How to substitute for valves that are no longer available

A big problem for anyone restoring vintage radios is obtaining new valves, particularly for very old sets. In this article, we describe how it is possible to substitute valves with similar characteristics and even eliminate rectifiers while still maintaining an original appearance.

From time to time, vintage radio buffs find that they don’t have a particular valve that is used in a very old, little known model made by an obscure manufacturer. For example, where would you get an A141 valve? Never heard of it! They are very rare and some others are even rarer. A 49 MAY be able to replace it, although its characteristics are quite different and so the result of replacing the A141 with a 49 is uncertain.

Having exhausted all practical avenues to obtain a valve, what do you do? The only practical alternative is to fit a close relative of the valve. This may involve some modifications to the set, although it is desirable to keep these to an absolute minimum to maintain originality.

Selecting a replacement

Manufacturers had the habit of designing many types of valves which had similar but not identical characteristics. One manufacturer would produce an XYZ valve with specific characteristics and then another manufacturer would produce valve ABC, similar but not the same – either the base wiring was different or the characteristics varied just a little. Toward the end of the valve era though, manufacturers used a lot more sense and built virtually identical valves but with their own label (AWV, Philips, Mullard, etc). I imagine they had some sort of licensing agreements to cover this.

Some valves were still only available from one manufacturer, such as the 6BV7 from AWV. Even some “identical” valves from different manufacturers are not the same under certain circumstances. Take the 6DQ5, for example. This was used in early American colour TV sets as the horizontal output valve. Certain characteristics were designed into the valve and one of the most important was its ability to draw many hundreds of milliamps in pulse mode – which its function as a horizontal output valve requires it to do.

Now single sideband (SSB) radio transmitters operate virtually in pulse mode due to the peaky nature of the human voice. An American manufacturer of amateur radio transceivers decided to use the 6DQ5 as the power amplifier (PA) valve in some of its early single sideband (SSB) transmitters. The 6DQ5 was considerably cheaper than similar transmitting...
photographs and its ability to draw high current for short periods was ideal for use in SSB transmitters. The transmitters worked well until the 6DQ5 needed replacement. If replaced with the same brand all was well but if another brand of 6DQ5 was substituted, the output power was low and the valves had a short life.

If they were “identical” why was one valve so much better than the other? The reason for the difference was that the valves were designed for horizontal output (flyback) in a TV set running at roughly 16kHz and each brand met those design parameters. But while one particular brand of 6DQ5 might have been adequate for SSB use (by good fortune), others were only suitable for TV use.

Valve data books

The best way to find out which valve can be used as a replacement for an unobtainable valve is to look up a valve data book. Preferably, the data book will have all the performance graphs so that the characteristics of all the likely replacement valves can be compared. To the average vintage radio buff that is a lot of hard work and in most circumstances, it is not necessary.

A valve data book such as the “Miniwatt Technical Data” (7th edition best) gives abridged specifications and this data is usually enough to determine whether any particular valve can replace another. However, it doesn’t have much on very old valves. If you think that you may have to do much substitution work, get as many valve data books as you can, particularly early ones or reprints of early ones.

The 6V6 and equivalents

Now let’s look at some comparisons. Take the ubiquitous octal-based 6V6, for example. Checking in the data book, it can be seen that the 6V6 has the same ratings as variants 6V6G, 6V6GT, 6V6GT/G and 6V6GTA. These are plug-in equivalents but due to the shape of the glass envelope, some may not physically fit into the set. (GT stands for glass tubular envelope).

Now consider the 6BW6. This is a 9-pin miniature type and the data says “* For data and notes refer to type 6V6G”. But it is not likely that you will replace a 6V6G with a 6BW6 as it is less common than the 6V6G, having
been used almost exclusively by STC. The 7C5 is also identical in characteristics to the 6V6G – but where would you get a valve socket for it?

Then we could consider the 6AQ5 and 6AQ5A. The first few lines of information are the same as for the 6V6G but following data is different. The differences are mainly due to the fact that the 6AQ5 is physically a smaller valve and is derated so that it doesn't get too hot and melt down.

So there we have four physically different valves that are electrically identical in many ways but may or may not be suitable for substitution, depending on the set and its circuit.

Most restorers would rather use valves that look similar to the originals if at all possible. Let's see what octal-based valve could be used to replace the 6V6. The following could be considered:

- 6EY6 plug-in, greater heater current and requires more bias;
- 6F6G plug-in, greater heater current, requires more bias and a higher impedance plate load;
- 6K6G plug-in, less heater current, requires more bias and a higher impedance plate load;
- 6L6G plug-in, greater heater and plate current, lower impedance plate load;
- 6W6GT plug-in, considerably more heater current but approximately the same bias and plate impedance;
- 6Y6G plug-in, considerably higher heater current, higher plate current, lower plate voltage and plate load impedance.

So there are six possible plug-in valve types that could possibly be used in place of the 6V6GT. Some would have to be crossed off the list as the extra heater current may stress the power transformer too much. Bias would need to be altered in most cases and the audio output speaker transformer impedance may need to be altered.

In another example, the 42 valve can be replaced by the 6F6G if the socket is replaced. And with slight alteration of the operating conditions, the 6V6GT could replace the 42. So by doing a bit of research backwards and forwards through the data, it is possible to determine if and what valve could replace that "hard to get" one.

**Alternative RF and IF valves**

RF (Radio Frequency) valves are another area where alternative types may need to be used. This time we'll look at possible octal replacements for the remote cut-off 6U7G. For those new to valves, "remote cut-off" means that the gain of the valve is gradually reduced as the negative bias on the grid is increased. The 6U7G valve can be considered to be cut off and not amplifying when a bias of -50V is applied to the grid. Valves such as the 6U7G are very suitable for use in circuits that have automatic gain control (AGC).

The 6K7G is a plug-in closely similar to the 6U7G, with the 6S7G being somewhat similar. The 6AR7GT, 6B8G and 6G8G are all duo diode RF remote or semi-remote pentodes but the socket would need rewiring to suit. The 6SF7, 6SG7, 6SK7 and 6SS7 are all single-ended valves but could be worth considering too.

Of course, the large 7-pin 2B7 and 6B7 valves may need replacement too. They are electronically the same as the 6B8G but the heater of the 2B7 is 2.5V. If you are really hard up and have suitable valve sockets the 7V7, 7R7, 7H7, 7E7, 7B7, 7A7 and 7AH7 would also be possible replacements.

Perhaps the set uses one of the duo-diode/pentodes with all elements in use and you only have a straight pentode to replace it. The straight pentode can be put in the rewired socket but it would then be necessary to use either a couple of germanium or silicon signal diodes to do the work of the diodes from the defunct valve.

**Sharp cut-off octal and large 7-pin base RF pentodes** are sometimes used in receivers but are not usually connected to AGC lines. Once again, by going through the data book, various replacement valves will be found. The 6f7 and the 6SH7 octal valves are probably the most common of this type, although there are a few others to consider such as 6SE7GT and 6W7G.

**Replacement converter valves**

Converter valves are probably more of a worry, as they tend to become faulty more regularly, being a family of valves with quite complex internal structures. A common converter valve is the 6J8G and 6J8GA triode-heptode. Note that the GA version has a 0.45A heater filament whereas the G version requires only 0.3A.

The only other relatively common triode-heptode is the 6AJ8 9-pin miniature, arguably the best of the converter valves. The 6K8G triode-hexode can be plugged in place of the 6J8G and works satisfactorily even though it is slightly different internally. In 9-pin miniature triode-hexodes, the options are 6AN7(A), 6AE8 and 12AH8. The 12AH8 may be used on 6V or 12V heater lines.

Pentagrid converters are noticeably different to the triode-heptode and triode-hexode converters and therefore use different circuitry. If you compare the circuit around a 6BE6 pentagrid converter and that of a 6AN7 triode-hexode you will see what I mean.

Here is a list of common and not so common pentagrid converters. 2A7*, 6A7*, 6A8G+, 6B8G+, 6L7G+, 6SA7GT+, 6SB7+, 6BA7# and 6BE6!.

* = Large 7-pin base, + = octal base, # = 9-pin miniature base and ! = 7-pin miniature base.

Electrically, the 2A7, 6A7 and 6A8G are identical. If you cannot get a 2A7 or a 6A7, a 6A8G will do the job if you change the valve socket. However, when replacing the 2A7 it will be necessary to fit a 6.3V filament trans-
The Astor GR

"Football" Mantle Radio

This is the highly sought after Astor “Football” radio. It is commonly called this because its size, shape and colour is suggestive of a football. Its model number is GR or GRP and was a basic TRF circuit produced around 1948. It has three valves including the rectifier, so has a rather limited performance despite its use of a reflex circuit. They sell at auction for up to $300, depending on condition and colour.

Duo-diode/triode substitutes

There is quite a variety of octal and pre-octal valves that are duo-diode/triodes as used in the second detector and first audio stage of most receivers. Electrically, the 2A6, 6SQ7GT, 6B6G and the 75 are the same except for their bases and some heater voltages. A few others that can be considered are 6Q7, 6R7, 6SR7GT, 6ST7, 6SZ7, 6T7G, 55 and 85. In each case, it will be necessary to check their characteristics, particularly whether they are high or low-gain valves as the bias and plate resistors may need to be changed. If a higher gain valve is fitted, feedback may occur.

Miniature duo-diode triodes that are somewhat similar are the 6AQ6, 6AT6, 6AV6 in 7-pin and 6BD7 in 9-pin form.

Rectifier replacements

Replacement of rectifier valves is in some ways easier than any other valve because if a replacement cannot be found, you can always resort to silicon rectifier diodes. The circuit of Fig.1 shows how two 1000PIV diodes, such as 1N4007s, can be wired across the valve plates and common cathode.

If the transformer secondary voltage is above 250V per side, two 1000PIV diodes in series must be used to replace each section of the valve rectifier, otherwise the peak inverse voltage (PIV) rating of the diodes may be exceeded, particularly if the mains supply has any spikes on it. Catastrophic failure may occur with the diodes shorting and causing the transformer to burn out. A 6X4 has a peak inverse voltage rating of 1250V and a 5Y3GT a rating of 1400V.

Since silicon diodes are much more efficient than rectifier valves like the 5Y3GT and 6X4, it is necessary to put a resistor in series with the diodes. This keeps the DC voltage of the supply at much the same level as that produced by the valve rectifier. The value of the resistance will need to be determined by experiment but 300Ω at 5W is a good starting point.

Provided the defunct valve has no faults other than loss of emission, it can remain in circuit and the set will then look to be in original condition.

Surge voltage ratings

There is one more point to be considered if you substitute silicon diodes for a valve rectifier. Because they don’t have filaments which take time to heat up before the cathodes can start to emit electrons, when a silicon diode rectifier is used, the HT (high tension) voltage is immediately applied to the filter and bypass capacitors at switch-on.

And because it takes time for the other valves to heat up and start drawing current, the initial HT may be substantially higher than when all the valves are drawing current. It is therefore prudent to check that the voltage at switch-on does not exceed the voltage ratings of any of these capacitors.

In this case, we can take advantage of the “surge voltage” ratings of the capacitors, provided they are new. Typically, the surge voltage rating of a new electrolytic capacitor is 15% higher than the “working voltage” (WV or VW). However, if the set has the original capacitors in it, they will have to be “formed up” to the higher voltage, with no valves in the set, as described in the December 2000 issue.

Note that, if you exceed the surge

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voltage rating of any electrolytic capacitor, even for a very short period, it is likely to break down immediately and spray its contents all over the inside of the set, with disastrous results.

**Miniature valve equivalents**

I deliberately haven’t discussed miniature valve equivalents to any extent as they are much more common than octal and pre-octal valves and shouldn’t be too hard to obtain. One valve that appears to be not particularly common is the 6M5. It can be replaced with the 6BQ5, with a slight rewiring of the socket. The pentode section of a 6BM8 could also be used in place of a valve such as the 6M5. Rewiring of the socket and alteration of the bias will be necessary. 6BM8 valves are as common as mud after a flood.

A common problem with 6M5 valves concerns migration of metal between the screen and grid (pins 2 and 1) which causes them to appear to be gassy. Scrape between these two pins with a metal scriber and in many cases the valve will again work well, saving it from the rubbish bin.

**Battery valves**

Battery valves from the early to mid 1930s onwards usually had 1.4V or 2V filaments. Prior to this, a variety of voltages were used. A number of octal and pre-octal valves are identical except for the base. Several valves had sub-models like the 1B4, 1B4P and 1B4T pre-octals. Electrically they are not sufficiently different to warrant a different number and are similar to the 1E5GT and 1E5GP octal valves.

Valves with 2V filaments draw 0.06A, 0.12A or 0.24/0.26A filament current. In some cases, where parallel filament wiring is used with a 2V battery, the amount of filament current drawn is not critical. However, where series/parallel wiring is used from a 6V battery, replacement valves need to draw the same filament current unless a careful redesign of the filament circuit is undertaken.

The same requirement applies to 1.4V valves, although they tend to draw either 0.05A or 0.1A of filament current. Output valves such as the 3S4 have a 3V filament that is centre-tapped, which makes it easy to use on either 1.4V or 2.8V.

The typical valve line up of a 5-valve battery set using 2V valves is as follows, with possible alternatives in brackets. They are certainly not all direct equivalents:

- Converter 1C7G (1C6, 1A6, 1D7G);
- RF/IF remote/medium cutoff 1M5G (1D5*, 1A4*, 1C4, 34);
- Sharp cut-off 1K5G (1K4, 1B4*, 1E5*, 15, 32);
- Detector/audio pentodes 1K7G (1K6, 1F7*, 1F6);
- Triodes 1H4G (30, 1H6);
- Audio output 1L5G (1D4, 33, 49, 1G5G, 1F4, 1F5G);
- Twin triodes 1J6G (19, 31);
- Twin pentode 1E7G.

* means that there are several minor variants of this type number.

**Summary**

While I haven’t given you a blow-by-blow description of which valves can replace which, I trust I have given you some ideas on how to find a substitute when the correct one is unavailable. If you are in a quandary of not being sure if a particular valve will do what you require, consult a fellow collector — particularly if they have a valve data book — and work out what valve will do the job. It can be a lot of work but it can also be fun figuring out how to solve the problem and save money into the bargain.

When checking the compatibility of various valves, it is necessary to look at the heater/filament volts and current, the HT volts and current, screen volts and bias voltages. For example, if a possible replacement valve draws too much HT current, it may be made to suit by lowering the screen volts and/or increasing the negative bias on the grid.

It is also important not to replace a low gain valve with one that has considerably higher gain, as oscillation and other strange symptoms may appear which may not respond to remedial attention. Some valves have an internal shield — others don’t, so if replacing a valve with an internal shield with one that hasn’t a shield, an external earthed shield may be necessary.

An example of this problem is discussed in my article in the February 2001 issue. I found that a 6BE6 (unshielded construction) needed to be shielded for optimum performance of the receiver.

The equivalents for a receiver using 1.4V valves is as follows:

- Converter 1R5 (1A7GT, 1AC6, 1L6);
- RF/IF amplifiers, sharp and remote cutoff 1T4 (1L4, 1N5G, 1P5G, 1U4);
- Diode first audio 1S5 (1U5, 1G4G, 1H5G);
- Audio output 3V4 (3S4, 1S4, 1Q5GT, 1T5GT, 3Q4, 3Q5GT, 1C5G, 1A5G).

One valve that has no equivalent is the 1D8GT, diode/triode/pentode (output). Miniature dry battery valves universally used the miniature 7-pin base, whereas a miniature 1D8GT would have needed a miniature 9-pin base. What a shame, as I believe it would have been a popular valve.

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