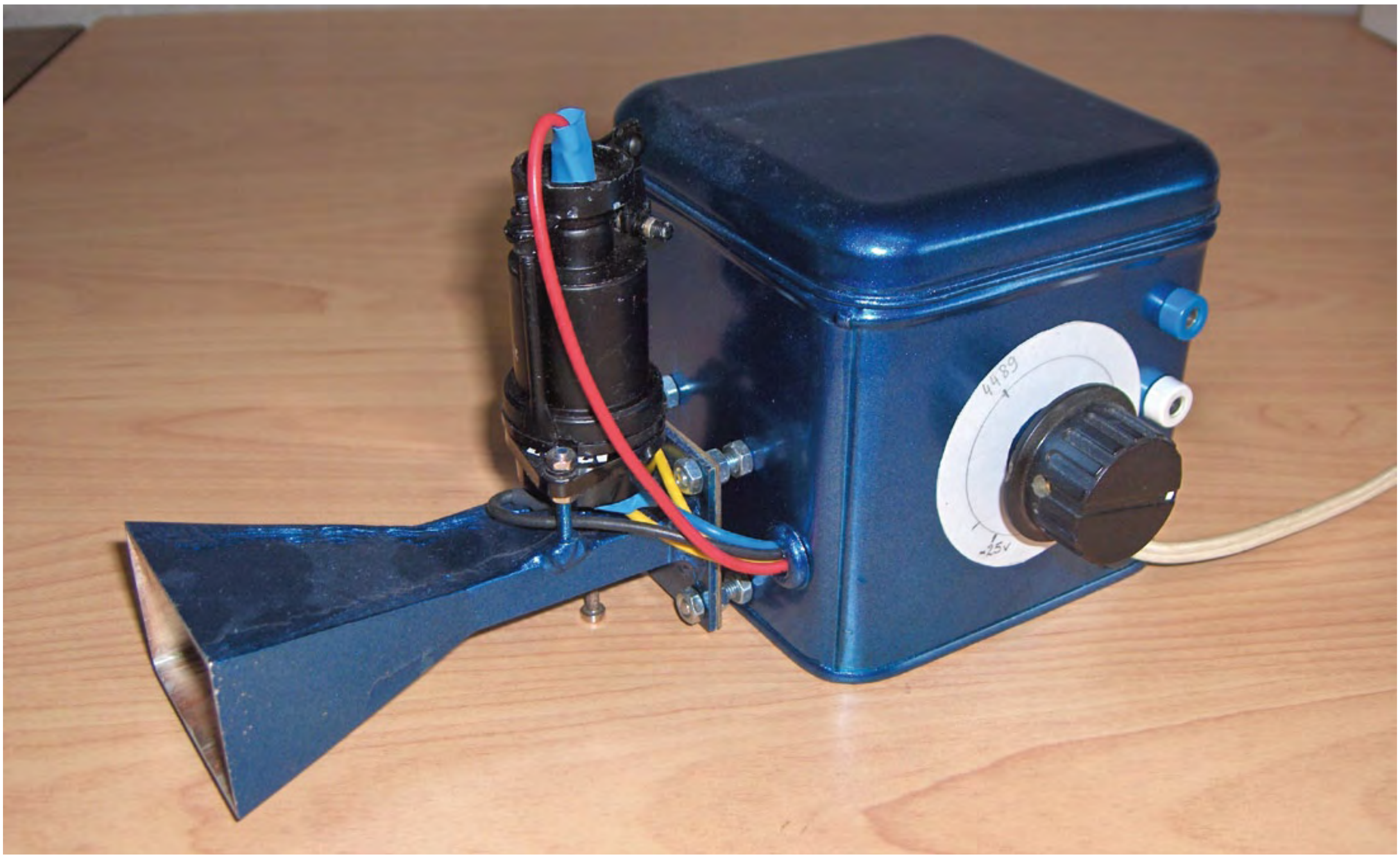
Klystrons type 2K25 and 2K56



By Jean Herman (Belgium)

The klystron was invented, and a first prototype constructed, by the brothers Sigurd and Russel Varian working at Stanford University (CA) in 1937. After a paper on the new device appeared in *Journal of Applied Physics* in 1939, radar experts were soon upon the brothers and not surprisingly the klystron was embraced big time by the US military. The klystron's heyday was to last, well, about 50 years.

Several types of klystron exist; one model has two or more cavities centred on an electron beam focused by magnets; the first cavity receives the signal from a local oscillator, it modulates the beam, it acts as a sort of control grid, the second cavity close to a collector (anode) where the signal appears highly amplified. These klystrons exist for all the UHF and microwave bands and all powers, right up to 1 MW and esoteric components as they might appear to the non-initiated, you may have been enjoying its practical use for more hours than you realize simply by watching TV between 1960 and 1995 (roughly).

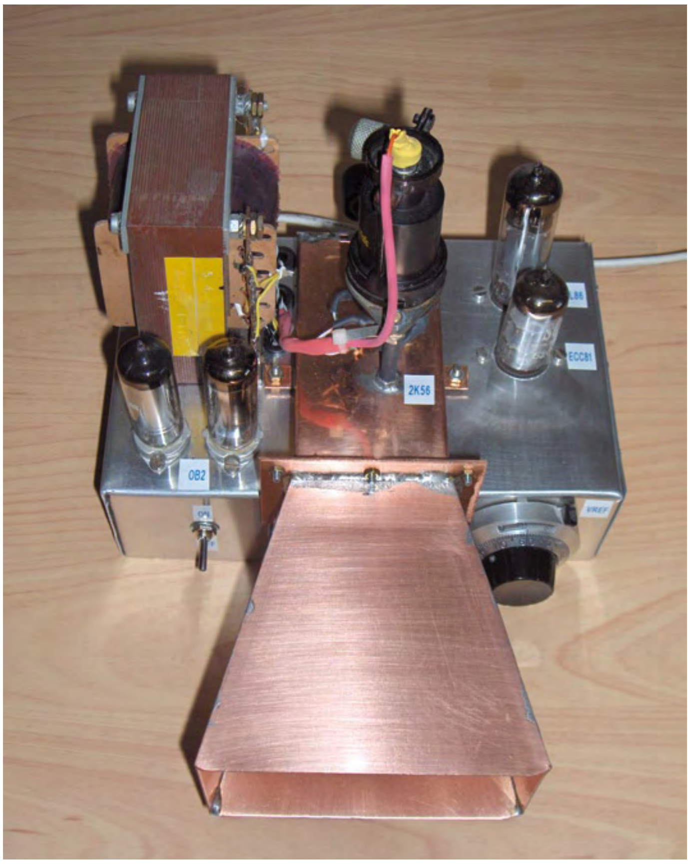
Another type of klystron is known as 'reflex' (**Figure 1**); this is an oscillator, it only has one cavity centred on the electron beam. The volume of the cavity is slightly adjustable, and hence the resonant frequency too.

It could be thought of as a little like a whistle, except that here the flow tangential to the lips of the cavity is a beam of electrons instead of air. The speed of the electrons is close (and adjustable) to the variation in the alternating voltage on the two lips of the cavity. With the help of a reflector, the electrons pass and then pass again a second time across the lips of the cavity. When the reflector voltage is just right, the electrons exchange energy with the cavity twice (each time they pass). They finish up on the outside of the cavity or on the metal of the valve envelope.

In an accelerated electron beam, the spectrum of the speed of the electrons is wide. Hence it is important that the median speed is centred on the cavity's resonant frequency. In this way, faster or slower electrons will form distinct packets that will be speeded up or slowed down at the lips of the cavity — in other words, they exchange energy with the cavity. Out of chaos, harmony (and RF power) is born!

I've had a type 2K56 reflex klystron for 50 odd years. It came from a WW2 bomber radar unit. Getting hold of the specifications [1] was very troublesome, although its sibling the 2K25 is very common. The '56 and the '25 are pin compatible, but their resonant frequencies are very different: the 2K56 oscillates at 4400 MHz (3840–4460 MHz); while the 2K25 oscillates at 9050 MHz (8500–9660 MHz).

Over 30 years ago, I ventured out to build a circuit 'around' the 2K56. In fact it boiled down to a fairly complex power supply for this tube, which was fitted onto a piece of RG52/U waveguide (1" × 0.5"). What a mistake, it should have been fitted to a length of



Specifications of the 2K25 and 2K56 klystrons

- Nominal cathode/cavity voltage: + 300 V
- Cavity/cathode current: approx. 22 mA
- Reflector/cathode voltage variable from −24V to −180V
- Reflector current: < 7 µA
- Reflector resistance must be < 100 kΩ
- Heater voltage: 6.3 V @ 0.44 A.

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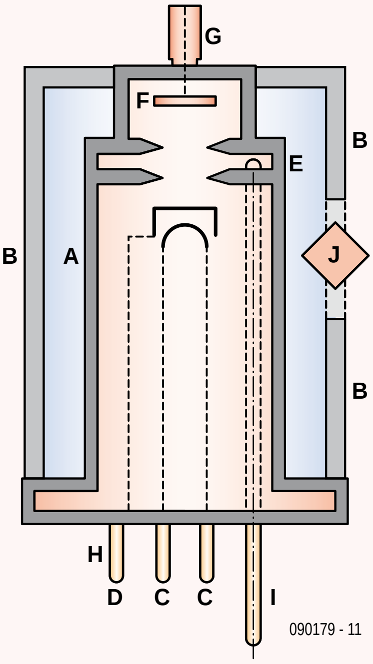

Cutaway representation of a klystron.
A: envelope (anode); B: cavity tuning pillars; C: heater filament terminal; D: cathode terminal; E: RF coupling loop; F: reflector; G: reflector voltage terminal; H; filament and cathode pins; I: antenna; J: frequency adjustment screw.

RG49/U waveguide (2" × 1")! However, when tested, a weak microwave signal was detected; measuring its frequency, I realised that it was too low for this type of waveguide. I then had the idea of fitting a dielectric into the waveguide. Experimenting with a stick of Perspex soon resulted in recovery of about 50 mW of gigahertz RF power from the klystron.
The 2K25 is an old favourite with radio amateurs who command our respect for having pioneered much of today's microwave communication infrastructures (taken for granted by millions of cellphone users unaware of the SHF link systems carrying their conversations). With a few judiciously applied dents in the cavity, an ex-army 2K25 is easily pulled into the 10 GHz (3 cm) amateur radio band.
If you think that the 'cantenna' was invented during the WiFi and WLAN age, you are mistaken. One of the finest and most appealing applications developed for surplus klystrons and widely published by the ARRL in the 1960s was the 'Klystron Polaplexer' [2]. Two suitably tuned Polaplexer units using (US size) bean cans were capable of covering line-of-sight links of tens of miles with just a few milliwatts of RF power in the 9 cm (3.4 GHz) band. Full-duplex (!) wideband FM communication 'on a shoestring' was achieved using a portable VHF FM radio as the final converter and demodulator. Borrowing a term from today's world of microcontrollers, the Polaplexer/Cantenna design was "easily migrated" to the 3 cm (10 GHz) "platform" simply by fitting the klystron on a piece of WG16 waveguide and adapting the antenna shape and dimensions.
Finally, 2K25 klystrons are by no means difficult obtain, for example, through Ebay.

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Editor's note: the author has developed both a tube-based and a transistorised power supply unit (PSU) for the klystrons described here. Scans of his original circuit diagrams may be downloaded free from the Elektor website [3].

Internet Links

[1] www.pmillett.com/tubedata/HB-3/Transmitting_Tubes/2K56.pdf

[2] www.ham-radio.com/sbms/sd/ppxrdsgn.htm

[3] www.elektor.com/090179

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