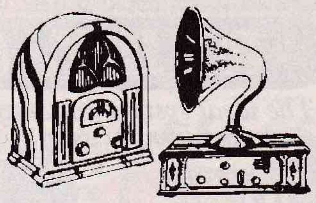
Vintage Radio

by PETER LANKSHEAR



Valve filament/heater voltages

Have you ever wondered, when searching for a replacement valve for an old treasure, why there were so many different filament voltages, and how they came to be selected in the first instance? And did you know that at one time 'air batteries' were used for filament heating?

The very first purpose built radio valves were some diodes made by lamp manufacturers Edison & Swan in 1904 to the order of Professor J.A. Fleming, the Marconi Company's technical adviser, and his order specified four volt carbon filaments. Just why he chose 4V is not known for sure, but from catalogues of the period, it is apparent that this was a popular voltage for low wattage lighting and bicycle lamps. By a coincidence it was eventually to become a major standard for valves.

The first triode valve in quantity production, the Western Electric 101A, was not intended for radio applications but was used early in 1915 for repeater service on the original transcontinental telephone line, connecting New York with San Francisco. Again, the filament was rated at 4 volts.

Incidently, the 101 series, which went through at least 10 developments was in production until 1985, 70 years later! Obviously, suitability for the job and proven performance rather than fashion, governed W.E. valve selection!

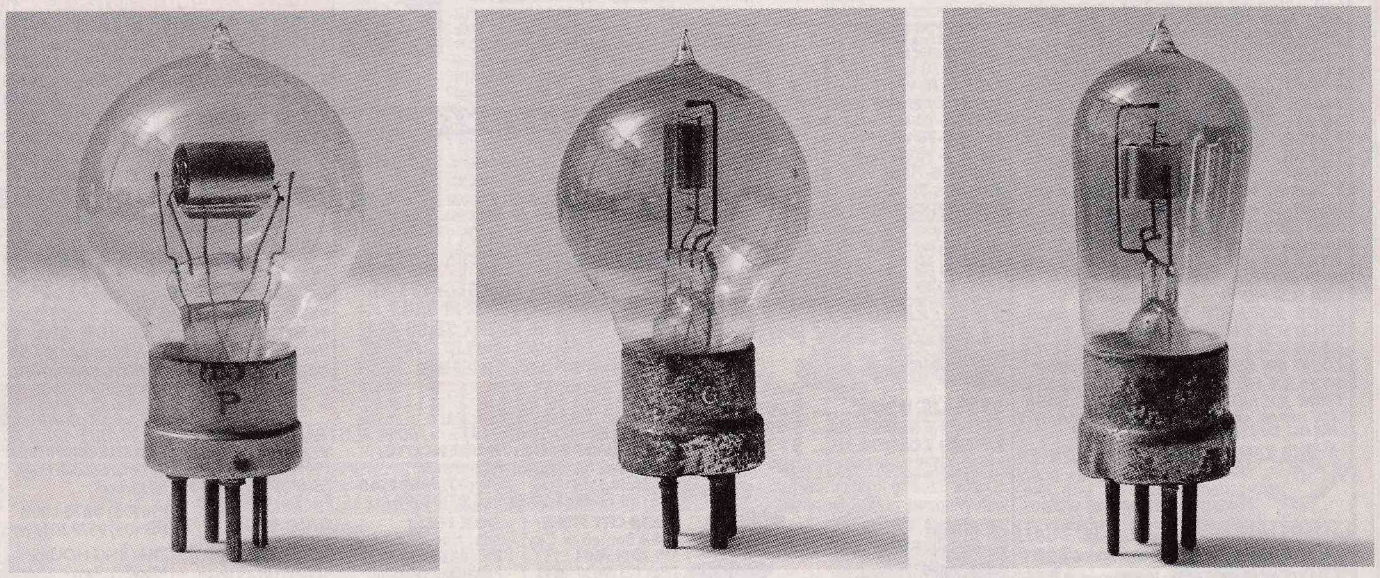
Probably the earliest standardised radio receiving triode made in any quantity was the famous type R, adapted from a World War I French design. Not only was the R valve made in large quantities by several manufacturers, but from it further types were developed to become the first generation of valves used in domestic receivers.

The pure tungsten filament of the R valve was a relatively inefficient emitter of electrons, requiring about three watts of heating. This is far too much for dry cells, especially with multi valved receivers. Some primary cells such as the bichromate type might have might have been adequate for lighting one or two valves, but the lead/acid accumulator was by far the most satisfactory source of filament power. A two-cell 4.0 volt battery was a convenient and available size and at this voltage, the current for drawn by one R valve filament was about 0.75 amperes.

Landmark valve

A landmark in American valve development came in late 1920, with the production by General Electric (for the newly formed RCA) of the UV201 and its companion gaseous detector, the UV200. A fuller account of this valve, and its successor the UV201A, which held a preeminent position for most of the 1920s, was given in this column away back in April 1991. Like the R valve, the UV201 had a pure tungsten filament, and, with performance a major consideration, this was given a generous rating of no less than five watts! There was no possibility of these valves being lit from dry cells.

In America, with its healthy economy and the activities of manufacturers like Henry Ford, the motor car indus-



These first three photos are of direct developments from the French R valve. At left is a Philips ZI, practically identical in appearance to the R, but with a higher anode voltage rating. Centre is the Mullard type K, with the electrode assembly vertically mounted, while at right is the Mullard ORA (Oscilates, Rectifies, Amplifies) — a small bulb version of the K, also dating from 1920. Note the absence of silver gettering in the R type valves, which had pure tungsten filaments operating at about four volts.

try, with an electrical system standard of six volts, was thriving. Automotive secondary batteries were therefore readily available and convenient for lighting the new radio valves. As each valve would need a current of the order of 1A, an allowance was made for a significant voltage drop in connecting leads, receiver wiring and for reduced voltage when the battery was nearing the fully discharged condition. Accordingly the filament rating of the UV201 was set at 5V at 1A.

It was usual then to have individual filament control series rheostats for adjustment, and to judge actual operating voltage, little windows were commonly provided in receiver front panels. The idea was to compare filament colour with that of a standard incandescent lamp, as a guide to correct operation!

During the early and mid 1920's, the American scene was dominated by the '01A and '99. In contrast with the pure tungsten filament valves, these thoriated tungsten types needed heavy gettering.

Within a short time of its introduction, the UV201 was superseded by the UV201A which had a considerably more efficient thoriated tungsten filament. Although the current was dramatically reduced to 250mA, the voltage remained unchanged at 5.0V. The number of '01A valves made worldwide is reckoned by some authorities to be the largest of any valve type — ever. Inevitably then, 5.0V became the standard voltage for storage battery triodes introduced during the 1920s. Quite incidentally it was later to become perpetuated in a quite different series of valves.

Low consumption valves suitable for dry battery operation were developed during the 1920s. Most popular in America was the little '99, with a 3.0V, and later, a 3.3V 60mA filament intended for operation from three series connected dry cells with an end voltage of 1.0V for each cell. Very similar valves to the '99, but not so widely used, were the '11 and '12, which had 1.1V/250mA filaments. None of these voltages was used for valves developed after 1927.

A companion to the original '200 and '201 valves was the '202, a small transmitting triode. This had a 7.5V filament, a voltage that shortly later was used for the '210 triode, the '216(A) and '216(B) and '281 rectifiers, and then the massive '250, the first of the big output triodes that are still popular with dedicated high quality sound enthusiasts. The 7.5V filament was not used further, although it survived with small transmitting valves.

Rectifier standard

Early on in the history of broadcast receivers, mains power supplies were used to eliminate anode supply or 'B' batteries. Although electrolytic and copper oxide rectifiers had some success in these supplies, the future clearly lay with valve rectifiers, and in 1925, General Electric developed a small double rectifier, the UX213.

This was a similar sized valve to the '01A, and similarly was given a 5V filament. However, at this time, developments in radio were rapid and within a short time, an uprated replacement superseded the '213, and retained the same filament rating. This was the well known type '80 — which especially as the octal 5Y3 version, was to continue to be available for as long as valves remained in production. The 5V filament was to be used as a standard for a wide range of American rectifiers.

There remained one more major voltage standard to appear in America before 1930. As we related in this column for last November, the process of evolution of the mains powered valve initially created some odd filament voltages, but with the wide acceptance of the new type '27 triode, 2.5V was adopted as the filament supply standard for mains powered radios. It is likely that 2.5V was selected as it was considered desirable in the interests of hum reduction to keep voltages as low as possible, and halving the previous standard of 5V seemed as good a figure as any.

To summarise the American valve situation in 1929, there were the recently introduced AC valves were rated at 2.5V which were a considerable improvement over the existing obsolete battery valve range. This consisted of three or four triodes with 5V/250mA filaments and for dry cell operation, there were, with 3.3V filaments, two triodes and the pioneer screen grid type '222. It was clearly time to produce some modern battery valves.

Meanwhile though, we will return to Britain, where car ownership was much less common than in America. Here small accumulators were specifically made for radio and usually could be readily charged. In contrast with the American scene where the domination by RCA meant that there were relatively few valve types, there were in the early 1920s many British valve manufacturers making a wide range of valves with little standardisation, and filament ratings varied from 1 - 6V.

From around 1925, however, with the general adoption of oxide coated filaments to replace thoriated tungsten, there was a rationalised production. Unified families of valves were produced in 2V, 4V and 6V filament ranges and in making a 2V range, they were ahead of the Americans. Very popular in Australia and New Zealand was the Philips 'Point One' series. The name referred to their filament current, and these valves could be used as economical substitutes for the high current American 5V valves.

Battery eliminators were also popular in Britain, and from 1927 a range of rectifiers became available. Whereas at this stage the Americans concentrated on the '80, English manufacturers had by 1930 produced at least 20 different rectifier types, varying in filament voltage from 4 - 7.5V.

By 1929, the British were concentrating on 2V filaments for battery powered valves. Furthermore, they were not far behind America in producing indirectly heated AC heated cathodes. And whereas previously English filament voltages had been a bit chaotic, apart from a couple of experimental Osram triodes all makers standardised on 4V heaters and AC filaments.

Many receiver manufacturers used 4V valves right up until WWII, and it was only after the fanfare accompanying the American octal valves in 1935, that there was a British and Continental move to what eventually became the international standard of 6.3V.

New valves, battery

By 1930, the American battery valve series was, as we have previously noted, thoroughly out of date. In that June RCA announced a new series of economic valve. These were the 230 general purpose triode, the 231 low-mu output triode and the 232 screen grid tetrode.

America thus now had 2V battery valves, and with a 120mA filament, the '31 required only 270mW compared with the 1.25W of the '71A it replaced. This was a dramatic reduction in filament consumption, and the improvement with the other two valves was even more impressive. They had 60mA filaments, consuming only one eighth of a watt.

The 2V valves did not, in some instances, work out quite as well in America (or in Australia and New Zealand for that matter) as they had in England, as for many US radio users there was a significantly different situation. Many could not use lead-acid batteries, because living remotely from any large town, they were not able to trot off with a filament battery to a handy radio shop or garage for recharging.

One rough and ready solution was to use a car battery, one cell at a time; but this still needed charging, and the idle sections could deteriorate between charges.

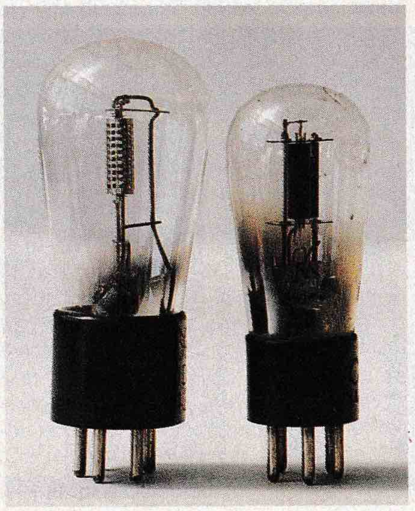
Unfortunately there is no combination of dry batteries that can provide 2V, and anyway these have a poorer voltage constancy than lead-acid batteries. To operate safely from a two-cell dry battery, which steadily drops in voltage throughout its life, a receiver needed an adjustable series resistor in the filament line, and ideally a voltmeter as well.

The air cell battery

Shortly after their introduction, the National Carbon Company announced the unlikely sounding Eveready 'Air Cell Battery' for the new valves. About the size and shape of a car battery, the air battery, like modern alkaline batteries, provided a much more constant voltage than the dry cell.

A useful feature for remote localities was that it was inert until its two 1.25V cells were activated by the addition of about 3.5 litres of water to dissolve the appropriate amount of sodium hydroxide (caustic soda) electrolyte. The negative electrodes of each cell were a pair of heavy zinc plates with a positive electrode made of porous carbon, with its upper end in contact with the air — which provided oxygen as a free depolariser.

When current was drawn from the battery, the zinc electrodes reacted with the electrolyte to form sodium zincate and hydrogen. The hydrogen migrated to the carbon electrode, where it combined with oxygen from the air to form water. Provided that evaporated water was replenished, and the battery was run within its ratings, its capacity was an impressive 600 ampere-hours. According to Eveready, this was equivalent performance to that from three dozen No.6 cells.



Two historically significant indirectly heated triodes were, at the left, the 2.5 volt 227 and with very similar characteristics, the 6.3 volt 237.

The New Zealand price in 1939 for an air battery was 55 shillings ($5.50), while 36 No.6 cells would have cost 90 shillings ($9.00). Melbourne's Vealls Radio and Electrical Catalogue for 1935 lists a range of 'AD' (air depolarised) batteries ranging from 60 to 500 ampere-hour capacities, plus a full set of separate components for rebuilding batteries. These seem to have been an 'in house' type using sal ammoniac (ammonium chloride) rather than caustic soda for the electrolyte.

Australian specials

Regardless of any difficulties in lighting the filaments, the 2V filament range of valves expanded in both Britain and America during the 1930s, and in Australia the Amalgamated Wireless Valve Company developed a series of 2V valves suited to local conditions. These required twice the filament current of the standard series, but had performances approaching that of indirectly heated cathode valves.

From the earliest days of broadcasting, enthusiasts had combined the hobbies of radio and motoring, and some very haywire and impractical lashups resulted. However, in the late 1920s, serious efforts were made to produce practical car radios, and naturally the car's battery was used for lighting the filaments.

Directly heated valves were microphonic and subject to electrical system noise, especially for the RF and detector operation, but the indirectly heated 2.5V valves were much more successful. It was found that although three valves with series connected heaters were under run when lit from a car battery, performance was nevertheless promising.

It was only a matter of time before some enterprising manufacturer brought out valves which could be used with car electrical systems. In May 1931, National Union won the race with a series of valves with 6.3V/400mA heaters. These were the NY64, NY65, NY67 and NY68. The first two corresponded to the standard '24A and '35 screen grid tetrodes, the NY67 was equivalent to the '27 triode, and the NY68 was a new development — an indirectly heated output pentode.

A couple of months later RCA brought out a landmark series of equivalent valves, but with important differences. The 236 was the sharp cutoff tetrode, the 237 the triode, and the 238 was, like the NY68, an output pentode. Completely new was the innovative 239, the first variable-mu RF pentode. The whole series had the new space saving small S12 bulb, but of greatest significance was their 6.3V/300mA heater rating.

A lead-acid battery's voltage varies considerably, depending on its condition, degree of charge and charging rate, but as a compromise, 6.3V was set as the design centre voltage for use with automotive batteries. The pre-war American car electrical system can therefore be said to have been responsible for what eventually became the international standard heater voltage for valves, and accounts for the apparently odd value of 6.3V.

Direct mains operation

With the 300mA rating and indirect heating of the new valves, another type of receiver became a practical proposition. Direct current mains were common worldwide, and although they could be used for HT supplies, heating of existing valves provided considerable difficulties. Filamentary valves introduced too much noise from mains born interference, and the 1.75A required by a string of 2.5V valves was very inefficient, as even with 110V mains, dropping resistors needed to dissipate around 175 watts.

The new 300mA automotive valves reduced this to about 25W, a much more practical value, and these transformerless receivers made mains operation possible in DC mains areas. Fitted with rectifiers, these radios became especially popular in 110V AC as well as DC areas as budget priced sets. Although for higher voltage mains, more heat had to be dissipated, the transformerless receiver nevertheless filled a need.

For rectifier and output valves, the approximately 2W of heating provided by the 300mA heater was insufficient for larger output valves and rectifiers. For 6.3V operation the current rating of these valves was increased, but for series-connected filaments, 25V 300mA heaters were developed. Eventually, quite a range of voltages, even up to 117V could be found for output valve and rectifier heaters. After all, the excess heat might just as well be dissipated in a valve as in a resistor.

A further development was to reduce the current to 150mA and double the basic voltage to 12.6V. Eventually, with the advent of television, series operation of heaters became very common.

During the 1930s the British standard voltage for transformer equipped receivers remained at 4V for all types of valves, but series-connected valves intended for transformerless sets were also developed. Typical was the Philips C series of 200mA heaters, popular in Australia.

Following the initial success of the 6.3V valves, the range was soon extended to include valves such as the 78 RF pentode and the 42 output pentode that were to become established favourites.

In fact, for a while, the 2.5V valves, which were the still the standard AC mains series, were left behind, but this situation was soon redressed and equivalents were produced in both series, and many were identical apart from the heater voltage. Thus the 6.3V type 42 had a 2.5V counterpart in the 2A5, and the 75 diode high-mu triode the 2A6. Some later pairs, including the 2B7/6B7 and the 2A7/6A7 were introduced simultaneously.

Germany's Telefunken were making indirectly heated valves very soon after America, but with 4V heaters. This REN1004 dates from 1928.

Duplications

Although the 2.5V series was established as the AC mains standard, there was a minor problem, especially with the earlier 1.75A types. Heater current for a large receiver could be in the region of 10A. Not only did this require extra heavy heater wiring, but suitable transformer windings used large wire gauges which can be difficult to handle in winding.

Nevertheless, until the mid-1930s most manufacturers, here as well as in America, used the 2.5V series for AC mains transformer equipped receivers. A few however, notably among them Philco, as soon as the 6.3V series became available, successfully switched to them for all mains and car receivers. With the performance of 6.3V valves proven, there was little point in duplication, and the last new 2.5V designs appeared in 1933.

The advent of the octal valves in 1935 finally provided a universal standard, and by the outbreak of World War II in 1939, the 6.3V heater was firmly established world wide, and remained thereafter as the international standard voltage.

And finally...

There remained one more voltage to become a standard. Although 'non spillable' accumulators did receive some acceptance, liquid filled lead acid and air batteries were not very practical for portable receivers, and during the late 1930s it was increasingly apparent that there was a considerable need for filaments that could operate from a single dry cell. This was not easy as the voltage of a dry cell varies during its working life from more than 1.5V to about 1.0V.

The problems were solved with improved filaments designed for a median of 1.4V. At first, the new valves had octal bases and then in 1940, RCA released the revolutionary new seve-pin button based series of miniature 1.4V valves. These were used in great numbers until they were eventually supplanted by semiconductors.

This has been a very brief outline of a significant aspect of valve history. It has only dealt with the major developments, and there were many other voltages and might-have-beens. For readers interested in the subject in greater depth, the following books are reference standards and are all good reading:

70 Years of Radio Tubes and Valves, by John W. Stokes.

History of the British Radio Valve to 1940, by Keith R. Thrower.

Saga of the Vacuum Tube, by Gerald F.J. Tyne. ❖