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Stuart G. Hibben

Informatics, Incorporated

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report includes abstracts and bibliographical lists on contractual subjects that were completed in October, 1973. The major topics are: laser technology, effects of strong explosions, geosciences, particle beams, and material sciences. A section on items of miscellaneous interest is included as an optional topic; material on geomagnetic pulsations is to be abstracted in a separate report. (Continued)		

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20. Abstract (Continued)

Laser coverage is generally limited to high power effects; all current material is routinely entered in the quarterly laser bibliographies.

An index identifying source abbreviations and a first-author index to the abstracts are appended.

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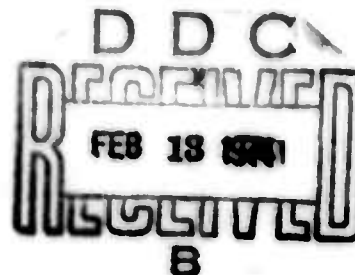
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Stuart G. Hibben
Tel: (301) 770-3000 or
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1. Laser Technology

A. Abstracts

Savranskiy, V. V., and A. A. Samokhin.

Laser heating of a tubular target. DAN

SSSR, v. 210, no. 5, 1973, 1053-1055.

The authors analyze the dynamics of a laser plasma confined in a cylindrical volume, for the case in which plasma heating causes appreciable vaporization of the interior walls. Tests were done using a 3-10 cm long glass tube of ID = 0.16-0.18 cm, with one end sealed off. Plasma was generated by a free-running Nd glass laser, focused at $f = 7$ cm to a point inside the tube's open end, and triggered by a giant pulse from a second Nd laser whose beam was angled 70° to the main beam and focused slightly in front of the open end. Tests were done at room ambient conditions.

High speed photos show that plasma generated at the open end rapidly propagates inward, ionizing unionized gas before it. After several oscillations in the tube for 50-100 μ s a stationary plasma column is established which is stable during the remaining excitation period of about 1.3 milliseconds. The degree of compression was found to increase with pulse energy as well as with reduction in tube length; for example at $L = 5$ cm and a 400j laser input, internal pressure p reaches several hundred atmospheres.

Maximum temperature T_0 of the plasma column was deduced from given parameters to be in the range of 10^5 deg. K, confined to a narrow axial region; this was based on the experimental evidence that the plasma remains relatively transparent to the laser radiation throughout. The latter phenomenon distinguishes the present configuration from the case of a plane target or a target inside a capillary, where shielding by vapor products begins shortly after the beam is applied.

Wall heating from plasma radiation was determined to reach the order of $T_1 = 3 \times 10^3$ deg. K, causing vaporization and ionization of wall material.

The energy thus expended by the column was found by the product of heated plasma volume ($6 \times 10^{-3} \text{ cm}^3$), thermal capacity $c = 2 \text{ j/cm}^3 \times \text{deg.}$ and T_i , giving a figure of 36 j in the cited case. Raising the laser energy appears to cause a nearly square-law increase in pressure and an almost linear rise in plasma peak temperature; however this conclusion is based on a rather narrow input energy range of 280-430 j, and should be checked further.

Gulyayeva, A. S., M. A. Gurevich, L. A. Zhukova, N. M. Klimova, B. A. Krasnyuk, and V. N. Maslov. Structural changes in gallium arsenide caused by laser radiation. FizKhOM, no. 3, 1973, 17-21.

Structural effects of laser radiation on n-GaAs single crystals are described. Te-doped plane-parallel specimens were used with laser pulses incident on the $(\bar{1}\bar{1}\bar{1})$ surface, while structural variation was studied on the (111) surface. Irradiation was by an Nd glass laser at 1.06μ , developing single pulses of 10 j at $500 \mu\text{s}$ which gave an incident flux density of $\sim 5 \times 10^5 \text{ w/cm}^2$; specimens were placed about 11 cm from the focus lens ($f = 25 \text{ cm}$).

Comparative results were analyzed from metallographic, electron microscope and electronographic observations. Test faces were first ground and polished, then recorded by the three methods before and after laser exposure. Fig. 1 is an example of results from a single pulse exposure. In analysis of the laser effects the authors assume a polished surface structure initially comprising in order an amorphous surface layer, a disordered-crystal layer and an oriented crystal layer, totalling $\sim 10 \mu$; a layer of deformation, $\sim 100 \mu$; and the undisturbed matrix.

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Fig. 1. Deformation structure of GaAs surface layer: before (left) and after (right) laser exposure.

a - metallographic, x200; b - electron microscope, x6000; c - electronographic, L = 250 mm, 75 kv.

Results vary as a function of average incident flux and of repeat exposure as well as on the crystal structural state. A portion of the polished surface evaporates; at deeper levels the radiation damage structure (twinning, cracks and dislocations) is concentrated in the deformation layer. Cracks and twinning decreased with depth, and disappeared while a few dislocations remained; at depths beyond 100 μ the crystal was apparently unaffected by laser radiation.

Gurevich, G. L. Theory of thin film destruction by laser radiation. FikHOM, no. 3, 1973, 5-11.

A theoretical discussion of the destruction process is given for laser drilling of thin films. The assumed model is that of Fig. 1, in which Δ is on the order of h so that the temperature at any point in the film



Fig. 1. Laser drilling of thin film.

transition region can be assumed the same. Identifying V as a magnitude on the order of sonic velocity, T = temperature at the destruction point, and $T^* =$ a constant of atomic bond energy in the film, the author expresses hole growth rate by

$$\dot{s} = V \exp \left[-\frac{T^*}{T(s, t)} \right] \quad (1)$$

It is further assumed that radial heat transfer from the hole periphery is negligible, hence for beam radius V we have

$$\left. \frac{\partial T}{\partial r} \right|_{r=V} = 0 \quad (2)$$

With this model the author obtains solutions for $s(t)$ and $T(s, t)$ for both free-running and c-w laser cases. Final expressions relate hole size to film and substrate parameters as well as laser characteristics.

Goncharov, V. K., I. Ya. Min'ko, Ye. S. Tyunina, and A. N. Chumakov. Experimental study of optical properties of an erosion laser plasma in the interaction zone. IN: Sbornik. Kvantovaya elektronika, no. 1(13), 1973, 56-62.

An optical investigation was conducted of the surface layer plasma formed by laser irradiation of metals at a flux density up to $6 \times 10^6 \text{ w/cm}^2$. An Nd glass laser with an energy 150 joules and pulse duration 1 μsec was used in the experiment, with radiation focused on the end of a thin brass wire ($d = 1.3 \text{ mm}$) by a lens of $f = 100 \text{ mm}$, to obtain a focused spot of 2.4 mm. Exposure was done both with an open wire and with a quartz tube around it for confining plasma scattering (Fig. 1).

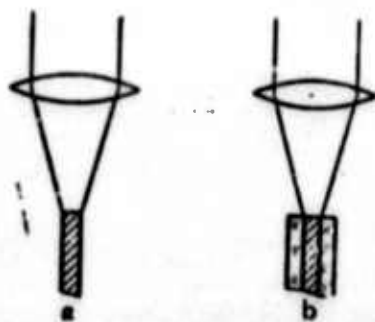


Fig. 1. Laser focusing: (a) wire without tube and (b) wire in quartz tube.

Plasma flare spectra were recorded by ISP-30 and ISP-51 spectrographs along the flare and perpendicular to it at different distances from the base (origin) (Fig. 2). A unique luminescence character was

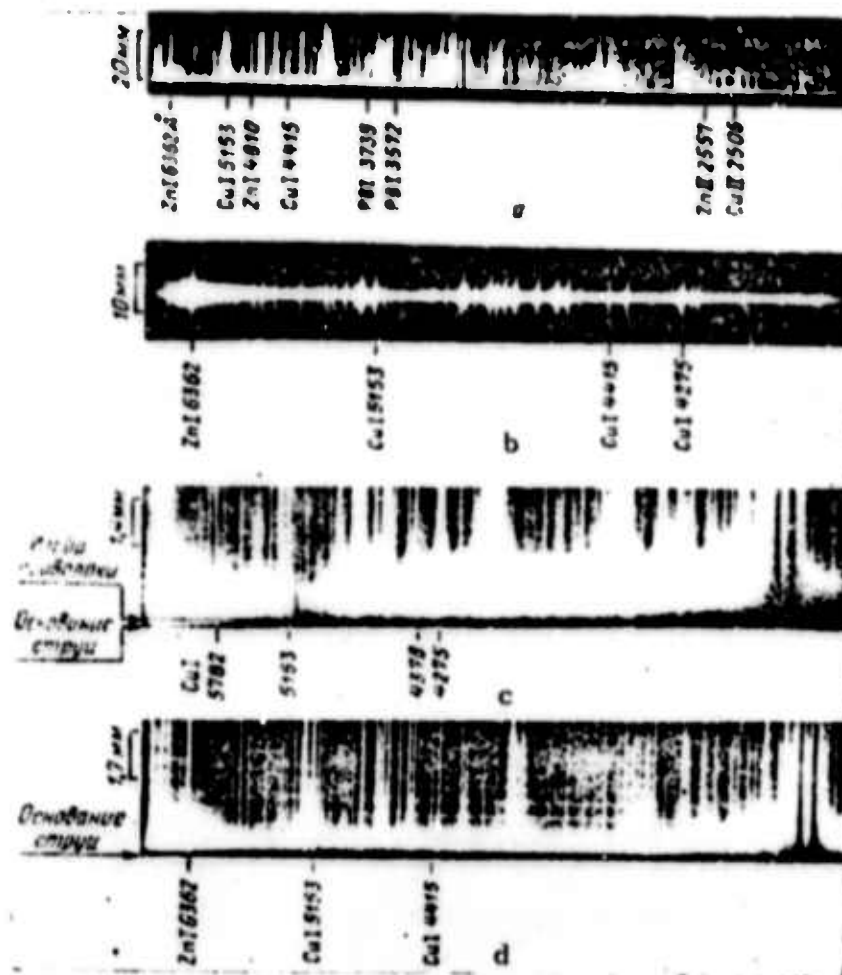


Fig. 2. Spectra of a laser plasma flare.
a, c, d - linear spectra; b - lateral spectrum.

observed of a dense background and spectral lines in the surface layer region. It is shown that the c-w radiation reaches its maximum intensity at a height of 0.8-0.9 mm above the disintegrating surface. The transparency of the plasma was studied by the optical scheme shown in Fig. 3. The erosion

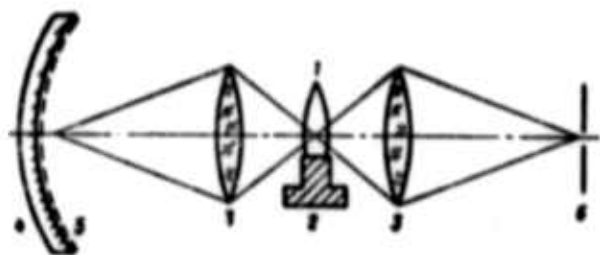


Fig. 3. Optical scheme for determining transmission coefficient.

1- flare; 2- target; 3- lens; 4- mirror;
5- screen; 6- spectrograph slit.

plasma flare over the surface layer up to a 2 mm region was found to be opaque.

Temperature distribution was also measured along the flare over the surface layer (0.3-2 mm) (Fig. 4). The increase in temperature

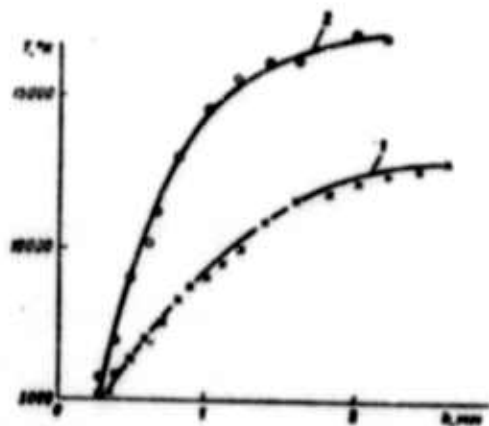


Fig. 4. Temperature variation along plasma flare.

(1) with quartz tube (2) without quartz tube.

is connected with the heating of the flare by laser radiation in the process of gas dynamic motion. Experimental results showed that in the lower range of gas dynamic action, a significant shielding takes place of the evaporation surface from laser radiation interaction, owing to absorption by destruction products over the surface.

Volod'kina, V. L., K. I. Krylov, M. P. Libenson, and V. T. Prokopenko. Heating an oxidizing metal by CO₂ laser radiation. DAN SSSR, v. 210, no. 1, 1973, 66-69.

Results are described of variations in reflection of powerful 10.6 μ radiation from a metal. In general physical and mathematical models are considered of the metal heating process by this radiation in the presence of oxygen. Experiments were conducted with chromium and aluminum film of thickness 0.5-1.0 μ , deposited on a dielectric substrate. Radiation was by a 50 w CO₂ laser with a NaCl lens of $f = 30$ mm. Incident and reflected radiation from the specimen metallic films were recorded by a low-inertia piezo detector and an oscillograph. Fig. 1 shows the oscillogram of power absorption in a chromium film. The curve breaks at the point which corresponds to the moment of film destruction.



Fig. 1. Change in time of absorption power A of chromium film at $\lambda = 10.6 \mu$ and radiation density $q_0 \approx 570 \text{ w/cm}^2$, focused to a spot radius $\cdot 1 \text{ mm}$.

A typical nonlinear relationship of the destruction time t^* of a metallic film as a function of radiation density q_0 is shown in Fig. 2.

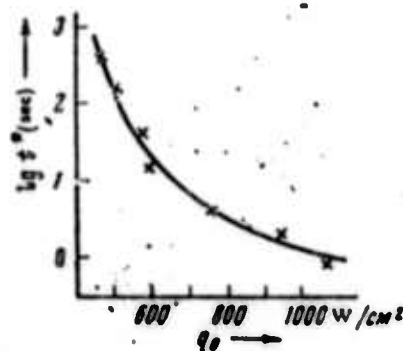


Fig. 2. Destruction time t^* of chromium film of thickness 1 mm, on a glass substrate, as a function of flux density q_0 ; $r_0 = 1$ mm.

Detailed qualitative and quantitative analyses are outlined on the process of metal heating. It is noted that the oxidation reaction accelerates the heating process in two ways: 1) due to its exothermicity, and 2) due to the increase of absorption power of oxidizable metals.

Sultanov, M. A., and V. A. Ageyev.

Investigating the destruction of polymeric films due to laser radiation. DAN Tad SSR, v. 16, no. 4, 1973, 25-28.

An experimental study is described on the action of an unfocused laser beam on the film surface of non-oriented polystyrene, polyethylene, dacron (laxsan), polypropylene, teflon, kapron, and copolymer styrene with α -methylstyrene. Experiments were conducted with an Nd glass laser having rod dimensions = 12 x 140 mm in a free-running regime with energy 5 joules and pulse duration of 1.4×10^{-3} sec. The following were observed:

1. The surface and internal destruction.
2. The destruction character of polymers according to types and material structure.
3. The destruction of polymers with crystalline structures.
4. The destruction of polymeric films as a function of the reflecting power of their substrate.

Microphotographs were taken of the damaged areas; four examples are given. It was seen that the type of incident flux plays an important part on both surface and internal destruction of polymer films during the interaction of laser radiation. Based on this observation, the authors suggest probable processes which take place in high-molecular compounds under laser irradiation.

Sinitsyn, A. P., V. A. Krivilev, Yu. V. Sidorin, and V. A. Upadyshev. Stresses in a rod resulting from electromagnetic radiation. PM, v. 9, no. 5, 1973, 109-114.

The article gives a theoretical and experimental study on the dynamic action of heat flux on rods. Expressions are derived for pulsed force, lateral deflection of rods due to oscillations, and bending stress. An experiment was conducted with π -type double-hinged ST-3 steel frame of dimensions: support height $h = 327$ mm, span $l_0 = 395$ mm, width of the support and crossbar $b = 24$ mm, and cross-section 3×24 mm² (Fig. 1). The thermal source used was a GLS-1 pulsed Nd glass laser of dimensions 15×260 mm. Pulse waveform is shown in Fig. 2. It was noted that laser radiation gave rise to oscillations in the frame, the amplitude of which

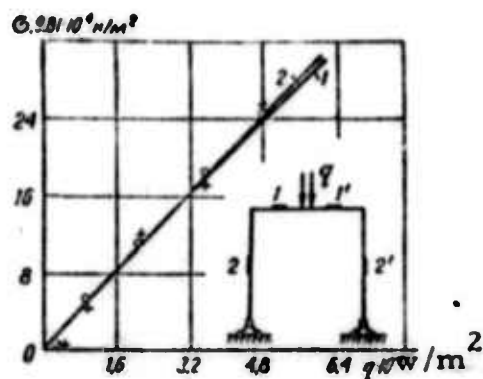


Fig. 1. Oscillation amplitude as a function of heat flux density.

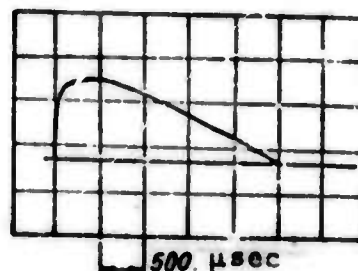


Fig. 2. Laser pulse form.

depended on the intensity of the heat flux. Fig. 1 shows the calculated and experimental values of amplitude of stress oscillations at the center of crossbar span, as a function of flux density. Calculated and experimental values are in good agreement. It was seen from the experiments that oscillations occur in the frame at laser radiations with wave length $\lambda = 1.06 \mu$ and pulse duration $\tau = 2.5 \times 10^{-3}$ sec.

Experiments were also conducted with optically transparent bodies of a polymethylmethacrylate specimen and consisting of a simple hinge-supported rectangular beam of cross-section $19 \times 39 \text{ mm}^2$ and span 390 mm. General conclusions are drawn for the conditions resulting in internal heat stress and oscillation in laser-heated rods with this type of suspension.

Buravl'ov, Yu. M., B. P. Nadezhda, and
I. O. Novokhats'kiy. Certain characteristics
of the effect of focused laser radiation [on
materials]. IN: Fiz. tverdogo tela. Res.
mezhved. temat. nauch-tekhn. sb., no. 2,
1972, 87-90. (RZhMetallurgiya, 6/73,
no. 61863) (Translation)

Studies were made on laser erosion characteristics of 23 pure metals as functions of their melting point and thermal conductivity, at varying laser pulse widths. The melting points of the tested metals covered the range from 30° to 3380° . Tests were done with a K-3M laser having a peak pulse energy of 1.5 j at a 3--5 ms pulse, a 1200 mf capacitor bank, and 2 kv voltage. Erosion was determined by weighing specimens before and after irradiation; erosion level was taken to be the average effect of ten pulses on a given specimen.

It was found that erosion depends equally on melting point and thermal conductivity. Taking specimens in the direction of increased m. p., erosion increases starting with Ga up to Pb, then decreases to Zn, after which it remains practically constant regardless of m. p., as in the case of Cu and W. In the low m. p. metals (Ga, In, Sn etc.), craters of 0.5-0.6 mm diameter were formed; for the higher m. p. metals this dimension was 0.2-0.3 mm. The results are discussed with respect to use of lasers for local spectral analysis of metals and alloys.

Rudakov, L. I. Instability and scattering
of light in a diverging multi-element plasma.
ZhETF P, v. 17, no. 7, 1973, 382-385.

The author discusses one possible cause of plasma corona fogging due to a laser beam, when the plasma consists of two or more kinds of ions with different Z_e/M , e. g. a thermonuclear deuterium-tritium plasma. Owing to the uneven acceleration of ions by the ambipolar electric field of the corona, the frictional force of ions in the rarefied corona region does not equalize the velocity, i. e. lighter ions move faster and a dual-flow motion is created which gives rise to an unstable condition. The electric field and corona density fluctuate with a characteristic scale of approximately Debye ion radius. Ion scattering in turbulent electric fields results in effective friction between elements, and part of the work of the ambipolar electric field goes into ion heating.

On this basis the author derives equations of turbulent heating. The scattering depth of a laser beam in these fluctuations is estimated. The depth is seen to depend on optical frequency, electron temperature and plasma ions. An Nd-glass laser propagating through the corona with $T_e = 10^4$ ev, $r = 1$ mm, reaches a critical density where $\omega_f = \omega$, and probably a strong absorption would take place, if ion temperature is less than 300 ev. A CO_2 laser scatters at a further distance from critical density.

Sapozhnikov, A. T. Self-similar dispersion of vaporization products of a solid wall caused by variable energy release. ZhPMTF, no. 3, 1973, 49-54.

The author derives self-similar equations for the motion of vapor products from a solid surface under variable incident energy concentrations. An idealized model is assumed in which the target initially occupies the half-space $x \geq 0$ and is at rest with an initial density ρ_0 and pressure p_0 ; the surface $x = 0$ interfaces with a vacuum. At $t > 0$ energy release starts at a rate given by

$$\frac{dE/dt}{\left(m + \int_0^x \rho dr\right)} = Q = Cm^{-\alpha} t^{1-\alpha} \quad (1)$$

where E = unit internal energy; m = Lagrange mass coordinate; and c and α are the constants $C > 0$ and $0 < \alpha < 1$. Those conditions stipulate that a finite amount of energy is evolved from a finite mass of $0 \rightarrow x$ during the interval $0 \rightarrow t$. Also, from the constraints on α it follows that energy release rate drops with increase in both m and t .

From this model a set of gas dynamic equations is derived describing vapor product motion in terms of the assumed parameters. Solutions are given for several possible variants of operating conditions, under the two general cases of continuous vapor generation and generation with a shock wave present. The solutions are shown to be unique for the assumed model.

B. Recent Selections

i. Beam-Target Effects

Bakeyev, A. A., Yu. M. Vas'kovskiy, N. N. Vorob'yeva, V. K. Orlov, and R. Ye. Rovinskiy. The role of a plasma flare in the energy balance during laser radiation interaction with a material. Kvantovaya elektronika, no. 2(14), 1973, 77-80.

Bakosh, Y., A. Kish, L. Sabo, and M. Tendler. Measurement of atomic excitation level due to intensive light, using a resonance multiphoton ionization process. ZhETF P, v. 18, no. 7, 1973, 403-407.

Barinov, V. V., and S. A. Sorokin. Exploding water drops by optical radiation. Kvantovaya elektronika, no. 2(14), 1973, 5-11.

Begunov, A. N., N. V. Volkova, B. N. Spiridonov, and P. N. Tsurul'nik. Effect of polishing mixture composition on the threshold surface ablation of KDP crystals by optical radiation. OMP, no. 9, 1973, 66-67.

Burenkov, G. L., V. B. Deymontovich, L. O. Zhenin-Mayskaya, M. Z. Kol'chinskiy, A. V. Perepelkin, and A. I. Raychenko. On structural and concentration changes in alloys, exposed to laser radiation. IN: Metallofizika. Resp. mezhved. sb., no. 45, 1973, 75-81. (RZhMetal, 9/73, no. 91244).

Korolev, N. V., V. V. Ryukhin, and G. B. Lodin. Possibilities of using the MSL-2 analyzer for electric discharge microanalysis with laser stabilization of the discharge channel. ZhPS, v. 19, no. 3, 1973, 400-403.

Krishtal, M. A., et al. Struktura i svoystva splavov, obrabotannykh izlucheniym lazera (Structure and properties of alloys subjected to laser radiation). Moskva, Izd-vo Metallurgiya, 1973, 192 p. (RBL, 4/73, no. 777).

Lokhov, Yu. N., V. S. Mospanov, and Yu. D. Fiveyskiy. Optical strength of a transparent dielectric surface. Kvantovaya elektronika, no. 2(14), 1973, 71-74.

Machulka, G. A., and L. P. Muratova. Self-channelling of a laser beam in opaque solid media. Kvantovaya elektronika, no. 2(14), 1973, 93-96.

Petukhova, T. M. Device for studying emission during laser interaction [with solids]. IN: Tr. Ural'sk. politekhn. in-ta., no. 215, 1973, 85-88. (RZhF, 8/73, no. 8Zh476).

Vakulenko, V. M., V. G. Zakharov, L. P. Ivanov, et al. The Kvant-9 apparatus for drilling holes. Kvantovaya elektronika, no. 2(14), 1973, 99-102.

Zel'manov, I. L., V. N. Kologrivov, V. I. Kulikov, and V. V. Pedanov. Interference method of investigating explosive motion in solid media. IN: Sb. Vses nauch.-tekhn. konf. Sovrem. sos'oyaniye i perspektivy vysokoskorostn. fotogr. i kinomatogr. i metrol. bystroprotekayushchikh protsessov. Tezisy dokl. Moskva, 1972, 166-167. (RZhMekh, 9/73, no. 9B234)

ii. Beam-Plasma Interaction

Andryukhina, E. D., M. A. Bloch, G. S. Voronov, O. I. Fedyanin, P. V. Kholnov, and I. S. Shpigel. Inzhektsiya plazmy, sozdabayemoy lazernyizlucheniym, v stellarator. (Laser plasma injection into a stellarator). 5th Eur. conf. contr. fusion and plasma phys., Grenoble, 1972, Vol. 1. Grenoble, 81 p. (RZhF, 9/73, no. 9G373).

Basov, N. G., V. A. Boyko, S. M. Zakharov, O. N. Krokhin, Yu. A. Mikhaylov, G. V. Sklizkov, and S. I. Fedotov. Mechanisms for generating neutrons in a laser plasma. ZhETF P, v. 18, no. 5, 1973, 314-317.

Basov, N. G., O. N. Krokhin, A. A. Rupasov, G. V. Sklizkov, and S. I. Fedotov. Zadayushchiy generator i sistema predvaritel'nykh kaskadov usileniya moshchnoy lazernoy ustanovki dlya vysokotemperaturnogo nagreva plazmy. (Master oscillator and the preamplifier system for amplifying a powerful laser for high-temperature heating of plasma). Moskva, 1973, 48 p. (RZhF, 9/73, no. 9G402)

Galeev, A. A., G. Laval', T. O'Neel, M. Rozenblyut, and R. Z. Sagdeyev. Interaction of a powerful electromagnetic wave with plasma. ZhETF, v. 65, no. 3, 1973, 973-989.

Gluchowski, W., S. Kaliski, T. Rusinowicz, and K. Smolarek. Numerical analysis of laser concentric heating of a two-temperature plasma, resulting from thermal conductivity. Biul. WAT J. Dabrowskiego, v. 22, no. 2, 1973, 15-24. (RZhF, 8/73, no. 8G271).

Gluchowski, W., S. Kaliski, T. Rusinowicz, and K. Smolarek. Numerical analysis of conduction-type laser heating of two-temperature plasma, taking into account energy released in nuclear fusion. Proc. Vibrat. Probl. Pol. Acad. Sci., v. 14, no. 1, 1973. 61-71. (RZhF, 9/73, no. 9G408).

Gluchowski, W., S. Kaliski, T. Rusinowicz, and K. Smolarek. Numerical analysis of laser concentric conductive heating of a two-temperature plasma. Bulletin de L'academie polonaise des sciences, Serie des science techniques, v. 21, no. 7-8, 1973, 89[595]-97[603].

Gribkov, V. A., V. M. Korzhavin, O. N. Krokhin, et al. Eksperimental'noye issledovaniye kumulyatsii plazmy. (Experimental study of plasma cumulation), 5th Eur. conf. contr. fusion and plasma phys., Grenoble, 1972, vol. 1, Grenoble, 64 p. (RZhF, 9/73, no. 9G298).

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2. Effects of Strong Explosions

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1. Geoscience

A. Abstracts

Kulikov, V. M., and B. P. Sibiryakov.

Elastic waves in two-dimensional thin-layered media, as excited by a directional force source. *Geologiya i geofizika*, no. 5, 1973, 79-87.

The results of observations of direct elastic waves in a thin-layered periodic model are compared to the results of computations for the mathematical model of an anisotropic layered medium, constructed without assuming sharp interfaces between layers.

It was shown that with respect to elastic parameters, a thin-layered periodic medium is equivalent to an anisotropic medium if the wave length exceeds the thickness of individual layers by a factor of four.

Vvedenskaya, A. V. The wave field of a propagating source in the form of a slip surface. IN: *AN SSSR. Izvestiya. Fizika Zemli*, no. 6, 1973, 11-27.

A mathematical model of the wave field associated with a propagating fracture surface in earthquake foci is given. The local increase in the density of structural defects of a medium over the fracture surface Σ

is treated as an increase in the density of continuously distributed coupled elastic dipoles over the surface Σ . The density of dipoles refers to the density of that portion of free energy which is transformed into the energy of the displacement field associated with the propagating fracture surface. The process of the propagation of the fracture surface is described by the dislocation theory.

It is shown that, depending on the ratio between the rate of fracture propagation and the velocity of wave propagation, displacement in the waves within different regions of the space are described by different solutions. The parameters of the fracture propagation and five solutions for different regions are outlined in the text.

The analysis of the characteristics of the wave field associated with propagating fracture surface shows that, depending on the location of the observing point and observation time, the source acts as a solenoidal, quasipotential, and potential force.

The regions and the corresponding theoretical seismograms described by different mathematical solutions (I to V) are illustrated in Figure 1.

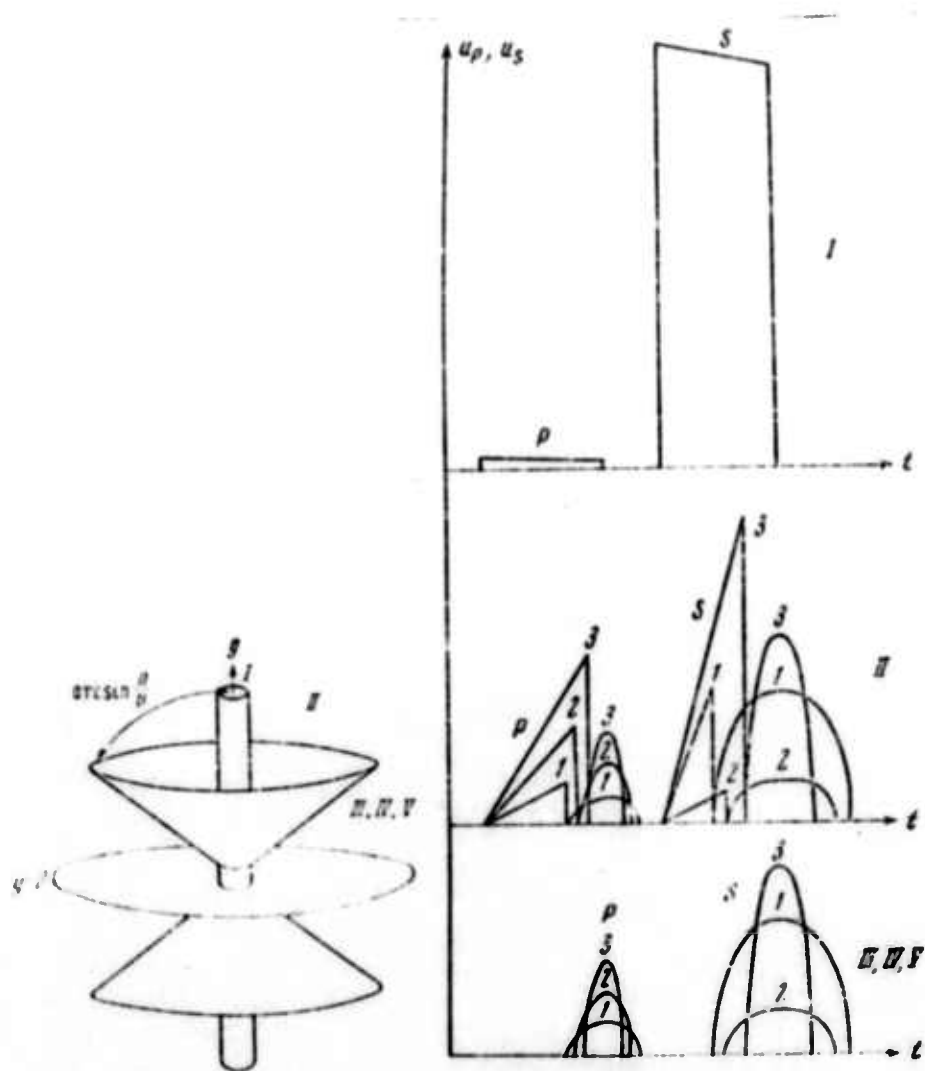


Fig. 1.

v - fracture propagation rate; a - wave velocity; and g - source radius.

Garmyshev, I. K. Deep seismic studies
in the Tym'-Porolayskaya lowland (Island
of Sakhalin). *Geologiya i geofizika*, no. 3,
1973, 117-122.

The results of deep seismic soundings conducted in 1966 along the 150-km-long Leonidovo - Krasnaya Tym' profile are described. Field work was conducted using a discrete observing system with a moving shot point for every 5 km of profile and four recording stations spaced 25-30 km apart. The instrumentation consisted of CC-30/60 CMRW seismic systems and NS-3 seismometers arranged in 1400-m-long lines.

Seismic and velocity sections along the profile are shown in the text.

A refracting surface at depths of 1-4 km with $V_p = 5.2 - 5.9$ km/sec is identified as the folded basement surface. Another refracting surface at a depth of 20 km with $V_p = 7.0$ km/sec, which is detected only in the central part of the profile, is identified as the Conrad discontinuity. Seven reflecting surfaces at depths of 24-40 km are assumed to outline the crust-mantle transition. The average velocities to these surfaces vary from 5.9 - 6.3 km/sec. Two low-velocity layers within the crust-mantle transition are assumed.

The velocity section is divided into three sectors (southern, central and northern) with different velocity distribution by anomalous zones.

Proskuryakova, T. A., and V. G. Alkaz.

Study of long-period microseisms in the
10-150 sec. range. IN: AN SSSR. Izvestiya.
Fizika Zemli; no. 6, 1973, 88-92.

The records of long-period microseisms, made at the Pulkovo and Baldone stations during the 28-30 September 1969 microseismic storm, are analyzed.

The amplitude spectra exhibit resonances at 8-10, 24-26, 45-57, 70-75 and 120-130 sec. The source of the microseisms within the 10-80 sec range was found to be associated with a cyclone in the Atlantic Ocean. The source of the 120-130 sec microseisms with an amplitude exceeding the amplitudes of the other microseisms by 5-10 times is assumed to be associated not only with the cyclone, but also with the fluctuation of atmospheric pressure over an extended air front passing over the stations during the microseismic storm.

The polarization of microseisms, which is found to be close to the elliptic, indicates that long-period microseisms represent superposed R- and L-waves.

The crustal model which fits the dispersion data does not conflict with previous results (thickness 38 km, low-velocity layer at 115 km).

Kun, V. V., and G. S. Pod'yapol'skiy.

Characteristics of seismic waves corresponding to a layer of finite thickness. IN:
AN SSSR. Izvestiya. Fizika Zemli, no. 6,
1973, 33-49.

An analysis was made of the waveform, amplitude and attenuation of seismic waves associated with a finite layer. The characteristics of the sum head wave from a finite layer were compared to those of the head wave from a half-space or thick layer. The calculations were carried out for the model shown in the table, with the ratio between the layer thickness and wave length varying from 1 to 5.3.

Layer	V_p , km/sec	V_s , km/sec	ρ , gr/cm ³	h , km
1	2.2	1.0	2.2	1.0
2	4.5	2.5	2.2	0.075-0.40
3	3.6	1.8	2.2	∞

It was found that:

1. If the layer thickness is reduced to one-two wave lengths, the waveform of reflected waves propagating within the layer becomes similar to the waveform of a head wave; for greater layer thickness, the waveform of reflected waves is similar to that of an inverse incident pulse;
2. The amplitude of the sum head wave decreases with a decrease of the layer thickness for a layer thickness of the magnitude of a wave length; it is slightly smaller than that of the head wave from a half-space;
3. The waveform of the sum head wave depends greatly on the layer thickness;
4. The first phase of the sum head wave vanishes as the distance from the source increases;
5. Low-frequency oscillations appear in the later parts of individual reflections and the sum head wave as the layer thickness decreases;
6. The sum head wave from a finite layer and the head wave from a half-space differ significantly with respect to waveform and insignificantly with respect to amplitude and attenuation.

Karmaleyeva, R. M. Study of long-period
surface waves by means of quartz strain gages.

IN: AN SSSR. Izvestiya. Fizika, Zemli; no.
9, 1972, 25-38.

The results are described of the determination of earthquake source parameters from G-waves recorded by long-base strain gages.

$G_2 - G_9$ - modes generated by the Aleutian earthquake of 4 February 1965 with $M = 8.5$ were recorded at the Talgar station with a 25-in-long base strain gage aligned in a NS direction. $G_2 - G_8$ - modes from the Hokkaido earthquake of 16 May 1968 with $M = 8.5$ were recorded at the Moscow station, using 17.3-17.5-base strain gages in the NS and EW directions.

The reliability of the G-waves identification was confirmed by a comparison of surface waves with periods up to 100 sec recorded by strain gages and long-period seismometers, as well as by the comparison of the group-velocity dispersion data for Love- and Rayleigh-waves recorded by strain gages with corresponding world data.

The source parameters were determined by the method developed by Ben-Menahem, Toksoz, 1962. The source parameters of the Aleutian earthquake were determined both from phase and amplitude spectra of G_2 -, G_3 -, G_4 - and G_5 -waves. The mean value of the fault length determined from phase spectra at $\theta_0 = 16^\circ$ is found to be $b = 458$ km. The theoretical

and experimental directivity function for the Aleutian earthquake, for which radiation asymmetry appeared to be prominent, agree best at $b = 400 - 500$ km and $v = 4.0 - 4.4$ km/sec.

The fault length for the Hokkaido earthquake was determined only from the phase spectra of G_2 -, G_3 -, and G_4 -modes, since its radiation asymmetry was not pronounced. The mean value of fault length at $\theta_0 \approx 23^\circ$ was found to be $b = 540$ km.

The values of the quality factor Q calculated from the attenuation factor of G -waves from the Aleutian and Hokkaido earthquakes are as follows:

T, sec		314	209	157	126
February 4, 1966	Q	231.4	146.2	107.7	104.3
May 16, 1968		226.8	112.3	114.1	118.9

Grigorova, E., and D. Sokerova. Crustal structure in southeastern Europe, based on the study of Bulgarian earthquakes. IN: BAN. Izvestiya na geofizichniya institut. v. 18, 1972, 93-102.

The crustal structure in southeast Europe is studied using data on 34 earthquakes ($\Delta = 130-1000$ km, $M \geq 4.5$) originating in Bulgaria.

The crustal thickness in southeastern Europe varies from 30-50 km, its average value being 40 km. The crust consists of two layers: the granitic with an average thickness of 24 ± 2 km and the basaltic with an average thickness of 16 ± 1 km.

The respective velocities of compressional and shear seismic waves were determined to be: 5.50 km/sec and 3.39 km/sec in the upper crustal layer; 6.48 km/sec and 3.75 km/sec in the lower crustal layer; and 7.87 km/sec and 4.42 km/sec in the subcrustal layer.

Traian, I., and I. Sieglinde. Energy study of earthquakes from the Vrancea region. Data on the upper mantle. Revue Roumaine de Geologie Geophysique et Geographie. Serie de Geophysique, no. 1, 1973, 85-91.

An attempt is made to study the upper mantle structure using energy data on microearthquakes. More than 200 microearthquakes

($-0.3 < M < 2.5$) originating in the Vrancea region during 1968-70 were recorded at the Vrancea station located within the epicentral region and equipped with VEGIK seismometers.

The magnitudes of microearthquakes were determined using the empirical energy - magnitude relation ($\lg E = 10.5 + 2.0 M$) determined from the data on the Vrancea earthquakes. An analysis of the $\lg A/T$ - magnitude and t_{S-P} - magnitude relations revealed a discontinuity at 85 km. This discontinuity is interpreted to be the upper surface of a low-velocity layer within the upper mantle.

Yegorkina, G. V., I. A. Sokolova, L. M.

Yegorova, T. D. Dvoskina, and G. Ya.

Minniayarova. Crustal structure in the north-western part of Armenia. Sovetskaya geologiya, no. 6, 1973, 80-91.

The results of crustal studies carried out during 1967-68 along three traverses with a total length of 400 km, using the method of converted waves from near and distant earthquakes, are described. The instrumentation employed consisted of "Zemlya" seismic units set up at 5-km intervals along the traverses, as well as VEGIK three-component seismograph systems with a bandpass between 0.5-10 Hz.

The crust in Armenia is characterized by block-layered structure. The crustal blocks are separated by deep-seated faults. The crustal thickness varies from 38 km in the north to 52 km in the south of the region. The crust consists of a granitic layer with a thickness of 15-20 km, and a basaltic layer 18-25 km thick.

Chesnokov, Ye. M. Elastic anisotropy of multicomponent models of the upper mantle structure. Fizika Zemli, no. 5, 1973, 28-38.

Elastic anisotropy for multicomponent models of the oceanic and continental upper mantle is analyzed. The elastic parameters were computed for the following models (according to Vinogradov et al., 1969 and Dmitriyev, 1969):

Model	Olivine, %	Rhombic pyroxene, %	Monoclinic pyroxene, %
I	60.9	24.1	15.0
II	70.7	19.2	10.1
III	63.9	3.1	33.0
IV	84.1	4.5	11.4

Oceanic upper mantle (models I and II). The computations were made assuming that the "b" or "a" crystallographic axes of olivine

are oriented perpendicular or parallel to transform faults, respectively. The results of the computations show that coefficients of anisotropy α_P and α_S increase linearly with an increase in the number of oriented crystals. It was found that the values of $V_{P\perp}$ and $V_{P\parallel}$ obtained for model I (30-40% oriented olivine crystals and b axis perpendicular to transform fault) are in best agreement with experimental data reported by Raitt et al., 1969.

Continental upper mantle (models III and IV). The computations were made assuming that the "c" axis of olivine is oriented parallel to the maximum stress. The results show that $\alpha_P = 0$, while α_S increases linearly with an increase in the number of oriented olivine crystals, reaching a value of 10%.

The velocities of compressional and shear elastic waves and the coefficients of anisotropy α_P and α_S calculated for different quantities of oriented olivine crystals are tabulated in the text.

An additional computation shows that α_P and α_S due to oriented pyroxene crystals are very low, and do not essentially affect the anisotropy of the models considered.

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Myachkin, V. I., and S. I. Zubkov.

Combined graph of earthquake forerunners.

IN: AN SSSR. Izvestiya. Fizika Zemli,
no. 6, 1973, 28-32.

The dependence of earthquake energy on the antecedency time of earthquake forerunners is considered. Data reported on the forerunners of about a hundred crustal earthquakes originating in Central Asia, Japan, and Kamchatka during 1956-1970 are analyzed.

The combined graph in Fig. 1 shows a plot of the logarithm of antecedency time ($\lg \Delta T_{an}$) vs energy index K . Data points corresponding to anomalous changes in the gradient of atmospheric electric potential, geoacoustic activity, and earth currents fall below the main group on the graph and are not considered. These forerunners are suggested to be of the short-range variety. Data on ground tilt are randomly scattered (ΔT_{an} values vary from several hours to several years)

It is pointed out that the slope of the combined graph in Fig. 1. ($\sigma = 0.48$) is very close to the average value of the slopes of recurrence graphs derived for different regions.

Another interesting fact revealed is that ΔT_{an} corresponding to $k = 0 - 2$, obtained by extrapolation of the graph in Fig. 1, agree fairly well with laboratory data on rock fracturing under pressures and temperatures in the 0-25 km range.

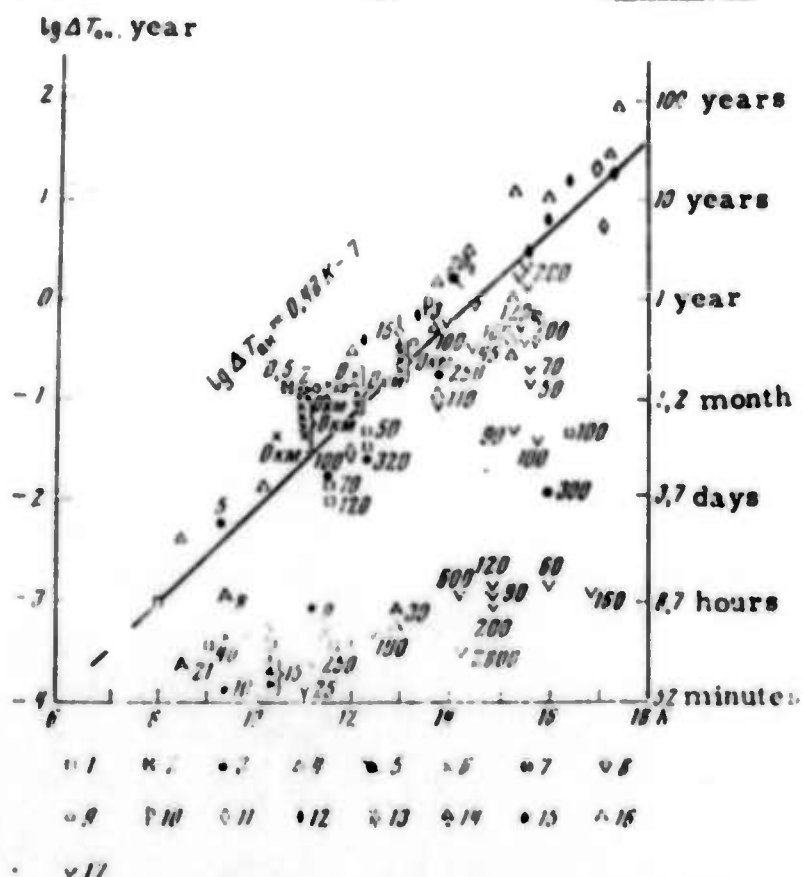


Fig. 1. Combined Graph of Earthquake Forerunners.

1 - Earth currents; 2 - electric resistance; 3 - ground
 3 - ground tilt, ϵ (after Latynina, 1970);
 4 - ground tilt, ϵ (after Rikitake, 1969, and
 Nishimura, 5 - ground tilt, ϵ (after Enman, 1971);
 6 - $\Delta t_S/t_P$; 7 - V_P ; 8 - $\lg P_{5,0}/P_{2,5}$; 9 - t_P , t_S ,
 A_P (Kamchatka focal zone, 1966-1970); 10 - radon
 content; 11 - seismic activity, A_{10} ; 12 - $2 E^{2/3}$;
 13 - ground tilt, W/t ; 14 - Az^0 ; 15 - gradient of the
 atmospheric electric potential; 16 - geoacoustic
 activity; 17 - ground tilt, ψ'' .

Numerals indicate hypocentral distances.

Kalashnikov, N. G., U. N. Pavlovskiy, G. V.

Simakov, and R. F. Trninin. Dynamic compressibility of minerals of the calcite group. IN: AN SSSR.

Izvestiya. Fizika Zemli, no. 2, 1973, 23-29.

The results of dynamic compression of calcite, dolomite, magnesite and chalk with different initial density (including moisture - saturated) up to pressures of about 1.2 Mbar are described. The purpose of these experiments was to provide evidence of the equivalency of the adiabatics of dense phases of minerals and rock to those of a mixture of closely packed oxides of their constituent elements. The measurements were performed by the impedance-match technique. In the experiments, shock waves up to about 400 kbar were generated by explosive charges, while higher pressures were generated by the collision of aluminum and steel impactors accelerated to a velocity of 5-6 km/sec. Shock waves in samples were recorded by the method of electric contactors. The experimental data are given in Table 1. D was determined with an accuracy of 1%. The error in the determination of density at maximum shock-wave amplitudes was $\Delta \rho \approx 0.05 \text{ gr/cm}^3$.

The D - U relation was approximated by linear relation $D = C'_0 + \lambda U$. The calculated values of C'_0 and λ are given in Table 2.

Table 1

Material	Shield	U_{shield} km/sec	ρ , km/sec	Q , km/sec	P , kbar	ρ/ρ_0
Dolomite $\rho_0 = 2.84 \text{ g/cm}^3$	Al	0.69	6.22	0.68	120	1.123
	"	1.14	6.35	1.13	259	1.224
	"	1.50	6.92	1.51	297	1.279
	"	1.80	7.23	1.83	375	1.339
	Cu	1.64	7.92	2.25	506	1.397
	Fe	2.72	8.30	2.76	651	1.498
Magnesite $\rho_0 = 2.975 \text{ g/cm}^3$	Al	0.69	6.92	0.60	124	1.095
	"	1.14	7.32	1.05	229	1.167
	"	1.50	7.78	1.39	322	1.217
	Cu	1.76	8.93	2.30	611	1.347
	Al	2.72	9.42	2.54	712	1.369
	Fe	82	10.59	3.61	1136	1.516
Calcite $\rho_0 = 2.665 \text{ g/cm}^3$	Al	0.69	4.85	0.81	105	1.202
	"	1.14	5.51	1.25	181	1.291
	"	1.50	6.07	1.63	264	1.367
	"	2.72	7.78	2.87	505	1.584
	Fe	2.45	8.55	3.345	762	1.643
	"	2.82	9.21	3.845	914	1.717
Chalk $\rho_0 = 2.07 \text{ g/cm}^3$	Al	1.11	4.14	1.51	126	1.174
	"	1.50	4.87	1.93	190	1.245
	"	2.72	7.00	3.255	463	1.401
	Fe	2.45	7.75	3.70	579	1.427
	"	2.82	8.42	4.18	711	1.481
Chalk $\rho_0 = 1.705 \text{ g/cm}^3$	Al	1.14	3.73	1.65	105	1.128
	"	1.50	4.51	2.08	160	1.167
	"	2.72	6.81	3.49	407	1.281
	Fe	2.45	7.29	3.86	480	1.336
	"	2.82	8.03	4.34	594	1.368
Moist Chalk $\rho_0 = 2.2 \text{ g/cm}^3$	Al	0.69	4.00	0.89	78	1.285
	"	1.14	4.78	1.41	148	1.418
	"	1.50	5.40	1.83	217	1.513
	"	2.72	7.43	3.13	512	1.728
	Fe	2.45	8.01	3.61	636	1.820

Table 2

Parameter	Material					
	Dolomite $\rho_0 = 2.84$ g/cm ³	Magnesite $\rho_0 = 2.975$ g/cm ³	Calcite $\rho_0 = 2.665$ g/cm ³	Chalk $\rho_0 = 1.705$ g/cm ³	Chalk $\rho_0 = 1.705$ g/cm ³	Moist Chalk $\rho_0 = 2.2$ g/cm ³
C_0 , km/sec	4.00	6.10	3.80	1.70	1.10	2.70
$\lambda = \frac{dP}{dV}$	1.30	1.25	1.42	1.63	1.63	1.50

Using the average value for $\Gamma = \frac{1}{\rho} \left(\frac{\partial P}{\partial E} \right)_\rho = \frac{1}{\rho} \frac{\Delta P}{\Delta E}$,

which was determined to be $\bar{\Gamma} = 1.18$, the equation of state for calcite was selected in the form

$$P - P_0 = \Gamma \rho (E - E_0),$$

where $P_0 = \rho_0 \frac{dE_0}{d\rho} = \frac{\rho_0 C_0^2}{n} (\sigma^* - 1)$ is compressive strength at absolute zero;

$\rho_0 = 2.71$ gr/cm³ is the crystallographic density of calcite; $n = 4.0$; and

$C_0 = 3.7$ km/sec.

This equation yielded the expression for the dynamic adiabatic in the form:

$$P_r = \frac{\rho_0 C_0^2}{n(h - k\sigma)} \left[\left(h - \frac{n+1}{n-1} \right) \sigma^* + \frac{2n}{n-1} \sigma - (h+1) \right].$$

where $h = 1 + 2/\Gamma$ - compressibility limit, and $k = 2.71/\rho_0$ - porosity factor.

The dynamic adiabatics for calcite, calculated using the expression derived, are shown in Fig. 1 together with the experimentally determined adiabatics.

Additive adiabatics for CaCO_3 and H_2O mixtures were calculated under the following assumption: The compression of each individual component at fixed P is equal to the compression of the same constituent in the mixture. The calculated additive adiabatics conform

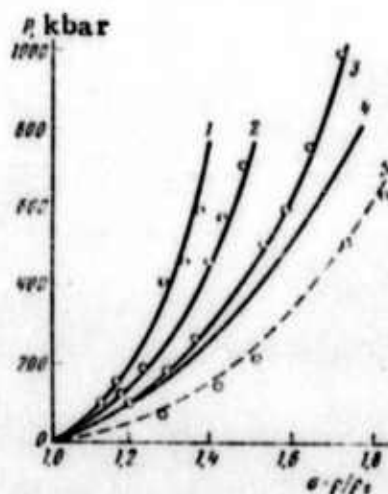


Fig. 1. Calculated Dynamic Adiabatics.

1, 2, & 3 - for chalk and calcite with initial density of 1.705, 2.02, and 2.665 g/cm³, resp.; 4 - isotherm for calcite at $T = 0^\circ\text{K}$; 5 - additive adiabatic for moist chalk.

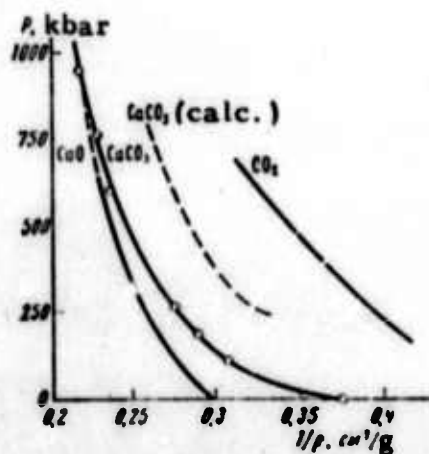


Fig. 2. Comparison of Experimental Impact Adiabatics for CaO , CO_2 , and CaCO_3 , with Additive Adiabatics Calculated for CaO and CO_2 Mixture.

to experimental data for moisture-saturated chalk (see Fig. 1). However, additive adiabatics for mixtures of carbon, calcium, and magnesium

oxides do not conform to the experimental curves for calcite, dolomite, and magnesite (see Fig. 2 above).

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Aleshin, A. S. Fluctuations of compressional wave intensity in a three-dimensional solid model of a randomly nonhomogeneous medium. IN: AN SSSR. *Izvestiya. Fizika Zemli*, no. 9, 1973, 96-101.

Averbukh, A. G., and G. A. Berezina. Compressional-wave velocity in the pre-Cambrian basement rock of the East European platform, based on field and laboratory studies. *Prikladnaya geofizika*, no. 70, 1973, 85-96.

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Dmowska, R. Crack fault model and surface deformation associated with dip-slip faulting (in English). IN: PAN. *Instytut geofizyki. Materiały i prace*, no. 62, 1973, 125-140.

Hangya, A. Theory of detonation-like phase transformations in the Earth's interior (in English). IN: PAN. *Instytut geofizyki. Materiały i prace*, no. 62, 1973, 75-84.

Kostrov, B. V. Seismic moment, earthquake energy and seismic flow of rocks (in English). IN: PAN. *Instytut geofizyki. Materiały i prace* no. 62, 1973, 25-47.

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Ryaboy, V. Z. Travel-time anomalies of Pn waves and velocity discontinuities in the upper part of the mantle in the USSR. AN SSSR. Doklady, v. 212, no. 1, 1973, 88-91.

Rybicki, K. Some aspects of aftershock problem in the light of the dislocation theory (in English). IN: PAN. Instytut geofizyki. Materiały i prace, no. 62, 1973, 141-154.

Schenk, V., and L. Waniek. Experiments on the seismic near field of underground explosions with respect to focal mechanism studies (in English). IN: PAN. Instytut geofizyki. Materiały i prace, no. 62, 1973, 107-114.

Solov'yev, S. L., et al. The Moneron earthquake of 5-6 September 1971. AN SSSR. Doklady, v. 212, no. 1, 1973, 92-95.

Teisseyre, R. A structural model of earthquake processes in the generalized continuum (in English). IN: PAN. Instytut geofizyki. Materiały i prace, no. 62, 1973, 55-73.

Trapeznikova, N. A. Reflection and refraction coefficients in imperfectly elastic media. Prikladnaya geofizika, no. 70, 1973, 3-21.

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Wojteczak-Gadomska, B. Distributions of the released seismic energy and the number of earthquakes in deep structures of the Pacific area (in English). IN: PAN. Instytut geofizyki. Materiały i prace, no. 62, 1973, 155.

Yegorkina, G. V. Nature of phase shifts in recording converted PS waves. Prikladnaya geofizika, no. 70, 1973, 74-84.

4. Particle Beams

A. Abstracts

Bazhenov, G. P., Ye. A. Litvinov,
G. A. Mesyats, D. I. Proskurovskiy,
A. F. Shubin, and Ye. V. Yankelevich.

Metal influx into the cathode flare during
explosive emission of electrons from metallic
points. Part 1. Initial explosion of points with
typical geometry of the field emitters. ZhTF,
no. 6, 1977 1255-1261.

Erosion of metal is experimentally determined from technically pure metallic points of VA-3 tungsten and MRN molybdenum (radius = $(1-5) \times 10^{-5}$ cm and apex angle $\Theta = 2-40^\circ$), during explosive emission of electrons from these points. Experiments were conducted in vacuum at pressures down to 5×10^{-6} torr. Currents and voltages were recorded by low-inductive low-resistance shunts and oscillograph.

Photographs of the points (Fig. 1) were taken by means of the

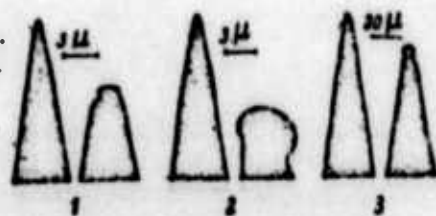


Fig. 1. Profile of points before and after the current with duration t_i of (1)-5; (2)- 20, (3)- 40 nsec.

EM-6 electron microscope before and after explosive emission. Relationships were plotted of the metal eroded from the points as a function of the apex angle θ (Fig. 2). It was found that during the first impulse, the metal ejected into the cathode flare strongly depended on the angle θ . The mass M_1 ejected from the points decreases by nearly 1-2 times with increase of θ from 2 to 40° . The problem is also discussed analytically by considering a model of joule heating of the points to show the correlation of ejected mass with the geometry of points, physical constants of the metal, and

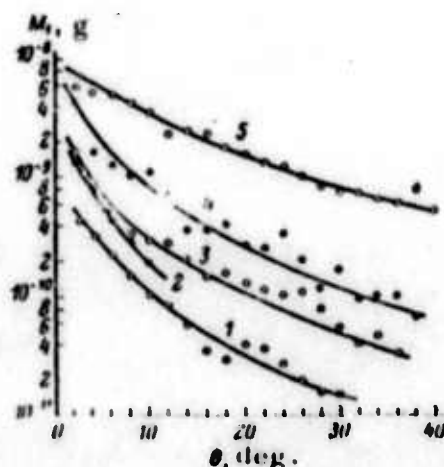


Fig. 2. Experimental relation between metal disposal M_1 from the points and the apex angle of the points. t_i , nsec: 1, 2-5; 3, 4-20; 5-40. 1, 3, 5- Mo; 2, 4-W.

the electron current. It is found that with other factors unchanged, the metal ejected from the cathode is proportional to $\left[\int_0^{t_i} i^2(t) dt \right]^{3/4}$, where $i(t)$ is electron current and t_i is pulsed current duration.

Bazhenov, G. P., Ye. A. Litvinov, G. A.
Mesyats, D. I. Proskurovskiy, A. F. Shubin,
and Ye. B. Yankelevich. Metal influx into
the cathode flare during explosive emission of
electrons from metallic points. Part 2. Multiple
pulsing of current. ZhTF, no. 6, 1973, 1262-
1268.

In a continuation of the foregoing paper, the authors go on to describe experimental studies on the behavior of metal influx into the cathode flare of individual cathode points made of Mo, Cu, Al and Ni, operating in a regime of explosive electron emission in a vacuum diode. The case of multiple current pulsing is examined here. The experimental method is previously described. Durations of individual high-voltage square pulses were 5, 10 and 20 nsec, and their amplitudes were varied from 10 to 40 kv. Distances between points and the anode were 0.5, 1.0 and 2.0 mm. Photographs were taken of the points by means of MKU-1 and EM-6 microscopes (Fig. 1).

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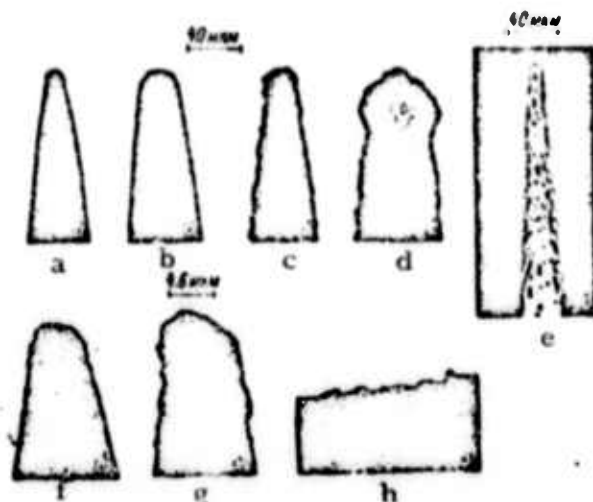


Fig. 1. Profile and surface of different metal points after multiple pulsing of current.

a - Mo point, $U_0 = 25$ kv, $t_i = 20$ nsec; $d = 2$ mm, $N = 3200$; b, d - Cu, Al, $U_0 = 30$ kv, $t_i = 20$ nsec, $d = 1$ mm, $N = 3200$; c - Ni $U_0 = 30$ kv, $t_i = 5$ nsec, $d = 1$ mm, $N = 3200$; e - lateral surface of Mo in reflected light, $N = 50$; f - Mo point, $U_0 = 20$ kv, $t_i = 5$ nsec, $d = 2$ mm, $N = 8.000$; g - Mo point, $U_0 = 20$ kv, $t_i = 20$ nsec, $d = 2$ mm, $N = 1.600$; h - lateral surface of Mo, $U_0 = 20$ kv, $t_i = 20$ nsec, $d = 2$ mm, $N = 13.000$.

It was seen that the cathode flare affects material ejected from the point tips as well as from side surfaces, and changes significantly with the point profile, as Fig. 1 shows. Relationships were plotted between the total mass of ejecta M and the total number of current pulses N . For a given point material, the total mass M of material ejected increases with the amplitude of pulse voltage U_0 , pulse duration t_i , and the decrease of

cone angle of the point θ and interelectrode gap d . Figure 2 shows the curves $M(N)$. From the curve $M(N)$, material ejected at any pulse sequence was found by differentiating at the corresponding point, yielding $M_1(N)$ for various metals (Fig. 3). Two regions are noted in the $M_1(N)$

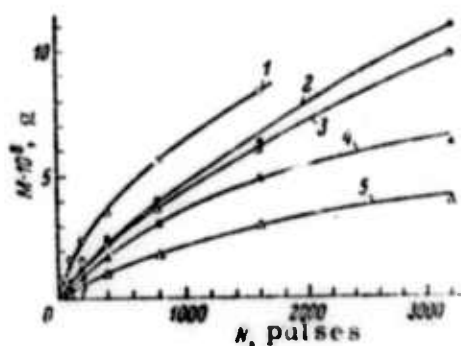


Fig. 2. $M(N)$ relationship at $U_0 = 30$ kv and $d = 1.0$ mm.

1- Ni; 2, 3- Mo; 4- Al; 5- Cu.
1, 2, 4- $t_i = 5$ nsec; $\theta = 10^\circ$ 3, 5- $t_i = 10$ nsec; $\theta = 2.4^\circ$.

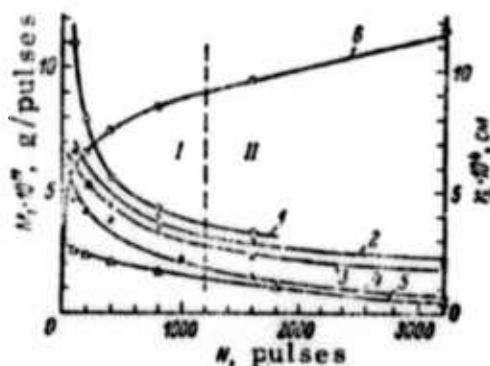


Fig. 3. $M_1(N)$ relationship (1, 2, 3, 4, 5) and $r_e(N)$ relationship (6).

1- Ni; 2, 3- Mo; 4- Al; 5- Cu.
Experimental conditions are as in Fig. 2. 6- Mo: $U_0 = 30$ kv, $d = 1.0$ mm $t_i = 5$ nsec; $\theta = 12^\circ$.

curves, namely a sharp change of M_1 with $N(I)$ and a gradual change of M_1 with $N(II)$. This changeover took place at the radius of the point tip $r_e = 8-12 \mu$. A typical relation for $r_e(N)$ is also shown in Fig. 3. At $r_e > 8-12 \mu$, the mass M_1 depends very little upon the cone angle θ . An attempt is made to explain the above results with the use of a joule model for cathode heating in the region of current constriction.

Fursey, G. N., N. V. Yegorov, S. P.

Manokhin, and M. K. El'Nimr. Relaxation effects during field emission from silicon.

FTT, no. 5, 1973, 1360-1363.

An investigation is described of relaxation processes on atomically-pure surfaces of p- and n-type silicon. Experiments were conducted with needle-form emitters of p-Si ($\rho = 2000 \text{ ohm} \times \text{cm}$) single crystals at temperatures of 120-150° C and pressures $p = 1 \times 10^{-9} - 5 \times 10^{-10}$ torr. Dual pulsed voltages were used in the experiment with a duration 10 to 100 μsec and amplitude of 0 to 20 kv; the interval between pulses was varied from 50 μsec to 50 msec. A residual relaxation effect is seen only in the saturation region of emission current. In weak fields, corresponding to the straight line part of the VA characteristic, relaxation effects do not exist. Field emission images from silicon immediately after desorption by field and thermal means are seen in Fig. 1.

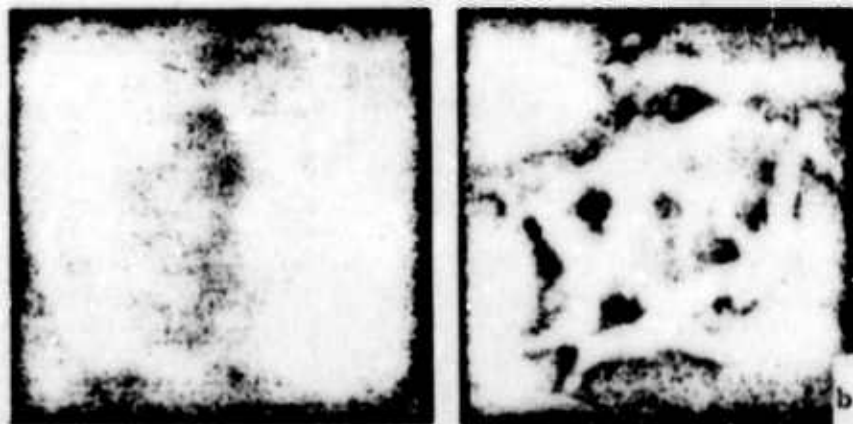


Fig. 1. Field emission images.

a) after cleaning by field desorption, b) after heating to 850° C.

Kurilko, V. I. Mechanism of beam instability development in plasma. DAN SSSR, v. 208, no 5, 1973, 1059-1061.

Instability of a monoenergetic electron beam in a homogeneous plasma is evaluated quantitatively with allowance for the effect of coherence of Cerenkov radiation from longitudinal waves in plasma, and reaction of the modulated beam field to beam particle motion. The resultant radiation field E of the modulated beam and hydrodynamic increment ϵ of the plasma-beam instability are expressed as functions of radiation characteristics of an individual plasma electron.

The field E , formulated as the sum of the elementary radiation fields, is shaped as a plane traveling wave whose amplitude depends on the percentage of beam modulation ω_p and the frequency difference $\delta = \omega_p - \omega_M$, where ω_M is the frequency of the traveling wave. The increment ϵ is formulated both for $\delta \gg \epsilon$ and $\delta \lesssim \epsilon$. The similarity of both formulas for ϵ to formulas derived earlier from hydrodynamic analysis led to the conclusion that quantitative evaluation of ϵ with allowance for the coherence effect and the reaction of E was correct. Intensification of beam modulation by the radiation field at $\omega_M < \omega_p$ is explained in terms of beam focusing. A similar approach can be applied to instability resulting from beam interaction with transverse waves in a plasma, thus explaining gain in traveling wave tubes.

Golov, A. A., G. N. Fursey, I. D. Ventova,
A. D. Lebedev, and S. A. Valnyskiy. Comb-
type field emitter. Author's Certificate, USSR,
no. 342241, published June 29, 1972. (RZhElektr,
5/73, no. 5A26 P). (Translation).

A comb-type field emitter is proposed in which emitting
elements form a single unit with a base. The emitting elements have square
cross-sections which makes the emitter technically simple and increases
reliability and stability of operation.

Bykov, A. P. A linear electron accelerator.
Author's Certificate, USSR, no. 317351,
published June 28, 1972. (RZhElektr, 5/73,
no. 5A291 P). (Translation)

A linear electron accelerator is proposed which consists of
an electron injector, an accelerating system with wave-type converter and
a prebunching device. A waveguide is used in the form of a buncher which
couples the generator with the accelerating system, having openings in its
walls for passing electron beams. The waveguide is curved such that the
axis of the openings in its walls coincides with that of the accelerating
system. To increase bunching effectiveness, there are several bends in the
waveguide between the injector and accelerating sections, and several
openings in its broad wall coaxial with the accelerating system.

B. Recent Selections

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Bayer, V. K., and L. S. Selov'yev. Determining self-field and distribution of particle beam density in a linear resonance accelerator by an analog computation technique. IN: Sb. Primeneniye tsifr. i analog vychisl. mashin v yader. fiz. i tekhn., no. 4. Moskva, Izd-vo Atomizdat, 1971, 126-136. (RZhF, 6/73, no. 6A444).

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Kovalev, N. F., M. I. Petelin, M. D. Rayzer, A. V. Smorgonskiy, and L. E. Tsopp. Generation of powerful electromagnetic radiation pulses by relativistic electron flux. ZhETF P, v. 18, no. 4, 1973, 232-235.

Levin, M. I., A. I. Mints, Ye. D. Naumenko, and T. N. Filimonova. Gyromagnetic compressor of powerful relativistic dense electron fluxes of tubular form. DAN SSSR, v. 211, no. 5, 1973, 1085-1088.

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Matlis, S. B., and D. I. Vaysburd. Change in ion conductivity of KCl crystals during irradiation by x-rays and powerful nanosecond electron beams. IVUZ Fiz, no. 9, 1973, 137-139.

Metelkin, Ye. V., and G. Ya. Trukhanov. Effect of resonances on unstable neutron spectra. Atomnaya energiya, v. 35, no. 3, 1973, 192-193.

Mushkarden, E. M., and A. F. Kozhukhar'. Field emission characteristics of cathodes of vacuum microdevices. RiE, no. 9, 1973, 1990-1992.

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Podmoshenskiy, I. V., A. M. Pukhov, and A. V. Yakovleva. Investigating characteristics of a heavy-current pulsed discharge in argon. ZhPS, v. 19, no. 4, 1973, 624-627.

Pranevichus, L. I., G. N. Fursey, and A. D. Lebedev. Method of electron beam generation. Author's certificate, USSR, no. 391632, published February 26, 1970. (Otkr izobr, 31/73, p. 166).

Rabinovich, M. S. Session of the scientific council on plasma physics. Atomnaya energiya, v. 35, no. 2, 1973, 140-142.

Rabinovich, M. S., and V. N. Tsytovich. Perspektiva razvitiya novykh kollektivnykh metodov uskoreniya. (Prospects for developing new collective methods of acceleration). Fiz. in-t AN SSSR, Preprint. Moskva, 1973, 29 p. (RZhF, 9/73, no. 9A334).

Saychenko, A. N., V. K. Semenov, and I. A. Spektorov. Supersonic flow of pulsed discharge plasma. IN: Tr. Kirg. un-ta. Ser. fiz. n., no. 3, 1973, 45-46. (RZhF, 9/73, no. 9G173).

Smirnov, O. I., and V. D. Chalyy. Using a computer method for central composition planning of experiments in controlling multi-section linear accelerators. IN: Sb. Primeneniye tsifr i analog. vychisl. mashin v yader. fiz. i tekhn., no. 4, Moskva, Izd-vo Atomizdat, 1971, 95-104. (RZhF, 6/73, no. 6A507).

5. Material Science

A. Abstracts

Askar'yan, G. A., V. A. Namiot, and M. S. Rabinovich. Using supercompression of material by reactive pressure for obtaining micro-critical masses of fissionable material to generate superstrong magnetic fields and for particle acceleration. ZhETF P, v. 17, no. 10, 1973, 597-600.

The article discusses the theoretical production of extremely small critical masses of fissionable materials from supercompression by reactive pressure, generated by high-temperature evaporation of material. It is assumed that powerful laser radiation impacts the entire surface of the target material. Expressions are obtained for pressure during evaporation, nuclear concentration and neutron multiplication. It is noted that pulsed micro-critical masses may be used for obtaining powerful pulsed neutron and neutrino fluxes ($\sim 10^{17}$ neutrons in 10^{-10} sec). The authors also show that during supercompression of material, it is possible to obtain superstrong magnetic fields ($\geq 10^9$ oersted) and particle acceleration.

Zaytsev, V. I., Ye. A. Pavlovskaya, and
B. P. Filatov. Effect of hydrostatic pressure
on substructure development during f.c.c-
polycrystal deformation. UFZh, no. 5, 1973,
854-858.

Results are given of an experimental study on substructure development in an austenitic alloy, slightly strained from the effect of a 20 kbar hydrostatic pressure. The study was done to verify the theoretically predicted formation of an ordered dislocation structure under pressure. The structure of an annealed ferrous alloy with percent contents of Ni-6, Cr-4, Mn-12, C-0.5, and V-1.5 was studied by x-ray diffraction and electron microscopy after deformation up to 20% under the cited pressure. The x-ray micrographs of specimens strained to 4% show the single-oriented traces of slip plane intersection with the interference plane. With increase in strain from 2 to 4%, formation of new fragments smaller than the original is observed within grain boundaries with simultaneous development of a substructure within each fragment. The fragment size diminishes even more with the increase in strain to 20%.

It is believed that fragmentation of grains indicates an ordering of a significant number of dislocations at an early stage of deformation, i.e., conditions suitable for a cellular type structure formation at this stage of deformation from high-pressure effects. The x-ray micrograph of a specimen strained to 20% by hydrostatic extrusion shows reflections from subcrystals which contain relatively few dislocations.

Hence there is an appreciable ordering of dislocations. In contrast, the x-ray micrograph of a specimen strained to 20% by ordinary drawing shows strongly elongated reflections. It is deduced from this comparison that dislocations during deformation in a highly-pressurized liquid are ordered to a higher degree than during deformation from drawing. Tabulated experimental values of the fragment size and disorientation confirm the cited qualitative data.

The electron micrographs show cells in the process of formation and dislocation-free cells in a specimen strained by hydrostatic pressure, and dislocations over the entire grain area in a specimen strained by drawing. It is concluded that a cellular type structure develops at an early deformation stage in an alloy with fcc-lattice under a high hydrostatic pressure.

Banik, I., and J. Zamecnik. Dependence of V-A characteristics of $\text{Ge}_{15}\text{Te}_{81}\text{S}_2\text{As}_2$ amorphous semiconductor on hydrostatic pressure. Czech. J. phys., v. 23, no. 4, 1973, 479-483.

The pressure dependence of the volt-ampere characteristics of $\text{Ge}_{15}\text{Te}_{81}\text{S}_2\text{As}_2$ vitreous semiconductor is expressed in a first approximation as an exponential function. This functional dependence was derived for

hydrostatic pressures to 5 kbar, on the assumption of a linear decrease of the energy gap with increasing pressure and with allowance for the effect of temperature changes in a specimen from passage of current. Temperature effect is taken into account in the expression of electrical conductivity.

The exponential pressure-dependence of the V-A characteristics becomes linear at small current densities. The V-A curves calculated from the derived exponential pressure dependence expression are shown to be in a relatively good agreement with the experimental V-A curves within the cited pressure range. A greater discrepancy is noted in the vicinity of critical voltages, where the derived V-A versus p dependence is no longer valid.

Shashkov, D. P. Effect of pressure on the
brittleness of chromium. FMiM, no. 4,
1973, 837-838.

Results are presented of an experimental study on the plasticizing effect of pressures to 5 kbar in pure (99.85%) chromium. The study was undertaken because of insufficient available data on the pressure effect on brittle-to-plastic state transition in Cr and other refractory metals, and the mechanism of this transition. In the briefly described experiments temperature threshold T_b of brittleness was determined from measurements of the bending angle γ of a specimen in a high-pressure

apparatus. The bending strain rate was 12 mm/min. Bending tests at elevated temperatures (150 and 300° C) were carried out in a resistance furnace, in which the apparatus was placed after a given pressure was attained. The test data (Fig. 1) show that pressure at transition to the

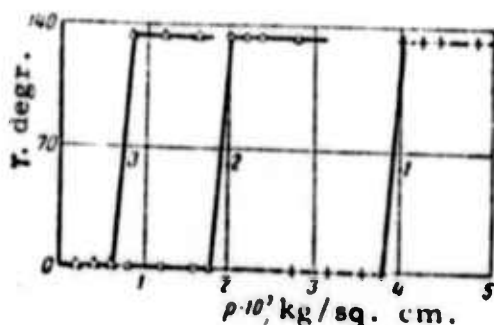


Fig. 1. Effect of hydrostatic pressure on plasticity index in bending γ of chromium specimens at test temperatures: 1-20, 2-150, and 3-300° C.

plastic state decreases, as temperature is increased. Thus the transition p was 4,000, 2,000, and 800 kg/cm² respectively, at 20, 150, and 300° C. In the absence of hydrostatic pressure, T was 340° C. The experimental $T_b(p)$ plot is linear, i.e., T_b decreases linearly with increase in p to 4 kg/cm². The gas content dependence of transition p was also determined in bending tests at room temperature of specimens which had been degassed at 700° in vacuum for 15 hours. Transition to plastic state in degassed specimens occurred at $p \approx 2,800$ kg/cm² in contrast with $p \geq 4,00$ kg/cm² for non-degassed specimens.

Altshuler, L. V., M. A. Podurets, G. V. Simakov, and R. F. Trunin. Highly compacted forms of fluorite and rutile. FTT, no. 5, 1973, 1436-1440.

Dynamic compressibility of rutile (TiO_2) and fluorite (CaF_2) natural single crystals was studied over a range of pressures to 3 Mbar. Study of these crystals under ultra-high pressures is of great importance in the field of geophysics, as well as in solution of the problem of dielectric metallization. In the experiments, 4-6 mm thick specimens were compressed by shock waves of different intensity, which were transmitted to a specimen through a metal screen. Shock wave propagation rate D through a specimen was recorded and shock compression parameters were determined.

The experimental D , mass velocity U behind a wavefront, pressure P , and shock compression density $\rho = \rho_0 D/D-U$ data are tabulated and plotted in $D-U$ and $P-\rho$ coordinate systems (Fig. 1). The lower and upper

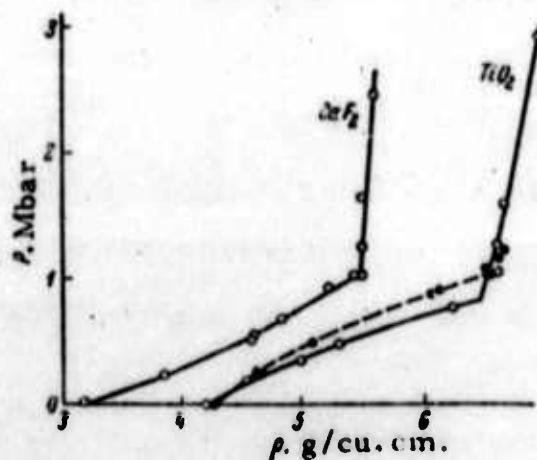


Fig. 1. Shock adiabat of fluorite and rutile: ●-literature data; ○-authors' data.

branches of the shock adiabat of CaF_2 are described, respectively, by the equations

$$D = 5.10 + 1.005U, \quad (1)$$

$$D = 0.61 + 2.231U \quad (2).$$

The upper branch of the TiO_2 adiabat is described by

$$D = 1.82 + 2.214U. \quad (3)$$

The upper branches reflect properties of highly compacted, low-compressibility forms of CaF_2 and TiO_2 , which exist at $P \geq 1$ Mbar.

Since the crystal structure of shock-compressed CaF_2 remains unchanged, the shape of its shock adiabat reflects a two-step process: convergence of F ions, and the process after anion-anion contact is effected. Crystallochemical considerations, with the use of the stability diagrams of Shannon and Prewitt, made it possible to determine regions of stability of CaF_2 and TiO_2 . It was concluded that the upper branches of TiO_2 and CaF_2 shock adiabats reflect compressibility of the anion-contact sublattice with the initial ionic coordination. The possibility exists, on the basis of geometric criteria, that metallic, MgCu_2 -type lattices can be formed in CaF_2 and TiO_2 at significantly higher pressures.

Zasavitskiy, I. I., A. I. Likhter, E. G. Pel', and A. P. Shotov. Device for optical studies of semiconductors at 77° K and pressures to 10 kbar. PTE, no. 2, 1973. 203-205.

A high-pressure apparatus with an optical chamber is designed for hydrostatic pressures to 10 kbar and a 77° K temperature. He gas is used as transmission medium. The gas is compressed first to 2 kbar by means of a compressor, then to 10 kbar by a standard pressure booster before it is admitted into the optical chamber. The latter contains a PbSe pulsed laser and is mounted in a high-pressure chamber placed in a liquid nitrogen cryostat. The laser beam exits from the chamber through a cone-shaped window made of a Si, Ge, or sapphire single crystal and a textolite vacuum cell, to be focussed on a monochromator. The window shape is designed to increase reliability of sealing, and the vacuum cell makes a gas-tight junction between the optical chamber and the cryostat.

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Experimental data are given on the effect of hydrostatic pressures to 5 kbar on the laser emission spectrum at 77° K. A typical emission spectrum shows an increase in emission wavelength with increase in pressure. The emission spectra from the laser under high pressure were still reproducible after 1-2 years. The described chamber can be used also for study of optical absorption and at an even higher pressure, if more pressure-resistant materials are used for the gas capillary tube and the window.

Sirenko, A. F., G. P. Klinishev, V. N.

Zubov, and Vu Tkhe Khoy. Effect of hydrostatic pressure on the kinetics of copper recrystallization. FMiM, no. 4, 1973, 767-772.

The effect of hydrostatic pressures to 15 kbar was studied on technical grade copper specimens, preliminarily subjected to plastic deformation to > 90%. Recrystallization annealing of the cold-worked specimens was done at 140-200° C under 1 to 15 kbar pressures. Recrystallization kinetics during annealing was studied by x-ray diffraction, the method of microbeams, and micrography. The relative recrystallization volume X was determined from x-ray data. The experimental X versus annealing time t plots (Fig. 1b) are described by

$$X = 1 - \exp[-(Kt)^n], \quad (1),$$

where $K = K_0 \exp - \frac{Qp}{RT}$ and Qp is the effective activation energy of recrystallization.

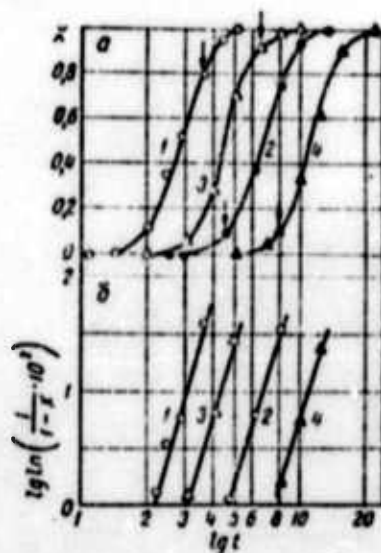


Fig. 1. $X(a)$ and $\log \ln(1/(1-X))(b)$ versus $\log t$ plots for copper specimens, prestrained to 95%: 1- 180° C, 1 bar; 2- 180°, 8 kbar; 3- 140°, 1 bar; 4- 140°, 8 kbar. Arrows indicate t of detection of recrystallization centers (nuclei). -67-

The data calculated from Fig. 1 and (1) show that the K_p factor decreases with increase in pressure but m and Q_p are independent of both temperature and pressure. The average linear grain dimension after one hour anneal at 200-600° C increases with increased pressure.

The cited data point to a significant role of volume diffusion, besides intercrystalline diffusion, in kinetics of recrystallization centers growth under pressure. The x-ray data indicate that nucleation is more sensitive to pressure than growth of nuclei, i.e., that formation of recrystallization centers is slowed by the effect of pressure to a lesser degree than growth of these centers. Simultaneously with the overall retardation of recrystallization kinetics a more perfect coarse-grained structure results from the effect of annealing under hydrostatic pressure. Volume diffusion is the mechanism controlling nucleation rate. In the framework of the Li theory of recrystallization an increase in activation energy of vacancy formation is the chief factor of the volume diffusion retardation by the pressure effect.

Amirkhanov, Kh. I., Ya. B. Magomedov,
and S. N. Emirov. Effect of hydrostatic
pressure on thermal conductivity of tellurium.
FTT, no. 5, 1973, 1512-1515.

Thermal (λ) and electric (σ) conductivities of tellurium
single crystals were measured at temperatures in the 285-423° K range

under 1-2, 500 kg/cm² hydrostatic pressures. Measurements of λ and σ were carried out by the static method in the apparatus shown in Fig. 1.

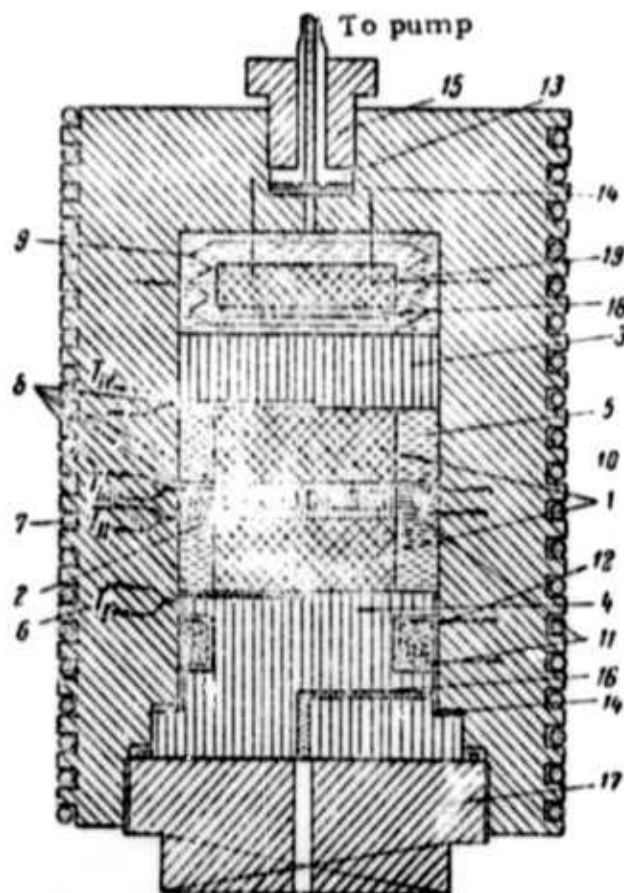


Fig. 1. Sketch of the experimental apparatus:

1, 19-specimens, 2- heater, 3 and 4- coolers, 5- pressure-transmitting liquid (castor oil), 6- high-pressure cylinder, 7- external cooler, 8- wells for thermocouples T_I - T_V , 9- clamping bellows, 10- heater; 11, 18- insulation, 12- manometer, 13- castor oil inlet connection, 14- sealing gasket, 15, 17- sealing plugs, 16- wire duct.

The arrangement of specimens 1 and 19 served for measurement of λ and σ , respectively. The experimental λ (Fig. 2) and σ increase with increased P.

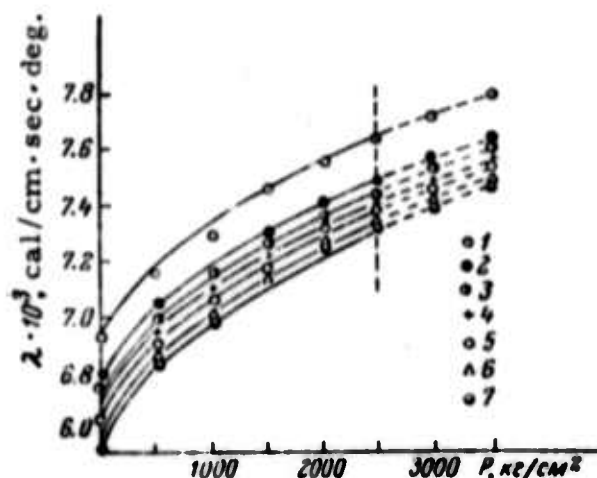


Fig. 2. Tellurium thermal conductivity versus hydrostatic pressure and temperature, $T(^{\circ}\text{C})$.

1- 12, 2- 25, 3- 50, 4- 75, 5- 110, 6- 125, and 7- 150.

The experimental $\lambda(T)$ dependence at atmospheric pressure and $\sigma(P)$ dependence are in good agreement with earlier literature data. An empirical formula was developed for $\lambda(T, P)$, which is analogous to the formula of phonon thermal conductivity in dielectrics. The $\lambda(P)$ curves extrapolated to 3,500 atm from the empirical formula are in agreement with the experiment. The increase in λ of tellurium appears to be due to the increase in phonon component of λ . Subsequent experiments at higher pressures would help to clarify the yet unknown mechanism of pressure effect on λ of tellurium.

Leonidova, G. G., and I. N. Polandov.

Conductivity of ammonia near the triple point.

ZhFKh, no. 5, 1973, 1261.

Resistivity ρ of ammonia during the liquid to solid state transition was measured, in connection with the theoretical estimation that metallization of NH_4 crystal would occur at 60-140 kbar pressures. In the experiments, carried out in a high-pressure steel chamber, ρ of condensed ammonia was measured at temperatures down to (-100°C) . The experimental $\rho(T)$ plot shows that ρ decreased with decrease in T to 5×10^3 ohm $\times$ cm at the triple point. There were stepwise changes in ρ at the minimum and again an increase to a very high value after solidification. At hydrostatic pressures to 1.5 kbar, ρ at the minimum decreased by a 2-3 factor, but the $\rho(T)$ pattern remained unchanged. Qualitatively, the $\rho(T)$ data obtained at normal pressure agree with the $\rho(T)$ data from the literature for SO_2 near its triple point.

Brandt, N. B., Kh. Dittmann, and Ya. G.

Ponomarev. Gapless state occurring in

$\text{Bi}_{1-x}\text{Sb}_x$ semiconductors under high pressure.

FTT, no. 3, 1973, 824-835.

Experimental data are given on the galvanomagnetic tensor components of $\text{Bi}_{1-x}\text{Sb}_x$ ($0.06 \leq x \leq 0.15$) semiconductor alloys in a weak magnetic field ($\mu\text{H} \leq 1$), at temperatures in the 4.2 - 300° K range and

pressures in the $1 \text{ atm} \leq p < 20 \text{ katm}$ range. The experimental study was done to reveal the peculiarity of a gapless state brought about by the effect of pressure, causing band inversion, i.e., interchange between the bottom of the conduction band and the top of the valence band.

The experimental plots show there is a minimum energy gap ϵ_{gL} in a point L of the Brillouin zone at a critical pressure p_K which varies from 2 to 10.5 kbar with increase in x to 0.15. The ϵ_{gL} change rate $\partial \epsilon_{gL} / \partial p$ was determined to be $(-2.5 \pm 0.5)10^{-6}$ and $(1.5 \pm 0.5)10^{-6} \text{ eV/atm}$ before (at $p < p_K$) and after inversion (at $p > p_K$), respectively.

Concurrently with the ϵ_{gL} decrease at $p \rightarrow p_K$, the carrier effective mass m_i^* decreases and mobility μ_i increases. This effect is maximized with the decrease in the carrier Fermi energy, i.e., with increase in purity, of the $\text{Bi}_{1-x}\text{Sb}_x$ single crystals. At $T = 4.2^\circ \text{ K}$ the maximum μ_i was at $p = p_K$. The value of μ_i along the binary axis of the constant energy ellipsoid was found to be $\sim 3 \times 10^8 \text{ cm}^2/\text{V} \times \text{sec}$ at $p = 6.8 \text{ katm}$ for the purest alloy.

Novitskiy, Ye. Z., A. G. Ivanov, and N. P. Khokhlov. Study of the shock polarization of polymers. IN: Sb. Goreniye i vzryv, Moskva, Izd-vo Nauka, 1972, 579-583.

Shock polarization P_0 of a series of polymers, e.g., PVC masticated rubber, high-pressure polyethylene, poly (tetrafluoroethylene),

polypropylene, and molding powders, was studied in comparative experiments. P_0 was determined as a function of $j_0 t_1$, where j_0 is the current density at the time $t = 0$, when the shock wave penetrates into the sample, and t_1 is the shock wave propagation time through the sample. In contrast with alkali halide crystals, no correlation was found between $j_0 t_1$ and dielectric constant ϵ of the polymers at 100 ± 10 and 150 ± 5 kbar pressures. All the polymers exhibited the classical $I(t)$ dependence of linear dielectrics: I_0 jump at $t = 0$, increase or decrease of current I during $t < t_1$, depending on ϵ evolution behind shock front, and a sharp decrease of I at $t = t_1$.

The $I(t)$ dependence of the molding powders exhibited two I peaks at $t = 0$ and $t = t_1$. In addition, current oscillations appear on $I(t)$ curves of powders with quartz filler, and an explicit dependence of polarization current on density is shown for the powders with foam polystyrene filler. It was concluded that the P_0 characteristics of polymers are more complex than those of alkali halide crystals.

Kasatochkin, V. I., L. Ye. Shterenberg, M. Ye.

Kazakov, V. N. Slesarev, and L. V. Belousova.

Thermal conversion of carbyne under pressure.

DAN SSSR, v. 209, no. 2, 1973, 388-391.

The authors present data from their x-ray diffraction study of crystal structure transformations in carbyne, from the effect of high

pressure and elevated temperature. The experiments were carried out in a high-pressure chamber designed at the Institute of High Pressure Physics of the Academy of Science. A comparison of the tabulated x-ray diffraction data for original, untreated carbyne and carbyne following a high pressure treatment led to the conclusion that, in the process of treatment, the original amorphous phase of carbyne converts to a crystalline phase (graphite) and the original crystalline phase recrystallizes. At the same time the α hexagonal phase converts almost completely to a more dense β hexagonal phase by a 5 min. treatment at 90 kbar and 1800°. In the presence of a catalyst, at 70 kbar and 1500° the $\alpha \rightarrow \beta$ conversion was incomplete.

It was concluded that, in general, the crystalline chain allotropic carbon modification (carbyne) is stable to 90 kbar and 1800°, but the α -phase converts to the more stable β -phase. The amorphous carbon phase of the original carbyne converts partly to an imperfect graphite crystal lattice, and partly to the original crystalline phase of carbyne.

Rozanov, B. V., L. Yu. Maksimov, R. S.

Vasil'yeva, N. G. Saliy, and V. S. Kabakov.

Apparatus for testing materials at high hydrostatic pressures with recording of deformation.

ZL, no. 4, 1973, 474-476.

An apparatus is described for study of plastic deformation in materials at hydrostatic pressures to 20,000 atm. The apparatus, developed

at the All-Union Scientific Research Institute of Metallurgical Machinery in Moscow, measures and continuously records applied stress, specimen deformation, and pressure inside the high-pressure chamber. Tensile, compression, bending, double shearing, indentation and other tests can be run in this apparatus. Tensile and bending tests are described in detail and illustrated with schematic drawings of the corresponding modifications of the apparatus. Separate calibration curves are shown for stress and pressure. Instrument readings are nearly proportional to stress and to hydrostatic pressure to 10,000 atm. A typical oscilloscope trace of tensile testing of type 20 steel is shown. The apparatus has been used also for testing specimens of cast and hot-pressed molybdenum, ABMTs alloy, TsSDM magnesium alloy, silicon iron, and other materials.

Adadurov, G. A., O. N. Breusov, V. N.

Drobyshev, and S. V. Pershin. Effect of shock waves on matter. Phase and chemical transitions in niobium pentoxide. IN: Sb. Goreniye i vzryv, Moskva, Izd-vo Nauka, 1972, 540-543.

Experimental data are given on crystal structure changes in Nb_2O_5 after shock compression to over 1.5 Mbar pressure. Shock compression of low-temperature orthorhombic T- Nb_2O_5 produced high-temperature monoclinic H- Nb_2O_5 and vice versa, at 50-70% conversion. The T- $\text{Nb}_2\text{O}_5 \rightarrow$ H- Nb_2O_5 and H- $\text{Nb}_2\text{O}_5 \rightarrow$ T- Nb_2O_5 phase transitions occurred at pressures in the 150-250 and 65-150 kbar ranges respectively. Possible transition mechanisms are discussed.

At pressures to 1.5 Mbar and above, another transition, peculiar for solid state, was detected, irrespective of the initial modification type. This transition consists of T- or H-Nb₂O₅ changing, practically without change in composition, into a tetragonal rutile-type structure of Nb^{IV}O₂. A series of disordered nonstoichiometric phases of tetragonal structure were obtained by changing dynamic loading conditions and container material. Disorder is of the cation vacancy type. Determination of lattice parameters of Nb_xO₂ phases confirmed formation of cationic vacancies.

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Adadurov, G. A., V. V. Gustov, M. Yu.
Kosygin, and P. A. Yampol'skiy. Plastic
deformation and post-polymerization as
possible factors in shock compression of
acrylamide. IN: Sb. Goreniye i vzryv,
Moskva, Izd-vo Nauka, 1972, 529-532.

Polymerization of acrylamide from shock compression was studied experimentally to determine the effects of multidimensional deformation and thermal post-polymerization. Nondestructive shock compression tests in conventional ampules at a 130 kbar end pressure and a strain percent ϵ in the 5 to 15% range showed 13-26% and 6 fold increases in total yield of the polymer and number of polymeric chains, respectively, relative to compression tests in the absence of significant plastic deformation. The pressure dependence of the total yield was obtained in nondestructive tests at 20° C and $\epsilon \approx 1$ and 17% in a multilayer assembly.

Comparative tests at $(-)$ 196° C showed a decrease in yield and a steady increase in molecular weight up to 260 kbar. This temperature effect on shock polymerization suggested possible thermal postpolymerization. The latter is shown to increase polymer yield. Hence, it is concluded that monomer activation by shock wave is followed with polymer chain growth, by a mechanism similar to thermal explosion or on account of the post effect.

Brazhnev, V. V., Z. M. Gelunova, and L. I. Gerasimenko. Fine structure of Armco iron, treated by shock wave pressures up to 1.2 megabar.

IN: Trudy Volgogradskogo politekhnicheskogo instituta, no. 4, 1972, 92-99. (RZhMetallurgiya, 5/73, no. 5162). (Translation).

Results are given of an x-ray study of fine structure of Armco iron, after treatment by plane or glancing shock waves. The 10 mm thick specimens were annealed for 2 hours at 680° , cooled in the furnace, then dispersed in a matrix of lead and exposed to shock waves. Micrographic structural analysis showed that a strong strain hardening after plane loading up to 300 kbar corresponds to an intensive twinning and development of all the elements of fine structure, i.e., physical broadening of β diffraction lines (110) and (220), a sharp breaking up of crystal blocks, and increases in microstresses and dislocation density. In the 300-700 kbar pressure range, pressure dependence of strain hardening is weak, block dimensions are stabilized and dislocation density and microstresses decrease. Debye diffraction patterns point to polygonization at this stage of treatment. The

third stage commences when pressure attains 700 kbar; it produces a sharp drop in microstresses, a chaotic growth of crystal blocks, and a decrease in dislocation density. At still higher pressures, x-ray reflection patterns indicate accumulative recrystallization. In glancing-wave treated specimens, fine structure varies also with pressure. Only two stages of strain hardening were observed, but neither hardness nor fine structure development attain the same level as after plane shock wave treatment.

Rozanov, B. V., V. N. Sumarokov, R. Ye.

Murashko, G. S. Pobrovnihiy, and Yu. D

Klebanov. Device for developing high pressures.

Author's certificate USSR, no. 364863, published

August 20, 1970. (Otkr izobr, 5/73, p. 126.

This high pressure device (Fig. 1) consists of a strong frame

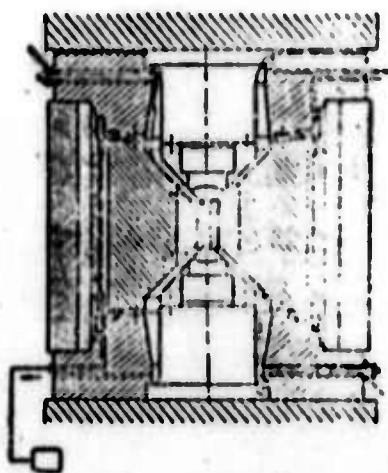


Fig. 1. High pressure device.

with hydraulic jack and associated high pressure apparatus. The frame consists of upper and lower lids, side sections with dies, vertical dies, elastic seals surrounding the side sections, and a specimen holder. Details at the structural elements and seals are included.

Polyakova, I. I. Phase state of the surface layer (up to 0.10 mm) of cobalt during high-speed impact.

IN: Trudy Volgogradskogo politekhnicheskogo instituta, no. 4, 1972, 168-173. (RZhMetaliurgiya, 5/73, no. 51280). (Translation).

Pressures of 150, 200, and 250 kbar were developed on impact of an Armco iron or Co striking plate on Co specimens in an argon atmosphere. In the case of the Co plate, only the β' -Co high-temperature stable phase is formed. In the case of the Armco iron striking plate, β -Co and β' -Co f.c.c. phases were detected. The lattice constant of β' -Co increases with an increase in pressure, while that of β -Co remains constant within the experimental pressure and temperature ranges. Phase composition and phase state at different distances from the surface were determined by x-ray structural analysis of sequential layers. Phase content was determined from the ratio of (200) diffraction intensity peaks of β - and β' -Co. Diffused interference lines indicated a stressed state of Co phases within a specimen. Two Co phases coexist to a 100 μ depth and are predominant to 30 μ . In the 30-100 μ layer a martensite-like h.c.p. Co phase was observed with an insignificant amount of high-temperature phases. Work-hardened α -Co was detected at depths $> 100 \mu$. On heating in argon β' -Co decomposition is completed from 200 to 500°, while β -Co remains stable to 500° and only

recrystallizes. Stability of β -Co on heating is due to the presence of Fe in the surface layer. Formation of the Fe-Co substituted solid solution (designated as β' -Co) is connected with penetration of the striking plate material atoms into the specimen.

Tambovtseva, L. N., and D. P. Cheprasov.

Structural changes in hardened steel from oblique and plane shock waves. IN: Trudy Volgogradskogo politekhnicheskogo instituta, no. 4, 1972, 146-154. (RZhMetallurgiya, 5/73, no. 51256). (Translation).

Strain hardening of St 45 and 40 Kh hardened steels, obtained from the effect of oblique shock waves (OSHW) at 130-160 kbar pressure, was analogous to that from plane shock waves (PShW) at 150-200 kbar pressure. The most significant strain hardening of St 85 and U10 hardened steels was obtained from the effect of OShW at 10-60 kbar ($HV \sim 80$); additional strain hardening resulted from the effect of pressures to 160 kbar. Strain hardening of all steels studied from the effect of PShW was independent of the martensite content in C, or alloying elements. Tempering curves of the shock-treated specimens are slightly above those of the conventionally hardened steels (one hour tempering at 150-500°). Tempering at 200° caused some weakening of the PShW-treated steels and more rapid weakening of the OShW-treated steels, because of a greater number of high-energy defects from OShW deformation. X-ray diffraction patterns of the OShW-treated U10 steel revealed an intense austenite-to-martensite conversion in certain shock surface areas. PShW effect on martensite crystal structure

in UIO steel is stronger than that of OShW. Formation of a nearly α -Fe lattice in addition to the original tetragonal lattice results from martensite decomposition in two phases. In addition, the PShW effect is shown to decrease C content of martensite, more so at a ShW pressure higher than the phase transition pressure. The OShW effect is stronger on the surface than in the peripheral areas.

Omel'chenko, A. V., and E. I. Estrin. Effect of pressure on the kinetics of polymorphic transitions. IN: Sbornik. Probl. metalloved i fiz. met., no. 1, Mskva, Metallurgiya, 1972, 5-14. (RZhMetallurgiya, 5/73, no. 51178). (Translation)

Magnetometric and dilatometric study of phase transitions in alloys at high hydrostatic pressures was carried out in a piston-cylinder type apparatus. A method was introduced for calculating pressure-induced shift of C-shaped phase transition curves, using the data from T-P phase diagrams and self-diffusion activation energy of the initial phase at normal pressure. The calculated shifts of the C-shaped curves of $\gamma \rightarrow \alpha$ and II $\rightarrow$ I transitions in Fe-8.2% Cr alloy and InSb, respectively, were found to be in a satisfactory agreement with the experiment.

Gorskiy, V. V., and Yu. V. Polezhayev.

Heat and mass transfer on the surface of glass-reinforced plastics in a high-temperature air flow. I-FZh, v. 24, no. 3, 1973, 407-413.

Main thermodynamic relationships determining ablation of glass-reinforced plastics are analyzed within the 2000-3500° K range of temperatures, on the assumption that the material surface layer at these temperatures is composed of SiO_2 and C (graphite). Consideration of oxygen mass balance in the gaseous boundary layer led to establishment of the formulas for critical ablation rates $G_{\Sigma, w}^{(1)}$ and $G_{\Sigma, w}^{(2)}$, and the corresponding surface temperatures $T_w^{(1)}$ and $T_w^{(2)}$ of transitions from the first to second and the second to third ablation regimes, respectively.

It is shown that $T_w^{(1)}$ and $T_w^{(2)}$ depend only on pressure at the boundary layer and on the coefficient of heat transfer (α/Cp), respectively. An ambiguous region in the $\tilde{G}_{\Sigma, w}(T_w)$ dependence is explained as the effect of carbon burnout on the surface. Numerical calculations for a supersonic laminar air flow over a blunt body show that an increase in $G_{\Sigma, w}$ at a given T_w , and a decrease in thermal effect of surface chemical reactions, are the main results of carbon burnout. At a high $G_{\Sigma, w}$ sharp intensification of material gasification leads to a significant decrease in T_w and increase in the effective enthalpy of the material.

Shvedov, L. I. A new heat-resistant steel.

MITOM. no. 3, 1973, 70-71.

Laboratory test data are given for a recently developed heat-resistant austenitic steel type 3 Kh 15N 13 Yu 3, as compared to three other austenitic steels. Chemical composition of the new steel is (in %): C-0.2-0.4, Cr 13.5-16, Ni 12-14.5, Al 2.3-3.0, Si to 1, Mn 0.5-0.9, S and P to 0.03. The tabulated data show that the new steel exhibits a higher heat resistance up to 1,000° C and a smaller elongation after thermal cycling than the other three steels tested. Also, the number of load cycles which the new steel sustains without cracking is higher than for the other three steels. Service life of heat-treating furnace components made of cast 3 Kh 15N 13 Yu 3 steel is found to be 1.2-2.0 times that of the same components made of 3Kh25Ni9C2 steel.

The effect of variations in Si, Al, Ni, and C contents on steel characteristics and microstructure was also determined. Flowability of the steel was found to increase with the increase in Si content. Specifications are given for steel casting, hot forging, and rolling. The new steel is being used in casting bottom plates, mufflers, grates, radiation pipes, and other parts of heat-treating furnaces operating up to 1,050° C.

Yermolenko, I. N., Zh. V. Malashevich,
B. A. Bezukh, and A. N. Kuz'min. Effect
of plasma on carbon and metallocarbon fibers.
DAN BSSR, no. 5, 1973, 431-433.

The effect was studied experimentally of a plasma from an electrodeless h.-f. induction discharge in helium on carbon fibers obtained by pyrolysis at 400-1400° C from oxidized cellulose or its salts. The study was undertaken to determine high temperature effects on heat resistant fibers, and to evaluate the possibility of chemical modification of the fibers from high temperature effects. The experimental quartz chamber used and the procedure followed are described. Gas translational temperature was measured by emission spectroscopy to be ~5000° K and electron temperature was estimated to be ~12000° K.

Spectral analysis indicated that metals (Al, Fe, Cr, Ce) in the fibers are in the form of nonvolatile compounds. Comparative element analysis revealed that the chemical composition of the plasma-treated carbon fibers did not change significantly after 1-3 min. irradiation, but that the carbon content of iron-carbon fibers increased somewhat under similar conditions. X-ray diffraction patterns of the metal-carbon fibers do not show a crystalline structure, nor graphitization of C residue after a short duration plasma treatment. Thus the possibility was shown of selecting plasma treatment conditions which would minimize deep structure changes in carbon fibers, and hence would allow modification of the fiber surface.

Okrainets, P. N., and V. K. Pishchak.

Characteristics of high-temperature creep
of metals with an fcc-lattice. IAN Met, no.
3, 1973, 151-156.

Experimental data obtained earlier by Kozyrskiy and the above authors (FMIM, v. 33, no. 3, 1972, 634 and v. 34, no. 3, 1972, 607) are discussed, in an effort to establish the mechanism of high-temperature creep of metals with an f.c.c. lattice. The authors' data on mechanical (creep) and structural (x-ray) tests of Al, Ni, Cu, and Ag are correlated with the available literature data on creep activation energy of these metals. On the basis of all available data the authors refute the widely accepted belief that transition to high-temperature creep of all metals with f.c.c. lattice occurs at the same homologous temperature $T_{tr} \sim 0.5$ m.p., i.e., at the same value of diffusion coefficient.

In addition, they establish the empirical correlation $\gamma(T_{tr}/m.p.)^5 = \text{const}$ between transition temperature and stacking fault energy γ . Additional creep tests at different T_{tr} for each metal and at the same σ/E ratio revealed that steady-state creep rate and changes in substructure disorientation are practically identical, and independent of γ . Apparently, in the framework of the theory of creep with recovery, the effect of γ on dislocation growth rate which controls high-temperature creep can be explained by interaction of split dislocations with vacancies.

Ignatova, I. S., L. V. Uzberg, V. A.
Perepelitsyn, and G. V. Gauer. Investigating
formation conditions of ZrO_2 solid solution in
 MgO . NM, v. 9, no. 5, 1973, 805-808.

Experimental data are given on ZrO_2 solubility in MgO ceramic specimens with 2 to 20 wt % ZrO_2 admixtures. The specimens were prepared by compacting and baking at $2,000^\circ C$ of $MgO-ZrO_2$ mixtures obtained by chemical co-precipitation and calcination of the hydroxides or by baking $MgO-ZrO_2$ melts. Micrographic analysis and the tabulated refractive indices of the baked and air-quenched specimens confirmed the existence, presumed earlier by many authors, of a ZrO_2 solid solution in MgO . A complete solubility was observed in the specimens with 2-5% ZrO_2 and only partial solubility with over 5% ZrO_2 content in a specimen. The maximum ZrO_2 content of solid solution was estimated to be 5-6 wt% at $2,000^\circ C$.

Simultaneously with ZrO_2 dissolution, periclase crystal size almost doubled. In the specimens baked at $1650-1700^\circ C$ (the usual baking temperature for periclase ceramics), ZrO_2 content in the solid solution was equal to or less than 3 wt%. Melts and compacted material exhibited basically the same structural and optical characteristics, which points to a limited ZrO_2 solubility in MgO . This fact was confirmed by measurements of electrical conductivity and relative density. The lower temperature limit of solid solution stability was estimated to be around $1,200^\circ C$, from the observed decrease in electric resistivity and increase in density of the specimens with 2-5% ZrO_2 , when holding temperature is increased from 1,000 to $1,200^\circ C$.

Tkachenko, I. G., and Ye. K. Fen'. Electro-physical properties of hot-pressed niobium pentoxide. Poroshkovaya metallurgiya, no. 5, 1973, 78-81.

D-c and a-c resistance and thermoelectric power of Nb_2O_5 in the solid state were measured within a 20-1450° C range both in the air and in vacuum. The specimens were prepared by hot-pressing Nb_2O_5 powder at 1200-1300° C, followed by homogenizing annealing at 1,200° C in the air. A significant emf polarization was observed during d-c resistance measurements at room and 100° C temperatures. This polarization increases in the 20-150° C range with increasing temperature. A difference between values of the forward and reverse currents is attributed to formation of an electrode layer of increased resistance, called the back-biased barrier, to unipolar conduction. Resistance variation with change in current direction is explained in terms of thermionic polarization.

The specimen conductivity exhibited a hysteresis due to formation faster than destruction of the back-biased barrier. A resistance increase to 150° C is confirmed by a-c resistance measurements at different frequencies and temperatures. A-c resistance from 350-400° C up is practically independent of frequency and coincides with d-c resistance. The $\log \sigma$ versus $1/T$ dependence measured with d-c current in air is typical of semiconductors at high T only; the dependence measured in vacuum is nearly rectilinear. It is concluded that σ of Nb_2O_5 is sensitive to oxygen partial pressure. The primarily electronic conductivity type of Nb_2O_5 is deduced

from the values of the current carrier activation energies in air and vacuum.

Lyutyy, Ye. M. Effect of preload stress values on long-term strength of 1Kh18N9T steel at elevated temperatures. Problemy prochnosti, no. 5, 1973, 76-78.

Experimental data are given on the effect of preload stress value σ on time limit τ_{cr} of long-term strength $\sigma_{l.t.}$ of preloaded 1Kh18N9T steel at 700 and 800° C. Time τ_{cr} is defined as the time when $\sigma_{l.t.} = \sigma_{l.t.}$ of the original steel samples. The vacuum-annealed original samples were preloaded by static tension for 100 hours at 20° C, then tested for $\sigma_{l.t.}$ comparatively with the original samples ($\sigma_{l.t.}$). The σ value varied from 11.4 to 51.3 kg/mm². The observed increase in dislocation density with increased σ value suggested corresponding changes in $\sigma_{l.t.}$ in subsequent tests. Time τ_{cr} was determined from intersection of the $\sigma_{l.t.}$ and $\sigma_{l.t.}$ versus test duration τ rectilinear plots.

In the same way, confirmation was obtained of the time inversion of $\sigma_{l.t.}$ variation versus $\sigma_{l.t.}$. At 700° C, τ_{cr} at $\sigma = 51.3$ kg/mm² was nearly 20 times shorter than at 700° C. The time inversion of $\sigma_{l.t.}$ variation is explained in terms of dislocations rearrangement.

It was concluded from the cited data that there is a T_{cr} value at each temperature below which preloading increases $\sigma_{n l.t.}$. Regions of positive and negative effects of preloading were established at each temperature in two and three dimensional coordinate systems. These data can be used to determine upper applicability limit of preloaded materials.

Poloskin, Yu. V., and N. L. Makarovskiy.

Effect of temperature on the effectiveness of
hardening heat-resistant alloy parts. MITOM,
no. 5, 1973, 56-59.

Results are given of an experimental study on the effect of surface cold hardening of nickel-base alloy parts on their fatigue strength at temperatures to 900° C. Test specimens of type KhN77TYuR and EI929 alloys were milled in the shape of mass-produced turbine blades with a cut simulating the first slot of the blade root. Fatigue limit σ was determined after 2×10^7 cycles (5.55 h) on an electrodynamic vibrator at 500-900° C from vibrational stress at the bottom of the cut. The experimental plots of σ versus temperature show that σ of the shot-blasted KhN77TYuR and EI929 alloys was increased by 50% at 500-600° C and 40% at 700° C, respectively, over σ of milled alloy specimens at corresponding temperatures. At higher temperatures, the absolute σ value and the difference between σ of the milled and shot-blasted specimens decreased continuously. At 900° C, σ of the milled specimens equaled that of the shot blasted. Thus, the surface cold hardening is effective up to a certain temperature, e.g., 900° C, only.

Additional tests were carried out to determine the short-term temperature effect on relaxation of residual stress in the cited alloys, plus a type ZhS6K alloy. It is shown that the maximum residual stress decreases continuously with increasing temperature, in agreement with the σ data. It is concluded that σ of the surface hardened parts decreases at the same operating temperature at which favorable residual compression stress is relieved. Simultaneously structural changes in the surface layer of cold-hardened alloys are more pronounced than in milled samples of the same alloys.

Logachev, Yu. A., and L. N. Vasil'yev

Temperature dependence of phonon thermal conductivity of Ge, Si, and A^{III}B^V compounds at high temperatures. FTT, no. 5, 1972, 1612-1614.

The role of optical phonons in decrease of thermal conductivity χ at high temperatures is discussed in terms of phonon-phonon scattering. The temperature dependence of relaxation times τ_1 , τ_2 , and τ_3 of transverse acoustical phonons (TA) is analyzed separately for each of the three possible scattering processes: $TA \uparrow A \rightarrow A$, $TA \uparrow 0 \rightarrow T0$, and $TA \uparrow LA \rightarrow 0$. The analysis led to formulation of $\chi_{TA}(T)$ dependence which contributes the major part of the total $\chi(T)$ dependence. The theoretical $\chi_{TA}(T)$ plots for Ge, Si, and InSb in the 0-800° K range were obtained by substituting ω_{TO} frequency

for ω_0 in the expression of $\tau_{2,3}^{-1}$ and using the cited formula. Experimental $\chi(T)$ data from literature agree with the theory based on the processes with participation of optical phonons (0). The $\chi(T)$ dependence thus established is stronger than T^{-1} .

It is concluded that the $\chi(T)$ dependence of the cited elements and compounds can be explained qualitatively with allowance for the role of 0 phonons in phonon-phonon scattering. 0 phonons in Ge, Si, and $A^{III}B^V$ compounds scatter heat-transferring acoustical phonons, without taking part in heat transfer.

Bondarenko, V. P., V. V. Kandyba, Ye. N.
Fomichev, N. P. Slyusar', A. D. Krivorotenko,
and A. A. Kalashnik. Measuring enthalpy, heat
of fusion and melting point of materials in the
condensed phase at high temperatures. Metrologiya,
no. 5, 1973, 3-8.

High-temperature thermodynamic data obtained over a period of several years at the Kharkov Scientific Research State Institute of Metrology (KhGNIIM) are tabulated for a number of heat-resistant elements oxides, carbides, and silicides in the condensed phase. Enthalpy ($H_T - H_{298.15}$) data were determined experimentally in the 500-2800° K range with a 0.3-0.8% maximum relative error. Temperature and heat of the solid-to-liquid phase

transition were determined for certain elements and oxides from enthalpy jump at a transition point. In addition to the cited thermodynamic data, the experimental temperature range, ampule material, number of points, and the factors of the enthalpy interpolation equation are tabulated.

The tabulated enthalpy data of most materials were obtained for the first time and subsequently confirmed by other investigators. High-temperature enthalpy data obtained for corundum (Al_2O_3), BeO , and MgO are singled out as the most important for metrological service. Deviations of the authors' enthalpy data for Al_2O_3 at 1000-2200° K from earlier Soviet and American data are shown to be 0.5% maximum near 1000° K. The heat of fusion of Al_2O_3 was determined to be (118.4 ± 2.4) kJ/mole. The m.p. of $(2054 \pm 6)^\circ\text{C}$ for corundum is recommended as the new secondary reference point on the International Practical Temperature Scale.

Vertogradskiy, V. A., and V. Ya. Chekhovskoy.

Thermophysical properties of rhenium at high temperatures. TVT, no. 1, 1973, 84-87.

Electrical and thermal conductivities and integral hemispherical emissivity of pure polycrystalline rhenium wires were measured at temperatures in the 1200-3000° K range. Electrical conductivity ρ was measured potentiometrically with ~1% error at 0.95 confidence level. Thermal conductivity λ was measured by a modified method of exponential temperature distribution with a 3-5% error at the same confidence level.

The temperature dependence of ρ and λ is described by quadratic and linear equations, respectively. The integral hemispherical emissivity ϵ was determined simultaneously with λ , from current measurements and $\rho(T)$ dependence, with a 5% maximum error. The measured ρ , λ , and ϵ data are plotted against T , comparatively with earlier data of other authors. Discrepancies between the ρ , λ , and ϵ data of different authors are discussed and tentative reasons for these discrepancies are given.

Tarasov, V. D., V. Ya. Chekhovskoy, E. E.

Shpil'rayn, D. N. Kagan, and L. S. Barkhatov.

High temperature heaters for type TVV-2 and
TVV-4 ovens. ZIL, no. 5, 1973, 623-625.

A simplified technique has been developed for manufacturing tungsten wire (type I) and rod (type II) heaters which are being successfully used in the type TVV-2 and TVV-4 ovens, for determining high-temperature enthalpy and heat capacity of refractory materials. The type I heating element is made of a 0.8-1.5 mm diam. wire in the form of a basket and compressed into current-carrying copper conductor by means of copper rings. The type II heating element is made of a number of 2 to 5 mm diam. rods which are inserted into holes drilled through a copper conductor. Molybdenum heat shields provide additional shielding at each end of a type I element up to $\sim 1/3$ height of the heater. Similar tungsten and molybdenum shields are installed on type II heating element along its entire height.

Temperatures to $\sim 2,800^{\circ}\text{C}$ were obtained with type II shielded heater at 30 kw power level. The experimental thermal characteristic $t(P)$ of a type II heater is shown. Resistance of the type I and II heaters was determined to be 25% higher and 25% lower, respectively, than the resistance of a standard heater.

Matyushenko, N. N., A. A. Matsakova, and
N. S. Pugachev. Superconductivity in beryllides
of various transition metals. UFZh, no. 4, 1973,
672-674.

Structural parameters (type and lattice parameters) and superconductivity characteristics were determined in MoBe_2 , RhBe_2 , MBe_{12} ($M = \text{Mo, Ta, Nb, W}$), MgBe_{13} , MoBe_{22} , and WBe_{22} specimens prepared by the procedure described elsewhere by the authors. The main purpose of the study was determination of critical transition parameters of MoBe_{22} and WBe_{22} with the highest reported transition temperature T_c . The tabulated experimental data show that, in agreement with the literature, T_c of MoBe_{22} and WBe_{22} in a zero critical magnetic field H_c varies from 2.485° to 2.545° and from 4.038° to 4.12° K, respectively. All other beryllides studied exhibited superconductivity below 1.7° K only. Magnetization curves show that MoBe_{22} and WBe_{22} are type I superconductors. The experimental $H_c(T)$ curves of MoBe_{22} and WBe_{22} were extrapolated to 0° K using a parabolic $H_c(T)$ equation. The $H_c(0)$ and $dH_c/dT|_{T_c}$ parameters were then determined with a maximum relative error of 3%.

Pallstrant, M. Ye. Effect of pressure and paramagnetic impurities on superconducting properties of metals. TMF, v. 15, no. 2, 1973, 280-287.

In the framework of the BCS and Bogolyubov's theories, equations are derived to calculate the order parameter Δ and critical temperature T_c of superconductors with a changing Fermi surface topology owing to the effects of high hydrostatic pressures and paramagnetic impurities. Calculations were made for the cases of emergence of a new part of the Fermi surface ($\alpha > 0$) and transition from an open to a closed Fermi surface ($\alpha < 0$). The equations were derived from Dyson's equation for the Green function of electrons with the use of diagrammatic methods.

Analysis of the equations for Δ and T_c/T_c^0 , where T_c^0 is the critical temperature of a pure superconductor without allowance for changes in density of states, leads to the conclusion that T_c/T_c^0 increases or decreases nonlinearly with an increase of the parameter $\epsilon_F' = \epsilon_F - \epsilon_c$, depending on whether $\alpha > 0$ or $\alpha < 0$. The nonlinearity becomes smoother when impurity concentration $\Gamma/\Delta(0)$ increases. At a given ϵ_F' value T_c/T_c^0 decreases with the increase in $\Gamma/\Delta(0)$. The singularity of the density of states, in connection with the changes in the Fermi surface topology, contributes significantly to the $\Gamma/\Delta(0)$ dependence of T_c/T_c^0 . The critical $\Gamma_c/\Delta(0)$ value increases at $\alpha > 0$ and decreases at $\alpha < 0$, when $\epsilon_F'/\Delta(0)$ is increased.

Vitovskiy, N. A., G. A. Vikhliy, T. V. Mashovets,
and S. M. Ryvkin. Formation conditions and the
nature of surface superconductivity in indium
antimonide. FTP, no. 5, 1973, 868-873.

A method of producing superconductive surface layers of indium antimonide is described. The method consists of mechanical surface treatment at a low temperature either by sanding the surface or by etching a 10-100 μ wide line into the surface by means of a pointed abrasive tool under 50-200 g load. Both processes were done at liquid or gaseous helium or liquid nitrogen temperatures. Measurements of temperature dependence of electrical conductivity show transition to superconducting state at 4.4-4.9° K in all treated specimens, regardless of the type and concentration of current carriers. Superconductivity disappeared completely after annealing at 263° K. T_c was decreased in the specimens annealed at $T < 263^\circ$ K prior to treatment.

It is concluded that the nature of surface layer in a specimen treated by low-temperature sanding is different from that in the untreated or annealed specimens. The data indicate that the surface layer of the treated specimens is composed of the orthorhombic metallic InSb modification, which is formed from the effect of locally high pressures during mechanical treatment. The described method may be used to produce any desired superconducting configuration on the surface, since the superconducting layer consists of filaments of uneven thickness.

Druinskiy, Ye. I., and I. I. Fal'ko. Weakening effect in pure double-band superconductors.

FMiM, no. 4, 1973, 681-686.

A theoretical analysis is made of the effect of transition to superconducting state on plastic deformation ϵ of pure metals. A two-band superconductor model is used to derive an expression of the known deformation increase or weakening effect $\delta\epsilon$ from the transition; this was done because the earlier theoretical $\delta\epsilon$ values calculated on the basis of a single-band model were too high in comparison with the experimental $\delta\epsilon$ values near T_c . Preliminary calculations show that the electronic component Γ of dislocation friction force in a two-band superconductor coincides with the absorption coefficient $\Phi(T)$ of low frequency longitudinal ultrasound, if dislocation rate is small. Consequently, $\delta\epsilon$ at a small constant applied strain is expressed as a function of $\Phi(T)$ at $T_0 \leq T < T_c$, where T_0 is the root of the equation $\Phi(T) \approx l_0/l$, and l_0/l is the ratio of the critical length to the length of dislocation segment.

It is shown that in the narrow temperature range $T_c - T \leq T_c$, $\delta\epsilon$ dependence on transition to the superconducting state is expressed as a function of the wider energy gap $\Delta_2(T)$ in the spectrum of quasiparticles. The $\delta\epsilon$ values calculated from this expression are in better agreement with the experimental $\delta\epsilon$ data than $\delta\epsilon$ calculated from the formula based on a single-band model.

Osipova, S. G., A. K. Shtol'ts, and P. V.

Gel'd. Intersolubility of lower chromium

and vanadium germanides. NM, no. 5, 1973,

860-861.

The present experimental study of the $V_{3.04}Ge_{0.96}$ and Cr_3Ge intersolubility was undertaken because of a relatively high superconducting transition temperature of V-base two- and three-component solid solutions with type A-15 structure. Micrographic and x-ray analytical data were accordingly obtained for $V_{3.04}Ge_{0.96}$, Cr_3Ge , and $V_{3.04}Ge_{0.96}$ - 5-15 mol % Cr_3Ge alloys. All alloys prepared by smelting their elementary components were found to be composed of two phases, with the base phase of the type A-15 structure. The second phase content decreased significantly in all alloys with up to 50 mol % Cr_3Ge , and decreased to zero in the alloys with 75 and 100% Cr_3Ge after 150 hours annealing at 1,000° C. The lattice constant of an elementary cell of the A-15 type phase decreased linearly with increase in Cr_3Ge mol % in all alloys studied. Microhardness of all alloys was practically the same (1,300-1,400 kg/mm²). The cited data led to the conclusion that continuous solid solutions with an A-15 type lattice form in the $V_{3.04}Ge_{0.96}$ - Cr_3Ge quasibinary cut of the V-Cr-Ge ternary system.

Volkov, A. F. Critical current in narrow superconducting bridges. FTT, no. 5, 1973, 1364-1368.

A theoretical analysis is presented on spatial variations of the order parameter ψ and critical current I_c in narrow thin film bridges. Formulas for I_c , amplitude f and phase χ of ψ are derived from the Ginzburg-Landau equation, taking into account nonlinear addends but disregarding the Meissner effect.

The cases of small current I (small deviation of f from its equilibrium value ≈ 1) and larger I (significant deviation of f from 1) are examined separately. In the first case, the formula for f shows strong ψ fluctuations in a narrow bridge at distances shorter than the coherence length ξ . The f values calculated from two formulas overlap within a certain range of dimensionless parameters $a = d/\xi \cos \alpha$, where d is the bridge width. Dimensionless I_c is expressed as a function of the film resistance R in the form:

$$I_c = (\xi R(\xi))^{-1}. \quad (1)$$

Eq. (1) coincides with that obtained by Aslamazov and Larkin (ZhETF P, v. 9, 1969, 156) on the condition that R in their expression designates resistance measured at a distance ξ from the bridge center.

Veselovskiy, A. S., V. F. Vorob'yev, et al.

A 100 kw alternator with superconducting inductor.

Elektrichestvo, no. 5, 1973, 28-32.

An alternator based on a stabilized superconducting magnetic system (SMS) is described and results of testing of its main components are given. The main components are the inductor, comprising two symmetric solenoids made of a superconducting coil; the rotor on a non-metallic (glass laminate) shaft with a cooling system for the rotor winding, and a helium cryostat. The inductor and the rotor are mounted at the bottom of the cryostat. Diagnostic and protection systems are provided for detection of normal state resistance in the SMS and current tapping in the case of voltage drop.

In preliminary tests of the SMS, a 5.2 T magnetic induction was attained at its center at 620 a. current. Mechanical tests of the rotor indicated that vibrations at 3,000 rpm remained within tolerance limits. Magnetic, thermal, and electrical characteristics of the assembled alternator were determined in tests with a 100 kw d.c. drive at the cited rotation speed. Fundamental test characteristics of the alternator are given and compared to the rated values.

The tests confirmed the practical feasibility of constructing similar electric machines with superconducting induction coils. Output power of such a machine is limited to several tens of megawatts, by the brush contact for power transmission from the rotor. Machines with a static

superconducting inductor may be used as a.c. or d.c. generators and motors.

Yeru, I. I., S. A. Peskovatskiy, and A. V.

Poladich. Nonthermal break in the V-A characteristics of a thin superconducting film.

FTT, no. 5, 1973, 1599-1601.

V-A characteristics were investigated of thin superconducting Pb and Sn films in the temperature range 1.9° K up to critical. Specimen thicknesses were 200-500 Å and widths, 0.1 - 2.0 mm. Sapphire substrates were used to decrease the thermal effect. V-A characteristics obtained from experiments are shown in Figs. 1 and 2. Initially, the voltage on the

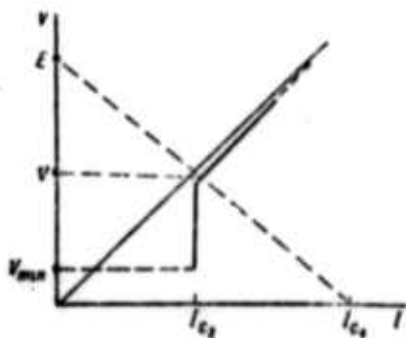


Fig. 1. General V-A characteristics of a superconducting film.

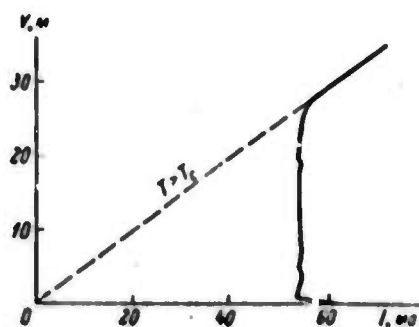


Fig. 2. V-A characteristic of a thin superconducting Sn-film, 500 Å thick.

$T = 2^{\circ}$ K; $I_c = 125$ ma; $T_c = 3.86^{\circ}$ K.

film specimen remains zero until the current reaches a critical value I_{c1} ; at this point current appears in the film, whose value is determined by the intersection of V-A characteristic and circuit load curve. With further increase of the source voltage E , voltage and current in the film increase according to its V-A characteristics. With decrease of E , the V-A characteristic also decrease, dropping very sharply at a certain current $I_{c2} < I_{c1}$, with only the film voltage V changing at a practically constant I_{c2} current. A continuous change in voltage V was found to be possible only at voltages higher than a minimum value V_{min} , (10 to 200-40 μ v), which depends on the film material and its temperature. The V-A characteristic was found to break below V_{min} .

The authors point out that this observed effect in V-A characteristics is common for all thin superconducting films, and that the results obtained agree well with those of previous works, where the break in V-A characteristics was not observed, probably due to: (1) the low value of V_{min} at temperatures close to the critical; (2) the low value of V_{min} , which might be due to an insufficient thermal conductivity of the film substrate; or (3) a very high internal source resistance.

Pan, V. M., V. I. Lатышева, and A. I. Sudovtsov. Causes of variations in critical temperatures of Nb_3Al and $Nb_3Al_xGe_{1-x}$ superconducting compounds. IN: Metallofizika, Resp. mezhved. sb., no. 36, 1971, 104-107. (RZhMetallurgiya, 5/73, no. 51312).

Relationships were investigated of the critical temperature T_c of Nb_3Al and $Nb_3Al_xGe_{1-x}$ superconducting compounds, as a function of their composition and thermal processing conditions. Variations of T_c were considered in a "strong coupling" model and were compared with the results of the phase boundary locations of stability regions of these compounds and electron density fluctuations, obtained by an electron-positron annihilation method. It was shown that the increase of T_c in Nb_3Al during increase of Al concentration correlates with rise of electron density $N(E_F)$. The values of T_c obtained were still higher in the case of unbalanced alloys, in which high contents of Al and Ge are obtained during fast cooling. During low-temperature anneal (700-750°), the compounds do not approach an equilibrium state, Al and Ge are not depleted from the composition by age, and the level of long-range order of atoms increases.

Ganzhula, N. N., V. I. Latysheva, V. M.

Pan, and K. V. Chuistov. Investigating the segregation process in superconducting niobium-aluminum alloys. Metallofizika. Resp. mezhved. sb., no. 36, 1971, 107-111. (RZhMetallurgiya, 5/73, no. 51228). (Translation).

An x-ray study was made of poly- and micro-single crystalline Nb-18 at. % Al alloy specimens. Ordering of the solid solution with formation of a CsCl-type structure was observed on heating after hardening in the 750-800° C range. Decomposition of the Nb-Al alloy quenched from 1750°C, and its significant strengthening, were noted after one hour heating at 800° C. Maximum hardness is attained after 1 hr. ageing at 1,200° C. A Nb₃Al-base phase with lower than stoichiometric Al content is precipitated during decomposition. A presegregation phase was not detected. A diffuse transition to the superconducting state begins at 14° K in an alloy with 15 at % Al after a 70% deformation and a 10 hr. anneal at 900° C. The magnetic field dependence of critical current density at 4.2° K in the cited alloy obeys the exponential law $j_c(H) \approx j_c(0)[1-H/H_{c2}]$, where $j_c(0) \approx 3.5 \times 10^5$ amp/cm² and $H_{c2} = 22$ kOe.

Khromova, L. I., S. M. Khromov, L. N.
Fedotov, V. A. Suvorov, V. I. Krasnykh,
and A. I. Il'ichev. Critical current of a
superconducting type 70 B strip with electrolytic
copper coating. IN: Sbornik. Pritsizionnyye
splavy, no. 1. Moskva, Metallurgiya, 1972,
100-103. (RZhMetallurgiya, 5/73, no. 51293).
(Translation).

A study is presented on the effect of tin bath impurities on superconductivity of an Nb strip, and of the most economical technique of stabilizing the Cu coating on the strip. Temperature dependence of electrical resistance is given for a 70 B type strip specimen. Critical temperature $T_c = 16.6^\circ \text{K}$ corresponds to $R/R_0 = 0.5$. Critical current of the Cu-plated superconducting strip at 4.2°K was 20 amp. per mm. of strip width in a transverse magnetic field of 4.8 Mamp/m (60 kOe) intensity. Up to 30μ thick stabilizing Cu layers can be deposited on an Nb_3Sn -coated strip by electroplating. Apparently, a prolonged holding of the Nb strip in the tin bath causes a change in growth pattern of the superconducting Nb_3Sn layer.

Pan, V. M. Relationship of turbulent and
filamentary models for nonideal super-
conductors of the second type. IN:
Metallofizika. Resp. mezhved. sb., no. 36.
1971, 98-104. (RZhMetallurgiya, 5/73, no.
51303). (Translation).

Current dependence of the cited superconductor behavior in a transverse magnetic field is qualitatively analyzed. Existence is assumed of a system of two type II superconductor structures in one specimen, each having different a Ginzburg-Landau parameter κ and upper critical field H_{c2} values. The two superconductor structures intermingle and form a multicoupled network of thin filaments or layers with typical dimension $d \leq \lambda_0$. It is concluded that the behavior of such superconductors can be described by a turbulent as well as a filamentary model. Regions of the turbulent, filamentary, and normal states can be delineated in a j_c -H coordinate system. The turbulent-to-filamentary state transition occurs when the structure with lower κ and H_{c2} converts to the normal state and the thin filaments (layers) system remains superconducting in a normal matrix. The peak effect is explained in terms of the above cited analysis. Critical current increases with an increase in magnetic field only in the case of the turbulent-to-filamentary state transition, the latter determining higher critical current at a constant field. The transition occurs only up to limited current values for which dissipation processes do not cause overheating near the approach to the critical regime.

Rassman, G., and L. Illgen. Relation between structure and critical current density in superconducting titanium-niobium binary alloys.

Neue Hutte, v. 17, no. 9, 1972, 321-328.

(RZhMetallurgiya, 5/73, no. 51309). (Translation).

The concentration dependence of critical current density j_c was studied in recrystallized, cold-worked, and heat-treated Ti-Nb alloys with 20-70 at. % Nb in a 25-65 kOe applied transverse magnetic field. The data thus obtained are correlated with alloy structure. Impurities in Kroll titanium stabilize the α -phase with a resulting definite increase in j_c . Cold strain percent increases to a value necessary for producing optimum characteristics, when the Nb content is increased. Intermediate annealing increases j_c in the absence of a significant weakening of the alloys.

Rassman, G., and L. Illgen. Relation between structure and critical current density in superconducting titanium-niobium alloys with α -stabilizer admixtures. Ibid., 547-553. (RZhMetallurgiya, 5/73, no. 51306). (Translation).

The effect of the α phase stabilizing admixtures of O, N, H, and Al on critical current density j_c was investigated in Ti-20% Nb and Ti-40% Nb superconducting alloys at 4.3° K in 50 kOe fields. Initially an increase in O content to 0.08 % causes an increase in j_c to 5×10^4 amp/cm²,

followed by a decrease due to Nb_2O_5 and V_2O_3 formation. An N admixture somewhat increases j_c owing to a supplemental strengthening of the flow lines. A noticeable increase in j_c from 2×10^4 to 5×10^4 amp/cm² is achieved by simultaneous alloying with oxygen and nitrogen. The effect of a C admixture is correlated with precipitation of finely dispersed Ti and Nb carbides. Precipitation of carbide needles, with simultaneous increase in j_c from 2×10^4 to 4.5×10^4 amp/cm², was observed in an alloy with 0.15 % C after 24 hours heating at 500°. Alloying with Al improves the mechanical characteristics but sharply reduces j_c .

Bobrov, V. S., and E. Yu. Gutmanas.

Kinetics of plastic deformation at super-
conducting transitions. Phys. status solidi

(b), v. 54, no. 2, 1972, 413-424. (RZhMetallurgiya,
5/73, no. 51404). (Translation)

Analytical expressions, based on models of viscous and thermally activated dislocation motion, describe the flow stress kinetics and variations of plastic deformation rate at transitions to and from the superconducting state. Changes of the cited parameters were observed in 99.99% Pb single crystals. Specimens were compressed at 4.2° C using an Instron machine. Flow stress kinetics change considerably when the deformation rate is changed. Transition time to a steady-state plastic deformation decreases by a factor of 10, when the clamp motion rate increases from 0.35

to 8.33×10^{-5} cm/sec. In the case of transition from a superconducting to normal state, transition time to steady-state plastic deformation is 10 times the value of transition time for the inverse transition. The experimental data are in agreement with the model of viscous motion of dislocations.

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Vanyukov, A. V., G. A. Krasulin, N. G. Mnatsakanyan, and
V. V. Tokmakov. Distribution of supersaturated vapor phase over
the deposition zone during the growth of cadmium sulfide films
via vapor transport in a hydrogen flow. IN: *ibid.*, 138-144.
(RZhF, 6/73, no. 6A751)

6. Miscellaneous Interest

A. Abstracts

Zaderigolova, M. M. Locating underground cavities by an r-f method.

Osnovaniya, fundamenty i mekhanika
gruntov, no. 2, 1973, 14-16.

An r-f method of surveying abandoned underground workings and loose deposits in underground cavities and caverns is described. The method can supplement exploratory drilling to insure safety of foundations for civilian and industrial buildings. Examples are cited of cavity surveying from the surface using a type RRK-1.76 r-f equipment transmitting at 1.76 MHz. The cited data show high noise rejection and reliability of the apparatus in detection and delineation of abandoned underground workings. In controlled experiments the mean relative error was found to be 1-3%. The method is noise-free at distances more than 30 m. from high-voltage transmission lines. A complete agreement between geological anomalies detected by exploratory drilling and anomalies detected by the r-f method was established in comparative tests; comparative results are shown graphically. It was thus demonstrated that application of the r-f method in conjunction with other surveying methods, e.g., drilling, can increase the accuracy and reliability of geological surveys.

Mints, R. I., I. I. Mil'man, V. I. Kryuk, and
L. S. Tarasov. Natural exoelectron emission
from anorthosite rocks retrieved by Luna-20.

DAN SSSR, v. 209, no. 3, 1973, 586-588.

Natural exoelectron emission from all fragments of lunar soil retrieved by Luna-20 was detected in experiments described elsewhere by

Mints et al (IN: Sb. Lunar soil from the Sea of Fertility, Izd-vo Nauka, 1972). Thermostimulated exoelectron emission (TSEE) from different fragments exhibits a different number of peaks, different temperature distribution of peaks, and activation energies E . The TSEE curves are shown for two structural groups of fragments (Fig. 1).

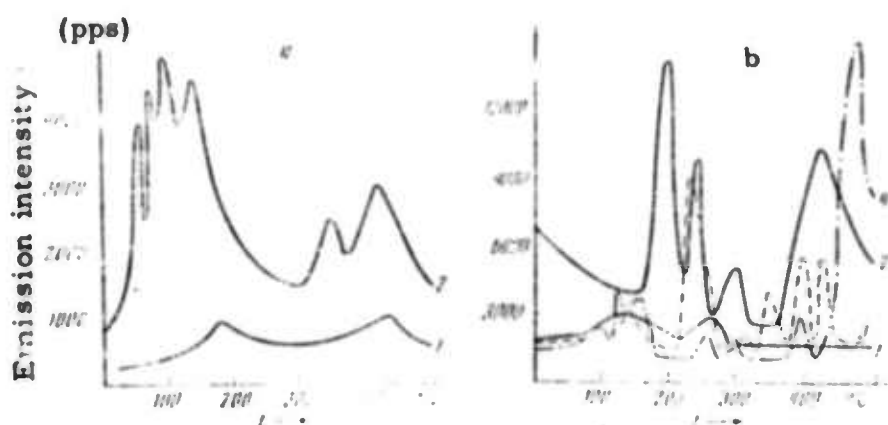


Fig. 1. Exoelectron emission from: a- feldspar grains M535 (1) and M536 (2); b- fragments of recrystallized anorthositic rocks M537 (1), M539 (2), M538 (3), and M541 (4).

The experimental data suggest the presence of structural defects which were produced by different conditions. Analysis of the TSEE curves of both groups of fragments points to defects as the local emission centers (low-temperature peaks with $E = 0.45-1.5$ eV), which were generated by deformation effects peculiar to lunar conditions. Electron emission at a temperature $\geq 250^\circ$ may be due to annealing of deeper structure changes which depend on the thermal history of the samples, such as defects of the amorphous phase-crystallite interface or intercrystalline boundaries. The experimental data show that the number of emission peaks, particularly the high-temperature peaks, and the corresponding E both increase as recrystallization of the anorthosite rock fragments increases.

Kalyatskiy, I. I., S. S. Pel'tsman, and
D. D. Khalilov. On studying the energy
characteristics of a pulsed electrical
breakdown channel in solid dielectrics.
IAN Az, Seriya fiz-tekhn. i mat. nauk,
no. 4, 1972, 117-120.

Theoretical formulas are derived for calculating characteristics of an electric discharge channel as functions of discharge circuit parameters. The formulas for current in the circuit, power N , power rise rate N' , energy W , peak power $N_{\max}$, peak power rise rate $N'_{\max}$, and energy W_1 at $N_{\max}$ in the channel were obtained using the approximation $R(t) = A/l$, where $R(t)$ is the time dependence of the discharge channel resistance, l = channel length, and $A = \text{const}$. Applicability of this approximation to study of electrical breakdown in rock was verified in experiments with eight types of rocks. The experimental values of the constant n determined at the time $\tau_{\max}$ of the first $N_{\max} = N_0 \varphi_1(n)$ are tabulated for marble, quartzite, and hornstone at various circuit parameters and l values. Graphical comparison is made of the experimental $N_{\max}/N_0$ data for sandstone with the normalized $N_{\max}/N_0$ values calculated at $R = \text{const}$ and $R = A/t$. It is shown that the latter approximation is the most satisfactory for evaluating energy characteristics of the spark channel and for design of industrial discharge systems under conditions of extreme circuit oscillations ($A \leq L$).

Dmitriyev, M. T. New problems in ball
lightning. Priroda, no. 4, 1973, 60-67.

The author, a laboratory head at the Institute of General and Municipal Hygiene, Academy of Medical Sciences USSR, reports and analyzes some freshly published data on sightings of ball lightning in the USSR. The eyewitness observations of an earlier published sighting are described, and

an X-ray diffraction pattern is shown of a deposit left by the observed ball lightning on window glass. A 1972 photograph of ball lightning is reproduced and microphotometric data obtained in the author's laboratory from an earlier published photograph are given.

Analysis of the cited observations and experimental data give evidence of the internal source of ball lightning radiation and the gaseous (plasma) state of ball lightning itself. In addition, indications are that ball lightning contains a significant amount of energy. Three hypotheses on the internal energy sources are discussed: self-sustaining direct chemical oxidation of atmospheric nitrogen; nuclear reaction of atmospheric xenon; and annihilation of anti-matter particles in the Earth's atmosphere. The chemical hypothesis, advanced by V. I. Martynov, is considered highly improbable on theoretical grounds and is unsupported by experiment. The nuclear hypothesis, proposed by V. I. Arabadzhi, is more plausible theoretically, but remains to be verified. The anti-matter hypothesis of Ashby and Whitehead is considered to be scientifically important, but so far is unsupported by facts or calculations.

Bereslavskiy, V. Launching into the depths of the seas. Nedelya, no. 48, 26 Nov - 2 Dec 1973, p. 6, col. 1.

Sometime in December, the Soviet Union's newest undersea research vehicle - TINRO-2 - will undergo pilot familiarization tests in the Black Sea, followed by sea trials in the Atlantic and Indian Oceans. The two-man TINRO-2 was designed for the Ministry of Fisheries by Giprorybflot, a fisheries technology design institute headquartered in Leningrad. Although no specs data are given in the present source, previously published information attributes to TINRO-2 a 300-meter depth capability, a 2 - 4 day life-support endurance, and a 20 nautical-mile cruising range at 3 knots.

The present article states that TINRO-2 has nine view ports to accomodate photographic equipment to be used in conjunction with external fixed and rotating illuminators. Other equipment includes: a system for the sampling and rapid analysis of the ambient water; navigational and hydroacoustic equipment; containers for food and drinking water; and an air conditioning system. The tender for TINRO-2 will be the recently built R/V Ikhtiandr*. Following the tests, the vehicle will be turned over to a Soviet west coast fisheries reconnaissance organization (Zaprybpromrazvedka). This is somewhat curious since TINRO-2 was original'y ordered by the Pacific Ocean Scientific Research Institute for Fisheries and Oceanography and the vehicle even bears the Institute's acronym - TINRO. A small, blurry photo taken bow on accompanies the article.

* Selected Material from Soviet Technical Literature, June 1973, p. 161

B. Recent Selections

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10. SOURCE ABBREVIATIONS

AiT	-	Avtomatika i telemekhanika
APP	-	Acta physica polonica
DAN ArmSSR	-	Akademiya nauk Armyanskoy SSR. Doklady
DAN AzSSR	-	Akademiya nauk Azerbaydzhanskoy SSR. Doklady
DAN BSSR	-	Akademiya nauk Belorusskoy SSR. Doklady
DAN SSSR	-	Akademiya nauk SSSR. Doklady
DAN TadSSR	-	Akademiya nauk Tadzhikskoy SSR. Doklady
DAN UkrSSR	-	Akademiya nauk Ukrainskoy SSR. Dopovidi
DAN UzbSSR	-	Akademiya nauk Uzbekskoy SSR. Doklady
DBAN	-	Bulgarska akademiya na naukite. Doklady
EOM	-	Elektronnaya obrabotka materialov
FAiO	-	Akademiya nauk SSSR. Izvestiya. Fizika atmosfery i okeana
FGIV	-	Fizika gorenija i vzryva
FiKhOM	-	Fizika i khimiya obrabotka materialov
F-KhMM	-	Fiziko-khimicheskaya mekhanika materialov
FMiM	-	Fizika metallov i metallovedeniye
FTP	-	Fizika i tekhnika poluprovodnikov
FTT	-	Fizika tverdogo tela
FZh	-	Fiziologicheskij zhurnal
GiA	-	Geomagnetizm i aeronomiya
GiK	-	Geodeziya i kartografiya
IAN Arm	-	Akademiya nauk Armyanskoy SSR. Izvestiya. Fizika
IAN Az	-	Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk

IAN B	-	Akademiya nauk Belorusskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IAN Biol	-	Akademiya nauk SSSR. Izvestiya. Seriya biologicheskaya
IAN Energ	-	Akademiya nauk SSSR. Izvestiya. Energetika i transport
IAN Est	-	Akademiya nauk Estonskoy SSR. Izvestiya. Fizika matematika
IAN Fiz	-	Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya
IAN Fizika zemli	-	Akademiya nauk SSSR. Izvestiya. Fizika zemli
IAN Kh	-	Akademiya nauk SSSR. Izvestiya. Seriya khimicheskaya
IAN Lat	-	Akademiya nauk Latviyskoy SSR. Izvestiya
IAN Met	-	Akademiya nauk SSSR. Izvestiya. Metally
IAN Mold	-	Akademiya nauk Moldavskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk
IAN SO SSSR	-	Akademiya nauk SSSR. Sibirskoye otdeleniye. Izvestiya
IAN Tadzh	-	Akademiya nauk Tadzhiksoy SSR. Izvestiya. Otdeleniye fiziko-matematicheskikh i geologo-khimicheskikh nauk
IAN TK	-	Akademiya nauk SSSR. Izvestiya. Tekhnicheskaya kibernetika
IAN Turk	-	Akademiya nauk Turkmenskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh, khimicheskikh, i geologicheskikh nauk
IAN Uzb	-	Akademiya nauk Uzbekskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IBAN	-	Bulgarska akademiya na naukite. Fizicheski institut. Izvestiya na fizicheskaya institut i ANEB
I-FZh	-	Inzhenerno-fizicheskiy zhurnal

IR	-	Izobretatel' i ratsionalizator
ILEI	-	Leningradskiy elektrotekhnicheskiy institut. Izvestiya
IT	-	Izmeritel'naya tekhnika
IVUZ Avia	-	Izvestiya vysshikh uchebnykh zavedeniy. Aviatsionnaya tekhnika
IVUZ Cher	-	Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya
IVUZ Energ	-	Izvestiya vysshikh uchebnykh zavedeniy. Energetika
IVUZ Fiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Fizika
IVUZ Geod	-	Izvestiya vysshikh uchebnykh zavedeniy. Geodeziya i aerofotos"yemka
IVUZ Geol	-	Izvestiya vysshikh uchebnykh zavedeniy. Geologiya i razvedka
IVUZ Gorn	-	Izvestiya vysshikh uchebnykh zavedeniy. Gornyy zhurnal
IVUZ Mash	-	Izvestiya vysshikh uchebnykh zavedeniy. Mashinostroyeniye
IVUZ Priboro	-	Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye
IVUZ Radioelektr	-	Izvestiya vysshikh uchebnykh zavedeniy. Radioelektronika
IVUZ Radiofiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika
IVUZ Stroi	-	Izvestiya vysshikh uchebnykh zavedeniy. Stroitel'stvo i arkhitektura
KhVE	-	Khimiya vysokikh energiy
KiK	-	Kinetika i kataliz
KL	-	Knizhnaya letopis'
Kristall	-	Kristallografiya
KSpF	-	Kratkiye soobshcheniya po fizike

LZhS	-	Letopis' zhurnal'nykh statey
MiTOM	-	Metallovedeniye i termicheskaya obrabotka materialov
MP	-	Mekhanika polimerov
MTT	-	Akademiya nauk SSSR. Izvestiya. Mekhanika tverdogo tela
MZhiG	-	Akademiya nauk SSSR. Izvestiya. Mekhanika zhidkosti i gaza
NK	-	Novyye knigi
NM	-	Akademiya nauk SSSR. Izvestiya. Neorganicheskiye materialy
NTO SSSR	-	Nauchno-tekhnicheskiye obshchestva SSSR
Os	-	Optika i spektroskopiya
OMP	-	Optiko-mekhanicheskaya promyshlennost'
Otkr izobr	-	Otkrytiya, izobreteniya, promyshlennyye obratzы, tovarnyye znaki
PF	-	Postepy fizyki
Phys abs	-	Physics abstracts
PM	-	Prikladnaya mekhanika
PMM	-	Prikladnaya matematika i mekhanika
PSS	-	Physica status solidi
PSU	-	Pribory i sistemy upravleniya
PTE	-	Pribory i tekhnika eksperimenta
Radiotekh	-	Radiotekhnika
RIE	-	Radiotekhnika i elektronika
RZhAvtom	-	Referativnyy zhurnal. Avtomatika, telemekhanika i vychislitel'naya tekhnika
RZhElektr	-	Referativnyy zhurnal. Elektronika i yeye primeneniye

RZhF	-	Referativnyy zhurnal. Fizika
RZhFoto	-	Referativnyy zhurnal. Fotokinotekhnika
RZhGeod	-	Referativnyy zhurnal. Geodeziya i aeros"- yemka
RZhGeofiz	-	Referativnyy zhurnal. Geofizika
RZhInf	-	Referativnyy zhurnal. Informatics
RZhKh	-	Referativnyy zhurnal. Khimiya
RZhMekh	-	Referativnyy zhurnal. Mekhanika
RZhMetrolog	-	Referativnyy zhurnal. Metrologiya i izmer- itel'naya tekhnika
RZhRadiot	-	Referativnyy zhurnal. Radiotekhnika
SovSciRev	-	Soviet science review
TiEKh	-	Teoreticheskaya i eksperimental'naya khimiya
TKiT	-	Tekhnika kino i televideniya
TMF	-	Teoreticheskaya i matematicheskaya fizika
TVT	-	Teplofizika vysokikh temperatur
UFN	-	Uspekhi fizicheskikh nauk
UFZh	-	Ukrainskiy fizicheskii zhurnal
UMS	-	Ustalost' metallov i splavov
UNF	-	Uspekhi nauchnoy fotografii
VAN	-	Akademiya nauk SSSR. Vestnik
VAN BSSR	-	Akademiya nauk Belorusskoy SSR. Vestnik
VAN KazSSR	-	Akademiya nauk Kazakhskoy SSR. Vestnik
VBU	-	Belorusskiy universitet. Vestnik
VNDKh SSSR	-	VNDKh SSSR. Informatsionnyy byulleten'
VLU	-	Leningradskiy universitet. Vestnik. Fizika, khimiya
VMU	-	Moskovskiy universitet. Vestnik. Seriya fizika, astronomiya

ZhETF	-	Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhETF P	-	Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhFKh	-	Zhurnal fizicheskoy khimii
ZhNiPFiK	-	Zhurnal nauchnoy i prikladnoy fotografii i kinematografii
ZhNKh	-	Zhurnal neorganicheskoy khimii
ZhPK	-	Zhurnal prikladnoy khimii
ZhPMTF	-	Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki
ZhPS	-	Zhurnal prikladnoy spektroskopii
ZhTF	-	Zhurnal tekhnicheskoy fiziki
ZhVMMF	-	Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki
ZL	-	Zavodskaya laboratoriya

8. AUTHOR INDEX

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