

HISTORY AND DEVELOPMENT OF THE ALL-METAL RADIO TUBE

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AWA is proud to be able to print the first serious historical research on the development of the all-metal tube. The author made numerous field trips and interviews to obtain firsthand, reliable information. Members attending the 1975 Conference saw his original documentation. -BK

INTRODUCTION

Although orphaned shortly after birth when, conceived by one company, she was raised by another, this spunky little tube not only survived but lived to make history. Her birth ushered in the modern age of tube technology when the umbilical cord binding her to an incandescent-lamp heritage was severed. History positioned her arrival mid-way between the birth of the vacuum tube and its incipient decline. The announcement of her birth sparked more publicity and controversy than any prior or subsequent tube. It is ironic that the very technology that occasioned her birth and cured her childhood ills was ultimately to cause her demise.

Unfortunately, this "Depression baby," after a history-making childhood, a dedicated adult life, and distinguished service in WW II, was all but forgotten in later life. It is only fitting that, in her old age and before death of her species, the "plain Jane" of the tube world, long neglected by collectors and historians alike, be restored to her rightful place in history and be given some of the recog-

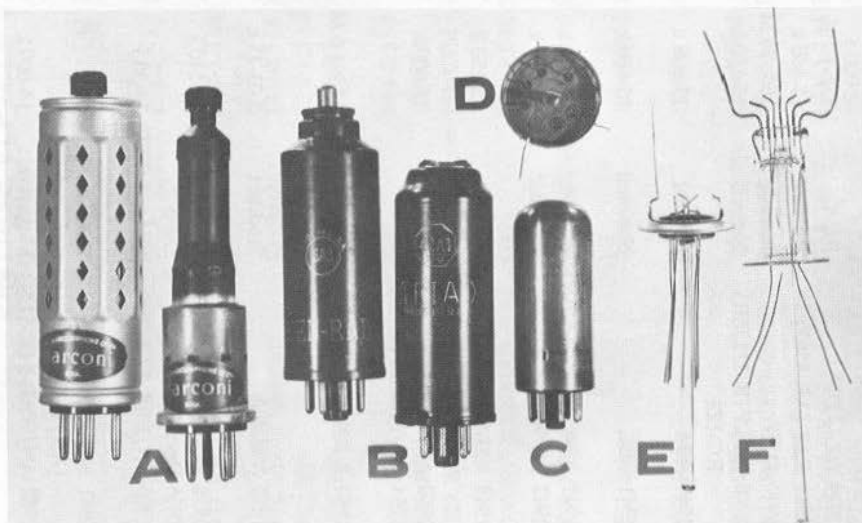
nition denied her throughout adult life.

DEVELOPMENT HISTORY

The all-metal tube made its debut 40 years ago last September. It was originally conceived as a unique selling point to mark the return of the General Electric Company to the receiving-tube and radio-receiver fields after an absence of five-and-a-half years. GE timed its re-entry for the fall of 1935, when it planned to unveil its new receiver line featuring its "eternal" all-metal tube.

The GE engineers developed the idea of the all-metal tube, which was to be unbased and wired directly into the set, and planned to make it so durable that it would last the life of the receiver. Although they had initiated and perfected most of the early manufacturing techniques, GE was unable, because of long absence from this field, to produce the all-metal tubes economically and on time. Consequently, they turned over the manufacturing job to RCA on October 9, 1934.

To place the above remarks in perspective, it is necessary to go back to the late Twenties when radio's Big Four - RCA, GE, Westinghouse and AT&T (Western Electric) - engaged in some hard-nosed negotiations designed, for economic reasons, to prevent needless duplication of research and manufacturing efforts and to avoid unnecessary competition.



A: Marconi Catkin tubes. B: Ken-Rad and Triad MG tubes. C: Bullet-tube prototype. D: Early eyelet-type metal-tube header. E: Glass-button-stem header. F: Old-style seal press.

As a result of these negotiations, the RCA Radiotron Company was formed as of January 1, 1930, and GE's Harrison, N.J., Lamp Works was turned over to RCA at the same time. RCA agreed to limit its research, development, and manufacturing efforts to radio receivers and receiving tubes. GE and Westinghouse agreed to confine their efforts to radio transmitters, transmitting tubes, and the application of vacuum tubes to industrial uses.

In May, 1930, the government brought suit against RCA, claiming these agreements constituted a "restraint of trade." The suit dragged on until November 21, 1932, when the now-famous Consent Decree was handed down. The decree permitted the concerned companies, after a lapse of two-and-a-half years, to engage in competition in all fields as of May 21, 1935.

In the interim, GE had dismantled its radio-receiver and receiving-tube engineering departments at Schenectady and the personnel from these departments had sought work elsewhere. At this time J. C. Warner, B. J. Thompson and George M. Rose joined RCA at Harrison.

Preparing to resume activity, GE had to reorganize these departments. This it did as of January 1, 1933. George F. Metcalf was appointed to head the new Vacuum Tube Engineering Department. He was joined shortly thereafter by J. M. Cage and James E. Beggs in April and R. J. Bondley in November. These are the men who, together with William C. White, were responsible for the all-metal receiving tube.

In January 1933, at the first meeting of the newly formed departments, the determination was made to develop something radically novel if they were to have a marketing edge in the competitive receiver field upon their return in 1935.

During the early months of 1933, they did considerable research on the electron-beam tube and on small glass tubes for high-frequency use. In April, Metcalf built a sample receiving tube with a copper anode as part of the container, as with the water-cooled transmitting tubes of the day and the recently released British Catkin tube.

The results of these experiments convinced them that they must look elsewhere if they were to find an answer to their problems. To understand why the group had not considered the idea of an all-metal tube prior to this time, or at least why they did not pursue the idea even though GE was then very much involved with the production of an all-metal tube, we must go back several years.

The idea of an all-metal tube was not new - patents and dockets predate 1915. However, the technology was not available for practical production. From 1919 through the early Twenties the technology for making high-power glass-metal transmitting tubes was developed and perfected.

Unfortunately, it had no practical application to production of an all-metal tube.

In November, 1931, White ("father of the all-metal vacuum tube") suggested to the staff members of GE's Vacuum Tube Development group that they consider developing an all-metal phantotron or thyatron tube. A short time later, H. J. Nolte was specifically directed to investigate this matter. By May 25, 1932, he had built, exhausted and tested the first all-metal tube (tin-can shell as anode, two refrigerator seals for filament-wire feed-through, a coated ribbon filament and a copper seal-off tube lined with solder).

During the next few months a number of similar tin-can tubes were completed and tested. These were followed by a series of copper-can tubes. Although many difficulties were experienced with these tubes, none were considered to be of fundamental nature.

Between January and June 1933, the GE engineers found solutions to the remaining major technical problems that had prevented them from producing a practical and economical all-metal tube. In rapid succession, thyatron-controlled welding was successfully investigated and Fernico, an alloy with the same coefficient of expansion as "AJ" glass, was developed. The "eyelet" seal for low-current tubes and the "pedestal" seal for high-current tubes were perfected. Although much work remained to be done before a practical and economical all-metal tube could be produced, the goal was in sight.

When the members of the Vacuum Tube Engineering department met in July, it was only natural, in the light of recent events, that the subject of an all-metal tube should be discussed. In August, pursuing an idea he initiated at the July meeting, Beggs completed the design of the first all-metal receiving tube. On September 7, he successfully built, exhausted, tested and demonstrated the first steel-shell model of this design. It was so well conceived that it served as a model for other types.

The designs of these early tubes, virtually unchanged, were used by RCA in production almost two years later. Beggs deserves great credit for the novel and ingenious developments which made the all-metal receiving tube a success.

Messrs. White and Metcalf were favorably impressed with the demonstration of the sample tube and agreed it was most promising. R. J. Bondley joined the group in November and was assigned the task of finding practical solutions to the manufacturing problems of the new tubes. During the next year he made many significant contributions to this new technology, by either initiating new methods or perfecting existing ones, especially in the field of welding. By January 1934 GE was firmly committed to the use of the all-metal tube in its receiver-development program.

In April 1934, GE made two apparently contradictory moves. Messrs. Metcalf, Beggs and Bondley were sent to Ohio to work under the direction of Mr. Pritchard. Their job was to ready GE's incandescent-lamp factory at Nela Park, Cleveland, for the production of metal tubes in quantity. GE then entered into negotiations with RCA to have them take over the manufacture of all-metal tubes! The first move was probably made to give them a lever in the negotiations and also to protect themselves should the negotiations fail.

In May, H. F. Mayer completed development on the pencil-rectifier tube and built several successful samples. This work lead directly to the development of the uniquely designed 5Z4 power rectifier. By July 1934, Nela Park completed the first batch of all-metal prototypes. Throughout the summer the top-secret negotiations between GE and RCA continued, known only to the upper administrative echelon in each company. The proposed permanent-component aspect of the new metal tubes must have been a stumbling block in these negotiations because GE decided in September to use terminal boards to accommodate the tube leads.

Finally, on October 9, 1934, a contract was signed between GE and RCA. RCA assumed full responsibility for manufacture of metal tubes. Two days later at their Nela Park plant, GE released plans, designs and samples of the all-metal tubes to J. C. Warner of RCA. On October 23, RCA announced its plan to base the metal tubes with their newly developed "octal" base.

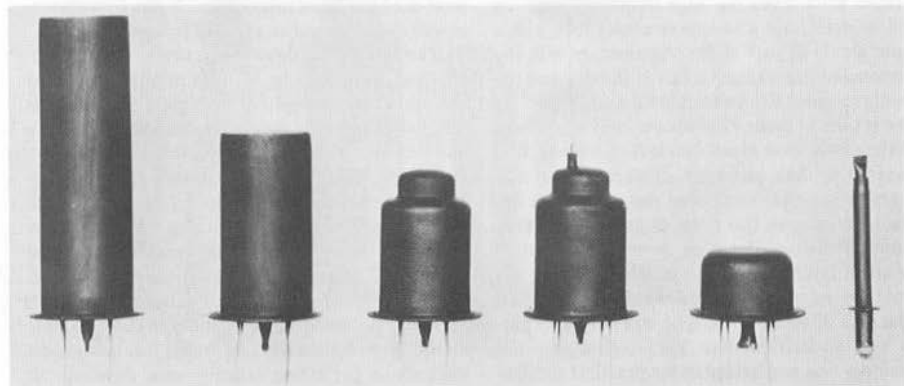
Plans were made immediately to equip "Factory #1" at Harrison for the manufacture of metal tubes. A section of the factory was boarded off and all activities carried out in utmost secrecy. RCA assigned men from their Engineering Research and Production departments to this project, together with advisors from GE. By the end of

November the machinery was set up and ready to operate. The first working samples were produced in early December. George "Wally" Crawford was in charge of metal-tube production. Fortunately, he kept a personal diary giving an almost daily history of the trials and successes encountered in the first production.

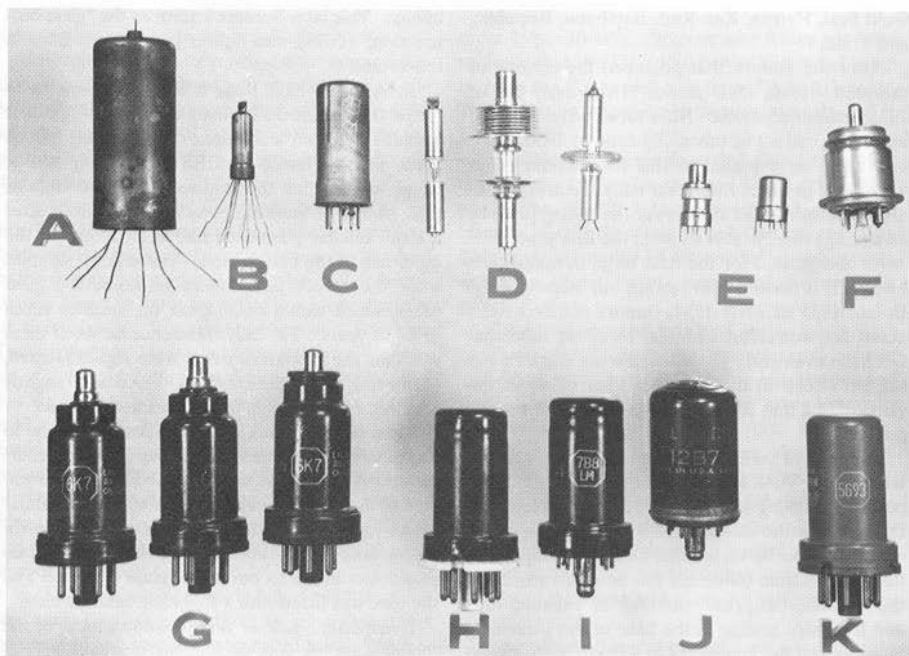
It is a tribute to the skill, patience and perseverance of these men that were able to meet their deadlines. By March 1935, they were ready to send a large number of each tube type to the GE receiver plant at Bridgeport, Conn., for testing in the new receivers scheduled for release in the Fall.

On April 1, 1935, GE and RCA unveiled their revolutionary all-metal receiving tube at the annual IRE show in New York City. Their big secret had apparently been kept well. Although the "grapevine" had leaked some vague rumors, the other tube and receiver manufacturers were totally unprepared for this bombshell. There was good reason for their panic, since by this late date they were already committed to their Fall line. The all-out publicity of the next few months was effective. By the end of June over 25 companies had joined the metal-tube bandwagon and more were to follow. This announcement of the metal tube sparked reams of coverage in the literature of the day, some of it controversial or negative.

Many of the smaller manufacturing companies could not afford to compete in the metal-tube market because of the expensive equipment required. During the course of the next year a number of them developed MG (metal-glass) tubes to solve their problems. These were tubular glass-shell tubes with close-fitting aluminum shields crimped over the base and painted black to resemble metal tubes. Although somewhat larger and different in shape, these were widely accepted as "metal" tubes. They were made by at least the following companies: Arcturus, CeCo, Champion,

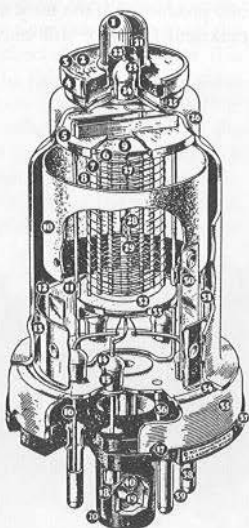


All-metal tubes produced by GE at Nela Park, Cleveland, in July, 1934, and turned over to RCA on October 9, 1934.

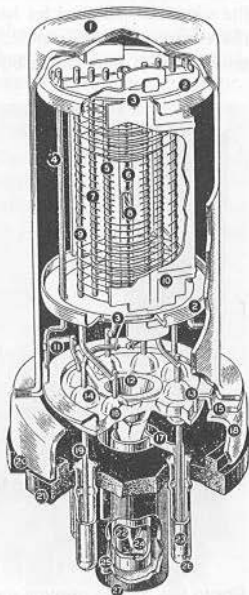


A: Early experimental metal tube (September, 1933). B and C: Developmental subminiature types. D: UHF pencil tubes. E: Nuvistors. F: Gold-plated metal lighthouse-style tube, Western Electric 416A. G: Three vintages of the 6K7. H: Developmental isolantite-base metal tube. I: Localt-metal (LM) type. J: GE's 12B7 (low-cost LM). K: 5693 "Special Red" high-reliability computer tube.

- 1—SOLDER
- 2—CAP INSULATOR
- 3—ROLLED LOCK
- 4—CAP SUPPORT
- 5—GRID LEAD SHIELD
- 6—CONTROL GRID
- 7—SCREEN
- 8—SUPPRESSOR
- 9—INSULATING SPACER
- 10—PLATE
- 11—MOUNT SUPPORT
- 12—SUPPORT COLLAR
- 13—GETTER TAB
- 14—GLASS BEAD SEAL
- 15—EYELET
- 16—LEAD WIRE
- 17—CRIMPED LOCK
- 18—ALIGNING KEY
- 19—PINCHED SEAL
- 20—ALIGNING PLUG
- 21—GRID CAP
- 22—GRID LEAD WIRE
- 23—GLASS BEAD SEAL
- 24—EYELET
- 25—BRAZED WELD
- 26—VACUUM-TIGHT STEEL SHELL
- 27—CATHODE
- 28—HELICAL HEATER
- 29—CATHODE COATING
- 30—PLATE INSULATING SUPPORT
- 31—PLATE LEAD CONNECTION
- 32—INSULATING SPACER
- 33—SPACER SHIELD
- 34—SHELL-TO-HEADER SEAL WELD
- 35—HEADER
- 36—SHELL CONNECTION
- 37—OCTAL BASE
- 38—BASE PIN
- 39—SOLDER
- 40—EXHAUST TUBE



- 1 — METAL ENVELOPE
- 2 — SPACER SHIELD
- 3 — INSULATING SPACER
- 4 — MOUNT SUPPORT
- 5 — CONTROL GRID
- 6 — COATED CATHODE
- 7 — SCREEN
- 8 — HEATER
- 9 — SUPPRESSOR
- 10 — PLATE
- 11 — BATHALUM GETTER
- 12 — CONICAL STEM SEAL
- 13 — HEADER
- 14 — GLASS SEAL
- 15 — HEADER INSERT
- 16 — GLASS-BUTTON STEM SEAL
- 17 — CYLINDRICAL BASE SHIELD
- 18 — HEADER SHORT
- 19 — LEAD WIRE
- 20 — CRIMPED LOCK
- 21 — OCTAL BASE
- 22 — EXHAUST TUBE
- 23 — BASE PIN
- 24 — PINCHED SEAL
- 25 — ALIGNING KEY
- 26 — SOLDER
- 27 — ALIGNING PLUG



The original all-metal tube (40 parts) and the S-line single-ended tube (27 parts).

Gold Seal, Hytron, Ken-Rad, Raytheon, Republic, and Triad.

After the fanfare that preceded the coming of the metal tubes, their arrival in the early fall of 1935 was anticlimactic. Nine tubes were released in the original set of tubes. By June of 1936, more new types were added to this list. Metal tubes were here to stay. Improved manufacturing techniques permitted RCA to lower the selling price by an average of 20% at the end of the first year.

As background for the next stage in metal-tube history, it is necessary to retrace our steps slightly. In late 1933 or early 1934, rumors reached RCA about the wonderful all-metal receiving tube that GE had developed. This caused some concern and set the wheels in motion for a total effort to develop a tube that could be competitive with the all-metal tube.

Early in 1933, as a prelude to this work, George Rose of the Tube Research and Development Department, having just completed the developmental work on the acorn tube with Thompson, decided to follow up on an idea he had for improving the glass vacuum tube. He felt he could eliminate the "parallel-flat-press" method of exhaust tube and lead-wire sealing in the base of the glass tube by arranging the lead-wires in a circle, with the exhaust tube at the center, and pressing the glass "button shape" at right angles to the lead-wires and exhaust tubes. This required only an eighth of an inch or so of glass to be in contact with each lead-wire in the seal, permitting the wires to be made considerably shorter. The circular arrangement of the wires also allowed for better spacing. Both of these improvements enabled the tube to be made much smaller and increased high-frequency capa-

bilities. This later became known as the "glass-button-stem" (GBS), and figures prominently later in this article.

In April of 1933 Rose built a few samples to "show the engineers it could be done." The first samples used soft lead-wires. Shortly after this he made another batch of GBS tubes using heavy-gauge wire so that the lead-wires might double as pins. A few of these samples were exhausted after a small tubular glass shell had been sealed to the outer rim of the button-stem. These latter samples were the direct forerunners of miniature glass tubes, which would not appear for another seven or eight years! The only difference between them was that the miniature tubes were top-exhausted, permitting the "pin-ring" to be made slightly smaller. This idea was then filed for future use.

When the work was started to develop a tube to compete with GE's metal tube, the GBS was resurrected. A small tube was designed to take advantage of the new stem and was sealed with a tubular round-topped glass shell, less than an inch in diameter and two inches long. A close-fitting brass shield was made to cover the glass envelope and the tube was fitted with a six-prong bakelite base.

To capitalize further on the compactness of the "bullet tube," it was decided to design a special base. T. M. Schraeder developed the octal base with its orienting key. The final version of the "bullet tube" was fitted with a close-fitting aluminum shield crimped over the base. At the completion of this project, E. W. Ritter informed Rose that he was satisfied that the bullet tube was the answer to GE's metal tube and that it would be put into production if the need arose. At this time the rank and file were still unaware of the GE-RCA

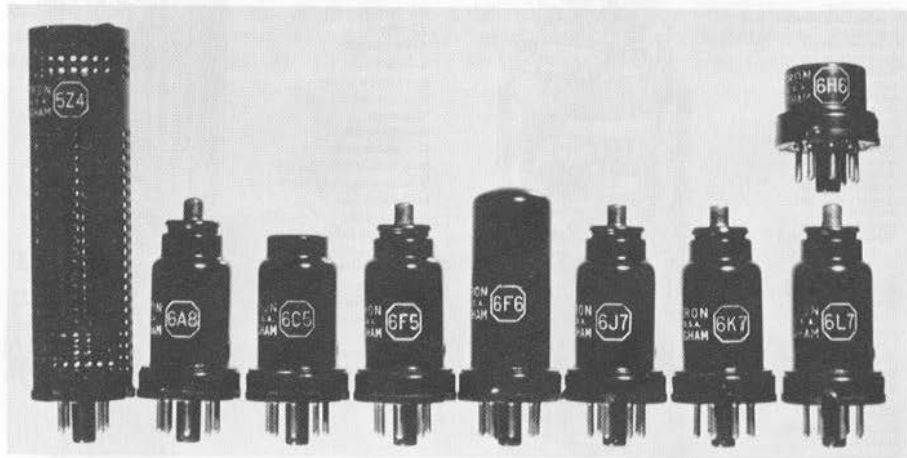


Photo No. 1. The original nine all-metal receiving tubes designed by GE and made by RCA, released in the fall of 1935. The steel-stamped labels were whitened for legibility.

negotiations relative to the metal tube.

Although the bullet tube never went into production it is most significant. It was the first of the MG (metal-glass) tubes, the first to use the GBS and the octal base. All these points played an important role in RCA's contributions to the all-metal tube.

In May 1934 Wally Crawford, unaware of the existing GE-RCA negotiations, was sent to England to study the manufacturing processes involved in the production of the Catkin tube. When he returned home in June he brought a large quantity of these tubes. The Engineering and Research Departments at Harrison made a thorough analysis of them. In July, Rose designed a special GBS and succeeded in building an RCA Catkin, considerably smaller than the British version, which could be truly called an all-metal tube. Again, apparently nothing ever came of this investigation. However, the evidence seems to indicate that the idea for the perforated metal shell used by RCA in the original 5Z4s was copied directly from the design of the Catkin tube.

In the late summer or early fall of 1935 the GBS was again recalled from obscurity. This time it was to come to the rescue of the metal tube. This recall came as a result of a cost-analysis meeting held at Harrison to examine the production expenses of the metal tube. The relatively high cost of the header (the structural base of the tube) was discussed at length. At this meeting Rose indicated that he was reasonably certain that the GBS could be adapted to the metal tube header. This would eliminate the need for the Fernico eyelets, glass beads, and copper rings then used to seal the lead-wires. He was directed to investigate this matter immediately. In February 1936, a patent was obtained for the application of the GBS to the metal-tube header. During the remainder of the year over one hundred thousand metal tubes with the new header were made and subjected to rigorous laboratory and field tests. The results were most successful and plans were made to place

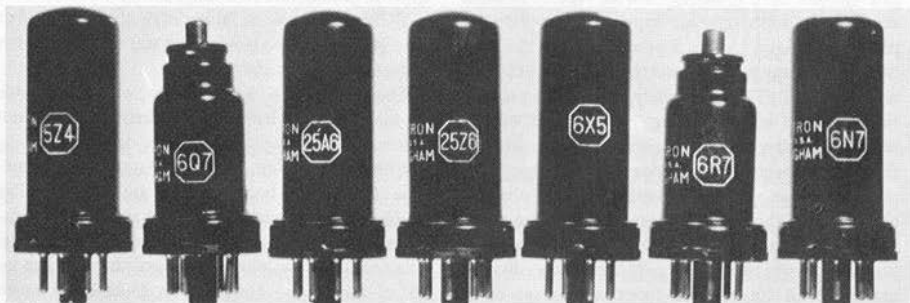
them in production. Warner and Ritter confided to Rose that the GBS had "saved the metal tube" by reducing the header cost from 7-½ to 2-½ cents. The first tube with the new header was released in March 1937.

The advent of the single-ended tube late in 1938 marked the last major changes in the pre-WW II metal tube. The "S" tube series enabled all the grid leads in multi-grid tubes to exit through the base. This was accomplished by special shielding and, except in special cases, eliminated the need for grid-cap tubes.

Only two conventional-type metal tubes were registered by RCA during the war and another half-dozen afterward. During the late Forties and throughout the Fifties, miniature tubes gradually replaced the metal family in new equipment. Starting in the late Fifties and into the early Seventies at an increasing rate, miniature tubes suffered the same fate at the hands of the transistor. The Compactron made its appearance in the early Sixties and, after putting up a valiant fight over a decade, it also fought a losing battle with the transistor and the latest arrival on the scene - the integrated circuit.

The rugged all-metal tube did not give up without a struggle. Shortly after WW II Rose was given the task of developing an efficient UHF tube. The metal "pencil" tube resulted from this development work. It replaced the temperamental "lighthouse" tube and enjoyed great popularity for a number of years, particularly in avionic equipment.

In the mid-Fifties, when it was evident that the transistor was making headway, Rose was assigned to develop a tube to compete with the transistor. In 1960, the last and smallest of the all-metal receiving tubes appeared. Christened the "nuvistor," it was a direct descendant of the pencil tube and was credited with saving the RCA color TV receiver. Its days were also numbered; its demise marked the end of an era in the history of radio communication.



Second generation of 5Z4 (Fall 1935) and second batch of all-metal tubes, released in the early part of 1936. These have physical characteristics of the original nine. (Labels are whitened.)

THE ALL-METAL RECEIVING TUBE - A COLLECTOR'S ITEM?

This title, if cited in collector circles, would be sure to cause some raised eyebrows, elicit quizzical looks and perhaps cast some doubt on the sanity of the speaker. Christened the "tin-tube" even before it was released, how could this unglamorous device, which was made in such vast quantities, ever become a "hot" collector's item?

Regrettably, as a result of its small stature, somber appearance, and efficient performance, the metal tube was taken for granted almost from the beginning. Its contributions to tube technology went virtually unnoticed and unappreciated. In the minds of many, the look-alike construction of a multiplicity of varied tube types caused all the metal receiving tubes to be lumped into one category, with a consequent loss of their individual identities. This unfortunate, "seen-one-seen-them-all" attitude did little to help the cause of the metal tube in the eyes of the collector.

To the casual observer, all metal tubes may look alike - yet nothing could be further from the truth. In the pre-WW II metal tubes at least, a succession of visible changes took place. A study of these changes enables the initiated to date and trace stages in the fascinating development of the "new" technology of the all-metal tube.

Surprising as it might appear, the original metal tubes, as well as the "vintage" tubes of each early type, possess, to some degree, all the characteristics of the ideal collector's item. These characteristics are: (A) Antique - the original metal tubes were released over 40 years ago. This more than qualifies them as "antique" under the AWA definition. (B) Rare - although RCA produced over eighty million metal tubes prior to WW II, many of the original types and many vintage versions are in short supply and may be considered in the rare-tube class. In fact, present evidence indicates that a few of these deserve to be classified as "very rare." There are several reasons for this: (1) As metal-tube technology developed, progressive improvements were made in existing types. In most cases these improvements brought about external physical changes. As each new version of the various types appeared, production of the previous model ceased. This effectively limited the production numbers of the "vintage" versions as well as most of the later models of each tube type. During the prewar period label-styles were changed frequently, either with or independently of physical changes, and this served to limit further the availability of certain variant types. (2) The prewar production of over eighty million was divided among about 60 different types, as well as innumerable variants of most of these types. (3) These many different types were not produced in equal quantities. (4) Some of the types were su-

perseded shortly after their release. (5) At present no evidence is available to indicate that these early models, to any great degree, were intentionally preserved. (C) Beautiful - no one, I am sure, will argue the case for the aesthetic beauty of the metal tube, yet its functional beauty cannot be denied. Unfortunately, most of its real beauty, its technical value, is hidden beneath its shell. (D) Historical significant - the all-metal tube was the first to break away from the incandescent-lamp heritage of the vacuum tube. A completely new technology had to be developed to produce the metal tube. The development of this technology ushered in the modern age of the vacuum tube and set new standards for efficiency, precision, compactness and ruggedness that were to have a profound effect on the future of the tube. (E) Personally significant - this will vary from one individual to another, but, unless very young, few can claim that, directly or indirectly, the metal tube did not play some role in their lives. (F) Easily identified and dated - it is possible to date and identify the early metal tubes simply and with reasonable accuracy by using a combination of known characteristics and label-style information. (G) Limited production - as mentioned above, the frequent changes in the early metal tubes resulted in the production of many variants of each type. This limited the production run of each "vintage" model, as well as later models of each type, to a comparatively short period after its release.

IDENTIFYING AND DATING PRE-WW II RCA METAL TUBES

Most of the listed physical characteristics and changes were obtained through the courtesy of RCA from "spec sheets" in their old files. The dates listed represent the dates on which these physical changes were authorized and not necessarily the dates of implementation.

Most of the label information was made available through the courtesy of the Newark Stamp and Die Works. Where listed, the date in parentheses to the right of the label indicates the date on which the completed label-stamp was delivered to RCA. Then, as in later years, the metal tubes were labeled before leaving the warehouse and not at the time of manufacture.

The registration dates in the Tube-Data Table are taken directly from the EIA listings and do not necessarily represent tube-release dates.

Where convenient, the types listed in the Tube-Data Table have been grouped into series. The original types in each series all have the same label-style as indicated in the Label-Style Table. This permits easy identification of the "vintage label" of each type. However, in some cases, more than one version of a particular type was made while a label style was still in effect. In these cases the physical characteristics of the tubes must be

(Courtesy of Newark Stamp and Die Works. Diagrams are not exact copies.)

1



RADIOTRON
Made in USA.
CUNNINGHAM



TUBE SERIES
1A AND 1B

STYLE 1: MID-1935 TO MID-1936

2A



RADIOTRON
Made in USA.



LICENSED
AS STATED
ON CARTON

TUBE SERIES 2
(5-19-36)

(Probably used as distribution code)

2B

LICENSED
AS STATED
ON CARTON



RADIOTRON
Made in USA.



STYLES 2A AND 2B: MID-1936 TO MID-1938

3



RADIOTRON
Made in USA.



XXX
LICENSED
AS STATED
ON CARTON

TUBE SERIES 3
(5-17-38)

STYLE 3: MID-1938 TO MID-1939

4A



RADIOTRON
Made in USA.



XXX

TUBE SERIES 4
(4-11-39)

4B



RADIOTRON
Made in USA.



XXX

STYLES 4A AND 4B: MID-1939 TO EARLY WW II (?)

(xxx): Date code:
combinations of
2- or 3 letters
or numbers.

5A

When the
RCA word
"Radiotron"
was dropped,
the logo was
enlarged
slightly.



XXX

5B



XXX

STYLES 5A AND 5B: EARLY 1942 (?)

Probably used
on home front
during WW II.

6



MADE IN
U. S. A.
XXX

STYLE 6: EARLY 1942 ON (?)

In use by Armed
Forces by at least
May 1942. JAN
labels started
early 1943.

used, if possible, to identify vintage tubes.

For the convenience of the reader in following the changes listed herein, it is recommended that running reference be made to the Tube-Data Table, the Label-Style Table and the accompanying photos. "P" indicates a photographic reference.

The following facts are as accurate as presently available information permits. RCA started using date codes on metal tubes in mid-1938. No prewar dating-code information is currently available.

A. All the Series 1A and 1B metal tubes were die-stamped, on the shell, with the "Radiotron-Cunningham" label. The "License Clause" (LICENSED ONLY TO EXTENT INDICATED ON CARTON) was molded in a circle on the bottom of the bakelite base just outside the pin ring.

The rubber-stamped (painted) label replaced die-stamping about mid-1936 with the release of

the 6L6. At this time the word "Cunningham" was dropped from the label and the "License Clause" wording was shortened (*LICENSED AS STATED ON CARTON*) and made part of the shell label. The "License Clause" stayed part of the shell label until mid-1938, when it returned to the bottom of the base in its original wording. The bottom of the base was blank from mid-1936 to mid-1938.

B. The shell of the original 5Z4 was much taller and wider than those of the other metal tubes and was perforated (P 1). The second-generation 5Z4 (probably early Fall of 1935) was made identical, in size and shape, to the 6F6. The label on the original version was die-stamped.

C. The shell of the original and early 6H6 was much shorter than those of the other metal tubes and had a flat top (P1). In November 1938, dome tops appeared. The 12H6 was released after this date; there was no flat-top 12H6 (P 2R & 2S).

D. The original and early 6C5 had a distinctive recessed collar at the top of the shell (P 1). This collar disappeared in March 1941. It was the last characteristic of the original metal tubes to vanish. Afterward the 6C5 was made identical in size and shape to the 6J5, etc. (P 2A).

E. In the construction of the original and early metal tubes, the header (the flat, structural base of the tube) and the base skirt (used to house, position and support the octal base) were made from a single piece of metal (top view P 2L, and bottom view P 2M). Holes were punched in the header to allow insertion of the Fernico eyelets (P 2J) with the eyelets flange on the bottom side of the header (P 2M). The eyelets and exhaust tube were then simultaneously resistance-welded to the header. Copper rings were slipped over the eyelet stems on the top side of the header and melted to insure a vacuum seal in case the eyelet-to-header weld did not take. The fused copper ring is visible between the eyelet-stem base and header (P 2L).

Early, probably in the fall of 1935, the copper-ring method of making the insurance seal was replaced by the copper-gutter method. A gutter was impressed on the bottom side of the header and a piece of copper wire was tack welded in the "key" of the gutter (see whitened gutter P 2N). In the manufacturing process, the copper wire was melted, in a hydrogen atmosphere, and guided from eyelet to eyelet and around each eyelet by means of the gutter.

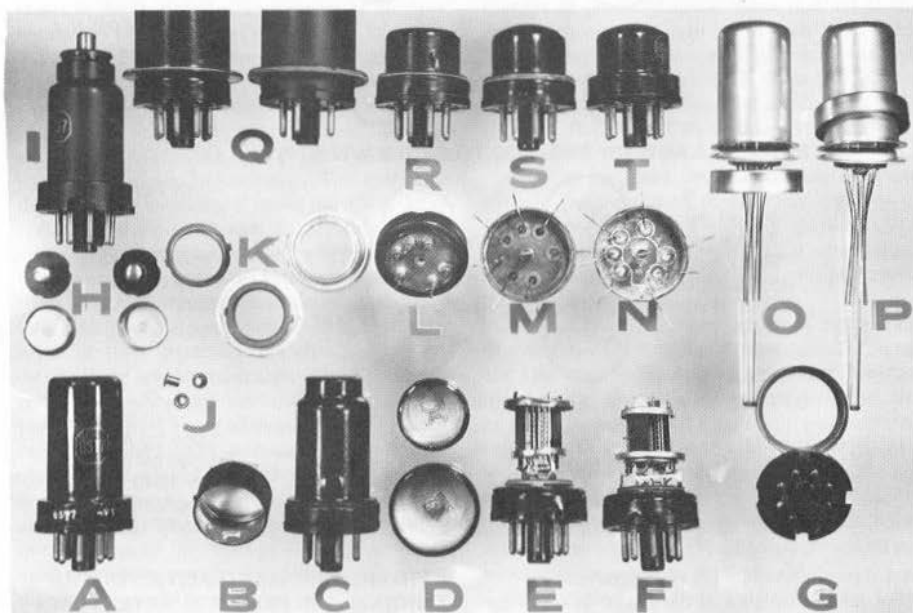


Photo No. 2. A: Die stamped base skirt. B: Getter support tab. C: Getter bump. D: Getter pellet in dome. E: Getter coil assembly. F: Getter ribbon. G: Octal base and base skirt. H: Grid-cap insulator and support wafer, top; grid cups, bottom. I: Grid-cup bump. J: Eyelets. K: Header-insert ring, right; header proper, left; welded header and gutter, center. L: Top view of original header. M: Bottom view of original header. N: Copper gutter. O: Mockup of two-ply exposed weld seam. P: Mockup of covered weld. Q: Two- and three-ply 6L6 types. R: Single-ply exposed weld seam. S: Two-ply exposed weld seam. T: Covered weld seam.

In most cases this gutter can be detected externally, thus permitting easy identification of the original and second-generation tubes. The first 5Z4 is self-dating. All the other early types, except the 6A8, have one or more unused pin-holes in the base. A wire may be used to probe for the gutter through these holes.

F. The shell connection (ground) in the original metal tubes was brought through a hole in the header and connected to a base pin for external grounding. Later, probably when the copper gutter came into use, connection was made to the shell by spot-welding a wire to the inside of the base skirt and leading it directly to a base pin (compare P 2M and 2N).

G. The original and early versions of the 6A8, 6C5, 6F5, 6H6, 6J7, 6K7, 6L7, 6Q7 and 6R7 all showed a "getter bump" about $\frac{1}{4}$ inch above the header on the shell of the tube (visible in P 2C and 2R). This bump was made to accommodate and locate the getter pellet for flame flashing, externally by torch, during the exhausting of the tube. The getter pellet was held in place internally by tack welding a metallic strip (P 2B) or wire mesh (P 2D) over the pellet.

The getter bump disappeared from the early metal tubes as the "pellet" method of gettering was gradually replaced. Starting in late 1936 or early 1937 the "getter coil" assembly began to supplant the pellet. The getter coil assembly (P 2E) consisted of a coiled tantalum wire coated with the first form of "batalum" getter -- mainly barium carbonate. The coil was surrounded by a three-sided shield open on the shell side to direct the flash and prevent contamination of tube elements by the getter vapor. The getter was fired electrically through the base pins during exhaust. This method of gettering was expensive, and about mid-1938 was replaced by the "getter ribbon." This consisted of a thin tantalum strip with a small channel or "canoe" pressed into the center portion of the ribbon. The channel was filled with the second form of batalum getter -- barium beryllate mixed with a binder. The channel doubled as a shield. The getter was flashed electrically during either exhausting or aging. In the mid-1940s the final batalum form, barium tantalate, replaced barium beryllate on the ribbon (P 2F).

By late 1938 most of the early tube types had been converted to the getter ribbon. Some were first converted to the coil and then to the ribbon; others went directly to it. The 6J5 was the first new type to be released without the getter bump, in mid-1937. All new types released after this date lacked a bump.

H. The 6F6, 6L6, and similar dome-top tubes did not have a getter bump. The getter pellet was placed in the dome of the tube and flashed externally by flame (P 2D).

In the original and pre-glass-button-stem (GBS) metal tubes with header and base skirt in one piece, the top of the header was embossed along its outer rim to accept the shell-flange weld. This resulted in an exposed "single-ply" weld-seam visible just above the header (P 2R). This is an identifying characteristic of the earlier tubes.

Starting early in 1937, as tubes were gradually equipped with the GBS, the header and base-skirt were made as separate pieces. The header was then formed of two concentric metal rings. The inner ring (header-insert ring) was made with a collar to accept the GBS (P 2K, left). This inner ring was welded to the outer silver-plated ring (header proper, P 2K, right) prior to sealing in the GBS (welded header, P 2K, center).

The outer diameter of the header was made the same as the diameter of the outer rim of the shell flange (P 2Q). These pieces were then welded. The base skirt was made with an inward flange (P 2G & 2O) and tack-welded to the bottom side of the header. This left an exposed "two-ply" weld seam just above the base skirt (P 2S & 2O). This two-ply seam indicates presence of the GBS. In some tubes, depending on the completeness of the welding job, the two-ply nature of the seam can be detected only by careful examination.

Later, probably in 1939 or 1940, some experimental single-piece headers were made. The outer header diameter of these, as well as of some two-piece headers (probably made about this time) was slightly smaller than the diameter of the outer rim of the shell flange. This resulted in an exposed single-ply weld seam. Label-style dating must be used to distinguish these from the earlier single-ply seam tubes.

I. Starting in January 1941, for economic reasons, the gauge of the metal used was reduced to about half its former thickness. This made the practice of tack-welding the base skirt to the bottom side of the header impractical. Over a period of time (no dates available) several methods were tried to solve the base-skirt problem: (a) The shell and base skirt were formed of a single piece of metal - easily detected: no exposed weld seam. (b) The diameter of the inner rim of the base skirt's inward flange was made to fit snugly over the shell and was crimped to support the octal base (P 2P) - shell and base skirt two pieces, easily detected: no exposed weld seam. (c) Same as method b except that the base skirt was welded to the top of the shell flange for better support of the octal base. Probably early in WW II, method c became standard practice.

Except for the 6F6, which made the change one year earlier (probably for field testing) and the 6L6 and similar-sized tubes which never lost their exposed weld seams, an exposed seam automatically dates the manufacture of a tube prior to Jan-

uary 1941 (exposed weld seam P 2O, R, S; covered seam P 2A, T; 6L6 P 2Q).

J. The original and early 6L6s and similar-sized tubes were taller and wider than conventional metal tubes and were made of heavier metal. The shell-flange-to-header weld was exposed and two-ply (P 2Q, left). The base skirt was made with an inward flange and was tack-welded to the bottom side of the header. Because the inward flange had a slight inward flare (due to thick metal) and the base-skirt diameter was smaller than the header diameter, a noticeable indentation ring appears between the base skirt and header (P 2Q, left).

When the GBS was applied, the base skirt could no longer be welded to the inner part of the header. The base skirt was then made with an outward flange having the same outer diameter as the header. It was then welded to the bottom of the header simultaneously with the header-to-shell weld. From this point on, the exposed weld seam became "three-ply" (P 2Q, right) and the indentation ring disappeared. This change took place on the 6L6 in June 1939. The weld seam in the 6L6 and similar-sized tubes always remained exposed.

K. The original 1851 tubes, issued early in 1938, were equipped with a top grid pin that was about half the diameter on later 1851s.

L. The original and early metal tubes with top caps used a brown wafer to insulate and support the cap. Late in 1940 black wafers began to replace the brown. By January 1941 the change was almost complete. Exceptions probably resulted from the clean-out of old stock. The black wafer was used ever after (P 2H, top).

M. In the original and early tubes with top caps the grid cup (metal cup welded to the top of the shell and crimped to support the insulating wafer) was embossed around its entire bottom circumference. Later, probably in 1944, the grid cup was only partially embossed, leaving two small unembossed bumps on opposite sides of the grid cup (P 2H, bottom). These bumps are visible between the underside of the grid cup and the top of the shell (P 2I). They were probably added to strengthen the grid-cup-to-shell weld.

N. Throughout 1938-39 a few grid-cap types were made in several different shapes. When the GBS was first applied to the metal tubes a disk was punched from the center of the header insert to allow for the insertion of the GBS. For a while RCA experimented with different ways of using these disks to form the top grid seal. Three forms of the 6K7, two of the 6S7 and two of the 6K8 have been verified.

O. Metal tubes with exposed weld seams made prior to January 1941 have been found with wartime labels. Some of these were marked "for replacement use only." Evidently RCA cleared its

warehouse of old tube stocks during the wartime tube shortage for distribution on the home front.

P. Probably during 1945, the practice began of die-stamping the tube identification of the side of the base skirt. On most tubes a letter-number code, probably a date code, is also found die-stamped into the base skirt (P 2A).

Last month the "Giant" was put quietly to sleep - on April 30, 1976, the RCA receiving tube plant at Harrison ceased all production of metal, as well as glass, tubes. Even though greatly understaffed, Harrison was true to its fine tradition until the very end. Its last days were spent feverishly stockpiling tubes to meet contract commitments.

Sylvania has taken over the manufacture of the RCA "nuvistor" line. Perhaps it is most fitting that the only tube to survive Harrison, the nuvistor, is the youngest member of the all-metal tube family, the family that played a bigger role than any other in establishing RCA's reputation in the receiving-tube field.

The demise of the Harrison plant brings to a close another era in the history of communications. Although the era that lies ahead will doubtless prove technically superior to any past period, it is doubtful that it will ever match the romance of the vacuum tube. *THE VACUUM TUBE IS DEAD - LET'S PRESERVE ITS MEMORY.*

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Bruce Roloson
Howie Schrader
John Stokes
Jerry Tyne

TUBE DATA

TUBE TYPE	REGIS. DATE	COILED GETTER	BUTTON STEM	RIBBON GETTER
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Series 1A - The original nine (released early Fall 1935)

6L7	4-29-35	4-21-37	4-21-37	5-21-38
5Z4	5-7-35	--	--	--
6F6	5-7-35	--	7-21-37	4-18-38
6F5	5-28-35	3-25-37	3-25-37	6-8-38
6A8	8-15-35	4-21-37	4-21-37	5-12-38
6C5	8-15-35	1-14-37	3-1-37	9-28-38
6H6	8-15-35	--	1-20-38	1-20-38
6J7	8-15-35	9-29-37	9-29-37	5-12-38
6K7	8-15-35	12-29-36	9-22-36	3-2-38

Series 1B - Released first half of 1936 (original characteristics)

6Q7	11-12-35	3-17-38	4-29-38	4-29-38
25A6	12-9-35	--	1-6-41	1-6-41
25Z6	12-9-35	2-3-38	1-12-39	1-12-39
6R7	1-21-36	--	11-3-38	11-3-38
6X5	2-13-36	--	7-16-41	7-16-41
6N7	--	--	7-25-38	6-27-39

Series 2 - Released mid-1936 to mid-1938 (start of paint-stamped label)

6L6	3-24-36	--	6-25-39	6-27-39
5W4	4-1-36	--	4-30-38	--
6B8	6-15-36	3-2-37	3-2-37	11-18-38
25L6	11-4-36	12-21-36	5-11-38	5-11-38
5T4	2-4-37	--	6-6-41	6-6-41
6J5	6-24-37	3-26-37	3-26-37	12-15-38
6V6	1-3-38	7-27-37	7-27-37	2-2-40
6K8	1-31-38	--	12-2-37	12-2-37
6S7	2-23-38	--	1-20-38	1-20-38
1851	--	(orig.)	11-23-38	4-5-38

Series 3 - First "single-ended" tubes (released late 1938 to mid-1939)

6SF5	10-7-38	--	12-16-38	12-16-38
6SJ7	10-7-38	--	8-31-38	8-31-38
6SK7	10-7-38	--	8-31-38	8-31-38
6SQ7	10-7-38	--	7-1-38	7-1-38
1852	3-18-39	--	11-4-38	11-4-38
1853	3-18-39	--	10-4-38	10-21-38
6SA7	11-18-38	--	2-24-39	2-24-39
6SC7	11-18-38	--	3-31-39	3-31-39
12SA7	2-2-39	--	3-31-39	3-31-39
12SC7	2-2-39	--	3-31-39	3-31-39
12SJ7	2-2-39	--	1-9-39	1-9-39
12SK7	2-2-39	--	3-31-39	3-31-39
12SQ7	2-2-39	--	3-31-39	3-31-39
12C8	2-2-39	--	12-30-38	12-30-38
6AC7/				
1852	3-18-39	--	10-26-38	10-26-38
6AB7/				
1853	3-18-39	--	3-9-39	3-9-39
6AG7	5-24-39	--	3-1-40	3-1-40

TUBE TYPE	REGIS. DATE	TUBE TYPE	REGIS. DATE
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Series 4 - Released mid-1939 to end of 1941 (last types prior to WW II).

12SF5	9-21-39	6ST7	12-1-41
12K8	10-16-39	6AJ6	1-25-44
12A6	10-16-39	6AK7	2-8-44
12SR7	10-16-39	12SY7	9-25-45
6SR7	4-10-40*	6SZ7	11-20-45
6SG7	2-17-41	6SB7Y	1-10-46
12SG7	2-17-41	6SV7	6-20-46
6SF7	3-3-41	12SW7	6-20-46
12SF7	3-3-41	12SY7	6-20-46
6SS7	4-22-41	12J5	4-6-50
12H6	5-5-41	5693+	4-30-48
6D5	5-6-41	5961	7-18-50
6SH7	8-1-41	6134	5-22-53
12SH7	8-15-41		

* Weld seam gone 1-1-41

+ "Special Red"

Suffix (Y): Micanol base (spec. ground)

Suffix (X): Ceramic base (spec. ground)

OTHER MAKERS' TUBES

TUBE TYPE	REGIS. DATE
GE 6137	2-18-52
Ken-Rad 6N6	7-9-36
Ken-Rad 25Z4	12-12-38
Hytron 25A7	6-23-36
Hygrade 12A4	8-18-50
Raytheon 0Z4	10-24-35
Raytheon 0Y4	9-20-45

"LM" LOCTAL METAL TUBES

TUBE TYPE	REGIS. DATE
RCA 7A7-LM	9-21-39
RCA 7B6-LM	3-13-40
RCA 7B8-LM	3-13-40
GE (Blue) 12B7-LM	6-6-39

"1600" METAL-TUBE SERIES

1611	6F6 selected for cutoff
1612	6L7, low microphonic noise
1613	6F6 selected for trans. ratings
1614	6L6 selected for trans. ratings
1619	6L6, 2.5-V quick-heating fil., 9-24-43
1620	6J7, low microphonic noise
1621	6F6 selected for long life
1622	6L6 selected for long life
1631	6L6, 12.6-V heater version
1632	25L6, 12.6-V heater version
1634	12SC7 with matched triode sections
1649	6AC7, low microphonic noise
1655	6SC7 with matched triode sections
1664	Special 12C8