SECTION 6 ELECTRICS

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ON ELECTRICS - PART 1

M.E.Chaney.

GAZETTE NO.8 OCTOBER 1971

At the risk of boring readers already thoroughly familiar with electrical matters, I will devote this first article to the more basic principles in so far as they apply to the motor car. Oddly enough electrical energy as such is rarely, especially within the confines of cars, ever used for its own sake, but is merely used as a convenient means of transmitting energy to be converted to another form.

Just what goes on inside a length of wire carrying electricity is, as far as we are concerned, only of academic interest.

Suffice to say a current is flowing, the amount of which is measured in Amperes.

As in the case of water flowing through a pipe, a pressure has to be applied. In electrical terms this is known variously as Electromotive force (E.M.F.); Potential; or Voltage, and is measured in Volts.

Back to plumbing again, the amount of water flowing depends not only on the pressure, but also on the length and bore of the pipe. Reverting to electricity, this opposition to the flow of current is known as Resistance, and is measured in Ohms.

Within an electrical circuit, Current, Voltage and Resistance are related by ‘Ohms Law’, which is perhaps best summarised by the simple equation:

$$I=V/R$$

Where I is in Amperes, V in Volts and R in Ohms.

Let us see 12 volt battery to a lamp which how this applies to a simple circuit. Suppose a i12 volt battery is connected with a wire of negligible resistance to a lamp which happens to have a resistance of 24 Ohms (Fig.45) As the name ‘circuit’ implies, the current (I) must flow from the battery, along the wire, through the lamp (which is drawn as a resistor) and back to the battery along the other wire.

The value of the current is:

$$I= \frac{12 \text{ Volts}}{24 \text{ Ohms}} =0.5 \text{ Amperes.}$$

When the current is passed through a resistor, power is dissipated in it, this is measured in Watts, and may be worked out from the simple formula:

$$W = VI$$

Where W is in Watts, I in Amperes and V in volts.

So in the above example

W = 0.5 Amperes x 12 volts = 6 watts.

Since energy cannot be created or destroyed, when electric power is dissipated, it is converted into another form. In the case of a resistive element most of the power is converted to heat, and often visible light, lamps are in fact simply specially constructed resistors.

There is a plain resistor in every voltage regulator unit, this apart, intentional resistors are a rarity in motor vehicles, however, those of an unintentional nature are not altogether uncommon, and are most undesirable. Any loose or dirty connection has some resistance, the effect of which can be illustrated by re-drawing the original circuit to be that for a side lamp with an incredibly nasty earth connection with a resistance of 24 Ohms. (Fig.46)

So now the total resistance in the circuit is:

R= 24-+24 = 48 Ohms

Therefore the current will be:

$$I = \frac{12\ V}{48\ Ohms} = 0.25\ Ampere$$

The potential across the lamp can also be worked out:

V= I R = 0.25 x 24 = 6 Volts

So it can be seen that the current through the lamp and the potential across it are reduced by half, but the power dissipation, and that's what really matters, is down to a quarter, so it would be decidedly dim. If a similar additional resistor were in the circuit of a 48 watt lamp, the reduction in brilliance would be even more dramatic, in fact the higher the current normally drawn by a circuit, the greater the reduction of efficiency due to stray resistance. Lamps aside, most of the other electrical items depend on electromagnetic effects which I hope to tackle in the next issue.

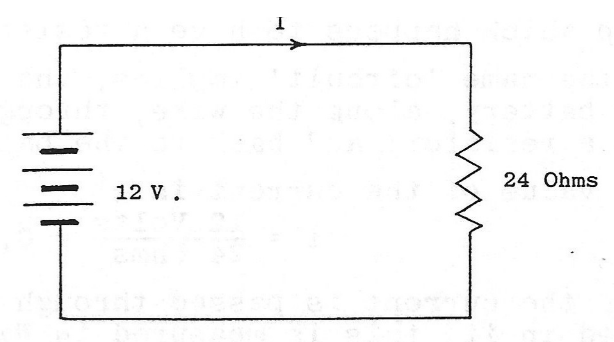


Fig.45.

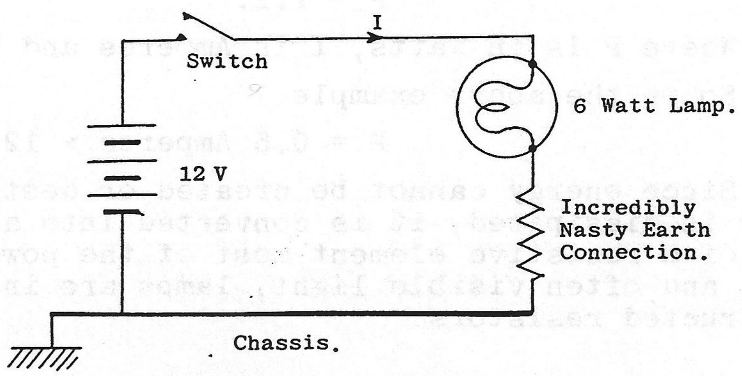


Fig.46.

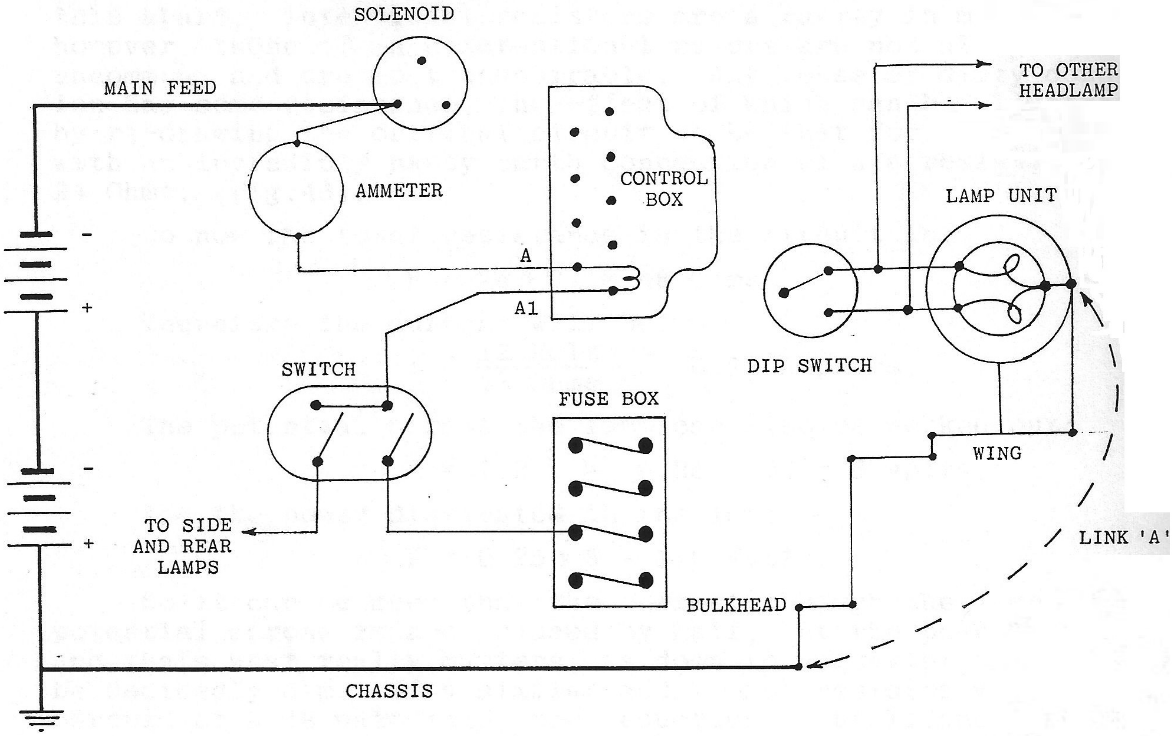


Fig.47.

Some earlier models were fitted with single filament headlamp bulbs. The foglights were used for dipped beams and also incorporated the side lights. With this arrangement the mainbeam (headlamp) filaments and dipped beam (foglamp) filaments were separately fused as shown in Fig. 48 below.

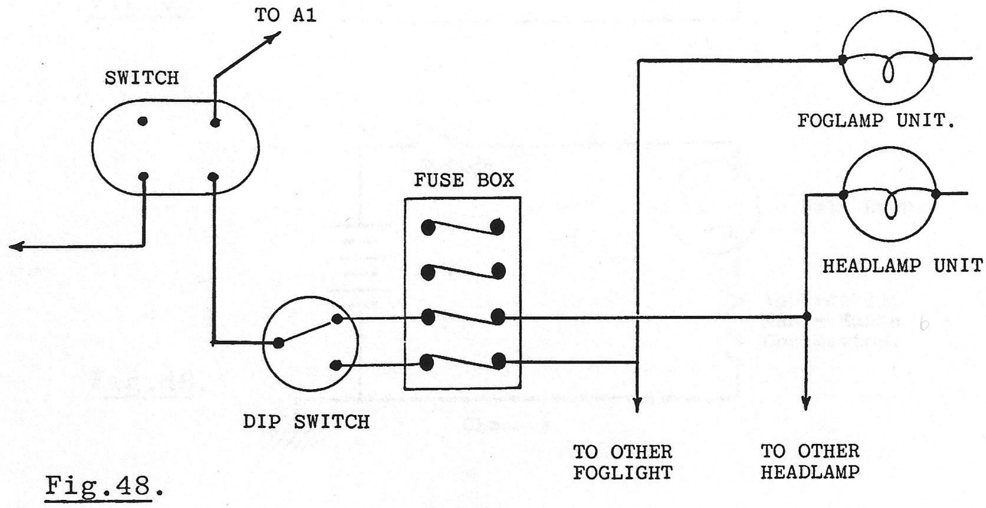


Fig.48.

ON ELECTRICS - PART 2

M.E.Chaney.

GAZETTE NO.9 FEBRUARY 1972

In the last issue I mentioned resistance and the undesirable effect when a few extra Ohms appear in a circuit, which brings me to the location of this type of fault. If a broken wire or other form of 'open circuit' (O.C.) is, for convenience, defined as a Resistor of infinite value, then it follows that a common method of approach may be employed.

Ignoring any side effects, if additional resistance is present in a circuit, then that circuit will draw less current than would be the case if all were well, and in the extreme condition of an O.C., none whatever. The symptoms of such a fault vary from impaired efficiency, to not working at all. In other words, lamps become dimmer, and electromagnetic devices such as petrol pumps, get sluggish in operation.

A case which would fit the symptoms outlined would be that of a car on which everything is working with the exception of one headlamp which happens to be dim on both dipped and main beam.

Having decided that the fault is resistive, it is a worthwhile exercise to make sure by checking that the current drawn from the battery without the engine running is approximately correct. The value of the current indicated by the ammeter will vary from one model to another, but to take a simple example:-

2 rear lamps at 6W = 12
2 side lamps at 6W = 12
2 Headlamps at 48W = 96

Total power = 120 W

Now P = IxV so I = P/V = 120/12 = 10 Amperes.

In other words, in a 12 volt system, 1 amp for every 12 Watts.

If one headlamp is not working, then the total power is only 72 watts, in which case a discharge of 6 amps is to be expected. So in the example under consideration, a current between six and ten amperes would be reasonable. Should this test reveal a really enormous discharge, then it can be assumed that the dreaded short circuit condition exists, and that it is best to switch off before a fire starts!

Once it has been established that the fault is indeed resistive, the next move is to take a look at the wiring diagram and trace out the relevant current path. As such diagrams are not all that easy to follow, and are often incomplete, I have drawn the part pertaining to the problem under consideration and have included the earth return, which I consider to be of equal importance to the rest (See Fig.47)

(i) If everything else is working, then the feed from the battery to terminal "A" on the control box must be in order.

(ii) Likewise as the other headlamp also works, then the circuit must be continuous as far as the two outlets of the dip switch.

(iii) Working back from the other side of the battery, the fact that the other headlamp works, also means that there must be return continuity at least from the bulkhead.

It can therefore be deduced that the trouble lies in one of three places:

(i) A similar fault in each of the feeds from the dipswitch, unlikely, but not unheard of.

(ii). Corroded contacts inside the headlamp.
(iii) A poor connection in the return path from the lamp unit to the bulkhead.

Note that everything so far can be achieved from the comfort of the driving seat! The condition of the contacts within the headlamp can be established by inspection with the unit dismantled, or by proving whether or not the fault is elsewhere. As the third of the listed possibilities can be checked with the least effort, it is worth trying this first. All that is required is to take a length of reasonably thick wire, about six feet long, and hold it to make a connection between the rim of the offending lamp and the bulkhead. The wire (link 'A') on the diagram then forms a bypass the part of the circuit under suspicion. If the result of this test is negative, then the third possibility is excluded, on the other hand should the lamp then function normally, the fault must lie inside the bridged section, in which case the link should be shortened to say between one of the wing nuts and the lamp, and so on, until eventually the wire is held on either side of the faulty connection.
Poor electrical contact between adjacent sections of bodywork can usually be attributed to corrosion of one kind or another, so to just clean up the contacting surfaces is only a temporary solution. When faced with this problem, the best remedy is to wire in a permanent link from the troublesome unit to a reliable earth point on the chassis or the bulkhead. In many cases the corrosion is actually caused by the current flowing through a joint, especially where dissimilar metals are involved, so that the advantage of such a modification are not only electrical.

ON ELECTRICS - PART 3

M.E.Chaney

GAZETTE NO.10

In my last article I mentioned that when a connection becomes resistive or goes "open circuit" there can be side effects. By this I was referring to the possibility that there can be additional symptoms which do not appear to be associated, and are therefore confusing. A quite common example, more often observed on cars other than one's own, concerns combined rear and stop lamp units. One rear lamp would seem to be a little dim, but when the brakes are applied it goes and the only stop lamp to function is the one on the other side. Once one realises what is actually happening, such an effect is helpful to fault location. The current flowing in a circuit and the applied voltage are related by Ohms law. However, once several circuits are combined it is often difficult to see the wood from the trees. Fortunately the flow of currents and the voltages that appear around any combination of closed networks follow set rules, and these were set down by G.R.Kirchhoff in two Laws as long ago as 1845.

1st. Law. The algebraic sum of the currents at a junction of an electrical circuit is zero.

2nd Law: The algebraic sum of the e.m.f's in a complete electrical circuit is equal to the algebraic sum of all the IR products in the circuit, where I is the current in a resistance R. Regarding the first Law, it is assumed that if the currents flowing into a junction are positive, then those flowing away are negative, which boils down to: what goes in, must come out. The e.m.f's in the second Law refer to such voltages as may be applied from a battery or dynamo and the IR products to the voltages that appear across the lamps and other resistive elements. So if a 12 volt battery is wired to a lamp at which there is only 10 volts, then the other two volts must appear at some place in the wiring.

Current values

I_1 = 0.5 Amps
I_2 = 0.5 Amps
I_3 = 1.5 Amps
I_4 = 1.5 Amps

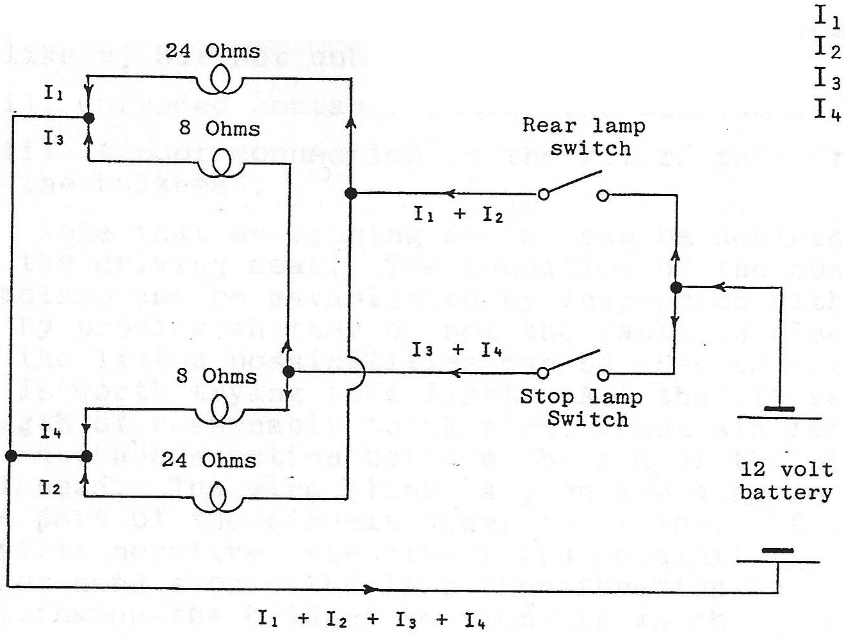


Fig.49

Current values

Rear lamps only
I_1 = 0.3 Amps
I_2 = 0.5 Amps

Stop and rear lamps
I_1 = 0
I_2 = 0.5 Amps
I_3 = 0
I_4 = 1.5 Amps.

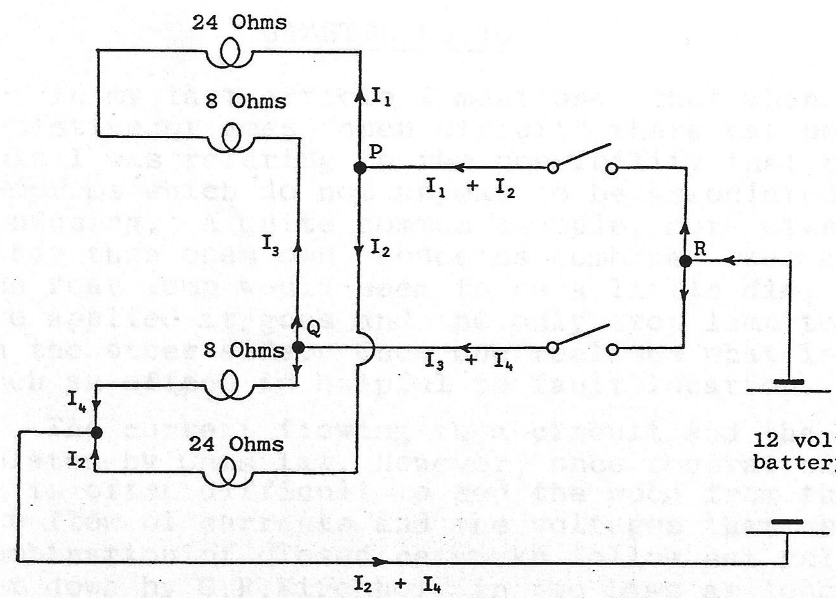


Fig.50

Note: Rear lamps are 6 Watt (24 Ohms).
Stop lamps are 18 Watt (8 Ohms).

Fig.49 is a simplified circuit of a normal rear and stop light wiring. Since there are four lamp filaments, this is a combination of four circuits, and hence currents need to be considered. The route taken by each current is, I think, straight forward. It can be seen that the "first Law" applies at each junction, and the voltage drop for each current is equal to that of the battery at each lamp, so the second Law is also satisfied. Fig.50 shows the same circuit but with the common earth connection on one half ‘open circuit‘. With only the rear lamps switched on, it can be seen that IR remains as before, however, I_1, is deprived of its normal return path, so it will take the line of least resistance which is via the stop lamps to find an earth on the other side. Since only one current is flowing in the defective arm the value can be determined by Ohms Law by the simple addition of the extra 16 Ohms. If Kirchhoff's second Law is used, the same result is obtained.

e.m.f = Sum of IR products

$12 = 24\ I_1 + 8I_1 + 81_1$

$12 = 40\ I_1$

so L = 12/40 = 0.3 Amps

hence one dim rear light!

When the stop light switch is operated, I_2 and I_4 will bethe same as before, on the other side, things are very different as the junctions P and Q are now joined together at R, so there is a useless circuit going nowhere with no volts applied, in which case there is no point in indulging in algebraic excercises to prove that I_1 and I_3 both equal zero.
Additional lamps mounted adjacent to those already mentioned, such as flashing indicators, serve to complicate matters when a fault of this kind arises. In the rear lamp only condition, dimness would be less, as an extra parallel path is provided, and operation of either brake lights or winkers would cause both to come on dimly, since they are of similar resistance. As side and headlamps also share earth returns, the same state of affairs is just as possible at the front of the car. No matter where this type of fault occurs, it is usually located in one of three places, the outer contact between lamp and lampholder; the contact between the lamp unit and the wing; or between the wing itself and the rest of the bodywork. With the exception of the first of these, the goodness or otherwise of any suspected joint can be quickly verified by the use of that handy length of wire I mentioned in Gazette No.9.

The only type of wiring fault not dealt with so far, is the dreaded short circuit. Actually, so long as one is able to prevent a fire starting, this affliction can be sorted out without too much difficulty. Anyway, that is what I hope to prove in the next issue.

ON ELECTRICS - PART 4

M.E.Chaney.

GAZETTE NO.11

The electrical fault most likely to cause the greatest possible disaster is a 'short circuit'. This often heard jargon refers to the presence of an additional, and highly undesirable, low resistance path within a circuit. Fig.51 shows a simple lamp circuit, the 'live wire' of which happens to pass through an earthed bulkhead. As long as the insulation at the hole remains in good order all will be well, however, should it crumble away and let the wire come into contact with the metalwork, then an additional path to earth is formed, that is, a short circuit would exist.

Once a short circuit occurs, all wiring beyond it becomes insignificant. The battery, or source of power, simply 'sees' the unwanted circuit, the resistance of which is likely to be very low indeed. As always, Ohms Law applies, that is:-

I=V/R Current = Voltage/Resistance

As the resistance (R) approaches zero, the current (I) will approach infinity. However, resistance is rather like friction and an absolute value of zero cannot be achieved under normal conditions. None the less, short circuit current can often be several hundred amperes, furthermore there is worse to come, since such resistance as there is, is unlikely to be evenly distributed, the significance of which is perhaps best illustrated by example. Suppose there is connector between the battery and the short that happens to have a resistance of 0.1 Ohms, an amount of little consequence at 1 amp, and the short circuit current is 100 amps, the power dissipated in the connector would be

$$P = I \times V \text{ and } V = I \times R$$
$$\text{so } P = I^2R$$
$$P = 100 \times 100 \times 0.1$$
$$P = 1000 \text{ Watts}$$

When the heat normally given by an electric fire is concentrated inside a small tubular object surrounded by oily rubber, it is more than probable that it will burst into flames!

If the worst happens, it is important to recognise the symptoms and act with all possible haste: Generally the following symptoms are to be expected:-

(1) Dimming of lights and/or engine cutting out.
(2) An enormous discharge reading on the ammeter, unless the fault is in the main feed, the starter, or the horn.
(3) A fuse blowing if the fault is after a fuse, which should, of course, prevent further damage.
(4) Smell of rubber or plastic cooking.
(5) Smoke and fire.

Assuming any combination of these has happened, the engine should be switched off, the car stopped, and one of the battery leads (either one of them) be disconnected. Once both the source of electrical energy can no longer supply current, it is time to tackle the fire, if there is one. (*In my experience, taking into account the fact that the Tickford batteries are extremely inaccessible under the rear seat, and that the interior of the car may be filling up with extremely toxic fumes while the owner is struggling to gain access to them, C.I902 has been fitted with a heavy duty cut off switch. This is situated on the vertical part of the chassis, just below the rear seat, near the off—side door post, for easy access. It is wired into an extended earth lead, and can therefore kill all power supply within seconds! R.K.Sugg*).

When trying to locate a short circuit it is important to realise that the point where the most heat has been generated is the point of greatest resistance within the faulty circuit, and the actual cause of the trouble may be some distance away. Likely locations for shorts are:—

(a) Where wire go through holes, especially when grommets have disintegrated or disappeared.
(b) Where wires can rub against each other, or metalwork.
(c) Where the insulation is unfairly treated by water, oil, or excessive heat.
(d) Where a lead has become disconnected, and the loose end has flopped down and found an earth.
(e) Where screws have become undone and are rolling around inside components.
It should also be noted that motors and dynamos are virtual short circuits when they are not rotating, a jammed starter, or a cut out that stays 'in' will both cause very large currents to flow, not doing either components any good!
Being observant at the time the fault occurs can considerably reduce the time and effort needed to find the cause of the trouble Symptoms (b) and (c) are helpful in that they indicate which part of the wiring one needs to start looking at. It is also worth trying to remember if the fault simply happened, or if it was the result of some action while driving, such as using the indicators, or switching lights, in which case the circuit last used should be number one suspect. Before the battery is reconnected, a low power 12 volt lamp (3 Watts would do) should be connected in series with the supply at a point known to be the battery side of the short; if one has no idea at all as to where the fault is, then the place for the lamp is at the battery. In most cases a fuse will have blown, then the lamp can go in place of the fuse. I find that 'festoon lamps' will plug straight into most fuse holders. The next move is to switch off, or disconnect, all items after the test lamp, the battery can then be brought back into the circuit. This may seem rather involved, but if Fig.52 is referred to, it can be seen that the short circuit current has to flow through the lamp, which means that it is limited by the extra resistance, with the added bonus that the lamp will remain alight until the short is removed. If there are several feeds leading from the fuse holder, then the number of possibilities can be reduced by removing one at a time. Final location is a

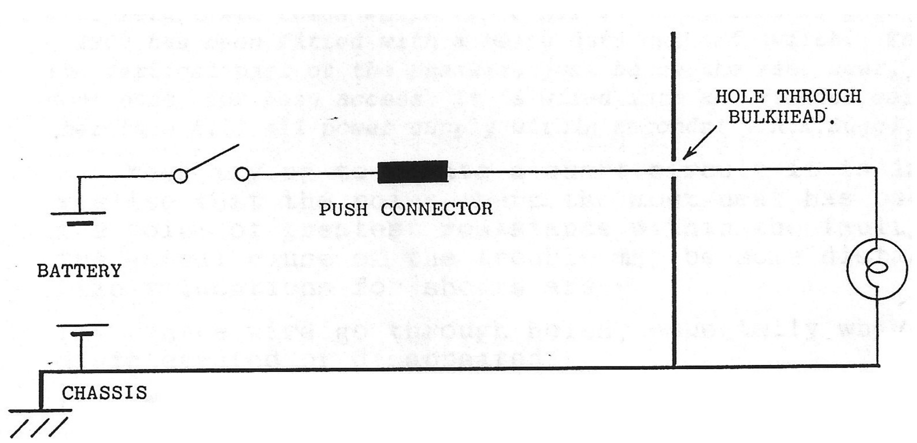


Fig.51

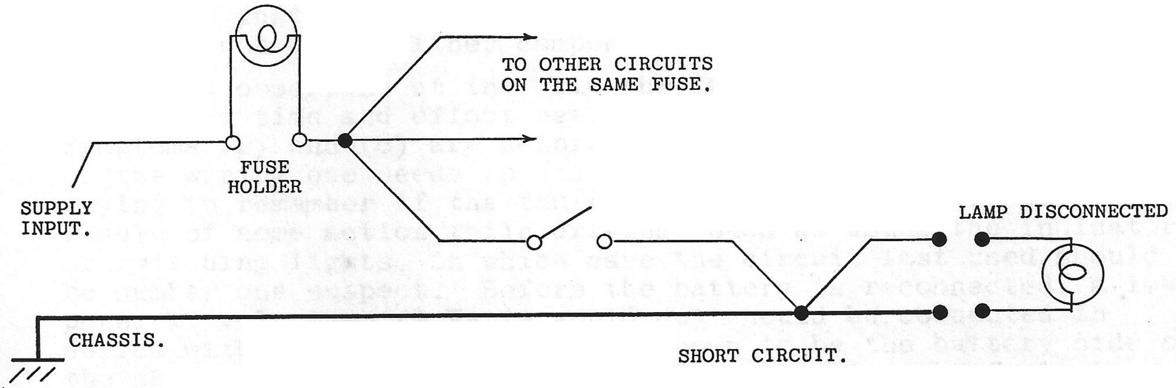


Fig.52

matter of observation, the fault being clear when the test lamp is extinguished.

ON ELECTRICS - PART 5

M.E.Chaney.

GAZETTE NO.l2

Some of the effects associated with electromagnetic devices are a little obscure, so in the hope that nothing of relevance will be overlooked, I will start from first principles. When a direct current flows along a wire there is a concentric magnetic field set up around it (see Fig.53). Should a wire be wound to form a coil, then the fields due to adjacent turns will combine in such a manner that as a whole, the field pattern is very similar to that of a bar magnet. The addition of a soft iron core would cause the resultant magnet to be much stronger, furthermore, the core may be extended outside the coil to create a magnetic field of almost any desired shape. The strength and polarity of a given electromagnet is simply controlled by variation or reversal of the current flowing through the coil. It is therefore a relatively simple, and exceedingly handy device which forms the basis of a multitude of inventions of varying degrees of merit.

Electromagnets also have a property known as 'Inductance', and it is as a consequence of this that many electro-mechanical devices are prone to failure.

If a wire, a group of wires, or as is relevant, a coil, is within the influence of a magnetic field that is moving, or of changing strength, then a voltage is induced within it. It therefore follows that if there is magnetic coupling between two coils it is possible by variation of the current in one, to induce a voltage in the other. Fig.54 shows a coil connected to a battery via a switch. On closing the switch current will start to flow and cause the coil to produce a magnetic field. In so doing the field will have to build up from zero strength, i.e. the coil will be subjected to a changing field of its own making, and this will cause an e.m.f. to be induced within it. The induced voltage will be in opposition to that of the battery and so reduce the flow of current, however, the forward voltage will always be greater than the reverse, which only occurs while the field strength is changing, with the net result that the value of the current will slowly climb to a final level as determined by Ohms Law. The rate at which a coil opposes current build up is the measure of its 'Inductance'. When the switch is opened the magnetic field will collapse, and in so doing will produce a ‘back e.m.f. which will do its level best to maintain the flow of current. As the switch is open there is no longer a current path, or is there? ‘Back e.m.f.‘ can well build up to many times the supply voltage, and the instant the switch contacts part the distance between them is negligible, and this fact combined with the high potential of the ‘back e.m.f.‘ leads to an arc forming across the gap from the time of opening until the ‘back e.m.f.‘ decays.

Electrical energy dissipated in an arc is converted to heatand a random spectrum of electromagnetic waves including both visible and radio frequencies, none of which is desirable in the context of switching. There is another effect, which I have to admit has always been a mystery to me, namely the curious ability of an arc to cause metal to migrate from one electrode to the other. If the electrodes are switch contacts, a pit is eroded from one while the other acquires a corresponding spike, with the consequence that the contacting surfaces cease to make and break cleanly.

Arcing, and therefore its effects, can be reduced to a considerable extent by the addition of a capacitor connected to bridge the offending contacts. Although this is not a complete solution, as is demonstrated by the frequency at which ignition points require attention, it will definitely prolong the active life of contacts switching an inductive circuit such as in an S.U. fuel pump. The required value is not critical, anything between 0.1 and 0.5 micro-Farads (uF) will do, but it is important to use a component rated to withstand at least 250 volts, as the ‘back e.m.f.’ may well be from ten to twenty times that of the supply. I find those marketed to suppress radio interference from dynamos etc. to be very satisfactory. If it is expedient to carry out repairs on an inductive circuit with the supply voltage on, care should be taken to avoid leaving oneself bridging an effective switch, as is easily done by holding a component terminal with one hand and removing the wire from it with the other. The short sharp electric shock resulting from such action presents little danger to anyone in sound health, but I find that electrical energy dissipated in such a manner is often converted into a form that is quite unprintable!

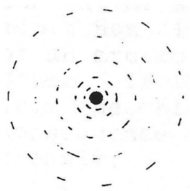
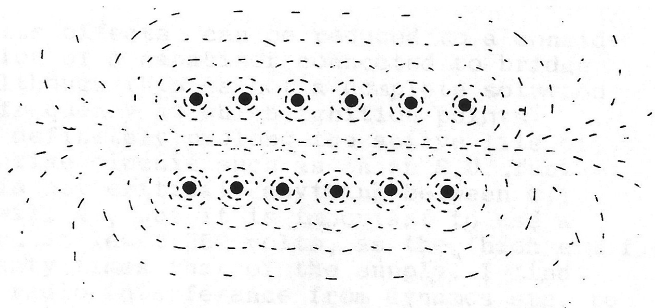


Fig.53 MAGNETIC FIELD PATTERNS.

Top left - a single conductor viewed end on.
Right - a coil viewed in section.



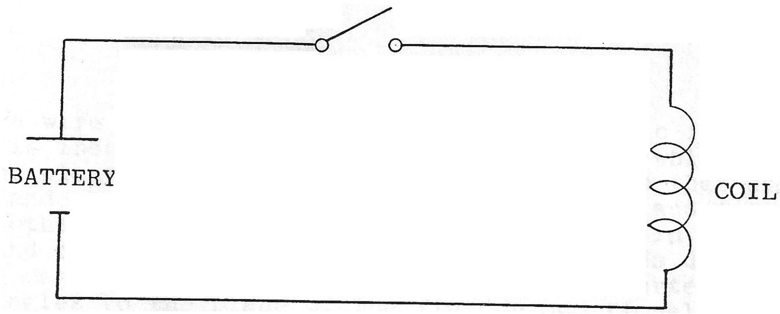


Fig.54.

ON ELECTRICS - PART 6
M.E.Chaney.

GAZETTE NO.l3

GENERATORS AND MOTORS.

If a wire is caused to move across a magnetic field, an e.m.f. is induced in the wire, the magnitude of which is greatest when the plane of movement is at right angles to that of the field, and proportional to the rate of movement and field strength. On the other hand, if a similar wire is at rest in a magnetic field and current is passed along it, the fields due to the current and the magnet react and cause a force to be exerted on the wire at right angles to the plane of the field proportional to the current and field strength. These two reciprocal effects are the basis of operation of generators and motors respectively, hence the similarity of construction, indeed many machines will function as either. In order to avoid undue confusion I will work towards a practical generator in stages. Fig.55. shows a simple machine comprised of a single turn coil attached by unspecified means to a spindle supported on imaginary bearings between poles of a horseshoe magnet. Rotation of the spindle causes the upper and lower sections of the coil to cut the magnetic field more or less at right angles, thus inducing e.m.f's which are additive and appear at the output leads. Unfortunately there are problems with this design: The output voltage from a single turn coil is very low, the output polarity is reversed every half revolution, and after a few revolutions and the output wires would become twisted around the spindle and break.

The Mk.II machine illustrated in Fig.56 features a multi-turn coil connected to a commutator with the output taken via carbon brushes. The output is increased in proportion to the number of turns on the coil, the commutator and brushes reverse the polarity is the problem machine, it for part of connections every 180°, and therefore the output polarity is constant. The brush connection also overcomes the problem of the output leads. Although this is a practical machine, it has limitations; as the coil only cuts the field for part of each revolution there is only output during that period. In spite of the number of turns on the coil, the output is not very large since the field strength is limited by the length of the air gap. The poor mechanical support for the coil limits maximum safe speed due to the effects of centrifugal force.

Fig.57 shows the much improved Mk.III machine, this incorporates a multicore armature to ensure that at least one coil is effective at any angle. The armature is wound in slots let into an iron core which not only ensures mechanical stability, but also considerably reduces the length of the air gap within the magnetic circuit.

Another feature is the use of shaped poles on the magnet to produce a nearly radial field throughout the working angle, thus the output is both high and virtually level. This machine could well be used for many applications. However, the operational environment of the motor car renders it impracticable since the output voltage is proportional to r.p.m. Happily there is a simple solution to this problem, as the output is also proportional to the field strength, which is easily controlled if an electromagnet is used in place of the permanent one.

Fig.58 shows a typical field magnet as is used on vehicle dynamos. This is effectively two horseshoe magnets face to face with the coil on one of the common legs, such a layout has the double advantage of compactness, as well as forming the outer structure of the machine.

The only dynamo components subject to appreciable wear are the brushes, these are quite easy to change and not very expensive. Should they become too short, excessive sparking will occur with subsequent commutator damage. It is also worthwhile to check the condition of the bearings from time to time, since if they permit too much lateral play, the armature could come into physical contact with the field poles, and that would mean a big job!

Other than the points just mentioned, dynamo faults are generally inflicted from the outside, incorrect regulator adjustment being the most common cause. If a dynamo is in good condition and connected correctly it will also run as a motor, and I consider this to be as good a check as any. To do this the drive belt should first be removed, then the cut-out relay in the regulator depressed, then the dynamo should motor strongly in the direction it is normally driven. Should it be reluctant to start, or tend to stall, this could be due to poor brush contact or to the contacts on the regulator relay being high resistance. The latter can be checked by connecting a temporary link between the ‘D’ and 'T' terminals. The motor method is also handy if it is suspected that an undesirable noise emanates from the dynamo.

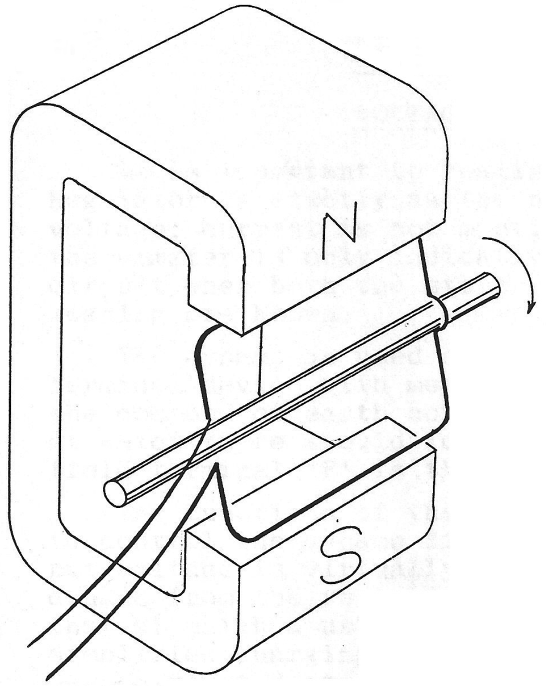


Fig.55

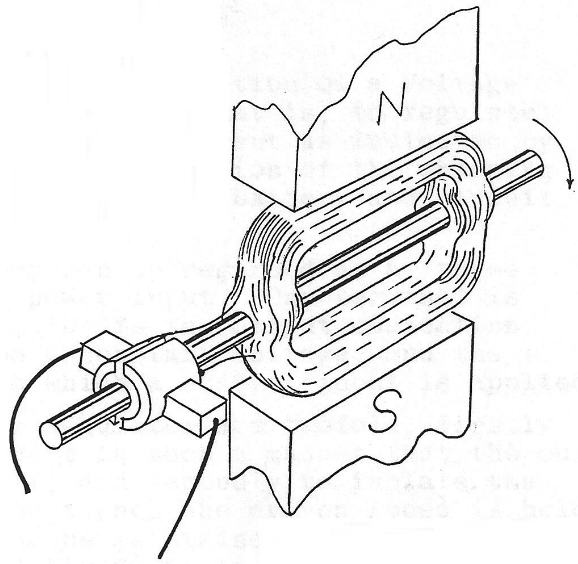


Fig.56.

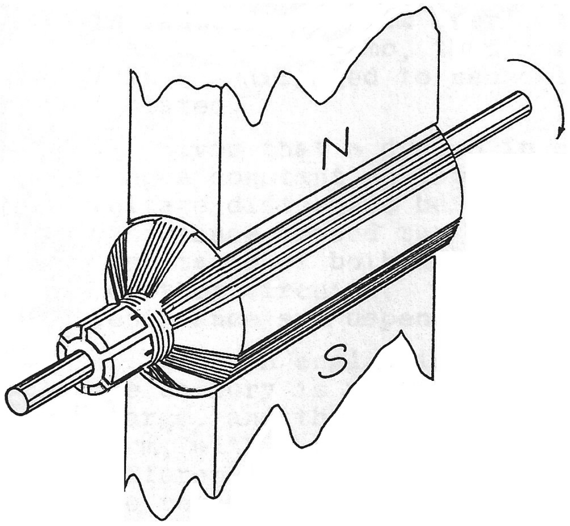


Fig.57.

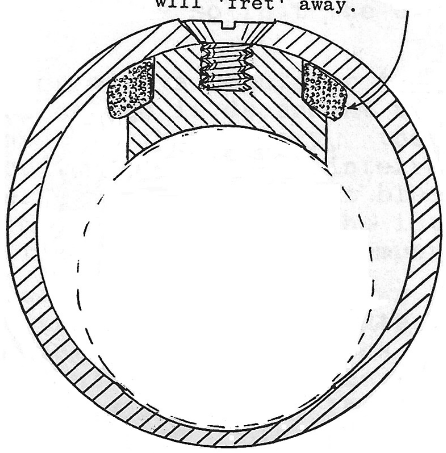


Fig.58.

ON ELECTRICS - 7
M.E.Chaney.

GAZETTE NO.l5

VOLTAGE REGULATION.

It is important to realise that the function of a Voltage Regulator is exactly as the name implies, that is, to regulate voltage; current is not mentioned. The current as indicated by the ammeter is only indicative of the condition of the charging circuit when both the state of charge of the battery and circuit loading are known.

The dynamo as used on Healeys can be regarded as a ‘three terminal' device with mechanical power input. One terminal is the common, or earth connection, 'D' is the output connection at which there should ideally be a constant voltage, and the field terminal ‘F’ is the one to which a control input is applied. The functions of the Voltage Regulator are two fold, firstly to control the dynamo field current in such a manner that the output voltage is virtually constant, and secondly to isolate the dynamo from the rest of the circuit when the driven speed is below that at which a useful output can be maintained. Fig.59 shows a simplified charging circuit, and Fig.60 is an idealised graph of open circuit dynamo voltage against engine speed. At very low r.p.m. the output terminal 'D', due initially to residual magnetism, is routed by the control relay directly to the field ‘F’, and as the voltage is low the remainder of the wiring is isolated by the cut-out. An increase in engine speed will cause the voltage at 'D' to rise, and when the critical level is reached, the cut out relay will energise and connect the dynamo output to the rest of the circuit.

As the speed is increased further the voltage will rise to a level at which the control relay energises. This causes the field current to be reduced and therefore the output at ‘D’ falls, and the control relay relaxes to increase the field current again, in turn causing the level at 'D' to rise, and so on. Thus the dynamo output voltage is held within finite limits. When the engine speed is reduced to tickover, the battery voltage will be greater than that of the dynamo, thus a reverse current will flow, the cut-out relay is arranged to sense this, and relaxes so that the dynamo is isolated.

Given that a dynamo in conjunction with a regulator is generating a constant voltage, the rate of charge is dependent upon the voltage difference between the dynamo and the battery, the total resistance around the charging circuit including the internal resistance of both dynamo and battery, and the current bled off to other circuits. The battery terminal voltage and the internal resistance are dependent upon the state of charge and temperature.

When an engine is started from cold, the current drawn from the battery is very high, this not only reduces the state of charge, and thereby the terminal voltage, but also causes it to warm, with a subsequent reduction of internal resistance. Thus the difference in voltage between the battery and dynamo is large while the resistance around the circuit is low, and a high rate of charge is to be expected. On the other hand, should a long daylight run be undertaken in warm weather, then the combination of temperature and extended charging will cause the battery voltage to approach that of the dynamo, the negligible different voltage resulting in an almost zero ammeter indication. This latter condition can, but should not, give cause for alarm. A battery is an electric reservoir, and once it is full up no good can be done by trying to force more in, it will just gas with a subsequent reduction of electrolyte level. Should peace of mind be needed, it can be obtained by a simple test:-

With the engine running at about 1500r.p.m., switch on the headlamps, so long as there is not a discharge indicated, all is well. The temptation to crank up the regulator should be resisted, since apart from cooking the battery on the way home, a burst of high engine speed may herald all the lamps having a final moment of extreme brilliance.

ON ELECTRICS - 8

M.E.Chaney.

GAZETTE NO.I7.

THE VOLTAGE REGULATOR.

On electrics Part 7 dealt with voltage regulation in general terms, the actual regulator unit being regarded as a ‘magic blackbox‘. It is hoped that the following will remove some of the magic and associated humbug.

Fig.61 shows a voltage regulator type RF 95. Due to the difficulty of combining a circuit diagram and a mechanical drawing, the former is correct, while considerable license is used on the latter. It should perhaps be explained that the metal frame supporting both relays acts as a common electrical path isolated from earth. The relays are shown as they would be with the engine stopped or running slowly, i.e. they are both relaxed, and in this condition the contacts of the cut-out are open, while those of the control relay are closed. Both relays are similar in that they have two windings, one of many turns of fine wire which draws little current and causes the relay to operate at a specific voltage, and one of few turns of heavy gauge wire which is current dependent. If the currents in both voltage and current windings are flowing in the same direction, the effect is additive. On the other hand, if both currents are in opposition a contrary effect will result.

The output from the dynamo is applied to terminal 'D', and the field connection to terminal ‘F‘. The battery is wired via the ammeter to terminal ‘A‘ and all other circuits, with the exceptionof the starter and horn, are routed via terminal ‘A1’. Terminal ‘E’ is the common earth connection of the relay voltage coils. Terminals ‘A2’ to ‘A,’ merely provide access to the fuses that happen to be mounted on the regulator.

As can be seen on Fig.61, the dynamo output is routed from 'D' via the isolated frame to both relay voltage coils. At idling speed the dynamo voltage is too low to energise either relay, so the closed contacts of the control relay make direct connection between 'D' and ‘F’, while the open contacts of the cut-out ensure that all the ‘A‘ terminals are isolated from the dynamo. An increase in engine speed will cause the dynamo voltage to rise, and eventually, at a level just above battery voltage, the cut-out will energise and allow current to flow via the relay current coils to the external circuits. Once the cut-out is closed, both relay voltage coils are held at battery potential, however, the sudden slight reduction of level should not cause relaxation for a combination of two reasons.

All relays exhibit some degree of electrical backlash; i.e. there is a difference between ‘pull-in’ and 'drop-out' levels. Secondly, in the charge condition the effect of the current coil is additive, so a correctly set cut-out has no tendency to buzz or chatter.

A further increase in r.p.m. with a subsequent rise in the potential applied to the relay voltage coils will eventually cause the control relay to energise. This removes the direct connection between ‘D’ and ‘F'. However, field current still flows at a reduced level via the resistor ‘R’. The reduction of field current is sufficient to lower the dynamo potential below that required to maintain the control relay in an energised state. When the control relay contacts restore the direct connection between ‘D’ and 'F' the dynamo output voltage rises, and the cycle is repeated. If correctly set, the control relay will automatically vary its ‘on to off‘ ratio to keep the mean dynamo output voltage constant, so long as the operating r.p.m. is above a certain minimum and the load current does not exceed the rated maximum. Should the driven speed of the dynamo fall below the operating minimum, the output potential will be below that of the battery, in which case the current flow through the relay current coils will become reversed as the battery tries to ‘motor’ the dynamo. The discharge current will continue to rise until the reverse field produced by the cut-out current coil backs off that of the voltage coil, due to the battery via the contacts, enough to cause the cut-out relay to relax, and the circuit to revert to the condition illustrated.

There are at least five different 12 volt versions of the model RF 95 regulator, and it is important to fit the correct unit, service No.37065, when replacing. The principle difference between units lies in the number of turns incorporated in the control relay current coil above and below the ‘A’ connection. Without current coils the control relay would try to keep the dynamo potential constant, regardless of circuit loading, and enormous currents could flow with subsequent damage to both battery and dynamo. Current flowing through the battery via ‘A’ lowers the operating voltage of the control relay, thus if the battery exhibits a very low voltage, the charging current is limited to a reasonable value. Similarly, if a large current is drawn via 'A1' this will lower the dynamo potential still further and protect the dynamo against excessive circuit loading.

The amount of power (i.e. Watts = Volts x Amperes) that can be drawn from a given dynamo depends to a large extent upon its armature temperature. Heating is due both to the engine and to power dissipated within the armature because of current passing through the internal resistance. Thus, when the dynamo is cold, just after starting the engine, it is possible for it to supply a much higher current. As this is also desirable, the regulator is arranged to hold the dynamo potential at a higher level when cold. The control relay is temperature compensated by having the leaf spring which bears on the adjusting screw backed with a bi-metal strip. Since it is armature temperature that really matters, it would seem logical to mount the regulator so as to have good thermal contact with the dynamo. However, this is not the general practice on British vehicles, and it would seem to be located more or less at random anywhere on the bulkhead. On Riley engined Healeys, other than Silverstones, the control box is usually mounted as near as possible to the exhaust manifold, thus ensuring that the time for which an enhanced rate of charge is enjoyed after starting is reduced to a few seconds!

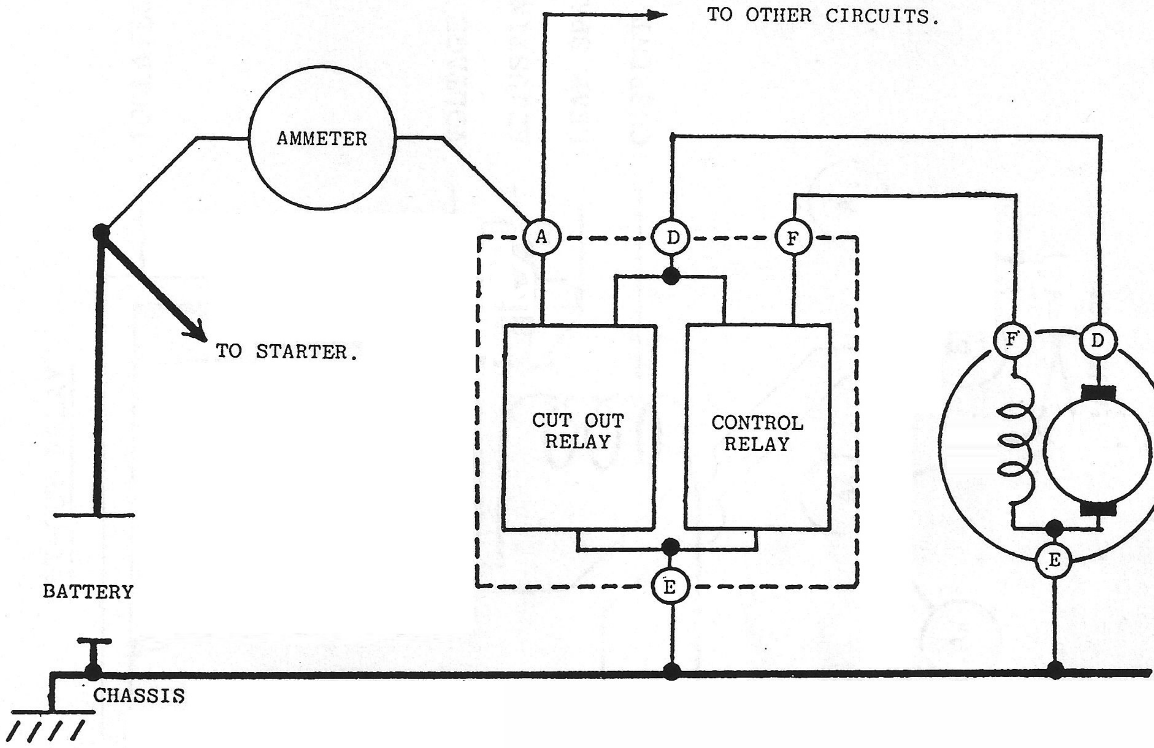

TO OTHER CIRCUITS.
AMMETER
A
D
F
TO STARTER.
CUT OUT RELAY
CONTROL RELAY
F
D
E
BATTERY
E
CHASSIS

Fig.59.

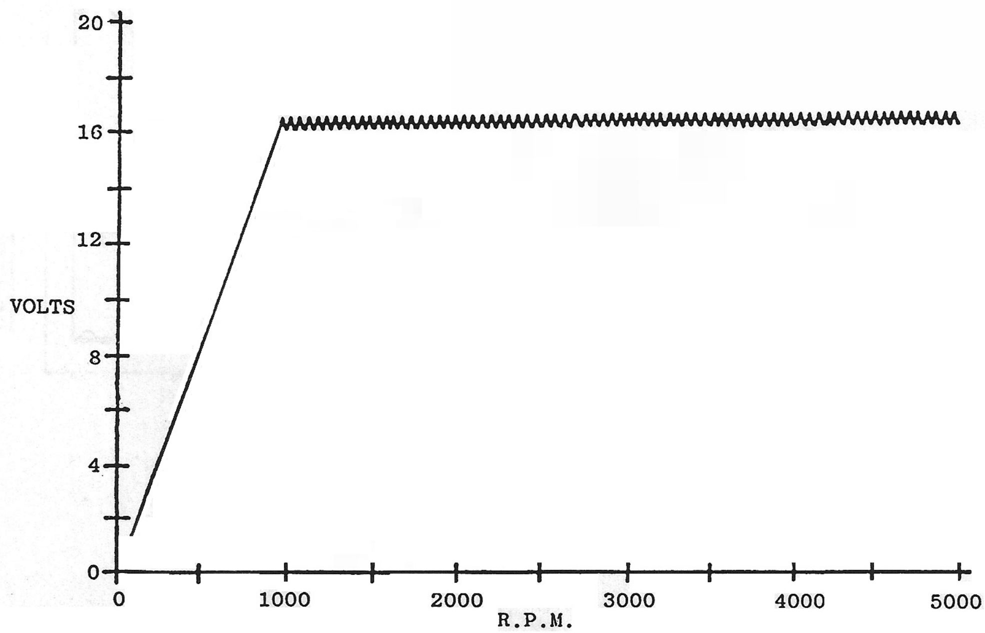

20
16
12
VOLTS
8
4
0
0
1000
2000
3000
4000
5000
R.P.M.

Fig.60.

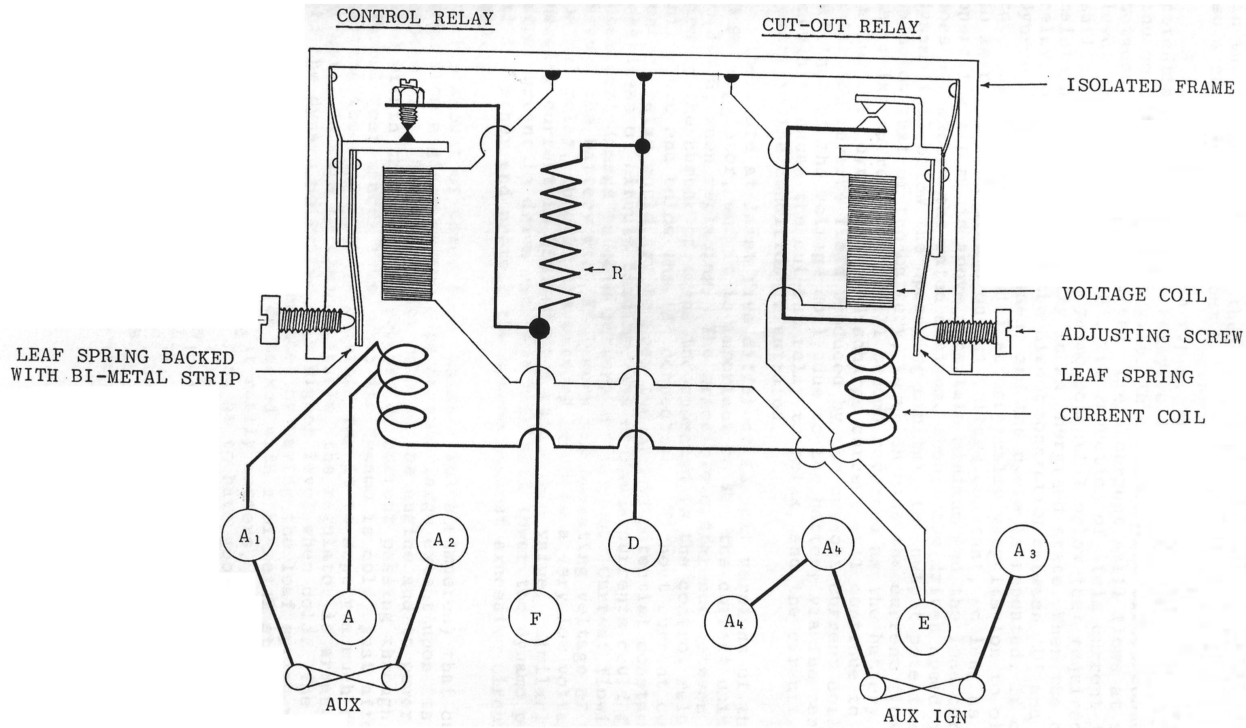


Fig.61

M.E.C/R.K.S

ON ELECTRICS - 9
M.E.Chaney.

GAZETTE NO.19

CHECKING AND ADJUSTING THE VOLTAGE REGULATOR

Before attempting to adjust the voltage regulator, it is important to ensure that the mechanical settings have not been tampered with. Mechanical adjustment will only be required if an armature has been removed, or if it has been necessary to reface the contacts. In the latter case, providing that caution has been exercised and one has not gone berserk with a file, it is unlikely that mechanical adjustment will be needed. I had hoped at this juncture to be able to refer readers to a drawing showing the mechanical settings for regulators type RF 95, However, no such drawing exists, since although I have discovered a mine of information regarding the mechanical settings of many varied and obscure units, I have, so far, located none about model RF 95. If any member is able to furnish this information, it will be gratefully received. It is therefore fortunate that most of the mechanical adjustments entail messing about with shims and bending things, and are unlikely to attract the attention of the dreaded phantom twiddler. The control relay contacts are a notable exception, being very accessible and fitted with a locknut, they are far too inviting, and are almost bound to have received uninformed ministration. These should therefore be checked, and in the absence of hard data, I suggest a setting of 0.010 to 0.014 inches with the armature pressed down.

In order to verify, or adjust, the electrical settings it is essential to have the use of a reasonably accurate D.C. voltmeter with a resolution of 0.1 volts or better at the required settings

The ideal instrument, if you are so lucky, is an AVO model 8, using the 25 volt range, but one can make do with lesser devices.

I use an old AVO 7 to which I have fitted an external modification to convert the 10 volt range into one of 20 volts, and this is ideal, so long as one can live with the mental strain of multiplying all the readings by two. The official way of checking a voltage regulator is given in the Riley Workshop Manual, Section No.9. However although Fig.N 12 illustrates the outside of an RF 95, Figs N.13 and 14 show, with excellent detail, the inside of an altogether different type, and the text would appear to refer to this. There is also the business of disconnecting various wires in order that the system is ‘off load‘, all a bit fiddly, especially when the same end can be achieved with a piece of cardboard.
The method I use to check and adjust a regulator is as follows:-

1. Remove the regulator cover.

2. Check the control relay contacts.

3. Connect the Voltmeter negative lead to terminal 'D' and the positive to terminal ‘E’, or any good chassis connection.

4. Place a piece of folded cardboard, or other handy insulating material, between the cut-out contacts so that they cannot close.

5. Start the engine. Slowly increase r.p.m. and observe that the voltage increases until it stabilises and becomes independent of further speed increases. (See Gazette No.15, Fig.60)

6. Check that the stabilised voltage complies with the following table:-

10°C (50°F) 16.1 to 16.7 volts.
20°C (68°F) 16.0 to 16.6 volts.
30°C (86°F) 15.9 to 16.5 volts.
40°c (104°F) 15.8 to 16.4 volts

7. If not within the above limits adjust by turning the screw, locked with a spring and paint, above the control relay clockwise to increase, or anti-clockwise to decrease the voltage. This screw is the one that bears on the leaf spring backed with the bi-metal strip. (See Fig.61)

NB. I don't usually bother with a thermometer, but adjust for 16.2 to 16.5 volts, and do so quickly before the exhaust manifold has had time to roast the regulator.

8. Remove the piece of cardboard from the 'cut-out'.

9. Slowly increase the engine speed from tick-over and note the voltage at which the cut-out energises, this should be between 12.7 and 13.3 volts.
NB. It would appear that one needs to look at both the 'cut-out' and the voltmeter at the same time, actually this is not the case because as soon as the 'cut-out' closes the indicated voltage will be pulled down to that of the battery, and it is merely a matter of observing the value immediately before that happens.

10. If the cut-in voltage is outside the limits, the spring and paint locked screw above the cut-out relay should be turned clockwise to increase, or anti-clockwise to decrease the cut-in voltage. This setting is rather critical and it is best to only turn the screw a very small amount before re-checking.

11. If the cut-out has been adjusted, make sure that it doesn’t indeed cut out, and that the momentary discharge indicated by the ammeter is not more than six amperes.

12. Disconnect the voltmeter, if any adjustment has been made, relock the adjusters with paint, and replace the regulator cover.

With normal usage, the only fault to which regulators are prone, is for the contacts to become pitted, or if the car is not used for a long period the contacts may get tarnished. In either case the cure is quite simple. It is most unlikely that a regulator will get out of adjustment of its own accord. In my experience the most common cause of regulator troubles iswithout doubt none other than the dreaded phantom twiddler!

CONCLUDED. M.E.Chaney.

FIRE RISK
Ray Sugg

AUGUST 1989 NEWSLETTER.

There are two basic causes of spontaneous combustion in those parts of a car where there is not supposed to be combustion.
(1) Electrical faults, which were discussed by Mike Chaney on page 171. And on page 174, I made some comment on the desirability of a total power cut off switch.

(2) Leakage of petrol. It is my opinion that there are three possible causes of fire in the distributor/ carburetter area:-

(a) Flooding of the float chamber due to worn float valve or leaking float. I have only experienced this once in my 34 years of Healey motoring, when it caused the exhaust silencer to explode; New valves were fitted, and as a precaution taller cap nuts were made so that a 'banjo' and pipe could lead excess petrol or petrol fumes into the air intake box. The main/reserve petrol switch was removed, and two toggle switches substituted. Fuel can then be switched off with the engine running.

(b) Loosening of the banjo bolt securing the main petrol pipe to the float chamber lid. This is by far the most dangerous possibility, since the fuel is emitted at relatively high pressure. I would not be surprised if most of the fires which have damaged Healeys were caused by this. I was fortunate that when it happened to me on the return journey from Braemore in 1988, it was the rear carburetter that was affected. since the front one is dangerously near to the distributor, which is, of course, full of big fat sparks. It seems to happen when new fibre banjo washers have been fitted.

One dare not tighten them too much in the first place, since it would be quite easy to strip the thread in the float chamber cap. They must, however, be 'followed up' after every journey until they will not tighten any further. (You will remember that the same thing applies to rocker box joints and nuts. It also applies to heavily painted components. That beautifully restored road wheel with its lovely thick paint, may well come loose as the paint frets and is extruded from between the wheel and the brake drum, check it regularly until it settles down).

(c) Spitting back through the carburetters on those cars not fitted with air intake boxes (Silverstones).

If I were to become aware of fire under the bonnet of C.l902.
I would try to take the following action (while stopping).

(1) Switch off both petrol pumps.

(2) Set hand throttle to about 3/4000 r.p.m., to use up petrol and suck in flames.

(3). Switch off electric radiator fan (C.1902 has no belt driven fan).

(4) Once stationary, attack fire with extinguisher.

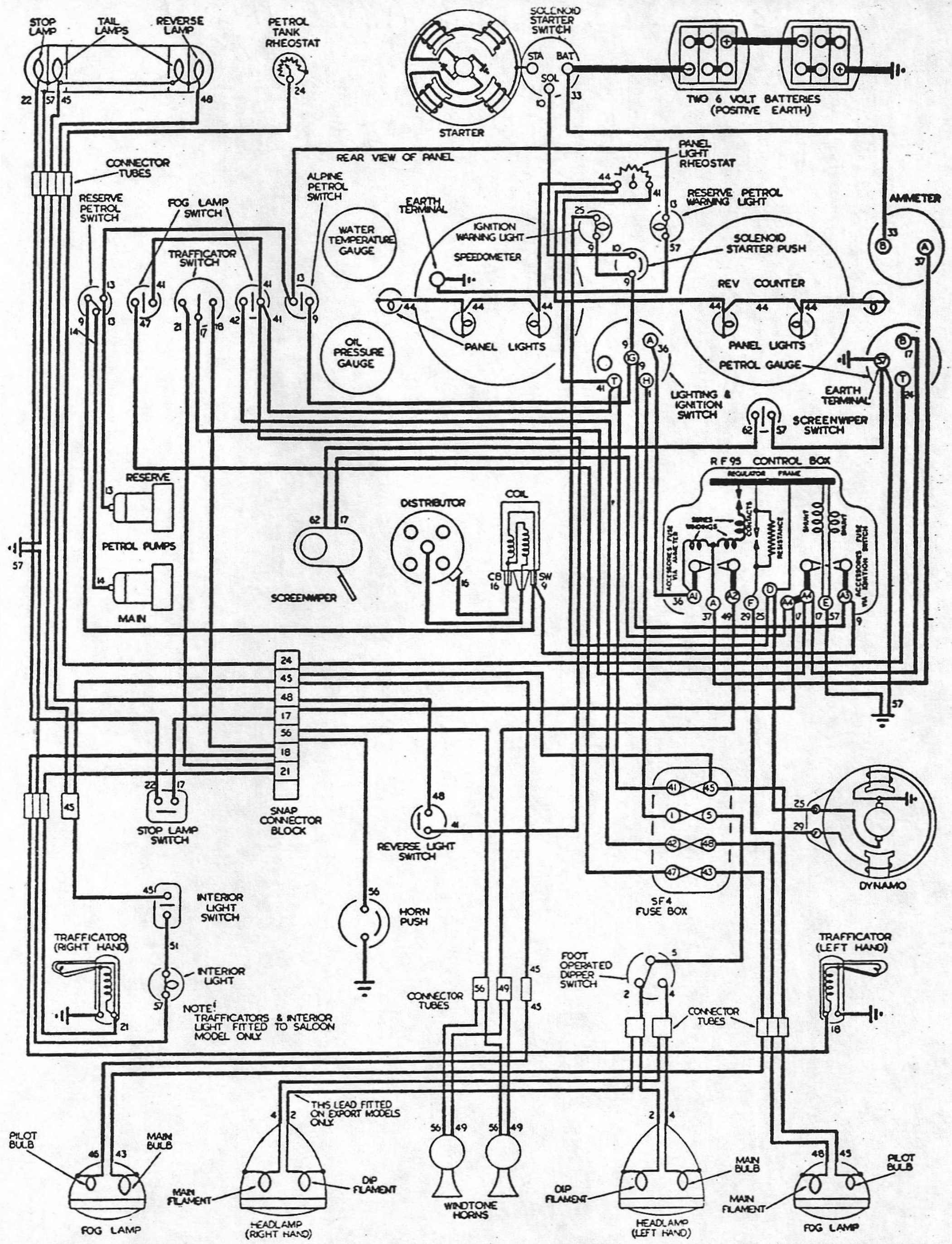
I do not feel that the fitting of a guard over the distributor is practical, due to the limited amount of space between the front carburetter and the distributor, and the possibility of leakage of high tension sparks, especially in damp conditions.
R.K.S.

LUCAS WIRING DIAGRAM

LUCAS ELECTRICAL EQUIPMENT

HEALEY 2.4 LITRE CARS (1948)

SALOON & ROADSTER



KEY TO CABLE COLOURS

1 BLUE
2 BLUE with RED
3 BLUE with YELLOW
4 BLUE with WHITE
5 BLUE with GREEN
6 BLUE with PURPLE
7 BLUE with BROWN
8 BLUE with BLACK
9 WHITE
10 WHITE with RED
11 WHITE with YELLOW
12 WHITE with BLUE
13 WHITE with GREEN
14 WHITE with PURPLE
15 WHITE with BROWN
16 WHITE with BLACK
17 GREEN
18 GREEN with RED
19 GREEN with YELLOW
20 GREEN with BLUE
21 GREEN with WHITE
22 GREEN with PURPLE
23 GREEN with BROWN
24 GREEN with BLACK
25 YELLOW
26 YELLOW with RED
27 YELLOW with BLUE
28 YELLOW with WHITE
29 YELLOW with GREEN
30 YELLOW with PURPLE
31 YELLOW with BROWN
32 YELLOW with BLACK
33 BROWN
34 BROWN with RED
35 BROWN with YELLOW
36 BROWN with BLUE
37 BROWN with WHITE
38 BROWN with GREEN
39 BROWN with PURPLE
40 BROWN with BLACK
41 RED
42 RED with YELLOW
43 RED with BLUE
44 RED with WHITE
45 RED with GREEN
46 RED with PURPLE
47 RED with BROWN
48 RED with BLACK
49 PURPLE
50 PURPLE with RED
51 PURPLE with YELLOW
52 PURPLE with BLUE
53 PURPLE with WHITE
54 PURPLE with GREEN
55 PURPLE with BROWN
56 PURPLE with BLACK
57 BLACK
58 BLACK with RED
59 BLACK with YELLOW
60 BLACK with BLUE
61 BLACK with WHITE
62 BLACK with GREEN
63 BLACK with PURPLE
64 BLACK with BROWN

WIRING DIAGRAM
No. W73421
12 VOLT.

ISSUED:
MAY 1948

NUMBERS INDICATE CABLE IDENTIFICATION COLOURS, SEE KEY ABOVE.
FOR SPECIFICATION OF EQUIPMENT SEE OVERLEAF.