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NUMERICAL ANALYSIS OF FLOW PROPERTIES ABOUT BLUNT BODIES MOVING AT SUPERSONIC SPEEDS IN AN EQUILIBRIUM GAS

by Harvard Lomax and Mamoru Inouye

Ames Research Center
Moffett Field, Calif.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • JULY 1964

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SUMMARY

An inverse method is presented for the numerical calculation of the flow field behind the bow shock wave of a blunt-nosed body traveling at hypersonic speeds. Numerical difficulties encountered with the inverse method are categorized and discussed. Examples of instabilities introduced by particular combinations of analytical and numerical methods are presented. Certain techniques for suppressing some of these instabilities are illustrated. A one-parameter family of shock-wave shapes has been found to yield spherical-nosed, axisymmetric bodies to a high degree of accuracy. Solutions have been obtained for perfect gases over a Mach number range from 5 to 100 for specific heat ratios from 1.1 to 1.6667 and for air in thermodynamic equilibrium over a speed range from 10,000 to 45,000 ft/sec for altitudes from 100,000 to 300,000 feet. Results for the shock-wave shape and standoff distance are presented for all the solutions, and comparisons with other methods are made. For the real air results, tabulations are presented for the body data and shock-wave and sonic line coordinates. Some results for ellipsoids and paraboloids are also shown.

INTRODUCTION

The numerical calculation of the flow field between the bow shock wave and a blunt-nosed body traveling at hypersonic speeds is of considerable interest, both from a mathematical and a physical point of view. On the mathematical side, it combines all forms of second-order partial differential equations - hyperbolic, parabolic, and elliptic - coupling the analytic and numerical difficulties associated with each. On the physical side, it provides information pertinent to the analysis and design of vehicles entering planetary atmospheres. Although many papers have dealt with the subject, the understanding of both the mathematical and physical problem is far from complete.

The purposes of this paper are twofold. One is to isolate and categorize some fundamental numerical problems associated with the inverse method of solution, and, where possible, to present techniques which help overcome these problems. The other is to present some results of the application of the inverse method to the calculation of the flow field around blunt-nosed axisymmetric bodies. The reader who is concerned with just this aspect of the

problem may begin with the section entitled Relating the Shock and Body Shapes. Included in the succeeding sections are some comparisons with other theories and experiments and a comprehensive tabulation of solutions for spherical noses in air in thermodynamic equilibrium.

SYMBOLS

A_5	shock-wave shape parameter (see eq. (21))
a	speed of sound
B_b	body bluntness parameter (see eq. (20))
HT Error	error in local total enthalpy relative to free-stream total enthalpy
h	enthalpy
M	Mach number
PSI	stream function, zero on body
p	pressure
R_b	radius of curvature of the body for $y = 0$
R_s	radius of curvature of the shock wave for $y = 0$
S	entropy
s,t	transformed and sheared coordinates
T	temperature
$\tan \sigma$	shock-wave slope for shock point on field data line
u,v	velocity components in x,y directions
V	velocity
XB,YB	cylindrical coordinates with origin at stagnation point on body and normalized by R_b
X(y)	shock-wave shape
x,y	Cartesian coordinates for $\epsilon = 0$ and cylindrical coordinates for $\epsilon = 1$ with origin on shock wave
γ	ratio of specific heats or isentropic exponent, $\frac{a^2\rho}{p}$
Δ	shock standoff distance
ϵ	index for number of space dimensions: 0 for two-dimensional flow, 1 for axisymmetric flow

μ Mach angle

ρ density

ρ_o reference density, 0.002498 slug/ft^3

τ time

φ angle subtended by circular arc measured from stagnation point, radians

Subscripts

∞ free-stream conditions

st stagnation point on body

MATHEMATICAL FORMULATION

Basic Assumptions and Considerations

The physical problem to be considered is that of a blunt body traveling in a homogeneous gas with known thermodynamic properties. In this report the study is confined to the effects on the gas behind the bow shock wave and in the vicinity of the subsonic region near the forward portion of the nose, as shown in figure 1. A solution is sought that extends sufficiently far into the supersonic region to provide initial conditions for a continuing analysis by the method of characteristics. Steady inviscid flow is assumed such that the effects of viscosity, heat conduction, and radiation are assumed negligible. No heat or mass addition is permitted, and the gas is assumed to be in thermodynamic equilibrium such that entropy is constant along streamlines, provided no shocks are crossed. The bodies to be considered are either plane or axisymmetric and at zero angle of attack.

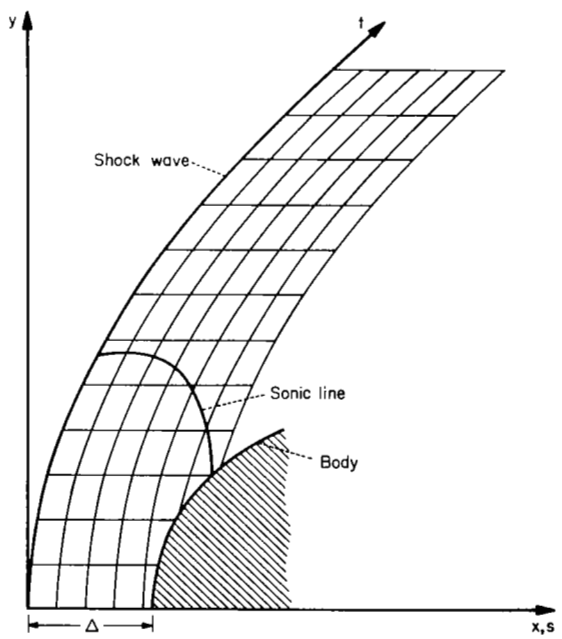


Figure 1.- Sketch of flow field around blunt-nosed body and coordinate system.

A final remark is made with regard to the mathematical discussion which follows. It is assumed at the outset that the calculations will be carried out numerically by difference, rather than differential, equations and, further, that these computations will be

performed on a digital computer. Use of finite difference schemes necessitates some consideration of the convergence and stability of the methods employed, and the efficient use of a digital computer necessitates that some consideration be given to numerical procedures that minimize both machine memory requirements and operation time. Both of these considerations will be involved in the following discussions.

Thermodynamic Properties of the Gas

The gas in which the body is traveling can be in any state of molecular excitation, provided it is in thermodynamic equilibrium. The treatment of such a gas, in calculating its flow about a body, poses two numerical problems. The first of these is well recognized and certainly the most difficult. It is the problem of calculating all the state properties of a gas given any two properties. We consider this problem to be solved; that is, formulas for the equilibrium state of the gas over the desired range of variables are assumed to be available.

The task of expressing the thermodynamic properties in a form that a digital computer can use efficiently leads to the second numerical problem. Clearly, the entire calculations undertaken to produce a tabulated value in reference 1, for example, cannot be repeated each time a thermodynamic relationship is desired. Some form of numerical approximation must be employed that requires a reasonably small amount of machine time and still is sufficiently accurate. This is not a trivial problem. Aside from the obvious necessity of accuracy is the question of consistency or continuity. If the gas properties are approximated by different equations (e.g., polynomials) over different regions, care must be taken that along lines joining the regions, the gas properties are consistent. Discontinuities in the thermodynamic calculations can lead to serious difficulties since the finite difference methods subsequently employed are unstable.

Several approaches to this problem have been tried. One is to return to physical considerations and to develop a mathematically simplified model for the gas. A good example of this method is demonstrated in reference 2. Another approach is to develop a bivariant interpolation procedure that provides accurate, continuous data over a range limited only by the numerical tables provided. The latter method was used in this report and is discussed briefly below.

Machine requirements.- The thermodynamic properties for air were taken from references 1 and 3, the latter being used for the speed of sound. The data cover a temperature range from 180° to $27,000^{\circ}$ R, a density range from 10^{-6} to 10^{2} times sea-level density, and a pressure range of 10^{-6} to 10^{4}

atmospheres as shown in figure 2. Since the data tabulated in reference 1 have a lower temperature limit of 3,600° R, the dashed portions of the curves down to 180° R in figure 2 were obtained by using data presented in reference 4. Initially, over 10,000 tabulated values were stored in machine memory, but the use of more refined interpolation methods (see ref. 5) reduced the storage requirements to about 2,200 values. At present the entire (FORTRAN) subprogram, both data and logic, required to calculate in air the speed of sound, enthalpy, temperature, and entropy for given pressure and density or pressure and entropy, is less than 4,000 words. Estimates of the required operational times[1] are given in the following table:

Given	Find	Gas type	Time, millisec
p,ρ	a	Real	3.4
p,ρ	a,h,S,T	Real	5.5
p,S	a,h,ρ,T	Real	13.8
p,S	a,h,ρ,T	Perfect	2.0

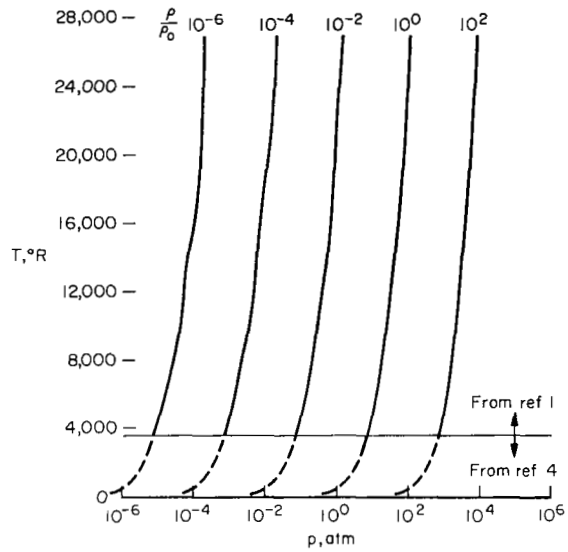


Figure 2.- Temperature and pressure ranges of table for thermodynamic properties of air in equilibrium.

Accuracy.- Estimates of the accuracy of the interpolation procedure were obtained by using the compacted interpolation tables in the final real-gas program to recalculate the original data. Given the pressure and density, the speed of sound, enthalpy, entropy, and temperature were calculated. The difference between the calculated value and the original tabulation (none of the original data appears in the tables used for interpolation) gives a measure of the accuracy to which the gas properties are represented. The numbers shown in the following table are the percentages of interpolated points with errors greater than the given value. Of the 2624 comparisons

Error	0.5 percent	1 percent	2 percent	3 percent	4 percent	5 percent	10 percent
a	13.15	4.63	1.20	0.45	0.17	0.08	0
h	5.04	.45	0	0	0	0	0
S	.21	0	0	0	0	0	0
T	0	0	0	0	0	0	0

made for each variable, none was in error by more than 2 percent except for the speed of sound. About 5 percent of the calculated values for the speed of sound disagreed with the tabulated ones by more than 1 percent. This disagreement occurred in the very high temperature and low density region where

[1]The actual calculations were performed on an IBM 7090 which has average addition and multiplication times of 14 and 25 microseconds, respectively, and a cycle time of 2.18 microseconds.

the basic data itself disagrees with more recent calculations (ref. 6). It should be pointed out that the thermodynamic contributions to the blunt-body calculations presented in the following sections depend, except for crossing the shock, entirely on the relation between the speed of sound, density, and pressure. The solutions reported herein are based on a gas that differs from argon-free air generally by less than 1 percent, but can, in some regions, differ by as much as 3 percent.

Consistency.- Most interpolation schemes constructed for two or more independent variables make use of only a small number of the total number of entries to calculate any given point. This means that certain lines or planes exist, on either side of which different sets of entries are used for the interpolation. Consider, for example, figure 3. Suppose a nine-point interpolation method uses columns 2, 3, and 4 and rows 2, 3, and 4 to calculate values of the dependent variables in the region ABFE and, to avoid extrapolation, uses columns 3, 4, and 5 with rows 2, 3, and 4 to calculate values in the region BCGF. The object is to make the interpolated quantity continuous across line BF. The method chosen to accomplish this is to interpolate first along rows independent of the columns (or vice versa) and then to interpolate the results in the remaining direction, making sure the interpolation formula always exactly reproduces the control points. In this way, no matter which set of points is used, only points along column 3 actually affect the value of the function on BF. If we imagine that points in the mesh represent the locations of poles of varying heights, this amounts to placing pinned bars with continuous first and second derivatives (a spline fit, see ref. 5) across the poles in one direction and interpolating between the bars in the other direction. Such a method did not contribute, so far as could be determined, to any stability problem in the numerical computations presented in this report.

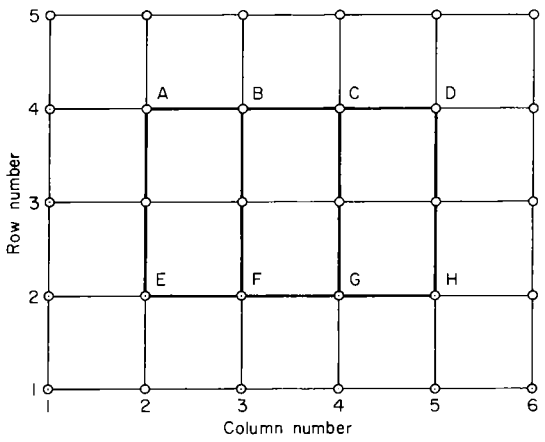


Figure 3.- Sketch of general interpolation method used for properties of real gas.

Field Equations

The basic Eulerian equations representing the continuity of mass and momentum in a plane Cartesian ($\epsilon = 0$) or axisymmetric ($\epsilon = 1$) coordinate system are (the subscripts representing differentiation)

$$v\rho_y + \rho v_y + u\rho_x + \rho u_x + \frac{\rho v \epsilon}{y} = 0 \tag{1}$$

and

$$\rho u u_x + \rho v u_y + p_x = 0 \tag{2a}$$

$$\rho u v_x + \rho v v_y + p_y = 0 \tag{2b}$$

respectively. For a gas in equilibrium, the pressure is determined by any two thermodynamic variables, say

$$p = \rho(\rho, S)$$

Then

$$\frac{Dp}{D\tau} = \left(\frac{\partial p}{\partial \rho}\right)_S \frac{D\rho}{D\tau} + \left(\frac{\partial p}{\partial S}\right)_\rho \frac{DS}{D\tau}$$

where the subscript now denotes the fixed value in the partial differentiation, and the symbol $D/D\tau$ represents the Eulerian derivative along a streamline. Since the entropy is constant along streamlines,

$$\frac{DS}{D\tau} = 0$$

and one finds

$$u p_x + v p_y - a^2 u \rho_x - a^2 v \rho_y = 0 \tag{3}$$

where a is the local speed of sound, $\sqrt{(\partial p/\partial \rho)_S}$. The thermodynamic relationship

$$a = a(p, \rho) \tag{4}$$

provides the fifth equation, connecting the five unknowns p, ρ, u, v, and a. Equations (1) through (4) are converted to finite difference equations and solved numerically. A discussion of this procedure is given in the section on numerical analysis.

Coordinate Transformation

The complexity in the details of programming difference equations with more than one independent variable depends critically on the boundary conditions, not only as to what they are, but also as to how they are treated. The algebraic complexity of the equations is relatively unimportant. For this reason the governing equations are usually transformed to a coordinate system suitable for the simplest application of the boundary values.

Let us introduce the following transformations:

$$\left.\begin{aligned} s &= s(x,y) \\ t &= t(x,y) \end{aligned}\right\} \tag{5}$$

and

$$\left.\begin{aligned} x &= x(t,s) \\ y &= y(t,s) \end{aligned}\right\} \tag{6}$$

then

$$\frac{\partial}{\partial x} = s_x \frac{\partial}{\partial s} + t_x \frac{\partial}{\partial t}$$

$$\frac{\partial}{\partial y} = s_y \frac{\partial}{\partial s} + t_y \frac{\partial}{\partial t}$$

and, using the definitions

$$\left.\begin{aligned} F_1 &= s_x u + s_y v \\ F_2 &= t_x u + t_y v \end{aligned}\right\} \tag{7}$$

and

$$R_1 = -\frac{\rho v \epsilon}{y} - F_2 \rho_t - \rho t_x u_t - \rho t_y v_t$$

$$R_2 = -t_x p_t - \rho F_2 u_t$$

$$R_3 = -t_y p_t - \rho F_2 v_t$$

$$R_4 = -F_2 p_t + a^2 F_2 \rho_t$$

we can write the field equations in the matrix notation

$$[A] \quad [B] = [C] \tag{8}$$

where

$$[A] = \begin{bmatrix} 0 & F_1 & \rho s_x & \rho s_y \\ s_x & 0 & \rho F_1 & 0 \\ s_y & 0 & 0 & \rho F_1 \\ F_1 & -a^2 F_1 & 0 & 0 \end{bmatrix} \tag{9}$$

$$[B] = \begin{bmatrix} p_s \\ \rho_s \\ u_s \\ v_s \end{bmatrix} \tag{10}$$

and

$$[C] = \begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ R_4 \end{bmatrix} \tag{11}$$

For practical purposes, the transformations (5) and (6) must be in a form that a machine can readily translate, or their usefulness is lost. In our present applications they are simple enough for straightforward analytical inversion.

Boundary Conditions

Blunt bodies in a supersonic flow have received considerable attention from a number of authors (see, e.g., refs. 7-17). The various approaches to the problem can be categorized into two groups. In one, the direct problem, the location of the body is specified, together with the condition that the Rankine-Hugoniot equations be satisfied across some upstream shock of unknown location. In the other, the inverse problem, the location of the shock and the conditions for crossing it are both given and whatever body results is found as part of the solution. The direct problem is generally approached by means of a method of integral relations developed by Dorodnitzn (ref. 18) and adapted by Belotserkovskii to the particular case of the blunt body (refs. 10 and 11). The inverse problem was solved successfully by several others (see ref. 19) who found that suitable numerical methods would yield sufficiently accurate results even though such methods have regions of numerical instability.

The analysis presented in this report is concerned entirely with the inverse problem. In the opinion of the authors, however, neither method is superior to the other as a completely general approach, both having their merits and deficiencies. It is gratifying that, where comparisons can be made, both give identical results to the degree of accuracy claimed (see the section on Results and Discussion).

NUMERICAL ANALYSIS

Difference Equations

The coordinate system chosen for the solutions given in this report is shown in figure 1. It is identical to that used by Fuller in reference 14. One set of coordinates is parallel to the free-stream direction. The axis of the other set is the shock itself, and the coordinates are those lines obtained by a uniform displacement of the shock in the free-stream direction. Thus, if the equation of the shock is

$$x = X(y)$$

then we can assign coordinates such that

$$\left.\begin{aligned} s &= x - X(y) \\ t &= y \end{aligned}\right\} \tag{12}$$

and

$$\left.\begin{aligned} x &= s + X(t) \\ y &= t \end{aligned}\right\} \tag{13}$$

replace equations (5) and (6), and equations (7) become

$$F_1 = u - \frac{dX}{dy} v$$

$$F_2 = v$$

This coordinate system is obviously convenient for starting the inverse problem although not optimum for studying body shapes. The coordinates are equally spaced in both directions, and their intersections define the points for the difference mesh.

The numerical calculations are divided into two parts. First the derivatives p_t, ρ_t, u_t, and v_t are calculated numerically for the known values of p, ρ, u, and v along a t coordinate. Only the first derivatives are needed,[2] and they are determined by a standard five-point central difference method. (The numbers are first "smoothed" along the t coordinate - see the section on Stability and Divergence.) The s axis is a plane of symmetry, and the data at the upper end of a t coordinate are differentiated by a skewed five-point difference scheme. This information is used to advance the solution in the s direction by a predictor-corrector technique.

---

[2]On the axis where $t = 0$, it is necessary to calculate p_{tt} also.

Consider, for example, that the pressure p has been calculated or is given at all points along the t coordinates for which $s = (i - 1)\Delta s$ and $s = i\Delta s$. We proceed to find p at points for which $s = (i + 1)\Delta s$ by the following steps. (The solution was started by a first-order predictor followed by two correctors.)

	Step	
Given from previous step	1	p_i, p_{i-1}
First corrector	2	Numerically differentiate p_i along t giving p_{t_i}
	3	Find p_{s_i} using partial differential equation, $p_{s_i} = f(p_i, p_{t_i}, \rho_i, \rho_{t_i}, \ldots)$
	4	Find first corrector, $\bar{p}_i = p_{i-1} + 0.5\Delta s(p_{s_{i-1}} + p_{s_i})$
Second corrector	5	Numerically differentiate $\bar{p}_i$ along t
	6	Find $\bar{p}_{s_i} = f(\bar{p}_i, \bar{p}_{t_i}, \bar{\rho}_i, \bar{\rho}_{t_i}, \ldots)$
	7	Find $\bar{\bar{p}}_i = p_{i-1} + 0.5\Delta s(p_{s_{i-1}} + \bar{p}_{s_i})$
Predictor for next step	8	Numerically differentiate $\bar{\bar{p}}_i$ along t
	9	Find $\bar{\bar{p}}_{s_i} = f(\bar{\bar{p}}_i, \bar{\bar{p}}_{t_i}, \bar{\bar{\rho}}_i, \bar{\bar{\rho}}_{t_i}, \ldots)$
	10	Predict $p_{i+1} = p_{i-1} + 2\Delta s\bar{\bar{p}}_{s_i}$

(14)

In this process $f(p_i, p_{t_i}, \rho_i, \rho_{t_i}, \ldots)$ is the function obtained by solving for the matrix $[B]$ in equation (8).

Convergence

The question of convergence is generally considered in two parts. First, as the mesh size is reduced, do the difference equations converge to the differential equations; and second, assuming they do, does the calculation procedure itself converge throughout the region of application? The complexity of the governing equations makes the answer to these questions

impossible from a purely mathematical approach. We are more fortunate, however, when viewing the situation from the physical side. With regard to the first question, if the difference equations do not reduce to the specified differential equations, then they must reduce to some set of differential equations which violate one or more of the conservation laws. But there are independent checks of whether or not these laws have been violated. For example, the body surface is located by the condition of mass conservation and if momentum or energy is not conserved (which amounts to adding or absorbing heat) the entropy and total enthalpy calculated at the body location would not be constant. These conditions were checked, and for the solutions presented, entropy was constant (to an accuracy consistent with the calculations) along streamlines, and the total enthalpy was constant throughout the flow. These are independent checks since entropy and enthalpy are not used in calculating the flow field. They allow us to be reasonably certain that the results of the finite difference methods employed do correctly represent solutions to equations (1) through (4).

We treat the answer to the second question, that is, whether or not the calculation procedure itself converges, by the following argument. If the calculations give answers that are physically consistent (e.g., satisfy the conditions mentioned above) and are not significantly affected by change in mesh size, we assume they have converged and represent a correct answer. Procedures that diverge are discussed in the next section.

Stability and Divergence

We seek to study the flow properties behind a prescribed shock given the flow properties ahead of it. Mathematically this amounts to the study of an initial value or Cauchy type problem. If we are, in fact, seeking a specific body shape behind the shock, then we are attempting, in mathematical terms, to replace a boundary-value problem with an initial-value problem. The difficulties arising from such an attempt lead to some of the most fundamental problems in the numerical treatment of both partial and total differential equations. Discussions of these difficulties as they specifically pertain to the inverse, blunt-body problem have already reached the textbook stage (see, e.g., ref. 19). We repeat some of this discussion in order to develop some points we wish to clarify.

In the study of equations (1) through (4) by means of equations (14), numerical instabilities are easy to detect once they have started. The boundary of their onset separates regions where the variables are at least physically possible from regions where they fluctuate beyond all reason (negative pressures, densities, etc.). The complexity of the problem makes complete mathematical rigor in these studies practically impossible, and one is forced to rely on experience with linearized equations and familiarity with the physical problem for help in making the arguments plausible. Nevertheless, an attempt is made to identify all the difficulties encountered in this study with one of the following categories (see ref. 20 for terminology and further background):

1. Inherent instabilities

   (a) Due to ill conditioning (nonessential)

   (b) Due to singularities (essential)

2. Induced instabilities

Consider the two main categories. Inherent instabilities are brought about because the differential equations themselves contain an unstable (exponentially growing) solution in the direction of one independent variable while remaining bounded in the other, or because the differential equations contain a solution that is singular. Such instabilities are not caused by the finite differencing. Induced instabilities are brought about by the particular numerical techniques employed, mesh size, degree of truncation, implicit or explicit methods, etc., and can lead to implications quite spurious with regard to true solutions to the partial differential equations.

Discussion of inherent instabilities.- For convenience, the two different kinds of inherent instabilities mentioned above will be referred to as essential and nonessential. The terminology is, perhaps, not apt because what is referred to as an essential instability is actually caused by the appearance of a singularity or group of singularities in the flow region between the shock and body. These singularities are invariant to coordinate transformations and represent the locations of sources or sinks that would appear in an exact analytic solution behind an analytic shock. Nevertheless, we refer to the numerical behavior caused by them as an instability because of its similarity in appearance to other numerical phenomena which are identified by that term.

The important distinction between an essential and a nonessential instability is that the latter would not occur in an exact analytic solution. What we refer to as nonessential instabilities are started by round-off, truncation or end-of-array inaccuracies due entirely to the fact that numerical methods are employed. In most of the literature pertaining to the stability of partial differential equations, the statement is made or implied that initial value data are always unsuitable for elliptic equations (see ref. 21). In our terminology it is the existence of nonessential instabilities that leads to this conclusion, a conclusion that is valid if such instabilities cannot be controlled.

A great deal has been written on the effect and control of (what we have defined as) nonessential instabilities. So far as the authors know, all of the reported discussion attempting to identify these instabilities with the local form of the governing equation (elliptic, parabolic, or hyperbolic) have been limited to the elliptic or subsonic region. Although nonessential instabilities could be detected in the subsonic portion of the flow field if the numerical differentiation in the t direction was of very low order and no smoothing was used, no difficulties were encountered in this area in the studies being reported. The really critical area for instability was located in the supersonic portion of the flow, roughly in the shaded region

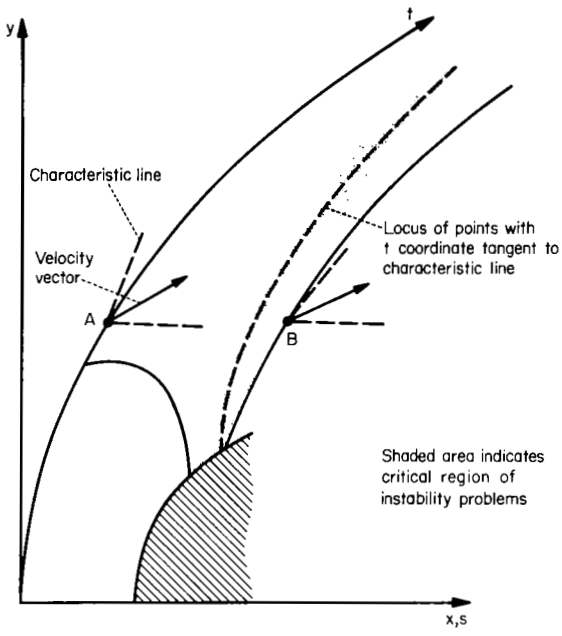


Figure 4.- Sketch of flow field showing critical region of instability problems.

in figure 4. In fact, in this region it was possible to isolate all three of the major types of instabilities listed above. (We should mention at this point that the difficulties inherent in the asymmetric differentiation formulas used at the upper end of the arrays often accentuate the breakdown, but they are not the cause of an instability.)

Mathematical definitions and implications.- Consider the flow behind the shock in the area where it is supersonic. As we march inward from one t coordinate to the next, we are perpetrating an initial value problem. Let us use the term properly set in the usual way; that is, Cauchy data (function and derivative) are properly set for the wave equation along the $t = 0$ axis, and Neumann or Dirichlet data (function or derivative) are properly set for Laplace's equation. Usually, stability proofs for hyperbolic equations stem from the assumption that initial values or Cauchy data are properly set. Hadamard (ref. 21) pointed out (and it is well known in studies of supersonic wing theory) that according to how the line carrying the initial data crosses each characteristic, Cauchy data may or may not be properly set for a hyperbolic equation. By Hadamard's terminology, a data line is duly inclined if Cauchy data are properly set, and nonduly inclined if they are not. One can easily show that a shock is a nonduly inclined surface in the region where the flow is supersonic behind it (see point A, fig. 4), and Cauchy data are, therefore, nowhere properly set along it. In fact, the t coordinate continues to be nonduly inclined until the upgoing characteristics lie to its right as is shown at point B in figure 4.

If we consider the linearized wave equation for the velocity potential, φ, in the form

$$\varphi_{xx} - \varphi_{yy} - \varphi_{zz} = 0$$

and admit only bounded disturbances in a y,z plane at $x = x_o$ (see fig. 5(a)), we have terms of the form

$$\varphi = e^{i\beta y} e^{i\gamma z} e^{\alpha(x-x_o)}$$

where α is given by the expression

$$\alpha = \pm i\sqrt{\beta^2 + \gamma^2}$$

Such solutions, which stem from duly inclined data planes, are everywhere inherently stable since φ also remains bounded in the x direction. On the other hand, bounded data given in the x,y plane at $z = z_o$ (see fig. 5(b)) give terms of the form

$$\varphi = e^{i\alpha x} e^{i\beta y} e^{\gamma(z-z_o)}$$

where γ is determined by the expression

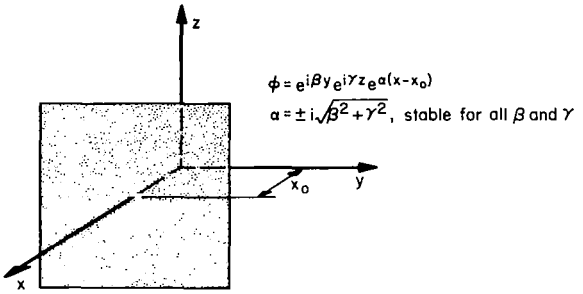
$$\gamma = \pm i\sqrt{\alpha^2 - \beta^2}$$

If $\beta > \alpha$, solutions for this nonduly inclined data exhibit nonessential inherent instabilities.

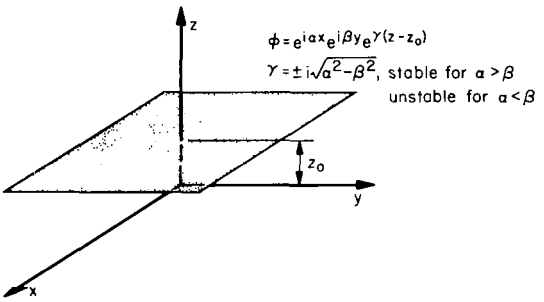
Actually the axisymmetric form of the linearized wave equation

$$\varphi_{xx} - \varphi_{yy} - \frac{1}{y}\varphi_y = 0$$

has no solutions that are inherently unstable, regardless of the inclination of the data plane. On the other hand, the wave equation



(a) Bounded disturbances in y,z plane.



(b) Bounded disturbances in x,y plane.

Figure 5.- Illustration of stability results for wave equation, $\varphi_{xx} - \varphi_{yy} - \varphi_{zz} = 0$.

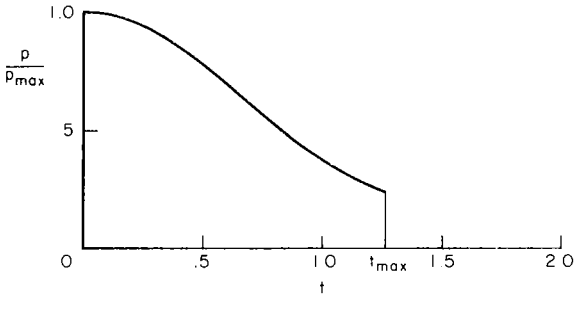
$$\varphi_{xx} - \varphi_{yy} - a\varphi_y = 0$$

where a is a constant greater than zero, is stable for nonduly inclined data, and unstable for duly inclined data! (The two previous cases are examples of local or "weak" instability not resulting in over-all or "strong" instability.) The principal point being made here is that the nonlinear equations governing the flow field may have inherent instabilities in the supersonic as well as in the subsonic regions. In fact much of the numerical discussion, as well as most of the criticism, of the inverse method concerns the existence and manner of treatment of the nonessential instabilities. The argument usually posed by those who use the inverse method is, simply, that the gas layer between the shock and body is thin enough that the errors caused by numerical calculations cannot grow sufficiently large to invalidate the first few significant figures in the results. In this report we hypothesize that this argument is sufficient to validate those cases for which the solution passes the consistency checks on total enthalpy and entropy mentioned in the previous section.

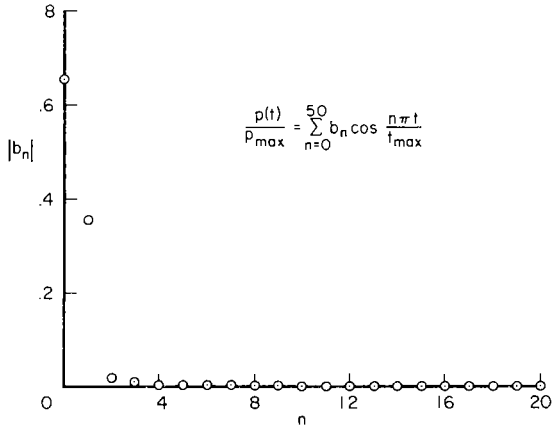
Absolute reliance upon the hypothesis just mentioned is not always satisfactory in application, and is certainly not satisfactory from a theoretical point of view. Basically, the validity of such a hypothesis is coupled with the word size (number of significant figures carried in each arithmetic operation and stored in memory) available in the computing machine. It is not always wise to demand larger computing capacity merely to push ahead a few more steps before exponentially growing instabilities started by numerical truncations swamp the first few significant figures in the calculations. A more sensible approach is to face the problem with analysis and attempt to suppress nonessential instabilities by appropriate numerical methods. One such method, that has been used by several authors (see refs. 14 and 19), is to "smooth" or filter the data along each t coordinate as the computations proceed. Since this method appears to be extremely useful, we shall discuss it in some detail.

Filtering.- Consider the variation of pressure along a t coordinate and behind a curved shock as shown in figure 6(a). Let us expand the pressure distribution in a Fourier series between the maximum absolute values of t used in the calculations; thus

$$\frac{p(t)}{p_{max}} = \sum_{n=0}^{50} b_n \cos \frac{n\pi t}{t_{max}} \qquad -t_{max} < t < t_{max} \tag{15}$$



(a) Pressure distribution.



(b) Fourier coefficients.

Figure 6.- Harmonic analysis of pressure distribution just behind bow shock wave.

The magnitudes of the coefficients are shown in figure 6(b). We see that the first few terms dominate the expansion; and higher order terms, corresponding to higher frequencies, are negligible. Next we assume that a Fourier expansion for any of the dependent variables over the same interval along any t coordinate between the shock and the body would exhibit the same general behavior, that is, could be expressed with acceptable error by the first few terms in a Fourier expansion.

The above assumption certainly warrants some discussion. However, to attack it simply on the basis that it arbitrarily prohibits high-frequency terms in the true solution is not justifiable, since any method using finite difference techniques is subject to such a criticism *per se*. In fact, it is a fundamental theorem

in communication theory (see ref. 22) that the highest resolvable frequency in any finite trigonometric series to be represented by a discrete number of points is related to the number of points themselves. Consequently, if more points are used than are required to resolve the highest frequency, the remaining points carry redundant information. The real assumption, then, is not that we arbitrarily exclude high-frequency terms, this being the case for numerical calculations in any event, but rather that we can take enough mesh points to make data contained in them largely redundant in the sense just mentioned. (Although we do not discuss it further here, certain coordinate transformations optimize this procedure.) Under these circumstances, high-frequency terms, appearing from more or less random errors brought about by numerical truncation in calculations made at discrete points, fall above the frequency range required to express the true solution and can be excluded if the proper numerical filter is applied. The following discussion briefly describes such a filter.

Let us consider an even function $F(x)$ that can be represented by a Fourier cosine series in the interval $0 \leq x \leq L$. Thus

$$F(x) = \sum_{m=0}^{\infty} a_m \cos \frac{m\pi x}{L} \tag{16}$$

Now define the operator f_j by the equation

$$f_j(F) = \frac{1}{2} [F(x + jh_o) + F(x - jh_o)]$$

where h_o is the spacing of the points in the x direction. Letting V_j be arbitrary weighting factors, the sequence of operations

$$\sum_{j=0}^{J} V_j f_j$$

applied to equation (16) results in the expression

$$\overset{(1)}{F}(x) = \sum_{j=0}^{J} V_j f_j(F) = \sum_{m=0}^{\infty} A_m \cos \frac{m\pi x}{L} \tag{17a}$$

where

$$A_m = a_m \sum_{j=0}^{J} V_j \cos \frac{jm\pi h_o}{L}$$

If we define a polynomial, P_f, such that

$$P_f = \sum_{j=o}^{J} V_j \cos \frac{jm\pi h_o}{L}$$

then we can write equation (17a) as

$$\overset{(1)}{F}(x) = \sum_{m=o}^{M} P_f a_m \cos \frac{m\pi x}{L}$$

It is evident that n repetitions of the operation results in the expression

$$\overset{(n)}{F}(x) = \sum_{m=o}^{M} P_f^{\,n} a_m \cos \frac{m\pi x}{L} \tag{17b}$$

A study of equation (17b) leads to the following conclusions:

1. If the function $F(x)$ is replaced by certain weights of its average at equally spaced intervals to the right and left of x (i.e., applying the operator $\sum_{j=o}^{J} V_j f_j$), the coefficients in its Fourier expansion are multiplied by P_f. Further, if the operator is applied n times, each coefficient is multiplied by the nth power of P_f.

2. The magnitude by which each coefficient is affected is independent of x. It depends only on the arbitrarily assigned weights V_j and the factor $m\pi h_o/L$.

3. Define a new parameter, z, in terms of the point spacing, h_o, as follows:

$$z = 1 - \cos \frac{m\pi h_o}{L}$$

Now consider that a polynomial in z can be found for the interval $0 \leq z \leq 2$. Let its coefficients, W_j, be defined by the relation

$$\sum_{j=o}^{J} W_j z^j = \sum_{j=o}^{J} V_j \cos \frac{jm\pi h_o}{L}$$

Multiple applications of the above operations amount to forming the polynomial, $P_f^{\,n}$, in equation (17b). They will leave the harmonics for which

$0 \leq z \leq z_1$ unchanged and will destroy all harmonics for which $z_2 \leq z \leq 4 - z_2$. Harmonics for which $z_1 < z < z_2$ will be distorted according to the nature of the polynomial (see fig. 7(a)). Specifically, if

$$\frac{m_1}{L} = \frac{1}{\pi h_o} \cos^{-1}(1 - z_1)$$

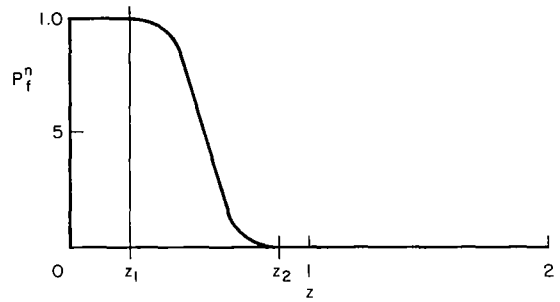
$$\frac{m_2}{L} = \frac{1}{\pi h_o} \cos^{-1}(1 - z_2)$$

harmonics below m_1 will be undistorted and those above m_2 (except for very high frequencies) will be destroyed.

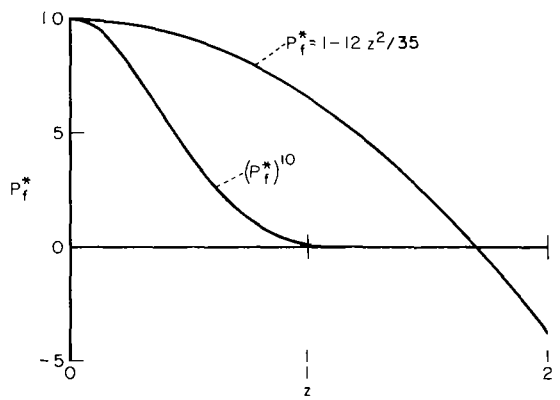
In our application, h_o is unknown. We simply assume an L exists for which our numerical results can be expressed with acceptable error below some m_1/L and for which our numerical procedures will introduce errors that lie above m_2/L. Numerical experimentation with the spacing h and the polynomial form of P_f have verified that this is so.

The actual polynomial used for the results presented is

$$P_f^* = 1 - \frac{12}{35} z^2 \qquad (18)$$



(a) Typical polynomial filter.

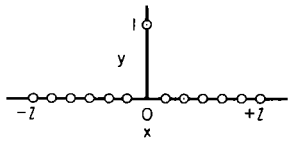


(b) Filter used in present report.

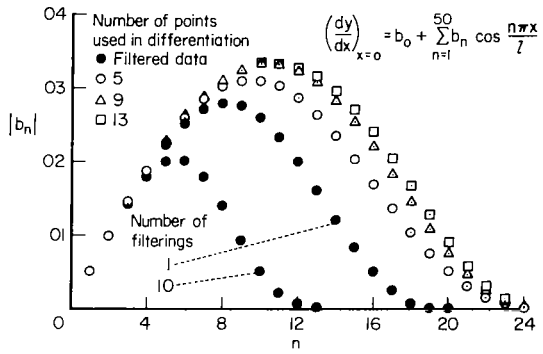
Figure 7.- Effect of filtering on harmonic function.

Each application of P_f^* amounts to moving the central point in a group of five to the curve obtained by fitting a least-squares quadratic to them (see ref. 23, p. 318). The effect of applying P_f^* over a range of frequency to spacing ratios is illustrated in figure 7(b) and presented also in reference 24. The sharper filter, $(P_f^*)^{10}$, is also shown in the figure.

The use of numerical filters of this type can be contrasted to the use of higher order numerical differentiating processes. Consider, as shown in figure 8(a), a set of data all zero except for one "bad" point. These data were numerically differentiated by central difference schemes and the results harmonically analyzed. The results given in figure 8(b) show that with higher order difference methods the amplitudes of higher frequency terms are increased and the over-all maximum amplitude itself is increased. On the other hand, a five-point difference scheme followed by repeated filtering, of the type just described, has the opposite effect. This does not mean, of course, that relative to low-order schemes, high-order differentiating



(a) Set of data with one "bad" point.



(b) Harmonic analysis of data after differentiation and filtering.

Figure 8.- Effect of differentiation and filtering on data.

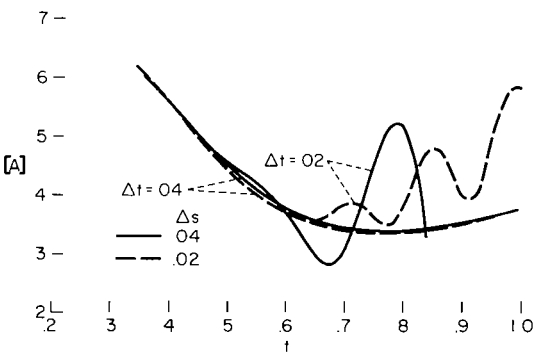


Figure 9.- Effect of interval size on determinant [A] in equation (9).

processes are inferior. Their value comes in reducing the initial error. (Even this, however, depends upon the number of significant figures carried in the calculation. See, e.g., ref. 17.) But once this error has been committed, the higher order methods are of no value in controlling its effect on the stability.

Examples of inherent instabilities.- We now present an example of an inherent instability. Four curves are shown in figure 9, one corresponding to each of the four possible combinations of two spacings for Δs and Δt. The quantity plotted is the magnitude of the determinant [A] in equation (9), the value of which is, of course, critical in evaluating the s derivatives of the dependent variables. (Actually, any one of the dependent variables could be used to display the same result.) The points are located along a t coordinate in the supersonic region above the body and downstream from the shock. Notice that the instabilities have no correlation with the ratio of $\Delta t/\Delta s$ (all other conditions were held constant), but rather with the absolute value of Δt. For the larger Δt no fluctuations at all are observed, whereas, for the smaller Δt, unstable oscillations begin at a t of around 0.6, and the distance between successive maxima and minima is about five times the Δt interval size.

An explanation of this behavior can be proposed by applying the results shown in figure 7. The z (eq. (18)) in figure 7(b) corresponding to the smaller t spacing is about 0.2, at which value P_f^* is about 0.99 for one application of the filter and about 0.90 for 10 successive applications. Hence, the amplitude of a term with the frequency corresponding to the oscillating curves presented in figure 9 is only slightly damped by the filter represented in figure 7(b). A corresponding study for a value of z equal to 0.7 (representing the larger t spacing in figure 9) shows that the same frequency would be heavily damped, especially for multiple applications of the filter.

This is considered to be a typical case of a nonessential instability. Since it can be controlled, the term nonessential appears to be appropriate. The extent of the curves shown in figure 9 was well within the region where the t coordinates in the supersonic flow are nonduly inclined (a region defined by the inequality $[A] > 0$).

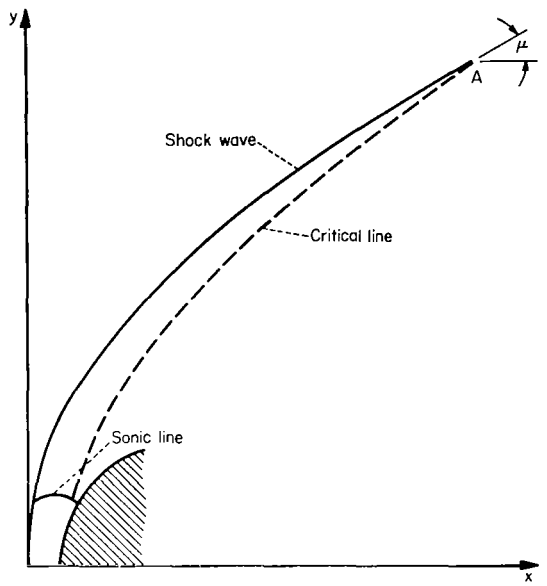


Figure 10.- Sketch of flow field with essential instability.

We next present an example of an inherent instability which we have classified as essential. The authors attempted to find the body following an elliptic shock because references 8 and 14 gave solutions for a series of shocks that were portions of conic sections. For the particular case chosen, the calculations showed violent fluctuations just as the sonic line met the body. Since it was necessary to obtain data in the supersonic region in order to start a characteristic solution, this situation could not be tolerated. As more and more attempts were made to force the solution into the supersonic region near the body, using various smoothing processes similar to and including the one just described, it became increasingly clear that the kind of instability illustrated in the previous example was not at the root of the trouble. A total of five different kinds of smoothing and four different kinds of end-of-array controls were tried. The flow fields were examined and in each case a line was constructed past which the fourth difference of the density along a t coordinate began to fluctuate violently. Values of Δt and Δs were also varied but, not only were all cases unstable, all of the lines dividing the unstable from the stable area fell within a narrow band. Finally the length up the shock, along which the initial data were given, was greatly extended and this critical line was discovered to intersect the elliptical shock where the shock became tangent to a free-stream Mach line, point A in figure 10.

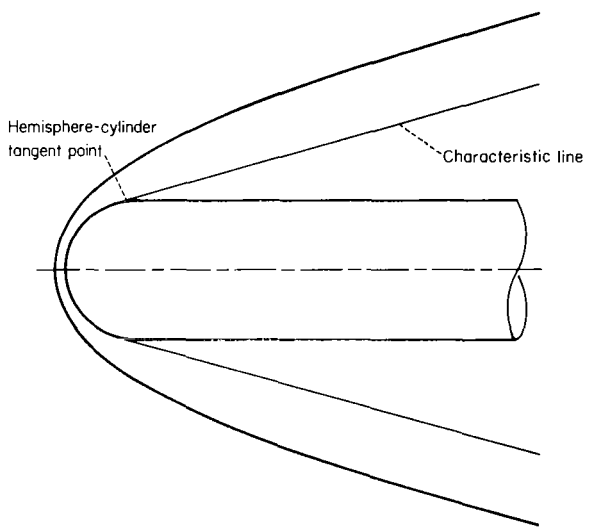


Figure 11.- Sketch of flow field showing characteristic line emanating from tangent point.

In retrospect, the situation is clear. Consider the case shown in figure 11 which represents the actual shock caused by some blunt-nosed cylinder. We hypothesize (see Lighthill in ref. 25, p. 440) that the slope of the

entire shock all the way to infinity is determined entirely by the shape of the nose ahead of its point of tangency with the cylindrical afterbody. Only at infinity does the shock become tangent to a free-stream characteristic or Mach line. If we were to construct an elliptic shock, then, not only must we provide some sort of sink sheet in the region behind the critical line in figure 10, but no matter how far (in terms of a unit body diameter) away point A might be, the sink line would extend into the nose region. In actual practice (e.g., in fig. 10) point A is far above the largest value of t used. Nevertheless, a basic postulate of the inverse method depends upon the validity of analytic continuation, and the existence of the singular region is contained in the shock data all the way down to the axis of symmetry. An accurate solution must contain these singularities for they are a true solution to the flow field following an elliptic shock. Hence, and it is to be emphasized, elliptic shocks were not used for the solutions presented in this report. Subsequently, the authors found that Schwiderski (ref. 15) has discovered the same result and has even analyzed the asymptotic behavior of the singular characteristic when it intersects the shock at large distances from the body.

For the practical purpose of constructing the flow about blunt bodies, this kind of singularity and its attendant essential instability is an unwanted by-product of the inverse method. Shocks that are exactly elliptic up to point A in figure 10 simply do not occur ahead of blunt bodies in source-free flow.[3] The difficulty is easily overcome, however, simply by starting with an analytic shock shape that is not elliptic and never becomes tangent to a free-stream Mach line. Actually, the shock equation used in this report asymptotically approaches twice the slope of a free-stream Mach line; and, by means of its use, essential instabilities such as that just exemplified disappear. The question of just how close the shock can come to the free-stream Mach line and just how it should behave at infinity does not have to be settled for most bodies, because we need only to enter the supersonic region far enough to provide information which can be successfully continued by the method of characteristics. Usually this means that the body shape need conform to its desired value only up to a point where the local Mach number is around 1.05 to 1.15. Past this point we imagine the body to be expanding in the form of a cone, the exact shape of which is immaterial. The importance of this concept lies only in the fact that analytic shock equations for such bodies with source-free flow ahead of the limiting characteristic are not difficult to construct.

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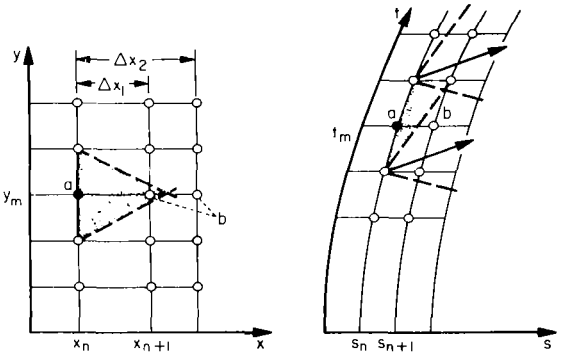
[3] This does not mean the results given in references 8 and 14 are not valid. The body shape and the variables on the body were determined by extrapolating inward from the smooth portion of the flow. Where comparisons were made, these published results differed only slightly from the results calculated using the shock shapes described in a later section of this report. These differences were limited to the final points in the transonic region, see figure 17.

Induced instabilities.- The instabilities discussed above existed because of the nature of the differential equations. They would actually have existed in a frictionless flow if the boundary conditions were exactly reproduced. Another kind of instability arises which is caused by the particular choice of numerical procedure. This kind of instability we refer to as an induced instability, and it can presumably be eliminated by the proper choice of coordinates, mesh size, and differencing technique.

The study of the stability of difference methods, as they apply to hyperbolic equations, usually pertains to the continuation of Cauchy data given along a duly inclined line. The criterion given for the stability of the simplest explicit difference equation (see, e.g., ref. 20) is illustrated in figure 12. The equation is based on a three-point central-difference formula written about the point m,n for the first derivatives in both directions. Given equally spaced data along column n, the method is stable if, as we proceed from point a to point b in figure 12(a), the columns are spaced by Δx_1 and unstable if spaced by Δx_2. The condition for stability is related, simply, to whether the point at the mth row and $n + 1$ column does or does not lie in the shaded area bounded by the characteristics shown. If this criterion were to apply to our case (when the nth column became duly inclined), point b in figure 12(b) would have to fall in the shaded region shown. Actually our case is much more complicated. A five-point difference scheme is used along the columns and, after smoothing, two corrector equations are applied.



(a) x,y plane. (b) s,t plane.

Figure 12.- Sketch of conditions for stability.

Coupled with the ever present nonlinear form of our basic equation, these complications make a stability analysis of the situation quite involved. However, it was observed that whenever the flow crosses into a region where a t coordinate is duly inclined, the calculation becomes unstable.[4] For the cases presented in this report, this crossing only occurs in the high supersonic region so no attempt was made to control it. The line along which the crossover occurs simply becomes a boundary past which calculations were not continued.

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[4] When the t coordinate changes from a nonduly to a duly inclined line, the value of $[A]$ in equation (9) passes through zero. Since $[A]$ is the denominator in the equation for the forward-marching derivatives, this can lead to difficulties in numerical methods (although, of course, the numerators also must vanish). As was the case for the end-of-array, asymmetric, numerical differentiation this occurrence may help start the growth of instability but it is not the cause of it.

This way of treating such an instability is only an expedient. Blunter bodies and solutions at lower Mach numbers demand that these instabilities be controlled. Studies to this effect are continuing.

RELATING THE SHOCK AND BODY SHAPES

If we assume that all the stability and convergence problems can be controlled where necessary, the real success of the inverse method still depends upon the ability to find some relationship between families of shock and body equations. In other words, it depends upon the ability to formulate a shock equation that can be systematically modified to a point where it yields a given body to a prescribed accuracy. The following method was used in this report.

As was pointed out in the Numerical Analysis section, elliptical or spherical shock shapes introduce singularities into the flow field which can cause essential instabilities to occur in the low supersonic region near the body. In order to avoid these difficulties, the equation

$$X(y) = \frac{\sum_{n=1}^{12} A_n y^{n-1}}{\sum_{n=1}^{12} B_n y^{n-1}} \tag{19}$$

is used for the shock variation. This equation is simply a ratio of polynomials.

Since the body shape and size corresponding to the given shock are not known at this time, it is convenient to reference the x,y coordinates to R_s, the radius of curvature of the shock wave at $y = 0$.

Most body shapes of interest are conics or can be approximated by one. The general equation for a conic can be written in terms of the present coordinate system as

$$\frac{y^2}{2(x - \Delta)} + \frac{1}{2} B_b(x - \Delta) = R_b \tag{20}$$

where Δ is the shock standoff distance, B_b is the body bluntness parameter, and R_b is the radius of curvature of the body at $y = 0$. The only conics considered in this report are ellipsoids which include a sphere and a paraboloid as special cases. The relationships between the body shape parameters are (fig. 13):

Body shape	B_b
Ellipsoid	$(b/R)^2$
Sphere	1
Paraboloid	0

In relating the body shape to the shock shape, two factors must be considered. First, the ratio, R_b/R_s, which relates the size of the calculated body to the shock shape must be determined, and, second, the closeness of fit of the calculated body points to the desired body shape characterized by B_b must be determined. The following procedure is used in the present method.

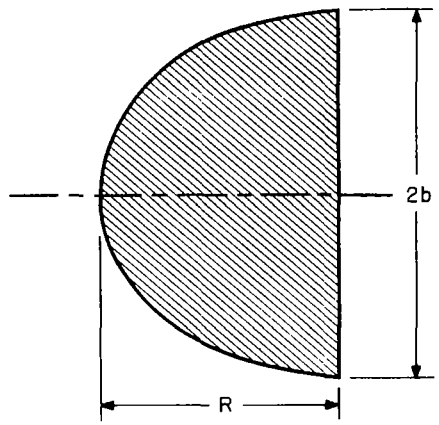


Figure 13.- Sketch of ellipsoid.

1. Values for the shock shape parameters are assumed, and the flow field is calculated including the body shape.

2. The body coordinates[5] for surface Mach numbers between 0.5 and about 1.05 are substituted into the left side of equation (20) and plotted against $(x - \Delta)/R_s$. These points are fitted with a horizontal straight line that minimizes Σ_o, the sum of the absolute differences between the points and the line. The ordinate of the line is the ratio, R_b/R_s, and the sum of the absolute differences is a measure of the closeness of fit to the desired conic.

3. Any given parameter in the shock equation can be changed by a specified increment until Σ_o is minimized.

4. This procedure is repeated, if necessary, for the other shock parameters.

Each iteration requires approximately half a minute on an IBM 7090 for a real gas and less time for a perfect gas. The success of this method and the details of its application to specific bodies for given free-stream conditions are discussed in the next section.

RESULTS AND DISCUSSION

Spheres for a Perfect Gas

Since shock-wave shapes for hemisphere-cylinders in a perfect gas have been studied extensively, both experimentally and theoretically, this problem is logically one of first concern. Some experimentation with equation (19), using the method outlined, showed the rather remarkable fact that

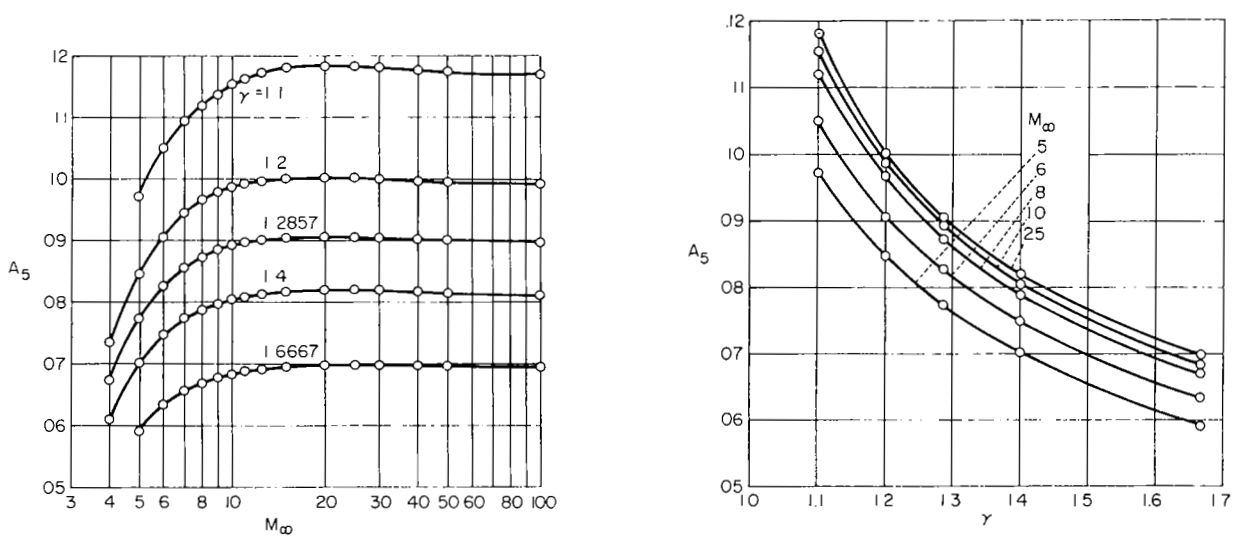
[5]The body coordinates for Mach numbers less than 0.5 are ignored because they generally lie on a circular arc and because of the scatter introduced by small values of the denominator, $x - \Delta$, in the first term of equation (20).

spherical-nosed, axisymmetric bodies are produced to a high degree of accuracy (at least as accurate as a spherical representation of the earth) by the simple, one-parameter equation

$$\frac{X}{R_S} = \frac{0.5\left(\frac{y}{R_S}\right)^2 + A_5\left(\frac{y}{R_S}\right)^4}{1 + \frac{2A_5}{\sqrt{M_\infty^2 - 1}}\left(\frac{y}{R_S}\right)^3} \tag{21}$$

where A_5 is the shock-wave parameter. This equation is valid for free-stream Mach numbers greater than 5 for γ from 1.1 to 1.6667. The numerator of equation (21) represents the first two terms for the series expansion of a conic section. The denominator provides that for large distances from the nose, the shock slope is twice the Mach line slope. This condition was imposed to avoid essential instabilities, but it does not necessarily prevent the shock angle from becoming smaller than the Mach angle in some intermediary region.

Values of the shock-wave parameter, A_5, for a sphere are shown in figure 14. Since the method used to optimize A_5 depends slightly on the magnitude of the step size, Δs, a standard value of $\Delta s = \Delta/7.1$ was used.



(a) A_5 vs. M_∞

(b) A_5 vs. γ

Figure 14.- Shock-wave parameter for sphere.

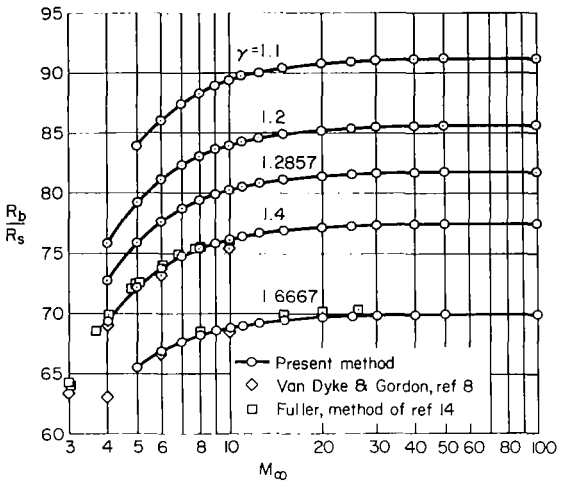
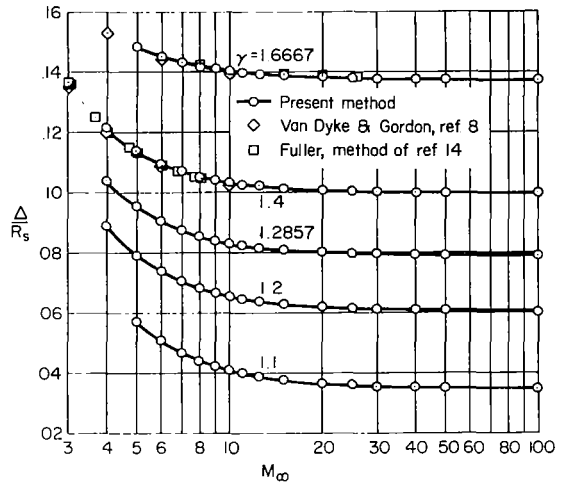


Figure 15.- Ratio of nose radius to shock radius for sphere.

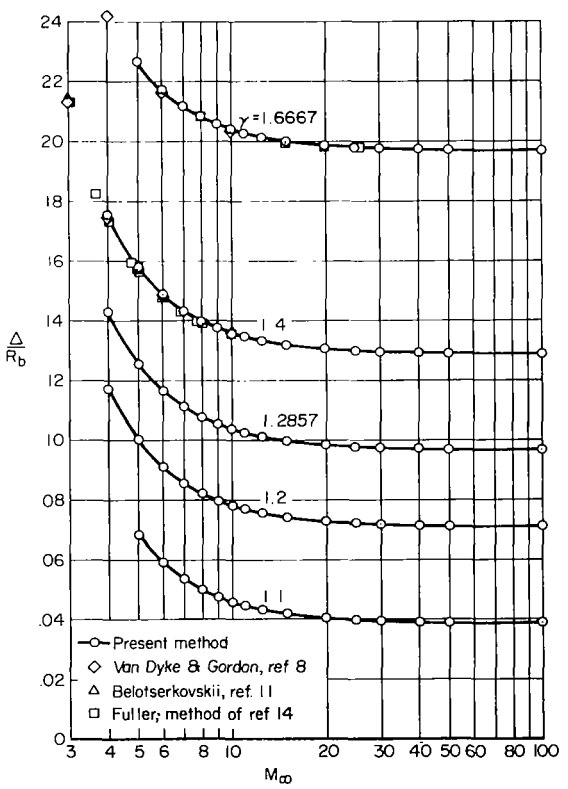
The ratio of nose radius to shock radius is shown in figure 15, and the shock standoff distance in terms of shock radius and nose radius is shown in figure 16. The corresponding results of Van Dyke and Gordon (ref. 8), Fuller (method of ref. 14),[6] and Belotserkovskii (ref. 11) are shown for comparison.

It was noted in reference 26 that the surface pressure distribution in the transonic region of a sphere obtained by the Fuller method showed deviations from experiment and that this resulted in a discontinuity in the slope of the surface pressure distribution when the flow-field calculations were continued with the method of characteristics. This difficulty is believed to be caused by the singularities brought about by the use of an elliptical shock. As a typical example, the pressure distribution on a sphere for $M_\infty = 10$ and $\gamma = 1.4$ is shown in

[6]Although only two-dimensional results are reported in reference 14, the method is applicable to axisymmetric flow also. Some of these results are shown in reference 26.



(a) Δ/R_s



(b) Δ/R_b

Figure 16.- Shock standoff distance for sphere.

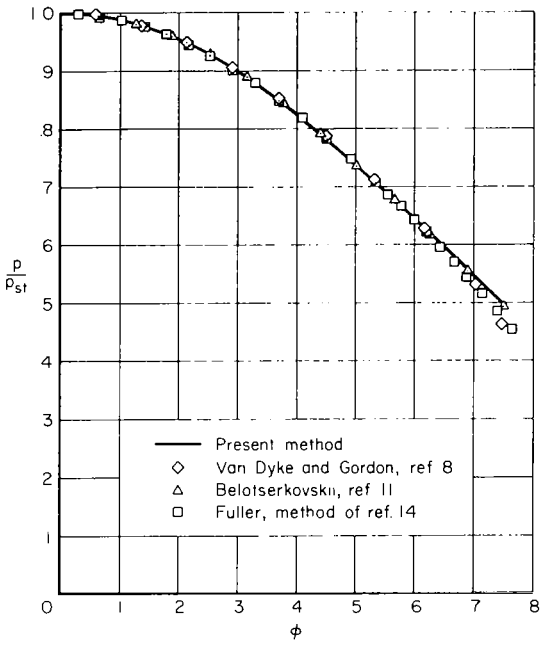


Figure 17.- Theoretical pressure distribution on sphere; $\gamma = 1.4$, $M_\infty = 10$.

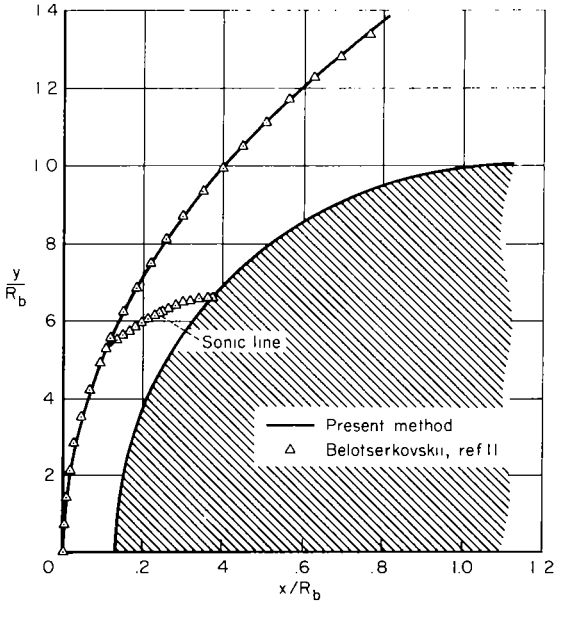


Figure 18.- Shock-wave shape and sonic line for sphere; $\gamma = 1.4$, $M_\infty = 10$.

figure 17. The results of the present method are in good agreement with Belotserkovskii's results, whereas the results of Van Dyke and Gordon and Fuller's method yield lower pressures in the transonic region. Comparisons with Belotserkovskii's results for the shock shape and sonic line are shown in figure 18.

The validity of the blunt-body solution has been demonstrated in previously published comparisons with experimental measurements of shock standoff distance, shock shape, and surface pressure distribution (e.g., refs. 8 and 26). Flow-field properties between the body and shock wave have been determined by Sedney and Kahl (ref. 27) from interferograms of spheres in free flight. A comparison of measured and calculated constant density lines is shown in figure 19

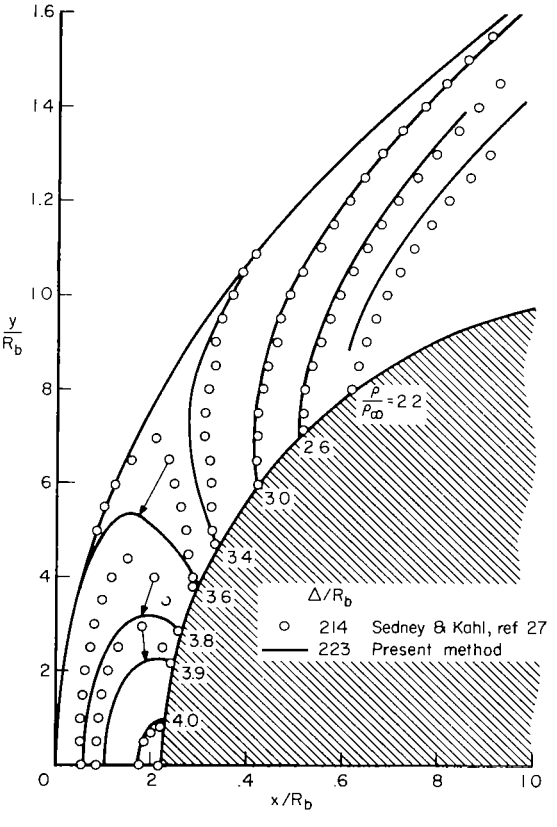
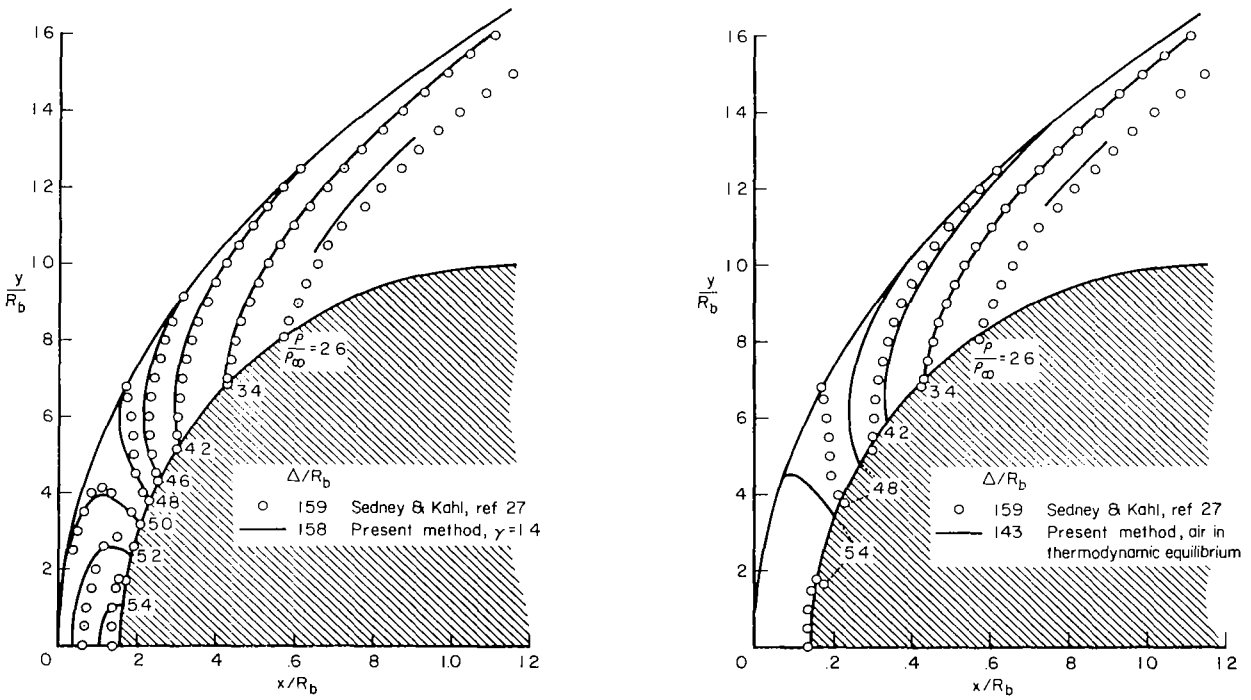


Figure 19.- Constant-density lines for sphere in argon; $\gamma = 1.6667$, $M_\infty = 5.329$.

for argon with $M_\infty = 5.329$ and in figure 20 for nitrogen with $M_\infty = 5.017$. For argon, the comparison is poor in the stagnation region. In fact, the calculated shock standoff distance is 5 percent greater than the measured value. Since the shock standoff distance depends strongly on γ, it is possible that the argon used in the tests was slightly contaminated with air. For nitrogen, the constant density lines and shock standoff distance calculated for $\gamma = 1.4$ compare well with the measurements as shown in figure 20(a). This result supports the conclusion of Sedney and Kahl that the vibrational states of nitrogen were not excited. This conclusion is also supported by the poor agreement with the real-gas calculation shown in figure 20(b). This calculation method, which will be discussed next, assumes the gas properties to be those of air in thermodynamic equilibrium.



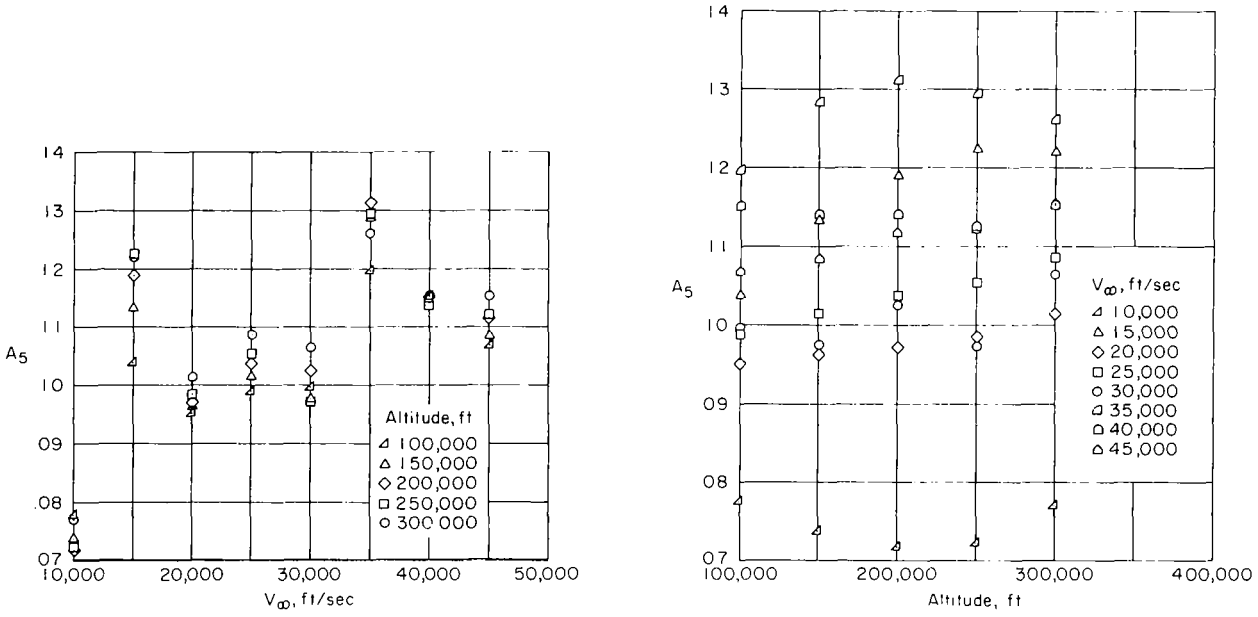
(a) Perfect gas calculation.

(b) Real-gas calculation.

Figure 20.- Constant-density lines for spheres in nitrogen; $\gamma = 1.4$, $M_\infty = 5.017$.

Spheres for a Real Gas (Air in Thermodynamic Equilibrium)

The same one-parameter family of shock shapes obtained for a perfect gas has also been found to be applicable for real-gas calculations for air in thermodynamic equilibrium. Values of A_5 have been obtained for the velocity range from 10,000 to 45,000 ft/sec and for the altitude range from 100,000 to 300,000 feet as shown in figure 21. This range of solutions includes the effects of dissociation of oxygen and nitrogen and the effects of ionization. The atmospheric properties were obtained from reference 28.



(a) A_5 vs. velocity.

(b) A_5 vs. altitude.

Figure 21.- Shock-wave parameter for sphere.

The ratio of nose radius to shock radius is shown in figure 22, and the shock standoff distance is shown in figure 23. The shock standoff distance can be correlated with the density ratio ρ_∞/ρ_{st} as shown by Ridyard (ref. 29). The present results for both a real and a perfect gas are shown in figure 24. Values of the local isentropic exponent, $\gamma = a^2\rho/p$, for stagnation-point conditions are shown in figure 25.

The shock-wave shape parameters and stagnation-point conditions for all the solutions are presented in table I. Body data and shock wave and sonic line coordinates for all the solutions are presented in table II. In addition, table II includes flow-field data between the body and shock wave on a line normal to the body at the point where $M = 1.05$. These data can be used as inputs for a method of characteristics program to calculate the flow in the supersonic region. It is noted that for the highest speeds and lowest altitudes, the stagnation temperature exceeds 27,000° R, the limit for the thermodynamic data used. The total enthalpy error in this region becomes as large as 5 percent.

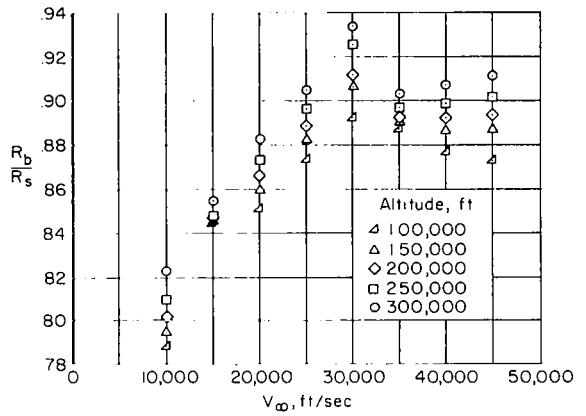
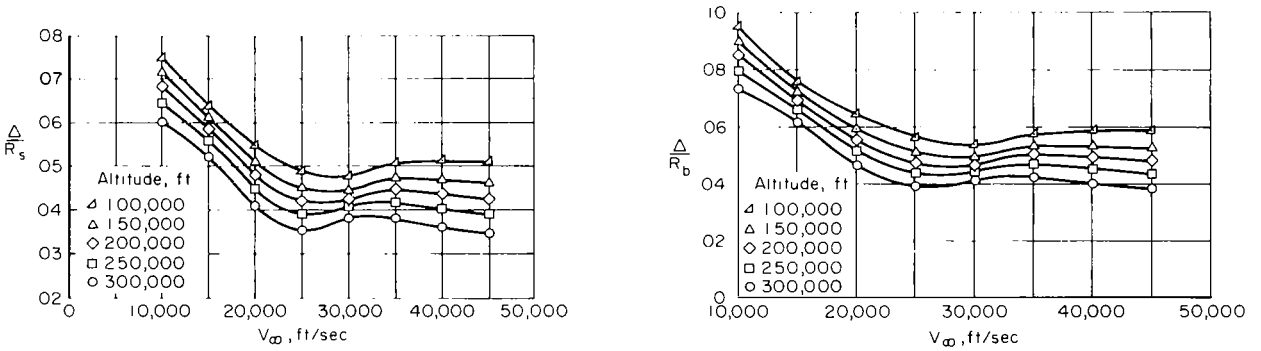


Figure 22.- Ratio of body radius to shock radius for sphere.



(a) Δ/R_s (b) Δ/R_b

Figure 23.- Shock standoff distance for sphere.

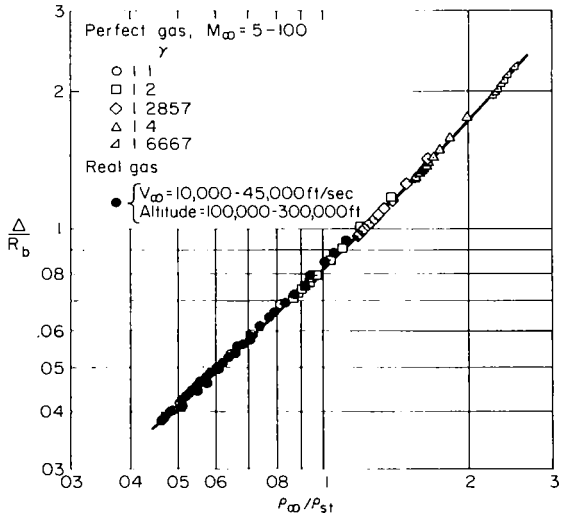


Figure 24.- Correlation of shock standoff distance with density ratio for sphere.

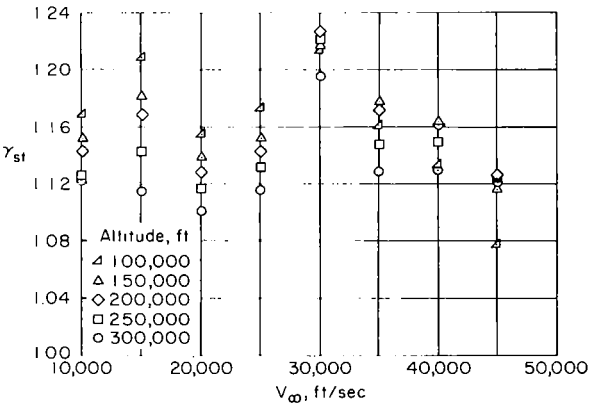


Figure 25.- Local isentropic exponent for stagnation-point conditions.

Comparison of Real-Gas and Perfect-Gas Solutions for a Sphere

The use of a perfect-gas solution to obtain flow-field results when real-gas effects are significant has been proposed by many researchers. From figure 25 it is noted that the local isentropic exponent for stagnation-point conditions is roughly 1.1 to 1.2. From figure 21(a) it is noted that for velocities greater than 15,000 ft/sec, the shock-wave parameter A_5 for the real-gas solutions has nearly the same value as shown in figure 14(a) for perfect-gas solutions for $M_\infty > 15$ and $\gamma \sim 1.1$ to 1.2. Finally, figure 24 shows that the correlation of shock standoff distance with density ratio for real-gas solutions is nearly the same as for perfect-gas solutions with $\gamma \sim 1.1$ to 1.2. These facts suggest that the local isentropic exponent for stagnation-point conditions might be the appropriate value of γ to be used in a perfect-gas solution.

A typical comparison of shock-wave shapes and sonic lines for real-gas and perfect-gas solutions is shown in figure 26 for $V_\infty = 30,000$ ft/sec and an altitude of 200,000 feet where $M_\infty = 28.885$ and $\gamma_{st} = 1.2279$. The equivalent perfect-gas solution was obtained for the same M_∞ and $\gamma = \gamma_{st}$. The differences between the two solutions for the shock standoff distance and sonic line are appreciable. Better agreement is obtained for the surface pressure distributions as shown in figure 27. Since the surface pressure distribution follows Newtonian flow for all solutions, the pressure at the $M = 1.05$ location is a measure of the agreement between real- and perfect-gas solutions. The values of $(p/p_{st})_{M=1.05}$, for all the real-gas solutions, are shown in figure 28 as a function of the effective value of γ. Generally, the agreement with the perfect-gas solutions is good. At least for the subsonic-transonic region, it appears that a perfect-gas solution is adequate to obtain the surface pressure distribution on a sphere.

Ellipsoids and Paraboloids

Nose shapes other than spheres are also of interest, particularly blunt ellipsoids. The one-parameter family of shock shapes given by equation (21) has been found to yield ellipsoids to a high degree of accuracy for values of the body bluntness parameter up to 2.25. Values of A_5 for $\gamma = 1.4$ and $M_\infty = 6$ and 10 are shown in figure 29. (The size of Δs was maintained at $\Delta/7.1$.) The ratio of nose radius to shock radius is shown in figure 30, and the shock standoff distance is shown in figure 31. It is interesting to note that the shock standoff distance in terms of the shock radius is nearly independent of the body bluntness. As the bluntness approaches zero, the ellipsoid becomes a paraboloid in the limit. Values of A_5 for $\gamma = 1.4$ and $M_\infty = 4$ to 100 for a paraboloid are shown in figure 32. Solutions have also been obtained for an ellipsoid in a real gas. As an example, for free-stream conditions of $V_\infty = 32,000$ ft/sec at 180,000 feet altitude, the values of A_5 for body bluntness parameters as high as 5 are shown in figure 33. The preceding examples illustrate the wide range of free-stream conditions for which blunt-body solutions can be obtained by the present method.

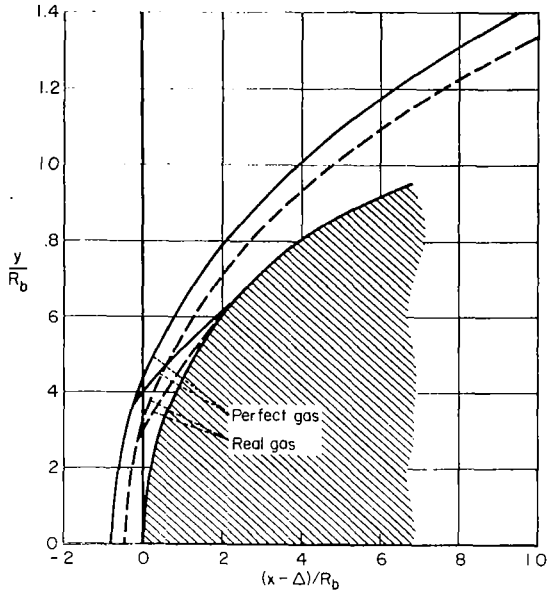


Figure 26.- Comparison of shock shapes and sonic lines for sphere for perfect- and real-gas solutions; V_∞ = 30,000 ft/sec, altitude = 200,000 ft.

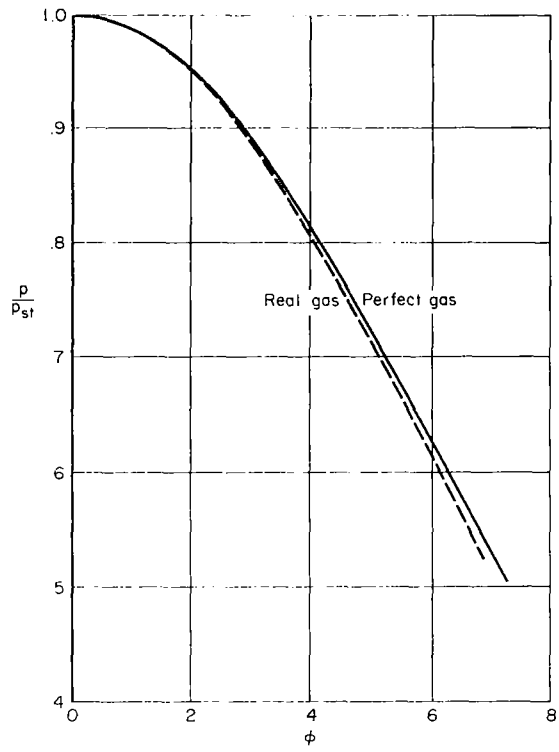


Figure 27.- Comparison of pressure distributions on sphere for perfect- and real-gas solutions; V_∞ = 30,000 ft/sec, altitude = 200,000 ft.

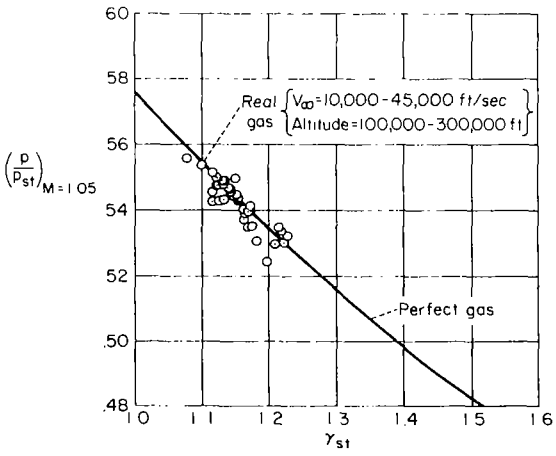


Figure 28.- Pressure at M = 1.05 point on a spherical nose.

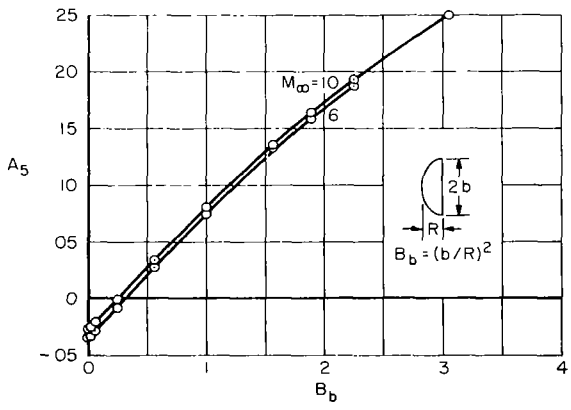


Figure 29.- Shock-wave parameter for ellipsoids; γ = 1.4.

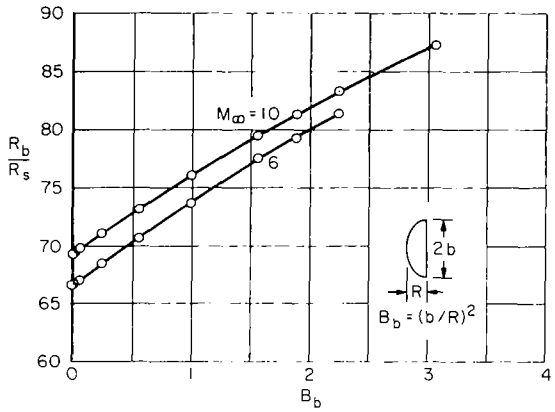
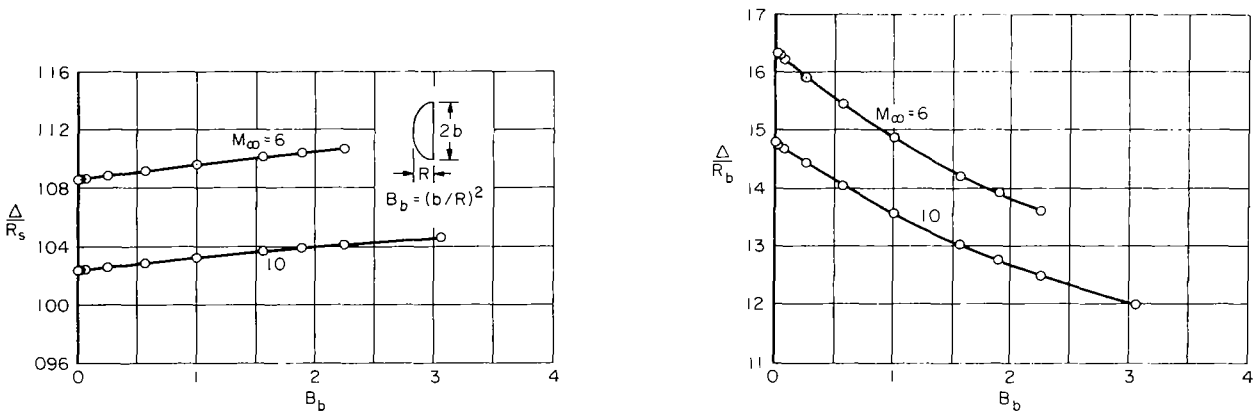


Figure 30.- Ratio of nose radius to shock radius for ellipsoids.



(a) Δ/R_s (b) Δ/R_b

Figure 31.- Shock standoff distance for ellipsoids; $\gamma = 1.4$.

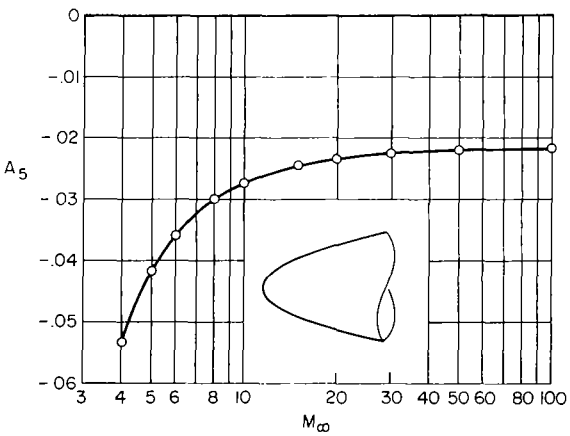


Figure 32.- Shock-wave parameter for paraboloid; $\gamma = 1.4$.

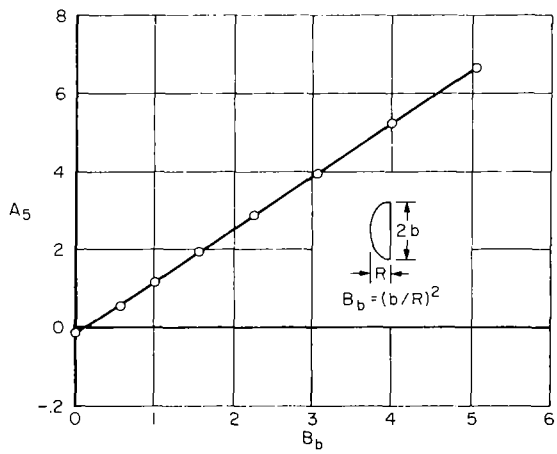


Figure 33.- Shock-wave parameter for ellipsoids in real gas; V_∞ = 32,000 ft/sec, altitude = 100,000 ft.

SUMMARY OF RESULTS

The inverse method, wherein a shock-wave shape is assumed, and the corresponding body shape is found, has been used to study inviscid, hypersonic flow over blunt-nosed bodies. Instabilities associated with the numerical methods employed are discussed and shown to be not informidable. Solutions have been obtained over a wide range of free-stream conditions for both perfect- and real-gas flows.

1. A one-parameter family of shock-wave shapes has been found to yield spherical-nosed, axisymmetric bodies to a high degree of accuracy for perfect gases over a Mach number range from 5 to 100 for values of γ from 1.1 to 1.6667 and for air in thermodynamic equilibrium over a speed range from 10,000 to 45,000 ft/sec for altitudes from 100,000 to 300,000 feet.

2. Comparisons of the results with other numerical methods and experiments showed good agreement.

3. Comparison of a real-gas solution for a sphere with a perfect-gas solution, in which the stagnation-point isentropic exponent was the value of γ used, showed good agreement for the surface pressure distribution but poor agreement for the shock standoff distance.

4. The one-parameter family of shock-wave shapes is also applicable to body shapes other than spheres, such as ellipsoids and paraboloids.

5. A comprehensive tabulation of solutions is presented for spheres in air in thermodynamic equilibrium. The results include body data, shock-wave and sonic line coordinates, and flow properties in the shock layer along a line normal to the body in the transonic region. The latter data can be used as inputs for a method of characteristics solution.

Ames Research Center
National Aeronautics and Space Administration
Moffett Field, Calif., March 4, 1964

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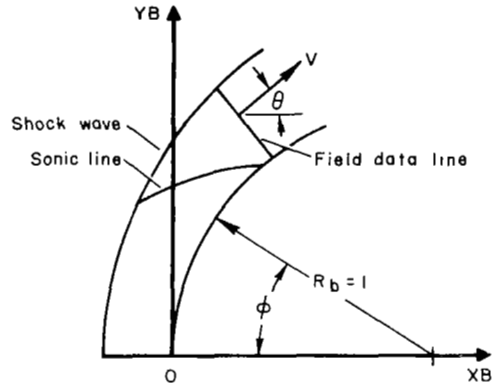
TABLE I.- RESUMÉ OF REAL-GAS SOLUTIONS

Free-stream conditions						Stagnation-point conditions						Shock-wave shape conditions						
Altitude, ft	p_∞, lb/ft^2	ρ_∞, slug/ft^3	T_∞, °R	V_∞, ft/sec	M_∞	p_{st}, lb/ft^2	ρ_{st}, slug/ft^3	T_{st}, °R	γ_{st}	h_{st}, ft^2/sec^2	$\frac{\rho_\infty}{\rho_{st}}$	A_s	$\frac{R_b}{R_s}$	$\frac{\Delta}{R_s}$	$\frac{\Delta}{R_b}$	Δs	Δt	tan σ
100,000	23.08	0.3211-4	417.4	10,000	10.03	3050	0.2[illegible]1-3	5912	1.169	0.5250+8	0.1122	0.0775	0.7881	0.0746	0.0947	0.010510	0.020	1.5521
				15,000	15.05	6908	.3472-3	9545	1.209	.1150+9	.0925	.1038	.8433	.0637	.0755	.008970	.020	1.4727
				20,000	20.06	12360	.4121-3	12500	1.155	.2025+9	.0779	.0951	.8517	.0548	.0643	.007712	.020	1.4883
				25,000	25.08	19400	.4699-3	14470	1.172	.3150+9	.0[illegible]	.0909	.8736	.0469	.0560	.006893	.020	1.4703
				30,000	30.09	27960	.4647-3	17560	1.215	.4525+9	.0[illegible]2	.0990	.8920	.0478	.0536	.006731	.020	1.4345
				35,000	35.11	37950	.4511-3	2[illegible]200	1.162	.6150+9	.0711	.1196	.8869	.0509	.0574	.007152	.025	1.4314
				40,000	40.12	49530	.4457-3	27930	1.13[illegible]	.8025+9	.0720	.1151	.8760	.0514	.0586	.007209	.025	1.4326
				45,000	45.14	62690	.4400-3	31500	1.070	.1015+10	.0716	.1063	.8723	.0511	.0586	.007196	.020	1.4799
150,000	3.060	.3564-5	498.5	10,000	9.21	340.0	.3345-4	5532	1.152	.5299+8	.1046	.0737	.7945	.0714	.0898	.010050	.020	1.5636
				15,000	13.81	769.1	.4042-4	6970	1.182	.1155+9	.0862	.1132	.8464	.0611	.0721	.008601	.020	1.4653
				20,000	18.41	1377	.4970-4	11330	1.140	.2030+9	.0717	.0963	.8597	.0509	.0593	.007175	.020	1.4943
				25,000	23.02	2161	.5734-4	13020	1.152	.3155+9	.0[illegible]22	.1015	.8826	.0451	.0511	.006347	.020	1.4690
				30,000	27.62	3112	.5918-4	15860	1.216	.4530+9	.0[illegible]13	.0976	.9056	.0447	.0494	.006296	.020	1.4219
				35,000	32.22	4224	.5403-4	21170	1.178	.6155+9	.0[illegible]0	.1284	.8903	.0476	.0535	.006689	.025	1.4198
				40,000	36.83	5518	.5470-4	24570	1.166	.8030+9	.0[illegible]52	.1139	.8860	.0470	.0531	.006608	.025	1.4174
				45,000	41.43	6987	.5[illegible]-4	27350	1.110	.1015+10	.0[illegible]40	.1034	.8860	.0463	.0523	.006525	.020	1.4487
200,000	.4715	.6118-6	447.2	10,000	9.71	58.50	.[illegible]0-5	5152	1.144	.5266+8	.1010	.0718	.8018	.0682	.0850	.009601	.020	1.5660
				15,000	14.56	132.2	.72[illegible]-5	8495	1.169	.1152+9	.0842	.1189	.8473	.0586	.0692	.008260	.020	1.4681
				20,000	19.41	236.9	.9120-5	10470	1.126	.2027+9	.0[illegible]71	.0971	.8662	.0481	.0555	.006771	.020	1.4960
				25,000	24.26	371.8	.1031-4	11890	1.143	.3152+9	.0[illegible]77	.1037	.8890	.0422	.0475	.005944	.020	1.4680
				30,000	29.12	535.1	.1057-4	14770	1.228	.4527+9	.0579	.1024	.9118	.0425	.0466	.005990	.020	1.4132
				35,000	33.97	726.6	.9900-5	19560	1.175	.6152+9	.061[illegible]	.1312	.8922	.0449	.0503	.006316	.025	1.4209
				40,000	38.82	949.7	.1010-4	22250	1.161	.8027+9	.0[illegible]01	.1141	.8918	.0438	.0491	.006158	.025	1.4182
				45,000	43.68	1203	.1047-4	24390	1.126	.1015+10	.0[illegible]	.1114	.8929	.0428	.0479	.006024	.025	1.4501
250,000	.04364	.7748-7	328.2	10,000	11.26	7.418	.8194-6	4798	1.126	.5197+8	.094	.0722	.8096	.0644	.0796	.009075	.020	1.5707
				15,000	16.89	16.77	.9717-6	7960	1.143	.1145+9	.0797	.1224	.8482	.0559	.0659	.007867	.020	1.4819
				20,000	22.52	30.07	.1248-5	9578	1.117	.2020+9	.0[illegible]21	.0984	.8737	.0449	.0514	.006329	.020	1.4963
				25,000	28.15	47.18	.1410-5	10790	1.132	.3145+9	.0[illegible]1	.1053	.8965	.0392	.0437	.005524	.020	1.4686
				30,000	33.78	67.84	.1402-5	13960	1.224	.4520+9	.0552	.0973	.9261	.0409	.0441	.005752	.025	1.4024
				35,000	39.42	92.23	.1354-5	17060	1.148	.6145+9	.0572	.1295	.8961	.0419	.0468	.005897	.025	1.4254
				40,000	45.04	120.6	.1413-5	19930	1.150	.8020+9	.0546	.1135	.8979	.0404	.0450	.005689	.025	1.4287
				45,000	50.68	152.8	.1465-5	21610	1.124	.1014+10	.0529	.1130	.9007	.0392	.0435	.005514	.025	1.4475
300,000	.002118	.4123-8	299.4	10,000	11.79	.3961	.4726-7	4388	1.123	.5180+8	.0672	.0770	.8222	.0601	.0731	.008469	.020	1.5654
				15,000	17.69	.8950	.5563-7	7350	1.115	.1143+9	.0741	.1220	.8544	.0524	.0613	.007377	.020	1.4544
				20,000	23.58	1.605	.7363-7	8522	1.101	.2018+9	.0560	.1014	.8829	.0411	.0465	.005783	.020	1.4962
				25,000	29.48	2.518	.8713-7	9465	1.116	.3143+9	.0473	.1086	.9050	.0355	.0392	.004994	.020	1.4669
				30,000	35.38	3.617	.8040-7	12840	1.196	.4518+9	.0513	.10[illegible]4	.9329	.0383	.0410	.005402	.025	1.3777
				35,000	41.27	4.923	.8033-7	15750	1.131	.6143+9	.0513	.1201	.9023	.0381	.0422	.005366	.025	1.4234
				40,000	47.17	6.439	.8508-7	17240	1.130	.8018+9	.0485	.1154	.9058	.0362	.0400	.005100	.025	1.4392
				45,000	53.06	8.157	.8592-7	18490	1.122	.1014+10	.04[illegible]4	.1152	.9106	.0349	.0383	.004909	.020	1.4426

Note: 0.3211-4 = 0.3211×10^{-4}

TABLE II.- REAL-GAS SOLUTIONS FOR AIR



ALTITUDE = 100,000 FT VELCCITY = 10,0CC FT/SEC

BCCY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAC	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	C.	0.	C.	0.3050E 04	0.2861E-03	0.	0.0004	-0.0947	0.
0.CC04	0.0254	0.1274E 03	0.0254	0.3047E 04	0.2859E-03	0.036	0.C004	-0.0937	0.0508
0.CC13	C.C508	0.2548E C3	0.0508	0.3040E 04	0.2853E-03	0.072	0.C004	-0.0906	0.1015
0.CC29	0.0761	0.3825E 03	0.0762	0.3029E 04	0.2844E-03	0.108	0.0004	-0.0855	0.1523
0.CC52	C.1015	0.5106E 03	0.1017	0.3012E 04	0.2831E-03	0.145	0.0003	-0.0784	0.2030
0.CC81	0.1269	0.6389E 03	0.1272	0.2992E 04	0.2814E-03	0.181	0.C003	-0.0692	0.2538
0.C117	C.1523	0.7678E C3	0.1529	0.2966E 04	0.2794E-C3	0.218	0.CC02	-0.0578	0.3045
0.0159	C.1777	0.8974E 03	0.1786	0.2936E 04	0.2769E-03	0.255	0.0002	-0.0444	0.3553
0.C208	C.2030	0.1028E 04	0.2044	0.2901E 04	0.2741E-C3	0.292	0.0001	-0.0287	0.4061
0.C264	0.2284	0.1159E 04	0.2304	0.2862E 04	0.2710E-03	0.330	0.0001	-0.0109	0.4568
0.0327	C.2538	0.1291E 04	0.2566	0.2819E 04	0.2674E-C3	0.368	-0.C000	0.0092	0.5076
0.C397	C.2792	0.1423E 04	0.2829	0.2771E 04	0.2636E-03	0.406	-0.0002	0.0316	0.5583
0.C475	C.3045	0.1556E 04	C.3C94	0.2719E 04	0.2593E-03	0.445	-0.0003	0.0564	0.6091
0.0560	0.3299	0.1694E 04	0.3362	0.2664E 04	0.2548E-03	0.484	-0.C004	0.0837	0.6598
0.C653	C.3553	0.1828E C4	0.3632	0.2603E 04	0.2499E-03	C.524	-C.C005	0.1134	0.7106
0.C753	C.3807	0.1963E 04	0.3905	0.2539E 04	0.2446E-03	0.563	-0.0007	0.1456	0.7614
0.C862	0.4061	0.2099E 04	C.4181	0.2472E 04	C.2390E-03	0.604	-0.0008	0.1806	0.8121
0.0979	0.4314	0.2239E 04	0.4461	0.2400E 04	C.2330E-03	0.645	-0.0010	0.2182	0.8629
0.1105	C.4568	0.2384E C4	0.4744	0.2324E 04	0.2267E-C3	0.689	-0.C010	0.2586	0.9136
0.124C	C.4822	0.2527E 04	C.5032	0.2245E 04	0.2201E-03	0.732	-0.0013	0.3019	0.9644
0.1384	0.5076	0.2671E 04	0.5324	0.2164E 04	0.2133E-03	0.776	-0.0016	0.3481	1.0151
0.1539	0.5330	0.2820E 04	0.5621	0.2078E 04	0.2060E-03	0.821	-0.0018	0.3974	1.0659
0.1704	C.5583	0.2970E C4	0.5924	0.1990E 04	0.1985E-03	C.868	-C.0019	0.4498	1.1167
0.1881	C.5837	0.3122E 04	0.6233	0.1900E 04	0.1908E-03	0.915	-0.0017	0.5055	1.1674
0.2069	0.6091	0.3279E C4	0.6549	0.1806E 04	0.1827E-03	0.964	-0.0014	0.5645	1.2182
0.2271	0.6345	0.3436E 04	0.6873	0.1712E 04	0.1745E-03	1.014	-0.0011	0.6269	1.2689
0.2486	C.6598	0.3598E C4	0.7206	0.1615E 04	0.1661E-03	1.066	-C.0010	C.6928	1.3197

FIELD CATA								SCNIC LINE	
XB	YB	V FT/SEC	THETA RAC	P LB/SC FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2419	0.6521	C.3548E C4	0.8608	0.1644E 04	C.1687E-03	1.050	0.	-0.0257	0.4151
0.2312	C.6613	C.3722E C4	0.8476	0.1675E C4	0.1730E-C3	1.105	C.3574E-02	-0.0041	0.4389
0.2222	C.6691	0.3872E 04	C.8382	0.1700E 04	0.1769E-03	1.153	0.6821E-02	0.0177	0.4618
0.2133	C.6767	C.4027E C4	0.83C0	0.1726E 04	0.1810E-03	1.202	C.1030E-01	0.0396	0.4840
0.2044	0.6844	0.4185E C4	0.8229	0.1753E 04	0.1853E-03	1.254	0.1403E-01	0.0616	0.5053
0.1955	C.692C	0.4346E 04	0.8167	0.1779E C4	C.1900E-C3	1.307	C.1802E-01	0.0836	0.5256
0.1867	0.6996	0.4510E 04	0.8112	0.1807E 04	0.1950E-03	1.362	C.2230E-01	0.1054	0.5447
0.1779	0.7071	0.4677E 04	0.8C64	0.1835E 04	0.2C04E-03	1.419	0.2689E-01	0.1270	0.5627
0.1692	0.7146	0.4846E 04	0.8020	0.1863E 04	0.2060E-03	1.477	0.3180E-01	0.1482	0.5792
0.1605	C.7221	0.5018E 04	0.7979	0.1892E 04	0.2120E-03	1.537	C.3707E-01	0.1690	0.5943
0.1518	C.7296	0.5191E C4	0.7941	0.1921E 04	0.2183E-03	1.599	C.4272E-01	0.1892	0.6080
0.1432	0.7370	0.5365E 04	0.7904	0.1949E 04	0.2249E-03	1.662	0.4877E-01	0.2089	0.6202
0.1346	0.7444	0.5540E 04	0.7868	0.1978E 04	0.2319E-03	1.726	0.5525E-01	0.2213	0.6273

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 100,000 FT VELOCITY = 15,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.6908E 04	0.3472E-03	0.	0.0002	-0.0755	0.
0.0003	0.0237	0.1658E 03	0.0237	0.6903E 04	0.3470E-03	0.034	0.0002	-0.0746	0.0474
0.0011	0.0474	0.3315E 03	0.0474	0.6889E 04	0.3464E-03	0.068	0.0002	-0.0717	0.0949
0.0025	0.0711	0.4975E 03	0.0712	0.6865E 04	0.3454E-03	0.102	0.0001	-0.0669	0.1423
0.0045	0.0949	0.6641E 03	0.0950	0.6832E 04	0.3440E-03	0.136	0.0001	-0.0603	0.1897
0.0071	0.1186	0.8313E 03	0.1189	0.6789E 04	0.3422E-03	0.170	0.0001	-0.0516	0.2372
0.0102	0.1423	0.9990E 03	0.1428	0.6737E 04	0.3400E-03	0.204	0.0002	-0.0410	0.2846
0.0139	0.1660	0.1167E 04	0.1668	0.6675E 04	0.3374E-03	0.239	0.0003	-0.0283	0.3320
0.0181	0.1897	0.1336E 04	0.1909	0.6604E 04	0.3344E-03	0.273	0.0002	-0.0135	0.3795
0.0230	0.2134	0.1506E 04	0.2151	0.6523E 04	0.3311E-03	0.308	-0.0001	0.0033	0.4269
0.0285	0.2372	0.1676E 04	0.2394	0.6434E 04	0.3274E-03	0.344	-0.0005	0.0224	0.4743
0.0346	0.2609	0.1849E 04	0.2639	0.6335E 04	0.3233E-03	0.380	-0.0005	0.0437	0.5217
0.0413	0.2846	0.2023E 04	0.2886	0.6227E 04	0.3186E-03	0.416	-0.0001	0.0674	0.5692
0.0487	0.3083	0.2198E 04	0.3134	0.6111E 04	0.3135E-03	0.452	0.0006	0.0935	0.6166
0.0567	0.3320	0.2372E 04	0.3384	0.5986E 04	0.3081E-03	0.489	0.0009	0.1220	0.6640
0.0654	0.3557	0.2548E 04	0.3637	0.5855E 04	0.3016E-03	0.526	0.0042	0.1532	0.7115
0.0747	0.3795	0.2725E 04	0.3892	0.5714E 04	0.2958E-03	0.563	0.0035	0.1870	0.7589
0.0848	0.4032	0.2903E 04	0.4149	0.5565E 04	0.2897E-03	0.602	0.0025	0.2237	0.8063
0.0956	0.4269	0.3083E 04	0.4410	0.5407E 04	0.2833E-03	0.641	0.0008	0.2632	0.8538
0.1071	0.4506	0.3267E 04	0.4674	0.5241E 04	0.2766E-03	0.681	-0.0014	0.3057	0.9012
0.1195	0.4743	0.3456E 04	0.4941	0.5065E 04	0.2699E-03	0.724	-0.0050	0.3513	0.9486
0.1326	0.4980	0.3651E 04	0.5212	0.4881E 04	0.2618E-03	0.767	-0.0047	0.4002	0.9961
0.1466	0.5217	0.3848E 04	0.5488	0.4691E 04	0.2532E-03	0.811	-0.0040	0.4525	1.0435
0.1616	0.5455	0.4051E 04	0.5768	0.4494E 04	0.2443E-03	0.856	-0.0030	0.5082	1.0909
0.1775	0.5692	0.4264E 04	0.6054	0.4291E 04	0.2349E-03	0.904	-0.0013	0.5676	1.1384
0.1945	0.5929	0.4471E 04	0.6345	0.4083E 04	0.2255E-03	0.951	-0.0011	0.6307	1.1858
0.2126	0.6166	0.4685E 04	0.6643	0.3867E 04	0.2156E-03	1.001	-0.0004	0.6977	1.2332
0.2319	0.6403	0.4904E 04	0.6949	0.3646E 04	0.2054E-03	1.053	-0.0001	0.7688	1.2806

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2308	0.6390	0.4892E 04	0.8737	0.3658E 04	0.2060E-03	1.050	0.	-0.0202	0.3589
0.2260	0.6429	0.5065E 04	0.8675	0.3690E 04	0.2092E-03	1.090	0.2910E-02	-0.0013	0.3842
0.2190	0.6488	0.5328E 04	0.8599	0.3742E 04	0.2146E-03	1.153	0.7556E-02	0.0184	0.4101
0.2120	0.6547	0.5599E 04	0.8534	0.3796E 04	0.2208E-03	1.219	0.1260E-01	0.0390	0.4366
0.2050	0.6606	0.5882E 04	0.8481	0.3853E 04	0.2276E-03	1.290	0.1809E-01	0.0603	0.4631
0.1980	0.6664	0.6175E 04	0.8437	0.3914E 04	0.2354E-03	1.365	0.2407E-01	0.0820	0.4892
0.1911	0.6722	0.6478E 04	0.8400	0.3978E 04	0.2441E-03	1.446	0.3060E-01	0.1040	0.5142
0.1841	0.6780	0.6791E 04	0.8369	0.4047E 04	0.2538E-03	1.532	0.3775E-01	0.1259	0.5378
0.1772	0.6838	0.7117E 04	0.8343	0.4121E 04	0.2646E-03	1.627	0.4559E-01	0.1476	0.5597
0.1704	0.6895	0.7454E 04	0.8320	0.4200E 04	0.2763E-03	1.728	0.5420E-01	0.1687	0.5797
0.1635	0.6953	0.7802E 04	0.8301	0.4284E 04	0.2889E-03	1.835	0.6367E-01	0.1891	0.5975
0.1567	0.7010	0.8157E 04	0.8283	0.4373E 04	0.3026E-03	1.948	0.7407E-01	0.2086	0.6134
0.1499	0.7067	0.8519E 04	0.8266	0.4468E 04	0.3179E-03	2.069	0.8553E-01	0.2122	0.6161

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 100,000 FT VELOCITY = 20,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1236E 05	0.4121E-03	0.	0.0002	-0.0643	0.
0.0003	0.0235	0.2015E 03	0.0235	0.1235E 05	0.4119E-03	0.034	0.0002	-0.0633	0.0470
0.0011	0.0470	0.4029E 03	0.0470	0.1233E 05	0.4112E-03	0.068	0.0002	-0.0605	0.0939
0.0025	0.0704	0.6046E 03	0.0705	0.1229E 05	0.4099E-03	0.103	0.0002	-0.0558	0.1409
0.0044	0.0939	0.8069E 03	0.0941	0.1223E 05	0.4083E-03	0.137	0.0002	-0.0492	0.1879
0.0069	0.1174	0.1010E 04	0.1177	0.1215E 05	0.4061E-03	0.172	0.0001	-0.0406	0.2348
0.0100	0.1409	0.1214E 04	0.1414	0.1206E 05	0.4034E-03	0.207	0.0001	-0.0301	0.2818
0.0136	0.1644	0.1419E 04	0.1651	0.1195E 05	0.4003E-03	0.242	0.0001	-0.0176	0.3287
0.0178	0.1879	0.1625E 04	0.1890	0.1183E 05	0.3967E-03	0.277	-0.0000	-0.0030	0.3757
0.0226	0.2113	0.1832E 04	0.2129	0.1168E 05	0.3926E-03	0.312	-0.0001	0.0136	0.4227
0.0279	0.2348	0.2040E 04	0.2370	0.1153E 05	0.3880E-03	0.348	-0.0001	0.0324	0.4696
0.0339	0.2583	0.2250E 04	0.2613	0.1135E 05	0.3829E-03	0.384	-0.0001	0.0535	0.5166
0.0405	0.2818	0.2461E 04	0.2856	0.1116E 05	0.3773E-03	0.421	-0.0001	0.0767	0.5636
0.0477	0.3053	0.2674E 04	0.3102	0.1096E 05	0.3713E-03	0.458	-0.0002	0.1024	0.6105
0.0556	0.3287	0.2893E 04	0.3350	0.1074E 05	0.3649E-03	0.496	-0.0003	0.1305	0.6575
0.0641	0.3522	0.3109E 04	0.3600	0.1050E 05	0.3580E-03	0.534	-0.0004	0.1611	0.7044
0.0733	0.3757	0.3325E 04	0.3852	0.1026E 05	0.3506E-03	0.572	-0.0006	0.1943	0.7514
0.0832	0.3992	0.3543E 04	0.4107	0.9992E 04	0.3428E-03	0.611	-0.0008	0.2302	0.7984
0.0938	0.4227	0.3765E 04	0.4364	0.9716E 04	0.3346E-03	0.651	-0.0010	0.2689	0.8453
0.1052	0.4461	0.3995E 04	0.4625	0.9427E 04	0.3260E-03	0.692	-0.0013	0.3105	0.8923
0.1173	0.4696	0.4222E 04	0.4889	0.9126E 04	0.3170E-03	0.733	-0.0014	0.3551	0.9393
0.1302	0.4931	0.4450E 04	0.5158	0.8816E 04	0.3076E-03	0.774	-0.0015	0.4029	0.9862
0.1440	0.5166	0.4681E 04	0.5430	0.8496E 04	0.2979E-03	0.816	-0.0016	0.4539	1.0332
0.1586	0.5401	0.4917E 04	0.5707	0.8166E 04	0.2877E-03	0.860	-0.0012	0.5084	1.0801
0.1742	0.5636	0.5153E 04	0.5988	0.7829E 04	0.2774E-03	0.904	-0.0015	0.5663	1.1271
0.1906	0.5870	0.5394E 04	0.6275	0.7484E 04	0.2667E-03	0.949	-0.0016	0.6279	1.1741
0.2082	0.6105	0.5636E 04	0.6568	0.7136E 04	0.2559E-03	0.995	-0.0018	0.6932	1.2210
0.2267	0.6340	0.5880E 04	0.6867	0.6784E 04	0.2449E-03	1.041	-0.0020	0.7625	1.2680
0.2464	0.6575	0.6124E 04	0.7174	0.6433E 04	0.2339E-03	1.088	-0.0023	0.8358	1.3150

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2303	0.6384	0.5925E 04	0.8826	0.6718E 04	0.2429E-03	1.050	0.	-0.0185	0.3256
0.2223	0.6449	0.6453E 04	0.8730	0.6807E 04	0.2487E-03	1.149	0.7298E-02	-0.0022	0.3499
0.2163	0.6499	0.6860E 04	0.8672	0.6881E 04	0.2536E-03	1.227	0.1342E-01	0.0149	0.3751
0.2103	0.6548	0.7275E 04	0.8624	0.6961E 04	0.2591E-03	1.307	0.2008E-01	0.0330	0.4014
0.2043	0.6597	0.7695E 04	0.8585	0.7048E 04	0.2652E-03	1.390	0.2733E-01	0.0520	0.4283
0.1984	0.6647	0.8122E 04	0.8553	0.7143E 04	0.2720E-03	1.475	0.3520E-01	0.0718	0.4555
0.1924	0.6695	0.8554E 04	0.8527	0.7245E 04	0.2795E-03	1.563	0.4377E-01	0.0923	0.4824
0.1865	0.6744	0.8992E 04	0.8505	0.7357E 04	0.2878E-03	1.654	0.5307E-01	0.1131	0.5086
0.1806	0.6793	0.9436E 04	0.8487	0.7477E 04	0.2972E-03	1.748	0.6320E-01	0.1341	0.5337
0.1747	0.6841	0.9885E 04	0.8471	0.7606E 04	0.3077E-03	1.845	0.7421E-01	0.1550	0.5572
0.1688	0.6890	0.1034E 05	0.8456	0.7746E 04	0.3197E-03	1.946	0.8622E-01	0.1755	0.5791
0.1629	0.6938	0.1080E 05	0.8443	0.7896E 04	0.3333E-03	2.051	0.9933E-01	0.1957	0.5993
0.1571	0.6986	0.1126E 05	0.8429	0.8057E 04	0.3486E-03	2.160	0.1137E-00	0.2103	0.6133

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 100,000 FT VELOCITY = 25,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1940E 05	0.4699E-03	0.	0.0004	-0.0560	0.
0.0003	0.0229	0.2320E 03	0.0229	0.1939E 05	0.4696E-03	0.033	0.0004	-0.0551	0.0458
0.0011	0.0458	0.4638E 03	0.0458	0.1935E 05	0.4688E-03	0.067	0.0004	-0.0524	0.0916
0.0024	0.0687	0.6960E 03	0.0687	0.1929E 05	0.4675E-03	0.100	0.0003	-0.0478	0.1374
0.0042	0.0916	0.9290E 03	0.0917	0.1920E 05	0.4657E-03	0.134	0.0003	-0.0413	0.1832
0.0066	0.1145	0.1163E 04	0.1147	0.1908E 05	0.4633E-03	0.167	0.0002	-0.0329	0.2289
0.0095	0.1374	0.1398E 04	0.1378	0.1894E 05	0.4604E-03	0.201	0.0002	-0.0227	0.2747
0.0129	0.1603	0.1633E 04	0.1609	0.1878E 05	0.4570E-03	0.235	0.0001	-0.0105	0.3205
0.0169	0.1832	0.1870E 04	0.1842	0.1859E 05	0.4531E-03	0.270	-0.0000	0.0038	0.3663
0.0214	0.2060	0.2108E 04	0.2075	0.1838E 05	0.4487E-03	0.304	-0.0001	0.0200	0.4121
0.0265	0.2289	0.2347E 04	0.2310	0.1814E 05	0.4437E-03	0.339	-0.0003	0.0384	0.4579
0.0322	0.2518	0.2588E 04	0.2546	0.1788E 05	0.4382E-03	0.374	-0.0004	0.0589	0.5037
0.0385	0.2747	0.2831E 04	0.2783	0.1759E 05	0.4322E-03	0.410	-0.0006	0.0817	0.5495
0.0453	0.2976	0.3075E 04	0.3022	0.1728E 05	0.4257E-03	0.446	-0.0008	0.1068	0.5952
0.0528	0.3205	0.3327E 04	0.3263	0.1695E 05	0.4188E-03	0.483	-0.0011	0.1343	0.6410
0.0608	0.3434	0.3575E 04	0.3505	0.1659E 05	0.4112E-03	0.520	-0.0013	0.1643	0.6866
0.0695	0.3663	0.3823E 04	0.3750	0.1621E 05	0.4032E-03	0.557	-0.0015	0.1969	0.7326
0.0789	0.3892	0.4073E 04	0.3998	0.1582E 05	0.3947E-03	0.595	-0.0017	0.2321	0.7784
0.0889	0.4121	0.4327E 04	0.4248	0.1540E 05	0.3857E-03	0.633	-0.0019	0.2701	0.8242
0.0997	0.4350	0.4587E 04	0.4501	0.1496E 05	0.3763E-03	0.673	-0.0021	0.3110	0.8700
0.1111	0.4579	0.4853E 04	0.4757	0.1450E 05	0.3663E-03	0.714	-0.0020	0.3550	0.9158
0.1233	0.4808	0.5116E 04	0.5016	0.1402E 05	0.3560E-03	0.754	-0.0024	0.4020	0.9615
0.1362	0.5037	0.5381E 04	0.5279	0.1353E 05	0.3453E-03	0.796	-0.0027	0.4523	1.0073
0.1500	0.5266	0.5651E 04	0.5546	0.1303E 05	0.3342E-03	0.838	-0.0029	0.5060	1.0531
0.1646	0.5495	0.5925E 04	0.5818	0.1251E 05	0.3227E-03	0.882	-0.0033	0.5632	1.0989
0.1801	0.5723	0.6201E 04	0.6095	0.1197E 05	0.3109E-03	0.926	-0.0037	0.6241	1.1447
0.1966	0.5952	0.6482E 04	0.6376	0.1143E 05	0.2986E-03	0.971	-0.0039	0.6888	1.1905
0.2140	0.6181	0.6768E 04	0.6664	0.1087E 05	0.2862E-03	1.018	-0.0043	0.7574	1.2363
0.2324	0.6410	0.7060E 04	0.6958	0.1031E 05	0.2733E-03	1.066	-0.0046	0.8302	1.2821

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2261	0.6334	0.6962E 04	0.8874	0.1050E 05	0.2777E-03	1.050	0.	-0.0160	0.3008
0.2196	0.6387	0.7631E 04	0.8795	0.1062E 05	0.2840E-03	1.158	0.8332E-02	-0.0012	0.3251
0.2144	0.6429	0.8178E 04	0.8748	0.1073E 05	0.2898E-03	1.247	0.1580E-01	0.0146	0.3510
0.2092	0.6471	0.8736E 04	0.8709	0.1085E 05	0.2963E-03	1.340	0.2400E-01	0.0316	0.3785
0.2040	0.6514	0.9303E 04	0.8679	0.1098E 05	0.3036E-03	1.436	0.3297E-01	0.0498	0.4074
0.1988	0.6556	0.9879E 04	0.8655	0.1113E 05	0.3118E-03	1.536	0.4281E-01	0.0692	0.4370
0.1937	0.6598	0.1046E 05	0.8636	0.1129E 05	0.3210E-03	1.639	0.5357E-01	0.0895	0.4667
0.1885	0.6640	0.1106E 05	0.8621	0.1147E 05	0.3313E-03	1.747	0.6534E-01	0.1105	0.4958
0.1834	0.6682	0.1166E 05	0.8609	0.1166E 05	0.3429E-03	1.859	0.7824E-01	0.1317	0.5235
0.1782	0.6724	0.1228E 05	0.8600	0.1188E 05	0.3559E-03	1.975	0.9238E-01	0.1528	0.5495
0.1731	0.6765	0.1290E 05	0.8592	0.1212E 05	0.3706E-03	2.097	0.1079E-00	0.1736	0.5736
0.1680	0.6807	0.1352E 05	0.8584	0.1238E 05	0.3872E-03	2.224	0.1249E-00	0.1938	0.5956
0.1630	0.6848	0.1415E 05	0.8578	0.1266E 05	0.4060E-03	2.358	0.1437E-00	0.2072	0.6094

TABLE II.- REAL-GAS SOLUTIONS FOR AIR

ALTITUDE = 100,000 FT VELOCITY = 30,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.2796E 05	0.4847E-03	0.	0.0002	-0.0536	0.
0.0003	0.0224	0.2703E 03	0.0224	0.2794E 05	0.4844E-03	0.032	0.0002	-0.0527	0.0448
0.0010	0.0448	0.5404E 03	0.0449	0.2789E 05	0.4837E-03	0.065	0.0002	-0.0500	0.0897
0.0023	0.0673	0.8108E 03	0.0673	0.2780E 05	0.4824E-03	0.097	0.0002	-0.0455	0.1345
0.0040	0.0897	0.1082E 04	0.0898	0.2767E 05	0.4806E-03	0.129	0.0001	-0.0392	0.1794
0.0063	0.1121	0.1354E 04	0.1123	0.2751E 05	0.4784E-03	0.162	0.0000	-0.0310	0.2242
0.0091	0.1345	0.1628E 04	0.1349	0.2732E 05	0.4756E-03	0.195	-0.0000	-0.0209	0.2691
0.0124	0.1569	0.1902E 04	0.1576	0.2709E 05	0.4723E-03	0.228	0.0001	-0.0090	0.3139
0.0162	0.1794	0.2178E 04	0.1803	0.2683E 05	0.4683E-03	0.261	0.0003	0.0050	0.3587
0.0206	0.2018	0.2455E 04	0.2032	0.2653E 05	0.4640E-03	0.295	0.0003	0.0209	0.4036
0.0254	0.2242	0.2732E 04	0.2261	0.2619E 05	0.4593E-03	0.328	0.0000	0.0389	0.4484
0.0309	0.2466	0.3011E 04	0.2492	0.2582E 05	0.4542E-03	0.362	-0.0006	0.0591	0.4933
0.0369	0.2691	0.3294E 04	0.2724	0.2542E 05	0.4486E-03	0.397	-0.0011	0.0814	0.5381
0.0434	0.2915	0.3580E 04	0.2958	0.2499E 05	0.4421E-03	0.432	-0.0008	0.1060	0.5829
0.0506	0.3139	0.3869E 04	0.3193	0.2452E 05	0.4348E-03	0.468	0.0002	0.1330	0.6278
0.0583	0.3363	0.4177E 04	0.3430	0.2402E 05	0.4255E-03	0.505	0.0045	0.1624	0.6726
0.0666	0.3587	0.4466E 04	0.3669	0.2349E 05	0.4179E-03	0.541	0.0041	0.1943	0.7175
0.0756	0.3812	0.4753E 04	0.3911	0.2293E 05	0.4099E-03	0.577	0.0033	0.2289	0.7623
0.0851	0.4036	0.5038E 04	0.4155	0.2234E 05	0.4016E-03	0.614	0.0021	0.2662	0.8072
0.0954	0.4260	0.5325E 04	0.4401	0.2172E 05	0.3931E-03	0.651	0.0002	0.3064	0.8520
0.1063	0.4484	0.5620E 04	0.4651	0.2108E 05	0.3843E-03	0.690	-0.0021	0.3495	0.8968
0.1180	0.4708	0.5918E 04	0.4903	0.2041E 05	0.3757E-03	0.731	-0.0057	0.3957	0.9417
0.1303	0.4933	0.6226E 04	0.5159	0.1972E 05	0.3650E-03	0.771	-0.0056	0.4452	0.9865
0.1435	0.5157	0.6536E 04	0.5419	0.1901E 05	0.3540E-03	0.812	-0.0052	0.4980	1.0314
0.1574	0.5381	0.6850E 04	0.5683	0.1828E 05	0.3426E-03	0.855	-0.0050	0.5543	1.0762
0.1721	0.5605	0.7167E 04	0.5952	0.1754E 05	0.3309E-03	0.898	-0.0050	0.6142	1.1211
0.1877	0.5829	0.7486E 04	0.6225	0.1678E 05	0.3189E-03	0.942	-0.0047	0.6778	1.1659
0.2042	0.6054	0.7816E 04	0.6503	0.1601E 05	0.3063E-03	0.987	-0.0036	0.7454	1.2107
0.2217	0.6278	0.8144E 04	0.6787	0.1522E 05	0.2937E-03	1.034	-0.0036	0.8171	1.2556
0.2401	0.6502	0.8479E 04	0.7078	0.1443E 05	0.2807E-03	1.081	-0.0029	0.8930	1.3004

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2280	0.6356	0.8260E 04	0.8861	0.1495E 05	0.2892E-03	1.050	0.	-0.0150	0.2920
0.2234	0.6394	0.8886E 04	0.8803	0.1507E 05	0.2944E-03	1.136	0.7600E-02	-0.0006	0.3167
0.2184	0.6434	0.9561E 04	0.8755	0.1521E 05	0.3012E-03	1.233	0.1654E-01	0.0152	0.3436
0.2135	0.6475	0.1025E 05	0.8717	0.1537E 05	0.3093E-03	1.333	0.2643E-01	0.0323	0.3725
0.2086	0.6515	0.1096E 05	0.8688	0.1556E 05	0.3183E-03	1.439	0.3734E-01	0.0510	0.4032
0.2037	0.6555	0.1168E 05	0.8665	0.1576E 05	0.3286E-03	1.550	0.4939E-01	0.0710	0.4349
0.1988	0.6595	0.1242E 05	0.8648	0.1599E 05	0.3402E-03	1.666	0.6270E-01	0.0922	0.4668
0.1939	0.6635	0.1319E 05	0.8635	0.1625E 05	0.3533E-03	1.790	0.7741E-01	0.1141	0.4979
0.1890	0.6674	0.1397E 05	0.8625	0.1654E 05	0.3681E-03	1.920	0.9369E-01	0.1363	0.5275
0.1842	0.6714	0.1476E 05	0.8618	0.1686E 05	0.3850E-03	2.057	0.1117E-00	0.1583	0.5549
0.1793	0.6754	0.1558E 05	0.8612	0.1723E 05	0.4042E-03	2.202	0.1318E-00	0.1799	0.5802
0.1745	0.6793	0.1640E 05	0.8607	0.1763E 05	0.4262E-03	2.356	0.1540E-00	0.2009	0.6031
0.1697	0.6832	0.1724E 05	0.8603	0.1809E 05	0.4514E-03	2.518	0.1789E-00	0.2090	0.6116

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 100,000 FT VELOCITY = 35,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.3795E 05	0.4516E-03	0.	-0.0015	-0.0574	0.
0.0004	0.0282	0.4100E 03	0.0282	0.3791E 05	0.4512E-03	0.041	-0.0015	-0.0559	0.0564
0.0016	0.0564	0.8200E 03	0.0564	0.3779E 05	0.4500E-03	0.083	-0.0014	-0.0517	0.1128
0.0036	0.0846	0.1231E 04	0.0847	0.3760E 05	0.4481E-03	0.125	-0.0012	-0.0446	0.1691
0.0064	0.1128	0.1645E 04	0.1130	0.3734E 05	0.4454E-03	0.167	-0.0009	-0.0346	0.2255
0.0100	0.1409	0.2061E 04	0.1414	0.3700E 05	0.4418E-03	0.209	-0.0005	-0.0216	0.2819
0.0144	0.1691	0.2478E 04	0.1700	0.3658E 05	0.4375E-03	0.251	-0.0000	-0.0055	0.3383
0.0197	0.1973	0.2897E 04	0.1986	0.3609E 05	0.4325E-03	0.294	0.0005	0.0137	0.3946
0.0258	0.2255	0.3320E 04	0.2275	0.3552E 05	0.4267E-03	0.337	0.0010	0.0363	0.4510
0.0327	0.2537	0.3746E 04	0.2565	0.3488E 05	0.4201E-03	0.381	0.0016	0.0623	0.5074
0.0406	0.2819	0.4176E 04	0.2858	0.3417E 05	0.4127E-03	0.425	0.0025	0.0919	0.5638
0.0493	0.3101	0.4609E 04	0.3153	0.3339E 05	0.4045E-03	0.470	0.0035	0.1253	0.6202
0.0590	0.3383	0.5052E 04	0.3451	0.3255E 05	0.3956E-03	0.516	0.0047	0.1628	0.6765
0.0696	0.3665	0.5496E 04	0.3752	0.3163E 05	0.3860E-03	0.562	0.0057	0.2044	0.7329
0.0812	0.3946	0.5943E 04	0.4057	0.3064E 05	0.3757E-03	0.609	0.0067	0.2506	0.7893
0.0938	0.4228	0.6398E 04	0.4366	0.2959E 05	0.3647E-03	0.657	0.0076	0.3014	0.8457
0.1075	0.4510	0.6865E 04	0.4679	0.2847E 05	0.3530E-03	0.707	0.0085	0.3573	0.9021
0.1223	0.4792	0.7352E 04	0.4998	0.2730E 05	0.3409E-03	0.760	0.0091	0.4184	0.9584
0.1383	0.5074	0.7839E 04	0.5322	0.2606E 05	0.3275E-03	0.812	0.0108	0.4851	1.0148
0.1556	0.5356	0.8329E 04	0.5652	0.2478E 05	0.3137E-03	0.865	0.0127	0.5577	1.0712
0.1741	0.5638	0.8833E 04	0.5990	0.2345E 05	0.2992E-03	0.920	0.0149	0.6366	1.1276
0.1941	0.5920	0.9348E 04	0.6335	0.2209E 05	0.2843E-03	0.977	0.0169	0.7220	1.1839
0.2155	0.6202	0.9872E 04	0.6690	0.2069E 05	0.2691E-03	1.035	0.0187	0.8144	1.2403
0.2387	0.6484	0.1041E 05	0.7054	0.1928E 05	0.2534E-03	1.096	0.0206	0.9140	1.2967

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2210	0.6270	0.1000E 05	0.8937	0.2035E 05	0.2653E-03	1.050	0.	-0.0176	0.2968
0.2140	0.6327	0.1094E 05	0.8851	0.2061E 05	0.2746E-03	1.158	0.1269E-01	-0.0024	0.3221
0.2086	0.6370	0.1168E 05	0.8802	0.2083E 05	0.2833E-03	1.246	0.2341E-01	0.0142	0.3495
0.2034	0.6413	0.1244E 05	0.8763	0.2107E 05	0.2936E-03	1.340	0.3528E-01	0.0322	0.3790
0.1981	0.6455	0.1324E 05	0.8732	0.2135E 05	0.3059E-03	1.442	0.4845E-01	0.0519	0.4103
0.1928	0.6497	0.1407E 05	0.8707	0.2166E 05	0.3204E-03	1.552	0.6314E-01	0.0730	0.4426
0.1876	0.6539	0.1495E 05	0.8688	0.2200E 05	0.3375E-03	1.674	0.7960E-01	0.0952	0.4748
0.1824	0.6582	0.1588E 05	0.8673	0.2240E 05	0.3574E-03	1.810	0.9814E-01	0.1179	0.5058
0.1771	0.6623	0.1687E 05	0.8661	0.2286E 05	0.3801E-03	1.966	0.1191E-00	0.1407	0.5347
0.1719	0.6665	0.1791E 05	0.8653	0.2338E 05	0.4060E-03	2.139	0.1429E-00	0.1630	0.5612
0.1668	0.6707	0.1900E 05	0.8646	0.2397E 05	0.4364E-03	2.333	0.1701E-00	0.1846	0.5849
0.1616	0.6749	0.2014E 05	0.8641	0.2466E 05	0.4727E-03	2.549	0.2013E-00	0.2025	0.6032

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 100,000 FT VELOCITY = 40,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.4953E 05	0.4457E-03	0.	-0.0024	-0.0586	0.
0.0004	0.0285	0.4748E 03	0.0285	0.4948E 05	0.4453E-03	0.042	-0.0024	-0.0572	0.0571
0.0016	0.0571	0.9498E 03	0.0571	0.4933E 05	0.4441E-03	0.085	-0.0022	-0.0529	0.1142
0.0037	0.0856	0.1426E 04	0.0857	0.4908E 05	0.4421E-03	0.127	-0.0019	-0.0457	0.1712
0.0065	0.1142	0.1905E 04	0.1144	0.4872E 05	0.4393E-03	0.170	-0.0014	-0.0356	0.2283
0.0102	0.1427	0.2387E 04	0.1432	0.4827E 05	0.4357E-03	0.213	-0.0009	-0.0225	0.2854
0.0147	0.1712	0.2872E 04	0.1721	0.4772E 05	0.4313E-03	0.256	-0.0002	-0.0062	0.3425
0.0201	0.1998	0.3362E 04	0.2011	0.4706E 05	0.4261E-03	0.300	0.0006	0.0132	0.3995
0.0264	0.2283	0.3855E 04	0.2303	0.4631E 05	0.4201E-03	0.345	0.0016	0.0360	0.4566
0.0335	0.2568	0.4354E 04	0.2597	0.4546E 05	0.4132E-03	0.389	0.0028	0.0623	0.5137
0.0416	0.2854	0.4856E 04	0.2894	0.4451E 05	0.4056E-03	0.435	0.0041	0.0922	0.5708
0.0505	0.3139	0.5364E 04	0.3193	0.4346E 05	0.3972E-03	0.481	0.0054	0.1259	0.6278
0.0605	0.3425	0.5894E 04	0.3495	0.4233E 05	0.3882E-03	0.529	0.0069	0.1636	0.6849
0.0714	0.3710	0.6412E 04	0.3801	0.4110E 05	0.3782E-03	0.576	0.0085	0.2055	0.7420
0.0834	0.3995	0.6930E 04	0.4111	0.3979E 05	0.3676E-03	0.624	0.0102	0.2520	0.7991
0.0965	0.4281	0.7453E 04	0.4424	0.3840E 05	0.3564E-03	0.672	0.0120	0.3031	0.8561
0.1106	0.4566	0.7989E 04	0.4743	0.3695E 05	0.3445E-03	0.722	0.0139	0.3592	0.9132
0.1259	0.4851	0.8531E 04	0.5067	0.3543E 05	0.3322E-03	0.772	0.0159	0.4206	0.9703
0.1425	0.5137	0.9070E 04	0.5397	0.3388E 05	0.3194E-03	0.823	0.0179	0.4876	1.0274
0.1602	0.5422	0.9616E 04	0.5733	0.3228E 05	0.3061E-03	0.874	0.0205	0.5604	1.0844
0.1793	0.5708	0.1017E 05	0.6077	0.3064E 05	0.2925E-03	0.927	0.0226	0.6395	1.1415
0.1998	0.5993	0.1073E 05	0.6428	0.2895E 05	0.2784E-03	0.981	0.0254	0.7251	1.1986
0.2217	0.6278	0.1131E 05	0.6788	0.2722E 05	0.2640E-03	1.037	0.0277	0.8176	1.2557
0.2452	0.6564	0.1190E 05	0.7158	0.2545E 05	0.2489E-03	1.095	0.0303	0.9175	1.3127

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2270	0.6344	0.1144E 05	0.8911	0.2682E 05	0.2605E-03	1.050	0.	-0.0185	0.3003
0.2227	0.6379	0.1208E 05	0.8856	0.2700E 05	0.2653E-03	1.114	0.8312E-02	-0.0033	0.3250
0.2173	0.6423	0.1291E 05	0.8801	0.2726E 05	0.2720E-03	1.198	0.1981E-01	0.0131	0.3515
0.2119	0.6466	0.1376E 05	0.8755	0.2754E 05	0.2796E-03	1.288	0.3245E-01	0.0308	0.3798
0.2065	0.6510	0.1464E 05	0.8719	0.2786E 05	0.2882E-03	1.383	0.4636E-01	0.0499	0.4094
0.2011	0.6553	0.1555E 05	0.8690	0.2820E 05	0.2980E-03	1.484	0.6169E-01	0.0707	0.4399
0.1958	0.6597	0.1649E 05	0.8667	0.2859E 05	0.3094E-03	1.592	0.7861E-01	0.0914	0.4705
0.1904	0.6640	0.1746E 05	0.8649	0.2902E 05	0.3228E-03	1.708	0.9733E-01	0.1134	0.5004
0.1851	0.6683	0.1848E 05	0.8635	0.2950E 05	0.3386E-03	1.835	0.1181E-00	0.1358	0.5290
0.1798	0.6726	0.1953E 05	0.8623	0.3003E 05	0.3577E-03	1.975	0.1414E-00	0.1581	0.5559
0.1745	0.6769	0.2063E 05	0.8614	0.3063E 05	0.3815E-03	2.130	0.1676E-00	0.1801	0.5807
0.1692	0.6812	0.2179E 05	0.8605	0.3132E 05	0.4117E-03	2.300	0.1973E-00	0.2015	0.6034
0.1639	0.6854	0.2301E 05	0.8597	0.3211E 05	0.4508E-03	2.493	0.2315E-00	0.2073	0.6093

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 100,000 FT VELOCITY = 45,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.6269E 05	0.4486E-03	0.	-0.0045	-0.0586	0.
0.0003	0.0229	0.4267E 03	0.0229	0.6265E 05	0.4483E-03	0.035	-0.0045	-0.0576	0.0459
0.0011	0.0459	0.8531E 03	0.0459	0.6253E 05	0.4475E-03	0.070	-0.0042	-0.0549	0.0917
0.0024	0.0688	0.1280E 04	0.0688	0.6232E 05	0.4462E-03	0.104	-0.0039	-0.0503	0.1376
0.0042	0.0917	0.1709E 04	0.0918	0.6204E 05	0.4443E-03	0.139	-0.0034	-0.0438	0.1834
0.0066	0.1146	0.2140E 04	0.1149	0.6167E 05	0.4418E-03	0.174	-0.0027	-0.0354	0.2293
0.0095	0.1376	0.2573E 04	0.1380	0.6122E 05	0.4388E-03	0.210	-0.0018	-0.0251	0.2751
0.0129	0.1605	0.3007E 04	0.1612	0.6069E 05	0.4353E-03	0.245	-0.0007	-0.0129	0.3210
0.0169	0.1834	0.3443E 04	0.1845	0.6008E 05	0.4312E-03	0.281	0.0003	0.0014	0.3668
0.0215	0.2064	0.3883E 04	0.2078	0.5939E 05	0.4267E-03	0.317	0.0014	0.0178	0.4127
0.0266	0.2293	0.4327E 04	0.2313	0.5861E 05	0.4217E-03	0.353	0.0026	0.0363	0.4586
0.0323	0.2522	0.4776E 04	0.2550	0.5776E 05	0.4160E-03	0.390	0.0044	0.0570	0.5044
0.0386	0.2751	0.5228E 04	0.2787	0.5683E 05	0.4095E-03	0.427	0.0068	0.0799	0.5503
0.0455	0.2981	0.5680E 04	0.3027	0.5582E 05	0.4025E-03	0.464	0.0095	0.1053	0.5961
0.0529	0.3210	0.6133E 04	0.3268	0.5474E 05	0.3952E-03	0.501	0.0119	0.1331	0.6420
0.0610	0.3439	0.6588E 04	0.3511	0.5359E 05	0.3856E-03	0.538	0.0193	0.1634	0.6878
0.0698	0.3668	0.7053E 04	0.3756	0.5236E 05	0.3778E-03	0.576	0.0208	0.1964	0.7337
0.0792	0.3898	0.7517E 04	0.4004	0.5106E 05	0.3697E-03	0.615	0.0219	0.2322	0.7796
0.0893	0.4127	0.7982E 04	0.4255	0.4970E 05	0.3615E-03	0.654	0.0220	0.2709	0.8254
0.1000	0.4356	0.8461E 04	0.4508	0.4828E 05	0.3533E-03	0.694	0.0210	0.3126	0.8713
0.1115	0.4586	0.8925E 04	0.4765	0.4680E 05	0.3458E-03	0.735	0.0162	0.3574	0.9171
0.1238	0.4815	0.9420E 04	0.5025	0.4526E 05	0.3352E-03	0.776	0.0201	0.4055	0.9630
0.1368	0.5044	0.9922E 04	0.5288	0.4369E 05	0.3242E-03	0.818	0.0246	0.4571	1.0088
0.1507	0.5273	0.1044E 05	0.5556	0.4207E 05	0.3128E-03	0.862	0.0297	0.5122	1.0547
0.1653	0.5503	0.1099E 05	0.5828	0.4040E 05	0.3012E-03	0.908	0.0347	0.5711	1.1005
0.1809	0.5732	0.1150E 05	0.6106	0.3872E 05	0.2897E-03	0.951	0.0389	0.6338	1.1464
0.1973	0.5961	0.1201E 05	0.6388	0.3701E 05	0.2778E-03	0.994	0.0436	0.7006	1.1923
0.2147	0.6191	0.1252E 05	0.6676	0.3530E 05	0.2661E-03	1.038	0.0480	0.7716	1.2381
0.2331	0.6420	0.1304E 05	0.6970	0.3358E 05	0.2540E-03	1.082	0.0534	0.8471	1.2840

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2195	0.6252	0.1266E 05	0.9013	0.3484E 05	0.2629E-03	1.050	0.	-0.0200	0.2952
0.2154	0.6285	0.1334E 05	0.8958	0.3505E 05	0.2663E-03	1.109	0.8694E-02	-0.0050	0.3197
0.2099	0.6329	0.1426E 05	0.8899	0.3536E 05	0.2726E-03	1.192	0.2128E-01	0.0112	0.3460
0.2043	0.6373	0.1520E 05	0.8850	0.3571E 05	0.2807E-03	1.280	0.3514E-01	0.0286	0.3740
0.1988	0.6416	0.1618E 05	0.8810	0.3609E 05	0.2895E-03	1.374	0.5042E-01	0.0473	0.4036
0.1933	0.6460	0.1719E 05	0.8778	0.3652E 05	0.2996E-03	1.472	0.6726E-01	0.0673	0.4340
0.1879	0.6503	0.1824E 05	0.8752	0.3700E 05	0.3109E-03	1.577	0.8587E-01	0.0883	0.4644
0.1824	0.6546	0.1932E 05	0.8731	0.3753E 05	0.3240E-03	1.689	0.1065E-00	0.1098	0.4941
0.1770	0.6589	0.2044E 05	0.8714	0.3813E 05	0.3390E-03	1.809	0.1293E-00	0.1317	0.5225
0.1715	0.6632	0.2160E 05	0.8700	0.3880E 05	0.3564E-03	1.939	0.1547E-00	0.1533	0.5486
0.1661	0.6675	0.2280E 05	0.8688	0.3955E 05	0.3768E-03	2.080	0.1832E-00	0.1745	0.5726
0.1607	0.6718	0.2405E 05	0.8678	0.4039E 05	0.4013E-03	2.235	0.2151E-00	0.1952	0.5947
0.1554	0.6760	0.2535E 05	0.8668	0.4134E 05	0.4311E-03	2.410	0.2512E-00	0.1995	0.5991

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 150,000 FT VELOCITY = 10,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.3400E 03	0.3345E-04	0.	0.0003	-0.0898	0.
0.0004	0.0252	0.1235E 03	0.0252	0.3398E 03	0.3342E-04	0.036	0.0003	-0.0888	0.0503
0.0013	0.0503	0.2470E 03	0.0504	0.3390E 03	0.3336E-04	0.072	0.0003	-0.0858	0.1007
0.0029	0.0755	0.3707E 03	0.0756	0.3378E 03	0.3325E-04	0.108	0.0002	-0.0807	0.1510
0.0051	0.1007	0.4945E 03	0.1009	0.3360E 03	0.3310E-04	0.145	0.0002	-0.0737	0.2014
0.0080	0.1259	0.6186E 03	0.1262	0.3337E 03	0.3290E-04	0.181	0.0002	-0.0645	0.2517
0.0115	0.1510	0.7432E 03	0.1516	0.3309E 03	0.3266E-04	0.218	0.0002	-0.0533	0.3021
0.0157	0.1762	0.8684E 03	0.1771	0.3276E 03	0.3238E-04	0.254	0.0001	-0.0399	0.3524
0.0205	0.2014	0.9942E 03	0.2028	0.3238E 03	0.3206E-04	0.291	0.0001	-0.0244	0.4028
0.0260	0.2266	0.1121E 04	0.2286	0.3196E 03	0.3169E-04	0.329	0.0001	-0.0068	0.4531
0.0322	0.2517	0.1248E 04	0.2545	0.3148E 03	0.3128E-04	0.367	0.0000	0.0131	0.5035
0.0391	0.2769	0.1376E 04	0.2806	0.3096E 03	0.3083E-04	0.405	0.0001	0.0353	0.5538
0.0467	0.3021	0.1505E 04	0.3069	0.3039E 03	0.3034E-04	0.443	0.0002	0.0598	0.6042
0.0551	0.3273	0.1639E 04	0.3334	0.2978E 03	0.2981E-04	0.483	0.0004	0.0867	0.6545
0.0641	0.3524	0.1770E 04	0.3602	0.2912E 03	0.2923E-04	0.523	0.0006	0.1161	0.7049
0.0740	0.3776	0.1900E 04	0.3872	0.2842E 03	0.2862E-04	0.562	0.0008	0.1479	0.7552
0.0847	0.4028	0.2032E 04	0.4145	0.2767E 03	0.2796E-04	0.602	0.0010	0.1824	0.8056
0.0962	0.4280	0.2167E 04	0.4422	0.2689E 03	0.2727E-04	0.643	0.0012	0.2195	0.8559
0.1085	0.4531	0.2306E 04	0.4702	0.2606E 03	0.2654E-04	0.686	0.0015	0.2593	0.9062
0.1217	0.4783	0.2445E 04	0.4987	0.2519E 03	0.2578E-04	0.729	0.0016	0.3019	0.9566
0.1359	0.5035	0.2586E 04	0.5276	0.2429E 03	0.2497E-04	0.772	0.0018	0.3474	1.0069
0.1511	0.5286	0.2730E 04	0.5570	0.2335E 03	0.2413E-04	0.818	0.0020	0.3958	1.0573
0.1673	0.5538	0.2877E 04	0.5869	0.2238E 03	0.2325E-04	0.864	0.0021	0.4473	1.1076
0.1846	0.5790	0.3025E 04	0.6175	0.2138E 03	0.2235E-04	0.911	0.0022	0.5019	1.1580
0.2031	0.6042	0.3179E 04	0.6487	0.2034E 03	0.2140E-04	0.960	0.0024	0.5597	1.2083
0.2229	0.6293	0.3332E 04	0.6807	0.1929E 03	0.2045E-04	1.010	0.0024	0.6208	1.2587
0.2440	0.6545	0.3490E 04	0.7135	0.1821E 03	0.1945E-04	1.062	0.0024	0.6854	1.3090

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2391	0.6488	0.3454E 04	0.8639	0.1846E 03	0.1968E-04	1.050	0.	-0.0247	0.4020
0.2280	0.6583	0.3652E 04	0.8503	0.1881E 03	0.2022E-04	1.114	0.4257E-03	-0.0040	0.4257
0.2195	0.6656	0.3810E 04	0.8416	0.1909E 03	0.2066E-04	1.166	0.7830E-03	0.0170	0.4489
0.2110	0.6728	0.3971E 04	0.8341	0.1937E 03	0.2112E-04	1.219	0.1166E-02	0.0382	0.4715
0.2025	0.6801	0.4135E 04	0.8275	0.1966E 03	0.2161E-04	1.273	0.1577E-02	0.0596	0.4934
0.1941	0.6873	0.4301E 04	0.8219	0.1996E 03	0.2213E-04	1.329	0.2018E-02	0.0810	0.5145
0.1857	0.6944	0.4470E 04	0.8170	0.2026E 03	0.2267E-04	1.386	0.2491E-02	0.1025	0.5346
0.1773	0.7016	0.4641E 04	0.8126	0.2057E 03	0.2325E-04	1.445	0.2997E-02	0.1237	0.5535
0.1690	0.7087	0.4813E 04	0.8086	0.2089E 03	0.2385E-04	1.505	0.3539E-02	0.1447	0.5711
0.1607	0.7158	0.4986E 04	0.8050	0.2122E 03	0.2449E-04	1.565	0.4118E-02	0.1652	0.5872
0.1525	0.7228	0.5159E 04	0.8016	0.2155E 03	0.2515E-04	1.627	0.4738E-02	0.1852	0.6020
0.1442	0.7299	0.5333E 04	0.7983	0.2188E 03	0.2584E-04	1.689	0.5400E-02	0.2047	0.6153
0.1360	0.7369	0.5505E 04	0.7950	0.2221E 03	0.2656E-04	1.751	0.6107E-02	0.2187	0.6242

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 150,000 FT VELOCITY = 15,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.7691E 03	0.4042E-04	0.	-0.0001	-0.0721	0.
0.0003	0.0236	0.1615E 03	0.0236	0.7685E 03	0.4040E-04	0.034	-0.0001	-0.0712	0.0473
0.0011	0.0473	0.3229E 03	0.0473	0.7670E 03	0.4033E-04	0.068	-0.0001	-0.0684	0.0945
0.0025	0.0709	0.4847E 03	0.0709	0.7643E 03	0.4021E-04	0.102	-0.0001	-0.0636	0.1418
0.0045	0.0945	0.6470E 03	0.0947	0.7606E 03	0.4005E-04	0.137	-0.0000	-0.0569	0.1890
0.0070	0.1181	0.8100E 03	0.1184	0.7559E 03	0.3983E-04	0.171	0.0000	-0.0483	0.2363
0.0101	0.1418	0.9736E 03	0.1423	0.7501E 03	0.3958E-04	0.206	0.0000	-0.0377	0.2836
0.0137	0.1654	0.1138E 04	0.1662	0.7432E 03	0.3927E-04	0.240	-0.0001	-0.0250	0.3308
0.0180	0.1890	0.1303E 04	0.1902	0.7353E 03	0.3892E-04	0.276	-0.0002	-0.0103	0.3781
0.0228	0.2127	0.1470E 04	0.2143	0.7264E 03	0.3852E-04	0.311	-0.0001	0.0066	0.4253
0.0282	0.2363	0.1638E 04	0.2385	0.7164E 03	0.3807E-04	0.347	0.0001	0.0257	0.4726
0.0343	0.2599	0.1806E 04	0.2629	0.7054E 03	0.3757E-04	0.383	0.0004	0.0471	0.5199
0.0410	0.2836	0.1975E 04	0.2875	0.6935E 03	0.3703E-04	0.419	0.0006	0.0708	0.5671
0.0483	0.3072	0.2145E 04	0.3122	0.6805E 03	0.3645E-04	0.455	0.0004	0.0970	0.6144
0.0563	0.3308	0.2315E 04	0.3372	0.6667E 03	0.3584E-04	0.492	-0.0001	0.1257	0.6616
0.0649	0.3544	0.2485E 04	0.3623	0.6520E 03	0.3524E-04	0.529	-0.0022	0.1570	0.7089
0.0742	0.3781	0.2659E 04	0.3877	0.6363E 03	0.3451E-04	0.567	-0.0020	0.1911	0.7561
0.0842	0.4017	0.2836E 04	0.4134	0.6197E 03	0.3375E-04	0.606	-0.0018	0.2281	0.8034
0.0949	0.4253	0.3016E 04	0.4393	0.6022E 03	0.3294E-04	0.646	-0.0016	0.2680	0.8507
0.1064	0.4490	0.3202E 04	0.4656	0.5837E 03	0.3208E-04	0.687	-0.0012	0.3109	0.8979
0.1187	0.4726	0.3397E 04	0.4922	0.5645E 03	0.3120E-04	0.730	-0.0012	0.3571	0.9452
0.1317	0.4962	0.3583E 04	0.5192	0.5445E 03	0.3027E-04	0.771	-0.0011	0.4066	0.9924
0.1457	0.5199	0.3772E 04	0.5466	0.5237E 03	0.2929E-04	0.814	-0.0008	0.4596	1.0397
0.1605	0.5435	0.3967E 04	0.5745	0.5022E 03	0.2826E-04	0.858	-0.0000	0.5161	1.0870
0.1763	0.5671	0.4166E 04	0.6029	0.4796E 03	0.2721E-04	0.903	-0.0003	0.5764	1.1342
0.1930	0.5907	0.4370E 04	0.6319	0.4563E 03	0.2611E-04	0.951	-0.0006	0.6406	1.1815
0.2109	0.6144	0.4583E 04	0.6615	0.4319E 03	0.2494E-04	1.000	-0.0007	0.7088	1.2287
0.2300	0.6380	0.4803E 04	0.6919	0.4067E 03	0.2374E-04	1.052	-0.0013	0.7812	1.2760

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2291	0.6369	0.4793E 04	0.8774	0.4079E 03	0.2379E-04	1.050	0.	-0.0194	0.3495
0.2245	0.6407	0.4969E 04	0.8714	0.4114E 03	0.2419E-04	1.091	0.3201E-03	-0.0012	0.3747
0.2177	0.6463	0.5236E 04	0.8642	0.4170E 03	0.2483E-04	1.155	0.8244E-03	0.0178	0.4007
0.2110	0.6519	0.5517E 04	0.8581	0.4228E 03	0.2555E-04	1.223	0.1373E-02	0.0378	0.4273
0.2043	0.6574	0.5807E 04	0.8531	0.4290E 03	0.2635E-04	1.295	0.1971E-02	0.0587	0.4543
0.1977	0.6630	0.6108E 04	0.8490	0.4357E 03	0.2725E-04	1.371	0.2624E-02	0.0801	0.4810
0.1911	0.6685	0.6419E 04	0.8456	0.4429E 03	0.2826E-04	1.456	0.3339E-02	0.1020	0.5070
0.1844	0.6740	0.6743E 04	0.8427	0.4505E 03	0.2938E-04	1.547	0.4122E-02	0.1240	0.5318
0.1779	0.6795	0.7078E 04	0.8404	0.4588E 03	0.3063E-04	1.646	0.4983E-02	0.1458	0.5550
0.1713	0.6849	0.7426E 04	0.8384	0.4676E 03	0.3202E-04	1.753	0.5929E-02	0.1671	0.5761
0.1647	0.6903	0.7786E 04	0.8367	0.4771E 03	0.3361E-04	1.869	0.6974E-02	0.1875	0.5949
0.1582	0.6958	0.8156E 04	0.8351	0.4873E 03	0.3542E-04	1.998	0.8130E-02	0.2069	0.6112
0.1517	0.7012	0.8537E 04	0.8336	0.4982E 03	0.3751E-04	2.139	0.9414E-02	0.2108	0.6142

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 150,000 FT VELOCITY = 20,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1377E 04	0.4970E-04	0.	0.0002	-0.0593	0.
0.0003	0.0233	0.1921E 03	0.0233	0.1376E 04	0.4967E-04	0.034	0.0002	-0.0583	0.0465
0.0011	0.0465	0.3840E 03	0.0465	0.1373E 04	0.4959E-04	0.068	0.0002	-0.0555	0.0931
0.0024	0.0698	0.5762E 03	0.0699	0.1369E 04	0.4944E-04	0.103	0.0002	-0.0509	0.1396
0.0043	0.0931	0.7691E 03	0.0932	0.1362E 04	0.4924E-04	0.137	0.0001	-0.0443	0.1861
0.0068	0.1163	0.9628E 03	0.1166	0.1354E 04	0.4898E-04	0.172	0.0001	-0.0358	0.2327
0.0098	0.1396	0.1157E 04	0.1400	0.1344E 04	0.4866E-04	0.206	0.0001	-0.0254	0.2792
0.0133	0.1629	0.1352E 04	0.1636	0.1332E 04	0.4828E-04	0.241	0.0001	-0.0130	0.3257
0.0175	0.1861	0.1549E 04	0.1872	0.1318E 04	0.4784E-04	0.276	-0.0000	0.0015	0.3722
0.0221	0.2094	0.1746E 04	0.2109	0.1303E 04	0.4735E-04	0.312	-0.0001	0.0180	0.4188
0.0274	0.2327	0.1945E 04	0.2348	0.1286E 04	0.4680E-04	0.348	-0.0001	0.0366	0.4653
0.0333	0.2559	0.2145E 04	0.2588	0.1267E 04	0.4619E-04	0.384	-0.0002	0.0574	0.5118
0.0397	0.2792	0.2346E 04	0.2829	0.1246E 04	0.4552E-04	0.420	-0.0002	0.0805	0.5584
0.0468	0.3024	0.2549E 04	0.3073	0.1223E 04	0.4480E-04	0.457	-0.0003	0.1060	0.6049
0.0545	0.3257	0.2759E 04	0.3318	0.1199E 04	0.4403E-04	0.495	-0.0003	0.1338	0.6514
0.0629	0.3490	0.2964E 04	0.3565	0.1174E 04	0.4319E-04	0.533	-0.0004	0.1641	0.6980
0.0719	0.3722	0.3170E 04	0.3814	0.1146E 04	0.4231E-04	0.571	-0.0005	0.1971	0.7445
0.0816	0.3955	0.3377E 04	0.4066	0.1117E 04	0.4137E-04	0.609	-0.0006	0.2327	0.7910
0.0920	0.4188	0.3589E 04	0.4321	0.1087E 04	0.4038E-04	0.649	-0.0008	0.2711	0.8375
0.1031	0.4420	0.3807E 04	0.4579	0.1056E 04	0.3935E-04	0.689	-0.0008	0.3124	0.8841
0.1150	0.4653	0.4024E 04	0.4840	0.1022E 04	0.3826E-04	0.730	-0.0010	0.3566	0.9306
0.1276	0.4886	0.4243E 04	0.5105	0.9882E 03	0.3713E-04	0.771	-0.0012	0.4040	0.9771
0.1411	0.5118	0.4465E 04	0.5374	0.9528E 03	0.3596E-04	0.814	-0.0012	0.4547	1.0237
0.1554	0.5351	0.4692E 04	0.5647	0.9161E 03	0.3474E-04	0.857	-0.0014	0.5087	1.0702
0.1706	0.5584	0.4919E 04	0.5925	0.8788E 03	0.3349E-04	0.901	-0.0017	0.5661	1.1167
0.1867	0.5816	0.5151E 04	0.6208	0.8404E 03	0.3219E-04	0.946	-0.0018	0.6272	1.1633
0.2038	0.6049	0.5385E 04	0.6497	0.8016E 03	0.3088E-04	0.992	-0.0020	0.6921	1.2098
0.2219	0.6282	0.5621E 04	0.6792	0.7623E 03	0.2955E-04	1.039	-0.0022	0.7608	1.2563
0.2412	0.6514	0.5856E 04	0.7094	0.7235E 03	0.2822E-04	1.086	-0.0026	0.8335	1.3029

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2265	0.6338	0.5678E 04	0.8875	0.7529E 03	0.2922E-04	1.050	0.	-0.0175	0.3096
0.2187	0.6402	0.6266E 04	0.8780	0.7628E 03	0.2992E-04	1.165	0.8406E-03	-0.0023	0.3336
0.2131	0.6447	0.6691E 04	0.8729	0.7706E 03	0.3048E-04	1.249	0.1507E-02	0.0138	0.3590
0.2075	0.6492	0.7122E 04	0.8687	0.7792E 03	0.3110E-04	1.335	0.2234E-02	0.0310	0.3856
0.2020	0.6537	0.7558E 04	0.8654	0.7887E 03	0.3180E-04	1.424	0.3027E-02	0.0493	0.4133
0.1965	0.6582	0.8000E 04	0.8627	0.7991E 03	0.3258E-04	1.515	0.3890E-02	0.0686	0.4416
0.1910	0.6627	0.8446E 04	0.8605	0.8104E 03	0.3345E-04	1.609	0.4829E-02	0.0886	0.4698
0.1855	0.6672	0.8898E 04	0.8587	0.8229E 03	0.3443E-04	1.706	0.5852E-02	0.1091	0.4973
0.1800	0.6716	0.9354E 04	0.8573	0.8364E 03	0.3552E-04	1.806	0.6965E-02	0.1299	0.5237
0.1746	0.6761	0.9814E 04	0.8560	0.8511E 03	0.3674E-04	1.909	0.8178E-02	0.1506	0.5485
0.1692	0.6805	0.1028E 05	0.8550	0.8671E 03	0.3811E-04	2.016	0.9499E-02	0.1710	0.5716
0.1637	0.6849	0.1075E 05	0.8540	0.8843E 03	0.3964E-04	2.126	0.1094E-01	0.1910	0.5928
0.1583	0.6893	0.1122E 05	0.8530	0.9029E 03	0.4136E-04	2.240	0.1251E-01	0.2068	0.6089

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 150,000 FT VELOCITY = 25,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.2161E 04	0.5734E-04	0.	0.0001	-0.0511	0.
0.0003	0.0227	0.2197E 03	0.0227	0.2159E 04	0.5731E-04	0.033	0.0001	-0.0501	0.0453
0.0010	0.0453	0.4392E 03	0.0453	0.2155E 04	0.5721E-04	0.067	0.0001	-0.0474	0.0906
0.0023	0.0680	0.6590E 03	0.0680	0.2148E 04	0.5705E-04	0.100	0.0001	-0.0429	0.1360
0.0041	0.0906	0.8796E 03	0.0908	0.2139E 04	0.5683E-04	0.134	0.0001	-0.0365	0.1813
0.0064	0.1133	0.1101E 04	0.1135	0.2126E 04	0.5654E-04	0.167	0.0001	-0.0282	0.2266
0.0093	0.1360	0.1324E 04	0.1364	0.2111E 04	0.5619E-04	0.201	0.0001	-0.0180	0.2719
0.0126	0.1586	0.1547E 04	0.1593	0.2093E 04	0.5577E-04	0.235	0.0000	-0.0059	0.3172
0.0165	0.1813	0.1771E 04	0.1823	0.2072E 04	0.5529E-04	0.270	-0.0000	0.0081	0.3626
0.0210	0.2039	0.1997E 04	0.2054	0.2049E 04	0.5475E-04	0.304	-0.0001	0.0243	0.4079
0.0260	0.2266	0.2224E 04	0.2286	0.2023E 04	0.5415E-04	0.339	-0.0001	0.0425	0.4532
0.0315	0.2493	0.2453E 04	0.2519	0.1994E 04	0.5347E-04	0.374	-0.0001	0.0628	0.4985
0.0377	0.2719	0.2683E 04	0.2754	0.1963E 04	0.5274E-04	0.410	-0.0001	0.0854	0.5438
0.0444	0.2946	0.2915E 04	0.2990	0.1929E 04	0.5194E-04	0.446	-0.0002	0.1103	0.5892
0.0517	0.3172	0.3152E 04	0.3228	0.1892E 04	0.5109E-04	0.483	-0.0003	0.1376	0.6345
0.0596	0.3399	0.3388E 04	0.3468	0.1853E 04	0.5017E-04	0.520	-0.0004	0.1674	0.6798
0.0681	0.3626	0.3623E 04	0.3710	0.1811E 04	0.4920E-04	0.557	-0.0005	0.1997	0.7251
0.0772	0.3852	0.3861E 04	0.3955	0.1768E 04	0.4816E-04	0.594	-0.0007	0.2347	0.7704
0.0871	0.4079	0.4102E 04	0.4202	0.1722E 04	0.4708E-04	0.632	-0.0010	0.2725	0.8158
0.0975	0.4305	0.4349E 04	0.4451	0.1673E 04	0.4593E-04	0.672	-0.0012	0.3131	0.8611
0.1087	0.4532	0.4601E 04	0.4704	0.1623E 04	0.4473E-04	0.712	-0.0012	0.3568	0.9064
0.1206	0.4759	0.4851E 04	0.4960	0.1571E 04	0.4347E-04	0.753	-0.0014	0.4035	0.9517
0.1333	0.4985	0.5102E 04	0.5220	0.1517E 04	0.4218E-04	0.793	-0.0016	0.4536	0.9970
0.1467	0.5212	0.5358E 04	0.5483	0.1462E 04	0.4082E-04	0.835	-0.0016	0.5070	1.0424
0.1610	0.5438	0.5617E 04	0.5751	0.1405E 04	0.3943E-04	0.878	-0.0018	0.5639	1.0877
0.1761	0.5665	0.5879E 04	0.6024	0.1346E 04	0.3800E-04	0.922	-0.0022	0.6245	1.1330
0.1921	0.5892	0.6145E 04	0.6301	0.1286E 04	0.3651E-04	0.966	-0.0020	0.6889	1.1783
0.2091	0.6118	0.6416E 04	0.6584	0.1225E 04	0.3501E-04	1.012	-0.0024	0.7572	1.2236
0.2270	0.6345	0.6692E 04	0.6873	0.1163E 04	0.3345E-04	1.060	-0.0026	0.8296	1.2690

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2233	0.6299	0.6636E 04	0.8924	0.1176E 04	0.3377E-04	1.050	0.	-0.0151	0.2836
0.2170	0.6350	0.7377E 04	0.8849	0.1189E 04	0.3455E-04	1.175	0.9530E-03	-0.0015	0.3075
0.2123	0.6388	0.7948E 04	0.8807	0.1200E 04	0.3524E-04	1.272	0.1765E-02	0.0132	0.3334
0.2075	0.6427	0.8530E 04	0.8774	0.1213E 04	0.3601E-04	1.373	0.2659E-02	0.0293	0.3614
0.2028	0.6465	0.9120E 04	0.8748	0.1227E 04	0.3687E-04	1.477	0.3642E-02	0.0468	0.3911
0.1981	0.6503	0.9719E 04	0.8729	0.1243E 04	0.3785E-04	1.585	0.4722E-02	0.0656	0.4219
0.1933	0.6541	0.1033E 05	0.8714	0.1260E 04	0.3895E-04	1.697	0.5906E-02	0.0856	0.4532
0.1886	0.6579	0.1095E 05	0.8702	0.1280E 04	0.4019E-04	1.812	0.7206E-02	0.1064	0.4839
0.1839	0.6617	0.1157E 05	0.8693	0.1302E 04	0.4158E-04	1.933	0.8632E-02	0.1275	0.5133
0.1793	0.6655	0.1221E 05	0.8686	0.1326E 04	0.4314E-04	2.059	0.1020E-01	0.1487	0.5410
0.1746	0.6692	0.1285E 05	0.8681	0.1353E 04	0.4492E-04	2.190	0.1192E-01	0.1695	0.5665
0.1699	0.6730	0.1350E 05	0.8676	0.1382E 04	0.4693E-04	2.327	0.1381E-01	0.1899	0.5899
0.1653	0.6767	0.1415E 05	0.8671	0.1415E 04	0.4921E-04	2.470	0.1589E-01	0.2045	0.6058

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 150,000 FT VELOCITY = 30,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.3112E 04	0.5818E-04	0.	-0.0002	-0.0494	0.
0.0002	0.0221	0.2570E 03	0.0221	0.3110E 04	0.5815E-04	0.032	-0.0002	-0.0485	0.0442
0.0010	0.0442	0.5137E 03	0.0442	0.3104E 04	0.5806E-04	0.064	-0.0002	-0.0458	0.0883
0.0022	0.0662	0.7705E 03	0.0663	0.3095E 04	0.5791E-04	0.096	-0.0002	-0.0414	0.1325
0.0039	0.0883	0.1028E 04	0.0884	0.3081E 04	0.5771E-04	0.127	-0.0002	-0.0352	0.1766
0.0061	0.1104	0.1286E 04	0.1106	0.3064E 04	0.5745E-04	0.160	-0.0002	-0.0271	0.2208
0.0088	0.1325	0.1545E 04	0.1329	0.3043E 04	0.5712E-04	0.192	-0.0001	-0.0172	0.2650
0.0120	0.1546	0.1806E 04	0.1552	0.3018E 04	0.5672E-04	0.224	0.0001	-0.0054	0.3091
0.0157	0.1766	0.2069E 04	0.1776	0.2989E 04	0.5627E-04	0.257	0.0003	0.0083	0.3533
0.0199	0.1987	0.2334E 04	0.2000	0.2956E 04	0.5577E-04	0.291	0.0002	0.0240	0.3974
0.0246	0.2208	0.2600E 04	0.2226	0.2920E 04	0.5523E-04	0.324	-0.0001	0.0417	0.4416
0.0299	0.2429	0.2869E 04	0.2453	0.2879E 04	0.5463E-04	0.358	-0.0003	0.0615	0.4858
0.0357	0.2650	0.3140E 04	0.2681	0.2835E 04	0.5392E-04	0.393	0.0001	0.0834	0.5299
0.0420	0.2870	0.3412E 04	0.2911	0.2788E 04	0.5312E-04	0.427	0.0010	0.1076	0.5741
0.0489	0.3091	0.3683E 04	0.3143	0.2737E 04	0.5228E-04	0.462	0.0018	0.1341	0.6182
0.0564	0.3312	0.3954E 04	0.3376	0.2683E 04	0.5144E-04	0.497	0.0016	0.1630	0.6624
0.0645	0.3533	0.4223E 04	0.3611	0.2625E 04	0.5057E-04	0.532	0.0010	0.1944	0.7066
0.0732	0.3754	0.4501E 04	0.3848	0.2564E 04	0.4961E-04	0.568	0.0009	0.2283	0.7507
0.0825	0.3974	0.4778E 04	0.4088	0.2500E 04	0.4863E-04	0.605	0.0005	0.2649	0.7949
0.0924	0.4195	0.5059E 04	0.4330	0.2433E 04	0.4761E-04	0.643	-0.0004	0.3043	0.8390
0.1030	0.4416	0.5349E 04	0.4575	0.2363E 04	0.4655E-04	0.682	-0.0013	0.3466	0.8832
0.1143	0.4637	0.5649E 04	0.4823	0.2291E 04	0.4554E-04	0.724	-0.0040	0.3919	0.9274
0.1262	0.4858	0.5937E 04	0.5074	0.2216E 04	0.4429E-04	0.763	-0.0041	0.4404	0.9715
0.1389	0.5078	0.6228E 04	0.5329	0.2139E 04	0.4297E-04	0.803	-0.0036	0.4921	1.0157
0.1523	0.5299	0.6524E 04	0.5587	0.2060E 04	0.4156E-04	0.843	-0.0020	0.5472	1.0598
0.1665	0.5520	0.6835E 04	0.5850	0.1979E 04	0.4000E-04	0.884	0.0023	0.6058	1.1040
0.1815	0.5741	0.7133E 04	0.6117	0.1897E 04	0.3863E-04	0.926	0.0014	0.6681	1.1482
0.1974	0.5962	0.7436E 04	0.6389	0.1813E 04	0.3721E-04	0.970	0.0010	0.7341	1.1923
0.2142	0.6182	0.7741E 04	0.6666	0.1729E 04	0.3577E-04	1.014	0.0003	0.8042	1.2365
0.2318	0.6403	0.8049E 04	0.6949	0.1643E 04	0.3428E-04	1.060	-0.0002	0.8783	1.2806

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2281	0.6357	0.7984E 04	0.8876	0.1661E 04	0.3460E-04	1.050	0.	-0.0141	0.2775
0.2239	0.6391	0.8594E 04	0.8824	0.1673E 04	0.3540E-04	1.141	0.8119E-03	-0.0005	0.3021
0.2194	0.6428	0.9290E 04	0.8781	0.1688E 04	0.3634E-04	1.246	0.1797E-02	0.0145	0.3293
0.2148	0.6464	0.1001E 05	0.8747	0.1705E 04	0.3736E-04	1.358	0.2895E-02	0.0310	0.3589
0.2103	0.6501	0.1076E 05	0.8721	0.1724E 04	0.3846E-04	1.475	0.4113E-02	0.0493	0.3908
0.2058	0.6538	0.1152E 05	0.8702	0.1746E 04	0.3971E-04	1.598	0.5464E-02	0.0692	0.4242
0.2013	0.6574	0.1230E 05	0.8688	0.1772E 04	0.4111E-04	1.727	0.6962E-02	0.0905	0.4581
0.1969	0.6611	0.1309E 05	0.8678	0.1800E 04	0.4272E-04	1.864	0.8624E-02	0.1128	0.4912
0.1924	0.6647	0.1391E 05	0.8671	0.1832E 04	0.4455E-04	2.010	0.1047E-01	0.1354	0.5229
0.1879	0.6683	0.1474E 05	0.8667	0.1869E 04	0.4666E-04	2.164	0.1252E-01	0.1580	0.5523
0.1835	0.6720	0.1559E 05	0.8664	0.1911E 04	0.4909E-04	2.325	0.1481E-01	0.1800	0.5790
0.1790	0.6756	0.1646E 05	0.8663	0.1957E 04	0.5190E-04	2.496	0.1737E-01	0.2012	0.6031
0.1746	0.6792	0.1733E 05	0.8662	0.2010E 04	0.5514E-04	2.676	0.2023E-01	0.2087	0.6112

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 150,000 FT VELOCITY = 35,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.4224E 04	0.5403E-04	0.	-0.0005	-0.0535	0.
0.0004	0.0281	0.3935E 03	0.0281	0.4220E 04	0.5398E-04	0.041	-0.0005	-0.0521	0.0562
0.0016	0.0562	0.7871E 03	0.0562	0.4207E 04	0.5385E-04	0.082	-0.0005	-0.0478	0.1123
0.0035	0.0842	0.1182E 04	0.0843	0.4186E 04	0.5362E-04	0.123	-0.0004	-0.0408	0.1685
0.0063	0.1123	0.1579E 04	0.1126	0.4157E 04	0.5330E-04	0.165	-0.0003	-0.0308	0.2246
0.0099	0.1404	0.1979E 04	0.1409	0.4119E 04	0.5288E-04	0.207	-0.0001	-0.0178	0.2808
0.0142	0.1685	0.2381E 04	0.1693	0.4073E 04	0.5238E-04	0.249	0.0001	-0.0018	0.3370
0.0194	0.1966	0.2787E 04	0.1978	0.4018E 04	0.5178E-04	0.291	0.0003	0.0175	0.3931
0.0255	0.2246	0.3195E 04	0.2265	0.3955E 04	0.5109E-04	0.334	0.0004	0.0400	0.4493
0.0324	0.2527	0.3608E 04	0.2555	0.3884E 04	0.5032E-04	0.378	0.0005	0.0661	0.5054
0.0401	0.2808	0.4027E 04	0.2846	0.3804E 04	0.4945E-04	0.423	0.0007	0.0958	0.5616
0.0488	0.3089	0.4450E 04	0.3140	0.3716E 04	0.4848E-04	0.468	0.0010	0.1294	0.6177
0.0584	0.3370	0.4889E 04	0.3437	0.3622E 04	0.4745E-04	0.515	0.0011	0.1670	0.6739
0.0690	0.3650	0.5315E 04	0.3737	0.3519E 04	0.4630E-04	0.561	0.0015	0.2090	0.7301
0.0806	0.3931	0.5741E 04	0.4040	0.3410E 04	0.4507E-04	0.607	0.0021	0.2555	0.7862
0.0931	0.4212	0.6170E 04	0.4348	0.3295E 04	0.4376E-04	0.654	0.0028	0.3068	0.8424
0.1068	0.4493	0.6605E 04	0.4660	0.3173E 04	0.4238E-04	0.701	0.0034	0.3633	0.8985
0.1215	0.4774	0.7062E 04	0.4977	0.3045E 04	0.4090E-04	0.752	0.0045	0.4252	0.9547
0.1373	0.5054	0.7523E 04	0.5300	0.2909E 04	0.3935E-04	0.803	0.0047	0.4929	1.0109
0.1544	0.5335	0.7993E 04	0.5628	0.2767E 04	0.3774E-04	0.856	0.0047	0.5666	1.0670
0.1727	0.5616	0.8482E 04	0.5964	0.2618E 04	0.3603E-04	0.913	0.0047	0.6468	1.1232
0.1924	0.5897	0.8984E 04	0.6307	0.2465E 04	0.3425E-04	0.971	0.0048	0.7337	1.1793
0.2136	0.6177	0.9494E 04	0.6659	0.2307E 04	0.3242E-04	1.031	0.0047	0.8278	1.2355
0.2365	0.6458	0.1001E 05	0.7021	0.2148E 04	0.3054E-04	1.093	0.0046	0.9295	1.2917

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2207	0.6266	0.9657E 04	0.8949	0.2257E 04	0.3183E-04	1.050	0.	-0.0156	0.2892
0.2138	0.6322	0.1069E 05	0.8867	0.2286E 04	0.3293E-04	1.173	0.1456E-02	-0.0012	0.3140
0.2088	0.6361	0.1147E 05	0.8823	0.2310E 04	0.3387E-04	1.267	0.2631E-02	0.0146	0.3411
0.2039	0.6400	0.1227E 05	0.8789	0.2336E 04	0.3496E-04	1.367	0.3932E-02	0.0318	0.3704
0.1990	0.6440	0.1310E 05	0.8763	0.2366E 04	0.3625E-04	1.473	0.5375E-02	0.0508	0.4018
0.1941	0.6479	0.1397E 05	0.8743	0.2400E 04	0.3779E-04	1.589	0.6982E-02	0.0713	0.4345
0.1893	0.6518	0.1487E 05	0.8728	0.2438E 04	0.3965E-04	1.717	0.8778E-02	0.0932	0.4675
0.1844	0.6557	0.1583E 05	0.8716	0.2482E 04	0.4193E-04	1.860	0.1080E-01	0.1159	0.4997
0.1796	0.6596	0.1683E 05	0.8708	0.2532E 04	0.4478E-04	2.024	0.1309E-01	0.1387	0.5300
0.1747	0.6635	0.1789E 05	0.8702	0.2591E 04	0.4832E-04	2.213	0.1571E-01	0.1613	0.5578
0.1699	0.6673	0.1903E 05	0.8698	0.2660E 04	0.5260E-04	2.432	0.1874E-01	0.1830	0.5826
0.1651	0.6712	0.2023E 05	0.8695	0.2741E 04	0.5754E-04	2.680	0.2227E-01	0.2027	0.6035

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 150,000 FT VELOCITY = 40,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.5518E 04	0.5470E-04	0.	-0.0005	-0.0531	0.
0.0004	0.0282	0.4489E 03	0.0282	0.5513E 04	0.5466E-04	0.041	-0.0005	-0.0517	0.0564
0.0016	0.0564	0.8978E 03	0.0565	0.5496E 04	0.5452E-04	0.083	-0.0005	-0.0474	0.1129
0.0036	0.0847	0.1348E 04	0.0848	0.5469E 04	0.5428E-04	0.124	-0.0004	-0.0403	0.1693
0.0064	0.1129	0.1801E 04	0.1131	0.5430E 04	0.5395E-04	0.166	-0.0003	-0.0303	0.2257
0.0100	0.1411	0.2256E 04	0.1416	0.5380E 04	0.5353E-04	0.208	-0.0001	-0.0173	0.2822
0.0144	0.1693	0.2714E 04	0.1701	0.5319E 04	0.5301E-04	0.251	0.0001	-0.0012	0.3386
0.0197	0.1975	0.3176E 04	0.1988	0.5248E 04	0.5240E-04	0.294	0.0003	0.0180	0.3950
0.0258	0.2257	0.3641E 04	0.2277	0.5165E 04	0.5169E-04	0.337	0.0005	0.0405	0.4515
0.0328	0.2540	0.4111E 04	0.2568	0.5072E 04	0.5089E-04	0.381	0.0007	0.0664	0.5079
0.0406	0.2822	0.4586E 04	0.2861	0.4967E 04	0.4999E-04	0.426	0.0009	0.0959	0.5643
0.0494	0.3104	0.5066E 04	0.3156	0.4853E 04	0.4900E-04	0.471	0.0012	0.1292	0.6208
0.0591	0.3386	0.5570E 04	0.3455	0.4729E 04	0.4793E-04	0.519	0.0015	0.1665	0.6772
0.0698	0.3668	0.6056E 04	0.3756	0.4593E 04	0.4675E-04	0.565	0.0019	0.2079	0.7336
0.0815	0.3950	0.6543E 04	0.4062	0.4449E 04	0.4549E-04	0.612	0.0023	0.2537	0.7901
0.0943	0.4233	0.7035E 04	0.4372	0.4297E 04	0.4415E-04	0.660	0.0028	0.3041	0.8465
0.1081	0.4515	0.7538E 04	0.4686	0.4138E 04	0.4273E-04	0.709	0.0035	0.3595	0.9030
0.1230	0.4797	0.8049E 04	0.5005	0.3970E 04	0.4125E-04	0.759	0.0038	0.4200	0.9594
0.1391	0.5079	0.8556E 04	0.5330	0.3799E 04	0.3973E-04	0.809	0.0041	0.4860	1.0158
0.1564	0.5361	0.9064E 04	0.5662	0.3624E 04	0.3814E-04	0.860	0.0048	0.5577	1.0723
0.1750	0.5643	0.9576E 04	0.6000	0.3445E 04	0.3653E-04	0.912	0.0050	0.6356	1.1287
0.1949	0.5926	0.1009E 05	0.6345	0.3265E 04	0.3489E-04	0.964	0.0054	0.7198	1.1851
0.2162	0.6208	0.1060E 05	0.6699	0.3082E 04	0.3321E-04	1.018	0.0057	0.8109	1.2416
0.2390	0.6490	0.1113E 05	0.7061	0.2895E 04	0.3147E-04	1.073	0.0063	0.9091	1.2980

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2294	0.6374	0.1091E 05	0.8901	0.2972E 04	0.3219E-04	1.050	0.	-0.0157	0.2883
0.2244	0.6414	0.1181E 05	0.8838	0.2996E 04	0.3286E-04	1.144	0.1198E-02	-0.0016	0.3127
0.2195	0.6454	0.1271E 05	0.8791	0.3022E 04	0.3359E-04	1.239	0.2490E-02	0.0138	0.3390
0.2147	0.6493	0.1363E 05	0.8753	0.3052E 04	0.3442E-04	1.338	0.3916E-02	0.0306	0.3675
0.2098	0.6532	0.1457E 05	0.8722	0.3085E 04	0.3537E-04	1.442	0.5487E-02	0.0488	0.3976
0.2050	0.6572	0.1553E 05	0.8698	0.3122E 04	0.3646E-04	1.552	0.7219E-02	0.0684	0.4289
0.2002	0.6611	0.1653E 05	0.8679	0.3164E 04	0.3773E-04	1.668	0.9131E-02	0.0892	0.4605
0.1953	0.6650	0.1754E 05	0.8663	0.3211E 04	0.3920E-04	1.791	0.1124E-01	0.1108	0.4916
0.1905	0.6689	0.1859E 05	0.8651	0.3263E 04	0.4095E-04	1.924	0.1359E-01	0.1328	0.5214
0.1857	0.6728	0.1967E 05	0.8642	0.3322E 04	0.4309E-04	2.064	0.1620E-01	0.1551	0.5497
0.1810	0.6766	0.2079E 05	0.8634	0.3390E 04	0.4575E-04	2.216	0.1912E-01	0.1772	0.5761
0.1762	0.6805	0.2195E 05	0.8626	0.3467E 04	0.4908E-04	2.385	0.2242E-01	0.1989	0.6006
0.1715	0.6843	0.2316E 05	0.8620	0.3556E 04	0.5336E-04	2.575	0.2620E-01	0.2091	0.6115

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 150,000 FT VELOCITY = 45,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.6987E 04	0.5566E-04	0.	-0.0023	-0.0523	0.
0.0003	0.0226	0.4002E 03	0.0226	0.6983E 04	0.5563E-04	0.034	-0.0022	-0.0514	0.0451
0.0010	0.0451	0.8001E 03	0.0452	0.6969E 04	0.5554E-04	0.068	-0.0021	-0.0487	0.0903
0.0023	0.0677	0.1201E 04	0.0678	0.6947E 04	0.5538E-04	0.101	-0.0019	-0.0441	0.1354
0.0041	0.0903	0.1603E 04	0.0904	0.6916E 04	0.5515E-04	0.135	-0.0016	-0.0378	0.1806
0.0064	0.1129	0.2006E 04	0.1131	0.6876E 04	0.5487E-04	0.170	-0.0012	-0.0295	0.2257
0.0092	0.1354	0.2412E 04	0.1359	0.6827E 04	0.5452E-04	0.204	-0.0008	-0.0194	0.2709
0.0126	0.1580	0.2819E 04	0.1587	0.6769E 04	0.5411E-04	0.238	-0.0003	-0.0073	0.3160
0.0164	0.1806	0.3229E 04	0.1816	0.6702E 04	0.5363E-04	0.273	0.0003	0.0068	0.3612
0.0208	0.2032	0.3642E 04	0.2046	0.6626E 04	0.5308E-04	0.308	0.0011	0.0229	0.4063
0.0258	0.2257	0.4057E 04	0.2277	0.6542E 04	0.5247E-04	0.344	0.0022	0.0411	0.4515
0.0313	0.2483	0.4473E 04	0.2509	0.6449E 04	0.5178E-04	0.379	0.0034	0.0615	0.4966
0.0374	0.2709	0.4891E 04	0.2743	0.6347E 04	0.5106E-04	0.415	0.0042	0.0841	0.5418
0.0441	0.2934	0.5314E 04	0.2978	0.6237E 04	0.5031E-04	0.451	0.0045	0.1091	0.5869
0.0513	0.3160	0.5744E 04	0.3216	0.6119E 04	0.4951E-04	0.488	0.0044	0.1365	0.6320
0.0591	0.3386	0.6184E 04	0.3454	0.5993E 04	0.4907E-04	0.528	-0.0047	0.1665	0.6772
0.0676	0.3612	0.6620E 04	0.3696	0.5859E 04	0.4801E-04	0.565	-0.0019	0.1990	0.7223
0.0767	0.3837	0.7062E 04	0.3939	0.5717E 04	0.4689E-04	0.603	0.0017	0.2343	0.7675
0.0865	0.4063	0.7515E 04	0.4185	0.5569E 04	0.4566E-04	0.642	0.0066	0.2725	0.8126
0.0969	0.4289	0.7980E 04	0.4434	0.5413E 04	0.4430E-04	0.681	0.0137	0.3136	0.8578
0.1080	0.4515	0.8506E 04	0.4685	0.5251E 04	0.4277E-04	0.725	0.0251	0.3579	0.9029
0.1198	0.4740	0.8959E 04	0.4940	0.5082E 04	0.4155E-04	0.764	0.0267	0.4054	0.9481
0.1324	0.4966	0.9408E 04	0.5199	0.4909E 04	0.4029E-04	0.804	0.0284	0.4563	0.9932
0.1457	0.5192	0.9847E 04	0.5461	0.4730E 04	0.3894E-04	0.843	0.0312	0.5107	1.0384
0.1599	0.5418	0.1029E 05	0.5727	0.4547E 04	0.3740E-04	0.880	0.0387	0.5688	1.0835
0.1748	0.5643	0.1076E 05	0.5998	0.4361E 04	0.3606E-04	0.923	0.0401	0.6308	1.1286
0.1906	0.5869	0.1125E 05	0.6274	0.4172E 04	0.3469E-04	0.966	0.0417	0.6968	1.1738
0.2074	0.6095	0.1173E 05	0.6555	0.3982E 04	0.3329E-04	1.010	0.0436	0.7670	1.2189
0.2250	0.6320	0.1221E 05	0.6842	0.3791E 04	0.3191E-04	1.054	0.0448	0.8415	1.2641

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2233	0.6299	0.1217E 05	0.8962	0.3809E 04	0.3204E-04	1.050	0.	-0.0165	0.2821
0.2186	0.6337	0.1306E 05	0.8902	0.3837E 04	0.3308E-04	1.138	0.1235E-02	-0.0027	0.3063
0.2137	0.6376	0.1405E 05	0.8853	0.3870E 04	0.3400E-04	1.233	0.2652E-02	0.0124	0.3327
0.2089	0.6415	0.1508E 05	0.8815	0.3908E 04	0.3487E-04	1.332	0.4220E-02	0.0289	0.3612
0.2040	0.6454	0.1613E 05	0.8784	0.3950E 04	0.3593E-04	1.435	0.5951E-02	0.0469	0.3916
0.1992	0.6492	0.1721E 05	0.8760	0.3998E 04	0.3710E-04	1.543	0.7867E-02	0.0663	0.4233
0.1944	0.6531	0.1832E 05	0.8740	0.4052E 04	0.3846E-04	1.658	0.9985E-02	0.0869	0.4553
0.1896	0.6569	0.1946E 05	0.8725	0.4112E 04	0.3999E-04	1.780	0.1233E-01	0.1084	0.4867
0.1848	0.6608	0.2063E 05	0.8713	0.4181E 04	0.4177E-04	1.909	0.1494E-01	0.1302	0.5167
0.1800	0.6646	0.2184E 05	0.8704	0.4259E 04	0.4379E-04	2.049	0.1783E-01	0.1523	0.5453
0.1752	0.6684	0.2309E 05	0.8697	0.4347E 04	0.4619E-04	2.201	0.2107E-01	0.1740	0.5714
0.1704	0.6722	0.2437E 05	0.8690	0.4446E 04	0.4902E-04	2.365	0.2469E-01	0.1949	0.5951
0.1657	0.6760	0.2569E 05	0.8685	0.4559E 04	0.5246E-04	2.546	0.2877E-01	0.2034	0.6042

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 200,000 FT VELOCITY = 10,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.5850E 02	0.6060E-05	0.	0.0001	-0.0850	0.
0.0003	0.0249	0.1194E 03	0.0249	0.5846E 02	0.6056E-05	0.036	0.0001	-0.0840	0.0499
0.0013	0.0499	0.2388E 03	0.0499	0.5833E 02	0.6044E-05	0.072	0.0001	-0.0810	0.0998
0.0028	0.0748	0.3583E 03	0.0749	0.5811E 02	0.6025E-05	0.108	0.0001	-0.0760	0.1497
0.0050	0.0998	0.4782E 03	0.0999	0.5781E 02	0.5997E-05	0.144	0.0001	-0.0690	0.1995
0.0078	0.1247	0.5984E 03	0.1250	0.5742E 02	0.5962E-05	0.180	0.0000	-0.0599	0.2494
0.0113	0.1497	0.7190E 03	0.1502	0.5695E 02	0.5919E-05	0.217	0.0000	-0.0488	0.2993
0.0154	0.1746	0.8401E 03	0.1755	0.5639E 02	0.5869E-05	0.253	0.0000	-0.0356	0.3492
0.0201	0.1995	0.9617E 03	0.2009	0.5575E 02	0.5810E-05	0.290	0.0000	-0.0202	0.3991
0.0255	0.2245	0.1084E 04	0.2264	0.5503E 02	0.5744E-05	0.328	0.0000	-0.0027	0.4490
0.0316	0.2494	0.1207E 04	0.2521	0.5422E 02	0.5671E-05	0.365	0.0000	0.0170	0.4989
0.0384	0.2744	0.1331E 04	0.2779	0.5334E 02	0.5589E-05	0.403	-0.0000	0.0389	0.5488
0.0458	0.2993	0.1455E 04	0.3040	0.5237E 02	0.5501E-05	0.441	-0.0000	0.0632	0.5986
0.0540	0.3243	0.1585E 04	0.3302	0.5134E 02	0.5406E-05	0.481	-0.0000	0.0898	0.6485
0.0630	0.3492	0.1711E 04	0.3567	0.5022E 02	0.5302E-05	0.520	-0.0001	0.1188	0.6984
0.0726	0.3742	0.1837E 04	0.3835	0.4903E 02	0.5192E-05	0.559	-0.0001	0.1503	0.7483
0.0831	0.3991	0.1964E 04	0.4105	0.4777E 02	0.5075E-05	0.599	-0.0003	0.1844	0.7982
0.0943	0.4240	0.2094E 04	0.4379	0.4644E 02	0.4951E-05	0.640	-0.0004	0.2211	0.8481
0.1064	0.4490	0.2230E 04	0.4656	0.4504E 02	0.4820E-05	0.682	-0.0004	0.2604	0.8980
0.1194	0.4739	0.2364E 04	0.4937	0.4356E 02	0.4682E-05	0.725	-0.0006	0.3025	0.9479
0.1333	0.4989	0.2499E 04	0.5223	0.4204E 02	0.4538E-05	0.768	-0.0008	0.3475	0.9977
0.1481	0.5238	0.2639E 04	0.5513	0.4044E 02	0.4387E-05	0.813	-0.0010	0.3953	1.0476
0.1640	0.5488	0.2780E 04	0.5809	0.3879E 02	0.4230E-05	0.859	-0.0013	0.4462	1.0975
0.1809	0.5737	0.2922E 04	0.6110	0.3710E 02	0.4068E-05	0.906	-0.0017	0.5001	1.1474
0.1990	0.5986	0.3068E 04	0.6418	0.3536E 02	0.3900E-05	0.954	-0.0019	0.5573	1.1973
0.2182	0.6236	0.3216E 04	0.6733	0.3359E 02	0.3729E-05	1.003	-0.0024	0.6176	1.2472
0.2388	0.6485	0.3368E 04	0.7057	0.3176E 02	0.3550E-05	1.054	-0.0029	0.6814	1.2971

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2373	0.6467	0.3357E 04	0.8671	0.3190E 02	0.3564E-05	1.050	0.	-0.0236	0.3887
0.2259	0.6563	0.3584E 04	0.8534	0.3253E 02	0.3663E-05	1.125	0.7827E-04	-0.0038	0.4125
0.2178	0.6632	0.3750E 04	0.8454	0.3298E 02	0.3738E-05	1.181	0.1392E-03	0.0164	0.4358
0.2098	0.6700	0.3919E 04	0.8385	0.3345E 02	0.3818E-05	1.237	0.2047E-03	0.0369	0.4588
0.2018	0.6768	0.4090E 04	0.8326	0.3394E 02	0.3902E-05	1.295	0.2751E-03	0.0577	0.4814
0.1938	0.6836	0.4263E 04	0.8275	0.3444E 02	0.3990E-05	1.354	0.3505E-03	0.0787	0.5033
0.1858	0.6904	0.4438E 04	0.8230	0.3496E 02	0.4083E-05	1.415	0.4313E-03	0.0997	0.5243
0.1779	0.6971	0.4613E 04	0.8190	0.3549E 02	0.4181E-05	1.476	0.5179E-03	0.1207	0.5442
0.1700	0.7038	0.4790E 04	0.8154	0.3604E 02	0.4284E-05	1.538	0.6106E-03	0.1414	0.5629
0.1621	0.7105	0.4966E 04	0.8121	0.3660E 02	0.4391E-05	1.600	0.7097E-03	0.1618	0.5803
0.1543	0.7171	0.5142E 04	0.8090	0.3717E 02	0.4504E-05	1.663	0.8156E-03	0.1818	0.5964
0.1465	0.7237	0.5317E 04	0.8061	0.3774E 02	0.4620E-05	1.727	0.9286E-03	0.2013	0.6111
0.1387	0.7303	0.5491E 04	0.8031	0.3832E 02	0.4741E-05	1.790	0.1049E-02	0.2172	0.6223

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 200,000 FT VELOCITY = 15,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1322E 03	0.7263E-05	0.	0.0005	-0.0692	0.
0.0003	0.0236	0.1576E 03	0.0236	0.1322E 03	0.7259E-05	0.034	0.0005	-0.0683	0.0472
0.0011	0.0472	0.3152E 03	0.0472	0.1319E 03	0.7246E-05	0.068	0.0005	-0.0654	0.0944
0.0025	0.0708	0.4731E 03	0.0709	0.1314E 03	0.7225E-05	0.103	0.0004	-0.0607	0.1416
0.0044	0.0944	0.6317E 03	0.0946	0.1308E 03	0.7196E-05	0.137	0.0004	-0.0540	0.1888
0.0070	0.1180	0.7910E 03	0.1183	0.1300E 03	0.7157E-05	0.172	0.0003	-0.0454	0.2360
0.0100	0.1416	0.9511E 03	0.1421	0.1290E 03	0.7110E-05	0.206	0.0003	-0.0348	0.2832
0.0137	0.1652	0.1112E 04	0.1660	0.1278E 03	0.7055E-05	0.242	0.0002	-0.0221	0.3305
0.0179	0.1888	0.1274E 04	0.1900	0.1265E 03	0.6991E-05	0.277	0.0001	-0.0073	0.3777
0.0227	0.2124	0.1438E 04	0.2140	0.1249E 03	0.6918E-05	0.313	-0.0001	0.0096	0.4249
0.0281	0.2360	0.1602E 04	0.2383	0.1232E 03	0.6837E-05	0.349	-0.0003	0.0287	0.4721
0.0342	0.2596	0.1768E 04	0.2626	0.1213E 03	0.6746E-05	0.385	-0.0003	0.0501	0.5193
0.0408	0.2832	0.1935E 04	0.2871	0.1192E 03	0.6646E-05	0.422	-0.0003	0.0739	0.5665
0.0481	0.3068	0.2102E 04	0.3118	0.1170E 03	0.6539E-05	0.459	-0.0004	0.1002	0.6137
0.0561	0.3305	0.2274E 04	0.3368	0.1146E 03	0.6417E-05	0.497	0.0009	0.1291	0.6609
0.0647	0.3541	0.2445E 04	0.3619	0.1120E 03	0.6295E-05	0.535	0.0003	0.1606	0.7081
0.0741	0.3777	0.2614E 04	0.3873	0.1093E 03	0.6168E-05	0.572	-0.0006	0.1949	0.7553
0.0841	0.4013	0.2783E 04	0.4129	0.1065E 03	0.6036E-05	0.610	-0.0019	0.2321	0.8025
0.0949	0.4249	0.2955E 04	0.4389	0.1035E 03	0.5900E-05	0.649	-0.0037	0.2723	0.8497
0.1064	0.4485	0.3131E 04	0.4651	0.1004E 03	0.5756E-05	0.690	-0.0053	0.3157	0.8969
0.1186	0.4721	0.3310E 04	0.4917	0.9724E 02	0.5612E-05	0.731	-0.0080	0.3623	0.9442
0.1317	0.4957	0.3487E 04	0.5187	0.9390E 02	0.5447E-05	0.772	-0.0083	0.4124	0.9914
0.1456	0.5193	0.3670E 04	0.5461	0.9039E 02	0.5272E-05	0.814	-0.0082	0.4659	1.0386
0.1603	0.5429	0.3863E 04	0.5740	0.8671E 02	0.5089E-05	0.859	-0.0084	0.5232	1.0858
0.1760	0.5665	0.4060E 04	0.6023	0.8280E 02	0.4895E-05	0.905	-0.0092	0.5843	1.1330
0.1927	0.5901	0.4264E 04	0.6312	0.7874E 02	0.4691E-05	0.953	-0.0098	0.6494	1.1802
0.2104	0.6137	0.4478E 04	0.6607	0.7448E 02	0.4469E-05	1.004	-0.0089	0.7187	1.2274
0.2294	0.6373	0.4696E 04	0.6910	0.7011E 02	0.4249E-05	1.058	-0.0102	0.7922	1.2746

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2267	0.6340	0.4666E 04	0.8829	0.7072E 02	0.4279E-05	1.050	0.	-0.0189	0.3411
0.2219	0.6379	0.4864E 04	0.8767	0.7133E 02	0.4346E-05	1.097	0.5759E-04	-0.0015	0.3659
0.2155	0.6432	0.5142E 04	0.8699	0.7225E 02	0.4449E-05	1.164	0.1423E-03	0.0169	0.3915
0.2090	0.6486	0.5432E 04	0.8642	0.7321E 02	0.4565E-05	1.235	0.2346E-03	0.0362	0.4179
0.2026	0.6538	0.5731E 04	0.8596	0.7424E 02	0.4693E-05	1.309	0.3351E-03	0.0564	0.4449
0.1962	0.6591	0.6040E 04	0.8558	0.7535E 02	0.4837E-05	1.388	0.4447E-03	0.0775	0.4721
0.1898	0.6643	0.6358E 04	0.8527	0.7654E 02	0.5000E-05	1.472	0.5644E-03	0.0991	0.4990
0.1834	0.6696	0.6685E 04	0.8502	0.7782E 02	0.5190E-05	1.563	0.6953E-03	0.1211	0.5249
0.1771	0.6748	0.7024E 04	0.8481	0.7921E 02	0.5416E-05	1.661	0.8392E-03	0.1429	0.5491
0.1707	0.6800	0.7374E 04	0.8463	0.8071E 02	0.5688E-05	1.770	0.9980E-03	0.1641	0.5711
0.1644	0.6852	0.7739E 04	0.8447	0.8235E 02	0.6015E-05	1.893	0.1174E-02	0.1845	0.5905
0.1582	0.6903	0.8120E 04	0.8433	0.8413E 02	0.6401E-05	2.032	0.1372E-02	0.2039	0.6076
0.1519	0.6955	0.8517E 04	0.8420	0.8607E 02	0.6825E-05	2.184	0.1593E-02	0.2089	0.6117

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 200,000 FT VELOCITY = 20,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.2369E 03	0.9120E-05	0.	0.0003	-0.0555	0.
0.0003	0.0231	0.1848E 03	0.0231	0.2368E 03	0.9114E-05	0.034	0.0003	-0.0546	0.0462
0.0011	0.0462	0.3695E 03	0.0462	0.2363E 03	0.9099E-05	0.068	0.0003	-0.0518	0.0924
0.0024	0.0693	0.5545E 03	0.0693	0.2355E 03	0.9072E-05	0.102	0.0002	-0.0472	0.1385
0.0043	0.0924	0.7402E 03	0.0925	0.2344E 03	0.9035E-05	0.137	0.0002	-0.0407	0.1847
0.0067	0.1154	0.9266E 03	0.1157	0.2330E 03	0.8987E-05	0.171	0.0002	-0.0322	0.2309
0.0096	0.1385	0.1114E 04	0.1390	0.2313E 03	0.8928E-05	0.206	0.0001	-0.0219	0.2771
0.0131	0.1616	0.1302E 04	0.1623	0.2293E 03	0.8859E-05	0.241	0.0001	-0.0096	0.3233
0.0172	0.1847	0.1490E 04	0.1858	0.2270E 03	0.8779E-05	0.276	-0.0000	0.0048	0.3694
0.0218	0.2078	0.1680E 04	0.2093	0.2243E 03	0.8689E-05	0.311	-0.0001	0.0212	0.4156
0.0270	0.2309	0.1871E 04	0.2330	0.2214E 03	0.8588E-05	0.347	-0.0002	0.0397	0.4618
0.0328	0.2540	0.2063E 04	0.2568	0.2182E 03	0.8477E-05	0.383	-0.0003	0.0604	0.5080
0.0391	0.2771	0.2257E 04	0.2807	0.2146E 03	0.8355E-05	0.419	-0.0004	0.0833	0.5542
0.0461	0.3002	0.2452E 04	0.3049	0.2108E 03	0.8223E-05	0.456	-0.0005	0.1085	0.6003
0.0537	0.3233	0.2654E 04	0.3292	0.2067E 03	0.8082E-05	0.494	-0.0005	0.1362	0.6465
0.0619	0.3463	0.2852E 04	0.3537	0.2023E 03	0.7929E-05	0.532	-0.0006	0.1664	0.6927
0.0708	0.3694	0.3050E 04	0.3784	0.1977E 03	0.7767E-05	0.569	-0.0008	0.1991	0.7389
0.0803	0.3925	0.3250E 04	0.4034	0.1928E 03	0.7597E-05	0.608	-0.0011	0.2345	0.7851
0.0905	0.4156	0.3454E 04	0.4286	0.1876E 03	0.7417E-05	0.647	-0.0014	0.2726	0.8312
0.1014	0.4387	0.3664E 04	0.4542	0.1822E 03	0.7228E-05	0.687	-0.0017	0.3137	0.8774
0.1131	0.4618	0.3874E 04	0.4801	0.1766E 03	0.7029E-05	0.728	-0.0019	0.3577	0.9236
0.1255	0.4849	0.4084E 04	0.5063	0.1708E 03	0.6822E-05	0.769	-0.0020	0.4049	0.9698
0.1388	0.5080	0.4299E 04	0.5329	0.1647E 03	0.6607E-05	0.811	-0.0021	0.4552	1.0160
0.1528	0.5311	0.4517E 04	0.5599	0.1585E 03	0.6384E-05	0.855	-0.0022	0.5090	1.0621
0.1677	0.5542	0.4737E 04	0.5874	0.1521E 03	0.6156E-05	0.898	-0.0024	0.5662	1.1083
0.1836	0.5772	0.4959E 04	0.6154	0.1456E 03	0.5919E-05	0.943	-0.0024	0.6270	1.1545
0.2004	0.6003	0.5185E 04	0.6440	0.1389E 03	0.5680E-05	0.989	-0.0026	0.6915	1.2007
0.2181	0.6234	0.5413E 04	0.6731	0.1322E 03	0.5434E-05	1.035	-0.0026	0.7600	1.2469
0.2370	0.6465	0.5642E 04	0.7030	0.1255E 03	0.5189E-05	1.082	-0.0029	0.8324	1.2930

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2241	0.6308	0.5486E 04	0.8911	0.1301E 03	0.5356E-05	1.050	0.	-0.0167	0.2974
0.2163	0.6371	0.6126E 04	0.8819	0.1318E 03	0.5482E-05	1.179	0.1488E-03	-0.0023	0.3212
0.2111	0.6413	0.6565E 04	0.8773	0.1331E 03	0.5581E-05	1.268	0.2616E-03	0.0131	0.3466
0.2059	0.6455	0.7009E 04	0.8736	0.1345E 03	0.5691E-05	1.360	0.3851E-03	0.0296	0.3736
0.2007	0.6497	0.7458E 04	0.8706	0.1361E 03	0.5815E-05	1.454	0.5200E-03	0.0473	0.4018
0.1956	0.6539	0.7912E 04	0.8682	0.1379E 03	0.5953E-05	1.551	0.6670E-03	0.0661	0.4308
0.1904	0.6580	0.8370E 04	0.8664	0.1398E 03	0.6108E-05	1.651	0.8273E-03	0.0858	0.4600
0.1852	0.6622	0.8833E 04	0.8649	0.1419E 03	0.6280E-05	1.753	0.1002E-02	0.1061	0.4886
0.1801	0.6664	0.9301E 04	0.8636	0.1442E 03	0.6474E-05	1.858	0.1192E-02	0.1267	0.5160
0.1750	0.6705	0.9771E 04	0.8626	0.1468E 03	0.6690E-05	1.967	0.1399E-02	0.1473	0.5419
0.1699	0.6746	0.1024E 05	0.8618	0.1496E 03	0.6933E-05	2.079	0.1625E-02	0.1677	0.5659
0.1648	0.6787	0.1072E 05	0.8610	0.1526E 03	0.7205E-05	2.194	0.1871E-02	0.1876	0.5881
0.1597	0.6828	0.1120E 05	0.8603	0.1558E 03	0.7511E-05	2.313	0.2140E-02	0.2047	0.6061

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 200,000 FT VELOCITY = 25,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.3718E 03	0.1061E-04	0.	0.0002	-0.0475	0.
0.0003	0.0225	0.2106E 03	0.0225	0.3715E 03	0.1060E-04	0.033	0.0002	-0.0466	0.0450
0.0010	0.0450	0.4210E 03	0.0450	0.3708E 03	0.1059E-04	0.067	0.0002	-0.0439	0.0900
0.0023	0.0675	0.6316E 03	0.0675	0.3696E 03	0.1056E-04	0.100	0.0002	-0.0393	0.1350
0.0041	0.0900	0.8432E 03	0.0901	0.3680E 03	0.1051E-04	0.133	0.0002	-0.0330	0.1800
0.0063	0.1125	0.1056E 04	0.1127	0.3659E 03	0.1046E-04	0.167	0.0001	-0.0248	0.2250
0.0091	0.1350	0.1269E 04	0.1354	0.3633E 03	0.1040E-04	0.201	0.0001	-0.0147	0.2700
0.0125	0.1575	0.1483E 04	0.1581	0.3602E 03	0.1032E-04	0.235	0.0000	-0.0027	0.3150
0.0163	0.1800	0.1698E 04	0.1810	0.3567E 03	0.1023E-04	0.269	-0.0001	0.0113	0.3599
0.0207	0.2025	0.1915E 04	0.2039	0.3527E 03	0.1013E-04	0.304	-0.0002	0.0274	0.4049
0.0256	0.2250	0.2133E 04	0.2269	0.3483E 03	0.1002E-04	0.339	-0.0002	0.0455	0.4499
0.0311	0.2475	0.2352E 04	0.2501	0.3434E 03	0.9895E-05	0.374	-0.0002	0.0657	0.4949
0.0371	0.2700	0.2573E 04	0.2733	0.3380E 03	0.9759E-05	0.409	-0.0002	0.0882	0.5399
0.0437	0.2925	0.2795E 04	0.2968	0.3322E 03	0.9613E-05	0.445	-0.0004	0.1129	0.5849
0.0509	0.3150	0.3022E 04	0.3204	0.3260E 03	0.9457E-05	0.482	-0.0007	0.1401	0.6299
0.0587	0.3375	0.3248E 04	0.3442	0.3193E 03	0.9287E-05	0.519	-0.0009	0.1697	0.6749
0.0671	0.3599	0.3474E 04	0.3682	0.3123E 03	0.9107E-05	0.555	-0.0011	0.2019	0.7199
0.0761	0.3824	0.3702E 04	0.3925	0.3048E 03	0.8917E-05	0.593	-0.0015	0.2368	0.7649
0.0858	0.4049	0.3934E 04	0.4170	0.2970E 03	0.8717E-05	0.631	-0.0019	0.2744	0.8099
0.0961	0.4274	0.4171E 04	0.4417	0.2888E 03	0.8505E-05	0.670	-0.0022	0.3149	0.8549
0.1071	0.4499	0.4414E 04	0.4668	0.2802E 03	0.8282E-05	0.711	-0.0020	0.3585	0.8999
0.1188	0.4724	0.4654E 04	0.4921	0.2713E 03	0.8050E-05	0.751	-0.0024	0.4052	0.9449
0.1313	0.4949	0.4895E 04	0.5178	0.2621E 03	0.7810E-05	0.792	-0.0027	0.4551	0.9899
0.1445	0.5174	0.5141E 04	0.5439	0.2526E 03	0.7560E-05	0.833	-0.0027	0.5084	1.0349
0.1585	0.5399	0.5390E 04	0.5705	0.2429E 03	0.7303E-05	0.876	-0.0032	0.5653	1.0798
0.1733	0.5624	0.5641E 04	0.5974	0.2329E 03	0.7040E-05	0.919	-0.0037	0.6258	1.1248
0.1891	0.5849	0.5896E 04	0.6249	0.2227E 03	0.6765E-05	0.963	-0.0036	0.6902	1.1698
0.2057	0.6074	0.6156E 04	0.6529	0.2123E 03	0.6488E-05	1.009	-0.0042	0.7585	1.2148
0.2233	0.6299	0.6420E 04	0.6814	0.2017E 03	0.6202E-05	1.056	-0.0045	0.8310	1.2598

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2212	0.6272	0.6388E 04	0.8959	0.2030E 03	0.6237E-05	1.050	0.	-0.0144	0.2713
0.2150	0.6321	0.7188E 04	0.8888	0.2052E 03	0.6381E-05	1.189	0.1670E-03	-0.0016	0.2949
0.2106	0.6357	0.7777E 04	0.8850	0.2070E 03	0.6502E-05	1.293	0.3040E-03	0.0124	0.3207
0.2062	0.6392	0.8376E 04	0.8821	0.2091E 03	0.6639E-05	1.401	0.4554E-03	0.0278	0.3489
0.2018	0.6427	0.8984E 04	0.8799	0.2114E 03	0.6793E-05	1.512	0.6223E-03	0.0447	0.3791
0.1974	0.6463	0.9600E 04	0.8782	0.2141E 03	0.6968E-05	1.627	0.8058E-03	0.0630	0.4109
0.1930	0.6498	0.1023E 05	0.8770	0.2171E 03	0.7167E-05	1.746	0.1008E-02	0.0827	0.4432
0.1886	0.6533	0.1086E 05	0.8761	0.2205E 03	0.7392E-05	1.869	0.1229E-02	0.1033	0.4751
0.1842	0.6568	0.1150E 05	0.8754	0.2242E 03	0.7648E-05	1.998	0.1473E-02	0.1244	0.5057
0.1799	0.6603	0.1215E 05	0.8749	0.2284E 03	0.7938E-05	2.131	0.1741E-02	0.1456	0.5345
0.1755	0.6638	0.1281E 05	0.8746	0.2331E 03	0.8267E-05	2.270	0.2036E-02	0.1664	0.5611
0.1712	0.6672	0.1348E 05	0.8743	0.2383E 03	0.8640E-05	2.415	0.2360E-02	0.1868	0.5855
0.1668	0.6707	0.1414E 05	0.8740	0.2440E 03	0.9063E-05	2.565	0.2719E-02	0.2024	0.6030

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 200,000 FT VELOCITY = 30,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.5351E 03	0.1057E-04	0.	0.0002	-0.0466	0.
0.0002	0.0219	0.2491E 03	0.0219	0.5347E 03	0.1056E-04	0.032	0.0002	-0.0458	0.0439
0.0010	0.0439	0.4979E 03	0.0439	0.5338E 03	0.1055E-04	0.063	0.0002	-0.0431	0.0877
0.0022	0.0658	0.7470E 03	0.0659	0.5321E 03	0.1052E-04	0.095	0.0002	-0.0387	0.1316
0.0039	0.0877	0.9969E 03	0.0879	0.5298E 03	0.1048E-04	0.127	0.0002	-0.0325	0.1755
0.0060	0.1097	0.1248E 04	0.1099	0.5269E 03	0.1043E-04	0.158	0.0002	-0.0245	0.2193
0.0087	0.1316	0.1499E 04	0.1320	0.5233E 03	0.1038E-04	0.190	0.0001	-0.0147	0.2632
0.0118	0.1535	0.1751E 04	0.1541	0.5190E 03	0.1031E-04	0.223	-0.0001	-0.0030	0.3071
0.0155	0.1755	0.2006E 04	0.1764	0.5141E 03	0.1023E-04	0.255	-0.0002	0.0107	0.3510
0.0197	0.1974	0.2262E 04	0.1987	0.5086E 03	0.1014E-04	0.288	-0.0001	0.0263	0.3948
0.0243	0.2193	0.2519E 04	0.2211	0.5024E 03	0.1003E-04	0.321	-0.0001	0.0439	0.4387
0.0295	0.2413	0.2776E 04	0.2437	0.4956E 03	0.9924E-05	0.355	-0.0005	0.0637	0.4826
0.0352	0.2632	0.3033E 04	0.2663	0.4881E 03	0.9807E-05	0.388	-0.0011	0.0856	0.5264
0.0415	0.2851	0.3292E 04	0.2892	0.4801E 03	0.9678E-05	0.422	-0.0016	0.1097	0.5703
0.0483	0.3071	0.3556E 04	0.3121	0.4714E 03	0.9532E-05	0.457	-0.0016	0.1361	0.6142
0.0557	0.3290	0.3825E 04	0.3353	0.4621E 03	0.9372E-05	0.492	-0.0013	0.1650	0.6580
0.0636	0.3510	0.4115E 04	0.3586	0.4523E 03	0.9189E-05	0.530	0.0003	0.1964	0.7019
0.0722	0.3729	0.4382E 04	0.3821	0.4418E 03	0.9017E-05	0.566	-0.0003	0.2303	0.7458
0.0813	0.3948	0.4648E 04	0.4059	0.4309E 03	0.8839E-05	0.602	-0.0011	0.2670	0.7896
0.0911	0.4168	0.4916E 04	0.4299	0.4194E 03	0.8655E-05	0.639	-0.0024	0.3065	0.8335
0.1015	0.4387	0.5187E 04	0.4542	0.4073E 03	0.8462E-05	0.676	-0.0038	0.3489	0.8774
0.1125	0.4606	0.5461E 04	0.4788	0.3948E 03	0.8256E-05	0.715	-0.0050	0.3944	0.9212
0.1243	0.4826	0.5737E 04	0.5036	0.3819E 03	0.8035E-05	0.754	-0.0056	0.4430	0.9651
0.1368	0.5045	0.6022E 04	0.5289	0.3686E 03	0.7804E-05	0.794	-0.0060	0.4950	1.0090
0.1500	0.5264	0.6308E 04	0.5545	0.3550E 03	0.7565E-05	0.835	-0.0063	0.5504	1.0529
0.1640	0.5484	0.6597E 04	0.5805	0.3411E 03	0.7314E-05	0.877	-0.0061	0.6094	1.0967
0.1788	0.5703	0.6889E 04	0.6070	0.3269E 03	0.7063E-05	0.920	-0.0066	0.6722	1.1406
0.1944	0.5922	0.7183E 04	0.6339	0.3125E 03	0.6808E-05	0.963	-0.0072	0.7388	1.1845
0.2109	0.6142	0.7485E 04	0.6614	0.2979E 03	0.6537E-05	1.008	-0.0068	0.8095	1.2283
0.2284	0.6361	0.7785E 04	0.6894	0.2832E 03	0.6271E-05	1.055	-0.0073	0.8843	1.2722

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2266	0.6339	0.7755E 04	0.8884	0.2847E 03	0.6297E-05	1.050	0.	-0.0132	0.2693
0.2230	0.6368	0.8348E 04	0.8838	0.2864E 03	0.6415E-05	1.139	0.1247E-03	-0.0001	0.2939
0.2187	0.6403	0.9067E 04	0.8798	0.2889E 03	0.6575E-05	1.250	0.2901E-03	0.0144	0.3212
0.2145	0.6437	0.9802E 04	0.8766	0.2917E 03	0.6759E-05	1.368	0.4745E-03	0.0305	0.3515
0.2102	0.6472	0.1056E 05	0.8743	0.2950E 03	0.6969E-05	1.493	0.6800E-03	0.0486	0.3843
0.2060	0.6507	0.1133E 05	0.8727	0.2987E 03	0.7210E-05	1.625	0.9090E-03	0.0686	0.4189
0.2017	0.6541	0.1213E 05	0.8715	0.3030E 03	0.7486E-05	1.767	0.1164E-02	0.0900	0.4540
0.1975	0.6575	0.1296E 05	0.8708	0.3079E 03	0.7802E-05	1.916	0.1448E-02	0.1124	0.4883
0.1933	0.6610	0.1380E 05	0.8704	0.3135E 03	0.8165E-05	2.074	0.1766E-02	0.1352	0.5208
0.1891	0.6644	0.1467E 05	0.8702	0.3199E 03	0.8577E-05	2.241	0.2122E-02	0.1579	0.5509
0.1849	0.6678	0.1556E 05	0.8702	0.3273E 03	0.9045E-05	2.417	0.2521E-02	0.1801	0.5784
0.1807	0.6712	0.1647E 05	0.8703	0.3357E 03	0.9582E-05	2.603	0.2968E-02	0.2016	0.6033
0.1765	0.6746	0.1739E 05	0.8705	0.3454E 03	0.1020E-04	2.800	0.3472E-02	0.2078	0.6101

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 200,000 FT VELOCITY = 35,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.7266E 03	0.9900E-05	0.	0.0002	-0.0503	0.
0.0004	0.0280	0.3804E 03	0.0280	0.7259E 03	0.9891E-05	0.041	0.0001	-0.0489	0.0560
0.0016	0.0560	0.7608E 03	0.0561	0.7237E 03	0.9866E-05	0.082	0.0001	-0.0447	0.1121
0.0035	0.0841	0.1143E 04	0.0842	0.7202E 03	0.9824E-05	0.123	0.0001	-0.0377	0.1681
0.0063	0.1121	0.1527E 04	0.1123	0.7151E 03	0.9766E-05	0.165	0.0002	-0.0277	0.2242
0.0098	0.1401	0.1913E 04	0.1406	0.7086E 03	0.9690E-05	0.206	0.0001	-0.0147	0.2802
0.0142	0.1681	0.2303E 04	0.1689	0.7007E 03	0.9598E-05	0.249	0.0001	0.0013	0.3363
0.0193	0.1961	0.2696E 04	0.1974	0.6913E 03	0.9489E-05	0.291	-0.0001	0.0205	0.3923
0.0253	0.2242	0.3093E 04	0.2261	0.6805E 03	0.9363E-05	0.335	-0.0003	0.0430	0.4483
0.0322	0.2522	0.3495E 04	0.2549	0.6682E 03	0.9219E-05	0.379	-0.0003	0.0691	0.5044
0.0400	0.2802	0.3902E 04	0.2840	0.6544E 03	0.9057E-05	0.423	-0.0003	0.0988	0.5604
0.0486	0.3082	0.4312E 04	0.3133	0.6394E 03	0.8879E-05	0.469	-0.0003	0.1324	0.6165
0.0582	0.3363	0.4732E 04	0.3429	0.6231E 03	0.8685E-05	0.515	-0.0002	0.1701	0.6725
0.0688	0.3643	0.5143E 04	0.3729	0.6055E 03	0.8476E-05	0.561	-0.0003	0.2121	0.7285
0.0803	0.3923	0.5553E 04	0.4032	0.5870E 03	0.8253E-05	0.607	-0.0004	0.2588	0.7846
0.0929	0.4203	0.5965E 04	0.4339	0.5673E 03	0.8017E-05	0.654	-0.0005	0.3102	0.8406
0.1065	0.4483	0.6384E 04	0.4650	0.5466E 03	0.7767E-05	0.702	-0.0007	0.3669	0.8967
0.1211	0.4764	0.6821E 04	0.4967	0.5248E 03	0.7500E-05	0.752	-0.0005	0.4290	0.9527
0.1369	0.5044	0.7261E 04	0.5288	0.5017E 03	0.7220E-05	0.803	-0.0009	0.4970	1.0088
0.1539	0.5324	0.7711E 04	0.5616	0.4777E 03	0.6926E-05	0.856	-0.0014	0.5711	1.0648
0.1721	0.5604	0.8181E 04	0.5950	0.4525E 03	0.6612E-05	0.912	-0.0015	0.6517	1.1208
0.1916	0.5884	0.8661E 04	0.6292	0.4264E 03	0.6288E-05	0.970	-0.0019	0.7392	1.1769
0.2127	0.6165	0.9151E 04	0.6643	0.3995E 03	0.5953E-05	1.030	-0.0028	0.8340	1.2329
0.2353	0.6445	0.9652E 04	0.7003	0.3724E 03	0.5608E-05	1.093	-0.0033	0.9364	1.2890

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2197	0.6254	0.9309E 04	0.8987	0.3909E 03	0.5844E-05	1.050	0.	-0.0148	0.2799
0.2126	0.6310	0.1049E 05	0.8904	0.3960E 03	0.6029E-05	1.193	0.2664E-03	-0.0012	0.3042
0.2080	0.6347	0.1129E 05	0.8866	0.3999E 03	0.6177E-05	1.293	0.4654E-03	0.0138	0.3309
0.2033	0.6384	0.1212E 05	0.8837	0.4042E 03	0.6351E-05	1.399	0.6856E-03	0.0302	0.3600
0.1987	0.6421	0.1298E 05	0.8814	0.4092E 03	0.6559E-05	1.509	0.9297E-03	0.0484	0.3912
0.1941	0.6458	0.1386E 05	0.8797	0.4148E 03	0.6814E-05	1.627	0.1201E-02	0.0683	0.4241
0.1895	0.6494	0.1478E 05	0.8784	0.4212E 03	0.7137E-05	1.756	0.1504E-02	0.0896	0.4577
0.1849	0.6531	0.1574E 05	0.8775	0.4286E 03	0.7553E-05	1.898	0.1844E-02	0.1120	0.4908
0.1803	0.6567	0.1675E 05	0.8767	0.4370E 03	0.8089E-05	2.061	0.2231E-02	0.1348	0.5223
0.1757	0.6604	0.1783E 05	0.8761	0.4470E 03	0.8762E-05	2.251	0.2676E-02	0.1575	0.5513
0.1712	0.6640	0.1898E 05	0.8756	0.4587E 03	0.9575E-05	2.484	0.3193E-02	0.1795	0.5776
0.1666	0.6676	0.2021E 05	0.8752	0.4726E 03	0.1054E-04	2.757	0.3799E-02	0.2007	0.6012

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 200,000 FT VELOCITY = 40,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.9497E 03	0.1018E-04	0.	-0.0001	-0.0491	0.
0.0004	0.0280	0.4294E 03	0.0280	0.9488E 03	0.1017E-04	0.041	-0.0001	-0.0477	0.0561
0.0016	0.0561	0.8587E 03	0.0561	0.9460E 03	0.1014E-04	0.083	-0.0000	-0.0435	0.1121
0.0035	0.0841	0.1289E 04	0.0842	0.9413E 03	0.1010E-04	0.124	-0.0000	-0.0364	0.1682
0.0063	0.1121	0.1722E 04	0.1124	0.9347E 03	0.1004E-04	0.166	-0.0000	-0.0265	0.2243
0.0099	0.1402	0.2158E 04	0.1406	0.9262E 03	0.9961E-05	0.208	0.0000	-0.0136	0.2803
0.0142	0.1682	0.2596E 04	0.1690	0.9159E 03	0.9865E-05	0.250	0.0001	0.0024	0.3364
0.0194	0.1962	0.3037E 04	0.1975	0.9037E 03	0.9752E-05	0.293	0.0001	0.0215	0.3925
0.0255	0.2243	0.3482E 04	0.2262	0.8896E 03	0.9622E-05	0.336	0.0000	0.0438	0.4485
0.0323	0.2523	0.3932E 04	0.2551	0.8737E 03	0.9474E-05	0.380	-0.0000	0.0696	0.5046
0.0401	0.2803	0.4386E 04	0.2841	0.8560E 03	0.9308E-05	0.424	0.0000	0.0989	0.5607
0.0488	0.3084	0.4845E 04	0.3135	0.8364E 03	0.9124E-05	0.470	0.0001	0.1320	0.6167
0.0584	0.3364	0.5325E 04	0.3431	0.8153E 03	0.8926E-05	0.517	0.0002	0.1690	0.6728
0.0689	0.3644	0.5790E 04	0.3731	0.7922E 03	0.8707E-05	0.563	0.0003	0.2102	0.7289
0.0804	0.3925	0.6256E 04	0.4034	0.7678E 03	0.8474E-05	0.610	0.0005	0.2557	0.7849
0.0930	0.4205	0.6727E 04	0.4341	0.7419E 03	0.8226E-05	0.657	0.0005	0.3059	0.8410
0.1066	0.4485	0.7211E 04	0.4653	0.7145E 03	0.7962E-05	0.706	0.0009	0.3609	0.8971
0.1213	0.4766	0.7705E 04	0.4969	0.6858E 03	0.7686E-05	0.757	0.0008	0.4211	0.9531
0.1372	0.5046	0.8194E 04	0.5292	0.6564E 03	0.7402E-05	0.807	0.0006	0.4867	1.0092
0.1542	0.5326	0.8685E 04	0.5620	0.6260E 03	0.7106E-05	0.858	0.0008	0.5580	1.0653
0.1725	0.5607	0.9178E 04	0.5955	0.5955E 03	0.6807E-05	0.910	0.0006	0.6355	1.1213
0.1921	0.5887	0.9666E 04	0.6297	0.5646E 03	0.6502E-05	0.962	0.0005	0.7193	1.1774
0.2131	0.6167	0.1015E 05	0.6647	0.5338E 03	0.6196E-05	1.014	0.0002	0.8099	1.2335
0.2355	0.6448	0.1064E 05	0.7006	0.5025E 03	0.5879E-05	1.068	0.0004	0.9076	1.2895

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2280	0.6356	0.1048E 05	0.8926	0.5128E 03	0.5984E-05	1.050	0.	-0.0145	0.2766
0.2227	0.6398	0.1154E 05	0.8861	0.5171E 03	0.6116E-05	1.163	0.2275E-03	-0.0013	0.3005
0.2182	0.6434	0.1248E 05	0.8819	0.5213E 03	0.6244E-05	1.265	0.4473E-03	0.0132	0.3268
0.2137	0.6471	0.1343E 05	0.8785	0.5262E 03	0.6392E-05	1.370	0.6904E-03	0.0292	0.3553
0.2092	0.6507	0.1440E 05	0.8757	0.5317E 03	0.6561E-05	1.481	0.9590E-03	0.0467	0.3859
0.2047	0.6543	0.1540E 05	0.8736	0.5379E 03	0.6755E-05	1.596	0.1256E-02	0.0658	0.4179
0.2002	0.6579	0.1642E 05	0.8719	0.5450E 03	0.6980E-05	1.718	0.1583E-02	0.0861	0.4505
0.1958	0.6615	0.1747E 05	0.8705	0.5529E 03	0.7242E-05	1.847	0.1946E-02	0.1074	0.4826
0.1913	0.6651	0.1854E 05	0.8694	0.5620E 03	0.7551E-05	1.984	0.2347E-02	0.1292	0.5134
0.1869	0.6687	0.1964E 05	0.8686	0.5722E 03	0.7920E-05	2.132	0.2794E-02	0.1512	0.5426
0.1825	0.6722	0.2077E 05	0.8679	0.5839E 03	0.8368E-05	2.291	0.3293E-02	0.1732	0.5699
0.1780	0.6758	0.2194E 05	0.8674	0.5973E 03	0.8922E-05	2.466	0.3854E-02	0.1949	0.5953
0.1736	0.6794	0.2314E 05	0.8669	0.6128E 03	0.9647E-05	2.663	0.4491E-02	0.2072	0.6091

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 200,000 FT VELOCITY = 45,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1203E 04	0.1046E-04	0.	-0.0013	-0.0479	0.
0.0004	0.0280	0.4755E 03	0.0280	0.1202E 04	0.1045E-04	0.042	-0.0012	-0.0465	0.0560
0.0016	0.0560	0.9507E 03	0.0560	0.1198E 04	0.1042E-04	0.084	-0.0011	-0.0423	0.1120
0.0035	0.0840	0.1427E 04	0.0841	0.1192E 04	0.1038E-04	0.126	-0.0009	-0.0352	0.1680
0.0063	0.1120	0.1907E 04	0.1122	0.1184E 04	0.1031E-04	0.168	-0.0006	-0.0253	0.2240
0.0098	0.1400	0.2389E 04	0.1405	0.1173E 04	0.1023E-04	0.210	-0.0003	-0.0124	0.2800
0.0142	0.1680	0.2875E 04	0.1688	0.1160E 04	0.1013E-04	0.253	0.0002	0.0035	0.3360
0.0194	0.1960	0.3363E 04	0.1973	0.1145E 04	0.1001E-04	0.296	0.0007	0.0226	0.3920
0.0254	0.2240	0.3856E 04	0.2259	0.1127E 04	0.9874E-05	0.340	0.0013	0.0449	0.4480
0.0322	0.2520	0.4353E 04	0.2547	0.1107E 04	0.9719E-05	0.384	0.0020	0.0706	0.5040
0.0400	0.2800	0.4855E 04	0.2838	0.1085E 04	0.9545E-05	0.429	0.0027	0.0998	0.5600
0.0486	0.3080	0.5363E 04	0.3131	0.1060E 04	0.9353E-05	0.474	0.0035	0.1327	0.6160
0.0581	0.3360	0.5891E 04	0.3426	0.1034E 04	0.9148E-05	0.522	0.0042	0.1696	0.6720
0.0686	0.3640	0.6407E 04	0.3726	0.1005E 04	0.8919E-05	0.568	0.0053	0.2106	0.7280
0.0801	0.3920	0.6925E 04	0.4028	0.9740E 03	0.8675E-05	0.615	0.0065	0.2559	0.7839
0.0926	0.4200	0.7450E 04	0.4335	0.9413E 03	0.8416E-05	0.663	0.0078	0.3058	0.8399
0.1061	0.4480	0.7991E 04	0.4646	0.9069E 03	0.8141E-05	0.712	0.0092	0.3605	0.8959
0.1208	0.4760	0.8539E 04	0.4962	0.8706E 03	0.7852E-05	0.763	0.0105	0.4203	0.9519
0.1365	0.5040	0.9089E 04	0.5283	0.8331E 03	0.7553E-05	0.814	0.0118	0.4855	1.0079
0.1535	0.5320	0.9649E 04	0.5611	0.7942E 03	0.7239E-05	0.866	0.0135	0.5564	1.0639
0.1718	0.5600	0.1022E 05	0.5945	0.7543E 03	0.6917E-05	0.920	0.0149	0.6333	1.1199
0.1913	0.5880	0.1079E 05	0.6287	0.7135E 03	0.6585E-05	0.974	0.0166	0.7166	1.1759
0.2123	0.6160	0.1137E 05	0.6636	0.6726E 03	0.6251E-05	1.030	0.0180	0.8065	1.2319
0.2347	0.6440	0.1195E 05	0.6995	0.6313E 03	0.5910E-05	1.086	0.0199	0.9034	1.2879

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2202	0.6261	0.1158E 05	0.8995	0.6577E 03	0.6129E-05	1.050	0.	-0.0150	0.2699
0.2156	0.6297	0.1263E 05	0.8935	0.6624E 03	0.6256E-05	1.151	0.2194E-03	-0.0020	0.2938
0.2112	0.6333	0.1366E 05	0.8896	0.6680E 03	0.6399E-05	1.253	0.4583E-03	0.0121	0.3200
0.2067	0.6368	0.1473E 05	0.8862	0.6741E 03	0.6560E-05	1.359	0.7233E-03	0.0278	0.3487
0.2023	0.6403	0.1582E 05	0.8836	0.6812E 03	0.6744E-05	1.471	0.1017E-02	0.0451	0.3796
0.1978	0.6439	0.1694E 05	0.8816	0.6893E 03	0.6954E-05	1.588	0.1342E-02	0.0639	0.4122
0.1934	0.6474	0.1809E 05	0.8801	0.6986E 03	0.7194E-05	1.711	0.1703E-02	0.0842	0.4453
0.1890	0.6509	0.1927E 05	0.8789	0.7091E 03	0.7468E-05	1.840	0.2102E-02	0.1054	0.4779
0.1846	0.6544	0.2048E 05	0.8780	0.7210E 03	0.7784E-05	1.978	0.2546E-02	0.1271	0.5092
0.1802	0.6579	0.2173E 05	0.8773	0.7345E 03	0.8151E-05	2.124	0.3040E-02	0.1489	0.5386
0.1758	0.6614	0.2300E 05	0.8768	0.7498E 03	0.8581E-05	2.281	0.3590E-02	0.1704	0.5656
0.1714	0.6648	0.2431E 05	0.8763	0.7673E 03	0.9092E-05	2.451	0.4207E-02	0.1914	0.5903
0.1671	0.6683	0.2565E 05	0.8759	0.7872E 03	0.9704E-05	2.635	0.4902E-02	0.2009	0.6011

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 250,000 FT VELOCITY = 10,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.7418E 01	0.8194E-06	0.	0.0000	-0.0796	0.
0.0003	0.0247	0.1147E 03	0.0247	0.7413E 01	0.8188E-06	0.036	0.0000	-0.0786	0.0494
0.0013	0.0494	0.2295E 03	0.0494	0.7397E 01	0.8173E-06	0.072	0.0000	-0.0756	0.0988
0.0028	0.0741	0.3444E 03	0.0742	0.7370E 01	0.8146E-06	0.108	0.0000	-0.0707	0.1482
0.0049	0.0988	0.4596E 03	0.0990	0.7332E 01	0.8109E-06	0.144	0.0000	-0.0637	0.1976
0.0077	0.1235	0.5752E 03	0.1238	0.7284E 01	0.8062E-06	0.180	0.0000	-0.0547	0.2470
0.0111	0.1482	0.6912E 03	0.1488	0.7225E 01	0.8003E-06	0.217	0.0000	-0.0437	0.2964
0.0151	0.1729	0.8076E 03	0.1738	0.7155E 01	0.7935E-06	0.253	0.0000	-0.0306	0.3459
0.0197	0.1976	0.9245E 03	0.1989	0.7075E 01	0.7856E-06	0.290	0.0000	-0.0154	0.3953
0.0250	0.2223	0.1042E 04	0.2242	0.6985E 01	0.7767E-06	0.328	0.0000	0.0019	0.4447
0.0310	0.2470	0.1160E 04	0.2496	0.6884E 01	0.7667E-06	0.365	-0.0000	0.0214	0.4941
0.0376	0.2717	0.1279E 04	0.2752	0.6773E 01	0.7558E-06	0.403	-0.0000	0.0432	0.5435
0.0450	0.2964	0.1399E 04	0.3010	0.6653E 01	0.7438E-06	0.441	0.0000	0.0672	0.5929
0.0530	0.3211	0.1524E 04	0.3269	0.6523E 01	0.7309E-06	0.481	0.0001	0.0936	0.6423
0.0617	0.3459	0.1645E 04	0.3531	0.6383E 01	0.7169E-06	0.520	0.0001	0.1224	0.6917
0.0712	0.3706	0.1766E 04	0.3796	0.6234E 01	0.7020E-06	0.559	0.0001	0.1537	0.7411
0.0814	0.3953	0.1889E 04	0.4064	0.6076E 01	0.6862E-06	0.599	0.0000	0.1874	0.7905
0.0925	0.4200	0.2015E 04	0.4334	0.5909E 01	0.6693E-06	0.640	-0.0000	0.2238	0.8399
0.1043	0.4447	0.2145E 04	0.4608	0.5734E 01	0.6516E-06	0.682	0.0001	0.2629	0.8893
0.1170	0.4694	0.2274E 04	0.4886	0.5550E 01	0.6330E-06	0.724	-0.0000	0.3047	0.9387
0.1306	0.4941	0.2403E 04	0.5168	0.5360E 01	0.6137E-06	0.767	-0.0002	0.3494	0.9881
0.1451	0.5188	0.2535E 04	0.5454	0.5164E 01	0.5936E-06	0.811	-0.0003	0.3969	1.0376
0.1606	0.5435	0.2669E 04	0.5746	0.4960E 01	0.5728E-06	0.856	-0.0004	0.4475	1.0870
0.1771	0.5682	0.2805E 04	0.6043	0.4751E 01	0.5512E-06	0.902	-0.0007	0.5012	1.1364
0.1947	0.5929	0.2945E 04	0.6346	0.4532E 01	0.5285E-06	0.949	-0.0007	0.5580	1.1858
0.2135	0.6176	0.3089E 04	0.6657	0.4309E 01	0.5053E-06	0.998	-0.0011	0.6182	1.2352
0.2335	0.6423	0.3239E 04	0.6975	0.4075E 01	0.4807E-06	1.050	-0.0013	0.6817	1.2846
0.2550	0.6670	0.3394E 04	0.7302	0.3835E 01	0.4554E-06	1.104	-0.0017	0.7486	1.3340

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2335	0.6423	0.3239E 04	0.8729	0.4075E 01	0.4808E-06	1.050	0.	-0.0229	0.3718
0.2222	0.6517	0.3492E 04	0.8595	0.4155E 01	0.4942E-06	1.136	0.1025E-04	-0.0041	0.3955
0.2147	0.6581	0.3666E 04	0.8523	0.4211E 01	0.5038E-06	1.196	0.1783E-04	0.0151	0.4191
0.2071	0.6644	0.3843E 04	0.8461	0.4269E 01	0.5140E-06	1.257	0.2599E-04	0.0348	0.4427
0.1996	0.6707	0.4021E 04	0.8409	0.4329E 01	0.5248E-06	1.319	0.3477E-04	0.0549	0.4660
0.1921	0.6770	0.4201E 04	0.8364	0.4392E 01	0.5362E-06	1.382	0.4419E-04	0.0753	0.4888
0.1846	0.6833	0.4382E 04	0.8325	0.4457E 01	0.5483E-06	1.447	0.5431E-04	0.0959	0.5110
0.1772	0.6896	0.4564E 04	0.8290	0.4524E 01	0.5609E-06	1.511	0.6515E-04	0.1165	0.5323
0.1697	0.6958	0.4746E 04	0.8260	0.4594E 01	0.5743E-06	1.577	0.7676E-04	0.1371	0.5526
0.1623	0.7020	0.4928E 04	0.8231	0.4665E 01	0.5884E-06	1.643	0.8918E-04	0.1574	0.5715
0.1550	0.7082	0.5109E 04	0.8204	0.4738E 01	0.6035E-06	1.709	0.1025E-03	0.1774	0.5890
0.1476	0.7144	0.5289E 04	0.8178	0.4812E 01	0.6199E-06	1.776	0.1166E-03	0.1968	0.6050
0.1403	0.7205	0.5467E 04	0.8152	0.4887E 01	0.6373E-06	1.844	0.1318E-03	0.2157	0.6197

TALBE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 250,000 FT VELOCITY = 15,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1677E 02	0.9717E-06	0.	0.0006	-0.0659	0.
0.0003	0.0236	0.1532E 03	0.0236	0.1676E 02	0.9711E-06	0.034	0.0006	-0.0649	0.0472
0.0011	0.0472	0.3063E 03	0.0472	0.1673E 02	0.9694E-06	0.069	0.0006	-0.0621	0.0943
0.0025	0.0707	0.4599E 03	0.0708	0.1667E 02	0.9664E-06	0.104	0.0006	-0.0573	0.1415
0.0044	0.0943	0.6142E 03	0.0945	0.1659E 02	0.9623E-06	0.138	0.0006	-0.0507	0.1886
0.0069	0.1179	0.7691E 03	0.1182	0.1649E 02	0.9571E-06	0.173	0.0005	-0.0421	0.2358
0.0100	0.1415	0.9248E 03	0.1419	0.1636E 02	0.9508E-06	0.209	0.0003	-0.0314	0.2829
0.0136	0.1651	0.1082E 04	0.1658	0.1621E 02	0.9434E-06	0.244	-0.0002	-0.0188	0.3301
0.0178	0.1886	0.1240E 04	0.1897	0.1604E 02	0.9348E-06	0.280	-0.0007	-0.0040	0.3773
0.0226	0.2122	0.1400E 04	0.2138	0.1584E 02	0.9246E-06	0.316	-0.0005	0.0129	0.4244
0.0281	0.2358	0.1562E 04	0.2380	0.1562E 02	0.9127E-06	0.353	0.0005	0.0321	0.4716
0.0341	0.2594	0.1724E 04	0.2623	0.1538E 02	0.8996E-06	0.390	0.0016	0.0535	0.5187
0.0407	0.2829	0.1886E 04	0.2868	0.1512E 02	0.8861E-06	0.427	0.0011	0.0774	0.5659
0.0480	0.3065	0.2048E 04	0.3115	0.1483E 02	0.8729E-06	0.465	-0.0018	0.1037	0.6131
0.0560	0.3301	0.2203E 04	0.3364	0.1453E 02	0.8633E-06	0.502	-0.0132	0.1327	0.6602
0.0647	0.3537	0.2370E 04	0.3615	0.1420E 02	0.8460E-06	0.540	-0.0127	0.1643	0.7074
0.0740	0.3773	0.2536E 04	0.3869	0.1386E 02	0.8278E-06	0.579	-0.0120	0.1988	0.7545
0.0841	0.4008	0.2707E 04	0.4125	0.1350E 02	0.8087E-06	0.619	-0.0115	0.2362	0.8017
0.0949	0.4244	0.2885E 04	0.4385	0.1313E 02	0.7883E-06	0.660	-0.0097	0.2766	0.8488
0.1063	0.4480	0.3076E 04	0.4647	0.1275E 02	0.7689E-06	0.705	-0.0107	0.3203	0.8960
0.1186	0.4716	0.3242E 04	0.4913	0.1235E 02	0.7477E-06	0.745	-0.0106	0.3673	0.9432
0.1317	0.4952	0.3414E 04	0.5183	0.1193E 02	0.7244E-06	0.785	-0.0086	0.4178	0.9903
0.1456	0.5187	0.3591E 04	0.5456	0.1150E 02	0.6985E-06	0.826	-0.0034	0.4718	1.0375
0.1603	0.5423	0.3784E 04	0.5734	0.1104E 02	0.6683E-06	0.870	0.0088	0.5297	1.0846
0.1759	0.5659	0.3974E 04	0.6017	0.1055E 02	0.6427E-06	0.916	0.0075	0.5915	1.1318
0.1924	0.5895	0.4173E 04	0.6305	0.1004E 02	0.6156E-06	0.965	0.0069	0.6574	1.1789
0.2100	0.6131	0.4378E 04	0.6600	0.9512E 01	0.5874E-06	1.015	0.0059	0.7276	1.2261
0.2288	0.6366	0.4586E 04	0.6901	0.8970E 01	0.5585E-06	1.067	0.0042	0.8021	1.2733

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2224	0.6288	0.4516E 04	0.8936	0.9152E 01	0.5682E-06	1.050	0.	-0.0193	0.3282
0.2175	0.6328	0.4717E 04	0.8873	0.9228E 01	0.5795E-06	1.101	0.7559E-05	-0.0028	0.3524
0.2113	0.6378	0.5000E 04	0.8806	0.9333E 01	0.5932E-06	1.171	0.1793E-04	0.0147	0.3777
0.2051	0.6427	0.5304E 04	0.8752	0.9445E 01	0.6063E-06	1.245	0.2926E-04	0.0331	0.4040
0.1989	0.6477	0.5612E 04	0.8707	0.9565E 01	0.6212E-06	1.322	0.4158E-04	0.0526	0.4311
0.1928	0.6527	0.5928E 04	0.8671	0.9696E 01	0.6387E-06	1.401	0.5501E-04	0.0729	0.4586
0.1867	0.6576	0.6251E 04	0.8640	0.9836E 01	0.6596E-06	1.485	0.6968E-04	0.0941	0.4863
0.1805	0.6625	0.6584E 04	0.8615	0.9988E 01	0.6852E-06	1.573	0.8575E-04	0.1158	0.5131
0.1744	0.6674	0.6926E 04	0.8592	0.1015E 02	0.7163E-06	1.668	0.1035E-03	0.1374	0.5385
0.1684	0.6723	0.7283E 04	0.8572	0.1034E 02	0.7543E-06	1.772	0.1231E-03	0.1589	0.5623
0.1623	0.6772	0.7655E 04	0.8553	0.1054E 02	0.8010E-06	1.890	0.1450E-03	0.1794	0.5830
0.1563	0.6820	0.8047E 04	0.8535	0.1076E 02	0.8546E-06	2.024	0.1696E-03	0.1986	0.6007
0.1502	0.6869	0.8457E 04	0.8517	0.1100E 02	0.9104E-06	2.184	0.1973E-03	0.2046	0.6060

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 250,000 FT VELOCITY = 20,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.3007E 02	0.1248E-05	0.	0.0002	-0.0514	0.
0.0003	0.0229	0.1768E 03	0.0229	0.3005E 02	0.1247E-05	0.034	0.0002	-0.0505	0.0458
0.0011	0.0458	0.3534E 03	0.0458	0.2999E 02	0.1245E-05	0.068	0.0002	-0.0478	0.0916
0.0024	0.0687	0.5303E 03	0.0687	0.2989E 02	0.1241E-05	0.102	0.0002	-0.0432	0.1373
0.0042	0.0916	0.7079E 03	0.0917	0.2975E 02	0.1236E-05	0.137	0.0002	-0.0367	0.1831
0.0066	0.1145	0.8862E 03	0.1147	0.2958E 02	0.1230E-05	0.171	0.0001	-0.0284	0.2289
0.0095	0.1373	0.1065E 04	0.1378	0.2936E 02	0.1222E-05	0.206	0.0001	-0.0181	0.2747
0.0129	0.1602	0.1245E 04	0.1609	0.2911E 02	0.1212E-05	0.240	0.0000	-0.0059	0.3205
0.0169	0.1831	0.1426E 04	0.1842	0.2882E 02	0.1201E-05	0.275	-0.0000	0.0083	0.3663
0.0214	0.2060	0.1607E 04	0.2075	0.2849E 02	0.1189E-05	0.311	-0.0001	0.0246	0.4120
0.0265	0.2289	0.1790E 04	0.2310	0.2812E 02	0.1175E-05	0.346	-0.0002	0.0430	0.4578
0.0322	0.2518	0.1974E 04	0.2545	0.2772E 02	0.1160E-05	0.382	-0.0003	0.0635	0.5036
0.0385	0.2747	0.2160E 04	0.2783	0.2728E 02	0.1144E-05	0.419	-0.0004	0.0863	0.5494
0.0453	0.2976	0.2347E 04	0.3022	0.2680E 02	0.1126E-05	0.455	-0.0005	0.1113	0.5952
0.0527	0.3205	0.2540E 04	0.3262	0.2629E 02	0.1106E-05	0.493	-0.0005	0.1388	0.6410
0.0608	0.3434	0.2729E 04	0.3505	0.2573E 02	0.1086E-05	0.531	-0.0006	0.1688	0.6867
0.0695	0.3663	0.2919E 04	0.3750	0.2515E 02	0.1063E-05	0.568	-0.0007	0.2013	0.7325
0.0789	0.3892	0.3110E 04	0.3997	0.2454E 02	0.1040E-05	0.606	-0.0008	0.2365	0.7783
0.0889	0.4120	0.3305E 04	0.4247	0.2389E 02	0.1015E-05	0.645	-0.0010	0.2745	0.8241
0.0996	0.4349	0.3506E 04	0.4500	0.2321E 02	0.9895E-06	0.686	-0.0010	0.3153	0.8699
0.1111	0.4578	0.3707E 04	0.4756	0.2250E 02	0.9624E-06	0.726	-0.0012	0.3591	0.9156
0.1233	0.4807	0.3909E 04	0.5015	0.2177E 02	0.9343E-06	0.767	-0.0015	0.4061	0.9614
0.1362	0.5036	0.4114E 04	0.5278	0.2101E 02	0.9050E-06	0.809	-0.0017	0.4563	1.0072
0.1500	0.5265	0.4322E 04	0.5546	0.2023E 02	0.8748E-06	0.851	-0.0019	0.5098	1.0530
0.1646	0.5494	0.4532E 04	0.5817	0.1943E 02	0.8438E-06	0.895	-0.0022	0.5669	1.0988
0.1801	0.5723	0.4745E 04	0.6094	0.1861E 02	0.8116E-06	0.939	-0.0023	0.6276	1.1446
0.1965	0.5952	0.4962E 04	0.6375	0.1778E 02	0.7789E-06	0.984	-0.0026	0.6920	1.1903
0.2139	0.6181	0.5183E 04	0.6663	0.1692E 02	0.7451E-06	1.031	-0.0028	0.7604	1.2361
0.2324	0.6410	0.5407E 04	0.6957	0.1606E 02	0.7110E-06	1.078	-0.0032	0.8329	1.2819

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2213	0.6274	0.5274E 04	0.8952	0.1657E 02	0.7312E-06	1.050	0.	-0.0159	0.2836
0.2138	0.6334	0.5966E 04	0.8865	0.1678E 02	0.7485E-06	1.194	0.1922E-04	-0.0024	0.3071
0.2090	0.6373	0.6419E 04	0.8824	0.1694E 02	0.7615E-06	1.290	0.3328E-04	0.0122	0.3325
0.2041	0.6412	0.6878E 04	0.8792	0.1712E 02	0.7761E-06	1.388	0.4870E-04	0.0279	0.3598
0.1993	0.6450	0.7341E 04	0.8767	0.1732E 02	0.7925E-06	1.488	0.6559E-04	0.0450	0.3887
0.1945	0.6489	0.7809E 04	0.8747	0.1754E 02	0.8109E-06	1.591	0.8405E-04	0.0633	0.4186
0.1897	0.6527	0.8281E 04	0.8732	0.1778E 02	0.8316E-06	1.697	0.1042E-03	0.0827	0.4489
0.1850	0.6565	0.8758E 04	0.8720	0.1805E 02	0.8546E-06	1.805	0.1262E-03	0.1028	0.4787
0.1802	0.6604	0.9238E 04	0.8711	0.1835E 02	0.8805E-06	1.917	0.1501E-03	0.1233	0.5075
0.1754	0.6642	0.9722E 04	0.8703	0.1867E 02	0.9094E-06	2.031	0.1763E-03	0.1438	0.5346
0.1707	0.6680	0.1021E 05	0.8697	0.1903E 02	0.9419E-06	2.149	0.2048E-03	0.1642	0.5598
0.1660	0.6718	0.1070E 05	0.8691	0.1942E 02	0.9786E-06	2.270	0.2359E-03	0.1841	0.5830
0.1612	0.6756	0.1118E 05	0.8685	0.1984E 02	0.1020E-05	2.395	0.2699E-03	0.2023	0.6030

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 250,000 FT VELOCITY = 25,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.4718E 02	0.1460E-05	0.	0.0002	-0.0437	0.
0.0003	0.0223	0.2009E 03	0.0223	0.4715E 02	0.1460E-05	0.033	0.0002	-0.0429	0.0446
0.0010	0.0446	0.4015E 03	0.0446	0.4706E 02	0.1457E-05	0.066	0.0002	-0.0402	0.0892
0.0022	0.0669	0.6025E 03	0.0670	0.4691E 02	0.1453E-05	0.100	0.0002	-0.0357	0.1338
0.0040	0.0892	0.8042E 03	0.0894	0.4671E 02	0.1447E-05	0.133	0.0001	-0.0294	0.1785
0.0062	0.1115	0.1007E 04	0.1118	0.4644E 02	0.1440E-05	0.167	0.0001	-0.0213	0.2231
0.0090	0.1338	0.1210E 04	0.1343	0.4612E 02	0.1431E-05	0.200	0.0001	-0.0112	0.2677
0.0123	0.1562	0.1414E 04	0.1568	0.4573E 02	0.1421E-05	0.234	0.0000	0.0007	0.3123
0.0160	0.1785	0.1620E 04	0.1794	0.4529E 02	0.1409E-05	0.269	-0.0001	0.0146	0.3569
0.0203	0.2008	0.1826E 04	0.2021	0.4479E 02	0.1395E-05	0.303	-0.0002	0.0305	0.4015
0.0252	0.2231	0.2034E 04	0.2250	0.4424E 02	0.1380E-05	0.338	-0.0003	0.0484	0.4462
0.0306	0.2454	0.2243E 04	0.2479	0.4362E 02	0.1363E-05	0.373	-0.0004	0.0686	0.4908
0.0365	0.2677	0.2454E 04	0.2710	0.4295E 02	0.1344E-05	0.408	-0.0004	0.0909	0.5354
0.0430	0.2900	0.2666E 04	0.2942	0.4223E 02	0.1324E-05	0.444	-0.0004	0.1155	0.5800
0.0500	0.3123	0.2884E 04	0.3176	0.4145E 02	0.1302E-05	0.481	-0.0001	0.1425	0.6246
0.0577	0.3346	0.3100E 04	0.3412	0.4061E 02	0.1279E-05	0.518	-0.0003	0.1719	0.6692
0.0659	0.3569	0.3315E 04	0.3650	0.3972E 02	0.1254E-05	0.554	-0.0005	0.2039	0.7139
0.0748	0.3792	0.3532E 04	0.3890	0.3879E 02	0.1228E-05	0.592	-0.0007	0.2386	0.7585
0.0842	0.4015	0.3753E 04	0.4132	0.3780E 02	0.1200E-05	0.630	-0.0012	0.2760	0.8031
0.0944	0.4239	0.3979E 04	0.4377	0.3677E 02	0.1172E-05	0.669	-0.0016	0.3164	0.8477
0.1052	0.4462	0.4211E 04	0.4625	0.3570E 02	0.1142E-05	0.709	-0.0020	0.3597	0.8923
0.1167	0.4685	0.4440E 04	0.4876	0.3458E 02	0.1110E-05	0.749	-0.0021	0.4062	0.9369
0.1289	0.4908	0.4671E 04	0.5131	0.3342E 02	0.1077E-05	0.790	-0.0022	0.4560	0.9816
0.1418	0.5131	0.4905E 04	0.5389	0.3223E 02	0.1042E-05	0.831	-0.0021	0.5092	1.0262
0.1556	0.5354	0.5143E 04	0.5651	0.3100E 02	0.1007E-05	0.874	-0.0023	0.5659	1.0708
0.1702	0.5577	0.5383E 04	0.5917	0.2975E 02	0.9707E-06	0.917	-0.0024	0.6264	1.1154
0.1855	0.5800	0.5627E 04	0.6188	0.2847E 02	0.9330E-06	0.961	-0.0020	0.6907	1.1600
0.2018	0.6023	0.5875E 04	0.6465	0.2717E 02	0.8951E-06	1.006	-0.0023	0.7590	1.2046
0.2191	0.6246	0.6127E 04	0.6747	0.2584E 02	0.8559E-06	1.052	-0.0022	0.8314	1.2493

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2183	0.6236	0.6115E 04	0.9006	0.2590E 02	0.8577E-06	1.050	0.	-0.0137	0.2577
0.2125	0.6282	0.6960E 04	0.8939	0.2616E 02	0.8770E-06	1.203	0.2102E-04	-0.0017	0.2809
0.2084	0.6314	0.7567E 04	0.8906	0.2638E 02	0.8932E-06	1.315	0.3801E-04	0.0114	0.3067
0.2043	0.6347	0.8184E 04	0.8880	0.2663E 02	0.9118E-06	1.431	0.5685E-04	0.0260	0.3351
0.2002	0.6379	0.8810E 04	0.8862	0.2692E 02	0.9329E-06	1.550	0.7768E-04	0.0423	0.3660
0.1962	0.6411	0.9445E 04	0.8848	0.2725E 02	0.9569E-06	1.673	0.1007E-03	0.0602	0.3987
0.1921	0.6443	0.1009E 05	0.8838	0.2762E 02	0.9842E-06	1.801	0.1260E-03	0.0796	0.4323
0.1881	0.6475	0.1074E 05	0.8831	0.2804E 02	0.1015E-05	1.933	0.1539E-03	0.1001	0.4656
0.1840	0.6507	0.1141E 05	0.8826	0.2852E 02	0.1050E-05	2.070	0.1847E-03	0.1211	0.4976
0.1800	0.6539	0.1208E 05	0.8823	0.2905E 02	0.1090E-05	2.213	0.2186E-03	0.1423	0.5276
0.1760	0.6571	0.1276E 05	0.8821	0.2965E 02	0.1135E-05	2.361	0.2559E-03	0.1632	0.5553
0.1720	0.6603	0.1344E 05	0.8819	0.3032E 02	0.1186E-05	2.514	0.2971E-03	0.1836	0.5807
0.1680	0.6635	0.1413E 05	0.8818	0.3107E 02	0.1245E-05	2.675	0.3427E-03	0.1997	0.5994

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 250,000 FT VELOCITY = 30,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.6784E 02	0.1402E-05	0.	-0.0000	-0.0441	0.
0.0004	0.0270	0.3017E 03	0.0270	0.6778E 02	0.1401E-05	0.039	-0.0000	-0.0428	0.0540
0.0015	0.0540	0.6029E 03	0.0540	0.6759E 02	0.1398E-05	0.078	-0.0000	-0.0387	0.1080
0.0033	0.0810	0.9045E 03	0.0811	0.6727E 02	0.1393E-05	0.118	-0.0000	-0.0319	0.1620
0.0059	0.1080	0.1207E 04	0.1082	0.6682E 02	0.1385E-05	0.157	0.0001	-0.0224	0.2160
0.0092	0.1350	0.1511E 04	0.1354	0.6625E 02	0.1375E-05	0.197	0.0001	-0.0100	0.2700
0.0133	0.1620	0.1815E 04	0.1627	0.6556E 02	0.1363E-05	0.237	0.0002	0.0053	0.3239
0.0181	0.1890	0.2120E 04	0.1901	0.6474E 02	0.1350E-05	0.277	0.0000	0.0236	0.3779
0.0237	0.2160	0.2426E 04	0.2177	0.6381E 02	0.1334E-05	0.317	-0.0002	0.0449	0.4319
0.0300	0.2430	0.2736E 04	0.2454	0.6274E 02	0.1316E-05	0.359	-0.0003	0.0694	0.4859
0.0372	0.2700	0.3050E 04	0.2734	0.6156E 02	0.1295E-05	0.400	0.0001	0.0973	0.5399
0.0452	0.2969	0.3369E 04	0.3015	0.6025E 02	0.1272E-05	0.443	0.0007	0.1286	0.5939
0.0540	0.3239	0.3691E 04	0.3299	0.5881E 02	0.1246E-05	0.486	0.0012	0.1636	0.6479
0.0636	0.3509	0.4016E 04	0.3586	0.5725E 02	0.1220E-05	0.531	0.0010	0.2023	0.7019
0.0742	0.3779	0.4353E 04	0.3876	0.5559E 02	0.1192E-05	0.577	0.0003	0.2451	0.7559
0.0857	0.4049	0.4681E 04	0.4169	0.5382E 02	0.1161E-05	0.623	0.0007	0.2920	0.8099
0.0982	0.4319	0.5009E 04	0.4467	0.5197E 02	0.1128E-05	0.669	0.0010	0.3433	0.8639
0.1117	0.4589	0.5340E 04	0.4769	0.5004E 02	0.1093E-05	0.716	0.0013	0.3992	0.9178
0.1262	0.4859	0.5680E 04	0.5075	0.4803E 02	0.1058E-05	0.765	0.0014	0.4600	0.9718
0.1418	0.5129	0.6022E 04	0.5387	0.4595E 02	0.1020E-05	0.814	0.0019	0.5259	1.0258
0.1586	0.5399	0.6364E 04	0.5705	0.4382E 02	0.9805E-06	0.864	0.0026	0.5972	1.0798
0.1765	0.5669	0.6717E 04	0.6029	0.4164E 02	0.9391E-06	0.916	0.0038	0.6741	1.1338
0.1957	0.5939	0.7068E 04	0.6361	0.3942E 02	0.8977E-06	0.969	0.0044	0.7569	1.1878
0.2162	0.6209	0.7428E 04	0.6699	0.3716E 02	0.8536E-06	1.023	0.0062	0.8459	1.2418
0.2381	0.6479	0.7786E 04	0.7047	0.3489E 02	0.8107E-06	1.079	0.0068		

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2265	0.6338	0.7599E 04	0.8901	0.3607E 02	0.8329E-06	1.050	0.	-0.0130	0.2578
0.2198	0.6392	0.8783E 04	0.8826	0.3652E 02	0.8745E-06	1.239	0.3277E-04	-0.0005	0.2826
0.2158	0.6425	0.9528E 04	0.8796	0.3685E 02	0.9046E-06	1.364	0.5591E-04	0.0136	0.3105
0.2118	0.6457	0.1030E 05	0.8773	0.3724E 02	0.9392E-06	1.500	0.8196E-04	0.0297	0.3419
0.2078	0.6490	0.1111E 05	0.8757	0.3769E 02	0.9779E-06	1.646	0.1113E-03	0.0478	0.3764
0.2038	0.6522	0.1194E 05	0.8747	0.3822E 02	0.1020E-05	1.802	0.1443E-03	0.0681	0.4129
0.1998	0.6554	0.1281E 05	0.8740	0.3884E 02	0.1066E-05	1.966	0.1814E-03	0.0901	0.4502
0.1958	0.6586	0.1370E 05	0.8737	0.3955E 02	0.1116E-05	2.141	0.2231E-03	0.1133	0.4866
0.1919	0.6619	0.1462E 05	0.8736	0.4038E 02	0.1173E-05	2.325	0.2699E-03	0.1368	0.5209
0.1879	0.6651	0.1555E 05	0.8737	0.4134E 02	0.1239E-05	2.522	0.3226E-03	0.1601	0.5524
0.1840	0.6683	0.1650E 05	0.8740	0.4244E 02	0.1316E-05	2.731	0.3821E-03	0.1829	0.5809
0.1800	0.6715	0.1747E 05	0.8742	0.4372E 02	0.1406E-05	2.951	0.4494E-03	0.2049	0.6067

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 250,000 FT VELOCITY = 35,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.9223E 02	0.1354E-05	0.	0.0000	-0.0468	0.
0.0004	0.0279	0.3651E 03	0.0279	0.9214E 02	0.1353E-05	0.041	0.0000	-0.0454	0.0558
0.0016	0.0558	0.7302E 03	0.0558	0.9186E 02	0.1350E-05	0.083	0.0000	-0.0412	0.1116
0.0035	0.0837	0.1097E 04	0.0838	0.9141E 02	0.1344E-05	0.124	0.0001	-0.0342	0.1674
0.0062	0.1116	0.1465E 04	0.1118	0.9078E 02	0.1336E-05	0.166	0.0000	-0.0243	0.2232
0.0097	0.1395	0.1837E 04	0.1399	0.8996E 02	0.1325E-05	0.208	-0.0000	-0.0114	0.2790
0.0141	0.1674	0.2212E 04	0.1682	0.8896E 02	0.1313E-05	0.251	-0.0001	0.0046	0.3348
0.0192	0.1953	0.2590E 04	0.1965	0.8778E 02	0.1297E-05	0.294	-0.0001	0.0237	0.3906
0.0252	0.2232	0.2971E 04	0.2251	0.8641E 02	0.1280E-05	0.338	0.0001	0.0461	0.4464
0.0320	0.2511	0.3355E 04	0.2538	0.8487E 02	0.1259E-05	0.382	0.0005	0.0720	0.5022
0.0397	0.2790	0.3741E 04	0.2827	0.8314E 02	0.1237E-05	0.426	0.0006	0.1016	0.5580
0.0483	0.3069	0.4132E 04	0.3119	0.8125E 02	0.1212E-05	0.471	0.0003	0.1350	0.6138
0.0578	0.3348	0.4535E 04	0.3414	0.7919E 02	0.1186E-05	0.519	-0.0001	0.1725	0.6696
0.0682	0.3627	0.4936E 04	0.3712	0.7695E 02	0.1157E-05	0.566	-0.0000	0.2143	0.7254
0.0797	0.3906	0.5335E 04	0.4014	0.7458E 02	0.1126E-05	0.613	-0.0000	0.2606	0.7812
0.0921	0.4185	0.5737E 04	0.4319	0.7209E 02	0.1093E-05	0.660	-0.0002	0.3118	0.8370
0.1056	0.4464	0.6138E 04	0.4629	0.6948E 02	0.1059E-05	0.708	-0.0007	0.3681	0.8928
0.1201	0.4743	0.6544E 04	0.4944	0.6678E 02	0.1023E-05	0.757	-0.0005	0.4298	0.9486
0.1358	0.5022	0.6955E 04	0.5264	0.6397E 02	0.9850E-06	0.807	-0.0003	0.4974	1.0044
0.1526	0.5301	0.7377E 04	0.5590	0.6105E 02	0.9455E-06	0.859	-0.0001	0.5710	1.0602
0.1707	0.5580	0.7809E 04	0.5923	0.5798E 02	0.9036E-06	0.912	0.0003	0.6511	1.1160
0.1900	0.5859	0.8256E 04	0.6262	0.5480E 02	0.8599E-06	0.968	0.0007	0.7380	1.1718
0.2106	0.6138	0.8730E 04	0.6609	0.5145E 02	0.8137E-06	1.027	0.0014	0.8322	1.2275
0.2328	0.6417	0.9221E 04	0.6965	0.4802E 02	0.7660E-06	1.089	0.0022	0.9341	1.2833

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2187	0.6242	0.8911E 04	0.9037	0.5018E 02	0.7961E-06	1.050	0.	-0.0145	0.2666
0.2113	0.6300	0.1029E 05	0.8954	0.5086E 02	0.8219E-06	1.221	0.3692E-04	-0.0018	0.2903
0.2070	0.6334	0.1112E 05	0.8921	0.5132E 02	0.8413E-06	1.326	0.6181E-04	0.0122	0.3166
0.2026	0.6369	0.1197E 05	0.8896	0.5184E 02	0.8647E-06	1.437	0.8943E-04	0.0277	0.3455
0.1983	0.6403	0.1285E 05	0.8877	0.5244E 02	0.8928E-06	1.553	0.1201E-03	0.0450	0.3767
0.1940	0.6436	0.1375E 05	0.8863	0.5313E 02	0.9268E-06	1.676	0.1543E-03	0.0639	0.4098
0.1897	0.6470	0.1469E 05	0.8853	0.5392E 02	0.9681E-06	1.808	0.1924E-03	0.0845	0.4437
0.1855	0.6504	0.1567E 05	0.8845	0.5482E 02	0.1019E-05	1.952	0.2352E-03	0.1063	0.4777
0.1812	0.6538	0.1669E 05	0.8838	0.5587E 02	0.1085E-05	2.111	0.2837E-03	0.1289	0.5106
0.1769	0.6571	0.1777E 05	0.8833	0.5708E 02	0.1170E-05	2.302	0.3391E-03	0.1517	0.5416
0.1727	0.6605	0.1892E 05	0.8828	0.5851E 02	0.1286E-05	2.545	0.4034E-03	0.1742	0.5699
0.1684	0.6638	0.2016E 05	0.8825	0.6023E 02	0.1440E-05	2.852	0.4798E-03	0.1960	0.5955

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 250,000 FT VELOCITY = 40,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1206E 03	0.1413E-05	0.	0.0002	-0.0450	0.
0.0004	0.0278	0.4082E 03	0.0278	0.1205E 03	0.1412E-05	0.041	0.0002	-0.0436	0.0557
0.0016	0.0557	0.8162E 03	0.0557	0.1201E 03	0.1408E-05	0.082	0.0002	-0.0394	0.1114
0.0035	0.0835	0.1225E 04	0.0836	0.1195E 03	0.1402E-05	0.124	0.0001	-0.0324	0.1670
0.0062	0.1114	0.1637E 04	0.1116	0.1187E 03	0.1394E-05	0.165	0.0001	-0.0225	0.2227
0.0097	0.1392	0.2051E 04	0.1397	0.1176E 03	0.1383E-05	0.207	0.0001	-0.0097	0.2784
0.0140	0.1670	0.2468E 04	0.1678	0.1164E 03	0.1370E-05	0.250	0.0000	0.0061	0.3341
0.0192	0.1949	0.2887E 04	0.1961	0.1148E 03	0.1354E-05	0.292	-0.0001	0.0251	0.3898
0.0251	0.2227	0.3310E 04	0.2246	0.1131E 03	0.1336E-05	0.336	-0.0002	0.0473	0.4455
0.0319	0.2506	0.3737E 04	0.2533	0.1111E 03	0.1315E-05	0.379	-0.0004	0.0729	0.5011
0.0395	0.2784	0.4168E 04	0.2821	0.1088E 03	0.1292E-05	0.424	-0.0006	0.1020	0.5568
0.0481	0.3063	0.4604E 04	0.3113	0.1064E 03	0.1267E-05	0.469	-0.0006	0.1349	0.6125
0.0575	0.3341	0.5059E 04	0.3407	0.1037E 03	0.1239E-05	0.516	-0.0005	0.1716	0.6682
0.0679	0.3619	0.5500E 04	0.3704	0.1008E 03	0.1209E-05	0.562	-0.0006	0.2125	0.7239
0.0792	0.3898	0.5944E 04	0.4005	0.9777E 02	0.1177E-05	0.608	-0.0009	0.2577	0.7796
0.0916	0.4176	0.6393E 04	0.4309	0.9451E 02	0.1143E-05	0.656	-0.0012	0.3075	0.8352
0.1050	0.4455	0.6855E 04	0.4618	0.9108E 02	0.1106E-05	0.705	-0.0012	0.3621	0.8909
0.1194	0.4733	0.7325E 04	0.4932	0.8745E 02	0.1068E-05	0.755	-0.0015	0.4219	0.9466
0.1350	0.5011	0.7793E 04	0.5251	0.8374E 02	0.1028E-05	0.806	-0.0020	0.4870	1.0023
0.1518	0.5290	0.8263E 04	0.5576	0.7990E 02	0.9870E-06	0.857	-0.0021	0.5579	1.0580
0.1698	0.5568	0.8742E 04	0.5908	0.7600E 02	0.9452E-06	0.910	-0.0025	0.6348	1.1137
0.1891	0.5847	0.9212E 04	0.6247	0.7208E 02	0.9023E-06	0.963	-0.0025	0.7181	1.1693
0.2097	0.6125	0.9679E 04	0.6594	0.6819E 02	0.8598E-06	1.015	-0.0028	0.8081	1.2250
0.2318	0.6404	0.1014E 05	0.6949	0.6429E 02	0.8164E-06	1.068	-0.0026	0.9052	1.2807

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2240	0.6307	0.9983E 04	0.8975	0.6564E 02	0.8315E-06	1.050	0.	-0.0136	0.2629
0.2188	0.6349	0.1116E 05	0.8911	0.6618E 02	0.8494E-06	1.182	0.2998E-04	-0.0012	0.2865
0.2147	0.6382	0.1213E 05	0.8874	0.6668E 02	0.8659E-06	1.292	0.5728E-04	0.0123	0.3126
0.2105	0.6415	0.1312E 05	0.8844	0.6726E 02	0.8848E-06	1.407	0.8757E-04	0.0274	0.3413
0.2064	0.6448	0.1413E 05	0.8820	0.6793E 02	0.9067E-06	1.526	0.1211E-03	0.0442	0.3724
0.2022	0.6481	0.1516E 05	0.8802	0.6870E 02	0.9319E-06	1.650	0.1582E-03	0.0626	0.4053
0.1981	0.6514	0.1620E 05	0.8788	0.6959E 02	0.9612E-06	1.781	0.1993E-03	0.0826	0.4390
0.1940	0.6547	0.1727E 05	0.8778	0.7059E 02	0.9954E-06	1.918	0.2446E-03	0.1036	0.4723
0.1899	0.6579	0.1837E 05	0.8770	0.7175E 02	0.1036E-05	2.064	0.2950E-03	0.1251	0.5043
0.1858	0.6612	0.1949E 05	0.8765	0.7307E 02	0.1083E-05	2.218	0.3509E-03	0.1469	0.5345
0.1817	0.6645	0.2063E 05	0.8761	0.7458E 02	0.1142E-05	2.385	0.4132E-03	0.1686	0.5626
0.1776	0.6677	0.2181E 05	0.8759	0.7631E 02	0.1214E-05	2.565	0.4832E-03	0.1901	0.5887
0.1736	0.6710	0.2302E 05	0.8757	0.7832E 02	0.1308E-05	2.755	0.5625E-03	0.2036	0.6044

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 250,000 FT VELOCITY = 45,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1528E 03	0.1465E-05	0.	-0.0007	-0.0435	0.
0.0004	0.0278	0.4498E 03	0.0278	0.1526E 03	0.1463E-05	0.042	-0.0007	-0.0421	0.0555
0.0016	0.0555	0.8993E 03	0.0555	0.1522E 03	0.1459E-05	0.083	-0.0006	-0.0379	0.1110
0.0035	0.0833	0.1350E 04	0.0834	0.1514E 03	0.1453E-05	0.125	-0.0005	-0.0309	0.1665
0.0062	0.1110	0.1804E 04	0.1113	0.1504E 03	0.1444E-05	0.167	-0.0003	-0.0211	0.2220
0.0097	0.1388	0.2260E 04	0.1392	0.1491E 03	0.1433E-05	0.209	-0.0001	-0.0083	0.2776
0.0139	0.1665	0.2720E 04	0.1673	0.1474E 03	0.1419E-05	0.252	0.0002	0.0075	0.3331
0.0190	0.1943	0.3182E 04	0.1955	0.1455E 03	0.1402E-05	0.295	0.0005	0.0264	0.3886
0.0249	0.2220	0.3648E 04	0.2239	0.1433E 03	0.1383E-05	0.338	0.0008	0.0485	0.4441
0.0317	0.2498	0.4119E 04	0.2525	0.1408E 03	0.1362E-05	0.382	0.0013	0.0740	0.4996
0.0393	0.2776	0.4594E 04	0.2812	0.1380E 03	0.1338E-05	0.426	0.0018	0.1031	0.5551
0.0478	0.3053	0.5074E 04	0.3103	0.1349E 03	0.1311E-05	0.471	0.0022	0.1358	0.6106
0.0571	0.3331	0.5574E 04	0.3396	0.1316E 03	0.1283E-05	0.519	0.0026	0.1724	0.6661
0.0674	0.3608	0.6061E 04	0.3692	0.1279E 03	0.1251E-05	0.565	0.0033	0.2131	0.7217
0.0787	0.3886	0.6551E 04	0.3991	0.1241E 03	0.1217E-05	0.611	0.0040	0.2582	0.7772
0.0909	0.4163	0.7048E 04	0.4295	0.1200E 03	0.1181E-05	0.659	0.0047	0.3078	0.8327
0.1042	0.4441	0.7558E 04	0.4602	0.1156E 03	0.1143E-05	0.707	0.0054	0.3623	0.8882
0.1185	0.4719	0.8077E 04	0.4915	0.1111E 03	0.1103E-05	0.757	0.0060	0.4218	0.9437
0.1340	0.4996	0.8598E 04	0.5233	0.1064E 03	0.1062E-05	0.808	0.0067	0.4867	0.9992
0.1506	0.5274	0.9129E 04	0.5556	0.1015E 03	0.1018E-05	0.860	0.0076	0.5574	1.0547
0.1685	0.5551	0.9670E 04	0.5887	0.9641E 02	0.9735E-06	0.913	0.0082	0.6341	1.1102
0.1876	0.5829	0.1021E 05	0.6224	0.9126E 02	0.9272E-06	0.968	0.0091	0.7171	1.1658
0.2082	0.6106	0.1077E 05	0.6569	0.8605E 02	0.8805E-06	1.024	0.0096	0.8068	1.2213
0.2301	0.6384	0.1132E 05	0.6923	0.8077E 02	0.8325E-06	1.079	0.0106	0.9036	1.2768

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2184	0.6238	0.1103E 05	0.9020	0.8356E 02	0.8579E-06	1.050	0.	-0.0137	0.2556
0.2138	0.6274	0.1224E 05	0.8961	0.8417E 02	0.8759E-06	1.172	0.2998E-04	-0.0018	0.2790
0.2097	0.6306	0.1332E 05	0.8928	0.8485E 02	0.8945E-06	1.283	0.5977E-04	0.0114	0.3051
0.2057	0.6338	0.1443E 05	0.8900	0.8561E 02	0.9156E-06	1.399	0.9295E-04	0.0262	0.3340
0.2017	0.6370	0.1557E 05	0.8879	0.8649E 02	0.9399E-06	1.520	0.1298E-03	0.0427	0.3655
0.1976	0.6402	0.1673E 05	0.8864	0.8750E 02	0.9678E-06	1.647	0.1707E-03	0.0610	0.3991
0.1936	0.6434	0.1792E 05	0.8852	0.8867E 02	0.9999E-06	1.779	0.2161E-03	0.0808	0.4336
0.1896	0.6465	0.1913E 05	0.8844	0.9000E 02	0.1037E-05	1.919	0.2665E-03	0.1019	0.4678
0.1856	0.6497	0.2038E 05	0.8838	0.9152E 02	0.1080E-05	2.067	0.3225E-03	0.1235	0.5007
0.1816	0.6528	0.2165E 05	0.8834	0.9326E 02	0.1129E-05	2.223	0.3849E-03	0.1454	0.5315
0.1777	0.6560	0.2296E 05	0.8831	0.9525E 02	0.1188E-05	2.391	0.4545E-03	0.1669	0.5598
0.1737	0.6591	0.2430E 05	0.8829	0.9751E 02	0.1257E-05	2.572	0.5325E-03	0.1879	0.5856
0.1697	0.6623	0.2567E 05	0.8828	0.1001E 03	0.1340E-05	2.768	0.6203E-03	0.1995	0.5991

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 300,000 FT VELOCITY = 10,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.3961E-00	0.4728E-07	0.	0.0008	-0.0731	0.
0.0003	0.0243	0.1090E 03	0.0243	0.3959E-00	0.4725E-07	0.036	0.0008	-0.0722	0.0486
0.0012	0.0486	0.2180E 03	0.0487	0.3950E-00	0.4716E-07	0.071	0.0007	-0.0692	0.0973
0.0027	0.0730	0.3272E 03	0.0730	0.3936E-00	0.4701E-07	0.107	0.0007	-0.0644	0.1459
0.0048	0.0973	0.4367E 03	0.0975	0.3917E-00	0.4680E-07	0.142	0.0006	-0.0575	0.1946
0.0074	0.1216	0.5466E 03	0.1219	0.3891E-00	0.4653E-07	0.178	0.0005	-0.0487	0.2432
0.0107	0.1459	0.6568E 03	0.1465	0.3861E-00	0.4620E-07	0.214	0.0004	-0.0378	0.2919
0.0146	0.1703	0.7674E 03	0.1711	0.3824E-00	0.4581E-07	0.251	0.0002	-0.0249	0.3405
0.0191	0.1946	0.8787E 03	0.1958	0.3782E-00	0.4537E-07	0.287	0.0001	-0.0099	0.3892
0.0242	0.2189	0.9905E 03	0.2207	0.3735E-00	0.4486E-07	0.324	-0.0001	0.0072	0.4378
0.0300	0.2432	0.1103E 04	0.2457	0.3683E-00	0.4430E-07	0.361	-0.0003	0.0265	0.4865
0.0364	0.2676	0.1216E 04	0.2709	0.3625E-00	0.4368E-07	0.399	-0.0006	0.0480	0.5351
0.0435	0.2919	0.1330E 04	0.2962	0.3562E-00	0.4300E-07	0.436	-0.0009	0.0717	0.5838
0.0513	0.3162	0.1447E 04	0.3217	0.3494E-00	0.4228E-07	0.475	-0.0012	0.0978	0.6324
0.0598	0.3405	0.1562E 04	0.3475	0.3421E-00	0.4149E-07	0.514	-0.0015	0.1263	0.6811
0.0689	0.3649	0.1678E 04	0.3735	0.3344E-00	0.4065E-07	0.552	-0.0018	0.1573	0.7297
0.0788	0.3892	0.1794E 04	0.3997	0.3262E-00	0.3976E-07	0.592	-0.0021	0.1907	0.7784
0.0895	0.4135	0.1913E 04	0.4263	0.3175E-00	0.3881E-07	0.632	-0.0025	0.2268	0.8270
0.1009	0.4378	0.2036E 04	0.4532	0.3083E-00	0.3780E-07	0.673	-0.0025	0.2656	0.8757
0.1132	0.4621	0.2159E 04	0.4804	0.2987E-00	0.3675E-07	0.715	-0.0029	0.3071	0.9243
0.1263	0.4865	0.2282E 04	0.5080	0.2887E-00	0.3565E-07	0.758	-0.0035	0.3515	0.9729
0.1402	0.5108	0.2409E 04	0.5361	0.2783E-00	0.3451E-07	0.802	-0.0041	0.3989	1.0216
0.1551	0.5351	0.2538E 04	0.5646	0.2675E-00	0.3330E-07	0.846	-0.0045	0.4492	1.0702
0.1711	0.5594	0.2669E 04	0.5937	0.2563E-00	0.3205E-07	0.892	-0.0049	0.5027	1.1189
0.1880	0.5838	0.2805E 04	0.6233	0.2446E-00	0.3075E-07	0.940	-0.0050	0.5595	1.1675
0.2061	0.6081	0.2944E 04	0.6536	0.2326E-00	0.2939E-07	0.989	-0.0053	0.6195	1.2162
0.2254	0.6324	0.3089E 04	0.6847	0.2200E-00	0.2797E-07	1.041	-0.0058	0.6830	1.2648
0.2460	0.6567	0.3240E 04	0.7166	0.2071E-00	0.2650E-07	1.095	-0.0063	0.7499	1.3135

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2289	0.6367	0.3115E 04	0.8781	0.2178E-00	0.2772E-07	1.050	0.	-0.0214	0.3525
0.2185	0.6454	0.3385E 04	0.8659	0.2219E-00	0.2845E-07	1.145	0.5361E-06	-0.0038	0.3762
0.2115	0.6511	0.3570E 04	0.8594	0.2248E-00	0.2897E-07	1.210	0.9322E-06	0.0144	0.4004
0.2046	0.6569	0.3756E 04	0.8540	0.2278E-00	0.2954E-07	1.277	0.1359E-05	0.0333	0.4248
0.1976	0.6626	0.3943E 04	0.8495	0.2310E-00	0.3016E-07	1.345	0.1820E-05	0.0528	0.4493
0.1907	0.6684	0.4133E 04	0.8457	0.2343E-00	0.3082E-07	1.414	0.2317E-05	0.0727	0.4737
0.1839	0.6741	0.4323E 04	0.8424	0.2378E-00	0.3154E-07	1.484	0.2851E-05	0.0930	0.4975
0.1770	0.6798	0.4514E 04	0.8396	0.2415E-00	0.3229E-07	1.555	0.3425E-05	0.1134	0.5205
0.1702	0.6855	0.4706E 04	0.8370	0.2453E-00	0.3310E-07	1.627	0.4042E-05	0.1337	0.5423
0.1634	0.6911	0.4897E 04	0.8347	0.2493E-00	0.3394E-07	1.699	0.4704E-05	0.1539	0.5628
0.1566	0.6967	0.5088E 04	0.8326	0.2534E-00	0.3483E-07	1.772	0.5413E-05	0.1736	0.5817
0.1498	0.7024	0.5278E 04	0.8304	0.2577E-00	0.3576E-07	1.845	0.6173E-05	0.1929	0.5989
0.1431	0.7080	0.5466E 04	0.8283	0.2620E-00	0.3672E-07	1.917	0.6985E-05	0.2116	0.6146

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 300,000 FT VELOCITY = 15,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.8950E 00	0.5563E-07	0.	0.0005	-0.0613	0.
0.0003	0.0234	0.1472E 03	0.0234	0.8944E 00	0.5560E-07	0.035	0.0005	-0.0604	0.0468
0.0011	0.0468	0.2944E 03	0.0468	0.8926E 00	0.5550E-07	0.070	0.0005	-0.0576	0.0936
0.0025	0.0702	0.4418E 03	0.0703	0.8896E 00	0.5533E-07	0.104	0.0004	-0.0529	0.1405
0.0044	0.0936	0.5896E 03	0.0938	0.8854E 00	0.5509E-07	0.139	0.0003	-0.0462	0.1873
0.0069	0.1170	0.7381E 03	0.1173	0.8799E 00	0.5479E-07	0.174	0.0003	-0.0377	0.2341
0.0099	0.1405	0.8875E 03	0.1409	0.8733E 00	0.5442E-07	0.210	0.0003	-0.0271	0.2809
0.0135	0.1639	0.1038E 04	0.1646	0.8655E 00	0.5397E-07	0.245	0.0005	-0.0146	0.3277
0.0177	0.1873	0.1189E 04	0.1884	0.8564E 00	0.5346E-07	0.281	0.0005	0.0001	0.3745
0.0224	0.2107	0.1341E 04	0.2123	0.8461E 00	0.5289E-07	0.317	0.0001	0.0169	0.4214
0.0277	0.2341	0.1494E 04	0.2363	0.8346E 00	0.5227E-07	0.354	-0.0009	0.0359	0.4682
0.0337	0.2575	0.1651E 04	0.2604	0.8219E 00	0.5158E-07	0.391	-0.0018	0.0572	0.5150
0.0402	0.2809	0.1809E 04	0.2847	0.8081E 00	0.5079E-07	0.429	-0.0014	0.0809	0.5618
0.0474	0.3043	0.1969E 04	0.3092	0.7930E 00	0.4990E-07	0.467	0.0004	0.1070	0.6086
0.0552	0.3277	0.2145E 04	0.3339	0.7769E 00	0.4880E-07	0.509	0.0075	0.1358	0.6554
0.0637	0.3511	0.2304E 04	0.3588	0.7595E 00	0.4783E-07	0.547	0.0073	0.1672	0.7023
0.0729	0.3745	0.2462E 04	0.3839	0.7412E 00	0.4681E-07	0.585	0.0071	0.2014	0.7491
0.0828	0.3979	0.2619E 04	0.4094	0.7219E 00	0.4572E-07	0.623	0.0068	0.2385	0.7959
0.0934	0.4214	0.2774E 04	0.4351	0.7017E 00	0.4461E-07	0.661	0.0055	0.2787	0.8427
0.1047	0.4448	0.2926E 04	0.4611	0.6806E 00	0.4341E-07	0.697	0.0058	0.3220	0.8895
0.1169	0.4682	0.3093E 04	0.4875	0.6591E 00	0.4219E-07	0.738	0.0055	0.3687	0.9363
0.1297	0.4916	0.3258E 04	0.5142	0.6372E 00	0.4098E-07	0.779	0.0041	0.4188	0.9832
0.1435	0.5150	0.3422E 04	0.5413	0.6148E 00	0.3979E-07	0.819	0.0007	0.4725	1.0300
0.1580	0.5384	0.3581E 04	0.5689	0.5922E 00	0.3869E-07	0.860	-0.0070	0.5299	1.0768
0.1734	0.5618	0.3748E 04	0.5969	0.5689E 00	0.3732E-07	0.901	-0.0067	0.5913	1.1236
0.1896	0.5852	0.3922E 04	0.6255	0.5444E 00	0.3591E-07	0.944	-0.0069	0.6568	1.1704
0.2069	0.6086	0.4106E 04	0.6545	0.5183E 00	0.3438E-07	0.990	-0.0071	0.7265	1.2173
0.2251	0.6320	0.4304E 04	0.6842	0.4906E-00	0.3276E-07	1.040	-0.0072	0.8005	1.2641
0.2445	0.6554	0.4513E 04	0.7146	0.4613E-00	0.3105E-07	1.093	-0.0079	0.8792	1.3109

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2287	0.6364	0.4343E 04	0.8886	0.4852E-00	0.3245E-07	1.050	0.	-0.0184	0.3142
0.2221	0.6418	0.4703E 04	0.8807	0.4908E-00	0.3303E-07	1.139	0.5856E-06	-0.0028	0.3383
0.2164	0.6464	0.5010E 04	0.8754	0.4962E-00	0.3371E-07	1.216	0.1147E-05	0.0138	0.3637
0.2107	0.6511	0.5322E 04	0.8711	0.5019E 00	0.3453E-07	1.295	0.1760E-05	0.0314	0.3903
0.2050	0.6557	0.5644E 04	0.8676	0.5082E 00	0.3544E-07	1.377	0.2429E-05	0.0500	0.4177
0.1993	0.6603	0.5973E 04	0.8648	0.5150E 00	0.3646E-07	1.462	0.3161E-05	0.0697	0.4457
0.1937	0.6649	0.6311E 04	0.8624	0.5224E 00	0.3762E-07	1.550	0.3961E-05	0.0901	0.4737
0.1881	0.6695	0.6658E 04	0.8603	0.5303E 00	0.3894E-07	1.642	0.4838E-05	0.1112	0.5013
0.1824	0.6740	0.7015E 04	0.8584	0.5389E 00	0.4046E-07	1.739	0.5800E-05	0.1327	0.5281
0.1768	0.6786	0.7381E 04	0.8566	0.5482E 00	0.4228E-07	1.842	0.6860E-05	0.1543	0.5537
0.1713	0.6831	0.7759E 04	0.8548	0.5582E 00	0.4449E-07	1.958	0.8032E-05	0.1760	0.5780
0.1657	0.6876	0.8149E 04	0.8530	0.5691E 00	0.4730E-07	2.103	0.9339E-05	0.1971	0.6001
0.1602	0.6921	0.8557E 04	0.8514	0.5811E 00	0.5099E-07	2.283	0.1081E-04	0.2104	0.6133

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 300,000 FT VELOCITY = 20,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.1605E 01	0.7363E-07	0.	0.0001	-0.0465	0.
0.0003	0.0227	0.1667E 03	0.0227	0.1604E 01	0.7359E-07	0.034	0.0001	-0.0456	0.0453
0.0010	0.0453	0.3332E 03	0.0453	0.1601E 01	0.7346E-07	0.068	0.0001	-0.0429	0.0906
0.0023	0.0680	0.5000E 03	0.0680	0.1596E 01	0.7325E-07	0.102	0.0001	-0.0383	0.1359
0.0041	0.0906	0.6675E 03	0.0907	0.1588E 01	0.7295E-07	0.136	0.0001	-0.0319	0.1812
0.0064	0.1133	0.8357E 03	0.1135	0.1579E 01	0.7257E-07	0.171	0.0001	-0.0237	0.2265
0.0093	0.1359	0.1005E 04	0.1363	0.1568E 01	0.7210E-07	0.205	0.0001	-0.0135	0.2718
0.0126	0.1586	0.1174E 04	0.1592	0.1555E 01	0.7154E-07	0.240	0.0001	-0.0014	0.3171
0.0165	0.1812	0.1345E 04	0.1822	0.1539E 01	0.7090E-07	0.275	0.0000	0.0127	0.3624
0.0210	0.2039	0.1516E 04	0.2053	0.1522E 01	0.7018E-07	0.310	-0.0001	0.0288	0.4077
0.0260	0.2265	0.1688E 04	0.2285	0.1503E 01	0.6937E-07	0.346	-0.0002	0.0470	0.4530
0.0315	0.2492	0.1862E 04	0.2518	0.1482E 01	0.6848E-07	0.382	-0.0003	0.0674	0.4983
0.0376	0.2718	0.2037E 04	0.2753	0.1458E 01	0.6750E-07	0.418	-0.0002	0.0899	0.5436
0.0443	0.2945	0.2214E 04	0.2989	0.1433E 01	0.6644E-07	0.454	-0.0002	0.1148	0.5889
0.0516	0.3171	0.2397E 04	0.3227	0.1406E 01	0.6530E-07	0.492	-0.0000	0.1421	0.6342
0.0595	0.3398	0.2575E 04	0.3467	0.1377E 01	0.6407E-07	0.529	-0.0001	0.1718	0.6795
0.0680	0.3624	0.2754E 04	0.3709	0.1347E 01	0.6277E-07	0.567	-0.0003	0.2042	0.7248
0.0772	0.3851	0.2935E 04	0.3953	0.1314E 01	0.6140E-07	0.605	-0.0005	0.2391	0.7701
0.0870	0.4077	0.3119E 04	0.4200	0.1280E 01	0.5996E-07	0.643	-0.0008	0.2769	0.8155
0.0974	0.4304	0.3308E 04	0.4449	0.1245E 01	0.5846E-07	0.683	-0.0012	0.3175	0.8608
0.1086	0.4530	0.3498E 04	0.4702	0.1207E 01	0.5686E-07	0.723	-0.0014	0.3612	0.9061
0.1205	0.4757	0.3689E 04	0.4958	0.1169E 01	0.5521E-07	0.764	-0.0016	0.4079	0.9514
0.1331	0.4983	0.3883E 04	0.5217	0.1129E 01	0.5349E-07	0.805	-0.0017	0.4579	0.9967
0.1466	0.5210	0.4080E 04	0.5481	0.1087E 01	0.5170E-07	0.848	-0.0020	0.5113	1.0420
0.1608	0.5436	0.4280E 04	0.5748	0.1045E 01	0.4987E-07	0.891	-0.0023	0.5682	1.0873
0.1759	0.5663	0.4482E 04	0.6021	0.1001E 01	0.4798E-07	0.935	-0.0025	0.6288	1.1326
0.1919	0.5889	0.4689E 04	0.6298	0.9569E 00	0.4604E-07	0.980	-0.0030	0.6932	1.1779
0.2089	0.6116	0.4899E 04	0.6581	0.9114E 00	0.4404E-07	1.026	-0.0031	0.7615	1.2232
0.2268	0.6342	0.5113E 04	0.6870	0.8657E 00	0.4203E-07	1.074	-0.0037	0.8339	1.2685

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2178	0.6231	0.5007E 04	0.9003	0.8883E 00	0.4302E-07	1.050	0.	-0.0148	0.2666
0.2107	0.6287	0.5766E 04	0.8922	0.8993E 00	0.4403E-07	1.215	0.1042E-05	-0.0024	0.2897
0.2063	0.6322	0.6237E 04	0.8887	0.9072E 00	0.4476E-07	1.320	0.1774E-05	0.0111	0.3150
0.2019	0.6357	0.6714E 04	0.8860	0.9163E 00	0.4559E-07	1.426	0.2580E-05	0.0259	0.3426
0.1976	0.6391	0.7195E 04	0.8840	0.9266E 00	0.4652E-07	1.535	0.3466E-05	0.0422	0.3722
0.1932	0.6426	0.7681E 04	0.8824	0.9381E 00	0.4756E-07	1.647	0.4437E-05	0.0599	0.4033
0.1889	0.6460	0.8171E 04	0.8813	0.9510E 00	0.4873E-07	1.762	0.5499E-05	0.0788	0.4351
0.1846	0.6495	0.8665E 04	0.8805	0.9654E 00	0.5005E-07	1.879	0.6659E-05	0.0987	0.4666
0.1802	0.6529	0.9163E 04	0.8798	0.9813E 00	0.5153E-07	2.000	0.7927E-05	0.1191	0.4969
0.1759	0.6563	0.9663E 04	0.8793	0.9989E 00	0.5319E-07	2.124	0.9311E-05	0.1396	0.5256
0.1716	0.6597	0.1017E 05	0.8790	0.1018E 01	0.5506E-07	2.252	0.1082E-04	0.1599	0.5521
0.1673	0.6631	0.1067E 05	0.8787	0.1040E 01	0.5717E-07	2.383	0.1247E-04	0.1798	0.5765
0.1630	0.6665	0.1117E 05	0.8784	0.1063E 01	0.5954E-07	2.517	0.1428E-04	0.1991	0.5988

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 300,000 FT VELOCITY = 25,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.2518E 01	0.8713E-07	0.	0.0001	-0.0392	0.
0.0002	0.0221	0.1885E 03	0.0221	0.2516E 01	0.8708E-07	0.033	0.0001	-0.0383	0.0442
0.0010	0.0442	0.3767E 03	0.0442	0.2512E 01	0.8694E-07	0.066	0.0001	-0.0356	0.0884
0.0022	0.0663	0.5652E 03	0.0663	0.2504E 01	0.8670E-07	0.100	0.0001	-0.0312	0.1326
0.0039	0.0884	0.7545E 03	0.0885	0.2493E 01	0.8636E-07	0.133	0.0001	-0.0250	0.1768
0.0061	0.1105	0.9447E 03	0.1107	0.2479E 01	0.8593E-07	0.167	0.0000	-0.0169	0.2210
0.0088	0.1326	0.1136E 04	0.1330	0.2462E 01	0.8540E-07	0.200	0.0000	-0.0070	0.2652
0.0120	0.1547	0.1328E 04	0.1553	0.2442E 01	0.8477E-07	0.234	-0.0000	0.0049	0.3094
0.0157	0.1768	0.1521E 04	0.1777	0.2419E 01	0.8405E-07	0.268	-0.0000	0.0186	0.3536
0.0199	0.1989	0.1714E 04	0.2002	0.2393E 01	0.8323E-07	0.303	-0.0000	0.0344	0.3978
0.0247	0.2210	0.1909E 04	0.2228	0.2363E 01	0.8231E-07	0.338	-0.0001	0.0522	0.4420
0.0300	0.2431	0.2106E 04	0.2455	0.2331E 01	0.8131E-07	0.373	-0.0003	0.0722	0.4862
0.0358	0.2652	0.2304E 04	0.2684	0.2296E 01	0.8021E-07	0.408	-0.0005	0.0944	0.5304
0.0421	0.2873	0.2504E 04	0.2914	0.2257E 01	0.7901E-07	0.444	-0.0006	0.1188	0.5746
0.0490	0.3094	0.2711E 04	0.3145	0.2216E 01	0.7775E-07	0.481	-0.0012	0.1456	0.6188
0.0565	0.3315	0.2913E 04	0.3379	0.2172E 01	0.7635E-07	0.518	-0.0012	0.1749	0.6629
0.0646	0.3536	0.3116E 04	0.3614	0.2125E 01	0.7486E-07	0.554	-0.0010	0.2068	0.7071
0.0733	0.3757	0.3320E 04	0.3851	0.2076E 01	0.7327E-07	0.591	-0.0007	0.2413	0.7513
0.0826	0.3978	0.3528E 04	0.4091	0.2024E 01	0.7159E-07	0.629	-0.0004	0.2786	0.7955
0.0925	0.4199	0.3740E 04	0.4333	0.1970E 01	0.6985E-07	0.668	-0.0004	0.3188	0.8397
0.1031	0.4420	0.3956E 04	0.4579	0.1913E 01	0.6803E-07	0.707	-0.0002	0.3620	0.8839
0.1144	0.4641	0.4171E 04	0.4827	0.1854E 01	0.6614E-07	0.747	-0.0005	0.4084	0.9281
0.1263	0.4862	0.4388E 04	0.5078	0.1793E 01	0.6420E-07	0.787	-0.0009	0.4581	0.9723
0.1390	0.5083	0.4608E 04	0.5333	0.1730E 01	0.6218E-07	0.829	-0.0012	0.5112	1.0165
0.1524	0.5304	0.4832E 04	0.5591	0.1665E 01	0.6008E-07	0.871	-0.0015	0.5679	1.0607
0.1667	0.5525	0.5058E 04	0.5854	0.1600E 01	0.5794E-07	0.913	-0.0019	0.6283	1.1049
0.1817	0.5746	0.5286E 04	0.6122	0.1532E 01	0.5573E-07	0.957	-0.0021	0.6927	1.1491
0.1976	0.5967	0.5520E 04	0.6394	0.1463E 01	0.5348E-07	1.002	-0.0025	0.7610	1.1933
0.2144	0.6188	0.5756E 04	0.6672	0.1393E 01	0.5116E-07	1.047	-0.0027	0.8336	1.2375
0.2322	0.6409	0.5998E 04	0.6955	0.1322E 01	0.4882E-07	1.094	-0.0030	0.9105	1.2817

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2154	0.6200	0.5770E 04	0.9056	0.1389E 01	0.5102E-07	1.050	0.	-0.0127	0.2409
0.2099	0.6244	0.6707E 04	0.8993	0.1402E 01	0.5218E-07	1.229	0.1150E-05	-0.0018	0.2635
0.2062	0.6272	0.7338E 04	0.8965	0.1413E 01	0.5308E-07	1.352	0.2033E-05	0.0102	0.2890
0.2026	0.6301	0.7979E 04	0.8945	0.1426E 01	0.5413E-07	1.478	0.3017E-05	0.0238	0.3176
0.1989	0.6330	0.8628E 04	0.8930	0.1441E 01	0.5532E-07	1.609	0.4108E-05	0.0392	0.3491
0.1953	0.6358	0.9286E 04	0.8919	0.1458E 01	0.5669E-07	1.743	0.5316E-05	0.0565	0.3829
0.1916	0.6387	0.9954E 04	0.8912	0.1477E 01	0.5825E-07	1.882	0.6651E-05	0.0754	0.4180
0.1880	0.6415	0.1063E 05	0.8908	0.1499E 01	0.6004E-07	2.026	0.8124E-05	0.0957	0.4531
0.1844	0.6444	0.1132E 05	0.8906	0.1524E 01	0.6209E-07	2.176	0.9750E-05	0.1167	0.4868
0.1808	0.6472	0.1201E 05	0.8905	0.1553E 01	0.6444E-07	2.332	0.1154E-04	0.1379	0.5185
0.1772	0.6501	0.1271E 05	0.8905	0.1585E 01	0.6714E-07	2.493	0.1353E-04	0.1589	0.5477
0.1736	0.6529	0.1342E 05	0.8905	0.1622E 01	0.7023E-07	2.662	0.1572E-04	0.1794	0.5744
0.1700	0.6557	0.1413E 05	0.8906	0.1663E 01	0.7376E-07	2.836	0.1815E-04	0.1993	0.5986

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 300,000 FT VELOCITY = 30,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.3617E 01	0.8040E-07	0.	-0.0001	-0.0410	0.
0.0004	0.0268	0.2899E 03	0.0268	0.3614E 01	0.8034E-07	0.040	-0.0001	-0.0397	0.0536
0.0015	0.0536	0.5792E 03	0.0536	0.3604E 01	0.8014E-07	0.079	-0.0001	-0.0356	0.1072
0.0033	0.0804	0.8688E 03	0.0805	0.3587E 01	0.7983E-07	0.119	-0.0000	-0.0289	0.1608
0.0058	0.1072	0.1159E 04	0.1074	0.3564E 01	0.7941E-07	0.158	-0.0001	-0.0194	0.2144
0.0091	0.1340	0.1450E 04	0.1344	0.3533E 01	0.7887E-07	0.198	-0.0002	-0.0071	0.2680
0.0131	0.1608	0.1741E 04	0.1615	0.3497E 01	0.7819E-07	0.238	-0.0002	0.0081	0.3216
0.0179	0.1876	0.2035E 04	0.1887	0.3454E 01	0.7734E-07	0.278	0.0002	0.0263	0.3752
0.0234	0.2144	0.2331E 04	0.2161	0.3404E 01	0.7634E-07	0.319	0.0009	0.0476	0.4288
0.0296	0.2412	0.2630E 04	0.2436	0.3348E 01	0.7527E-07	0.360	0.0011	0.0721	0.4824
0.0367	0.2680	0.2931E 04	0.2713	0.3285E 01	0.7419E-07	0.402	0.0003	0.1000	0.5360
0.0445	0.2948	0.3234E 04	0.2993	0.3215E 01	0.7300E-07	0.444	-0.0007	0.1314	0.5896
0.0532	0.3216	0.3541E 04	0.3274	0.3140E 01	0.7159E-07	0.486	-0.0007	0.1664	0.6431
0.0628	0.3484	0.3853E 04	0.3559	0.3058E 01	0.6992E-07	0.530	0.0004	0.2054	0.6967
0.0731	0.3752	0.4190E 04	0.3846	0.2971E 01	0.6802E-07	0.576	0.0030	0.2484	0.7503
0.0845	0.4020	0.4504E 04	0.4137	0.2877E 01	0.6623E-07	0.621	0.0030	0.2957	0.8039
0.0967	0.4288	0.4820E 04	0.4432	0.2778E 01	0.6438E-07	0.665	0.0026	0.3475	0.8575
0.1099	0.4556	0.5140E 04	0.4731	0.2674E 01	0.6244E-07	0.711	0.0019	0.4041	0.9111
0.1242	0.4824	0.5469E 04	0.5034	0.2565E 01	0.6042E-07	0.758	0.0010	0.4657	0.9647
0.1395	0.5092	0.5819E 04	0.5343	0.2453E 01	0.5815E-07	0.809	0.0019	0.5326	1.0183
0.1559	0.5360	0.6154E 04	0.5657	0.2337E 01	0.5595E-07	0.858	0.0010	0.6051	1.0719
0.1735	0.5628	0.6495E 04	0.5978	0.2218E 01	0.5363E-07	0.908	0.0006	0.6835	1.1255
0.1924	0.5896	0.6836E 04	0.6306	0.2098E 01	0.5130E-07	0.959	-0.0004	0.7680	1.1791
0.2126	0.6164	0.7183E 04	0.6642	0.1977E 01	0.4889E-07	1.012	-0.0010	0.8590	1.2327
0.2342	0.6431	0.7531E 04	0.6986	0.1854E 01	0.4648E-07	1.067	-0.0025		

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2275	0.6350	0.7426E 04	0.8864	0.1891E 01	0.4721E-07	1.050	0.	-0.0114	0.2504
0.2219	0.6396	0.8507E 04	0.8801	0.1912E 01	0.4975E-07	1.232	0.1549E-05	0.0006	0.2751
0.2182	0.6426	0.9268E 04	0.8773	0.1929E 01	0.5159E-07	1.367	0.2751E-05	0.0142	0.3034
0.2145	0.6457	0.1006E 05	0.8753	0.1949E 01	0.5365E-07	1.513	0.4114E-05	0.0300	0.3356
0.2108	0.6487	0.1089E 05	0.8740	0.1973E 01	0.5591E-07	1.673	0.5655E-05	0.0482	0.3716
0.2071	0.6517	0.1176E 05	0.8732	0.2001E 01	0.5843E-07	1.847	0.7399E-05	0.0689	0.4104
0.2034	0.6547	0.1267E 05	0.8729	0.2034E 01	0.6131E-07	2.038	0.9372E-05	0.0917	0.4500
0.1998	0.6577	0.1360E 05	0.8729	0.2073E 01	0.6463E-07	2.246	0.1161E-04	0.1157	0.4884
0.1961	0.6607	0.1458E 05	0.8733	0.2119E 01	0.6847E-07	2.464	0.1415E-04	0.1399	0.5242
0.1925	0.6636	0.1558E 05	0.8738	0.2173E 01	0.7286E-07	2.693	0.1705E-04	0.1638	0.5566
0.1888	0.6666	0.1661E 05	0.8745	0.2237E 01	0.7786E-07	2.935	0.2035E-04	0.1868	0.5856
0.1852	0.6696	0.1766E 05	0.8752	0.2313E 01	0.8372E-07	3.190	0.2413E-04	0.2079	0.6103

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 300,000 FT VELOCITY = 35,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.4923E 01	0.8033E-07	0.	0.0001	-0.0422	0.
0.0004	0.0277	0.3443E 03	0.0277	0.4918E 01	0.8026E-07	0.041	0.0001	-0.0408	0.0554
0.0015	0.0554	0.6884E 03	0.0554	0.4904E 01	0.8005E-07	0.083	0.0001	-0.0367	0.1108
0.0035	0.0831	0.1034E 04	0.0832	0.4880E 01	0.7971E-07	0.124	0.0000	-0.0297	0.1662
0.0061	0.1108	0.1381E 04	0.1111	0.4846E 01	0.7923E-07	0.166	-0.0001	-0.0198	0.2217
0.0096	0.1385	0.1732E 04	0.1390	0.4803E 01	0.7861E-07	0.208	-0.0001	-0.0071	0.2771
0.0139	0.1662	0.2085E 04	0.1670	0.4751E 01	0.7784E-07	0.251	0.0000	0.0088	0.3325
0.0190	0.1939	0.2441E 04	0.1952	0.4688E 01	0.7691E-07	0.294	0.0003	0.0277	0.3879
0.0248	0.2217	0.2799E 04	0.2235	0.4616E 01	0.7585E-07	0.337	0.0005	0.0500	0.4433
0.0316	0.2494	0.3159E 04	0.2520	0.4535E 01	0.7468E-07	0.381	0.0002	0.0756	0.4987
0.0391	0.2771	0.3525E 04	0.2807	0.4444E 01	0.7340E-07	0.426	-0.0006	0.1049	0.5541
0.0476	0.3048	0.3898E 04	0.3097	0.4344E 01	0.7197E-07	0.472	-0.0015	0.1380	0.6095
0.0570	0.3325	0.4288E 04	0.3390	0.4234E 01	0.7053E-07	0.521	-0.0043	0.1751	0.6650
0.0673	0.3602	0.4668E 04	0.3685	0.4115E 01	0.6873E-07	0.568	-0.0039	0.2164	0.7204
0.0785	0.3879	0.5047E 04	0.3984	0.3990E 01	0.6683E-07	0.615	-0.0031	0.2622	0.7758
0.0908	0.4156	0.5427E 04	0.4288	0.3858E 01	0.6481E-07	0.662	-0.0021	0.3128	0.8312
0.1041	0.4433	0.5806E 04	0.4595	0.3720E 01	0.6269E-07	0.710	-0.0009	0.3684	0.8866
0.1185	0.4710	0.6186E 04	0.4907	0.3579E 01	0.6057E-07	0.758	-0.0009	0.4293	0.9420
0.1340	0.4987	0.6566E 04	0.5225	0.3434E 01	0.5838E-07	0.807	-0.0010	0.4959	0.9974
0.1506	0.5264	0.6952E 04	0.5548	0.3284E 01	0.5607E-07	0.856	-0.0000	0.5685	1.0528
0.1683	0.5541	0.7342E 04	0.5877	0.3128E 01	0.5370E-07	0.907	-0.0002	0.6474	1.1083
0.1873	0.5818	0.7746E 04	0.6213	0.2967E 01	0.5121E-07	0.960	0.0002	0.7331	1.1637
0.2075	0.6095	0.8172E 04	0.6556	0.2797E 01	0.4860E-07	1.017	0.0002	0.8258	1.2191
0.2291	0.6372	0.8612E 04	0.6908	0.2623E 01	0.4591E-07	1.076	-0.0000	0.9260	1.2745

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2196	0.6253	0.8420E 04	0.9057	0.2699E 01	0.4708E-07	1.050	0.	-0.0134	0.2511
0.2156	0.6285	0.9280E 04	0.9007	0.2716E 01	0.4785E-07	1.163	0.1094E-05	-0.0018	0.2743
0.2117	0.6315	0.1013E 05	0.8974	0.2737E 01	0.4874E-07	1.277	0.2291E-05	0.0111	0.3002
0.2078	0.6346	0.1101E 05	0.8948	0.2760E 01	0.4977E-07	1.395	0.3624E-05	0.0255	0.3290
0.2039	0.6377	0.1190E 05	0.8929	0.2786E 01	0.5096E-07	1.519	0.5106E-05	0.0417	0.3604
0.2000	0.6407	0.1282E 05	0.8916	0.2817E 01	0.5237E-07	1.648	0.6751E-05	0.0597	0.3940
0.1961	0.6438	0.1375E 05	0.8907	0.2852E 01	0.5403E-07	1.784	0.8577E-05	0.0794	0.4286
0.1922	0.6468	0.1471E 05	0.8900	0.2893E 01	0.5606E-07	1.929	0.1061E-04	0.1005	0.4635
0.1884	0.6499	0.1570E 05	0.8896	0.2939E 01	0.5865E-07	2.083	0.1287E-04	0.1227	0.4977
0.1845	0.6529	0.1672E 05	0.8893	0.2992E 01	0.6218E-07	2.243	0.1542E-04	0.1454	0.5303
0.1806	0.6559	0.1779E 05	0.8889	0.3054E 01	0.6713E-07	2.421	0.1832E-04	0.1681	0.5606
0.1768	0.6589	0.1894E 05	0.8885	0.3127E 01	0.7415E-07	2.631	0.2171E-04	0.1902	0.5882
0.1730	0.6619	0.2017E 05	0.8880	0.3216E 01	0.8328E-07	2.916	0.2574E-04	0.2015	0.6015

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONTINUED

ALTITUDE = 300,000 FT VELOCITY = 40,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	FT ERROR	XB	YB
0.	0.	0.	0.	0.6439E 01	0.8508E-07	0.	0.0002	-0.0400	0.
0.0004	0.0276	0.3813E 03	0.0276	0.6432E 01	0.8501E-07	0.041	0.0002	-0.0386	0.0552
0.0015	0.0552	0.7621E 03	0.0552	0.6414E 01	0.8479E-07	0.082	0.0002	-0.0344	0.1104
0.0034	0.0828	0.1144E 04	0.0829	0.6383E 01	0.8443E-07	0.124	0.0001	-0.0275	0.1656
0.0061	0.1104	0.1528E 04	0.1106	0.6339E 01	0.8392E-07	0.165	0.0001	-0.0177	0.2208
0.0096	0.1380	0.1916E 04	0.1384	0.6284E 01	0.8327E-07	0.207	0.0000	-0.0050	0.2760
0.0138	0.1656	0.2305E 04	0.1664	0.6215E 01	0.8247E-07	0.250	-0.0000	0.0107	0.3312
0.0188	0.1932	0.2697E 04	0.1944	0.6135E 01	0.8152E-07	0.292	-0.0001	0.0295	0.3864
0.0247	0.2208	0.3093E 04	0.2226	0.6042E 01	0.8043E-07	0.336	-0.0002	0.0516	0.4416
0.0313	0.2484	0.3492E 04	0.2510	0.5937E 01	0.7919E-07	0.379	-0.0004	0.0770	0.4968
0.0388	0.2760	0.3896E 04	0.2796	0.5820E 01	0.7781E-07	0.424	-0.0006	0.1059	0.5520
0.0472	0.3036	0.4303E 04	0.3085	0.5691E 01	0.7629E-07	0.469	-0.0007	0.1385	0.6072
0.0565	0.3312	0.4731E 04	0.3376	0.5551E 01	0.7464E-07	0.516	-0.0009	0.1750	0.6624
0.0667	0.3588	0.5143E 04	0.3670	0.5399E 01	0.7281E-07	0.562	-0.0011	0.2156	0.7176
0.0778	0.3864	0.5558E 04	0.3968	0.5237E 01	0.7087E-07	0.608	-0.0012	0.2606	0.7728
0.0899	0.4140	0.5978E 04	0.4269	0.5065E 01	0.6881E-07	0.655	-0.0015	0.3101	0.8280
0.1030	0.4416	0.6409E 04	0.4575	0.4884E 01	0.6663E-07	0.704	-0.0018	0.3645	0.8832
0.1172	0.4692	0.6850E 04	0.4885	0.4692E 01	0.6431E-07	0.754	-0.0022	0.4240	0.9384
0.1325	0.4968	0.7293E 04	0.5201	0.4495E 01	0.6191E-07	0.805	-0.0025	0.4889	0.9936
0.1489	0.5244	0.7739E 04	0.5522	0.4290E 01	0.5937E-07	0.856	-0.0022	0.5595	1.0488
0.1665	0.5520	0.8199E 04	0.5850	0.4081E 01	0.5681E-07	0.910	-0.0028	0.6361	1.1040
0.1854	0.5796	0.8650E 04	0.6184	0.3869E 01	0.5420E-07	0.963	-0.0032	0.7192	1.1592
0.2056	0.6072	0.9101E 04	0.6527	0.3660E 01	0.5161E-07	1.017	-0.0038	0.8090	1.2145
0.2272	0.6348	0.9541E 04	0.6877	0.3452E 01	0.4900E-07	1.070	-0.0044	0.9058	1.2697

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2189	0.6244	0.9376E 04	0.9038	0.3531E 01	0.4999E-07	1.050	0.	-0.0125	0.2447
0.2139	0.6283	0.1070E 05	0.8977	0.3558E 01	0.5103E-07	1.206	0.1640E-05	-0.0015	0.2677
0.2102	0.6312	0.1171E 05	0.8946	0.3584E 01	0.5196E-07	1.326	0.3050E-05	0.0109	0.2935
0.2065	0.6341	0.1273E 05	0.8921	0.3613E 01	0.5302E-07	1.451	0.4621E-05	0.0249	0.3223
0.2028	0.6370	0.1377E 05	0.8902	0.3648E 01	0.5427E-07	1.581	0.6367E-05	0.0407	0.3541
0.1991	0.6399	0.1484E 05	0.8888	0.3688E 01	0.5572E-07	1.716	0.8304E-05	0.0583	0.3881
0.1954	0.6428	0.1592E 05	0.8877	0.3735E 01	0.5740E-07	1.857	0.1045E-04	0.0777	0.4234
0.1917	0.6457	0.1702E 05	0.8870	0.3789E 01	0.5936E-07	2.005	0.1283E-04	0.0984	0.4585
0.1881	0.6486	0.1815E 05	0.8865	0.3851E 01	0.6166E-07	2.161	0.1547E-04	0.1198	0.4924
0.1844	0.6515	0.1930E 05	0.8863	0.3923E 01	0.6438E-07	2.327	0.1841E-04	0.1415	0.5241
0.1807	0.6544	0.2047E 05	0.8862	0.4005E 01	0.6764E-07	2.505	0.2168E-04	0.1630	0.5534
0.1771	0.6573	0.2167E 05	0.8862	0.4101E 01	0.7165E-07	2.697	0.2534E-04	0.1842	0.5805
0.1734	0.6601	0.2289E 05	0.8863	0.4212E 01	0.7662E-07	2.906	0.2948E-04	0.1991	0.5985

TABLE II.- REAL-GAS SOLUTIONS FOR AIR - CONCLUDED

ALTITUDE = 300,000 FT VELOCITY = 45,000 FT/SEC

BODY DATA								SHOCK SHAPE	
XB	YB	V FT/SEC	PHI RAD	P LB/SQ FT	RHO SLUG/CU FT	M	HT ERROR	XB	YB
0.	0.	0.	0.	0.8157E 01	0.8892E-07	0.	-0.0002	-0.0383	0.
0.0002	0.0220	0.3346E 03	0.0220	0.8152E 01	0.8887E-07	0.033	-0.0002	-0.0374	0.0439
0.0010	0.0439	0.6686E 03	0.0439	0.8137E 01	0.8873E-07	0.066	-0.0002	-0.0348	0.0879
0.0022	0.0659	0.1003E 04	0.0659	0.8112E 01	0.8849E-07	0.099	-0.0002	-0.0303	0.1318
0.0039	0.0879	0.1339E 04	0.0880	0.8077E 01	0.8815E-07	0.132	-0.0001	-0.0241	0.1757
0.0060	0.1098	0.1677E 04	0.1100	0.8033E 01	0.8771E-07	0.165	-0.0001	-0.0161	0.2196
0.0087	0.1318	0.2016E 04	0.1322	0.7978E 01	0.8717E-07	0.199	0.0000	-0.0062	0.2636
0.0119	0.1537	0.2357E 04	0.1544	0.7913E 01	0.8654E-07	0.233	0.0002	0.0055	0.3075
0.0155	0.1757	0.2700E 04	0.1766	0.7838E 01	0.8580E-07	0.267	0.0003	0.0193	0.3514
0.0197	0.1977	0.3044E 04	0.1990	0.7754E 01	0.8498E-07	0.301	0.0004	0.0350	0.3953
0.0244	0.2196	0.3390E 04	0.2214	0.7659E 01	0.8408E-07	0.335	0.0002	0.0528	0.4393
0.0296	0.2416	0.3740E 04	0.2440	0.7555E 01	0.8308E-07	0.370	-0.0000	0.0727	0.4832
0.0353	0.2636	0.4093E 04	0.2667	0.7441E 01	0.8196E-07	0.406	0.0000	0.0949	0.5271
0.0416	0.2855	0.4450E 04	0.2896	0.7317E 01	0.8072E-07	0.441	0.0005	0.1194	0.5711
0.0485	0.3075	0.4808E 04	0.3126	0.7184E 01	0.7937E-07	0.477	0.0013	0.1462	0.6150
0.0559	0.3295	0.5185E 04	0.3357	0.7043E 01	0.7784E-07	0.515	0.0036	0.1756	0.6589
0.0638	0.3514	0.5546E 04	0.3591	0.6891E 01	0.7636E-07	0.551	0.0036	0.2076	0.7028
0.0724	0.3734	0.5907E 04	0.3827	0.6731E 01	0.7480E-07	0.588	0.0034	0.2423	0.7468
0.0816	0.3953	0.6271E 04	0.4065	0.6563E 01	0.7316E-07	0.625	0.0031	0.2799	0.7907
0.0914	0.4173	0.6641E 04	0.4305	0.6387E 01	0.7145E-07	0.663	0.0025	0.3204	0.8346
0.1018	0.4393	0.7020E 04	0.4549	0.6204E 01	0.6962E-07	0.702	0.0026	0.3641	0.8785
0.1129	0.4612	0.7405E 04	0.4795	0.6012E 01	0.6771E-07	0.741	0.0027	0.4110	0.9225
0.1247	0.4832	0.7791E 04	0.5044	0.5815E 01	0.6575E-07	0.781	0.0025	0.4613	0.9664
0.1373	0.5052	0.8181E 04	0.5297	0.5613E 01	0.6373E-07	0.822	0.0021	0.5152	1.0103
0.1505	0.5271	0.8576E 04	0.5554	0.5404E 01	0.6166E-07	0.864	0.0014	0.5729	1.0543
0.1645	0.5491	0.8977E 04	0.5814	0.5191E 01	0.5950E-07	0.906	0.0014	0.6344	1.0982
0.1793	0.5711	0.9382E 04	0.6079	0.4974E 01	0.5728E-07	0.949	0.0016	0.7000	1.1421
0.1950	0.5930	0.9791E 04	0.6349	0.4754E 01	0.5502E-07	0.993	0.0016	0.7699	1.1860
0.2115	0.6150	0.1020E 05	0.6624	0.4531E 01	0.5272E-07	1.037	0.0017	0.8442	1.2300
0.2290	0.6369	0.1062E 05	0.6904	0.4307E 01	0.5041E-07	1.083	0.0016	0.9231	1.2739

FIELD DATA								SONIC LINE	
XB	YB	V FT/SEC	THETA RAD	P LB/SQ FT	RHO SLUG/CU FT	M	PSI	XB	YB
0.2165	0.6214	0.1032E 05	0.9054	0.4466E 01	0.5205E-07	1.050	0.	-0.0123	0.2377
0.2119	0.6249	0.1176E 05	0.9000	0.4501E 01	0.5314E-07	1.203	0.1729E-05	-0.0016	0.2605
0.2084	0.6277	0.1290E 05	0.8971	0.4533E 01	0.5415E-07	1.328	0.3284E-05	0.0104	0.2863
0.2048	0.6305	0.1406E 05	0.8949	0.4572E 01	0.5535E-07	1.457	0.5024E-05	0.0240	0.3153
0.2013	0.6333	0.1525E 05	0.8933	0.4617E 01	0.5673E-07	1.592	0.6965E-05	0.0396	0.3476
0.1977	0.6361	0.1646E 05	0.8922	0.4670E 01	0.5833E-07	1.732	0.9125E-05	0.0571	0.3824
0.1942	0.6388	0.1770E 05	0.8915	0.4731E 01	0.6018E-07	1.879	0.1153E-04	0.0765	0.4187
0.1907	0.6416	0.1896E 05	0.8910	0.4801E 01	0.6233E-07	2.033	0.1420E-04	0.0974	0.4549
0.1872	0.6444	0.2026E 05	0.8907	0.4883E 01	0.6483E-07	2.196	0.1718E-04	0.1190	0.4898
0.1836	0.6471	0.2158E 05	0.8906	0.4976E 01	0.6776E-07	2.368	0.2049E-04	0.1409	0.5224
0.1801	0.6499	0.2293E 05	0.8905	0.5084E 01	0.7123E-07	2.552	0.2420E-04	0.1626	0.5524
0.1766	0.6526	0.2430E 05	0.8906	0.5208E 01	0.7533E-07	2.748	0.2836E-04	0.1838	0.5797
0.1731	0.6554	0.2571E 05	0.8907	0.5352E 01	0.8025E-07	2.959	0.3304E-04	0.1977	0.5967