

## 6.2 - Velocity Modulated Tubes: Klystrons

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Even if magnetron structures were described since the twenties, more serious investigation on velocity modulated or VM tubes started around the second half of the thirties, to overcome the severe frequency limitations due to the transit time of electrons in conventional space charge amplifiers. VM tubes include several families, differing from each other for their operating principle, or better for the way used by input port to exchange energy with electrons and back, from electrons to the output port. Basically they comprise Heil tubes, klystrons, magnetrons and traveling wave tubes, also known as TWTs.

### 6.2 - Klystron tubes

Klystron tubes appeared around the early days of WWII. In the article '[Klystron tubes](#)' there are some notes about their structure and operation. Varian brothers are credited to have designed the early [working prototypes at Stanford University](#) from 1937 to 1939 for an aircraft blind landing system financed by Sperry. In the same days other investigations were in progress at least at Bell and in England as microwave power sources to be used in range detecting equipment, but quite soon magnetron tubes were preferred for the purpose. Klystron devices derived from the early designs were then mainly used through the war as local oscillators in microwave receivers, first at 10 cm, soon later in the X-band and then in the K-band. Just Sperry in America made a few medium power types for special applications and EMI in England made the high-power [CV150](#). Anyway the development of high-power klystrons was only slightly delayed and soon after the end of the war their use became widely diffused in many fields, including UHF TV repeaters and LINACs.

The collection includes samples of the very early klystrons developed in England and in America, at Stanford and at Bell. Worth of note are the [Sperry Prototype](#) which can be dated around 1939, the British S-band [10E/501/NR89](#) 'Sutton tube', also [unbased](#) and followed by [CV35](#) and [CV67](#), the Canadian REL [type 8](#), the Bell design [707A](#) available by the end 1941 and the British experimental prototype [10AL1](#). Moving to the X-band, we find samples of the very early [723A](#), of the improved [723A/B](#) which was followed by the industry standard [2K25](#) and of the British types [CV87](#), [CV129](#) and [CV217](#) and other frequency variants. Other interesting samples of early designs are the K-band [2K33A](#), developed by Raytheon starting from a British design, the electronically tuned WE equivalent, [2K50](#), and the linear beam [402A](#) by Western Electric.

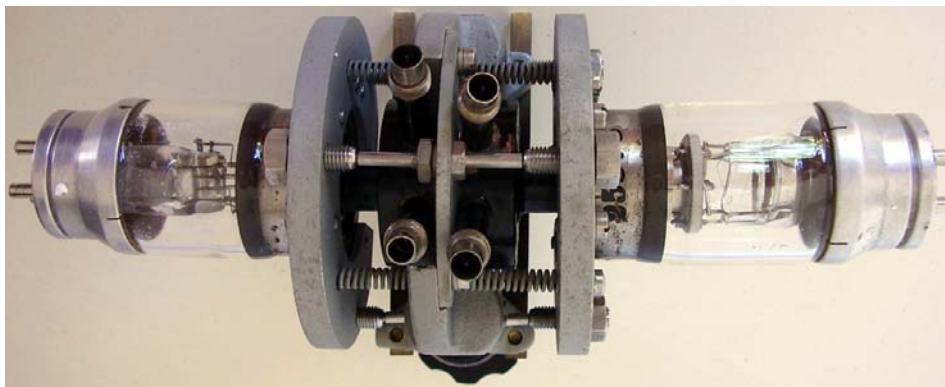


Fig. 6.2.1 - One of the very early klystrons manufactured at Sperry according to the design of Varian brothers, the [Sperry prototype](#), about 1939. Probably intended for an experimental blind landing system. The sample is complete with its rare Type 11 tuner. (Click on image to enlarge)

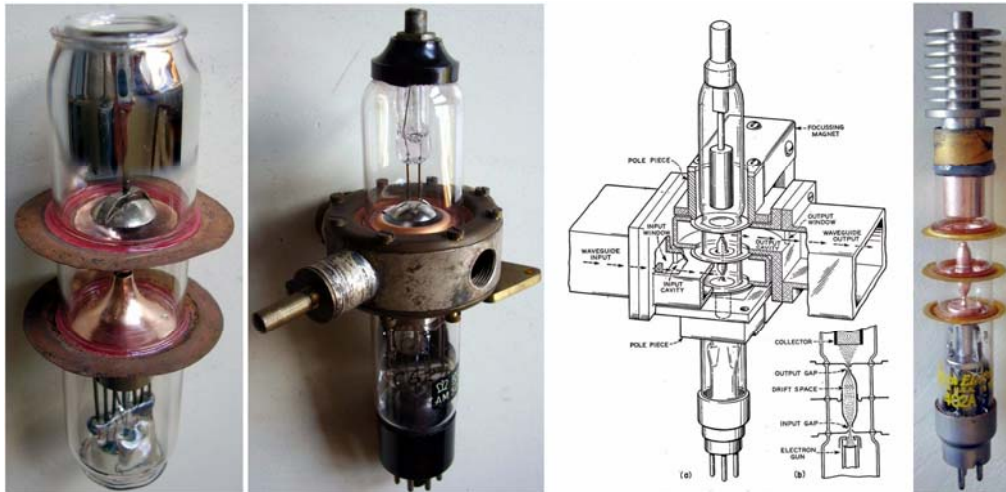


Fig. 6.2.2 - Samples of the early ‘Sutton tubes’, an [unbased unit](#) and a [10E/501](#). Center, cutaway view of the waveguide mount for a Bell Telephone klystron amplifier. Right, derived from the 1436 prototype WE [402A](#) was an early linear beam klystron gone into production. (Click on image to enlarge)



Fig. 6.2.3 - British, Canadian and American klystrons used as local oscillators in the early S and X band radar sets. A) [CV35](#) was one of the early British klystrons used since 1941 as local oscillator in S-band radar sets. It replaced the developmental type NR89 or ‘Sutton tube’ by the name of its designer. B) [CV67](#) was a frequency variant of CV35. C) Canadian REL [8B](#) was presumably derived from the NR89 Sutton tube, by adding a metal shield and a 4-pin base. D) The WE [707A](#) was the very early American design of an S-band klystron in WWII. Its efficiency was quite poor and the grids became almost white in operation. D) [723A](#) and the improved [723A/B](#) were the early X-band reflex klystron designed by Western Electric before the 2K25. (Click on image to enlarge)



Fig. 6.2.4 - More klystron tubes developed during WWII. A) [CV238](#), capable of operating at 250 volts, was introduced in 1943 to replace high voltage types, as CV35, in airborne applications. B) [CV129](#), a British X-band klystron, was readily phased-out in favor of 723A/B. C) [2K41](#) was one of the many klystron devices designed by Sperry during the war. D) [2K33A](#), the first K-band klystron, was the result of a design performed in England at Clarendon and perfected in America by Raytheon. E) The electronically tuned [2K50](#) was the refined WE answer to 2K33. (Click on image to enlarge)

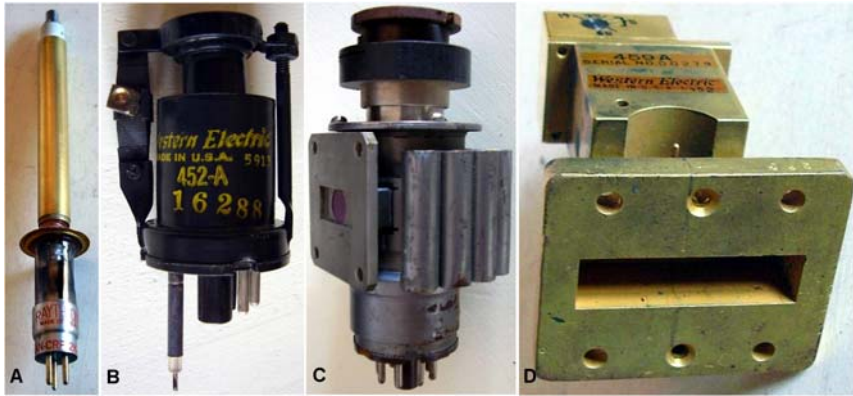


Fig. 6.2.5 - Western Electric klystrons. A) In the [2K48](#) the top grid was connected to a long tubular section, to be mounted in cavities tunable over wide ranges, from 4.2 to over than 10.5 GHz. B) [452A](#) was one of the many frequency variants all based upon the design of 2K25. C) [445A](#) was designed to operate around 11 GHz in the TJ microwave relay system. Also used as pump in the parametric amplifier of the NASA Echo radar which tracked the Moon around 1960. D) Vapor-phase-cooled [459A](#) was used in microwave relay systems at 6 GHz. (Click on image to enlarge)

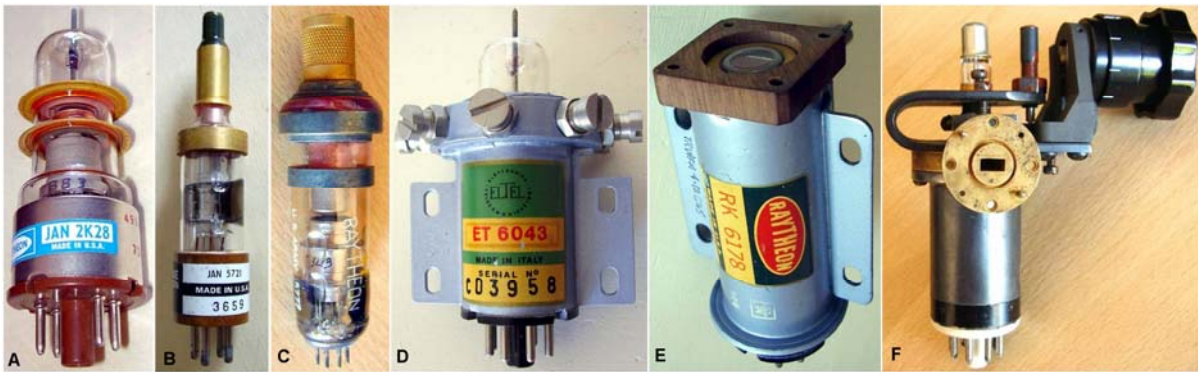


Fig. 6.2.6 - Raytheon was the largest supplier of microwave tubes during the war, retaining a leading role even later. A) [2K28](#) was registered in 1944 as improved version of the early 707A. B) [5721](#) was one of the many successive variants of a base model intended for wide band microwave signal generators. C) [5777](#) was modified to fit a custom tunable cavity in Polarad instrumentation. D) [6043](#) was a variant of 2K28 with factory installed cavity widely used in marine radars. This sample was made by Italian Eltel whose plant had been owned and fully qualified by Raytheon in the fifties, as ELSI acronym of Elettronica Sicula. E) [6178](#) was a top-flanged klystron operating around 15 GHz. F) One of the many derivatives of 2K33 operating over than 30 GHz, the [QK290](#). (Click on image to enlarge)

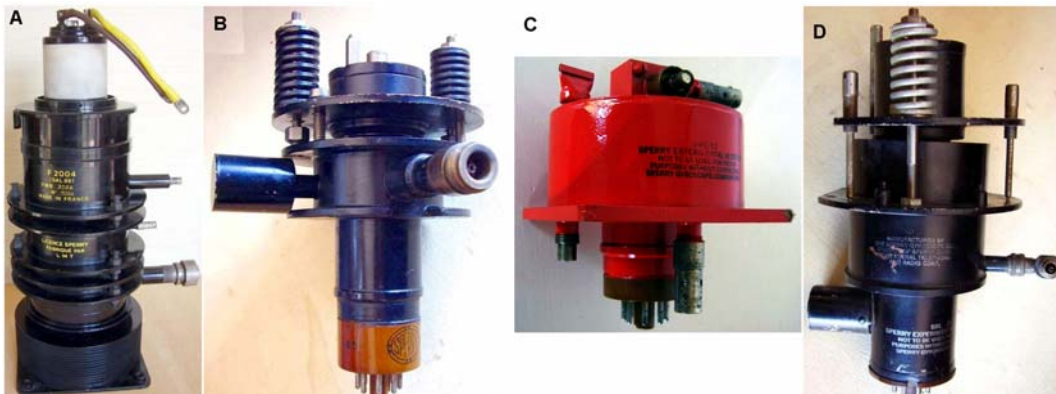


Fig. 6.2.7 - Sperry pioneered the use of klystron even before WWII as power generator for blind landing systems. In the years its production listed several power types. A) [SAL89](#) was introduced in 1957 to generate 25 kW pulses for TACAN ground or shipboard installations. The above sample, dual marked as F-2004, was license built by French LMT. B) [SRL-7C](#), early fifties, was rated for 5 to 10 W output power around 2 GHz. Electrostatic beam focusing. C) Sperry experimental [SMC-11A](#) was a frequency multiplier with an unusual 1 to 6 factor and 400 mW typical optput power. D) [SRL-7H](#) was rated for about 10 W output power at frequencies over than 2 GHz. (Click on image to enlarge)

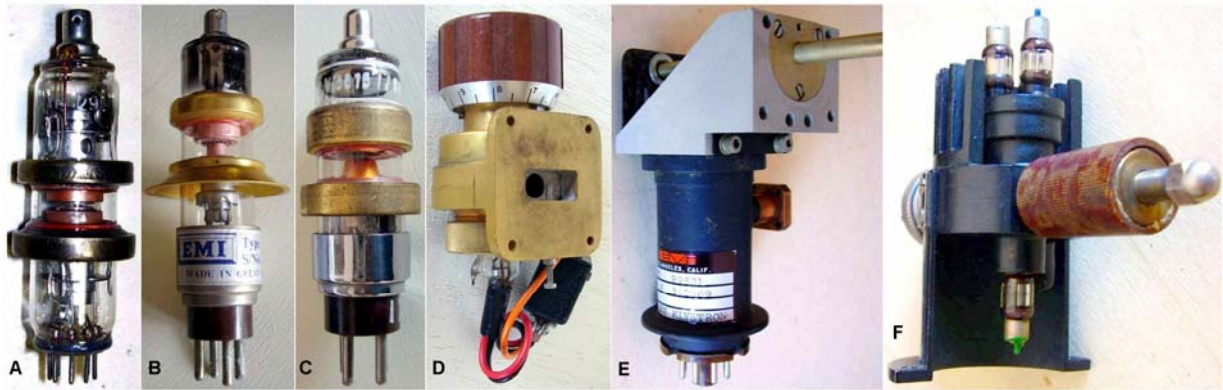


Fig. 6.2.8 - After the war British industry introduced countless klystron types, often jointly developed with some American firms or sold on the American market. One of the most active firm was EMI. A) [VX5029](#) was the EMI prototype of [CV2116](#). B) The experimental [R9559](#), presumably prototype of [CV6071](#), has a skirted flange to be mounted in some kind of special cavities. C) This EMI klystron approved as [CV3615](#) was fully compatible with [6BM6 / 6BM6A](#). D) [R9562](#) looks to be an X-band klystron, here mounted in a flanged cavity. E) [R9521](#) was rated for 15 mW minimum output from 35 to 40 GHz. The label indicates an EMI/US, North Hollywood, CA, maybe just a sales office for musical and film products. By the way EMI was the acronym of Electro Musical Instruments. F) This undocumented [8RK8](#) was made by Elliot-Litton. (Click on image to enlarge)

## The very unique klystron power oscillator of WWII



Fig. 6.2.9 - The collection includes a rare sample of British EMI [CV150](#), the only S-band power klystron intended to replace magnetrons as pulsed oscillator in airborne radar sets. Click on image to enlarge.

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