Repairing an output transformer from an R-390A

“Slim” Revision beta 1.0

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My most recent EAC R-390A did not have its original audio output transformer. It had long since been discarded in favour of an unsightly but none-the-less functional eight ohm transformer. Since it is always my ambition to preserve these receivers in the form that the designer intended, I asked around with the hope of buying a transformer. Spare parts are hard to come by in the UK. I also did not have much luck in sourcing one from the US. It would have been possible to buy an entire AF module, but breaking up a complete module was not an attractive proposition for me.

My friend John Branson offered me a transformer in good cosmetic condition but with an open-circuit primary. Of course I could not resist this interesting challenge! And since Steve was spending the weekend we could pool our capabilities.

Repair procedure

These transformers are potted in wax. I think the wax was originally introduced through holes in the top. The holes were subsequently sealed before the can was painted. We did not want to mar the paintwork unnecessarily. So it was decided to attempt to unsolder the base from the can. This process will lead to hot wax escaping from the can, possibly under pressure so the job was moved outside. The can was initially secured bottom side up in a suitable vise. Nuts were fitted to two of the four threaded spigots to enable the lid to be levered out of the can using robust pliers.

Heat was applied using a small butane torch. The flame was directed so that as far as possible neither the paint nor the feed-through insulators were in the direct path of the flame. Once a small section began to unsolder, molten wax started to bubble out of the can, thus clearing the solder from a small section of the seam. The can was then held horizontally with the newly created leak lowermost. A foil tray was placed beneath the edge to catch the liquid wax. Heat was then applied evenly to the whole of the seam by constantly moving the flame. Initially the liquid wax was dispersing the heat from the solder, but eventually the wax nearest the joint was exhausted and the temperature was able to rise. Once the entire bead of solder was molten it was possible to lever the cap away from the can.

I am sorry, we did not take a picture of this step. I think thoughts of self-preservation were uppermost in our minds!

After allowing the assembly to cool, the internal wires were snipped from the feed-through terminals. In order to soften the remaining wax, the can was placed in a small saucepan of water. The water was brought to the boil on the hob and allowed to simmer for a few minutes. Eventually the wax softened sufficiently to allow the transformer to be withdrawn from the can using its lead-out wires. This was achieved by the careful use of two dining forks whilst one of us kept watch for the rightful occupant of the kitchen!

The wax was gently chiseled, using a plastic spatula, from the transformer and the can and was preserved for future use. The transformer turned out to be of conventional E and I construction with a folded steel clamp. I would estimate we recovered ninety percent of the wax. The clamp was opened and the assembly removed.

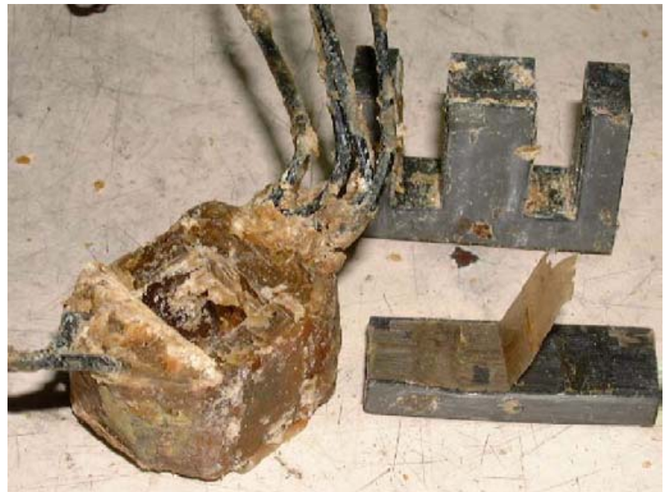
With the clamp removed it was a simple matter to separate the I and E laminations. In the case of a single ended output transformer it is necessary to introduce a small gap into the magnetic circuit. This prevents the net unidirectional current from causing a sufficient flux to allow saturation of the iron during the audio peaks. In this case the gap comprised a two thousandths of an inch paper shim between the E s and the I s. Not interleaving the laminations also effectively introduces a small gap.

You can see here the thin paper shim peeling away from the block of laminations.

Next the bobbin assembly, still within the E laminations, was gently staked between the jaws of a bench vise. The centre core of the laminations was driven out using a non marring plastic drift. The stack of laminations was removed, and subsequently replaced, as an entity. They were very effectively stuck together with wax.

This picture shows the laminations and the bobbin assembly separated.

The bobbin assembly was then dismantled. The lead-out wires were secured with cardboard and tape. These were removed first. Then the beginning of the outer winding, one of the secondaries, was located. We needed to count the turns. There were 417 turns on each secondary.



The primary winding was not counted. It was not practical to do this because there are thousands of turns, and the winding was rotten in several places. The original construction utilised a 0.002" paper insulator between each layer of primary winding.

The bobbin was a simple square waxed card cylinder with no end cheeks. It was felt that some temporary cheeks should be fabricated in order to provide lateral support for the windings. Once they were secured with tape and varnish, the cheeks would be removed.

The number of primary turns was calculated as follows. The secondary has two windings, each of 417 turns. The entire secondary when connected in series therefore has 834 turns (N2).

The resistance of the secondary should be 58 ohms. Adding this to the external load of 600 ohms gives 658 ohms. The resistance of the primary should be 580 ohms. Subtracting this from the desired anode load resistance gives 10000-580=9420 ohms.

Therefore the impedance transformation ratio is 9420 / 658 = 14.32.

The turns ratio is the square root of the impedance transformation ratio.

N1/N2=sqrt (14.32) = 3.78.

So the primary turns equals the turns ratio times the secondary turns:

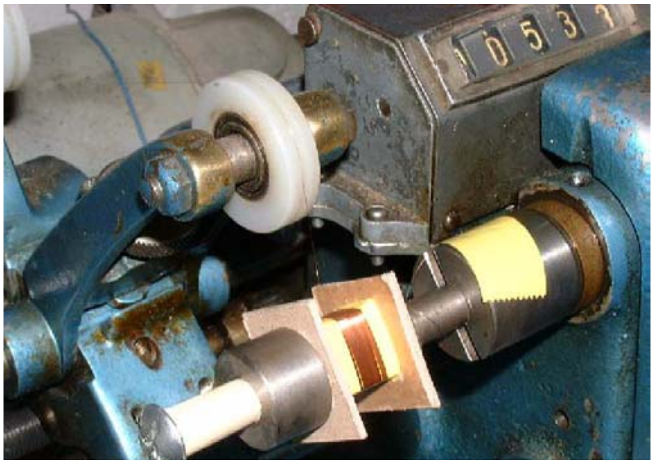
N1= 3.78 * N2 = 3152.

The measured diameter of the primary wire including the varnish was 0.0037 inches. With the varnish removed it was 0.0031". I converted this to 0.08 mm, and chose to use the nearest I had in stock, 0.071 mm wire. However, when comparing the resistance of equal lengths of the old wire and my new wire, the new wire had nearly twice the resistance of the old. I used it anyway, but had I had any, I would have used 0.09 mm instead. I cannot account for the difference in dc resistance on the grounds of cross sectional area alone.

The secondary wire measured 0.0065" including its varnish. I think that the varnish on the original wires was very thin. I used my nearest, 0.125 mm. Ideally it should have been 0.15 mm.

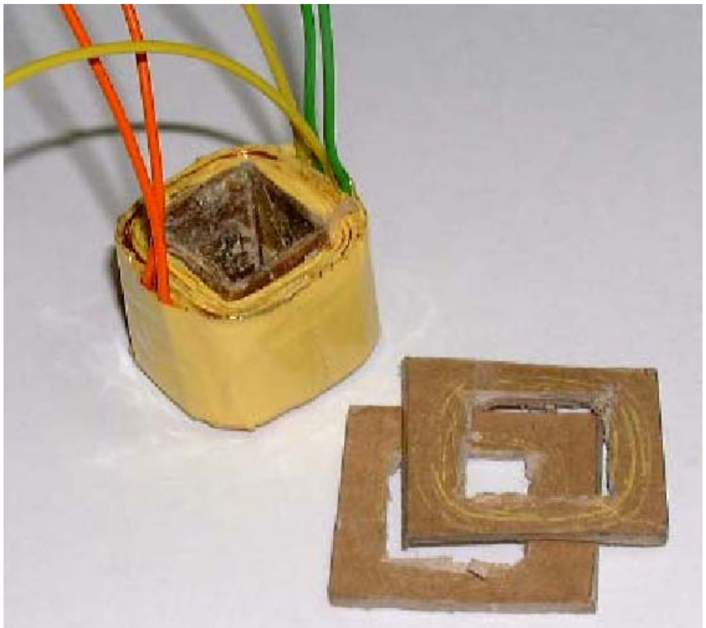
There was none of the sectionalising of windings which one might expect in a hi-fi output transformer. The primary was originally wound in its entirety as one section. I chose not to place insulation after every layer. My wire had grade two enamel, so its self capacitance would be less than the original anyway. Polyester tape was applied after every third layer.

A generous amount of polyester tape was used to separate primary from secondary, and the tape was encouraged to ride up the sides of the cheeks so that the creepage distance between primary and secondary would be increased. The two secondaries were then wound. The first one to go on will have the lower dc resistance of the two; they are specified as 28 and 30 ohms. The secondaries were isolated from each other with a moderate amount of polyester tape.

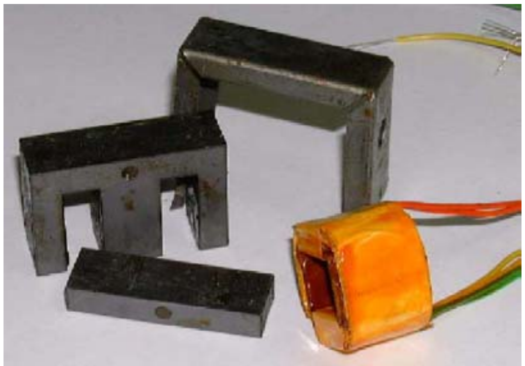


On completion, the assembly was removed from the machine, taking care not to snag any of the
delicate wires hanging from the edges. Then the temporary cheeks were removed.

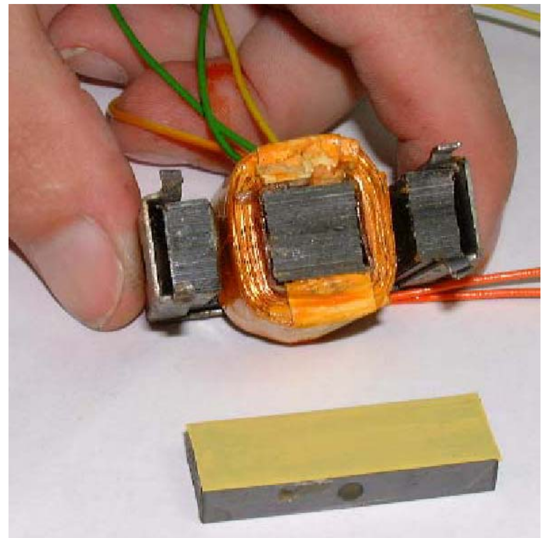
In accordance with the style of construction of the original, the insulated lead-out wires were attached after the bobbin was finished and they were secured externally with tape.



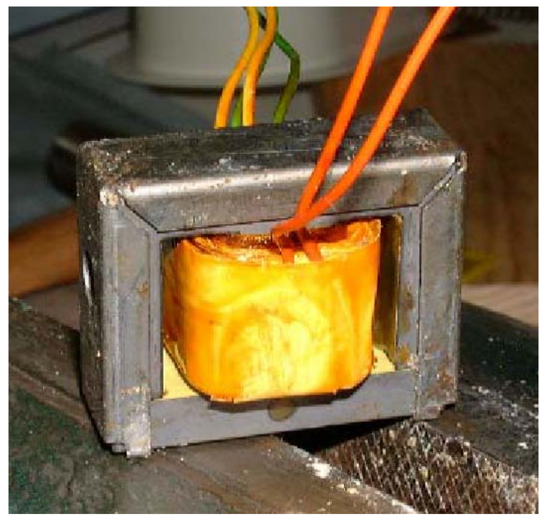
Then, a small amount of varnish was sprayed around the edges to provide environmental protection and a little more strength. A little tape was applied around the inside of the bobbin and over the edges where the laminations would sit.



The bobbin was reassembled into the lamination stack. One layer of polyester tape was interposed between E and I laminations to implement the de-saturation gap.



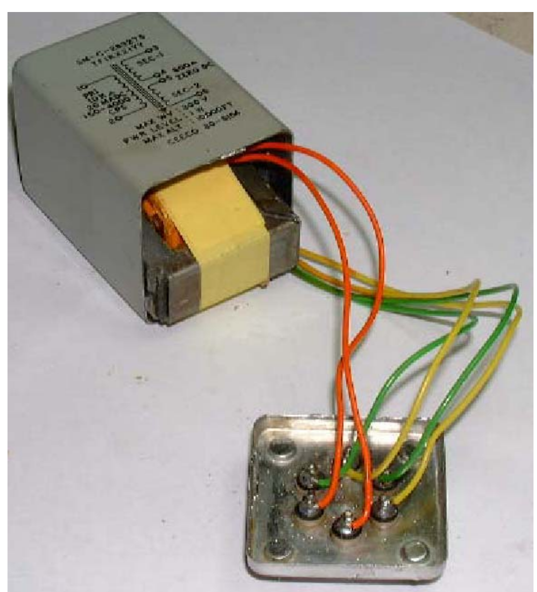
The clamp was closed by a combination of tapping and squeezing. Look at all that space ... I could have used thicker wire.



The transformer assembly was reunited with its freshly cleaned can.

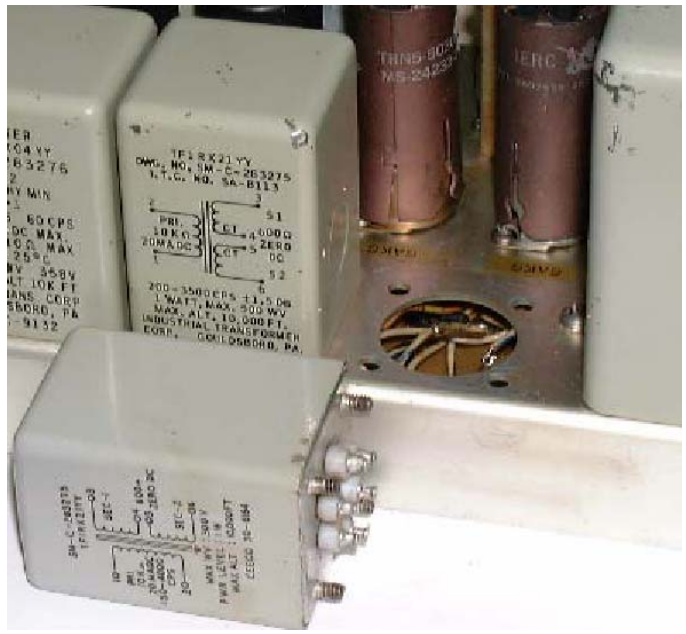
Use was made of air conditioning pipe foam insulation to provide a securing cushion around and beneath the transformer.

The wires were carefully dressed to avoid pressure from the terminals. Note the very slight blistering of the paintwork.



We decided not to re-solder the base. It is a very tight push fit. I am considering the use of an adhesive. If in the future I acquire spools of wire of a closer gauge, I might pull it down and rewind it.

Here is the assembled transformer ready to fit..



Here it is in place. Not a perfect match but it is very close and I am extremely pleased with it. Thank you John and Steve!

The resulting sound quality is pretty well indistinguishable from the other EAC which has its original transformer. The transformer obviously gets warm, but to a similar degree as its "line out" neighbour and similar to the transformers in the other radio.

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