



Rejuvenating valves

A major advantage of semiconductors is that normally they don't wear out. Valves, of course, slowly lose their cathode emission to the point where they are eventually unservicable. Of interest to the vintage radio enthusiast was the Serviceman's column in the July 1991 edition of *EA*, which included a story about reviving a tired old 6V6G valve by a method sometimes used to extend the life of black and white TV picture tubes.

Now that manufacture of valves has virtually ceased, any method of extending their life is clearly worth investigation. Accordingly I carried out some experiments with a selection of valves to see how effective the 'picture tube' method was. More about my results shortly; first some background.

The conventional oxide-coated cathode was patented by Arthur Wehnalt in 1904, but exactly how it operates is imperfectly understood and manufacturing processes have not been widely published. I did however, find a description in *Fundamentals of Radio-valve Technique*, published by Philips in 1949.

During manufacture, the emitting surface of a cathode is coated with a mixture of 'rare earth' carbonates — primarily barium but including others like strontium and calcium — which, during evacuation of the valve are decomposed to oxides. At completion of evacuation, the

valve is not 'activated' but must be 'burned out' or 'seasoned'. This involves operating the filament at up to double its normal voltage, and connecting the grids and anodes to a positive voltage supply.

The electron flow from the cathode steadily increases during this process, and after a while, the control grid voltage is reduced, reducing the electron flow. The filament voltage is then further increased for a period, until the valve is fully activated. Very important is the presence in the oxide coating of small amounts of metallic barium and strontium, which contribute significantly to the emitting properties of the cathode.

Why do valves wear out?

There appear to be two reasons for the eventual loss of cathode emission. Most commonly, there seems to be a gradual 'wearing out' of the cathode coating, at a rate related to the anode voltage and cur-

rent. Despite the importance of this phenomenon, I have not been able to find an explanation of exactly what happens to the coating; but valves operating well within their limits can generally be expected to provide the longest service.

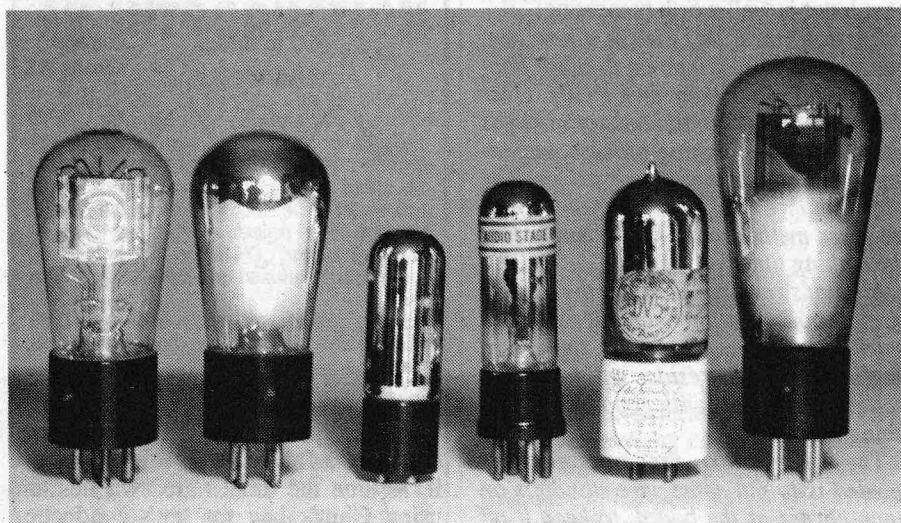
Whereas the fine filaments in battery valves had a life expectancy of about 1000 hours, at the other end of the scale, special quality industrial types made under rigid conditions were guaranteed for 10,000 hours. A special run by Western Electric of their 175HQ valves for a submarine telephone cable gave an actual continuous service life of 22 years, or 190,000 hours. When expense was no object, very long lives could be achieved.

Cathode poisoning

The second reason for loss of emission seems to be better understood. Valves operating at zero or very low anode currents can suffer from premature failure, from what is known as 'cathode poisoning'. This condition results from the absorption of minute traces of water vapour and oxygen left behind in the evacuation process, and it is likely that the metallic components in the cathode coating are oxidised. Some industrial valves likely to be operated for long periods at zero anode current were given special degassing, to minimise the risk of cathode poisoning.

A valve which no longer has sufficient emission is usually discarded, but the cathode-ray tubes used in 'black and white' TV receivers, with essentially the same cathodes as valves, were expensive and various ways to extend their lives have been explored.

One common means of getting more 'mileage' was to increase the heater voltage by about 25%, but another method



Some common valves with thoriated tungsten filaments. From left to right are the 200A, 201A, UV199, 120, DV5 and 210. Note the absence of reflective 'gettering' in the unique gas-filled 200A.

called *rejuvenation* was also widely used. In its crudest form this consisted of progressively applying up to about 50% excess filament voltage and applying mains voltage via a low wattage lamp, between the cathode and the other electrodes connected in parallel. As the lamp started to glow, the filament voltage was backed off and the process repeated until the lamp would still glow at the rated filament voltage. At this stage, cathode emission was often found to have been significantly improved.

Trying it out

This somewhat brutal treatment is fundamentally the same as the burning-in during in manufacturing, and to test its effectiveness with ordinary valves, a test rig was assembled.

First a row of various valve sockets was mounted on a baseboard, and wired so that all grid and anode pins were paralleled and connected through a low wattage 230-volt lamp to a 250V transformer winding. A 5-watt lamp was used with low current valves, and a 15-watt lamp for output valves. The other side of the winding was connected to the cathode pins.

Although a tapped winding could have been used for the filament supply, a 'Variac' variable transformer was available to control the primary of a transformer with 6.3 volt and 5.0 volt windings connected in series.

Although I normally throw out low-emission valves, I found sufficient representatives of various types to experiment with. Filament voltage was slowly advanced until the lamp glowed, often accompanied by spluttering and flashing from the cathode. The filament voltage was immediately reduced until the lamp was extinguished, and then was again advanced until the lamp again glowed — and so on, until there was no change in the filament voltage at which the glow commenced.

The results

The results are listed in Table 1. The first three valves were directly heated type 45 output triodes. Number 1 remained practically unchanged, number 2 was degraded and number 3 was improved slightly, but still nowhere near new performance.

Three very early indirectly heated valves, type 27 general purpose triodes, were next. The results here were more encouraging, with significant improvements, although full performance was not achieved.

Results with three 2A5/6F6G output pentodes were poor, with one expiring

MEASUREMENTS WITH AVO MARK IV VALVE CHARACTERISTICS METER

SAMPLE NO.	VALVE TYPE	VALVE CHARACTERISTICS					
		RATED		INITIAL		AFTER TREATMENT	
		Gm	PLATE Ma	Gm	PLATE Ma	Gm	PLATE Ma
1	45	2.10	34.00	0.68	10.00	0.68	11.00
2	45	2.10	34.00	1.20	13.00	0.80	11.00
3	45	2.10	34.00	0.90	9.50	1.10	12.00
4	27	0.90	5.20	0.35	2.00	0.40	3.50
5	27	0.90	5.20	0.20	1.60	0.50	2.10
6	27	0.90	5.20	0.10	0.95	0.60	2.80
7	2A5	2.50	34.00	1.00	10.00	**	**
8	6F6G	2.50	34.00	*	0.25	*	1.75
9	6F6G	2.50	34.00	0.85	8.50	0.85	10.00
10	6V6GT	4.10	45.00	0.60	7.00	0.20	7.00
11	6D6	1.50	8.00	0.70	5.20	0.70	5.20
12	DH63	1.20	1.10	0.10	0.50	1.10	1.10
13	75	1.10	0.90	0.50	0.60	1.00	1.00
14	2A6	1.10	0.90	0.75	0.55	0.75	0.55
15	2A6	1.10	0.90	0.15	0.50	1.10	1.00
16	2A6	1.10	0.90	0.45	0.35	0.85	0.50

* TOO LOW TO MEASURE
** VALVE DID NOT SURVIVE

Table 1: The results achieved by the author with his experiments to investigate rejuvenation of oxide-coated cathodes. Really successful results were obtained with the valves listed as number 12, 13, 15 and 16.

completely! Unlike the 6V6 involved in the July article, mine, number 10, did not respond. Neither did number 11, a standard 6D6 RF pentode.

Finally, numbers 12 to 16, the group of five double-diode high-mu triodes were much more successful, with three regaining full performance.

Conclusions

Although results with the high current output valves were disappointing, the lower current triodes recovered to a degree. But the recovery of some of the high-mu triodes was excellent, and similar to the results that can be achieved with TV picture tubes.

There is a possible explanation for the different results. Whereas the output valves were 'worn out', I suspect that the original loss of emission of the high-mu triodes and picture tubes was not due to wearing out of the oxide coating, but cathode poisoning. These tubes operated at low anode currents, in the case of the triodes only a few hundred microamperes, over a long period and this was possibly insufficient to keep the metallic barium from oxidising. In this situation the rejuvenation technique is successful, as it is similar to the seasoning process when the barium layer is formed during original manufacture.

Valves with thoriated tungsten filaments

There is obviously a challenge for further research into rejuvenating high anode current valves with oxide coated cathodes. But the good news is that the revival of thoriated tungsten filaments is an old established practice, and is re-

markably successful. The process is quite different from that just described, however.

During the early and mid-1920's, valves with thoriated tungsten filaments dominated American radios — the best known example being the 201A. They were very popular in Australasia and to a certain extent in Europe.

Thoriated tungsten filaments are quite unlike the familiar oxide coated type. They operate at the high temperature of 1800 - 1900K or bright yellow, and good emission depends on the presence of a molecularly thin layer of thorium on the surface of the tungsten. This thorium layer is relatively fragile and disappears during normal use or the application of excessive voltage. Fortunately, restoration of full performance is quite easy.

Alert vintage radio enthusiasts can today benefit from this characteristic. Collections of early equipment often contain low emission thoriated tungsten filament valves, which were put to one side by owners who did not realise that they could be rejuvenated.

Never discard this type of valve without first trying restoration! From my own experience, provided that there are no shorted or loose elements, and that the filament and vacuum are intact, restoration techniques to be described have at least a 90% success rate — frequently restoring the valve to full performance. They can also be applied several times.

Two approaches

The first method, described on the information sheet supplied with RCA valves, is to disconnect all plate supplies and operate the filament at full voltage

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for 20 minutes or so. Often this will be sufficient restoration.

In many cases however, a stronger method is needed. First the filament is 'flashed', or heated to a much higher temperature than normal to bring thorium to the surface. Then the filament temperature is reduced somewhat and 'seasoned' for half an hour or so. During restoration it is most important that no plate supplies are connected.

Guide table

Figures for valves most likely to be encountered are given in Table 2. At first sight, flashing the filament at more than double normal voltage must appear to be guarantee for a burnout, but the positive temperature coefficient of tungsten acts to limit current. In reality the temperature during flashing is no greater than that of a tungsten filament lamp, and the

oxide-coated filaments and of course, these cannot be flashed. Obviously, careful identification is essential.

There are two clues. As thoriated tungsten filaments are very sensitive to gas, a considerable amount of 'gettering' was always used. Consequently, with the exception of the 200A gas-filled detector, it is difficult to see much of the interiors of these valves as most of the internal surface of the glass has a heavy mirror coating. However, a large area of gettering alone is not a guarantee of a thoriated tungsten filament.

An important confirmation is the colour of the light from the filament. At the correct voltage, oxide filaments glow a dull red or orange, whereas the light from thoriated tungsten filaments is a *bright yellow* and illuminates much of the interior of the bulb.

For valves not listed, filaments should

THORIATED TUNGSTEN FILAMENT REJUVENATION

VALVE TYPE	FILAMENT		FLASHING		AGEING	
	VOLTS	AMPS	VOLTS	SECONDS	VOLTS	MINUTES
UV199, UX199	3.3	0.06	12.0	10 TO 20	4.0	15 TO 60
C299, CX299	3.3	0.06	12.0	10 TO 20	4.0	15 TO 60
AWA33, AWA99, 99X	3.3	0.06	12.0	10 TO 20	4.0	15 TO 60
DV-1, DV-3, DV-3A	3.3	0.06	12.0	10 TO 20	4.0	15 TO 60
UX120, CX320	3.3	0.125	12.0	10 TO 20	4.0	15 TO 60
UV'01A, UX'01A	5.0	0.25	16.0	20 TO 30	7.0	10 TO 60
AWA101A, AWA101X	5.0	0.25	16.0	20 TO 30	7.0	10 TO 60
PHILIPS C509	5.0	0.25	16.0	20 TO 30	7.0	10 TO 60
DL-2, DV-2, DV-5	5.0	0.25	16.0	20 TO 30	7.0	10 TO 60
UV'00A, UX'00A	5.0	0.25	16.0	10 TO 20	7.0	10 TO 60
UX240, CX340	5.0	0.25	16.0	10 TO 20	7.0	10 TO 60
171, 371 (NOT 71A)	5.0	0.5	16.0	10 TO 20	7.0	10 TO 60
210, 310	7.5	1.25	NO	FLASHING	10.0	2 TO 15
213, 313 RECTIFIER	5.0	2.0	NO	FLASHING	7.0	10 TO 60
216B, 316B " "	7.5	1.25	NO	FLASHING	10.0	10 TO 60

Table 2: The recommended rejuvenation conditions for the more common valve types which have a thoriated tungsten filament. Note that the 'flashing' technique can only be used with this type of valve. Other types of filament will be destroyed.

risk of a burnout is slight.

Provided that there is accurate metering, either AC or DC filament voltage is suitable. A comprehensive valve tester is ideal, but a tapped transformer or variable bench supply is fine.

Identifying candidates

It is most important to note that only thoriated tungsten filaments can be rejuvenated by 'flashing'. Any other type of filament will be destroyed. As well as the valves listed in Table II, some English and European valves made during the early 1920's also had thoriated tungsten filaments, but detailed information is hard to find. BE WARNED!

Replacements for thoriated tungsten types made during the 1930's often had

be flashed for 30 seconds at 250% of normal voltage and then aged at 125% for about 30 minutes.

Some very early valves had pure tungsten filaments, and like oxide-coated types, these will be destroyed by flashing. Such valves can be recognised by the absence of gettering, and the filament operating at full lamp brilliance.

So there it is. Both oxide-coated cathodes that have operated at low currents and thoriated tungsten filaments respond to rejuvenation. Results with other types are not so consistent. Clearly there is plenty of opportunity for further investigation into this increasingly important aspect of vintage radio.

I'd be happy to hear from anyone able to provide further information. ❖