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MAGNETRON ELECTRON GUN (U)
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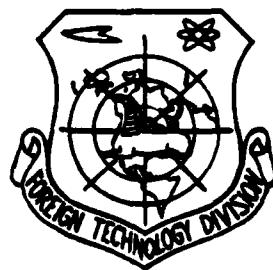
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MAGNETRON ELECTRON GUN

by

A. L. Gol'denberg, T. B. Pankratová and M. I. Petelin



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JUN 25 1980

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	А а	A, a	Р р	Р р	R, r
Б б	Б б	B, b	С с	С с	S, s
В в	В в	V, v	Т т	Т т	T, t
Г г	Г г	G, g	У у	У у	U, u
Д д	Д д	D, d	Ф ф	Ф ф	F, f
Е е	Е е	Ye, ye; E, e*	Х х	Х х	Kh, kh
Ж ж	Ж ж	Zh, zh	Ц ц	Ц ц	Ts, ts
З з	З з	Z, z	Ч ч	Ч ч	Ch, ch
И и	И и	I, i	Ш ш	Ш ш	Sh, sh
Й й	Й й	Y, y	Щ щ	Щ щ	Shch, shch
К к	К к	K, k	Ъ ъ	Ъ ъ	"
Л л	Л л	L, l	Ы ы	Ы ы	Y, y
М м	М м	M, m	Ь ь	Ь ь	'
Н н	Н н	N, n	Э э	Э э	E, e
О о	О о	O, o	Ю ю	Ю ю	Yu, yu
П п	П п	P, p	Я я	Я я	Ya, ya

*ye initially, after vowels, and after ъ, ѣ, elsewhere.
When written as ѣ in Russian, transliterate as yě or ẽ.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh ⁻¹
cos	cos	ch	cosh	arc ch	cosh ⁻¹
tg	tan	th	tanh	arc th	tanh ⁻¹
cotg	cot	cth	coth	arc cth	coth ⁻¹
sec	sec	sch	sech	arc sch	sech ⁻¹
cosec	csc	csch	csch	arc csch	csch ⁻¹

Russian English

rot curl
lg log

EDITED TRANSLATION

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2 MAGNETRON ELECTRON GUN

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and M. I. Petelin

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MAGNETRON ELECTRON GUN

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This invention involves a system of generating helical electron beams for cyclotron resonance masers operating in the centimeter, millimeter and submillimeter wave range.

The electrons in beams generated by magnetron electron guns may oscillate at cyclotron frequency. But electron oscillation in magnetron guns, which are used in a variety of microwave equipment, is reduced to a minimum with proper selection of mode of gun operation.

The object of the present invention is to create a method of generating intense helical electron beams with a high ratio of electron oscillator energy to electron translational energy and comparatively small velocity spread. This has been achieved by selecting the optimum mode of operation and electrode shape for the magnetron electron gun.

Figure 1 shows the location of the electrodes in the electronic gun and electrical and magnetic field distributions; Figure 2 illustrates the same thing with gun electrons in the supercritical mode.

The electron gun itself consists of axisymmetric electrodes--an anode 1 and a cathode 2, part of which is coated with an emissive layer 3. The cathode is heated by the coil 4. The gun anode

may be insulated from the housing 5, which comprises the working volume of the device. The solenoid 6 generates the magnetic field required for the device. The electron gun is located in the solenoid stray field or in the field of the auxiliary electrode, which is not shown in Figure 1. The electron gun operates in the near-critical mode so that electrons escaping the cathode almost come into contact with the anode or in the supercritical mode, when the electron trajectory passes a considerable distance from the anode.

The electrons are emitted from cathode under the effect of the voltage applied (the force lines of the electrical field are shown by the solid lines with arrows). The magnetic field (force lines indicated by broken lines) deflects the electrons (electron trajectories shown without consideration of azimuthal drift), and under the effect of the electrical and magnetic fields the electrons pass over the surface of the cathode in near-cycloidal trajectories. The component of the electrical field parallel to the magnetic field deflects the electrons in the direction of the interaction space in the process (Figure 1 shows only the resonator housing 5) in proportion to electron penetration of the region in which the electrical field decreases and the electron trajectory is transformed into helical lines. If the fields do not change very sharply (within the dimensions of a cycloid or the step in a helical line), the vibrational energy of the electrons varies in proportion to the intensity of the magnetic field.

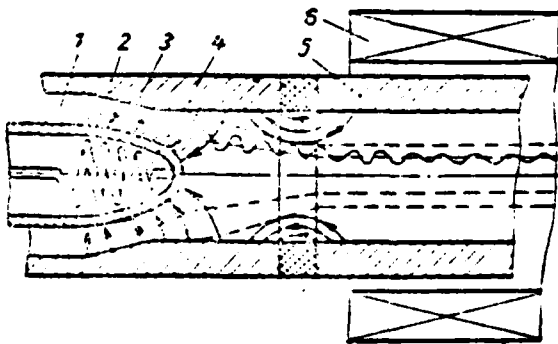


Figure 1

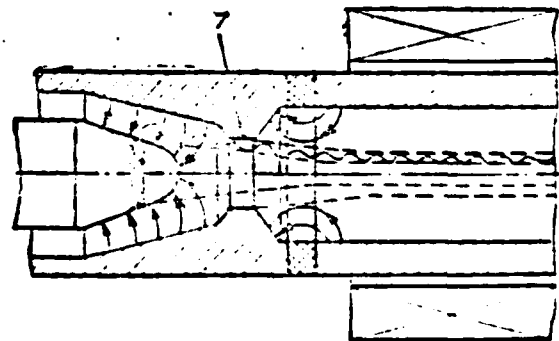


Figure 2

While the motion occurs within the increasing magnetic field of the solenoid 6, the energy of the rotating electrons will therefore increase as well. The field between the anode and the housing may serve as an additional source of electrons. If necessary, additional electrodes may be placed between the existing electrodes; beam generation terminates in the region of the solenoid's uniform magnetic field 6.

Let us introduce the following designations:

U_a - anode potential; U_p - potential of the space in which occurs interaction of the beam with the high-frequency field;

α - ratio of the intensities of the magnetic fields in the interaction space and at the point of electron emission. In the case of a gun operating in a critical mode, when $\alpha \approx 4 \frac{U_p}{U_a}$, the electron energy will be completely converted into the energy of rotational motion. This relationship is obtained for guns in which there is a sufficiently small (less than 20°) angle of intersection between the force lines of the magnetic field and the surface of the cathode. If the electron gun is operating in a mode other than critical, the analogous value for the ratio of magnetic fields

$$\alpha \approx 4 \frac{U_p U_{a \text{ cr}}}{U_a^2},$$

where $U_{a \text{ cr}}$ - critical anode voltage equal at a given magnetic field value to the anode voltage at which the electron trajectories come into contact with the surface of the anode. When the electron beam is paraxial, the latter relationship makes it possible to calculate the basic dimension of the cathode, the diameter of the emitting surface, if we know the diameter of the beam $\mathcal{L}_0$ in the working space with the uniform magnetic field. It turns out in this instance that the diameter of the emitting surface of the cathode should be equal to or slightly less than

$$\mathcal{L}_k = 2\mathcal{L}_0 \frac{(U_p U_{a \text{ cr}})^{\frac{1}{2}}}{U_a^2}.$$

The initial electron velocity dispersion results in the fact that within the increasing magnetic field, electrons having maximum rotational speeds may be reflected and not enter the interaction space. This causes loss of part of the beam, reduction of the efficiency of the apparatus and other consequences adversely affecting its normal operation. When gun electrons are in the supercritical operational mode, extension 7 (see Figure 2) serves as an outlet for the reflected electrons.

For the purpose of reducing electron velocity dispersion, the width of the emitting layer 3 should be of the order of the distance between the anode and the cathode, its maximum width calculated on the basis of maximum permissible dispersion. The cathode operates under conditions of a temperature limitation of the current when the distribution of the electrical field between the cathode and the anode differs little from this distribution in the absence of a current.

OBJECT OF INVENTION

1. A magnetron electron gun for cyclotron-resonance masers comprising a cylindrical anode and cathode with an emitting region, distinguished by the fact that for the purpose of generating a flow of electrons moving in helical trajectories, the diameters of the cathode d_k and of the electron beam d_b are selected in accordance with the relationship

$$\frac{d_k}{d_b} = \beta \frac{(U_p - U_{\text{anp}})^{\frac{1}{2}}}{U_a}$$

where β - numerical coefficient whose value lies between 1.7 and 2.2; U_p - potential of working volume; U_a - anode potential; U_{anp} - critical electron gun voltage, cathode potential assumed equal to zero.

2. A gun as in paragraph 1 distinguished by the fact that for the purpose of draining off electrons possessing excess oscillation energy, the anode is provided with an extension near the outer boundary of the electron beam.