FROM RESEARCH LAB TO THE FIELD – G.E.'s VACUUM TUBE CONTRIBUTIONS DURING WORLD WAR 1 1915 - 1918

Beginning in 1912, the Research Laboratory at GE was constantly experimenting and making developmental samples that could be used in their general quantity production fully expecting to supply future demands. [1]. It must have become apparent very quickly what needed to be done at the General Electric Company when, in late 1917, the US Navy placed the first order for 1000 receiving tubes. This order was based on 6 examples. William C. White quote- *"Early in December, the Navy had come forward with a request for tubes, an order being placed for 1000 receiving tubes on the basis of six examples produced by the lamp factories sent by the Research Laboratory to the Navy". This was the first actual order for tubes from the Government to be placed with General Electric and the necessary steps were immediately taken to build up an organization in the lamp factories, laying out equipment for considerable quantity production". [2]*

Fig. 1

Close-up of anode in Fig. 1

The tube shown in Fig. 1 is a developmental pliotron triode receiving tube designed by W. C. White in1915 or 1916. [3]. It has a conical plate, indicative of their early work, supported by a rod through the top of the tube connected to a multi-strand wire. 4 wires extend through the bottom- 2 for each leg of the filament and 2 for each leg of the grid all using multi-strand wire. This tube also has the number 706 written with a red material on the bulb that is considered to be a GE museum accession identification and the letters p a. and number 408 etched on the bulb. [4]. Since this pliotron came from the GE museum in Schenectady, it can be said with some confidence that it was made at the GE Research Lab in Schenectady by White. [4]. It could have possibly been sent to Nela Park for their research at a later time and returned. Although this tube is un-based, another example observed in the Vanicek collection has a white, composition material DeForest type base. Also shown is a close up of the anode.

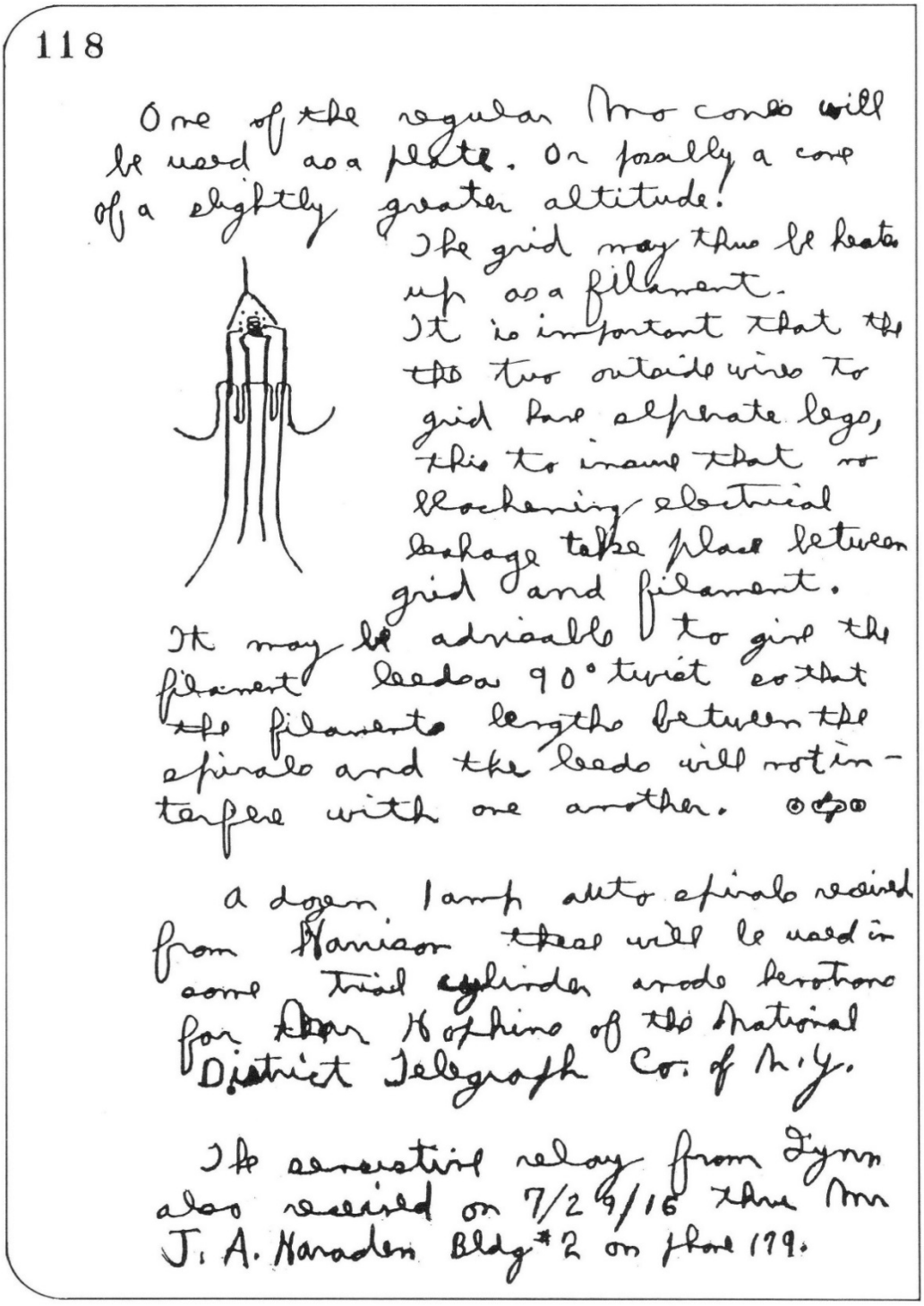


Fig. 9 This is White's first sketch of a cone-anode pliotron. Previously the cone had been used only for small kenotrons (rectifiers). From this inverted shape grew the T and G pliotrons of WW I. W. C. White's notebook #690, dated July 14-29, 1916.

Fig. 2

Shown in Fig. 2 is a page from W.C. White's notebook #690, dated July 14-29, 1916. [5]. The information from this page in the notebook gives a great deal of evidence that the cone shaped plate pliotron in Fig.1 was a developmental step towards the G.E. research lab tubes they named the type G and T pliotron's. [5]. In one sentence in White's notebook he advises giving the filament leads a 90 degree twist so as not to interfere with one another. [5]. The example in fig. 1 has a 90 degree twist in the grid leads.

Fig. 3

The experimental tube in Fig. 3 is thought to have been made in 1917 from an earlier White design and presumed to have become the type T pliotron transmitting tube. [6]. The anode is cone shaped and resembles the internal structure of the prototype in Fig. 1. No markings on the press make it difficult to know where it was made but probably at the Research Lab at Schenectady.

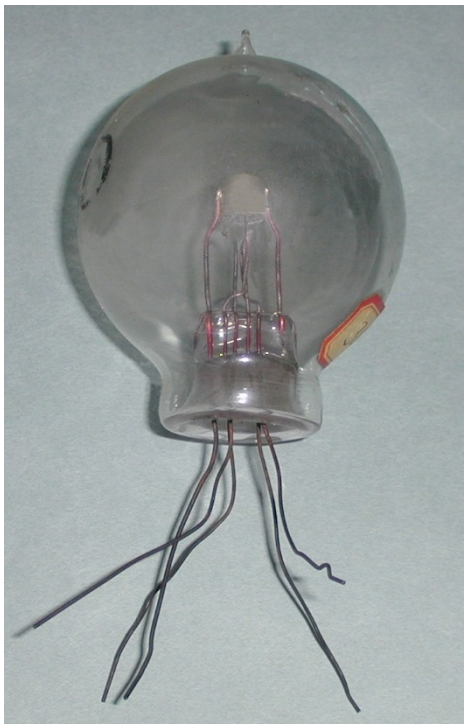


Fig. 4

Close-up of anode in Fig. 4

The small receiving pliotron, shown in Fig. 4, may possibly be the type of one of the first six examples made by the GE Lamp Works and submitted to the US Navy by the GE Research Laboratory [7]. It was probably made in early or mid1917. The anode is a cylinder rather than cup shaped but the remainder of the general internal structure design will be shown to have been carried through to the final design of the 1000 tubes shipped to the Navy, namely the CG-886's.

Fig. 5

Another more refined and familiar looking developmental tube leading to the CG-886 is shown in Fig. 5. [8]. Notice the similarity to the internal structure to the example shown in Fig. 4. The cup shaped anode is now part of the design of this tube and must have been quite successful. It has what became the de Forest US Navy standard 3 pin base made of a composition material, in this case black in color. This tube was probably made around mid or late 1916 or 17 and was a step closer to the final design. G137 is etched on the glass of this tube so it was probably made at the Nela Park Research Lab in Cleveland, Ohio.

In early May, 1918, the 1000 GE type G pliotron's ordered were supplied to the US Navy they called CG-886. They were to be used as a detector, amplifier and oscillator on land stations and on ships by both the US Navy and Signal Corps. [9]. The CG-886 had a 3 pin base with the side pin being the 2nd connection to the filament. The base is made of a composition material, again, like those supplied by de Forest to the Navy. These 2 design features were to be abandoned quite soon in favor of the more familiar 4 pins on the bottom of the base. This tube was made at Nela Park. The shipping box along with the labeled box top and 3 pin base can be seen in Fig's 7, 8 and 9.

Fig. 6

Fig. 7

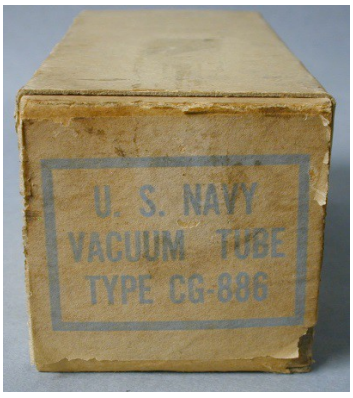


Fig. 8

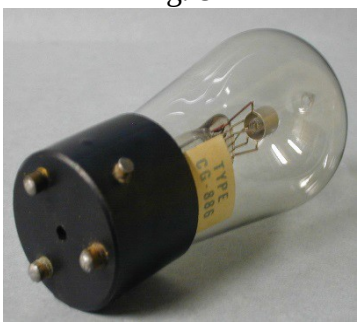
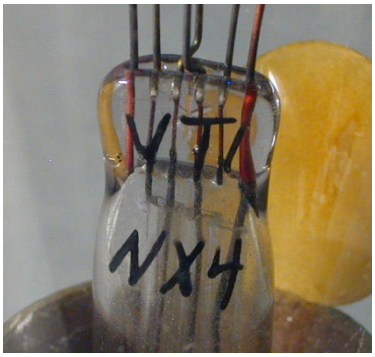


Fig. 9

Fig. 10



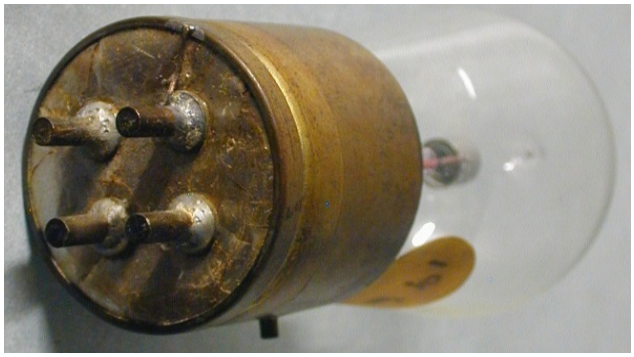


Fig. 11

At this point the US Signal Corps become interested in the CG-886 tube but requested that the filament be redesigned to meet the Signal Corps voltage needs, etc. [10]. Samples were submitted and accepted for manufacture and the final design is shown in fig. 10. GE marked the tubes VT-1-NX4. Tubes marked NX4 are confirmed to be the very first purchased by the Signal Corps [10] and were made at Nela Park. [10]. The number of tubes marked in this manner is speculated to be quite low. Shown in Fig.11 is a small wire soldered to the base and to one of the filament leg pins. The reason for this is not known at this time. The Signal Corps specs must have called for the pins to be insulated with mica shown in fig. 11. Please see a further explanation in the VT-1 fig.13 description.

Fig. 12

A second example of the VT-1 is shown in fig. 12. The paper tag states that it is a VT-1- early VT-11 and the year 1918, receiving type used as an amplifier, detector and oscillator similar to samples manufactured for the Army Signal Corps. by GE. This tube has VT-1 on the press as well. The paper tag was probably made and taped on the tube by William White and placed in the GE tube museum in Schenectady, NY. [8]. The base, bulb shape and internal construction matches the VT-1 in fig. 11 exactly including the wire from the base to one filament pin that was subsequently broken off.

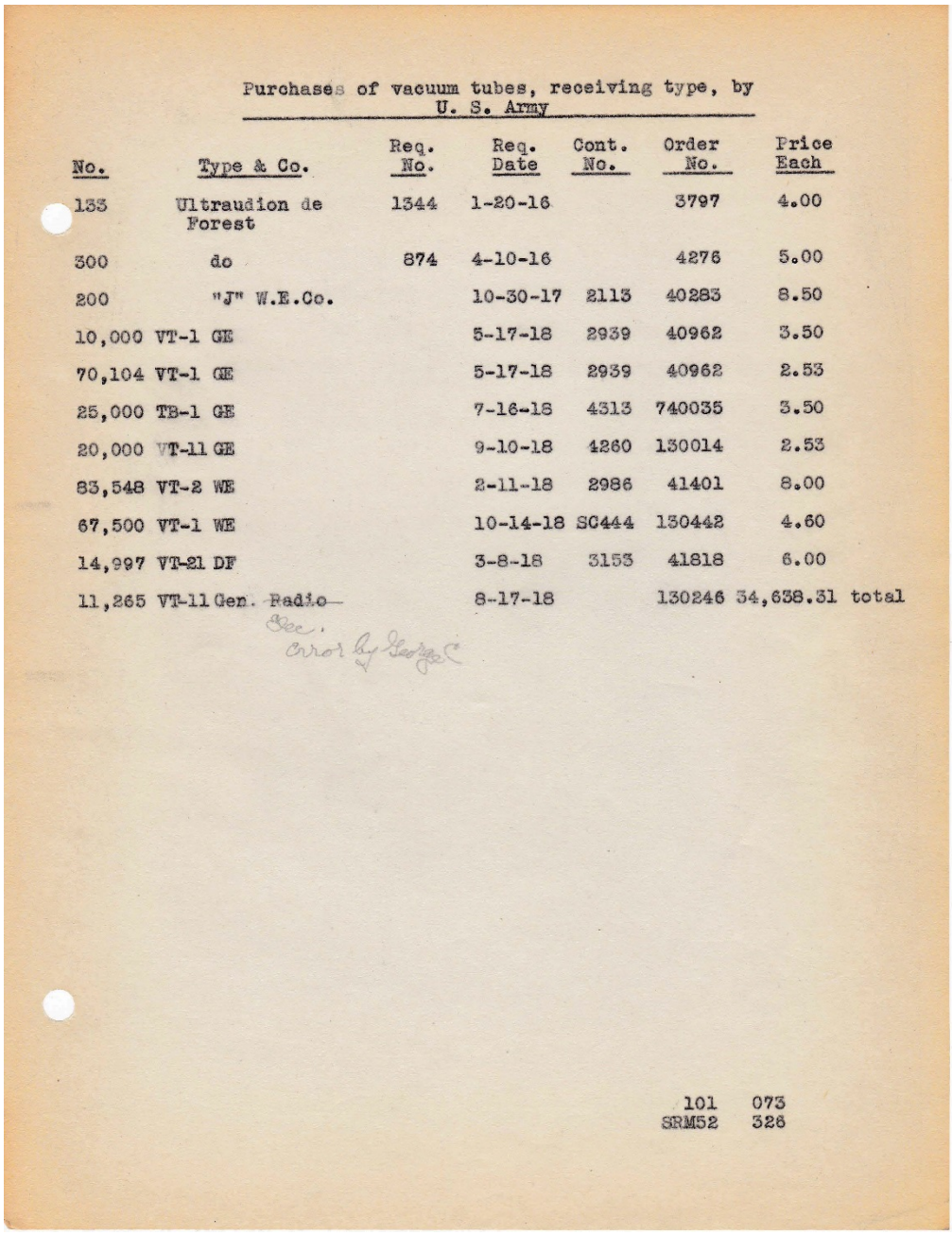
The Signal Corps now became actively interested in the G. E. tubes, and finally, on January 23, 1918, after tests in Schenectady, National-made tubes designated as NX_4 were accepted for manufacture. The question of the rate of manufacture was raised, and Nela Lamp Division went on record as being able to produce 250 per day immediately, and to increase the production gradually to 2,500 per day within 120 days. To the surprise of all engaged in the work, the order came through for 40,000, with a production schedule only one-sixth as heavy as that which we had told the Government

Fig. 13

It is confirmed, by the document above, that the first tubes to be manufactured by G.E. for the war effort were designated VT-1 NX4 shown in fig. 13. This paragraph is a scan from the book "The National in the World War" made by the General Electric Company. [7]

Fig.14

During the manufacture of the VT-1- NX4 it appears that more improvements were made and confusion averted with the W.E. VT-1 by the Signal Corps renaming it the VT 11, shown in Fig. 14. [13]. The Navy conformed to that new design but renamed it the CG-890. This same tube would then have a paper tag stating CG-890, VT-11 on the press or often times both markings, and be shipped to the Navy and Signal Corps. The VT- 11 and CG-890 tubes were now equipped with a porcelain insert to hold the 4 pins. Notice the similarities in the internal design with the tubes in Fig.'s 4, 5, 6 and 10. The VT- 11 Signal Corps tubes were to be used for amplifiers, detectors and oscillators in the same equipment that used the Western Electric VT-1 tubes. Tyne quote regarding the General Electric VT-11 and Western Electric VT-1- *"No more forcible illustration could be made to bring out the point that each company brought to the field of development of the vacuum tube its own particular back round of experience gained through trying to solve its own problems in other fields. The scientists and engineers of these two companies who sought answers to the same questions had, because of experience, taken different paths to arrive at a common destination"*. [11]



Purchases of vacuum tubes, receiving type, by U. S. Army

No.	Type & Co.	Req. No.	Req. Date	Cont. No.	Order No.	Price Each	
133	Ultraudion de Forest	1344	1-20-16		3797	4.00	
300	do	874	4-10-16		4276	5.00	
200	"J" W.E.Co.		10-30-17	2113	40283	8.50	
10,000	VT-1 GE		5-17-18	2939	40962	3.50	
70,104	VT-1 GE		5-17-18	2939	40962	2.53	
25,000	TB-1 GE		7-16-18	4313	740035	3.50	
20,000	VT-11 GE		9-10-18	4260	130014	2.53	
83,548	VT-2 WE		2-11-18	2986	41401	8.00	
67,500	VT-1 WE		10-14-18	SC444	130442	4.60	
14,997	VT-21 DF		3-8-18	3153	41818	6.00	
11,265	VT-11 Gen. Radio		8-17-18		130246	34,638.31	total

Error by George C.

101 073
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Fig. 15

The document above, Fig. 15, is one of many scans the authors made of the copied papers Tyne made from the historical files George Clark abstracted on Sept. 15th, 1938 that appear to be compiled for a court case. It involved the Fleming Patent, Marconi WT Co. of America, plaintiff, VS.de Forest T&T Co. of Audion bulbs and equipment sales up to Feb. 27th, 1919. The fact that the GE tubes sold is included seems to be just a coincidence. It shows the receiving tube types purchased by the US Army. Considering the lack of examples of the GE VT-1 that have survived, it is difficult to imagine that more than eighty thousand were ordered, produced and purchased. It is more likely that GE produced a small number of VT-1's when improvements were made and the remaining tubes produced were then designated VT-11. Some types, dates and numbers also conflict with the William C. White paper entitled "The Story of Electronics Development at the General Electric Company". He states that the US Signal Corps *"ordered 80,000 tubes they called the VT-11 in 1913"*. [12]. Overlooking the fact that the 80,000 tubes purchased are VT-1's in the document the numbers somewhat match assuming only a few VT-1's were purchased when the name switched to VT-11. Perhaps White meant the VT-1's or VT-11's were ordered in 1918. This is more likely. Now the dates match and the only mystery left is the VT-1 - NX4 itself and the quantity GE actually produced. Some purchases of the VT-1 and VT-11 may have been cancelled which could explain some of the number differences. Coincidently, the Clark papers contain the only document ever found by the authors that even mentions the GE VT-1. Clearly, more information needs to be found. [13]

Fig. 16

Fig. 17

In early 1918, the US Signal Corps put in an order for transmitting tubes G. E. designed and called the type T pliotron, named VT-12 by the Signal Corps shown in Fig. 15. The VT-12 was a low power oscillator used for wireless telephony in aircraft transmitters. The VT-12 was made to be used in transmitting sets that also used the Western Electric VT-2. [14]. Like the W.E.VT-2, the VT-12 has the side pin in line with one of the bottom pins. The base has a porcelain insert to hold and insulate the pins. Tyne's "Saga" calls the tube shown in Fig. 8-21 on page 150 the VT-12. This seems to be an editing error as the VT-12 is actually shown in Fig. 8-22 on page 151. The Signal Corps box is shown in Fig. 16.

Fig. 18

General Electric soon redesigned and improved the VT-11 and CG-890 receiving tubes to improve their ruggedness and radio characteristics. [15]. The Navy retained the CG-890 designation while the Signal Corps renamed it the VT-13. The tube pictured in Fig.17 is the CG-890 and has that etched on the bulb. The CG- 890 and VT-13 were probably to be used as amplifiers, detectors and oscillators like the VT-11 and perhaps as a better replacement to the W.E. VT-1. [16]. The tube shown has 20 on the press. What the 20 signifies is unknown at this time but the same type tube is shown in fig. 8-20, page150 in the Tyne book that also shows 20 on the press. Some examples may have VT-13 on the bulb or press but none have been observed. Like the VT-1, this CG 890 has a strap connecting the base and one of the filament pins on the bottom as can be seen in the close-up. Again, the reason for this is not known. A total of around 5000 of both types of the CG-890 and VT-13 tubes were delivered to the US Military at about the time WW 1 ended in 1918.

Fig. 19

The VT-12 was used by the Signal Corps and Navy for only a short time when improvements were made to increase its life. [17]. The newly designed tube was numbered CG-1162 by the Navy and called VT-14 by the Signal Corps and is shown in Fig. 18. This tube has CG-1162 etched on the glass bulb and VT-14 on the press. Like the VT-12, the VT-14 was a transmitting tube that was to be used on sets that used the W.E.VT-2 and had the side pin in line with one bottom pin as on the VT-2. Fig. 8-21 on page 150 in Tyne's book calls the tube shown the VT-12. This appears to be an editing error. The tube shown seems to be the CG-1162. The CG-1162 and VT-14 tubes had gold soldered on the pin tips for good contact. Many of these types have had the gold removed and the side pin relocated so they could be used in standard sockets. Tyne quote-"*It is interesting to note that many of these tubes were used by amateurs as Barkhausen oscillators in the earlier days of amateur activity at ultra-high frequencies, after they had appeared on the salvage market*". [18]. This explains the pin changes. The tube shown is unchanged. This tube has a Shaw base but some came with a porcelain insert and this type seem to be less common.

Fig. 20

GE redesigned the type T Pliotron but the numbers CG- 1162 and VT-14 were retained by the Navy and Signal Corps shown in Fig. 19. [19]. This tube has CG-1162 etched on the glass bulb and on the press as well. The side pin has been relocated so as to fit in a standard socket as can be seen in the base as a newly soldered side pin and ground off original. It does retain the gold pin tips. Some tubes may be marked CG-1162, VT-14 or both. Notice the difference in the internal construction when compared with the tube in Fig. 17. The shipping carton for the CG-1162 is shown in Fig.20.

Fig. 21

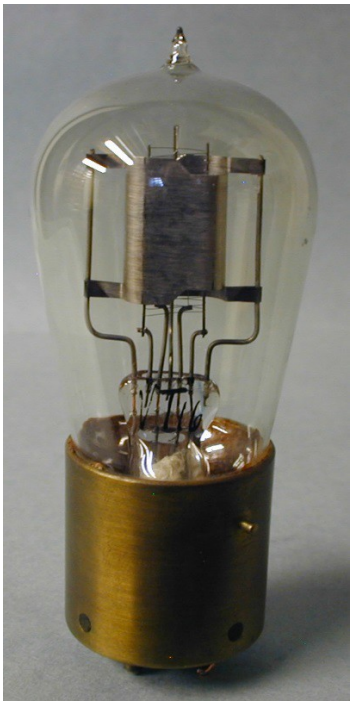

Fig. 22

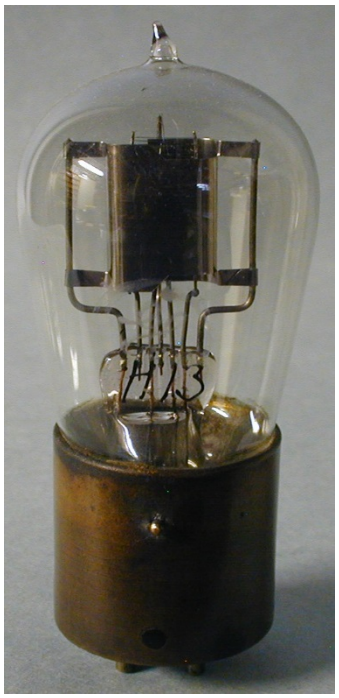

Fig. 23

General Electric soon developed a new transmitting tube working to improve the VT-14. Two versions of the General Electric designed transmitting tube the Signal Corps called the VT-16 were designed to improve the ruggedness for use in airplane service and were in the developmental stage towards the end of WW1. [20]. The latter version is shown in Fig.21. The internal design has been carried forward to the new G.E. UV-200 and the UV-201. Note those similarities in the early GE UV-200 with a Shaw base in Fig. 22.

Footnotes:

Authors: Jerry Vanicek and Joe Gruber

All tubes pictured are from the Gruber collection except those in figures 2, 3, 12 and the document in fig. 11. Those reside in the Vanicek collection.

George Clark devised the numbering system for the US Navy. Before the type number was a letter designation indicating the source: SE(Bureau of Steam Engineering) for a Navel design and C if a commercial design followed by one or two more letters indicating the particular originating company. Therefore CG-886 would be Commercial - General Electric - type number 886. [21].

References:

1. White, W. C. *"The Story of Electronics Development at the General Electric Company"*, page 22
2. as [1]
3. Vanick, J. Conversation regarding the Pliotron in Fig. 1
4. Vanicek conversation with Howard Schrader regarding his acquisition of similar accession numbered prototypes from William White held at the G.E. Museum at that time.
5. Anderson, J. M. *"A Sketch of Early Radio Vacuum-Tube Research and Development at the General Electric Company" from the Antique Wireless Association Review #4, 1989.* page 24. Used with the permission of the AWA via Robert Hobday.
6. as [5], page 23, 24

7. General Electric Company, book, “The National in the World War, April 6th, 1917- November 11th, 1918”, between pages 242 and 243, center photo and conversation with Jerry Vanicek regarding this tube in his collection.
8. Vanicek, J., tube in Vanicek collection and conversation about the internal structure.
9. as [7], page 242.
10. General Electric Company, book, “The National in the World War, April 6th, 1917- November 11th, 1918”, page 237.
11. Tyne, Gerald “Saga of the Vacuum Tube”, page 154
12 as [1].
13. The conclusions in this sentence and the entire description presented are assumed to be correct based on the information shown in fig. 13 and 15 and 10. Tyne papers in the Vanicek Coll.
14. as [11], page 154
15. as [14]
16. White, W. C. “The Development of the General Electric Company of Radio Receiving Tubes”. page 11.
17. Tyne, Gerald “Saga of the Vacuum Tube”, page 149.
18. as [17], page 150.
19. as [9], page 243.
20. as [1], page 23.
21. Howeth, Captain L. S., “History of Communications-Electronics in the United States Navy”, 1963, pages 218, 219, 57.