# Soviet Aerospace Literature

## This month: *Supersonic Flow*

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**Support for assembling and publishing the selected abstracts has been provided by the Innovative Science and Technology Directorate of the Strategic Defense Initiative Organization (SDIO), with the sponsorship and technical management of the abstract service by the Office of Naval Research (ONR) under ONR Grant N0014-87-6-0137.**

**Abstracts in this listing have been taken from the semimonthly abstract journal International Aerospace Abstracts (IAA), published by the American Institute of Aeronautics and Astronautics (AIAA) in cooperation with the National Aeronautics and Space Administration (NASA) under Contract No. NASW-4112. Additional material can be obtained through searching the Aerospace Database – available online via DIALOG or NASA RECON.**

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**A87-39218 Motion of a high-lift wing in supersonic flow (Dvizhenie mekhanizirovannogo kryla v sverkhzvukovom potoke)** B. A. ERSHOV, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024-0850), Oct. 1986, pp. 14-16.

For a high-lift wing of infinite span moving with a constant supersonic velocity, calculations are made of the lifting force, pitching moment, and hinge moments. The approach used here is based on a linear model of a thin wing and on a model of a high-lift wing whose median line consists of n hinged stiff links. Calculation results are presented for arbitrary motions of the wing elements.

**A87-36088 Three-dimensional hypersonic flow of a dusty gas past a wing (O prostranstvennom obtekanii kryla giperzvukovym potokom zapylennogo gaza)** V. N. GOLUBKIN, *PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Jan.-Feb. 1987, pp. 15-20. 12 Refs.

Three-dimensional hypersonic flow of a gas containing solid particles past a low-aspect-ratio wing is investigated analytically using the method of a thin shock layer. The analysis allows for the mutual effect of the solid and gas phases. The corresponding similarity parameters are defined, and the effect of a solid impurity on the pressure distribution over the wing is determined.

**A87-44281 Acoustic emission of a supersonic boundary layer (Izluchenie akusticheskikh kolebanii sverkhzvukovym pogranichnym sloem)** A. A. MASLOV and N. V. SEMENOV, *(AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki* (ISSN 0002-3434), April 1987, pp. 58-63. 11 Refs.

A method for generating artificial perturbations in a boundary layer is proposed which can be used for studying the boundary layer structure at supersonic velocities and the acoustic emission of supersonic boundary layers. The induced acoustic emission of a boundary layer is investigated experimentally using thermoanemometry, and the experimental data are processed on a computer using Fourier analysis. It is found that, in the near field, the Tollmien-Schlichting waves are responsible for the main contribution to the perturbations; in the far field, the signal is made up of acoustic perturbations with different phase velocities.

**A87-31709 A study of flows in hypersonic nozzles using simplified Navier-Stokes equations (Issledovanie techenii v giperzvukovykh soplakh v ramkakh uproshchennykh uravnenii Nav'e-Stoksa)** M. I. MUCHNAIA, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Nov.-Dec. 1986, pp. 20-26. 14 Refs.

Simplified Navier Stokes equations are used to calculate flows in the nozzles of wind tunnels. In particular, calculations are made for conical and profiled hypersonic nozzles over a wide range of Mach and Reynolds numbers; the results are in good agreement with experimental data. It is shown that the role of viscous-nonviscous interaction in the nozzles becomes significant at large hypersonic Mach numbers.

**A87-35823 Drag of a slender cone in supersonic flow of a rarefied gas (Soprotivlenie ostrogo konusa v sverkhzvukovom potoke razrezhennogo gaza)** F. S. VORONIN and L. N. ZHDANOVA, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1987, pp. 187-189. 14 Refs.

The paper reports the results of an experimental study of the drag of a slender cone for flow conditions approaching those of free molecular flow. The experiments were carried out in a wind tunnel at free-stream Mach 11.2 using cones with a half-angle of taper of 5, 10, and 15 deg and a base diameter of 5 and 10 mm. The experimentally determined drag coefficients are found to be close to the values calculated for free molecular flow.

**A87-28453 Hypersonic motion of a thin cone in a mixture of a gas and solid particles (Giperzvukovoe dvizhenie tonkogo konusa v smesi gaza i tverdykh chastits)** A. IA. SAGOMONIAN, *Moskovskii Universitet, Vestnik, Seriia 1, Matematika, Mekhanika* (ISSN 0579-9368), Sept.-Oct. 1986, pp. 42-46.

The problem of the hypersonic motion of a thin cone in a stationary mixture of a gas and solid particles is analyzed for the case where the volume concentration of solid particles in the mixture is small, so that the motion of the particles cannot be described by equations of motion for continua. The problem is solved using the approximation of a piston moving inside a cylindrical pipe filled with a gas-particle mixture. The cases of inelastic and absolutely elastic interaction between the particles and the piston surface are examined.

**A87-25231 A study of the shape of the cross-section profile of a minimum-drag three-dimensional conical body moving in a rarefied gas (Issledovanie formy poperechnogo kontura konicheskogo prostranstvennogo tela minimal'nogo soprotivleniia, dvizhushchegosia v razrezhennom gaze)** A. I. BUNIMOVICH and G. E. IAKUNINA, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.-Oct. 1986, pp. 112-117. 9 Refs.

The objective of the study is to determine the optimal shape of three-dimensional bodies characterized by minimum drag during flight in a rarefied gas at intermediate altitudes. The optimal shape of the cross-section profile of minimum-drag bodies is determined by solving a variational problem for a functional in a class of piecewise smooth functions with isoperimetric and closed-profile conditions. The limiting cases of Newtonian hypersonic and free-molecular flows of a rarefied gas are examined. It is shown that star-shaped bodies are more efficient in terms of drag than bodies of revolution at all altitudes. However, the efficiency of using star-shaped bodies in comparison with equivalent bodies of revolution decreases with increasing flight altitude (gas rarefaction).

**A87-29086 Some features of the approximate calculation of the integral aerodynamic characteristics of polygonal lifting configurations at supersonic flight velocities (Nekotorye osobennosti priblizhennogo rascheta summarnykh aerodinamicheskikh kharakteristik poligonal'nykh nesushchikh konfiguratsii pri sverkhzvukovykh skorostiakh poleta)** I. I. MAZHUL, *(AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki* (ISSN 0002-3434), Oct. 1986, pp. 52-57. 11 Refs.

The use of approximation method for calculating the integral aerodynamic characteristics of polygonal lifting configurations is discussed with reference to problems related to the parametric analysis and aerodynamic optimization of flight vehicles. The application of the shock-expansion method to polygonal shapes is examined with allowance for experimentally determined structural characteristics of flow past these configurations. A quasi-two-dimensional approach based on the hypothesis of local two-dimensionality of hypersonic flow is shown to provide reasonably good agreement with experimental data for Mach 2-3 or greater in the case of polygonal lifting configurations.

**A87-29893 Solvability of some problems concerning supersonic flow past a wedge using the Lavrent'ev-Bitsadze approximation (O razreshimosti nekotorykh zadach sverkhzvukovogo obtekaniia klina v ramkakh priblizheniia Lavrent'eva-Bitsadze)** A. V. GRISHIN, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), vol. 26, Dec. 1986, pp. 1868-1877. 5 Refs.

Boundary value problems corresponding to nonsymmetric supersonic jet flow past an infinite wedge and nonsymmetric infinite supersonic flow with a separated shock wave past a finite wedge are formulated and analyzed in the hodograph plane using the Lavrent'ev-Bitsadze approximation. An analysis is also made of the problem of symmetric supersonic flow past an infinite wedge. A class of problems is identified for which the uniqueness of the solution to the corresponding boundary value problem in the hodograph plane is the necessary condition of flow realizability in physical plane.

**A87-35817 A solution to the variational problem of the optimal shape of supersonic nozzles (K resheniiu variatsionnoi zadachi ob optimal'noi forme sverkhzvukovykh sopel)** A. A. SERGIENKO and A. A. SOBACHKIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1987, pp. 138-142.

The variational problem of the optimal shape of supersonic nozzles is analyzed using a formulation that does not stipulate a vanishing term in the first variation of the Lagrange functional. The region of existence of a solution to the resulting boundary value problem is examined. Calculations are carried out for such a problem, with the isolation of both an extreme of a known type and uknown boundary extremes.

**A87-35824 A study of the effect of the separation zone on the oscillations of a cone (K issledovaniiu vliianiia otryvnoi zony na kolebaniia konusa)** V. A. PLATONOV and V. N. SHMANENKOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1987, pp. 190, 191.

The factors responsible for the dynamic loss of stability of a cone with a circular conical stabilizer are investigated numerically in the context of linear theory for bodies of finite thickness. It is found that, for such cones, the dynamic loss of stability in hypersonic flow is largely due to the inertia of the flow separation zone, which should be taken into account in aerodynamic calculations. The results are supported by wind-tunnel test data.

**A87-50972 Control of the intensity of convective heat transfer in a Laval nozzle under conditions of turbulent flow and in the presence of local separation zones (Upravlenie velichinoi konvektivnogo teploobmena v sople Lavalia pri turbulentnom techenii i nalichii lokal'nykh zon otryva)** E. G. ZAULICHNYI and V. M. TROFIMOV, *PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), May-June 1987, pp. 110-115. 13 Refs.

The pressure and heat transfer coefficients on the walls of a cavern with a step in the direction opposite to the flow direction in the supersonic section of a Laval nozzle are investigated experimentally. The effect of changes in the shape of the cavern on the flow and heat transfer characteristics is examined. Details of the experimental procedure and results are presented.

**A87-46093 Convergent flows and air intakes of simple and compact-channel designs (Konvergentnye techeniia i vozdukhozaborniki, prosteishie i s predel'no kompaktnym kanalom)** B. I. GUTOV and V. V. ZATOLOKA, *PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.-Apr. 1987, pp. 57-62. 7 Refs.

A class of supersonic flows and air intakes is considered in which transverse jet flows are compressed along convergent intersecting directions. These intakes differ from conventional ones (plane and divergent) by the small area of the channel walls and essential three-dimensionality. Air intakes of this type are first specified by simple combinations of two-dimensional flows using gasdynamic design methods. A very simple method (cutting along flow surfaces) is then used to obtain a large number of configurations, including air intakes with an extremely compact channel. Tables for calculating and designing convergent flows and air intakes are given.

**A87-25127 An analysis of the combustion of a turbulent supersonic nonisobaric hydrogen jet in supersonic wake flow of air (Raschet goreniia turbulentnoi sverkhzvukovoi neizobaricheskoi strui vodoroda v sputnom sverkhzvukovom potoke vozdukha)** S. I. BARANOVSKII, A. S. NADVORSKII, and V. A. PERMINOV, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), vol. 22, July-Aug. 1986, pp. 14-18. 5 Refs.

A two-dimensional mathematical model of turbulent supersonic flow based on simplified Navier-Stokes equations is used to investigate the effect of heat evolution on the static pressure and processes in the mixing layer. With reference to results obtained for the combustion of a turbulent supersonic hydrogen jet in supersonic wake flow of air, it is shown that heat evolution may lead to a significant (up to 25 percent) increase in pressure, an increase in the jet range, and a deterioration of mixing. It is also shown that the dimensionless excess velocity profile in the mixing layer of the reacting jet cannot be described by the Schlichting curve.

**A87-17594 Radiation heating of three-dimensional bodies in nonviscous supersonic air flow (Radiatsionnyi nagrev prostranstvennykh tel, obtekaemykh neviazkim sverkhzvukovym potokom vozdukha)** E. Z. APSHTEIN, N. V. VARTANIAN, and V. I. SAKHAROV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1986, pp. 183-187. 8 Refs.

Flow past axisymmetric and three-dimensional bodies of various shapes (sphere, hyperboloid, axisymmetric and three-dimensional ellipsoids, and power-law bodies of revolution) is calculated for velocities of 10-18 km/hr, flight heights of 40-80 km in the earth atmosphere, and characteristic dimensions of 0.01-20 m. The numerical calculations performed here show that, for all the axisymmetric bodies with a finite curvature radius, R, at the critical point, the radiant heat flux to this point is determined by the value of R and is independent of the body shape for given velocity and height.

**A87-25232 A study of supersonic three-dimensional flow past pointed axisymmetric bodies (Issledovanie sverkhzvukovogo prostranstvennogo obtekaniia zaostrennykh osesimmetrichnykh tel)** V. I. LAPYGIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.-Oct. 1986, pp. 127-133. 11 Refs.

Flow past bodies of revolution with a long pointed cylindrical nose section is analyzed in the context of an ideal gas model using a numerical model based on McCormak's finite difference scheme. The existence in the shock layer of internal shocks of both longitudinal and transverse orientations is demonstrated. Changes in the aerodynamic coefficients of the configuration are investigated as a function of its length, angles of attack, and the Mach number of the incoming flow. The results obtained are compared with experimental data, and a relationship is established between flow parameters on the body surface and the position of the boundary layer separation line on the lateral surface of the body. A method is proposed for taking account of the effect of the boundary layer on the aerodynamic coefficients of bodies of revolution of large aspect ratios at small angles of attack.

**A87-50819 Calculation of convective heat fluxes for three-dimensional flow around a body according to a given pressure distribution (Raschet konvektivnykh teplovykh potokov pri trekhmernom obtekanii po zadannomu raspredeleniiu davleniia)** V. V. ZNAMENSKII and A. V. ZUBAREV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1987, pp. 160-167. 13 Refs.

A method is developed for calculating convective heat fluxes for three-dimensional flow around bodies of arbitrary shape according to a given pressure distribution. It is shown that, at the frontal surface, the effect of the three-dimensionality of the flow in the boundary layer on the heat fluxes is small; the determining factor is the dependence of heat flux on local pressure. The results obtained are compared with those obtained on the basis of linear theory for quasi-axisymmetric bodies. The case of hypersonic flow at a freestream Mach number of 20 is considered.

**A87-50818 Investigation of a hypersonic viscous shock layer near blunt bodies with nonuniform flow around them (Issledovanie giperzvukovogo viazkogo udarnogo sloia okolo zatupiennykh tel pri neravnomernom obtekanii)** I. G. EREMEITSEV, N. N. PILIUGIN, and S. A. IUNITSKII, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1987, pp. 154-159. 16 Refs.

Nonseparated viscous-gas flow around a blunt body is analyzed numerically on the basis of the theory of thin viscous shock layers. The equations of a hypersonic viscous shock layer with generalized Rankine-Hugoniot conditions on the shock wave are solved by a finite difference method in a wide range of Reynolds numbers, values of the temperature factor, and nonuniformity parameters. Calculation results are presented which characterize the effect of the nonuniformity of the oncoming flow on the velocity and temperature profiles across the shock layer, on the heat-transfer and friction coefficients, and on the separation of the shock wave. Critical values of the nonuniformity parameter are obtained in the case of which reverse-circulation zones arise on the front surface of the body depending on the Reynolds number.

**A87-50809 Three-dimensional gas/particle jet with phase transformations (Trekhmernaia gazodispersnaia struia s mezhfaznymi prevrashcheniiami)** M. M. GILINSKII, A. L. STASENKO, and A. V. SHUINOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1987, pp. 36-41. 12 Refs.

The mixed flow of a gas/particle and vapor/droplet mixture in a nonaxisymmetric nozzle (with two symmetry planes) and a submerged supersonic jet is analyzed numerically. Allowance is made for the possibility of the evaporation and condensation growth of droplets as well as for the effect of the temperature difference of particles and gas on their momentum and energy transfer. It is shown that the nonaxisymmetric shape of the nozzle leads to significantly nonuniform azimuthal distributions of the particle number density and size. It is noted that these effects can be used to control the action of a two-phase jet on a surface (e.g., of a flight vehicle) and spatial variations of its radiation indicatrix.

**A87-26323 An analysis of supersonic three-dimensional flow past air intakes under conditions of shock spillage (Raschet sverkhzvukovogo prostranstvennogo obtekaniia vozdukhozabornikov na rezhimakh s vybitoi udarnoi volnoi)** V. I. MILESHIN, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), vol. 26, Nov. 1986, pp. 1704-1718. 15 Refs.

An analysis is made of supersonic flow of an ideal gas past axisymmetric and nearly axisymmetric bodies with an annular passage and a tapered central body at angle of attack under conditions of shock spillage. The approach used here consists in analyzing the flow on individual meridional half-planes in cylindrical coordinates, with the Godunov finite difference scheme used on each half-plane. An algorithm is proposed for isolating a three-dimensional shock wave whose surface has a singular splitting line (a line of points of triple interaction of compression shocks). The method is illustrated by examples.

**A87-41840 Calculation of axisymmetric flows of a viscous gas in the near wake of bodies with a tail of complex shape (Raschet osesimmetrichnykh techenii viazkogo gaza v blizhnem sliede za telami s kormoi slozhnoi formy)** T. B. LUZIANINA and V. M. PASKONOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Mar.-Apr. 1987, pp. 31-37. 9 Refs.

The aerodynamic characteristics of a blunt cylindrical body in supersonic flow of a compressible heat-conducting gas and the flow structure in the near wake of the body are investigated as a function of the shape of the tail part of the body using a full system of Navier-Stokes equations. Wake flows are calculated for bodies with tail parts of different shapes (e.g., a hemisphere, a truncated cone, and a tail with an annular groove). For all the tail shapes analyzed, the base pressure is found to be higher than in the case of a cylindrical body with a plane base section.

**A87-50822 Interaction of a liquid jet with an oncoming gas stream (Vzaimodeistvie strui zhidkosti so vstrechnym potokom gaza)** M. A. KOVAL' and A. I. SHVETS, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1987, pp. 178-181.

Wind-tunnel tests were carried out to study the interaction between water jets issuing from various types of nozzles (including cylindrical) and subsonic and supersonic air streams with Mach numbers from 0.3 to 3 and Reynolds numbers from 1 x 10 to the 6th to 3 x 10 to the 7th. The following interaction structure was observed: (1) at moderate outflow velocities, the liquid jet has an extended region, which subsequently expands abruptly as a spherical or mushroom-shaped drop; (2) this drop is atomized in the peripheral region and is carried away as a gas-liquid mixture; (3) a shock wave is formed in front of the jet in the oncoming supersonic stream; and (4) a separated flow region is present in the vicinity of the cylindrical nozzle section.

**A87-34220 Investigation of the radiation brightness of gases around a burning model moving at supersonic velocity (Issledovanie iarkosti izlucheniia gazov okolo goriashchei modeli pri dvizehnii so sverkhzvukovoi skorost'iu)** N. N. BAULIN, D. G. KUVALKIN, N. N. PILIUGIN, O. K. TAGANOV, and S. G. TIKHOMIROV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), vol. 25, Jan.-Feb. 1987, pp. 133-140. 9 Refs.

Experimental results are presented on the ablation and shape change of burning models made of a pyrotechnic composition moving in air at supersonic velocity. A radiometer was used to measure the radiation brightness at a wavelength of 0.63 micron in the shock layer and wake of the burning models. The glow characteristics are determined as a function of the initial air pressure in the path of motion; and a theoretical model for the motion and ablation of burning bodies flying at supersonic velocity is developed which satisfactorily describes the experimental results. The present study is of interest in connection with the aerodynamic heating of vehicles flying at hypersonic velocity in planetary atmospheres.

**A87-42173 Wave resistance of an exponential body with a front-mounted disk in supersonic flow (Volnovoe soprotivlenie tela stepennoi formy s ustanovlennym vperedi diskom v sverkhzvukovom potoke)** I. A. BELOV, S. A. ISAEV, V. N. KONOVALOV, and A. IU. MITIN, *(Leningradskii Mekhanicheskii Institut, Leningrad, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki* (ISSN 0002-3434), Feb. 1987, pp. 24-29. 9 Refs.

The wave resistance of a body of exponential geometry with a front-mounted disk in supersonic flow is investigated theoretically and experimentally over a wide range of geometrical parameters and free-stream Mach numbers. The optimal disk diameter, the optimal length of the exponential part of the body, and the exponent corresponding to a minimum wave resistance are determined. It is shown that, by mounting a disk in front of an exponential body, it is possible to decrease the wave resistance of the body in supersonic flow by a factor of 1.5-2.

**A87-35911 Calculation of supersonic flow of a chemically nonequilibrium gas past three-dimensional blunt bodies (O raschete sverkhzvukovogo obtekaniia prostranstvennykh zatuplennykh tel khimicheski neravnovesnym potokom gaza)** V. P. KOTENEV, V. I. SAKHAROV, and G. A. TIRSKII, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), vol. 27, March 1987, pp. 411-415. 7 Refs.

A numerical method is proposed for calculating supersonic flow of a viscous gas past blunt bodies in the subsonic region of the flow with allowance for chemical reactions. The system of equations describing such a flow is separated into a gasdynamic system and a relaxation system, which are solved consecutively. The gasdynamic equations are solved by using Godunov's finite difference scheme and an explicit finite difference scheme of second order of accuracy; the relaxation equations are integrated using an implicit scheme. Results of calculations for axisymmetric and three-dimensional flow of nonequilibrium air are presented.

**A87-41732 A monotonic second order approximation scheme for the finite-difference calculation of nonequilibrium flows (Monotonnaia skhema vtorogo poriadka approksimatsii dlia skvoznogo rascheta neravnovesnykh techenii)** A. V. RODIONOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), vol. 27, April 1987, pp. 585-593. 9 Refs.

With reference to the analysis of stationary supersonic flows of a nonequilibrium gas, a finite difference scheme based on the Godunov-Kolgan scheme is proposed which provides second-order approximation in all directions. Calculations carried out for several problems, including flow of a calorically ideal gas and supersonic flow of a multicomponent gas mixture into a submerged space, demonstrate the efficiency of the scheme proposed here.

**A87-31717 Nonstationary and nonequilibrium air flow in the vicinity of the critical flow line (Nestatsionarnoe i neravnovesnoe techenie vozdukha v okrestnosti kriticheskoi linii toka)** M. B. ZHELEZNIAK, A. KH. MNATSAKANIAN, and S. V. PERVUKHIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Nov.-Dec. 1986, pp. 170-172. 5 Refs.

The problem of gas flow ahead of the frontal point of a blunt body moving at a supersonic velocity in air with variable parameters is investigated with allowance for the processes of chemical relaxation behind the front of the shock wave. Numerical calculations are carried out using the method of characteristics, with the isolation of the bow shock. Determinations are made of the position of the shock wave front, which varies with time, and of the distributions of the composition and gasdynamic parameters in the shock layer.

**A87-25228 The effect of a finely dispersed admixture on the boundary layer structure in hypersonic flow past a blunt body (Vliianie melkodispersnoi primesi na strukturu pogranichnogo sloia pri giperzvukovom obtekanii zatuplennogo tela)** A. N. OSIPTSOV and E. G. SHAPIRO, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.-Oct. 1986, pp. 55-62. 14 Refs.

Heat flow toward the critical point of a blunt body in hypersonic flow of a dusted gas is investigated analytically, with allowance for the effect of particles on the motion of the carrier phase made only in the boundary layer due to a sharp increase in particle concentration near the wall. The motion of the gas in the shock layer is described by using the constant-density solution. The equations of the boundary layer in the vicinity of the critical point are solved over a wide range of parameters. It is shown that, even in the case of low mass concentrations of particles in the incoming flow (2-5 percent), a significant increase (up to 100 percent) of heat flow toward the critical point of the body is possible.

**A87-51007 A three-dimensional boundary layer on blunt bodies with a porous surface at angles of attack and sideslip (Prostranstvennyi pogranichnyi sloi na zatuplennykh telakh s pronitsaemoi poverkhnost'iu, obtekaemykh pod uglami ataki i skol'zheniia)** A. I. BORODIN and S. V. PEIGIN, *(Tomskii Gosudarstvennyi Universitet, Tomsk, USSR) Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), vol. 25, May-June 1987, pp. 509-516. 10 Refs.

The paper is concerned with hypersonic flow of a homogeneous compressible gas in a three-dimensional laminar boundary layer on blunt bodies with a porous surface at angles of attack and sideslip. An efficient numerical method with a high order of approximation with respect to the transverse coordinate is used to calculate the equations of the three-dimensional boundary layer for the case where there are no planes of symmetry in the flow. The effects of the body surface temperature, injection parameter, and angles of attack and sideslip on the principal flow characteristics are determined.

**A87-46092 An experimental study of the effect of the bluntness of the leading edge of a flat plate on the evolution of three-dimensional waves in a supersonic boundary layer (Eksperimental'noe issledovanie vliianiia pritupleniia perednei kromki ploskoi plastiny na razvitie trekhmernykh voln v sverkhzvukovom pogranichnom sloe)** A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV, *PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.-Apr. 1987, pp. 53-56. 13 Refs.

The effect of the bluntness of the leading edge of a flat plate on the stability characteristics of three-dimensional perturbations in a boundary layer is investigated experimentally for Mach 2. The evolution of three-dimensional wave packets from a point source is studied by thermoanemometry. Three-dimensional wave spectra are obtained by using two-dimensional Fourier expansion in plane waves.

**A87-51671 Calculation of three-dimensional supersonic flow past cone-like bodies with a separated shock wave (O raschete prostranstvennogo sverkhzvukovogo obtekaniia o konusovidnykh tel s otoshedshei udarnoi volnoi)** P. I. CHUSHKIN, IN: Numerical modeling in aerohydrodynamics (A87-51651 23-02). *Moscow, Izdatel'stvo Nauka,* 1986, pp. 219-230. 19 Refs.

A numerical solution is presented to the problem of three-dimensional supersonic flow past cone-shaped bodies with an elliptical cross section and a small bluntness at the apex. Mixed flow behind a separated bow shock is calculated by the method of integral relations in special variables, taking into account the flow behavior at the apex of the body. Calculation examples are presented for cone-like bodies with different relative thickness for different angles of attack.

**A87-10614 Numerical investigation of supersonic flow past spike-tipped blunt bodies (Chislennoe issledovanie sverkhzvukovogo obtekaniia zatuplennykh tel s vydvinutoi vpered igloi)** V. N. KARLOVSKII and V. I. SAKHAROV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1986, pp. 119-127. 19 Refs.

A method is developed for calculating the supersonic flow of an ideal gas near axisymmetric spike-tipped blunt bodies. An analysis is made of the flow past a truncated cone with a spherically blunted cylindrical spike as a function of the ratio (K) of the spike length to the diameter of the end part of the body, and as a function of the Mach number. Several steady flow regimes were observed, including a regime involving the formation of circulation zones and internal shock waves in the shock layer. It is shown that the mounting of the spike on the truncated cone can reduce the cone drag by 40-50 percent. The drag coefficient is studied as a function of K at M = 3.

**A87-31710 A hypersonic viscous shock layer in a swirling gas flow on a porous surface (Giperzvukovoi viazkii udarnyi sloi v zakruchennom potoke gaza na pronitsaemoi poverkhnosti)** E. A. GERSHBEIN and S. V. PEIGIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Nov.-Dec. 1986, pp. 27-37. 20 Refs.

Hypersonic swirling flow of a viscous compressible gas past rotating axisymmetric blunt bodies is investigated for the case where the velocity vector of the flow is parallel to the rotation axis of the body. An analytical solution valid for low Reynolds number is obtained to the first approximation of the integral method of successive approximations. Based on the results of a numerical solution obtained over a wide range of the principal parameters of the problem, a study is made of the effect of flow swirling, angular velocity of the body, Reynolds number, and injection (suction) parameters on the structure of the compressed layer and friction and heat transfer coefficients on the body surface. It is shown that an increase in the nonzero circumferential component of the gas velocity vector in the shock layer may produce qualitative changes in flow characteristics.

**A87-31713 Hypersonic nonuniform flow of a viscous gas past a blunt body (Giperzvukovoe obtekanie zatuplennogo tela neravnomernym potokom viazkogo gaza)** N. N. PILIUGIN and R. F. TALIPOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Nov.-Dec. 1986, pp. 120-125. 12 Refs.

A self-similar solution to equations of the viscous boundary layer near the critical point is obtained for the case of supersonic flow past an axisymmetric blunt body located behind another body. The results are then used to develop a criterion for nonseparated flow. The effect of flow nonuniformity and Reynolds number on shock detachment, convective thermal flow, and the friction resistance of the blunt body is examined.

**A88-10193 Fine structure of the flow of a supersonic underexpanded turbulent jet (Tonkaia struktura techeniia sverkhzvukovoi nedorasshirennoi turbulentnoi strui)** S. A. NOVOPASHIN, A. L. PEREPELKIN, V. N. IARYGIN, (AN SSSR, Institut Teplofiziki, Novosibirsk, USSR); and S. S. KUTATELADZE, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), vol. 295, no. 3, 1987, pp. 556-558. 5 Refs.

A pulsed laser technique was used to determine the magnitude and region of turbulent pulsations of density in a supersonic underexpanded jet. The data indicate the existence of a complex fine structure. An analysis of measurements at the initial section of the jet demonstrate that density pulsations are absent in the jet core and directly behind the Mach disk, but arise in the mixing layer in the region with a maximum density gradient. Results are presented for a Reynolds number (suitably defined for the initial section) of 10,000.

**A87-11280 Numerical solution of coupled problems of supersonic flow past deformable shells of finite thickness (O chislennom reshenii sviazannykh zadach sverkhzvukovogo obtekaniia deformiruemykh obolochek konechnoi tolshchiny)** P. N. KOROTIN, I. B. PETROV, V. B. PIROGOV, and A. S. KHOLODOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki)* (ISSN 0044-4669), vol. 27, Aug. 1987, pp. 1233-1243. 10 Refs.

The problem considered here concerns supersonic flow of an inviscid non-heat-conducting gas past a blunt body which simultaneously undergoes elastic deformation. The body is formed by a single-layer or a multiple-layer shell of finite thickness with specified elastic-plastic properties; the shell may be stiffened by ribs. Under the effect of a head shock wave, the body may change its shape through deflections, thus affecting gas flow. The problem is solved by using an explicit grid scheme classified as a positive approximation scheme.