separate Indicator Lamps. The correct bulb is No. 382. This is a 12 volt 21 watt single-filament bulb with a single contact cap. The original bulb used was the No. 221 (12 volt 18 watt). The corresponding 6 volt bulb is No. 317 (6 volt 18 watt).

The Combined Stop Tail and Indicators use Bulb No. 380. This is the 12 volt bulb with 6 and 21 watt filaments. It has a small bayonet cap (9/16″ dia.) with off-set pins to ensure that the bulb is correctly positioned.

The 6 watt filament is used for the side or rear light and the 21 watt filament for the Indicator or Stop Light.

The stop lamp filament was originally 18 watts but was subsequently increased to 21 watts to increase the brilliance. This increase is noticeable when the indicator is used in strong sunlight. If the 6–18 watt bulb is required as a replacement in one of the earlier installations, the correct number is 361.

Warning Light. The bulb used is No. 987, 12 volt 2·2 watts, with a Miniature Edison Screw Cap (M.E.S.) This is the same type of bulb as used in the ignition warning lights where no resistance is fitted ; it is



also used extensively for instrument panel illumination. For the 6 volt system a similar bulb No. 990 (6 volt 3 watts) is used.

A new type of warning light bulb, known as a Lilliput Bulb is shown at the extreme bottom of the picture. It is No. 280, fitted to the TC82 Direction Indicator Switch and is only available in 12 volt.

THE FLASHER SET AS AN ACCESSORY

A Flasher Indicator Set is now available as an accessory for vehicles not already fitted with this type of indicator. This is fully described and detailed in our Sales Leaflet No. 1100.

The set consists of FOUR Type 488 Lamps, a Flasher Unit and a Warning Light. No Direction Indicator Switch is supplied as generally the existing self-cancelling switch on the steering column will be used. For vehicles where this is not so, an Indicator Switch No. TS82 is available.

A Fitting Instruction Leaflet is supplied with each set, the wiring circuit being that which we examined on page 49.

The correct size cable for either the 12 or 6 volt layout is 14 strand/·012 auto-cable. The colours we recommend for new car installations are :—

1. Ignition Auxiliary fuse A4 to Terminal B on the Flasher Unit — GREEN.
2. Terminal P on the Flasher to the warning light — LIGHT GREEN.

3. Terminal L on the Flasher to the centre terminal on the Direction Indicator Switch — GREEN and BROWN.
4. Direction Indicator Switch to the lamps on the near-side of the vehicle — GREEN and RED; and to the off-side, GREEN and WHITE.

L559 FLASHER INDICATOR SET

A TWO Lamp Set is also provided for ' after sales ' fitment and is available for both 6 and 12 volt working. It is mainly applicable to earlier types of cars, vans, taxis, etc., and as an interesting and profitable Service Sales line is worthy of some detailed examination.

The set comprises the components shown in the picture which it will be noticed does not include a switch.

Where a trafficator switch is already installed this will be quite suitable. In the event of a switch being required the most popular suitable model is the TS82 Panel mounting TWO-WAY and OFF Switch as illustrated on the right.

THE CIRCUIT ARRANGEMENT

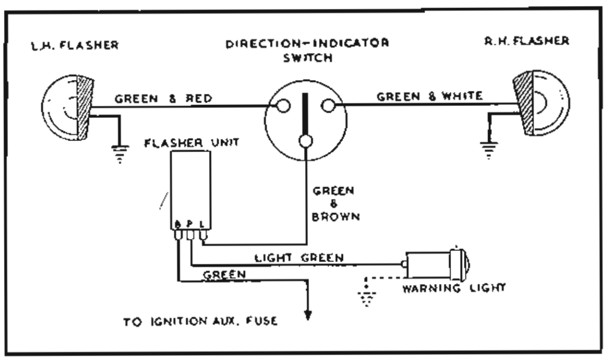
The very simple circuit arrangement shown in this illustration can be easily followed.

Current supply from the A4 terminal at the control box or fuse panel connects directly to terminal B (battery) on the Flasher unit and from terminal L (Lamps) to the centre contact of the TWO WAY and OFF panel mounted switch.

From each side of this switch the supply is wired directly through the lamp bulbs to earth.

As with the FOUR Lamp Sets the warning lamp bulb is wired directly from terminal P (Pilot) on the Flasher unit through the warning lamp to earth.

The cable required for installation will be size 14/·012, Master Colour Green and for convenience in subsequent service, the tracer colours as shown in the diagram should be used if possible.



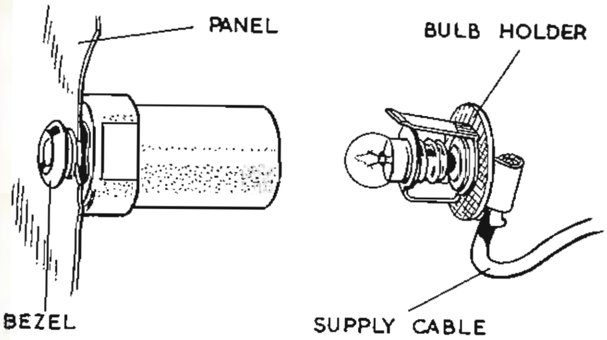
THE TYPE FL3 FLASHER UNIT

This unit is special for the TWO lamp set and whilst having the standard flash rate of 60–120 per minute is designed for a current of 15–21 watts only. This unit is part number 35007 for the 12 volt and 35008 for the 6 volt model.

When installing a set it is important that the Flasher unit should be positioned where it will not be affected by engine vibration or exposure to the weather and mounted upright with the wiring terminals pointing downwards.

As a point of interest it may be noted that the Flasher Unit for the Four Lamp Set carrying 42 watts is FL3 Part No. 35003 for the 12 volt and Part No. 35005 for the 6 volt.

It will be appreciated at once that the TWO and FOUR Lamp Flasher Units are not interchangeable.



THE WARNING LAMP TYPE WL12

The Warning Light shown should be installed in a prominent position on the facia panel directly in the driver's line of vision as far as possible.

This lamp is a single hole fixing model and the bulb is installed from the rear as shown.

The correct bulbs are as follows :—

12 volt sets :	Lucas 987	2·2 watts	MES
6 „ „	„ 990	3·0 „	MES

(Miniature Edison Screw)

THE No. 559 LAMPS

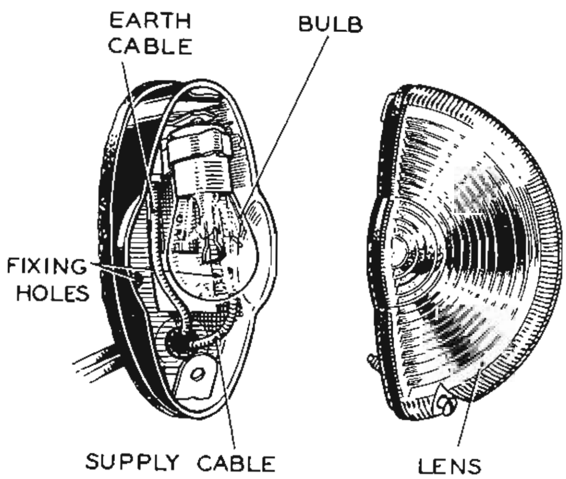
These should be installed in a conspicuous position at the widest part of the vehicle not more than 7′ 6″ from the ground or less than 1′ 5″ and not more than 6. 0″ behind the windscreen. They should also be mounted upright in order that the maximum amount of light be projected towards oncoming traffic.

In the detailed Instruction Leaflet No. 1210 supplied with each set a drilling template is provided for convenience of installation.

The general arrangement of the lamp is clearly shown in the illustration, and on the back is shown the flexible rubber mounting pad which is supplied with it.

To ensure satisfactory operation it is essential that lamp bulbs of the correct wattage are used, and the replacement numbers specified below will be useful to note, particularly in the event of any service trouble being encountered with the Flasher Unit, in which case the first thing to do will be to check the bulbs.

12 volt sets	Lucas No. 382	21 watt	SCC
6 „ „	„ „ 317	18 „	SCC

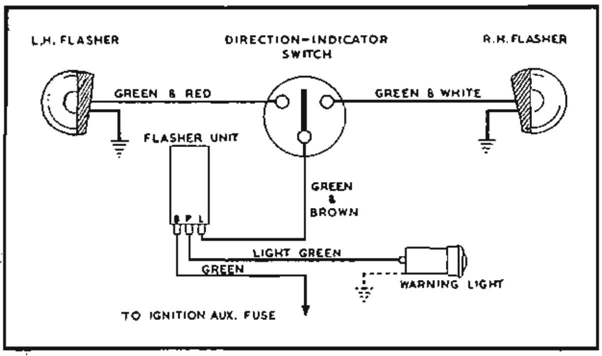


THE SWITCH

If the vehicle has been previously fitted with direction indicators the existing switch can of course be used.

When installing a new switch, care in choosing a position of maximum convenience and accessibility to the driver's hand is of value.

One of the most popular and readily available switches for panel mounting is the model TS82 as illustrated, but any other type of TWO WAY and OFF switch capable for carrying 3 amperes may be used.



THE WIRING

The wiring up of the TWO Lamp Indicator set will be as laid out in this diagram and is an operation which may frequently be simplified by the use of snap connectors.

If the vehicle has no convenient fuse point available from which to take the current supply it may be connected from a point on the Ignition switch circuit such as the coil terminal on the ignition switch or the SW terminal of the ignition coil itself. This will preclude the possibility of the Indicators being left ON when the engine is stopped prior to getting out of the vehicle.

Care should be taken to provide an effective earth from each Indicator lamp and also the warning lamp, by installing separate earth wires wherever necessary.

A particular useful hint is to test out the wiring after installation with the Flasher unit itself out of circuit. To do this, before connecting the feed to the fuse disconnect the three flasher unit connections and join them all together. Connect the feed wire to the current supply terminal and then operate the indicator switch. If anything is incorrect it will immediately show up and can be rectified without risking damage to the Flasher Unit itself.

SERVICE TESTING THE FLASHER INSTALLATION — SEPARATE INDICATORS

Having told you all about the indicator equipment, we can now consider how to test this equipment in Service. To do this, we will divide the procedure into the two basic circuits.

We start with the simple circuit first, i.e., that employing four separate indicator lamps.

1. **With the ignition switch on, check for a voltage reading at the following points :—**

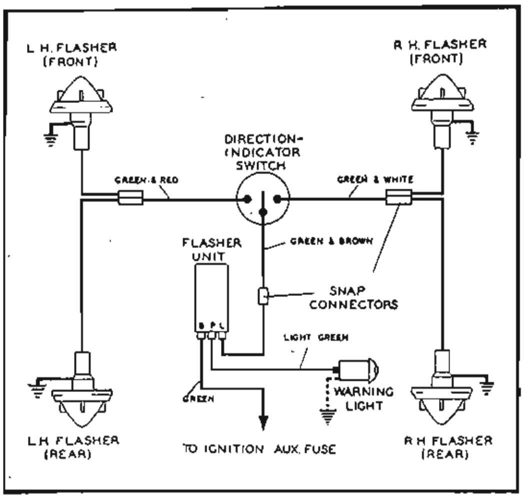
   (a) A4 Fuse.

   (b) ' B ' Terminal of the Flasher Unit.

   (c) ' L ' Terminal of the Flasher Unit.
   A reading at both these terminals of the Flasher unit proves continuity of the flasher unit itself. If there is a reading at one terminal only, the unit should be changed.

   (d) The Feed Terminal of the Direction Indicator Switch.

2. **To check the remainder of the wiring and system.** Turn the indicator switch to either side, when both lamps (one rear and one front) will ' flash '.



If any one lamp does not light, it is an easy matter to check through the wiring with a voltmeter for an open circuit or blown bulb, etc.

SERVICE TESTING THE FLASHER INSTALLATION — INCORPORATING DB10 RELAY

Service testing is slightly more complicated when a DB10 relay is incorporated in the circuit.

The procedure then would be as follows :—

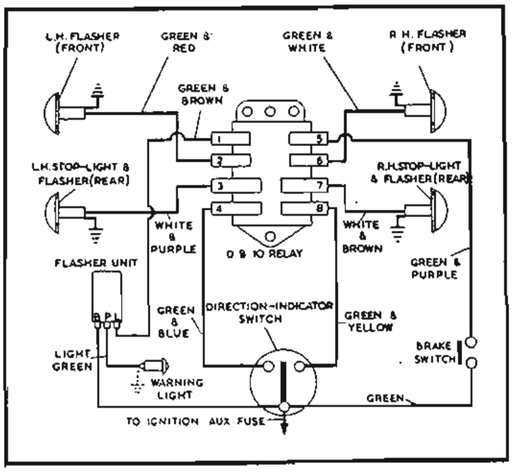
1. **Switch on the Ignition.**
   Battery voltage should be registered between earth and the following points :—

   (a) **A4 terminal on fuse board** — if no reading is obtained, check fuse and A3 supply.

   (b) **Direction indicator switch feed terminal** — if inaccessible, check at nearest possible point, e.g., base of steering column, snap connector, etc.

   (c) **Flasher Unit feed terminal B** — if letter ' B ' is not visible, reference to test (d) below shows that voltage should be registered at the two directly opposite terminals.

   (d) **Flasher Unit terminal ' L ' (opposite ' B ')** — reading proves continuity through the unit. — no reading indicates a faulty unit.



   (e) **DB10 relay No. 1 terminal** — voltage registered only if a reading was obtained at ' L '.

Continued

2. Connect a temporary feed wire from the A4 terminal, in turn, to the following terminals of the DB10 relay.

(a) **No. 3 and No. 7.**

Both stop lamps should light each time. If the *same* lamp does not light in either test, the fault must be in the wiring to that lamp, or in the bulb, the holder, earth, etc. If *alternate* lamps light individually during both tests, the fault will be in the relay.

(b) **No. 2 and No. 6.**

Each front indicator lamp should light. If not, check bulb, holder, lamp earth and wiring (from relay to lamp).

(c) **No. 4 and No. 8.**

Each relay should operate in turn, accompanied by flashing of one front and one rear indicator lamp.

If neither relay operates, first check that the unit is earthed. If it is, the DB10 is faulty.

If one relay does not operate — internal fault in the DB10.

If one relay operates and front and rear indicator lights on that side flash, but both lamps do not flash on the other side, even though their relay can be heard closing, the DB10 is faulty.

If both relays close, but none of the lights flash, the fault can be in either the DB10 or the flasher unit. In which case, eliminate one or the other by linking terminals 1 and 3 of the DB10.

If the flasher now operates, the DB10 is faulty. No change indicates a faulty flasher.

3. To check the remainder of the wiring and the indicator switch.

Turn the switch first to one side and then to the other. Each relay will be heard to close and all lights should flash. If this is not so, check wiring between switch and DB10 relay. (Terminals 4 and 5.) If wiring is in order, check switch itself.

4. Final checks.

(a) **Pilot Light** — This should flash in sympathy with indicators.
If it is not operating, check with voltmeter between earth and terminal 'P' flasher unit. A reading should be obtained at every flash of the indicators. No reading proves flasher unit faulty. If correct reading is obtained, check pilot light bulb and wiring.

(b) **Rate of flash.**

N.B. If flashing rate is not within the prescribed limits, do not suspect the flasher unit before ascertaining that the *indicator lamps* are of the *correct wattage*.

Incorrect bulbs will also seriously affect the operation of the pilot light.

Additional Test for Stop Lamps.

This test need only be carried out if the flasher system is in order, but the stop lamps do not operate.

Voltage should be registered at the following points :—

(i) **Stop lamp switch, feed terminal** — if this is inaccessible depress the brake pedal and check at (ii) below :—

(ii) **DB10 Relay No. 5 terminal** — no reading indicates a fault in the wiring from the stop-lamp switch, a faulty switch or an incorrectly adjusted brake linkage.

Interior Lamp Circuits and Door Operating Switches

GENERAL

On several recent saloon cars the lamps required for interior illumination and which are generally operated by a plain ON-OFF switch, have been fitted up with supplementary plunger switches operated by the opening and closing of the doors.

Generally the arrangement is that upon opening either door the switch will be ON and one or more interior lamps will light up. When the door is closed — presumably after the entry of the passengers — the switch will again be OFF and the lights will go out.

If for any reason the lights are still required after entry they can be switched ON and OFF by means of a separate lever type switch usually built into the lamp itself.

As these individual wiring arrangements may be difficult to follow out when seen *in situ* on the vehicle, they will be illustrated and described separately.

In all the different arrangements it should be noted that the current supply is taken from the A2 fuse terminal and connected directly to the lamp bulb and the switch and switch wire is on the earthed side.

The cable used for these circuits is usually 14/012 BROWN and GREEN from the fuse, and BLACK on the earth side.

Various types of lamps are installed, and altogether some FOUR models of lamp bulbs are in use. A particular type can most conveniently be obtained by reference to the Lucas parts list for that model, or the bulb replacement list if the lamp fitted is not of Lucas manufacture.

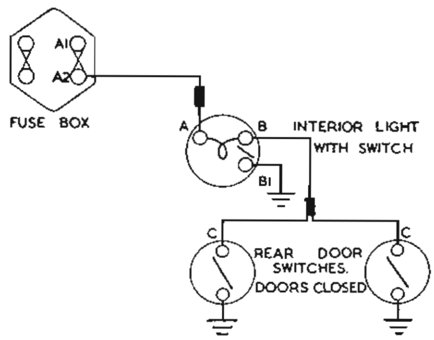
INTERIOR LIGHT CIRCUIT WITH TWO DOOR SWITCHES AS FITTED ON AUSTIN A40, A50 and A90 MODELS FOR 1954-55

The current supply from the A2 fuse is junctioned through a ‘ Snap ’ connector directly to the light bulb in the interior lamp at (Terminal A).

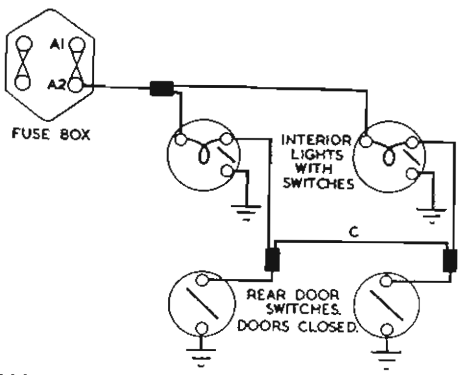
For local operation the Switch B1 is connected direct to earth.

When fitted with TWO door switches as shown an additional cable is wired from the bulb connection at B, by means of a snap connector to one side of each door switch C and C1, the other switch terminals connecting directly to earth.

With the doors closed both switches will be OFF, but when either door is opened the switch will be ON and the interior lamp will remain alight until either or both doors are re-closed. Optional control of the lamp is still available from the local switch B1.



DOOR SWITCH CIRCUIT FOR AUSTIN A40 A50 A90. 1955.



DOOR SWITCH CIRCUIT FOR WOLSELEY 6/90 1955.

INTERIOR LAMP AND DOOR SWITCH CIRCUIT — WOLSELEY 6/90, 1955

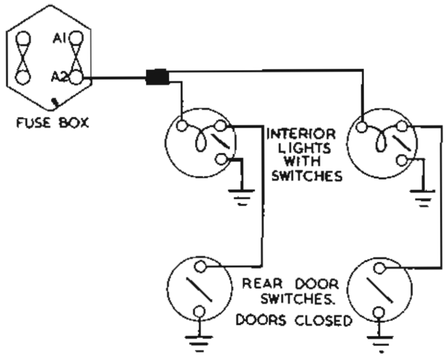
On this model using two interior lights it should be observed that whilst the circuit is basically the same as the one just examined, for convenience the wiring arrangement is slightly different.

The lamp on each side is connected directly to its nearest door switch through a snap connector and to enable both lamps to be brought on when either door is opened an inter-connecting cable (C) is looped between the two snap connectors.

Local control is obtained by the individual switches on each light.

INTERIOR LAMP AND DOOR SWITCH CIRCUIT — HUMBER MK. VI AND RILEY PATHFINDER MODELS

Although there are Two Interior Lamps with their independent switches on these cars, the circuit is so arranged that each interior lamp is connected independently to it's own door switch.



DOOR SWITCH CIRCUIT FOR RILEY PATHFINDER & HUMBER MKVI 1955.

INTERIOR LAMP AND MAP READING LAMP CIRCUIT WITH PANEL AND DOOR SWITCHES 1955 MK. VII. JAGUAR

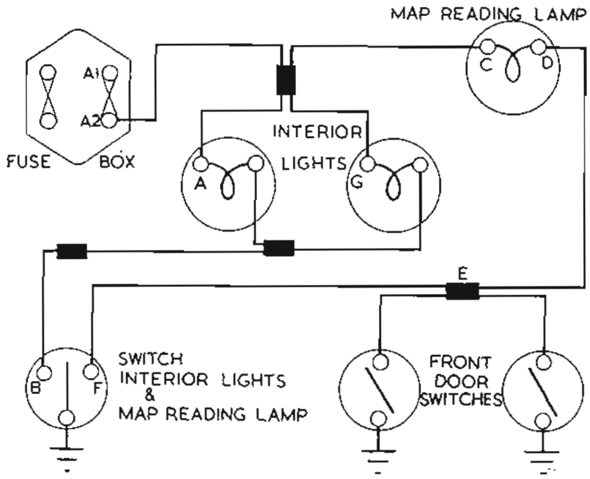
On this model TWO interior lamps are supplemented by a ' Map Reading ' lamp and the control for all three is provided by means of a panel mounted TWO WAY and OFF switch. Additionally, DOOR switches are installed in the FRONT doors only.

Following the circuit through, it will be seen that the current supply from A2 is taken via a snap connector direct to one side of both interior lamps and also the map reading lamp, as shown at A, G and C.

The return from both interior lamps is joined by a snap connector to terminal B of the panel switch. The centre or common terminal C of this switch being connected to earth.

The return from the map reading lamp D is via the snap connector E to the other terminal F of the panel switch.

Now for the Door switches. The return from the map reading lamp only is connected by the snap connector E to one side of each door switch and across both switches to earth. Thus, if either door is opened the switch will bring on the map reading lamp only, which will again be automatically switched off when the door is closed.



DOOR SWITCH CIRCUIT FOR JAGUAR MK VII 1955.

LUCAS

TECHNICAL SERVICE

OVERSEAS TECHNICAL CORRESPONDENCE COURSE

Section 9
ELECTRICALLY CONTROLLED OVERDRIVE

JOSEPH LUCAS (SALES & SERVICE) LTD · BIRMINGHAM 18

Printed in England

INTRODUCTION

With the ever increasing demand for higher cruising speeds with fuel and oil economy, the overdrive, which offers these advantages, is now becoming increasingly popular among British automobile manufacturers. In point of fact the overdrive, with which we are concerned in this section of the course, is fitted as standard equipment to several cars in the high performance range and is an optional extra to many others. The overdrive unit is basically the same on all cars, but the method of controlling it may differ, depending on the requirements of the individual manufacturer.

Lucas engineers have devised a variety of methods for operational control of the overdrive, and all are designed for driver comfort and ease of operation. These methods range from a simple manual control, to a fully automatic system with overriding manual control.

This section describes in detail the construction, operation and servicing of the Lucas electrical equipment controlling the overdrive, together with circuit testing procedure, a study of which will impart sufficient knowledge of the equipment to enable you to carry out any servicing required, quickly and efficiently.

CONTENTS

JOSEPH UCAS (SALES & SERVICE) LTD., BIRMINGHAM, ENGLAND.

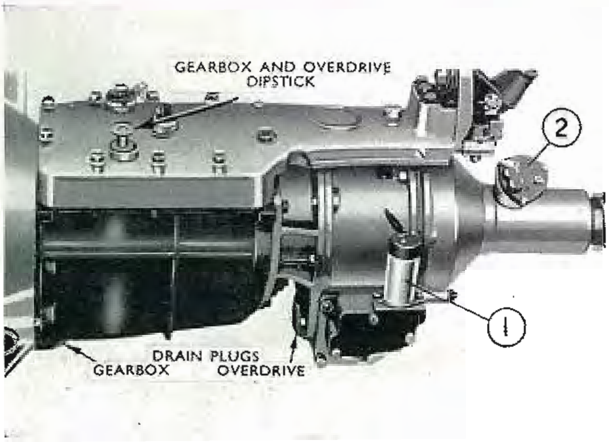
Working Principles

APPLICATION

The Laycock de Normanville 'Overdrive' with Lucas Electrical Control is now being applied to an increasing number of British Cars.

The vehicles which come to mind at once are : The Austin Healey — 100, The Standard Vanguard, Triumph Roadster and Renown, Jaguar Mark VII — XK 140, Triumph TR2, Bristol 405, Vauxhall Velox and Wyvern, Sunbeam Alpine Special and MkIII, Humber Hawk MkVI, Ford Zephyr and Consul, Swallow Doretti.

For those of us who are unfamiliar with the Overdrive, we shall explain the general functioning of the equipment and its electrical control.



THE OVERDRIVE ON THE CAR

This picture shows the 'Overdrive' Gear Box in place behind the normal gear box. Two of the major electrical components are visible, the Main Operating Solenoid low down on the side (1) and the Centrifugal Switch mounted on top at the back of the gear box at point 2.

To give some general idea as to how this equipment works we cannot do better than briefly run over the manufacturer's own description of it.

As will be generally realised, a motor car engine depends partly for its power development on the number of revolutions per minute, hence the provision of intermediate gears enabling the engine to revolve at higher revolutions for a given road speed, and so provide the additional power required for acceleration and hill climbing.

In direct or top gear the only multiplication of engine revolutions in terms of the driving road wheels is through the rear axle, in which the crown wheel and pinion provide a reduction ratio to suit the particular vehicle.

Considerations of engine power available, the weight of the vehicle, wind resistance and other factors, determine the actual ratios and top gear performance.

The direct top gear, whilst providing for high cruising speeds must remain sufficiently flexible to avoid frequent gear changes at lower road speeds.

It will be appreciated therefore, that the selection of such an axle ratio must be something of a compromise. To provide for flexible top gear performance at lower speeds, something must be sacrificed at the maximum. In other words, the engine revolves faster than is actually necessary at higher speed.

A means of overcoming this problem is to overgear, or 'overdrive' the speed of the propeller shaft, and thus the road wheels, in relation to engine revolutions, or, vice versa, to reduce the speed of the engine in relation to the road speed.

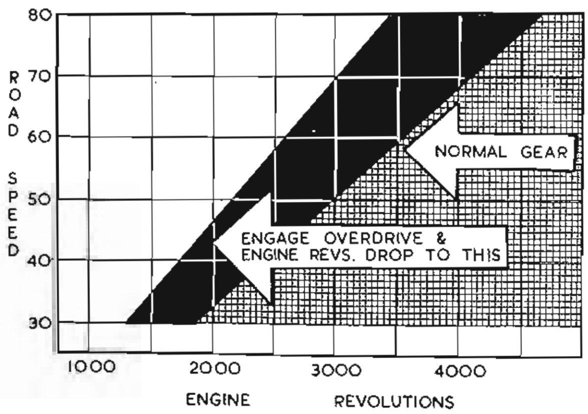
A very high top gear, possibly a fifth, could be incorporated in the ordinary gearbox. With such a gear, however, it would then be necessary to make far more frequent use of clutch, accelerator and gear lever to engage the next lower gear in order to meet any sudden power demand.

ROAD SPEED COMPARISONS

This diagram shows a typical example of engine speeds in top gear and overdrive in relation to road speed.

The vertical ordinate of the graph shows road speed, and the horizontal, engine revolutions. The hatched area shows the comparative road speeds and engine revolutions in normal gear, and the black section makes the same comparison with the car in overdrive. Let us take one example — that of 3,000 engine revolutions which you will see on the bottom line. If you carry your eye up to the inter-section of the hatched area and the black you will see that at 3,000 engine revolutions in normal gear we have a road speed of 50 miles per hour, with a corresponding road speed of 70 miles an hour when in overdrive at the same engine speed.

Converse[illegible] if we take a road speed of 50 miles an hour it [illegible] be seen that in normal gear the engine is doin[illegible]ig over 2,000 revolutions for the same road speed. We should therefore, anticipate a substantial improvement in petrol economy in overdrive.

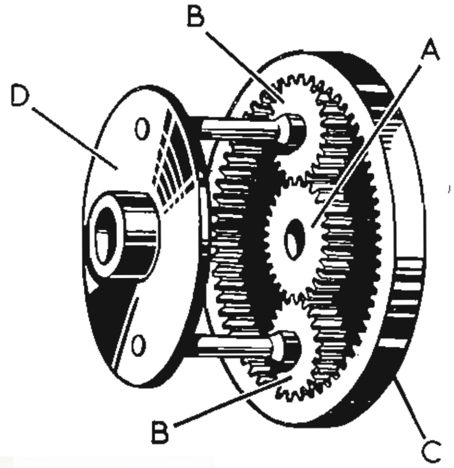


PRINCIPLE OF OPERATION

Basically the 'Overdrive' consists of an epicyclic gear train, which comprises a SUN wheel A, a pair of PLANET Wheels B mounted on a PLANET CARRIER D, and an ANNULUS or outer ring C.

If the planet carrier is rotated whilst the sun wheel is locked to the annulus or the planet carrier, the whole gear train will rotate as a solid unit giving a direct through drive.

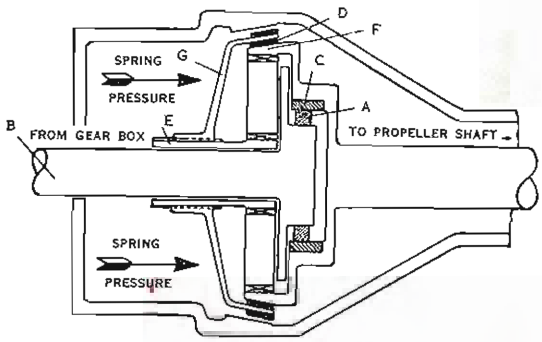
If on the other hand, the sun wheel is locked preventing it from rotating, and the planet carrier is turned, the annulus will be overdriven at a higher speed than the planet carrier.



HOW IT WORKS

In addition to an epicyclic gear train similar to the one depicted in the last picture, there is also a hydraulic pump, a hydraulic accumulator or pressure storage chamber, a roller clutch and a sliding cone clutch.

When in direct gear the overdrive is inoperative. The drive is taken from the driving shaft B through the rollers A of the roller clutch to the annulus C. It will be realised that the roller clutch, being uni-directional can transfer power in one direction only, and that if the car were to over-run the engine, the roller clutch would act as a free wheel leaving the car without engine resistance to assist braking. It would also be impossible to reverse the car for the same reason. This problem is overcome by means of the cone clutch member G which slides on a splined extension E on the sun wheel and is pushed by eight compression springs so that the inner lining D engages with the corresponding cone on the outer rim of the annulus F. This therefore, locks the sun wheel to annulus so that the entire gear train and cone clutch rotate as a solid unit with the drive being taken through the roller clutch, and overrun and reverse being taken through the cone clutch.

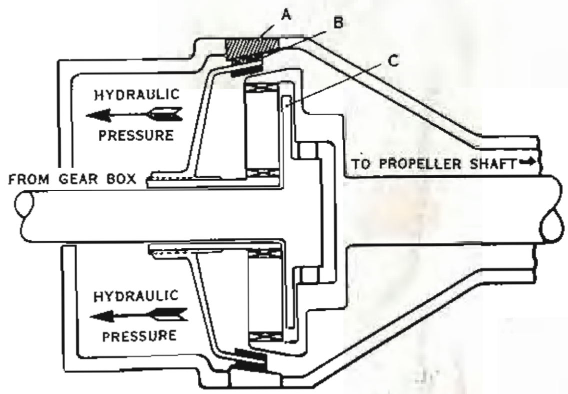


WITH OVERDRIVE ENGAGED

When the overdrive is engaged, a valve in the unit is opened, applying hydraulic pressure from the pressure accumulator to two pistons which work in cylinders formed in the unit housing. These pistons exert pressure against the cone clutch member, overcoming the spring pressure and pushing the cone clutch away from the annulus until the outer lining (B) presses against a conical brake ring (A) built into the main casing of the gear box.

The sun wheel, which carries on its splined extension the cone clutch, is free to rotate on the driving shaft, therefore, when the cone clutch comes into contact with the brake ring, both cone clutch and sun wheel are brought to rest and held stationary. The planet carrier (C) which is splined to the driving shaft is driven round the stationary sun wheel so that the planets rotate and overdrive the annulus at a higher speed than the driving shaft.

In overdrive, the outer member of the roller clutch overruns the inner member. Engine braking is again provided by the cone clutch which holds the sun wheel from rotating in either direction.



METHOD OF OPERATION

The change into or out of overdrive is made without effort, and with perfect smoothness, only the rise or fall in engine note being noticeable, with resultant increase or decrease in engine noise and vibration.

The use of overdrive claims to provide considerable fuel economy, at least 10 per cent dependant upon usage and circumstances, with additional saving in oil and engine wear.

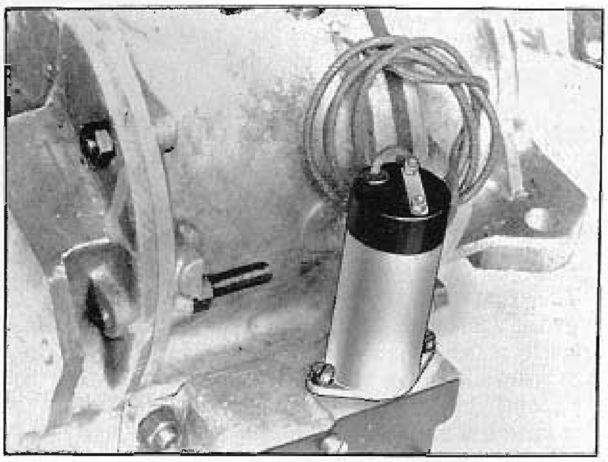
It is relevant to mention that the overdrive gear may operate on top gear only, or on top and second gear, or top and third — in a four speed box — as arranged in the original layout of the vehicle.

There are also a variety of ways of effecting the change into overdrive. One is direct through mechanical linkage, the others with which we shall now concern ourselves are the electrical control methods.

ELECTRICAL CONTROL

There are two forms of electrical control in use, manual or automatic.

In either case, the principal unit is a solenoid switch, which is featured in this picture, and is mounted on the side of the gear box. Its function is



simply to open and close the hydraulic actuating valve for the overdrive gear change.

The various other components used on either or both systems are concerned only with the control of this main solenoid.

We can now examine the simple form of manually operated electrical control.

THE MANUALLY OPERATED ELECTRICAL CONTROL

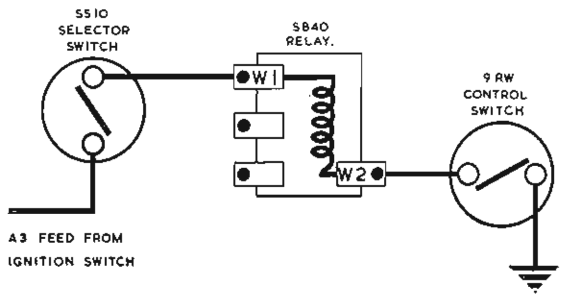
In this arrangement the main solenoid is operated through a relay switch type SB40 which is itself actuated by two separate switches.

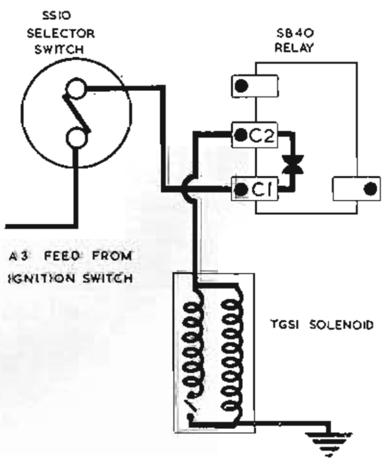
The current supply which is generally under the master control of the ignition switch and is taken from the A3 terminal of the ignition switch is shown at the left of the picture.

A first requirement of the arrangement is that the overdrive must not operate in reverse gear or in the first or first and second gear of the 3 or 4 speed boxes respectively. The current supply is therefore taken direct to a plunger type switch SS10 as shown on the left of the picture, which may be installed in the side of the gear box, or alternatively linked to the gear change mechanism and operated by the gear selector lever. This switch ensures that the circuit for the overdrive solenoid is never complete unless the correct gear is selected.

From the other side of this switch the current is fed via terminal W1 and W2 of the relay windings through a simple ON-OFF switch to earth.

The comparatively heavy current required to operate the Solenoid itself, is switched by the main contacts of the relay at terminals C1 and C2. This current supply provides a feed for both windings in the solenoid which are earthed. We shall be dealing more fully with these ' Main ' and ' Hold-on ' windings later on.





ELECTRIC MANUAL CONTROL

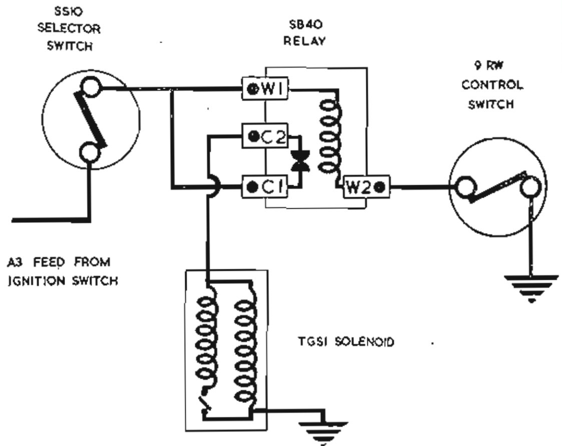
In this picture we have the complete circuit for the electrically operated manual control.

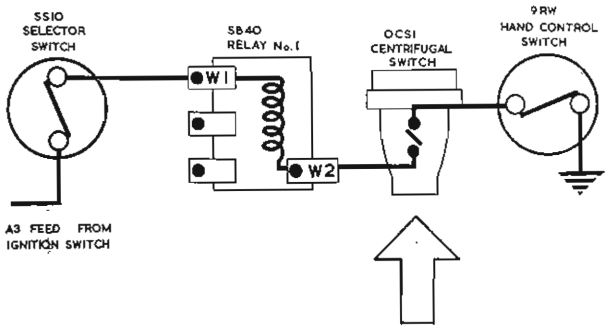
To allow the overdrive to become operative, the hand control switch 9RW shown on the right of the picture, must first be closed.

When top or the other prescribed gears are engaged, the selector switch SS10 will then also be closed, and current can pass through the relay windings W1 and W2 to earth.

The Relay will then close contact C1 and C2, allowing current to flow through the solenoid windings to earth ; the solenoid plunger will then lift and open the hydraulic valve which will engage the overdrive gear, and it will remain engaged until either of the two switches are re-opened.

The current supply to C1 terminal of the relay is often taken direct from ammeter or main battery fuse.





THE AUTOMATICALLY OPERATED ELECTRICAL CONTROL

We can now deal with the Automatically Operated Electrical Control.

To achieve automatic changing into and out of overdrive it is necessary to install firstly, a centrifugal or governor type of switch which is driven from an extension of the Speedometer Drive Spindle.

In this component a single pair of contacts are opened and closed by a governor at pre-arranged road speeds. In general terms the governor closes the switch contacts at about 40 miles per hour and opens them at between 30–35 miles per hour.

As shown in our picture this switch is placed in the circuit between the W2 terminal of the No. 1 relay and the hand control switch.

Thus, with the hand control switch in the CLOSED position, the governor switch will operate the relay and engage and disengage automatically. That is : change into overdrive at about 40 miles an hour and change back to normal at about 30 *miles an hour.*

The centrifugal switch by itself will not fulfil all the requirements, and it is necessary t[illegible] introduce a further relay operated by means of a switch linked to the accelerator pedal which we [illegible] consider.

LIGHT RUNNING CONDITIONS

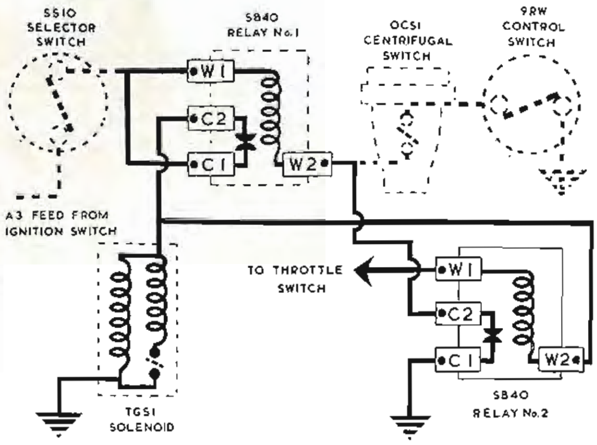
When coasting at small throttle openings, even at speeds below 30 miles per hour — when the centrifugal switch will be open — it is not desirable to come out of overdrive unless it is required to accelerate sharply, when the throttle will be opened up.

So, in order to keep the gear in ' overdrive ' under this Light Running Condition, a throttle switch linked to the accelerator pedal, together with an additional relay is introduced. We shall refer to this second relay, shown at the bottom right of the picture, as No. 2 relay.

The No. 2 Relay connected as shown — serves to keep the No. 1 relay points CLOSED after the centrifugal switch contacts have been opened.

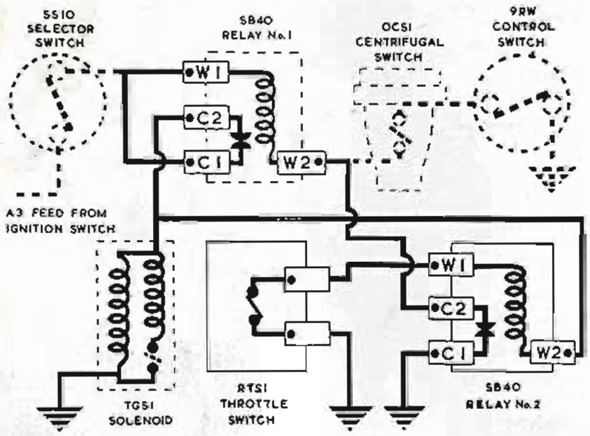
This No. 2 Relay will be energised when the throttle switch is CLOSED, but as soon as the throttle switch is opened, the earth side of the relay circuit is broken thus allowing the gear to change back to normal.

In brief, with the carburetter butterfly and the THROTTLE SWITCH closed, the car will remain in overdrive.



With the throttle more than one fifth open the switch will also be open and the car will return to normal gear until the centrifugal switch contacts again close and changes it back into overdrive.

Our picture shows quite simply how the No. 2 relay is added and connected to the No. 1 relay already in the circuit.



THE No. 2 RELAY AND THE THROTTLE SWITCH

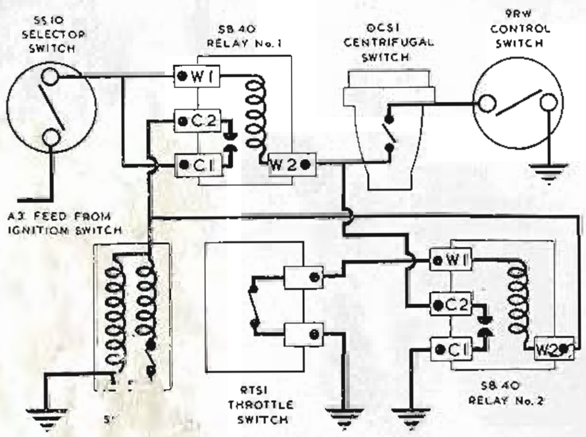
This picture shows the throttle switch added to the No. 2, and relay placed in the circuit.

Now try to follow this circuit through : the conditions are that the car is run in overdrive at less than 30 miles per hour with the gear selector and the control switches closed, and the centrifugal switch open.

For this condition current is fed from the C2 main contact of the No. 1 relay direct to the W2 terminal of the No. 2 relay, as shown at the bottom right, through the windings to W1 and thence across the contacts of the throttle switch to earth.

In this condition the No. 2 relay is energised, the contacts C1 and C2 will be closed, thus keeping the No. 1 relay energised, and the hold-on current for the main operating solenoid will be maintained irrespective of the centrifugal switch being open.

This condition will remain until such time as the throttle is opened and the throttle switch contacts also opened, thus breaking the current supply to the solenoid when the overdrive will change back to normal.



AUTOMATIC OPERATION

Here we have the complete circuit of the automatic control which you may wish to study before commencing on the next part.

THE ELECTRICAL COMPONENTS

So far, we have built-up our overdrive control, using the following components:—

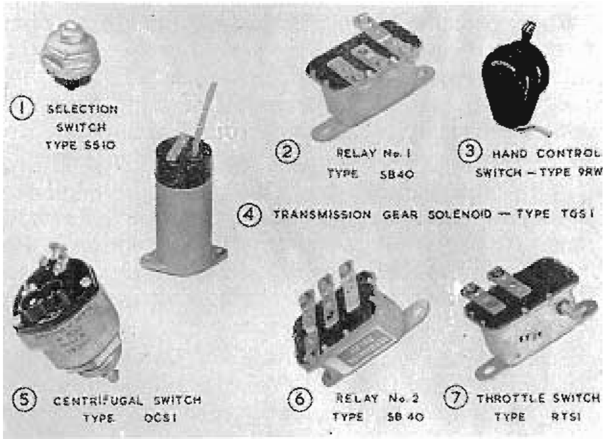
Commencing at the top left of the picture for the 'Manual Control' System there are four units.

1. The Gear Selector Switch, type SS10.
2. The Relay type SB40 Relay.
3. The 'Hand' or 'Overdrive' Control Switch type 9RW.
4. The 'Transmission Gear Solenoid' type TGS1.

For 'Automatic' Control there are three additional units:

5. The 'Centrifugal' Switch type OCS1.
6. An additional SB40 Relay.
7. The Rotary Throttle Switch type RTS1.

You will remember that the various switches exist only to make the No. 1 Relay actuate the transmission gear solenoid under differing conditions, and that this solenoid opens the hydraulic valve in order to change the gears from 'Normal' to 'Overdrive' and *vice versa*.



We can now examine these components individually.

GEAR SELECTOR SWITCH TYPE SS10

As previously mentioned this switch is usually the first component in the current supply line and may be installed in the side of the gear box.

Its function is to keep the overdrive gear out of engagement generally in first and reverse gears.

In construction it is a simple ON-OFF Plunger type switch. It is not a diaphragm switch and it is not oil proof.

At the same time oil passing through it will not generally affect its operation.

Service troubles with this switch are mostly due to incorrect setting of the external linkage, not providing sufficient plunger travel to properly close the contacts.

It can easily be tested on or off the vehicle by means of a Voltmeter or Lamp bulb across the contacts.

With Plunger 'out' switch should be open.

With Plunger 'down' the switch is closed.

TYPE SB40 RELAYS

You may be aware that the general function of a relay switch is to enable a current, particularly a fairly heavy current, to be switched 'on or off' from a remote position, thus minimising the voltage loss, generally termed 'Volt Drop,' which may occur.

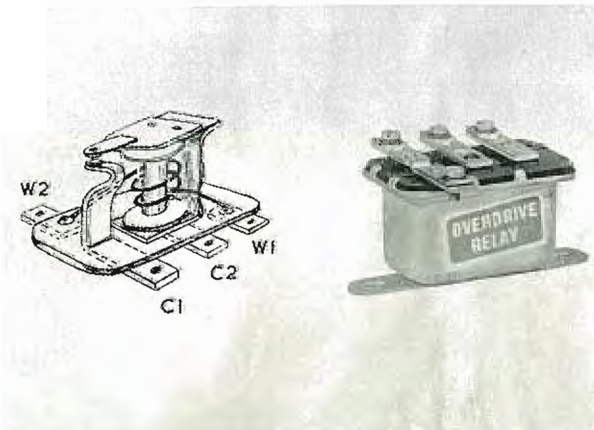
The SB40 relay shown is a typical example of this class of switch.

The main current supply is connected at the C1 and C2 terminals, and terminates at the contact points as shown.

When the armature is drawn down on to the bobbin core, the points close allowing a current to pass.

Terminals W2 and W1 are connected to the ends

continued



TYPE SB40 RELAYS—*continued*

of the relay coil winding as shown. A quite small current passing through this winding creates a strong magnetic field in the core and pulls down the armature, and so closes the main contacts which will remain closed for as long as the relay coil is energised.

This model of the SB40 has been built specially for the overdrive and the label 'Overdrive Relay' distinguishes it from the model SB40 generally used as a horn relay, which is not suitable for the overdrive, the main difference being that one is designed for continuous working and the other for intermittent service only. Both the SB40 Relays used on the overdrive are identical and interchangeable.

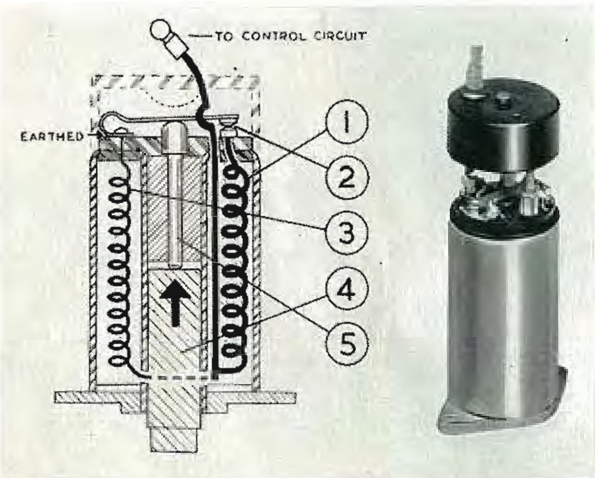
Normally these relays are practically foolproof other than when the points become overheated and damaged, as may result from an external short circuit.

They can be proved by two very simple continuity tests.

1. For the Relay Windings.
2. To check continuity under load across the main contacts.

THE OVERDRIVE CONTROL SWITCH

This is a plain ON-OFF Switch, lever actuated, and may be of various patterns according to the mounting position, which is generally on the steering column or facia panel.



THE TRANSMISSION GEAR SOLENOID

The transmission Gear Solenoid when energised is the unit which brings about the change into and out of overdrive.

As shown in the picture the solenoid itself has two windings. A heavy, or closing winding shown on the right (1), connected to EARTH through a pair of contacts (2).

The hold-on winding is connected directly to earth (3), as shown on the left. Both of these windings are in circuit when the current is applied.

When the solenoid plunger (4) is pulled into the coil the end of the plunger lifts the striker pin (5), and opens the main winding contacts (2). These contacts remain open whilst the plunger is in the raised position thus keeping the main winding open circuited.

The heavy or closing winding requires 18 to 19 amperes and is only in circuit momentarily.

The hold-on-winding requires about 1 to 1½ amperes and is sufficiently powerful to hold-up the Solenoid Plunger indefinitely.

Point clearance and air gaps are pre-set and cannot be altered in service.

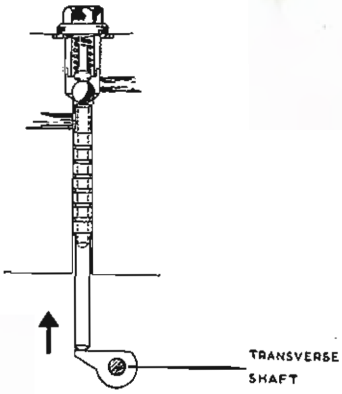
It will be realised at once that the ingress of metal, dust, dirt, water or oil into the solenoid assembly can seriously interfere with its operation and in the event of failure of this unit, wholly or in part, this is the first thing to look for.

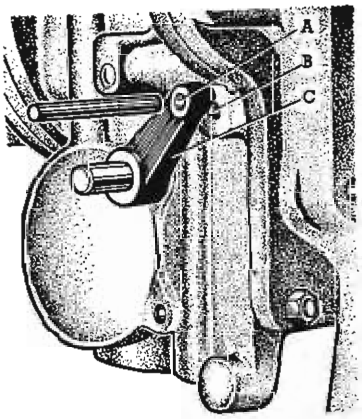
TRANSMISSION GEAR SOLENOID ATTACHMENT — THE HYDRAULIC ACTUATING VALVE

We next come to the attachment and set-up of the transmission gear solenoid to the gear box itself.

To ensure satisfactory operation, it is necessary that the set-up of the solenoid to the gearbox is correct, and in the event of trouble or during a re-setting operation this is the first thing to check.

The Hydraulic Valve shown here is actuated by a cam fixed to a transverse shaft running through the gearbox. The Solenoid plunger operates through a lever attached to the other end of this shaft. When the solenoid is operated this valve must be fully opened.





THE VALVE SETTING LEVER

With the solenoid energised, the setting of this valve can be easily checked at the offside of the gearbox shown in the picture.

The end of the valve actuating shaft carries a short lever (C) with a $\frac{3}{16}''$ hole at the outer end, which should register with a similar hole in the casting as shown at A and B. If it does so the valve setting is correct.

For the purpose of setting the solenoid plunger — which we shall deal with later — a $\frac{3}{16}''$ pin such as a drill shank — will be inserted to hold the valve in its correct open position whilst setting the solenoid lever at the other side of the gearbox.

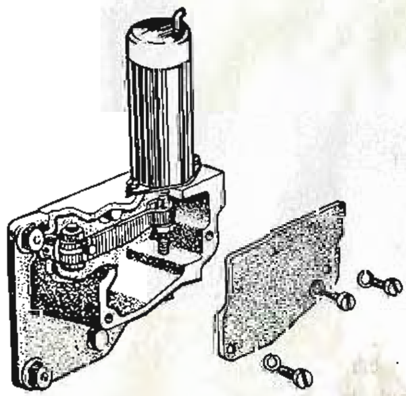
THE REPLACEMENT OF THE TRANSMISSION GEAR SOLENOID

If for any reason the solenoid has to be changed, the original Plunger may be left in position provided that it is clean and free from rust.

In this circumstance it will be necessary to check the setting for correct valve operation after fitting the new solenoid.

To do this the following operations are necessary :

1. Energise the solenoid.
2. Check the position of the valve setting lever — offside of box — by inserting the $\frac{3}{16}''$ pin and if the holes will not line-up the solenoid assembly must be re-set.



THE SETTING OF THE TRANSMISSION GEAR SOLENOID

A complete re-set of the Solenoid assembly is carried out in the following manner :

Commencing with the $\frac{3}{16}$" pin in position on the valve setting lever to hold the valve open proceed to :

Remove the cover plate (1).

Loosen the lever clamping bolt (2).

Energise the solenoid (3) (Check that the plunger travels the full movement).

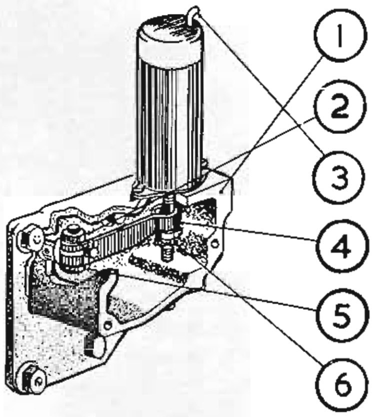
Hold the lever lightly against the plunger bolt head (4).

Re-tighten the lever clamping bolt (5) taking care to see that there is no end play in the cross shaft.

Check the REST stop clearance to $\frac{1}{4}$" (6).

Remove the locating pin from the offside of the gearbox.

Operate the solenoid several times to check for correct working.



Note.—A simple way to energise the solenoid is to break the snap connector at the Solenoid terminal and connect with a short lead direct to battery negative.

THE CENTRIFUGAL SWITCH

Driven from the speedometer take-off spindle, this switch comprises two components :

An orthodox type of flyweight governor (1) actuating a plunger shown at 4.

A micro switch movement (2) opening and closing a single pair of contact points, shown at (3).

Increasing speed throws the weights outwards and lifts the plunger, which in turn closes the micro switch contacts. Thus switching ON the current to the Overdrive solenoid through the No. 1 Relay.

The points close at round about 800 governor r.p.m. This speed is pre-set and varies according to the model of vehicle.

With falling speed, the points re-open at 80 per cent of the closing speed.

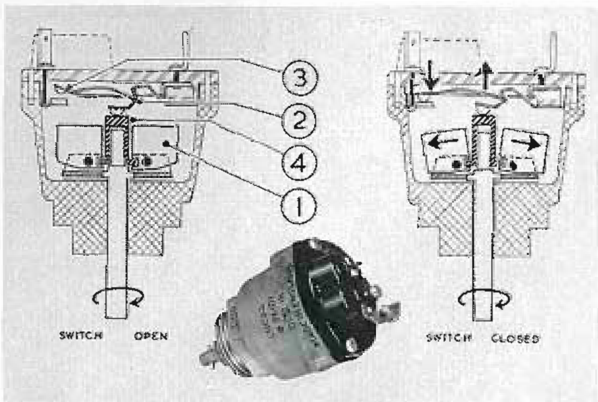
In practice this means that the vehicle generally changes to overdrive around the 40 miles per hour mark and returns to normal gear round about 30–35 miles per hour.

A figure giving the closing revolutions of the switch is stamped on one of the flats of the hexagon body.

If trouble is experienced in service, several points can be looked to :

Damaged or loose terminals which may result from contact with any external obstruction and may cause [illegible]atic operation.

Term[illegible] [illegible]ecoming intermittently earthed, due to [illegible] the tunnel casing.



After removal of the switch, check that it is being driven and for possible end float at the spindle. This should be without ·002" and may cause erratic operation if excessive.

A further cause of erratic running may also result from excessive vibration at the gear box itself which the fitting of a replacement switch will not generally overcome.

These switches are all pre-set at the works and must not be altered *in situ*. Also the moulded top assembly should not be interchanged or the settings will be completely upset.

THE ROTARY THROTTLE SWITCH

You will remember that the function of this switch which is linked to the accelerator pedal, is to maintain current to the overdrive solenoid by means of the No. 2 relay. This applies when the vehicle is running in top gear below 30 miles per hour with the throttle CLOSED and the cetrifugal switch OPEN.

You will see in the picture that the switch comprises :

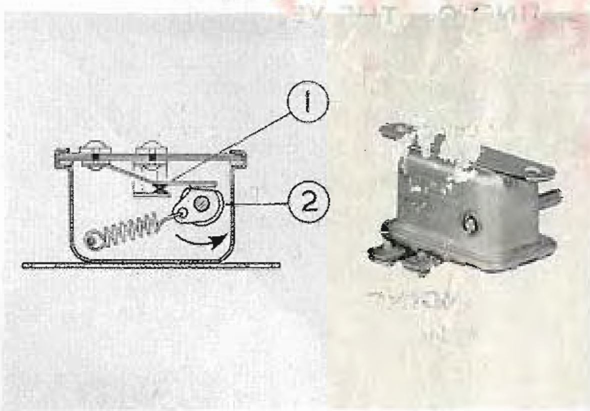
1. A pair of contacts on a spring blade.
2. A circular cam with a flat section, which is rotated by means of a lever linked to the accelerator pedal. A spring is incorporated to return the cam to its original position when the accelerator pedal is released.

With the throttle closed, the points will also be closed ; when the cam is rotated the points will open and remain so until the throttle is again closed.

It is a simple matter to check this switch :

1. See that the points are opening and closing.

   This can be done by means of a voltmeter, or a Test Lamp connected in series with the two terminals.



2. See that the rotating cam is correctly timed to the accelerator pedal.

   The correct setting of the cam is as follows :

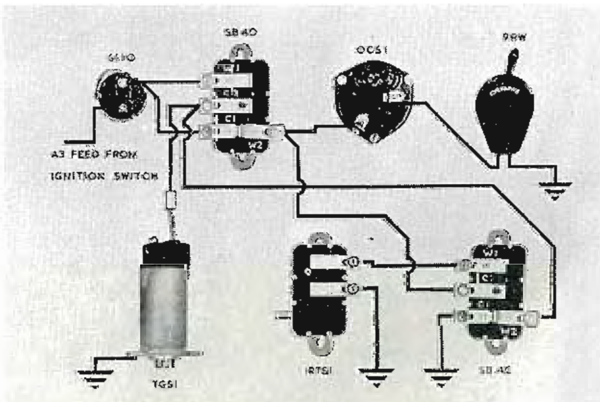
   Referring to the extreme right of the picture, the screw-driver slot in the end of the shaft should be horizontal with the switch in the rest position.

   The total movement of the cam is 90° and the contacts should remain closed for the first 15° to 35° of rotation.

THE COMPLETE AUTOMATIC CONTROL

Finally here is the pictorial diagram of the complete Automatic Control from which it may be seen how simple the whole arrangement is.

You may perhaps like to study this and make a copy of it for future reference.



TESTING ON THE VEHICLE

Checking and testing of this equipment *in situ* on on the vehicle may be simply and easily carried out if the following instructions are carefully followed when any defective unit or wiring will show-up.

A quick overall test can be carried out almost in a single operation without any special tools.

A full diagnosis test can be done with a simple test voltmeter and ammeter.

FAULT FINDING GUIDE

We shall deal primarily with faults which may develop on the vehicle in service. The chart shown here lays out the kind of symptoms which may be met and, as you will see, those concerning the electrical equipment are a minority.

From the chart it will be seen that there are five main items :

No. 1. OVERDRIVE DOES NOT ENGAGE.

Electrically this may be due to the solenoid operating lever adjustment or any other electrical defect.

No. 2. OVERDRIVE DOES NOT RELEASE.

Electrically this may also be due to incorrect solenoid plunger and operating lever adjustment, or some other electrical defect.

No. 3. CLUTCH SLIP IN OVERDRIVE.

Again this may be due to incorrect adjustment of the solenoid operating lever.

No. 4. As auto-electricians we are not concerned.

No. 5. OVERDRIVE ENGAGES.

With excessive braking effect when returning to normal gear with the throttle CLOSED.

This trouble will be primarily due to incorrect setting of the throttle switch lever, or it might be a faulty relay for example.

The test routine that we shall specify will cover in a few simple operations anything that can happen to the electrical equipment under all of the headings shown, which is all that the electrician is concerned with.

NO. 1 —— OVERDRIVE DOES NOT ENGAGE.
Insufficient oil in unit.
CHECK SOLENOID OPERATING LEVER ADJUSTMENT.
CHECK ELECTRICAL SYSTEM.
Check operating valve.
No oil pressure.

NO. 2 —— OVERDRIVE DOES NOT RELEASE.
Check operating valve.
CHECK ELECTRICAL SYSTEM.
CHECK SOLENOID PLUNGER AND OPERATING LEVER ADJUSTMENT.
Check for sticking cone clutch.

NO. 3 —— CLUTCH SLIPS IN OVERDRIVE.
Check oil in unit.
CHECK SOLENOID OPERATING LEVER ADJUSTMENT.
Check for low hydraulic pressure.

NO. 4 — CLUTCH SLIP IN REVERSE OR FREE WHEEL CONDITION IN OVERDRIVE.
Check restriction valve jet causing sluggish operation of cone clutch.

NO. 5 — OVERDRIVE ENGAGES AND EXCESSIVE BRAKING EFFECT WHEN RETURNING TO NORMAL WITH THROTTLE CLOSED.
CHECK FOR CORRECT SETTING OF ROTARY THROTTLE SWITCH LEVER.
CHECK ELECTRICAL SYSTEM.

CHECKING THE MANUALLY OPERATED ELECTRICAL CONTROL

Let us first deal with the hand operated electrical control — the simpler of the two. Irrespective of any specific complaint which may be made, a quick and simple overall test of workability can be carried out in three operations, after removing the floor casing to gain access :

Switch ON the ignition (1).

Close the hand control switch (2) and engage top gear, thus closing the gearbox switch contacts (3).

If the system is working the solenoid will immediately operate and open the hydraulic valve.

Check this visually by observing the movement of the valve setting lever on the offside of the gearbox, when the two $\frac{3}{16}''$ pin holes should register.

This proves immediately that :

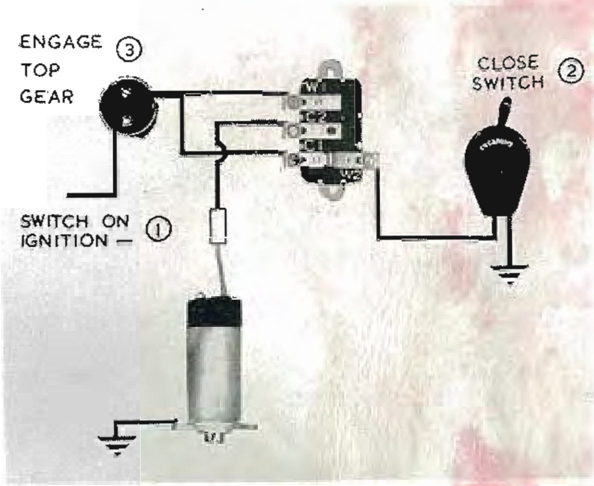
The current supply is on.

The gearbox switch is closing properly.

The hand control switch is closing properly.

The relay main contacts and operating windings are both working.

That the main solenoid is also operating.



Lastly, from an observation of the valve setting lever we shall know that the Hydraulic Valve is being fully opened.

CHECKING THE AUTOMATIC CONTROL SYSTEM

We can next apply a similar check to the automatic system in four operations.

With the vehicle stationary and the engine stopped, Proceed to :—

Switch on the ignition.

Close hand control switch and engage top gear.

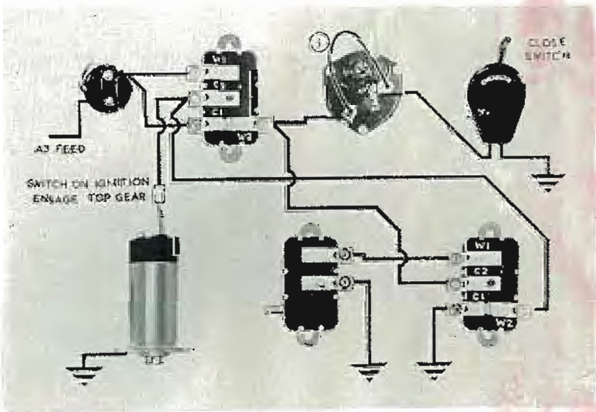
Link the terminals of the centrifugal switch as shown at (1). Then :—

If the system is operative, the main solenoid will be raised and will remain in this position.

Check the correct 'Open' position of the valve setting lever on the offside of the gearbox.

This simple operation of linking the terminals of the centrifugal switch proves :

1. The current supply is ON.
2. The gearbox switch is closing properly.
3. The hand control switch is closing.
4. That the main solenoid is operating.
5. That the hydraulic valve is opening fully.



If, when the link is removed, the solenoid plunger is still held, we also prove :

6. The main contacts and relay winding of *both* relays are operative.
7. That the throttle switch is closed.

TEST PROCEDURE

If the equipment fails to operate when the foregoing checks have been carried out, it will be necessary to make a methodical fault diagnosis.

This can most easily be done in three stages :

Stage 1. The circuit comprising — the SS10 switch, the hand control switch, the No. 1 relay and the main solenoid.

Stage 2. The circuit including the No. 2 relay and the throttle switch.

Stage 3. A test for the centrifugal switch and the main solenoid.

This is equally applicable to the manual circuit and represents the complete test for it.

STAGE 1 TEST

To Test the SS10, the Hand Control Switch, the No. 1 Relay and the Main Solenoid.

(A)

This test is carried out in six operations as follows :

With the engine stopped and the car stationary. Switch on the ignition.

Select top gear, thus closing the SS10 gearbox switch.

Bridge the terminals of the centrifugal switch (if automatic control).

Close the hand control switch. If the current is O.K. the main solenoid will come into operation and remain in the raised position.

Check the position of the valve setting lever (off-side Gearbox).

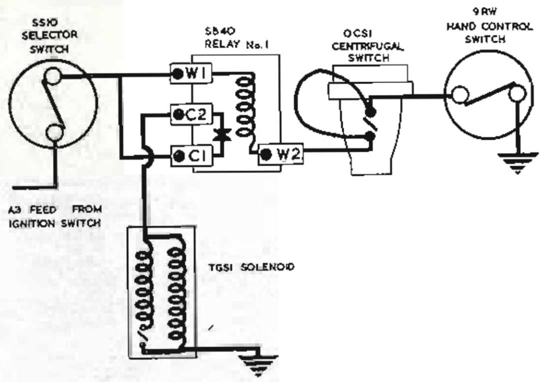
(B)

If the Solenoid fails to operate,. proceed to :

Break the snap connector at the Solenoid and energise it repeatedly by means of a jump lead direct from the battery negative.

If the solenoid proves to be in order :

Open the hand control switch and check through for full voltage readings with the negative volt-meter at the following points :



Across both terminals of the SS10.

Between — W1, W2 and C1 terminals of the No. 1 relay respectively and earth.

Between live side of the hand control switch and earth.

Close hand control switch when the voltage reading should fall to zero if the switch and earth line are O.K.

The No. 1 Relay should then close and a voltage reading should be obtained at Contact C2 (No. 1 relay) and also at the end of the solenoid feed wire. If no voltage is obtained at C2, the relay is defective.

STAGE 2 TEST

The part circuit, comprising the No. 2 relay and the throttle switch.

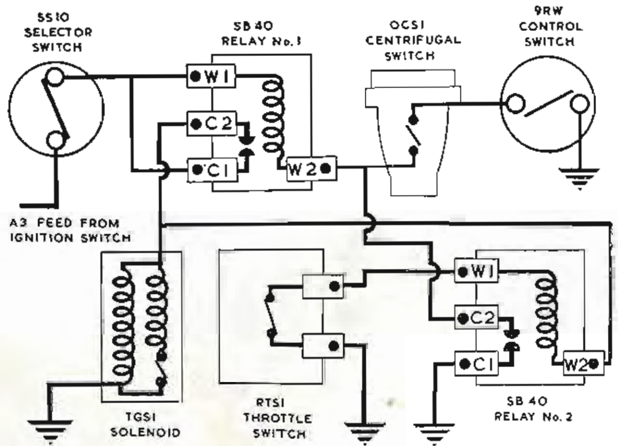
Still with the ignition switch on and top gear engaged, remove the bridged lead from the centrifugal switch.

Link terminals C1 and C2, of the No. 2 relay when the solenoid should come into operation and remain in the raised position.

If no operation when the C1 and 2 terminals are linked, check relay No. 2 for a good earth connection to C1 terminal, or for a broken wire between the W2 terminal of No. 1 relay and C2 terminal of No. 2 relay — put in order.

On the removal of the link between C1 and C2 terminals after the solenoid has closed, the solenoid should remain raised and return to

continued



STAGE 2 TEST — *continued*

normal rest position when the accelerator pedal is depressed.

If, when removing the link, the solenoid returns immediately to the rest position and does not hold, check the throttle switch setting also link the C1 and C2 terminals again then with a voltmeter check for a voltage at the W2 terminal of the No. 2 relay. If in order transfer the voltmeter lead to W1 terminal and with the throttle SW open voltage will be registered if the relay winding is O.K. and voltage reading will disappear when the throttle SW is closed proving the switch circuit is complete to earth. If not put in order.

STAGE 3 TEST — CONTROL SWITCH AND SOLENOID

To check the operation of the Centrifugal Switch and the solenoid.

Jack-up the back wheels.

Open the push-in connector adjacent to the solenoid and insert the test ammeter in this line.

Start up the car and engage top gear.

Increase engine speed and the centrifugal switch should close at slightly above 40 m.p.h. The main solenoid should then close with a surge of current and the ammeter should remain at 1–1½ amps. showing that the 'hold-on' coil is operative and the main winding cutting out. If a heavy current about 20 amps registers continually, it will probably be necessary to check the solenoid which will have become overheated. Immediately check the valve setting lever as shown on page 14.