smaller than 50 Hz for a generation frequency of 100 MHz). Laĭkhtman[7] recently worked out the theory of the generator and its line widths under the conditions of comparatively large values of the difference $E - E_{thr}$. It turned out that the possible states are those stable states of the generator in which only one mode is generated and all the others are suppressed owing to the nonlinear interaction. The generation frequency is of the order of ω_m, while the number of the steady-state mode is determined by the previous history, i.e., by the method of switching on the generator.

The line width depends very strongly on the electron concentration. For example, for CdS it is insignificant at concentrations smaller than approximately 10^{13} cm^{-3} (typical values of the width are 10^{-7}–10^{-4} sec^{-1}). At concentrations of the order of 10^{14} cm^{-3}, however, it increases so sharply that the generation of a monochromatic signal becomes impossible and the piezo semiconductor is converted into a noise generator.

The question of the buildup of acoustic noise and its interaction is considered in[8].

Other operating conditions for the generator were discovered in[6], but these have not as yet been theoretically interpreted. For example, periodically recurrent nanosecond current pulses were observed, which were apparently due to narrow deformation pulses of the solitary-wave type, propagating back and forth in the semiconductor, and being reflected from its surfaces.

Further development of what has been done in the study of the generator is advisable for three reasons:

1) This problem is of considerable physical interest.

2) The generated high-frequency sound signal can be used in physical investigations.

3) Such a device may find an application in a number of instruments[6].

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G. A. Mesyats, S. P. Bugaev, and D. I. Proskurovskii. Explosive Emission of Electrons from Metallic Needles.

Metallic needles are widely used as sources of pulsed electron currents of up to 10^5 A and greater. Our investigations[1-9] have shown that the appearance of such strong electron currents precedes the electric explosion of the tip of the needle and the formation of a plasma as a result of heating by the autoelectronic current. This was first shown in[1]. If the electric field at the tip of a tungsten needle $E \geq 1.2 \times 10^2$ V/cm, then the time lag before its explosion is $t_d \leq 10^{-9}$ sec.

The results of investigations by Dyke's and Elinson's groups, and also by Furseĭ's group, showed that the cause of the explosion of the tip is the heating of it by the field-emission current.

For a current density of $j = 5 \times 10^7 - 5 \times 10^9$ A/cm^2 from the tungsten tip, the product $j^2 t_d \approx 4 \times 10^9$ A^{2}sec^5/cm^4, which explains the heating of the metallic needle by Joule heat with allowance for the Nottingham effect[6].

The rate of scattering of the plasma on the explosion of a W, Cu, or a Mo needle is $v \approx 2 \times 10^6$ cm/sec, the mean concentration of particles during 5–20 nsec is $10^{17} - 5 \times 10^{15}$ cm^{-3}, and the electron temperature is 5 eV. The mass carried away in the explosion of the needles is of the order of 10^{-11} g per pulse (see the figure). One of the probable causes of the emission of electrons from a cathode is the intensification of the electric field at the plasma-cathode interface[8].

The volt-ampere characteristic of a diode with a spiked cathode and a plane anode is described by the empirical dependence[8] $i \approx 30 \times 10^{-6} u^{3/2}\, vt/(d - vt)$, where t is the time, and d is the distance between the anode and cathode. This is close to a "(3/2)-power" law for the space between a sphere of radius vt and the plane anode.

When the strength of the field applied to the needle is increased considerably above the field necessary for $t_d \approx 10^{-9}$ sec, the $i(t)$ curves lie above the ones given by the formula. The beam on the anode then takes the form of a ring with a halo inserted at the center. This is accounted for by the emission of electrons from the lateral surfaces of the needle.

For the control of the moment of appearance of an explosive emission of electrons, the use of the contact of a needle with the surface of a dielectric plate, the other side of which is metal-plated, is suggested[7]. The explosion of the needle then happens on account of a voltage pulse between the needle and the metallized side of the dielectric, while the extraction voltage is applied between the anode and the needle. Electron emission in such a system is due to the contact of the needle with the plasma made of the material of the dielectric and the needle[7].

All the electron sources of heavy-current pulse accelerators, in which explosive emission is used, can be subdivided into the following: sources containing one or several needles, multineedle, with a plane rough cathode and plane cathodes with a contiguous dielectric. Diodes with single-tip cathodes have a high beam divergence and, owing to the spreading of the beam, they do not make a constant resistance for the duration of a pulse possible, which makes the matching of the line with the diode difficult. Diodes with plane rough cathodes have beams of nonuniform cross section and, in a number of cases, because of the nonsimultaneity of the explosions of the microprojections on the cathode, the lamination of the electron beam in the diode is destroyed. To eliminate these defects, we must use cathodes with a large number of emitting centers on its surface. Multineedle cathodes and cathodes with a dielectric are examples of such cathodes. If the explosion time of the emitting needles $t_d \ll t_f$, the mean distance between the emitting centers $a \ll d$, and the surface area of the cathode $s \gg d^2$ (t_f is the rise time of the front of a pulse, while d is the distance between the anode and the cathode), then for such a diode the "(3/2)-power" law is obeyed. The conditions for maximum efficiency of such a diode are

$$\int d\mathbf{p}\,\frac{p^2}{2m_e}\,F_e^{(2n)} \sim \frac{\varkappa T_e}{r_E^3}\,e^{2\gamma t}.$$

where R is the wave impedance of the line, and t_p is the pulse duration.

Controlled cathodes with a dielectric allow us, on account of an initial input of a master pulse, to fill a diode with a plasma and increase the beam perveance by a factor of 10 or more[10].

Two types of accelerators using the explosive emission of electrons have been developed: one with a controlled cathode which operates at a voltage of 500 keV and a current of 10 kA[10]; the second type—with multineedle cathodes, which operate at a voltage of 1000 keV and a current of 50 kA[11].

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E. K. Zavoĭskiĭ. Turbulent Plasma Heating

In a paper on the problem of controlled thermonuclear fusion presented at a recent session of our division by L. A. Artsimovich, only the problem of the confinement of a plasma in closed magnetic traps, mainly in Tokamaks, were considered. However, there is in the thermonuclear problem a no less important aspect—the production of a hot plasma. And this can be seen on the example of the same Tokamaks, for which the problem of plasma heating is still an unsolved problem. A hot plasma is necessary not only for filling traps. Its production is important in its own right, since it is possible to construct a thermonuclear reactor without confinement—thermonuclear mini-explosions. This way of solving the problem has in a number of cases advantages and, undoubtedly, its regions of applicability. Such a detonation of a DT mixture by an electron beam or by a laser may produce the effect of detonation of a relatively large block. In this case the question of the efficiency of the device initiating the detonation does not practically arise, and this is important. However, I shll not touch upon this side of the matter.

Why does the problem of plasma heating arise at all? It seems natural to pass a current through the plasma and Joule heating will lead to the desired result. However, as is well known, the Coulomb cross section, which determines the resistance of the plasma, decreases as v^3, i.e., as $T_e^{3/2}$. Therefore, at thermonuclear temperatures (~10 keV), the resistance of the plasma is about one-hundredth of the resistance of copper and huge current densities are required to heat up the plasma. Of course, we could heat the plasma with a low current but for a long time. This is impossible, since, in the first place, a hot plasma radiates, and, on the other hand, energy losses due to diffusion across the magnetic field is fairly high. Obviously, the current cannot be severely reduced, for then equilibrium between heating and losses will set in at a low temperature of the plasma.

In the early Sixties, when physicists were perplexed by newer and newer plasma instabilities in different magnetic traps, suggestions were made at the Institute of Atomic Energy (IAE) and experiments were begun on the use of certain types of instabilities for plasma heating. Certain types of instabilities, such as the beam, the Budker-Buneman, and the ion-acoustic instabilities, were known at that time. Beam instability arises when the velocity of the electrons in a beam penetrating a plasma greatly exceeds the thermal velocity of the electrons of the plasma. The Budker-Buneman instability is excited when the ordered velocity of the electrons is somewhat higher than the thermal velocity of the plasma electrons. The ion-acoustic instability appears when the directed velocity of the electrons is of the order of the velocity of ion sound. However, the state of the theory of these instabilities was such that it was impossible to predict the effectiveness of the heating of the electrons and ions of a plasma on the appearance of these instabilities. It was also not certain that the excitation of these instabilities would not lead to a strong drift of the plasma from the traps. The first experiments were set up at the IAE with the object of detecting the collective effects in a plasma when the current flows across the magnetic field. In these experiments a high-intensity magnetosonic wave, propagating across the constant magnetic field, was produced in the cold plasma. It