where $k^0 = (\vec{k}^2 + \mu^2)^{\frac{1}{2}}$. Of course, the right sides of (1) and (1') are equal only when $k^2 = -\mu^2$.

It is convenient (and by virtue of (3) possible) to choose

$$\tilde{\varphi}(x) = \partial^\mu J_\mu^A(x). \tag{9}$$

Comparing (3) with (8), we obtain for the indicated choice of $\tilde{\varphi}(x)$

$$\gamma = -i\mu^2 f_\pi, \tag{10}$$

and (1') coincides with (2) with $C = \mu^2 f_\pi$. Thus, Eq. (2) with $C = \mu^2 f_\pi$ is exact and always valid. There is no need to introduce the renormalized Heisenberg pion field $\varphi(x)$ in terms of (1), and then remove it with the aid of PCAC. This remark is quite trivial and is well known [3]. Nonetheless, we wish to point out that the hypothesis that the divergence of the axial-vector current is proportional to the pion-field operator is referred to in the literature with increasing frequency. It is not actually needed at all to derive the result (2).

The author is grateful to Professors K. A. Ter-Martirosyan, V. Ya. Fainberg, V. M. Shekhter, and B. L. Ioffe for interesting discussions, and also Academicians I. E. Tamm and I. Ya. Pomeranchuk for hospitality during his stay at the Lebedev Physics Institute and the Institute of Theoretical and Experimental Physics.

[1] M. Suzuki, Phys. Rev. Lett. 15, 986 (1965); H. Sugawara, ibid. 15, 870 (1965); C. G. Callen and S. B. Treiman, ibid. 16, 212 (1966); K. Kawarabayashi and M. Suzuki, ibid. 16, 255 (1966); S. K. Bose and S. U. Biswas, ibid. 16, 330 (1966); Y. Hara, Y. Nambu, and J. Schechter, ibid. 16, 380 (1966); U. S. Mathyr, S. Okubo, and L. K. Pandit, ibid. 16, 371 (1966).

[2] R. Haag, Phys. Rev. 112, 669 (1958).

1) A. P. Sloan fellow.

2) At the invitation of the USSR Academy of Sciences in accordance with the Program of Scientific Exchange between the National Academy of Sciences and the USSR Academy of Sciences.

3) K. Nishijima, Translations of International Conference on Weak Interactions, Argonne National Laboratory, 25 - 27 October 1965, p. 418.

GENERATION OF ELECTROMAGNETIC OSCILLATIONS IN AN OPEN RESONATOR

F. S. Rusin and G. D. Bogomolov
Institute of Physics Problems, USSR Academy of Sciences
Submitted 14 June 1966
ZhETF Pis'ma 4, No. 6, 236-239, 15 September 1966

The use of open resonators is quite promising for the generation and amplification of electromagnetic oscillations. It makes it possible to improve appreciably the frequency selection, a fact especially important for the short millimeter and submillimeter bands. A self-exciting generator using an open resonator can be realized by passing a straight-line beam of electrons over a periodic structure deposited on one of the mirrors of the open resonator. If the period of the structure is much shorter than the wavelength of the oscillations, then slow spatial harmonics of the natural oscillations are produced near the mirror of the resonator, and their phase velocities are close to $cl/\lambda n$, where c is the velocity of light, l the period of the structure, λ the wavelength of the electromagnetic oscillations in free space, and n = 1, 2, 3, ... When the electron velocity is close to the phase velocity of one of the spatial-harmonics, an effective interaction takes place between the electron beam and the electromagnetic field of the open resonator, and at sufficiently large beam currents the "beam-resonator" system can become self excited.

An experimental verification of the proposed generation method was carried out in an instrument which we named "orotron" (instrument with open resonator and reflecting grating). Its schematic diagram is shown in Fig. 1.

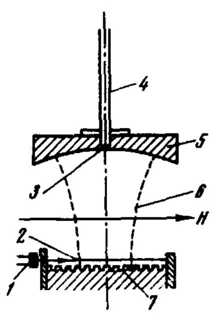

Fig. 1. Schematic diagram of the orotron (section): 1 - cathode, 2 - electron beam, 3 - coupling aperture, 4 - waveguide, 5 - spectral mirror, 6 - field-caustic boundary, 7 - mirror with periodic structure.

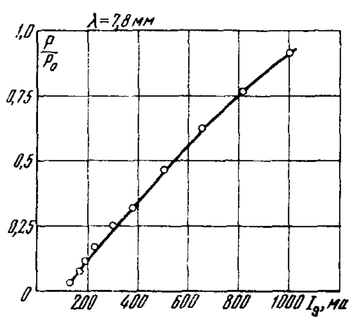

Fig. 2. Output power of the orotron vs. emission current.

The open resonator was made up of plane mirror (38 mm diameter) and a spherical mirror (60 mm diameter, radius of curvature 60 mm) [1]. The distance between mirrors could be varied continuously from 20 to 30 mm. A grating with a period of 1 mm, groove width 0.5 mm, and depth 1.5 mm was deposited over the entire surface of the plane mirror. The Q of the open resonator with the grating on the plane mirror was close to 3000 at 8.45 mm wavelength, whereas without the grating, with a smooth plane mirror, the Q was approximately 20,000. The coupling between the resonator and the waveguide was through an opening in the center of the spherical mirror, with a coupling coefficient of approximately 10% (at λ = 8 mm).

A diode gun produced an electron beam, a ribbonlike section of which (3.5 x 0.5 mm) was cut out by means of a diaphragm. This beam was accelerated by a dc or a pulsed voltage. The instrument was continuously evacuated to 10^{-7} mm Hg.

To focus the beam, the entire system was placed between the flat polepieces of an electromagnet producing a uniform field directed along the beam, with induction up to 5500 G.

The apparatus could generate at wavelengths from 5.3 to 12.2 mm. The generation frequency was established by varying the distance between mirrors and by varying the accelerating voltage between 1500 and ~9000 V. Generation was observed at starting currents ~100 mA, which coincided with theoretical estimates.

At a fixed distance between mirrors, generation was observed at several frequencies, corresponding to the 01n open-resonator modes with different longitudinal indices n [2].

The plot of Fig. 2 (in relative units) shows that the output power depends on the current almost linearly at cathode emission currents from 100 to 1000 mA. The pulsed output power at 8.10 mm wavelength and 1000 mA emission current was approximately 4 W.

The described instrument is a self-excited generator for microwave oscillations with a nonrelativistic electron beam. The feedback is effected by the open resonator, making it possible to transform the incoherent radiation of the electron beam passing over the periodic structure [3] into coherent monochromatic radiation.

Let us indicate some of the characteristics of such a generator: 1) Variation of the accelerating voltage with fixed distance between the open-resonator mirrors makes possible generation at several frequencies in a range larger than an octave. 2) Variation of the distance between mirrors effects continuous frequency tuning. 3) The orotron being a quasi-optical instrument, is easily matched with other quasioptical systems, an especially important feature in the submillimeter band.

The preliminary experiments and the theoretical estimates give grounds for hoping that the proposed method will make it possible to progress from the millimeter band to the submillimeter one. This investigation will be described in greater detail in the collection "Elektronika bol'shikh moshchnostei" (High Power Electronics) No. 5 or 6.

The authors thank P. L. Kapitza for support, S. P. Kapitza and L. A. Vainshtein for valuable advice and numerous discussions, and M. B. Golant for technical help.

[1] F. S. Rusin and G. D. Bogomolov, Claim No. 943533 of 16 February 1965.
[2] L. A. Vainshtein, JETP 45, 684 (1964), Soviet Phys. JETP 18, 471 (1965).
[3] S. J. Smith and E. M. Purcell, Phys. Rev. 92, 1069 (1953).

ERRATA

Article by V. V. Korobkin and R. V. Serov, Vol. 4, No. 3 (1 August 1966)

On page 70, the second paragraph of the article begins with "Raizer [5] investigated..." This should read "Askar'yan et al. [5] investigated..."