



Fig. 73

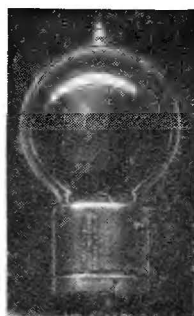


Fig. 74



Fig. 75

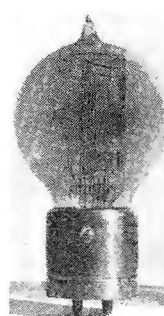


Fig. 76

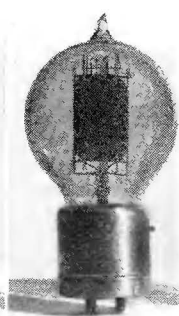


Fig. 77

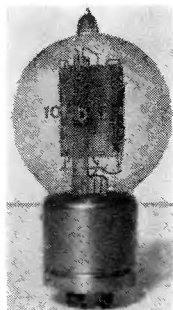
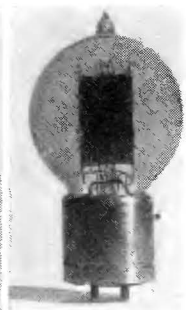


Fig. 78



Fig. 79

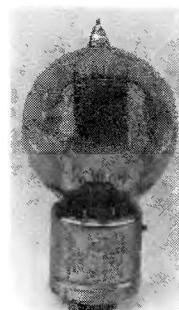


Fig. 80

THE SAGA OF THE VACUUM TUBE

by **GERALD F. J. TYNE**

Research Engineer, N. Y.

Part 9. The early constructional problems of the Western Electric type-101 vacuum tube—covering its multiplicity of shapes and sizes.

NOW we come in our story to the point where we need to know a bit more about this modern Aladdin's lamp; how it looked, how it was constructed, and the multiplicity of forms into which it grew.

To the tube collector, the tube is known by its appearance. So much emphasis in what follows is laid on appearance; on significant changes in construction and markings. The identifying of these changes is a reminder that a great deal of engineering effort goes into developing something which is really serviceable to mankind. Few people have any idea of the multitudinous details of construction and materials involved, or the meticulous measurement work and performance testing.

In this article our consideration will be of the Western Electric 101-type vacuum tube, from the point at which it was left at the end of the preceding article up to the present time, for it is still in use. The early Western Electric tubes merit particular attention for several reasons. They were little known to the public, having been developed for use in the telephone repeater plant, which is largely "behind the scenes." They were by far the best of the early tubes, and they provide a striking example of intensive organized research to produce an article, not for general use or sale in the market place at an attractive price, but for service in a highly specialized application, in a plant where they were treated with care, and in which reli-

ability and long life were the desiderata to be attained.

Late in 1917 the type of base used on Western Electric Vacuum Tubes and Repeater Bulbs was changed. As has been described, up to this time it was a heavy, machined brass, seamless shell. The new base was a formed casing of German silver. Into the bottom of this formed casing was fitted an insulating member on which the contact studs were mounted. (See Fig. 73). The space around the insulating member was filled with a red wax known as "Zinssner's Regular Insulating Wax." This was a mixture of red iron oxide with shellac gums. The wax was poured in to fill the base flush with the bottom of the formed shell and a die applied to form the letters

and numerals of the code marking in the center, in raised characters. This type of base was used until about 1925, although later a different filling compound was used. The color of the Zinsner's wax was always red, although the shade varied from lot to lot, sometimes almost to brown. The compound which was later used was black in color.

When the new type of shell was put into use the patent marking read as follows, (see Figure 74) :

PAT. IN USA
1-15-07 TWO PATENTS
2-18-08 4-27-15
12-19-16
PAT. APPLIED FOR

The first of the tubes made using this shell bore the code marking only in the wax filling of the shell.

Late in 1918 the markings on the base of the 101B and all other repeater bulbs were changed (as shown in Figure 75) to include the property marking of the A. T. & T. Co. The marking of the 101B thus became :

PROPERTY OF
AMERICAN
TEL. & TEL.
COMPANY
101B

PAT. IN U.S.A.
1-15-07 TWO PATENTS
2-18-08 4-27-15
12-19-16
PAT. APPLIED FOR

The construction of the 101B Repeater Bulb up to this time was that shown in the bulb depicted in Figure 76. The element assembly was supported by a glass arbor which was sealed to the edge of the press, and the plane of the element assembly was at right angles to the plane of the press, both being vertical. Difficulties were experienced with this form of assembly however, the most common source of trouble being breakage of the arbor at the point where it was welded to the press. Many of the tubes still in existence show such breakage.

To overcome these difficulties the element was redesigned and, beginning early in 1919, the arrangement shown in Figure 77 was used. Here the arbor has been made heavier and was welded to the stem somewhat below the press. The positioning of the arbor was such that the element assembly was made parallel to the press instead of at right angles to it. The grid structure was changed from 9 to 11 laterals and the plates were made rectangular with edges turned up at right angles to provide stiffening. The tie wires at the top of the assembly were welded to the turned-up edges instead of the flat surfaces, as had previously been the case.

Late in 1919 the patent marking was changed to read as follows:

(Continued on page 54)

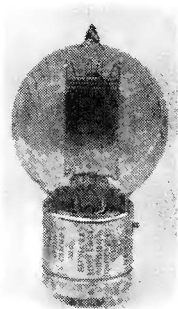


Fig. 81.



Fig. 82.



Fig. 83.

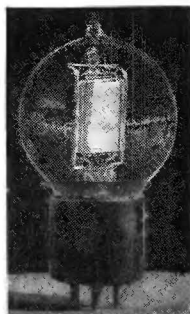


Fig. 84.

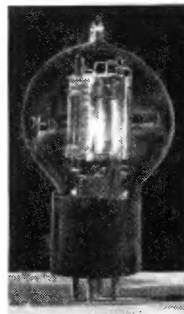


Fig. 85.



Fig. 86.



Fig. 87.



Fig. 88.



Fig. 89.



Fig. 90.



Fig. 91.



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Some of the many suggestions incorporated in the book may be helpful to you or to the operators in your assembly lines, and your suggestions incorporated in later issues of OK METHODS may help speed production in other plants.

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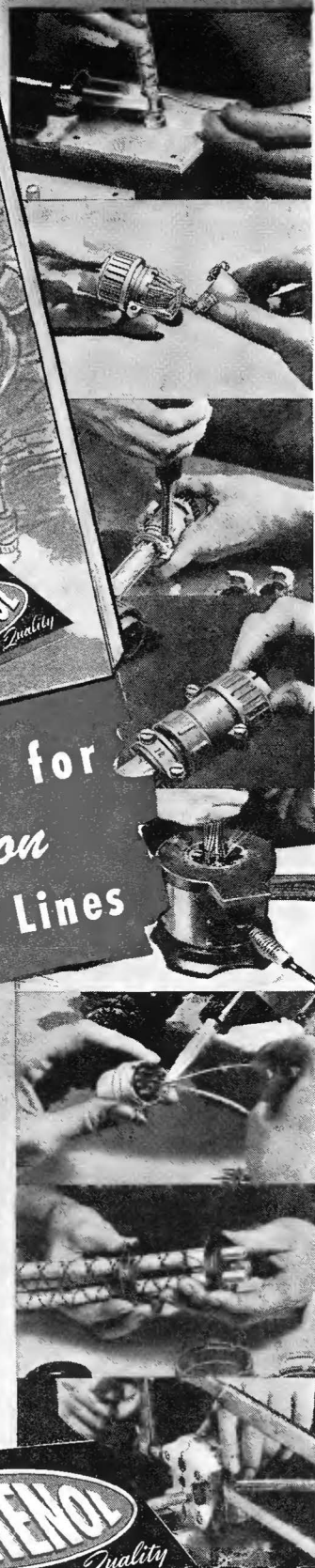
You may send me.....copies of OK METHODS.

Name.....Title.....

Company.....

Street Address.....

City.....State.....



Saga of Vacuum Tube

(Continued from page 39)

PAT. IN U.S.A.

- 1-15-07 TWO PATENTS
- 2-18-08 4-27-15
- 10-17-16 12-19-16
- 12-17-18

PATS. APPLIED FOR

Early in 1921 the patent date 10-5-20 was added to this marking.

Meantime, work had been carried on with a view to improving the characteristics of this tube, especially in the matter of power required for the filament. By 1921 theoretical studies and laboratory experience indicated that this could be done without sacrificing the other characteristics, and accordingly, late in 1921 the 101B was replaced by the 101D.

The 101D was the same as the 101B except for the filament; the first of the 101D tubes operated at a filament current of 1.15 amperes as against the 1.30 amperes required for the 101B. The filament of the 101D had a platinum-nickel core instead of the platinum-iridium previously used, and was untwisted. In order to readily distinguish these lower current tubes from their predecessors, the tips were colored green by the application of lacquer. This practice was continued until 1924.

The manufacture of the 101B was discontinued in 1923.

The first of the 101D tubes had the code marking etched on one side of the bulb in letters approximately 1/4 inch high, as shown in Figure 78, and had the serial number etched on the opposite side of the bulb. These tubes bore the following patent marking:

PAT. IN U.S.A.

- 1-15-07 TWO PATENTS
- 2-18-08 10-17-16
- 12-19-16 10-5-20

PATS. APPLIED FOR

Early in 1922 this marking was discontinued and the standard type of marking was applied on the base, both on the shell and in the wax. Soon thereafter the patent marking was changed to read as follows:

PAT. IN U.S.A.

- 1-15-07 12-19-16
- 2-18-08 12-17-18
- 10-17-16 1-27-20

PATS. APPLIED FOR

A short time later the patent date 10-5-20 was added. (See Figure 79.)

Early in 1923 the practice of the American Telephone and Telegraph Company was changed and vacuum tubes were sold directly to the Operating Companies instead of being leased to them. Hence the marking of tubes as the "Property of the American Tel. & Tel. Company" was discontinued and henceforth they were marked "Western Electric—Made in U.S.A." (Figures 80 and 81).



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Arabian Nights' analogies are left far behind when we talk about the future possibilities of electronic energy in thin glass tubes: the twentieth century genie in a bottle. An incredibly sensitive and positive control of industrial processes is now possible, and every industry must face the probability of technical revolution.

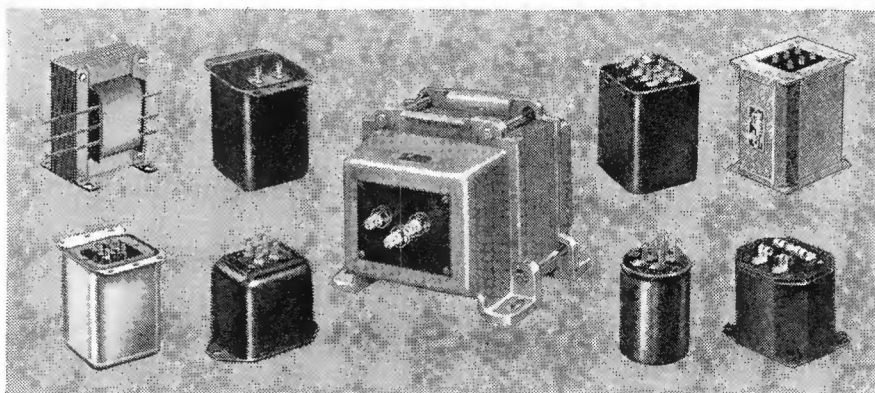
Back of the electron tube, energizing it, is the transformer. Both in war and in peace this mechanism is the special concern of Stancor engineers. Many improvements developed and tested in war, and new developments planned for peace, will emerge from the Stancor laboratory to contribute to post-war industry.



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In 1925, in order to effect economies in manufacture, and permit the use of the same shell on all tubes, the markings were removed from the base and applied to the bulb in a single band as shown in the tube depicted in Figure 82.

Later in 1925 the design of the 101D tube was changed to use a molded base, with the code and patent markings being applied to the bulb in a single band as before. The metal bases previously used were difficult to manufacture to the close dimensional limits required; the filling wax tended to flow out under extreme temperature conditions, and the micarta inserts on which the studs were mounted sometimes absorbed moisture.

The first design of molded base, which used soldering tabs on the contact studs, was employed for about a year and was then replaced by a molded base with a type of stud in which the lead-out wire was threaded through a hole in the stud and soldered on the outside. Essentially the same type of contact stud is still used on these tubes. In order to reduce the variations in the resistance of the contact between the stud and the socket spring, all repeater tubes have been equipped, since the early days of the metal shell, with precious metal contact tips on the base prongs.

The practice of magnesium flashing to aid in obtaining high vacuum was introduced just before the change from metal to molded base, and one of the metal-based flashed tubes is shown in Figure 83. Some tubes were still made without this flashing, for use in certain types of carrier systems.

By 1927 studies of filament materials and characteristics had progressed to such a point, and methods of manufacture had been so improved, that satisfactory operation could be obtained with a new type of filament which operated at approximately 0.5 ampere filament current, and approximately the same filament voltage. This represented a great increase of efficiency and consequent lower operating cost, since it halved the power required for filament operation.

Around this new filament was designed a new repeater tube, with approximately the same plate characteristics as the 101D. This new tube was known familiarly as the "half-ampere L tube" and officially as the "101F Vacuum Tube." At the same time the mechanical structure of the element assembly was entirely redesigned. The plate was made of the completely enclosing type, the grid a continuously wound spiral, and the spacing between the elements greatly reduced. One of these tubes is shown in Figure 84. The 101F did not completely replace the 101D, which still continued to be made.

In April 1927 there occurred a revision of the United States Patent Law which provided that the patent marking of any article made under a patent issued after that date should consist of the patent number rather than the date of issue, as heretofore. An article

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made under patents issued prior to the effective date of the change in the law could be marked with either the date of issue or the patent numbers.

In accordance with the provisions of this law the markings on the bulbs of the 101D and 101F tubes were changed, in 1928, from dates of issue to patent numbers. Photographs of 101D and 101F tubes so marked are shown in Figures 85 and 86.

In 1929 the practice of magnesium flashing the 101D was discontinued and some minor changes in design, such as the relocation of the plate lead and the use of a shielded grid-lead-in wire, were made. About the same time the practice of putting the code marking on the base, in depressed characters, was adopted. (See Figure 87). The patent markings were, at the same time, removed from the bulb and applied to the carton in which the tube was packed.

The construction of the 101D remained practically unchanged from 1929 until 1940, when the tube was completely redesigned and modernized. This redesigned tube, which is in current manufacture, is shown in Figure 88.

The practice of putting the code marking and Western Electric name on the molded base, in depressed characters, was instituted for the 101F at the same time as for the 101D. Figure 89 shows a 101F tube with these markings.

Later the 101F was changed to use a pear-shaped bulb instead of the spherical one, and this tube is shown in Figure 90.

When the 101D was redesigned in 1940 similar changes were made in the 101F, resulting in the tube shown in Figure 91, which is of current manufacture.

Still further studies have since been made which have resulted in the realization of a tube which operates at one-half the filament current of the 101F, and this tube, known as the 101L, is now in production.

The story of the 101-type tube is a most interesting one. The evolutionary steps which they have gone through is an excellent example of what can be accomplished by continued study and long experience in the manufacture and use of a particular type for a definite purpose. The 101 types are, always have been, and probably always will be designed and manufactured for use in telephone repeaters. The conditions under which they operate are exacting, and it is greatly to the credit of the research workers, designers and manufacturer that these conditions have continued to be met satisfactorily. This has been accomplished in spite of the fact that the latest designs require only one-fifth the filament power of the first tubes of this type. And in the process the useful life of the tube has been increased a hundred fold, from the 400 hour life of the 101A to the 40,000 hour life of the 101D.

Truly a remarkable achievement!

CAPTIONS FOR ILLUSTRATIONS

Figure 73. Formed sheet metal base with micarta insert, used on Western Electric Repeater Bulbs and Vacuum Tubes 1917-1925. View before base has been filled with wax.

Figure 74. First type of 101B Repeater Bulb to use formed sheet metal base. The code designation appeared only in the wax filling of the base, and the patent marking was applied in depressed characters to the metal base shell. The markings have been filled white in the illustration, for photographic purposes.

Figure 75. Later manufacture 101B showing code marking and A.T.&T. Co. property marking applied to sheet metal base. The code number was also applied to the wax filling of the base.

Figure 76. Two views of the early 101B Repeater Bulb. This shows the construction in which the arbor supporting the element assembly was attached to the edge of the press. This particular tube was made at the Hawthorne Works of the Western Electric Company, as evidenced by the "H" following the serial number on the glass.

Figure 77. Two views of the improved 101B Repeater Bulb. The glass supporting arbor is heavier, and is welded to the stem below the press. This was a more sturdy construction than that shown in Figure 76.

Figure 78. Early type 101D Vacuum Tube. The code marking appeared only on the glass bulb.

Figure 79. Later type 101D, showing code marking, A.T.&T. Co. property marking, and patent marking on base.

Figure 80. Later 101D than that shown in Figure 79. A.T.&T. Co. property marking has been replaced by Western Electric marking and patent marking has been revised. Markings are in 1/16 inch high characters.

Figure 81. Same as Figure 80 ex-

Passing the half-way mark up the 200-foot tower of the Maine State Police Department WBNV, Augusta, Me. A 3/8" coaxial gas-fed line leads to a coaxial radial antenna on top of it.



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cept that markings are in 3/64 inch high characters.

Figure 82. 101D Vacuum Tube with molded phenol plastic base, code and patent marking on bulb in baked enamel lettering. Patent marking given as dates of issue of relevant patents.

Figure 83. 101D Vacuum Tube with metal base and magnesium flashing.

Figure 84. Early 101F Vacuum Tube—code and patent marking on bulb, patent marking given as dates.

Figure 85. Later 101D Vacuum Tube—markings on bulb—patent numbers have replaced patent dates.

Figure 86. Later 101F Vacuum Tube—markings on bulb—patent numbers have replaced patent dates.

Figure 87. 101D Vacuum Tube with molded base. Code number is in depressed characters on base. Base markings have been filled white for photographic purposes. Patent markings were applied to the carton in which this tube was packed.

Figure 88. 101D Vacuum Tube of latest construction—new element assembly and domed bulb.

Figure 89. 101F Vacuum Tube with markings in depressed characters on phenol plastic base.

Figure 90. 101F Vacuum Tube in pear-shaped bulb.

Figure 91. 101F Vacuum Tube of latest construction.

(To be continued in March issue)

Theory of U.H.F.

(Continued from page 34)

of the various references given with this article. They contain practically all the published knowledge of the Klystron tube as used with ultra-high frequencies. Those references that have an asterisk contain a mathematical analysis of the Klystron while the others are more or less descriptive.

The operation of another ultra-high-frequency tube will be considered in the next part of this series of articles. The principle of operation will depend upon the instability of moving electrons in a magnetic field. This tube is commercially known as the Magnitron and is also capable of producing ultra-high frequencies in the range of 3000 megacycles.

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- (To be continued in March issue)

Flying Fortress

(Continued from page 23)

The radio man sat back on his parachute pack, loosened his "Mae West," relaxed and listened. Over the intercom came the voices of the crew and observer-commentator as the ship sped towards the continent to bomb the Nazi-held airfield:

Nussbaum: "It's now 8:20. Zero hour is at 8:45. In exactly twenty-five minutes, at zero hour, every plane, every bomber, every fighter on this operational mission. . . ."

Pilot: "Pilot to tail gunner. Check your glasses and see if you can get the number of that aircraft to the right of us."

Tail gunner: "Tail gunner—Roger. Four two eight. . . . I think it is four two eight. Roger."

Pilot: "Thank you. Roger."

Nussbaum: "As I said, at 8:45, which is in about twenty-five minutes, all the planes on this mission, whether they be bombers or fighters, will be in the air on the way to the target. That is known as zero hour. I can now see the wing ahead of us. It is in perfect formation. They are scheduled to go into the target two minutes ahead of us. We have not as yet made our rendezvous with our fighter escort."

Bombardier: "Altitude 10,000 feet. Put on your oxygen masks. We are at oxygen level."

Tail gunner: "Tail gunner. Roger."

Nussbaum: "As you can hear, we are going on oxygen now. I have just put on my mask, and it may make my



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