Notes on reconditioning a Lucas C39 'tacho' dynamo for a Mk1 'Frogeye' Sprite

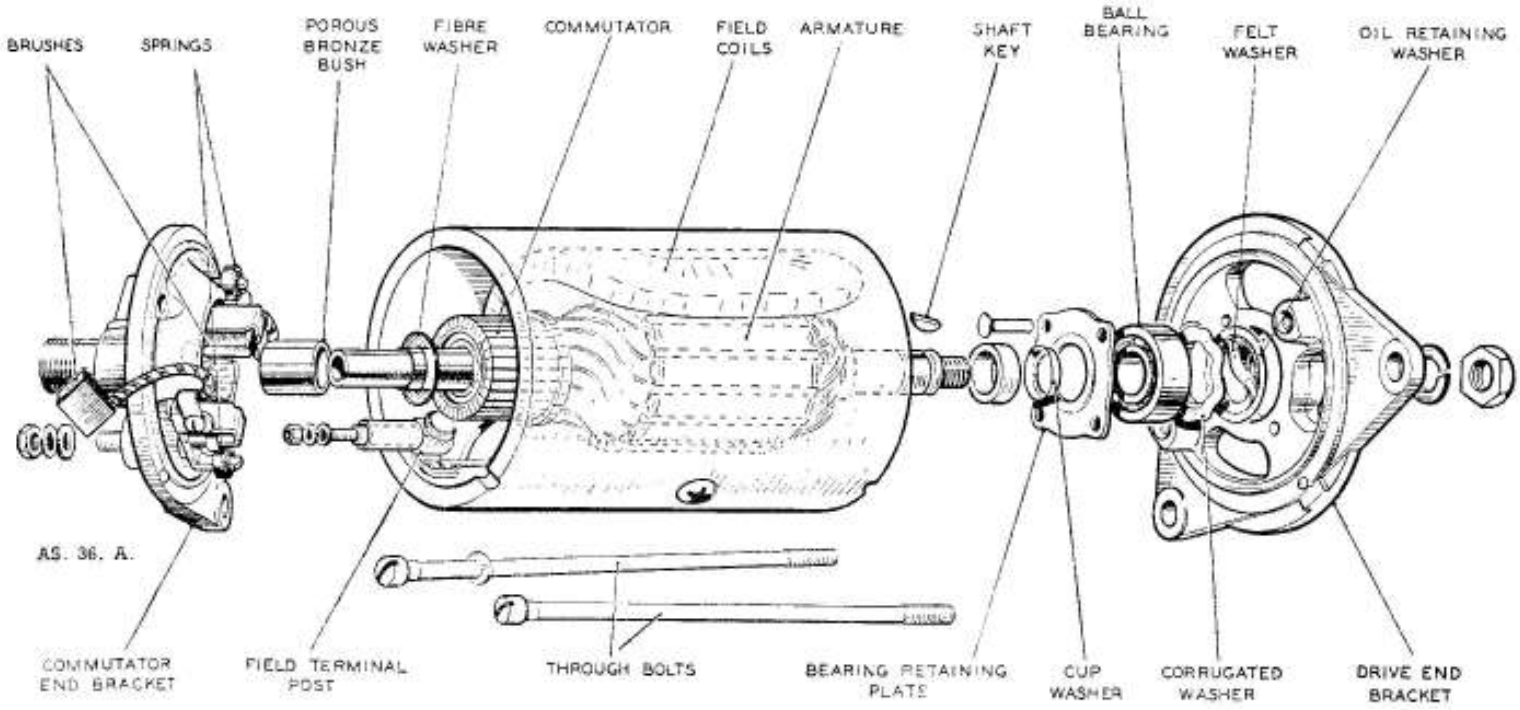


Fig. M.2. The generator exploded.

These step-by-step notes will refer to the parts labelled in this diagram (a tachometer-drive C39 dynamo): they are designed to complement the instructions in the Workshop Manual and in Grahame Bristow's book 'Restoring Sprites & Midgets, an enthusiast's guide' (Brooklands Books Ltd 2002).

This is the dynamo featured in the production of these notes. Purchased from ebay, this was the only image provided by the vendor. It is an early C39 windowed-yoke dynamo removed from a 1953 MG TD when the vehicle was converted (or rather, *vandalized*) to negative earth and alternator. Save for the pulley, this same dynamo was fitted to all Mk1 (Frogeye) Sprites – a fact confirmed by the number '227773' on the commutator end bracket.

If the pully and fan are present (they were absent on the ebay dynamo), use Bristow's 'sisal trick' to remove the large pulley retaining nut. Any attempt to stop the pulley spinning by wedging levers or screwdrivers under either fan or pulley will likely cause irrevocable damage. Don't hammer on the end of the shaft either, the thread can be damaged very easily. Note that the pulley fitted to early Sprites and Midgets (92mm rim-to-rim diameter) is now a rare and expensive item (ca £40-£50 from the usual suppliers).

Once the nut is removed, the pulley and fan should pull straight off. ***Don't*** try to prise the pulley off with a screwdriver. A bearing puller can help, using one's fingers (not a socket wrench!) to turn the screw.

The shaft or 'woodruff' key, can be removed by first hitting ***down*** at one end with a suitable punch ....

... and then hitting ***up*** at the other end with the same punch. This is a tiny part, easily lost, so store it away safely with the pulley nut, its spring washer and the spacing collar which can now be slipped off the shaft. An old Vegemite jar makes an ideal storage container but any old box or jar will do.

After removing the two through-bolts, the dynamo can be separated into its three major pieces: the barrel ('yoke') and field coils, the commutator end bracket with its brushes and the drive plate with its armature still firmly attached. Don't lose the fibre washer - instead, add it immediately to your Vegemite jar. A glance into the yoke of the more than 60-year old ebay dynamo presented a grisly sight – the taped wrappings of the field coils were dirty, oil-soaked, frayed and decayed. Almost certainly, they had never been touched since the date of manufacture stamped on the yoke: January 1953. We begin restoration with these field coils ...

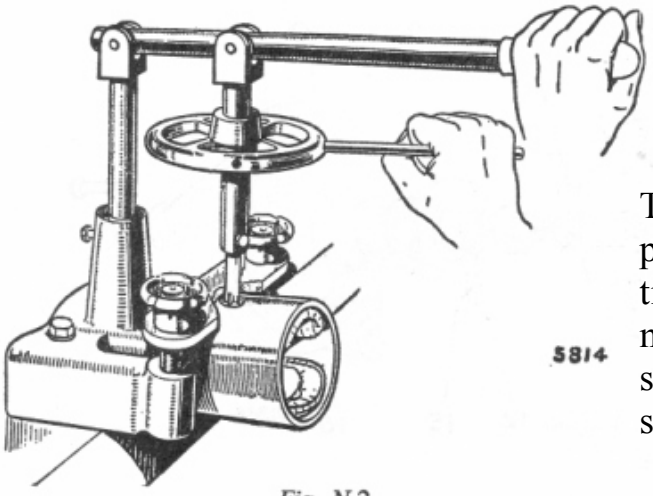
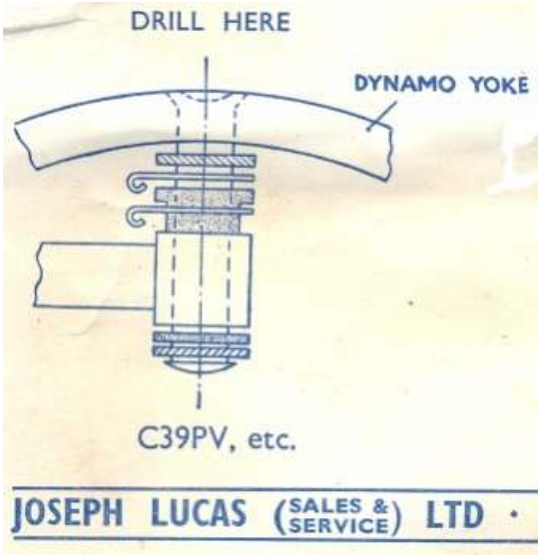


Fig. N.2
Using a wheel-operated screwdriver to remove the pole-shoe screws

The two screws securing the pole shoes and field coils present the first real challenge: these are always very tight, apparently frozen into the yoke. The workshop manual recommends using a 'wheel operated screwdriver' but this is not very helpful: have you ever seen one? I haven't.

Instead, I recommend a big hammer, an impact wrench and my late engineer friend George Long's favourite battlecry "If in doubt, give it a clout - then, if it doesn't move, knock 's**t' out it". Some people worry that this treatment may distort the yoke but fear not: these yokes are massively strong, "formed" over a cylindrical plug in a 200-ton power press which bent each blank as if it was tin-plate. Nine or ten decent clouts by an Australian like me should suffice, but a mere Englishman may need to give 50 blows or even more. Alternatively, with care the screws can be drilled out – but note, new screws are rare and expensive.

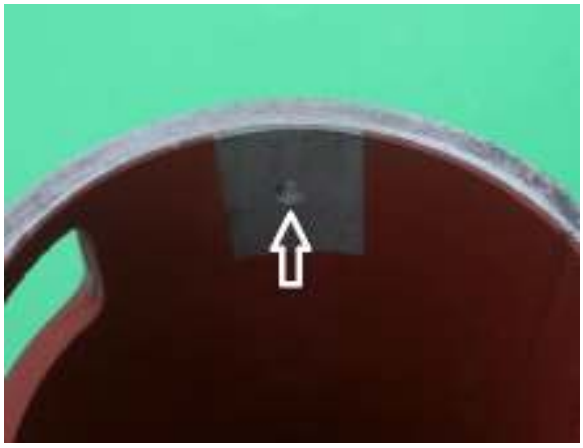


With the pole shoes still loosely screwed to the yoke, drill out the rivet which secures the field coil terminal post assembly to the yoke. The pole shoes with their field coils can now be removed from the yoke.

Initially, the field coils were a rather sorry sight. Do not lose the little black cylindrical insulator on the terminal post (arrowed, white), add it to the Vegemite jar. When unsoldering the wires, try not to shorten the ones (arrowed, yellow) joining the field coils together: these must be rejoined later. I heat this connection in a small flame and unwind the wires with a pair of pointy pliers.

When what was left of the old taped wrappings was removed carefully, the field coils of the ebay dynamo were seen to be in excellent condition. This was not a surprise, it's what usually happens: at manufacture, before these coils were taped at the Lucas factory, they were dipped in high-melting point wax. This wax has preserved the coils so perfectly that ...

... after re-taping with proper Egyptian cotton field coil tape (still available via ebay and other suppliers), they are as good as new, fit for another 60 years of service. With care, old field coil terminal posts can be re-used - but a new one was available for this job.



With field coils and pole shoes *out*, this is the moment to clean and re-paint the yoke. I use a blast cabinet to produce a surface perfect for new paint. Use masking tape to leave bare metal on the rim of the yoke which must make good electrical contact with the commutator end bracket. Similarly, leave bare metal around the hole (arrowed) which is used to secure the field coil post: this post ***must*** make good electrical contact with the yoke. A beautifully painted dynamo that doesn't work is useless unless you plan to hang it in The Tate. Actually, this isn't such a mad idea: a Lucas dynamo is a real work of art and could win the Turner prize!

Before attempting to re-fasten the pole shoes and field coils to the yoke, be sure to add the insulating card (blue in this photo) which prevents the (now re-soldered) connection between the two field coils from touching the through-bolt on that side. Once the pole shoe screws are tightened, this card is held (squashed) firmly in place by the coils. No card is needed for the other through-bolt because no short circuit is possible on that side.

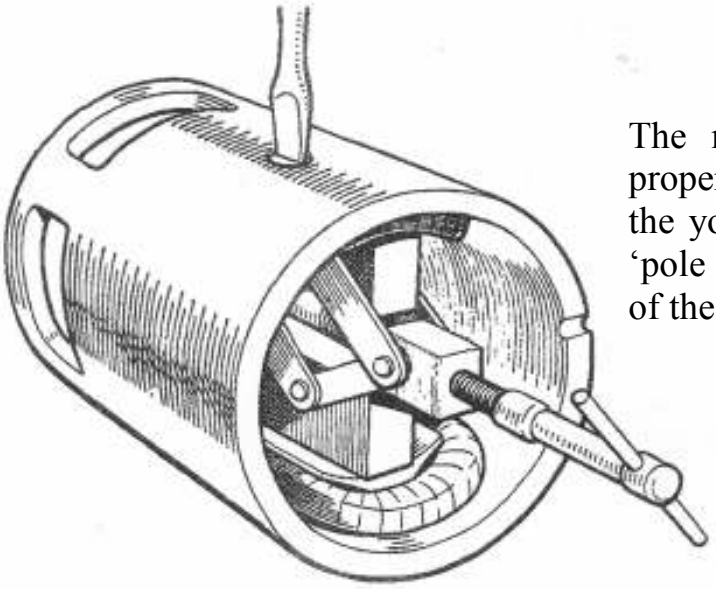


Fig. N.6.
An expander in use for fitting pole shoes.

The next challenge is to tighten the pole screws properly while the pole shoes are pressed hard against the yoke. The workshop manual recommends a fancy 'pole shoe expander' tool - but who has ever seen one of these gadgets? Not me!

Instead, I use two 100mm '*Record*' G-clamps. One will probably suffice, the force required is really not very great. Our job may be easier than that faced by the factory because the coils were ***flat*** when they were first made. After more than 60 years in position, these old field coils are the right shape. The workshop manual states that the pole shoes should be returned to their original positions but I have never bothered to do this: the shoes were 'coined' in a 1000 ton press and finished to an accuracy of two thousandths of an inch! I do use a dab of '*BONDLOC'* high-strength retainer B638 on the screws and a large strong screwdriver which fits the screws perfectly, the type that can be turned by a spanner attached to its handle. Result? Both field coils very firmly and properly attached.

The original Lucas service pack for the field post terminal includes a special rivet (arrowed yellow) for attaching the post to the yoke – but these rivets cannot be clinched without the right tool (see later). If you lack the tool and rivet, a simple brass nut and screw with some spring washers (arrowed white) can be used instead, making sure that the brass screw is a tight sliding fit in the yoke and terminal post.

This brass nut and screw do protrude into the yoke a little more than the original rivet, but there's still plenty of space once the screw has been trimmed to size: there's no danger of this hitting the commutator. A little solder can be added to the nut but I doubt this is necessary. Note that the black wire from the coil on the right in this photo is always earthed to the yoke, the red wire from the coil on the left is always attached to the field coil post. These wires may be coloured differently on different dynamos.

The dies for clinching the rivets properly are small but expensive. The hand-operated aircraft-grade tool which will accept them is VERY expensive but (happily) not necessary for our job. Instead, I made two new jaws for my vice, extended at one end with two sets of holes which allow the dies to be placed either at the extended end of the jaws (for the terminal post rivet) or in the middle of the jaws (for the drive bracket rivets).

Here a terminal post rivet is being clinched between the special extended jaws of my vice. Early fears that the vice might not be strong enough or that the new jaws would bend were all unfounded: the rivets are aluminium and the vice is easily powerful enough. In fact, care is needed here to avoid over-squashing the rivet.

The result is a very firmly attached terminal post which cannot be wiggled from side-to-side. This is vital for establishing good electrical connection between the earth wire of the field coils and the yoke of the dynamo: **the dynamo will not work properly if this post is loose.**

To allow the thin metal band cover (which covers the windows of the yoke) to rotate smoothly, the head of the brass screw (if used instead of the proper rivet) can be filed back a little, flat with the outer surface of the yoke. Now check the field coils by measuring their resistance: this should be in the range 6.0 – 6.3 ohms. Alternatively, connect a 12V battery with an ammeter in series between the field terminal and the dynamo yoke: the reading should be approximately 2 amps. If all is well, this completes the restoration of the yoke and field coils. Otherwise, new field coils may be required. The coils of the ebay dynamo passed their checks with 1st class honours.

After removing the brushes from the commutator end bracket, cleaning the bracket and storing the brush springs away safely, the old phosphor bronze bush must be removed. I first stop the tachometer gear box hole with a plug made from the brass nut of an old tacho gearbox, then screw a M16x2.0 (5/8 in.) tap into the bush, then wind the bush out of the bracket (the tap pushing against the plug below). In this photo, the bush (arrowed) is partially withdrawn. Bristow recommends breaking the bush up *in situ* – but this might damage the bracket (now a very rare and rather expensive item).

Before fitting the new bush it must be soaked for at least 24 hours in thin (S.A.E. 20) engine oil: this allows the pores of the bush to be filled with lubricant. I keep a supply of these bushes soaking much longer in – you've guessed it – another Vegemite jar. This one has probably soaked for months.

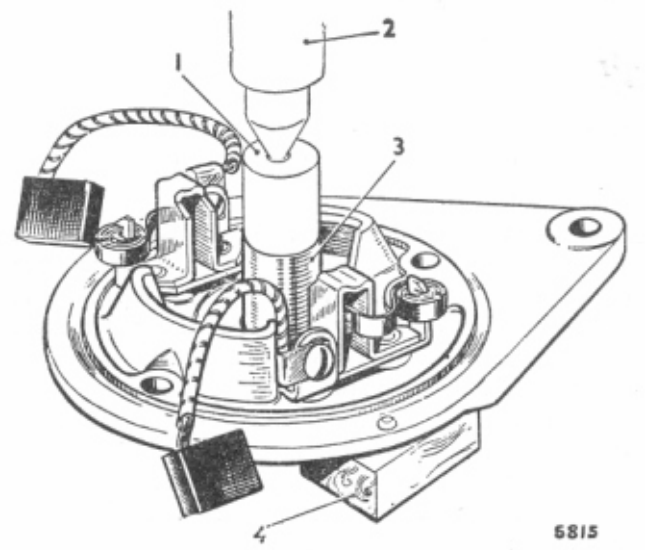


Fig. N.3

The method of pressing in the commutator end bracket bush

1. Shouldered mandrel.
2. Hand press.
3. Bearing bush.
4. Support block.

The workshop manual recommends pressing the new bronze bush into the end bracket with a 'shouldered, highly polished mandrel ... until the visible end of the bearing is flush with the inner face of the bracket'.

It is possible to use a suitably sized socket as a drift but this risks damaging the fragile bush. A friend kindly made me a suitable 'mandrel' with his lathe – and this does make the job much easier. I do not possess a hand bearing press but ...

... the standard jaws of my trusty vice serve just fine, providing everything is quite square before the push begins. Do not even *think* of trying to bang this fragile bush home with a hammer: a slow steady controlled push is required.

I drill a small hole in the bronze bush after it has been pushed into the bracket, to allow lubricant from the brass lubricator to reach more easily the inner surface of the bush and the rotating shaft. Original dynamos may not have possessed this hole and the Lucas Company recommended grease (not oil) in the lubricator, something that may explain the short life of many bushes. For more discussion, see MASCOT June 2015, pages 12-14. Do not install the commutator brushes yet, it's best to leave this job until after the armature has received its new ball bearing.

The next big challenge is to remove the drive end bracket from the shaft of the armature to allow the old ball bearing to be replaced. This bearing is a tight (often *very* tight) press fit on the shaft. A three legged puller, each leg attached to the rim of the drive bracket, is *not* a good idea: this risks either breaking the bracket or pulling the rivets out of the bearing retaining plate, mangling the retaining plate and leaving part or all of the ball bearing still firmly attached to the shaft of the armature.

Instead, a 'harmonic balance puller' with two big washers under the head of the two bolts is a much better tool for the job: I have had no more accidents since I switched to this method. Some later (C40) style end brackets have a triangular retaining plate and only three rivets, in which case *three* bolts and washers can be used with the same puller. A good dose of penetrating fluid is recommended - it cannot fail to assist matters. The end bracket of the ebay dynamo pulled off a little too easily, indicating a worn shaft. This problem will be addressed later.

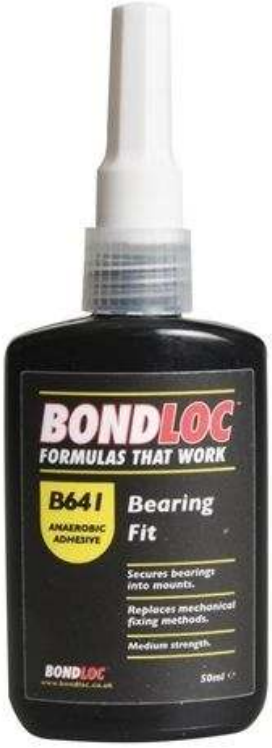
If the little cup washer is loose, be sure not to lose it, add it to the Vegemite jar. This one on the ebay dynamo's armature shaft was tight so it was left in place. It's a fragile thing, easily bent and buckled if one tries to force it off.

After drilling out the four rivets which secure the ball bearing to the end bracket, the old ball bearing can be pressed out. New rivets from after-market service packs may have a slightly larger diameter than the originals, so the holes in the bracket and retaining plate may have to be enlarged by drilling. The ball bearing is readily available: Challenge 6202-2RS-C3 or (better) Koyo 6202ZZCM FGSR. The felt washer should be greased lightly before installation.

The outer ball bearing journal is a light push-fit in the bearing housing. If the after-market rivets are just a little too long (very common), a spacing washer under each one allows a neater job. I clinch the rivets with my special vice (described above, p7) - but with care the rivets can be hammered home. There is no real load on this plate, it just retains the bearing, prevents it from slipping out of the bracket. Contrary to the exploded diagram, the rivets should be clinched on the retaining plate side (the plate being stronger than the cast bracket). Also note: those parts of the bracket which secure the dynamo to the car should be left unpainted – this helps to ensure that the dynamo will have a good earth connection when installed in the car. For economy, many restorers leave both end brackets unpainted, it's your choice. The factory ***did*** paint them – but only after the dynamo had been attached to the engine (and so properly earthed), a process which often left the engine block side of the dynamo's yoke unpainted, subject to excessive rust.

Proper testing of the armature requires a 'growler', a serious bit of kit, not for the faint-hearted, guaranteed to wake the neighbours if it is used late at night. Here's a YouTube video which shows one in action ...
https://www.youtube.com/watch?v=t8PnIbdkQcc
Without access to a growler, there are still some useful checks that can be performed with a simple meter ...
https://www.youtube.com/watch?v=qNV7TylIzSY
If the armature fails these tests and/or shows any sign of damage (pits or burnt spots on the commutator, burnt armature wires *etc*) it must be replaced. This company will rewind your armature ...
http://www.robsonandfrancisrewinds.co.uk/
... but be warned, it's an expensive process. Happily, the ebay armature passed its MoT.

The one remaining challenge is to press the new ball bearing (now in the drive plate) back onto the shaft of the armature. Neither the Workshop manual nor Bristow is much help here because their instructions suddenly become uncharacteristically vague. Before attempting this job one should understand what must be done: ideally, the bearing needs to be positioned on the shaft with accuracy less than the thickness of the fibre washer. Pressing the bearing *down* is relatively easy but it must not be pressed down too much, otherwise the woodruff key will not hold the fan in place. Also, to prevent damage to the bearing, it should be pressed on its inner journal only. Finally, if one does press the bearing too far down, pulling it up again (on the *outer* journal, with the harmonic balance puller) may damage the bearing. Unless one is a bit careful this can all go horribly wrong.



To ensure a tight fit on the ebay dynamo's worn shaft, a smear of 'BONDLOC' bearing adhesive was applied to the shaft before the bearing was pressed (or rather *slid*) onto the shaft. This miracle of chemistry can secure all types of bearings, shafts and cylindrical parts: it cures when confined between the parts, allows disassembly in the future and has an excellent operating temperature range (-55degC - +150degC).

In this photo I am about to tap the bearing down onto the shaft with a suitable drift. My friend with the lathe made me the tool, perfect for the job, but a suitably sized socket would serve. Whatever the tool, it must fit through the hole in the drive bracket and mate with the inner journal of the bearing. The yoke, commutator plate (without brushes), fibre washer and armature were all in place here, before the tapping began. Don't forget the fibre washer. The aim is to tap the bearing down and achieve a perfect fit, first time.

Here the bearing has been tapped down the armature shaft until the rim of the drive plate just meets the yoke, making sure that the locating dowel in the plate (arrowed) mates with the locating slot in the yoke. Now check the fit by installing the two through bolts, tightening them down properly and making sure that the armature can spin freely. If the fibre washer has been squashed between the commutator end bracket and the commutator, the armature will *not* spin freely and the bearing must be pushed down the shaft a tad more. This can be accomplished by removing the through bolts, adding a *temporary* ½ thickness fibre washer to the original fibre washer and tapping down again. Alternatively, try a thinner fibre washer. This trial fitting (shimming) process is much easier if the brushes are not in place on the commutator bracket. Some patience and a cup of tea may be required here.

Once the armature is spinning freely, with the through bolts tightened and no detectable end-float on the shaft, the dynamo is almost ready for final assembly. A last job is to add the little cylindrical black insulator (arrowed) to the field post. This small but vital piece ensures that the field post is electrically insulated from the yoke. If it is missing or in poor condition, a winding of black insulating tape will serve just as well. The fibre washer is absent in this photograph. The commutator should be cleaned and checked following the instructions given in the workshop manual.

Now – at last - the commutator brushes can be installed. They are spring loaded and must be held carefully away from the commutator when the bracket is slid onto the armature's shaft. This can be accomplished with a screwdriver but I use two pieces of string (blue in this photograph). Make sure that the wires connected to the brushes do not become trapped between bracket and yoke. Also, make sure that each wire is secured firmly to its brush box with a screw *and a star washer*.

Sadly, the piece which should link the 'D' and 'F' terminals (arrowed yellow) was missing from the ebay dynamo. However, I was able to replace it with a new one, acquired with luck at an auto-jumble. Some think that this piece stops the black insulator falling off the 'F' post but I believe it is designed to protect the rather fragile lower part of the 'D' terminal (arrowed white) from being snapped off by a ham-fisted mechanic over-tightening the 'D' terminal's nut.

Because the circular 'F' post is firmly attached to the yoke, the special 'link' piece stops the square sectioned 'D' post from twisting and snapping off. Even so, take care not to over-tighten the terminal nuts and be sure to use a star washer with each one. The 'D' post terminal is the Achilles heel of the C39 dynamo: a really strong-armed but weak-minded person can break both post and link piece. If your link piece is missing, do not panic: just use a second spanner to hold the square post firm while the terminal nut is tightened.

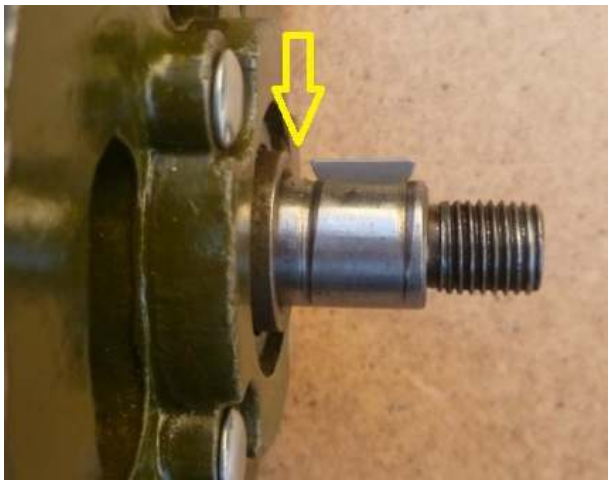
Further evidence that the 'link piece' protects the 'D' terminal post is provided by subsequent factory modifications. Here the square 'D' post of a later, standard (non-tacho) C39 dynamo is not tied to the 'F' post at all but rather to the rivet of its brush box. An improvement definitely - but this post is still a weak point. This problem was finally solved with the C40 dynamo and the switch to Lucar connectors.

Originally, fan and pulley were both supplied by BMC (not Lucas) and never had stamped part numbers. The pulleys are sometimes stamped 'MOWOG' (**MO**rris**WO**lsleym**G**). Aftermarket pulleys (some with intregral fan) are perfectly satisfactory but the rim-to-rim diameter must be 92mm for correct tachometer readings.

This NOS fan is correct for Mk1 Sprite - it was properly identified only because the part number (AEC_82) was printed on the BMC box.

Now painted MOWOG green and ready for installation, this fan (left) is here compared with the larger fan fitted to C40 type dynamos. Because these two fans are interchangeable, things have become somewhat mixed up over the years, probably because some dynamo restoration shops were, shall we say, somewhat chaotic. Lucas put many of these firms out of business with their 'B90' exchange dynamos which were always excellent value, often effectively brand new except for the yoke.

An excellent alternative is the Rootes P103911 combined pulley/fan for a Sunbeam Hillman: I suspect this is very much more the sort of thing the Lucas company imagined when they designed the dynamo shaft and woodruff key. Made of alloy, this pulley has the correct diameter for a Mk1 Sprite (92mm rim-to-rim) The problem with the original separate fan and pulley arrangement is that ...



... despite one's best efforts, the gap (arrowed) between the spacing collar and the shaft (woodruff) key is often too large to allow the little cutout in the fan to engage with the key. Taller spacing collars are included in dynamo service packs from some suppliers but alternatively ...

... a simple spacing washer can close the gap. When adding the fan and pulley, be careful not to over-tighten the pulley nut because this can draw the shaft up through the ball bearing, further increasing the gap between the spacing collar and the woodruff key. When operating, the dynamo turns so that the nut is naturally tightened onto its spring washer, not loosened, so there is not much danger of the nut ever coming adrift in service.

Fully assembled with new terminal nuts and with the cylindrical brass lubricator polished until it gleams, the ebay dynamo is now restored, ready to face the most fastidious pin stripe suited concours judge.

This pulley end view is good too, although there is a slight imperfection in the flexible metal band cover. But note: this is not a ‘dent’ – it is a *battle scar*, to be displayed with pride, the one indication that this thing is not brand new. In fact it is 63 years old, almost ‘on the nought’ in binary arithmetic. Looked after, it can run for another 63 years – and may well do so because these dynamos are, at last, after years of neglect, beginning to receive the sort of care and attention they deserve.

Finally, the dynamo should be tested by running it as an electric motor for 20 minutes, to bed in the brushes, just as the factory did when it was first made. To do this, connect the ‘D’ and ‘F’ terminals together, then connect the positive terminal of a 12V car battery to the yoke, the negative terminal to the ‘D’ (or ‘F’) terminal (or vice versa if you wish to polarise the dynamo for a negatively earthed car). The motor should run smoothly, with hardly any vibration and very little noise. One final warning: **do not** try this if the dynamo is on the car (a dynamo is not a starter motor!)

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