Lucas C45E 6 volt dynamo as fitted to SV Minors

This dynamo was fitted to most of the side-valve Minors from approximately chassis number SV101 up to chassis SV33778. Above that they became more "Morris 8" but the general information still applies to the dynamo fitted although the resistor unit is fitted in the cut out unit.

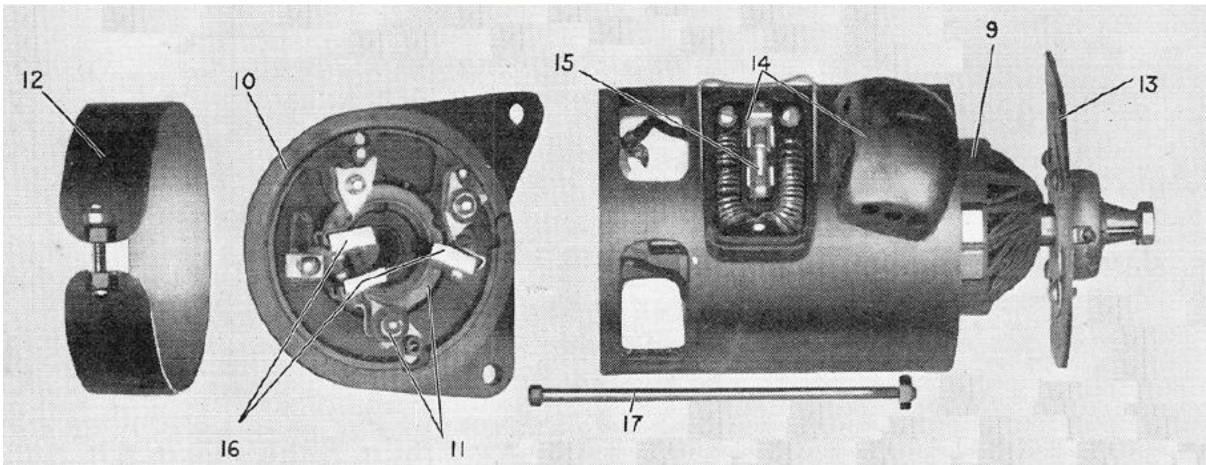
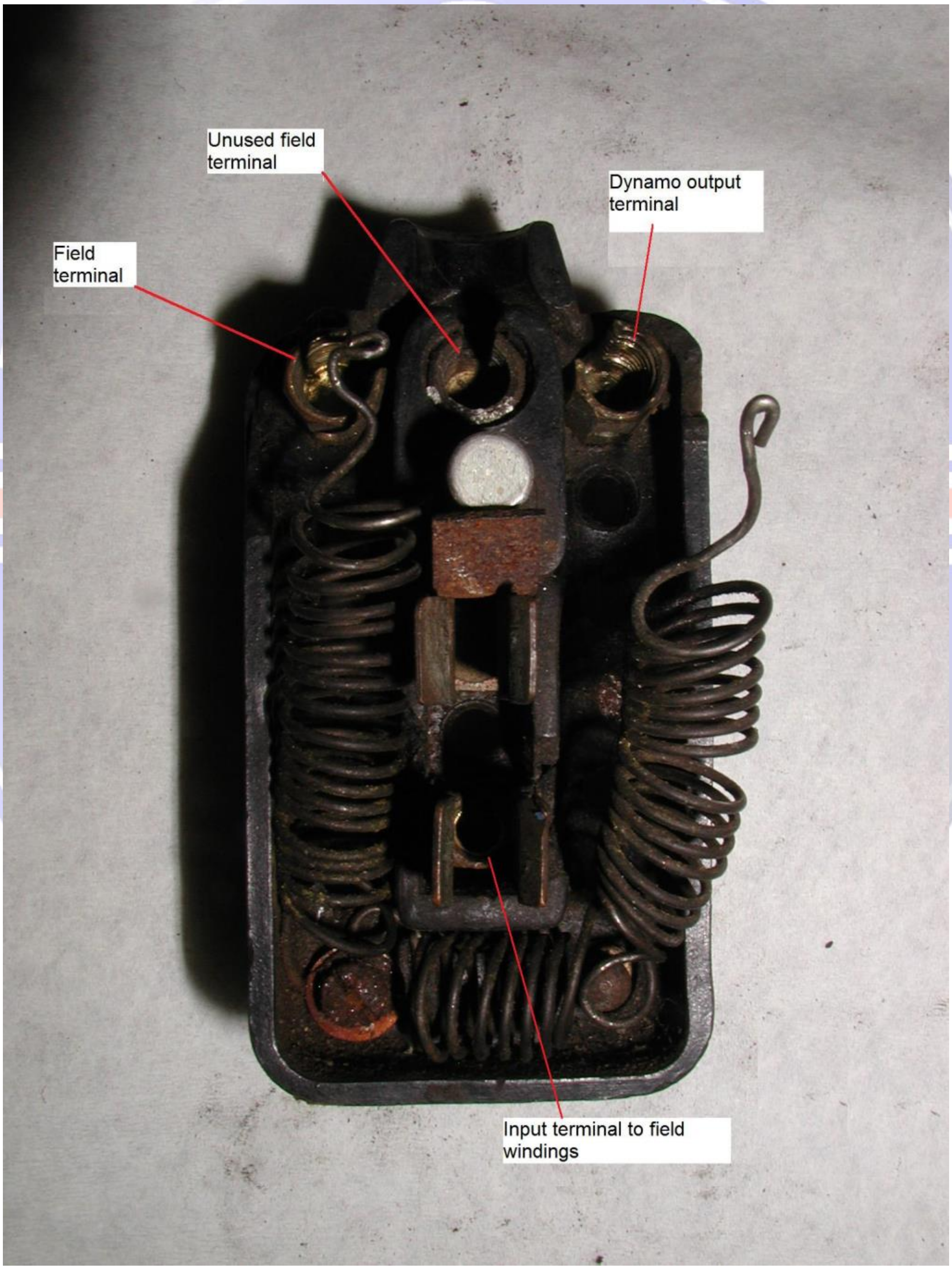


Fig 1

Item	Description
9	Armature assembly complete
10	Brush carrier plate and end bearing bush assembly
11	Control brush and sliding adjustment carrier plate
12	Brush cover plate (access for adjustment)
13	Pulley end ball race bearing plate
14	Field resistor unit and field fuse carrier
15	Field fuse – 8 amps (1inch long) [you can use a 5 amp domestic fuse]
16	Dynamo output brushes
17	Main assembly bolts and nuts (2 off)

Looking at the field resistor unit on the side of the dynamo from above, the right hand section of the resistor coil and also the short bit on the bottom are one resistor of approximately 1.3 ohms resistance whilst the third part on the left hand side is approximately 1 ohm resistance. All 3 resistance coils are in series such as to create a field resistor of approximately 2.3 ohms with a tapping at 1.3 ohms in the bottom left hand corner. More about all this later on. The field resistor unit is held on to the case by 2 x 2BA screws hidden under the left and right resistors. These can be undone together with the Dynamo output lead and the field coil connection lead so as to remove the unit. Keep the paper type gasket underneath and also most importantly carefully retain the Bakelite insulating bush that insulates the wires that go into the dynamo. If it is missing or damaged then an insulated bush will need to be made as the D+ output cable can get a bit warm!



Some versions of the Dynamo were originally designed to have 3 possible output rates and if you look carefully at the top of the resistor unit where the D+ and field wires connect on a lot (but not all it appears) of the dynamo you will see a terminal in the middle without a screw in it. Also, if you look at the back of your dashboard PLC switch you will see F1 and F2 terminals. They are or should be strapped together across the back of the PLC switch to give only two charge rates. Summer and flat out for winter and lights on.

As an additional piece of useful information, the larger grub screws on the resistor unit F1, possibly F2 if it's there and D+ are all ¼ BSF thread. New replacement brass screws are available from www.spaldingfasteners.co.uk by post. They also fit the later Morris 8 CFR2 cut out unit as well.

The PLC switch has 3 completely separate functions, ignition, lighting and finally charging. No need to go into any more detail on this switch as excellent and very detailed information is available elsewhere courtesy of the Austin 7 brigade. Note the comments though on test voltages. ON NO ACCOUNT USE MAINS VOLTAGES TO TEST!

http://www.austin7.org/Technical%20Articles/PLC%20Switch%202/

http://www.austin7.org/Technical%20Articles/PLC%20Switch%201/

The rear grub screws on the PLC switches are all 2 BA thread.

Operating conditions on my PLC switch are

Summer Charge	D terminal no connection to any terminal
Winter charge	D terminal connected to F1
Side lights on front & back	D terminal connected to F1
Headlights and rear light(s) only on.	D terminal connected to F2

My PLC switch is a Lucas PLC 2 with a proper key so your conditions may be slightly different and I think mine either is a replacement or off an MG car.

As the terminals F1 & F2 are normally strapped on the back of the PLC switch on the SV Minor wiring diagram we only have two charge rates – Summer and flat out.

NOTE – BEWARE of Lucas PLC switches and the various types. There are at least 6 different designs and not all contain the same functionality. Some lighting and charging control sequences are different between types. Some in particular are for motorcycles only. Some of the new substitutes have a lot less connections on the back.

Originally at some stage, the system was designed it appears to have an additional charging step for winter charge (F1) and then flat out for everything on (F2) but it appears it was decided it was not needed. On some C45E dynamos the middle tap grub screw terminal on the resistors is not provided (See picture Fig 2). On the later Morris 8 with the CFR2 cut out the PLC shorting link F1 to F2 is not there and the two resistors are in the back of the CFR2 and the three charging rates are used again.

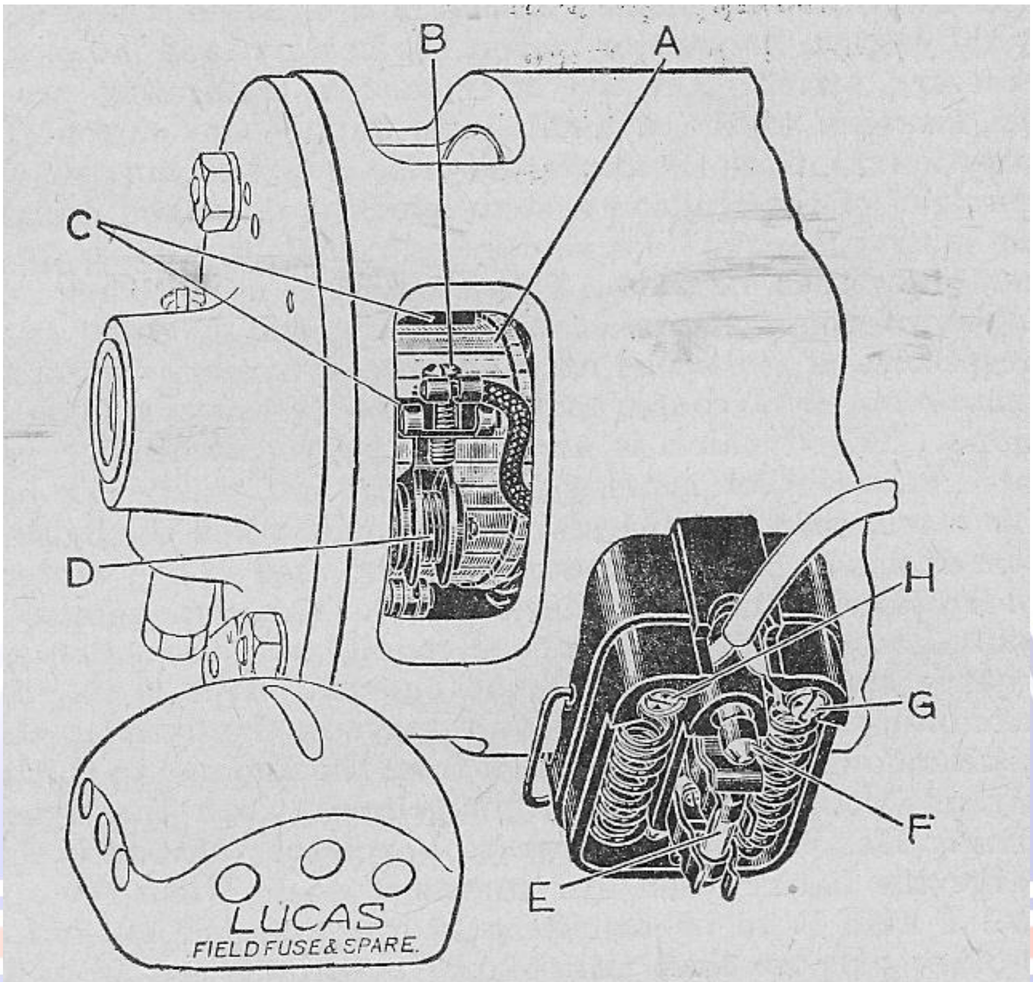


FIG. 49. DYNAMO WITH COVER REMOVED

A = Commutator	*E* = Field fuse
B = Screw securing brush	*F* = Spare fuse
C = Brushes	*G* = Positive terminal
D = Brush tension spring	*H* = Field terminal

Fig 2

One major problem with the early C45 series dynamos is that there are no ventilation slots in the ends of the case and therefore no cooling fan. This is one of the limiting factors as to how much current you can get out of it before something fails. A lot of the information in this article also can apply to the later Morris 8 C45 3 brush dynamo but there are some design differences.

<u>What goes wrong ?</u>

Brushes, Brush spring assemblies, Bearings, armature, commutator, field coils, resistor(s) unit, broken wire (s) Field fuse.   (There isn't much left is there !)
Oh yes there is – Total lack of any residual magnetism. Without this the dynamo is just a lump of useless rotating metal. (More anon.)

As I am currently restoring my 1932 Minor, I found that like everything else on my car the dynamo did not work as it was not showing a charge on the dashboard ammeter.

1. Check the field fuse plus F1 and D+ connections.
2. Slide back cover (item 12) and inspect inside. Don't fiddle with the insides yet. No apparent visible faults so far.
3. Disconnect the dynamo wiring and connect the field terminal to the car battery positive for a few seconds to polarise (Flash) the dynamo residual magnetism. There were a few small sparks.
4. Reconnect and try again by running the engine. No luck.
5. Remove dynamo belt and try to get the dynamo to "Motor" as all dynamo's should do this albeit maybe not very efficiently. (More info on this later). No Luck.
6. Remove dynamo from car to bench.

On the bench it was apparent the pulley end bearing was a bit stiff so first of all remove cooling fan (2 bolts) NOTE – These bolts on mine are metric thread M8 x 1.0 pitch so don't get it mixed up with any 5/16 BSF ones. Remove pulley (1 bolt inside) and with a few gentle taps it came off as it fits onto a not very good taper. NOTE – This bolt is metric thread M8 x 1.0 pitch so don't get it mixed up with any 5/16 BSF ones. Remove the two long bolts / nuts (17) and then remove the 4 screws that hold the bearing cover inside the dynamo front to gain access to the ball race bearing together with the felt seal and spring washer. I had to do it this way as the bearing was a very good fit on the shaft. The stiff bearing was cleaned and once all the dust etc was carefully washed out with cleaner / degreaser I left it to dry. NOTE – It is advisable not to let the armature windings get wet or any solvent get on them or the commutator. Similarly, the field coils should not be cleaned with any solvents or water as the materials used are old and the insulation could be affected. A few drops of light oil and I found the bearing was free and in good order. If you need to replace the bearing then remove the "C" ring and spacer ring on the shaft and pull off the bearing with a puller. The cause of the crunchy bearing was because the felt seal at the front was worn out. A new suitable felt seal is available from Ian Harris Morris Spares. Pack some high temperature grease into the bearing, soak the felt seal with a light oil and then the re assembly of the pulley bearing end to the armature assembly is in reverse order of above but make sure the 4 screws have the lock washers under them and they are tight. If you need to replace the ball race bearing then your local bearing supplier should be able to find one. It may be difficult to remove it but don't risk damaging the armature windings.

Disconnect the wire from the output brush that goes to the terminal / resistance unit D + terminal and pull off carefully the plate 10 with the brush gear on it. Disconnect the connection on the thin brush that goes to the field coils. Inspect the end bearing bush (it was OK on mine) and the brushes. One large one should be earthed to the plate via a flexible braid and the other large one is the output to the D+ terminal. The thin one is the field control brush. Note the position of the field control brush as this is what sets maximum output. Also note the shape of the tips of the old brushes if they are still there. They are worn in to match the direction of rotation and it is important they are refitted the correct way round otherwise the dynamo might be noisy for a while and also struggle to give a good output until they are worn in. I obtained a new complete Lucas set from Ian Harris. Genuine Lucas ones appear to be pre shaped to minimise running in.

Clean the dynamo brush end up of all the old grease and carbon dust and ensure the slideable ring that the third brush (charging rate control) mounts on is free and lightly greased. Remove old worn brushes and clean off any carbon dust etc from the holders. Check that the earthing strap for the chassis connection brush holder is in good order and tight. Check the brush end bearing on the shaft for play. If it's worn find a replacement. The bush is a form of sintered bronze which is porous to oil. Note the condition of one of the larger brushes in Fig 3. I think this was one of my problems. Check the brush springs ant the brush spring assemblies in general for faults and any weakness in spring tension.

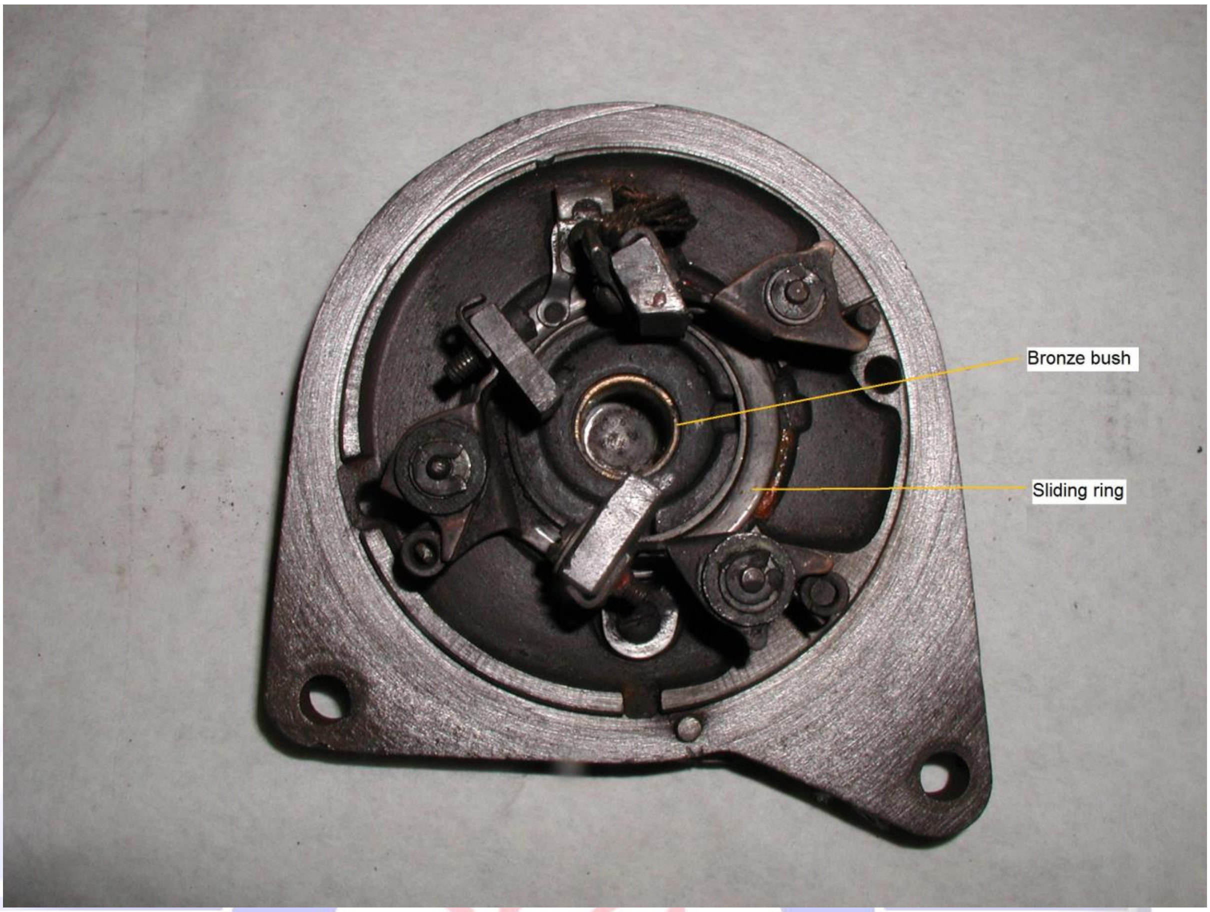


Fig 3

Next thing to look at is the main case itself which houses the field coils. The screws holding the field coils in place should be tight. Check the link wire soldered joint between the two coils. This should be positioned both to miss the long case screw (17 in Fig 1) and also not be able to rub on the armature.

Field Coils

You can check the resistance of each field coil approximately using a test meter but the resistance is so low accuracy is a bit difficult as the resistance of the test leads are similar to the coils! If the field coils are both about 1 ohm in resistance that’s probably OK. If one is open circuit then that’s your possible fault you are looking for. I found very dubious soldering on the field coil connection to the tag that goes on to the third brush (the thin one) and the wire appeared loose. I re-soldered it to be sure. I think this was another of my problems. Check the insulation level from one coil end to the case of the dynamo using the same test meter. DON’T use a mains wiring tester as they can apply 500 Volts or more and the coils insulation will definitely break down. No more than say 50 volts applied to be safe. Low field coil insulation will cause low or no output. Without specialised equipment further tests such as finding shorted turns are difficult if not impossible. If you suspect shorted turns then try another set of coils or seek expert help.

Armature Visual inspection

First rule. If it all looks OK you are in with a chance. The windings do look a bit brown but don't panic !

Visually check the commutator for loose segments. If there are any loose it will almost certainly be scrap. Seek expert help or another dynamo / armature.

Visually check the soldering between the windings and the inboard ends of the commutator segments. If they look like the solder has melted then the dynamo has been over run / over heated by asking for too much output. It could be scrap. Seek expert help about possible repairs or another dynamo / armature.

Visually check the windings on the armature for any mechanical damage such as that caused by impact. If you can clean and solder any breaks without shorting turns then try it or seek expert help or another dynamo / armature.

Visually check the commutator and see if there is any surface wear. If there is then a light polish with very fine emery paper or wet & dry should be sufficient. Clean the residue off with a cloth afterwards. If the commutator is very badly worn then skimming on a lathe could be all it needs but before you do this, do all the other checks first. I was lucky that the commutator segments were still slightly under cut so I left them "as is". If you need to undercut the insulation between the commutator segments then it's a lot of fiddly work, but don't go very deep.

Armature Electrical Inspection

Mr Lucas designed the C45 series armature with what is called “Lap Windings”. See Fig 5. It’s a bit more complicated than you think a DC generator would be, based on simple DC motor theory but in basic terms it is more efficient and can give a better more stable output voltage and higher current as a generator than the simple theory idea. That means it is not possible to fully test individual windings on a C45 type dynamo without specialised methods available only to a dynamo specialist.

So, what can we do? Using our test meter, measure across the commutator between opposite segments, and then measure the resistance. There are 28 copper segments in total so there needs to be 14 measurements. The readings will be very low but all should be about the same. Then measure between adjacent segments and again all the adjacent measurements should be low and the same as each other. If there are any high resistance measurements then there could be an open circuit. Also, it is necessary to test the insulation resistance from the commutator and windings to the body of the armature. Check the insulation level from one copper segment to the body of the armature using the same test meter. Again, DON’T use a mains wiring tester as they can apply 500 Volts or more and the coils insulation will definitely break down. No more than say 50 volts applied to be safe. Low resistance insulation will cause low or no output. Without specialised equipment further tests such as finding shorted turns are difficult if not impossible. If you suspect shorted turns then try another armature or seek expert help as testing for these problems requires specialised test equipment.

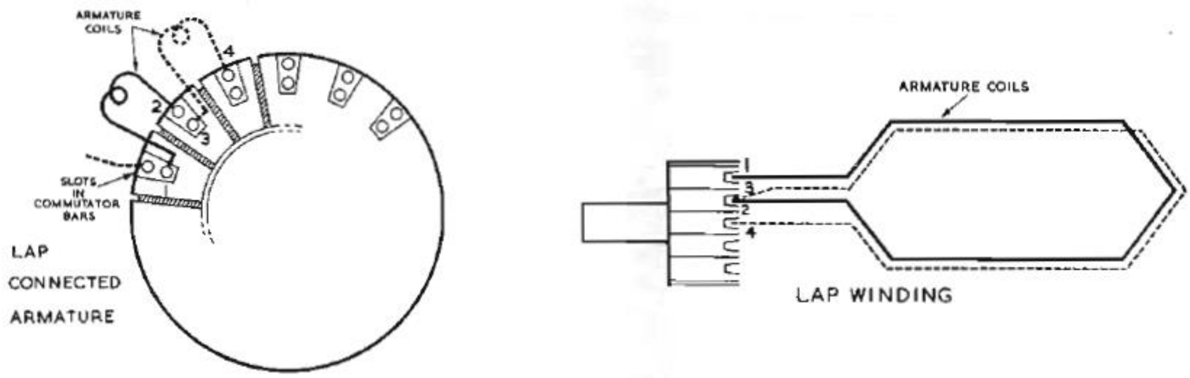


Fig 5

Reassembly

Firstly, slide the armature assembly with the pulley end plate assembly into the casing and line up the plate to the key slot.

Put a little high temperature grease (Not a lot!) into the bronze bush on the brush end plate and also re pack the screw in lubricating wick underneath the bearing with the same grease and replace. Fit the new brushes the correct way round to match the commutators shape and lightly tighten the brush retaining screws. Ensure the field terminal and output terminal wires are out of the way and start to feed the brush end plate onto the armature shaft. You will need to use a thin bladed screwdriver to lift the brushes over the end of the commutator and on to the copper segments through the three windows on the case. Do this one at a time and it will all slide together. Rotate the plate to align with the key slot on the case end. Insert the long bolts (17) from the front and fit the nuts on the other end and lightly tighten. Check that the armature spins freely and then tighten up the nuts on the long bolts (17). Locate and connect the internal wiring to the relevant field brush and D+ output brush and then tighten the screws to retain them in place but DO NOT OVERTIGHTEN THEM or you may crush or break the carbon brushes. Ensure there are some locking star washers under the screw heads as well. If you have removed the field resistor unit then re assemble this on the case and reconnect the field winding wire and D+ output wire to the relevant terminals.

Fit the drive pulley on the taper and then put a drop or two of Loctite on the threads of the centre bolt before fitting it and then tighten it securely. If it comes loose the fan will eat a very expensive radiator core. Fit the fan as well with locking washers under bolt heads and a drop of Loctite on the threads.

Residual Magnetism

Iron and steel by their nature are affected by magnetism and can be magnetised. The trouble is, they are not very good at retaining its effects for long. If you magnetise the field windings by passing a DC current through them the cores will become magnetised. When you remove the DC current most of the magnetism decays quickly but just a little will remain.

This little bit is all we need for a DC dynamo to get it started each time the engine starts. Once the dynamo is turning it produces a little voltage using the small amount of residual magnetism and this feeds back into the field coils. It then produces a larger magnetic field which in turn produces more output at the D + terminal. Once running most of the current produced is available to charge the battery and light the lights etc. and a small proportion of the output is used to keep the magnetic field going. In simple terms this is how a DC generator or dynamo works.

Flashing a Dynamo.

A dynamo without any residual magnetism is just a useless lump of rotating different metals. One feature of the magnetism in the field coils other than providing the start up magnetism is to decide which polarity the dynamo will give at the D + terminal. Put in the wrong polarity magnetic field and a negative output voltage will be produced which could do a lot of damage when the cut out closes. The cut out doesn't worry which polarity voltage is put into the start coil but when it operates a negatively earthed battery with a lot of stored energy available on the positive terminal gets directly connected to a dynamo D + terminal with a negative voltage on it and with quite a few amps available –something possibly melts. Always check that the magnetic field polarity is correct after you have worked on the dynamo or if you are fitting something untested from an autojumble.

To flash a dynamo first of all check what terminal of the battery is connected to chassis. In the case of a Minor and Eight it is the negative terminal so we connect the battery negative terminal to the case. Insert the field fuse in it's holder. The positive terminal of the battery is then connected to the field fuse F1 input terminal on the resistor unit. The current should be about 3 amperes and after a few seconds disconnect the battery connection.

Checking the dynamo

Before you reinstall it on the car follow on from the above and connect the battery positive to the D+ terminal on the resistor unit and with a bit of luck the dynamo should "motor". The field winding is energised via the two resistors in the resistor / fuse unit. It will not be fast but if it motors then you can disconnect all the wires and re install it in the car. Leave off the cover band for now.

Once installed connect up the wiring and start the engine. Set the PLC switch to winter charge. Check that the ignition light goes out when the engine is running. Ensure the cut out has picked up on it's own and see what charging current there is on the ammeter. Adjust the third brush position until you get what you consider an acceptable charge rate at a speed of say 30 mph but don't ask for too much. If you overdo it you will damage the armature. Repeat the process with the headlights on and check again for a small positive charge if possible. Re adjust the third brush if necessary but don't ask too much of this dynamo. I have seen a maximum UNOFFICIAL figure of 15 amps quoted for a Morris 8 dynamo which is a similar design to the Minor. I have also seen only 10 – 11 amps in a Singer car handbook of the same era and similar 3 brush dynamo. Replace the cover band when finished. As a matter of information, due to the internal magnetic field design of the 3 brush dynamo dynamo the output rises with an increase in revolutions to a point then starts to taper off. In theory I have read that the output can go down if the revs keep on increasing so setting up for a suitable town driving speed is the best option it would appear.

Check the cut out operation

Why? Well if it does not pick up at the correct voltage and drop off correctly things could get a bit warm. One problem I found when testing the dynamo on my test rig was that with no battery or load connected the output can reach 25 to 30 volts. This circulates current through the two field resistors in series and into the field winding. The two field resistors get very warm. This could be a reason for some burned out resistor units on the dynamo. Once connected via the CF3 cut out they are not over stressed as the voltage is only around 7 volts. The CF3 cut out is like a BIG high current diode rectifier which only allows current to flow into the battery but not in reverse out into the dynamo. It needs a voltage of around 6.5 to 7.5 volts to convince it to pick up. It's best not to try to adjust it unless you are sure it is set incorrectly. Look at the diagram below Fig 6 :-

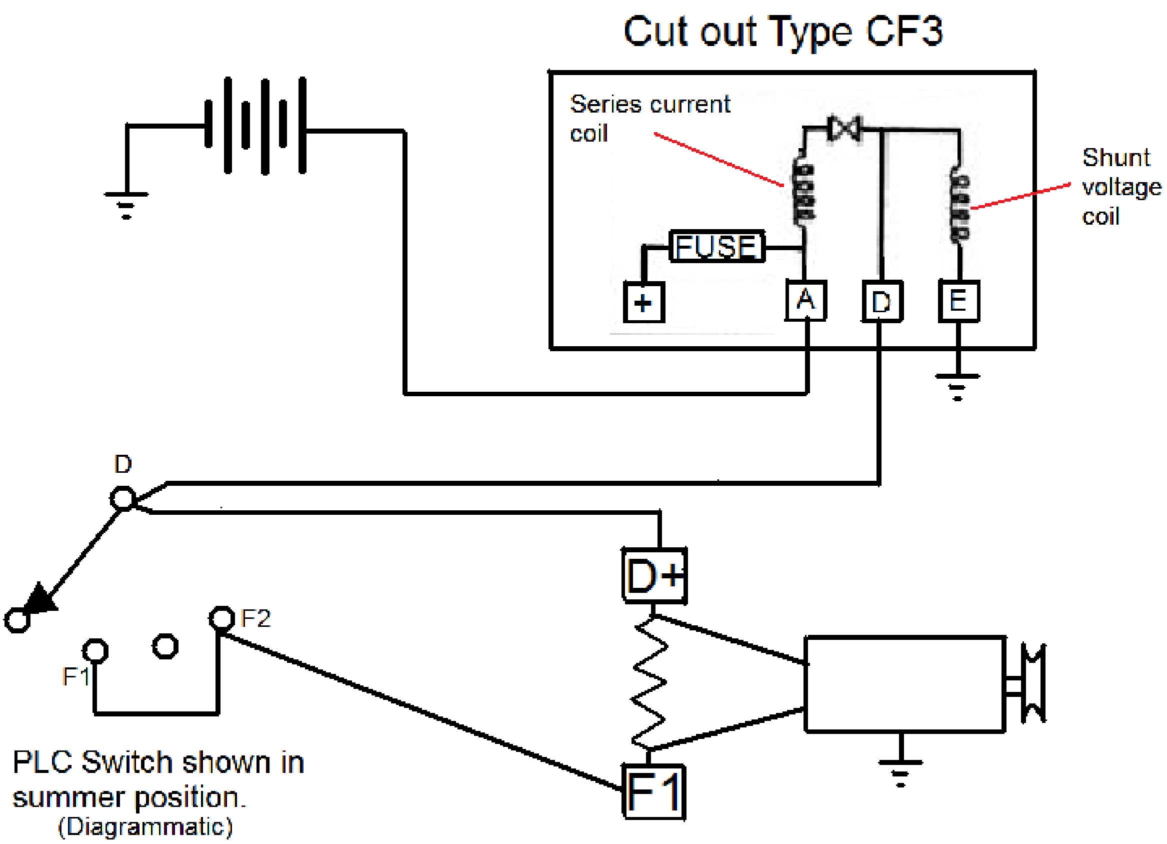


Fig 6. Charging system on the SV Minor

The dynamo output rises with speed and once more than say 6.5 volts is across the CF3 shunt “sensing “ winding this creates a sufficiently powerful magnetic field in the coil and causes the contacts to close. The battery starts charging from the dynamo output and at the same time the dashboard ignition light goes out. The current flowing passes through the series current coil which adds to the magnetic field in the coil and thus helps keep the contacts closed. The shunt sensing winding is now also energised by the battery as well so contrary to what might be thought the shunt winding does not cause the contacts to open when the dynamo output falls too low, it is actually the series current coil. As the current in the series coil reduces with falling dynamo output the magnetic field reverses (fed by the battery discharging into the dynamo) in opposition to the shunt sensing winding field and as the sum of the magnetism passes through zero the contacts open. The battery is thus disconnected from the dynamo safely. This action produces a sort of “clonk” sound from the CF3 unit.

Dynamo Lubrication

The front ball race is packed with grease and is effectively inaccessible once assembled. More modern replacement bearings can be "sealed for life" and don't need any extra grease.

The front felt seal needs a couple of drops of engine oil through the little hole under the "flip away" plate on the front plate. Do this at engine oil changes at least.

The rear plate bush is again lubricated with a couple of drops of engine oil through a flip up oiler cap on the plate. Do this at engine oil changes at least. At greater intervals remove and repack the greaser underneath as necessary.

Vehicle Power Management

When the car was built the electrical load was quite low. Remember we are using a 6 volt system.

ONE rear light / number plate light	3 watts (0.5 amps)
TWO front side lights (off when headlamps on)	3 +3 watts (0.5 + 0.5 amps)
TWO headlamp bulbs	12+12 watts (2 +2 amps)
Ignition (2 amps nominally)	12 watts (2 amps)
SU Petrolift (averaged current)	9 watts (1.5 amps)
Dash lamp	3 watts (0.5 amps)
Horn (used sparingly or as necessary)	Varies
Starting only	A LOT !

Worst case scenario when running at night 3+12+12+12+3 +9= 51 watts which equals around 8.5 amps. The dynamo can meet this load plus a little bit more to charge the battery for starting but you have to beware of leaving lights and or ignition on when stationary or parked. Continuous driving with headlights on and not charging up the battery properly will produce the obvious result. Usually the petrol pump will be the first to make you aware of this shortly followed by the engine spluttering and stopping. Keep the starting handle ready and consider using it to start the car at night to save power!

Unfortunately staying safe on the road in the modern world and all the legislation which some sceptics might say is partially designed to discourage us from using our cars encourages us to add to this electrical load.

Headlamps (minimum supposedly required by legislation) 30 + 30 watts (5+5 amps) An additional 2 +2 amps to the original load (See the current version of the Motor vehicles lighting regs. http://www.legislation.gov.uk/uksi/1989/1796/schedule/4/made)

Electric windscreen wiper motor	24 watts (4 amps)
Flashing indicators (when in operation)	30 watts (5 amps)
Extra rear light (Most people have fitted these)	3 watts (0.5 amps)
Brake lights (when in operation)	42 watts (5.3 amps)

So the worst case scenario just got worse ! If you are running at night with an electric wiper motor on add 4 amps to the 8.5 amps of the original loading plus the extra 3+3 required for headlamps = 18.5 amps. You are now probably beyond what you set as a reasonable charging rate and beyond the safe output of the dynamo. As you ask for more on the highest setting of the PLC switch it also has to consume more current in the field windings and is electrically less efficient. Also, a lot of people use 6 watt bulbs in rear lights so this adds another amp. I am definitely looking at possibly reconditioning the vacuum wiper system !

To a certain extent you can manage the power consumption by turning off what you don't need but a way forward could be LED lights. They use very little power and give a bright light although the "colour" of the white light I think is a bit monochromatic. Side lights can be replaced with them as can brake lights, and the red light produced via the rear light coloured lenses is fine but headlights - Hmm ! They appear to work well but just don't look right. Some users suggest that the difference between dip & main beam is too wide. Only time will tell and things will no doubt improve.

Sad though it may seem a study of the regulations in the link above reveals a lot of what you theoretically can and can't do. It takes a while to sift through all the If's, buts and maybe's and I would suggest that a lot of our cars may not be able to meet them realistically and in that in fact the use of LED headlights may be technically actually illegal although it appears that side and rear lights wattage is not specified. Neither is the method of providing the illumination. They just need to be "Visible". A compliant LED headlight if it were possible that actually consumes 30 watts would give out a powerful beam and would be pointless in terms of power saving! This all needs checking out by someone who has access to the necessary legislation as it appears that not even the traffic police in the UK are sure what is OK or not.

In conclusion – re battery and power management. Consider using the car sparingly after dark with the possible legally required 30 watt headlights on as you might run out of power, particularly if using an electric wiper motor. Start the car with the starting handle whenever you can. It might be difficult or not be possible to operate reliably in some countries of the EU which require you to use headlights in the daytime as well. Also, buy one of those little chargers that are described as battery maintainers. Ones with 6 volt options are available and they work well. They will top up the battery fairly quickly once you are home and keep the battery at its best including over the winter months. An alternative is to go to a 12 volts system and use a 12 volt dynamo, a modern alternator or have your dynamo converted to an alternator but this is expensive.