

THE SAGA OF THE VACUUM TUBE

by **GERALD F. J. TYNE**

Research Engineer, N. Y.

Part 7 of the series, covering the period during which the first commercial grid-type Audion tube was manufactured for civilian use.

THE first public disclosure of the grid-type Audion was made at the Brooklyn Institute of Arts and Sciences on March 14, 1907 by Dr. Lee de Forest, in connection with a paper on "The Wireless Transmission of Intelligence."

Immediately after this disclosure Dr. Forest organized the "De Forest Telephone Company" and its subsidiary, the "Radio Telephone Co." to manufacture and market wireless apparatus on which he owned or controlled patent rights. Directly thereafter the first grid-type Audion was manufactured for commercial use. It was made with a narrow flat plate mounted near a metal filament. Between these two was fixed a grid wire.

In 1909, in order to increase the conductivity of the tube, and to enable the use of larger energy, the use of two grids and two plates, one set on either side of the filament, was introduced. These were called "double Audions" and were sold at a higher price.¹⁴⁰ A photograph of one of these Audions is shown in Figure 44. Some of these double Audions had separate leads brought out from each grid and plate, as shown in the tube in Figure 45.

The filament structure was changed

in 1913 to the so-called "Hudson X" type developed by Dr. Walter Hudson. Dr. Hudson was an independent worker, an avid wireless fan, who had used the tantalum filament type Audion, and found it more emissive than the tungsten type. However, the tungsten filament had a longer life, and Hudson conceived the clever idea of combining both elements, by wrapping a short piece of tantalum wire around the tungsten. He induced McCandless to build up some bulbs of this type, which proved superior to the tungsten filament type, and were in correspondingly greater demand thereafter, even though sold at a higher price. A double grid, double plate Audion employing the Hudson type filament is shown in Figure 46. The tantalum wire wrapping can be seen on the top arc of the filament.

Having briefly outlined the various steps in the evolution of the structure of the earlier Audions, let us now see how they were made available to the purchaser. As far as the author has been able to determine the first Audions offered for sale to the amateur were advertised on page 288 of the September, 1909, issue of "Modern Electrics," in an advertisement by the

Radio Telephone Company. This company had been advertising wireless apparatus in that magazine since January, 1909, but the September advertisement was the first to mention "Audion Detectors." A reproduction of this advertisement is shown in Figure 47. The Audions were offered for sale as part of an assembly denoted as the "RJ4 Detector." The designation "RJ," meaning "Radio Junior" was adopted for pieces of equipment that were developed especially for sale to amateurs, and distinguished from the so-called "professional equipment" intended for commercial use.

The bulbs first sold with the RJ4 Detector were spherical and contained a double horseshoe filament, a single grid, and a single "wing" or plate, and were fitted with a candelabra base. The center contact of the base was connected to the common point of the two filaments. The second end of one filament was connected to the threaded shell of the base, and the second end of the other filament was brought out on a wire which came out just above the base, but insulated therefrom by a piece of cotton sleeving. There was a heavy knurled rubber band placed on the base, just below the line where the bulb emerged. The bulb was used until the first filament burned out. Then the projecting wire was wrapped around the base and held in contact therewith by slipping the rubber band over it, thus anchoring it firmly in position. This brought the second filament into use. The life of the average filament was 35-100 hours, despite the higher values claimed in the advertisements.

These detectors were regularly furnished with the regular or so-called "S" grade of Audion bulb which had a tantalum filament. An extra-sensitive or so-called "X" grade bulb could be obtained at an additional cost. After the development of the Hudson type filament, bulbs using this filament could be obtained in both the "S" and "X" grades, but at a higher price than the tantalum filament bulb. A typical advertisement offering the RJ4 and RJ5 Detectors for sale, and listing the various bulbs is shown in Figure 48.

The RJ4 Detector consisted of a ma-

Fig. 44

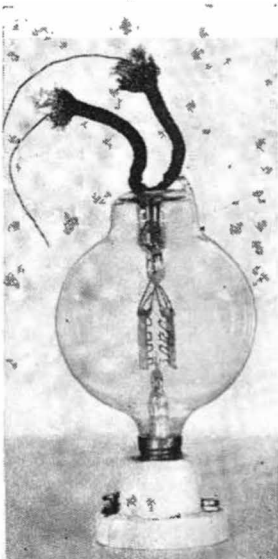


Fig. 45

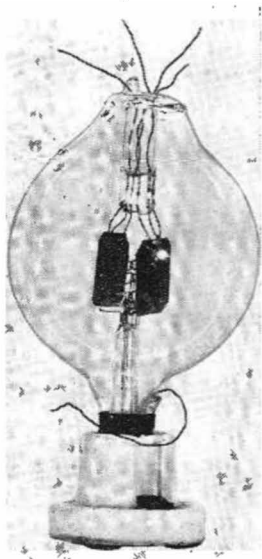
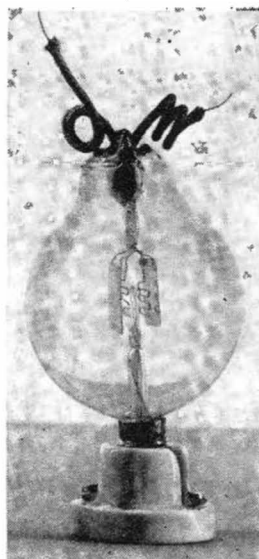


Fig. 46



hogany box, in which were placed the flashlight cells which were used as the "B" battery. On the front of the box were two switches. The one at the left of the "street-light" bracket from which the bulb hung was a tap switch on the "B" battery. The one on the right was the "Off-On" switch for the filament. The filament current was controlled by a porcelain-based rheostat mounted on the right hand end of the box. Binding post connections were provided for the filament battery, the terminals of the input circuit (which was usually the secondary of a "loose-coupler"), and the telephones. The earlier RJ4 Detectors were equipped with a three-point switch for controlling the "B" battery voltage.

For a long time after the Audion was put on sale, it could be obtained from the Radio Telephone Company only by the purchase of a complete detector instrument, such as the RJ4. (*The author understands, however, that audion bulbs were also sold by the H. W. McCandless Company on an over-the-counter basis to customers who came looking for them.*) Owners of such detectors could procure renewal bulbs only on the return of the old bulb at the time the order for the renewal was placed, except as noted below. The price of the RJ4, the cheapest of the RJ series of detectors, was \$18, as will be noted from the advertisement shown in Figure 48. This represented a small fortune to many an experimenter. Hence, ways and means were sought to circumvent the necessity of such a purchase.

The only element of this detector which the amateur could not readily acquire was the Audion bulb itself. The rheostat, batteries, switches, etc., were all common articles of commerce. The early Audion bulbs were extremely fragile pieces of apparatus. In fact, they were popularly known as "onion-skins." In order to obviate the necessity of returning broken bulbs, in cases where accidents occurred, a renewal bulb could be obtained if, in lieu of the complete bulb, the grid and plate from the broken bulb were returned. Since the earliest bulbs had only one grid and plate, the return of one grid and plate was sufficient to permit the purchase of such a renewal.

When the double grid, double plate Audion was placed on the market it became a means whereby the less plutocratic amateurs might obtain the coveted Audions. When one of these bulbs passed to its eternal reward the fortunate owner thereof promptly broke it up, returned one set of elements for his renewal, and sold the other set to someone less blessed with this world's goods, who could then return the second set and thus purchase a bulb for himself. This was such a common practice that old-timers will remember advertisements in the "swap" columns of the amateur magazines of that day, offering to buy and sell such elements.

The first popular article on the grid-
(Continued on page 78)

De Forest Apparatus

DESIGNED BY EXPERTS

WIRELESS TELEGRAPH AND TELEPHONE

RECEIVING OR TRANSMITTING

HIGH CLASS APPARATUS OF ALL SORTS AT REASONABLE PRICES

Variometers, Loose Couplings, Variable Condensers of all sizes, Helices and Spark Gaps, large and small, Heavy Transmitting Keys, Audion and Radion Detectors, Wavemeters, Telephone Receivers of extreme sensitiveness, Complete Commercial Tuners, etc., etc.

Our R. J. Variometer comprises two instruments in one—a Variable Tuning Coil without sliding contacts, and a loose coupling of novel design. Our R. J. Wavemeter comprises THREE instruments in one—it will measure either SENT or RECEIVED wave lengths, is a Tuned Receiving Circuit, or can be used as a Variable Tuning Condenser. We find our Radion the best of mineral-type Detectors.

Technical advice and assistance will be gladly given to all purchasers by our expert engineers.

If you wish a REAL Wireless Station go to those who KNOW HOW! Address

SALES DEPT.

RADIO TELEPHONE CO.

1 Madison Avenue, New York City

Fig. 47

Fig. 48

DeFOREST AUDION DETECTORS

Incomparably Superior to Any Other Known Type



Type RJ4 Audion Detector



Type RJ5 Audion Detector

If you desire long distance reception of messages, you must have an Audion Detector. Tests of the Bureau of Standards show it to be the most sensitive and reliable detector ever invented. It stays in adjustment even where a transmitting set is used, and can be depended upon, absolutely, at all times.

The above types are regularly furnished with regular, or "S" grade, tantalum filament Audion Bulbs. Fitted with other grade bulbs at the difference of price of bulbs as listed below. A 4-volt-storage battery or three dry cells are needed to light the filaments of the detectors, but are not furnished at these prices.

Bulbs are sold only for purposes of renewal, and then only upon return of the old bulb.

Price List, F. O. B. New York

Type RJ4 Audion Detector, with regular "S" grade bulb.....	\$18.00 net
Type RJ5 Audion Detector, with regular "S" grade bulb.....	25.00 net

Renewal Bulbs

Type "S" Regular Grade Audion Bulb (Tantalum Filament).....	\$3.50 net
Type "X" Extra Sensitive Audion Bulb (Tantalum Filament).....	5.00 net
Type "S" Regular Grade Audion Bulb (Hudson Filament).....	5.00 net
Type "X" Extra Sensitive Audion Bulb (Hudson Filament).....	7.50 net

Hudson Filament Bulbs have a very long life, between 800 and 1,000 operating hours, which is about three times the life of tantalum filament bulbs

All reliable wireless dealers handle Audion Detectors and renewal Bulbs. If you do not know your local dealer, we will give you his name.

For further information, see your dealer, or write us.

DeForest Radio Telephone & Telegraph Co.

101 PARK AVE.

NEW YORK

is the weaker of the two then 190 degrees is the correct direction.

There are several methods employed to give direct readings of the corrected bearings in which the error is already compensated for by mechanical means, the most common types employing a roller and cam arrangement, usually a flat disk has the curve plotted around its circumference and the cam cut out as per the resultant curve which is somewhat elliptical in shape. This, of course, must be calibrated in the usual manner and then the necessary curve drawn and the disk cut as required. As there are many variations of these compensation systems, details of types of course, vary greatly with the different manufacturing concerns.

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Saga of Vacuum Tube

(Continued from page 27)

type Audion which the author has been able to find appeared in the October, 1908 issue of "Modern Electrics."¹⁴¹ This article was written by John V. L. Hogan, Jr., one of de Forest's early assistants, and now a consulting engineer. In this article the statement was made that there were at that time six distinct varieties of Audion. These were: (1) the flame Audion, (2) the arc Audion, (3) the two-element U-wing type, (4) the external electrostatic control type, (5) the external magnetic control type, and (6) the grid type Au-

dion is described in the following:

"The grid audion is usually a 6-volt, low candlepower incandescent lamp with a tantalum filament having a small platinum plate (approximately 10 x 15 millimeters) fastened approximately 3 millimeters from the filament and a grid bent from rather large (say number 22) platinum wire placed nearly midway between the two."

Despite the fact that the title of the patent on the first three-electrode Audion was "Device for Amplifying Feeble Electrical Currents," the three-element Audion was for many years used only for detection. De Forest and his associates are said to have attempted even at that time to use the grid Audion to obtain audio-frequency amplification, but were unsuccessful. It is probable that attempts to so utilize it were failures because of insufficient knowledge of the characteristics of the device, and the use of high frequency type coupling in an attempt to obtain audio-frequency amplification. Of course, it is probably true that the grid type Audion operated as the sensitive detector that it was, by virtue of its inherent amplifying properties, but it was not used as such by de Forest or by anyone else in the United States as an amplifier *per se* until 1912, about five years after its development.

Many reasons have been advanced to account for the fact that the Audion, throughout the first years of its existence was employed in radio telegraphy only to a limited extent. "Wireless" as a commercial utility suffered damaging setbacks in that period because of sundry stock-jobbing schemes¹⁴² based on earning claims many years in advance of what was likely to be possible. Other reasons sometimes given are: that the majority of users of wireless receivers were boys working as amateur experimenters, to whom the high cost of Audions, previously noted, acted as a deterrent to their use; that the Audion was erratic and little more sensitive than the best of the crystal detectors, which were quite inexpensive devices; and that patent litigation or the threat thereof prevented its use by those who operated ship and shore stations in marine service.

De Forest, following the events of 1912-14, was subjected to no little criticism for having nursed the Audion through infancy and adolescence without discovering the full potentialities of the device. In considering the justification for such criticism the following should be borne in mind. During this period the Audion came into some attention on the part of scientists, engineers, and the more serious wireless experimenters. These men also failed to realize the possibilities inherent in this Aladdin's lamp.

Such a hiatus is not unusual in the development of a new device or system. It will be recalled that a period of seven years elapsed between the announcement by Hertz in 1888 and the achievements of Marconi in 1895.

WHEN THE LIGHTS COME ON AGAIN

AUDIOGRAPH

THE FIRST NAME IN SOUND

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JOHN MECK INDUSTRIES
PLYMOUTH, INDIANA

EXCELLENCE IN MUSIC AND VOICE REPRODUCING EQUIPMENT

From 1906 to 1912 the de Forest companies were involved in financial difficulties, and de Forest took a job with the Federal Telegraph Company on the Pacific Coast. There he found the Federal Company using continuous wave arc type transmitters, and attempting to transmit telegraphy at high speed. This development brought with it the problem of getting energy enough to make a record of the high speed signals, for later reproduction and transcription at lower speeds. They were attempting to use the Poulsen telegraph as a recorder, but the energy of the received signals was insufficient to record satisfactorily. Realizing that what was needed was a device to

"boost" the energy of the received signal, deForest took up the Audion anew and attempted to get it to amplify. The problem was one of obtaining amplification at audio frequencies.

In the spring of 1912, de Forest obtained an assistant, H. B. Van Etten. Van Etten was familiar with audio frequency circuits and apparatus, having previously worked for the telephone company in New York. In May and June of 1912, Van Etten, under de Forest's supervision, started experimenting with audio frequency transformers with which to better interconnect a radio detector with receiving head phones.

In July and August, 1912, they suc-

ceeded in getting real amplification out of a "double Audion." Later, while still trying to improve the arrangement as an amplifier, they got a howling feedback circuit, and thus was born the Audion oscillator.

De Forest then got in touch with his friend John Stone Stone, also a former telephone company employee, and through him arranged to demonstrate the Audion for use as a telephone repeater. The results of this demonstration, and the process by which the Audion was developed into a practical telephone repeater, will be discussed in a later article. For the present it is sufficient to say that the rights to the Audion for use as a telephone repeater were purchased by the American Telephone and Telegraph Company.

With this transaction the Audion passed out of the realm of the individual inventor into that of the industrial research laboratory. Though de Forest did not know it at the time this was to be the final touch to the years of tribulation he had suffered with his brain-child. He thought his feet were firmly planted on the threshold of success when he saw his child being trained to serve a new master. But when the new master succeeded in developing the child, and had groomed him to perform a specific task, de Forest's paternity was overshadowed by the new developments.

Did de Forest drop his own work on the Audion? Not for long!

Figure Captions

Figure 44. First type of "Double Audion." This specimen has tantalum filament. Photograph courtesy Radio Corporation of America.

Figure 45. Double Audion with separate leads from each plate and grid. Photograph courtesy Bell Telephone Laboratories.

Figure 46. Double Audion with Hudson type filament. The tantalum wire wrapping can be seen on the top arc of the filament.

Figure 47. Reproduction of the first advertisement offering the Audion for sale to the radio amateur. Reproduced from *Modern Electrics* of September, 1909.

Figure 48. Advertisement showing RJ4 and RJ5 Detectors, and giving prices on various grades and types of Audion bulbs. Reproduced from *Modern Mechanics* of February, 1915.

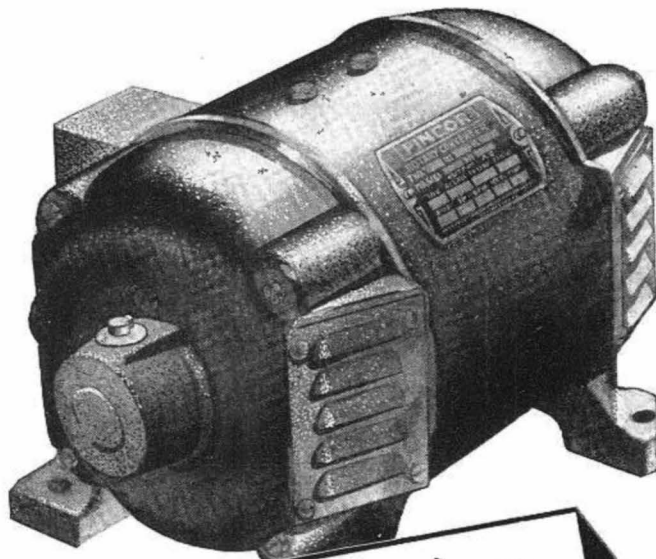
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140. de Forest, Lec: "The History of the Radio Tube, 1900-1916." *RADIO NEWS*, Vol. 24, No. 6, December 1940, p. 8.

141. Hogan, John V. L., Jr.: "The Audion: A Third Form of the Gas Detector." *Modern Electrics*, Vol. 1, No. 7, October 1908, pp. 232-233. The diagram given in this article is incorrect, but a correction appears on p. 275 of the November 1908 issue.

142. Fayant, Frank: "The Wireless Telegraph Bubble." *Success Magazine*, New York, Vol. 10, No. 158, July 1907, pp. 387-388. Vol. 10, No. 157, June 1907, pp. 387-388. Vol. 10, No. 156, May 1907, pp. 387-388.

(To be continued)



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