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Russian and Japanese Aerospace Literature

During 1994 the *AIAA Journal* will carry selected abstracts on leading research topics from Russian aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Supersonics from Russia and Large Space Structures from Japan.

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Russian Aerospace Literature This month: *Supersonics*

A93-55019 Development of separation due to interaction between a shock wave and a turbulent boundary layer perturbed by rarefaction waves (Razvitie otryva pri vzaimodejstvii skachka uplotneniya s turbulentnym pogranichnym sloem, vozmushchennym volnami razrezheniya). A. A. ZHELTOVODOV, EH. KH. SHILEJN, and C. C. HORSTMAN, *National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA. PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 34, No. 3, May-June 1993, pp. 58–68.

The interaction of a turbulent boundary layer with rarefaction and shock waves in flows past inclined steps was investigated experimentally and theoretically. The experiments were carried out in supersonic wind tunnels with test sections of 0.6 x 0.6 m and 0.2 x 0.2 m, with adiabatic conditions on the surface model. Based on detailed measurements of pressure fields, velocity, and surface friction, combined with results of optical visualization and analysis of limiting flow lines, three characteristic flow regimes are identified. These are (1) nonseparated flow at small step angles, (2) formation of a local separation zone with a free separation point at moderate step angles, and (3) formation of a large-scale separated flow with a fixed separation point at sufficiently large step angles. The quantitative gasdynamic schemes and surface pressure distributions for these flow regimes are shown for Mach 2.85.

A93-55014 Steady-state supersonic flow of a vibrationally excited gas past a slender body of revolution at a small angle of attack (Obtekanie tonkogo tela vrashcheniya pod malym uglom ataki statsionarnym sverkhzvukovym potokom kolebatel'no-vozbuzhdennogo gaza). A. N. BOGDANOV and V. A. KULIKOVSKIJ, *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 34, No. 3, May-June 1993, pp. 11–20. Documents available from AIAA Technical Library.

The problem of supersonic flow of a vibrationally excited gas past a slender body of revolution at a small angle of attack is solved analytically using a linear approximation. The solution makes it possible to calculate the transverse force acting on the body and the moment of this force relative to the body nose. It is found that the relaxation of the vibrational excitation changes the magnitude of the force and, in the case of sufficient initial nonequilibrium, even its sign.

A93-51913 An experimental study of the dynamic effect of a supersonic underexpanded jet on a plane surface parallel to the nozzle axis (Ehksperimental'noe issledovanie dinamicheskogo vozdejstviya sverkhzvukovoj nedorasshirennoj strui na ploskuyu poverkhnost', parallel'nuyu osi sopla). E. N. BONDAREV, S. S. VTULKIN, E. I. MOSPANOV, and A. V. PECHERITSA, *Problems in the aerodynamics of flight vehicles and their components* (A93-51901 22-02). Moscow, Russia, Moskovskij Aviatsionnyj Institut, 1992, pp. 75–80. 5 Refs. Documents available from AIAA Technical Library.

The paper reports results of an experimental study of pressure distribution along the line of symmetry of flow on a plane surface parallel to the axis of a circular nozzle. The effect of the governing flow parameters on the magnitude and position of the pressure maximum on the obstacle is analyzed. Attention is also given to the magnitude and position of the second pressure peak. The results are presented in graphic form.

A93-53365 Determination of heat transfer to flow in a duct with a pseudodiscontinuity (Opredelenie teplopodvoda k potoku v kanale s psevdoskachkom). P. K. TRET'YAKOV, *Fizika Goreniya i Vzryva* (ISSN 0430-6228), Vol. 29, No. 3, May-June 1993, pp. 71–77. 8 Refs. Documents available from AIAA Technical Library.

Heat transfer due to propellant combustion in a duct with supersonic flow leads to flow deceleration. The resulting gasdynamic structure is characteristic of a pseudodiscontinuity and is essentially inhomogeneous over the duct cross section. In this case, the extent of combustion or the amount of heat transferred to the flow are determined by measuring static pressure on the duct wall. The use of a one-dimensional method may lead to an erroneous result. The method proposed here is based on the characteristics of the change of the inhomogeneity coefficient, which is derived from a one-dimensional representation of the conservation equations. The method uses the pressure differential of isothermal flow with heat transfer; friction and heat transfer to the wall are taken into account. As an example, the method is applied to the combustion of hydrogen and kerosene.

A93-51912 Calculation of a plane supersonic jet simulating the exhaust jet of a hypersonic flight vehicle engine (Raschet ploskoj sverkhzvukovoj strui, modeliruyushchej vykhlopnuyu struyu dvigatelya giperzvukovogo LA). V. V. SILAEV, *Problems in the aerodynamics of flight vehicles and their components* (A93-51901 22-02). Moscow, Russia, Moskovskij Aviatsionnyj Institut, 1992, pp. 70–75. 5 Refs. Documents available from AIAA Technical Library.

The main differential equation of gas dynamics for a plane steady state potential nonviscous flow is solved by the layer-by-layer method of characteristics. The method combines the properties of orthogonal grid methods and those of the traditional version of the method of characteristics. A full system of equations is then derived which includes differential equations of characteristics, compatibility conditions, the Bernoulli equation, and the equation of state. Based on this approach, a program has been developed for calculating plane supersonic jets simulating the exhaust flow of the engines of hypersonic flight vehicles. A calculation example is included.

A93-27639 Experience with the use of liquid crystals in conjunction with the filament method is studying the structure of supersonic flow downstream of a plane step (Opyt primeneniia zhidkikh kristallov v komplekse s metodom nitei pri izuchenii struktury sverkhzvukovogo techeniia za ploskim ustupom). V. M. TROFIMOV, S. I. SHTREKALKIN, and S. V. NAUMENKO, *Sibirskii Fiziko-Tekhnicheskii Zhurnal* (ISSN 0869-1339), No. 5, Sept.–Oct. 1992, pp. 85–91. Documents available from AIAA Technical Library.

Liquid-crystal thermal indicators were used in conjunction with the filament method to investigate longitudinal vortex structures of the Taylor-Goertler kind in the boundary layer reattached downstream of a plane step with a view to obtaining more information about the temperature field and the field of mean velocity vectors. The high sensitivity of liquid-crystal thermal indicators made it possible to detect temperature gradients as small as 2 K and to identify the details of complex separated flows with longitudinal vortices. The characteristic regions of separated flow beyond the plane step are determined, and large-scale three-dimensional effects are identified, as are other details of the flow structure.

A93-51910 Calculation of supersonic flow past a body of revolution with a piecewise linear distribution of singularities at its axis (Raschet sverkhzvukovogo obtekaniya tela vrashcheniya s kusochno-linejnym raspredeleniem intensivnosti osobennostej na ego osi). YU. S. SOROKIN, *Problems in the aerodynamics of flight vehicles and their components* (A93-51901 22-02). Moscow, Russia, Moskovskij Aviatsionnyj Institut, 1992, pp. 53–61. Documents available from AIAA Technical Library.

A method for calculating supersonic flow past bodies of revolution is proposed whereby the body of revolution is modeled by sources and dipoles along the body axis with a piecewise linear law of intensity variation along the axis. This approach makes it possible to obtain finite analytical expressions for velocities and significantly reduce the computational effort. Examples of calculations are presented to demonstrate the validity of the approach.

A93-51901 Problems in the aerodynamics of flight vehicles and their components (Voprosy aehrodinamiki letatel'nykh apparatov i ikh chastej). YU. A. RYZHOV, ED. Moscow, Russia, Moskovskij Aviatsionnyj Institut, 1992, 91 pp. (For individual items see A93-51902 to A93-51914).

The papers presented in this volume provide an overview of recent theoretical and experimental work in the field of flight vehicle aerodynamics and general aeromechanics. In particular, attention is given to the calculation of compressed gas flows on optimal difference grids, spline-collocation solution of a Fredholm equation of the second kind in the problem of flow past an airfoil, a study of the aerodynamics of a wing with end slots, and aerodynamic characteristics of airship models of different shapes. Other topics discussed include determination of the aerodynamic characteristics of a thin body of revolution with a piecewise linear distribution of singularities at its axis, calculation of a plane supersonic jet simulating the exhaust jet of a hypersonic flight vehicle engine, and a stability condition for the motion of a continuous incompressible medium.

A93-51822 Effect of the parameters of an external feedback loop on the characteristics of self-oscillations during the impingement of an underexpanded jet on a finite obstacle (Vliyanie parametrov vneshnej tsepi obratnoj svyazi na kharakteristiki avtokolebanij pri natekanii nedorasshirennoj strui na konechnuyu pregradu). S. G. MIRONOV, *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0044-4626), No. 1, Jan.–Feb. 1993, pp. 94–100. Documents available from AIAA Technical Library.

The effect of the velocity of acoustic waves traveling from the obstacle to the nozzle and their intensity near the nozzle edge on the amplitude-frequency and phase characteristics of self-oscillations generated during the impingement of an underexpanded jet on the end of a finite cylinder is investigated experimentally. The results obtained are analyzed from the standpoint of the two principal mechanisms of sustained self-oscillations in such jet systems: feedback through waves in the shock layer between the obstacle and the central shock wave and feedback through acoustic waves propagating in the ambient medium.

A93-51815 Shock wave formation at the boundary of a local supersonic region (O formirovanii udarnoj volny na granitse mestnoj sverkhzvukovoj zony). S. A. SHCHERBAKOV, *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0044-4626), No. 1, Jan.–Feb. 1993, pp. 24–32. Documents available from AIAA Technical Library.

A self-similar solution to an equation of plane potential flow is obtained near the point of formation of a shock wave defining the boundary of a local supersonic region. In accordance with this solution, a shock wave of variable intensity exists at the boundary of the local supersonic region. The characteristic at the point of shock wave formation includes continuous derivatives of the gasdynamic parameters along the coordinates. The solution obtained here is consistent with the theorems of Nikolskii and Taganov (1946).

A93-51786 Experimental studies of supersonic flow past wedges with longitudinal slots on the windward side (Ehksperimental'nye issledovaniya sverkhzvukovogo obtekaniya klin'ev s prodol'nymi pazami na navetrennoj storone). V. I. VORONIN, G. S. UL'YANOV, and A. I. SHVETS, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 2, Mar.–Apr. 1993, pp. 173–175. Documents available from AIAA Technical Library.

By using a simple hypersonic lifting shape in the form of a wedge as an example, an experimental study is made of a method of increasing the lift-drag ratio of waverider configurations. The method investigated here involves the use of longitudinal slots on the windward side. It is shown that the wave drag can be reduced without any decrease in the lifting force by appropriately selecting the angle of the slot surface and the relative width of the slots. The aerodynamic characteristics of the models tested are presented as a function of the slot angle and relative width.

A93-27607 Calculation of three-dimensional supersonic flow past lifting surfaces (K raschetu prostranstvennogo obtekaniia nesushchikh poverkhnostei sverkhzvukovym potokom). S. S. GRAS'KIN, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 2, 1992, pp. 27–32. Documents available from AIAA Technical Library.

The possibility of using the discrete vortex method for solving the problem of three-dimensional supersonic flow past lifting surfaces is examined. A mathematical validation of the discrete vortex method when applied to problems in supersonic aerodynamics is presented. The analysis presented here allows for singularities at compression shocks.

A93-51780 Supersonic flow past a cone with heat transfer near its tip (Sverkhzvukovoe obtekanie konusa pri teplopodvode v okrestnosti ego vershiny). V. A. LEVIN and L. V. TERENT'EVA, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 2, Mar.–Apr. 1993, pp. 110–114. Documents available from AIAA Technical Library.

Supersonic flow past a cone in the wake of a spherical heat source is investigated analytically. The problem is reduced to that of solving a system of gas dynamics equations written in nondimensional form. The equations are solved numerically using the McCormack method. It is shown that heat transfer toward the nose of the body effectively reduces its wave resistance.

A93-51772 Development of resonance perturbations in a supersonic jet (Rezonansnoe razvitie vozmushchenij v sverkhzvukovoj strue). N. A. ZHELTUKHIN and N. M. TEREKHOVA, *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), No. 2, Mar.–Apr. 1993, pp. 82–89. Documents available from AIAA Technical Library.

Dynamics of wave formation in a thermally nonconducting gas outflowing from a circular nozzle is considered using a model of a nonlinear three-wave resonance system with minimum interactions relatively to initial linear processes. The dynamical model is verified taking into account realization conditions for resonance mechanisms in the development of wave processes in flows. Calculation results are applied to three cases: (1) the intensity of a spiral wave is greater than that of an axisymmetric wave; (2) the intensity of an axisymmetric wave is greater than that of a spiral wave; and (3) the intensities of all waves are different.

A93-48973 Supersonic flow past energy release regions (Sverkhzvukovoe obtekanie oblastej ehnergovydeleniya). L. V. TERENT'EVA, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 5, Sept.–Oct. 1992, pp. 179–182. Documents available from AIAA Technical Library.

The problem of supersonic flow past three-dimensional axisymmetric regions of heat release is solved in the context of linear theory. The distribution of parameters over the flow is investigated as a function of the shape of the heat release region. It is shown that, in all cases of supersonic flow past cylindrical heat release regions, an extended low-pressure zone is formed behind these regions.

A93-48970 Numerical modeling of three-dimensional viscous flows by a marching procedure with global pressure iterations (Chislennoe modelirovanie trekhmernykh vyazkikh potokov marshevym metodom s global'nymi iteratsiyami davleniya). A. A. MARKOV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 5, Sept.–Oct. 1992, pp. 132–147. Documents available from AIAA Technical Library.

A method is presented for calculating steady-state compressible and incompressible flows using simplified Navier-Stokes equations written in invariant conservative form in arbitrary curvilinear coordinates. In the governing equations, the longitudinal pressure gradient is determined in the process of global iterations of the pressure field, which makes it possible to allow for perturbation propagation in the upstream direction in subsonic layers and in incompressible flows. Pressure relaxation procedures during global iterations are examined. Results of calculations of simplified Navier-Stokes equations are presented for some problems of supersonic flow past blunt bodies of bielliptical cross section.

A93-48924 Effect of anomalous aerodynamic heating during the descent of a parachute along a trajectory (Ehffekt anomal'nogo aehrodinamicheskogo nagreva pri spuske parashyuta po traektorii). YU. M. DAVYDOV and V. A. MOZGOVOJ, *Rossijskaya Akademiya Nauk, Doklady* (ISSN 0869-5652), Vol. 330, No. 1, May 1993, pp. 48–51. Documents available from AIAA Technical Library.

Numerical calculations and experimental studies of descent in the atmosphere indicate that temperatures under the parachute canopy often exceed breaking temperatures calculated for given trajectory points, when calculations are performed using equations of motions for streamlined aerodynamic bodies, such as aircraft or rockets. This paper presents a numerical experiment in which the air temperature under the parachute canopy is calculated for a supersonic conical parachute descending through the earth atmosphere, taking into consideration the fact that the density of the air flow under the canopy increases continuously during the descent. It is shown that consideration of this additional continuously increasing pressure makes it possible to identify certain new effects that are not detectable in steady motion analysis.

A93-43028 An approach to the construction of marching algorithms for solving steady state problems in gas dynamics (Ob odnom podkhode k konstruirovaniyu marshevykh algoritmov resheniya statsionarnykh zadach gazovoi dinamiki). V. B. KARAMYSHEV, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 32, No. 10, Oct. 1992, pp. 1677–1679. Documents available from AIAA Technical Library.

In the case of supersonic flows, the system of steady state equations of gas dynamics is hyperbolic and can be solved by a marching method involving layer-by-layer integration of equations along the coordinate direction with a supersonic velocity component. An algorithm for constructing a marching scheme is examined using two-dimensional steady state equations of gas dynamics in Cartesian coordinates as an example.

A93-48848 Aerodynamic characteristics and static stability margin of conical star-shaped bodies at supersonic velocities (Aehrodinamicheskie kharakteristiki i zapas staticheskoj ustojchivosti konicheskikh zvezdoobraznykh tel pri sverkhzvukovykh skorostyakh). M. A. ZUBIN and N. A. OSTAPENKO, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 6, Nov.–Dec. 1992, pp. 142–150. Documents available from AIAA Technical Library.

Results of an experimental study of the aerodynamic characteristics of conical bodies with a star-shaped cross section are reported for a wide range of geometrical parameters for a freestream Mach of 6. The position of the center of pressure of star-shaped bodies with an optimal shape of the trailing edge is investigated as a function of theoretically determined similarity parameters. A correlation is established between the derivatives of the normal force with respect to the angle of attack of star-shaped pyramidal bodies and bodies with an optimal trailing edge.

A93-46975 Heat transfer on blunt cones in nonuniform supersonic flow in the presence of gas injection from the surface (Teploobmen na zatuplennykh konusakh pri sverkhzvukovom neravnomernom obtekanii i nalichii vduva s poverkhnosti). N. N. PILYUGIN and R. F. TALIPOV, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 31, No. 1, Feb. 1993, pp. 97–104. Documents available from AIAA Technical Library.

The parameters of laminar flow and heat transfer on a blunt cone in a nonuniform supersonic flow are calculated using the equations of the total viscous shock layer (TVSL) model, with particular consideration given to the characteristics of the oncoming wake-type flow and to the effect of gas injection from the surface. The results of TVSL calculations of the flow and heat-transfer parameters are compared with other numerical and asymptotic solutions. It is shown that the efficiency of gas injection at the critical point of the model for the purpose of lowering the heat flow intensity can be significantly increased by using the nonuniformity of the oncoming flow.

A93-42405 A numerical study of the flutter of conical shells (Chislennoe issledovanie flattera konicheskikh obolochek). V. V. DITKIN, B. A. ORLOV, and G. I. PSHENICHNOV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Tverdogo Tela* (ISSN 0572-3299), No. 1, Jan.–Feb. 1993, pp. 185–189. Documents available from AIAA Technical Library.

The paper is concerned with the problem of the aerodynamic stability of thin shells in supersonic flow of a compressible gas. An efficient iteration method for solving problems of this kind is proposed. The problem of supersonic flow of a gas past a cantilever conical nozzle is analyzed as an example.

A93-39124 A numerical investigation of supersonic flow of a viscous gas over long blunt cones, taking into account equilibrium physicochemical transformations (Chislennoe issledovanie sverkhzvukogo obtekaniia zatuplennykh konusov bol'shoi dliny potokom viazkogo gaza s uchetom ravnovesnykh fiziko-khimicheskikh prevrashchenii). S. V. UTIUZHNIKOV, *Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 1, Jan.–Feb. 1993, pp. 202–205.

A numerical study was made of supersonic axisymmetrical flow of a viscous heat-conducting gas past a spherically blunted elongated cone at high Reynolds numbers, using a high-efficiency method based on global iterations to solve the equations of the viscous shock layer. Results elucidate the overall effect of a second approximation of the boundary layer theory and the effect of equilibrium physicochemical transitions on the thermal load on elongated cones.

A93-39115 A one-dimensional theory for supersonic gas jets above the critical pressure (Odnomernaia teoriia sverkhzvukovykh neraschetnykh strui gaza). F. I. LUKHTURA, *Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 1, Jan.–Feb. 1993, pp. 48–56. Documents available from AIAA Technical Library.

Journal Announcement: IAA9315 A method is proposed, based on a quasi-one-dimensional study of a supersonic jet above the critical pressure, for calculations of the parameters of such a jet. The method is used to compute the jet parameters at the section of its adaptation to the ambient conditions, directly adjacent to the exhaust nozzle exit section. The features of the jet which determine the jet structure and its attenuation behavior are examined.

A93-36784 A study of the origin of residual stresses and strains in the windows of supersonic aircraft (Issledovanie prichin vozniknoveniia ostatochnykh napriazhenii i deformatsii v osteklenilakh sverkhzvukovykh samoletov). V. F. VOROB'EV, V. I. MERKUR'EV, and S. E. POSTNOV, *Stress-strain analysis and optimal design of aircraft structures* (A93-36782 14-39). Moscow, Izdatel'skii Otdel TsAGI, 1992, pp. 21–28. Documents available from AIAA Technical Library.

Results of an analysis of the service data for supersonic aircraft are reviewed with a view to establishing the factors responsible for the generation of residual stresses and strains in the aircraft windows. These data as well as results of bench tests indicate that the residual stresses and strains result from creep and stress relaxation processes and increase gradually with service time and with the number of loading cycles during testing. Particularly high residual stresses and strains are generated in organic glasses in the case where the outer surface temperature during the supersonic flight exceeds the glass transition temperature. The use of a more thermally stable glass eliminates crack formation. Good results are also obtained by replacing solid glass with laminated composite transparencies.

A93-35346 Intermode exchange in a supersonic boundary layer (Mezhmodovyi obmen v sverkhzvukovom pogranichnom sloe). A. V. FEDOROV and A. P. KHOKHLOV, *PMTF—Prikladnaia Mekhanika i Tekhnicheskaia Fizika* (ISSN 0044-4626), No. 6, Nov.–Dec. 1992, pp. 67–72. Documents available from AIAA Technical Library.

The initial stage of the laminar-turbulent transition in a boundary layer is characterized by the development of unstable modes. Here, the intermode exchange near the spectrum bifurcation points is analyzed for a supersonic boundary layer. A boundary layer on a plate in supersonic flow of an ideal gas is considered as an example. The results of the analysis are sufficiently general and can be applied to other classes of unstable weakly nonparallel flows.

A93-35344 A study of the temperature of bodies in the flow-around regime in the case of surface gas injection (Issledovanie temperaturnykh rezhimov obtekaemykh tel pri vduve gaza s poverkhnosti). V. I. ZINCHENKO, A. G. KATAEV, and A. S. IAKIMOV, *PMTF—Prikladnaia Mekhanika i Tekhnicheskaia Fizika* (ISSN 0044-4626), No. 6, Nov.–Dec. 1992, pp. 57–64. Documents available from AIAA Technical Library.

The problem of heating in the case of supersonic flow of air around a blunt cone is solved with allowance for different flow regimes in the boundary layer and gas injection from the spherical blunt section of the cone. In particular, attention is given to the effects of the flow regimes and flow rate coefficients of the injected gas, geometry of the shell, and thermophysical properties of the body material on the characteristics of unsteady coupled heat and mass transfer. The results of the study can be used in interpreting results of aerodynamic tests.

A93-35266 Unsteady supersonic flow around a blunt body in thermal inhomogeneities in turbulent shock layer flows (Nestatsionarnoe sverkhzvukovoe obtekanie zatuplennogo tela v teplovykh neodnorodnostiakh pri turbulentnom rezhime techeniia v udarnom sloe). IU. P. GOLOVACHEV and V. V. ZEMLIAKOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 33, No. 1, Jan. 1993, pp. 151–155. Documents available from AIAA Technical Library.

Unsteady turbulent supersonic flow around a sphere moving through thermal inhomogeneities is investigated numerically using a viscous shock layer model. It is shown that the flow is characterized by significant changes in the shape of the head shock, occurrence of internal shock waves and high-temperature jets in the shock layer, and substantial changes in the distribution of drag and heat transfer parameters on the body surface. The behavior of the heat flow on the body surface is affected to the greatest extent by the laminar-turbulent transition.

A93-35265 The quasi-characteristic difference scheme and its application to the calculation of supersonic gas flows (Raznostnaia skhema kvazikharakteristik i ee primenenie dlia rascheta sverkhzvukovykh techenii gaza). M. P. LEVIN, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 33, No. 1, Jan. 1993, pp. 131–141.

A second-order quasi-characteristic difference scheme is proposed for solving mixed problems for systems of hyperbolic equations. The scheme is based on the representation of equations in expanded characteristic form. The approximation and the stability of the scheme proposed here are analyzed using the Cauchy problem as an example.

A93-33346 Self-oscillations during the parallel outflow of two supersonic nonisobaric jets (Avtokolebaniia pri parallel'nom istechenii dvukh sverkhzvukovykh neizobaricheskikh strui). S. G. MIRONOV, *PMTF—Prikladnaia Mekhanika i Tekhnicheskaia Fizika* (ISSN 0044-4626), No. 5, Sept.–Oct. 1992, pp. 29–36. Documents available from AIAA Technical Library.

The generation of self-oscillations in a system of two parallel supersonic nonisobaric jets is examined with reference to new experimental results obtained by schlieren photography using a stroboscopic lamp synchronized by acoustic pressure pulses. Models are proposed which describe the directional characteristics of acoustic emission and the conditions of excitation of self-oscillations. The validity of the models is demonstrated experimentally.

A93-31219 Heat transfer in a supersonic heterogeneous flow (Teploobmen v sverkhzvukovom geterogennom potoke). IU. V. POLEZHAEV, I. V. REPIN, and D. S. MIKHATULIN, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 30, No. 6, Nov.–Dec. 1992, pp. 1147–1153. Documents available from AIAA Technical Library.

Based on a generalization of a large amount of experimental data, a physical model is developed for the heat transfer of bodies in a high-velocity, high-temperature heterogeneous flow. The study covers Mach numbers of 2.6-4.2 and Reynolds numbers of 0.4-0.5 x 10 exp 6, calculated from the model diameter and stagnation parameters. The size and concentration of the disperse component vary from 20 to 250 microns and from 0 to 1 percent, respectively. An expression for calculating heat transfer near the critical point of a blunt body is derived and verified experimentally.

A93-27605 Shock wave ahead of a liquid jet in supersonic cross flow (Udarnaia volna pered struei zhidkosti v sverkhzvukovom snosiashchem potoke). S. I. BARANOVSKII and D. M. DAVIDENKO, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 2, 1992, pp. 21–24.

A model is proposed for calculating the shape and deflection of a shock wave ahead of a liquid jet that is normal to the supersonic cross flow. Empirical computational formulas are obtained using the available experimental data. Results of calculations are presented.