Heil Tubes or Heil Oscillators

This is a quite small family of little known velocity modulated high-frequency tubes, often confused with klystrons. Even if both devices are velocity-modulated (VM) tubes, their developments were not related.

In 1935 Oskar Heil, a German engineer, and his wife Agnessa Arsenjeva, coming from the Department of Physics at the Leningrad Polytechnic Institute, published the first article describing their idea on how electrons could be bunched by velocity modulation. Later Mrs. Heil returned to Russia, while O. Heil started an intense work at the British STC that led to a line of microwave oscillators based upon the same operating principle.

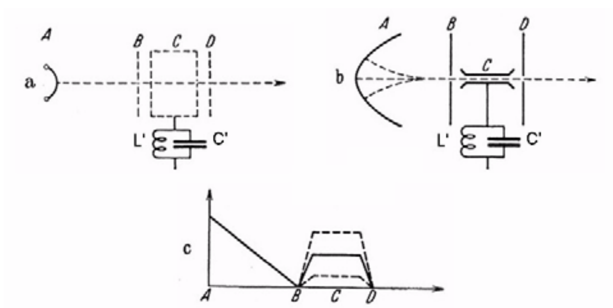

Fig. 1.1 – (a) equivalent circuit of Heil tube; (b) section of the tube; (c) potential distribution through electrodes. From original drafts of the early devised structure.

A section of the Heil tube and its equivalent circuit are given in figs. 17(b) and 17(a). A is the cathode, the electron beam being indicated as arrow terminated dotted line; B and D are focusing grids; C is the drift electrode or resonator, coupled to the resonating cavity here represented as lumped L'C' circuit. Fig. 17(c) shows how instantaneous potential of the drift electrode C varies (dotted segments), following the oscillations in the high-Q resonator. Electrons are first accelerated by the uniform field from cathode A to the grid B, gaining a constant velocity. Then, in the region from grid B to the resonator C, electrons are alternately more or less accelerated by the oscillating potential on C itself, so that bunching occurs. Bunched electrons interfere with the drift electrode, releasing energy and sustaining oscillations in the associated resonating circuit.

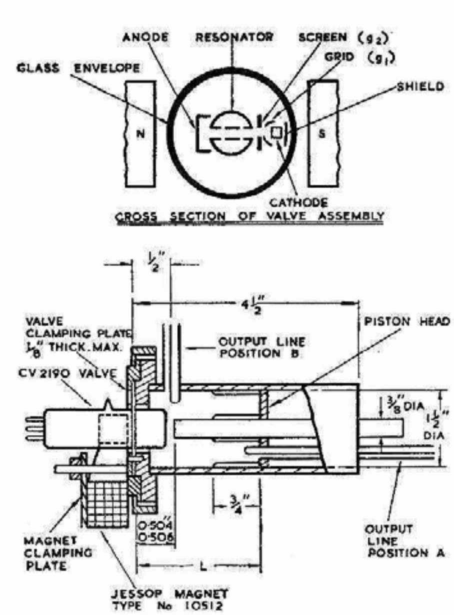

Fig. 1.2 - Here are cross-section and mounting drawings of an actual Heil tube, the STC V233A/1K. The electrode structure has been slightly modified, adding a screen grid and replacing the second focusing grid, D in Fig. 1, directly with the anode. A powerful magnet is required to keep the electron beam focused inside the resonator. The resonator is biased by a DC voltage, typically between 150 and 400V, the actual value depending upon the operating frequency, from 2700 to 4200MHz.

Heil tubes could be AM modulated applying modulation signal either to G1 or to the screen grid. FM modulation was also possible, applying the signal to the resonator. Efficiency was poor, in the order of 10 % and probably this was the reason why Heil tubes became soon outdated in favor of the most versatile klystrons. Anyway Heil oscillators were investigated during the war as possible microwave sources in radar applications. The collection includes very rare and undocumented samples of early devices designed to operate even at 10 and 3 cm wavelenght.

Fig. 1.3 - Some rare samples of Heil oscillators presumably made around 1940 or 1941. From left, the CV230 looks to be designed to fit in the external wall of a waveguide. The DV27 in the middle was an oscillator operating at 10 cm. The DV57 on the right is given on the label as a frequency variant of a DV55, designed to operate at 3 cm.

British STC produced some Heil tubes both for military applications and for microwave communication relays, well in the late fifties. Some Heil tubes were also built in Germany, where Oskar Heil moved at outbreak of WWII.

Fig. 1.4 - Some samples of British Heil oscillators. From left, CV228 and its alternate selection CV485, CV5463. The last two photos are of CV5048 and CV2190.

In the fifties STC also introduced a line of oscillators derived from the Heil tubes, but using a waveguide section in place of the drift electrode. These devices, also known as H-wave oscillators, were proposed mainly for microwave communication relays.

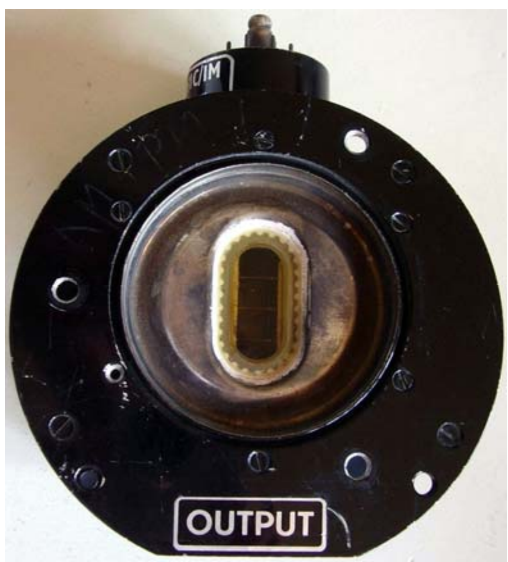

Fig. 1.5 - The V261C/1M was a H-wave microwave oscillator designed to operate around 6 GHz.

The article was edited by Emilio Ciardiello. Last revision July 2020