MAGNETRONS

Development on centimetre tubes was, for the most part, carried out by the tube research laboratories of Telefunken. However, various organisations controlled by the Reichstelle für Hochfrequenzforschung, notably FFO, did considerable experiment and calculation on the theoretical aspects of oscillators for wave lengths in the centimetre and millimetre region. Prior to capture of H2S, magnetrons were used generally for CW oscillations, the possibilities of pulsing having not been considered.

The difficulties encountered in producing copies of the Allied magnetron for use in the Berlin-Gerät, brought about methods of producing glass to glass, and metal seals were effected by a utilization of a nickel-iron compound soldered to the metal anode (usually copper) with silver solder, while glass to glass seals were made by using a glass solder in paste form. MAYER, of FFO, used this latter method to a great extent in his experiments at PLANNECG, where he conducted tests with diodes for detection, and magnetrons for oscillation, at centimetre wavelengths. MAYER and BACHEM fabricated experimental tubes with anodes of from 4 to 16 segments which produced measurable oscillations of about 6 mm wavelength, however, the shortest waves were produced by a 4 segment anode within a cavity resonator of cylindrical form.

Telefunken was more concerned with the tuning and stabilizing of magnetrons for both transmitters and receivers operating at about 3 cm wavelength. To increase the stability of low power magnetrons for receiver local oscillators, it was found that an increase in the number of segments was required to provide good characteristics. One tube of Telefunken, operating at 1.6 cm, was tunable in frequency about 10%. The tuning was Not continuous, however, as it was found that in the range 1.6 cm. 10%, there were about 30 distinct frequencies. Tuning was accomplished by mechanically varying the proximity of a flexible diaphragm to the anode.

The technique in measurements made by both FFO and Telefunken left much to be desired. Heat comparison was normally used in power measurements, while frequencies were measured visually either from standing waves on a wire in an ionized gas, or by means of on interferometer and the standing waves on a wire covered with vaporized paraffin.

After the production of LMS10 (the copied Allied tube), Telefunken utilized the results of tests and development in the production of tubes of German design, although some characteristics of the Allied prototype were carried over. Of the series produced, LMS 100 exhibited the most promising characteristics. It was rated at 100 Kw. output at 10 cm. was 10% efficient, and operated with a field strength of 1500-2000 gauss, 30% over the critical value. It was air-cooled and was suitable for a space/mark ratio of 1000. The characteristics of other transmitting tubes as well as those of receiving tubes will be found in Appendix 3 of this report.

KLYSTRONS AND DIODES

The status of development of Klystrons and VHF triodes for centimetre wavelengths was much the same as that of magnetrons, as prior to the capture of the first intact H2S, late in 1943, Klystrons were not used in operational equipment. After the appearance of the Allied tube, Dr. Labus of the Institut fur Technische Physik in Prague, Telefunken, and other agencies, did considerable work in copying and attempting to improve the captured model, with the intent of providing a tube of high output for use in jamming transmitters. Early copies were made with dielectric rather than metal plugs for tuning the "buncher" cavity, while later ones were constructed with flexible rhumbatrons. In both cases, trouble was experienced in obtaining stable oscillations of high output.

Dr. Oskar Heil at Konstanz did a great deal of work on tubes in the velocity modulated field, and developed an experimental model to operate at 3 cm. wave-length. Using electric focussing, the tube was capable of an average output of 20 watts, when pulsed at a 1/10 - 1/20 duty cycle. Heil's investigations covered thoroughly the aspects of electron focussing and transit-time phenomena, and he devised ingenious methods of measuring the energy of electron beams, methods of measuring beam dispersion at various points and several untried applications of the secondary emission characteristics of surfaces in producing oscillation of short wavelength.

Closely related to Heil's use of positive ions in obtaining focussing effects, Dr. Schumann of the Electro-Physical Laboratory, Munich, subjected oscillations in Plasma to investigation. Oscillatory currents of a few milliamperes were obtained, but as attempts were made to increase the current, the oscillations stopped because of an unexplained phenomena. Calculations and experiment indicated that the oscillations were caused by conditions equivalent to a combination series-parallel resonant circuit wherein "L" was represented by the electron mass, parallel capacitance by the physical inter-electrode capacity, and series capacitance by the sheath on the grid. See Section 1-5 para.11 for further information on Schumann's work on this subject.

It is evident that little of the theoretical research had resulted in practical developments, for by February 1945 about 50-100 Klystrons had been produced for operational use. Those tubes operated on a wavelength of 9 cm and produced outputs of from 50 to 100 watts, 50 watts being considered the minimum usable in an effective jammer. Subsequent to the capture of H2S, higher frequency Klystrons for jamming transmitters at a wavelength of about 3 cm. were attempted, but the output of 5 - 6 watts, a very inadequate figure for effective jamming, could not be appreciably increased. That the development of triodes met with more success than did the Klystron is fairly obvious when the number of standard types of the former is considered. Likewise developed primarily for use in jamming transmitters such as Anti-Rotterdam (Feuermolch) and certain other units with names prefixed by "Feuer", triodes were produced which were capable of 10 KW. peak output with space/mark ratios of from 50 to 10. Among the ceramic/metal grounded-grid typos were: LD 7, LD 9, LD 11, LD 12, LD 13, LD 70, LD 90, LD 110, LD 120, and LS 1000. A detector diode, LG 11, was produced by using the fabrication technique evolved in the manufacture of transmitting types.

Soft rhumbatrons or T-R switches corresponded very closely to the Allied H2S prototype in arrangement of elements. Listed as LG 76 and called Nullode, the tube contained the resonant cavity gap, input and output loops, water vapour, and "Keepalive" electrode. Produced primarily for use in the airborne unit "Berlin", condensation at low temperatures was prevented by heating coils. Other T-R tubes, (Sperröhren) were the LG 77, LG 78, LG XE, LG 79, 80, 81 and 82. LG 78, 79 and 80 were copies of American 3 cm. types; LG 81 and 82 were in development as of November 1944.