

Russian and Japanese Aerospace Literature

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Russian Aerospace Literature This month: *Spacecraft Guidance/Control*

A91-16916 The ASTRO-1M as part of the attitude control system of the unmanned SPEKTR satellite. ALEKSANDR V. RYBACHEV and ALEKSANDR I. ULIASHIN, *Jena Review* (ISSN 0448-9497), Vol. 35, No. 3, 1990, pp. 117, 118.

A star sensor employed in the attitude-control system of the unmanned SPEKTR satellite is described. The sensor (ASTRO-1M) consists of three optical blocks fixed rigidly to the spacecraft body, an electronic computer block, and a power supply block. It operates on the principle of geometric star selection: the relative coordinates of the brightness centers of all stars seen by each of the optical blocks are measured and compared with the data in a digital star catalog stored in the system. Two-dimensional CCD arrays employed as detectors are covered, as well as positioning of the optical blocks, their protection from elements, and a two-way exchange of data between ASTRO-1M and an onboard computer.

A91-13927 Investigations of thermal control coatings optical characteristics on board near-earth orbital stations. A. A. GORODETSKII, S. A. DEMIDOV, and S. F. NAUMOV, *IAF, 41st International Astronautical Congress*, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 pp. (IAF Paper 90-281).

A reliable method and instrumentation for determining radiation characteristics of spacecraft thermal control coatings is described. The method is based on solving the thermal balance differential equations for flat samples of coating subjected to external heat flows determined by ballistic data and attitude parameters. Data are presented on solar radiation absorptivity of coatings based on ZnO and BaCO₃ which confirm the high stability of silicon coatings based on ZnO for orbits at 300-400 km lasting for five years.

A90-48304 Application of the recursive method of parabolic extremum approximation to the problem of optimum spacecraft behavior (*Primenenie rekurrentnogo metoda parabolicheskoi approksimatsii ekstremalei v zadache optimal'nogo povedeniia KA*). A. L. VOROB'EV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, July-Aug. 1990, pp. 513-520.

A recursive extremum approximation method has been developed which describes the behavior of a dynamic system during a rapid transition from the initial phase state to a final state with allowance for the limits of the system motion characteristics. A solution to the problem of a rendezvous between a spacecraft and a satellite is obtained by modifying the one-dimensional Pontryagin regulator for use with a two-dimensional system.

A91-49497 Determining the orientation of a maneuvering spacecraft without the use of gyroscopes (*Opredelenie orientatsii manevriruiushchego KA bez ispol'zovaniia giroskopov*). E. M. POTAPENKO, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, May-June 1991, pp. 480-484.

The present study shows that if a spacecraft maneuvers on an orbital basis and if a local vertical plotter is added to the star trackers, the need for information obtained by gyroscopes is unnecessary. It is then possible to determine a spacecraft's angular velocity and orientation and to calibrate instruments without identifying celestial bodies and using navigational information during random spacecraft rotation.

A90-41967 Algorithms for controlling the descent distance of a spacecraft in the atmosphere with prediction of the acceleration magnitude (*Algoritmy upravleniya dal'nost'iu spuska appara v atmosfere s prognozirovaniem dozy peregruzki*). E. F. KAMENKOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, May-June 1990, pp. 391-401.

The paper examines approximate methods for determining the acceleration magnitude at all sections of the direct descent trajectories of a manned spacecraft in the atmosphere in the case of hyperbolic entry velocities. Algorithms for the control of descent distance are obtained, with prediction of the acceleration magnitude in the case of a digital computer in the control loop. The notion of the range of possible descents is introduced in order to 'link' the autonomous and nonautonomous parts of the flight control system. Calculations results are presented for the limit trajectories of a descent vehicle in the earth's atmosphere in the case of control according to attack and roll angles.

A90-41963 Channel-type hydraulic nutation dampers (*Kanalovye zhidkostnye dempfery nutatsionnykh kolebani*). A. IU. KOGAN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, May-June 1990, pp. 346-351.

A method is proposed for calculating and optimizing the characteristics of a channel-type damper for attenuating elastic vibrations in precision passive systems of spacecraft attitude control. Formulas are given for the parameters of an equivalent pendulum-type damper.

A91-23785 Calculation of spacecraft sensor pointing accuracy according to autonomous measurements of the angular attitude of the target (*K raschetu tochnosti navedeniia apparatury KA po avtonomnym izmereniiam uglovogo polozheniya ob'ekta issledovaniia*). A. A. CHERNOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Nov.-Dec. 1990, pp. 837-845.

An approach to estimating sensor pointing accuracy is proposed where only the angle-measurement channel is used in the spacecraft information and measurement system. The pointing system utilizes the combined control mode with disturbance compensation. Errors of the filters which evaluate the angular attitude of the target in the body axis coordinate system, discrepancies in the implementation of the combined control mode, and errors of the baseline coordinate system are assumed to be prescribed. The signal hysteresis is also considered.

A92-53851 Determination of the actual motion of the Salyut-7—Cosmos-1686 orbital complex relative to the center of mass in high orbit (*Opredelenie fakticheskogo dvizheniya orbital'nogo kompleksa "Salyut-7"—"Kosmos-1686" otносitel'no tsentru mass na vysokoi orbite*). V. A. SARYCHEV, V. V. SAZONOV, M. IU. BELIAEV, N. I. EFIMOV, I. L. LAPSHINA, and V. M. STAZHKOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 30, No. 2, Mar.-Apr. 1992, pp. 147-156.

Dynamic effects due to the gravitational one-axis stabilization of the Salyut-7—Cosmos-1686 orbital complex are described. The effects were discovered as a result of statistical data processing of on-board measurements of the solar and magnetic sensors. The motion of the orbital complex around the center of mass at various times is illustrated.

A92-40656 Synthesis of the optimal nonlinear control of spacecraft rotation (Sintez optimal'nogo nelineinogo upravleniya vrashcheniem kosmicheskogo appara). V. V. MARTYNENKO and S. V. PUSHKOVA, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 30, No. 1, Jan.–Feb. 1992, pp. 52–59.

Nonlinear feedback control laws are developed which are intended for the rotation control (reorientation maneuvers) of a spacecraft whose motion is described by nonlinear Euler equations. A system of four bodies consisting of a dynamically nonsymmetrical spacecraft and three flywheels is considered as an example. In the case considered the control is realized via the control moments of the flywheels.

A92-40655 Determination of satellite orbit parameters via measurements of the angular position of the satellite from an orbital spacecraft (Opredelenie parametrov orbitby ISZ po izmereniiam ego uglovogo polozheniya s orbital'nogo kosmicheskogo appara). A. I. DAUGAVET and E. V. POSTNIKOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 30, No. 1, Jan.–Feb. 1992, pp. 45–51.

A method is proposed for determining the orbit parameters of an earth satellite using angular measurements from a spacecraft that has known orbit and attitude parameters. It is noted that this method is suitable for the case of short-duration observations. Formulas for calculating the rms errors associated with the parameters estimated are presented.

A92-36538 Nonlinear controller design for strapdown inertial navigation systems (Konstruirovaniye nelineinogo reguliatorya dlia besplat-formennykh inertsiyal'nykh navigatsionnykh sistem). L. M. IAKOVLEVA, *Kibernetika i Vychislitel'naya Tekhnika* (ISSN 0454-9910), No. 91, 1991, pp. 25–31.

A method for the construction of a set of permissible controllers is applied to error equations for strapdown inertial navigation systems described by ordinary differential equations with stochastic perturbations of initial conditions and right-hand terms. The problem is solved analytically using the second Liapunov method. For a particular case, a method for optimizing free controller parameters is proposed.

A92-33789 Modification of equations for errors in determinations of rigid body orientations (using strapdown inertial navigation system) (Modifikatsiya uravnenii pogreshnosti opredeleniya orientatsii tverdogo tela). V. F. SOKOL, *Mekhanika Girokopicheskikh Sistem* (ISSN 0203-3771), No. 10, 1991, pp. 99–103.

A new form of equations for errors in determinations of the orientation of moving objects using a strapdown inertial navigation system is proposed which is convenient for analytical studies. Conditions are determined under which such errors are maximum. The equations proposed here make it possible to significantly simplify the estimation of errors of strapdown inertial navigation systems.

A92-31953 Noise-immune estimation of the navigation parameters of autonomous strapdown inertial systems (O pomekhoustoichivom otsenivaniyu navigatsionnykh parametrov avtonomnykh besplat-formennykh inertsiyal'nykh sistem). S. V. SOKOLOV, *Priborostroenie* (ISSN 0021-3454), Vol. 34, No. 7, 1991, pp. 25–31.

Equations of state for an autonomous strapdown inertial navigation system and observer equations for the state vector of such a system are derived in stochastic symmetrized form. This approach makes it possible to use methods of optimal nonlinear filtering to minimize the rms error of navigation parameter estimation in the case of arbitrary motion of an object in near-earth space over any time interval.

A92-30407 A three-degree-of-freedom electromechanical transducer in the spacecraft angular stabilization system (Trehstopennoi elektromekhanicheskii preobrazovatel' v sisteme uglovoi stabilizatsii kosmicheskogo appara). E. V. DVOINYKH, *Tekhnicheskai Elektrodinamika* (ISSN 0204-3599), May–June 1991, pp. 46–52.

The possibility of using hydraulic drives based on a 3-DOF electromechanical transducer in the distributed angular stabilization system of spacecraft is investigated. The principle of stabilizing moment synthesis is described for different distributions of the elementary kinetic moment carriers of the angular stabilization system over the spacecraft volume. Some practical recommendations concerning the use of a 3-DOF electromechanical transducer in spacecraft stabilization applications are given.

A92-23583 Investigation of the transfer trajectory to the halo orbit near the L2 libration point in the earth-sun system using the moon's gravity (Issledovanie traektorii poleta na galo-orbitu v okrestnosti tochki libratsii L2 sistemy zemlia-solntse s ispol'zovaniem gravitatsii lunny). M. L. LIDOV, V. A. LIAKHOVA, and N. M. TESLENKO, *Pis'ma v Astronomicheskii Zhurnal* (ISSN 0320-0108), Vol. 17, Dec. 1991, pp. 1124–1134.

The mission scheme for transfer to the halo orbit in the earth-sun system proposed by Farquhar (1991) is studied in connection with the Relikt-2 project. According to this scheme, a spacecraft performs two preliminary revolutions along a high-eccentricity orbit. The orbit parameters are chosen so as to provide a close encounter with the moon at the first half-orbiting during the third revolution. As a result, the spacecraft would enter an orbit asymptotically approaching the halo orbit near L2. The moon's gravity effect allows the spacecraft to reach the halo orbit with much smaller dimensions than in the case of direct transfer. A preliminary analysis of approximate trajectories in 1994 is presented.

A92-33788 Gyroscope and accelerometer calibration using the output data of redundant inertial navigation systems (Kalibrovka girokopov i akselerometrov po vykhodnoi informatsii dublirovannykh inertsiyal'nykh navigatsionnykh sistem). M. A. PAVLOVSKIY and A. A. LEONETS, *Mekhanika Girokopicheskikh Sistem* (ISSN 0203-3771), No. 10, 1991, pp. 73–79.

The possibility of using the standard output data of redundant inertial navigation systems for estimating the multiplicative and additive errors of gyroscopes and accelerometers is investigated. A system of equations is obtained which makes it possible to estimate the errors in the scale factors of gyroscopes and accelerometers, gyroscope drifts, accelerometer zero drift, and small rotation vector, determining the mutual orientation of systems, from the output signals of redundant inertial navigation systems.

A92-21645 Approximate calculation of orbit-formation maneuvers for an earth satellite with a low-thrust engine (Priblizhennyi raschet manevrov formirovaniya orbitby sputnika zemli s dvigatelyem maloi tiagi). V. V. SALMIN and V. O. SOKOLOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, Nov.–Dec. 1991, pp. 872–888.

The problem of finding control laws for an earth satellite with a low-thrust engine in a noncentral gravitational field is considered. The optimal control structure for a selected orbit is established, and approximate analytical solutions for the control of orbit evolution are obtained. In addition, analytical relationships are obtained for calculating expenditures of characteristic velocity needed to change the orbit and to bring the spacecraft to a specified point in the orbit.

A92-21641 Stabilization of a satellite with flexible rods. II (O stabilizatsii sputnika s gibkimi sterzhniami. II). S. I. ZLOCHEVSKIY and E. P. KUBYSHKIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, Nov.–Dec. 1991, pp. 828–839.

The paper examines the stabilization of the angular position of a satellite with two flexible rods with respect to its center of mass using jet engines, taking the entire frequency spectrum of the flexible rods into account. The rod material is considered to be viscoelastic. An analysis is made of the stability region of the stabilization system in the feedback-coefficient space. Two models for the rod viscoelasticity are considered: the Foecht model and the linear model of hereditary viscoelasticity. (L.M.)

A91-55327 Modification of the linear programming simplex method in the case of degeneration (for spacecraft guidance and control) (O modifikatsii simpleks-metoda lineinogo programmirovaniya v sluchae vyrozhdeniya). M. L. LIDOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, July–Aug. 1991, pp. 499–508.

Linear programming methods are used to solve problems associated with spacecraft guidance and control such as the trajectory correction problem. Some special difficulties arise when the linear programming problems are solved by the simplex method in the case of degeneration. A modification of the simplex method is considered here which can be applied to such cases and makes it possible to reduce the computational time required for the problem solution.

A91-55197 Initial orbit determination by Laplace's method (Ob opredelenii predvaritel'noi orbitby metodom Laplasa). M. IU. KLOKACHEVA, *Astronomicheskii Zhurnal* (ISSN 0004-6299), Vol. 68, July–Aug. 1991, pp. 863–871.

An iteration process allowing the simultaneous improvement of the orbital elements and the derivatives of spherical coordinates is described. The approximate values of the first and second derivatives of spherical coordinates required for Laplace's method are determined by a differentiation of polynomials. Examples are presented of orbit determination for geostationary satellites to illustrate the method under consideration.

A91-52586 Mathematical modeling of Euler turns of the Mir orbital complex using gyrodynes (Matematicheskoe modelirovaniye eilerovotokov razvorotov orbital'nogo kompleksa 'Mir' girodinami). V. A. SARYCHEV, M. IU. BELIAEV, S. G. ZYKOV, V. V. SAZONOV, and V. P. TESLENKO, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, July–Aug. 1991, pp. 532–543.

Three mathematical models of the Eulerian turn of the Mir complex in inertial space using gyrodynes are described. The models are based on the combined integration of the equations describing a change in the total angular momentum of the gyrodynes and the equations of the complex's motion about the center of mass. The models have been implemented as programs for the IBM PC/XT and are employed for planning scientific experiments to be performed on the orbital complex.

A91-49483 Optimization of the two-impulse rendezvous maneuver of two spacecraft in circular orbit under constraints (Optimizatsiya dvukhimpul'snogo manevra vstrechi dvukh apparatov na krugovoi orbiti pri nalichii ogranicenii). V. V. IVASHKIN and G. G. RAIKUNOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, May–June 1991, pp. 352–366.

The optimization problem (in terms of minimal characteristic velocity) of the two-impulse rendezvous maneuver of two spacecraft moving initially in the same circular orbit is investigated. Limits are imposed on the distance from the spacecraft to the center of gravity and on the transfer time. The qualitative and quantitative characteristics of the solutions are analyzed during changes of the initial angular misalignment between the spacecraft.

A91-49482 Optimal control of spacecraft terminal reorientation based on an algorithm with a predicting model (Optimal'noe upravlenie terminal'noi pereorientatsiei KA na osnove algoritma s prognoziruiushchey model'iu). N. E. ZUBOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, May-June 1991, pp. 340-351.

An analytical construction method based on the criterion of generalized work in tandem with a predicting model is used to solve analytically the problem of the terminal reorientation of a spacecraft for two forms of kinematic equations: with directing cosines and with quaternions. A comparative analysis of these algorithms is performed. The spacecraft motion equations are found to be linear relative to the control actions; the domain of possible values of the control actions is not closed.

A91-39133 Optimal spatial turn of a spacecraft with a changing mass geometry (Optimal'nyi prostranstvennyi razvorientatsiia kosmicheskogo appara s peremennoi geometriie mass). V. I. GULIAEV, V. L. KOSHKIN, and I. V. SAVILOVA, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, Mar.-Apr. 1991, pp. 221-230.

This paper examines the problem of optimal control of a satellite motions relative to its mass center. The control is accomplished by using small reactive moments and by changing the length of rigid gravitational rods with masses attached on their ends. Time-optimal computer programs for controlling spatial turns are developed for various constraints on the control moments.

A91-23992 Investigation of the work of the founders of astronautics and its contemporary problems (Russian book) (Issledovanie tvorchestva osnovopolozhnikov kosmonavtiki i ee sovremennoe problemy). B. V. RAUSHENBAKH, ED. Moscow, Izdatel'stvo Nauka, 1989, 178 pp. No individual items are abstracted in this volume.

The scientific work of the 'founders' of astronautics in the Soviet Union is described, with particular emphasis on Blagonravov, Babakin, and Bushuev. Consideration is then given to various current problems in astronautics, including: spacecraft and rocket design; engine theory and design; power systems and electrorocket engines; and applied celestial mechanics and motion control.

A91-17094 Errors of a gimbaless orientation system resulting from laser gyroscope errors (O pogreshnostiakh beskardannoi sistemy orientatsii, obuslovlennykh oshibkami lazernykh giroskopov). A. IU. EVSTAF'EV, E. D. MASLENOK, and D. K. MYNBAEV, *Priborostroenie* (ISSN 0021-3454), Vol. 33, April 1990, pp. 43-46.

Numerical solutions are obtained for error equations describing the scatter of the orientation parameters of a gimbaless orientation system resulting from laser gyroscope errors. It is shown that orientation errors associated with calibration errors increase with time at a greater rate than orientation errors resulting from the random drifts of the normalization coefficients of laser gyroscopes.

A91-17031 Evolution of the rotational motion of two tethered bodies in orbit (Ob evolutsii rotatsionnogo dvizheniya sviazki dvukh tel na orbite). A. P. ALPATOV, P. A. BELONOZHKO, A. V. PIROZHENKO, and V. A. SHABOKHIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Sept.-Oct. 1990, pp. 692-701.

The kinematic evolution of two tethered point masses moving in an unperturbed Keplerian orbit is analyzed. It is shown that, in the first approximation, the motion of the kinetic-moment vector with respect to the motion of the system does not depend on oscillations along the tether. It is also demonstrated that the effect of the dissipative component of aerodynamic forces in circular orbit differs qualitatively from the effect described previously for a symmetrical rigid body.

A91-17029 A general method for determining the characteristics of the earth's gravitational field using graviinertial measurements conducted onboard a spacecraft (Obshchii metod opredeleniya kharakteristik gravitatsionnogo polia zemli s pomoshch'iu graviinertial'nykh izmerenii, provodimykh na). V. V. GOLIKOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Sept.-Oct. 1990, pp. 676-684.

The paper proposes and justifies a general method for determining the principal values of the tensor of the second derivatives of the force function of the earth's gravitational field using spaceborne graviinertial measurements. The design principles of the graviinertial measurement systems which can be used in these investigations are examined. Functional dependences on the spherical coordinates of the tensor components of the second derivatives of the force function are obtained.

A91-16917 Slow-scan-operated CCD photodetector arrays for spacecraft attitude sensing. VLADIMIR I. BEREZIN, EDUARD A. IZUPAK, and ALEKSANDR G. KHVILIVITSKII, *Jena Review* (ISSN 0448-9497), Vol. 35, No. 3, 1990, pp. 119, 120.

A Peltier-cooled CCD image-sensor head with slow-scan operation (readout register frequency of 500 Hz) is described. The head utilizes a two-dimensional array of 520 x 580 buried-p-channel charge-coupled devices operating in a frame-transfer mode. In order to increase sensitivity, especially in the short-wavelength range, the matrix configuration includes 'windows' not covered by poli-Si electrodes. A CCD head developed on the basis of a photosensitive CCD array with virtual phase is also described. It contains two clock and one virtual electrodes, and about half of its photosensitive area is not covered by poli-Si electrodes, so that the quantum yield in the 0.4- to 0.7-micron range may amount to 40 to 50 percent.

A91-17006 Control of the rotational motion of a rigid body containing cavities filled with liquid and gas (Upravlenie vrashchatelym dvizheniem tverdogo tela, soderzhashchego polost', zapolnennye zhidkost'iu i gazom). E. N. MATVEEVA, *Dynamics of control systems* (A91-17001 05-70). Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1989, pp. 61-66.

A motion model in the form of ordinary differential equations with a special structure is developed for a particular kind of mechanical system with a liquid rocket engine. The system contains a tank with gas and a tank containing liquid propellant and gas, and the two tanks are separated by a hermetic membrane. Control-stabilization algorithms are obtained including an algorithm with the identification of imprecisely known parameters.

A91-17004 Effect of an onboard computer on the dynamics of a spacecraft controlled by two pairs of powered gyroscopes (Vlaniie BTsVM na dinamiku nositelia, upravlaemogo dvumia sparkami silovykh giroskopov). N. I. KIRINA, *Dynamics of control systems* (A91-17001 05-70). Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1989, pp. 41-45.

A particular problem of the stabilization of the principal central axes of a spacecraft in the direction of the axes of the orbital coordinate system is considered. The stabilization is effected via two powered-gyro complexes and an onboard computer in the control loop. Conditions on the signal quantization step which provide for the required spacecraft-stabilization accuracy are defined.

A91-13946 Equilibrium attitudes of a gyrostat satellite in a circular orbit. V. A. SARYCHEV, IAF, 41st International Astronautical Congress, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 pp. (IAF Paper 90-315).

The motion of a satellite in a central Newtonian force field is studied. Particular attention is given to the case in which statistically and dynamically stabilized flywheel rotors are mounted in a satellite and are spinning with a constant angular velocity relative to the satellite body. Equations of motion for this gyrostat satellite are presented.

A90-48305 Experimental verification of a mathematical model of a spacecraft with in-tank dampers allowing for fluid vorticity (Eksperimental'naya proverka matematicheskoi modeli KA s vnutribakovymi dempferiushchimi ustroistvami, uchityvaiushchimi zavikhrennost' zhidkosti). V. G. LEBEDEV, A. I. MYTAREV, B. I. RABINOVICH, and G. A. CHURILOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, July-Aug. 1990, pp. 521-530.

Consideration is given to mathematical models of varying degrees of sophistication describing the rotation of a spacecraft with in-tank dampers about a longitudinal axis of symmetry with allowance for fluid vorticity. An analysis of the results of a full-scale experiment confirms the validity of the mathematical models proposed here; applicability regions are defined for each of the models. The effect of vorticity on the dynamics and stability of the controlled motion of the spacecraft is analyzed.

A90-48303 Spacecraft rendezvous control using the free trajectory method based on an algorithm with a prediction model (Sintez upravleniya sblizheniem KA po metodu svobodnykh traektorii na osnove algoritma s prognoziruiushchey model'iu). N. E. ZUBOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, July-Aug. 1990, pp. 506-512.

An approach to the problem of free-trajectory spacecraft rendezvous is proposed whereby the problem is treated as an optimal control problem using an algorithm with a prediction model. Simple analytical formulas for control calculations are obtained. The region of initial conditions for which the algorithm is valid is determined. A method is proposed for relating the generalized work functionals to the initial conditions.

A90-41961 Attitude control system of a flexible spacecraft with a dynamic filter (Sistema orientatsii deformiruemogo kosmicheskogo appara s dinamicheskim fil'trom). G. IA. LEDENEV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, May-June 1990, pp. 329-335.

Sufficient stability conditions are obtained for the attitude control system of a flexible spacecraft with a dynamic filter under the effect of a slowly varying perturbation. This filter substantially attenuates the elastic-vibration signal and excludes the effect of the slowly varying perturbations on the orientation precision. Relationships are obtained which make it possible to choose parameters of the filter that assure the stability of the attitude control system.

A90-37104 Oscillations of a tethered satellite of small mass due to aerodynamic drag. E. M. SHAKHOV, 16th Rarefied gas dynamics: Space-related studies; International Symposium, Pasadena, CA, July 10-16, 1988, Technical Papers (A90-37101 16-34). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, pp. 40-52.

This paper deals with the plane transverse oscillations due to aerodynamic drag of a tethered satellite of small mass at low orbit. The period of the oscillations is a single-valued function of the aerodynamic drag at the altitude of flight. In an atmosphere of nonuniform density the oscillations are asymmetric. Both the difference of half-periods and the amplitude difference in deviations up and down from a position of relative equilibrium are defined by the density gradient. Some possible ways of using the satellite-pendulum as a facility for experimental rarefied gasdynamics and aeronomy are discussed. (Author)