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# JPRS Report

# Science & Technology

## Central Eurasia: Engineering & Equipment

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# Science & Technology

## Central Eurasia: Engineering & Equipment

*JPRS-UEQ-93-005* *15 July 1993*

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## Formulation of Programmed Aircraft Motion Control

*937F0144A Moscow VESTNIK MOSKOVSKOGO GOSUDARSTVENNOGO TEKHNICHESKOGO UNIVERSITETA: SERIYA PRIBOROSTROYENIYE in Russian No 4, Oct-Dec 92 pp 3-14*

[Article by A.A. Malakhov, Moscow State Engineering University imeni N.E. Bauman; UDC 629.7.05.001]

[Abstract] The navigation and tactical tasks of aircraft motion control and the tasks involved in plotting the en-route flight along a path in the phase space, including the resulting boundary value problem, are discussed, and it is speculated that the approach to solving the boundary value problem in the class of known functions makes it possible to develop efficient flight data selection algorithms and formulate the requirements for the structure and parameters of the airborne navigation-flight control complex. The procedure of constructing the en-route flight control program execution algorithm is considered; to this end, the aircraft flight path within given altitude and speed ranges is optimized using the dynamic programming method. Various acceleration, climb, and deceleration flight modes are examined, and the optimum cruising flight parameters are calculated. The algorithm of solving the problem of mathematical simulation in assessing the aircraft motion data along a specified path is examined. Supporting functions are derived for solving the boundary value problem and utilizing the numerical optimization procedures; in so doing, the optimum control selection procedure is simplified and the feasibility of realizing the resulting flight paths with the help of existing controls is assessed. It is noted that the proposed simulation procedure eliminates the transient processes resulting from the piecewise structure of the phase trajectory and path section breaks at the supporting function segment junctions. Figures 2; references 3.

## Floated-Type Linear Acceleration Integrated Gyro With Electromagnetic Sensor Suspension

*937F0144B Moscow VESTNIK MOSKOVSKOGO GOSUDARSTVENNOGO TEKHNICHESKOGO UNIVERSITETA: SERIYA PRIBOROSTROYENIYE in Russian No 4, Oct-Dec 92 pp 15-27*

[Article by V.M. Krikun, Moscow State Engineering University imeni N.E. Bauman; UDC 629.7.058.82]

[Abstract] The use of integrating linear acceleration gyro for measuring the apparent velocities and the increasingly stringent requirements imposed on the accuracy of today's floated-type gyros are discussed; these requirements can be met by using electromagnetic suspensions. The effect of the sensor's electromagnetic suspensions on the dynamics of a floated-type gyro with a limited moment of momentum is examined and the integrating gyro's equations of motion are derived; a schematic diagram of the integrating linear acceleration gyro with additional electromagnetic suspension feedback is cited. The curve of the effect of external and internal frame support rigidity on the floated linear acceleration integrated gyro (GILU) stability for various specific damping moments and the characteristics of the GILU's own angular momentum effect on its stability are plotted. Recommendations are made for selecting the gyro's own angular momentum, and the possibility of using the feedback from the electromagnetic suspension for increasing the integrating gyro accuracy is assessed. It is shown that the use of additional electromagnetic suspension feedback makes it possible to improve the gyro accuracy; a decrease in the gyro's own moment of momentum below $5 \times 10^{-4}$ Nms expands the stability range and thus does not lead to an increase in static errors. The need for additional studies of the gyro's dynamic errors is stressed. Figures 7; tables 3; references 2: 1 Russian, 1 Western.

## Ensuring Unity of Monitoring Facilities and Methods During Life Cycle Stage of Aviation Engineering Products

*937F0154A Moscow METROLOGIYA in Russian No 12, Dec 92 pp 13-17*

[Article by Yu.I. Grabchak, V.M. Skipa; UDC 629.7.018.08-52]

[Abstract] The new requirements imposed on monitoring facilities by the increasing structural and functional complexity of aviation engineering (AT) products, the analog to digital signal processing transition, the hardware and software interpenetration, and an increase in the electronic circuitry speed due to an increase in the scale of integration are discussed, and the urgent task of designing and implementing computer-aided monitoring, measurement, and diagnostics facilities which encompass all product life cycle stages—from R&D to operation and maintenance—is defined. The specific requirements imposed on control and monitoring systems and methods at various stages are outlined; the findings indicate that the operational monitoring scope is part and parcel of the monitoring volume of all life cycle stages whereby the scope of each stage's monitoring contains a part of the subsequent phase. It is shown that the use of the ground-based computer-aided monitoring and diagnostics (NASK) systems is the most expedient from both the technical and economic viewpoint. The peculiar features of the unified NASK structure is described and its advantages are demonstrated. A unified NASK system may be based on an SM-4 or Elektronika-60 microcomputer. The possibility of integrating the NASK system with other equipment for realizing the fullest data collection, telemetry, and control functions is discussed. References 3.

## Methods of Forming Rational Requirements for Monitoring Fullness of Functional Systems and Aircraft as Whole

*937F0154B Moscow METROLOGIYA in Russian No 12, Dec 92 pp 18-27*

[Article by L.L. Shichko, V.G. Uchamprin; UDC 629.07.083]

[Abstract] The quantitative requirements for the monitoring worthiness indicators of aircraft functional systems which must be formulated pursuant to the regulatory documents governing development requests for proposals and the shortcomings of the "the higher—the better" concept which is being used today and often leads to nonoptical designs are discussed. It is noted that in order to formulate rational (i.e., optimum) requirements for the functional aircraft system monitoring fullness, it is expedient to consider sets of aircraft (LA) element failures (or damage) developing during the functional system (FS) operation. The functional system failure distribution among the monitoring facilities (SK) is outlined, and a block diagram of the failure distribution algorithm according to the monitoring facility type is cited. The use of various early diagnostics methods of identifying damage at an early stage, particularly ground-airborne (NBSK) and ground-based (NSK) monitoring facilities is analyzed. The procedures of formulating optimum requirements are described in detail; it is demonstrated that the optimum monitoring fullness requirements imposed on the aircraft's functional systems and the aircraft as a whole must be formulated according to the following principles: the monitoring fullness of all monitoring facilities and methods used in operating a given aircraft must be equal to unity; all failure conditions affecting the flight safety must be tested, ensuring timely detection of prefailure conditions; and the monitoring fullness of the monitoring devices used for identifying failures which do not affect the flight safety must be distributed according to the minimum monitoring outlay criterion. Figures 1; tables 2; references 10: 9 Russian, 1 Western.

## Study of Acrylic Plastic and Teflon in Repeat Shock Compression and Isentropic Relaxation Waves: Polymers' Equations of State at High Energy Densities

*937F0125A Moscow DOKLADY AKADEMII NAUK in Russian Vol 329 No 5, Apr 93 pp 581-584*

[Article by A.V. Bushman, M.V. Zhernokletov, I.V. Lomonosov, Yu.N. Sutulov, V.Ye. Fortov, K.V. Khishchenko, Scientific Research Center of Thermal Shock Impact Physics at Russia's Academy of Sciences, Moscow; UDC 536.2]

[Abstract] The behavior and thermodynamic properties of materials at a high energy density under shock compression and their phase diagrams are discussed and the lack of data on the properties and behavior of polymer materials widely used as load bearing members capable of withstanding high thermal and static loads is noted. An attempt is made to investigate the compressibility of acrylic plastic and teflon in repeat shock compression and isentropic expansion waves and summarize the experimental results in the form of a wide-band equation of state. To this end, acrylic plastic and teflon samples with an initial density of 1.18 and 2.2 g/cm$^3$ are studied whereby shock waves are generated by steel strikers (through copper screens) accelerated by detonation products of condensed explosives to a velocity of 5.0 and 6.1 m/s. The initial shock wave front and the shock wave front in the obstacles with a varying dynamic impedance placed behind the samples are measured, making it possible to determine the final state parameters. The experimental and analytical shock adiabats, repeat compression curves, and expansion isentropes of acrylic glass and teflon samples, both porous and solid, and constitution diagrams at high densities and pressures are plotted. The findings cover a new range of densities and pressures and make it possible to describe with a high degree of reliability these materials' behavior at high energy densities. This, in turn, makes it possible to use the resulting wide-band equations of state for numerical simulation of the shock impact of high-intensity energy fluxes on polymers. Figures 3; tables 1; references 15: 9 Russian; 6 Western.

## Plasma Electron Source With Radially Converging Beam

*937F0137A Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 93 pp 131-136*

[Article by A.P. Semenov, V.P. Narkhinov, Buryat Natural Sciences Institute at the Siberian Department of Russia's Academy of Sciences, Ulan-Ude; UDC 621.3.032.269.1]

[Abstract] The use of electrode structures in which a ring discharge is ignited and electrons are extracted from a narrow cylindrical plasma layer for generating a converging electron beam suitable for such practical applications as hardening, melting, soldering, welding, curing resin, disinfecting grain, and neutralizing effluents is discussed and it is noted that glow discharge plasma steadily ignited in a Penning electrode system is highly emissive. The design of an electron source containing a discharge chamber with a cathode from stainless steel 12Kh18N9T where the discharge is ignited in an electrode rod structure with a common hollow anode in a magnetic field is described and the conditions for effective electron extraction are examined. The dependence of the electron beam current on the extracting voltage with and without the anode insert is plotted. The simple and reliable plasma source design is distinguished by the specific features of the new discharge chamber design while the source performance attests to the expediency of its implementation in commercial practices. The beam current and specific power can be increased substantially: given an accelerating voltage of 20 kV and a discharge current of $>0.5$ A, a beam current of $>0.2$ A has been attained; this figure may be increased further following simple engineering improvements of the discharge chamber cooling system and by increasing the dielectric strength of the source structure. Figures 3; references 3.

## Pulsed Electron Beam Magnetic Focusing System for Electric Ionization Lasers

*937F0137B Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 93 pp 137-140*

[Article by D.A. Zayarnyy, L.V. Semenova, N.N. Ustinovskiy, I.V. Kholin, A.Yu. Chugunov, Physics Institute imeni P.N. Lebedev at Russia's Academy of Sciences, Moscow; UDC 621.373.826.038.823]

[Abstract] The problem of generating a uniform magnetic field with a $\geq 1$ kG strength in high-pressure electron beam (e.p.) and electric ionization (e.i.) gas lasers with a large cell is addressed and it is speculated that it can be solved by using a pulsed magnetic focusing system with two plane coils fed by an electric power integrator. A pulsed magnetic focusing system with a capacitive integrator power supply developed for the Tandem all-purpose electric ionization laser unit is proposed and its schematic diagram as well as a schematic diagram of the charging and discharging circuits of the electrolytic capacitor bank are cited. The discharge current pulse oscillogram in the magnetic coil and the dependence of the magnetic flux density at the magnetic coil center on the charge voltage of the capacitor bank are plotted. Extended operation of the device during several years demonstrated its reliability and convenience. Its only flaw is due to the need for electric forming of the electrolytic capacitors for several hours after a week-long service interruption. Figures 4: references: 4 Western.

## Superconducting Magnet With Uniform Field

*937F0137C Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 93 pp 172-176*

[Article by L.B. Luganskiy, V.V. Travkin, V.P. Bubnov, I.S. Krainskiy, Physics Problems Institute imeni P.L. Kapitsa at Russia's Academy of Sciences, Moscow, and Department of Chemical Physics Institute imeni N.N. Semenov at Russia's Academy of Sciences, Chernogolovka; UDC 538.244.2]

[Abstract] The need for a highly spatially uniform and stable magnetic field for nuclear magnetic resonance (YaMR) tomography, e.g., that generated by superconducting (SP) magnets operating in the frozen field condition, is discussed and a superconducting magnet with a horizontal axis designed and built in the Physics Problems Institute imeni P.L. Kapitsa at Russia's Academy of Sciences for use in NMR tomography is described. A general view of the magnet is shown and its schematic diagram is cited. The field distribution along the magnet axis is plotted. The magnet's winding consists of two pairs of symmetric coaxial coils with a horizontal axis while the superconducting correction system contains five zonal field harmonic correction coils and six tesseral harmonic correction coils whereby all correcting coils use the same power supply, are connected in series, and are equipped with superconducting gates. The time stability of the frozen state field after the correction procedure is so high that it cannot be measured by existing instruments; it is estimated to be better than $10^{-8}$ 1/h and points toward the high quality of the superconducting keys. The above four-coil magnet is compact and uses much less superconducting wire than usual solenoids. The authors are grateful to A.V. Dubrovin, V.G. Zatsepin, D.L. Filimonov, V.I. Chekin, and the staff of pilot plant at the Physics Problems Institute for help with making the magnet. Figures 3; references 8: 5 Russian, 3 Western.

## Manufacturing of Surface Acoustic Wave Transducer

*937F0137D Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 93 pp 189-190*

[Article by V.S. Borshchan, Yu.G. Rezvov, O.D. Sivkova, Novomoskovsk Branch of the Moscow Chemical Engineering Institute imeni D.I. Mendeleyev; UDC 534.232]

[Abstract] The design and operating principle of a new transducer for exciting surface acoustic waves (PAV) in piezoelectric materials made as a single piece with the acoustic line are outlined and the manufacturing method is described. The production method for making the excitation and additional surfaces calls for using ionic etching equipment. The mechanical procedure of making the transducer which is reproducible virtually in any laboratory is presented. The device is made by gluing a strip shaped as a rectangular parallelepiped to the surface on which the surface acoustic wave propagates, then grinding the open part of the acoustic line surface whereby the lateral side of the strip serves as a grinding bar guide. Then the strip is removed, and electrodes are applied to the edges of the resulting additional surface and propagation surface. The transducer described here was made from a lithium niobate chip with a Y+128° cut and had a center frequency of 10.4 MHz at an excitation efficiency of 27 dB. The proposed manufacturing method does not have principal constraints on the excitation frequency. Figures 2; references 1.

## Electron Gun With Ribbon Beam

*937F0137E Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 93 pp 200-203*

[Article by A.A. Kravchenko, L.G. Magayev, Taganrog Radio Engineering Institute; UDC 621.9.048.7]

[Abstract] Surface modification—a promising glass technology trend—and the outlook for using electron beam treatment (ELO) for local heat exposure for this purpose are discussed and it is noted that ribbon electron beams formed by Pierce guns in a potential-free space and transported to the surface without additional magnetic fields are the most suitable for heat treatment of glass. The principal requirements imposed on ribbon beam electron guns, such as the design simplicity, beam parameter reproducibility following the cathode replacement, and short cathode replacement and gun tuning procedures, are outlined. An electron gun with a near-cathode Pierce electrode (PKE) which meets these requirements is described and a schematic diagram of the gun's cathode assembly is cited. The gun has a power density of 50-$10^5$ W/cm which is controlled by the cathode filament current and accelerating voltage. The beam has a 20-500 mA current at a 1-15 keV electron energy and (0.5-3.0) x (15-150) mm dimensions. The electron beam with a W or W+Al cathode is used for electron beam surface treatment of glass substrates and products and for surface hardening of steels. The thin film structures on treated substrates have better parameters while hardened steels increase their contact strength by two- to threefold. Figures 2; references 5.

## High-Voltage High-Speed Gate for Electrooptic Device Control

*937F0137F Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 93 pp 223-225*

[Article by A.N. Safonov, S.I. Svetlichnyy, Branch of the Energy Problems Institute of Chemical Physics at Russia's Academy of Sciences, Chernogolovka; UDC 621.375.1.6]

[Abstract] The need for radio electronic devices which form pulse with an amplitude of several hundred volts with a rise and decay time of several tens of nanosecond capable of carrying a capacitive load and the lack of designs ensuring the necessary output voltage and leading and trailing edge durations prompted the development of a unit for controlling the ML-103A electrooptic modulator with a 240-280 V half-wave operating voltage. A schematic diagram of the control unit is cited and a typical oscillogram of the unit's output pulse with a 300 pF capacitive load is plotted. The gate with the modulator were used to modulate the emission of the LG-126 He-Ne laser is produced the following parameters: a contrast gamma of at least 100 at a wavelength of 0.63 and 1.15 μm and a leading and trailing edge duration of 70 ns. The design does not call for tuning if assembled correctly. Figures 2; references 3.

## On Measuring Long-Focus Mirror Curvature

*937F0137G Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 93 pp 226-227*

[Article by V.S. Kazakevich, P.A. Mikheyev, A.A. Shepelenko, Samara Branch of the Physics Institute at Russia's Academy of Sciences; UDC 535.313.08]

[Abstract] The difficulty of measuring the curvature of reflecting surfaces with a radius of $>5$ m, e.g., long-focus mirrors, prompted the development of a simple optical design in which the mirror is stationary while the beam moves parallel to itself. To this end, a PM-90 measurement plate attached to a turntable and designed as a glass cylinder with strictly parallel 90 mm long ends and a 50 mm diameter is used. The optical train of the mirror curvature measurement device is cited and the formulae are derived for the mirror's radius of curvature. The measurement accuracy is 1% for a mirror with a close to 10 m radius. The proposed design is used to measure the curvature radius of industrial laser resonators. Figures 1; references 1.

## Effect of Phase Transition on Optical Trap Recharging in Ferroelectric Film on Silicon

*937F0150A Moscow POVERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA in Russian No 12, Dec 92 pp 43-45*

[Article by L.B. Gorodnik, A.V. Petrov, A.G. Petrukhin, V.V. Starostin, Physics Department of the Moscow State University imeni M.V. Lomonosov; UDC 621.315.592]

[Abstract] The outlook for using active insulator films which are polarized in the absence of external fields in insulator-semiconductor (DP) and MIS (MDP) structures, i.e., ferroelectric (SE) films on a silicon substrate, is discussed. The behavior of charge transfer and the trapping sites during a ferroelectric phase transition and the processes of optical trap recharging in a ferroelectric film on a Si substrate within a broad temperature range, including the phase transition interval which contains the Curie temperature, are investigated. To this end, 0.8 μm-thick films of $Ba_{0.9}Sr_{0.1}TiO_3$ deposited by RF sputtering in an oxygen atmosphere on the surface of Si single crystals is examined, and the optical recharging spectra of the Si-ferroelectric film structure after heating at 700K for 1 h is plotted. The film charging under light exposure is recorded by the change in contact difference of potential between the sample and the oscillating gold electrode. The findings reveal a sign reversal of the charge accumulated on the Si surface at temperatures in the vicinity of the phase transition. This phenomenon is attributed to the disappearance of spontaneous ferroelectric film polarization at the Curie temperature. Figures 1; references 5: 4 Russian, 1 Western.

## Radiation-Induced Modification of Corundum Single Crystal Surface and Optical Functions in Vacuum Ultraviolet Region

*937F0150B Moscow POVERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA in Russian No 12, Dec 92 pp 108-111*

[Article by V.V. Arutyunyan, V.A. Gevorkyan, N.Ye. Grigoryan, Yerevan Physics Institute; UDC 535.37:539.12.04]

[Abstract] Applications of radiation-induced structure and composition modifications of the subsurface crystal layer in solid state technologies and methods of utilizing these phenomena are discussed, and the processes of surface breakdown of corundum single crystals under the effect of electron irradiation in the optical spectra, i.e., the functions of electrons' energy losses, are considered. To this end, α-$Al_2O_3$ crystals grown by horizontal oriented crystallization whose $C_3$ optical axis is parallel to the large sample face are irradiated with 50 MeV electrons, and the optical function are calculated using the Kramers-Kronig variational formula on the basis of the experimental reflection spectra at a 293K temperature within a 5-30 eV range. The spectral dependence of the corundum single crystal reflectance at various synchrotron radiation orientations and the spectral dependence of the electron loss function of irradiated and nonirradiated corundum single crystals are plotted. These high-quality spectra reveal a spectral band anisotropy and show that the cation component reduction under irradiation is due to the radiation-induced oxygen desorption from the surface. The resulting subsurface layer defects lead to both an increase and decrease in the crystal reflectance. Thus, irradiation upsets the subsurface layer stoichiometry due to the elastic interaction of high-energy particles with the lattice. Figures 2; references 7: 5 Russian, 2 Western.

## Information Capabilities of Holographic Interferometry in Engineering Metrology

*937F0153A Moscow STANKI I INSTRUMENT in Russian No 4, Apr 93 pp 18-22*

[Article by A.M. Geniatulin; UDC 621.9.048.6.06]

[Abstract] The increasing uses of holographic interferometry in science and engineering and the underlying principles of the method are outlined and some specific examples of holographic interferometry applications and its information capabilities are discussed. In particular, attention is focused on measuring the surface deformation of machine elements and analyzing their taut strained state, analyzing vibration in metal-cutting machine tools, carrying out nondestructive testing, and investigating the surface relief parameters. The advantages of holographic interferometry over classical (optical) interferometry are presented, and typical interference patterns are cited. The conclusion is drawn that the use of holographic interferometry at industrial enterprises, combined with strain measurements and photoelasticity phenomena, make it possible to expand the scope of data necessary for design and operation purposes and for analyzing the physical principles of actual processes in machine elements. It is noted that despite its versatility, holographic interferometry does not replace other experimental deformable solid analysis methods. Figures 1; references 13: 11 Russian, 2 Western.

## Spherical Transient Wave Diffraction by Circular Cylinder

*937F0157A Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 39 No 3, May-Jun 93 pp 414-420*

[Article by N.A. Artsykova, A.K. Pertsev, St. Petersburg State Marine Engineering University; UDC 539.3]

[Abstract] Diffraction of a spherical transient shock wave propagating in an acoustic medium by a rigid circular cylinder is studied, and a new version of the solution which greatly simplifies the computational algorithm is proposed. To this end, an infinitely long circular cylinder placed in a boundless acoustic medium in a cylindrical system of coordinates with a source of spherical shock wave located at a certain point and described by the liquid velocity potential is considered. The liquid motion generated under the impact of the shock wave on

the cylinder is described by the wave equation for the velocity potential. The spherical wave diffraction is examined in a linear formulation, and a precise solution is derived in an integral form. A numerical algorithm is developed for calculating the diffraction pressure, and the diffraction pressure on the cylinder surface and the limiting pressure on the cylinder surface under the effect of the stepped wave are plotted. The limiting pressure reached on the cylinder under the effect of the stepped wave and the pressure momentum under the effect of a wave with a random pressure drop law behind the front on the cylinder are computed. Approximate formulae necessary for engineering analyses and for measuring the diffraction pressure are derived by approximating the diffraction pressure. It is noted that the linear theory adequately describes the diffraction phenomena in water at shock wave pressures of up to 50 MPa and in the air—at up to 0.01 MPa. At higher pressures, the nonlinear phenomena become significant and must be taken into account for correctly assessing the impact of air shock waves on various objects. Figures 2; references 6: 5 Russian, 1 Western.

### Piezoelectric Mechanism of Optoacoustic Interaction in Laminar Photoconductor-Piezoelectric Structure

*937F0157B Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 39 No 3, May-Jun 93 pp 467-472*

[Article by I.S. Grudzinskaya, P.A. Pyatakov, A.A. Chaban, Acoustics Institute imeni N.N. Andreyev at Russia's Academy of Sciences; UDC 534.2-16]

[Abstract] Experimental observations of theoretical descriptions of acoustic wave excitation under the effect of two coherent light beams with a frequency shift (i.e., a traveling grating developed by interference) both in the case of bulk and surface acoustic waves (PAW) are discussed, and an attempt is made to construct a consistent theory of surface acoustic wave generation in a laminar photoconductor-piezoelectric structure by a traveling light grating in the presence of an external drift field with both impurity and intrinsic photoconduction. To this end, two uniform half-spaces one of which is a photoconducting medium and the other—a piezoelectric medium whereby the gap between the two is negligible are considered. The dependence of the surface acoustic wave energy flux on the light intensity and frequency is plotted on the basis of theoretical data. The findings are consistent with earlier experimental data. It is emphasized that the above acoustic wave excitation method is characterized by its exceptional efficiency and is rather simple to implement. Figures 2; references 11: 7 Russian, 4 Western.

### Model of Ultrasonic Motor With Frictional Motion Mode Conversion Under Slip Conditions

*937F0157C Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 39 No 3, May-Jun 93 pp 479-488*

[Article by O.Yu. Zhariy, Kiev University imeni Taras Shevchenko; UDC 534.1]

[Abstract] Ultrasonic motors—engineering devices which transform the vibratory and undulatory motion of elastic bodies into the translational or rotary motion my means of contact frictional forces—are considered, and the shortage of theoretical studies in this field is noted. An attempt is made to formulate a model of an ultrasonic motor with frictional mode conversion and to prove the validity of the assertion that mechanical models of ultrasonic motors are the most exhaustive and diverse compared to other possible motors, e.g., those based on equivalent electric circuits. A mechanical diagram of the motor is presented, and it is assumed in the model that the rod is axially nondeformable, the excitation frequency is small compared to the lowest resonance frequency of transverse rod vibrations, and the rod end is in continuous sliding contact with the rotor's lateral surfaces. The operating principles of the motor is examined and transient conditions and their timing charts as well as mode conversion efficiency are plotted. The findings demonstrate that after the transient process attenuates, the rotor spins unidirectionally at a constant angular velocity; the motor efficiency in the sliding mode is rather low (<8%); the maximum load torque is proportionate to the radius and force of the initial rod compression to the rotor; and the rotation speed depends on the excitation parameters and rotor characteristics and decreases with an increase in the load torque. Figures 5; references 12: 3 Russian, 9 Western.

### Investigation of Effect of Airfoil Vibrations on its Edge Noise

*937F0157D Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 39 No 3, May-Jun 93 pp 489-497*

[Article by V.P. Ilin, Yu.L. Levkovskiy, Central Scientific Research Institute imeni Krylov; UDC 534.532]

[Abstract] The concept and mechanism of edge noise and the role of wing vibrations on its trailing edge noise are discussed. An experimental study is carried out in order to ascertain which of the two proposed theoretical noise mechanisms—the vibrating airfoil surface as an acoustic radiator antenna or the trailing edge vibrations as the source of the flow reordering in its vicinity—is quantitatively predominant. The design of the experimental unit used for this purpose is examined, and the spectral radiation levels and the dependence of the spectral maximum levels on the screw propeller rotation speed and the dependence of the discrete values of noise on the rotation speed are plotted. The conclusion is drawn that vibrations increase the rate of radiation and lead to the appearance of maxima in the spectrum at the natural wing vibration frequencies due to an increase in the intensity of the vortices leaving the trailing edge and their regularization. It is shown that the edge noise and propeller humming have the same physical origin, i.e., trailing edge noise is equivalent to "sluggish humming" in blade mechanisms. In other words, in humming, not the vibrating blade excited by the vortical trail but the transient flow, i.e., the vortices themselves, are the radiator. The authors are grateful to G.Ya. Barabanova for helping with the experiment and data processing. Figures 8; references 5: 3 Russian, 2 Western.

## Nonlinear Phenomena in Acoustic Pulse Focusing With Shock Front

*937F0157E Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 39 No 3, May-Jun 93 pp 510-516*

[Article by A.G. Musatov, O.A. Sapozhnikov, Moscow State University imeni M.V. Lomonosov; UDC 534.222]

[Abstract] The role of nonlinear media in high-power acoustic pulse focusing and focusing of high-power pulses at various wave front opening angles are outlined; the lack of adequate studies of the effect of acoustic nonlinearity is noted. The outcome of an experiment to examine the focusing process as a function of the wave amplitude is discussed. The acoustic pulses are excited with the help of an optoacoustic (OA) converter using a Nd glass solid state laser as an optical source whereby the transverse intensity structure in the light beam is smoothed by placing an opaque plate in front of the optoacoustic converter. The acoustic pulse profiles, the dependence of the squared shock front time shift on the distance traveled by the wave, the peak pressure behavior, the dependence of the acoustic beam diameter on the distance from the radiator, the transverse peak pressure distribution in the focal plane, and the peak pressure in the focus as a function of the initial peak pressure are plotted. It is shown that in using 0.2 μs short pulses with a 10-500 atm shock front, the nonlinear absorption and self-refraction effects greatly alter the focusing picture. As the pulse intensity increases, the focal area increases in size, and the pressure gain in the focus drops. The findings show that nonlinear absorption is due to energy dissipation, and self-refraction is due to nonlinear shock front acceleration. The results of the experiment are compared to two theoretical models. Figures 7; references 12: 9 Russian, 3 Western.

## Absorption Minimization in Zinc Fluoride and Selenide Film-Based Mirrors

*937F0158A St. Petersburg OPTIKA I SPEKTROSKOPIYA in Russian Vol 74 No 3, Mar 93 pp 621-625*

[Article by Ye.N. Kotlikov, B.F. Shifrin, Physics Institute at the St. Petersburg State University, Peterhoff; UDC 535.34:535.87:537.311.33]

[Abstract] The advantages of zinc fluoride and zinc selenide—popular materials with a high refractive index—for making multilayered interference coats and the demand for low absorption materials for $CO_2$ lasers prompted an investigation into the possibility of designing a multilayered dielectric two-component mirror with minimal losses at the center wavelength. The absorption spectra of multilayer mirrors are examined and the possibility of optimizing the mirror design is considered. The absorption spectra of standard mirrors with 14 quarter-wave layers and new designs and the total mirror loss spectra are plotted. It is shown that the loss minimization task, i.e., design optimization, is a multicriterial problem in which not only the absorption level but also the spectral absorption minimum shift must be taken into account. For a mirror with quarter-wave films, the absorption minimum band falls within $1.08\text{-}1.16\lambda^*$ where $\lambda^*$ is the center wavelength. An algorithm for arriving at an optimum mirror design with a minimum absorption is presented and tested, and the findings are compared to published data. The use of the algorithm demonstrates that given a refractive index ratio of 1.5-2.2, a design containing blocks of films with a particular thickness (as a ratio of high and low refractive index component) is optimum. Such blocks make it possible to attain a close-to-minimum absorption within a rather wide range. Figures 2; references 11: 7 Russian, 4 Western.

## Interrelation of Certain Operating Parameters of LGN-208 He-Ne Laser

*937F0158B St. Petersburg OPTIKA I SPEKTROSKOPIYA in Russian Vol 74 No 3, Mar 93 pp 626-629*

[Article by G.Kh. Chedzhemov, L.V. Kachan, Ya.M. Bondarchuk, Physical Chemistry Institute imeni L.V. Pisarzhevskiy, Lvov; UDC 621.375.826+537.53]

[Abstract] The dependence of the radiating power of He-Ne lasers on the mixture pressure in the active element (AE) and laser operation with a glow discharge are discussed and an attempt is made to record the full dependence of the radiating power and active element voltage on the laser medium pressure for He-3 with Ne-20 mixtures at various partial pressure ratios. To this end, an experiment is carried out whereby 14 LGN-208 He-Ne lasers are alternately connected to a unit which makes it possible to record the dependence of the radiating power on pressure under a continuous slow increase in the active element pressure. A projection of the envelopes of the spatial dependence of the radiating power upon the pressure-power, pressure-voltage, and voltage-power planes for various partial pressure ratios are plotted. The processes occurring in the active element with changes in the mixture pressure are examined assuming that the electron temperature is constant at the power peaks and that the discharge contracts and the positive discharge column separates from the capillary wall. Figures 3; references 6: 5 Russian, 1 Western.

## Feasibility of Underground Nuclear Reactors Debated

### Possible Safety Improvements Touted

*93WN0414Z Moscow ROSSIYSKAYA GAZETA in Russian 5 May 93 p 4*

[Article by Lev Shadrin, candidate of technical sciences: "This Is the Basis of Human Rights in an Industrial Society"]

[Text] Since Chernobyl, work has been going on to ensure the internal safety of the active zone of reactors at all AES [nuclear electric power station] in operation and under construction. The system of protection control is being modernized, and systems for ensuring against possible operator error and for the diagnostics of incipient defects in reactors, etc., are being established.

But even this does not preclude the possibility of breakdowns and accidents.

The consequences of the Chernobyl catastrophe are well-known: Thirty persons perished, 237 were stricken with radiation sickness, and 14 oblasts were "tainted" with radiation in Russia alone. According to the status as of the beginning of 1990, the damage inflicted on the national economy is estimated at 9.2 billion rubles [R].

The figure is monstrously high. But even it does not compare with the "record" established by the Americans. According to reports, the damage from the accident at Three Mile Island (1979) is estimated at approximately $130 billion.

But would that the tragedy at Chernobyl was the only one in our country! How many other "irregular situations" occur at our AES! Many are accompanied by radioactive emissions.

It is also impossible not to mention a new circumstance which arose at the very beginning of the "Desert Storm" operation—the destruction by American bombers of practically all of the atomic facilities of Iraq, including the nuclear center near Baghdad. Thus, a country that possess aboveground nuclear electric power stations and nuclear stations for thermal supply can be turned suddenly into the chaos of massive radiation destruction... either by an enemy or by terrorists.

That is why it is necessary to endow the AES with a guaranteed 100 percent safety. This requirement should become the basic position of the human rights code in an industrial society.

This kind of safety can be guaranteed by a rather massive layer of earth. Therefore, all AES and nuclear plants should be built underground.

Even given a maximum theoretically possible accident that exceeds the destructive force of the Chernobyl disaster by tens and hundreds of times, the thickness of earth will serve as a reliable barrier against the spread of radioactivity. In any case, radioactive substances will not get into the atmosphere, but in the surrounding earth. The population and all of the natural environment in the area of the AES will be beyond danger.

In the opinion of Academician A. Sakharov, the placement of nuclear reactors underground is the cardinal method of ensuring the safety of nuclear power engineering.

Of course, the cost of construction increases approximately by a factor of two, and its period by one and a half to two years. However, when a country is hit by a calamity under the name of Chernobyl or Three Mile Island, it is forced to accept astronomical costs, if only to get the situation under control, to save people, and to restore the environment. And, what is of no small importance, to restore the reputation of a responsible neighbor. In addition, underground AES can be placed a lot closer to the main consumers than their aboveground counterparts.

Mankind will succeed in achieving guaranteed safety and an almost lost sense of ecologic comfort in the nuclear epoch only in the event that the question of underground disposition of nuclear power engineering facilities will be decided simultaneously in all countries. Only in this case will nuclear power engineering regain its former trust.

In the meantime, there is no adequate alternative to nuclear power engineering either in our country or in any other countries. The conclusion follows from this: It is necessary to use the unique scientific, industrial, and raw materials potential of our country in the sphere of nuclear power engineering in a more rational way. For this, develop and implement a program of construction on the territory of Russia of a network of ecologically safe underground AES and AST [nuclear power station for thermal supply].

### New Uncertainties Foreseen

*93WN0415B Moscow ROSSIYSKAYA GAZETA in Russian 5 May 93 p 4*

[Article by Viktor Kosogorov, chief specialist of the All-Russian Scientific Research Institute (VNII) Atomenergoproyekt: "It Is Not a Panacea, But Just One of the Ways"]

[Text] Chernobyl is, nonetheless, an exception in an almost 40-year history of world nuclear power engineering. The accident at Three Mile Island produced emissions of radioactivity a thousand times lower than that of Chernobyl, and there were no human losses. And, as far as I know, the maximum cost of eliminating its aftereffects amounted to several billion dollars, but nothing like $130. However, even this is not the point.

As in the entire world, it is honestly admitted in our country that the theoretical probability of an accident cannot be zero, and safety, 100 percent. In such a case,

according to the laws of mathematical logic, no kind of "adequately massive layer of earth" will help.

It is obvious, however, that the list of such accidents, and also their causes, can be different for aboveground and underground AES. The abundance of aboveground structures even on an underground AES and the enormous amount of utility systems (technological, hydrotechnical, ventilation, and others) also conditions the potential danger of the escape of radiation into the atmosphere.

Underground placement also does not guarantee effective protection against terrorism—both from individual and from state action (in the event of military operations).

Now, about a certain "maximum theoretically possible accident that exceeds the destructive power of the Chernobyl catastrophe by tens and hundreds of times." This estimate is incorrect, inasmuch as at Chernobyl, according to various estimates, from three to several tenths of percents of the activity accumulated in the reactor was discharged. That is, an increase by tens and, what is more hundreds of times, is not possible.

Something else is also known: Academician Sakharov admitted in conversations with specialists that underground placement changes little in the sense of safety, but, psychologically, he said, the human illusion of the majority should be met half way.

Nevertheless, a "Concept for the Underground Placement of Nuclear Power Engineering Facilities" was recently developed in our industry. It abstracted a vast amount of material on all aspects of their design, construction, safety estimates, foreign experience, etc. (The working group included specialists of dozens of enterprises and organizations of various profiles that have different views and competing interests). A voluminous work was produced, with several volumes of attachments. The basic conclusions are these.

It is still too early to come to an unequivocal conclusion on the feasibility or infeasibility of the development in one or the other direction. It is enough to report that the placement of an AES underground, in an untraditional environment that has not been studied much, raises a whole series of uncertainties. While the consequences of some accidents can be more favorable for the atmosphere, the very probability of the emergence of accidents increases because of a worsening of the conditions of normal operation, repair, the organization of heating and ventilation, fire safety, smoke removal, flooding danger, etc.

In the world in 1960-1963, only five underground experimental and special purpose nuclear power stations of a total capacity of about 400 megawatts were started. All of the other studies and designs remained on paper. This is probably not without a purpose: The developed countries are not only able to calculate the costs, but, no less than ours, they are concerned about the safety and protection of the environment. And no less than ours, they fear state terrorism. Thus, their position and the practice of industrial construction after this of only aboveground AES deserves our attention.

Nevertheless, the underground placement of individual buildings and structures of an AES is one of the ways being investigated, if we want to increase the level of their safety. And at the same time, we have to be concerned about the competitiveness of the energy source being created.

Another possible direction can be the construction of underground AES there, where the specific local conditions coincide with the requirement of the region for energy and with the desire and financial capabilities of the customer and other important factors.

## On Assessing Accessory Components in Sheet-Infiltration Uranium Deposits

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[Article by M.I. Fazlullin, V.D. Chekushkin, G.F. Pudan, V.V. Kochetkov, V.P. Bukar, All-Russian Scientific Research Institute of Chemical Engineering, under the rubric "Protection of mineral resources and ecology"; UDC [553.495:622.839.43]: 54.02-032.5.003.12]

[Text] The experience gained in prospecting and exploration of uranium deposits by underground leaching (PV) methods shows that the ores or the underground leaching process solutions contain considerable concentrations of many valuable rare elements whose side recovery—either comprehensive or selective—may ensure the most efficient utilization of the Earth's interior and considerably increase the cost of marketable products. Among these, the most interesting are the elements which are characterized by a variable valency in natural geochemical media and which accumulate together with uranium on the reduction barrier in the field of the sheet oxidation outcropping area up to the formation of commercial concentrations, i.e., selenium, molybdenum, uranium, and vanadium, and less frequently and in considerably quantities, germanium, silver, and some other elements.

These elements differ considerably in their geological and technological properties depending on the conditions and accumulation forms in the area of ore deposition. Uranium and molybdenum which are concentrated in ores in similar or more reducing conditions relative to uranium are easily recovered by all solvents used in underground uranium leaching, especially with oxygen additions. Selenium and vanadium which accumulate in the rear section of the ore zone in a more oxidative environment require considerably higher oxidizers for attaining better recovery (chlorine, etc.) or special process conditions for selective recovery (sodium sulfide solutions for selenium).

A summary of available data also demonstrates that the concentration levels of the elements accumulating on the reduction barrier and, likewise, in process solutions differ substantially at objects in different provinces and to a lesser extent—within the provinces. Consequently, the list of useful components which are economically efficient for recovery is different somewhat at different facilities.

Although other rare and trace elements do not form considerable accumulations in the ore zone, they are also partially leached from the ore-enclosing sands with sulfuric underground leaching solutions. They may accumulate in the solutions to a level which makes it possible to recover them profitably. These are primarily scandium, yttrium, and lanthanides, and also possibly gallium, aluminum, etc.

Our research and summaries of data on most underground leaching objects unfortunately do not confirm the concepts of certain authors[5, 6] about a considerable accumulation of these elements in the ore deposition area on the acid-alkali barrier. These are primarily scattered in relatively difficult-to-develop clay, mica, and phosphate minerals. Their distribution is developed by the lithological characteristics of the rock. The mineral forms are altered only slightly during the epigenesis with a certain increase in the proportion of more soluble forms. This determines the generally low (no more than 10-20%) recoverability of these elements into the underground leaching solutions which, according to mineralogical-process research data, may vary within different ranges in different geochemical zones.

The development of efficient techniques for testing and assessing the recovered useful constituent resources is one of the important tasks of setting up comprehensive underground leaching development at the deposits under study. The principles and requirements imposed on calculating the associated constituent reserves are contained in relevant instructions of the State Committee on Mineral Resources (GKZ)[4] and in other publications. Yet as A.M. Sechevitsa mentions[1, 2], no sufficient and generally acceptable classification of associated constituents and the methods and indicators of their assessment in combined raw materials have been developed. These issues have not been addressed for uranium deposits explored by underground leaching.

In classifying useful constituents, it is primarily necessary to identify those which are comparable to uranium with respect to their concentration, reserves, and extractive value and, under certain conditions, may serve as an object of independent profitable recovery; otherwise, profitable ore exploration becomes possible only if all base constituents are jointly recovered. Only in this case the deposits or their ores can be considered as being complex; these elements are regarded as base elements and are assessed by a procedure and with a degree of detail which are similar to the base ore constituent with predominant value (uranium).

For illustration, let us consider selenium which is present on a considerable scale in many objects. In essence, these objects must be classified as selenium-uranium deposits. Unfortunately, limited demands and the outlook for using selenium contribute uncertainty to the issue of the expediency of detailed assessment of its reserves. At some deposits, molybdenum may be regarded as a base constituent while at others—vanadium.

From this viewpoint, only those elements which do not form aggregations having independent commercial value may be regarded as associated useful constituents. These can be extracted from the Earth's interior at an efficient economic basis only if the base or a group of base constituents are present in the deposit under study provided that the total recovery and processing expenditures are credited to these base constituents.

The methods of assessing the associated constituents which call for special geological-mineralogical, engineering, and economic research must differ substantially from the methods of assessing the base constituents. First of all, the problem of identifying the set of associated valuable constituents must be solved for each entity on the basis of testing individual blocks or a cross-section typical of the object as well as the products of all process stages combined with the necessary engineering and economic analyses. In assessing the expediency of recovering valuable constituents, it is especially important to study their distribution in the underground leaching solutions allowing for the development stages in the sorption, desorption, and other intermediate products since the profitability of the associated constituent production is primarily determined by the level of their concentration in these products. Having established the yield of valuable constituents into each product, one can tentatively estimate their recoverable quantity as a function of the underground leaching enterprise productivity for solutions and other products.

The methods of assessing the resources and the necessary degree of detail of studying certain associated constituents differ significantly depending on their prices on the domestic and world markets, the needs and commercial use trends, concentration levels and concentration degree in the ores and technological products, spatial and mineral bonds with the base constituent, the possibility of recovering into intermediate and final products with existing practices, and in the final analysis—on the cost of product and the recovered value of each constituent.

In estimating the reserves of associated valuable constituents at the uranium deposits developed by underground leaching, it seems expedient to follow A.K. Lisitsyn's method and divide them into two groups: geologically associated (uranium, molybdenum, selenium, and vanadium) and technologically associated constituents (scandium, yttrium, and lanthanides). The first group elements which are accumulated during the epigenesis together with uranium, in a general case, call for a more detailed investigation of their distribution and a calculation of their reserves in the Earth's interior than those

of the second group. They are studied by systematic group sampling. The samples are taken according to the type and grade of the ore allowing for the lithology, geochemical zonation, and morphological elements of uranium deposits. As A.M. Sechevitsa mentions[1, 2], even if group samples are used, it would be inefficient to test all ore intersections. The prospecting network for taking group samples to analyze associated and base constituents can be made much thinner.

The entire effective depth of the ore-bearing horizon explored by the process solutions will be tested. Since the associated constituents are recovered only together with uranium, their reserves are determined within the area outlines of the balanced uranium ore bodies. A more detailed testing with mapping of ore accumulations may be profitable only in the areas of considerable associated constituent concentration if this makes it possible to organize selective recovery of valuable constituents without diluting the productive solutions. Naturally, in the cases where some of the elements under study are classified as base elements on the scale of mineralization, the approach to testing them and calculating their reserves must change radically.

For the second group of elements present in the ores and rock in a trace form and usually characterized by limited recovery into the underground leaching solutions, the procedure for assessing the reserves must be different. There is no reason to carry out large-scale testing for these constituents and artificially identify "ore bodies." A thin net of mineralogical-geochemical profiles is sufficient for determining the level of their concentration and distribution characteristics in the ores and enclosing rock. Calculation of gross reserves of these elements is also inexpedient. For the purpose of side recovery, it is much more important to determine the rare element reserves which can be realistically recovered into the solutions under the underground leaching conditions used per ton of oxidized ore body mass.

The most efficient method of assessing the recoverable resources in our opinion is systematic geotechnological ore testing combined with a complex of laboratory and scientific research which clarify the characteristics of the rare element transition to the solutions. It is expedient to conduct testing according to the mineralogical-geochemical profiles encompassing the characteristic elements with the epigenetic zonation and lithological-filtration ore types. Since only the recoverable resources are determined in the course of testing, it is no longer necessary to analyze the solid samples for rare elements before and after leaching. This simplifies the analytical procedure, greatly decreases the analysis scope, and makes it possible to make a more detailed analysis of the sample quality and increase the control analysis volume.

In the procedure of testing for trace elements, it is necessary to keep in mind that these are primarily enclosed in difficult-to-develop minerals which decompose only partially during the underground leaching of uranium and do so quite slowly during the entire period of their contact with the acid solutions. Consequently, in order to shorten the testing duration, it is necessary to increase the rate of sufficient development of these minerals which is attained by using more rigid conditions (more acidic solutions and sample heating and grinding).

Thus, V.M. Panteleyev treated the samples ground beforehand with a 20% nitric acid (S:L = 1:2) in a cold environment for 8 hours with stirring in order to determine the acid-recoverable proportion of valuable constituents and increase the process speed. Yu.A. Balashov and Yu.P. Girin used a two-stage phase analysis in 1969 in order to estimate the volatile proportion of rare earth elements (RZE) in the sedimentary rock. During this first stage, they used an ammonium oxalate solution and at the second stage—a 2% hot hydrochloric acid (with a 6-hour contact duration) which dissolves iron carbonates, phosphates, and oxides yet has relatively little effect on the clay and associated mineral lattices.

We tested a large number of samples from certain deposits and determined rare elements in the dry residues of the solutions by the approximate-qualitative spectral method and by sieving into the three-phase arc plasma. Testing was conducted in two stages: first using a solution of ammonium acetate in order to identify easily mobile forms, then for one hour with hot 10% hydrochloric acid.

Summarized data on microtesting with a sample classification by the sand grain size and geochemical zones shown in the table generally correspond to data of laboratory technological experiments. Yet in order to obtain a more differentiated distribution pattern of the recovered resources by deposits, blocks, and geochemical zones, the use of more accurate analytical methods is required.

**Acid-Recovered Amounts of Rare Elements of Core Samples for Operating Underground Leaching Blocks of Sheet-Infiltration Deposit, g/t**

| Elements | Gray Sands | | | | | Oxidized Sands | | | | Sand Average | Ground Aleurolite |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Consertal | Average | Fine | Medium | Coarse | Average | | |
| Number of samples | 55 | 26 | 13 | 4 | 98 | 9 | 13 | 7 | 29 | 127 | 27 |
| Sc | 0.16 | 0.11 | 0.12 | 0.16 | 0.14 | 0.13 | 0.11 | 0.17 | 0.13 | 0.14 | 1.17 |
| Y | 2.11 | 2.07 | 2.14 | 2.24 | 2.11 | 2.80 | 1.67 | 4.94 | 2.81 | 2.27 | 4.63 |
| Yb | 0.16 | 0.12 | 0.15 | 0.14 | 0.15 | 0.13 | 0.12 | 0.18 | 0.14 | 0.15 | 0.25 |
| La | 9.37 | 9.56 | 7.53 | 15.15 | 9.41 | 20.88 | 6.19 | 13.14 | 12.43 | 10.10 | 13.24 |
| Ce | 12.59 | 12.90 | 8.59 | 17.75 | 11.33 | 18.44 | 8.24 | 11.31 | 12.15 | 11.52 | 18.83 |
| V | 3.30 | 4.36 | 2.78 | 9.45 | 3.76 | 3.87 | 0.85 | 0.90 | 1.80 | 3.32 | 9.54 |
| Be | 0.33 | 0.28 | 0.30 | 0.45 | 0.32 | 0.48 | 0.46 | 0.29 | 0.42 | 0.34 | 1.78 |

Although the proposed microtesting procedure calls for considerable refining with respect to the specific entities, we think it is expedient to speed up efforts on its implementation at underground leaching enterprises. Using this procedure, one can quickly obtain the necessary data for preliminary analyses of commercially recoverable resources within a broad range of valuable constituents without carrying out extensive pilot efforts. We need a differentiated approach to determining the resources of associated valuable constituents at the specific underground uranium leaching entities as a function of the concentration degree in the ores and solutions and the recoverable value of each constituent. This will make it possible to obtain all necessary data for determining the optimum deposit development complexity level with minimum outlays.

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## Economic Barometer Reads Atomic. Nuclear Power Industry Development Trends Are Like Barbed Wire: Its Knots of Contradiction are Frequent and Acute

*937F0129A Moscow ROSSIYSKIYE VESTI in Russian No 89(258), May 93 p 4*

[Article by Erik Nikolayevich Pozdyshev, Russian Atomic Energy Concern]

[Text] There are so many obstacles in the path of nuclear power and it is being criticized frequently and so vehemently that one may doubt at times whether it can have any future.

Undoubtedly, atomic power as it exists today will become a thing of the past in the near future. Yet it will far from shrink but, on the contrary, will undergo an unusually rapid development.

After all, accumulated knowledge has not found a more reliable source of heat and light. The remaining branches of the power industry are plagued with finite raw materials and sharply increasing distances between the sources of fossil fuel and the most important locations of its consumption. Yet a nuclear power plant can run a whole year on eight railroad cars of fuel while its resources on our planet are virtually unlimited.

At times, the "greens" insist on replacing nuclear power plants with fossil fuel plants. I am certain that mankind simply cannot afford to do this. According to studies of official international organizations carried out in different countries, nuclear power plant energy is cheaper than that of coal-and gas-fired plants whereby the difference is significant: from 10 to 70%. In the long run, an increase in the electric power rates will be determined by an introduction of a fee for industrial discharges of harmful substances by the world community, primarily carbon dioxide. And here the comparison is clearly favoring nuclear power. Thus, operation of a single generating unit of a nuclear power plant with 1,000 MW power in place of a coal-fired thermoelectric power plant with the same capacity during one year makes it possible to avoid ejecting 1,200 tons of particles, 17,000 tons of nitrous oxides, 60,000 tons of sulfur oxides, and 7 million tons of carbon dioxide. Furthermore, this prevents combustion of 5.6 million tons of oxygen from the atmosphere (can you imagine how much forest must be planted to restore it!) and reduces discharges of vanadium, aerosols, and other substances which inflict considerable ecological harm on nature and the population. Finally, nuclear power plant operation is not fraught with the danger of the greenhouse effect and does not cause acid rain.

In other words, scientists, politicians, and the population of all civilized countries is coming to an inevitable conclusion: the power industry cannot survive on fossil fuel. The energy crisis which frightens everybody, on the one hand, and the inexorably advancing ecological catastrophe on the other are forcing mankind to search for salvation in the atom—in nuclear power. And this is so important that, e.g., in the United States where, as we all know, a serious accident occurred at the Three Mile Island nuclear power plant, the nuclear phobia has not gained wide currency, and reason has prevailed. Today, the American national energy strategy calls for a sharp increase in electric power generation at nuclear power plants: between 2010 and 2030, it will rise from 650 to 1,200 million kilowatt-hours!

The same trend can be seen elsewhere. Even today, 16% of all electric energy in the world is generated by nuclear power and in the ten leading countries—more than 20% while this proportion is on the rise. In France, nuclear power is generally preferred to other sources of energy: here, 75% of all electric energy is generated by nuclear power plants yet the French have a profound respect for the environment.

Unfortunately, only 12% of the electric energy generated in Russia comes from nuclear power plants. This area is noticeably lagging yet it would be wrong to think that the lag is a result of backwardness—in science, engineering, and machine-building. There are other reasons. What is at fault is... our wealth. About one-third of a century ago, our policy was based on the following premise: we possess inexhaustible reserves of petroleum, coal, and gas. So we habitually shipped these resources over the longest railroad routes in the world and over oil and gas pipelines directly into the furnaces of electric power plants.

There are nine nuclear power plants operating in the Russian Federation with a total capacity of 20,242 MW. These nuclear power plants include 28 generating units which, according to the reactor plant types, are divided into the following groups:

12 generating units with pressure vessel water-cooled, water-moderated VVER-440 reactors (6 units) and VVER-1000 reactors (8 units);

15 generating units with graphite-moderated pressure-tube uranium reactors (of these, 11 have RBMK-1000 reactors); and

1 generating unit with a fast neutron reactor.

The following are under construction in the Russian Federation:

generating unit 4 at the Balakovo nuclear power plant, units 3 and 4 at the Kalinin nuclear power plant, and units 1-4 at the Rostov nuclear power plant.

In fact, even under these circumstances, the nuclear power development trends seemed to be pretty brisk here: today, we could (and should) bring on stream up to ten generating units a year. But... Chernobyl confounded everything. Burdened with enormous stress, we are overcoming a series of formidable obstacles in the development of domestic nuclear power, the development which virtually ground to a halt and froze...

Nuclear power plant opponents are referring to the radiation danger of our reactors, especially those similar to the early "Chernobyl reactors," i.e., RBMK-1000. But that which causes a number of media writers to engender panic sentiments is for us a subject of daily professional activity. I would be prepared to address this issue separately. The designs of existing generating units, there are 28 of them in operation at nine Russian power plants with a total capacity of 20,242 megawatts—have been developed over more than two decades. Naturally, different generations of reactors have different safety levels. The level of requirements imposed on them also has not remained static.

Our last regulatory document (1988) generally meets the IAEA (MAGATE) standards. Consequently, it shouldn't be surprising that several generating units do not meet today's requirements, including the four first-generation RBMK units. In their time, their designs did not stipulate these features since the standard did not require that and certain safety measures, e.g., for large pipeline and reactor plant ruptures, did not even call for the emergency containment system in some of them. What should be done today with these units? First of all, the reactivity control systems must be replaced together with the reactor channels which have exhausted their service life. Moreover, it is necessary to design multichannel safety

systems, increase the steam dump capacity, and finally, increase the power and reliability of electrical power supply systems.

Yet I am calling the attention of those who are wittingly or unwittingly hyping the panic: the conclusions of international commissions at any level, including IAEA, and all their remarks and recommendations do not contain any categoric statements about the impossibility of operating any generating units at Russia's nuclear power plants. Why? Because all serious experts can see the efforts being carried out here in increasing the unit safety and reliability: these include overhauls, multiple increase in the monitoring stringency, and a considerable increase in the number of shift personnel (here there are a lot more people than in new generating units).

The question may arise: Does it make sense to overhaul obsolete generating units and isn't it easier to retire them altogether? Retirement of force-generation high-power pressure-tube reactors (RBMK) is fraught with underutilizing their potential of 342 billion kilowatt-hours which roughly corresponds to 13 billion dollars of electric power. Yet renovations which improve the safety levels of these reactors to the level of similar good units worldwide costs 200-250 million dollars, i.e., only one-and-a-half to two percent of the cost of potential production. This gives a lot of food for thought, especially with today's crisis and shortage of funds, doesn't it?

Chernobyl-type reactors in operation today are reliable and have been improved considerably. The Smolensk nuclear power plant which runs these generating units, according to last year's data, was the best in Russia while according to the station operation evaluation, their safety level is unsurpassed. The number of violations classified on the seven-point international scale of events may serve as an operational indicator of Russia's NPPs during the last year; there were a total of 31 of them. Is it much or little? Their number has decreased compared to 1991 by seven while the number of violations due to staff fault has also dropped. Moreover, there were no emergencies which are classified as fourth-seventh level events.

Such a classification of power plant operation violations which, by the way, cannot be avoided in real life not only at our stations but at all stations in the world, facilitates mutual understanding among nuclear workers, the media, and the public in assessing the safety issues. But for some reason, this has been conspicuously ignored by certain "greens" for whom any incident at a nuclear power plant is an emergency, a catastrophe, and a threat of a new Chernobyl. Yet this is far from being so.

In other words, today Russian nuclear power plants meet the safety standards adopted throughout the world, and as for designs already underway, they are at a world level. An international commission has compared Russian new generation designs to German, Canadian, and Swedish designs. And what did it find? For medium-power reactors, we are ahead of the French and the Americans. Furthermore, our advances are especially noticeable in passive safety systems.

What does this mean? This is a realistic eventuality of switching to environmentally absolutely clean energy sources. Scientists are working on developing reactors with internal self-protection. The safety system which includes passive elements operates even if all electric power supply sources fail and eliminates the dangerous consequences of human errors. A generating unit with such properties and 630 megawatts of power has already passed international expert examinations. It has been recommended for commercial use. Eventually, systems based on alternative nuclear reactor types which, due to their internal properties, will completely eliminate risk, will be developed.

Increasing the nuclear power plant safety and reliability is also the main emphasis in the concern's cooperation with international organizations. In cooperation with the IAEA, trips have been made to evaluate the safety of the Kola, Novovoronezh, Kursk, and Balakovo NPPs. Plans for this year call for a trip to the Smolensk NPP and repeat checks of the Kola and Novovoronezh stations.

Yet the main obstacle today is the rejection of nuclear power by many people ranging from the population to government departments, the concern, the wall of mistrust, and nuclear phobia. I can assure you that no one is working today under such stressful conditions as we are. Obviously, the awareness of the public and population about the need for nuclear power is having its effect. Thus, it turned out that 60% of the respondents in the Rostov NPP region do not know what the station is providing for them. This means that we must continue educational efforts based particularly on the Government Decree "On Measures of Social Protection of the Population in the Territories Adjacent to Nuclear Power Installations."

Judging from the December Government Resolution on renewing nuclear power plant construction, we can conclude that there has been after all a positive move in favor of nuclear power plants in the public mind although the "greens" gave a hostile reception to this resolution. Yet there is a contradiction in this resolution: the document mentioned the need to complete construction of a number of installations in 1992—and this was in late December! There is a simple explanation: the draft of the resolution was prepared back in February. You can see the amount of mistrust and red tape obstacles which had to be overcome in the halls of power! Thus, not everything is simple. And how can one explain the unpardonable delay with passing the law "On Using Nuclear Power," "On State Policy in the Area of Radioactive Waste Handling," and "On Radiation Safety of the Population?"

So, the concern is forced to defend the economic interests of nuclear plants under such unfavorable conditions and in this circle of rejection. I should reiterate that the concern is a state enterprise operating nuclear plants.

The principal tasks of the energy policy are being solved here under the direct leadership of the ministry. Thus, together with the Atomic Power Ministry, much work has been done at all levels of state management on determining the sources of the concern fund and reserve formation and utilization trends. We examined the economic model of nuclear power under the conditions of a market economy and entered into contracts with the Fuel Energy Ministry enterprises. Today, the nuclear workers are carrying out a strict policy of clearing accounts on a legal basis using punitive sanctions. However, a sharp decrease in production in some regions and the insolvency of enterprises are preventing this system from gaining full speed.

There are nevertheless reasons for optimism. We should not forget that the first nuclear power plant in the world was built in Russia (1954) and that today we are blazing the trail for others; we were also first in developing a fast neutron power plant and a steam-gas installation. Consequently, even under today's difficult conditions, we are not throwing in the towel and are making the best effort to develop nuclear power further. Many probably already know that work on bringing into operation and reaching the design capacity at the fourth generating unit of the Balakovo NPP is nearing completion. Yet one should remember that during the last 2 years, not a single reactor has been brought on stream! We should remain being decisive in speeding up construction and erection of the third generating unit of the Kalinin plant and the fifth generating unit of the Kursk nuclear power plant.

Some are still trying to represent the active position taken by the nuclear workers as departmental parochialism; this is a mistake. The turn of events made them agents of the national interest. After all, the well-being of our economy will increasingly depend on its adaptability to nuclear power.

## On Designing Steel-Reinforced Concrete Large-Diameter Pipelines

*937F0131A Moscow GIDROTEKHNICHESKOYE STROITELSTVO in Russian No 4, Apr 93 pp 5-11*

[Article by V.M. Sokolov; UDC 627.751.4.001.24]

[Abstract] The characteristic features of designing large-diameter steel and reinforced concrete hydroelectric and pumped-storage hydroelectric power plant pipelines are considered. In so doing, the internal pressure force is found on the basis of solving the plane elasticity theory problem while taking into account the actual properties and qualities of the pipeline material. For illustration, the design head, inside diameter, facing thickness, reinforced concrete lining thickness, and relative reinforced concrete lining thickness of pipes at the Bratsk, Krasnoyarsk, Chirkeysk, Sayany-Shushenskoye, and Zagorsk power plants are summarized. The multilayer pipeline design is examined, the stress distribution in the reinforcement after the radial crack formation in the reinforced concrete layer, hydrostatic pressure stress in the facing and reinforcement rings of the Krasnoyarsk turbine water guide, stress in the downstream section facing and reinforcement, and the Zagorsk facing and reinforcement ring stress are plotted. In addition to the internal pressure, the pipeline's own weight, the weight of water in the pipeline, temperature factors, and other parameters are taken into consideration. The conclusion is drawn that the circular uniform internal pressure analysis of a reinforced concrete steel pipeline should be made using a multilayer pipeline technique allowing for concrete cracking; in extreme cases, limited plastic deformations of the pipeline materials leading to a slight force redistribution in the rings are permissible since they make it possible to optimize metal outlays. Figures 7; tables 1; references 11.

## Software Package for Assessing Electric Power Plant Automation System Reliability

*937F0141A Moscow TEPLOENERGETIKA in Russian No 2, Feb 93 pp 35-37*

[Article by S.A. Vilkomir, S.V. Vinogradskaya, M.A. Yastrebenetskiy, Central Scientific Research Institute of Comprehensive Automation, Kharkov; UDC 621.311.22.002.51.62-5.62-192]

[Abstract] The urgency of ensuring the reliability of automation systems at fossil fuel, nuclear, and hydroelectric power plants and thus ensuring the safety, reliability, and operating efficiency of the power plants themselves and the labor intensity and complexity of assessing the automation systems prompted the development of a software package entitled "Electric power plant automation system reliability analysis" and aimed specifically at resolving these problems. The software package is developed at the Kharkov department of the Central Scientific Research Institute of Comprehensive Automation and is intended for IBM PC XT/AT or IBM-compatible microcomputers. The software package consists of two parts—BANK and PRANA. The former makes it possible to assess the reliability indicators of several thousand automation devices such as sensors and contains a data bank in a dbase-IV environment and a routine written in the Clipper language. The latter—a reliability analysis routine—makes its possible to analyze the reliability of a structurally complex system consisting of an arbitrary combinations of series, parallel, and majority structures. The reliability analysis methodology is outlined and a block diagram of the control system is cited. The software package is simple and convenient; it has been used to assess the automation system reliability at a number of power plants and generating units as well as a teaching aid for students majoring in process automation. Figures 2; tables 1; references 10.

## 160-MW Turbine Modernization by Turboatom Scientific Production Association

*937F0141B Moscow TEPLOENERGETIKA in Russian No 2, Feb 93 pp 49-55*

[Article by Ye.V. Levchenko, B.A. Arkadyev, V.I. Muravyev, V.N. Galatsan, B.M. Poluyanov, Turboatom Scientific Production Association; UDC 621.165.001.57]

[Abstract] Obsolescence of power engineering equipment which, as a rule, precedes its mechanical wear and ways of alleviating its negative impact on the industry by upgrading and modernizing the equipment are discussed and the efforts in this field undertaken by the Turboatom Scientific Production Association are described. In particular, the principal issues involved in modernizing and upgrading the PVK-150 and K-160-130 turbines which have been manufactured since 1958, are addressed. Today, 85 of these turbines are in operation at domestic thermal power plants and the remaining 10—in Bulgaria, Rumania, and Hungary. The design features of the modernized intermediate- and high-pressure cylinders, the possibilities of modernizing the low-pressure cylinder and the condensation plant, and the outlook for increasing the heat production are considered in detail. The principal indicators of 160 MW turbines and the specifications of the low-pressure turbine are summarized; the dependence of the heating system water temperature and the specific electric power shortfall on the return heating water temperature and the behavior of the turbine efficiency, heat drop, and the flow exit angle with the relative steam consumption for extraction are plotted. This modernization of 35-year-old turbines makes it possible to keep a large number of generating units in operation, preserve buildings and structures and turbine-driven plant foundations and auxiliary equipment, reduce capital outlays, and increase the economic efficiency, electric power, and heat supply capabilities of the turbine-driven sets. The latter factors will help pay off the modernization expenditures. Figures 6; tables 2; references 5.

## Efficacy of Enhancing Heat Exchange by VVER-100 Reactor Fuel Element Roughness

*937F0141C Moscow TEPLOENERGETIKA in Russian No 2, Feb 93 pp 56-58*

[Article by V.V. Olimpiyev, Kazan Branch of the Moscow Power Engineering Institute; UDC 536.24+532.5]

[Abstract] The economic and technical necessity of continuing reliance on nuclear power and the need to improve power plant performance by enhancing the fuel element heat exchange prompted an examination of ways to optimize the VVER-1000 water-moderated water-cooled power reactor whose design has been upgraded by protrusions on the fuel elements (tvel). These protrusions make it possible to attain a more optimum hear release:water circulation rate ratio (*Q:N*) compared to conventional reactors with smooth fuel elements. The procedure for searching for the optimum protrusion height and spacing on the fuel element cladding is outlined and the software package for optimizing the nuclear reactor (YaR) is described. The software makes it possible to optimize VVER, PWR (U.S.), AGR (U.K.), HTGR (U.S.), and fast and thermal neutron reactors using $UO_2$ and $UC_2$ fuel with stainless steel, zirconium, and reactor graphite cladding. The software is written in the Basic-plus language for the Elektronika DZ-28 computer operating in the interactive mode. The calculation results are generally consistent with the theory and practice of heat exchange enhancement. An analysis shows that heat exchange enhancement due to fuel element cladding roughness makes it possible to improve the temperature condition and thermal and hydraulic quality of the core, thus confirming the expediency of heat exchange enhancement. Tables 1; references 9.

## On Improving Chemical Correction System of Nuclear Power Plant Water Coolant

*937F0141D Moscow TEPLOENERGETIKA in Russian No 2, Feb 93 pp 59-61*

[Article by V.N. Fateyev, V.P. Pakhomov, V.A. Yurmanov, V.F. Tyapkov, V.A. Mamet, A.F. Chabak, V.D. Rusanov, Atomic Energy Institute imeni I.V. Kurchatov and All-Russia Scientific Research Institute of Nuclear Power Plants; UDC 621.039.534]

[Abstract] The urgent need for a critical reevaluation of the designs being used in the research, development, and building of nuclear power plant systems which determine the safety and reliability level of both operating and prospective generating units prompted attempts to use scientific and technical advances from other areas, particularly membrane technology and hydrogen power engineering, for increasing nuclear power plant safety. The tendency toward avoiding the use of radiation- and chemically unstable reagents for chemical water cooling correction except those which produce water or its decomposition products (hydrogen, oxygen, hydrogen peroxide, and ozone) under radiation and chemical interaction is noted and the shortcomings of existing chemical water coolant correction systems are discussed. The use of a solid electrolyte electrolyzer for chemical water treatment is suggested; this electrolyzer's characteristics greatly exceed those of today's water-alkali electrolyzers; pilot prototypes have been manufactures at the Kurchatov institute for use in RBMK high-power pressure-tube and nuclear heat supply plants (AST). A diagram of the electrolyzer's principal operating conditions and a block diagram of the electrolyzer tests are cited. The hydrogen oxidation kinetics during the electrolyzer operation as a hydrogen pump and the hydrogen production kinetics under static conditions are plotted. The findings confirm the possibility of using the solid electrolyte system for hydrogen correction of water coolant. Immediate plans call for carrying out pilot-commercial service life tests of the electrolyzer under various conditions. Figures 4.

## Steam Turbines, Problems of Their Development and Operations

*937F0151A Moscow TEPLOENERGETIKA in Russian No 5, May 93 pp 2-5*

[Article by editorial board; UDC 621.165]

[Abstract] The state of the art in domestic steam turbine building and the operating indicators of steam turbines and turbine plants are examined, and the problems related to the research and development and operation of steam turbines are considered. In particular, the lagging (except for the military industrial complex

(VPK)) of the domestic industry and the resulting excessive reliance on imports are discussed and it is noted that steam turbine making is an exception to the rule: domestic steam turbines are often superior to best world models. The issue of skilled staff training for turbine plants, scientific institutes, and power plants is addressed. An attempt is made to explain the high volume of steam turbine exports as compared to the rest of the industry. The success of steam turbine making it attributed mostly to the diversification of the development and manufacturing effort, the high skill level of engineers and researchers, and the well-developed experimental base. The issues which still require urgent attention are noted, and the emerging dangerous trend toward cutting back R&D work due to the shortage of funds is identified. The experience of the most developed countries is examined. The poor operating level of local and regional power plants in the Russian Federation and ways of improving the operating and reliability indicators of steam turbines are summarized. The importance of published sources for improving skill training is stressed, and the declining volume of translations and publications is noted. The need for financial assistance from the government is emphasized. Tables 1.

## Steam Extraction Turbines and Ways of Further Improving Them

*937F0151B Moscow TEPLOENERGETIKA in Russian No 5, May 93 pp 5-10*

[Article by A.I. Alekso, G.D. Barinberg, Turbine Motor Plant Production Association, Yekaterinburg; UDC 621.165-172:697.34]

[Abstract] An overview of the development of steam turbine making in the former Soviet Union and Russia is presented; it is characterized in that the installed capacity of extraction turbines is close to 30% of the total thermal power plant capacity. Attention is focused on steam extraction turbines manufactured by the Turbine Motor Plant Production Association in Yekaterinburg. The turbine making development trends are investigated, and the principal premises of selecting the turbine flow setting and design are presented. The heat users are divided into two categories, depending on the daily and seasonal demand variations, and the issues which are peculiar to combined heat and electric power generation are addressed. The characteristic features of the existing and prospective steam turbines—type T extraction turbines with heating steam extraction and turbines with steam extraction for process needs, heating, and backpressure (types PT and R, respectively)—are outlined. The conclusion is drawn that production and assimilation of high-power extraction turbines, subsequent improvements in mass-produced turbines, and the designing of new turbines will create the conditions necessary for developing the heat and power generation industry. Figures 2; references 1.

## Design Characteristics of Leningrad Metal Works Steam Turbines

*937F0151C Moscow TEPLOENERGETIKA in Russian No 5, May 93 pp 10-21*

[Article by I.I. Pichugin, A.M. Tsvetkov, M.S. Simkin, Leningrad Metal Works Production Association; UDC 621.165.001.2]

[Abstract] The history of turbine making at the Leningrad Metal Works (LMZ) since the 1940's when the plant began large-scale production of 50 and 100 MW condensing and extraction turbines with 8.8 MPa, 500°C steam is reviewed and the principal steam turbine design concepts used at the LMZ are outlined. The specifications given to the plant called for manufacturing fast single-shaft economical and reliable turbines for various purposes capable of operating with the maximum possible rarefaction. The modular design principle is the underlying premise of LMZ turbine design. Design versions of the LMZ condensing turbines with various types of blades are considered and the main LMZ turbine specifications are summarized. The uses of more than 50 types and versions of 30-1,200 MW LMZ steam turbines are discussed, and five specific uses are examined in detail. The issues of turbine plant efficiency and of improving the flow setting design are addressed. Pilot studies and field work on refining the flow setting and its elements using full-scale test benches and operating turbines are described. The tests confirm the high level of gas dynamic perfection of the newly designed flow settings. Figures 9; tables 2; references 10.

## New-Generation Turbines of Turboatom Scientific Production Association

*937F0151D Moscow TEPLOENERGETIKA in Russian No 5, May 93 pp 22-29*

[Article by Ye.V. Levchenko, V.N. Galatsan, V.P. Sukhinin, B.A. Arkadyev, Turboatom Scientific Production Association; UDC 621.165]

[Abstract] The turbine development, manufacturing, installation, and setup experience accumulated at the Kharkov Turbine Plant—the forerunner of the Turboatom Scientific Production Association—is reviewed, and the range of products and principal specifications of various types of steam turbines, both current and under development at the association, are outlined. Attention is focused on the principal turbine plant development concepts, steam turbines, steam-and-gas units (PGU) and their indicators and specifications, and nuclear power plant turbines. The characteristics of low-pressure turbine blades and flow settings are examined in detail. The methods of improving the operating indicators of the turbines used by the plant itself are considered. It is noted that in addition to supplying the countries of the former Soviet Union with turbines with a 50, 25, or 60 1/s speed, the plant exports its turbines to Bulgaria, Hungary, Germany, China, Korea, Cuba, Rumania, and Finland. Figures 4; tables 3; references 10.

## Assessment of Actual Radionuclide Inflow Into Environment With Nuclear Power Plant Gas and Aerosol Discharges

*937F0152A Moscow METROLOGIYA in Russian No 4, Apr 93 pp 29-33*

[Article by G.G. Leontyev, L.N. Moskvin, S.N. Nekrestyanov, V.V. Chetverikov, I.F. Uchevatkin, A.I. Ivanov; UDC 539.163/.166]

[Abstract] The urgency of timely assessment of environmental contamination with radioactive substances due to nuclear power plant operation and the increasing awareness of the population necessitate the development of methods and equipment for estimating the actual radionuclide influx into the environment from power plant gas and aerosol discharges. In solving this problem, difficulties must be overcome for each of the three principal gas and aerosol discharge component: inert radioactive gases (IRG), radioactive aerosols, and radioactive iodine. The procedures and equipment necessary for on-line monitoring of contamination during the nuclear power installation (AEU) operation are outlined, and a comprehensive procedure based on direct gamma-spectral analysis of the gas flow continuously forming in the measuring line which may be linked in series to any requisite control point is proposed. The system makes it possible not only to lower the detection threshold in the discharges (thus increasing the monitoring confidence) but also monitor the inert radioactive gas activity in the coolant—their source—and diagnose the reactor core condition. The equipment developed on the basis of this method and the relevant regulatory documents are described. The two measurement procedure techniques (MVI) prepared as a result are summarized and their performance, such as detection levels and standard deviation, is discussed. All procedures passed metrological certification at the Scientific Production Association of the All-Russia Scientific Research Institute imeni D.I. Mendeleyev. The system will serve as the basis for carrying out reliable quasicontinuous monitoring of the actual contaminant inflow with all gas and aerosol discharge components. References 5.

## Ensuring Confident Gamma-Spectrometry Activity Measurement of Radionuclides in Nuclear Power Plant Coolant and Low-Activity Aqueous Media Using Sorbent Filters

*937F0152B Moscow METROLOGIYA in Russian No 4, Apr 93 pp 33-36*

[Article by G.G. Leontyev, L.N. Moskvin, S.N. Nekrestyanov, V.N. Yepimakhov, I.F. Uchevatkin, O.V. Shilnikov; UDC 539.163/.166]

[Abstract] The need for detailed data on the composition and activity level of radionuclides, primarily at the source—the primary circuit coolant and subsequent leakage channels of radioactive substances with aqueous discharges and gas and aerosol effluents—for reliably assessing the nuclear power plant's impact on the environment prompted efforts to ensure confident gamma-spectrometric monitoring of the radionuclide activity in these sources and media. In particular, attention is focused on analyzing aqueous media, including the cooling, low-activity water effluents, and cooling ponds and natural water. The principal factors ensuring the monitoring confidence are outlined, and it is shown that the proximate chromatography analysis method (EKhRA) employing sorbent filters meets all requirements. The chemical procedures involved in the method and the factors governing the selection of the specific analysis procedure are summarized. Two analytical techniques have passed metrological certification. Based on the certification findings, a number of radionuclides are detected with a standard deviation of 0.35-0.70 within a $5 \times 10^{-3}$ - $5 \times 10^{3}$ Bq/l range. The bulk β-radiation activity of strontium radionuclides is detected within a 0.05-1 x $10^{3}$ Bq/l range at a square deviation of 0.40. References 2.

## Rare Elements in Russia: Status Report and Development Trends

*937F0128A Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 2-7*

[Article by A.A. Kremenetskiy, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 546.65.005.004.14(470+571)]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute (IMGRE). The use of rare elements in today's industry, the characteristic features and problems of rare element production, the outlook and development trends of rare element production in Russia, and the thrust of state scientific, engineering, and investment policy in this field are examined in detail. Attention is focused on the rare earth metal industry problems, the rare elements' raw material base in Russia, and the development of new rare metal raw material processing practices. It is suggested that state policy be aimed at promoting the pooling of capital in order to fund rare element production projects, streamlining the licensing and exporting procedures, ensuring investment risk, and committing state funds until the private commercial structures get on their feet. The author is grateful to V.V. Ivanov, Ye.D. Osokin, T.Yu. Usova, V.M. Rogovoy, E.F. Mintser, F.I. Shaderman, and others for providing date and making useful remarks.

## New Unique Rare Metal Deposits in Carbonatite Weathering Crusts

*937F0128B Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 7-11*

[Article by A.V. Lapin, A.V. Tolstov, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 553.493.5:[553.068.36:552.331.:553.22]]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute (IMGRE). The importance of carbonatite weathering crusts—one of the most prolific rare metal ore formations—as sources of niobium and lanthanide raw materials is discussed and such rare metal deposits are divided into three principal categories: hydromica, laterite, and epigenetically altered laterite weathering crusts. The hypergenesis and formation characteristics of these types of deposits are outlined and it is noted that the latter two types of crusts are characterized by a much higher yield. The ore type, estimated ore reserves, and the $Nb_2O_5$ and $TR_2O_3$ concentration of seven principal deposits are summarized and schematic geological cross sections of the Tomtor weathering crust deposit are cited for illustration. The Chuktukon and Tomtor deposits (located in Russia) are examined in detail. It is speculated that the newly discovered deposits will be able to meet the worldwide demand not only for niobium but also for lanthanides, yttrium, scandium, vanadium, strontium, and other rare metals. The total ore component concentration in unique rare metal ores reaches 30-50%. Figures 1; tables 1; references 8: 3 Russian, 5 Western.

## Developed and Potential Sources of Accompanying Rare Elements

*937F0128C Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 11-15*

[Article by N.M. Fedorchenko, O.V. Vershkovskaya, N.Yu. Barinkova, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 546.65:[553.43/.45+553.481+553.492]]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute (IMGRE). The properties of the accompanying rare elements, e.g., cadmium, indium, thallium, selenium, tellurium, and gallium which are found as impurities in nonferrous metal deposits, and their characteristics are outlined and it is stressed that the accompanying element reserves can be examined and evaluated only as a part of the nonferrous metal deposit studies. The geological and commercial characteristics of the accompanying rare metal sources explored in Russia, i.e., the geological and industrial type of deposits, metal reserves (as a percentage), the geological and tectonic position, principal host minerals, the mean concentration of Cd, In, Tl, Se, Te, and Ga, and the metal distribution in the concentrates, are summarized. It is noted that Pb-Zn vein deposits in carbonate or silicate rock related to the tectonic-magmatic activation of peripheral zones are the best developed sources of cadmium and indium while the alumina raw material (in bauxites) is the principal source of gallium worldwide. Russia is thought to possess sufficient gallium resources. The importance of determining the hitherto unexplored sources of raw materials in Russia using known rare metal recovery technologies and the need to study the incidence of rare metals and assess the predicted resources in promising types of deposits within known metallogenic zones are emphasized. Tables 1; references 7.

## New Geological-Industrial Type of Rare Metal Placers

*937F0128D Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 15-19*

[Article by A.A. Kremenetskiy, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 553.493.6:553.068.5]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute (IMGRE). The

sources of rare earth elements (RZE) are surveyed and it is noted that yellow monazite mined primarily from various types of rare earth placers had been the principal REM source until 1960 after which it became gradually replaced with bastnaesite deposits; interest in monazite has increased in recent years due to the fact that it contains such valuable scarce metals and Nd, Y, and yttrium-group lanthanides which are indispensable for today's technologies. Existing rare earth placers are divided into three principal geological-industrial categories: modern and ancient littoral marine, modern and ancient alluvial lacustrine, and ancient metamorphized deposits. The commercial potential of these types of deposits is assessed and it is noted the the first and second categories are the most promising from the commercial viewpoint. A map of existing placer deposits with yellow Eu-monazite is presented and the types of REM, Y, and Th oxide distribution in yellow and grey monazite in rare earth placers as a ratio to the mean composition of magmatic monazites from granite and pegmatite are plotted. The rare earth metal, yttrium, and thorium oxide concentration in Australia, the United States, South Africa, Spain, France, Taiwan, and other countries is summarized. The genesis and principal sources of authigenic Eu-monazite are reconstructed and the physical and chemical mechanism of REM concentration in carbon-terrigenous deposits are identified; it is noted that these phenomena have the same origin and are controlled by the same factors. The formation of Eu-monazite placers is examined and the predicted resources and commercial outlook for Eu-monazite are assessed. The conclusion is drawn that existing processing enterprises and the developed infrastructure in CIS and Western European countries make it possible to recommend that new types of rare earth placers be surveyed, evaluated, and explored. Figures 2; tables 1.

## Nontraditional Sources of Rare Metals

*937F0128E Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 19-21*

[Article by Ye.S. Meytov, V.D. Rodionov, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 553.94/.96:546.65]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute (IMGRE). In particular, fossil coals or their byproducts—which, strictly speaking, are not a nontraditional source of rare metals—are considered. The history of rare metal-containing coal deposit exploration and published sources on this subject are reviewed and attention is focused on germanium resources in germanium-coal deposits, both in CIS and worldwide, and the characteristic features of germanium mineralization and ore body are outlined. Known practices in metal recovery from coal byproducts, such as ash, gas, tar, and smoke (from patents, claims, and publications) are summarized for Li, alkaline metals, Sc, Va, Ga, Ge, Zr, Y, rare earth metals, Sb and other rare elements. The geological-geochemical, technical, market, and economic preconditions for expanding the use of rare metal potential of Russia's coal and coal byproducts and concentrates are outlined and it is noted that man-made formations related to the use of coal (e.g., power plant ash heaps) are a promising source of rare metals and are geochemically as unique as coal from different deposits. The conditions for realizing these formations' rare metal component potential are discussed. It is suggested that coal-burning enterprises realize additional profit by utilizing the rare metal components. Tables 1; references 2: 1 Russian, 1 Western.

## New Rare Element Minerals

*937F0128F Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 21-22*

[Article by A.P. Khomyakov, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC [546.65:553.08].608.1]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute. New rare earth minerals—e.g., nastrophite, mineyevite, sidorenkite, barentsite, arctite, laplandite, and olympite—named after particular people or places or according to their principal components are described and their useful technical properties which make them promising for use as molecular sieves, piezoelectric elements, and ionic conductors are outlined. The soda content and soda mineralization of rock are discussed and it is speculated that soda mineralization is hypogenic in origin. The role of salts in alkaline petro- and orogenesis is examined and the contribution made by the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute to solving the problem of rare element mineralogy and geochemistry as well as a series of fundamental studies in this field are recognized. The rare metal minerals discovered since 1969 are summarized and the outlook for further expanding the mineral system is assessed. The two opposite views of the this issue—the finite vs. infinite range of species—are compared. References 5.

## Ecogeochemistry of Rare Elements

*937F0128G Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 24-27*

[Article by V.V. Ivanov, O.Ye. Yushko-Zakharova, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC [550.4:574]:546.65]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data

collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute. The concept of ecological geochemistry (ecogeochemistry)—a comprehensive geochemical investigation of entities, ecological media (i.e., the environment), and landscapes in order to determine their conditions with respect to the active life of organisms and the outlook for using natural resources—is examined from the viewpoint of geochemistry, biogeochemistry, soil agrochemistry, hydrogeochemistry, and atmospheric geochemistry. The study is carried out on the assumption that the methods and parameters specially tailored to each particular area are the most efficient. Public health standards for toxic elements and compounds in the form of the maximum permissible concentrations (PDK) are used as the principal ecological indicators while the element concentration degree and integral elemental ecogeochemical index (the hazard scale) is used as the principal geochemical indicator. The geotoxicity of relatively scarce elements and pathotoxicity, ecotoxiphilia, and total ecogeochemical potential of rare and scarce elements are classified. The geological-geochemical groups and mineral classes of the principal types of metal deposits and the principal industrial types of ore deposits of the main minerals are summarized. The findings make it easier to predict and assess the environmental safety and lower the man-caused burden on the ecosystem. Tables 4; references 8.

## Occurrence Patterns of Endogenic Rare Metal Deposits

*937F0128H Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 27-29*

[Article by Ye.N. Altukhov, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 553.493.5.062/067]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute. The occurrence patterns of endogenic rare metal deposits are discussed and it is noted that from the geotectonic viewpoint, rare metal magmatites are divided into proto- and deutero-orogenic or crust-forming and crust-transforming. These patterns are examined using extensive metallogenic data collected by N.A. Solodov and A.D. Shcheglov. The crust-forming rare metal pegmatites and crust-transforming rare metal magmatites are considered in detail. An analysis of the occurrence of endogenic rare metal deposits in the earth crust structures makes it possible to identify new patterns with important practical applications. Of these, the following findings are the most significant: relative to the chemical behavior of the enclosing geological bodies, the rare metal magmatites and related deposits occupy both the cogenetic and epigenetic position yet the most productive rare metal magmatites are related to epigenetic processes; the active role of ancient structures in the formation, migration, localization, and formation processes of productive rare metal magmatites of varying origin is identified; and the strong correlation of rare metal carbonates with the crust segments whose structure involves deeply metamorphized elevated-pressure rock complexes is revealed. The need to take these patterns into account in the forecasting and exploration practices is emphasized. References 4.

## Forecasting and Prospecting of Rare Metal Placer Deposits

*937F0128I Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 29-32*

[Article by T.F. Boyko, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 553.493.5:553.068.5]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute. The economic efficiency of the placer rare metal vs. bedrock deposit exploration and the increasing worldwide demand for rare metal raw materials from placer deposits prompted an increased interest in the forecasting and prospecting of rare metal placer deposits which today provide 98% of Zr, 80% of Ta, and 40% of heavy and light lanthanides and yttrium. The status of the rare metal raw material base in Russia is studied and it is noted that no placer deposit is being currently explored in the country despite acute shortages of Zr and other metals. Rare metal placer deposits are classified and evaluation criteria are formulated for marine littoral (PMR), continental (deluvial-proluvial), and lake alluvial deposit forecasting. Examples of small-scale commercial exploration of rare metal continental placer deposits in Taiwan, Sri Lanka, India, and Brazil are considered and promising deposit regions are identified. Experience shows that the best results in rare metal deposit prospecting have been attained in efforts specifically targeted at particular metals. It is speculated that marine littoral deposits containing Zr, Hf, and rare earth elements are the most promising in the near future while continental placers should be treated as a secondary raw material source. The needs for Ta can be met most realistically in the near future by placer deposits. References 9.

## New Rare Metal Raw Material Processing Trends

*937F0128J Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 35-36*

[Article by N.F. Chelishchev, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 622.7:553.493.5]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute. Significant increases in the rare element consumption levels in recent years and the low level of rare metal recovery (less than 50%) called for reevaluating the rare metal raw material base and processing practices and prompted an investigation into the methods of metal recovery from ore dressing tailings and other industrial byproducts and waste and attempts to restructure existing practices in order to recover additional components. The importance of side recovery of rare metal, e.g., Ga recovery in Al production, Re recovery in Mo and Cu production, and Cd recovery in Zn production, as a means of expanding the rare metal raw material base is stressed and attention is focused on the study of the surface properties of mineral in order to enhance the flotation processing and establish the correlation of the minerals' floatability and the characteristics of their composition, structure, genesis, and surface modification capability. The thermal and chemical stability of minerals, their dissolution kinetics, and the relationship between the chemical properties and structural, composition, and genesis characteristics are analyzed. The role of nonmetallic mineral in selecting the methods of decomposing rare metal ores is studied. The findings demonstrate that the raw material base of rare elements may be significantly widened by improving the processing practicing and mastering new raw material sources and utilizing low-grade ores and flotation dumps and tailings, waste water, and gas exhausts. The impact of the latter steps on improving the environment is noted. References 9: 8 Russian, 1 Western.

## Hydromineral Raw Materials in Today's and Future Industrial Production

*937F0128K Moscow RAZVEDKA I OKHRANA NEDR in Russian No 3, Mar 93 pp 38-40*

[Article by F.I. Shaderman, Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute; UDC 556.553.04:[658"312"+"313"]]

[Abstract] The issues of mineralogy, geochemistry, and development of the raw material base of rare elements in Russia are addressed from the viewpoint of the data collected at the Rare Elements Mineralogy, Geochemistry, and Crystal Chemistry Institute. The development of closed-cycle production complexes and industrial production systems imposes new requirements upon the quality of raw materials used, primarily minerals. One of the new types of mineral raw materials which meets these conditions is the mineralized native water which is commonly known under the name of "hydromineral raw material" (GMS). The use of natural water in today's production practices is discussed and native water is considered as a source of rare elements. The methods of mastering hydromineral raw materials are surveyed and a geological-processing classification of native water with a potential for use as hydromineral raw materials is presented; the water type and subtype (according to the principal anion composition or origin), its geochemical type, mineralization, use in today's processes, the components actually recovered from it, prospective useful components, and modern and future processes involving these materials are summarized. The conclusion is drawn that native water is a good source on a regional basis; allowing for the industrial production development trends, one can expect a high degree of hydromineral raw material utilization in environmentally sensitive technologies of the future. Tables 1.

## On Designing of Cryoturbogenerator With Superconducting Stator

*937F0132A Moscow IZVESTIYA AKADEMII NAUK: ENERGETIKA in Russian No 2, Mar-Apr 93 pp 69-75*

[Article by V.F. Bolyukh, V.G. Danko, S.M. Kozhemyakin, A.I. Stankevich, Kharkov; UDC 621.313.322-81.537.312.62]

[Abstract] The characteristic features of the use of superconducting excitation windings (SPOV) which makes it possible to virtually eliminate excitation losses, increase the magnetic flux density in the armature winding zone, and increase the utilization factor at a high magnetomotive force (MDS) and the difficulties of improving the cryoturbogenerator (KTG) parameters, compared to traditional turbogenerators, are discussed. It is speculated that the cryoturbogenerator design can be improved by substituting the copper armature winding with a superconducting one, thus increasing the magnetomotive force, lowering the winding mass and dimensions, and increasing the machine utilization factor. The configuration, schematic diagram, and vector magnetic potential distribution in the cryoturbogenerator cross section are presented and the dependence of the magnetic induction on the superconducting magnetic screen radius is plotted. The magnetic induction in the air gap, linear current density (A/m), efficiency, and weight and overall dimensions of two cryoturbogenerators and a water-cooled turbogenerator are summarized. A schematic diagram of an experimental unit is cited. The study shows that the development of a cryoturbogenerator with a superconducting stator in which the magnetic flux is confined with the help of the superconducting electromagnetic screen (SPE) makes it possible to improve performance dramatically; in principle, it is possible to make a superconducting screen from ceramic high-$T_c$ materials and thus develop a fully superconducting cryoturbogenerator. Figures 3; tables 1; references 9: 5 Russian, 4 Western.

## On One Effect of Motion Instability of Spinning Body Near Vertical

*937F0138A Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 93 pp 10-19*

[Article by V.N. Koshlyakov, Kiev; UDC 531.382]

[Abstract] The solution of the equation of unstable motion of a fast vertically spinning body derived by the author in *Mekhanika tverdogo tela* No. 4, 1988 and *Ukrainskiy matematicheskiy zhurnal* Vol. 41 No. 9, 1989 is discussed and an attempt is made to improve the accuracy of the solution. The problem of a randomly shaped body with a fixed point spun around the axis of a orthogonal trihedron linked to the body whose directions of axes coincide with the axes of principal symmetry of the body while the body center of gravity is assumed not to be located on the axis of rotation is formulated. For certainty's sake, the case of rotation around the center axis of Poinsot's ellipsoid and stationary Staude rotations are not studied and the energy dissipation is assumed to be negligible. An analogue of Euler-Poisson equations expressed through Rodrigues-Hamilton parameters is derived in the matrix notation; the Rodrigues-Hamilton parameters are expressed by Euler's angle functions. A partial solution of a system of nonlinear differential equations with constant coefficients and its geometrical interpretation are examined and the nondisturbed motion equations are analyzed. It is shown that the instability is due to the destabilizing effect of transverse imbalances. The author is grateful to V.F. Zhuravlev, D.M. Klimov, and V.V. Rumyantsev for discussing the findings and making remarks. Figures 1; references 5.

## On Effect of Viscoelastic Properties of Body's Material on its Rapid Rotations in Gravitational Field

*937F0138B Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 93 pp 31-38*

[Article by Ye.V. Sinitsyn, Moscow; UDC 531.35:539.374]

[Abstract] The evolution of rapid rotations of a dynamically symmetric viscoelastic body in a circular orbit is considered and a general model of the linear theory of viscoelasticity is used. The body's material is simulated by a multivariable model and an attempt is made to show that the body material properties affect both the quantitative and qualitative characteristics of its motion evolution. To this end, a uniform isotropic viscoelastic body of a given density from a material with known properties and a constant Poisson's ratio is considered. The underlying correlations of the linear theory of viscoelasticity at small deformations are derived. It is assumed that the body's period of free elastic vibrations and their damping time are much smaller than the characteristic time of rotation around the center of mass. It is assumed that the center of mass motion does not depend on the motion relative to the center of mass. The system's motion relative to the center of mass is described with the help of canonical Andoiller variables and is analyzed by the averaging method. Fast and slow evolution and the evolution of rapid rotations of the body performing longitudinal vibrations are examined in detail. It is shown that the so-called conservative evolution during which the moment of momentum precesses around the normal to the orbital plane occurs over relatively short time intervals. Figures 2; references 14.

## Model Estimates of Walking Machine's Energy Consumption

*937F0138C Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 93 pp 65-74*

[Article by V.V. Lapshin, Moscow; UDC 531.8]

[Abstract] The role of energy efficiency of multipede walking machines in the outlook for their practical applications and the lack of adequate and simple model estimates for machines vs. men and animals prompted a review of model analyses of the energy outlays solely for the purpose of movement by statically stable walking machines and their comparison to the energy outlays of various vehicles and animals. The machine parameters and trotting patterns are examined on a horizontal plane whereby the machine's body moves uniformly and rectilinearly parallel to the horizontal bearing surface and all legs perform an identical periodic motion relative to the body with a phase shift. The energy outlays for the walking machine movement, for ensuring the leg motion relative to the body, for supporting the body weight, and for developing the thrust force as well as the total energy consumption for its locomotion are examined in detail. The issue of energy recovery during the locomotion is addressed and the energy outlays are compared to those of animals. The energy outlays for lifting and lowering the legs and for the soil deformation are omitted for simplicity. Ways of reducing the energy consumption are investigated. Figures 7; references 27: 20 Russian, 7 Western.

## Bending Stability of Composite Cylindrical Shell With Longitudinal Stiffening Ribs

*937F0138D Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 93 pp 169-177*

[Article by A.V. Lopatin, Krasnoyarsk; UDC 539.3:534.1]

[Abstract] The stability of a composite cylindrical shell with longitudinal stiffening ribs loaded along the edges by bending moments through rigid frames is considered in the framework of the problems of assessing the load bearing ability of stiffened aircraft airframes subjected to bending during operation. The problem is solved using

equations of the theory of stiffened composite shells; the discrete character of the rib spacing and positioning, shearing strain in the shell and ribs, and the material lamination and orthotropy are taken into account in the framework of this theory. In so doing, the shell surface on which the stiffening ribs are located—referred to as the initial surface—is assumed to be the shell shape agent. For illustration, the buckling bending moment for a shell with four longitudinal stiffening ribs variously placed both relative to the bending plane and the initial shell surface is calculated. It is noted that the calculation procedure electiveness depends both on the rib cross section size and on shell surface on which the ribs are located; moreover, for a shell stiffened by internal ribs, a decrease in the buckling moment with an increase in the cross section size is observed. This behavior is attributed to the shell interaction with the rib under buckling. Figures 4; tables 2; references 2.

### Nonlinear Interaction of Technological Imperfections and Their Effect on Thin-Walled Shell Stability. Part II: Multifactor Approach

*937F0138E Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian*
*No 1, Jan-Feb 93 pp 178-184*

[Article by A.M. Mitsyn, Dnepropetrovsk; UDC 539.3:534.1]

[Abstract] The interaction of technological imperfections which manifest themselves comprehensively in the behavior patterns of shells before and after buckling under compressive axial forces is investigated by decomposing the polynomial second-order model which describes the correlation between the load-bearing ability parameters and the technological imperfections and on the basis of the multifactor theoretical-experimental method-based model. The coefficients of the load-bearing ability vs. mathematical model of technological imperfection are determined on the basis of a multifactor experiment with thin-walled shells. The model's goodness of fit and efficiency are tested by statistical and physical criteria and by inter- and extrapolation in the domain of known single-factor experiment. The joint effect of the shell conicity and oblateness is examined. An analysis shows the highly nonlinear dependence of the load-bearing ability on the complex of technological factors whereby the effect of each factor depends on the others. The findings reveal that a correct analysis and interpretation of the data of single-factor experiments must be complemented with an assessment of the level of accompanying imperfections: the existence of two or more imperfections simultaneously may either significantly decrease the buckling load under axial compression or increase it. The resulting model may be used efficiently in diagnosing and predicting the load-bearing ability in stability and strength control systems of actual thin-walled structures, for optimizing production practices, and for developing manufacturing tolerances. Figures 5; references 12.

### Numerical Investigation of Conical Shell Flutter

*937F0138F Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian*
*No 1, Jan-Feb 93 pp 185-189*

[Article by V.V. Ditkin, B.A. Orlov, G.I. Pshenichnov, Moscow; UDC 533.6.013.42]

[Abstract] The aerodynamic stability of thin shells in a supersonic flow of compressible gas is investigated allowing for aerodynamic damping whereby excess pressure is defined by a linearized correlation; the latter factor leads to a spectral problem for a quadratic bundle of operators whose eigenvalues are always complex. The computational difficulties of this problem prompted the development of an effective iteration method whereby the boundary value problems for ordinary linear differential equations are solved by the method of orthogonal matching. The boundary value problem is formulated and solved for a nozzle which is a thin-walled elastic shell shaped as a truncated circular cone whose smaller-diameter end is restrained while the other shell edge is free. The calculations made for specific shells demonstrate that in some cases the critical pressure may increase if the first term in the excess pressure equation is taken into account. The aerodynamic damping has a considerable stabilizing effect. The total computation time on a BESM-6 mainframe computer for obtaining the unknown critical pressure parameter with three decimal points is one hour. The method is especially efficient when the initial estimate of the nozzle deflection is defined in the form of a sine curve, i.e., crudely. Figures 3; references 9: 8 Russian, 1 Western.

### Issues of Extending Hydrodynamic Coefficient Determined by Damping Oscillation Method to Forced Oscillations or Effect of Waves on Underwater Engineering Facilities (PTO)

*937F0138G Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian*
*No 1, Jan-Feb 93 pp 197-207*

[Article by Yu.V. Razumeyenko, St. Petersburg; UDC 629.12:532.59]

[Abstract] An analysis of the coefficients of associated mass (moments of inertia) and damping factors of bodies of revolution, cylinders, and floats with an exponential generator (*Mekhanika tverdogo tela* No. 4, 1991) is continued and the issue of whether the coefficients determined by the method of damped oscillating motion can be extended to forced vibrations of the same body under the effect of waves is addressed. The validity of such operation is discussed with respect to underwater installations under the effect of waves. The conditions of comparability of damped and undamped vibrations are formulated as the correspondence of instantaneous velocities and acceleration at the characteristic points of the transient process. The damped oscillating motion (pitching, rolling, heaving and yaw) experiment method used for examining the damped process patterns and a

special unit built for analyzing damped heaving (UZVK) are described and a procedure is recommended for processing experimental data. A pitching, rolling, and heaving experiment with a calibrated dynamometer is outlined and certain patterns of damped processes are analyzed. The conclusion is drawn that the free damped oscillation method is quite applicable to the problems of forced vibrations but calls for taking into account the corresponding reduction coefficients for velocities and accelerations. It is noted that inertial rather than damping forces are dominant in the disturbing effect on a poorly streamlined body in an actual liquid; this challenges the applicability of the stationarity hypothesis in the problem of pitching and rolling even at small amplitudes. Figures 9; references 7.

## Periodic Motion Modes of Contact-Free Gyro

*937F0139A Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 93 pp 12-17*

[Article by S.I. Gubarenko, V.G. Kuzmenko, Moscow; UDC 531.383]

[Abstract] A contactless gyro placed in a two-degree-of-freedom gimbal suspension whose base is stationary relative to the Earth and whose servo systems continuously align the rotor's dynamic symmetry axis with the case axis is considered is order to examine the gyro motion modes at which the angle between the vector directed along the rotor's dynamic symmetry axis and the axis which is parallel to, and codirectional with, the vector of the Earth's angular velocity remains constant while the gyro's axis executes a periodic motion along a circular cone relative to the Earth. The gyro's equations of motion are derived and a method of approximate solution of these equations of motion is formulated. The structure of the disturbing moment is examined and the averaged equation is derived for the slow variable μm. The conditions at which the limiting cycles exist are formulated. The limiting cycles are analyzed allowing for the gyro case drifts and conservative and nonconservative disturbing moments. For illustration, the motion of a polar gyro (i.e., near the direction toward the North star) is considered. The authors are grateful to Yu.G. Martynenko for discussing the findings. Figures 2; references 8.

## On Tensor Slaving in Gravitational-Inertial Navigation System

*937F0139B Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 93 pp 18-25*

[Article by D.V. Lebedev, A.I. Tkachenko, Kiev; UDC 531.36]

[Abstract] The problem of correcting precision gravitational-inertial navigation systems containing precision gradiometers and the effect of even small measurement errors on the kinematic and navigation parameter accuracy are discussed and the task of determining the instrument's movement trihedral attitude of a gyro-free gravitational-inertial navigation system installed on an oscillating object is considered. *A priori* data on the second derivative tensor of the gravitational potential in the instrument base are obtained by gradiometry and are used as the information whose accuracy is comparable to that of the system itself; a comparison of two notations and invariants of the same tensor in the reference and instrument bases may produce relationships between the values which must be estimated during the gravitational-inertial system correction. The problem is formulated, the gradiometry operations and instrument errors are described, the error model coefficients and attitude parameters are evaluated, and kinematic equations are derived and integrated. The initial conditions for integrating the equations solved for operating precision navigation systems are formulated. A model example is considered for illustration. Similar results were obtained in the case where constant zero drifts of the newtonmeters are used as the systematic error sources. References 12: 10 Russian, 2 Western.

## On Pulse-Width Control of Rigid Body Dampening

*937F0139C Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 93 pp 26-36*

[Article by L.Yu. Anapolskiy, A.L. Litvinov, Irkutsk; UDC 531.38]

[Abstract] Movement of a rigid body with one fixed point in projections on the principal axes of inertia described by Euler's equations is considered and it is assumed that the moments of all given forces except for the control forces are determined by a known expression and all controls are synchronized, i.e., the initial pulse moment and repetition period are identical for all controls. The problem of this body dampening, i.e., the problem of decreasing the angular velocity magnitude to the minimum possible level, is solved for the control moment executing pulse-width modulation in each angular velocity component. It is asserted that there exists a constant at which the solution of the system of equations of motion is an perfectly converging series whose terms can be successively determined. It is shown that the findings also extend to the case of symmetric rigid body dampening. References 4.

## Random Plane and Cylindrical Elastic Wave Diffraction on Half-Plane and on Finite-Width Strip

*937F0139D Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 93 pp 67-74*

[Article by P.V. Tretyakov, Kaliningrad; UDC 539.3]

[Abstract] An elastic medium with two longitudinal and transverse wave propagation velocities into which an absolutely rigid half-plane is inserted without friction whereby certain conditions are satisfied on its surface is

considered in the case where a longitudinal elastic wave with a certain potential, which is the solution of the wave equation, is incident upon the half-plane edge. An attempt is made to demonstrate that the problem is reduced to finding the solution in the diffraction region in the form of random and a transverse potentials. It is shown that the problem can be more conveniently reduced to the problem of diffraction of individually incident and individually reflected waves on Riemann's surface with a period of $4\pi$. A number of solutions are obtained in the form of elementary functions and the solution of the problem of diffraction on the half-plane is analyzed. The problem of diffraction is then solved for a finite-width strip; the solution requires that the reflected wave problem be solved first; then the incident and reflected wave solutions are combined. The analysis of the boundary conditions of free slip ensures the independence of the initial boundary value problems for the tension-compression and shear wave potentials, making it possible to solve the problem separately for longitudinal and transverse waves. It is shown that the problem of diffraction on a finite-width slot can be solved by a similar method. Figures 2; references 4.

## Problem of Contact Burst of Charge With Rectangular Cross Section Embedded Flush With Surface

*937F0139E Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian*
*No 2, Mar-Apr 93 pp 75-80*

[Article by A.V. Krymskiy, A.S. Udalov, Moscow; UDC 532.511]

[Abstract] The problem of an explosive (VV) charge with a rectangular cross section placed in a recess adjacent to the surface and shaped as a rectangular trench is considered and the explosive charge is simulated by a perfect compressed gas with is at rest at the initial moment and has an adiabatic exponent of 3. The initial density and pressure are uniformly distributed in the gas volume and are equal to 2 g/cm$^3$ and 100 kbar, respectively, and it is assumed that the solid deformable half-space is continuously filled with soft soil particles which can be described by S.S. Grigoryan's model. A contact burst of the charge is examined and the problem is solved numerically allowing for the blast product slip along the media contact boundary on which the finite-difference net nodes are bifurcated. In addition, a symmetric burst of an infinite cylindrical charge with the same thermodynamic characteristics as the rectangular charge simulated by the same perfect gas is considered. An analysis of the effect of the free surface on the taut strained state of soil particles make it possible to assess the effective energy of the deeply embedded infinite cylindrical explosive charge whose burst initiates a compression waves similar to the one propagating along the symmetric charge axis during the contact burst. The maximum velocity and stress ratios of the soil particles near the free surface and on the above symmetry axis are calculated. The authors are grateful to S.S. Grigoryan and Ya.A. Sozonenko for interest in the study. Figures 6; references 5.

## Plasticity Theory: State of Art and Outlook

*937F0139F Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian*
*No 2, Mar-Apr 93 pp 102-116*

[Article by V.D. Klyushnikov, Moscow; UDC 539.214; 539.374]

[Abstract] The full text of a report presented to the Seventh All-Union Congress of Theoretical and Applied Mechanics held in Moscow on 15-21 Aug 91 is reprinted. Existing versions of the plasticity theory classified by the underlying correlation principle structure are reviewed on the basis of numerous published sources. The first group of theories defined by the term of "regular plasticity" is examined and its shortcomings which prompted the development of subsequent theories are enumerated. A new theory—the yield theory—developed on the basis of Drucker's and Prager's principles is considered. An attempt is made to rectify the shortcomings of the classical yield theory in the framework of the limiting surface concept based on slips. The theory of analytical plasticity which does not rest upon the limiting surface notions is introduced. The hypothesis of limiting properties of plastic deformation is addressed. The phenomenon of electroplasticity and the related superplasticity effect are discussed and it is noted that the theory of superplasticity warrants an individual study. The authors stress that the review is aimed at experts and many comments are therefore omitted; moreover, they apologize to the authors of the many publications reviewed for leaving out certain well-known theories. Figures 3; references 50: 43 Russian, 7 Western.

## Axisymmetric Deformation of Shells of Revolution Connected by Elastic Ring

*937F0139G Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian*
*No 2, Mar-Apr 93 pp 150-155*

[Article by V.A. Pukhloy, V.I. Shalashilin, Moscow; UDC 539.3]

[Abstract] The axisymmetric deformation in shells of revolution joined rigidly by an elastic ring is considered and the stress-strain relationship of the shells of revolution is defined by a system of nonlinear differential equations. The shells and the ring turn by the same angle due to the rigidity of the joint. The deformation increment equations of the radial and axial coordinates of the median surface derived using radial and axial forces by the authors in *Mekhanika tverdogo tela* No. 4, 1989 are extended to a study of shells with a variable stiffness connected by an elastic ring. The boundary value deformation problem is formulated and solved by the modified method of successive approximations in which the telescopic shift method of Lanczos's power series is used

for speeding up the solution convergence and the initial system of equations is represented in Cauchy's normal notation. For illustration, the chamber of a pneumatic spinning machine made from D16T duralumin spinning at a speed of 45,000 $min^{-1}$ is analyzed. Figures 4; references 3.

## Intermediate Asymptotics in Nonlinear Shell Dynamics

*937F0139H Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 93 pp 172-177*

[Article by I.V. Andrianov, Ye.G. Kholod, Dnepropetrovsk; UDC 539.3:534.1]

[Abstract] The approximate equations which describe the nonlinear vibrations of a sloping spherical shell are derived and analyzed in the case of rigid restraining of the spherical panel edges. An ordinary differential equation and a finite correlation are derived from the initial relationships in order to determine the time function; then asymptotic expressions are derived for tangential displacements. It is noted that V.V. Bolotin's dynamic fringe effect theory can be interpreted as an intermediate asymptotic. The intermediate asymptotic concept introduced by G.I. Barenblatt and Ya.B. Zeldovich is discussed citing numerous published sources and it is shown that under certain boundary conditions, the precise solutions of the problem of nonlinear plate and sloping shell vibrations are the asymptotics of other solutions in the internal region while localized states, i.e., dynamic fringe effects, form near the boundaries. References 12.

## Dynamic Stability Critical Load Estimate of Shells With Holes

*937F0139I Moscow IZVESTIYA AKADEMII NAUK: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 93 pp 178-182*

[Article by L.V. Andreyev, M.Ye. Maslov, I.D. Pavlenko, Dnepropetrovsk; UDC 539.3:534.1]

[Abstract] The solutions of a series of basic problems of nonstationary thin-walled shell dynamics obtained by other scientists are discussed and a cylindrical shell with a central circular hole loaded by an external pressure shock uniformly distributed on the lateral surface is considered. The problem of obtaining a theoretical solution prompted an experimental study using shell models with a single central hole made by spot welding from Kh18N9-N sheet steel blanks with a yield strength of 820 MPa and a material density of $8 \times 10^3$ $kg/m^3$. To this end, a hole was drilled beforehand in a sheet stack while the external pressure shock was developed by an electromagnetic unit. The pressure was manipulated by a close-to-harmonic law with a $130 \times 10^{-6}$ s pressure shock duration. The residual deflection was measured by comparing the profiles plotted before and after loading. The pressure shock which resulted in a residual sag was designated as the critical load. The structure's load bearing ability is characterized by buckling under axial compression. A regression analysis of the experimental data is conducted and a multicriterial multifactor regression equation is derived from a multiplicative regression model. A theoretical-experimental method based on using the experimental data for taking into account the factors which complicate the precise solution is considered. Joint static-dynamic loading is examined and simple and reliable correlations are derived for assessing the dynamic load bearing ability of the shell on the basis of the regression and theoretical-experimental methods. The resulting relationships for estimating the critical impulse differ in accuracy, applicability, and types of constraints. Figures 4; references 6.

## Heat Exchange on Tip Fins in Hypersonic Flow

*937F0140A Moscow IZVESTIYA ROSSIYSKOY AKADEMII NAUK: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 2, Mar-Apr 93 pp 18-25*

[Article by V.Ya. Borovoy, T.V. Kubyshina, Moscow; UDC 532.526.011.6]

[Abstract] The flow and heat exchange near the windward surfaces of wing tips are investigated at Mach numbers of 5 and 8 and a Reynolds number at the mean wing chord of $(0.6\text{-}1.1) \times 10^6$. Attention is given to the flow and heat exchange in the area where the tip fin meets the wing. To this end, a simplified tip and wing design is used as a result of which the findings cannot be used directly in practical applications but give a good idea about important flow and heat exchange patterns. Both the wing and the fin are flat and are made from a 4 mm thick cloth-based laminate with a 100 mm mean chord. The wing is attached to a fuselage shaped as a blunted half-cone with a 5 mm blunting radius. Two cycles of experiments—at Mach numbers of 5 and 8—are conducted in periodic-action wind tunnels and the heat exchange is examined with the help of heat-sensitive indicator coats. The findings show that the greatest local heat exchange enhancement on the windward side is due to the flow separation along the path from the wing to the fin; the separation can be controlled by smoothly mating the wing with the fin. The authors are grateful to S.D. Fonov and T.A. Yershova for the numerical analysis of the pictures taken by thermoindicator coats. Figures 6; references 5: 4 Russian, 1 Western.

## On Boundary Layer Laminarization of Vibrating Wing

*937F0140B Moscow IZVESTIYA ROSSIYSKOY AKADEMII NAUK: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 2, Mar-Apr 93 pp 26-34*

[Article by S.V. Manuylovich, Moscow; UDC 532.526.2]

[Abstract] The use of boundary layer flow laminarization for reducing the aircraft drag is discussed and a new type

of Tollmien-Schlichting waves excited by wing vibrations is investigated. An attempt is made to show that the vibration generation mechanism amounts to a nonlinear interaction of the nonsteady excitation resulting from the vibration of the smooth wall with the steady-state boundary layer inhomogeneity over surface roughness. A straight wing with an infinite span and a smooth surface in a flow of an incompressible viscous liquid is considered. The flow over a curved vibrating surface and the process of suppressing the monoharmonic instability wave generating on the vibrating wing are examined theoretically. The study is extended to the case of a frequency spectrum and it is shown that suppression of the monoharmonic instability wave calls for two elementary irregularities. For illustration, a boundary Blasius layer disturbed by two Tollmien-Schlichting waves is studied and it is assumed that the wing vibrations are characterized by a continuous spectrum. The conclusion is drawn that the method under study can be used to suppress not only the Tollmien-Schlichting waves packet simultaneously present in the boundary layer but also a single instability wave at a fixed frequency at various approach flow velocities whereby the irregularity shape may also be adjusted for suppressing the most unstable frequency under different flight conditions. Figures 5; references 11.

### Nonplanar Airfoils With Minimum Induced Drag

*937F0140C Moscow IZVESTIYA ROSSIYSKOY AKADEMII NAUK: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 2, Mar-Apr 93 pp 103-109*

[Article by S.V. Lyapunov, Moscow; UDC 533.6.011.34:533.69.01]

[Abstract] The models traditionally used for describing the flow of an incompressible perfect liquid about a high-aspect-ratio wing whereby the wing is substituted with a bound vortex and a vortex sheet behind it and the issue of optimum bound vortex shape are discussed. The optimum bound vortex shape conditions are examined by direct variations of the induced drag functional at given lift and wing span and given bound vortex sag and length. The first variation of the induced drag functional of a straight high-aspect-ratio wing in a potential flow is considered whereby the roll-up of the sheet is ignored and it is assumed that it is parallel to the approach flow. The optimum shape solutions of the problem of minimizing induced drag is obtained in the form of a planar airfoil with end plates. The optimum circulation distributions along the bound vortex and the values of induced drag are calculated and it is shown that in the absence of wing span constraints at given approach flow and lift, the induced drag bottoms out in a planar wing with an elliptic circulation distribution. The author is grateful to P.L. Krapivskiy for valuable remarks. Figures 5; references 9: 3 Russian, 6 Western.

### Supersonic Flow About Cone Under Heat Influx in Vicinity of Vertex

*937F0140D Moscow IZVESTIYA ROSSIYSKOY AKADEMII NAUK: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 2, Mar-Apr 93 pp 110-114*

[Article by V.A. Levin, L.V. Terentyeva, Moscow; UDC 533.6.011.72]

[Abstract] Supersonic flow over a cone placed in the wake behind a spherical heat source (for developing additional aerodynamic force) with a Gaussian law of heat release is investigated; the heat source located in the supersonic flow generates nonlinear waves and shock waves which are followed by a heated gas wake with reduced pressure and density. A system of gas dynamics equations is derived in a nondimensional form and solved numerically by McCormak's method. The isobaric field of the entire flow at M=3, the parameter distribution along the symmetry axis, the pressure on the cone surface, the dependence of the shock wave drag on the cone length, the dependence of the cone drag on the approach flow Mach number, and the dependence of the cone drag on the distance between its apex and heat source located at the origin of coordinates are plotted. The calculations show that there exists an optimum heat release source position relative to the apex at which the drag gain peaks. The minimum drag values and the corresponding distances are summarized. The findings reveal that heat inflow in the neighborhood of the aircraft cone at a supersonic velocity may substantially lower the shock wave drag not only of blunted but also of tapered bodies, including cones. It is noted that a frontal separation zone may also develop in front of the blunted bodies, thus reducing drag. Figures 6; tables 1; references 12: 10 Russian, 2 Western.

### Aero- and Thermodynamic of High-Altitude Flight

*937F0140E Moscow IZVESTIYA ROSSIYSKOY AKADEMII NAUK: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 2, Mar-Apr 93 pp 142-152*

[Article by V.N. Gusev, Moscow; UDC 533.6.011.8]

[Abstract] The report presented to the fluid mechanics section at the Seventh Theoretical and Applied Mechanics Congress held in Moscow in Aug 91 is summarized. The high-altitude flight of a flying vehicle at hypersonic velocities is examined and tentatively divided into three categories: continual flight at Knudsen numbers of much less than unity, free molecular flight at Knudsen numbers of much greater than unity, and transition flight at Knudsen numbers of close to unity. The flow structure and methods of determining the aerodynamic and thermodynamic characteristics of these conditions are investigated. In a general case, the high-altitude flight in a hypersonic wind tunnel cannot be simulated today due to the fact that in addition to realizing full-scale values of Mach and Reynolds numbers, it is also necessary to reproduce high air enthalpy values; numerical simulation is used instead whereby the

scaling laws formulated in various fields are employed. The corrections which take into account the effect of viscosity and rarefaction under the frozen composition of the air and the effect of the physical and chemical processes are incorporated into the aerodynamic characteristics. For illustration, the procedure of determining the aerodynamic characteristics of hypersonic flight vehicles—from the continual to free molecular flow conditions—used in designing the Buran orbiter is considered. The characteristic features of hypersonic flow over thin bodies in the transition area are addressed and analyses produced using Navier-Stokes and Boltzmann equations are compared. Figures 8; references 28: 18 Russian, 10 Western.

## Discharge Characteristics of Converging-Diverging Nozzles With Cylindrical Minimal Cross Section Path

*937F0140F Moscow IZVESTIYA ROSSIYSKOY AKADEMII NAUK: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 2, Mar-Apr 93 pp 164-165*

[Article by N.L. Yefremov, Moscow; UDC 532.525]

[Abstract] The use of convergent-divergent nozzles with a cylindrical path of minimal cross section as discharge and flow metering devices for various perfect gases is discussed and the effect of the subsonic path slope of the nozzle generator and the adiabatic exponent of the gas on the discharge coefficient is examined; the effect of the turbulent boundary layer on the discharge coefficient is specifically studied for a nozzle with a 45° slope at an adiabatic exponent of 1.05, a Reynolds number of $10^6$, and an initial displacement thickness of 0.001. The gas friction is analyzed by numerical integration of Euler's equations by the Godunov-Colgan procedure using adaptive nets. A certain increase in the discharge coefficient when the gas viscosity is taken into account is attributed to a decrease in the effective subsonic nozzle generator slope. The author is grateful to R.K. Tairov for his interest in the study. Figures 3; references 5: 4 Russian, 1 Western.

## Experimental Investigation of Supersonic Flow Over Wedges With Longitudinal Slots on Windward Side

*937F0140G Moscow IZVESTIYA ROSSIYSKOY AKADEMII NAUK: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 2, Mar-Apr 93 pp 173-175*

[Article by V.I. Voronin, G.S. Ulyanov, A.I. Shvets, Moscow; UDC 533.6.011.5]

[Abstract] Interest in theoretical and experimental studies of the flow about the most promising hypersonic waverider flight vehicles which do not have a clear boundary between the bearing member and the airframe with the shock wave attached to the leading edge is mentioned and it is noted that compared to other hypersonic flight vehicles, waveriders employ their lower surface—the compression surface on which most of the lift develops at high supersonic speeds—much more efficiently. For illustration, a method of increasing the waverider's lift-to-drag ratio is considered using wedges with longitudinal grooves. The method is based on the premise that the lift-to-drag ratio can be increased in flight vehicles most of whose lift is developed due to the flow compression on the lower surface by reducing drag without substantially changing the pressure on these surfaces. The geometric characteristics of the wedges and aerodynamic characteristics of the models as a function of the wedge/slot height ratio are summarized. The findings show that the lift-to-drag ratio peaks at the height ratio of 0.036. Figures 4; tables 2; references 5: 3 Russian, 2 Western.

## On Limit of Motion of Systems With Dry Friction

*937F0142A Moscow ROSSIYSKAYA AKADEMIYA NAUK: PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 57 No 1, Jan-Feb 93 pp 12-19*

[Article by A.S. Sumbatov, Moscow; UDC 531.36]

[Abstract] A mass system which is subject to some time-independent constraints, is under the effect if internal forces with a potential which is either positive or equal to zero in all feasible system positions, contains rigid bodies or points sliding with friction relative to each other, and has an internal-force force-function which remains smaller than a certain limit in all feasible system positions is addressed, and an attempt is made to prove that over a time interval in which at least one contact with sliding is preserved in the system, the frictional force power's upper bound is zero. In other words, it is speculated that in systems with friction described by the Amonton-Coulomb law, motions exist in which at the end of an arbitrarily long time interval, the mechanical energy is dissipated through friction. It is assumed that a dry frictional force is exerted by a body sliding upon the reference body, and a mass curve along which a heavy bead may move with friction is considered. For illustration, plane parallel motion of a heavy nonuniform wheel on a rectilinear rail is considered, and the motion mode alternation conditions, rolling stability, and motion with constantly alternating rolling and sliding are examined in detail. References 4.

## Asymptotic Integration of Dynamic Equations of Elasticity Theory in Case of Thin Shells

*937F0142B Moscow ROSSIYSKAYA AKADEMIYA NAUK: PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 57 No 1, Jan-Feb 93 pp 83-91*

[Article by Yu.D. Kaplunov, I.V. Kirillova, L.Yu. Kossovich, Moscow; UDC 539.3]

[Abstract] The lack of asymptotic derivations of two-dimensional dynamic equations of the theory of shells

from three-dimensional equations of the theory of elasticity and the considerable difference between the asymptotic properties of the taut strained state of dynamic and static shells prompted an investigation into a thin elastic shell with a relative half-thickness equal to the ratio of the shell thickness to the characteristic curvature radius of its median surface. The dynamic equations of the theory of elasticity which describe the shell motion as a three-dimensional elastic body are derived, and it is assumed that differentiation with respect to nondimensional variables does not change the asymptotic order of the original quantities. It ia also assumed that the shell's face surfaces are free of external loads. These three-dimensional dynamic equations of the elasticity theory are integrated asymptotically in the case of thin shells, and the two-dimensional equations of motion are examined in terms of forces and moments. The characteristic features of the shell's taut strained state (NDS) is discussed in dynamic cases where it is necessary to prove the existence of domains or intervals of consistent solutions obtained on the basis of the two-dimensional theory of shells and the boundary layer theory. The limiting two-dimensional systems of equations are derived; it is noted that by simultaneously keeping all terms in two-dimensional equations of motion, one can obtain a full system of two-dimensional equations of the Kirchhoff-Love dynamic theory of shell. references 7.

### Dynamic Electroelasticity Problem for Inhomogeneous Cylinder

*937F0142C Moscow ROSSIYSKAYA AKADEMIYA NAUK: PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 57 No 1, Jan-Feb 93 pp 116-122*

[Article by Yu.E. Senitskiy, Samara; UDC 539.3:534.1]

[Abstract] A nonstationary connected electroelasticity problem of dynamic torsion of a finite hollow cylinder made from an inhomogeneous piezoelectric material is considered in the case where randomly time-dependent electric potential or tangential stresses are defined on its surfaces. To this end, a hollow circular finite cylinder which occupies a given area and is a linearly elastic anisotropic body made from an inhomogeneous piezoelectric materials whose physical and mechanical characteristics change continuously along its radius is considered in a circular system of coordinates in the case where the cylinder ends are free of stress and electric charges while the above electric potential and tangential stress are applied to its external and internal curvilinear surfaces, respectively. The mathematical model of the formulated problem is derived in the form of differential equations of motion and electrostatics of a piezoelectric continuum. The method of expansion in terms of vector eigenfunctions in the form of a structural algorithm of finite integral transforms (KIP) is employed in order to demonstrate that a closed solution may be obtained under an exponential law of heterogeneity of the electric, elastic, and inertial characteristics of the material. It is noted that under certain conditions, the equations of dynamic torsion under the interaction of conjugated force and electric fields and boundary conditions satisfy class 422 and 622 crystals. References 11.

### Solution of Linear and Nonlinear Boundary Problems of Shell and Plate Theory Based on Lines Method

*937F0145A Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 29(39) No 4, Apr 93 pp 3-11*

[Article by Ya.M. Grigorenko, N.N. Kryukov, Mechanics Institute at the Ukranian Academy of Sciences, Kiev; UDC 539.3]

[Abstract] The taut strained state of thin shells and plates exposed to nonuniform force and thermal loads at various contour restraining methods is outlined and linear and nonlinear boundary value problems are formulated for systems of partial differential equations with variable coefficients. An attempt is made to solve these problems by reducing two-dimensional problems to one-dimensional since local and boundary value phenomena of the stressed state exist in shells and plates. One of such approaches based on jointly using the method of straight lines to reduce the dimension of two-dimensional nonlinear boundary problems, linearizing unidimensional problems, and using the stable numerical method of discretely orthogonalizing the solution of linear boundary value problems is employed. To this end, the approach is used to study the taut strained state of thin flexible laminar shells whose coordinate surface is shaped as a surface of revolution closed in the circumferential direction. The approaches to solving the problems numerically are realized by routines in the FORTRAN language and tested using numerous examples. For illustration, the use of the methods of lines and spline collocation is discussed. Figures 2; tables 2; references 9.

### Nonlinear Elastic State Near Elliptic Hole in Orthotropic Spherical Shell

*937F0145B Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 29(39) No 4, Apr 93 pp 39-45*

[Article by L.I. Golub, V.A. Maksimyuk, I.S. Chernyshenko, Commercial Scientific Association imeni Artem and the Mechanics Institute at the Ukranian Academy of Sciences, Kiev; UDC 539.378.678]

[Abstract] The problems of elastic state, both linear and nonlinear, near the elliptic hole which slackens the orthotropic spherical shells are discussed and the principal correlations and nonlinear equations of shells with an elliptic hole are formulated on the basis of the nonlinear theory of elasticity and plasticity of anisotropic media and the theory of thin shells. The procedure of solving such problems is examined. To this end, a thin orthotropic shell slackened by an elliptic hole and exposed to a system of surface and boundary loads

whereby nonlinear elastic strain develops in the stress concentration zone material is examined. In so doing, it is assumed that the shell's taut strained state can be described by the Kirchhoff-Love hypotheses and nonlinear theories of elasticity and plasticity of anisotropic media. An elliptical system of coordinated connected to a rectangular system of Cartesian coordinates is used. The specific results of the numerical investigation of the stress and strain distribution in the orthotropic shell allowing for the nonlinear properties of its material are presented. The stress and strain peak on the hole contour when the elliptic coordinate $\eta = 0$. It is also noted that by ignoring the ellipticity of the hole, one can reduce the maximum values of stress by 19.77 and 16.85% in the linear and nonlinear problem formulation, respectively. Tables 1; references 12.

### Acoustic Shock Wave Interaction With Cylindrical Piezoelectric Ceramic Shell Located Near Planar Boundary

*937F0145C Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 29(39) No 4, Apr 93 pp 46-54*

[Article by A.E. Babayev, Yu.N. Ryabukha, V.G. Savin, Mechanics Institute at the Ukranian Academy of Sciences, Kiev; UDC 533.6.013.42]

[Abstract] The lack of published data on the interaction of ceramic piezoelectric transducers with each other and with shock waves in the case where the interface does not belong to a single family of coordinate surfaces in a transient formulation prompted an investigation into the interaction of an external planar weak shock wave with an infinitely long piezoelectric ceramic cylindrical shell operating as a detector and located near a planar boundary, i.e., a rigid wall or a free surface. The electrodes covering the shell surfaces are open, the shell's inner volume may be filled with a fluid, while the incident shock wave front is sloping at an arbitrary angle to the planar boundary. The disturbed movement of the piezoelectric ceramic cylinder and the external and internal media in contact with it is described in the framework of the theory of electroelastic shells based on Kirchhoff's and Love's hypotheses and acoustic approximation. For illustration, numerical calculations are made for a piezoelectric ceramic cylindrical shell from the TsTBS-3 material whose inner volume is a vacuum while the ambient space is water. The calculations show that the plane boundary may significantly affect the wave field in the liquid and the taut strained state of the piezoelectric ceramic shell; these factors must be taken into account in shell design. Figures 4; references 8.

### Analysis of Straining Characteristics of Glass-Reinforced Plastic Parabolic Shells

*937F0145D Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 29(39) No 4, Apr 93 pp 55-60*

[Article by L.B. Berman, Special Design and Technology Office of the Mechanics Institute at the Ukranian Academy of Sciences, Kiev; UDC 539.3]

[Abstract] Extensive development of modern satellite television systems and long-distance space radio communication as well as a growing reliance on composites for making antenna reflectors increase the urgency of developing the methods of reliable theoretical estimates of the taut strained state (NDS) of such structures—the principal structural member of space communication systems. The principal relationships for analyzing the taut strained state of glass-reinforced parabolic shells are examined, the characteristic features of the computational algorithm developed for this purpose are outlined, and data illustrating the possibilities of the analytical procedure are cited. The equations derived earlier from the correlations of the S.P. Timoshenko-type shell theory are used to describe the taut strained state of the reflector shells in a polar system of coordinates which do not coincide with the lines of principal curvature allowing for the additional assumptions of the sloping nature of the shells. In the framework of the assumptions made, the taut strained state is described by membrane forces, bending moment and torque, shearing forces, tensile, shearing, bending, and flexural strains, tangential displacements and deflection of the median surface, and rotation angles of the normal connected to each other by known correlations. The system of equations is solved by separation of variables. The findings confirm the possibility of using the procedure for analyzing specific structures. It is noted that the results attest to the versatility of the procedure and that the possibility of numerically assessing the effect of the problem parameter on the taut strained state makes it possible to optimize the parabolic antenna design depending on the requirements imposed on the specific systems. Figures 5; tables 1; references 8: 7 Russian, 1 Western.

### Experimental Investigation Into Taut Strained State of Ribbed Cylindrical Shell Under Pulse Loading

*937F0145E Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 29(39) No 4, Apr 93 pp 61-64*

[Article by V.F. Sivak, Mechanics Institute at the Ukranian Academy of Sciences, Kiev; UDC 539.14:5.39.37]

[Abstract] A procedure for an experimental investigation into the taut strained state of a liquid-filled rib-stiffened cylindrical shell under the effect of longitudinal and transverse pulse loads is examined. To this end, a closed circular cylindrical shell with a 0.1 m radius, a 0.58 m diameter, and a 0.6 mm wall thickness stiffened on the outside by 24 longitudinal ribs spot welded to the shell is tested. The shell and the ribs are made from the 0T4-1 titanium alloy with an elasticity modulus is $1.1 \times 10^5$ MPa, a density of 4,,400 kg/m$^3$, and a Poisson ratio of 0.34. The shell was installed into circular slots in massive steel discs filled with molten Wood metal; when the metal solidified, the shell edges became rigidly constrained. The shell was filled with water during the experiment. During the experiment, vibrations were generated in the shell and its deflection and strain were

measured by various methods. An analysis of the experimental data indicates that the dependence of vibration stresses on the total shock pulse is close to linear; under the longitudinal shock in a fully filled shell, vibration stresses are greater than those in a dry shell while the membrane stress is always greater than the bending stress. Under the transverse shock in both filled and dry shells, the membrane vibration stress is always much greater than the bending stress while filling the shell with water has little effect on the bending stress. Figures 3; references 4.

## Effect of Elastic Wave Inertia During Cylindrical Shell Rotation

*937F0145F Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 29(39) No 4, Apr 93 pp 65-69*

[Article by S.A. Sarapulov, Yu.K. Minayev, Ritm Scientific Research Institute at the Kiev Polytechnic Institute; UDC 581.383]

[Abstract] The elasticity theory problems for a spinning medium in which elastic waves are excited and elastic wave inertia is observed—the phenomenon used in navigation instruments—are discussed and the effect of elastic wave inertia in a rotating shell which may be used as the gyro sensor is examined. Linear equations of motion are derived for the cylindrical shell, and it is assumed that the angular velocity is constant. It is noted that in actual instruments, e.g., solid wave gyros, the sensor is a thin shell of revolution where the second harmonic is the operating vibration mode. An analysis shows that in a thin cylindrical shell under the effect of spinning, a pattern of standing wave precession (bending and tension) proportionate to the angular velocity is is observed while the standing wave rotation angle depends on the geometrical shell parameters, restraining conditions, and the vibration harmonic number. The findings point toward the possibility of using the phenomenon of elastic wave inertia in the cylindrical shell for practical applications. References 4: 3 Russian, 1 Western.

## Safety Advantages of Fast Neutron Reactors Touted

*934D0197B Moscow MOSKOVSKIYE NOVOSTI in Russian No 22, 30 May 93 p B7*

[Article by German Lomanov under the rubric "Power Engineering": "Fast Reactors May Become the 'Medics' of Atomic Power Engineering"]

[Text] **The concept of development of fast neutron reactors formulated by the Obninsk Physics-Power Engineering Institute [FEI] together with the organizations and enterprises of Ministry of Atomic Energy of Russia envisions an improvement in the ecological situation in nuclear power engineering.**

There are four fast neutron reactors (FNR) operating in the CIS: BR-10 (Obninsk), BOR-60 (Dmitrovgrad), BN-350 (Mangyshlak), and BN-600 (the Beloyarsk AES). The experience of their operation, which comes to 85 reactor years (in the world there are some 200), confirms the greater level of safety of FNRs as compared to water-cooled nuclear reactors plus their simplicity of control and minimal impact on the environment. The average discharge of radioactivity into the atmosphere at BN-600, for example, was 9.5 curies per day and after modernization of the active zone declined to 1.3 curies per day (with an acceptable norm of 500 curies per day. The FNR's discharges into the air for the most part contain inert radioactive gases which are not dangerous to humans since they do not join into chemical compounds and their half-life is only a few dozen hours. The discharges do not contain any dangerous radionuclide easily assimilated by the thyroid gland like $I^{131}$.

Unique experiments were done on the French Rhapsody reactor and the American EBR-II and FFTF to simulate the most dangerous accidents (stoppage of the pumps and the emergency safety systems' failure to trigger). And not once did the active zones lose working capacity, thanks to the characteristics of good self-protection inherent in the FNR. In short, fast reactors can be extremely safe.

In addition, FNRs are the most effective burners of so-called small actinides (americium and curium)—ecologically the most dangerous radioactive waste, with a half-life of millions of years. And 25-35 kilograms of small actinides are formed a year in both a thermal and a fast reactor with capacities of 1,000 megawatts and using uranium-plutonium fuel. But a VVER [water-moderated water-cooled power reactor] accumulates them while a FNR burns them. One fast reactor can burn the "dirt" of 3-4 VVER-1000s. And if the diagram of the active zone is optimized, such a specialized fast reactor destroys waste from even 10 VVERs. The director of the FEI, Victor Murogov, believes that one out of six or seven reactors in atomic power engineering should be fast reactors. He is confident that FNRs are reliable "medics" of atomic power engineering and without them we will simply leave all our "dirt" to our grandchildren and great-grandchildren.

A fast reactor is omnivorous; it can be loaded with absolutely pure weapons-grade plutonium as well as "dirty" energy plutonium—an FNR works fine on either. By contrast, light-water atomic reactors like the VVER do not burn plutonium but distill it into more toxic transuranium elements, building up radioactive "dirt" for future generations. But fast reactors clean the energy plutonium without building up more toxicity and burn the weapons-grade fuel. This is especially important because of the upcoming nuclear disarmament; during this process about 100 tonnes of weapons-grade $Pu^{239}$ will be removed from warheads.

In using plutonium (both weapons-grade and energy-class), FNRs may build up $U^{233}$, the physical characteristics of which ensure safer work by thermal reactors. Using $U^{233}$ as fuel will also improve the ecological safety of atomic energy, since in this case the amount of highly toxic and long-lived transuranium elements in the spent fuel is reduced.

Studies show that introducing FNRs based on uranium-plutonium fuel completely rids atomic power engineering of the need to mine uranium—the sector will work for hundreds of years "burning" the accumulated waste from enrichment production. Because of the slowing of the rate of development of atomic power engineering and the appearance of conversion $Ru^{239}$ and $U^{235}$, conservation of fuel resources has disappeared from among the primary tasks, but it would be irrational to ignore it altogether.

The concept formulated by the FEI and accepted by the sector envisions before the end of the century building four BN-800 energy blocs on the sites of the Mayak Production Association and the Beloyarsk AES, creating a closed fuel cycle infrastructure, and finishing construction at Mayak of the N-300 shop (essentially a plant to produce plutonium fuel for FNRs) where construction is for now frozen (50-percent ready).

It has been proposed to begin to use weapons-grade $Pu^{239}$ in the BN-600 reactor on the base of the modernized Paket unit and to formulate a plan and begin building a BN-600M reactor of average capacity which is safer than light-water reactors but competitive with them in terms of economic indicators.

It should be acknowledged that while FNRs exceed light-water reactors in terms of many constructive and technical features, they are inferior to them in terms of economics—specific capital expenditures and the cost of the electricity produced are higher for them. Thus, the cost of 1 kilowatt of installed power is 1.5 times higher for a BN-600 than for its counterpart VVER-1000 at the Novovoronezhskiy AES. That is understandable: the FNRs were put into operation 10 years after the light-water reactors, which by that time were already being series produced. Their designs were formulated with a strength reserve, since all the factors affecting the

working capacity of the equipment were not yet altogether clear. Finally, stainless steel is extensively used in FNR's with their sodium cooling agent.

Expert projections show that it is altogether realistic to reduce specific capital investments and operational expenses at FNRs to the level of thermal reactors. But while even at first fast reactors will be negligibly more expensive (by 10-15 percent), this difference is altogether compensated by their ability to burn radioactive "dirt" efficiently and conserve weapons-grade $Ru^{239}$.

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### Clean Room Technology Devices and Systems

*937F0134B Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 10, Nov 92 pp 29-32*

[Article by M.Kh. Kardanov, Nalchik; UDC 331.422.2:62-784.43]

[Abstract] Clean room technologies, such as microelectronics, and the increasingly stringent requirements imposed on the dust and microorganism content in the work areas are discussed, and the work of the Tekhnovent Joint Venture between the western German company Babcock-BSH—a leader in clean production room (ChPP) design and implementation—and the Kabardino-Balkar Production Association Tekhnopribor is outlined. Data on the installation of clean production rooms made by the Tekhnovent Joint Venture are presented. The design, operation, and specifications of various clean production modules are summarized and their general views and schematic diagrams are shown. In particular, the operation of ventilation and filtering systems is described in detail. Specific recommendations are given for optimum use of various types of modules. It is noted that the system uses described in the article may be expanded using numerous domestically manufactured units. Figures 6; tables 2.

### Programmable Enhanced-Reliability Controller

*937F0134A Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 10, Nov 92 pp 24-25*

[Article by A.I. Lukanov, V.S. Yemelyanov, L.I. Postnikov, T.N. Pleshkova, V.A. Mekeshkin, N.N. Korovin, Progress NITI, Izhevsk; UDC 681.326.75:678.073.007-52]

[Abstract] A programmable process equipment system controller developed jointly by the Progress NITI and Izhevsk Motor Works and introduced into mass production is described. The device is intended for controlling complicated industrial equipment, has a relatively small number of inputs and outputs, and requires a well-developed man-machine interface in the form of a monitor and a keyboard. The controller has a modular design with attendant advantages and is characterized by an enhanced reliability due to the use of elements with top acceptance rating, modern production and quality control practices, the possibility of executing the proportional plus integral plus derivative (PID) control law, the possibility of positional control, built-in diagnostics, and direct link to the video monitor. The operating procedures are outlined and the principal specifications are summarized. The controller was successfully integrated in the automatic thermoplastic machine control system at the Krasnoyarsk Mechanical Engineering Plant. Work on expanding the controller capabilities is underway at the Progress NITI. Figures 1; tables 1.

### Study of Surface Preparation for Soldering of Vacuum Seals Using Selective Discharge in Vacuum

*937F0133F Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 7-9, Jul-Aug 92 pp 129-131*

[Article by L.I. Volchkevich, V.V. Zhukov, K.A. Nadyrbekov; UDC 621.793.02]

[Abstract] The high incidence of vacuum seal rejects after soldering due to the pores and microcracks resulting from poor surface adhesion to the solder and the inadequacy of existing methods of removing the defective layer from the surface before soldering prompted a study of a promising surface contamination removal method—treating the surface with selective discharge in a vacuum (IRV). The procedure of surface preparation for soldering by selective discharge application in a vacuum is described and depicted schematically, and the surface relief before and after treatment by selective discharge in a vacuum is cited. Reference spots form on the surface under the effect of selective discharge in a vacuum and move chaotically on the surface, which leads to explosion-like evaporation of surface contamination; this phenomenon forms the basis of the procedure. The use of the method improves the vacuum seal and mechanical strength of soldered vacuum tube parts while the surface roughness increases by more than twofold. The method is environmentally clean and the contamination removal time is about 10 s for a part with a 45 mm diameter. Such impurities as C, Mn, and Si which form oxide films and compounds can be removed from the surface by this method. Figures 2; references 1.

### On Effect of Normal Vibrations on Tractive-Gripping Properties of Walking Machines

*937F0133E Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 7-9, Jul-Aug 92 pp 116-120*

[Article by Ye.S. Bruskin, A.Ye. Rusakovskiy; UDC 629.1.033.3]

[Abstract] The use of walking vehicles for improving the cross-country capabilities of transport and production machinery and the effect of the propulsor support interaction with the soil and the physical and mechanical properties of the contacting surfaces on the cross-country

capabilities of walking machines are discussed; the motion dynamic of walking vehicles with vibrators placed on the walking mechanisms in order to develop an alternating load on the machine's supports is studied. It is noted that the cross-country capability depends not only on the resistance forces but also on the tractive force due to the grip for each specific pair of contacting materials. The limit of the tractive force without vibration and the limit of friction force under vibration, the power expended for moving the vehicle, and the slipping coefficient are plotted. The study shows that in the cases where traction due to grip is sufficient for moving the vehicle at a low slipping coefficient, the vibrators have no effect on the slipping coefficient and the mean engine power; yet as the relative towing force increases and the tractive force is no longer sufficient to move the vehicle or does so with considerable slipping, normal vibration on the support decreases both the slipping coefficient and the mean power necessary for moving the vehicle. Figures 2; references 6.

## On Failure Mechanism of Elements and Assemblies of Gas Turbine Engines Under Arc Brazing in Vacuum

*937F0133D Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 7-9, Jul-Aug 92 pp 74-81*

[Article by V.M. Vorobyev; UDC 621.438]

[Abstract] The shortcomings of the procedure currently used for restoring gas turbine engine (GTD) elements and assemblies with casting or operating defects prompted an investigation into the failure mechanism of gas turbine engine blades, nozzle blocks, and throttles made from the VZhL12U, ZhS3D, ZhS6K, and ZhS6U alloys in order to determine the reasons for the drop in the deformability of cast nickel-based superalloys. The nature and mechanism of superalloy element and assembly failure during arc brazing in a vacuum are studied by metallographic and fractographic analyses and mechanical tests of samples with vacuum arc brazing thermal cycling simulation. The tests revealed the brittleness temperature ranges (TIKh) both in the high- and low-temperature areas and identified the factors responsible for the loss of ductility. Practical recommendations are developed for increasing the crack resistance of brazed joints. In particular, the study shows that crack nucleation occurs as a result of the crystal slippage and displacement which lead to the pore and microcrack formation on the grain boundaries. It is suggested that the maximum temperature in the engine element body be lowered and the temperature interval of maximum deformation be shifted to the 1,000 to 1,100°C range. Heat treatment of restored parts is recommended for lowering the residual stresses, structural inhomogeneities, and nonuniformity of the alloy properties. Figures 3; references 6.

## Heat Power Engineering: Trends and Outlook

*937F0133C Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 7-9, Jul-Aug 92 pp 57-71*

[Article by V.I. Krutov; UDC 621.0]

[Abstract] The role of power engineering in the development of virtually all industries in the national economy on the basis of advances in science and engineering is discussed, and the possibility and outlook of each development trend in the power industry determined by the primary energy source type are reviewed. The opinions of leading scientific organizations, both academic and industrial, on the development trends and outlook for fossil fuels (oil, gas, and coal), nuclear power plants, hydroelectric power plants, renewable energy sources (VIE), and environmental protection, both at home and abroad, are examined in detail. The social factors in the development of, and outlook for, the power industry are taken into account. The conclusion is drawn that virtually all tasks arising in the power industry cannot be solved without first solving the problems facing other mechanical engineering fields, i.e., improving the design and manufacturing and operating practices, developing new materials, etc. It is emphasized that the solution of these development tasks is fraught with considerable difficulties, both economic and social, which must be overcome in order to lay the groundwork for improving the human condition. The important role of skilled personnel in addressing this issue is stressed. References 8.

## Taut Strained State of Flange Joints

*937F0133B Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 7-9, Jul-Aug 92 pp 37-41*

[Article by B.A. Obodovskiy, A.R. Burlachenko, V.K. Cherkezishvili (deceased); UDC 539.4:621.643]

[Abstract] The lack of sufficiently sound and commonly accepted methods of designing flange joints is mentioned and existing techniques as well as their shortcomings are reviewed. An improved procedure for analyzing the taut strained state of flange joints in a three-dimensional formulation based on employing the boundary integral equations method is suggested. The method's principal advantage is a lower (by unity) dimension of the problem due to the reduction of the resolving equations on the boundary surface of the structure under study. This makes it possible to paint a realistic picture of the stress field distribution without considerable CPU time outlays and without making simplifying assumptions. A schematic diagram of the flange joint stress analysis and a schematic diagram of the joint with strain gauges are cited. The stressed state analysis is carried out in two stages and the stresses are calculated using Gauss's and Cauchy's correlations, Gauss's generalized theorem, and Kantorovich's method. A YeS computer routine is compiled for calculating the stress values, and the stress in the flange elements is summarized. The findings indicate

that the relative deviation of the theoretical values from the experimental results is less that 15%, which does not exceed the error of the measurement method used and attests to the validity of the proposed technique. The technique may also be used for analyzing the taut strained state of other elements with a complex shape loaded by an arbitrary load. Figures 2; tables 1; references 4.

## Parameter Optimization of Vibration Damping Platform at Resonant Frequencies

*937F0133A Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 7-9, Jul-Aug 92 pp 8-12*

[Article by O.N. Florinskiy; UDC 628.517.4...531]

[Abstract] The problem of optimum selection of the vibration damping platform parameters intended for protecting people from vertical vibration and ensuring synchronization of all elastic platform elements—SKV-2P two-stage vibration dampers with motion conversion—is formulated. A schematic diagram of the vibration damping platform is cited and the design and operating principle of the platform are discussed in detail. The system's motion is described using second-kind Lagrange equations, and a nonlinear system of differential equations of motion is derived. Small system vibrations around the equilibrium position are studied and the vibration velocity amplitudes are computed by solving linear and nonlinear systems of differential equations. Two methods of simplifying the solution of the formulated problem are examined and the results of numerical calculations are plotted. The findings confirm that the vibration velocity amplitude peaks during the system vibrations around the equilibrium position which corresponds to the maximum permissible closure of the rope-type SKV-2P vibration damper. By optimizing the system at resonant frequencies, one can ensure that health standards are met at any regulated frequency is they are met at resonant frequencies. Figures 2; references 3.

## Computer Analysis of Dynamic Characteristics of Two-Channel Electric Drive With Elastic Element for Gantry Robot

*937F0147B Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA in Russian No 1, Jan-Feb 93 pp 82-85*

[Article by B.I. Kuznetsov, R. Koziol, I.M. Nekrasov, A.A. Khudyayev, Kharkov Engineering Teaching Institute and Krakow Mining Academy; UDC 681.518.22]

[Abstract] The uses and advantages of gantry robots which have a rather small footprint combined with a large coverage area and a series of gantry robots with two-channel drives which are being developed today at the Rotor Scientific Production Association are discussed, and the issues of computer analysis of the time and frequency characteristics of such two-channel gantry robot drives are addressed. The drives' channels are divided into a power (or crude) channel which employs a Razmer-2M high-duty-factor induction motor with frequency-current control and a wider-band precision control channel which ensures fast and accurate tool positioning and also uses a frequency-current controlled linear synchronous motor. The first channel is equipped with a flexible transmission element. A mechanical diagram of the two-channel robot drive and a block diagram of the two-channel electric drive with a flexible transmission element are cited. The timing charts of the system and its frequency response are plotted. A mathematical model is derived for the robot with an induction motor power drive whose force is transmitted to the carriage by the flexible transmission and a fine linear synchronous motor; the model is used for a computer analysis of the transient responses and frequency characteristics of the off-line drives and the two-channel drive. It is expedient to use the proposed electric drive in handling extended products as well as products with large overall dimensions and mass where an elevated control and tool positioning accuracy is required. Figures 4; references 5: 4 Russian, 1 Western.

## Electromechanical Effect of High-Current Discharges on Shell Structures

*937F0147A Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA in Russian No 1, Jan-Feb 93 pp 38-46*

[Article by S.K. Kamzolov, Moscow Civil Aviation Engineering Institute; UDC 629.735.067-758.37]

[Abstract] The use of rather crude assumptions in the analytical model for determining the mechanical stresses in conducting plates under the effect of electromagnetic pressure from high-current discharges prompted an attempt to develop the model further by taking into account the wave processes which accompany high-current pulses in conducting shells. The lightning-type pulse shape is approximated by an exponential function. The dependence of the stress intensity distribution on the pulse duration and the nondimensional parameter which characterizes the correlation between the discharge parameters and the plate material characteristics is obtained, and a computational formula is derived for the critical parameter—the limit of amplitude current at which the stress intensity exceeds the yield strength, i.e., the onset of plastic deformation in the shell. The theoretical results are consistent with experimental data obtained for a 1-mm-thick sheet of the D16AT material under an electric discharge with a 50-55 kA amplitude, making it possible to use the proposed model to assess the stressed state of shell structures under the effect of high-current discharge pulses, e.g., the lightning stroke. Figures 9; references 6: 5 Russian, 1 Western.

## Hardware and Software for Accelerating Tests and Studies of Processes in Friction Units of Machines and Mechanisms

*937F0146D Minsk TRENIYE I IZNOS in Russian Vol 14 No 2, Mar-Apr 93 pp 348-353*

[Article by S.A. Timashev, A.A. Reshetnikov, V.L. Fedyayev, A.I. Tikhonov, S.T. Popenko, V.V. Sedyshev, Chelyabinsk State University; UDC 621.432:621.891]

[Abstract] The lack of published reports—especially in *Treniye i iznos*—of the development of dedicated or all-purpose testing and study facilities aimed at increasing the utilization efficiency of old and newly designed instruments and test equipment prompted the development of software and hardware for upgrading existing computer-aided tribological test benches (such as friction testers, microhardness gauges, tribometers, profile gauges, etc.), thus making it possible to improve their functional and technical characteristics and utilization efficiency. A series of efforts undertaken to this effect by the scientific-engineering center of "Reliability and service life of large machine systems" at the Urals Regional Department of Russia's Academy of Sciences and Chelyabinsk State Engineering University is outlined. The functional module completeness principle, the unity of the aggregate and component base, and the possibility of layer-by-layer implementation underlie the development of the new hardware and software. Five versions of devices for setting the parameter variation laws (ZZU) and the designs for realizing complex control laws are described. The above hardware and software serves as the basis for developing a number of computer-aided benches and systems used for accelerated tests and studies of processes in friction-coupled internal combustion engines and motor-transmission pairs. References 20.

## Assessment of Contact Areas and Pressures in Shaft-Bush Pairs With Inclined Axis

*937F0146C Minsk TRENIYE I IZNOS in Russian Vol 14 No 2, Mar-Apr 93 pp 334-340*

[Article by M.E. Ayaots, M.I. Tamre, Tallinn Engineering University; UDC 621.822]

[Abstract] The premise that high stability and improved friction characteristics of plain bearings in voice, video, and data storage devices and drives require only the geometrical precision of the bearing parts is disputed, and an attempt is made to find an analytical model for such bearings with an inclined journal axis which would make it possible to assess the contact areas and pressures as a function of the shape of the specific friction surfaces and their positioning errors, investigate the patterns of frictional torque development, and search for new designs in order to lower and stabilize friction in these types of bearings. The specific journal and bush problem is solved in M.V. Korovchinskiy's formulation. The contact pressure diagram in a tape drive, the dependence of the theoretical and experimental maximum total elastic deformation on the radial load, and the dependence of the mean contact pressure on the friction surface slope and shape are plotted. It is noted that an analysis of the contact conditions in the bearings with the help of the proposed procedure makes it possible to optimize existing designs and to develop a number of other designs which are characterized by a high stability of their friction characteristics and a low frictional torque. Figures 5; references 12: 10 Russian, 2 Western.

## Modulus of Elongation Within Working Temperature Range of Nonmetallic Bearings

*937F0146B Minsk TRENIYE I IZNOS in Russian Vol 14 No 2, Mar-Apr 93 pp 328-333*

[Article by F.P. Snegovskiy, V.I. Lukashenko, Odessa Marine Engineers Institute and Special Design and Technology Office at the Physical Mechanics Institute at the Ukrainian Academy of Sciences; UDC 621.822:620.178.3]

[Abstract] Advances made in the hydrodynamic theory of lubrication in the past 40 years are reviewed, and the importance of contact parameters and shaft and bearing surface deformability for analyzing the shaft-bush pair operation is stressed. The shortcomings of traditional measurements of the modulus of elongation in testing machines—a destructive method—and the difficulty of using acoustic devices which fail to take into account the ultrasonic wave diffraction and interference at the polymer inhomogeneities, oriented filler structures, and circular cylindrical surfaces of the operating bearing prompted the designing and development of methods and devices for measuring the Young modulus in the plain bearing. The acoustic devices are employing the method of wave amplitude and frequency metering in the elastically deformed working bearing and are based on the principle of discriminating the single probing pulse. The modulus of elongation is measured by the duration of ultrasonic wave transmission through the bearing area under study. The study is carried out in an experimental unit which makes it possible to measure the circumferential velocity and loads. The ultrasonic wave propagation duration is measured by an Elast-1 instrument accurately within 1% and the bearing material temperature—accurately within 0.5°C. The elasticity-temperature plots of various bearings and the behavior of the bulk elasticity modulus are presented. The conclusion is drawn that Young's modulus distribution in the circumference and radial cross section is anisotropic: moreover, the closer the friction zone, the greater the manifestation of the elongation modulus drop of nonmetallic bearings. The experimental data on the elongation modulus distribution and the lubricating film thickness and shape and the pressure and temperature distribution in it can be useful in studies of thermoelastic hydrodynamic lubricants and friction pair designs. Figures 3; references 19.

## Plain Bearing Wear Allowing for Heat Release Due to Friction

*937F0146A Minsk TRENIYE I IZNOS in Russian Vol 14 No 2, Mar-Apr 93 pp 259-269*

[Article by Ye.V. Kovalenko, A.A. Yevtushenko, Mechanics Problems Institute at Russia's Academy of Sciences, Moscow, and Lvov State University; UDC 539.375.6:539.377]

[Abstract] The contact problem of thermoelasticity for the shaft-bush pair is considered allowing for wear; in so doing, the correlation between the temperature and mechanical fields is taken into account, and an attempt is made to solve the problem in the form of simple analytical formulae convenient for engineering analyses and to demonstrate that there exist critical shaft rotation speeds at which the quasistationary heat conduction and thermal-force stability conditions cease to prevail in the bearing. To this end, a bearing assembly consisting of a steel shaft, a plastic bushing (the bearing insert), and a bearing race simulated by a hollow elastic cylinder is considered. The problem is solved assuming that the bushing viscosity can be ignored, the shaft and the race are rigid whereby the shaft wear is negligible compared to the bearing wear; there is full engagement between the bush and race surfaces, and a perfect thermal contact exists between the bushing and the shaft; the inertial effect in the cage are ignored; and the frictional force is connected to the contact pressure by Coulomb's law with a temperature-dependent coefficient. Figures 3; references 16.

## Active Vibration Protection System With Controlled Damping and Modulated Feedback

*937F0135G Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN in Russian No 2, Mar-Apr 93 pp 100-105*

[Article by O.V. Radina, V.V. Yablonskiy, Moscow; UDC 534.8]

[Abstract] The stringent requirements imposed on machines and mechanisms as a source of noise and vibrations and the need to protect humans and the environment from their detrimental effect prompted a study of the efficiency of active vibration protection systems. To this end, wide-band active vibration protection systems on elastic supports with vibration force signal control are examined and it is shown that the simplest problem formulation leads to Mathieu's equation and a system with a zero equivalent rigidity. The difficulty of solving the problem allowing for static loads led to the use of a vibration protection system with a control circuit which satisfies actual conditions, i.e., contains a high-pass filter and a damping control circuit. It is shown that joint use of controlled damping of lower-frequency resonances and feedback factor modulation makes it possible to maximize the damping efficiency at the active force frequency and compensate for the principal harmonic at high frequencies almost completely. With respect to the transferred force decay slope, a system with conventional elastic supports is equivalent to a two-stage plastic passive vibration isolator but it becomes effective at lower frequencies and does not call for intermediate masses. The system is promising for multimode power plant equipment and precision devices. Figures 5; references 4.

## On Effect of Surface Hardening of Machine Elements on Magnitude of Ultimate Contact Loads

*937F0135F Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN in Russian No 2, Mar-Apr 93 pp 91-99*

[Article by Ye.M. Tretyakov, Moscow; UDC 539.37+669.058]

[Abstract] Various surface hardening methods used for prolonging the service life and increasing the reliability of friction assemblies, gearing, cam mechanisms, and other machine elements are discussed and the fundamental role of ultimate loads at the contact of loaded parts as well as the need to optimize the hardened layer depth are recognized. Correct solution of the problem of finding the optimum process conditions and methods call for determining the ultimate loads by the moment of free plastic deformation development in the deformable body. Semi-infinite body penetration by a plane die is considered as the base problem whereby a layer of material different from that of the base is applied to the body with known yield strength and shearing strength. The upper bound of ultimate loads in such elements is found and for illustration, simultaneous development of plastic deformation in the surface layer and the part itself at various values of yield strength is considered for a rigid-plastic material. Characteristic relationships and equations are derived for the above binary material. The dependence of the nondimensional ultimate pressure on the ratio of the layer depth to the die width is plotted. Due to the static equilibrium conditions, the slip line field on the base and layer interface are adequately described by the binary material equations. Figures 6; tables 1; references 2.

## Forming Reliability Assessment During Stamping of Axisymmetric Forgings in Open Dies

*937F0135E Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN in Russian No 2, Mar-Apr 93 pp 86-90*

[Article by L.G. Stepanskiy, A.V. Kutyshkin, Moscow; UDC 621.73.043:681.332.51]

[Abstract] The scarcity of data on the distribution random quantities which affect the stamped forging accuracy is noted and the issue of forming reliability and its relation to the probability of obtaining a forging with a specified configuration and without defects under

given process conditions are discussed. It is speculated on the basis of stamping data analysis for some axisymmetric forgings under industrial conditions that Poisson's distribution can be used for describing the unknown distribution whereby the streams of random events affecting the forging accuracy may be regarded as the simplest, i.e., having the property of being ordinary and steady-state and having no consequences. A state graph of the queuing system simulating the stamping of an axisymmetric forging with an arbitrary axial section in an open press tool is plotted. For illustration, stamping of a journal-type forging from steel 12KhN3A in a three-impression die is considered; there is a 0.95 probability that the forging will have no shape defects. The use of the queuing theory methods for flash hot stamping makes it possible to obtain the upper bound, i.e., the lowest probability of completing the process without shape defects. Figures 3; references 5.

### Study of Process of Reverse Double-Zone Extrusion of Hollow Blank

*937F0135D Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN in Russian No 2, Mar-Apr 93 pp 79-85*

[Article by Kh. Kurbanov, V.I. Ovchinnikov, A.F. Pimenov, Moscow]

[Abstract] The difficulty of making excitron-type hollow double-walled sleeves as flanges of special electric motors which today are usually produced by welding two pipes inserted into each other prompted the development of a new excitron-making method from hollow spin cast blanks which makes it possible to halve the metal consumption by using the external defective blank layer to form the product's outer pipe which serves as mechanical protection, use a part of blank metal to form the complete product bottom, reduce labor outlays by making the item in one plunger pass, and eliminate the welding operation. Since the double-zone reverse extrusion process is steady-state, the stressed state of the metal is determined only at the final extrusion stage. It is assumed that the strained state at each plastic zone point is planar, and the stressed state is described by a system of differential equations. The characteristic curves of the system of equations coincide with slip lines. It is noted that careful machining of the contact surfaces to remove defective layers and use of lubricants during stamping make it possible greatly to improve the quality of products and prevent the defects from spreading into the metal. Figures 6; references 3.

### Photoelastic Research and Development of Engineering Stress Analysis Procedure for Structures With Surface Defects

*937F0135C Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN in Russian No 2, Mar-Apr 93 pp 69-78*

[Article by B.N. Dranchenko, S.N. Komarova, V.K. Ponomareva, B.B. Portnov, A.V. Seleznev, Moscow; UDC 539.4:621.643]

[Abstract] The shortage of data on stress concentrator defects which may serve as a source of local crack nucleation due to the accumulation of plastic deformation and the urgency of experimental studies of structures with defects having characteristic shapes and dimensions prompted an attempt to continue the photoelastic studies which began in *Problemy mashinostroyeniya i nadezhnosti mashin* No. 1, 1991 and *Problemy prochnosti* No. 11, 1979 and to develop an engineering procedure of analyzing stress in structures with surface defects under operating quasistatic loads on the basis of classified empirical data. To this end, the problem of determining the bulk stressed state in the surface defect zones is considered as a function of geometrical parameters and a spatial system of quasistatic loads. The dependence of the stressed state in these zones on the geometrical and force factors is investigated using the experimental design theory and photoelastic "frozen" models. Families of suitable empirical formulae are derived and alignment charts are plotted; on this basis, an engineering technique is developed and recommended for implementation. To check the confidence of the procedure, analyses are made using equipment from the pressure vessel of the second generating unit the Novovoronezh Nuclear Power Plant. Figures 3; tables 4; references 5.

### Vibration Spectrum Analysis of Turbine-Driven Set's Shaft Line With Cross Crack

*937F0135B Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN in Russian No 2, Mar-Apr 93 pp 26-31*

[Article by N.G. Shulzhenko, V.P. Biletchenko, Kharkov; UDC 624.07:534.1-62-135-251.534]

[Abstract] The urgency of theoretical research into the rotor vibrations with a cross crack due to the need to identify the vibration symptoms and locate the crack prompted an investigation into flexural vibrations of a turbine-driven set's multisupport heavy shaft line with a residual unbalance and a cross crack formed in the annular welded joint. An attempt is made to determine the characteristic vibration symptoms in the early phase of the crack propagation. It is assumed that the amplitude of the forced vibrations of the cross section with the crack is smaller than its static displacement while the elastic line of shafting does not have a crack fracture. The method of determining the rotor vibration displacement spectrum due to the extended crack is borrowed from *Problemy mashinostroyeniya* No. 37, 1992, pp. 10-15. The relative harmonic amplitude as a function of crack dimensions at various parameters are plotted. The crack is represented as a cut-out in a shaft section in the tension area. The findings of an analysis for a specific shaft line considered for illustration attest to a significant monotonic increase in the harmonics' amplitude and a change in their phase with a crack increase to the one-eighth to one-fourth of the cross section; as the crack grows, the amplitude no longer increase monotonically, and the third and fourth harmonic amplitudes are comparable to the second and may serve as the crack propagation symptom. Figures 4; references 8: 6 Russian, 2 Western.

## Natural Frequency Spectrum Optimization of Rigid Body Suspension by Manipulation of Geometrical and Rigidity Parameters of Vibration Dampers

*937F0135A Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN in Russian No 2, Mar-Apr 93 pp 20-25*

[Article by V.V. Karaban, S.K. Kartsov, Yu.G. Safronov, A.V. Sinev, Moscow; UDC 651-752.2]

[Abstract] Spectral analyses of power plants in elastic suspensions and vehicle cabs on the basis of a rigid body model are discussed and a rigid body suspension with elastic pneumatic elements on the basis of rubber-cord shells is investigated. The vibration damper rigidity is examined in the framework of the mathematical model and the optimization problem is solved for a unit with vibration isolation installed on four identical vibration dampers so that any two adjacent vibration dampers are pairwise symmetric. The vibration damper coordinates and mounting angles are the objective variables while the optimization problem is reduced to searching for the parameter values at which the objective function assumes the minimum value. The optimization problem is solved in two stages: at the first, the optimum coordinates and the angle are found for the main vibration dampers and at the second—similar parameters for the remaining two dampers which are additional stiffening components attached at the mounting points of the main dampers. For illustration, the problem of compressing the vibration-isolated object spectrum is outlined. An algorithm of reducing the vibration frequencies to a narrow band by manipulating the geometrical and stiffening parameters of the dampers is proposed and it is demonstrated that the optimization method makes it possible to compress the natural oscillation frequency spectrum of the engine and cab vibration isolation systems into a rather narrow band, thus improving the vibroisolating and vibroacoustic characteristics of vehicles. Figures 2; references 7: 6 Russian, 1 Western.

## Principles of Metal Welding to Ceramic Materials

*937F0127A Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 12(698), Dec 92 pp 12-16*

[Article by E.S. Karakozov, G.V. Konyushkov, R.A. Musin, Remdetal Production Association and Saratov and Perm Polytechnic Institutes; UDC 621.791.4]

[Abstract] The effect of the quality of joints on the performance of ceramic-metal assemblies in devices and structures and their reliability and service life is discussed and it is noted that soldering does not always ensure stable operating properties. Studies of diffusion welding of ceramic and metal joints—a less complicated single-operation process—are reviewed. The mechanism of welded ceramic-metal joint formation, the thermodynamic processes and welding parameter selection, the effect of structural factors on the welded joint strength, and the effect of the heating and cooling rate and thermoelastic stresses during welding are examined in detail. The dependence of the joint strength of copper with the VK94-2 corundum ceramics and 30SCh6 ferrogarnet on the welding temperature and pressure and isothermal exposure and the effect of the copper part deformation during pressure welding on the perforation coefficient are plotted. The findings indicate that the bonds between the ceramics and metal are formed during the adjustment of the metal crystal lattice to the ceramic lattice while the welding temperature largely depends on the type of chemical interaction between the metal and ceramics. The metal deformability in standard ceramic-metal joints which determines the physical contact and activation process development depends significantly on its relative thickness which should be regarded as an important welding parameter. The magnitude and type of thermoelastic shrinkage stress distribution in the joint depends on the ratio of thermal characteristics of the metal and ceramics, the actual assembly design, the ratio of welded material thickness, relaxation properties of the materials, and the welding conditions. Diffusion welding also does not call for metallizing the ceramic parts and ensures higher strength and heat resistance of joints. Figures 2; tables 4; references 25.

## Adoption of High-Strength Corrosion-Resistant Steels in Full-Scale Aircraft Production

*937F0126A Moscow VESTNIK MASHINOSTROYENIYA in Russian No 4, Apr 93 pp 21-23*

[Article by A.G. Bratukhin, International Engineering Academy; UDC 669.018.8:[658.524:623.7]]

[Abstract] The experience of using high-strength corrosion-resistant steels in the airframe of supersonic aircraft, e.g., MIG-23, -25, and -31, is discussed and it is stressed that in addition to high strength within the operating temperature range, these structural materials must be characterized by high cyclical strength, crack resistance, and general and stress corrosion resistance as well as high weldability. Martensitic, austenitic-martensitic, and other Cr-Ni corrosion-resistant steels smelted within a narrow range of conditions meet these requirements. The specific brands of steels, the ranges of products, and their mechanical properties, particularly ultimate strength, yield point, elongation, reduction in area, and toughness, are summarized and the dependence of low-cycle fatigue on the pitting corrosion defect depth in the heat affected area of welded joints is plotted. The effect of welding on the behavior of chemical properties is examined and the operating reliability of welded joints related to the weld's resistance to brittle failure and cold cracking is analyzed. The issues of developing and selecting high-strength corrosion-resistant steels for supersonic aircraft airframes, improving the smelting processes, developing new heat treatment practices using enamel as the protective coat, implementing airframe welding methods, and identifying the cases of brittle failure as well as finding ways to increase the weld reliability are addressed. Figures 3; tables 1; references 4.

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