Working Principles

HOW AN E.M.F. IS PRODUCED

When a conductor is moved through a magnetic field an electro-motive force or E.M.F. is induced into it. If the conductor forms a loop or closed circuit, an electric current will register on a sensitive meter connected across the conductor. When the conductor is moved downwards, as shown in the illustration Fig. 12a, the needle swings in a direction corresponding to the direction of current flow.

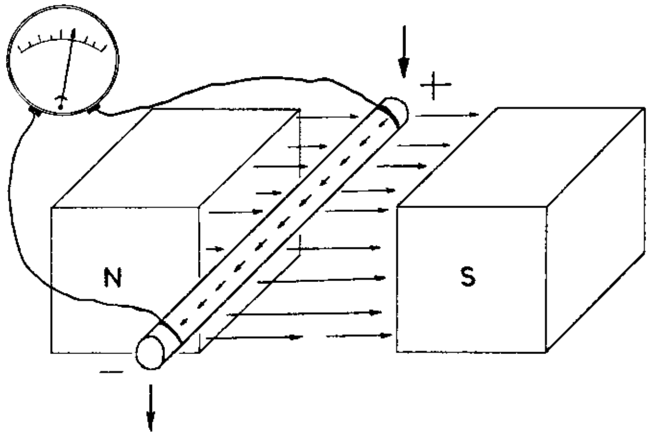


Fig. 12a

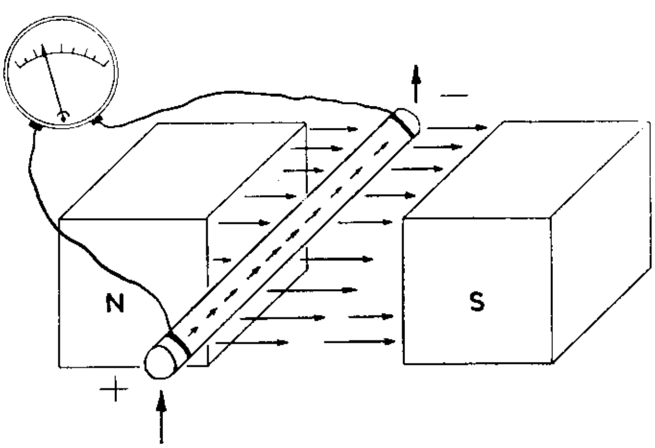


Fig. 12b

If the conductor is moved upwards, Fig. 12b, the needle will swing in the opposite direction, indicating that the current flow is also in the opposite direction.

The amount of movement of the needle will depend upon the speed at which the conductor is moved up and down, and the density of the magnetic field. The same effect can be obtained by moving a magnet in and out of a coil of wire, Fig. 13.

Induction will again take place and current flows in the wire coil. This time, because the coil consists of several turns of wire, instead of one single conductor, the induction will be increased, thereby giving a greater output. The sensitive meter, if connnected across the ends of the coil, will register in exactly the same manner as it did with the single conductor.

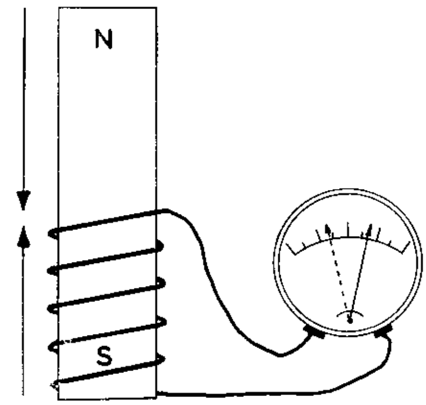


Fig. 13

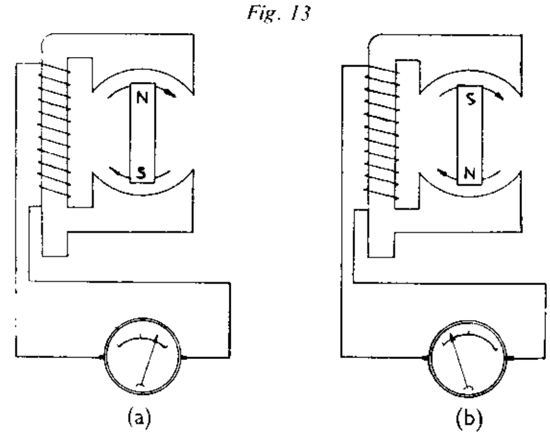


Fig. 14

A SIMPLE A.C. GENERATOR

Figure 14 shows an A.C. generator in its simplest form. The coil has now been wound round a piece of iron which forms a yoke. The yoke helps to concentrate the magnetic field around the coil. In the centre of the yoke a bar magnet is made to rotate.

The direction of the magnetic field will change every 180° of rotation of the magnet. In the left hand illustration the north pole is at the top, but after the magnet has rotated 180°, the south pole is at the top. The magnetic field has been reversed. The direction of current flow in the coil has also been reversed. Induction has taken place due to movement of the magnet in close proximity to the coil, and alternating current has been produced.

Exactly the same thing happens on a larger scale, with the LUCAS range of single-phase A.C. generators. The current generated in the coils is used for lighting, and ignition purposes, etc.

The principle of operation of the early LUCAS inductor type generator is the same as that of the present day rotating magnet type, the difference being in the method used to achieve this.

In the inductor generator (IA45) the coils and magnets are stationary and a six-pole, laminated steel rotor, fixed to the engine crankshaft, is used to cause the flux reversals (Fig. 15a).

The RM range of generators uses a magnetic six-pole rotor to cause the flux reversals, Fig. 15b, the coils are stationary, being fixed to the stator assembly.

Working Principles

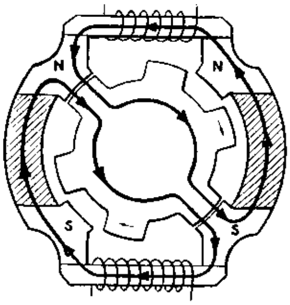


Fig. 15a

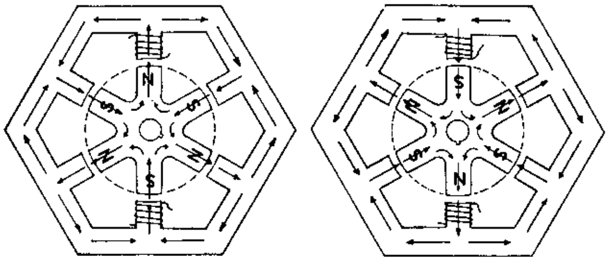


Fig.15b

THE SINE WAVE

The sine wave shown in Fig. 16 is simply a representation of the sort of current output from an elementary alternator. It shows the current output during one complete revolution of the bar magnet alternator in Fig. 14.

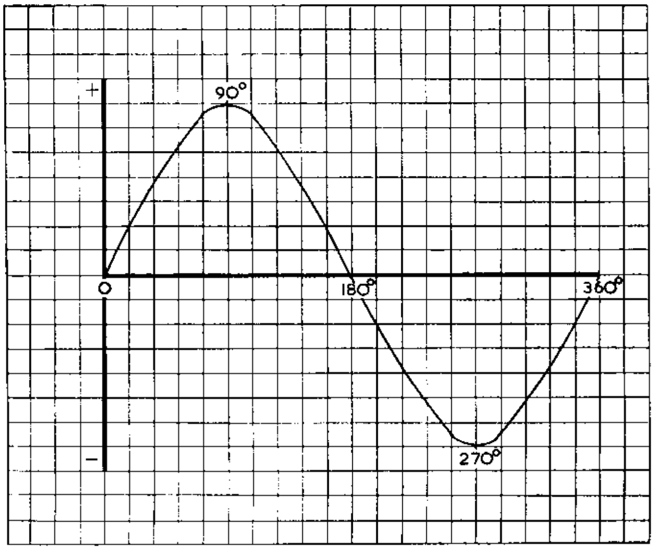
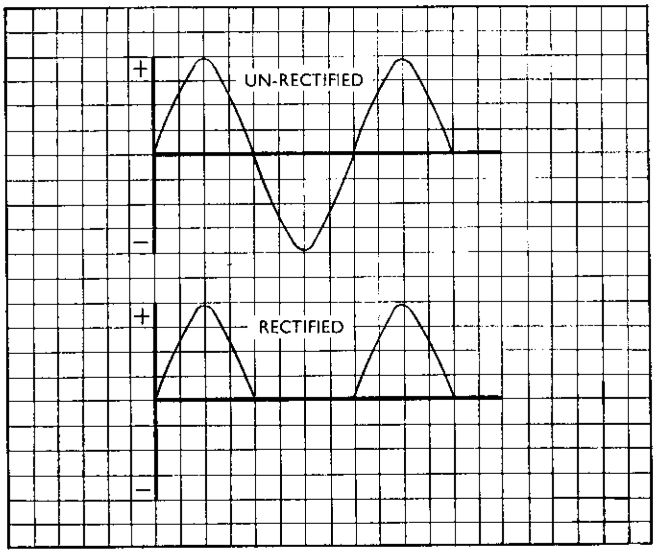


Fig. 16

The vertical line represents the amount of current in amperes, which is positive, above the neutral point or horizontal line; and negative below the neutral line. Starting from the left side, we divide this line into 360°, that is, one complete revolution of the bar magnet. From 0° the current gradually builds up to its maximum value at 90°; then gradually reduces, being zero again at 180°. It now carries on in the negative direction, reaching a maximum at 270°, then gradually reduces again, becoming zero at 360°. This cycle is repeated as long as the magnet is rotated.

RECTIFIER FOR BATTERY CHARGING

Because of the alternating characteristic of the current produced by the alternator it cannot be connected directly to a battery for charging purposes. A battery can only be charged by a D.C. or unidirectional current. If a battery is to be charged by the alternator, then a rectifier must be incorporated in the circuit.



Figs. 17a (top) and 17b (bottom)

A rectifier is a device for converting an alternating current, Fig. 17a, into a unidirectional current either by the suppression or inversion of alternate half-waves, Fig. 17b.

Both selenium plate and silicon diode type rectifiers are used with LUCAS A.C. sets. The formation of a selenium element is shown in Fig. 18. It consists of a steel base plate with selenium. A metal alloy is then sprayed on to the selenium, forming what is called a counter electrode. This combination of base plate, selenium and counter electrode has the property of allowing current to pass in one direction only, that is, from the base plate to the counter electrode. In practice, there is a small reverse current leakage, but from our point of view it can be disregarded.

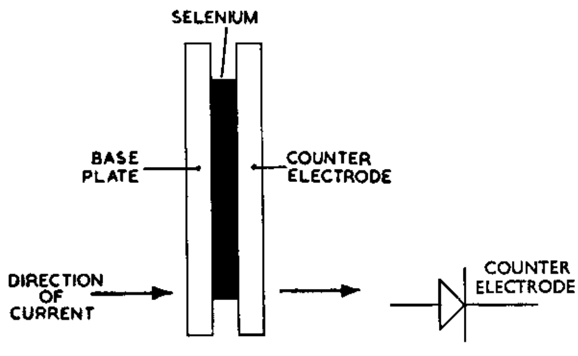


Fig. 18

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With rectifiers of this type in the circuit, the generator can be connected up to charge a battery. The alternating output, which in effect would try to flow round the circuit, first in a clockwise direction and then in an anti-clockwise direction, becomes D.C. or unidirectional, and current therefore will always flow through the battery in one and the same direction, Fig. 19. The negative half waves, which are shown below the horizontal line, Fig. 16a, have been suppressed, and only the positive half waves above the line are allowed to pass through the rectifier and round the circuit. This arrangement is known as half-wave rectification.

In using this method of battery charging however, one half-cycle of our generator output is unused. In practice this problem is overcome by the use of a full-wave rectifier.

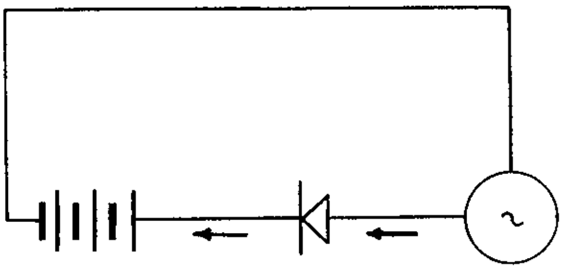
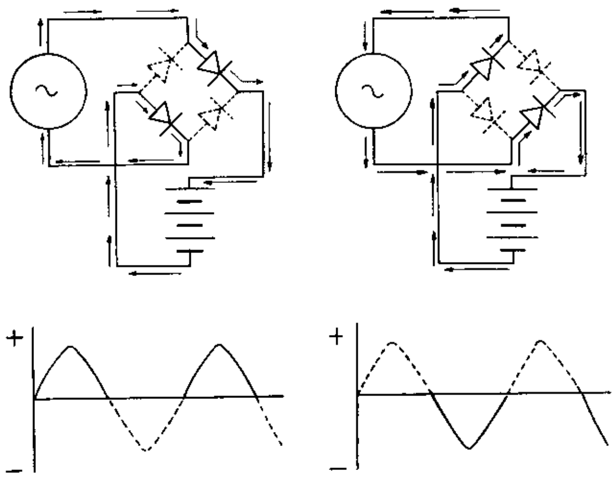


Fig. 19

FULL-WAVE RECTIFICATION

A full-wave rectifier consists of four elements, of the type shown in Fig. 18, connected so as to allow the full output from the alternator to pass through to the battery.

The illustrations in Fig. 20 show the bridge connected rectifier as it is called, connected in circuit with an alternator and battery. The left hand illustration (*a*) shows the circuit when current is flowing in a clockwise direction; the right hand illustration (*b*) an anti-clockwise direction. With this arrangement the full output from the generator is utilised. That is, both the positive half waves and the negative half waves are used to charge the battery. The efficiency of this type of rectifier is affected by the amount of tension on the plates, which are held together by a bolt and self-locking nut. The tension on this bolt is set correctly before leaving the works, and should not be tampered with in service.



(a) *Fig. 20* (b)

Another type of selenium plate rectifier, used with the earlier model IA45 and RM12 alternators which have a centre tapped winding, is the two element type illustrated in Fig. 21.

Although structurally different from the bridge connected type, it performs a similar function, rectifying the full alternator output for battery-charging purposes.

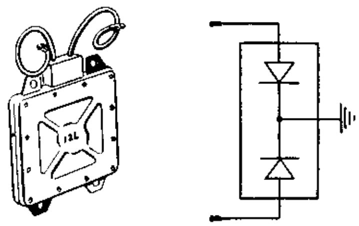


Fig. 21

Selinium plate rectifiers have now been superseded in service by the Silicon Diode rectifier. The silicon diode bridge rectifier incorporates four diodes, each mounted on a small circularplate which in effect constitutes a heat-sink. In appearance this type of rectifier resembles the small circular plate selinium rectifier, and in fact performs exactly the same functions. It is, however, much more robust and less prone to damage. A typical silicon diode bridge rectifier is illustrated in Fig. 22.

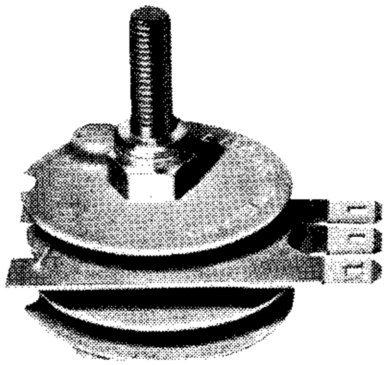


Fig. 22 Silicon diode bridge rectifier

CONTROLLING THE ALTERNATOR OUTPUT

The simple generator which has been described on page 8 is of course not satisfactory for normal requirements, and in practice contains not one, but several coils, each consisting of many turns of wire assembled to the stator, and the bar magnet becomes a multi-pole unit. The ampere output from such a machine is considerably more than would be obtained from the machine with the single coil and bar magnet. Some form of output control is necessary, otherwise the generator output would remain at a maximum irrespective of load requirements and the battery would eventually become overcharged.

Inductor Generator IA45

With the inductor generator, the method of output control is quite simple. A wire resistor, wound on a porcelain former is connected across the generator coil, as shown in Fig. 23.

The resistor is switched in or out of circuit automatically by operation of the lighting switch. When the resistor is in

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circuit part of the generator output is dissipated in heat, reducing the amount of current which flows into the battery and thereby avoiding overcharging.

Because the resistor is controlled by the action of the lighting switch it will only be in circuit when it is required. With the lighting switch in the OFF position the resistor is in circuit and so reduces the generator output. When it is in the PILOT or HEAD position, an increase in load, the resistor is out of circuit allowing an increase in output to compensate for the increase in load.

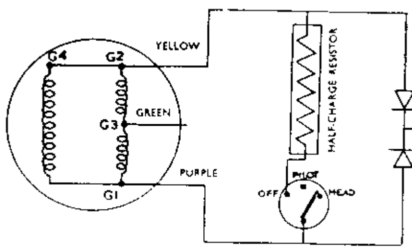

Fig. 23

Rotating Magnet Generators

Rotating magnet generators are also controlled by the action of the lighting switch, but instead of a resistor being used to reduce or control the output, the generator windings themselves are used.

The alternator stator, on the rotating magnet type, carries three pairs of series connected coils, one pair being permanently connected across the rectifier bridge network. The purpose of this latter pair is to provide some degree of charging current for the battery whenever the engine is running. Connections to the remaining coils vary according to the positions of the lighting and ignition switch.

With the ignition key in the IGN position, the basic output control circuits for rotating magnet alternators are as shown in Figs. 24a, b and c.

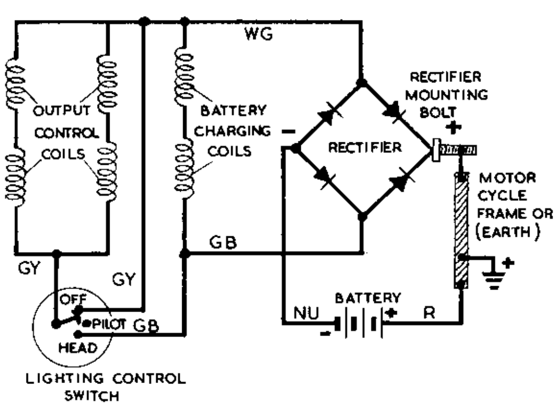

Fig. 24a Lighting switch in the "off" position

With the lighting switch in the OFF position, the output control coils are short circuited, as shown in Fig. 24a, and the alternator output is regulated to its minimum value by interaction of the coil flux, set up by the heavy current circulating in the short-circuited coils, with the flux of the magnet rotor. Trickle-charging is provided by the permanently connected charging coils.

NOTE: *On some machines taking the RM13 this arrangement has been modified, so that in the OFF position the control coils are not short-circuited but open-circuited, as in the PILOT position, giving an increased charge rate for normal running conditions.*

In practice, this is achieved by taking out the link between terminals 5 and 6 on the lighting switch. This should be done in every case when servicing the earlier machines. The link is now omitted on production machines taking the RM13 A.C. set.

In the PILOT position, Fig. 24b, the control coils are disconnected and the regulating fluxes are consequently reduced. The alternator output therefore increases and compensates for the additional parking light load.

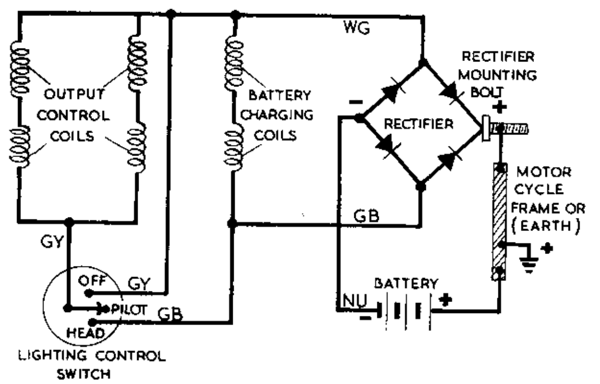

Fig. 24b Lighting switch in the "Pilot" position

In the HEAD position, Fig. 24c, the alternator output is further increased by connecting the control coils in parallel with the charging coils. Maximum output is now obtainable.

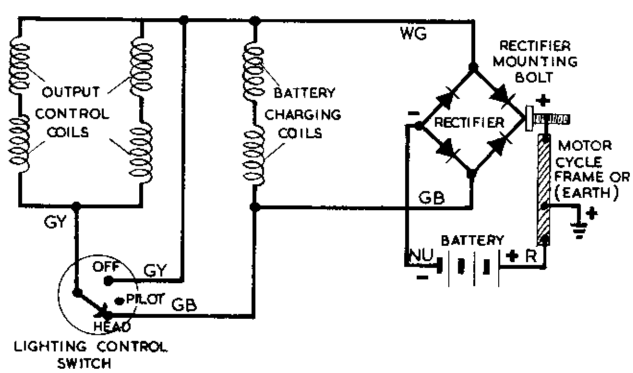

Fig. 24c Lighting position in the "Head" position

Special Control Applications

A.A. and Police machines fitted with two-way radio incorporate a separate "boost" control switch. This switch can be used at any time, irrespective of the position of the main lighting switch. When in the "boost" or closed position maximum output is obtained from the alternator,

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see Fig. 25. When the switch is open the output from the alternator is dependent upon the position of the lighting switch.

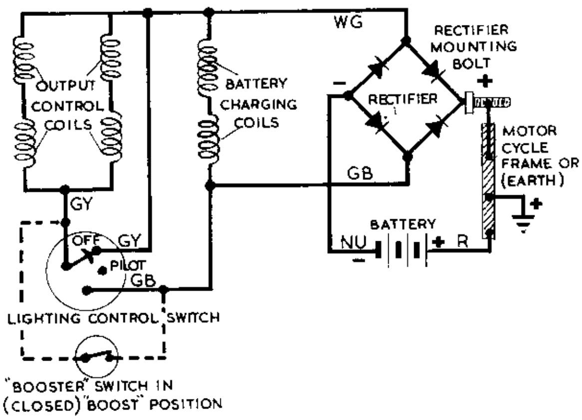

Fig. 25 Circuit with "Boost" switch in "Boost" position

The output of the earlier model RM12 series "C" machines is also controlled by varying the connections of the windings, through the action of the lighting switch, but the connections differ from those of the RM13 and RM14.

Six leads are brought out from the RM12 series "C" alternator, making the arrangement of the connections a little more complicated. However, the same principles apply, the coils being short-circuited or open-circuited as required, and the resultant interaction of the coil and rotor fluxes regulating the output accordingly.

The connections, with the lighting switch in the OFF, PILOT and HEAD positions are shown in illustrations Figs. 26a and b.

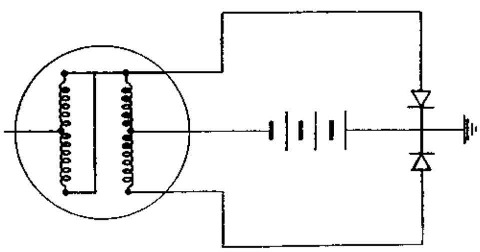

Fig. 26a RM12-Series "C". Arrangement of coils with lighting switch in "off" or "pilot" position

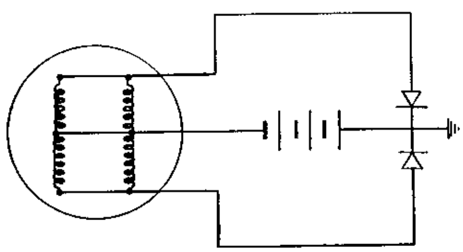

Fig. 26b RM12-Series "C". Arrangement of coils with lighting switch in "head" position

EMERGENCY STARTING

Motor cycles fitted with the alternator-rectifier battery charging system are normally provided with a means of starting the engine in the event of an otherwise healthy battery becoming badly discharged. For this purpose, a three-position ignition switch is used, labelled "Ign.", "Off" and "Emg.". On switching to "Emg." and kick-starting the engine, the battery receives a charging current and, after a while, the ignition switch should be turned back to the normal running position "Ign.". (With the circuit as used on single-cylinder machines and on twins fitted with two ignition coils, the appropriate time to change back to normal ignition is indicated by a tendency for the engine to misfire, due to the rising battery voltage being in opposition to the alternator voltage – thus a steadily reducing amount of energy is available for transfer to the ignition coil).

The emergency starting feature also enables short journeys to be made (if absolutely unavoidable) without battery or lighting. This is done by connecting the cable normally attached to the battery negative terminal to an earthed point on the machine and kick-starting the engine with the ignition switch in the "Emg." position, Fig. 27.

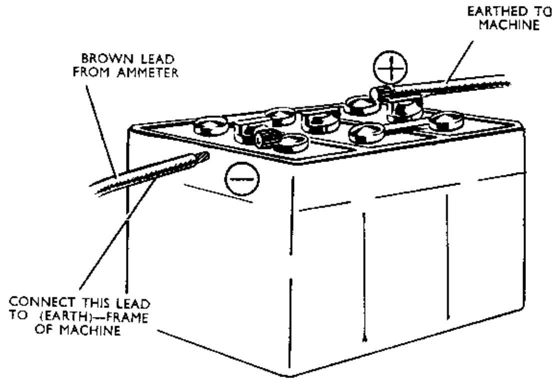

Fig. 27 Connections for running in "EMG" position without battery

Thus, a rider can make for home even if his battery has failed completely or has been pilfered. It must be emphasised, however, that continuous running under these conditions will result in badly burnt contacts in the distributor or contact breaker unit and cannot therefore be recommended.

Single-Cylinder Machines

When current flows through the windings in the direction indicated by the arrows in Fig. 28 and the contacts are closed, the main return circuit to the alternator is through one arm of the rectifier bridge. At the instant of contact separation, the built-up electro-magnetic energy of the alternator widings quickly discharges through an alternative circuit provided by the battery and the ignition coil primary winding. This rapid transfer of energy from the alternator to coil causes H.T. to be induced in the ignition coil secondary windings and a spark to occur at the plug.

When using a machine for trials or competition purposes, fitted with an RM alternator, and no lighting is required, the battery can be removed and the machine run continuously in the EMG position, providing the cable normally connected to the battery negative terminal is re-connected to an earthed point on the machine, see illustration in Fig. 27.

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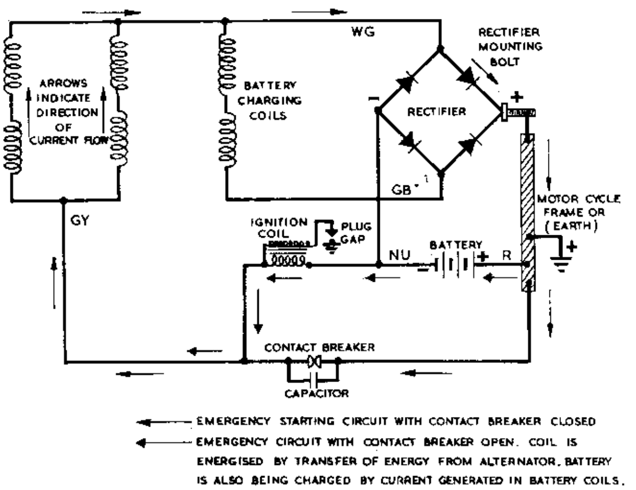

Fig. 28 Emergency Starting Circuit — Single Cylinder Machines

The inductor generator IA45, when connected for emergency start, has a conventional circuit, illustrated in Fig. 29. It will be seen from the illustration that the ignition coil primary winding, and the contact breaker are connected in series.

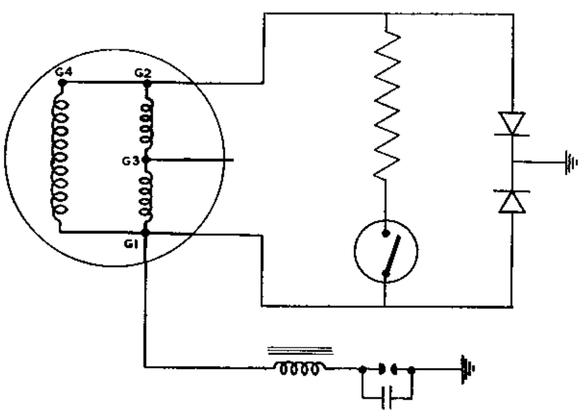

Fig. 29 IA45 — Connected for emergency starting

Also, the resistor is not connected in circuit allowing the full output to be utilised for ignition purposes.

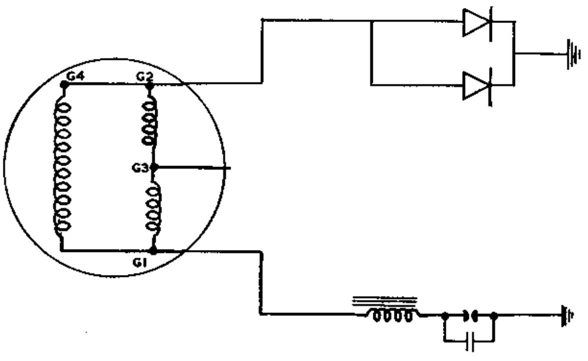

Fig. 30 IA45 — Connected for use without battery

As with the RM12 circuit, the battery does not receive a charge whilst running in the emergency position, so it is necessary to switch back to the IGN position if lighting or horn are to be used.

If it is required to use the machine for trials or competition purposes and no battery or lighting is required, then the circuit should be re-connected as shown in the illustration, Fig. 30.

Twin-Cylinder Machines (single ignition coil and distributor)

From Fig. 31 it will be seen that for twin cylinder machines the ignition coil primary winding and the contact breaker are connected in series, and not in parallel as for single cylinder machines. The adoption of this conventional practice permits a slightly more simple harness and switching system to be utilised. It is, however, unsuitable for use with single cylinder machines due to "idle" sparking occurring *before* the contacts separate. Twin engines when fitted with a distributor containing two electrodes, are unaffected by this premature sparking.

With single cylinder machines connected as shown in Fig. 28 "idle" sparking occurs *after* the contacts have separated and so does not affect these engines.

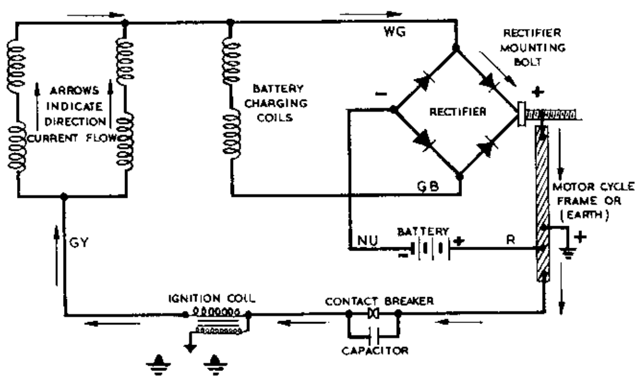

Fig. 31 Emergency starting circuit — twin cylinder machines with H.T. distributor. The H.T. coil and contact-breaker are connected in the conventional manner

Since with the emergency start circuit the battery receives a small charging current, causing the battery voltage to rise quickly, the machine should not be run, under normal conditions, continuously in the emergency start position, because the rising voltage of the battery opposes that of the alternator and gradually effects a reduction in the energy available for transfer to the ignition coil.

This reduction in spark energy will cause mis-firing to occur, which will, in fact, remind the rider that he has omitted to return the ignition key to the IGN position.

When using a machine for trials or competition purposes, fitted with an RM alternator, and no lighting is required, the battery can be removed and the machine run continuously in the EMG position, providing the cable normally connected to the battery negative terminal is re-connected to an earthed point on the machine, see illustration in Fig. 27.

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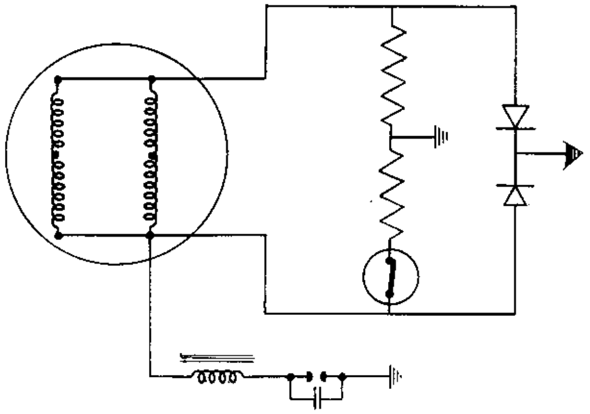

Fig. 32 RM12 — Series "C". Connected for emergency starting

RM12 Series "C" (Six Lead) – The circuit for emergency starting on this alternator differs from that used with the later machines. The arrangement of the stator coil winding differs; six leads are brought out instead of three. It is used in conjunction with a centre tapped rectifier (Fig. 21) and a resistor is connected across the alternator to allow for continuous running in the EMG position.

A disadvantage with the RM12 layout is that the battery does not receive a charge whilst the machine is being run in the emergency start position and, without a battery, it is not possible to use the lighting or horn. The illustration in Fig. 32 shows the emergency start circuit layout for the RM12 Series "C" alternator.

As with the RM13 and RM14 sets, the brown lead connected to the battery negative terminal should be reconnected to an earthed point on the machine, for trials or competition purposes, as shown in Fig. 28.

Twin-Cylinder Machines (twin ignition coils and twin contact-breakers)

With the ignition switch in the normal running position IGN, each coil, with its associated pair of contact-breaker contacts, serves one of the cylinders – each functioning as an ordinary battery coil ignition circuit. On switching to EMG, however, one of the ignition coils functions on the energy transfer principle.

The illustration (Fig. 33) shows the circuit used for emergency starting. With this circuit the No. 1 contact-breaker is arranged to open when the alternating current in the windings reaches a maximum in the direction shown by the large arrows. The circuit functions as follows:

With the contacts closed the main return circuit to the alternator is then via one arm (element) of the rectifier bridge and the closed contacts. In effect the four output control windings have been short-circuited allowing a heavy current to build up and circulate through them.

At the instant of contact separation this built-up energy quickly discharges through an alternative circuit provided by the battery and primary winding of the No. 1 or EMG ignition coil. The rapid transfer of current from alternator to ignition coil primary results in H.T. being induced in the secondary winding and an efficient spark, at the plug.

The efficiency of the energy transfer ignition is quite high because the alternative circuit through the battery, when the contacts are opened, is virtually a short-circuit

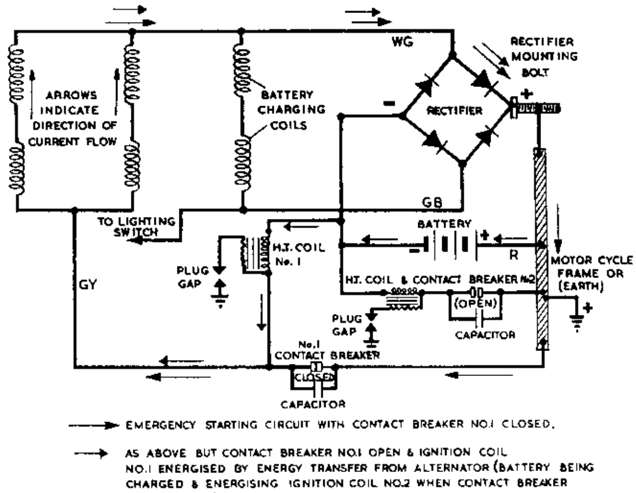

Fig. 33 Emergency starting circuit — Twin cylinder machines (with two ignition coils and double contact-breaker unit)

path owing to the fact that the "flat" battery has little or no potential difference across it. Therefore, very little energy is lost at this point.

However, due to the fact that the current surges do pass through the battery, and the fact that the two permanently connected charging coils are also in circuit, the battery begins to build up a potential difference across its terminals until, after several current pulses, assuming the engine has fired and is running on one cylinder, it gradually effects a reduction in the amount of energy available for transfer to the ignition coil. This reduction in spark energy will cause misfiring to occur, which in the event of the rider omitting to return the ignition key from position EMG to IGN, serves as a reminder to do so. The contact points will be badly burnt if the rider prolongs running in the EMG position.

Another feature of the system is that coil No. 2 eventually comes into operation during emergency starting, so that after a few seconds running on one cylinder, number two cylinder cuts-in and the engine functions as a normal twin-cylinder unit. The fact that it will operate on both cylinders after a few seconds does not detract from the statement, made in the previous paragraph, about the rising battery voltage causing misfiring to occur.

Although the No. 2 coil "SW" terminal is linked to the same feed cable as the "SW" terminal of No. 1 coil, it does not pass any of the energy transferred from the alternator, during the "energy transfer" pulse, as at this particular instant the No. 2 contact-breaker points are open, open-circuiting the No. 2 coil primary circuit. It is fed eventually however, because the battery voltage or potential difference builds up due to the current from the alternator passing through it, causing the battery to assume a stronger polarity characteristic. And therefore, in between the No. 1 coil being fed by energy pulses from the alternator, the No. 2 coil will, when its associated contacts close, receive current direct from the battery which is gradually becoming charged. This results in the engine firing on both cylinders. It will not run at full power until switched to the IGN position, because the energy now available for the

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Rectifiers should be kept clean and dry and so fitted as to allow air to circulate freely through the plates for cooling purposes.

Dirty or Corroded Battery Terminals

Battery connections should be kept clean and tight, particularly the one made to the frame of the machine. It is also important to keep the top of the battery clean and dry.

Sulphated Battery

A sulphated battery is usually the result of lack of maintenance, i.e., failure to maintain the electrolyte at the specified level, and allowing the battery to remain for long periods in a partially charged or discharged condition. A regular check on each cell should be made to see if it requires "topping-up" and if necessary distilled water should be added to the electrolyte to bring it up to the correct level.

A.C. IGNITION

An alternator designed for A.C. ignition has the ignition generating coils connected in series with each other and with the primary winding of a special ignition coil. The earlier model coil is known as the 2ET, the current model is called the 3ET, (Figs. 35 and 36).

These special ignition coils employ a closed iron circuit and have a primary winding whose impedence is closely matched to that of the ignition generating coils of the alternator. As a result of this electrical matching the ignition performance combines the good top speed characteristics of the magneto with the good low speed performance of the conventional ignition coil.

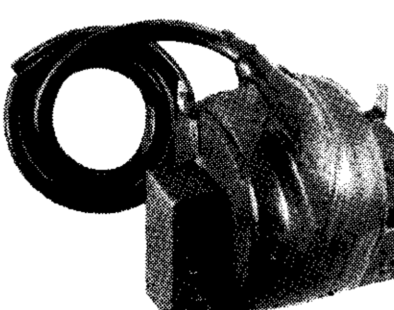

Fig. 35 Model 2ET Ignition Coil

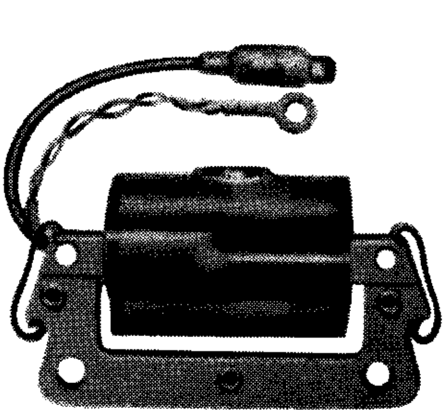

Fig. 36 Model 3ET Ignition Coil

The A.C. ignition system functions as follows:

The contacts of a contact-breaker unit or distributor are connected in parallel with the ignition coil primary windings, since one end of the stator winding, one end of the ignition coil primary winding and one side of the contact-breaker is earthed, as shown in Figs. 37 and 38.

Closure of the contact-breaker contacts short-circuits the ignition coil primary winding and, at the same time, creates a closed circuit of the stator ignition windings. As the magnet rotor turns, voltages are induced in the stator coils giving rise to alternating currents during the period that the contacts are closed. At the instant of contact opening, however, a pulse of electro-magnetic energy (developed in the stator during the contacts closed period) is discharged through the ignition coil primary winding. The effect of this energy pulse in the primary winding is to induce a high tension voltage in the ignition coil secondary winding which is then applied either directly or by way of a distributor to the appropriate sparking plug.

Timing considerations

Since the magnetic rotor of the alternator is keyed or otherwise located on the crankshaft, the magnetic pulse in the alternator stator, which produces the energy pulse to feed the ignition coil primary winding, must be timed to occur at the firing point of the engine.

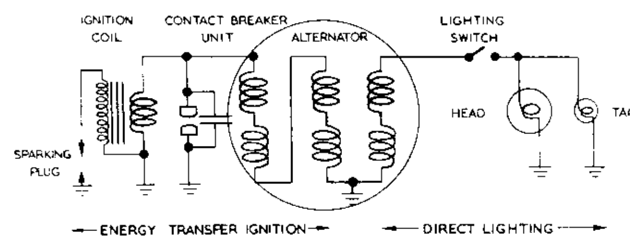

Fig. 37 A.C. ignition and direct lighting

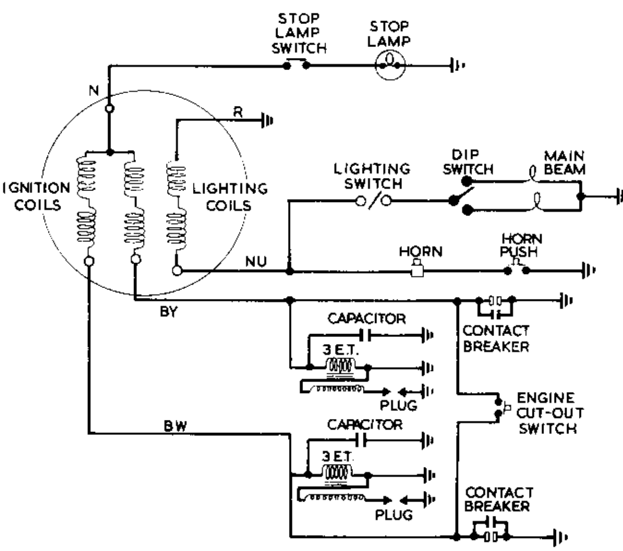

Fig. 38 A.C. ignition and direct lighting circuit for a twin-cylinder machine, using double contact-breakers and twin E.T. ignition coils

Working Principles

The magnetic pulse occupies several degrees of crankshaft (and therefore of rotor) rotation. A fairly wide angular tolerance would thus be available for a fixed ignition engine.

However, it is desirable with most four-stroke engines to incorporate an ignition timing control (usually centrifugally operated) giving a range of advanced and retarded sparking. The magnetic relationship of the alternator rotor to its stator must therefore be governed by this fact, namely, that the engine firing point will vary by several degrees between the fully retarded starting condition and the fully advanced running condition.

This is exactly the same problem which obtains with a manually controlled magneto and gives rise to the same characteristics, i.e., the available sparking voltage for a given kick-start speed reduces progressively with the amount of retard angle. A magneto, however, is a self-contained unit and will produce a spark however grossly it may be mistimed to the engine. This is because a magneto contact-breaker is always in correct relationship to the magnetic geometry of the unit. With an alternator, however, the position of the magnetic rotor with respect to the stator, and to the engine piston at the instant of firing, is pre-determined by its located position on the engine crankshaft.

The range of retarded magnetic timing that can be used with a particular engine depends in part on that engine's startability, since the required plug voltage is influenced by many factors of engine design. The speed at which it can be kicked over in attempting to reach this voltage will depend on piston and bearing friction, kick-starter ratio, etc.

The characteristics reproduced in Fig. 39 show how the available plug voltage varies with different magnetic timing positions and for different speeds of rotation. The reference point is known as the Magnetic Neutral position, when the interpolar gaps of the rotor are situated on the centre-lines of the stator limbs.

It will be seen that whilst the optimum magnetic position is some 4° past the Magnetic Neutral at 200 rev/min, it changes to some 12° past at 2,000 rev/min, due to distortion of the magnetic flux.

It will also be seen that the sparking performance deteriorates rapidly a few degrees before the Magnetic Neutral position. Hence commercial tolerances on keyways, etc., dictate the inadvisability of approaching too near to this critical point in the advanced or running position of engine timing.

As previously stated the extent to which the retard timing can be used depends on plug voltage requirements at starting and on kick-starter speed.

For example, if the required plug voltage is 6 kilo-volts, the retarded timing would be restricted to about 20° (engine) if the kick-starting speed was to be limited to 200 rev/min – in practice, a fairly low speed. On the other hand, at the fairly normal kick-starting speed of 400 rev/min, a timing range of some 30° could be accommodated with plug voltages up to about 8 kilo-volts.

It will be appreciated, therefore, that accurate ignition timing is an important requirement in the operation of an energy transfer system. The optimum conditions are

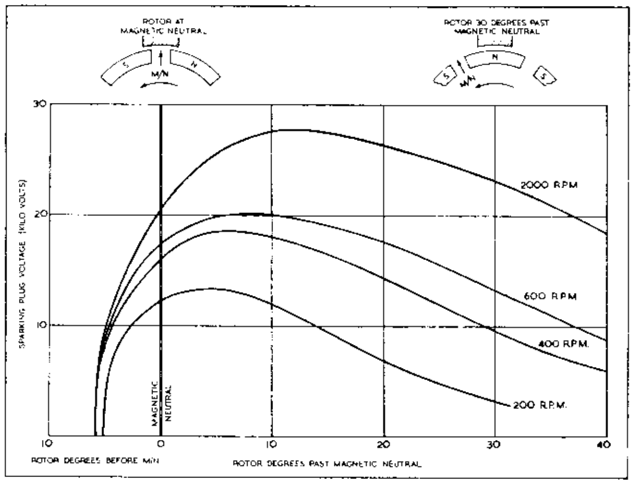

Fig. 39 Curves showing how sparking plug voltages depend on magnetic timing and kick-starting speeds

determined by the engine designers during the development stages and these conditions should always be maintained in order to ensure the highest performance, both from the engine and from the ignition system designed to work with it.

It will also be appreciated that amateur tuning, departing from the designers' recommendations, cannot be expected to improve a highly developed engine. Indeed, some harmful results may occur. For this reason, indifferent sparking outside the prescribed range will almost certainly indicate tampering and may well serve as a warning to the would-be tuner.

ZENER DIODE CHARGE CONTROL

The new LUCAS Zener Diode Charge Control for 12-volt alternator equipped motor cycles eliminates overcharging of the battery and permits the use of extra accessories such as flashing direction-indicators and a fog or long range driving lamp. With coil ignition machines, four coils of the conventional alternator are permanently connected across the rectifier. With magneto ignition, two coils are so connected. The Zener Diode is connected in parallel with the 12-volt battery (or two 6-volt batteries connected in series) between the ignition coil feed-wire terminal of the ignition switch and the Diode heat-sink, which is at "earth" potential.

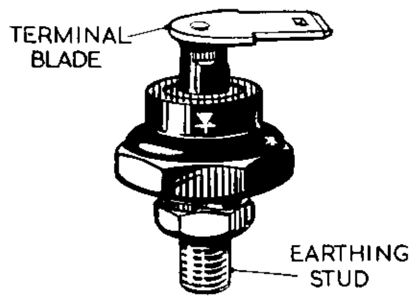

Fig. 40 Zener Diode

Working Principles

FUNCTION OF ZENER DIODE AS A CHARGING CURRENT REGULATOR

The illustrations in Fig. 41 show how the Diode is connected into the alternator circuit. Bearing in mind that it is in *parallel* with (or shunted across) the battery, it operates as follows:

Assuming the battery is in a low state of charge, its terminal voltage (the same voltage is across the Diode) will also be low, therefore the maximum charging current will flow into the battery from the alternator. At first none of the current is by-passed by the Diode, the latter being non-conductive due to the low battery terminal volts. However, as the battery becomes recharged its terminal voltage rises until, at approximately 14 volts, the Zener Diode, which up to this point has opposed the passage of current, becomes partially conductive, thereby providing an alternative path for a small part of the charging current. Further small increases in battery voltage result in large increases in Zener conductivity until, at approximately 15-volts (the on-charge voltage of a fully charged 12-volt battery), about 5 amperes of the alternator output is by-passing the battery. The battery will continue to receive only a portion of the alternator output as long as the system voltage is relatively high.

Depression of the system voltage, due to the use of headlamp or other lighting equipment, causes the Zener Diode current to decrease and the balance to be diverted and consumed by the component in use. If the electrical loading is sufficient to cause the system voltage to fall below 14-volts, the Zener Diode will revert to its high resistance state of virtual non-conductivity and the full generated output will go to meet the demands of the battery.

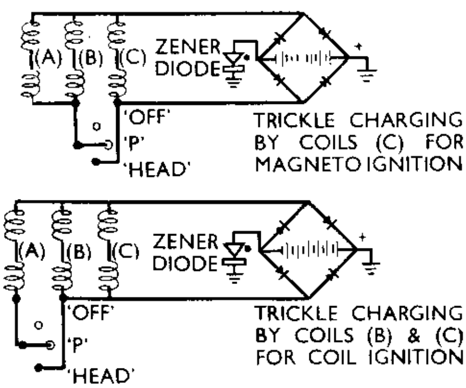

Fig. 41 Motorcycle alternator circuits with Zener Diode Charge Control

To prevent overloading of the Zener Diode (which has a nominal current rating of 5 amperes) some form of switching is still required. In lighting switch positions "Off" and "P" four coils of the stator are permanently connected across the rectifier for coil ignition circuits, and two coils for magneto circuits. In the "Head" position full alternator output is obtained by connecting all six coils across the rectifier. This is shown in Fig. 41. The Zener Diode is normally connected so that it is switched "in" and "out" of circuit by the action of the ignition switch.

Some 1966 motorcycles already incorporate another variation of the Zener Diode Charge Control. All six coils are permanently connected to give a continuous maximum output, there is no provision for varying it through the action of the lighting switch. In this application the Zener Diode is mounted on a heat-sink of approximately 36 sq. in. in area, which is positioned so that the maximum amount of air can flow over it. The alternator coil connections, on earlier machines, are made by joining together the external cables Green/Black and Green/Yellow. Eventually these connections will be made internally, on the stator windings. Page 84 shows the complete wiring circuit for this new system. Simplified switching and wiring circuits are possible with this arrangement, as compared with earlier systems.

Caution

Do not attempt to convert existing machines to this new system, unless the Zener Diode is first mounted on a heat-sink of not less than 36 sq in, and can be positioned on the machine so that the maximum cooling effect is obtained. It *must not* be fitted in any position where the air flow is poor, otherwise premature failure of the diode will ensue.

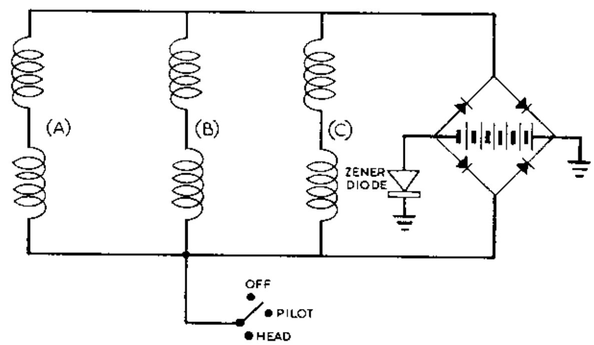

Fig. 42 Latest alternator circuit with Zener Diode Charge Control, full output from coils "A", "B" and "C" is obtained irrespective of position of lighting switch

Conversion of existing 6-volt alternator equipped Motorcycles to 12-volt — With Zener Diode Charge Control

Full details for carrying out the conversions are given in Publication No. 2380, available on request, together with a list of all of the various models of motor cycles, which can be converted to this new method of charging control. General details of the equipment required are given on pages 28 to 31.

CLIPPER DIODE — VOLTAGE STABILISER FOR MACHINES FITTED WITH DIRECT LIGHTING SYSTEMS

A common fault experienced with machines equipped with Direct Lighting is the blowing of bulbs. This may be due to faulty dipper switches, causing momentary voltage surges, bad connections or indefinite earths, or purely excessive voltage generation caused by improper design probably amplified by wide production tolerances in the manufacturing of the generator units. Whichever is the cause, the Clipper Diode will effectively protect the bulbs against filament failure. The diode will not offer protection against vibration, filament fractures or faulty bulb manufacture.

Working Principles

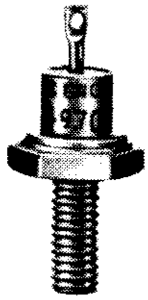

Fig. 43 Clipper Diode

The diode is wired into the circuit so that when the lights are switched on, the generator is also feeding the diode. This can be achieved by connecting either into the Tail-lamp feed or the wire supplying the Dipper Switch. If no Dipper Switch is used, the connection would be made directly to the Headlamp bulb feed.

Function of Clipper Diode as a Voltage Stabiliser

The Clipper Diode, as its name implies, limits or clips the positive and negative peaks of the generated voltage when it exceeds a certain maximum level, and in effect maintains or stabilises the system voltage at a constant safe value. It can be likened to an opened switch, in its non-conductive state, until the generated voltage exceeds the required system voltage, then it automatically closes, becomes conductive, dissipating the excess power in the form of heat. The Zener breakdown voltage of the diode is 9 — 11 volts.

It should be remembered that the Clipper Diode is in effect two Zener Diodes in a back-to-back arrangement, as both positive and negative voltage pulses need to be limited.