Modifications

Without going into lots of detail, I had more than one go at winding the Inter-Stage Transformer including more breaks than were acceptable to me. I believe the main reason for this was the way the wire came off the feed reel. This was now much wider than the former for the transformer and so once again there was the problem of ‘snagging’ when the wire was on one side of the feed reel and on the opposite side of the former. My solution was to increase the path length from the feed reel to the former, making the ‘angle of attack’ less coming off the feed reel. The inspiration for this was in seeing film of wire being drawn and coming from large drums to the die over room sized lengths.

Two things, amongst many, that I have learnt about coil winders is that they need to be solid, and if it can come loose and move it will. The mounting, for the left-hand, side was simply not up to the task; it could be flexed easily with light hand pressure. The other side was acceptable because of the twin walls needed for mounting the motor. So I have beefed up the construction, by including a back panel and fitting a length of 6 mm studding through the chrome tube, used for guiding the wire. Things coming loose included the chopper disc, which as the grommet started to wear, wound its way up the motor spindle eventually dislodging the sensor. Also it started to slip and so there was potential for miscounting.

Changes in Mounting the Feed Wire and the Slotted Switch

To mount the feed reel further away from the motor spindle additional pieces of 15 mm plywood were used (see picture). These were bolted onto the sides using the original feed reel spindle holes and in use overhang the front of the bench. The reel is moved out by seven inches and down by the same amount and doubles the wire path length to about to about fifteen inches. Would mounting it further away have been better still? It depends upon the bench and chair height but if it were much lower, knees would not go under it to use the foot pedal. For my set up, I could move the reel outwards by another four to five inches but would leave the height alone. Increasing the path length further may improve the feed but for this gauge (42 SWG) it was sufficient as the transformer was wound smoothly like this without breaks (nominally 15,000 turns). If making the winder from scratch then the feed reel extensions could be included as part of the sides and cut as one piece. However, having them as bolt on items does make for easier stowage of the machine.

Another possibility was just putting the feed reel on the floor and letting the wire spool off the top of the reel in fishing reel style. The twist in the wire seems of no consequence. I used to do this when winding series field coils with the battery drill in a vice. It certainly works but there are many ways of getting wire breaks and entanglement with the feet is one of them, particularly when the winder has a foot pedal. Actually, being able to easily see and manipulate the feed reel is an advantage, particularly if turns need to be taken off such as when the wire jumps a former cheek.

To get around the moving chopper disc I cut a new one and it is bolted securely to the motor- shaft with washers and lock nuts. The width of the slot in the side panel had to be increased so it passes the left-hand lock nut when withdrawing the shaft. The fixed disc does mean that coil bobbins can only mount from the motor end but this is not a problem. Lateral
positioning of the disc, in the slot, is done by setting it so minor adjustment can be made as the drill chuck is tightened.

**The Slotted Switch**

The Optek OPB625

At first sight of the Data Sheet this device, available from Farnell for just over three pounds, looks ideal for the task. It consists "...of an infra-red emitting diode and a monolithic integrated circuit which incorporates a photodiode, a linear amplifier and a Schmitt trigger on a single silicon chip". The package is small, easily fitting on a thumbnail, with a five mm gap for the disc. "So why are you bothering to make one with discrete components you Stupid Boy!"

Well, one immediate disadvantage is that the pin spacing is not tenth of a mm grid so it won’t fit on copper clad Vero Board. But worse it doesn’t work that well unless you can operate the sensor and disc in near darkness (they don’t mention that on the Data Sheet). When I first hooked up a package I was convinced that I had things wrong because it did nothing but this was because I was working next to a window on a sunny day. It’s interesting as with the light completely cut off from the diode (or it not even connected) the output can be made to change state just by shining a pocket torch across it (not directly into the receive window) from a foot away. One of the problems with the complete silicon chip package is that you can’t look inside, at intermediate circuit points, as you can with a discrete component design. It’s possible with this to optimise things so that there are good voltage changes at the output of the receive amplifier but with the integrated design you haven’t a clue. I had already built a new sensor, with the discrete transmit and receive devices, and saw no reason to change from it. If anyone wants to try the Optek device it should be electronically interchangeable as far as the counter is concerned (it replaces the devices and the Schmitt trigger). My trial conditions were a 10V well decoupled supply, 20 mA through the diode and a 10K pull up resistor for the output transistor, additional to the one inside the package.

**The New Slotted Switch with Discrete Components**

In making the new sensor I cut the slots in the MDF just right and the Vero board pieces were a nice tight fit in them. This allowed me to optimise their position, with the ‘scope monitoring the receive output, before sealing them in place with Epoxy. Doing this gave sensor output levels of just over 1 V to 8 V (with the light cut off). This sensor is affected slightly by external light but is a lot less sensitive to it, its insensitive anyway needing 40 mA through the diode for operation. If the torch is waved across the top of the disc, with it cutting off the light from the transmit diode, the 8V level blips slightly by maybe a volt. It’s not enough to change the Schmitt trigger output though, as typically, according to the data sheet it would have to fall to 4V to do this.

I tried two chopper discs; one cut from copper-clad fibreglass board and the other from the soft blue plastic top of another pillbox. I was hoping that it would be totally light tight, but it wasn’t, so I covered one side with self adhesive Metal Repair Tape, made by Gripetite and it does! It wasn’t wide enough to cover the disc in one pass and so I used two pieces and a black spirit pen over the junction. Of the two I prefer the soft one as it is more forgiving than the rigid fibre glass type. The hole tends to ‘chew’ if the disc moves a little, and it does, whereas the soft one just flexes. The reason the disc creeps is due
to a small amount of end float in the drill. I couldn’t see an easy way of eliminating this or in decoupling the disc from it. I did imagine the disc being on a separate shaft with a flexible coupler or belt but this is getting too complicated and beyond my mechanical abilities. In use, I kept an eye on the disc position and re-centred it if need be.

I decided to simplify the sensor mounting and make it just hinge out of the way (see pictures) and have fixed wiring. With hindsight the original arrangement was unnecessarily complicated.

Winding the Transformer

I did away with the masking tape over the ends of fore fingers and thumb because for this wire I needed as much dexterity as possible. Now don’t start laughing at this, but to counteract acids, whilst steering the wire, I painted the pads of the same digits with brushed super-glue. I don’t believe that used occasionally this has any harmful long-term affects; it is regularly applied to the hands by wind-surfers during prolonged sailing periods to avoid blisters; none that I know of have had any problems. A good soak in a hot bath with your tipple of choice is a pleasant way of removing it.

Source for new wire

There is a company with a web site, wires.co.uk, who supply several varieties of enamelled copper wire, on convenient sized spools, to as fine as 46 SWG.

Coil Former Construction

For simplicity I used the old former with the addition of cheeks made from thin cardboard. The original coil had been wound without cheeks, stopping short of the edges of the former by about three mm’s. I didn’t intend to do this and, winding right out to the cheeks, hoped to get back some of the turns lost from the larger wire size over the original 46 SWG. It was simple to cut out the cardboard cheeks and glue them to the ends of the substantial square former, with epoxy, before painting them with a couple of coats of shellac (French Polish) to keep out moisture.

Once again I used support cheeks made from 6 mm plywood (see picture) that include slightly tapered and glued on projections that were a snug fit inside the former centre. It’s easier to do this than make one solid centrepiece: to get a 10 mm hole, right through the centre for the motor spindle probably requires a lathe with a four jaw chuck. It needs to be central otherwise the resulting wobble, whilst winding, would make things even more difficult. Having two parts, from thinner material, gave wobble free running and they were made using just a column drill press. I don’t think I would want to try it with a hand drill although it may be possible.

Slots were needed through the former cheeks to feed out the wires for the individual windings. The position of these can be estimated and the slots made long enough to cover error. The slots were made using the smallest size on a leather punch. The first wire (the start of first secondary) exits through a hole made with a small drill, as the position of this is known. A hole or a slot is of course needed in the side support cheeks, but these can be made larger.

The book by B.B. Babani “Coil Design and Construction Manual”, recommends use of a lead out wire (I used stranded (4) double cotton covered) with two turns wrapped around the bobbin before the actual coil wire. I didn’t do this for several reasons: it takes up space I probably couldn’t spare, it makes the winding uneven and it is tricky to do. It’s easier to add the lead out wires when the transformer is wound and removed from its supports. My method was to strip the wires and join them, having enough length to bend and clench over the former cheek. This locates the lead out wire and it is then fixed with a dab of hot melt glue stick. When all the wires for one side had been done (primary on one side and secondaries on the other) then the hole in the former was covered with a small piece of tape and then glue stick (see picture sequence).

For the most even coupling the book by Babani, suggests winding one secondary first followed by the primary and then the second secondary. I insulated between the windings using a turn of Mylar film followed by a turn and a half of cut down 3M-parcel tape. The ‘Mylar’ tape actually came from the stiff clear wrapper (we used to call this cellophane) of a greetings card. If you are cautious you may want to put a temporary wrap over the final winding and not bother to connect a lead out wire. This enables a quick test with the transformer loosely ‘lammed’ up and if the balance between the secondaries is not spot on the turns of the final winding can be adjusted. My final wrap of the transformer was masking tape and then I sealed the edges of this to the bobbin cheeks with hot melt glue stick. This has the added advantage of holding everything solidly together.

The stack of laminations was approximately 2 1/2 x 2 x 3/4 inches and were installed as follows. All the E’s, bar two, went in from one side with these going in from the other side with all the I’s set between them. I suppose this gave much quicker installation than interleaving. Two brass compression plates go along the sides (the one where the I’s are) and once pressed home into the coil can everything is secure.

The transformer can was originally pitch filled and I used a hot oven to melt it out and then several soaks in White Spirit to clean everything up. I decided against re-filling with either pitch or wax; neither it seems to me guarantee that the wire won’t corrode and ‘greenspot’. Certainly whilst the radio is with me it won’t be going in a damp shed. Spools of wire left indoors come to no harm and I don’t see why the transformer should be any different. Hot fillings are a messy business and make doing a future rewind, due to unforeseen problems, so much more difficult. I did secure the transformer core to the can with a little hot melt glue stick.
Coil Calculations (see Appendix 1)

In Part 1, I gave sources for calculating the number of turns that would fit into a particular winding space. For this job I had to get things correct otherwise when I came to the last winding there might not be room! As the Internet method had been the most accurate, for the field coil, I used that. However, I was going to reduce the calculated number of turns by at least the 15% that I had previously found it high.

Calculation of the Number of Turns (Appendix 1)

F. Langford Smith says “When a centre tapped secondary is used the turns ratio is calculated for the whole secondary”. Well I shan’t forget this another time as I initially wound the transformer with a 2:1 step up to each half. Apart from audio gain I didn’t need there were insufficient primary turns and inductance. The consequence of this is a poor low frequency response as the falling reactance loads the Ra of the driver tube.

The number of turns that would fill the winding space was calculated as 17,762 and 15% less would give about 15,000 turns. To be on the safe side I opted to wind three windings of 4800 turns each.

Conclusions

The changes to construction have been worthwhile and the winder should handle wires as fine as 44 SWG. The simplified design of the slotted switch is easy to use although there are still some shortcomings with the switch. This is due to the small amount of end float of the drill allowing the disc to creep out of centre of the sensor. For an occasional use machine it’s acceptable and just requires keeping an eye on the sensor and readjustment whilst winding.

For the Inter Stage transformer the turns and insulating layers filled the former nicely to the brim. The reduction in the calculated turns, by the Internet Method, of 18% was just right.

Using a signal generator with a 10K Ohm feed resistor, to simulate the Ra of the audio driver tube, it was easy to check performance with an oscilloscope. Frequency response was 3dB down at 55 Hz and flat to beyond 10 Khz. Re-checking the figures with the transformer in circuit and with DC in the primary gave similar results.

If you are tempted to use a modern tiny replacement transformer (available from Antique Electronic Supply in the USA) these are intended to be shunt fed, via a capacitor, and do show a marked fall off at low frequencies for even a small amount of direct current. I was able to loan one (Hammond P-T124B) for a try and the response was 3 dB down at 300 Hz with 6 mA of DC. Take away the direct current and the 3 dB point improves to 100 Hz. This is quite a tiny transformer weighing in at a mere 0.4 lbs. against the rewound transformer of more than a pound.

Appendix 1. Calculating the Number of Turns

F. Langford Smith says that “When a centre tapped secondary is used the turns ratio is calculated for the whole secondary”. For this transformer this is 2:25 to 1. Practically this is close to putting on three equal windings giving a turns ratio of 2 to 1 with only just over 1 dB of gain loss.

The bare wire diameter is 0.1016 mm. Using the Internet method and adding on 10% to allow for the coating equals 0.11176 mm. For random winding another 15% is added giving a ‘working wire’ diameter of 0.1285 mm.

The former inside length is 27.6 mm and so the turns per layer will be 214. The depth of the former is 10.7 mm, therefore the maximum number of layers equals 83. The maximum number of turns is therefore 17,762. But removing 15% for inaccuracies found when winding the field coil, gives approximately 15,000. To be safe wind three windings of 4800 turns each.