AD-776 086

SELECTED MATERIAL FROM SOVIET TECHNICAL LITERATURE, NOVEMBER, 1973

Stuart G. Hibben

Informatics, Incorporated

Prepared for:

Air Force Office of Scientific Research
Advanced Research Projects Agency

16 January 1974

AD776 086

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November, 1973

Sponsored by

Advanced Research Projects Agency

ARPA Order No. 1622-4

January 16, 1974

ARPA Order No. 1622-4
Program Code No: 62701E3F10
Name of Contractor:
Informatics Inc.
Effective Date of Contract:
January 1, 1973
Contract Expiration Date:
December 31, 1973
Amount of Contract: $343,363

Contract No. F44620-72-C-0053, P00001
Principal Investigator:
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Klaus Liebhold
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Short Title of Work:
"Soviet Technical Selections"

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by the Air Force Office of Scientific Research under Contract No. F44620-72-C-0053. The publication of this report does not constitute approval by any government organization or Informatics Inc. of the inferences, findings, and conclusions contained herein. It is published solely for the exchange and stimulation of ideas.

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127

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFOSR - TR - 74 - 0362	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Selected Material from Soviet Technical Literature November, 1973		5. TYPE OF REPORT & PERIOD COVERED Scientific---Interim
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Stuart G. Hibben		8. CONTRACT OR GRANT NUMBER(s) F44620-72-C-0053
9. PERFORMING ORGANIZATION NAME AND ADDRESS Informatics Inc. 6000 Executive Boulevard Rockville, Maryland 20852		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS ARPA Order No. 1622-4 Program Code No. 62701E3F10
11. CONTROLLING OFFICE NAME AND ADDRESS Advance Research Projects Agency/STO 1400 Wilson Blvd. Arlington, Virginia 22209		12. REPORT DATE January 16, 1974
		13. NUMBER OF PAGES - 122 -
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) AF Office of Scientific Research/NP 1400 Wilson Blvd. Arlington, Virginia 22209		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Scientific--Interim

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

High Power Lasers
Explosion Effects
Particle Beams
Material Sciences

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report includes abstracts and bibliographic lists on contractual subjects that were completed in November, 1973. The major topics are: Laser technology, particle beams, and material sciences. A section on items of miscellaneous interest is included as an optional topic.

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

INTRODUCTION

This report includes abstracts and bibliographic lists on contractual subjects that were completed in November, 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.

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

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

TABLE OF CONTENTS

I. Laser Technology

A. Abstracts

Uglov, A. A., and A. N. Kokar. Various effects during metal solidification in laser radiation interaction zones. FiKhOM, no. 3, 1973, 12-16.

The authors consider several theoretical factors governing wave motion on the melt surface of a laser-irradiated metal, as well as factors determining re-solidification of the melt zone. The problem may be treated as one-dimensional, since the melt depth is typically very small compared to the melt zone diameter. It is further assumed that superheat conditions do not apply, and that at the end of the laser pulse a uniform temperature exists throughout the melt. Then the solidification rate may be expressed by

$$v_m = b(a/\tau)^{1/2} \tag{1}$$

where the constant b is a root of the equation

$$C(t_m - t_0)L^{-1}\pi^{-1/2} = b\exp(b^2) \ . \tag{2}$$

Here C = specific heat, L = heat of fusion, t_m = melt temperature, and t_o = initial temperature of the metal. Eqs. (1) and (2) together with an expression for melt depth coordinate are used to show that with iron, for example (b = 0.75), solidification occurs in the order of a millisecond, for a melt depth of a few hundred microns.

The study also examines the surface capillary wave propagation resulting in the typical ring formations seen in Fig. 1.

Fig. 1. Concentric ring pattern in solidified metal following irradiation from a quasistationary laser.

Factors governing the wave pattern include recoil pressure from vaporization, laser optical pressure, heat convection in the melt and other effects. Theoretical expressions are confirmed by experiment, showing that viscosity rate relative to hardening rate varies, yielding the wave pattern toward the periphery but leaving the center region smooth, as the figure shows.

Poltavtsev, Yu. G., V. P. Zakharov, I. M. Protas, T. V. Remizovich and V. N. Chugayev. Investigating the molecular composition of the vapors and structure of a condensate during sputtering of some arsenic chalcogenides by laser emission. UFZh, no. 5, 1973, 752-755.

Mass spectrometric investigations of the molecular composition of crystalline As_2S, $AsSe_3$ and AsSe vapors, based on interaction of a focused laser beam and these materials, and the results of electron-diffraction investigations of the structure of condensed films are reported. It was found that molecules containing atoms of different types are primarily evaporated, whereas molecules containing more than four atoms are rarely found. The structural maxima on the curve of radial distribution of atoms in an amorphous film of As_2Se_3 are found at $r_1 = 2.2$ Å, $r_2 = 3.3$Å, $r_3 = 4.5$Å and $r_4 = 5.5$Å; the maxima in an amorphous film of As_2Se_3 are found at $r_1 = 2.0$Å, $r_2 = 3.15$Å and $r_3 = 4.6$Å; and the structural maxima in amorphous film of AsSe are found at $r_1 = 2.4$Å and $r_2 = 3.65$Å. It is concluded that the molecular composition of vapors has considerably less effect on the kinetics of formation of the film structure of the investigated materials than the processes of interatomic interactions on the substrate.

Zhiryakov, B. M., N. N. Rykalin, A. A. Uglov and A. K. Fannibo. Laws governing material ejection from a laser radiation interaction zone. IN: Sb. Kvantovaya elektronika, no. 1(13), 1973, 119-121.

The specific ejection of material M/E is calculated experimentally as a function of the flux density q of a quasi-stationary laser pulse,

which permits qualitative interpretation of the results from different positions. Graphs of the dependence of $M/E = f(q)$ in the range of flux densities close to threshold values for $q = (1\text{-}6) \times 10^6$ w/cm^2 are presented in Fig. 1.

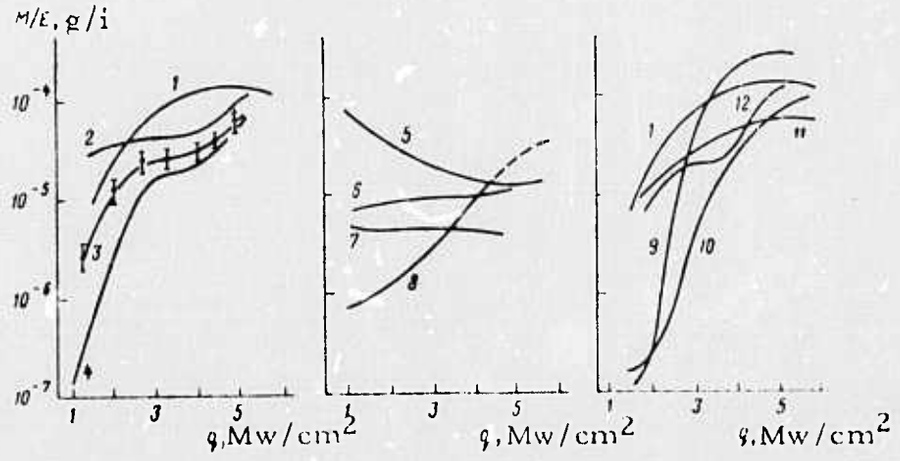

Fig. 1. Dependence of specific ejected mass M/E on flux density of a quasi-stationary laser pulse, q: 1 - brass; 2 - black copper; 3 - anodic copper; 4 - cathodic copper; 5 - carbon; 6 - germanium; 7 - chromium; 8 - silver; 9 - zirconium; 10 - Duralumin D16; 11 - gray iron; 12 - type St3 steel.

The results show that the value of specific material ejection for germanium and chromium hardly changed over the entire investigated range of flux densities, but that the graphs for all the remaining materials essentially have curves with a maximum, although their detailed behavior in the range of high flux densities was not determined. The authors conclude that the process is primarily similar to that of ejection of the liquid phase of electrode materials during an electrical discharge, when intensive vaporization of electrodes after completion of the discharge is accompanied by a rapid decrease of surface temperature, a sharp drop of reactive pressure, and development of internal superheating, at which the maximum temperature coordinate recedes inside the electrode, thus creating conditions for thermal explosion.

Zakharov, V. P., and I. M. Protas. Modifying a spark mass spectrometer with double focusing for studying the interaction of laser radiation with solids. PTE, no. 3, 1973, 162-165.

A high-resolution mass spectrometer with double focusing, integral recording of a wide ranging mass spectrum, and a high accelerating voltage is introduced as a substitute for time-of-flight mass spectrometer in the study of interaction of high power laser pulses with a solid. The mass spectrometer described is a modification of a standard apparatus, and is designed to minimize limitations inherent in time-of-flight devices. Ions are produced by $\sim 10^7$ w/cm^2 pulses from a free-running ruby laser and are accelerated by a 20 kV electric field. Resolution of the instrument is 1150 at a 50% level. Sensitivity of isotope determination is 1-3/A at.%, where A is the isotope abundance. The average maximum error estimated from the mass spectra of nickel ferrite is 24%; the average relative error is 8% in comparison with the literature data. The cited example of nickel ferrite analysis shows a high efficiency of the modified mass spectrometer in studies of laser radiation interaction with solids.

Karlov, N. V., N. A. Karpov, Yu. N. Petrov, and O. M. Stel'makh. Dissociation and illumination of a multilevel molecular gas caused by powerful CO_2 laser radiation. ZhETF, v. 64, no. 6, 1973, 2008-2016.

A study is reported on the interaction between intense infrared radiation and resonantly absorbing gases. A cascade radiation-collision mechanism is discussed of the vibrational excitation of a molecular

resonance system, which leads to the dissociation and illumination of the gases. Propagation of radiation in the medium is followed by illumination, dissociation and recombination waves. Experiments were conducted with the interaction of 10.6 μ radiation with BCl_3 and SF_6 gases. A 600 watt CO_2 laser was used operating in a quasicontinuous regime. Pulse radiation had an approximately square waveform. The radiation was collimated into a narrow parallel beam of 2 mm diameter practically uniform in cross-section. A calibrated barium titanate receiver was placed in the vessel with the tested gas, and intensity of the transmitted laser radiation in the gas was measured at distances from 0 to 6 cm. Measurements of the absorption were made at pressures from 0.01 to 1 atm.

Intensity curves drawn for transmitted radiation as a function of gas layer thickness are shown in Fig. 1. The experiments enabled

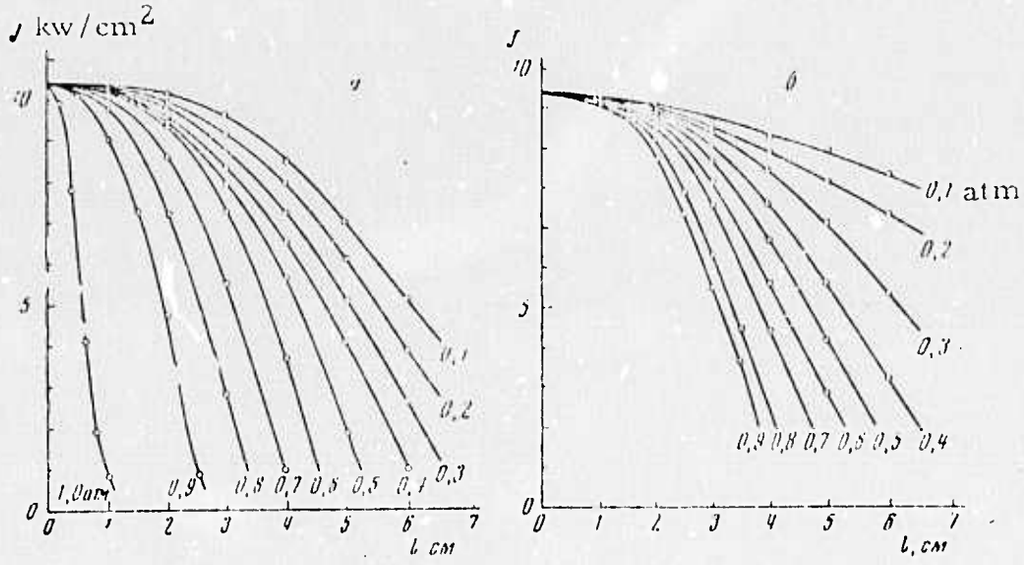

Fig. 1. Relationship of the intensity of transmitted 10.6 μ radiation as a function of gas layer thickness: a) BCl_3, b) SF_6 (J_o = 10.4 kw/cm², S = 0.05 cm², pressures 0.1 to 1.0 atm).

calculation of the characteristic time of transmitting excitations in a cascade process in the above gases, and evaluation of the distribution of molecule population according to vibration level and the dissociation degree, which equalled 97-99% at irradiation intensities ~10 kw/cm^2. Relationships were determined of the illumination wave propagation velocities as a function of irradiation intensities; it was noted that stable illumination occurs when practically all molecules are dissociated.

Askar'yan, G. A., and N. M. Tarasova.
Investigating passage of SHF radiation and current through a metallized film, evaporated by laser flare (pulse window for SHF). Generation and use of the steep fronts of SHF radiation.
ZhETF P, v. 18, no. 1, 1973, 8-10.

A laser evaporation technique for fast gating of an r-f signal is described. Fig. 1 shows the experimental arrangement. A

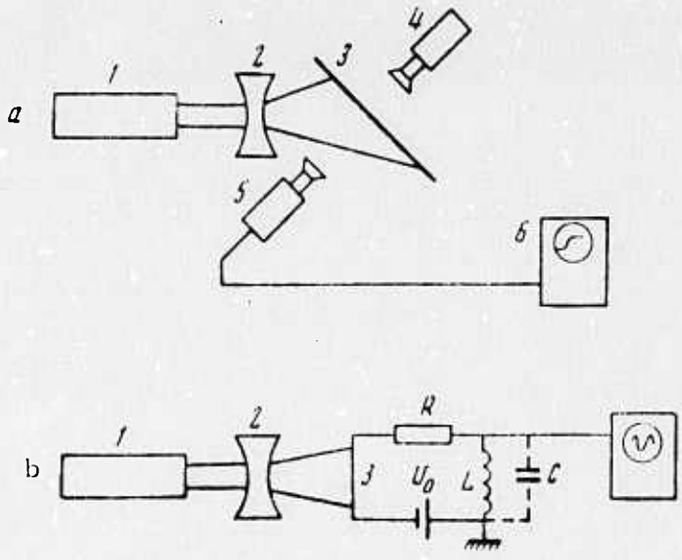

Fig. 1. Laser gating experiment.
1- Nd glass laser; 2- defocusing lens;
3- metallized film; 4- r-f transmitter;
5- receiver; 6- scope.

Q-switched Nd glass laser was used with a nominal 20 ns pulse width at 5 joules, developing a spot on a metallized polymer film from 1.5 to 5 cm in diameter. An r-f signal applied normal to the film (λ = 1 cm) was blocked until the laser evaporated metal from the focus spot, thus generating a window in the order of 1--10 nsec. Detection tests (Fig. 1b) showed that the gated r-f field did in fact have a rise time on the order of 10 nsec.

Developing such sharp r-f gradients suggests some interesting possibilities which the authors mention briefly. These include controlled movement of electrons in a plasma, where the acting force is a function of field gradient given by

$$f = -\frac{e^2}{m\omega^2} \nabla(E^2)_{av} \quad , \tag{1}$$

and development of quasistationary magnetic fields in a plasma.

Buzhinskiy, I. M., A. Ye. Pozdnyakov, and S. A. Ushakov. Dependence of the destruction threshold of F8 glass on irradiated surface diameter. OMP, no. 5, 1973, 69-70.

Tests to find the correlation between threshold intensity and spot size in laser breakdown of glass are described. Earlier tests showed that the relation $Q_{thres} \sim d^{-m}$ holds true at least over a limited range of small spot diameters; here Q is in j/mm^2, d is effective diameter of the surface spot, and m is a constant close to unity. A constant pulse width is assumed.

The present authors tested this relation over wider ranges of energy density and spot sizes, using an Nd glass laser focused on polished specimens of type F8 glass. The criterion of threshold breakdown is not mentioned, but in any case the results generally confirm the validity of $Q \sim d^{-m}$ as shown in Fig. 1. This suggests that the relation may be a

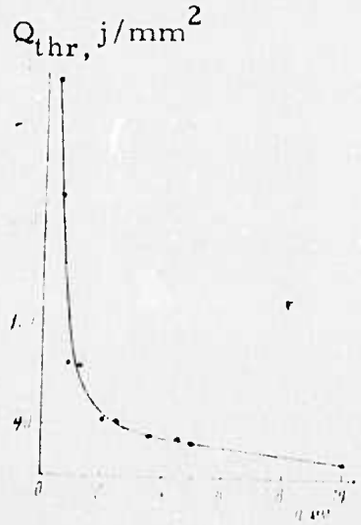

Fig. 1. Q_{thres} vs. spot diameter.

general law for all such interaction cases.

Buravl'ov, Yu. M., B. P. Nadezhda, and I. O. Novokhats'kiy. Some characteristics of the effect of laser radiation on metals. IN: Fiz. tverdogo tela. Res. mezhved. temat. nauchn.-tekhn. sb., no. 2, 1972, 87-90. (RZhF, 5/73, no. 5D1054). (Translation)

Characteristic effects of focused laser interaction with various metals are examined. It is shown that erosion from the target

metal is a complex function of its thermophysical properties. The data obtained are examined from the point of view of using lasers for localized spectral analysis of metals and alloys.

Arifov, U. A., M. R. Bedilov, T. G. Tsoy, D. Kuramatov, and A. Ibragimov. Discharge stimulated by a laser plasma. DAN UzSSR, no. 10, 1972, 120-122. (RZhF, 5/73, no. 5G121). (Translation)

Tests are described in which giant laser pulses were focused on the surface of a tungsten target. The ensuing discharge between the target and a collector, spaced 5 mm from it, was observed. Laser pulse density was 10^{11} w/cm^2, test chamber pressure was 760, 10^{-3} and 10^{-6} torr, and field gradient between target and collector was varied from E = (-)3 to +3 kv/cm. At E < 1.2 kv/cm, no discharge occurred. Only a sharp peak of electron or ion current was observed in the target-collector circuit, equal in duration to the laser pulse width. At higher field gradients a discharge developed, with a current that lagged the laser pulse by up to 2 μsec. In all cases the voltage-current characteristic showed saturation at currents over 10 a. Discharge was accompanied by intense radiation in the visible and u-v ranges. Mean crater diameter on the target was 0.1 mm.

Kaliski, S. Average equations of deuterium-tritium plasma compression due to laser explosion with a heavy cloud ablation, taking nuclear fusion energy into account. Biul. WAT J. Dabrowskiego, v. 21, no. 12, 1972, 11-12. (RZhF, 5/73, no. 5G234)

Solutions are given of averaged equations for the integral self-similar problem defining concentrated laser compression of a D-T plasma, generated by laser explosion of a heavy shell. A Fermi liquid model is taken to apply to the D-T pellet; the shell is modelled as an ideal two-temperature gas. The method of laser compression of a plasma is presented as a new step toward realization of microsynthesis reactions; it permits a reduction in critical level of laser energy, in comparison with other techniques. The derived equations, accounting for laser pulse energy and nuclear fusion yield, are solvable by computer.

Kaliski, S. Numerical analysis of averaged equations of laser concentrated plasma cumulation, taking into account nuclear fusion energy. IN: ibid., 3-9. (RZhF, 5/73, no. 5G233). (Translation)

Numerical solutions obtained by analog computer are given which define the intense compression of a plasma, obtained by laser explosion of a solid shell target. A simplified solution is presented in which the interaction with the shell is treated in terms of the initial velocity of a given mass of D-T plasma. A complete solution of the problem may be given based on more generalized equations of integral probability for the assumed model.

Kaliski, S. Conductivity-type laser heating of a nonhomogeneous plasma. Bull. Acad. pol. sci. Ser. sci. techn., v. 20, no. 12, 1972, 963-967. (RZhF, 5/73, no. 5G235). (Translation)

A generalized pulse method is applied here to thermally conductive heating of a nonuniform plasma, obtained from laser-target interaction. A general solution is obtained for nonuniform case, and a closed analytical solution is given. This method can also be applied to solve the problem of a spherical or cylindrical thermal wave, accounting for energy released in the plasma in the course of a thermonuclear reaction ; it applies also for the case in which ion and electron temperature differ (two temperature plasma). In the latter case, however, a closed solution cannot be obtained.

Afanas'yev, A. A., V. S. Burakov, and S. V. Nechayev. Resonance interaction of a laser radiation with potassium plasma. DAN BSSR, v. 17, no. 8, 1973, 702-705.

In connection with potential utilization of lasers in long distance communications and development of new methods of plasma diagnostics, experimental data are presented on spectral and spatial changes in a high power (1-3 Mw/cm^2) laser beam of a narrow ($\Delta\nu_o$ = 8-15 cm^{-1}) spectral range propagating through a low-temperature (5500° K) potassium plasma. A tunable liquid organic laser was used in most experiments. The incident beam divergence was $\theta_i = 8 \times 10^{-3}$ rad and pulse duration was 20-30 nsec.

The most important spectral changes in radiation from the effect of plasma were observed at the incident frequency ν_o in the vicinity of the $4S_{1/2} - 4P_{3/2}$ (ν_1) and $4S_{1/2} - 4P_{1/2}$ (ν_2) resonance transitions of potassium. The changes consisted of deformation of the spectral contour with shifting of the emission peak toward increasing frequency difference $|\nu_o - \nu_{1,2}|$. Spatial changes were reflected in an increased beam divergence at ν_1 with maximum $\theta_{ex}/\theta_i \geq 2$ attained at a 50 cm^{-1} distance from the $4S_{1/2} - 4P_{3/2}$ resonance. Spectral changes versus the incident power (5-7 Mw/cm^2) were observed in the experiments with the first Stokes component of the stimulated Raman scattering in nitrobenzene. The observed effects are interpreted in terms of spectrum broadening due to the phase-amplitude conversion of modulation and parametric interaction of different waves, combined with a strong selective absorption by the relatively dense plasma ($N = 10^{17}$ cm^{-3}).

Bel'skiy, A. M., and A. P. Khapalyuk.
Reflection of a laser beam from the interface of isotropic dielectrics. OiS, v. 35, no. 1, 1973, 117-119.

Reflection of a Gaussian-Hermitian polarized beam from the interface of two media with refractive indices n_1 and n_2 is analyzed, with the vector characteristic of the incident beam field taken into account. Only a TEM_{mq} mode is present in the incident beam. Using a Fourier transform of the incident beam field, approximate formulas are derived for transverse components of the reflected beam field. The formulas show that $TEM_{mq \pm 1}$ modes are present in the reflected beam output, in addition to the earlier obtained TEM_{mq} and $TEM_{m \pm 1, q}$ modes. The presence of $TEM_{m, q \pm 1}$

modes is correlated exclusively with the vector characteristic of the incident field.

The derived formulas make it possible to determine the reflected beam structure at any polarization. Using these formulas, the authors express the power conversion factors r_{mq}, $r_{m \pm 1,\, q}$, and $r_{m,\, q \pm 1}$ as functions of the angle of incidence θ_o and the Fresnel reflection factor. The $r_{m,\, q \pm 1}(\theta_o)$ dependence exhibits a peak at θ_o in the vicinity of the Brewster angle, and decreases to zero at a normal or a glancing θ_o. The $r_{m \pm 1,\, q}$ factors increase continuously with increase in θ_o. The $r^p_{m+1,\, q}$ and $r^p_{m,\, q+1}$ factors are calculated in the most important case of a p-polarized laser beam incident at the Brewster angle ($\mathrm{tg}\ \theta_o = n_2/n_1$), because in this case the fundamental TEM_{mq} mode is absent in the reflected beam.

B. Recent Selections

i. Beam Target Effects

Bayev, V. M., A. N. Savchenko, and E. A. Sviridenkov. Issledovaniye proboya rubina tsugom i odinochnymu ultrakorotkimi impul'sami (Studying breakdown in ruby by a pulse train and isolated ultrashort pulses). Moskva, 1973, 16 p. (KL Dop vyp, 10/73, no. 20430).

Bystrova, T. V., V. B. Librovich, and V. I. Lisitsyn. Elements of combustion theory in gas laser cutting of metals. FGiV, no. 5, 1973, 725-732.

Garashchuk, V. P., N. L. Kareta, I. V. Molchan, and V. E. Moravskiy. Band structure in the strengthening action of a laser beam on silicon iron single crystals. FiKhOM, no. 5, 1973, 113-116.

Ivlev, Ye. I. Action of pulsed laser radiation on an absorbing receiver. TVT, no. 5, 1973, 1025-1030.

Karasev, I. G., and V. M. Kirillov. Possibility of improving laser effectiveness in metal processing. FiKhOM, no. 5, 1973, 3-9.

Kask, N. Ye., L. S. Korniyenko, G. M. Fedorov, and D. B. Chopornyak. Dependence of destruction threshold of laser glass on dimensions of nonmetallic inclusions. OMP, no. 10, 1973, 61-62.

Medvedev, Yu. A., and V. D. Khokhlov. Criteria of shock wave excitation and its intensity during explosion in a rarefied gas. ZhPMTF, no. 5, 1973, 48-51.

Mezokh, Z. I., L. I. Ivanov, V. A. Yanushkevich, and L. D. Dobychina. Behavior of n-Ge under the action of giant laser pulses at 77° K. FiKhOM, no. 5, 1973, 10-14.

Novikov, N. P. Self-oscillating character of laser crack propagation. Mekhanika polimerov, no. 5, 1973, 923-925.

Petukhova, T. M. Device for studying emission during laser interaction. IN: Tr. Ural'sk. politekhn. in-ta., sb. 215, 1973, 85-88. (RZh Radiot, 8/73, no. 8Ye217)

Romanov, G. S., and V. K. Pustovalov. Heating and evaporation of spherical particles under monochromatic radiation. ZhTF, no. 10, 1973, 2163-2168.

Volod'kina, V. L., K. I. Krylov, and M. N. Libenson. Heating of metals by CO_2 laser radiation in an oxidizing atmosphere. FiKhOM, no. 5, 1973, 145-146.

Vuntsevich, I. L., O. Ye. Marin, N. F. Pilipetskiy, and V. A. Upadyshev. Laser crack profile in polymethylmethacrylate. Mekhanika polimerov, no. 5, 1973, 921-923.

ii. Beam-Plasma Interaction

Aksenov, V. A., V. M. Yeroshenko, A. A. Mushinskiy, and L. N. Pyatnitskiy. A device for recording spectra of the light scattering by plasma, using mechanical scanning. PTE, no. 5, 1973, 210-213.

Boykov, V. A., Yu. A. Drozhbin, S. M. Zakharov, et al. Issledovaniya neytronnogo vykhoda, rentgenovskogo izlucheniya i skorostnaya interferometriya lazernoy plazmy pri potokakh nagrevayushchego izlucheniya $\sim 10^{14}$ vt/cm^2. (Studying neutron output, x-ray radiation and the high-speed interferometry of a laser plasma at heating radiation fluxes $\sim 10^{14}$ w/cm^2). Moskva, 1973, 48 p. (RZhF, 10/73, no. 10G262).

Gribkov, V. A., V. M. Korzhavin, O. N. Krokhin, V. Ya. Nikulin, G. V. Sklizkov, N. V. Filippov, and T. I. Filippova. Eksperimental'nyye issledovaniya kumulyativnykh yavleniy v plazme. (Experimental study of cumulative phenomena in plasma). 5th Eur. Conf. Contr. Fusion and Plasma Phys., Grenoble, 1972, v. 1. Grenoble, s. a., 64 p. (RZhF, 10/73, no. 10B97)

Jach, K., S. Kaliski, and R. Swierczynski. Numerical analysis of averaged equations of the laser compression of a D-T pellet with an envelope. Biul. WAT J. Dabrowskiego, v. 22, no. 5, 1973, 17-37. (RZhF, 10/73, no. 10G258)

Kotsubanov, V. D., A. Ya. Leykin, and O. S. Pavlichenko. On increasing the effectiveness of laser applications in experiments on light scattering in plasma. IN: Fiz. plazmy i probl. upravl. termoyader. sinteza. Resp. mezhved sb., no. 4, 1973, 208-212. (RZhF, 10/73, no. 10G64).

Rupasov, A. A., G. V. Sklizkov, V. P. Tsapenko, and A. S. Shikanov. Issledovaniye otrazheniya lazernogo izlucheniya ot plotnoy plazmy. (Studying the reflection of laser radiation from a dense plasma). Moskva, 1973, Part 1, 22 p. (KL Dop vyp, 10/73, no. 20418).

2. Effects of Strong Explosions

A. Abstracts

Andreyev, A. F., and A. E. Meyerovich. The structure of shock waves. ZhETF, v. 64, no. 5, 1973, 1640-1652.

The problem of determining the structure of a plane stationary shock wave in an arbitrary liquid or gas at a great distance from the front is treated mathematically, using a coordinate system in which the wave front is stationary. The z-axis is normal to the front and its positive direction coincides with direction of the fluid velocity. It is shown that, at a sufficiently great distance z from the front, all hydrodynamic parameters (fluid velocity, density, pressure, etc.) approach their equilibrium values following a $z^{-3/2}$ law. Such a slow decrease of hydrodynamic parameters, regardless of how powerful the shock wave is, and in an arbitrary fluid, results from the allowance made for long-wave hydrodynamic fluctuations. In the vicinity of a shock front, the thermal fluctuations are nonequilibrium (reflected and refracted) and dissipate very slowly, because their mean free path is arbitrarily long.

The bulk of the study is devoted to calculation of the coefficients of the $z^{-3/2}$ law. The coefficients are expressed through thermodynamic parameters and kinetic coefficients of the medium. In the final form, all mean square fluctuations of hydrodynamic parameters are equal to the product of $z^{-3/2}$ and complex integrals of the functions which contain the coefficients of incident wave transformation into entropy, sound, or vortex waves.

Deribas, A. A. Certain phenomena occurring during high-speed collision of solids. FGiV, no. 2, 1973, 268-281.

Certain phenomena observed recently by different authors during glancing collision of metals at a small angle, such as in explosion welding, are described and their theoretical model is discussed. The phenomena described are formation of periodical waves, including sinusoidal waves without vortex formation; metal deformation outside the wave formation region; and disappearance of the cumulative metal jet. An inability to explain these phenomena in the framework of hydrodynamic theory of cumulation has led to different theories, which are described.

Godunov's theories, based on the concept of collision between ideal compressible liquid jets, are expanded by the author to explain wave generation as a self-oscillating process. Oscillator frequency and wavelength are calculated. Energy release in the surface layer is assumed to sustain undamped self-oscillations which generate waves; also calculations support the role of viscous flow in metal deformation from collision. The fact of disappearance of the cumulative jet at a small collision angle is explained in terms of viscosity forces, and criteria are developed for jet formation. Some methods are discussed of developing a mathematical model for the described phenomena. A set of equations developed by Godunov and Romenskiy for a nonlinear continuum is believed to offer one possibility to investigate more thoroughly the described phenomena, when the necessary experimental data are obtained.

Baykov, A. P., V. A. Belago, A. M. Iskol'dskiy, L. S. Gerasimov, and Ya. Ye. Nesterikhin. Studying the electrical explosion of foils. FGiV, no. 2, 1973, 286-291.

Experiments are described on electric explosion of 10^{-3} cm thick aluminum foils from discharge at 10^7 - 10^8 a/cm^2 current densities across the foil before its explosion in air. The experiments were designed to determine conditions of a uniform electric explosion, and the feasibility of practical use of foils as distributed detonators.

In the experiments, foil dimensions and LC circuit parameters were selected in agreement with the experimental data previously reported by Baykov et al (cf. June 1973 Report, p. 24). On the basis of an oscilloscope trace, frame photographic and chronographic recordings and x-ray photography of the explosion process, three regions corresponding to different explosion phases were detected on the plots of the foil relative resistance R/R_o versus the input energy W. Luminescence intensity of the exploding foil peaks in the second phase and partly at the onset of the third phase. The uniformity of luminescence along an exploding foil, together with the plane shock wave configuration, suggest a fairly uniform surface temperature distribution and the absence of MHD instabilities during the first two explosion phases. An interferometric study of configuration of the shock waves generated in the second phase under different conditions indicated the possibility of using exploding foils for generation of plane and cylindrical shock waves. The fact that w in the experiments (= 7 kj/g) was larger than the energy content ~4 kj/g of the usual explosives confirms the conclusion that exploding foil may be used as a distributed detonator.

Baykov, A. P., A. Ye. Voytenko, A. M. Iskol'dskiy, and Yu. Ye. Nesterikhin. Initiation of explosion along the charge surface. FGiV, no. 2, 1973, 323-325.

The experiments reported briefly by Baykov et al in the foregoing paper are described here in more detail. Detonation of low-density RDX charges of different thickness and geometry was initiated by electric explosion of aluminum foil in contact with the charge. The foil explosion from discharge of a capacitor battery at 35 kv and a 3×10^5 a peak current was recorded by means of a moving-image camera. Foil dimensions and discharge circuit parametes were selected as indicated in the previous report.

Emergence of a detonation wave on the free charge surface was delayed up to 7 μsec, depending on the charge thickness. The front propagation velocity increased gradually at increasing distances from the foil up to 6.6 km/sec (the normal RDX detonation velocity), at a distance over 20 mm from the foil. Detonation of all RDX charges was stable. A chronophotograph of a step-shaped charged detonation is shown. It is concluded that the described method of detonation initiation can be applied as well to an arbitrary cylindrical surface and to surfaces of arbitrary geometry, provided the busbar connections and foil geometry are selected to insure a uniform current density over the foil.

Spivak, A. A. Compression waves in a solid medium from detonation of an explosive charge in air. FGiV, no. 2, 1973, 263-268.

Measurements are described of compression wave parameters in the initial and subsequent periods of explosion of spherical TEN charges in air cavities with different dimension $\xi = R_c/R_o$, where R_c and R_o are the radii of the air cavity and the charge, respectively. The spherical air cavities of R_c = 1-2 cm were made in fused sodium thiosulfate blocks. TEN charges of R_o = 0.3-0.5 cm were detonated in the cavities and the mass velocity v of the compression wave was measured by an electromagnetic method. Oscilloscope traces of v show several consecutive compression phases. Percentage wise the first compression phase contributes the most to the maximum displacement u of medium particles. The first phase shortens with the increase in R_c. At ξ = 1.5-4, damping of the first peak v_1 is stronger at a reduced distance $r_o < r_*$ from the explosion center than at $r_o > r_*$, where r_* is a function of ξ. The outer boundary of demolition zone is $r_o = r_*$. Attenuation of the explosion effect is maximum at ξ = 3.

The second peak v_2 is delayed by $\Delta\tau$ with respect to v_1; the magnitude of $\Delta\tau$ increases with the increase in R_c. The $v_1(r_o)$, $v_2(r_o)$, and $u(r_o)$ functions are calculated for ξ = 1.5-6.7. It is shown that detonation product effect is the factor determining wall velocity v_w of the cavities with $R_c < 3R_o$, while reflections of the air shock wave determine v_w of cavities with $R_c > 3R_o$.

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3. Geoscience

A. Abstracts

Zvyagintsev, L. I. Anisotropy of elastic properties of rocks in a stressed state. IN: AN SSSR. Izvestiya. Seriya geologicheskaya, no. 6, 1973, 46-53.

Elastic anisotropy of rock samples was investigated under confined pressure up to 4000 kg/cm^2 and axial compression up to 1/3 of the rocks' compressive strength. The results are shown in Tables 1 and 2.

Table 1. Anisotropy V_{py}/V_{pz} Under Confined Pressure*

Sample	Pressure, kg/cm^2				
	1	500	1000	2000	4000
Quartzitic sandstone	1.04	1.02	1.01	1.01	1.0
Marble	1.19	1.11	1.03	1.01	1.0
Pellitic limestone	0.92	0.96	0.96	0.98	0.98
Sandstone	1.05	1.05	1.05	1.05	1.05
Granodiorite	0.99	0.95	0.95	0.95	0.95
Calcareous dolomite	1.02	0.9	0.86	0.8	0.76

* y-axis parallel to the dip of strata, z-axis perpendicular to strata.

Table 2. Anisotropy V_{pA}/V_{pC} Under Uniaxial Compression*

Sample	Pressure, kg/cm^2							
	1	100	200	250	300	400	500	750
Quartz diorite	0.95	0.95	0.89	-	0.93	0.92	0.94	
	1.03	1.0	0.99	-	0.97	0.97	0.97	
Sandstone	0.90	0.94	0.94	-	0.95	0.94	0.91	
Pellitic limestone	1.04	1.02	-	1.0	-	-	1.00	0.98

It is concluded that there exist two types of elastic anisotropy of rocks - one under atomospheric pressure (constant) and the other under high pressure (variable). In many cases, elastic anisotropy under high pressure has a sign opposite the one under atmospheric pressure ($A < 1$ - negative and $A > 1$ - positive), or anisotropy vanishes.

Krauklis, P. V., and N. V. Tsepelev. Near-surface waves in a heterogeneous medium with an arbitrary smooth surface. IN: AN SSSR. Izvestiya. Zemli, no. 5, 1973, 3-10.

A theory on the propagation of surface waves in an elastic medium heterogeneous in the direction of the three coordinate axes and bounded by a substantially smooth, curved surface is presented. An asymptotic solution is obtained for the free oscillation of an elastic medium concentrated near a stress-free surface. The dispersion, polarization, and attenuation characteristics of the interference SV and P waves is discussed.

* A - largest deformation axis, C - smallest deformation axis.

Kagan, Ya. Ya. Probabilistic description of seismic regime. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 4, 1973, 10-23.

A statistical model of seismic regime was developed, describing seismic regime as a stochastic point process. The theory of point processes is presented and the applicability of the suggested statistic model to the analysis of seismic events is discussed.

The totality of seismic events is described as a Poisson group process (Poisson cluster process), while events within a group, as a branching process (with respect to energy). Each center of a group (primary event) generates a member of a group (secondary event) independent of its history and the position of other group centers.

The results of the analysis of the experimental data using developed model are shown in Fig. 1a and 1b. The figure represents a normalized distribution of seismoacoustic pulses due to the pressure of rock masses in a coal mine. Seismoacoustic pulses with $E > 1J$ (Fig. 1a) display clear correlation: at hypocentral distance $r < 2$ m, one pulse is very probably followed by another one during the first 20-30 sec; at $2 \text{ m} < r < 4$ m during 20-40 sec, and at $r > 4$ m during 40-60 sec. However, weak pulses with $E < 1$ J do not display any correlation (Fig. 1b), suggesting either a different event mechanism or low accuracy in the determination of hypocentral coordinates.

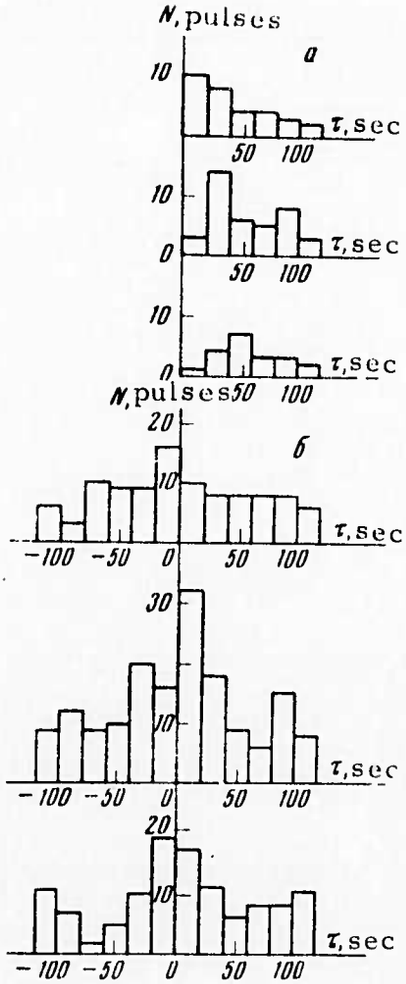

Fig. 1. Distribution of Seismoacoustic Pulses.

a - $E > 1$ J, b - $E < 1$ J.

Troyan, V. N. Statistical methods for the identification of seismic waves with parabolic cophasal axes. Voprosy geofiziki, no. 22, (Leningradskiy universitet. Uchenyye zapiski, no. 366), 1972, 244-248.

An optimum algorithm for the separation of interfering seismic waves having linear time-distance curves (Gol'tsman and Troyan, 1969) is generalized for seismic waves with parabolic time-distance curves. The equation of the parabolic time-distance curve for the μ -th wave is $t_{\mu k} = a_\mu x_k^2 + b_\mu x_k + c_\mu$, where a_μ, b_μ and c_μ are unknown parameters and $\mu = 1, 2, 3 \ldots, M$. The algorithm provides for a given waveform in two cases; 1) the form of signal is given; and 2) the form of signal is not given, only its duration. The random component is assumed to be normal, stationary, with zero mean value and uncorrelated along x and t.

The effectiveness of the algorithm is checked using a theoretical wave field calculated for different values of a_μ, b_μ, c_μ and a different number of waves.

A few examples illustrating the resolution of the algorithm are given.

It is concluded that the separation of interfering seismic waves with parabolic time-distance curves is effective in the case when $A/\sigma \geq 3$, c_μ differs by at least $15 \cdot 10^{-3}$ sec, b_μ differs by at least $12 \cdot 10^{-5}$ sec/m^2, and a_μ differs by at least $12 \cdot 10^{-7}$ sec/m^2.

Vinogradov, S. D., K. M. Mirzoyev, and N. G. Salomov. Seismic energy during the fracturing of samples under constant loading. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 3, 1973, 29-34.

The results of experimental studies of fracturing in heterogeneous materials under constant uniaxial loading are shown. An analysis is made of the elastic pulses caused by the fracturing of samples. The results are compared with those obtained in experiments involving steadily increasing loading (Vinogradov and Mirzoyev, 1970).

The experiments were carried out on 7 x 7 x 14 cm cement samples with coarse (~20 mm) and fine (~2-3 mm) inclusions at a 1:1 weight ratio.

The deformation process of the samples appeared to be a quasiviscous flow with a constant deformation rate. The deformation under a constant loading of 150-160 kg/cm^2 was measured to be 0.1-0.2 mm; the deformation rate was determined to be $\dot{\varepsilon}$ 1.2 x 0^{-9} and 1 x 10^{-9} sec^{-1} for samples with coarse and fine inclusions, respectively. The effective viscosity was about 10^{17} poise and the relaxation period $\tau \sim 2 \times 10^6$ sec. It is pointed out that the quantity $\dot{\varepsilon} . \tau \approx 10^{-9} \times 2 . 10^6 = 2 . 10^{-3}$ as obtained in this study agrees with values observed in seismically active regions.

Analysis of the elastic pulses recorded during the experiments showed that their temporal distribution depends on the size of the inclusions. It was further shown that the frequency-energy relation for the elastic pulses is characterized by a slope of $\gamma = 0.5$ and 0.7 for samples with coarse and fine inclusions, respectively.

The present results (at $\dot{\varepsilon} = 10^{-9} sec^{-1}$) are found to fit well with earlier ones.

The average seismic energy dE/dt, the energy W absorbed in fracturing, as well as their ratio are given in Table 1.

Table 1

Sample	Load, t	Displacement rate, cm/sec	W, erg/sec	dE/dt, erg/sec	dE/dt W
Coarse inclusions	7	1.9×10^{-8}	150	0.045	3×10^{-4}
Fine inclusions	8	1.4×10^{-8}	170	0.050	4×10^{-4}

It is pointed out that ratio $dE/dt/W = 3\text{-}4 \times 10^{-4}$ represents a "long-term seismic efficiency" and does not conflict with that obtained for individual earthquakes, which represent "short-term seismic efficiency".

Wagner, C., and W. Ullmann. Method for verification of Birch-Murnaghan's equation of state by use of seismic values. Gerlands Beitrage zur Geophysik, v. 82, no. 1, 1973, 66-72. (in English).

A method is considered for the verification of the applicability of the Birch-Murnaghan equation of state to different minerals and rocks using experimental data on seismic parameter Φ under high laboratory pressures.

An analysis is given of the seismic parameter $\Phi = v_p^2 - 4/3\ v_s^2 = k/\beta$ and the Birch-Murnaghan equation of state $P = k_1 \rho^{7/3} - k_2 \rho^{5/3}$ where $k_1 = 3/2\ k_0\ \rho_0^{-7/3}$ and $k_2 = 3/2\ k_0\ \rho_0^{-5/3}$. It is shown that the Birch-Murnaghan equation of state represents the particular solution of a rheolinear differential equation for initial conditions $P(\rho_0) = 0$ and $dP(\rho_0) = O$ and $dP(\rho_0)/d\rho = \Phi(0)$. Using appropriate transformations, formulas are developed in terms of $\Phi(P)$ and $d\Phi(P)/dP$ for $\rho(P)$, $k_1(P)$, $k_2(P)$, ρ_0 and k_0. It is shown that $k_0 = k(0)$ as was pointed out by Birch (1952). The approximate formulas are given for the calculations of these parameters from sets of experimental values for P and Φ.

The conditions for the applicability of the Birch-Murnaghan equation of state to certain minerals or rock is that the set of thus calculated k_1 and k_2 values must satisfy the condition $k_1(P) = \text{const}$ and $k_2(P) = \text{const}$.

Misharina, L. A., N. V. Solonenko and P. M. Khrenov. Confinement of the earthquakes in the Baykal rift zone to systems of fractures in the basement. Geologiya i geofizika, no. 2, 1973, 103-106.

The distribution of the epicenters of the earthquakes in the Baykal rift zone was analyzed using observations conducted during 1961-70.

The results are shown in the form of a map of isolines of epicenter density. It was found that the most of the regions with high epicenter density are confined to the tectonic nodes.

Bisztricsany, E., and L. Egyed. Determination of the LVL depth from data of closely spaced seismological stations. Geofizikai Kozlemenyek, XXI, 1-4 (in English)

A method for the determination of the depth of the low-velocity layer (Gutenberg channel) from data on P waves from shallow-focus earthquakes recorded by closely spaced seismograph stations is described. The method does not require information on the origin time of earthquakes.

The time-distance curve in the form $t = a\Delta^3 + b\Delta^2 + c\Delta + d$ is modified (using differential travel times and corresponding epicentral distances for pairs of seismological stations) into $\frac{t_i - t_k}{\Delta_i - \Delta_k} = a(\Delta_i^2 + \Delta_i \Delta_k + \Delta_k^2) + b(\Delta_i + \Delta_k) + c$. A least square solution forthe coefficients a, b and c is used in calculating the inflection point, i.e. the depth of the low-velocity layer.

The depth of the low-velocity layer determined from observations of earthquakes with $0^\circ < \Delta < 16^\circ$ at five seismological stations in Hungary is 88 km. This depth pertains to an area somewhat south of the city of Belgrade.

Mamadaliyev, Yu. A. Study of the parameters of the seismic regime of the Dushanbe-Vakhsh region in Tadzhikistan. Gerlands Beitraze zur Geophysik, v. 82, no. 1, 1973, 43-65.

A statistical analysis is given of the parameters of the seismic regime in the Dushanbe-Garm region in the Tadzhik SSR. The data used were recorded at 33 permanent and temporary stations during 1955-1964. The temperorary stations were equipped with VEGIK seismometers, GB-IV galvanometers, and RS-II recording systems.

An epicenter map for strong earthquakes originating in the Dushanbe-Garm region (south Tien-Shan seismic zone) during 1895-1964 is given in the article.

A statistical analysis of the N(E) dependence for the area between $37^{\circ}50'$ N - $39^{\circ}30'$ N and $68^{\circ}00'$ E - $71^{\circ}30'$ E during 1955-1964 is given.

The seismic activity $A = A_{10}$ and the slope γ of the recurrence graph (in $\lg N = \lg A - \gamma^{(K-10)}$ vary with time (see Table 1).

Table 1

Year	Number of earthquakes						Parameter of seismic regime.			
	K = 8	9	10	11	12	13	A	$\pm\sigma_A$	γ	$\pm\sigma_\gamma$
1955	343	105	54	13	6	2	1,6349	0,032	0,4412	0,022
1956	236	87	37	11	7	2	1,5534	0,033	0,3954	0,023
1957	222	116	31	12	4	2	1,0693	0,028	0,4474	0,020
1958	203	87	35	8	2		0,8941	0,014	0,5049	0,010
1959	191	71	23	6	3	1	0,8818	0,028	0,4681	0,020
1960	184	81	14	8	2		0,8114	0,048	0,4933	0,035
1961	177	64	16	7	1		0,6750	0,051	0,5457	0,036
1962	206	69	24	9	1	1	0,7462	0,069	0,5512	0,049
1963	231	88	26	5	4		0,9280	0,063	0,4768	0,045
1964	216	66	35	10	1		0,7908	0,103	0,5488	0,073
Average	221	83,4	29,5	8,9	3,1	0,6	1,4111	0,035	0,5040	0,020

There exists an inverse dependence between A and γ, which conflicts with the results of Riznichenko (1962) and corroborates the results of Vvedenskaya (1961).

Kondorskaya, N. V., L. N. Pavlova, R. Z. Tarakanov, and Kim Chun Un. Travel time tables for seismic waves from Far East earthquakes. IN: AN SSSR. Izvestiya. Fizika, Zemli, no. 5, 1973, 11-27.

The results of a statistical analysis of relative delay times of P waves from Far East earthquakes are shown. The data were recorded at 89 seismographic stations near to and distant from earthquakes (M = 4 1/2 -8; h = 15-150 km) occuring in the period 1958-1964.

The analysis of the dependence of delay times on the epicentral distance showed that:

1) At $\Delta < 5^{o}$, the recorded travel times of P waves agree sufficiently well with the Jeffreys-Bullen tables. However, P arrivals from earthquakes originating in the southern Kurile Islands displayed large delay times of up to 3 sec, i.e., negative (relatively early arrivals) for the wave paths along the island arc (Shikotan, Nemuro, Simushir stations) and positive for wave paths across the island arc (Uglegorsk, Okha, Yuzhno-Sakhalinsk).

2) At $\Delta > 5^{o}$, consistent negative delay times, increasing with epicentral distance up to 35^{o}, are observed (Klyuchi, Magadan, Yakutsk, Tiksi, Irkutsk, Guam, Petropavlovsk, and Vladivostok stations for earthquakes from the southern Kurile Islands).

3) At $\Delta > 35^{o}$, sufficiently good agreement between recorded travel times and the Jeffreys-Bullen tables is found.

It was also shown that relative seismic delay times do not depend on magnitude and focal depth of earthquakes. The epicentral coordinates determined for an incomplete set of data were demonstrated to be more accurate if the evolved correction tables are employed.

Artyushkov, Ye. V. Nature of high stresses in the Earth's crust. IN: AN SSSR. Vestnik, no. 3, 1973, 49-56.

The origin of stresses acting in the Earth's crust are considered and some of their effects are discussed.

A suggestion is made for the following general pattern of crustal dynamics: as density differentiation at the crustal boundary occurs, low-density matter reaches the crust and increases its thickness; during this process, the crust floats upward causing vertical movements; subsequently, low-density matter in the crust flows laterally causing horizontal movements. Thus, the general cause of crustal movements is the tendency of the Earth to attain the state of minimum potential energy.

Iliyeva, M. A. Some results of the determination of absorption coefficients based on the amplitude curves of seismic head waves. IN: BAN. Doklady v. 26, no. 1, 1973, 55-58.

The effective refractor absorption coefficient determined from the amplitude of head waves associated with the basement surface was found to vary from 8.0×10^{-5} - 1.0×10^{-3} m^{-1}; refractor absorption coefficient, from 2.0×10^{-4} - 1.1×10^{-3} m^{-1}; and absorption decrement, from 1.84×10^{-2} - 1.04×10^{-1}.

Gliko, A. O. Absorption of seismic waves due to thermal relaxation. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 4, 1973, 79-83.

Absorption of shear and compressional seismic waves due to thermal relaxation was considered for monomineral and polymineral polycrystals. Quality factors for different minerals and rocks were estimated using formulas developed.

The results of calculations for a temperature of 1400° C are shown in Table 1 and Fig. 1.

Table 1

	Olivine	Diopside	Ol. 80% Diop. 50%	Ol. 50% Diop. 50%	Ol. 20% Diop. 80%	Ol. 80% Plagioclase 20%	Ol. 80% Garnet 20%
Q_s^*	1700	1250	1100	680	770	300	1400

Note: $Q_s^{-1} = (2\text{-}5)\, Q_k^{-1}$

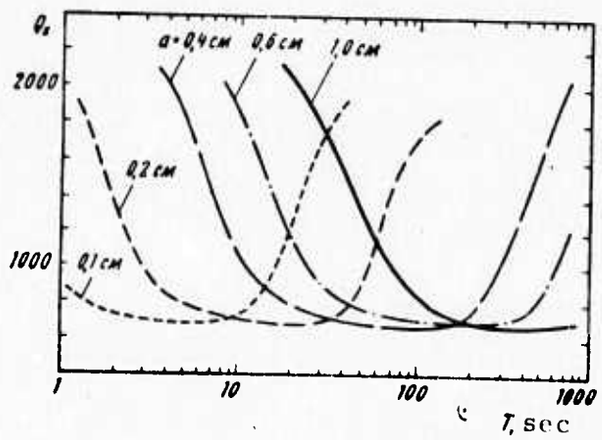

Fig. 1. Q_s (T) for Peridotite Consisting of 60% Olivine and 40% Diopside for Different Grain Sizes.

It was found that the absorption of seismic waves due to thermal relaxation is remarkably sensitive to the grain size. For different grain sizes and thermal conductivities, the maximum absorption is reached at different periods of seismic waves (Fig. 1). On the basis of the present results, the Earth's mantle was hypothesized to be coarse-grained, with grains reaching 1 cm.

Nikolayev, A. V., and A. G. Aver'yanov. Investigation of the amplitudes of compressional waves in a two-dimensional model of a medium with random velocity fluctuations. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 5, 1973, 95-101.

The results are described of a model study of the amplitude of compressional waves in a medium with random velocity and absorption fluctuations. A rough estimate is made of wave processes in a medium with small inhomogeneities. The model was fabricated from a perforated 6 x 6 cm Dural plate, with the original 1.1-mm-diameter holes being subsequently widened to 1.4 and 2.0 mm. Elastic waves were generated and were detected by 6 x 6 x 6 mm and 10 x 10 x 10 mm crystals of Rochelle salt with natural frequencies of 240 and 180 kHz, respectively.

The scattering factor was found to increase with the frequency of elastic waves as ν^5. Its average values at 150 and 110 kHz were found to be 0.025 and 0.002 cm^{-1}, respectively. The following expression for scattered energy was developed:

$$D\delta \ln A \sim (L/a)^4 \cdot (\lambda/a)^{-2} \overline{\xi^2}, \quad (1)$$

where L is the distance from the source, λ is wavelength, ξ standard deviation of refraction coefficient and a is the size of the inhomogeneities (holes). The major portion of the scattered energy was found to be in the form of multiply re-emitted diffuse waves which arrive at the observation points much later than P-waves.

Obolentseva, I. R., and L. G. Dantsig.
Characteristics of spatial polarization of transmitted compressional and converted waves in the case of inclined interfaces.
Geologiya i geofizika, no. 4, 1973, 93-102.

A solution was obtained for the spatial polarization of transmitted compressional and converted seismic waves for the following three crustal models, with the M discontinuity as a conversion surface (see Table 1):

1. inclined conversion surface;

2. inclined conversion surface and horizontal intercrustal interface (LVL top);

3. horizontal conversion surface and inclined intercrustal interface (refraction surface).

Table 1

Model	Interface	δ	γ	Δ_0	σ_0
1	M	0.75	0.57	0.57	0.865
2	LVL	0.2	0.2	0.57	0.7
		0.2	0.5	0.57	0.7
		0.5	0.5	0.57	0.8
		0.9	0.5	0.57	1
	M	0.75	0.57	0.57	0.865
3	RS	0.5	0.5	0.57	0.9
	M	0.75	0.57	0.57	0.865

Note: at $v_{sr} < v_{sq}$. $\delta = v_{sr}/v_{sq}$, $\gamma = v_{sr}/v_{pr}$, $\Delta_0 = v_{sq}/v_{pq}$, $\sigma_0 = \rho_r/\rho_q$.

It was found that in the case of an inclined conversion surface, there exist specific conditions under which the y and x components of converted waves have comparable magnitudes (i.e. at dip angle $\varphi > 5^o$-15^o epicentral azimuth close to the azimuth of the conversion surface strike, large epicentral distance). Phase shift between the y and x components occurs at $\varphi \geq 20^o$ and large incident angles, if the azimuth of the greatest rise line of the conversion surface and epicentral azimuth do not differ by more than 90^o. Furthermore, in the presence of an LVL, the horizontal components of compressional waves and the vertical component of converted waves decrease. However, an intercrustal inclined refraction surface does not affect the polarization of the seismic waves considered.

Waniek, L., K. Klima, J. Kozak, and O. Shamina. Study of the elastic waves propagating through regions of stress concentration by the Schlieren method. IN: AN SSSR. Doklady, v. 210, no. 2, 1973, 324-326.

The preliminary results of a model study of elastic waves propagating through regions of stress concentration are presented. The model consisted of a 50 x 50 x 4 mm or 80 x 80 x 8 mm plexiglass plate with a 15 mm or 30 mm diagonal slit, respectively. The observations (under axial pressure up to 200 kg/cm^2) were performed with an IAB-451 Schlieren system using a beam of parallel rays. It is shown that the experimental and theoretical data on the $\partial P/\partial x$ pattern in the loaded model are in close agreement.

Khalevin, N. I., V. A. Podnogin, and N. V. Sharov. Azimuth observations during deep seismic sounding in the Urals. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 5, 1973, 87-94.

The nature of seismic waves recorded during deep seismic sounding in the Urals was studied by employing additional azimuth observations. Azimuth arrangement of the instrumentation consisted of setting eight NS-3 seismographs at 30° to the horizontal plane in different azimuths, and one seismograph set vertically. The types of seismic waves recorded and their recording ranges are shown in Fig. 1. The majority of seismic waves were found to be complexly polarized with a predominant horizontal or vertical component.

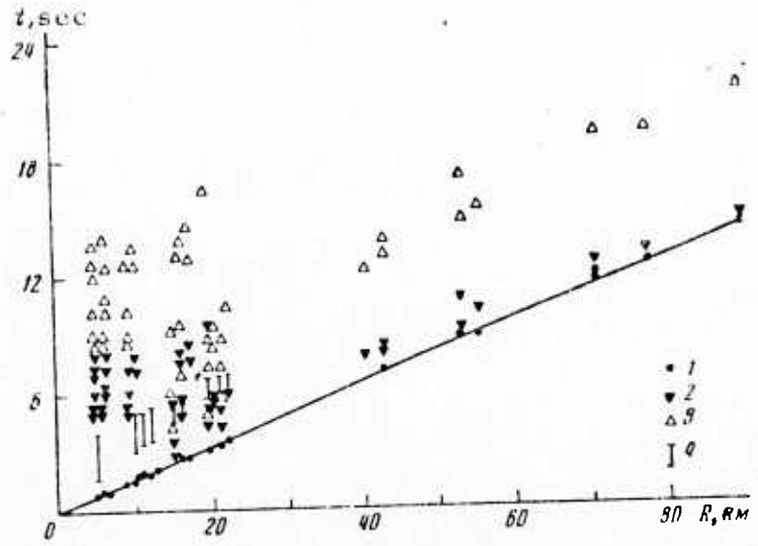

Fig. 1. Seismic Wave Distribution as Recorded During DSS in Ural.

1 - compressional waves; 2 - predominantly compressional reflections; 3 - shear reflections; 4 - intervals with predominant surface waves.

B. Recent Selections

Bagramyan, A. Kh., Ye. F. Savarenskiy, and D. I. Sikharulidze. Determining crustal thickness in various regions of the Kavkaz from surface waves. IN: AN Arm SSR. Doklady, v. 56, no. 4, 1973, 248-252.

Delitsyn, I. S., and O. I. Silayeva. Effect of quartzite grain contacts on compressional wave velocities in rock. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 10, 1973, 95-99.

Kogan, S. Ya. Seismic energy and the magnitude of an underground explosion. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 10, 1973, 42-49.

Kunin, N. Ya., et al. Deep structure of the southern Caspian. IN: AN Turk SSR. Izvestiya. Seriya fiziko-tekhnicheskikh, khimicheskikh i geologicheskikh nauk, no. 5, 1973, 85-90.

Maksimov, A. B. Ground reaction to intensive oscillations. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 10, 1973, 50-62.

Mavlyanov, G. A., et al. Phenomenon of a change in the chemical composition of ground water during an earthquake; Discovery Diploma No. 129. Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki, no. 42, 1973, 3-4.

Pritula, Yu. A., et al. Crustal structure of the Tungussk syneclise. Sovetskaya geologiya, no. 10, 1973, 29-39.

Riznichenko, Yu. V., et al. Seismicity and shakability of the Carpatho-Balkan region. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 10, 1973, 23-41.

Ryzhikova, Sn. Dispersion of PL-wave velocities recorded at Sofia. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 10, 1973, 89-94.

Sibiryakov, B. P. Excitation of elastic waves by a force concentrated in a certain sector of a hollow sphere. Geologiya i geofizika, no. 9, 1973, 119-123.

Solonenko, V. P. Earthquakes and relief. Geomorfologiya, no. 4, 1973, 3-13.

Tarantsov, A. V., and Ya. G. Birfel'd. Phenomenon of the effect of terrestrial seismicity on the ionosphere through acoustic waves; Discovery Diploma No. 128. Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki, no. 42, 1973, 3.

Tolkunova, T. L. Viscous stresses in the crust. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 10, 1973, 13-22.

Zunnunov, F. Kh., et al. Specific aspects of the structure of the crust and upper mantle in western Uzbekistan. Uzbekskiy geologicheskiy zhurnal, no. 4, 1973, 65-71.

Monographs

Hanyga, A. Thermodynamic and mechanical theory of rapid phase transformations in the earth's interior (in English). Warsaw, PAN, 1973, 146 p. (PAN. Instytut geofizyki. Materialy i prace, no. 64, 1973).

4. Particle Beams

A. Abstracts

Abu-Asali, Ye., B. A. Al'terkop, R. D. Dzhamalov, and A. A. Rukhadze. Nonlinear ionic surface oscillations in a semiconfined current-carrying plasma. ZhETF, v. 64, no. 6, 1973, 2051-2056.

A nonlinear theory is developed of the instability of surface ion-acoustic oscillations in a current-carrying nonisothermal (Te >> Ti) plasma, occupying the half space $x \geq 0$ in which electrons relative to ions drift parallel to the plasma surface. The problem is restricted to short waves ($\lambda = r_{De}$), in which ion-acoustic waves degenerate into ion oscillations. The excitation threshold for short surface waves is found lower than that of internal oscillations. The surface oscillations penetrate the plasma to a depth of the order $\delta \approx 1/K_{z\ Thres} \approx U_{Thres}/\omega_{Li}$.

It is shown that the basic mechanism which limits the growth of short-wave surface oscillation amplitude is the nonlinear shift in frequency of the excitation mode, similar to the internal oscillations. The frequency shift and amplitude of the steady-state nonlinear waves are found near the instability threshold.

Manzyuk, N. A., V. L. Sizonenko, K. N. Stepanov, V. A. Suprunenko, Ye. A. Sukhomlin, and A. M. Ternopol. Electrical conductivity of plasma during collective interactions in a heavy-current gas discharge. IN: Fizika plazmy i problemy upravlyayemogo termoyadernogo sinteza. Resp. mezhved. sb., no. 4, 1973, 15-20.

The article describes an experimental study on electrical conductivity of plasma during collective interactions in a heavy-current gas discharge. Experiments were conducted in a GROM-3 - a device for linear heavy current (up to 300 ka) discharge in hydrogen, stabilized by a magnetic field of 16 koe intensity. Plasma density was 7×10^{14} cm^{-3}. A detailed description of the device is found in an earlier paper by Suprunenko, Faynberg et al (Atomnaya energiya, no. 14, 1963, 349).

Electrical conductivity of the plasma was determined from measuring current density and electric field at the central active region of the discharge. The conductivity was also measured by local magnetic probes, which permitted taking measurements at any point in the discharge. It was noted from the experiments that electrical conductivity of the plasma drops with increase of electric field, and has a value considerably lower than that determined by considering only pair collisons. The experimental results are theoretically discussed, taking into account the ion-acoustic instability. Using kinetic equations for waves and electrons, the authors derive an expression for the electrical conductivity of the plasma in the presence of ion-acoustic instability, and a curve is plotted (Fig. 1). Results agree well with the theory of anomalous resistance and the plasma heating in presence of ion-acoustic pulsations.

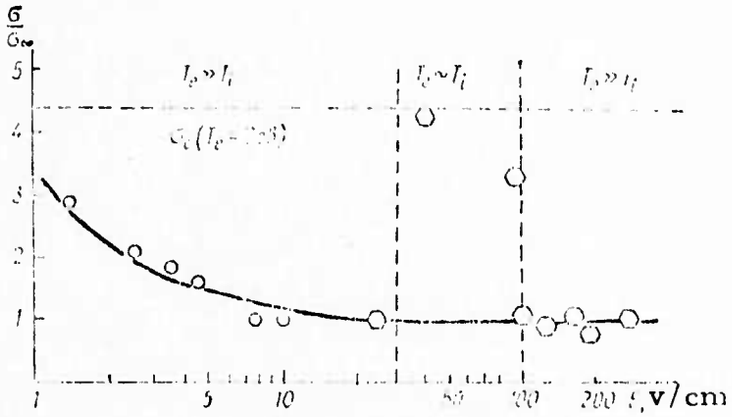

Fig. 1. Electrical conductivity of plasma vs. applied electric field.

o - Experiments in GROM-1 (α = 1.6)
o - Experiments in GROM-3 (α = 1.0)

Manzyuk, N. A., V. A. Suprunenko, Ye. A. Sukhomlin, and A. M. Ternopol. Effectiveness of current heating in the dense plasma of a heavy-current gas discharge. IN: ibid., 20-27.

This is an extension of the preceding article by the same authors. The physical effectiveness of the current heating of a dense plasma was investigated in a heavy current discharge, where effectiveness is a function of the fraction of energy which is consumed directly in plasma heating, with respect to the energy injected into the plasma by transient current during the heating interval. Experiments were conducted in the previously described GROM-3. The internal diameter of cylindrical discharge

chamber was 10 cm and the interelectrode distance was 25 cm. The discharge current reached 300 ka with a period 9 μsec, and the ambient gas pressure ranged from 1×10^{-2} to 5×10^{-4} torr. Measurements were conducted of the current density, at the discharge center, electric field, and the kinetic energy density in the plasma. Distribution of current density in the plasma was recorded by the system of magnetic probes already mentioned.

The radial distribution of current density at the moment of instability excitation in plasma is shown in Fig. 1. Theoretical analyses

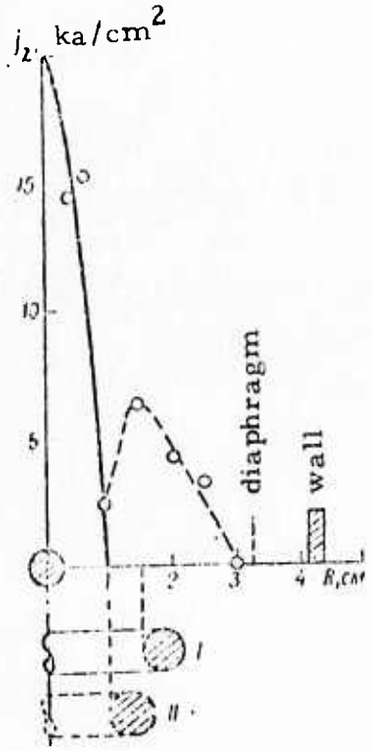

Fig. 1. Distribution of current density along a radius, obtained from a system of local magnetic probes. The continuous heavy curve forms a parabola with parameter a = 1 cm. (H_o = 14 k gauss, $p_o = 1.5 \times 10^{-2}$ torr).

were made by considering the energy balance during current heating, for which the conclusions are:

1) current heating of the plasma takes place all the time during passing of current in the active discharge region, and after heating some 60% of the energy introduced remains in the form of plasma heat energy;

2) at an electric field sufficiently above critical, the density of heat energy in the plasma increases nearly as E^2;

3) the study confirms previous results of the high values of heat energy density in the plasma during current heating regime ($nkT = 3 \times 10^{18}$ ev/cm^3).

Vekhov, A. A., F. A. Nikolayev, and V. B. Rozanov. Investigating heavy-current pulsed discharge emission in metal vapors in the vacuum UV region. ZhETF P, v. 17, no. 10, 1973, 570-573.

Experimental photoelectron and photon emission spectra are shown from a 220 kA pulsed discharge in lithium and indium vapors in the 10-100 ev quantum energy range. The photoelectron spectra were obtained with a retarding field analyzer scintillation counter system, described by the authors in a FIAN preprint currently in printing. The cited system is simpler and at least two orders of magnitude more sensitive than a diffraction spectrograph with photoelectric recording. The duration of a pulse emitted in the far UV was ~20 μsec. The photon spectra were

obtained by numerical differentiation of the photoelectron spectra.

The observed emission spectral peaks were found to be in qualitative agreement with the estimated emission intensity ratios of In II, In III, and In IV ions and the estimated LI III recombination radiation energy in the In and Li plasma, respectively. Hence the observed peaks could be attributed to recombination of the cited ions. It was concluded that a dense ($N = 10^{17} - 10^{19}$ cm^{-3}) plasma radiates mainly in the far UV spectral region, owing to electron recombination with double, triple, and higher multiplicity ions in the ground states. Such a plasma could be used as a powerful source of UV radiation with energy consumption only 1% of that required by a black body.

Yegorov, A. M., Ya. B. Faynberg, V. I. Kurilko, A. F. Kivshik, L. I. Bolotin and A. F. Bats. Electron acceleration in the slow wave field of a plasma waveguide. Atomnaya energiya, no. 3, 1973, 181-184.

The interaction of an electron beam with a slow-wave field of finite amplitude in an anisotropic plasma waveguide was investigated experimentally. The objectives were to detect capture of the particles of the injected slow-wave beam of this waveguide, to measure the dependence of the main parameters of the beam of captured particles on the characteristics of the plasma, external magnetic field and level of UHF output, and to check the agreement of these functions with the main laws predicted by theory.

The results of measuring the parameters of accelerated electron beams confirm the hypothesized mechanism of capture of slow-wave electrons of a plasma waveguide. The dependence of the flow of accelerated

particles on injection energy, the average energy of the beam on the phase velocity of the wave and the flow of accelerated particles on the level of the supplied output corresponds completely to theory. The results also confirm the presence of effective capture of electrons by the wave field. It is concluded that the prospects of accelerating electrons in a plasma waveguide have been improved by the recently discovered effect of wave field focusing at phase velocity $v_{ph} = c$ inside the plasma waveguide.

B. Recent Selections

Afonin, Yu. V., A. G. Ponomarenko, R. I. Soloukhin, and Yu. I. Khapov. Compact pulsed electron accelerator with a self-contained source. PTE, no. 5, 1973, 20-22.

Asinovskiy, E. I., N. A. Kozlov, and V. V. Fomin. Development of a discharge channel in pulsed tubular guns. TVT, no. 5, 1973, 939-945.

Bogdankevich, L. S., and A. A. Rukhadze. Problems of heavy-current relativistic electron beams. IN: Sb. Probl. teorii plazmy. Kiyev, 1972, 210-216. (RZhF, 7/73, no. 7G251)

Bugayev, S. P., V. A. Ilyushkin, Ye. A. Litvinov, and V. G. Shpak. Explosive electron emission from a metallodielectric cathode. ZhTF, no. 10, 1973, 2138-2142.

Fedorchenko, V. D., Yu. P. Mazalov, A. S. Bakay, A. V. Pashenko, and B. N. Rutkevich. Excitation of isolated waves in a beam-plasma system. ZhETF P, v. 18, no. 8, 1973, 477-480.

Grishin, V. K. Critical currents in the drift space of wave guides. ZhTF, no. 10, 1973, 2209-2211.

Kikvidze, R. R., V. G. Kotetishvili, and A. A. Rukhadze. Excitation of surface electromagnetic waves in a solid-state plasma. FTT, no. 10, 1973, 3129-3130.

Soldatenko, A. I., S. Sh. Zaydman, Yu. D. Khromoy, L. N. Shmyreva, and A. I. Shendakov. Controlled discharger with a magnetic field. PTE, no. 5, 1973, 177-179.

Volodin, V. A. A case of unstable current loading of a linac. ZhTF, no. 10, 1973, 2187-2190.

Yanshin, E. V., I. T. Ovchinnikov, and Yu. N. Vershinin. Optical studies of prebreakdown phenomena in water in the nanosecond range. ZhTF, no. 10, 1973, 2067-2074.

5. Material Science

A. Abstracts

Iordanskiy, S. V., O. V. Lokutsiyevskiy, Ye. B. Vul, L. A. Siderovich, and A. M. Finkel'shteyn. Structural instability of metallic hydrogen with respect to small changes from electron-electron interactions. ZhETF P, v. 17, no. 9, 1973, 530-534.

The problem of existence of a metastable metallic hydrogen at atmospheric pressure is treated in the framework of perturbation theory. In the earlier calculations of band energy by Brovman et al (ZhETF, v. 61, no. 6, 1971, 2429), errors were introduced by using an inaccurate formula for dielectric constant of a homogeneous electronic gas, and by neglecting correlation corrections in calculation of the electron-electron interactions.

In the present treatment, small second and third order corrections were made and their effect on conclusions about metastable metallic hydrogen was studied. A simple graphic representation of the electron-proton interactions made it possible to account for correlation corrections in calculations of the second and third order components E2 and E3 of bond energy. E2 and E3 were calculated by Habbard's approximation. In E3 calculations, the dimensionless tripolar Λ value was varied, (in contrast to Brovman) from 2 to ∞. The total bond energy was calculated as

$$E_{total} = Eo + E_{PR} + E2 + E3,$$

where Eo and E_{PR} are the electrostatic lattice and electron gas energies, respectively. The E_{total}, E_{PR}, E2, and E3 values calculated for a simple

hexagonal lattice are tabulated for different ratios c/a of lattice constants and dimensionless radius r_s = 0.903 Å of a sphere representing the atomic volume. E3 values are given for $\Lambda = 2$ and $\Lambda = \infty$.

It is noted that (E2 + E3) variation due to $\Lambda \neq \infty$ is about 4% of the (E2 + E3) value, hence the conclusion as to the existence of an E_{total} "metallic" minimum depends on small variations in calculations. This dependence is illustrated by the isoenergetic lines in a c/a - r_s coordinate system for $\Lambda = \infty$ and $\Lambda = 4$. At $\Lambda = \infty$ there is a saddle point which separates E_{tot} minimum required for the existence of metallic H from the region of molecular hydrogen with decreasing E_{tot} and density. At $\Lambda = 2$, the saddle point, and hence a metallic minimum, are absent. The stable state exists only in the region of low density and small c/a. It is calculated that the high-density minimum disappears at Λ_{cr} in the range $6 > \Lambda_{cr} > 4$. Hence allowance made in calculations for the second and third order terms of perturbation theory does not permit one to draw a definite conclusion about the existence of a metastable metallic hydrogen, because the values of the polarization operator and the tripolar of electron gas are not accurate enough.

Vereshchagin, L. F., A. A. Semerchan, N. N Kuzin, and Yu. A. Sadkov. On the metallic conductivity of iodine under high pressure. DAN SSSR, v. 209, no. 6, 1973, 1311-1313.

In an effort to clarify the conditions under which iodine acquires metallic conductivity, the temperature dependence of electrical resistance R of pure iodine single crystals was measured in the range from room temperature to 77° K, under a pressure which is known to be that of metallization onset. This pressure is lower than the estimated pressure

of hydrogen metallization; therefore, investigation of iodine metallization is of interest to the problem of finding a superconductor with a high transition temperature. Measurements in the high-pressure chamber are described in detail.

The resulting experimental R(p) curve at room temperature is similar to the curves earlier obtained by different authors. At 135 kbar pressure, R decreases by a factor of 1.1 within the cited temperature range; at 138 kbar, R decreases by a factor of 1.35. Thus the data confirm that iodine acquires metallic conductivity at 135-138 kbar pressures. Electric resistivity of iodine at the cited pressures was estimated to be $\cong 10^{-4}$ ohm x cm.

Kozorezov, K. I., L. I. Mirkin, and N. F. Skugorova. Saturation of metal surfaces by compounds and solid solutions, synthesized in a shock wave. DAN SSSR, v. 210, no. 5, 1973, 1067-1070.

Experimental data are presented on simultaneous synthesis of various metallic compounds and solid solutions on a metal surface, and saturation of the surface by them using a shock wave effect. Travelling or plane shock waves were generated by detonating an explosive charge of 1.68 g/cu. cm. density at a 7,800 m/sec velocity. A thin steel plate was thrown by detonation against a low-carbon steel plate with a layer of metal, e.g., tungsten, powder or alternate layers of a refractory metal and graphite powders deposited on the plate surface. Pressure on the plate attained 500 kbar. A continuous layer, several tenths of millimeter thick, was formed on the plate surface from the shock wave effect.

X-ray structural analysis revealed that the layer consisted of crystallized compounds, e.g. WC and W_2C, formed from the powdered components, e.g., carbon and tungsten. Micrographs show that the carbide layer is strongly adherent to the steel base. The data suggest that chemical reactions, besides thermal and mechanical effects, change the structure and properties of the shock compressed materials. The mechanism of the continuous layer formation is explained in terms of heating the powdered layer to a temperature above that required for carbide synthesis and simultaneous melting of the synthesized carbide and steel.

Extremely fast (a few microseconds) heating and cooling processes determine formation of perlitic grains in the steel base. These grains consist of martensite with carbon content (0.8%) close to that in perlite. The existence of a polygonized region below the region of perlitic grains confirms the thermal effect of shock waves.

The data obtained in the experiments with tungsten coatings on carbon steel show formation on the steel surface of a series of W-FE solid solutions over the entire range of concentrations. Formation of these solid solutions is the result of an extremely fast cooling. Thus the substantial thermomechanical effect of shock waves on a metal surface with deposited powder is verified. A layer of material different from the original materials is formed on account of the addition reaction between the powder components and the base material. The feasibility is emphasized of synthesizing compounds and coatings by simultaneous effect of high temperature and pressure.

Sobolenko, T. M., T. S. Teslenko, and A. F. Shalygin. Effect of shock waves on grain-oriented rolled materials and coarse-grained metals. FGiV, no. 2, 1973, 315-322.

Experimental data are given on the effect of shock wave loading on the microstructure and mechanical characteristics of grain-oriented aluminum, copper and titanium rolled products and coarse grained copper sheet. In the experiments with grain-oriented copper sheets, plane shock waves were generated by detonating low-density ammonite, RDX, or cast TNT-RDX charges at 3.5 - 7.2 km/sec. velocities. Grain-oriented aluminum sheets were loaded by glancing shock waves generated by 50/50 ammonite-saltpeter or RDX contact charges, or by plate impact. Grain-oriented titanium plates were explosion welded. Glancing shock waves in coarse-grained copper sheets were generated by detonating low-density RDX charges.

In all grain-oriented products, orientation peaks in the x-ray diffraction patterns disappeared following shock treatment. A more detailed study of the grain-oriented copper sheet revealed anisotropy of mechanical characteristics and grain-orientation destruction immediately after explosion treatment. This anisotropy can be eliminated by a suitable selection of detonation direction and loading conditions. Simultaneously, annealing temperature range is significantly expanded, e.g., to 750° C, without appearance of secondary anisotropy. Rolled copper sheets, with a coarse-grained structure produced by annealing at 750° C, exhibited, immediately after shock treatment at a maximum 100 kbar pressure, an increase in mechanical strength and a decrease in anisotropy of characteristics, which persisted even after repeated annealings. Grain size remained unchanged after treatment.

Protopopov, V. S., and V. A. Silin.
Approximate method for computing the onset of local heat transfer degradation at supercritical pressures. TVT, no. 2, 1973, 445-447.

In an earlier study by the authors (TVT, no. 2, 1972) a criterion for the local deterioration of heat transfer, characterized by the dimensionless ratio of the heat flow density q_c and mass velocity $\overline{\rho w}$, was derived in the form

$$\tilde{q} = (q_c / \overline{\rho w})(\beta_0 / c_p)_m \sqrt{8/\xi}, \tag{1}$$

$$\tilde{q}_{cr} = 0.034 \tag{2}$$

where $\beta\rho = -(1/\rho)(\partial\rho/\partial t)_p$ and $\xi = \xi$ (Re) is the friction coefficient of the liquid. On the basis of this criterion and on the other results of the cited study, an approximate method for calculating the point of local deterioration of heat transfer in flows under supercritical pressures is derived, as applied to turbulent flows of liquid in vertical heated tubes. From Eq. (1) the critical value $(q_c/\overline{\rho w})_{cr}$ is calculated. If $(q_c/\overline{\rho w}) > (q_c/\overline{\rho w})_{cr}$ then at some point in the tube a local deterioration of heat transfer takes place. The cross-section of the tube at which such deterioration occurs is sought on the basis of the value $\tilde{\Delta}t = 1.3$, where $\tilde{\Delta}t$ is a dimensionless form of a temperature difference between the outer boundary of a buffer layer (the three layer model of a turbulent flow is taken) and the tube's axis. For this purpose, by means of formula

$$\Delta\tilde{t} = \frac{(t_m - t_{in})\, c_{pm}\, (\xi/8)\, (\nu_c/\nu_m)^{1.3}}{(q_c/\overline{\rho w})} = 1{,}30 \pm 0{,}26, \tag{3}$$

at a given value of thermal flux density, the distribution of $\tilde{\Delta}t$ values along the tube may be calculated. In that cross-section of a tube at which the value of $\tilde{\Delta}t = 1.3$, the deterioration of heat transfer takes place. The authors note that the proposed method is not applicable for determining the local deterioration of heat transfer at the input part of the tube, where mass forces have the principal effect on deterioration.

Kunavin, A. T., F. I. Asinovskiy, A. V. Kirillin and Yu. S. Korshunov. Possible application of adiabatic compression to the study of a cesium plasma. TVT, no. 2, 1973, 261-265.

To study the P-V-T dependence of a cesium plasma at pressures 10 atm $\leq P \leq$ 300 atm and temperatures 1000° C $\leq T \leq 4000^{\circ}$ C, the method of adiabatic compression is proposed. The experimental installation used, which permits doing experiments with cesium vapors by the method of rapid ($\sim 10^{-2}$ sec) adiabatic compression, is described and its principal scheme is presented in Fig. 1.

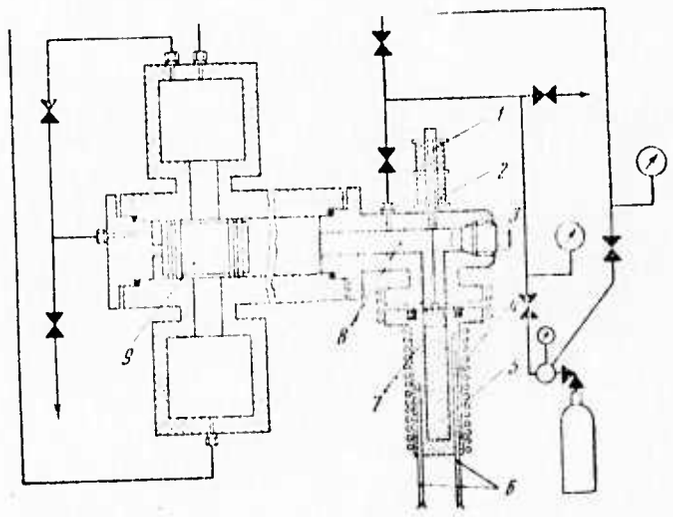

Fig. 1. Test chamber.

1, 2, 3- sensors; 4- heater; 5- specimen in capsule; 6- thermocouple; 7, 9- plungers; 8- chamber.

The principal advantages of this method are that high temperatures ($\sim 5000^{\circ}$ K) can be obtained and experiments can be carried out over a wide range of gas densities and for aggressive substances. During one experiment a series of adiabatic curve $P = P(v, S = \text{const})$ points where S is the cross-section of a capsule, can be obtained and the initial temperature T_o can be established. In a series of experiments a large number of points (P, v, S) can be obtained. Approximating polynomials $P = P(v, S)$ by the method proposed by Fortov and Krasnikov (ZhETF, v. 59, no. 5, 1970, 1695) and using the relation $\partial T / \partial v)_S = -(\partial P / \partial S)_v$, the temperatures can be calculated. With a sufficient number of experimental points, measuring P and v with accuracy of $\sim 3\%$ and T_o with accuracy of $\sim 1.5\%$, the temperature T should be calculable with an error of $\sim 10\%$. It is pointed out that so far the method described has been limited to argon and water vapors. Some of the cited results were presented at the Third All-Union Conference on low-temperature plasma physics; some of the same data are presented here in the form of three graphs.

Mirinskiy, D. S., and Ya. I. Shurin. Six-position distributor of liquid under 2 kbar pressure. PTE, no. 2, 1973, 201-202.

A distributor of pressure fluid with a slide valve is described. The six-position distributor is introduced to eliminate a great number of valves used in complex hydraulic systems in a high-pressure apparatus. The described distributor can be substituted for 5 to 11 valves in an apparatus designed for up to 2 kbar pressures. The number of positions can be increased to 10-12, if desired. A distribution diagram and cross-sectional view of the distributor are shown. A recess of special geometry cut in the contact surface of the slide valve provides for hermetic

closing of the valve. The contact surfaces of the slide valve and distributor case must be made perfectly plane and clean. The effective volumes serviced by the distributor can be connected to distribution ducts through common valves, if required. The slide valve is switched from one position to another while the valve barrel is depressurized by opening a drain valve. The slide valve face is pressed against the working surface of distributor case by means of a spring.

Nefedova, V. V., and A. P. Minin. High pressure chamber for optical studies at low temperatures. PTE, no. 2, 1973, 198-199.

A high-pressure chamber is described for study of semiconductor lasers at up to 10 kbar pressures. The chamber, which was developed from the constant-pressure chamber of Itskevich (PTE, no. 4, 1963, 148) features two optical windows made of sapphire which transmit laser radiation in the visible to 5 μ spectral range at liquid nitrogen temperature. A kerosene-oil mixture was used as the pressure-transmitting medium. At room temperature, this medium transmitted 90% radiation in the visible range and 37 to 70% in the IR range with 3.45, 6.85, and 7.35 μ absorption bands. Additional absorption at 2-3.3 μ was observed at liquid nitrogen temperature.

The effect of pressure on the emission spectrum of a GaAs injection laser was studied in this chamber at liquid nitrogen temperature. The shift of peak output energy owing to the pressure effect was found to be (1.15×10^{-5}) ev/bar, in good agreement with earlier data. It is concluded that pressure is hydrostatically transmitted and that the described chamber with its transmission medium is suitable for optical studies at high pressures.

Apshteyn, E. Z. Certain ablation characteristics of a vitreous body in a hot gas streamline flow. MZhiG, no. 3, 1973, 181-184.

Ablation is discussed of a vitreous heat-resistant coating, e.g., fused quartz, near the stagnation point of a body in a streamline hot gas flow. An intense ablation from the effect of convection and radiant heat fluxes is considered, on the assumption that the gaseous boundary layer is optically thin. This assumption makes it possible to apply an asymptotic solution to the gaseous boundary layer in conjunction with an approximate solution to the equations of motion of a liquid film.

Conditions at the thin film-gaseous boundary layer interface are formulated with allowance for nonequilibrium evaporation and dissociation of SiO_2 into SiO and O_2. Ablation rate in the vicinity of the stagnation point is calculated as a function of flow parameters and characteristics of coating material, such as spreading out of the liquid film, friction on the coating surface, and transparency of the material. Calculations reveal specific ablation characteristics of the cited materials; for example, in a hypersonic flow, body bluntness R dependence on m (Fig. 1) exhibits

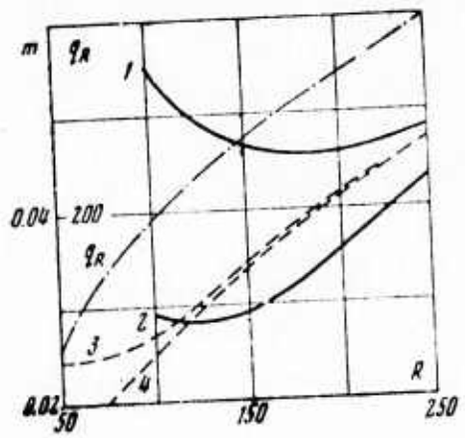

Fig. 1. Ablation rate and radiant flux vs. bluntness R.

solid lines - quenched dissociation, dashed lines - equilibrium dissociation.

a minimum. In certain cases, for a small R, $\dot{m}$ increases with a decrease in R. Unexpectedly, $\dot{m}$ calculated with allowance for equilibrium dissociation of SiO_2 is not always lower than $\dot{m}$ calculated on the assumption of a quenched dissociation. A possible decrease in temperature of injected gas at increased distances from the wall is attributed to nonequilibrium dissociation near the surface. In this case, heat flows by convection from the wall into the gas. Under certain conditions, a decrease in heat flux towards the body wall may cause an increase in $\dot{m}$. It is shown also that the effective enthalpy H of ablation depends on physical parameters of ablation and of the model adopted. The effect on H of quenched or equilibrium dissociation of SiO_2 is illustrated graphically.

Drozd, N. P., G. G. Maksimovich, S. M Kudlak, and V. S. Baranetskiy. Multiple position tensile testing machine for materials testing at high temperatures in vacuum or a gaseous medium. FKhMM, no. 3, 1973, 120-121.

A multiple-position tensile testing machine is described which was designed and built for metal testing at temperatures to 1,500° C in a 10^{-5} torr vacuum or an inert gas atmosphere. Simultaneous testing of a series of specimens is made feasible by introducing six independent pairs of holders which are positioned symmetrically in a circle within a vertical electric vacuum furnace. Each specimen is held by a pair of holders. The upper active holders are connected alternately to a swinging loading gear. The connecting holder is made vacuum tight by special elastic vacuum seals. A heater in the form of a squirrel cage composed of two molybdenum wheels interconnected by tungsten rods is placed around the specimens. Such a design increases productivity of the machine and provides for reproducibility of test conditions. Operation of the machine

is described and its performance characteristics are given. The simplicity of operation and reliability of the apparatus have been demonstrated over a period of several years of testing.

Zinov'yev, V. Ye., S. I. Masharov, and P. V. Gel'd. Kinetic properties of rhenium at high temperatures. FTT, no. 4, 1973, 1281-1284.

Thermal diffusivity a of a 99.99% pure rhenium single crystal was measured in the 850-3,200° K range in vacuum, using the method of plane temperature waves. Error of a measurements was 4%, that of temperature measurements was 1 and ~3% for up to 2,700° K and 3,000-3,200° K temperature ranges, respectively. The coefficient of thermal conductivity λ and its electronic component λ_e were calculated from the experimental literature data. In agreement with the literature, a decreases slowly and λ increases, when T is increased. The increase in λ is due to the increase in λ_e. The cited data are interpreted in terms of the Mott theory of s-d transitions with allowance for the effect of small groups of electron carriers near the Fermi surface.

Calculations indicate that scattering of carriers from these groups into a partly filled d-band does not affect the temperature dependence pattern of the electron-phonon component of metal resistance. This finding explains the nonlinear $\rho(T)$ and increase in λ with increase in T. Model applicability to description of kinetic properties of metals at high T is discussed on the basis of data on properties of alloys of a given metal, specifically for Re-Mo and Re-W alloys.

Mebed, M. M., R. P. Yurchak, and L. A. Korolev. Thermophysical properties of zirconium carbide at high temperatures. TVT, no. 2, 1973, 427-429.

The thermophysical properties of zirconium carbide were studied using a test apparatus described by the authors in earlier papers (High temperatures, high pressures, 1972; Zavodskaya laboratoriya, no. 10, 1972). The maximal measurement errors of thermal conductivity, heat capacity and heat conductivity were within 5, 4, 9% respectively. Sample No. 1 was obtained by cold molding of a zirconium carbide powder at pressures of 1.5-2T/cm^2 and then sintering it in an argon atmosphere for two hours at 2400° C. The chemical composition of the sample in % was: Zr - 86.3; C = 11.5, W = 0.48, N = 0.01, O - 0.51; stoichiometry = 0.95.

Sample No. 2 was obtained by means of hot molding and sintering of a zirconium carbide powder in vacuum for 30 min at 2100° C and 50 kg/cm^2 pressure. The chemical composition of this sample in % was: Zr = 87.4; C = 10.9; W = 0.6; N = 0.17; O = 0.34; stoichiometry = 0.85.

From this experiment it was established that both samples first have to be baked in vacuum for 30 min at 2600° K. The measurements of thermal conductivity and heat capacity for both samples are presented in two graphs. Results are compared with those obtained by Morrison and Sturgess (Rev. Intern. Hautes Temper. et Refract., 7, 351, 1970) and Levinson (J. Chem. Phys., 6, 39, 1963; 8, 42, 1965). Electrical conductivity of both samples was also measured. Measurement results are presented in tabular form.

Kantorovich, B. V., H. L. Lubny-Gertsyk, and Ye. M. Shvartshteyn. On the problem of controllable heat shields. I-FZh, v. 24, no. 4, 1973, 594-600.

The concept of a controlled heat-protective coating is clarified, and the question of how physical processes resulting in the formation of deposits can be used in the construction of dynamically stable heat protective coatings is analyzed.

Maintaining the thickness δ of a coating within a certain range of values is ensured by changing the direction (sign) of the resulting mass flow j. The resulting flow j is a function of working medium parameters z_i (i = 1, 2, . . . , n) and the temperature of the coating outer surface, which in turn depends on the heat exchange conditions and the coating thickness δ. If one neglects the thermal capacity of the coating and the heat flow along the coating surface, the following system of equations of heat and mass transfer are derived:

$$\frac{d\delta}{dt} = \frac{j}{\rho}, \tag{1}$$

$$j = j(T_п, z_i), \tag{2}$$

$$q(T_п, z_i, j) = \frac{\lambda}{\delta}(T_п - T_{ст}). \tag{3}$$

where λ and ρ are thermal conductivity and density of the coating, and $T_{ПТ}$, $T_{СТ}$ are temperatures on the coating surface and under the coating, respectively. In the general case, Eqs. (1) - (3) have solutions in the form of a system of functions $\delta = \delta(t, z_i)$, $T_п = T_п(\delta, z_i)$; $j = j(\delta, z_i)$. Specific cases of the set (1) - (3) are analyzed. The controlling of the coating thickness consists in the selection of process parameters z_i. General conditions, i.e. with an arbitrary heat and mass transfer mechanism of coating thickness

stabilization are derived. Examples for certain cases of heat and mass transfer are analyzed. The results obtained indicate that there are promising possibilities for the construction of controlled heat protecting coatings.

Kiselev, B. A., V. N. Bruyevich, V. A. Kudishina, N. A. Rozdina, I. S. Deyev, Yu. V. Zherdev, A. I. Mikhal'skiy and A. Ya. Korolev. Effect of long high-temperature exposure on mechanical properties and microstructure of glass textolite with aluminophosphate binder. NM, no. 4, 1973, 692-696.

The mechanical properties of a glass textolite with aluminophosphate binder are analyzed, and an attempt is made to find the reason for its strength decrease when exposed to temperatures of 400-600° C. It is described how test samples of glass textolite with aluminophosphate binder are produced and heat treated, and a detailed thermal analysis of specimens is made. The final heat treatment was at 300° C, when the optimal sample characteristics were obtained.

Table 1 lists results on the variation of static flexure strength

Table 1. Bend strength of glass textolite after heat treatment.

Exposure		$\sigma_{изг}$, kg/mm²
t, °C	τ, hrs.	
20		810
400	3	240
	200	230
500	0,5	230
	100	200
	200	200
600	0,5	200
	100	175
	200	190

of a sample after exposure to various temperature. During the heating process at temperatures of 400°, 500° and 600° C the strength of the textolite decreases first rapidly and then very slowly. Separation of substances from the heated samples was also investigated. From the data obtained it is evident, that in addition to water vapors a small amount of acidic products separates out. Penetration of acidic products through pores to the surface of the sample probably causes the destruction of the surface fibers.

Microstructural changes in the glass textolite were analyzed by electron microscope. From the results obtained it is stressed, that the decrease in strength of glass textolite with aluminum phosphate binding at temperatures above 300° C is mainly a result of the failure of glass fibers owing to prolonged heating and internal stresses.

Grigor'yev, A. P. High pressure chamber with water heating. TVT, no. 2, 1973, 416-417.

A test chamber for obtaining high temperatures at high pressures using water as the transmitting medium instead of argon or nitrogen, is described. Some difficulties arise connected with high electroconductivity, and aggressiveness of compressed water at high temperatures; however, in the high pressure chamber shown in Fig. 1, the harmful effects of these factors can be minimized.

The author explains the use of certain materials for the construction of the heater components and how these components perform. Heater tests were carried out at a pressure of 20 kbar. The performance of the heater at temperatures to 1273° K is described.

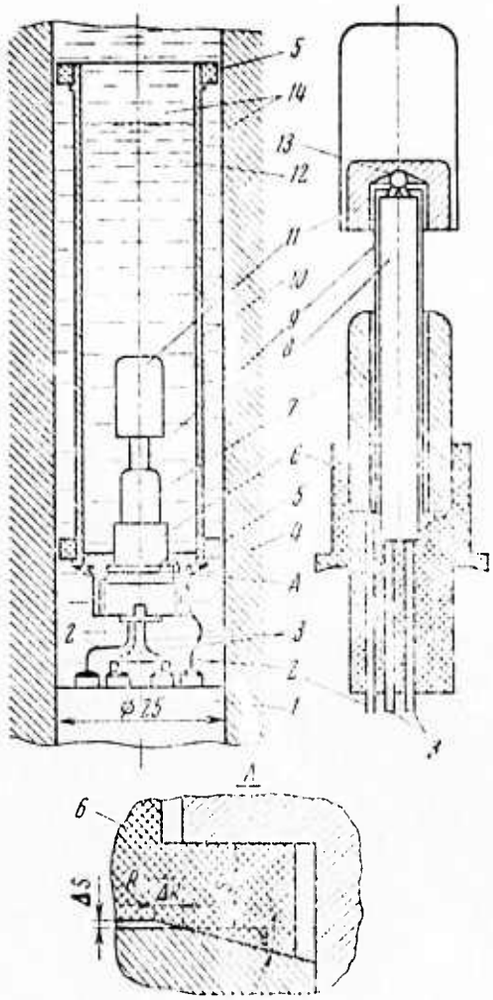

Fig. 1. Heater design.

1 - plug with leads and manganese pressure gage; 2 - feed wires; 3 - chromel-alumel thermocouple; 4 - wall of high pressure chamber; 5 - teflon rings; 6 - teflon insulation; 7 - alundum tube; 8 - two channel tube of T_iO_2; 9 - nichrome foil tube; 10 - heater shell of 1 x 18 HgT steel; 11 - copper ampule for thermocouple; 12 - water + brucite suspension; 13 - thermocouple junction; 14 - benzine.

Berman, I. V., N. B. Brandt, O. A. Zarubina, and A. L. Karuzskiy. Superconductivity of Nb and Ta at pressures to 250 kbar. FTT, no. 4, 1973, 1070-1074.

The pressure dependence of superconducting transition temperature $T_c(P)$ for Nb and Ta was determined experimentally, to obtain additional information on the mechanism of superconductivity in transition metals. Superconducting transitions at pressures to 250 kbar were recorded from r_T/r_o changes in high-purity Ta and Nb with $R_{300^\circ K}/R_{4.2^\circ K} = 10^4$. Pressure was created by an "icy" multiplier or a mechanical press. The error of P measurements was reduced from ± 10% to 3-5 % by the use of a Pb specimen as reference material in the high-pressure chamber. The accuracy of T measurement was within 0.05° K.

The $T_c(P)$ experimental plots show a steady decrease in T_c of Ta at P to 100 kbar and a practically constant T_c at P above 100 kbar. The $T_c(P)$ plot for Nb exhibits a minimum T_c at P = 40 kbar and a linear rise above that P at a rate $dT_c/dp = (2.6 \pm 0.2) \times 10^{-6}$ degrees/bar. The T_c data obtained are compared with the data from the literature. The observed T_c variations with compression are discussed in terms of variations of Debye temperature and the parameter λ of electron-phonon interaction in transition metals.

Izyumov, Yu. A. Temperature of the superconducting transition in compounds with a β-tungsten structure. FMiM, no. 4, 1973, 687-698.

The dependence of the relative temperature $t = T_c/T_c^o$ of the superconducting transition in intermetallic A_3B type compounds on the

parameter $u = T_c/\xi_o$ of interchain interaction is expressed implicitly by a pair of transcendental equations. The equations are derived by common solution of the BSC theoretical equation and the equation of the chemical potential of the system represented by the model of interchain interaction. The parameter u(or ξ_o) was introduced to take into account trimerization and diffusion of singularity of the one-dimensional d-electron spectrum.

Calculations for the density of states of d-electrons near the Fermi surface by the method of strong coupling confirmed validity of the model of interchain interaction. The density of states for the model of interacting chains exhibits at the spectral edge a root dependence characteristic of three-dimensional motion and a quasi-one dimensional behavior in depth of the energy band. The two density of states patterns are differentiated by the energy parameter ξ_o; it is shown that t decreases with an increase in ξ_o. At $\xi_o \geq T_c^o$, the BCS theory is valid and T_c^o is the limit of T_c at $\xi_o \rightarrow 0$. It is shown also that nonmagnetic impurities contribute to a decrease in T_c, which is described by substituting a parameter ξ fo ξ_o to take into account additional interchain interaction due to impurities substitution for A or B atoms.

Abdullayev, A., N. A. Vitovskiy, Ye. D. Krymova, T. V. Mashovets, S. M. Ryvkin, and A. Ya. Shik. Temperature dependence of the surface layer resistance of indium antimonide in the transition region to superconductivity. FTP, no. 5, 1973, 925-927.

This is an extension of a companion study by Vitovskiy et al (FTP, no. 5, 1973, 868) of the surface layer superconductivity arising from low-temperature mechanical treatment. In the present study,

experimental data are given for the superconductivity parameters on an InSb surface. It is shown that at $T > T_c$ and small currents (3-20 μA), the T dependence of the relative resistance R/R_N of a sanded InSb sample obeys a power law with exponent approximately 3/2, independently of current. This finding is in agreement with the authors' assumption that a system of quasi-one dimensional filaments is the most probable configuration of the metallic InSb modification from the effect of locally high pressures.

At higher currents (20-100 μA), the R(T) dependence becomes exponential due either to fluctuating destruction of superconductivity or to discontinuity in the filamentary system. The presence of steps in the current dependence of R/R_N near T_c confirmed the cited mechanism of superconductivity.

Baramidze, G. A. Vortex oscillation spectrum in a pure superconductor. AN Gruz SSR. Soobshcheniya, v. 10, no. 1, 1973, 57-60.

The longwave spectrum of vortex oscillations in a pure type II superconductor is analyzed on the basis of Bogolyubov's microscopic equations. These equations are generalized to take into account nonstationary phenomena in the case of applying a weak alternating field. Thus a set of generalized Bogolyubov equations is used to describe a superconductor in a time-dependent applied field.

The zero solution with respect to frequency ω_o and wave vector k_o was obtained for normal and conjugated Bogolyubov's amplitudes. From this solution a quadratic dispersion equation was derived, which

shows that vortex excitation obeys a quadratic law. The coefficients of the terms in ω_o and k_o in the dispersion equation near T_c can be determined more accurately than from the phenomenological equation. The first terms of the dispersion equation in the Ginzburg-Landau approximation agree with hydrodynamic limits. It is concluded that longwave undamped excitations exist in oscillation spectra of an isolated vortex, and obey a quadratic dispersion law.

Galayko, V. P. High-frequency current conditions in small superconductors. ZhETF, v. 64, no. 5, 1973, 1824-1838.

Nonlinear nonstationary processes in pure superconductors are analyzed theoretically on the basis of BCS theory. The kinetic equation for the generalized electron hole density matrix is used to derive the kinetic Boltzmann equation which describes electron quasiparticle-impurity collisions after completion of rapid formation of the superconducting condensate and quasiparticles. The cited condition implies that the inequality $T_c \geq 1/\tau$, where τ is the frequency of electron-impurities collisions, must be satisfied.

The Boltzmann equation, which contains the self-consistent field of the superconducting order parameter Δ, describes nonlinear nonstationary processes in the system with frequencies of current oscillations $\omega \leq T_c$. The equation is used for an approximate solution to the problem of high frequency spatially homogeneous current states in small superconducting samples, in contact with metallic masses in the normal state. The nonlinear response, i.e., the high-frequency electric field E corresponding to a given external current j_{ext} through the sample, is described qualitatively for the case of a sufficiently high temperature $T \neq T_c$. The peaks of E vs.

time curves are the characteristic features of the process described by the Boltzmann equation, which cannot be applied to dirty superconductors.

Urushadze, G. I. Tunneling of electron pairs in an acoustic field in superconductors. ZhETF, v. 64, no. 5, 1973, 1881-1886.

The modulation effect of acoustic vibrations on Josephson tunneling current in sandwich structures is analyzed theoretically. Applying thermal Green functions to description of the electron pairs leakage from one superconductor across the barrier, the author expresses sound-induced pair current as a function of sound frequency ω. This expression is then used to derive the formulas of the effective tunneling current $j(\omega)$ and the maximum Josephson current $j_s(\omega)$ flowing at absolute zero between clean superconductors or superconductors with nonmagnetic impurities.

In the case of clean superconductors, it was assumed that $qv \geq \Delta$ for both superconductors (q and V are the wave vector and velocity of sound, Δ is the energy gap in superconductor spectrum). The cited $j_s(\omega)$ formulas do not take into account the mechanism of the Cooper pair destruction, which affects $j_s(\omega)$ at $\omega > 2\Delta_2$. Hence, superconductors with energy gaps obeying the inequality $\Delta_1/3\Delta_2 < 1$ should be selected for experimentation to eliminate the effect of the cited mechanism on $j_s(\omega)$. Using the derived formulas the author determined j_s/j_o to be 30% and 15-20% for tunneling between Pb and Sn superconductors and for V and Nb, respectively, where j_o is the maximum current flow across the barrier in the absence of sound.

Zelechower, M. On a Josephson tunneling effect in superconductivity. Acta physica polonica, v. A43, no. 5, 1973, 733-735.

The Josephson current flow across an S-I-S tunnel junction is treated as a quantum Markov process in two states, in which electron pairs are considered as quasibosons. Wave vectors corresponding to the electron pair motion in two states are introduced into the Kolmogorov-Schroedinger equations, and formulas similar to those of Feynman are derived for tunneling current.

The two derived formulas apply to the cases of a constant electric field and a combined constant plus h-f field, respectively. In both cases, current density differs from zero, even if the original phase φ_o of the wave vector is equal to zero. In this respect, the formulas derived for current intensity are more general than the Feynman formulas. The coupling constant in the author's formulas is a complex number, while in the Feynman's formulas it is a real number. In contrast to the Feynman's formulas the author's formulas contain an additional term $\alpha \cos \varphi_o$, where α is a real constant.

Rabin'kin, A. G., V. N. Galev, and V. N. Laukhin. Effect of uniform high pressures and residual stresses on superconductivity of a $V_3(Si_{1-x}Ge_x)$ alloy system. ZhETF, v. 64, no. 5, 1973, 1724-1733.

Experimental data are given on pressure p and composition dependences of the temperature T_c of a superconducting transition, and also on compressibility $\Delta V/V$ of type $V_3(Si_{1-x}Ge_x)$ alloys. In the experiments p was varied from 0 to 30 kbar and x from 0 to 1. T_c and $\Delta V/V$ measurements

were carried out in a high-pressure chamber of the plunger-cylinder type with accuracy better than ± 0.05° K; the error in p determination was ± 2 kbar.

It was found that $dT_c/dp > 0$ in all alloys studied, and increases nearly linearly with increase of x from 4×10^{-5} to 7×10^{-5} degree/bar. A nearly linear increase was also observed in the initial T_c. The independence of $\Delta V/V$ from p in all alloys led to the conclusion that the crystal lattice constant a decreases linearly with increase in p. In disagreement with the theoretical prediction of Testardi, the sharp x dependence of T_c indicates that the mean atomic volume is not the only factor determining T_c of alloys. The data obtained with powdered alloys show the p-induced small residual stresses which produce a broadening of the T_c range, which is the most pronounced in V_3Si. The effect of residual stresses on the magnitude of the T_c range is explained by the probability of martensitic transition.

Golub, A. A. Excitation of acoustic oscillations in superconducting plates. FTT, no. 5, 1973, 1468-1472.

Generation of sound waves by an incident electromagnetic wave (EMW) in a superconducting plate is treated theoretically, owing to the importance of this problem in development of superconducting accelerators. Additional surface resistance R_S (residual losses) from sound generation is calculated by solving the equation of ion shift u(z) in a pure superconducting plate of thickness $d \geq \delta$, the depth of field penetration. It is assumed that the plate is in the $0 < z < d$ plane normal to the z axis, and its temperature T is in the ω to Δ range, where ω is the frequency of

EMW normal to the plate. The u(z) function at $z \geq \delta$ appears in the form of a travelling wave, if damping of the sound wave occurs at a distance < d. In the opposite case, a standing sound wave is developed, in which case EMW losses are proportional to damping. At T = 0, EMW absorption in pure superconductors is determined mainly by losses from acoustic oscillations. In the presence of a nonmagnetic impurity, the contribution of sound to absorption decreases significantly.

Andreyev, A. F., and V. Bestgen. Fluctuation theory of the two-dimensional mixed state of type I superconductors. ZhETF, v. 64, no. 5, 1973, 1865-1880.

An earlier theoretical study by Andreyev and Tekel' (ZhETF, v. 62, 1972, 1540) on the properties of a two-dimensional mixed state is expanded to cover the conditions under which superconductivity of a surface layer in the mixed state is almost completely suppressed by an electric field E, and exists only as small superconducting fluctuations. A generalized relationship between the electric energy parameter $\epsilon \leq 1$ and densities j_z and I_s of superconducting fluctuation current and total superconducting current is derived from the Ginzburg-Landau equation for the inner surface layer of a hollow superconducting cylinder. I_s is formulated in two boundary cases of a small current, J in relation to the second critical current J_z and J near J_{c2}.

It is shown that at $J \approx J_{c2}$, I_s in pure metals can be negligible, so that practically speaking the metal is in a normal state. At $J < J_{c2}$, the effect of E on properties of a mixed-state layer is weak in pure metals. At $J = J_{c2}$, a practically complete destruction of the mixed state layer

occurs even in at arbitrarily weak E. The experimentally observable electromagnetic impedance z of the inner surface in the presence of a mixed state layer is calculated for alloys and pure metals. In both cases Z in a high frequency alternating field is an oscillatory function of a certain parameter of the frequency.

Savitskiy, Ye. M., A. V. Revyakin, Yu. V. Yefimov, B. D. Glyuzitskiy, and V. N. Sumarokov. Ultra high-speed hardening of niobium and vanadium. DAN SSSR, v. 210, no. 2, 1973, 405-407.

Experimental data are presented on the effect of a cooling rate up to 10^7 degrees C/sec. of liquid niobium and vanadium metals on their microstructure, temperature T_c of superconducting transition, and microhardness. The experiments were carried out in a specially constructed vacuum chamber (cf. Revyakin et al, ZL, no. 3, 1972, 368) in which a metal rod was melted by induction and a liquidfied metal drop was coded on a rotating copper disc. It is shown that T_c of Nb and V solidified at a rate from 50 to 6×10^6 degree C/sec. decreased from 9.3 to 9.1° K and from 5.3 to 5.1-5.2° K, respectively. Simultaneously, a 0.3 to 0.5° K widening of the superconducting transition was observed. The critical current density at 4.2° K of Nb and V cooled at a 6×10^6 deg C/sec rate increased to $\sim 10^4$ and $>10^2$ A/cm^2, respectively, in a 5 koe and 1,000 oe fields.

Thus an increase in the rate of cooling has practically no effect on T_c of Nb and V, but does increase their critical current density. This effect of high-speed hardening is analogous to that of cold straining. Other observed effects of ultrahigh-speed hardening are shown to be a

drastic diminution of grain size andincrease in dislocation density. The latter effect causes an increase in microhardness and strength, without affecting plasticity of the metal.

Petrosyan, V. I., V. N. Molin, and P. A. Skripkina. Energy gap formation during semimetal-semiconductor quantum dimensional transition in Bi films. FTP, no. 5, 1973, 993-996.

An attempt is made to evaluate the film thickness dependence ϵ_g (L) of energy gap which was previously detected by Molin et al (ZhETF P, v. 14, no. 5, 1971, 323) in Bi films of $L \leq 180$ Å at 4.2° K. For this purpose, the temperature dependence within a $2.5\text{-}10^\circ$ K range and L = 40--400 Å dependence of carriers concentration n was determined experimentally in polycrystalline Bi films deposited by an electric explosion. Concentration n was calculated from the experimental electric conductivity, magnetoresistance, and Hall constant data, assuming n = p.

Superconducting phase inclusions with $T_c \sim 5\text{-}6^\circ$ K were detected in some of the films, apparently due to formation of a stable superconducting Bi modification from the effect of electric explosion. The n(L) dependence in nonsuperconducting films of $L < L_t$ confirmed the previously reported semimetal-to-semiconductor transition, but at $L_t \sim 150$ Å, are explained by the existence of a superconducting phase in the previously studied films. At $T < 3.5^\circ$ K, n is constant in films of different L, whereas at $T > 3.5^\circ$ K there is a slope on the n(T) curves. The n(L) and n(T) dependences are explained in terms of the semimetal-to-semiconductor quantum dimensional transition in Bi films with $L_t = 150$ Å. The value of $\epsilon_g \geq 4.5 \times 10^{-3}$ ev at L = 50 Å is estimated from the n(T) dependence.

Yermolenko, A. S., A. V. Korolev, and Ya. S. Shur. $SmCo_5$ single crystals with 32 million gauss x oersted magnetic energy. ZhETF P, v. 17, no. 9, 1973, 499-501.

The first achievement of a single-domain state with theoretical magnetic energy $(BH)_{max}$ in a permanent magnet at room temperature is reported as the result of magnetic properties measurement in $SmCo_{5+x}$ ($x = 0$-0.5) single crystals. The reported achievement was made possible by chemical etching and subsequent electropolishing of spherical specimens, on the theory that generation and growth of magnetic reversal nuclei is delayed by removal of a surface layer deformed from the preceding smoothing operation. It was assumed that the magnetic reversal nuclei are generated on localized crystal imperfections with a depressed anisotropy field.

Selection of $SmCo_5$ was made on the basis of its extremely high constant of uniaxial magnetic anisotropy. It is shown that the anisotropy field H_A in $SmCo_{5+x}$ alloys with $x \leq 0.3$ differs very little from $H_A = 440$ koe in $SmCo_5$. Persistent remanent magnetization of the specimens, even in a substantial negative applied field, indicated a strong hindering of the magnetic reversal nuclei generation as the result of removal of the deformed layer. A typical hysteresis loop of $SmCo_{5.3}$ alloy shows that saturation induction = 11.3 kgauss persists in the specimen up to $H_i = (-)5800$ oe, i.e., that $(BH_i)_{max} = 32$ million gauss x oersteds, which is the theoretical limit for permanent magnets at room temperature.

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v. Epitaxial Films

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Zotov, Yu. A., I. F. Chernomordin, V. N. Maslov, L. I. D'yakonov, and L. A. Nisel'son. Method of obtaining epitaxial films. Author's certificate, USSR, no. 330811, published January 19, 1973. (RZhKh, 20/73, no. 20L80 P)

The new method introduced by the members of the Institute of Spectroscopy, and based upon using a laser for separating the isotopes, achieves thepurpose much faster. As an example let us assume that we have to separate the nitrogen isotopes N^{14} and N^{15}. The first step remains unchanged, i.e. we combine nitrogen and hydrogen and produce ammonia - a volatile gas - and this gas in now exposed to a laser beam of discrete frequency.

Since in every ammonia molecule a nitrogen atom combines with three hydrogen atoms (NH_3) and since this bond is not rigid, i.e. the atoms can meet and run apart like balls on springs, the following principle is applied. The oscillation frequency of an elastic molecule would naturally depend on the weight of any such "ball" and hence on the presence of a lighter or heavier isotope; i.e. the oscillation frequency would change if one of the two isotopes would be substituted by another. It is this factor that determines the frequency of the laser beam to which ammonia is being exposed: laser light would induce oscillations of the molecules that contain the isotope which is to be removed from the gas mixture.

The ammonia is simultaneously irradiated with a beam of different frequency that is sufficient to split the oscillating molecules; for molecules at rest this beam would present no danger. In the process of disintegration each molecule would liberate one nitrogen atom; separation of nitrogen from ammonia would then be no problem. We may note that in this procedure we isolate always one definite isotope of nitrogen from the gas mixture.

Already during initial tests the authors of the new method have proven its high effectiveness. In the initial gas mixture the proportion of both nitrogen isotopes was more or less equal. Following one single treatment, the compound contained only 20 percent of the unwanted isotope.

Kravets, A. N., V. P. Kuznetsov and A. A. Kurmangaliyeva. Possibilities of using NaCl crystals as memory cells. IVUZ Fiz, no. 5, 1973, 140-142.

The possibility of using stained NaCl crystals for recording and storage of data at temperatures below room temperature was investigated. It was established that raising the temperature of the crystal to 70° C and alloying it with calcium did not lead to any appreciable change in the quality of the image obtained. In order to determine the methods of increasing the light sensitivity of the crystals, the kinetics of optical bleaching of the F-centers in irradiated NaCl crystals was investigated under different conditions, when thermal bleaching was negligible. The probability of an electron moving from the excited level of the F-center to the conductivity zone, and also the mobility of anion vacancies, increase with temperature and therefore, the rate of bleaching of the crystal increases, as shown in Fig. 1.

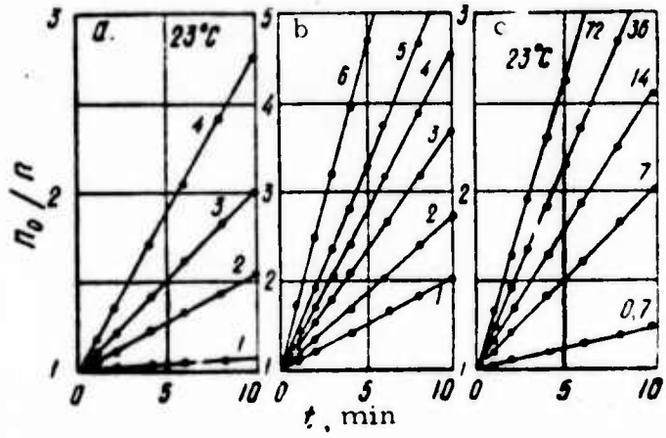

Fig. 1. Dependence of relative concentration of F-centers in NaCl on the time of optical bleaching:

a) 1 -- additively stained crystal; 2-4 -- irradiated crystals; 2 -- NaCl + 0.01 mol % $PbCl_2$; 3 -- chemically pure NaCl; 4 -- NaCl + 0.1 mol % $CaCl_2$; b) 1, 3, 5 -- chemically pure NaCl; 2, 4, 6 -- NaCl + 0.1 mol % $CaCl_2$; 1, 2 -- 23; 3, 4 -- 50; 5, 6 -- 70° C; c) bleaching at different light intensities in mw/cm^2.

A system of equations is presented to describe the process of bleaching of the F-centers.

Velikhov, Ye. P., A. A. Vedenov, A. D. Bogdanets, V. S. Golubev, E. G. Kasharskiy, A. A. Kiselev, F. G. Rutberg and V. V. Chernukha. Feasibility of generating megagauss magnetic fields using high pressure compressed gas linings. ZhTF, no. 2, 1973, 429-438.

A device designed to obtain a megagauss pulsed magnetic field in a large space is described, in which the magnetic field is intensified by compression of it by a cylindrical metal shell driven by a high-pressure gas (1-2000 atm.). The anticipated energy value in the compressed magnetic field is several Mj and the lifetime of the field is of the order of 10 microseconds. The instability of the elastic shell and also the Rayleigh-Taylor instability contribute to the instability of the liner. It was found that the instability of the elastic shell may be eliminated by rapid and azimuthal-symmetric increase of external pressure around the liner, which causes the latter to move. Equations are derived to calculate the energy losses to plastic deformation of the liner, the system for opening the diaphragm and the system for developing the initial magnetic field. It is concluded that the device is indestructible and does not require development of superpowerful storage and commutators of electromagnetic energy, since it consists of readily available assemblies. Fig. 1 shows a sectional view of the apparatus; performance data are also given.

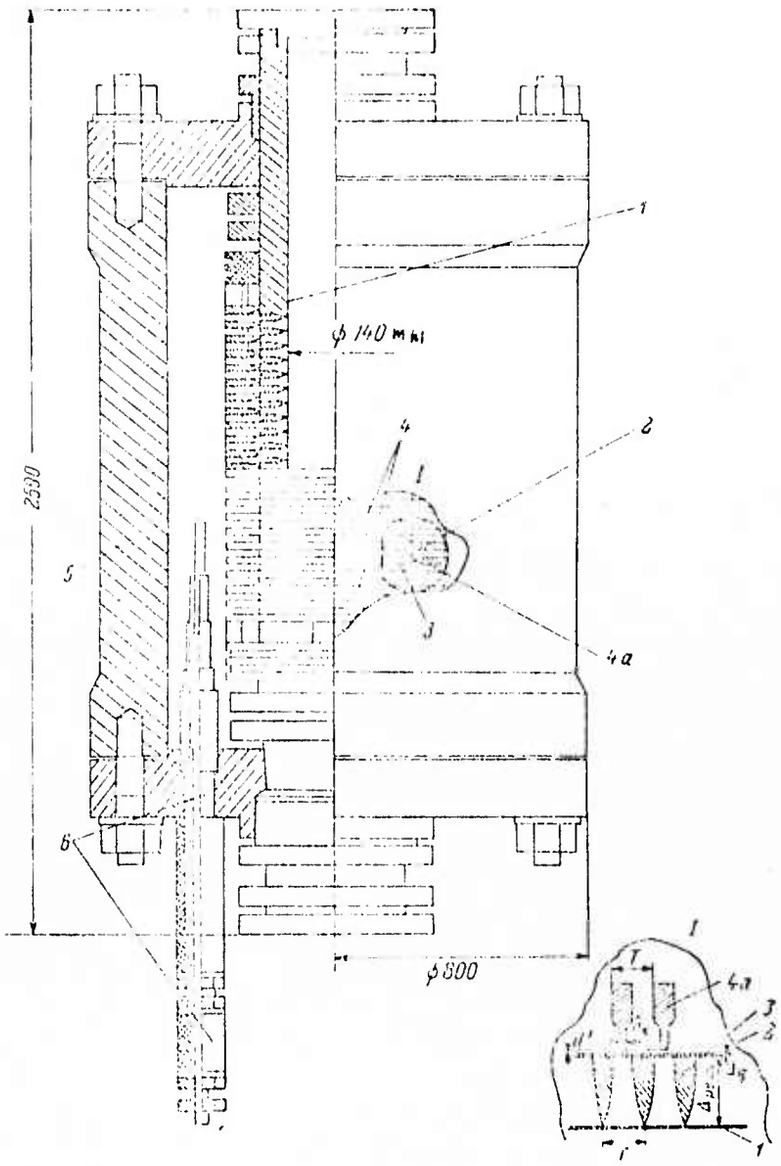

Fig. 1. Generating chamber.

1 - liner; 2 - diaphragm; 3 - threshold grid;
4 - magnetic system; 4a - concentrator;
5 - shell; 6 - current leads.

Krysin, I. R., R. D. Azelitskaya and V. F. Chernykh. Effect of magnetically-treated water on properties of solutions and concretes. EOM, no. 1, 1973, 38-40.

The results are presented of studies on the effect of magnetically-treated water in cement mortar upon the strength of various concretes and also on changes in physico-chemical processes of cement hardening. Four samples of Portland cement are taken and their mineralogical compositions are tabulated. An analysis of the water used is also given. Concrete specimens (2 x 2 x 2 cm cubes) using ordinary and magnetized water in the mortar were produced. The strength of these samples in compression is presented in Table 1 for various periods of

Table 1. Compression strength of concrete specimens, kg/cm^2.

Specimen	Curing period, days		
	3	7	28
1	486 / 550	843 / 857	866 / 886
2	529 / 558	550 / 714	572 / 723
3	354 / 409	603 / 609	633 / 729
4	353 / 510	445 / 604	783 / 837

Numerator - regular water; denominator-magnetized water.

cement curing. Results are presented as fractions where the numerators are strengths of samples produced with ordinary water and denominators, strengths of samples produced with magnetized water. The results of

Table 1 are analyzed as functions of concrete composition and magnetic dwell time.

It is pointed out that in order to obtain stable increases in strength of concrete using magnetized water one must control the water's chemical composition and its pH value. If these characteristics change it is necessary to introduce certain corrections in the parameters of processing.

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7. 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 goreniya 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	-	Fiziologicheskiy 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 s ANEB
I-FZh	-	Inzhenerno-fizicheskiy zhurnal

IiR	-	Izobretatel' i ratsionalizator
IL_I	-	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
OiS	-	Optika i spektroskopiya
OMP	-	Optiko-mekhanicheskaya promyshlennost'
Otkr izobr	-	Otkrytiya, izobreteniya, promyshlennyye obraztsy, 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 izmeritel'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 fizicheskiy 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