The secret radar valve the EF50 Part 1

By Graham Dicker

Introduction

Over the last 50 years or so I have had a love & hate affair with the EF50, having said that the more that I work with this valve the more I can appreciate the secrets that it's design unravel as time progresses and information comes available. I am sure that this wonderful valve has been overlooked by many for all kinds of projects by the home constructor. In this two part series I will attempt to unlock some of it's characteristics, idiosyncrasies that I have discovered. There is plenty of information on the web about this so I don't intend to re-hash what you can already find, but concentrate my efforts on what is not so obvious , and harder to find and understand. Some history along the way is always a good thing.

The EF50 is also known as the VR91 CV1091 ARP35, later versions are the EF54, EF55 and the EF90. The valve is a fully controlled pentode, and as such was used in a number of FR applications the most famous as an IF strip.

Prior to WW2, most radio communication work was in the HF band (below 30mhz), most RF valves at that time tended to perform quite poorly at 30mhz and above, while being researched and being used communication had not extended above 100mhz at the time due to poor valve gains at these frequencies. There were two main issues, the first was caused by the inductance and capacitance of the internal leads, the second was due to the finite time that the electrons took to travel between the valve electrodes.

The problem that arose from early methods of construction was that the length of the connections from the electrodes to their terminating pins, resulting in large inductance and capacitance between them. At frequencies above 30 MHz these factors became an issue difficult to overcome, one solution at the time was to use grounded grid circuit topologies to isolate the input and output circuits and the associated capacitances.

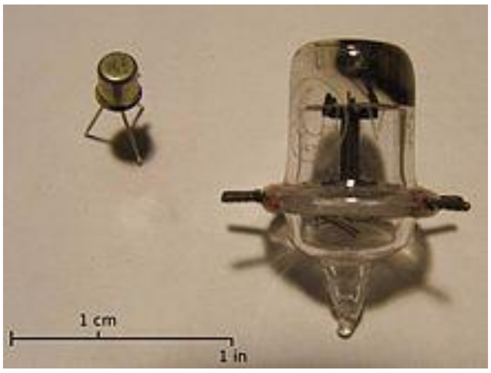
For a typical RF valve the transit time for the electrons to move between the cathode and control grid is about one nanosecond, at frequencies of a few megahertz, this time was insignificant compared with the time for one cycle of the signal frequency. At 100 MHz, this is a significant factor. The time lag results in a low input impedance at high frequencies, which significantly reduced the amplification available. Many designers are unaware in RF design that the grid leak resistor should be scaled to reduce at a rate of the ratio of the square of the input frequency. For example at 10mhz the value may be 4k ohms at 40 mhz for the same valve this value should now be 1k. at 80mhz, 250R.

The secret radar valve the EF50 Part 1

Enter the Acorn valve

One solution was to reduce the size of the valve, RCA during the early 1930's, spend some research on valves at VHF where it was found that improved circuit performance could be achieved if the valve dimensions were reduced. 1n 1934 RCA developed the metal can valve the 6J7 to try to reduce lead length, with substantially improved performance and shielding, but this was still not able to work at high VHF.

The tiny 'Acorn' valves resulted from this development work and were capable of providing amplification at frequencies up to about 400 MHz. The 955 and other valves were soon used here in Australia for experimentation at VHF and UHF in the post war days, and I remember in my early teens (pre ham ticket days) experimenting with others using these valves on the 1 metre band and later with lecher lines on 220mhz. As Robbie at Queenstown (the grandfather of disposals junk here in Adelaide) had plenty of these they could be purchased for the low sum at the time of a bob each (translated 10 cents).



An acorn valve alongside a bipolar transistor

Some great project to build using these valves can be found at the following URL http://www.vintageradio.me.uk/radconnav/acorn.htm

One of the greatest issues of the acorn tube was to find a valve socket for them, in the 60's this became increasingly more difficult and the cost of a socket often exceeded the disposals price of the valve many times over, I remember paying as much as a quid (two dollars) in those days at ham auctions (a lot of money for a school kid back then, probably two months pocket money) just to get one socket.

The secret radar valve the EF50 Part 1

About 50 “quids” worth of sockets in the photo above, with today’s inflation about $10,000 worth based on the cost at the time. Sadly truth is that no one has an interest in these anymore, and they can still be found on Ebay for around $5 each.

British valve makers, found the acorn valves very difficult to manufacture because of the highly skilled labour required. As a result, considerable quantities of the valves were imported from the US for use in military radar equipment during World War 2. The acorn valves were blacklisted by the Inter-Service Technical Valve Committee in June 1941 as a result of this.

German research in VHF

Philips were based in the Netherlands and provided R&D in valve manufacture, and production of valves for Mullard (the Philips arm in the UK) and also Telefunken and Seimens in Germany.

Up until and including the early part of WW2 , Philips in Eindhoven undertook research projects for VHF valves for the German manufacturers, the result of this work were the early EF11, EF12, EF13, Ef14, EF15 valves. These were clever in design as Philips simply turned the anode on side to shorten the lead lengths. These valves were used extensively for VHF work until the end of the war.

TV and the secret radar valve

With the commencement of high definition television in the UK in 1936, the transmission were 41.5 MHz for the sound channel and 45 MHz for the vision channel, In order to achieve satisfactory amplification of the video signal, valves were required with a high value of amplification and early valves produced for this role were far from satisfactory.

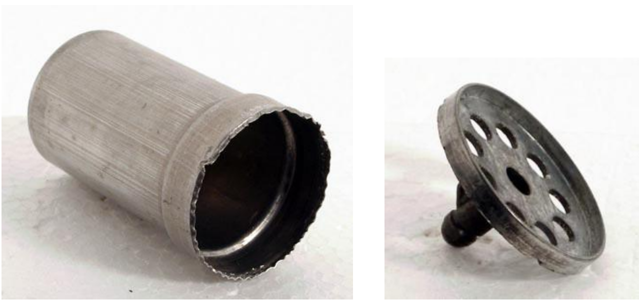
In the 1930’s Radar research was underway at Bawdsey Manor in Essex on radio direction finding (RDF) - later to be re-named radar. At this time the Mullard Valve Company, was liaising with the British government and were made aware of a requirement for a high performance VHF valve. Mullard approached Philips asking if there was a valve with the required specification. As Radar could not be mentioned the requirement was always referred to be for television. A special TV IF valve was under development at the time, the valve in question was the EF50, which became available for television use in 1939. At this time all the valves were being manufactured in Holland, and samples were earlier being evaluated by PYE electronics.

Enter PYE Electronics

In the early 1930's during the development time of the EF50, samples went across the channel to PYE electronics. These early variants were all glass, and samples tested by PYE were unstable in a TV-IF to say the least.

It was Professor Jonkers at Philips who developed the EF50 with a principal use for TV. It was PYE electronics UK who came up with the idea of the metal can to fully shield the original all glass EF50 prototypes. This carried through into production versions.

Original EF50 sample as supplied to PYE electronics



Metal can shield designed by PYE

Enter the EF50

The Mullard EF50 is of interest because it marked a significant departure from the conventional types used in Britain at the time. The usual Bakelite base and internal glass pinch were replaced by an all-glass base. The spigot was joined to an external metal screen that covered the whole base, with small holes to allow the pins through. Because of the screening provided, it was possible to bring all the connections out to the base, avoiding the need for a top cap connection. The EF50 was the first all glass valve to use pins through a sealed base. One of the problems prior to the EF50 was valves used wires through the glass

The secret radar valve the EF50 Part 1

seal (not pins) which were soldered to a separate valve base. These solder connections were a continued source of reliability problems over many decades, and often a problem for HRSA members when restoring old sets.

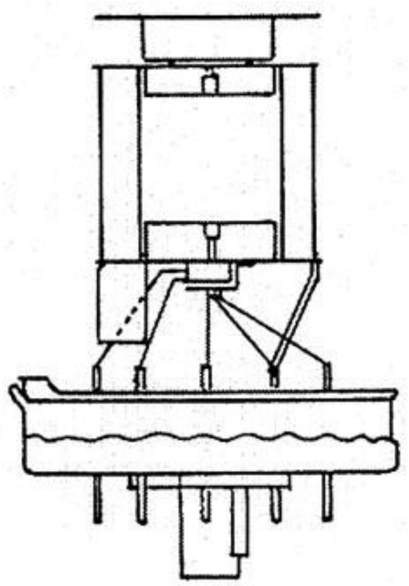


Figure 3: Construction of EF50.

A typical use of the EF50 was in the Pye 45MHz IF strip - Receiving Unit Type 153 - which was used universally in British radar equipment during the war. It had six EF50s (VR91s) and one EA50 (VR92) miniature signal diode.

A variant of the EF50 was the RL7 (VRI36). This had aligned grids to reduce partition noise, and the cathode was connected by leads to four separate pins to reduce still further the self-inductance. The valve was capable of proving RF amplification at 200MHz and could thus displace the acorn valve. In post war years it was re-designated as EF54.

In Part-2 of the article I will look at TV and radar, and some other interesting post war applications.