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A session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on February 17 and 18, 1971, in the Conference Hall of the P. N. Lebedev Physics Institute. The following papers were read at the session:

1. **V. L. Gurevich**, A Solid-state Audio-frequency Oscillator—an Acoustic "Laser."
2. **G. A. Mesyats, S. P. Bugaev, and D. I. Proskurovskiĭ**, Explosive Emission of Electrons from Metallic Needles.
3. **E. K. Zavoiskiĭ**, Turbulent Plasma Heating.
4. **V. P. Silin**, Anomalous Nonlinear Dissipation of UHF Waves in a Plasma.
5. **V. E. Golant**, UHF Methods of Plasma Heating.
6. **L. P. Pitaevskiĭ**, Superfluidity of Liquid Helium (New Results).
7. **D. S. Chernavskiĭ**, Elastic and Inelastic Interactions of High-energy Hadrons.

We publish below brief summaries of the papers presented.

V. L. Gurevich. A Solid-state Audio-frequency Oscillator--an Acoustic "Laser."

An active medium capable of amplifying sound is used in acoustic generators. This medium can be a piezoelectric semiconductor in which sound is intensified upon application of an electric field E, which causes the current carriers to drift. (The amplification effect was first observed by Hutson, et al. in CdS[1].)

There are two important differences between the properties of a sound amplifier and those of the optical amplifiers used in lasers.

1) Only sound propagating in the direction of drift of the carriers can be amplified; the backward sound wave is damped: However, as has been noted by White[2], in a sufficiently strong field E the amplification of the direct wave exceeds the attenuation of the backward wave.

2) The frequency dependence of light amplification often has a sharp peak. The location of the peak determines the frequency at which the laser operates. The coefficient of amplification (and, of absorption of sound) also passes through a maximum[2]. The corresponding frequency $\omega_m = w/R$, where w is the velocity of sound, and R is the Debye radius. However, a solid-state sound amplifier is a broad-band amplifier and the corresponding peak is broad.

An audio-frequency oscillator is a wafer with surfaces that reflect sound. The "eigenfrequencies" of such an acoustic resonator are determined by requiring that on passage of sound in the forward and backward directions the resultant phase difference be a multiple-of 2π. The threshold field E_{thr} is determined by the condition that for any "eigenfrequency" the amplification during the forward transmission of the sound should cancel both the attenuation during the backward transmission and the losses due to reflection.

The conditions for excitation of the oscillator and its performance for small differences of $E - E_{thr}$ have been investigated in a paper by Laĭkhtman and this author[3]. The generation frequency is the eigenfrequency nearest to ω_m. If the electron concentration is not too high (does not exceed 10^{13} cm^{-3} for CdS), then a sinusoidal monochromatic signal is generated, whose amplitude is proportional to $\sqrt{E - E_{thr}}$.

Such a generator was first experimentally realized by White and Wang[4], and, in the USSR, by Baĭbakov[5]. The performance of the generator on CdS under different operating conditions was thoroughly investigated in a series of experiments by Maines and Paige[6].

It was discovered that at large values of $E - E_{thr}$, one mode only can be generated if the field and the illumination of the crystal are chosen properly. Such a mode has a very small halfwidth (in one case, it was 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].

[1] A. R. Hutson, J. H. Mcfee, and D. L. White, Phys. Rev. Lett. 7, 237 (1961).

[2] D. L. White, J. Appl. Phys. 33, 2547 (1962).

[3] V. L. Gurevich and B. D. Laĭkhtman, Fiz. Tverd. Tela 6, 2884 (1964); 7, 3218 (1965) [Sov. Phys.-Solid State 6, 2299 (1965); 7, 2603 (1966)].

[4] D. L. White and W. C. Wang, Phys. Rev. 149, 628 (1966).

[5] V. I. Baĭbakov, Fiz. Tverd. Tela 10, No. 3, 678 (1968) [Sov. Phys.-Solid State 10, 533 (1968)].

[6] J. D. Maines and E. G. S. Paige, Electr. Lett. 3 (10), 459 (1967); Proc. Intern. Conf. Semicond., p. 928, Moscow, 1968; J. Phys. C, 2, 175 (1969); Solid State Commun. 8, 421 (1970).

[7] B. D. Laĭkhtman, Zh. Eksp. Teor. Fiz. 60, No. 2, (1971) [Sov. Phys.-JETP 33, No. 2, 398 (1971)].

[8] V. L. Gurevich, V. D. Kagan, and B. D. Laĭkhtman, Zh. Eksp. Teor. Fiz. 54, 188 (1968) [Sov. Phys.-JETP 27, 102 (1968)].

G. A. Mesyats, S. P. Bugaev, and D. I. Proskurovskiĭ. 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