MM-WAVE POWER AMPLIFIERS

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ABSTRACT

The report displays the advantages of amplifying TWT-chains in the 8 mm - wavelength range based on power output "transparent" TWT, packetized in permanent magnets for providing power levels of tens of kW. To obtain pulsed power levels of hundreds of kW to units of MW the hybrid "orotron-TWT" type design-based microwave device version is represented. First experimental results are given.

When designing compact mm-wave amplifiers with pulsed power up to tens of kW and average power of units of kW we use TWT amplifying chain concept.(fig.1). The chain consists of 2 tubes - preamplifying TWT with magnetic periodic focusing system (with low beam current and high amplification) and "transparent" for a microwave signal power TWT (with high current and low amplification) packetized in PM. (fig.2). In mm-wave range such design provides two basic advantages as compared to the standard design of power TWT with a focusing solenoid:
1) focusing solenoid is replaced by a system of permanent magnets several times reducing the amplifier weight and eliminating the need for solenoid power supply;
2) two-mode amplifier operation becomes available due to "transparent" TWT blanking.

It should be noted that output unisectional TWT "sedatively" effects the whole amplifying chain, it damps instability of preliminary stage output power at destabilizing factors action as it exhibits low sensitivity to the change of slowing structure voltage U_{ss}, beam current I_o, output microwave power P_T.

The amplifying chain is usually designed for the same voltage U_{ss} for both TWT, included into the chain. In this case the most optimal design for output "transparent" TWT is a multibeam design. Such solution is successfully realized in cm-wave chains. In mm-wave range the output TWT multibeam design has not been realized yet.

To obtain pulsed power of hundreds of kW - tens of MW other engineering approaches are used.

The example of such successful solution is a gyrotron, however, in some applications the presence of focusing high magnetic field intensity solenoid is impermissible, since it is often produced as a superconducting one. The development of O-type devices is of undoubted interest; the low relativistic electronic beam with required performance can be formed in the devices easy enough on the basis of the well-known techniques.

Below some elements of the device structure are discussed (fig.3). The device consists of a circular large diameter gun, that allows for the formation of thin pipe-shaped electron beam with a 1 mm thick wall. The beam transport is performed in uniform magnetic field of 1000 Oe intensity. Electron-optical system provides the current of 200 A for electron energy of 300 keV. The device structure makes possible to form and transport significant current, which value depends only on the emission cathode capability. The superdimensional electrodynamic structure of the device consists of two sections, a modulating one and an output one, that provide the power sink from the beam. The first section is devised as a quasioptical coaxial resonator; its outer reflective surface was coated with periodic structure. Here the beam interacts with the transversal resonator oscillations, and physical phenomena are quite similar to those in the orotron. The second section provides the power exchange with surface wave of the superdimensional periodic structure. Such mechanism of the device operation is frequently used in relativistic electronics and is adequately approbated. The sections are well "decoupled" relative to the device self-excitation due to the different types of interaction in them. Large spatial development (lateral dimensions of 10 - 15 wavelengths in operating frequency) simp-

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lifies the device cooling significantly.

The sealed-off prototype was built (fig.4) that was used for mastering current flow, checking the effectiveness of the beam modulation by the first section, as well as for examining the possibility of experimental optimization of the beam coupling factor and the electrodynamic structure based on the self-excitation mode of the second section in the vicinity of the π -type oscillations. The oscillation power was about 250 kW for 8 mm-wave range. The physical representation, achieved on the basis of numeric simulation techniques, as a whole agrees well with the results obtained.

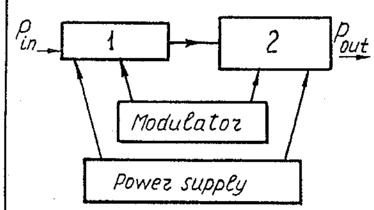

Fig. 1. Amplifying chain of TWT's.
1-TWT of preamplifier with PPM;
2-High-power "transparent" TWT packed in PM.

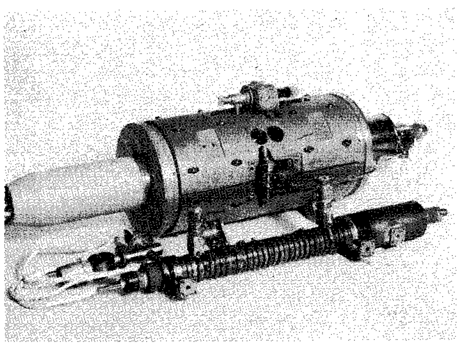

Fig.2. The amplifying TWT-chain (photo)

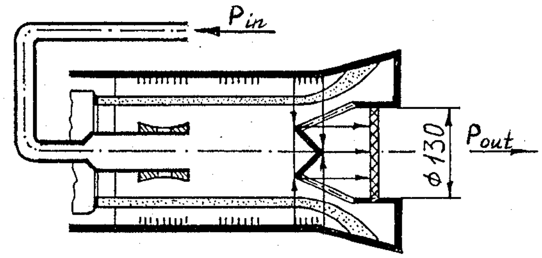

Fig.3. The schematic representation of high-power hybrid O-type amplifier.

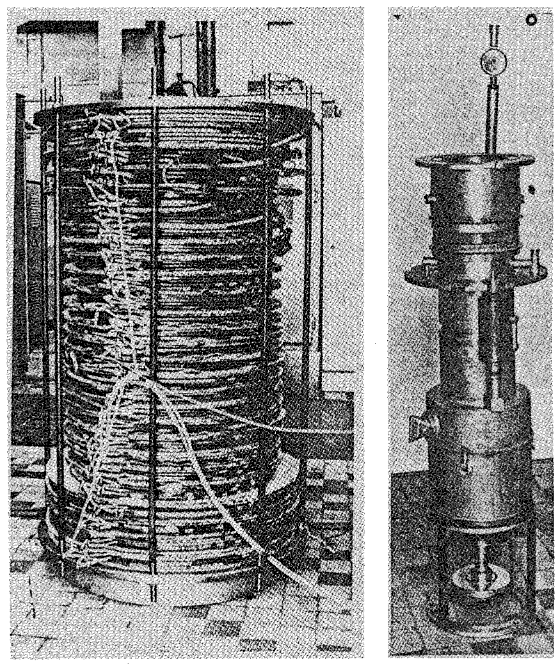

Fig.4. The experimental model of high--power amplifier based on focusing solenoid.