Soviet and Japanese Aerospace Literature

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Soviet Aerospace Literature
This month: *Spacecraft/Satellite Design*

A89-30100 The halo around spacecraft (Oreol vokrug kosmicheskikh apparatov). A. I. LAZAREV, S. V. AVAKIAN, and V. I. SEVAST'IANOV, *Priroda* (ISSN 0032-874X), Feb. 1989, pp. 100-102.

Astronauts aboard various spacecraft (e.g., Soyuz 10 and 23, and the Space Shuttle Columbia in March 1982) have observed an intense glow or halo around the spacecraft. The most likely hypothesis is that this glow is caused by the excitation of the rarefied atmosphere surrounding the spaceraft by fluxes of molecules and ions of the upper layers of the earth's atmosphere. It is noted that this glow phenomenon can be counteracted by the proper choice of materials (e.g., polyethylene) to cover the spacecraft surface.

A89-18438 Ground-based diagnostics of the state of the medium during disturbances of the charge of a geostationary satellite (Nazemnaia diagnostika sostoianiia sredy vo vremia vozmushchenii zariada geostatsionarnogo sputnika). IU. I. VAKULIN, O. S. GRAFODATSKII, L. G. DANILOVA, V. I. DEGTIAREV, G. A. ZHEREBTSOV et al., *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Sept.-Oct. 1988, pp. 725-730. 7 Refs.

The state of the medium during disturbances of the charge of the geostationary communications satellite Gorizont was evaluated on the basis of ground-based observations. It is shown that the charge disturbances occur when the satellite is located in the magnetospheric plasma sheet and coincide with substorm disturbances of energetic-particle fluxes.

A88-45467 Determination of the motion of the Salyut 6 and 7 orbital stations with respect to the mass center in the slow spin mode on the basis of measurement data (Opredelenie dvizheniia orbital'nykh stantsii 'Saliut-6' i 'Saliut-7' otnositel'no tsentra mass v rezhime medlennoi zakrutki po dannym izmerenii). V. A. SARYCHEV, M. IU. BELIAEV, S. P. KUZ'MIN, V. V. SAZONOV, and T. N. TIAN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, May-June 1988, pp. 390-405. 10 Refs.

A method is proposed for determining the rotational motion of Salyut 6 and 7 in the slow spin mode (with an angular velocity of not greater than about 0.2 deg/s) according to the readings of onboard sensors which measure the geomagnetic frield strength vector and the sun position vector. Particular attention is given to the motion of Salyut-7 with respect to the mass center over long periods of time. It is shown that, several days after the commencement of uncontrolled motion with a small initial angular velocity, the spacecraft is captured into a uniaxial gravity-gradient regime, in which its longitudinal axis undergoes stable oscillations with respect to the local vertical with an amplitude of about 40 deg.

A89-18434 Investigation of the accuracy of determining the rotational motion of the Salyut 6 and 7 orbital stations in the gravity gradient mode according to measurement data (Issledovanie tochnosti opredeleniia vrashchatel'nogo dvizheniia orbital'nykh stantsii 'Saliut-6' i 'Saliut-7' v rezhime gravitatsionnoi orientatsii po dannym izmerenii). V. V. SAZONOV, M. IU. BELIAEV, S. P. KUZ'MIN, and T. N. TIAN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Sept.-Oct. 1988, pp. 675-688. 7 Refs.

The paper describes an improved integral statistical method for determining the rotational motion of Salyut 6 and 7 in the gravity gradient mode according to onboard measurements of the geomagnetic field strength vector and the direction vector toward the sun. A least squares analysis shows that the proposed method is sufficiently accurate.

A89-17626 Spectrum - Unified spacecraft for astrophysical observations. V. M. KOVTUNENKO, R. S. KREMNEV, V. G. PERMINOV, V. N. TURCHANINOV, and O. V. PAPKOV, *IAF, 39th International Astronautical Congress,* Bangalore, India, Oct. 8-15, 1988. 26 pp. (IAF Paper 88-001).

Spektr, an astrophysics spacecraft being developed by the USSR for observations at gamma-ray to decimeter wavelengths, is described and illustrated with extensive drawings and diagrams. Spektr is designed for Proton launch to a high-apogee orbit and includes a 2000-kg payload with power requirement 500 W and data-transmission rate 128 Mbaud. The AOCS will provide constant-altitude accuracy 30-40 arcsec and stabilization angular velocity 0.0001 deg/sec, making possible continuous observations for 24 h in the autonomous precision-orientation mode.

A88-11236 Evolution of the gravity-gradient attitude control mode of a rotating satellite under the effect of a nonpotential aerodynamic moment (Evoliutsiia rezhima gravitatsionnoi orientatsii vrashchaiushchegosia sputnika pod deistviem nepotentsial'nogo aerodinamicheskogo momenta). V. V. SAZONOV and A. L. PETROV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 25, July-Aug. 1987, pp. 508-522. 12 Refs.

The perturbing effect of a nonpotential aerodynamic moment on the evolution of the gravity-stabilization mode of a rotating satellite is analyzed. A two-parameter integral surface of the equations of motion is constructed which describes the quasi-steady rotations of the satellite; it is proposed that these quasi-steady rotations be used to realize single-axis gravity stabilization. Mechanisms for the destruction of the gravity-stabilization mode are examined with particular emphasis on the capture of the quasi-steady rotations into resonance with oscillations of the longitudinal axis of the satellite.

A89-26157 Relative equilibriums of a satellite-gyrostat, their bifurcations, and stability (Ob otnositel'nykh ravnovesiiakh sputnika-girostata, ikh vetvlenii i ustoichivosti). V. N. RUBANOVSKII, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 52, Nov.-Dec. 1988, pp. 909-914. 7 Refs.

A study is made of a set of relative equilibriums of a satellite-gyrostat in a Newtonian attraction field. A geometrical representation of the set of equilibriums is proposed, and the bifurcation and stability of the equilibriums of a symmetrical gyrostat are analyzed. Results are presented in the form of bifurcation diagrams in which instability distribution of the equilibriums obeys the law of stability change at a fixed gyrostatic moment.

A89-20748 The way to Mars. V. GLUSHKO, L. GORSHKOV, and Y. SEMENOV, *Planetary Report* (ISSN 0736-3680), Vol. 8, Nov.-Dec. 1988, pp. 4-8.

An article from the Soviet newspaper, Pravda, is presented, which discusses issues related to missions to Mars. The type of vehicle needed for a Martian mission is examined, including the propulsion system, construction of the vehicle in earth orbit, living quarters, safety considerations, and the landing vehicle. Options for the mission route and ways of returning to earth are considered. Also, a proposal for a three phase program leading up to a manned mission to Mars is outlined.

A89-18436 Dynamics of a spacecraft with direct active control of the gravity gradient stabilizer (Dinamika kosmicheskogo apparata s priamym aktivnym upravleniem gravitatsionnym stabilizatorom). E. M. POTAPENKO, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Sept.-Oct. 1988, pp. 699-708. 8 Refs.

Equations of spacecraft motion are obtained with allowance for an arbitrary but finite number of tons of elastic oscillations of a controlled gravity gradient stabilizer. A dynamic controller is used to optimize the spacecraft attitude control and stabilization system with allowance for the first tone of the elastic oscillations.

A89-18433 Nonlinear oscillations of a system of two bodies connected by a flexible rod in a central force field (Nelineinye kolebaniia sistemy dvukh tel, soedinennykh gibkim sterzhnem, v tsentral'nom silovom pole). V. I. GULIAEV, V. L. KOSHKIN, P. P. LIZUNOV, and N. N. PRUDENKO, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Sept.-Oct. 1988, pp. 669-674. 7 Refs.

An analysis is made of the oscillations of two bodies connected by a flexible rod with respect to their mass center moving in an elliptical Keplerian orbit. The effect of the reduced mass of the system and the stiffness of the rod on the stability and mode of the relative motion is investigated.

A89-18432 Motion of a gravity gradient satellite with hysteresis rods in a polar-orbit plane (Dvizhenie gravitatsionno-orientirovannogo sputnika s gisterezisnymi sterzhniami v ploskosti poliarnoi orbity). V. A. SARYCHEV, V. I. PEN'KOV, M. IU. OVCHINNIKOV, and A. D. GERMAN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Sept.-Oct. 1988, pp. 654-668. 21 Refs.

The small oscillations of a three-axis gravity gradient satellite are analyzed. The energy of its oscillations is dissipated in hysteresis rods as they are magnetized in the geomagnetic field. Various oscillation damping laws depending on the orientation of the rods in the body are obtained.

A89-17864 Major development trends of orbital space stations. K. P. FEOKTISTOV, *IAF, 39th International Astronautical Congress,* Bangalore, India, Oct. 8-15, 1988. 10 pp. (IAF Paper 88-595).

The development history of orbiting space stations is reviewed, and the possible future of space stations is outlined. The Salyut and Mir stations are discussed. Basic trends in space station development are defined, including the creation of multipurpose orbital laboratories, the establishment of bases for servicing space vehicles in orbit, setting up a construction site for assembling major radiotelescopes, and organizing the production of superpure materials and medicinal and biological preparations.

A88-55397 The system of the Mir station motion control. V. N. BRANETS, V. P. LEGOSTAEV, and B. E. CHERTOK, IAF, 39th *International Astronautical Congress,* Bangalore, India, Oct. 8-15, 1988. 9 pp. (IAF Paper 88-334).

The motion control and navigation system (MCNS) of the Mir station are examined. The tasks of the MCNS are presented, including orientation, control relative to the center of mass, navigation and stabilization. The structure, composition, and operating modes of the MCNS are discussed. In addition, the sensing elements, digital computer complex, and reliability support of the Mir station are described.

A89-22247 Resonant oscillations of a charged body in a magnetic field (O rezonansnykh kolebaniiakh zariazhennogo tela v magnitnom pole). A. A. TIKHONOV, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024-0850), Aug. 1988, pp. 113-115.

Consideration is given to a rigid body with an electrostatically charged shield of arbitrary shape moving in circular nonequatorial near-earth orbit. The effect of Lorentz forces on the oscillations of a gravity-gradient-stabilized body under parametric resonances is investigated. Possible resonant frequency ratios of undisturbed-system oscillations are found, and corresponding curves on the inertial-parameter plane are constructed.

A88-53946 Spin stabilization of a heliocentric satellite with a solar sail (O stabilizatsii vrashcheniia geliotsentricheskogo sputnika s solnechnym parusom). T. A. RYBNIKOVA, T. F. BULATSKAIA, and A. V. RODNIKOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, July-Aug. 1988, pp. 625-628. 6 Refs.

A spin-stabilization algorithm is developed for a heliocentric satellite with a solar sail. The goal of the investigation is to establish the permanent rotation of the satellite about the dynamic-symmetry axis using an appropriate switching sequence of a parameter u, which is equal to unity when the sail is 'open' and equal to zero when the sail is 'closed'.

A88-53931 Periodic oscillations of a satellite gyrostat with respect to the center of mass under the effect of aerodynamic and gravitational moments (Periodicheskie kolebaniia sputnika-girostata otnositel'no tsentra mass pod deistviem aerodinamicheskogo i gravitatsionnogo momentov). V. V. SAZONOV and A. A. VORONIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, July-Aug. 1988, pp. 492-507. 11 Refs.

The motion of a satellite gyrostat with respect to the center of mass of the system under the effect of aerodynamic and gravitational moments in circular orbit is described by an autonomous system of sixth-order differential equations. Analytical and numerical methods are used to investigate symmetric periodic solutions of the system of equations, close to periodic solutions of the corresponding second-order degenerate system. The results obtained can elucidate the perturbed motion of satellites with an aerogyroscopic attitude-control system.

A88-53945 Spatial evolution of the residual-acceleration vector on board spacecraft (Prostranstvennaia evoliutsiia vektora ostatochnykh uskorenii na bortu kosmicheskikh apparatov). V. S. AVDUEVSKII, A. I. LIKHODED, V. V. SAVICHEV, V. B. DUBOVSKOI, S. S. OBYDENNIKOV et al., *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, July-Aug. 1988, pp. 621-625. 7 Refs.

Levels of small residual accelerations were measured on Salyut 6 and 7, the Progress transport vehicle, and a number of Mir rockets. The results indicate that the conditions necessary for space manufacturing operations on board spacecraft are characterized not only by a reduction in mass forces and accelerations but also by the variable character of these forces and accelerations in time and space. The data obtained were used to assess the possibility of prolonging the service life of Salyut-6.

A88-45466 Numerical analysis of the accuracy of a model of the optimal programmed turning of a satellite using a flywheel system (Chislennyi analiz tochnosti modeli optimal'nogo programmnogo razvorota sputnika s pomoshch'iu makhovichnoi sistemy). A. G. SOKOL'SKII and S. A. KHOVANSKII, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, May-June 1988, pp. 380-389. 8 Refs.

The paper describes a simple model for the time-optimal programmed turning of a satellite with respect to the roll angle using a flywheel. Numerical integration of the equations of motion is used to identify ranges of possible values of the satellite-flywheel system, providing for the acceptable accuracy. The characteristics of completed turnings of the satellite are examined.

A88-45465 Optimal control of the terminal reorientation accuracy of a spherically symmetric spacecraft (Optimal'noe upravlenie terminal'noi tochnost'iu pereorientatsii sfericheski simmetrichnogo KA). A. K. BAT'KIN, A. N. SIROTIN, and K. V. SOCHNOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, May-June 1988, pp. 374-379.

Consideration is given to the problem of the optimal control of the terminal reorientation accuracy of the axis of a spherically symmetric spacecraft. The solution is obtained using an expanded maximum principle for problems with fixed time and a free right end, the range of permissible control values of which depends on time. An analytical solution to the attitude control problem can be obtained on the basis of the necessary conditions of optimality obtained here.

A88-45464 Motion of a satellite carrying an end-loaded viscoelastic rod in circular orbit (O dvizhenii sputnika, nesushchego viazkoupruguiu shtangu s gruzom na kontse, na krugovoi orbite). V. G. DEMIN, IU. G. MARKOV, and I. S. MINIAEV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, May-June 1988, pp. 366-373.

The paper examines the rotation about the mass center of a system consisting of a symmetric rigid satellite carrying a viscoelastic rod with a point load at its end. It is assumed that the mass center of the system moves in circular orbit in a central Newtonian force field. The rotational motion of the system evolves as a result of bending deformations of the rod accompanied by energy dissipation. Approximate equations describing this evolution are obtained by the method of the separation of motions and averaging.

A88-39570 Gravity-gradient stabilization of satellites with gyrodynes (Gravitatsionnaia orientatsiia iskusstvennykh sputnikov s girodinami). V. V. SAZONOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Mar.-Apr. 1988, pp. 315-317. 7 Refs.

The use of gyrodynes to achieve gyrodamping in a gravity-gradient stabilization system has been demonstrated. Two simple control laws for the intrinsic kinetic moment of the gyrodyne system are examined, which provide for asymptotic stability of the three-axis gravity-gradient stabilization regime.

A88-39560 Stabilization of a spacecraft by means of a minimum number of impulses (Stabilizatsiia KA minimal'nym chislom impul'sov). L. D. AKULENKO, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Mar.-Apr. 1988, pp. 227-235. 14 Refs.

The total deceleration of the rotations of a spacecaft by means of a minimum number of impulses is examined in the framework of an absolutely-rigid-body model. Stabilization is achieved through a pair of engines rigidly attached to the spacecraft. Conditions of two-impulse stabilization are defined. Expressions for the impulses and the instant of their application are derived, and the possible further optimization of two-impulse stabilization modes is considered.

A88-39559 Two modes of the nonlinear resonant motion of an asymmetric spacecraft in an atmosphere (Dva vida nelineinogo rezonansnogo dvizheniia asimmetrichnogo KA v atmosfere). V. S. ASLANOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Mar.-Apr. 1988, pp. 220-226. 7 Refs.

The paper examines the nonlinear motion of a slightly asymmetric reentry vehicle around its center of mass during the atmospheric descent phase. Two possible modes of resonant motion are identified: bank resonance and rotational resonance. Averaged equations are obtained, and necessary and sufficient conditions for the existence of stable resonance are established. Expressions are derived for the critical asymmetry parameters in the case of which locking into resonance occurs.

A88-39558 Approximate analytical method for calculating the spatial maneuevers of a spacecraft in an atmosphere (Priblizhennyi analiticheskii metod rascheta prostranstvennykh manevrov kosmicheskogo apparata v atmosfere). N. L. SOKOLOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Mar.-Apr. 1988, pp. 209-219. 24 Refs.

A method is proposed for calculating the atmospheric entry maneuvers of a spacecraft. Errors are evaluated for calculations of spacecraft with zero and constant values of lift-drag ratio, as well as for problems of optimal control. Particular attention is given to the determination of the trajectory parameters of the ballistic descent of spacecraft from earth-satellite orbit.

A88-39557 Motion of the tether during the deployment and retrieval of a tethered system in orbit (O dvizhenii trosa pri razvertyvanii i svetyvanii trosovoi sistemy na orbite). E. M. LEVIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Mar.-Apr. 1988, pp. 199-208. 11 Refs.

The motion of a system of two bodies connected with a tether of variable length in elliptical orbit is considered. The excitation of transverse oscillations of the tether during its deployment or retreival are analyzed in the framework of a model of two material points connected by an inextensible flexible filament. Generative pendulum-like rigid-body motions of the system are identified. It is shown that the tether undergoes quasi-steady bending when it is deployed uniformly; the retrieval process is characterized by an increase in the transverse oscillations of the tether.

A88-39556 Evolution of the rotations of a satellite-gyrostat carrying a viscoelastic disk in circular orbit (Ob evoliutsii vrashchenii sputnika-girostata, nesushchego viazkouprugii disk, na krugovoi orbite). V. G. DEMIN, V. IA. KONKS, and IU. G. MARKOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Mar.-Apr. 1988, pp. 193-198. 5 Refs.

An analysis is made of the motion of a symmetric satellite-gyrostat around the mass center, assuming that a homogeneous viscoelastic disk is attached to the satellite in the equatorial plane of the ellipsoid of inertia. It is assumed that the mass center of the system moves in circular orbit in a Newtonian force field. An averaging method is used to obtain approximate equations describing the evolution of the system rotation. Steady-state motions of the system are determined, and their stability is analyzed.

A88-34016 Motion of a satellite relative to the center of mass with allowance for Lorentz forces and light pressure (Dvizhenie sputnika otnositel'nogo tsentra mass s uchetom sil Lorentsa i sil svetovogo davleniia). G. V. LIAKHOVKA, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), Jan.-Feb. 1988, pp. 100-102. 5 Refs.

The paper is concerned with the rotational motion, due to the Lorentz forces and light pressure, of an artificial earth satellite enclosed in an electrostatic shield for protection against ambient radiation. It is assumed that the rotation of the satellite about the center of mass does not affect the translational motion of the center of mass; the satellite orbit orientation relative to the sun is assumed to be constant. The motion of the satellite is described by equations of perturbed motion, with averaged components of light pressure moments included into the equations.

A88-34014 Theory of the plane turning of a spacecraft by a system of flywheels (K teorii ploskogo razvorota kosmicheskogo apparata sistemoi dvigatelei-makhovikov). S. A. AGAFONOV, K. B. ALEKSEEV, and N. V. NIKOLAEV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), Jan.-Feb. 1988, pp. 8-11.

The problem of the spatial reorientation of a spacecraft through a single plane turn is solved for the case of an arbitrary number of flywheel drives. The solution algorithm proposed here determines a program of control stress changes at the flywheeel input based on the minimum energy criterion with allowance for natural constraints. It is shown how the minimum energy requirement is related to the choice of control for each flywheel drive.

A88-30115 Rotation stability of a deformable flight vehicle (Ob ustoichivosti vrashcheniia deformiruemogo letatel'nogo apparata). L. V. DOKUCHAEV, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 52, Jan.-Feb. 1988, pp. 25-33. 10 Refs.

The Lur'e (1961) approach and the Kane (1980) method are used to obtain general equations describing the motion of a liquid-filled elastic flight vehicle in orbit. By generalizing results of earlier studies, conditions are obtained for the asymptotic stability of the rotation of a flight vehicle with allowance for damping. The analysis is illustrated by an example.

A88-28331 Simulation and interactive procedures of parameter search for Vega 1 and 2 type landing modules (Imitatsionnye i interaktivnye protsedury v zadache poiska parametrov posadochnykh ustroistv AMS tipa 'Vega-1, -2'). S. P. BUSLAEV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Jan.-Feb. 1988, pp. 41-48. 11 Refs.

The problem of determining optimal parameters for a Venus landing module is examined in the framework of a mathematical-model description of the external environment. The search for the effectiveness-function minimum in the presence of noise is considered, and attention is given to the relevant simulation and interactive procedures. Search-procedure features associated with the stochastic formulation of the problem are examined.

A88-28330 Thermal regime of Venera-type probes in the interplanetary trajectory (Teplovoi rezhim avtomaticheskikh mezhplanetnykh stantsii tipa 'Venera' na traektorii pereleta). V. V. BOGDANOV and M. M. IAKUBOVICH, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Jan.-Feb. 1988, pp. 37-40.

In their flight to Venus the Venera probes are subject to increasing solar radiative heat flux whose density varies from 1460 W/sq m (at the beginning of the trajectory) to 2700 W/sq m (at the end). This paper presents data which permit a rational design of active, semipassive, and passive thermal control systems for the Venera probes. These systems provide for the appropriate thermal regimes for hermetically sealed chambers, separated units, and external units in the interplanetary flight segment.

A88-28329 Techniques for the provision of the appropriate thermal regime for the Venera probes in the Venus atmosphere (Metody obespecheniia teplovogo rezhima avtomaticheskikh mezhplanetnykh stantsii 'Venera' v atmosfere planety). I. A. ZELENOV, A. F. KLISHIN, V. M. KOVTUNENKO, and A. F. SHABARCHIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Jan.-Feb. 1988, pp. 33-36.

The system that provides for the appropriate thermal regime for the second-generation Venera probes includes: (1) heat shielding for descent in the aerodynamic braking mode and (2) heat insulation during atmospheric descent and on the planetary surface. This paper examines the basic principles behind the provision of the thermal regime, with emphasis on techniques for providing for external heat insulation. A methodology for calculating the thermal regime is described, and calculation results are presented.

A89-24195 Optimization of spacecraft thermal control systems (Russian book) (Optimizatsiia sistem termoregulirovaniia kosmicheskikh apparatov). VLADIMIR V. MALOZEMOV and NATAL'IA S. KUDRIAVTSEVA, *Izdatel'stvo Mashinostroenie,* 1988, 112 pp. 35 Refs.

Mathematical models of spacecraft thermal-control units and systems are presented. A method is developed for solving thermal-control optimization problems. In addition, engineering methods and algorithms are developed for choosing appropriate design parameters for spacecraft thermal-control systems for stationary and nonstationary operating conditions.

A88-28309 Phobos - A multipurpose mission designed to study Phobos, Mars, the sun, and interplanetary space ('Fobos' - mnogotselevaia ekspeditsiia dlia issledovaniia Fobosa, Marsa, solntsa i kosmicheskogo prostranstva). V. M. KOVTUNENKO, R. S. KREMNEV, G. N. ROGOVSKII, and K. G. SUKHANOV, *Astronomicheskii Vestnik* (ISSN 0320-930X), Vol. 21, Oct.-Dec. 1987, pp. 278-285.

The basic characteristics of the multipurpose Phobos mission designed to investigate interplanetary space, Mars, Phobos, and the sun, are considered. Information on the flight scenario and on the mission to Phobos is presented and the spacecraft design and the spacecraft systems are described.

A88-11238 Spacecraft attitude control using an arbitrarily redundant structure of single-axis electropendulum engines (Upravlenie orientatsiei kosmicheskikh apparatov s proizvol'no-izbytochnoi strukturoi odnoosnykh elektromakhovichnykh dvigatelei). IU. A. KARPACHEV and M. A. PAVLOVSKII, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 25, July-Aug. 1987, pp. 530-536. 8 Refs.

It is shown that, in redundant electropendulum engines, the rotation axes of the pendulums must be uniformly distributed and oriented along the sides of a regular pyramid fixed in the axes of the spacecraft; the apex angle of the pyramid does not depend on the number of pendulum engines. An algorithm for the autonomous three-axis attitude control of a spacecraft with a redundant number of pendulums is proposed. Also developed is a time-suboptimal noniterative algorithm for the terminal reorientation of a spacecraft with respect to a programmed attitude basis rotating unsteadily in inertial space.

A88-11234 Stability of the steady motions of an electromagnetic tether system in orbit (Ob ustoichivosti statsionarnykh dvizhenii elektromagnitnoi trosovoi sistemy na orbite). E. M. LEVIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 25, July-Aug. 1987, pp. 491-501. 10 Refs.

The motion of two satellites connected by a current-carrying tether in geocentric orbit is investigated. The interaction of the tether current with the geomagnetic field can either generate electric power or produce low thrust. The effect of electromagnetic forces distributed along the tether on the dynamics of the tether system is examined using a model of two material points connected by an extensible flexible thread. In the case of direct current, the presence of these forces leads to an instability of the steady motions of the tether system. Stabilization can be achieved by controlling the current force in the tether.

A88-11239 Effect of vibrations of elastic elements with distributed masses on satellite attitude (O vliianii kolebanii uprugikh elementov s raspredelennymi massami na orientatsiiu sputnika). S. I. ZLOCHEVSKII and E. P. KUBYSHKIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 25, July-Aug. 1987, pp. 537-544. 5 Refs.

A novel approach to the development of a mathematical model of a satellite with elastic elements with distributed masses is proposed. A closed boundary problem for elastic transverse beam vibrations, described by a partial integrodifferential equation, is formulated and solved. The effect of the vibrations on the satellite attitude is thus reduced to moments which are known functions of time applied to the central rigid satellite body. The results are of interest in connection with the influence of solar panels on satellite attitude.

A88-11244 Investigation of the electrostatic charging of a conducting shielded body on the Cosmos-936 satellite (Issledovanie elektrostaticheskoi zariadki provodiashchego ekranirovannogo tela na ISZ "Kosmos-936"). E. E. KOVALEV, E. D. MOLCHANOV, V. K. LEBEDEV, T. IA. RIABOVA, IU. G. PEKHTEREV et al., *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 25, July-Aug. 1987, pp. 585-591. 13 Refs.

Experimental results are presented on the high-energy-electron electrostatic charging of a conducting body shielded against solar UV radiation and magnetospheric-plasma ions at heights of 200-400 km. It is shown that charge accumulated on the body can be stored for more than 100 hours. It is also demonstrated that high-voltage treatment is the main factor leading to an increase in the charging time and limiting the magnitude of the equilibrium potential.

A87-53523 Effect of geomagnetic field inhomogeneity on the dynamics of a shielded satellite (O vliianii neodnorodnosti geomagnitnogo polia na dinamiku ekranirovannogo sputnika). A. A. TIKHONOV, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024-0850), April 1987, pp. 67-73. 6 Refs.

A study is made of the effect of the inhomogeneity of the geomagnetic field on the stability of the relative equilibrium positions of an artificial satellite with a cylindrical electrostatic shield in circular equatorial orbit. The necessary and sufficient stability conditions are obtained. Regions of admissible satellite parameters are defined, and the effect of each component of the main moment of the Lorentz forces (resulting from the consideration of the inhomogeneity of the geomagnetic field in the shield volume) on the dimensions of the defined regions and satellite vibration frequencies are determined.

A89-10716 Physical/technical principles behind the development and application of spacecraft (Russian book) (Fiziko/tekhnicheskie osnovy sozdaniia i primeneniia kosmicheskikh apparatov). GENNADII PETROVICH DEMENT'EV, ALEKSANDR GRIGOR'EVICH ZAKHAROV, and IURII KONSTANTINOVICH KAZAROV, *Izdatel'stvo Mashinostroenie,* 1987, 264 pp. 217 Refs.

Various aspects of spacecraft design, development, and application are discussed, with some projections made concerning space programs up to the year 2000. Particular consideration is given to the functional design of spacecraft, the structural design and application of orbital complexes, the development of spacecraft with two-mode liquid rocket engines and low-thrust engines, the features of onboard computers, and advanced spacecraft construction materials.

A88-48084 Determination of loads in the aftereffect period for the compressed-gas catapult ejection of space probes (Opredelenie nagruzok v period posledeistviia pri gazovom katapul'tirovanii apparatov). P. P. LOGACHEV and V. I. DEGTIARENKO, *Kosmicheskaia Nauka i Tekhnika* (ISSN 0321-4508), No. 2, 1987, pp. 36-39.

Catapult-ejection systems are used to separate prober (e.g., for atmospheric or planetary-soil studies) from the main spacecraft body. The compressed gas issuing from the catapult channel after the object has been ejected exerts a strong influence on the main body during the aftereffect period. In this paper, the Godunov method is used to calculate the relevant gasdynamic parameters for the aftereffect period, and it is shown that pressure pulses act on the main spacecraft body during the aftereffect period, which change depending on the ambient pressure.

Japanese Aerospace Literature This month: *Aircraft/Spacecraft CAD/CAM'S*

A89-23771 Simplified design techniques for laminated cylindrical pressure vessels under stiffness and strength constraints. HISAO FUKUNAGA and TSU-WEI CHOU, *Journal of Composite Materials* (ISSN 0021-9983), Vol. 22, Dec. 1988, pp. 1156-1169. 10 Refs.

This paper treats the optimum design of graphite/epoxy laminated composite cylindrical pressure vessels under stiffness and strength constraints based upon the membrane theory. Stiffness constraints are specified as strain conditions both in the axial and circumferential directions. Tsai-Wu failure criterion is used for determining a first-ply-failure strength. The stiffness and strength characteristics of the laminate are discussed based upon the concept of lamination parameters. For small values of allowable axial and circumferential strains, the strain (or stiffness) condition is critical, while for large values of allowable strains the strengths conditon is critical. The optimal laminate configurations are determined for the various kinds of strain and strength.

A88-50200 Development of a graphic simulator augmented teleoperation system for space applications. K. MACHIDA, Y. TODA, T. IWATA, M. KAWACHI, and T. NAKAMURA, IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1 (A88-50160 21-08). Washington, DC, American Institute of Aeronautics and Astronautics, 1988, pp. 358-364. 6 Refs. (AIAA Paper 88-4095).

A teleoperation system augmented by a real time graphic simulator is proposed for efficient operation of a space teleoperator or telerobot, and is developed. An operator teaches the task sequences to a slave arm by driving the three dimensional graphic image of the arm on the simulator display, using an actual master arm. The sequences are stored and edited interactively, then the modified trajectories are transmitted to the slave arm. The flexible operation is realized by forward/reverse reproduction of variable time rate either on-line or off-line to the slave arm. In the simulator, the arm motion and interaction including the interference check and reconfiguration of primitives are computed in real-time, and the animation and the pseudoforce are fed back to an operator. This simulator is integrated with a slave manipulator system with the durability in vacuum environment and a master manipulator system with a universal hand-controller for space applications.

A88-31414 Optimum design of hybrid fibrous laminated composite plates subject to axial compression. MITSUNORI MIKI and KOUJI TONOMURA, IN: Composite structures 4; Proceedings of the Fourth International Conference, Paisley, Scotland, July 27-29, 1987. Volume 1 (A88-31401 12-24). London and New York, Elsevier Applied Science, 1987, pp. 1.368-1.377. 7 Refs.

A flexural lamination parameter diagram of hybrid fibrous laminates is constructed and a new analytical design method is proposed to determine the optimum lay-up of hybrid laminated plates subject to axial compression. The object of the design problem is to minimize the cost of the hybrid plates which have a composite surface with high performance and high cost, and a composite core with low cost, under the constraint that the plate has a given buckling strength. The optimum lay-up can be obtained from the material constants of the two kinds of unidirectional composites used, the plate aspect ratio, and the constraint on the buckling load.

A89-19943 Typical application of CAD/CAE in space station preliminary design. KATSUHIKO TAKAHASHI and YOSHIHARU HANAI, *Ishikawajima-Harima Engineering Review* (ISSN 0578-7904), Vol. 28, July 1988, pp. 197-201.

The role of CAD/CAE in the Japanese Experiment Module (JEM), Japan's contribution to the Space Station project, is examined. It is shown that CAD/CAE is significantly efficient in hardware layout design, component/structure interference analysis, window field of view analysis, manipulator operability analysis in equipment replacement, drawing development, data exchange with NASA and participating companies, and efficiency of data usage.

A89-16333 Recent trends in gearing technology. KIYOHIKO UMEZAWA, *JSME International Journal,* Series III (ISSN 0914-8825), Vol. 31, June 1988, pp. 357-362. 10 Refs.

A novel method for predicting the vibration of a helical gear pair is described. A theoretical analysis on the vibration of a narrow facewidth helical gear pair is presented as well as a vibration simulation and a performance diagram of vibration. Manufacturing trends are discussed with attention given to the NC hobbing machine and topological modification.