Vintage Radio

by PETER LANKSHEAR

AC mains heated valves

Unlike semiconductors, receiving valves are extremely inefficient — with quite large current and voltage requirements. In the early days of radio, these were usually supplied either by standard dry Leclanche primary batteries, or rechargeable lead-acid secondary types. Primary batteries were convenient, but not normally rechargeable and were relatively expensive. The first cost of rechargeable secondary batteries was even greater, and they were also messy and inconvenient.

Before the days of broadcasting, when the only radio 'traffic' was commercial or amateur communications, the cost of battery supplies was accepted. But when, in the 1920s, domestic entertainment radio 'broadcasting' became popular, there was a growing demand for cheaper and more convenient power sources.

For locations with AC power, reasonably successful high tension supplies or 'B' battery eliminators were developed, incorporating a transformer, rectifier and filtering system. But filament supplies presented serious problems. Using a transformer of the correct voltage was an obvious and simple enough method, and when balanced to earth with a centre tap, AC was satisfactory for high powered audio and transmitting valves. However it was unsuitable for receiving valves.

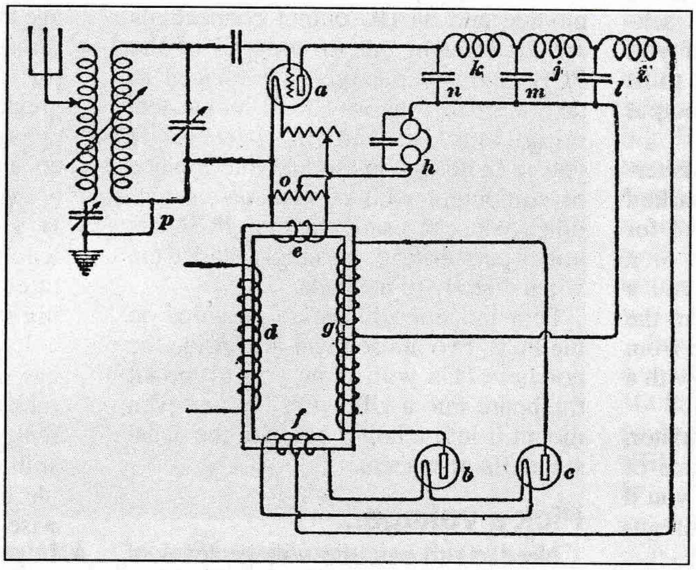


Fig.1: This circuit, found in a 1923 book, illustrates early attempts at all AC operation. It would not have been very successful.

One suggestion dating from the early 1920s is shown in Fig.1. On paper, it looks viable enough, and the HT supply should be satisfactory, but I suspect the circuit was never actually tried before publication! Although the filament supply is balanced to earth, the hum level would still have been quite intolerable.

Receiving valve filaments, even the husky 250mA types, had very little thermal inertia, and cooled sufficiently between each half cycle to modulate the electron stream. Also the alternating electrostatic and magnetic fields around the filaments were impossible to balance out completely.

For heating the filaments of existing receiving type valves, a source of direct current was therefore necessary. At least one manufacturer, Stromberg-Carlson, used gas-filled 'Tungar' battery charging rectifier bulbs with elaborate and expensive filter chokes, to provide acceptable supplies for parallel filament operation. Other filament power units used copper oxide or electrolytic rectifiers, with varying success. Paper capacitors were not really large enough, and only when electrolytic capacitors became available was adequate ripple filtering economically practical. By then, valves designed for AC operation were coming available anyway.

Mains powering was a more practical proposition if the filaments were series connected. The first recorded attempt was as early as June 1924, when the American 'Dynergy' receiver appeared using the standard 250mA filament 201A valves — lit by rectified and filtered current supplied by a pair of Tungar bulbs. But there is no record of this receiver ever being in production.

Later, a few American manufacturers used the Raytheon cold cathode type BA gas filled rectifier, which could deliver up to 350mA to provide both high tension and filament currents.

In areas with DC power mains, it was possible to filter commutator ripple more or less adequately to supply all power to specially designed receivers. Valve filaments were series connected and fed through high wattage resistors or even lamps. An adaptation of this system remained in use, especially for inexpensive transformerless receivers, right through to the end of the valve era.

Ingenious solutions

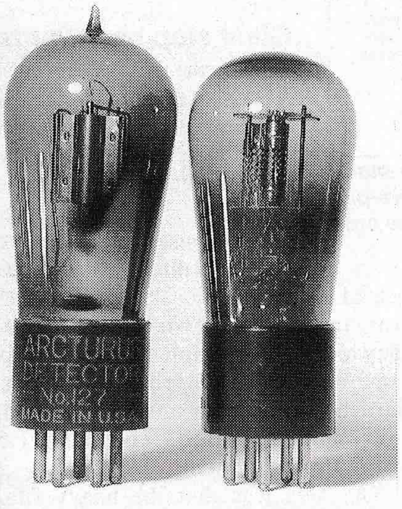
Some of RCA's deluxe superheterodyne receivers successfully used series-connected 60mA filament UX199 valves lit from the main HT supply of the receiver, although the output stage used a large type UX210 valve which was heated with AC. In one configuration, this receiver was paired with the RCA Rice-Kellogg Type 104 Speaker system described in this column back in

May 1990. The husky power supply had no trouble in providing the extra filament current.

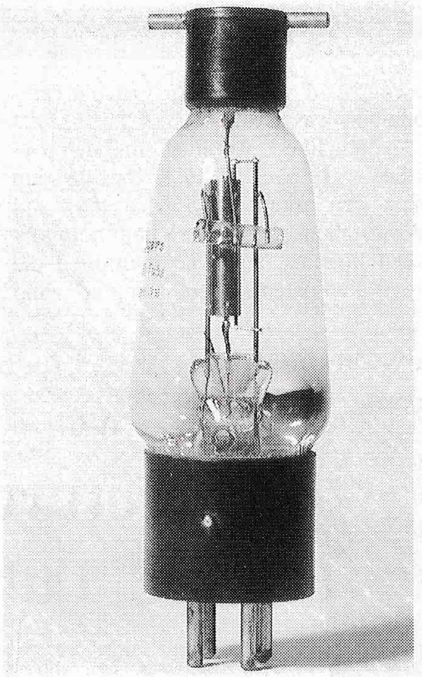
Although this form of filament supply was superseded within a couple of years, many readers will be aware that it was resurrected very successfully about 25 years later with the availability of the 1.4 volt 50mA filament seven-pin miniature dry battery powered valves, in what became known as AC/Battery portables which had the option of operating either from the mains where available, or from dry batteries.

A most ingenious solution was used by the Fansteel Company in their 1928 Balkeit B7 and B9 receivers. They used a small 4MHz transmitter to generate the 6.25 watts required to light five 01A valves. There would have been some problems, of course. To avoid intolerable interference, the oscillator frequency had to be well above the range covered by the receiver. As not many servicemen would have had RF voltmeters, it would have been difficult to adjust the exact filament voltage, and with the available technology, the only way to control receiver gain was by means of a volume control at the aerial input. For all that, it was a practical system, and may well have been used more if the indirectly heated valve had not been developed.

These 'work around' methods were all expensive and were restricted to prestige receivers. Many listeners, obliged to use standard battery receivers, compromised by using a mains powered 'B' eliminator for HT and a lead-acid battery for the filament supply. Trickle chargers could be used to keep the batteries charged, but only between periods of radio use, for they generated too much noise and interference for float charging.



A pair of early blue Arcturus type 127 valves. As the base engraving on the left hand example makes it clear, at first these valves were restricted to detector applications.



The first indirectly heated valve was the McCullough 401, available in 1925. Soon afterwards very similar valves appeared with the Kellogg label, and then as the Canadian Rogers type 32 shown here.

Solution already existed

The methods that have been described were makeshift compromises. Valves were needed that could be lit with an AC filament supply, and it is ironical that the solution had already been around for the best part of 10 years!

Back in 1914, in efforts to tame what was originally a crude and temperamental curiosity, much research and development was going on in Europe, Britain and America into valve design and behaviour. One problem encountered was the potential drop along the length of the filament. This variation meant that only one small section of the filament operated at exactly the correct bias. In practical operation this could be allowed for by basing calculations on the mid-point voltage, but for researching the exact valve characteristics, it was an annoying complication. What was required was a *uni-potential* cathode.

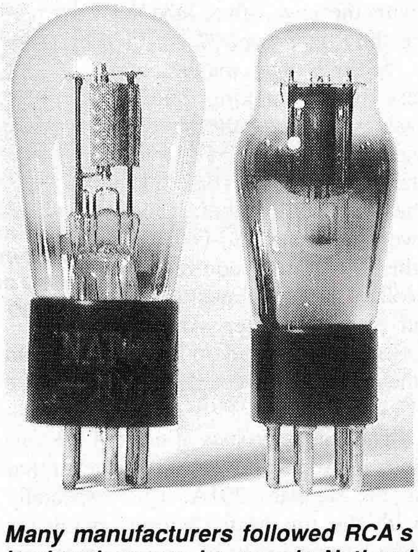
In Britain, Marconi's H.G. Round hit upon the idea of using a platinum sleeve coated with calcium oxide. This sleeve was heated by, but spaced from, a central carbon hairpin filament operating with DC. Why carbon was chosen has not been explained, but I suspect that it was to minimise any emission from the heater itself, a possibility if tungsten had been used. Round's patent was taken out in May 1914.

Meanwhile in America, A.M. Nicholson of Western Electric, having encountered a similar problem, also developed and applied for the patent in 1915 for a uni-potential cathode, again an internally heated sleeve.

There was no reference to AC heating of either of these indirectly heated cathodes, and presumably with their research work completed, Marconi and Western Electric filed their patents away. Valves continued to be fitted with directly heated filaments.

Next we come to late 1922. Hubert Freeman and Wallace Wade of Westinghouse (a part owner of RCA) applied for patents for several indirectly heated cathodes, one using a doubled-over filament with the two halves closely spaced and insulated by an inert mineral sleeve. This assembly was inserted into a metal cylinder coated with strontium and barium oxides — a construction which became the pattern for early production of indirectly heated valves.

Another Westinghouse employee at the time was F.S. McCullough, who a couple of years later set up in business



Many manufacturers followed RCA's lead and, as can be seen in National Union 27 at the left, minimised heating by using mesh anodes. The smaller stepped dome envelope on the RCA 27 at the right was introduced in 1932.

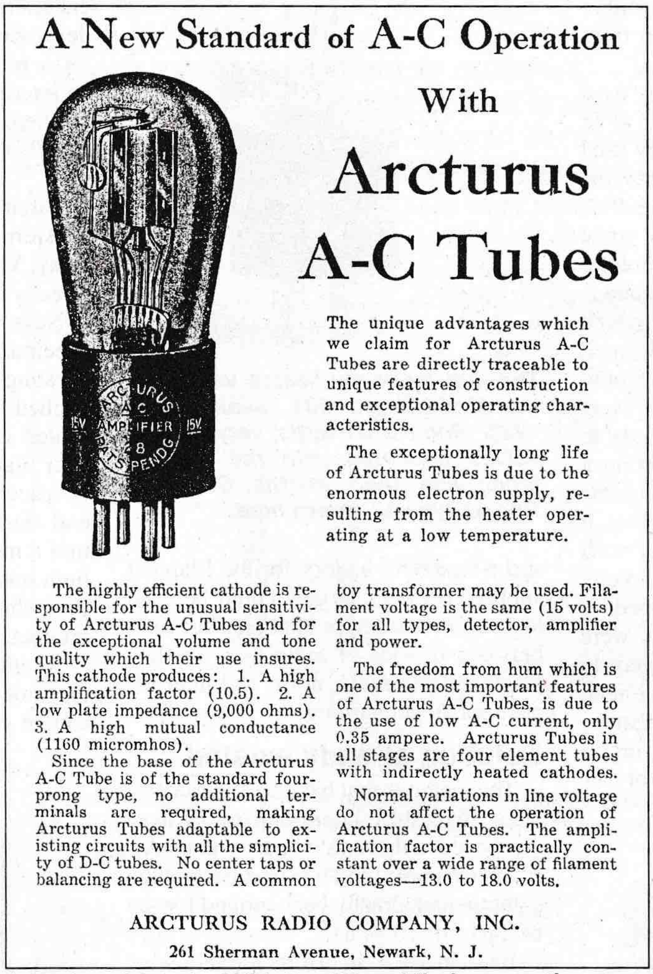
as the McCullough Sales Company of Pittsburgh. During mid 1925 he was advertising AC heated valves, which soon after were being made by the Kellogg Supply and Switchboard Co.

First AC valves

These McCullough/Kellogg type 401 valves were the first American genuine AC type, and had a most distinctive shape and construction. The standard receiving valve envelope at the time was known as the 'S' bulb, with a spherical top tapering down to the base. However the Kellogg envelope was inverted, being widest immediately above the base, and tapering to a significantly narrower top. A large Bakelite top cap had two projecting 'horns' for connecting to the heater wiring. The cathode was connected to what would have normally been one of the filament pins.

Working closely with McCullough was the Canadian pioneer Edward S. Rogers, who set up in business in Toronto and later in 1925 sold his Rogers Batteryless receivers fitted with the new valve, labelled as the Rogers type 32.

Several other manufacturers began making similar valves, some with top connectors, others with filament terminals on the base. The heaters for most these valves were rated at three volts, but the Marathon required six volts. One of the most unusual was the later Arcturus effort, with a standard four-pin base and the cathode connected to one end of the 15 volt filament.



Introduced late in 1927, the 27 rapidly became the standard indirectly heated amplifier valve; but the new five-pin base prevented its use in existing receivers. Arcturus produced this four pin version to help out.

The characteristics of most of the various indirectly valves were quite similar to the standard 201A. This, especially with the top heater wiring, enabled a simple conversion of existing receivers to mains operation — although there were practical problems as most sets used filament temperature for volume control, and thermal delay ruled this out for indirectly heated valves. It was to be a couple of years before variable cathode bias was used.

Although one would assume that royalties were paid to RCA, the question has been asked as to what they and Westinghouse, who were both normally keen litigants, and who controlled the key valve patents, were doing allowing this relative 'free for all' to go on — the more so when one of their ex-employees McCullough, was marketing a product of Westinghouse research. After all, if it worked, here was a development that could and eventually did have tremendous market potential.

One theory is that there were doubts about the eventual success of the indirectly heated cathode, which still had some serious shortcomings, and it was convenient to let independent small companies find out the problems. But as we shall see, there may have been another factor.

RCA at the time had a big stock of unsold receivers, including the mains-powered model 30 superhet mentioned previously. It was better perhaps to sit back and pick up the AC valve later when the dust had settled, and present receiver stocks were quit...

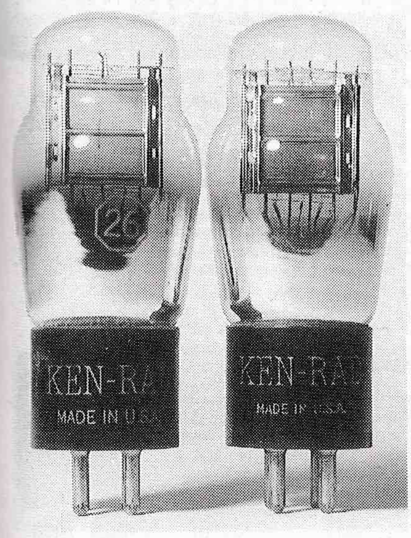
Westinghouse meanwhile continued with their development of AC valves, and in July 1925 sent some samples of a double-ended valve to RCA. The filament connector on the top appears in photographs to have been a small bayonet lamp fitting. Nothing further is reported to have happened until April 1926, when further samples were delivered to RCA, presumably for more testing. In June 1926, the new valve was given the designation of UX225.

At this stage, readers are reminded of the early American valve numbering 'system'. Only the last two digits and any suffix letters were significant. Thus UX201A, 201A, 301A and 01A all applied to the one valve. Similarly, UY227, 127, 227, 327, and 427 were all type 27.

Giant step backwards

Still there was no new RCA receiver. But three months later, in September 1926, in another strange move in the evolution of the indirectly heated valve, Westinghouse was asked to develop a directly heated AC heated valve. Obviously, the UX225 was in trouble. Two months later they delivered samples of what was none other than the reliable old standard UX201A with an oxide coated, low voltage high current (1.5 volt/1.05A) filament!

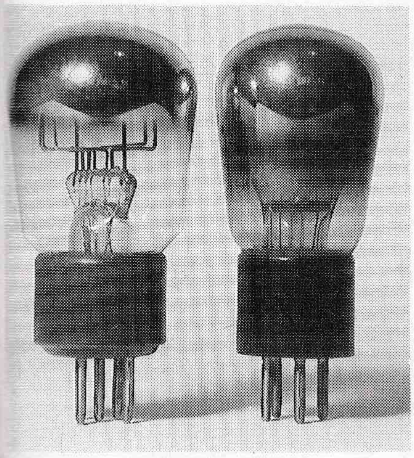
The idea was that the heavy filament would minimise thermal variations, while the small voltage would reduce electrostatic hum generation. This AC version of the 01A was in fact satisfactory for amplifier service,



This photo of a pair of replacement valves shows clearly the similarity between the parent 01A (right) and the 26. The only visible difference is the number of filament tensioners, the 26 having a simple inverted V filament while the longer filament of the 01A has an M configuration.

but it was a backward step technically, and the residual hum made it unsuitable for a detector.

There was a further a delay of more than six months until in April 1927, the indirectly heated valve was finally given the OK by RCA for detector service — although now it was single ended, with a new five-pin base and called the UY227. It become the first 'mainline' cathode type American valve, and was officially released in May 1927.



British indirectly heated valves were in production in 1927 and equivalent European valves were available the following year. At the left the valve with horizontal elements is Philips E416\5. The other is Telefunken's first mains heated valve, the REN1104.

Meanwhile, Britain and Europe were right up with the play. In January 1927, Marconi-Osram had introduced the KL1 indirectly heated triode, originally intended to have a carbon filament. Germany too was not far behind, and in 1928 Telefunken produced the REN1104.

Finally, in September 1927, the AC heated version of the 201A was announced, named the 226. At the same time, the RCA model 17 TRF receiver was released for sale. This was RCA's first receiver to use AC valves, with four of the 226 valves as amplifiers, and a 227 detector. The model 17 is generally regarded as the first receiver to use the 'mainline' series of mains heated valves.

Delays, malfunctions

It was more than two years after McCullough commenced production, and Westinghouse had made some samples of indirectly heated valves, that RCA marketed an AC valved receiver. Just why there was such a long delay has never been explained, but Alan Douglas provides a clue in volume III of *Radio Manufacturers of the 1920's*.

RCA suffered from being a large inflexible organisation, whose research and marketing sections did not always see eye to eye. Mistakes, delays and overproduction occurred that would have put a smaller organisation out of business. So enormous was the receiver inventory held over from 1925-26, that RCA skipped the 1926-27 season altogether.

There were problems with the 227. When it was eventually released, it was restricted to detector service. It appears that there were heat dissipation problems, which limited it to low anode voltage and current operation.

It will be noted that the original indirectly heated valves had small bright cylindrical anodes, much smaller in area than that of the 201A and closely surrounding the cathode — which in the case of the 227, radiated more than four watts. It is quite possible that in amplifier service, with an additional extra watt or so of anode dissipation, the grid (sandwiched between two hot electrodes) could itself have become hot enough to emit electrons.

Significantly, receivers with Kellogg valves had HT supplies limited to about 100 volts. As can be seen in the photo of the Arcturus type 127 valves, the original 'detector' version had a solid anode, but that of the later, general purpose type was perforated. For the same reason RCA 227's were fitted with gauze anodes, until in the 1930's they were given blackened solid types for improved heat radiation.

Another problem reported was unreliability of heaters, with the early examples being prone to fracture. Consequently, the common sense thing to do until the bugs were eliminated, was to restrict use of the 27 to detector service, where there was no practical alternative and where conditions were not so torrid, and use a more reliable design and lower filament wattage in the form of the 26 for use in amplifier stages. This pattern was adopted by many manufacturers keen to get into mains powered receiver production.

By 1929, the problems of the 27 were sorted out, and it became widely used as a very successful general purpose triode. Most of the independent styles soon disappeared. By the way, a consequence of the use of the type 26 for only the 1927/28 season is that dating of these receivers is particularly easy.

We have been able to provide only an outline of this intriguing story, and for readers who wish to learn more the following books are recommended:

70 Years of Radio Tubes and Valves, by John W. Stokes (Vestal Press)
History of the British Radio Valve, by Keith R. Thrower (MMA International)
Saga of the Vacuum Tube, by Gerald F.J. Tyne (H.W. Sams)
75 Years of Western Electric Tube Manufacturing by Bernard Magers (Antique Electronic Supply Co.) ❖