Restoration of a mid-1950's UK-Manufactured Leak Trough-Line Mk1 'Hi-Fi' FM Tuner - by Gerry O'Hara, VE7GUH, SPARC Member

Background

In the UK in the early to mid-1950's, several companies brought FM tuners to the market: Leak, Quad and even Eddystone had all introduced these items into their product lines by mid-1955. Why was this? - I would say that it was because there was a great (apparent) opportunity opening up due to the BBC introducing new services in the UK and the 'HiFi' bug was just catching on: more and more homes were acquiring radio and audio equipment that was capable of providing very good quality reproduction and there was a fledgling 'high-end' market developing for the more 'well-heeled' listener. The sidebar to the right provides some interesting background details of the status of FM broadcasting in 1950's Britain for the interested reader[1].

Above: a very early Leak Trough-Line MkI FM tuner with the pressed steel front, dating from around 1955.

Status of FM Broadcasting in the UK During the 1950's

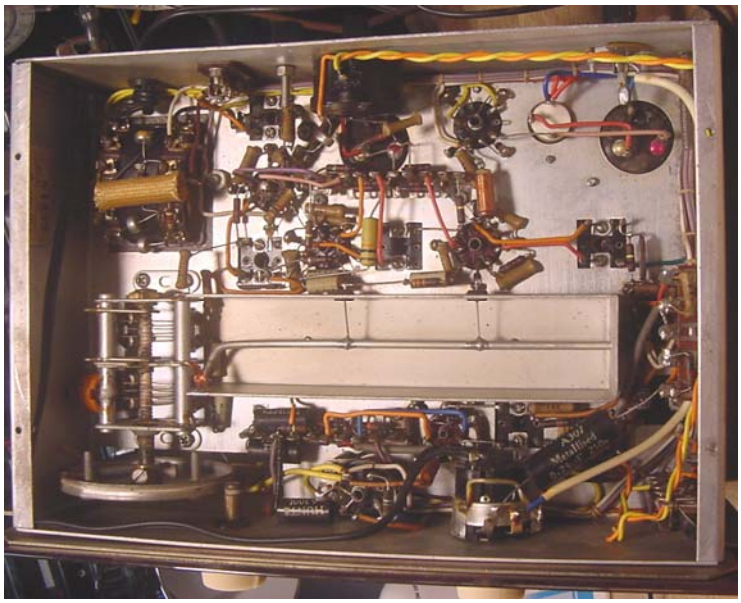
The first of the BBC's new Band II VHF FM radio transmissions started on May 2nd 1955 from the new mast at Wrotham, Kent. This new service brought high fidelity radio to around 13 million potential listeners in London and the South East from the Home 93.5 MHz, Light 89.1 MHz and Third Programmes 91.3 MHz. The FM mode of transmission was broadcast on VHF frequencies between 88.0 MHz and 95.0 MHz and was less susceptible to the types of interference often encountered on medium and long waves which used the AM mode of transmission. This fact coupled with the ability to use a higher bandwidth which could provide 'Hi-Fi' quality transmission and reception enabled the BBC to offer the then three radio services, Home, Light and Third with audio quality never before experienced by listeners. All transmissions were initially in mono however.

The BBC opened further high power VHF FM radio transmitters in December 1955. For the West of England and South Wales from the Wenvoe transmitter (120 kW) was opened and transmissions for the North East from Pontop Pike (60kW) commenced. In 1956 Sutton Coldfield (Midlands - 120 kW), Holme Moss (North - 120 kW), North Hessary Tor (South West - 60 kW), Tacolneston (East - 120 kW), Kirk O' Shotts (Central Scotland - 120 kW), Meldrum (North East Scotland - 60 kW) and Divis (Northern Ireland - 60 kW) followed. A transmitter at BlaenPlwyf (60 kW) was also installed to bring reception to the Cardigan Bay area along with a temporary transmitter in the Anglesey area where reception on the Welsh Home service was particularly poor.

More high power main-stations were soon introduced followed by many low power relay stations that filled in some significant pockets of poor reception and in January, 1958 the BBC commenced experimental stereo transmissions on VHF FM in the London area. In the USA, radio station WGFM in Schenectady, New York and station WEFM Chicago were transmitting the first regular programmes in FM stereo in June 1961 using the Zenith GE Pilot Tone System and the BBC commenced permanent VHF FM stereo radio broadcasting of the Third Programme in August 1962 from the Wrotham transmitter using the same technology on 91.3 MHz. Stereo broadcasting was very gradually rolled out across the BBC's network of VHF transmitters and national radio stations from the 1960's until the 1980's.

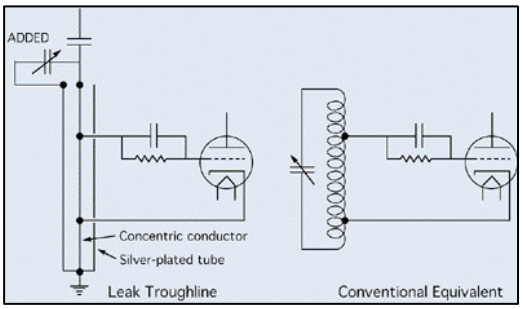
[1] Edited excerpt from 'UK Radio – A Brief History Part 2, Post War' on Mike Smith's very informative site http://www.arar93.dsl.pipex.com/mds975/Content/ukradio2.html

In the UK, the 'Leak' brand of HiFi equipment had launched their 'Trough-Line' (MkI) tuner in the early-1950's. The Trough-Line's main design/selling feature was a very stable oscillator circuit using a tapped transmission line formed by a 4 inch long metal 'trough' surrounding the resonant element (hence the catchy name). This unit was supplied without a case, it being meant for inclusion in a home-made console as was the vogue. A good description of this unit appeared in a contemporary issue of the UK magazine "HiFi News":



Above: Beneath-chassis view of the SPARC museum's Leak Trough-Line Mk1 tuner – note the rectangular trough-line used to resonate the local oscillator

"Leak have adapted for their oscillator, a variation on the quarter-wavelength line type of resonator. It has been found in communications engineering that for frequencies in the 100Mc/s region and above, it becomes increasingly difficult, for a multitude of reasons, to make the conventional coil and condenser combination operate satisfactorily; the chief among these reasons are the capacitance inherent in the coil, and the inductance in the condenser. Now, a quarter-wavelength section of transmission line, shorted at one end, behaves as a parallel resonant circuit of very high Q and electrically stability, while the mechanical construction of such a device leads almost automatically to great rigidity (and hence stability). The Q being high, tapping down will still permit adequate voltage at the output; and as the coil is a straight piece of wire, selection of optimum tapping points is obviously much facilitated. Below is a diagram of the resonator in the Leak circuit, and also the bread and butter version. It is clear that the Leak resonator is not a true quarter-wavelength section, its length being under 6 inches, but its frequency in the Trough-Line is controlled by added (variable) capacitance."



Above: Comparison of the tough-line circuit (left) versus conventional components (right)

Other details given in the review for the MkI Trough-Line are:

- Frequency Range: 88-100MHz.
- Foster-Seeley discriminator circuit.
- Magic eye tuning indicator, 2kHz accuracy.
- 10lbs weight.
- Self powered – quite a selling feature as it meant less of an installation effort unlike many other British tuners of the time, that required HT and LT power to be supplied from the audio amplifier they were being used with.
- Tube complement (8) was as follows: EM81 (magic-eye tuning indicator), EB 91, 2 x EF80, 3 x ECF80, EZ80 (rectifier).

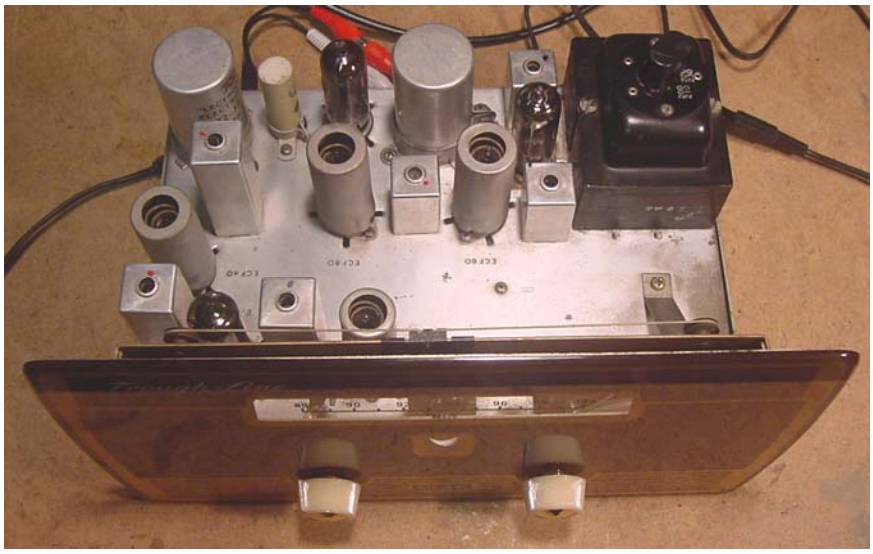
The original metal-faced Mk1 was replaced by a similar chassis version that sported a smart new maroon and gold silk-screened acrylic front panel a couple of years later (as per the museum's specimen), photo right, that is dated April 2, 1958 (S/N K1259, signed by 'John Singer').

The MkI Trough-Line was replaced by the squatter, though similar-looking MkII in late-1958 (photo, right – upper unit). This model had a quoted drift of 15kHz without its AFC switched on and with the AFC circuit switched on this was reduced to 3kHz drift (or approx 0.003%). The published specification for the MkII Trough-Line includes the following information:

- Frequency Range: 88-108 MHz (note the extended upper end of the band from 100MHz to 108MHz).
- 2 microvolt sensitivity for full limiting.
- 300 Ohms or 75 Ohms aerial input.
- Cathode follower audio output.
- Multiplex output for add-on stereo decoder.
- Tube complement (7) was as follows: 2x ECF80/6BL8, ECC84/6CW7, ECC85/6AQ8, EF80/6BX6, EM84/6FG6 (magic-eye tuning indicator), EZ80 (rectifier)

The MkII Trough-Line was originally issued as a mono unit, with provision for adding a stereo de-multiplexer later. Subsequent models were also available with solid-state stereo decoders.

The build-quality of the Leak units was generally very good, with well-thought-out point to point wiring and high-quality components used throughout such as TCC electrolytic capacitors, Mullard tubes and McMurdo tube sockets.



The Leak Mk1 and MkII tuner's circuit design was rather sophisticated for its day, featuring a cascode RF amplifier and a cathode-follower AF stage, the use of the trough-line tuning element and adjustable quieting ('squelch') to eliminate inter-station noise. In addition, the Mk II incorporated a switchable automatic frequency control (AFC), output for a stereo decoder and used solid-state diodes in the discriminator circuit.

Preliminary Clean-up, Inspection and Safety Checks

The top of the chassis needed a thorough clean using a de-greaser – I found that soapy automotive hand cleanser worked best on this chassis. Underneath, all that was necessary by way of cleaning was the careful use of a dry paintbrush and a vacuum cleaner to remove cobwebs and dust.

The MkI tuner is designed for 220v to 240v, 50-60Hz power. I decided to retain the original circuitry and components if possible, so I planned to power the tuner through a variac coupled to a 120v/240v step-up transformer. Following visual inspection for faulty wiring and obviously distressed components (eg. mechanical damage, baked or burned resistors), simple continuity checks on the power lead, power switch and transformer windings, I removed all the tubes and tested the transformer by gradually increasing the primary voltage up to 240v – all secondary windings were giving correct ac voltages.

Front Panel Removal and Replacement

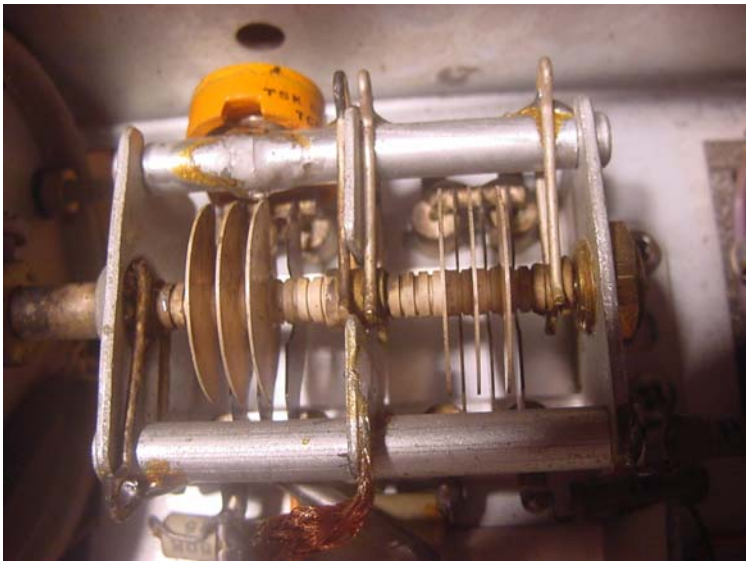
The front panel was very grubby and needed a thorough clean behind the transparent section where the tuning scale is. Dismantling of the front panel was straightforward: removal of five retaining screws and the volume control and tuning bushing nuts and off

it came. The acrylic panel had originally been affixed to the underlying metal plate with a black compound (tar?) that had lost its adhesion. Following careful cleaning of the rear of the panel with warm soapy water and the front with anti-static acrylic plastic cleaner I re-mounted the acrylic panel onto the underlying metal plate with 'Goop' and re-fitted the retaining screws and nuts. The tuning dial needed re-stringing after this operation, though it is a simple mechanism and this only took a few minutes.

I then cleaned hardened oil/grease from the tuning shaft bearings re-lubricated with suitable grease (I used a sparing amount of Moly-grease). The tuning pointer guide rail was also lightly smeared with Moly-grease.

Initial Power-UP and Electrical Checks

- I cleaned and checked all the tubes on my Precision 10-12 tube tester – they tested good to very good apart from two ECF80's: one had a cathode-heater short, the other had a low emission triode section. I suspect that some of the tubes may even be the original fitment as they were Mullard manufactured, made in the UK;
- Checked the resistance measurement from HT to chassis – rather low, rising to only around 5kohms after an initial dip to almost zero on the meter as the smoothing capacitors charged up. I decided that I would re-form the power supply electrolytic capacitors in-situ;
- I installed the rectifier tube (EZ80). Connected a DC voltmeter on its 300v range across the HT line and the chassis. Re-applied power gradually using the variac/step-up transformer arrangement and at around 60 volts AC applied to the transformer primary, some DC voltage began to appear across the HT smoothing capacitors; the capacitors were re-formed over a couple of hours by slowly increasing the applied AC voltage from the variac, monitoring the HT current draw (all tubes still removed except the rectifier) - increasing the voltage in stages, holding for up to 15 minutes and also switching off/on a couple of times at each stage. I increase the applied voltage in increments of 25v, up to the full HT volts of ~275v DC. Leakage current at the end of re-forming exercise was acceptably low on all capacitors – impressive for 50+ year old units. The EM81 'magic-eye' was glowing very dimly, suggesting that the phosphor coating on its plate has faded;



- Undertook some basic leakage checks on a few of the 'Hunts' (black) plastic encapsulated paper capacitors – those tested appeared ok, so I decided to try powering-up the set with a full set of tubes without replacing any of the

capacitors;
- Checked the HT smoothing resistor and a couple of the anode load resistors – all seemed within tolerance;

The next week I visited SPARC and obtained a couple of good ECF80 tubes from the tube vault.

- On returning home, I installed the replacement ECF80's and all the remaining tubes, connected a short aerial to the FM aerial connection and attached a (powered) computer speaker set to the (mono phono) AF output. Slowly brought the set up on the variac over around 15 minutes, monitoring the HT voltage;
- After about 30 seconds a station was heard: 'QM-FM' – sounded pretty good too (considering the limitations of the computer speakers);
- I did some rudimentary alignment checking and the tuner seemed pretty well aligned, however, I did adjust the tuning range slightly (orange-coloured trimmer attached to the tuning capacitor – see photo at base of previous page) to accommodate 'Rock 101'…
- I left the tuner on 'soak test' for a few hours and nothing seemed to be overheating. It stayed working ok during this period and proved very sensitive and stable.

'HiFi' Listening Test

I undertook a listening test with the tuner coupled to my (unfortunately solid state) 'HiFi' system - actually a homebrew dual 100W/channel power amplifier (labeled 'Krank' on the photo, right) constructed in a very large Kingston power supply case way back in 1986, coupled to a separate op-amp preamp scratch-constructed from an article in the UK magazine 'Practical Wireless' at the same time, the amplifier outputs are fed to a pair of speakers constructed from Wilmslow audio kits of similar vintage. My usual tuner is a high-quality solid state stereo Akai unit (photo, right), dating from mid-1990's (picked up in a Salvation Army 'Thrift' store for a bargain price of just $15) or a recently restored Eddystone S.820 tuner (below the Leak tuner) a contemporary of the MkI.

Compared with the Akai, the Leak sounded 'crisp' and lacking a little in the base department and slightly 'edgy' on some programming (especially voice-stations), suggesting that the discriminator de-emphasis

characteristics may not be exactly right. Noise levels (hum and hiss) were very low on strong signals and the quality is quite acceptable and provides very easy-listening (I double-checked the discriminator adjustment and it was found to be ok). The tuner is very sensitive, with full quieting on just a foot or so of wire connected to its VHF antenna socket. The tuner is remarkably stable and sits firmly on the selected frequency after the first few minutes or so of warming-up – a testament to the inherent stability of the trough-line oscillator components, component selection and design of the oscillator circuit.

Conclusion

The Leak Trough-Line Mk1 is quite a remarkable performer. It relies mainly on quality components and the inherent mechanical rigidity of the trough line to achieve adequate stability on VHF. Its very good sensitivity illustrated that it would have been able to operate well in marginal signal areas - a definite advantage in the early days of FM broadcasting and a therefore a good marketing feature. A limitation of the tuner in today's FM band is that it only tunes from 88MHz to 100MHz if the dial calibration is used when aligning (as I noted above, I cheated a bit and re-tuned the dial to cover from 89.5MHz to 101.5MHz so I could listen to Rock 101 while I was doing soak testing...).

Some Useful References

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