

THE VACUUM TUBE

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Why So Many Tube Types?

Anyone becoming familiar with the world of tubes quickly realizes what an ocean of types there are, in every possible physical format, with design vintage ranging from 1908 to “modern” times. In a perfect world, electronics could have gotten along nicely with perhaps a tenth of the thousands of tube types that exist. The core reasons for proliferation of tube designs were many, some obvious, some more subtle.

• **Technical Progress.** This is no surprise: with development occurring over a period of 70 years, to serve applications undreamed-of in the early years, a host of new designs was natural.

• **Search for a “unique selling proposition.”** The smaller tube makers were forever searching for a “hook” to sell tubes that were unavailable from RCA and the other major producers. They tried unique physical variants of standard tubes: Arcturus’ blue glass, Raytheon’s “Four-Pillar” glass press, Hytron’s “bantal” construction (a “GT” bulb on an octal wafer base with metal ring), Majestic’s zinc-coated/spray-shielded bulbs, and so on. They also pushed favorite tube types. Triad, in the late ’30s, emphasized a line of “Triadyne” output tubes with direct-coupled dual-triode form (the 6AB6G, 6B5, 6N6G, 25B5, and 25N6G). Arcturus, in 1939, introduced a line of multiple-unit tubes for simplified AC-DC radios (the 12B8GT diode-pentode, 25D8GT diode-triode-pentode, and the 32L7GT rectifier-output tube).

The rise of television brought about opportunities for specialized tubes for replacement use. CBS-Hytron introduced its 6CU6 sweep tube as a cure for short life in the common 6BQ6GT. Workman Associates sold a “5TV4” as a 5U4G replacement giving higher B+ voltage. On close inspection, that turned out to be an 83 mercury rectifier on an octal base, with a pair of thermistors in the plate leads to give a “soft” startup. Sheldon sold a “6S78,” a 6SN7GT replacement. There were numerous other TV upgrade types.

This search for niche markets was long-lasting. Tung-Sol opened new territory in 1956 by introducing a line of four miniature types, intended for hybrid tube-transistor car radios, that operated with 12 volts on their plates. However, this unique position didn’t last. By 1961 the

other makers had rushed in with dozens more types for the same use. The radios “went solid-state” shortly afterward.

• **Repackaging of existing, successful types.**

This was a perennial practice in the industry. If a maker devised a new favored format, it was easier to sell it to the setmakers if the tubes were electrically the same as familiar types. This let the set people reuse circuit designs and components for “the next season’s” radio, and was helpful whether the radio manufacturer had its own design staff or, like the smaller ones, used outside consultants.

The table shows the evolution of several popular tube types between 1934 and 1947, starting with a group of six-volt big-pin types. (Many of these had begun as 2.5-volt versions, but we’ll start the discussion after they had matured into the later heater voltage.) A major split occurred in 1935, when RCA shocked the competition by introducing metal tubes. The response from tube makers that didn’t adopt the metal design, was to put familiar glass tubes on the new octal base, yielding those “G” types (6A8G, 6K7G, etc.) that are familiar in Philco and Zenith radios. One Philco dealer bulletin sneered, “Present list prices of metal tubes are high. More metal tubes are required to equal the performance obtainable from Philco glass tubes. Poor performance per tube, high cost of metal tubes, production difficulties associated with any new type tube and lack of confidence in tubes kept in stock over a period of time are the major reasons why Philco has adhered to glass tubes.”

Some of RCA’s metal types were reissued in “single-ended” form, less their grid caps. Other types, intended for farm and automobile sets running from six-volt batteries, got new heaters for half-current (150-mA) operation. Thenylvania, starting in 1938, released its all-glass “lock-in” or “loktal” format, again with several equivalents of existing types.

Finally, at the end of World War II, RCA put out a line of seven-pin miniature types that replicated the functions of popular octal tubes. This “churn” in the tube world let setmakers, particularly in the area of communications receivers, claim the advertising advantage of using “the latest tubes.”

The chart shows only a sampling of this process, ignoring 12-volt or “GT”-bulbed variants and the like.

Repackaging went on until the end of mass-market tubemaking. When GE brought out its Compactron line in 1960, most of its types were rehashes of successful TV types, singly or in multiple. A 6AR11, for example, is a pair of

6GM6 IF pentodes; a 6AL11 is a “sound section in one bottle,” with a 6DT6 FM detector and 6AQ5 output tube. When RCA introduced its big nine-pin “novar” format in 1961, many of its types were repackages in the same vein.

As a final example familiar to the tube-audio hobby, Westinghouse put out the 7591 high-sensitivity output tube in 1960. Sylvania countered

EVOLUTION OF POPULAR RECEIVING TUBES—1935-47						
BIG-PIN PROTOTYPE	METAL	OCTAL “G”	SINGLE-ENDED METAL	150-MA FARM/AUTO	LOKTAL	MINIATURE
<i>Rectifiers</i>						
80		5Y3G ¹				
84/6Z4	6X5 ²	6X5G			7Y4	6X4
5Z3	5T4 ³	5U4G ⁴				
<i>Triodes</i>						
76		6P5G				
	6C5	6C5G				
	6F5	6F5G	6SF5		7B4	
<i>Duodiode-Triodes</i>						
75 ⁵		6B6G	6SQ7		7B6	6AV6
	6Q7 ⁶	6Q7G	6SZ7	6T7G	6AT6	
85 ⁷		6V7G ⁷				
	6R7G ⁸	6SR7		6ST7	7E6	
<i>Pentodes</i>						
77	~6J7	~6J7G	~6SJ7	6W7G	7C7 ⁹	
78	6K7	6K7G	~6SK7	6S7 ¹⁰	7A7	6BA6 ¹¹
6D6		6U7G				
<i>Pentagrid Converters</i>						
6A7	6A8	6A8G		6D8G	7B8	
			6SA7 ¹²		7Q7	6BE6
<i>Class-B Duotriodes</i>						
79		6Y7G				
<i>Power Pentodes</i>						
41		6K6G ¹³				
42	6F6	6F6G ¹³				
43	25A6	25A6G ¹³				
<i>Eyes</i>						
6G5/6U5					6AB5/6N5	
<i>Notes</i>						
1. With new pinout, became 5Y4G.		8. $\mu = 16$.				
2. Up-rated 16% on output current.		9. Heater reduced to 150 mA.				
3. Fil. current reduced; other ratings same.		10. Also single-ended 150-mA version, 6SS7.				
4. With new pinout, became 5X4G.		11. G_m raised. Also 150-mA version, 6BJ6.				
5. $\mu = 100$.		12. Functions of grids 2-5 revised.				
6. $\mu = 70$.		13. Development of this series stopped here—beam power tubes took over.				
7. $\mu = 8$.						

with the 6GM5, the same tube but in their then-favored "9-T9" format (a 9-pin miniature base with a T9 or GT-size bulb). RCA's answer was the 7868, with the same performance but in novar form.

• **The drive to improve popular types.** Tube technology has so many potential performance problems that there are boundless ways to improve it. The humble 12AU7, for example, with extra process controls and testing, turned into a JAN military version. At the behest of the airline industry, the 12AU7 was reworked into the high-reliability 5814, registered by GE in 1949. RCA once planned to sell the 6139, a 12AU7 with low grid current and close balance between sections, specifically for use in vacuum-tube voltmeters. For use in early digital computers, RCA registered the 5963 with high-purity nickel cathode tubing for long life. Another computer variant was CBS-Hytron's 7318.

The 6680 was a 12AU7 for mobile-radio use, registered by GE, capable of operating with heater voltage from 10.0 to 15.2. RCA developed the 7026 (a quiet 12AU7) as a companion to their 7025 (quiet 12AX7), but the 7026 apparently didn't "make it" commercially. The 7730 was a CBS-Hytron "instrument" version rated for 10,000 hours. An STC (British) premium 12AU7 was the 7489.

• **Concern over safety.** There were two safety hazards related to tubes. First, in the early '40s the Underwriters Laboratories put limits on the AC shock current that a radio chassis could produce (i.e., no more hot-chassis killers). It was noticed that a radio owner, after taking the tubes out for testing, could get them into the wrong sockets and cause a shock hazard. The culprits were the pinouts used by specific tubes.

In, say, the Sea Pal 101 radio (see Rider's), swapping the 1A7GT and 117L7GT would put 117 VAC on the base shell of the 1A7. Also, under specific conditions an otherwise safe AC-DC set could develop a hot (or at least "warm") chassis. In many postwar miniature-tube AC-DC sets, interchanging the 50B5 and 12BA6 could yield AC on the chassis via the AVC line. The same went for many AC-DC-battery radios, in which confusing the 3Q4 with the 1R5 could put plate voltage on the tuning capacitor. To fix these problems, new safe pinouts on old types yielded the following tubes:

<i>Old</i>	<i>New</i>
3Q4	3V4
35B5	35C5
50B5	50C5
117L/M7GT	117P7GT

The other safety concern addressed a more in-

sidious problem. In the late '60s, the story broke about some color TV sets putting out unacceptable levels of soft X-ray radiation, particularly if the high voltage on the picture tube were adjusted too high. The X-ray sources were the HV rectifier, HV shunt regulator, and the CRT.

General Electric ran a recall program to replace shunt regulators (6EA4, 6EF4, and white-branded 6LC6) in their color sets, and put out a money offer to buy back any spares that were in shop stocks. RCA's 1970 response to the problem was to issue a group of rectifiers (1AD2A, 1BC2A, 1BY2, 1G3GTA, 1K3A, 1X2C, 2AS2A, 3A2A) with 49% lead-glass bulbs. The same applied to shunt regulators (6EL4A/6BK4C, 6EM4), which got thicker bulbs.

All received radiation-limit ratings, for example, 0.5 milliroentgens per hour (mR/hr) for the 3A2A and 6EM4. So did picture tubes: the 25VABP22 was rated at the same 0.5 mR/hr with 35 kV and 300 μ A on the anode. GE introduced the 3DS3, an octal HV rectifier molded into a heavy rubber-and-lead shield from top cap to base and weighing an extraordinary six ounces. It too was rated at 0.5 mR/hr, whereas several other GE rectifiers were rated at 25 mR/hr.

• **The triple-heater TV market.** A further cause of "type proliferation" in later years was the need for multiple heater ratings. In the late '60s, as the radio and audio markets were lost to solid-state, the tube makers focused on television as a last stand. They put out new tube types narrowly optimized for minimum-cost receivers. By then, setmakers needed three lines of tubes, to handle 450-mA series heater strings, 600-mA series strings, and 6.3-volt parallel operation. Thus most new tubes had to come out in triple versions.

The registration people at the Electronic Industries Association were helpful in naming the new types, keeping the same letters and suffix number despite changes in the heater-voltage number. A series like 3AU6 - 4AU6 - 6AU6 (3.15 V @ 600 mA, 4.2 V @ 450 mA, and 6.3 V @ 300 mA respectively) is clear enough.

However, EIA often violated this rule: there was an audio triode-power-pentode confusingly coded 6BM8, 8B8, 32A8, and 50BM8 (6.3 V @ 780 mA, 8.0 V @ 600 mA, 32.0 V @ 150 mA, and 50.0 V @ 100 mA respectively). The "6BE6" family was identified in similar irregular fashion, running 3BE6 - 4BE6 - 6BE6 - 12BE6, but then continuing as 18FX6 - 26D6.

• **More powerful sweep tubes.** The number of TV horizontal-sweep tubes had to grow with time to keep up with the need for more deflection power, as picture tubes with 50° deflection

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Farnsworth: "Do you remember the "Mecograph" bug?"

Albright: "Oh, yes."

Farnsworth: "Do you remember the "AutoDot" bug?"

Albright: "Yes"

And one by one Farnsworth asked Albright for the names, each time framing his questions with to include the term "bug," until it was finally objected to by Vibroplex's attorney, Murray Corrington—but overruled. Judge Winslow asked Albright if there was any relationship between the fact that his trade mark applications were filed in May of 1920 one month before the first of their four primary patents was going to expire and wanted to know if there was any significance in that. Albright's answer: "None that I know of."

In January of 1928 the U.S. Circuit Court of Appeals upheld the lower court's decision in favor of J.H. Bunnell & Co. The three circuit judges in their Opinion stated: "a mark is less likely to signify origin when it is accompanied by others than if it stands alone." All this legal activity obviously had little effect on Vibroplex's popularity. The Bunnell Gold Bug was short

lived and quickly faded.

The Vibroplex Bug is admired today just as it was when Horace Martin first introduced it almost a hundred years ago. Ironically, during all this legal activity, J.H. Bunnell & Co. was an active dealer for Vibroplex and had been selling Vibroplex Bugs continuously since around 1912. Today if you hear one on the air it is usually very recognizable, because it simply sounds like a "bug." ☐

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yielded to 70°, 90°, and then 110°. The arrival of color, with the need to power three electron guns, aggravated the need. Thus sweep tubes of postwar design grew in dissipation rating:

6AU5GT (1949, 8 W)

6BQ6GT (1949, 10 W)

6DQ6 (1955, 15 W)

6DQ5 (1957, 24 W)

6KD6 (1965, 33 W)

Further multiplication of sweep types came from the tendency to release a given design with and without a top cap (e. g., 6GT5 vs. 6GJ5). Other types were derived from conventional designs, but with the suppressor grid pinned-out separately for use with a bias circuit that suppressed "snivet" oscillation in the picture.

A further source of new types was the rise of Japanese exports of TV sets and tubes in the early '60s. From far-away places, these had "strange-sounding names" like 6G-B3A, 6R-HH2, or 12G-K17. Many were dual-numbered with EIA identifiers; some were not. As the replacement market grew, some U.S. tubemakers like Raytheon distributed these types themselves.

The above suggests that most of the proliferation in tube types can be ascribed to (read:

"blamed on") the TV industry. By contrast, makers of communication gear and hi-fi systems were very conservative, sticking for decades to familiar tubes like the 6BA6. Only late in the game did they make much use of the new types that had been developed for TV use.

Proliferation of types in the TV field came down upon the poor service technician, of course. In 1950 the typical serviceman's tube caddy held about 100 types. By 1970 caddies had grown to capacities of 400 or so tubes, and it was not unknown to carry two caddies on the service truck!

Tube Collectors Association Celebrates Fifth

In closing, it is timely to note that the TCA has completed five years of service to the historian-user-collector community. Founded in 1999 at the suggestion of serious collector Al Jones, W1ITX, the group closed 2003 with 350+ members in 18 countries. The Association has focused strongly on publishing tube literature, and has brought out a good deal of previously unknown history. For details, interested readers are welcome to contact the writer at (new address) tube-lore@jeffnet.org, or on (541) 855-5207. ☐