THE EATON TUBE COLLECTION

1. THE STORY OF THE TUBE COLLECTION OF THE WASHINGTON NAVY YARD

George H. Clark

[From "Radioana" - SRM 52 299 - C.I. 5 596 100 179, February 27, 1938; now in the Smithsonian Institution. Copy originally supplied by Gerald F. J. Tyne.]

This collection for years hung on the wall of the Radio Test Shop, Washington Navy Yard. About 1929 I made sketches of the various tubes, for my collection of Radioana.

In 1933, I asked the Navy Department for a set of radio apparatus, of antique form, to display in the planned historical display of RCA at "A Century of Progress" [*the World's Fair of that year*]. Among other things, this tube collection was sent to me. It was exhibited in the original glass-covered case in which it came, and during my hourly lectures at the Fair I made especial mention of this historical relic. It attracted much attention, much more than other pieces of apparatus which were farther from the daily use of radio in the home.

At the end of the 1933 session of the Fair, I shipped this exhibit, with others of the Navy and my own collection, to New York for storage at our RCA Victor headquarters on 24th Street. It was planned to repeat the historical display at the Fair in 1934. But Mr. Joyce, of RCA Victor, vetoed this, and as RCA Victor had been given the job of getting up the exhibit at Chicago for all of RCA, his word was law. So, when I went to Chicago in 1934 to lecture, the historical display was left in storage.

In my absence in 1934, NBC made a raid on the entire historic collection. There had long been rivalry between NBC and myself as to who should be in charge of museum material, and while I was away, the head of my department, Glenn Tucker, "gave in" to NBC. So when I returned I found everything had been moved to NBC at No. 711 Fifth Avenue.

On returning, I made a fervent plea for the return of this material. My strongest point was that much of it had been loaned to me in person, as an old Navy employee, by the U. S. Navy and Army, and I had given a pledge to keep it my possession. This argument was upheld. At the same time, NBC began moving from 711 Fifth Avenue to Radio City, and could not take the collection with it, so I brought it back to its original status under me.

Room to store it was very kindly provided by Messrs. Sullivan and McConnach (respectively Comptroller and Secretary of RCA) in the RCA storeroom at 75 Varick Street, New York City.

In moving the apparatus back, I found, however, that much damage had been done to the items, while moving them to NBC or after they had been stored there. The interiors of many receivers, of historic value, had been looted for the "parts value" of the material; many smaller items, and the more priceless, had entirely disappeared (later appearing in the NBC display at Radio City); some apparatus had been smashed entirely.

Among the last named was the USN tube collection. It had not been packed in its original felt case, apparently, and when I found it at 711 Fifth Avenue every tube had been smashed to pieces.

2. THE EATON COLLECTION AND AWA

Bruce Kelley

The earliest vacuum-tube collection, to my knowledge, was the Navy grouping assembled by Lt. W. A. Eaton in 1918-19 and featured in Mary Texanna Loomis' 1927 book Radio Theory and Operating. Having been a tube historian since 1936, I was pleased to have an original photograph and additional information on the collection from an old friend, Ted Duvall. He gave me this account in 1959:

> "Between 1917-1919 I was employed as an Electrician, Radio 2nd Class, USNRF, at the Washington Navy Yard Radio Test Shop working directly under Lt. William A. Eaton, Radio Officer in Charge. Eaton was assigned the task of assembling a collection of all well known radio tubes of the period for evaluation. Some were supplied by the Navy, others by U. S. manufacturers and Allied governments. A few came from captured German apparatus.
>
> After the tubes were cataloged under the direction of Radio Expert Aide Lawrence Horle, fellow worker Raymond Shaffer and I were given the task of making a suitable display case. We made a 20" x 36" oak case 4" deep and lined with green felt. Shafer and I personally mounted the tubes and placed a hinged glass cover to protect them.
>
> On completion, a photograph was taken and a pamphlet written by Horle and approved by Eaton describing the contents. I was given one of the pamphlets, maybe because of my involvement in making the case and mounting the tubes. I am giving you [AWA] my copy for reference. Most of the tubes were common in 1918 but may be rare today."

Using Duvall's material, Lauren Peckham has identified the tubes further.

3. KEY TO THE PHOTOGRAPH*

Lauren Peckham

Although the original photograph of vacuum tubes contained in the collection was described by an accompanying table with a brief description of each (sheets 9 to 14 of a report coded RW50A267 and dated June 1919), historians of the 1991 period may desire additional information. In 1919 there was little need for lengthy explanations, and it is possible that such material as identifications of German types was difficult to obtain at the time. In addition, there were errors in some of the descriptions in the original key.

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* *Photo: AWA Museum.*

1. British Marconi, Fleming two-element valve. Carbon filament. Cylinder plate, mounted directly on stem. Second-generation type with two-point bayonet base and side lead.

2. As 1 above. Carbon filament supported by glass rod, an attempt to provide a more rugged element structure.

3. Early experimental diode. Two carbon filaments; wire ring plate. Miniature two-point screw base with side lead. No further information available.

4. Early experimental triode. Carbon filament; wire ring grid and wire plate. Miniature two-point screw base with side lead. No further information available.

5. De Forest Hudson. Dual oxide-pasted carbon filament. Zig-zag grid supported on double seals; double plate on wire supports to seal. Miniature screw base; double end seal. Supplied with early de Forest apparatus.

6. Wireless Specialty (Pickard). Carbon filament. Perforated sheet grid supported from second seal. Bent sheet plate supported on wire from second seal. Both grid and plate are supported by the glass mount, which also carries platinum lead wires. Two-point skirted miniature screw base; double end seal. Crude experimental type.

7. De Forest tubular Audion, similar to Type T. Tungsten "V" filament. Heavy copper spiral grid, supported from only one end. Aluminum cylinder plate, fits bulb. Miniature screw base; double end seal. Used by Navy.

8. Later de Forest Hudson. Dual oxide-pasted carbon filament. Zig-zag wire grid on glass-rod support. Flat unsupported plate. Miniature screw base with double end seal. Used by Navy.

9. Moorhead Relay. Tungsten filament. Fine wire grid wound on glass frame. Continuous bent aluminum plate supported on the grid frame. Skirted miniature screw base. Single end seal with wires from base. Commercial.

10. De Forest, early version of CF-185. Twisted "V" oxide filament on spring support. Fine wire grid wound on glass frame. Aluminum plate on glass supports from end seal. Miniature screw base. Plate lead emerges from end seal; grid lead, from side tap.

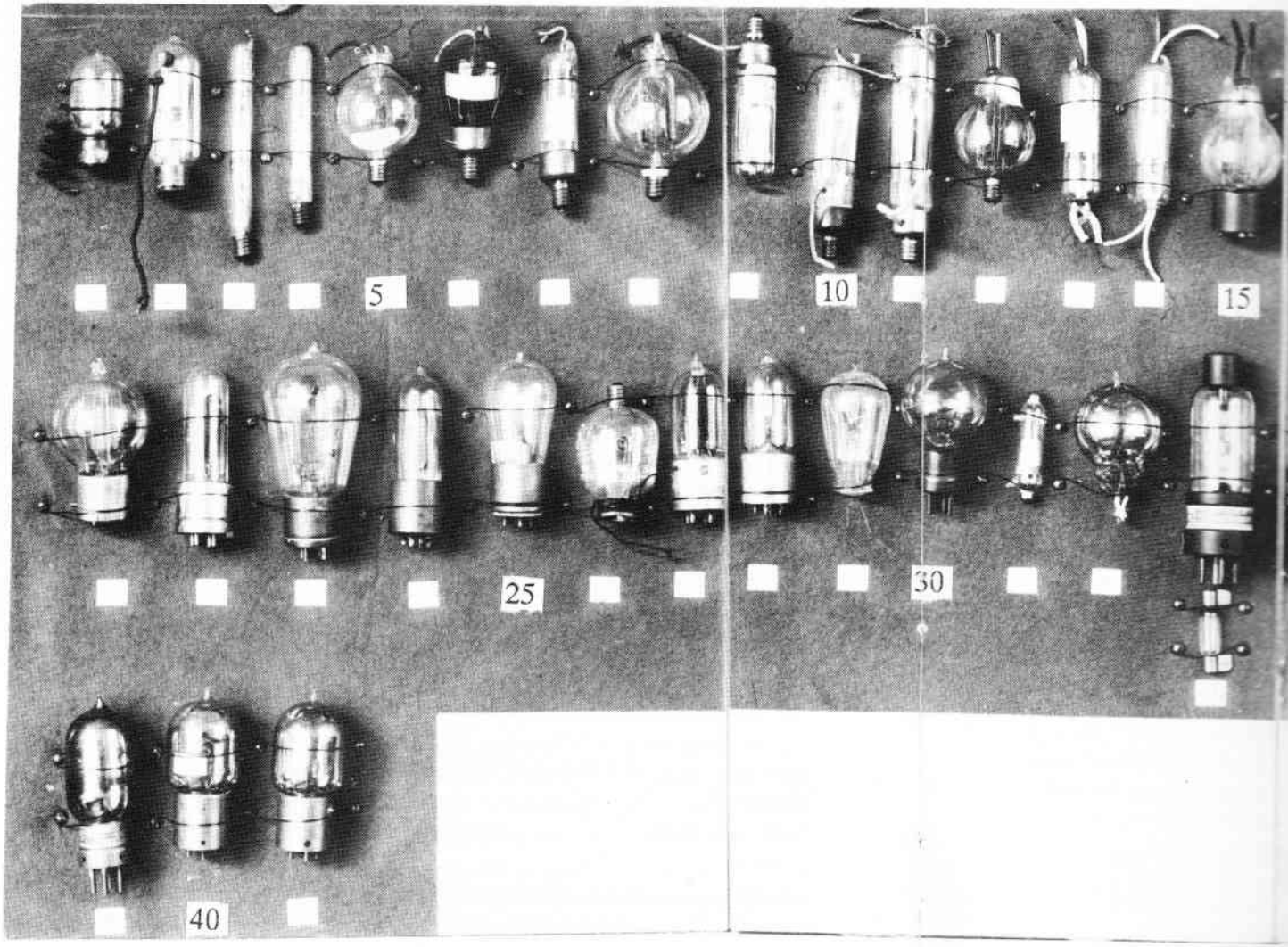
11. Same as 10 above. Plate lead comes through end seal; grid, through base.

12. Western Electric "V" (102A) tube, early version. Twisted "V" oxide filament with loop support. Fine grid, spot-welded and supported on glass stem. Flat double plate with cross-breaks. Double-ended construction. Miniature screw base with double end seal, predating usual four-pin cast brass base. Used by Navy.

13. Moorhead Electron Relay (E. R.). Tungsten "V" filament with three-lead support. Heavy copper helix grid, supported at one end. Aluminum cylinder plate, fits bulb tightly for extra support. No base: plate and filament at one end; grid and two filament leads at other. Electrically very similar to 7.

14. De Forest, similar to 13. Straight tungsten filament. Heavy copper helix grid supported at one end. Aluminum cylinder plate, fits bulb tightly for extra support. No base. Plate and filament at one end; grid and filament at other.

15. Western Electric "V" (12) on Navy three-point base. [The Navy favored the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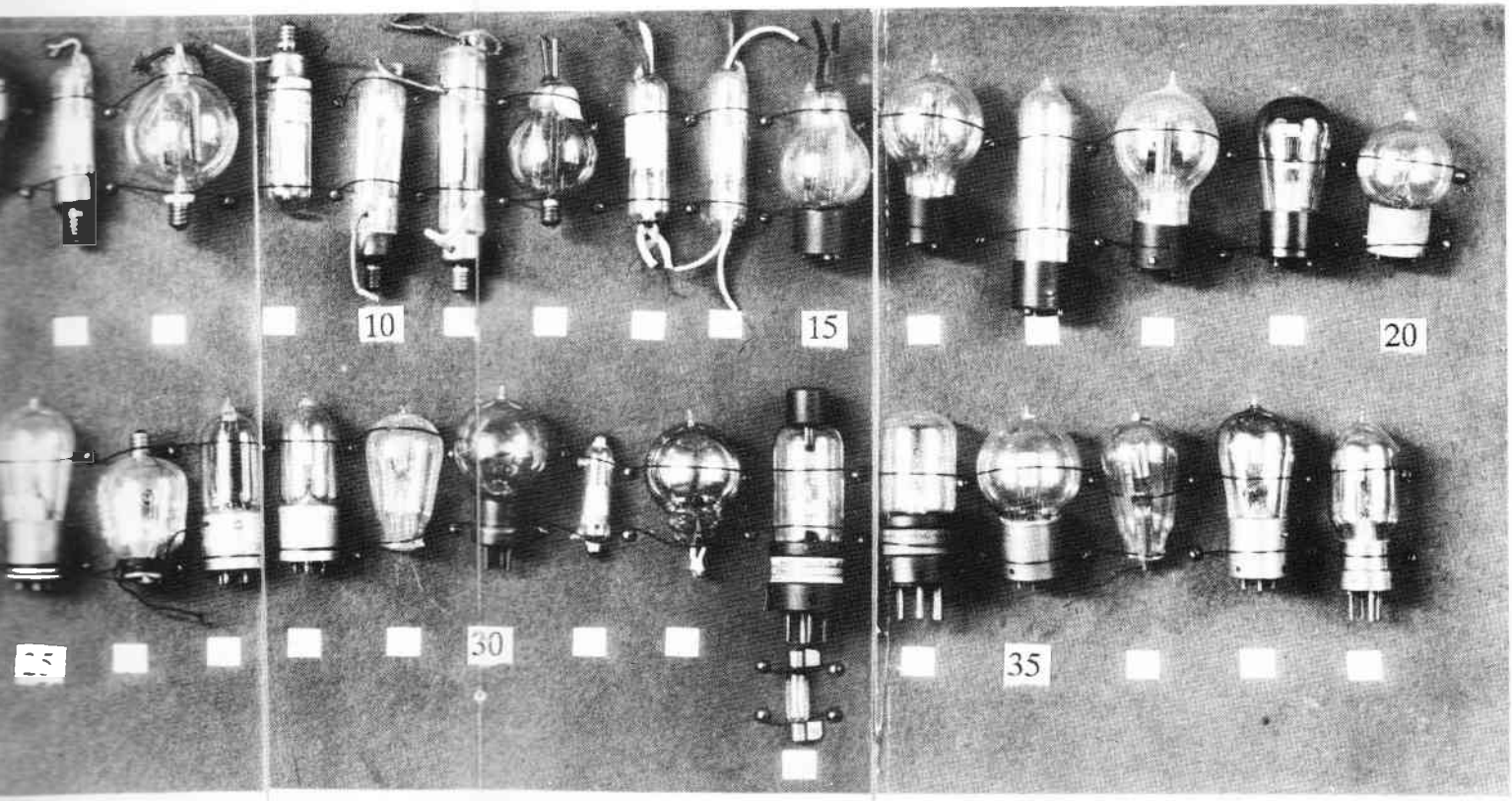

COLLECTION OF VACUUM RECEIVING TUBES

RADIO TEST SHOP

NAVY YARD, WASHINGTON, D.C. JUNE, 1919

RW 50A 267.

SHEET 15.

three-contact base over the candelabra style, as replacement was faster and easier.] Twisted spiral "V" filament on loop support. Two flat plates, braced on both ends. Second seal for plate and grids.

16. De Forest, early version of CF-185. Twisted, coated "U" filament. Fine grid wound on glass frame. Two aluminum plates anchored to same glass frame. Three-point base. Navy standard.

17. De Forest. Tungsten "V" filament, anchored. Otherwise same as 16 using tubular bulb.

18. De Forest, another version of the CF-185. Twisted, coated, anchored "V" filament. Fine grid wound on glass frame with metal guards. Two flat plates, anchored at four points to glass frame. Three-point base. Navy standard. [Original key erroneously identified this as a Western Electric item.]

19. General Electric, CG-886. Tungsten double spiral headlight-type filament. Small thimble-shaped plate. Three-point base. Standard pliotron.

20. General Electric, variant of CG-886. As [19]; differs in shape of bulb, details of seal, and supports of grid and plate. Brass shell-type base, probably with three pins.

21. Western Electric "D" or CW-186. Twisted coated "V" filament, anchored. Fine welded grid, supported on glass stem. Double plate, braced to glass stem. Three-point base, made as wax-filled metal thimble. Former Navy standard. Also known as 201A, but not related to the later RCA UV-201A.

22. Moorhead. Straight tungsten filament. Rather heavy wire grid wound on glass, with copper guards. One-piece aluminum plate, anchored by glass frame. Four-point metal base with Micarta insulation. Sample is same as 9, but with four-pin base.

23. General Electric, CA pliotron. Special amplifier bulb. Tungsten "V" filament, anchored. Very fine grid, wound on glass frame, close to filament. Stiff fine-wire plate, in zig-zag form, wide-spaced, anchored at top and bottom. Four-point base. Tungsten wire used for grid and plate is similar to the design used by Irving Langmuir for his original pliotrons. High vacuum was possible due to relatively easy outgassing during processing, with minimal metallic surfaces.

24. Western Electric "J" (203A), original version with cast brass base. Twisted coated "V" filament, anchored. Fine wire grid, welded, and supported from glass stem. Double plate, braced from glass stem. Four-point metal base with Micarta insulation and wax seal.

25. General Electric CG-890 (see 19). Four-point metal-porcelain base. Sample has thimble-shaped plate, same as original CG-886. CG-890 was the Navy designation for the Signal Corps VT-11.

26. British Osram (G. E.) Type R4. Straight tungsten filament with bow support. Helix grid with bow support. Nickel cylinder plate with single transverse support. Miniature screw base. Bulb is actually single-ended, with leads brought along sides to candelabra base, same as de Forest spherical audion; all leads to tip seal.

27. Western Electric "J" (203A) or CW-933 (Signal Corps VT-1). Coated twisted "V" filament, anchored to lava block, with crossed tensioning springs. Coarse

stamped one-piece grid, with welded braces also tied to lava block. Double corrugated, welded flat plate, clamped onto stem. Plate holds lava block. Four-point metal base, wax-insulated.

28. Western Electric VT-3. Very fine twisted oxide-coated filament; two parallel sides anchored to a lava strip. "V" springs maintain tension on filament wires; also serve as leads through the glass press. Medium-fine wound grid, welded to wire frame, spaced close to filament. Flattened cylinder plate, welded to wire supports. Four-point wax-insulated standard base. Not Navy standard.

29. Horle-Harrison. Carbon filament. Wire grid on harp frame. Single, flat, unanchored plate. Unbased, regular lamp seal. Historical: probably the first valve made in regular lamp works.

30. French "Fotos." Straight tungsten filament. Helical grid, supported at two ends. Cylindrical nickel plate with center support. Four-prong French-British standard base. The bulb for which most foreign apparatus was built.

31. British "Q." Straight tungsten filament with spring anchor. Wire mesh cylinder grid, insulated from filament leads. Cylinder plate fits tube. Leads of elements terminated on metal contact caps. Patent No. 4410. Used in first stages of British apparatus. Has bulb similar to Marconi V24 but is not comparable.

32. U. S. N. experimental, first form of Moorhead SE-1444. Straight (Navy) tungsten filament. Helical grid, turns welded to support. Cylinder plate with one wire support, axial in bulb. Unbased, but with round bulb for four-point base. First step of new standard. (Cloth-covered leads were connected directly to binding posts.)

33. German, similar to Telefunken EVN 94 but with four-pin base. Carbon filament in form of a bow, ballast tube to go in series. Flat spiral grid, on glass supports parallel to plate. Circular disc plate on glass supports. Filament leads from upper seal go to large four-point base. From captured apparatus.

34. German, Telefunken EVE 173. Straight tungsten filament. Medium-fine cylindrical grid; stamped, bent, braced, and welded. Bent, cylindrical, braced plate. Large four-point base. A well made copy of 26 and 30.

35. Sample submitted by Moorhead. Double spiral tungsten filament. Coarse double spiral grid, close to plate, with two anchors. Cylinder plate, double-anchored. Four-point metal and Micarta base. A rejected step toward the standard tube.

36. Sample from Westinghouse, intended for use in transmitters and rated at five watts. Straight tungsten filament on spring supports. Helix grid. Cylinder plate on wire support. Unbased [most samples seen have a Shaw base]. Elements weak mechanically.

37. General Electric. Tungsten "V" filament, anchored. Helix grid, supported at ends. Cylinder plate with two welded supports. Four-point metal and composition base; five leads. Redesign of CG-890 with both ends of grid brought out to allow heating to aid outgassing during exhausting.

38. Moorhead sample. Straight Navy tungsten filament. Helix grid with turns welded to anchor. Cylinder plate, welded to "L" support. Four-point base of British type. Gold color of bulb indicates presence of phosphorous getter used

to obtain a better vacuum. Type number is VT-32.

39. Same as 38. Made by Moorhead, possibly Type C.

40. Moorhead. Straight end-supported filament. Helix grid, with turns welded to support. Cylinder plate welded to horizontal "L" support. Four-point metal and composition base. Bulb shape changed. Proposed as standard; horizontal plate and method of seal rejected.

41. Moorhead SE-1444. Straight supported filament. Helix grid, with turns welded to support. Vertical cylinder plate, welded to "L" support. Four-point metal and composition base. Plate and grid at opposite sides of seal. Adopted as standard.

4. VACUUM RECEIVING TUBES - REPORT ON COLLECTION OF VARIOUS TYPES

L. C. F. Horle

[From sheets 1 to 8 of the report coded RW50A267.]

This collection is composed of the various types of tubes that have been tested at this Laboratory, some of which have been used regularly in Navy practice, from the Fleming two-element valve (1) to the present standard tube [SE-1444] (41). Some of these were purely experimental; some are, or have been standard with foreign nations; and some have merely an historical interest.

Form of the Valve

In the two-element valve, the obvious method of construction seems to have been to use a common type of small lamp base, and add a side seal for the plate. The three-element valve, however, made the seal problem a more difficult one.

The early valves as shown in the original de Forest tubes (1-12), were usually provided with a miniature (standard "candelabra") lamp base, with the plate and grid leads brought out through a second stem sealed into the tip of the lamp.

In the "Electron Relay" of Moorhead and the tubes of de Forest, after which it was patterned, the first step is taken toward one-seal construction. In the de Forest (11), only the plate and the plate support are at the tip. In the Moorhead (9), all are at the base, two leads being brought out through the skirt.

It is to be noted here that in power tubes operating at high potentials, there is a good reason for keeping the plate lead away from the other connections for clearness of connections and safety in operation. However, development of small tubes continued along these lines; except that the other extreme, the baseless, tubular, double-ended form, arose, shown by de Forest (14) and Moorhead (13) again. This type of tube and mounting, however, was never standard in military or commercial service. This form of tube, however, has advantages over the previous types for detection and amplification, more so when constructed as in the British "Q" tube (31), which is quite efficient for the first steps of amplification, particularly at radio frequencies.

The three-point base soon followed. The base was made of insulating material, and some fairly modern efficient tubes were constructed on this base. This

involves, however, the use of the socket as part of the circuit, and the unreliability and irregularity of electrical connection through the "bayonet" pin led to the adoption of the four-point base.

The metal shell as a holder for the wax filling was the simplest method to permit the use of plastic insulating material, and later when the necessity arose of building tubes to stand high temperatures, as transmitting tubes in tropical climates, the porcelain construction (25) and the infusible molded-in-place composition were adopted. A disc of bakelite material held in place by spinning the metal over it was used for the later bulb CW-931, used mainly for transmitting.

The long-prong type is popular with the British and French, but is not as safe against displacement in service and open-circuiting of the contacts, and also has the serious defect that in spite of the unequal spacing of the prongs, it is possible to expose the filament to plate potential, instantly destroying it in most cases. With the bayonet construction, this is impossible, and transmitting and receiving tubes are also distinguished and non-interchangeable. This latter feature may become useless, as the recent tubes function admirably as either, but the safety features of the present standard base, especially in connection with the present approved forms of socket, made the insertion of a tube an absolutely simple operation.

Since, in radio-frequency amplification, the bulb capacity is found to be the limiting factor in short-wave work, and while, in practice, we have been satisfied with the results of keeping leads well spaced and small as in the present standard socket, yet there is very good reason for the form of the British "Q" (31) and some of the other foreign forms where the plate and grid leads are brought out widely separated, through independent seals. This method must be resorted to where extremely short wave operation is essential. Where a single type of tube is to be used throughout, it is undoubtedly true that our standard form is better practice.

Support of the Elements

Certain basic methods of supporting the element have come down the line of progress, and are worthy of notice. Support of plate elements by clamping around the stem, seen in the first Fleming valve, is revised in the W. E. Co. J tube CW-933 (27). Plate fitted to inside of tube, seen in (7), occurs again in 13 and 14 and the British "Q" (31).

A glass stem supporting the whole element is a W. E. construction, still used in their transmitting tubes (12, 15, 21); but is probably difficult to construct and is subject to breakage.

Glass-rod frames are used in a number of de Forest and G. E. constructions, and are convenient for the support of fine close grids. Very short sturdy welded supports from the seal were first characteristic of G. E. constructions (19, 20, 25, 27), making all these tubes very desirable from the standpoint of ruggedness. Lava and mica to support filament and grid from plate are shown respectively in 27 and 28. Glass to support the grid from the filament support is used in 31. The whole element is supported from the tip seal in 26, possibly an anti-capacity construction, but obviously undesirable.

The trend of all the changes is found to be back to the simplest, sturdiest construction. The standard tube SE-1444 (41) is almost the ruggedest, due to the L-

section of the plate support, without the sacrifice of electrical characteristics. It shows that the manufacturers, by attention to the problem, have succeeded in producing a tube of thoroughly satisfactory makeup with a minimum of deviation from the usual operations of sealing, etc.

Filament Construction

The earliest filament was, of course, the carbon, very inferior in emitting properties, because of its low working temperature. It probably would be practically useless at the high vacua of the later bulbs. The Hudson filament, supplied by the de Forest company in some of their early tubes, was coated for a small part of its length with an oxide paste, giving higher electronic emission on the Wehnelt principle, and was highly successful.

From this developed the oxide filament used by de Forest and later W. E. Co., consisting of a twisted flat strip of metal coated with a metallic oxide, and burned with a dull orange glow. This filament was used in many tubes of the CW-931 and CW-933 (27) types and their forerunners, and has the advantage of furnishing a plentiful supply of electrons, and at the same time giving a long life. With a filament of this type using but 0.2 amps, the tube (28) gives very fair results.

The tungsten filament occurs in two principal forms, the straight or bowstring and the double spiral, as the tendency is toward cylindrical plates, These are the forms that are suitable, although the V is used in 37. The double spiral is used in the G. E. tubes 19, 20, and 25.

The straight filament, however, with concentric grid and plates, used in some of the foreign tubes and finally in 41, almost invariably gives the best performance all-round as amplifier, detector and oscillator; especially in conjunction with its economical and simple construction as standardized. A slight wave is given the filament to prevent easy breaking by vibration. It is seen that the German manufacturers had copied this construction, and made a very rugged copy of it (34).

Plate

It is interesting to note that plate construction has reverted exactly to the form of the Fleming Valve (2). This is an outcome of the desire to obtain constant spacing between F, G and P at all points; and to utilize all the emission of the filament. The straight filament and cylindrical plate accomplish this very well. All others differ merely in the method of support, and since the energy to be dissipated is nil, the heat resisting properties are unimportant so that aluminum was used in Navy types. An interesting exception is the G. E. amplifier tube (23) in which the plate is a zig-zag of fine stiff wire about 0.003" thick. This is designed for extremely high voltage amplification and its effect is probably to diminish the capacity, but as a result the impedance of this tube is said by Miller to be of the order of a megohm. The thimble-formed plates characteristic of the early G. E. "Pliotrons" have been dropped on their own initiative, and the cylindrical form is being furnished under the same type CG-890 (37).

With tungsten filaments and plates of nickel, heated during exhaustion, tubes operate well as transmitters at high potentials (up to 1000 volts) and with plates quite red. Of course, the highest vacuum is necessary for such performance.

Grid

The grid or control element is first shown, in 3 and 4, as a ring of wire between the electrodes. In the first practical tubes, we have a wire zig-zag, which takes many forms later. In 6 the grid is of sheet metal with punched holes. This was very crude: the holes were large and round, and did not comprise a large proportion of the "grid" area; however, in 27 this method is well used.

The next types of grid were the wire wound on glass supports, the welded, and the helical. Wire-wound grids may be carried to the extreme of close spacing and fineness shown in the amplifier tube (23), very favorable to high amplification constant. Usually a metal covering is used over the glass rods to tie the turns of the grid, both electrically and mechanically. The fine welded grids of 12 and 21 made these tubes very efficient in their time.

Helical grids of the double-helix or return-wound type are used in the G. E. tubes (19, 20, and 25) and the "Meyer" tube (35) but have been abandoned with the similar type of filament. The simple helical grid is perfectly natural in connection with the cylindrical plate. In the French "Fotos" bulb (30) the helix is unsupported. In the British "Osram" (26) it is attached turn-by-turn to a stiffening wire by means of a fine tie wire. The German copy (34) has a grid which is stamped and bent, but exactly imitates a braced helix. In the last types of bulbs the grid turns are each welded to the supporting wire for a maximum of stiffness.

The German tube (33) is difficult to justify as either an efficient amplifier or an oscillator, and is probably merely a delayed step in development.

Spacing and Characteristics

Large plate spacing and small grid spacing favor amplification, while large surfaces and short paths increase the energy delivery. Hence a compromise is necessary. The later tubes are usually far more thoroughly exhausted, operating on a true electron-emission characteristic rather than a gas characteristic. This gives far greater uniformity, although in certain cases the gas tubes (usually of types 7, 9, 13, or 14) are said to have given startling results when only rectification is required.

The high vacuum in the new types is obtained by the use of a phosphorus or other "getter" in conjunction with the heating of the elements, either electrically or electronically. Both ends of the grid are brought out for this purpose in the G. E. tube (37).

The simple geometrical theory of the action of the tube presented by van der Bijl and developed by Miller indicates that the simple elementary form back to which the tube has found its way is correctly based on theoretical considerations, and that no great improvement is to be expected from changes in tube construction.

APPENDIX
DESCRIPTION OF VACUUM TUBES IN NAVY SERVICE

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Radio Test Shop, U. S. Navy Yard, Washington, D. C.

[A report coded RW50A254, February 3, 1919.]

RECEIVER VACUUM TUBES

TYPE CW-186

This tube was formerly known as the Western Electric type D. It has a spherical glass bulb and is provided with the Navy-standard three-point base.

Overall length: 4"; diameter: 2 1/4".
The grid elements are spaced 1/16" on each side of the filament.
The plate elements are spaced 1/4" on each side of the filament and measure 1-1/8" long by 5/16" wide.

The grid is fairly fine and has a mesh of 26 to the inch. The filament is of the helicoidal (twisted strip) V type with an oxide coating. It is operated at a dull-red to orange brilliancy at filament currents of from 0.9 to 1.3 amperes. The plate voltage should be from 70 to 100. This tube is a good detector of spark signals and a fair oscillator. It was a standard Navy receiver until about April 1918; it has since been superseded by the type CW-933. The CW-186 tubes were purchased from the Western Electric Company at a cost of $8.50 each.

TYPE CW-933

This tube was formerly known at the Western Electric type J. It has a cylindrical glass bulb and is provided with a Navy-standard four-point base. This vacuum tube has superseded the type "D" receiving tube. More of the CW-933 tubes are being supplied to the Service than any other type of receiving tube.

Overall length: 4-l/2"; diameter: 1-5/16".
Diameter of base: 1 3/8".
The grid elements are spaced 1/16" on each side of the filament.
The plate elements are spaced 1/16" on each side of the filament, and measure 1-1/4" long by 3/4" wide.

The grid is much more open than in the type CW-186 tube, having a mesh of 10 per inch. The filament is of the twisted-strip V type with oxide coating. It is operated at a dull-red to orange brilliancy, at filament currents from 0.9 to 1.3 amperes. The plate voltage should be 30 to 50 volts.

This type is not as good a detector of spark signals as the CW-186, but is a very good oscillator. When used in a regenerative circuit (with either inductive or capacitive feedback) it amplifies spark signals much more than any other tube. It is the best bulb known at the present time for use in audio-frequency amplifiers and is now being purchased from the Western Electric Company at a cost of $5.00 each. This tube is a very powerful oscillator and, when used for receiving radio frequency oscillations, is approximately 10 times as powerful as any other receiving vacuum tube. It is considered that this may be a disadvantage against the use of this tube in oscillating receivers. Reports on this feature are desired.

The average operating plate current for this tube is about two milliamperes.

TYPE CG-890

This tube is also known as the General Electric Type G pliotron. It has a pear-shaped glass bulb and is provided with the Navy-standard four-point base.

Overall length with the Navy base: about 4-1/2"; diameter: about 1-3/4".
The plate element is a cylinder, 1/4" in diameter and 4/10" long.
The grid element is a double spiral of 1/8" diameter with a mesh of 18 to the inch.

The filament is of tungsten wire and is of the compact helical type used in automobile head lights. The filament is operated at the brilliancy of an incandescent lamp filament with a current of 0.90 to 0.95 amperes. The filament and grid are practically enclosed within the plate element so that there is no objectionable glare. The normal operating plate voltage is from 20 to 40 volts. This tube is a good oscillator and a good detector of spark signals. The capacity between individual elements of the tube is kept as low as possible by separating the leads-in and insulating each one with a piece of glass tubing about 3/32" in diameter. This tube has a much lower capacity between the elements than any other tube now used. It is therefore very useful for short-wave work (below 300 meters). As an oscillator this tube is classed between the type CW-186 and the type CW-933. It is now being made in great quantities in the lamp factories of the General Electric Company and is being purchased at a cost of $3.50 each.

TYPE SE-1444

This tube is being manufactured by several manufacturers from Navy drawings. It has a pear-shaped bulb and is equipped with a four-prong base.

Overall length: 3-1/4"; diameter: 1-3/4".
The plate is an open nickel cylinder, 0.4" in diameter and 0.6" long.
The grid is helical, of 11 turns of 0.01 nickel wire, and 0.6" long.

The filament is tungsten, designed to operate at 4 volts and a current of 0.65 amperes. It gives best operation at a plate voltage of about 40, with a bias of 1.3 volts.

This tube compares very favorably with the CW-933 in its characteristics, although it is not quite as good an oscillator, but is quite as good in the reception of spark signals and is especially useful in radio-frequency amplifiers. It is expected that this type of tube will become standard in Navy service. At present the cost of these tubes is $3.05.

In addition to its use in receiving, this tube may be used with a plate voltage as high as 750 volts for transmission. When so used, it is capable of developing a power output of 10 watts. This makes it suited for telephone work and for low-power undamped transmission.

It is to be noted that this is the only bulb in Navy service which combines the functions of the transmitter and receiver.

TRANSMITTING VACUUM TUBES

TYPE CW-931

This tube is otherwise known as the Western Electric type E. It is used at present in airplane and other low-power sustained-wave transmitters. This tube has

a spherical glass bulb and is provided with a four-point base; the pins are arranged somewhat differently from the Navy standard base so as to eliminate the possibility of using any other tube in the socket designed for this type bulb.

Overall length is about 4-1/4"; diameter is 2-5/16".
The grid elements are spaced 1/16" on each side of the filament.
The plate elements are spaced 3/16" on each side of the filament, and measure 1-1/8" long by 11/16" wide.

The grid is rather coarse and has mesh of 10 to the inch. The filament is of the twisted-W type with an oxide coating. It is operated at an orange brilliancy at a normal filament current of 1.35 amperes. The normal filament voltage drop is 7.1 volts. The plate voltage should be from 300 to about 375 volts.

The normal space current is 40 milliamperes, at a plate voltage of 350 volts and filament current of 1.35 amperes. This tube is a powerful oscillator and is used only in transmitting sets.

TYPE CF-340

This tube is otherwise known as the de Forest 1/4-kW tube. It has a cylindrical glass bulb.

Overall length: 12"; diameter: 2-3/4".
Plate lead is brought off at the sealing end and the grid and filament leads from the opposite end.
The plates are spaced 7/32" on each side of the filament.
The grid is of fine wire with a 24-to-the-inch mesh.

The plate voltage is 1500 volts with an operating plate current of 150 milliamperes. The maximum permissible plate current is 200 milliamperes. The filament is of tungsten wire operating at incandescent-lamp brilliancy with a current of 2.4 amperes on 30 volts supply. It is used on de Forest 1.2-kW patrol-boat sets, the de Forest 1/4-kW aeroplane set, and de Forest 1/2-kW dirigible sets. These tubes are being purchased by the Navy from the De Forest Radio Tel. & Tel. Co. at a cost of $30.00 each. The General Electric Company manufactures a tube which is somewhat similar to the CF-340. The combined productive capacity of these two companies for this type of tube at the present time is estimated at 40 per week.

TYPE CG-1162

This is a General Electric tube, designed to be electrically interchangeable with the CW-931 of the Western Electric Co.

Overall length: 4"; diameter: 1-3/4".
Plate is cylindrical, diameter being about 0.35", and its length about 0.5".
The grid is helical, being built up in a double reversed helix.
The filament is similarly constructed.
The grid and the filament are supported only at their lower ends.

This tube is designed to operate on 350 volts on the plate and a filament current of 1.75 amperes at 7.7 volts. Under these conditions it delivers about 5 watts of power.