REWINDING TRIX ARMATURES

Euan MacKenzie

If a job is worth doing, then it's worth doing well (Anon)

Re-winding an AC armature is not particularly difficult; however it does require patience - something not easily purchased in a shop! The process can conveniently be divided into four stages:-

1. Removal of the old windings and the commutator
2. Repairing, or better replacing, the insulation
3. Winding the 3 coils, each with ~230 turns of 38 SWG wire
4. Reassembly

Once experience has been gained, one can complete a rewind in a total time of about four and a half hours; however there are many steps in the operation, where it must be left for the Super Glue to harden off.

► Stage 1: removal of old windings and commutator

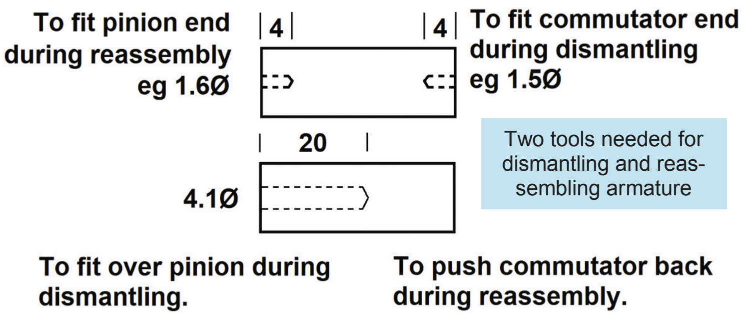
The first step is to unsolder the connections to the commutator; use **desoldering wick** to remove **all** the old solder from the slots in the middle of the commutator segments. If necessary, use a jeweller's saw to clean the slots; thus leaving them clean for re-soldering the ends of the new windings later. Next cut the thread binding the three pairs of wires on the inner shoulder of the commutator. Now remove the old windings; you will observe that the turns come off anti-clockwise; because all TTR armatures were wound clockwise, as seen from above the pole. Those of you who are dedicated 'rivet counters' might wish to count the number of turns. However it is more important to make a careful note (preferably written or better still drawn) of how and where the windings start and finish, as well as how they are connected together. Remember the old adage; a diagram is worth a thousand words.

Having removed the old windings, the next step is to dismantle the armature. Unfortunately, this is essential, because it is impossible to re-wind the three coils with the commutator in place. To remove the commutator we need to make a pair of simple tools or jigs to assist in the removal and at the same time protect the ends of the armature shaft from being damaged in the process. Clearly the exact internal diameter of these will depend on the diameters of the ends of the armature shaft; both of which have changed over the years, the commutator end more so. All the dimensions that I have encountered are listed in the table below:-

Table 1 The various sizes of armature shafts

Mark No.	Pinion End mm (inch)	Commutator End mm (inch)	General Remarks
1	1.68 (0.066)	1.98 (0.078)	Early thin wall chassis, eg SR EMU
2	1.68 (0.066)	1.49 (0.0588)	Late pre-war, 'triangular' shaped Bakelite comm. 4-6-2
3	1.68 (0.066)	1.44 (0.0568	Early post war 'circular' shaped Bakelite comm. 0-4-0 & 4-6-2
4	1.58 (0.0624)	1.38 (0.0545)	Late post war, 'circular' Bakelite comm. 0-4-0
5	1.59 (0.0625)	1.38 (0.0545	Fibre commutator, 0-4-0

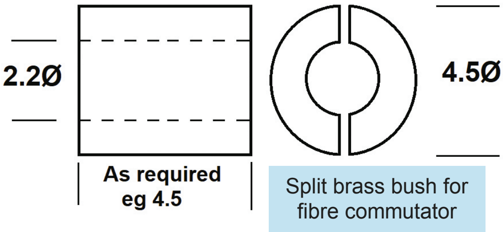
Allowing for normal running clearances and manufacturing tolerances, it would appear that initially the pinion bearing was 1.7 mm, and then it was changed to 1.6 mm. The commutator bearing was initially 2 mm, then 1.5 mm and finally 1.4 mm. The remarks section is only intended as a general guide and is not meant to be exclusive; you may, for example, encounter an armature with Mk 3 shaft dimensions and a fibre commutator in a Pacific. Perhaps the Northampton and Nürnberg factories used different dimensions on their production lines. In any event it will clearly be necessary to check the armature in question. The Mk 1 armature has no step down on the commutator shaft; from experience the 2mm shaft seems to be thick enough not to need protection; however the stepped down smaller diameters on the commutator end of the shaft definitely do need protection, otherwise they will be irretrievably bent when pressing the commutator off!



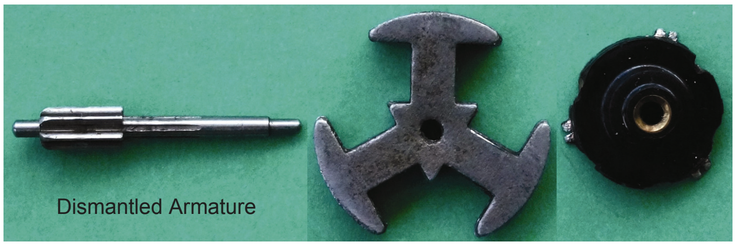
Two tools needed for dismantling and reassembling armature

Obviously it helps if you have access to a lathe, or know someone who has a lathe and is prepared to drill them for you (a trivial task). The external diameter, length and type of material used in the tools are not critical; although avoid using material with too small a diameter, as it makes it more difficult to keep the tools absolutely 'square' when performing the pressing operation in a vice. I used 3/8" diameter silver steel (unhardened), simply because that was the largest size that the chuck in the tailstock could accommodate. Brass would be quite satisfactory and is easier to drill, unless you were envisaging doing a large number of re-winds.

These tools are adequate for the Bakelite commutators used before or immediately after the war. The pre-war one is readily identifiable by its somewhat 'triangular' outline, after the war the outline was changed to completely circular. Both versions have the three copper segments cast in the Bakelite. However later armatures used a 'fibre' commutator, which has three **external** copper segments, which are **clamped** onto a fibre disc. All fibre commutators (as well as some of the later circular Bakelite ones) used a synthetic resin bonded paper (SRBP) ring, which had the three pairs of wires fed inside it, in order to prevent the wires from being rubbed by the flanges of the wheels. The fibre disc is located on the armature shaft by a short brass bush; unfortunately the TTR fibre disc is very prone to working loose on this small brass bush, and consequently severing the wires. It is best secured with a fillet of 24 hour Araldite placed on each side of the bush/fibre junction (but not on the shaft!). Check that the disc is square to the shaft and also in the correct orientation, relative to the poles, before putting it aside to cure. Fortunately, TRIX EXPRESS used an SRBF commutator and a slightly larger brass bush; so it does not suffer from this problem. In order to remove these fibre/SRBF commutators from the shaft without damaging them, we need to make an additional tool, in the form of a brass spacer; which is then cut in half with a small hacksaw, eg a Junior Eclipse. The two halves are then inserted between the laminations and the bush; their function is to transmit the thrust from the laminations to the brass bush during the pressing operation. If difficulty is experienced in keeping them in position, use a small amount of Blue Tack.



Before you press the commutator off the shaft, note that the gaps in the commutator are aligned with the centre of the laminated poles, (However: if you are rewinding a Märklin armature instead, the gaps are aligned 5º left of the pole centres; also the wire is wound anti-clockwise, when viewed from above the pole). Pressing the commutator off the shaft is accomplished by slipping the pinion tool over the pinion, so that it bears against the laminations and placing the commutator tool on the step down at the commutator end of the shaft in order to protect it. When they are carefully pressed together, the pinion tool pushes the laminations and commutator along the shaft, towards the stepped down end. This operation is best performed using a lathe; the pinion tool being gripped in a collet in the headstock and the commutator tool in a drill chuck mounted in the tailstock. The advantages of a lathe are that the alignment is automatic and that any excess force merely makes the pinion tool slide into the collet. The operation can be performed with **care**, using a good quality vice, ie **definitely not** a worn one with sloppy jaws. **Particular care** must be taken to align the two tools **accurately** (this is where the larger tool diameter helps) and that **excessive force** is not used; lack of care in either will result in a bent shaft. The good news is that the shaft can be straightened at this stage - if you have a lathe!


Dismantled Armature

► Stage 2: repairing or replacing the insulation

Clean the shaft and check that it runs true, (this could be done with an electric drill, on slow speed, if you do not have access to a lathe). The insulation on the laminated poles should now be checked. Usually the two face pieces are in a satisfactory condition but the three side pieces are either in poor condition, or on earlier versions completely absent; in the latter case a coat of paint (usually red but sometimes yellow, or black and white) had to suffice. As the laminated poles will be **handled extensively** during the actual re-winding, it is **essential** that all the insulation be **well secured** to the laminations using Super Glue. Unless the original insulation is in pristine condition, I strongly recommend that it is **replaced**. If it is neither replaced, nor well secured, then by the time you have finished winding, it will look decidedly ‘dog-eared’ or dilapidated. (Hence the quotation at the beginning of the article).

The ubiquitous manilla folder is a convenient source of suitable insulation of the correct thickness and Super Glue is an eminently suitable adhesive. For safety reasons always ensure that a bottle of Acetone is within easy reach, just in case the fingers become stuck together or to the pole pieces! It is not necessary to fastidiously cut out the manilla to the exact shape of the laminations (do you remember cutting out Micromodel locomotives out of card using a small pair of scissors during the war?). Cut a piece 25mm square from the manilla folder and liberally coat it with Super Glue (because we want to **impregnate** the manilla) and firmly press the stack of laminations face down onto it. When it has set, liberally coat the **outside** of the manilla and leave it to harden; then it can be trimmed to shape. A scalpel is much better, and considerably cheaper, than a trimming knife, but do remember what the scalpel was originally intended for! Pass a 2.05 mm Ø drill through the existing hole in the laminations and thus drill through the hardened manilla on the far side; then insert the shaft so that the pinion is pressed firmly against the insulated face of the laminations. If the laminations were loose on the shaft, due to rust for example, clean off and reassemble with Loctite 222, (which can be dismantled using normal tools). Check that the laminations are ‘square’ on the shaft and leave 24 hours for the Loctite to set. When the Loctite has set, apply a piece of manilla to the other face in the same manner, coat it and leave to set. Note: a small number of the later TRIX EXPRESS armatures used a 3mm Ø shaft to secure the lamination stack; however the remainder of the shaft was 2mm Ø.

The three side pieces are fiddlier; simply because they have five folds within a comparatively short distance. Since paper, or card, folds much better along the grain than across it, we need to ascertain which way the grain runs on the manilla folder. Mark out an exact square, say 3 cm by 3 cm, and draw a pencil line (for reference) right through it extending into the rest of the folder, then cut the square out. The purpose of the reference line is simply to establish the original orientation of the square once it has been cut out. Moisten **one** surface of the square evenly with water, within a few seconds it will curl around the direction of the grain, forming an arc of a cylinder; the longitudinal axis of the cylinder is the direction of the grain. Cut a strip of manilla 5 mm wide by 75 mm long, such that the grain runs across it (ie parallel to the 5 mm side) then divide it into three 25 mm pieces. Taking one of them, fold half of it into the shape of the side of **one** pole (ie making only two folds) and Super Glue it in place. A ‘non stick’ PTFE (Teflon) wedge, tapering from 5 to 6 mm wide is useful in persuading the manilla to stay in place while the Super Glue sets. When it is sufficiently dry, treat the other half of the manilla strip similarly on the adjacent pole; experience has shown that it is impracticable to try to cement both sides of adjacent poles at the same time. Using the second and third 25 mm pieces cover the other two sides in the same manner, then liberally coat the manilla surfaces all over with Super Glue and leave it to set. When it has set hard trim off any excess manilla with the scalpel, then file carefully to shape and round off the corners with a flat no.2 Swiss file; then coat yet again with Super Glue. In effect we are making our own synthetic resin bonded paper, molded *in situ*, by completely impregnating the manilla with SuperGlue.

► Stage 3: the actual re-winding

This is the part that requires both patience and good close up vision. If like me you got your first TTR set before the war then you will definitely need assistance with close up vision. I use 7 Dioptre OptiVISORS which give a binocular, magnified image at normal reading distance (25 cm). (Opticians specify the ‘power’ of a lens in Dioptres; it is simply the reciprocal of the focal length in metres.) OptiVISORS are relatively inexpensive and have a good field of vision. However they can be both cumbersome, because of their bulk, and uncomfortable to wear (especially during hot weather) for long periods. Binocular loupes, as worn by dentists for example, are a better alternative; they are more expensive but they are lighter and less bulky to wear. They also have less distortion due to the lenses (technically known as lens aberrations) than OptiVISORS; however they do have a distinctly smaller field of vision. My Zeiss V2x-330 can just take in the face of a Rolex watch for example; however this is adequate for re-winding TRIX armatures.

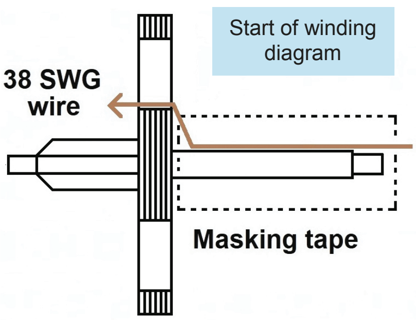
The AC armatures used 38 SWG enamelled copper wire, of diameter (measured over the enamel) 0.17 mm (0.0067”).

Caution is required in interpreting wire tables; as these specify the **copper** diameter, which is 0.15 mm (0.0060”) for 38 SWG **enamelled wire**. Although the factory specification was 220 turns; the actual number of turns on each pole varied considerably, from about 200 to about 240.

In my original article, written twenty years ago, I suggested Maplins for obtaining small spools of suitable wire; Maplins no longer supply small spools of wire (nor will they supply any of their items to overseas customers; evidently the world ends at the Channel, as far as Maplins is concerned). Fortunately the Scientific Wire Co is perfectly happy to supply small spools of suitable wire:- www.wires.co.uk
At the time of rewriting, November 2018, the Scientific Wire Co can supply a 50g reel of 0.150mm, 38 SWG, **solderable** enamelled Copper wire for £3.81, excluding VAT. Their reference is SX0150-050, and the reel contains approximately 318 metres of wire. If you intend doing lots of rewinds, then there are several sizes of larger reels available; the next size up is 125g, reference SX0150-125, at £4.86 excluding VAT, and contains approximately 795 metres.

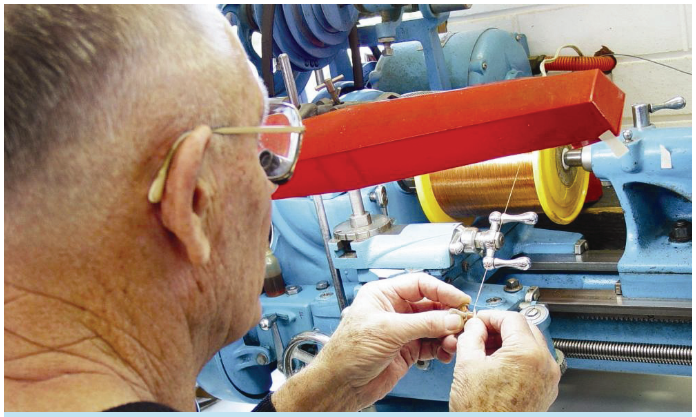
The **DC** armatures, with exactly the same outline which were used by TRIX EXPRESS, from 1954 to 1956, during the transition period from 14V AC (strictly ‘universal’) to 12V DC, can be identified by their noticeably finer gauge wire. Again as measured over the enamel, this has a diameter of 0.13 mm (0.005”) and about 400 turns per pole. The reason for the substantial increase in the number of turns is simple: the **field winding** (in the otherwise identical mechanism) has been replaced by a **permanent magnet**, in the form of a cylindrical rod; which was held in place by dabs of grey paint at each end. Clearly there is no longer any Voltage drop in the field winding; so the full 12V is applied to the armature. Owing to the finer gauge wire, these DC armatures are slightly more difficult to re-wind than AC armatures; although the technique remains exactly the same. The tension must be lighter of course, because the wire is easier to break. I would strongly recommend gaining experience on some AC armatures before tackling these DC ones. However for those wishing to try their hand, suitable wire is obtainable from the Scientific Wire Co, who can supply a 50g reel of 0.125mm, 40SWG, **solderable** enamelled Copper wire for £3.81, excluding VAT. Their reference is SX0125-050, and the reel contains approximately 458 metres of wire. Again, if you intend doing lots of DC rewinds, the next size up is 125g, reference SX0125-125, at £4.86 excluding VAT, and contains approximately 1,145 metres.

On no account should the wire be ‘cut to length’ beforehand; it is **essential** to keep the wire on the reel the **whole time** during the re-winding process to avoid **kinks** occurring. To facilitate keeping a light tension on the wire during re-winding, it is well worth **constructing** a suitable frame out of wood, TRIX, Märklin, Meccano etc. The purpose of the frame is simply to hold the reel on a horizontal axis, whilst at the same time allowing it to revolve (as the wire unspools) against a light braking force; using felt washers or similar, against the ends of the reel. Again access to a lathe is an asset here.

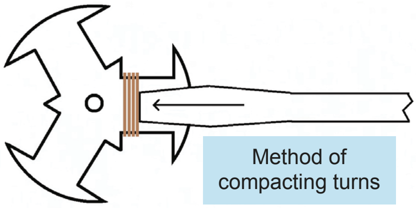


Start of winding diagram

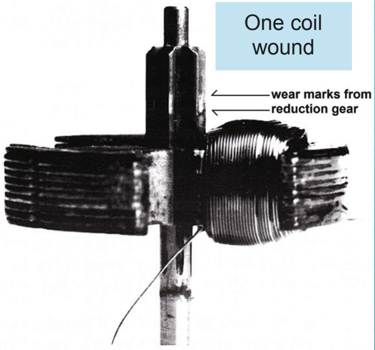
Cut six strips, about 8 mm wide, of 25 mm masking tape and temporarily park them, mostly overhanging, on the edge of the bench (or any handy surface). Fasten the ‘start’ end of the wire to the shaft with one of them, as shown in Fig 5; wrapping the masking tape around the shaft and aiming to leave 20 to 25 mm of wire clear of the pole (this will be soldered to the commutator later). Using a light tension on the wire rotate the pole slowly by hand, quarter of a turn at a time; so that the wire is being wound clockwise, as viewed from above the pole tip, ie looking down onto the shaft. It is **absolutely essential** that the turns lie **tightly ‘side by side’** on the first layer, as it literally lays the foundations for all the subsequent layers. Any irregularities in the first layer will become magnified layer by layer. I find that a well-rounded (or worn or blunt) small screwdriver, 9 cm (3½”), is a useful tool to use to push the turns tightly together, uniformly across **both** faces of the insulated laminations.


I have often been asked for photographs of my ‘winding machine’, this photo shows the Atlas lathe being used to support the 2kg reel of wire, and also apply light friction to the reel, using the tailstock.

Fortunately it is not necessary to try to gain access with the screwdriver to do the same to the sides, because the turns on the sides will automatically follow those on the faces when they are evenly compacted. Stop initially every 2 turns to do so, then after a total of 6 turns have been wound, every 3, on the first layer. Using a new or re-sharpened screwdriver may well damage the enamel insulation. Using 38 SWG you should obtain 26 ±1 turns on the first layer; the second layer will then lie neatly in the ‘valleys’ formed by the first layer and there is no need for the well-rounded screwdriver! As the number of layers increases (there are nine in all) you will not necessarily be able to obtain the full 26 turns per layer, owing to the increasing lack of end support as the height of the winding rises. In practice you should obtain a total of about 230 turns.


Method of compacting turns

I cannot overemphasize the importance of winding neat, tightly side by side turns in the layers during the re-winding process. If you look at the photograph carefully you can see how close the top of the winding is to the mesh marks made by the teeth of the reduction gear on the pinion. If the turns are ‘hank wound’ (as some of the poorer quality TRIX ones were) then the outermost layer of wire is guaranteed to strike the reduction gear; it will then be a complete waste of your time (and wire). Incidentally, this is by far the most common mode of failure for TRIX armatures.



One coil wound


Windings damaged by reduction gear

Having completed the ninth layer, use the second piece of masking tape to fasten the 'finish' wire back to the shaft but 120º further round from the 'start'. Taking the third piece of masking tape, fasten the 'start' wire for the second pole on the shaft alongside the previous 'finish' (when all the windings have been completed these pairs of wires will be soldered to the commutator). The second pole is then wound in exactly the same manner as the first; once experience has been gained it takes about 45 minutes to wind one pole. You may well wish to rest your hands at this stage! For mechanical balance aim to wind exactly the same number of turns on the second and third poles as you did on the first. When all three poles have been wound (and all six ends temporarily taped to the shaft) liberally coat the windings with insulating varnish. I recommend **Electrolube MR8008**, which is a urethane alkyd type air drying varnish, obtainable in 250mL tins from RS Components (formerly Radiospares) or Element 14 (formerly Farnell) and allow to dry. Several coats are necessary and will take time to harden. Shellac can be used, but several coats will take ages to dry.

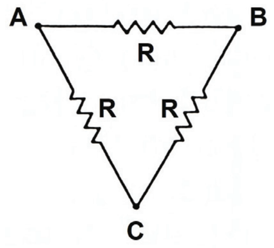
► Stage 4: reassembly

Only when the MR8008 has cured thoroughly hard, **very carefully** remove the six pieces of masking tape **one piece at a time**. **Warning**: experience shows that it is **extremely easy to break a wire** at this juncture! If necessary, soften the masking tape adhesive with mineral turpentine ('turps'); this will not soften the MR8008 on the windings. Pair off the starts and finishes and temporarily place the pairs between the appropriate pole pieces. Next carefully align the gaps in the Bakelite commutator with the centre of the pole faces (as you noted initially), check that there are no 'slipped turns' in the way near the shaft and reversing the roles of the tools, gently press the Bakelite commutator all the way back until it just touches the insulation on the face of the laminations. **Warning: excessive force at this stage, especially if using a vice, will bend the shaft.** Again if the commutator showed the slightest sign of being loose on the shaft prior to disassembly, use Loctite 222 when re-assembling.

The later fibre commutator must have its SRBP ring re-fitted first and the paired wires tucked under it then back towards the gaps between the poles. The commutator should be set back to the correct distance of **4.8 mm** from the end of the shaft (the short brass bush does **not** go all the way back to the insulated laminations). Although I have rewound two armatures, one belonging to the late Tony Matthewman and the other to Dixon Upcott, which had 'full length' brass bushes. Again if you have access to a lathe it is well worth making a custom brass spacer to fit on the shaft between the laminations and the underside of the short brass bush; this will then ensure the correct distance between the face of the fibre commutator and the end of the shaft; (it will also make it much easier to dismantle, should it ever need to be rewound in the future!)

Lay the three paired starts and finishes on the inside shoulder of the Bakelite commutator and neatly tie in place using 3 or 4 turns of linen thread (which is thicker and stronger than ordinary household cotton sewing thread). Seal both the thread and the reef knot with Super Glue and allow to dry. Then form the anchored, paired wires up the inside face of the Bakelite commutator (ie radially outwards). Using a suitable miniature, clean soldering iron (I recommend the **15W Antex model C**) carefully tin all six of the 'solderable enamel' wires. Although it is sold as 'solderable enamel', in practice it is not particularly easy to tin. Experience shows that it is best to start tinning the wire at the end of the wire, ie on the small circle of bare Copper, then run the tinning back down the enamelled wire. However 'solderable enamel' certainly beats having to scrape off polyurethane enamel! Then solder the pairs of wires in the appropriate commutator slots using only a high quality resin cored solder specifically intended for electronics; on no account use general purpose solder with a corrosive flux. I recommend **Ersin Savbit**, (obtainable from RS Components or Element 14) which contains five cores of non corrosive flux in a special alloy which contains a small amount of copper and enables fine copper wires to be soldered more efficiently. With the scalpel carefully trim any excess solder and wire from the face of the commutator. Anchor the wires in place with one or more coats of SuperGlue.

If you have, or have access to, a digital multimeter (a valuable service tool and not just for TRIX!) then measure the resistance between each of the three copper segments (ie across the gaps); the three values should be close to 3.4 Ohms (9.3 Ohms for DC armatures). The exact value depends on several variables: obviously the length of the wire, which in turn depends on the number of turns; less obviously on the temperature, and also on the purity, of the copper used in the windings. The resistivity of copper varies markedly with both of these parameters. The important feature is that all three values should be identical. Note that any one winding is effectively in parallel with the other two windings connected in series; as the diagram shows ►



This means that the value measured between the commutator segments is actually 2/3 of the resistance of an individual winding, as measured on its own; ie R in parallel with 2R = 2R/3 . Thus resistance values of say 5, 5 and 10 Ohms indicate an open circuit winding on an AC armature (14, 14 and 28 Ohms on a DC armature). So check the armature carefully, it may just be the soldering, or worse still a broken wire. The good news is that if it is at the end of a winding then it is a simple matter to remove one turn and re-solder. The bad news is that if it is at the start of a winding then it's a re-wind!

Assuming that you do obtain three identical values then the armature is ready to be put back into service. Clearly after all this work, it will pay to check very carefully that the reduction gear does not foul the windings; it should not, if the rewinding instructions have been followed carefully. However if it looks too close for comfort then place a 10BA or M1.7 washer on the pinion end of the shaft, to move the armature further away from the reduction gear (ie towards the carbon brushes); however if you do so, check that the wheel flanges do not rub on the commutator shoulder, on the opposite side.

If a commutator has been damaged by the wheel flanges, then most or all of the wires will be severed on the **inside shoulder** of the Bakelite commutator; this is another all too common mode of armature failure. Fortunately, the armature can be repaired; thus avoiding a complete rewind. With skill and care, it is possible to 'splice' additional wire onto the ends (which had been rubbed out on the shoulder) and resolder them to the commutator. From experience, it pays to secure the wires, where they leave the actual winding, with a small blob of Araldite, say 2 to 3mm in diameter. In particular, the start of the winding is rather prone to breaking off irretrievably, right at the start of the winding, and it cannot then be recovered. Fortunately, the end of the winding is less critical, because you can always remove one turn. Carefully scrape the enamel off the original wires, where they go radially outwards, up the inside face of the commutator; tin them, then solder short pieces of new wire to them, then solder the new wires into the commutator slots. As before, check for three equal resistances.

Part 2 including DC Armatures is in Gazette 175