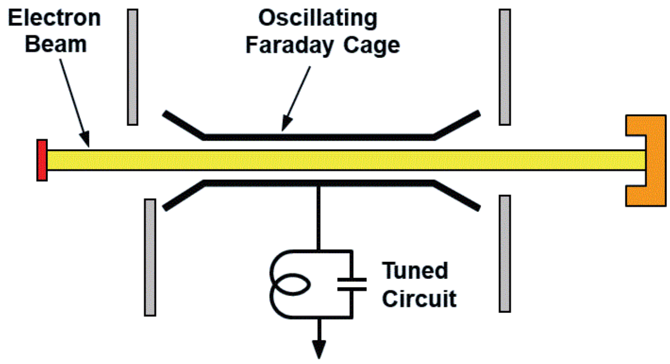
The Heil Tube

The fundamental principle behind the klystron, velocity modulation, was first described in a paper published in Germany in 1935, jointly authored by Oskar Heil and his wife A. Arsenjewa titled "A New Method for Producing Short, Undamped Electromagnetic Waves of High Intensity."

Oskar Heil (1908–1994) was a German electrical engineer and inventor. He studied physics, chemistry, mathematics, and music at the Georg-August University of Göttingen and was awarded his PhD in 1933, for his work on molecular spectroscopy.

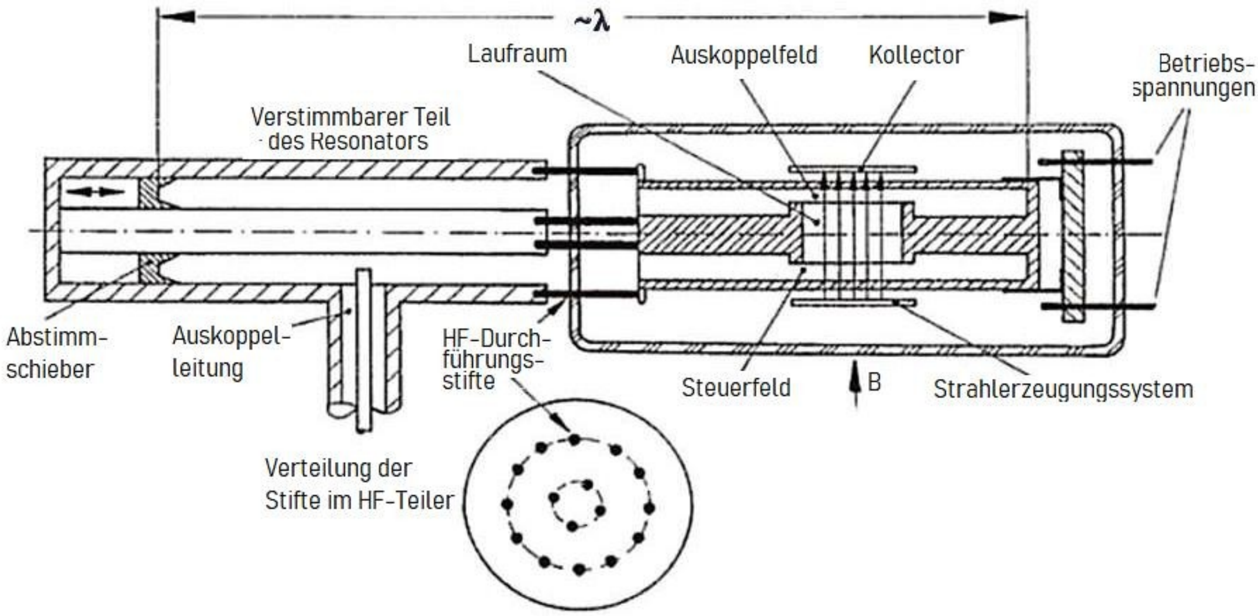
At the Georg-August University, Oskar Heil met Agnesa Arsenjewa (1901–1991), a promising young Russian physicist who also earned her PhD there. They married in Leningrad, the Soviet Union in 1934. Together they moved to the United Kingdom to work in the Cavendish Laboratory, University of Cambridge. While on a trip to Italy, they co-wrote the paper on the generation of microwaves which was published in Germany in the *Zeitschrift für Physik* in 1935. Agnesa subsequently returned to Russia to pursue this work further at the Leningrad Physico-Chemical Institute with her husband. However, he then returned to the UK alone; Agnesa, working in what had by then become a highly sensitive subject, was possibly not allowed to leave. Back in Britain, Oskar Heil worked for Standard Telephones and Cables.

The Heil tube is credited as being the first linear-beam device to use the principle of velocity modulation of electrons.

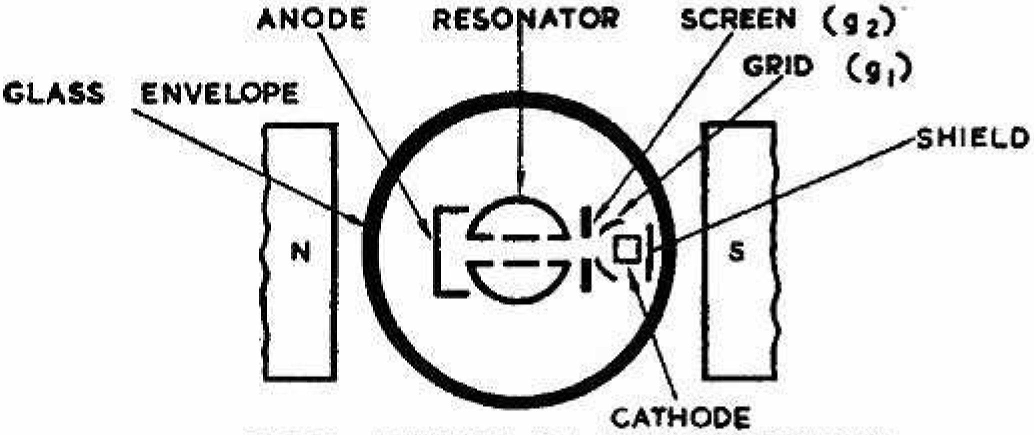


In the Heil tube, an electron beam passed through a floating drift tube, which the Heils called an oscillating Faraday cage, to a collector. The drift tube was connected to a tuned circuit. A small RF voltage across the gap at the entrance into the drift tube caused velocity modulation of the electrons. That is, the voltage across the gap accelerated some electrons and decelerated others. The faster electrons from the accelerating portion of a cycle caught up with the slower ones from the decelerating portion and so bunches of electrons were formed. When the bunches emerged from the drift tube, they induced a signal in the tuned circuit and, at the same time, enforced the velocity modulation of the beam entering the drift tube.

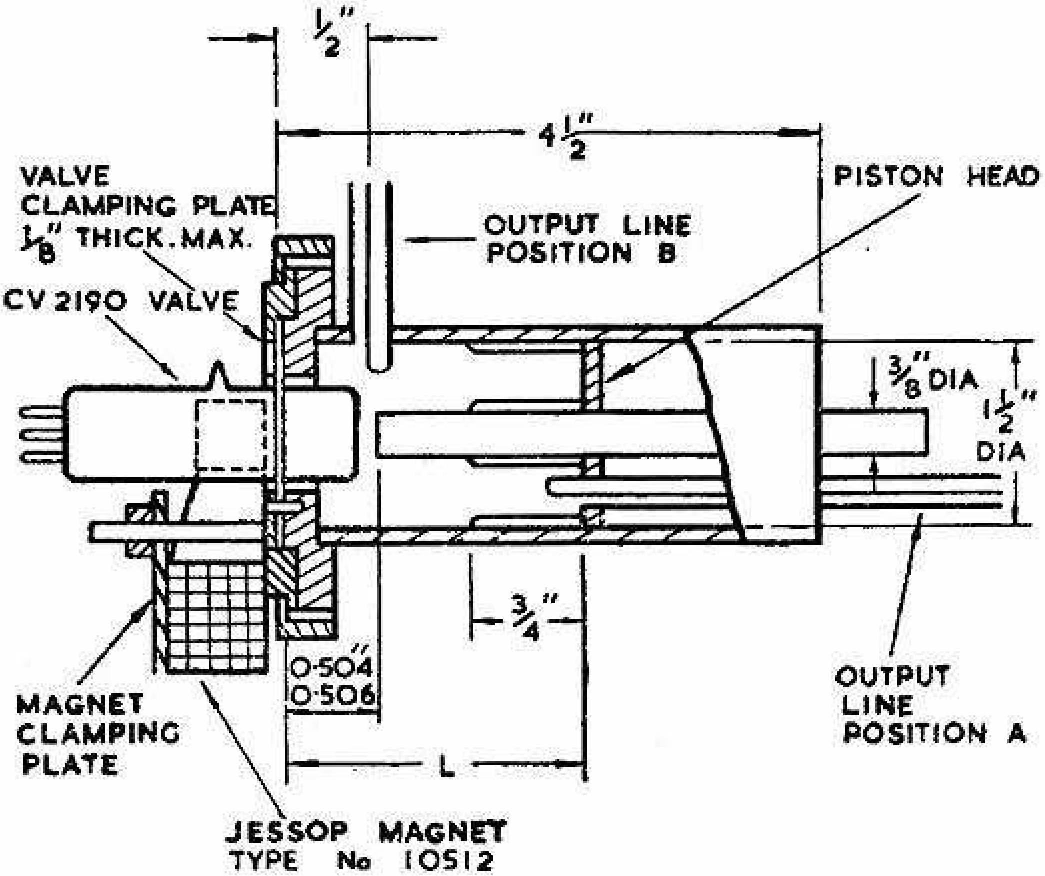
The following shows one version of the Heil tube:



Here are the cross-section and mounting drawings of an actual Heil tube, the STC V233A/1K:



CROSS SECTION OF VALVE ASSEMBLY



A powerful magnet is required to keep the electron beam focused inside the resonator. The resonator is biased by a DC voltage, typically between 150 and 400 V, the actual value depending upon the operating frequency, from 2 700 to 4 200 MHz.

The Heil tube used a resonant coaxial line and so had a lower Q than the cavity resonator, leading to the signal from the Heil tube being relatively noisy. They were however used quite extensively in microwave link and Electronic Warfare (EW) equipment and various of them would operate up from as low as 800 MHz up to 4GHz, with powers at the lower end (800 – 1 000 MHz) of >2 watts.

STC at Footscray in Kent were substantial manufacturers of Heil tubes (calling them Velocity Modulated Oscillators) from the 1940s through to the 1960s.

The major difference between the Heil tube and the reflex klystron is that in the Heil tube, the electron beam was magnetically focussed. The natural tendency of a beam of electrons is to repel each other and thus broaden the beam: in the reflex klystron, the cavity is shaped to provide sufficient electric field to keep the beam ‘bunched’.