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LAMINAR BOUNDARY LAYER WITH HEAT TRANSFER ON A CONE AT ANGLE OF ATTACK IN A SUPERSONIC STREAM

By Eli Reshotko

Lewis Flight Propulsion Laboratory
Cleveland, Ohio

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SUMMARY

The equations of the compressible laminar boundary layer for the windward streamline in the plane of symmetry (most windward streamline) of a yawed cone are presented. Since, for a Prandtl number of 1, the energy equation resembles the momentum equation in the meridional direction (along a generator), solutions are obtained for both insulated and cooled surfaces.

The heat-transfer rate to this most windward streamline increases significantly with angle of attack. For a surface cooled to absolute zero temperature, the relative increase with angle of attack is about 15 percent less than for an almost insulated surface. A supplementary calculation shows the heat transfer to vary with the Prandtl number Pr approximately as $Pr^{0.37}$, while the recovery factor is well estimated by the square root of the Prandtl number.

INTRODUCTION

The design considerations for proposed supersonic aircraft and hypersonic glide vehicles indicate the use of slender fuselages. As aerodynamic heating problems may considerably influence such a design, the heating rates for all possible modes of vehicle operation must be estimated closely. Since optimum cruise conditions or maneuvers may call for flight at angle of attack, the aerodynamic heating loads to bodies at angle of attack are of definite interest. With the use of laminar-boundary-layer theory, the present report considers this problem for a cone.

The boundary layer on a cone at angle of attack is a three-dimensional problem. In addition to the longitudinal and normal components of velocity that are considered at zero angle of attack, a crossflow velocity exists. The importance of this crossflow boundary layer is related to the magnitude of the component of free-stream velocity normal to the cone axis and, of course, increases with angle of attack.

The boundary-layer equations for cones at angle of attack were first formulated by Moore (ref. 1), who solved these equations for small angle of attack by a linearization process (ref. 2) and for large angle of attack by obtaining exact solutions to the appropriate set of nonlinear ordinary differential equations (ref. 3). Both references 2 and 3 are for insulated surfaces, and heat transfer is not considered. The combined effects of angle of attack and spin for an insulated cone in laminar flow are treated in references 4 and 5.

In an analysis not yet published, G. M. Low of the Lewis laboratory has extended the analysis of reference 2 to include heat transfer. His results show that large changes in heat transfer and skin friction occur with angle of attack and that there is a significant effect of surface-temperature level on the magnitude of this angle-of-attack effect. These results have prompted the present extension of the large angle-of-attack analysis of reference 3 to include heat-transfer effects. This extension is based on the fact that, for Prandtl number 1, the energy equation resembles the momentum equation in the zero pressure-gradient direction (meridional). As in reference 3, the present analysis is restricted to the windward streamline in the plane of symmetry, which will be referred to in the text as the "most windward streamline."

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Reference 2 further indicates that the boundary-layer equations for a slender cone at very large angle of attack approach those of a yawed cylinder. Consequently, the extension of the present results to larger angles of attack using the yawed cylinder results of reference 6 will be discussed.

BOUNDARY-LAYER EQUATIONS IN PLANE OF SYMMETRY

The present analysis differs from that of reference 3 only in the consideration of noninsulated surfaces. The presentation therefore will be a resumé of that analysis with a description of the minor changes required for the consideration of heat transfer.

In reference 1, differential equations are derived for the boundary layer over a cone at angle of attack. In reference 3, for large angle of attack, these equations reduce to ordinary differential equations only in the plane of symmetry, that is, for the most windward and the most leeward cone generators. However, except for very small angles of attack, the solutions to these equations were found to be indeterminate or nonexistent for the most leeward cone generator. The present solutions, therefore, are only for the most windward streamline, as are those of reference 3.

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The differential equations in the plane of symmetry are

$$\left(f + \frac{2}{3\theta} g_\varphi\right) f_{\lambda\lambda} + 2f_{\lambda\lambda\lambda} = 0 \tag{1a}$$

$$\left(f + \frac{2}{3\theta} g_\varphi\right) g_{\varphi\lambda\lambda} - \frac{2}{3\theta} (g_{\varphi\lambda})^2 - \frac{2}{3} g_{\varphi\lambda} f_\lambda - \frac{2}{3\theta} \frac{p^{*''}(\varphi)}{\rho^*} + 2g_{\varphi\lambda\lambda\lambda} = 0 \tag{1b}$$

$$\left(f + \frac{2}{3\theta} g_\varphi\right) T_\lambda^* + 4(f_{\lambda\lambda})^2 + \frac{2}{Pr} T_{\lambda\lambda}^* = 0 \tag{1c}$$

(A complete list of symbols will be found in appendix A.) The derivation of these equations assumes a thin boundary layer across which the static pressure is constant and a constant ratio of specific heats. Equation (1a) is the momentum equation in the generator or meridional direction. Equation (1b) is related to the crossflow momentum equation in the following manner: Since no crossflow velocity exists in the plane of symmetry, the crossflow momentum equation is identically zero there. Equation (1b) is obtained by differentiating the crossflow momentum equation with respect to a dimensionless crossflow coordinate φ and evaluating the result in the plane of symmetry. Equation (1c) is the energy equation and, in the presented form, allows consideration of noninsulated surfaces. The equation of state appropriate to equations (1) is

$$p^* = \frac{\gamma - 1}{2\gamma} \rho^* T^* \tag{2}$$

The functions $f(\lambda,\varphi)$ and $g_\varphi(\lambda)$ in equation (1) are related to the two-component vector potential discussed in reference 1 and are defined according to the relations

$$\left.\begin{aligned} u^* &\equiv f_\lambda \\ w^* &\equiv g_\lambda \end{aligned}\right\} \tag{3}$$

The coordinate λ is formed as follows:

$$\lambda = \sqrt{3}\left(\int_0^{y^*} \rho^* \, dy^*\right) x^{*^{-1/2}} \tag{4}$$

This coordinate is a composite of the Howarth transformation of the normal coordinate y, Mangler's transformation for conical flow, and a Blasius-type similarity along rays from the origin.

The quantities in equations (1) to (3) are in dimensionless form and are made dimensionless in terms of the quantities existing at the outer edge of the boundary layer for the particular angle of attack under consideration. These dimensionless quantities, which are starred, are defined as follows:

$$\left.\begin{aligned}
u^* &= \frac{u}{u_e} & w^* &= \frac{w}{u_e} \\
\rho^* &= \frac{\rho}{\rho_e} & T^* &= \frac{2c_pT}{u_e^2} \\
p^* &= \frac{p}{\rho_e u_e^2} & y^* &= \frac{\rho_e u_e y}{C\mu_e} \\
x^* &= \frac{\rho_e u_e x}{C\mu_e} & &
\end{aligned}\right\} \qquad (5)$$

where the constant C arises from the assumption of the Chapman-Rubesin temperature-viscosity relation (ref. 7)

$$\frac{\mu}{\mu_e} = C\frac{T}{T_e} \qquad (6)$$

where the constant C is used to match equation (6) to the Sutherland value of viscosity at the cone surface:

$$C = \left(\frac{T_w}{T_e}\right)^{1/2}\frac{T_e + S}{T_w + S} \qquad (7)$$

The constant S in equation (7) is taken as 198° R for air.

The dimensionless crossflow velocity $w^* = \frac{w}{u_e}$ is always zero in the plane of symmetry. However, as a consequence of equation (1b), the quantity of interest is w_φ^* or $g_{\lambda\varphi}$, rather than w^* or g_λ.

If, in the energy equation (1c), the dimensionless static temperature is replaced by a dimensionless stagnation enthalpy defined

$$H^* = T^* + (f_\lambda)^2 \qquad (8)$$

then, by using equation (1a), equation (1c) becomes

$$\Pr\left(f + \frac{2}{3\theta} g_\varphi\right)H_\lambda^* + 2H_{\lambda\lambda}^* = 4(1 - \Pr)\left(f_\lambda f_{\lambda\lambda\lambda} + f_{\lambda\lambda}^2\right) \tag{9}$$

Equation (9) is the energy equation for an arbitrary Prandtl number. The boundary conditions applicable to equations (1a), (1b), and (9) are:

$$\left.\begin{aligned} &\text{At } \lambda = 0, \\ &\qquad f = f_\lambda = g_\varphi = g_{\varphi\lambda} = 0;\ H^* = H_w^* \\ &\text{At } \lambda \to \infty, \\ &\qquad f_\lambda = 1;\ g_{\varphi\lambda} = w_{e_\varphi}^*;\ H^* = H_0^* \end{aligned}\right\} \tag{10}$$

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where H_0^* is the dimensionless external-stream stagnation enthalpy. If the quantity H^* is further replaced by the function

$$\Theta = \frac{H^* - H_w^*}{H_0^* - H_w^*} \tag{11}$$

equation (9) becomes

$$\Pr\left(f + \frac{2}{3\theta} g_\varphi\right)\Theta_\lambda + 2\Theta_{\lambda\lambda} = \frac{4(1 - \Pr)}{H_0^* - H_w^*}\left(f_\lambda f_{\lambda\lambda\lambda} + f_{\lambda\lambda}^2\right) \tag{12}$$

Because the pressure is assumed constant across the boundary layer, the density in equation (1b) can be expressed (using relations (2), (5), (8), and (11))

$$\frac{1}{\rho^*} = \frac{T^*}{T_e^*} = 1 + \frac{1}{T_e^*}\left[1 - (f_\lambda)^2\right] + \left(\frac{T_w}{T_0} - 1\right)\left(1 + \frac{1}{T_e^*}\right)(1 - \Theta) \tag{13}$$

When the following definitions are made (ref. 3)

$$\left.\begin{aligned} g_\varphi(\lambda) &\equiv \frac{3\theta}{2} k\ \psi(\lambda) \\ k &\equiv \frac{2}{3\theta} w_{e_\varphi}^* \end{aligned}\right\} \tag{14}$$

and a value of $p^{*''}(\varphi)$ in the plane of symmetry, consistent with equation (1b) evaluated at the outer edge of the boundary layer, is assigned, then equations (1a), (1b), and (12) become the following system:

$$(f + k\psi)f'' + 2f''' = 0 \tag{15a}$$

$$(f + k\psi)\psi'' + 2\psi''' - k(\psi')^2 - \frac{2}{3}\psi'f'$$

$$+ \left(k + \frac{2}{3}\right)\left[1 + \frac{1}{T_e^*}(1 - f'^2) + \left(\frac{T_w}{T_0} - 1\right)\left(1 + \frac{1}{T_e^*}\right)(1 - \Theta)\right] = 0 \quad (15b)$$

$$Pr(f + k\psi)\Theta' + 2\Theta'' = \frac{4(1 - Pr)}{H_0^* - H_w^*}\left(f'f''' + f''^2\right) \quad (15c)$$

with these boundary conditions for noninsulated surfaces:

$$\left.\begin{aligned} &\text{At } \lambda = 0, \\ &\qquad f = f' = \psi = \psi' = \Theta = 0 \\ &\text{At } \lambda \to \infty, \\ &\qquad f' = \psi' = \Theta = 1 \end{aligned}\right\} \quad (16)$$

For an insulated surface, the boundary condition $\Theta = 0$ at $\lambda = 0$ is replaced by $\Theta' = 0$ at $\lambda = 0$.

The parameters k and $1/T_e^*$, defined in reference 3, are functions of the stream Mach number, cone vertex angle, and angle of attack and are evaluated from the outer inviscid flow. In terms of the quantities tabulated in references 8 to 10 (using the notation of refs. 8 to 10 for the tabulated quantities), the expressions for k and $1/T_e^*$ are approximately (from ref. 3)

$$k = \frac{2}{3}\left[\frac{\alpha}{\theta}\frac{z}{\bar{u}} + 2\alpha^2\left(\frac{w_2}{\theta\bar{u}} - \frac{1}{\theta^2} - \frac{\sqrt{1 - \theta^2}}{\theta^2}\frac{z}{\bar{u}} - \frac{1}{2\theta}\frac{xz}{\bar{u}^2}\right)\right] + \cdot \cdot \cdot \quad (17)$$

and

$$\frac{1}{T_e^*} = \frac{\bar{u}^2}{1 - \bar{u}^2}\left\{1 + \alpha\left(\frac{2x}{\bar{u}} + \frac{\xi}{\bar{\rho}} - \frac{\eta}{\bar{p}}\right)\right.$$

$$+ \alpha^2\left[2\left(1 + \frac{u_0}{\bar{u}} + \frac{u_2}{\bar{u}}\right) + \frac{\rho_0}{\bar{\rho}} + \frac{\rho_2}{\bar{\rho}} - \frac{p_0}{\bar{p}} - \frac{p_2}{\bar{p}} - \frac{2\bar{u}^2}{1 - \bar{u}^2} + \frac{2x}{\bar{u}}\left(\frac{\xi}{\bar{\rho}} - \frac{\eta}{\bar{p}}\right)\right.$$

$$\left.\left.+ \frac{x^2}{\bar{u}^2} + \frac{\eta^2}{\bar{p}^2} - \frac{\eta}{\bar{p}}\frac{\xi}{\bar{\rho}}\right]\right\} + \cdot \cdot \cdot \quad (18)$$

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The quantity $1/T_e^*$ is related to the local surface Mach number at angle of attack by the expression

$$\frac{1}{T_e^*} = \frac{\gamma - 1}{2} M_e^2$$

SOLUTION OF EQUATIONS

Two types of solution are found for equations (15). The first is for a Prandtl number of 1.0. Under this circumstance, equations (15a) and (15c) are identical so that $\Theta = f'$. The resulting system and boundary conditions are

$$(f + k\psi)f'' + 2f''' = 0 \tag{19a}$$

$$(f + k\psi)\psi'' + 2\psi''' - k(\psi')^2 - \frac{2}{3}\psi'f'$$
$$+ \left(k + \frac{2}{3}\right)\left[1 + \frac{1}{T_e^*}(1 - f'^2) + \left(\frac{T_w}{T_0} - 1\right)\left(1 + \frac{1}{T_e^*}\right)(1 - f')\right] = 0 \tag{19b}$$

$$\left.\begin{array}{ll} \text{At } \lambda = 0, & \\ & f = f' = \psi = \psi' = 0 \\ \text{At } \lambda \to \infty, & \\ & f' = \psi' = 1 \end{array}\right\} \tag{20}$$

Solutions to equations (19) with boundary conditions (20) for the most windward streamline were obtained numerically for both insulated and cooled surfaces with an IBM 650 computing machine.

The second type of solution is obtained for a constant property fluid in low-speed flow $\left(\frac{T_w}{T_0} = 1, \frac{1}{T_e^*} = 0\right)$ with a Prandtl number different from 1.0. The technique used in obtaining these solutions is described in appendix B. Although these solutions are for constant property flow, past investigations have shown that the effects of Prandtl number on heat transfer and recovery factor are very little influenced by compressibility.

PROPERTIES OF SOLUTIONS

In the following sections, the solutions for the most windward streamline obtained in this study are presented, and their properties are discussed. All solutions are presented in tabular form: Table I shows the values of f, f', f'', ψ, ψ', and ψ'' tabulated against λ for a Prandtl number of 1.0. Table II presents a summary of the values of f_w'' or Θ_w' (related to shear in the meridional direction and also to the heat transfer) and ψ_w'' (related to circumferential shear) for the cases of table I. In table III are presented the results for a Prandtl number of 0.7, as obtained from the method of appendix B.

Velocity and Enthalpy Profiles

The meridional and circumferential velocity profiles and the enthalpy profiles obtained from the solutions for a Prandtl number of 1 (table I) are presented as functions of λ in figure 1.

The meridional and circumferential velocity ratios are, respectively,

$$\left.\begin{aligned} f' &= \frac{u}{u_e} \\ &\text{and} \\ \psi' &= \frac{\partial w/\partial\varphi}{\partial w_e/\partial\varphi} \end{aligned}\right\} \qquad (21)$$

from the definitions of f, ψ, and λ. It should be remembered that, for a Prandtl number of 1.0, the normalized enthalpy and meridional velocity profiles are identical. The distance y^* normal to the surface at a given location x^* along the most windward streamline is related to the similarity variable λ through equation (4) as follows:

$$y^* = \sqrt{\frac{x^*}{3}} \int_0^{\lambda} \frac{1}{\rho^*}\, d\lambda \qquad (22)$$

where the quantity $1/\rho^*$ for a Prandtl number of 1.0 is (eq. (13))

$$\frac{1}{\rho^*} = 1 + \frac{1}{T_e^*}\left(1 - f'^2\right) + \left(\frac{T_w}{T_0} - 1\right)\left(1 + \frac{1}{T_e^*}\right)(1 - f') \qquad (23)$$

The velocity overshoot in the circumferential velocity profiles should be noted in figure 1. That is, circumferential velocities that exceed the external circumferential velocity exist within the boundary layer. By obtaining the asymptotic solution to equations (19) in the manner of references 6 and 11, it can be shown that the circumferential velocity overshoot is obtained when the quantity

$$\left[2\left(\frac{1}{T_e^*}\right) + \left(\frac{T_w}{T_0} - 1\right)\left(1 + \frac{1}{T_e^*}\right) + \frac{2}{3k + 2}\right] > 0 \tag{24}$$

For $k \to \infty$, relation (24) reduces to the overshoot criterion of reference 6 for a yawed infinite cylinder. Among the present solutions, only those for $\frac{1}{T_e^*} = 0$, $\frac{T_w}{T_0} = 0$, $k > 0$ and $\frac{1}{T_e^*} = 0$, $\frac{T_w}{T_0} = \frac{1}{2}$, $k = 1.2$ should have <u>no</u> circumferential velocity overshoot. The apparent lack of overshoot for $\frac{1}{T_e^*} = 0$, $\frac{T_w}{T_0} = \frac{1}{2}$, $k = 0.6$ and $\frac{1}{T_e^*} = 0$, $\frac{T_w}{T_0} = 1.0$, $k = 1.2$ from table I is the result of an insufficient number of significant figures.

Skin Friction

The expressions for the meridional and circumferential components of viscous shear stress on the windward streamline in the plane of symmetry are, as derived in reference 3:

$$\left(C_{f,x}\right)_{\varphi=0} = \frac{1}{\frac{1}{2}\rho_e u_e^2}\,\mu\left(\frac{\partial u}{\partial y}\right)_{w,\varphi=0} \tag{25}$$

$$\left(C_{f,\varphi}\right)_{\varphi=0} = 0 \tag{26}$$

$$\left(\frac{\partial C_{f,\varphi}}{\partial \varphi}\right)_{\varphi=0} = \frac{1}{\frac{1}{2}\rho_e u_e^2}\left[\mu\,\frac{\partial}{\partial y}\left(\frac{\partial w}{\partial \varphi}\right)\right]_{w,\varphi=0} \tag{27}$$

In terms of the numerical results presented herein, these coefficients can be written

$$\left(C_{f,x}\right)_{\varphi=0} = 2f_w''\sqrt{\frac{3C}{Re_x}} \tag{28}$$

and

$$\left(\frac{\partial C_{f,\varphi}}{\partial \varphi}\right)_{\varphi=0} = 3\theta k \psi_w'' \sqrt{\frac{3C}{Re_x}} \tag{29}$$

where

$$Re_x = \frac{\rho_e u_e x}{\mu_e}$$

The quantities f_w'' and ψ_w'' are summarized in table II and plotted in figure 2 for all the Prandtl number 1 solutions obtained $(0 < k < 1.2)$. These solutions are obtained for values of k up to 1.2 only, because the external flow in this region can be calculated from references 8 to 10. It is possible to estimate the variation of f_w'' and ψ_w'' for larger values of k by using yawed infinite cylinder solutions. The technique for making this estimate is outlined in reference 2 and described in appendix C. Values of f_w'' estimated by this technique are shown in figure 3; the solid lines are drawn through the results of table II and are extended to tangency at large k by using the estimate of appendix C.

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Heat Transfer

The heat-transfer rate to the wall may be expressed

$$q = k_w\left(\frac{\partial T}{\partial y}\right)_w = \frac{\mu_w}{Pr}\left(\frac{\partial H}{\partial y}\right)_w \tag{31}$$

or, in terms of the presented numerical results,

$$q = \frac{\rho_e u_e (H_0 - H_w)\Theta_w'}{Pr} \sqrt{\frac{3C}{Re_x}} \tag{32}$$

In terms of the Stanton number, equation (32) is written

$$St = \frac{q}{\rho_e u_e (H_{aw} - H_w)} = \left[\left(\frac{H_0 - H_w}{H_{aw} - H_w}\right)\Theta_w'\right] \frac{1}{Pr} \sqrt{\frac{3C}{Re_x}} \tag{33}$$

where H_{aw} is the adiabatic wall enthalpy.

Prandtl number, 1.0. - For a Prandtl number of 1.0, where $H_{aw} = H_0$, equations (32) and (33) apply with the quantity Θ_w' evaluated from table II or from figures 2 and 3.

<u>Prandtl number, < 1.0</u>. - The solutions described in appendix B for a Prandtl number of 0.7 and listed in table II can be related to their Prandtl number 1.0 counterpart by a factor Pr^a. The variation of a (plotted in fig. 4) is from about 0.35 at $k = 0$ (often taken as 1/3) to 0.38 at $k = 1.2$ and is probably approaching the value of 0.4 for $k \rightarrow \infty$ as might be expected for the stagnation line of a yawed infinite cylinder. A single choice of $a = 0.37$ will give results to better than 1-percent accuracy for all values of k. Although evaluations at other Prandtl numbers were not made, it is assumed from experience that this factor reasonably represents the variation of heat transfer with Prandtl number on the most windward streamline of a yawed cone for Prandtl numbers close to 1.0. Formally, this variation is written

$$\left[\left(\frac{H_0 - H_w}{H_{aw} - H_w}\right)\Theta'_w\right]_{Pr\neq 1} = (\Theta'_w)_{Pr=1} Pr^{0.37} \tag{34}$$

The heat-transfer relations (32) and (33) for a Prandtl number different from 1.0 are written

$$q_{Pr\neq 1} = \rho_e u_e (H_{aw} - H_w)(\Theta'_w)_{Pr=1}\sqrt{\frac{3C}{Re_x}}\, Pr^{-0.63} \tag{35}$$

and

$$St_{Pr\neq 1} = (\Theta'_w)_{Pr=1}\sqrt{\frac{3C}{Re_x}}\, Pr^{-0.63} \tag{36}$$

Adiabatic Wall Temperature

The adiabatic wall or recovery temperature can be calculated if the recovery factor

$$r = \frac{T_{aw} - T_e}{T_0 - T_e} \tag{37}$$

is known. Values of the recovery factor have been calculated as described in appendix B for the cases $\frac{1}{T_e^*} = 0$, $\frac{T_w}{T_0} = 1$, $k = 0.4$, 0.8, and 1.2 for a Prandtl number of 0.7 and are listed in table III. If the recovery factor is represented by $r = Pr^b$, then the exponent b (plotted in fig. 5) varies from 0.503 for $k = 0$ to 0.476 at $k = 1.2$ and seemingly approaches the yawed infinite cylinder value of 0.46 (ref. 6) for very large k. In line with previous practice regarding the laminar recovery factor, it seems adequate to use

$$r = Pr^{1/2} \tag{38}$$

This recovery factor is further assumed to apply to enthalpy as well as to temperature.

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ENGINEERING CALCULATION OF HEAT TRANSFER TO MOST WINDWARD STREAMLINE OF YAWED CONE

Large Angle of Attack[1]

The local rate of heat transfer to the wall per unit wall area may be calculated from the relation

$$q = h(H_{aw} - H_w) \tag{39}$$

where h is a heat-transfer coefficient based on an enthalpy difference and H_{aw} is the adiabatic wall enthalpy, which may be obtained from the relation

$$H_{aw} = \frac{u_e^2}{2}\left[\frac{1}{\left(\frac{1}{T_e^*}\right)} + r\right] \tag{40}$$

where the quantity $1/T_e^*$ is the parameter described by equation (18) and the recovery factor, as previously shown, may be taken as the square root of the Prandtl number.

The heat-transfer coefficient for a yawed cone is most easily estimated by first calculating that coefficient for a cone at zero angle of attack and then calculating the ratio of yawed to unyawed heat-transfer coefficient under identical free-stream and surface-temperature conditions. From equation (35), the heat-transfer coefficient to a cone at zero angle of attack is

$$h_{\alpha=0} = \frac{q}{H_{aw} - H_w} = 0.575\ Pr^{-0.63}\sqrt{\frac{\rho_w \mu_w u_e}{x}} \tag{41}$$

where the fluid properties are evaluated at the wall temperature.

[1]Large in the sense of the tables in refs. 8 to 10.

For identical free-stream conditions and for the same surface temperature, the ratio of the heat-transfer coefficient at angle of attack to that at zero angle of attack is, from equation (35),

$$\frac{h_\alpha}{h_{\alpha=0}} = \frac{(\Theta'_w)_\alpha}{0.3321}\sqrt{\frac{(p_e u_e)_\alpha}{(p_e u_e)_{\alpha=0}}} \tag{42}$$

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The detailed calculation procedure of heat transfer to the most windward streamline is as follows:

(1) As a function of cone half-angle and free-stream Mach number, calculate the values of the parameters k and $1/T_e^*$ for the desired angles of attack from equations (17) and (18). These calculations have been made for cone half-angles of 5°, 7.5°, and 10° and are presented in figure 6. Also calculate the local surface velocity u_e and the pressure-velocity product $p_e u_e$. In terms of the notation of references 8 to 10, the appropriate expressions are

$$\frac{(u_e)_\alpha}{(u_e)_{\alpha=0}} = 1 + \alpha\frac{x}{\bar{\bar{u}}} + \alpha^2\left(\frac{u_0}{\bar{\bar{u}}} + \frac{u_2}{\bar{\bar{u}}} + 1\right) + \cdot\cdot\cdot \tag{43}$$

$$\frac{(p_e u_e)_\alpha}{(p_e u_e)_{\alpha=0}} = 1 + \alpha\left(\frac{x}{\bar{\bar{u}}} + \frac{\eta}{\bar{\bar{p}}}\right)$$
$$+ \alpha^2\left[\frac{u_0}{\bar{\bar{u}}} + \frac{u_2}{\bar{\bar{u}}} + 1 + \frac{x}{\bar{\bar{u}}}\,\frac{\eta}{\bar{\bar{p}}} + \frac{p_0}{\bar{\bar{p}}} + \frac{p_2}{\bar{\bar{p}}} + \frac{2\gamma}{\gamma - 1}\left(\frac{1}{T_e^*}\right)\right] + \cdot\cdot\cdot \tag{44}$$

(2) Obtain the heat-transfer coefficient at zero angle of attack from equation (41).

(3) Calculate $h_\alpha/h_{\alpha=0}$ from equation (42) by using the result of equation (44). Then calculate h_α.

(4) Find $(u_e)_\alpha$ from equation (43) and then calculate the adiabatic wall enthalpy by using equation (40).

(5) Calculate the heat-transfer rate by using equation (39).

Very Large Angle of Attack

When the angle of attack is of the magnitude of the cone included angle (twice the cone half-angle) or greater, the technique just described is difficult to use because of the inadequacies of the M.I.T. cone tables; that is, values of k and $1/T_e^*$ for the inviscid flow are not obtainable. For slender cones, these very large angles of attack can be handled by using yawed infinite cylinder relations, more specifically, the results of reference 6.

The expression for the heat-transfer coefficient to the stagnation line of a yawed infinite cylinder is (ref. 6)

$$h_\alpha = g_w' \, Pr^{-0.6} \sqrt{\rho_w \mu_w \left(\frac{D}{u_\infty} \frac{du_\infty}{dx}\right) \frac{u_\infty}{D}} \qquad (45)$$

where u_∞ is the component of the free-stream velocity normal to the cylinder axis, the quantity $\frac{D}{u_\infty} \frac{du_e}{dx}$ is a dimensionless velocity gradient depending only on the component of Mach number normal to the cylinder axis, and g_w' is a quantity from the exact solutions of reference 6 related to heat transfer; g_w' is not related to the function g used earlier in this report. For identical free-stream conditions and the same surface temperature, the ratio of the heat-transfer coefficient at very large angle of attack to that at zero angle of attack is, from equations (41) and (45),

$$\frac{h_\alpha}{h_{\alpha=0}} = \frac{g_w'}{0.813} \sqrt{\frac{(p_e)_\alpha}{(p_e)_{\alpha=0}} \left(\frac{D}{u_\infty} \frac{du_e}{dx}\right)_{M_{N_\infty}} \left(\frac{\sin \alpha}{\theta}\right) \left(\frac{M_\infty a_\infty}{(u_e)_{\alpha=0}}\right)} \qquad (46)$$

wherein the substitutions $u_\infty = M_\infty a_\infty \sin \alpha$ and $D = 2\theta_x$ have already been made.

The detailed calculation procedure for heat-transfer coefficient is as follows:

(1) Evaluate the yawed-cylinder yaw parameter t_0/t_{N_0} from figure 1 of reference 6. (Zero angle of attack for a cone corresponds to a cylinder at 90° yaw.) As a function of the yaw parameter and the surface-temperature level, evaluate g_w' from figure 6 of reference 6.

(2) Calculate the component of stream Mach number normal to the cone axis from

$$M_{N_\infty} = M_\infty \sin \alpha$$

and then, from figure 9 of reference 6, obtain the quantity $\frac{D}{u_\infty} \frac{du_e}{dx}$.

(3) Estimate $\frac{(p_e)_\alpha}{(p_e)_{\alpha=0}}$ as well as possible (perhaps from experiment or using Newtonian flow approximations).

(4) Calculate $h_\alpha / h_{\alpha=0}$ from equation (46); then calculate h_α.

Example

The effect of the angle of attack on the heat-transfer coefficient at the most windward streamline of a 5° half-angle cone at a Mach number of 3.1 has been calculated for a number of temperature levels. The results are presented in figure 7 in terms of the ratio of the heat-transfer coefficient at angle of attack to that at zero angle of attack.

There are three portions to the curves of figure 7. The first (to $\alpha = 8°$) is calculated by the method for large angle of attack, namely, from equations (42) and (44). The heat-transfer coefficient is seen to increase significantly with angle of attack, with the largest rate of increase at zero angle of attack. The higher the surface temperature level, the greater the influence of angle of attack on heat-transfer coefficient. However, even for a surface temperature of absolute zero, where the heat-transfer coefficient ratios are about 15 percent less than for an insulated surface, the heat-transfer coefficient doubles at 8° angle of attack.

For angles of attack of the order of 12° and greater, heat-transfer-coefficient ratios were calculated from equation (46) by using the yawed-cylinder approach described in the previous section. The large effect of angle of attack, regardless of surface-temperature level, is continued in this range. At an angle of attack of 25°, the heat-transfer coefficient is about four times that at zero angle of attack. The inflections in the curves at $\alpha \approx 18°$ occur where the crossflow Mach number is about 1. Unpublished experimental pressure data have been used in this portion of the calculations.

The curves of heat-transfer-coefficient ratio in the "no man's land" between large angle of attack and very large angle of attack were arbitrarily faired, tangent to both calculated portions. Also shown in figure 7 is the continuation of the yawed-cylinder-type calculation to smaller angles of attack. This technique is clearly inadequate for angles of attack less than the cone included angle.

The variation in the heat-transfer coefficient with angle of attack is probably due to the stagnation-line character of the most windward streamline with respect to the crossflow component of the free stream. The rapid increase in the magnitude of the crossflow velocity with angle of attack is reflected in the heat-transfer coefficient.

SUMMARY OF RESULTS

The equations of the compressible laminar boundary layer at the most windward streamline of a cone at angle of attack have been presented and solved for both insulated and noninsulated surfaces. The following are among the results obtained:

1. The heat transfer to the most windward streamline increases significantly with angle of attack. Thus, at a free-stream Mach number of 3.1, the heating to a 5° half-angle cone at 8° angle of attack is more than twice that at zero angle of attack while, for a 25° angle of attack, the heat-transfer coefficient is about four times that at zero angle of attack.

2. The increase in heat-transfer coefficient with angle of attack is not as great for cooled surfaces as for almost insulated surfaces. In the case just given, the heat-transfer-coefficient ratio for a surface temperature of absolute zero is about 15 percent less than for an almost insulated surface.

3. The heat transfer varies with Prandtl number approximately as $Pr^{0.37}$.

4. The recovery factor may be approximated by $Pr^{1/2}$.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio, September 11, 1957

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APPENDIX A

SYMBOLS

a	exponent of Prandtl number describing Prandtl number effect on heat transfer
a_∞	free-stream velocity of sound
b	exponent of Prandtl number related to recovery factor
C	constant appearing in temperature-viscosity relation
$C_{f,x}$	meridional component of skin friction
$C_{f,\varphi}$	circumferential component of skin friction
c_p	specific heat at constant pressure
D	diameter of cone in yawed infinite cylinder treatment
F	$f/\sqrt{3\theta}$
f	function related to meridional velocity u by eq. (3)
G	$g_\varphi/\sqrt{3\theta}$
g	function related to circumferential velocity w by eq. (3)
g'_w	quantity from exact solutions of ref. 6 related to heat transfer
H	stagnation enthalpy
h	heat-transfer coefficient based on enthalpy, $\frac{q}{H_{aw} - H_w}$
k	related to circumferential gradient of circumferential velocity in plane of symmetry (eq. (14))
M	Mach number
Pr	Prandtl number
p	static pressure
q	heat-transfer rate
Re	Reynolds number

r recovery factor

S Sutherland constant of 198° R for air

St Stanton number, $\dfrac{q}{\rho_e u_e (H_{aw} - H_w)}$

T static temperature

u meridional component of velocity

w circumferential component of velocity

x coordinate along cone generators

y coordinate normal to surface

α angle of attack

γ ratio of specific heats

Θ normalized stagnation enthalpy function, $\dfrac{H^* - H_w^*}{H_0^* - H_w^*}$

θ sine of cone half-angle

Λ $\lambda/\sqrt{3\theta}$

λ boundary-layer similarity parameter (eq. (4))

μ absolute viscosity

ρ density

φ angular coordinate around cone

ψ function related to circumferential velocity in plane of symmetry by eq. (14)

Subscripts:

aw adiabatic wall

e local conditions outside boundary layer (external)

w wall value

∞ free stream

0 free-stream stagnation value

α quantity at angle of attack

$\alpha=0$ quantity at zero angle of attack

Superscripts:

Primes denote differentiation with respect to λ

* dimensionless quantity, according to eq. (5)

APPENDIX B

HEAT TRANSFER AND RECOVERY FACTOR FOR PRANDTL NUMBER DIFFERENT FROM 1.0

The evaluation of the recovery factor and the heat transfer for low-speed flows over insulated surfaces with a Prandtl number different from 1.0 is accomplished by considering equations (15a), (15b), and for con- 4670
venience (1c) for $\frac{1}{T_e^*} \approx \frac{u_e^2}{2c_pT_0} \ll 1$ with $\left(1 - \frac{T_w}{T_0}\right) \ll 1$. These equations become

$$(f + k\psi)f'' + 2f''' = 0 \tag{B1a}$$

$$(f + k\psi)\psi'' + 2\psi''' - k(\psi')^2 - \frac{2}{3}\psi'f' + \left(k + \frac{2}{3}\right) = 0 \tag{B1b}$$

$$(f + k\psi)T^{*\prime} + 4(f'')^2 + \frac{2}{Pr}T^{*\prime} = 0 \tag{B1c}$$

Equations (B1a) and (B1b) taken together are those of the family of case $\frac{1}{T_e^*} = 0$, $\frac{T_w}{T_0} = 1$ and have been solved for $k = 0$, 0.4, 0.8, and 1.2. The heat transfer and the recovery factor for these cases with arbitrary Prandtl number can be obtained by substituting for the quantity $f + k\psi$ in equation (B1c) by using equation (B1a); this yields

$$T^{*''} - Pr\frac{f'''}{f''}T^{*''} + 2Pr(f'')^2 = 0 \tag{B2}$$

where T^* is defined

$$T^* = \frac{2c_pT}{u_e^2} \tag{B3}$$

For the purposes of the present calculation, a temperature difference will be used, rather than the temperature in equation (B2). The chosen temperature difference

$$\Delta T^* = \frac{2c_p(T - T_e)}{u_e^2} \tag{B4}$$

does not change the form of the differential equation (B2). Equation (B2) can be rewritten

$$(\Delta T^*)'' - \Pr \frac{f'''}{f''} (\Delta T^*)' + 2\Pr(f'')^2 = 0 \tag{B5}$$

(Note that equation (B5) is a linear nonhomogeneous equation.) Now let

$$\Delta T^* = \Delta T_1^* + \Delta T_2^* \tag{B6}$$

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so that

$$(\Delta T_1^*)_w = \frac{2c_p(T_w - T_{aw})}{u_e^2} \tag{B7}$$

and

$$(\Delta T_2^*)_w = \frac{2c_p(T_{aw} - T_e)}{u_e^2} \tag{B8}$$

The quantity $(\Delta T_1^*)_w$ and the derivative $(\Delta T_1^{*\prime})_w$ are related to the heat-transfer parameter used in the text by $\Theta_w' = \frac{(\Delta T_1^{*\prime})_w}{(\Delta T_1^*)_w}$, while the quantity $(\Delta T_2^*)_w$ is recognized as the recovery factor r so that $(\Delta T_2^{*\prime})_w = 0$.

The differential equations and boundary conditions for ΔT_1^* and ΔT_2^* are, respectively,

Homogeneous equation:

$$\left.\begin{aligned} &(\Delta T_1^*)'' - \Pr \frac{f'''}{f''} (\Delta T_1^*)' = 0 \\ &\text{At } \lambda = 0, \\ &\Delta T_1^* = (\Delta T_1^*)_w \\ &\text{At } \lambda = \infty, \\ &\Delta T_1^* = 0 \end{aligned}\right\} \tag{B9}$$

and

Nonhomogeneous equation:

$$\left.\begin{aligned} &(\Delta T_2^*)'' - Pr\,\frac{f'''}{f''}\,(\Delta T_2^*)' = -2Pr(f'')^2 \\ &\text{At } \lambda = 0, \\ &(\Delta T_2^*)' = 0 \\ &\text{At } \lambda = \infty, \\ &\Delta T_2^* = 0 \end{aligned}\right\} \tag{B10}$$

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The solutions for Θ_w' and r are, respectively,

$$\Theta_w' = \frac{(f_w'')^{Pr}}{\int_0^\infty (f'')^{Pr}\,d\lambda} \tag{B11}$$

and

$$r = 2Pr\int_0^\infty (f'')^{Pr}\int_0^\lambda f''^{(2-Pr)}d\lambda\,d\lambda \tag{B12}$$

The quantities Θ_w' and r have been evaluated for a Prandtl number of 0.7 by using the values of f'' tabulated in table I for the cases $\frac{1}{T_e^*} = 0$, $\frac{T_w}{T_0} = 1$, and $k = 0$, 0.4, 0.8, and 1.2. These results are listed in table III.

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APPENDIX C

EXTENSION OF PRESENT SOLUTIONS TO VERY LARGE ANGLE OF ATTACK USING YAWED INFINITE CYLINDER RESULTS

In reference 2, Moore suggests treatment of the slender cone at very large angle of attack by transforming the equations of a yawed cone to those of a yawed infinite cylinder. He specifically suggests the transformation

$$F = \frac{f}{\sqrt{3\theta}}; \quad G = \frac{g_\varphi}{\sqrt{3\theta}}; \quad \Lambda = \frac{\lambda}{\sqrt{3\theta}} \tag{C1}$$

and then neglects terms of order θ compared with order α. This process, applied to equations (19), results in the following set of differential equations:

$$F_{\Lambda\Lambda\Lambda} + GF_{\Lambda\Lambda} = 0 \tag{C2a}$$

$$G_{\Lambda\Lambda\Lambda} + GG_{\Lambda\Lambda} = G_\Lambda^2 - w_{e_\varphi}^{*2}\left[1 + \frac{1}{T_e^*}\left(1 - F_\Lambda^2\right) + \left(\frac{T_w}{T_0} - 1\right)\left(1 + \frac{1}{T_e^*}\right)(1 - F_\Lambda)\right] \tag{C2b}$$

Since the quantity $\left(1 + \frac{1}{T_e^*}\right)$ is exactly the t_0/t_{N_0} of reference 6, equations (C2) are identical to equations (25) of reference 6 when $w_{e_\varphi}^{*2} = 1$, or for $k = 2/3\theta$. For the yawed infinite cylinder, $\theta = 0$ and k becomes infinite. However, for slender cones at a very large angle of attack, k is a large finite number.

The pertinent results of reference 6, using the transformation (C1), are written

$$f_w'' = \frac{\theta_w'}{\sqrt{3\theta}} \tag{C3a}$$

$$\psi_w'' = \frac{f_w''}{\sqrt{3\theta}} \tag{C3b}$$

$$k = \frac{2}{3\theta} \tag{C3c}$$

where the quantities θ_w' and f_w'' on the right sides of (C3a) and (C3b) are taken from table III of reference 6 and are in the notation of that report.

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TABLE I. - BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0; \quad \frac{1}{T_e^*} = 0; \quad k = 0.6$

λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4330	0.0000	0.0000	0.5527
.1	.0022	.0433	.4330	.0028	.0552	.5514
.2	.0087	.0866	.4328	.0110	.1102	.5474
.3	.0195	.1298	.4323	.0248	.1646	.5410
.4	.0346	.1730	.4312	.0439	.2183	.5322
.5	.0541	.2161	.4296	.0684	.2710	.5213
.6	.0778	.2589	.4271	.0981	.3225	.5083
.7	.1059	.3015	.4237	.1329	.3726	.4934
.8	.1381	.3436	.4192	.1726	.4211	.4768
.9	.1746	.3853	.4135	.2170	.4679	.4587
1.0	.2151	.4263	.4066	.2661	.5128	.4392
1.1	.2598	.4665	.3983	.3195	.5557	.4186
1.2	.3084	.5059	.3886	.3772	.5965	.3971
1.3	.3609	.5442	.3775	.4387	.6351	.3749
1.4	.4172	.5813	.3650	.5041	.6714	.3521
1.5	.4772	.6172	.3512	.5730	.7055	.3290
1.6	.5406	.6515	.3362	.6451	.7373	.3059
1.7	.6074	.6844	.3201	.7203	.7667	.2828
1.8	.6774	.7155	.3030	.7984	.7938	.2601
1.9	.7505	.7449	.2851	.8790	.8187	.2379
2.0	.8263	.7725	.2666	.9620	.8414	.2163
2.1	.9049	.7983	.2478	1.0472	.8620	.1955
2.2	.9859	.8221	.2287	1.1344	.8805	.1757
2.3	1.0693	.8440	.2097	1.2233	.8972	.1569
2.4	1.1547	.8640	.1910	1.3137	.9120	.1393
2.5	1.2420	.8822	.1727	1.4056	.9251	.1229
2.6	1.3311	.8986	.1550	1.4987	.9366	.1077
2.7	1.4217	.9132	.1382	1.5929	.9466	.0938
2.8	1.5136	.9263	.1222	1.6880	.9554	.0811
2.9	1.6069	.9377	.1073	1.7839	.9629	.0697
3.0	1.7011	.9478	.0935	1.8805	.9693	.0595
3.1	1.7964	.9565	.0809	1.9778	.9748	.0504
3.2	1.8924	.9640	.0694	2.0755	.9795	.0424
3.3	1.9891	.9704	.0591	2.1736	.9834	.0355
3.4	2.0864	.9758	.0499	2.2721	.9866	.0295
3.5	2.1843	.9804	.0419	2.3709	.9893	.0243
3.6	2.2825	.9842	.0348	2.4700	.9915	.0199
3.7	2.3811	.9874	.0287	2.5692	.9933	.0161
3.8	2.4799	.9900	.0235	2.6686	.9947	.0130
3.9	2.5791	.9921	.0191	2.7681	.9959	.0104
4.0	2.6784	.9938	.0154	2.8678	.9968	.0083
4.1	2.7778	.9952	.0123	2.9675	.9976	.0065
4.2	2.8774	.9963	.0098	3.0673	.9981	.0051
4.3	2.9771	.9972	.0077	3.1671	.9986	.0040
4.4	3.0768	.9979	.0060	3.2670	.9989	.0031
4.5	3.1766	.9984	.0046	3.3669	.9992	.0024
4.6	3.2765	.9988	.0036	3.4668	.9994	.0018
4.7	3.3764	.9991	.0027	3.5668	.9996	.0014
4.8	3.4763	.9993	.0021	3.6667	.9997	.0010
4.9	3.5763	.9995	.0015	3.7667	.9998	.0008
5.0	3.6762	.9997	.0011	3.8667	.9998	.0006
5.1	3.7762	.9998	.0008	3.9667	.9999	.0004
5.2	3.8762	.9998	.0006	4.0667	.9999	.0003
5.3	3.9761	.9999	.0005	4.1667	.9999	.0002
5.4	4.0761	.9999	.0003	4.2667	1.0000	.0002
5.5	4.1761	1.0000	.0002	4.3667	1.0000	.0001
5.6	4.2761	1.0000	.0002	4.4667	1.0000	.0001
5.7	4.3761	1.0000	.0001	4.5667	1.0000	.0001
5.8	4.4761	1.0000	.0001	4.6667	1.0000	.0000
5.9	4.5761	1.0000	.0001	4.7667	1.0000	.0000
6.0	+.6761	1.0000	.0000	4.8667	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0; \quad \frac{1}{T_e^*} = 0; \quad k = 1.2$

λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5143	0.0000	0.0000	0.6570
.1	.0026	.0514	.5143	.0033	.0656	.6547
.2	.0103	.1028	.5139	.0131	.1308	.6478
.3	.0231	.1542	.5128	.0294	.1951	.6369
.4	.0411	.2054	.5108	.0521	.2580	.6220
.5	.0642	.2563	.5074	.0810	.3193	.6037
.6	.0924	.3068	.5025	.1159	.3787	.5823
.7	.1256	.3567	.4957	.1566	.4357	.5580
.8	.1637	.4059	.4869	.2029	.4902	.5314
.9	.2067	.4541	.4759	.2546	.5419	.5029
1.0	.2545	.5010	.4625	.3112	.5907	.4727
1.1	.3068	.5465	.4468	.3726	.6364	.4414
1.2	.3637	.5903	.4289	.4384	.6790	.4094
1.3	.4248	.6322	.4087	.5083	.7183	.3770
1.4	.4901	.6720	.3866	.5820	.7544	.3447
1.5	.5592	.7094	.3629	.6591	.7872	.3128
1.6	.6319	.7445	.3378	.7393	.8170	.2817
1.7	.7080	.7770	.3117	.8223	.8436	.2518
1.8	.7872	.8068	.2851	.9079	.8673	.2232
1.9	.8692	.8340	.2583	.9957	.8883	.1963
2.0	.9539	.8585	.2319	1.0855	.9067	.1711
2.1	1.0408	.8804	.2061	1.1770	.9226	.1480
2.2	1.1299	.8998	.1814	1.2699	.9363	.1268
2.3	1.2207	.9167	.1581	1.3642	.9480	.1077
2.4	1.3131	.9314	.1363	1.4595	.9579	.0907
2.5	1.4069	.9440	.1164	1.5557	.9662	.0756
2.6	1.5019	.9548	.0983	1.6527	.9731	.0625
2.7	1.5978	.9638	.0821	1.7503	.9788	.0512
2.8	1.6946	.9712	.0679	1.8484	.9834	.0415
2.9	1.7920	.9774	.0555	1.9469	.9871	.0333
3.0	1.8900	.9824	.0449	2.0458	.9901	.0265
3.1	1.9885	.9864	.0360	2.1449	.9925	.0209
3.2	2.0873	.9897	.0285	2.2443	.9943	.0163
3.3	2.1864	.9922	.0223	2.3438	.9958	.0126
3.4	2.2857	.9941	.0173	2.4434	.9969	.0096
3.5	2.3852	.9957	.0132	2.5432	.9977	.0073
3.6	2.4848	.9968	.0100	2.6430	.9983	.0054
3.7	2.5846	.9977	.0075	2.7428	.9988	.0040
3.8	2.6844	.9983	.0056	2.8427	.9991	.0030
3.9	2.7842	.9988	.0041	2.9426	.9994	.0021
4.0	2.8841	.9992	.0030	3.0426	.9996	.0015
4.1	2.9840	.9994	.0021	3.1426	.9997	.0011
4.2	3.0840	.9996	.0015	3.2425	.9998	.0008
4.3	3.1840	.9997	.0011	3.3425	.9999	.0005
4.4	3.2839	.9998	.0007	3.4425	.9999	.0004
4.5	3.3839	.9999	.0005	3.5425	.9999	.0003
4.6	3.4839	.9999	.0003	3.6425	1.0000	.0002
4.7	3.5839	1.0000	.0002	3.7425	1.0000	.0001
4.8	3.6839	1.0000	.0002	3.8425	1.0000	.0001
4.9	3.7839	1.0000	.0001	3.9425	1.0000	.0001
5.0	3.8839	1.0000	.0001	4.0425	1.0000	.0000
5.1	3.9839	1.0000	.0000	4.1425	1.0000	.0000
5.2	4.0839	1.0000	.0000	4.2425	1.0000	.0000
5.3	4.1839	1.0000	.0000	4.3425	1.0000	.0000
5.4	4.2839	1.0000	.0000	4.4425	1.0000	.0000
5.5	4.3839	1.0000	.0000	4.5425	1.0000	.0000
5.6	4.4839	1.0000	.0000	4.6425	1.0000	.0000
5.7	4.5839	1.0000	.0000	4.7425	1.0000	.0000
5.8	4.6839	1.0000	.0000	4.8425	1.0000	.0000
5.9	4.7839	1.0000	.0000	4.9425	1.0000	.0000
6.0	4.8839	1.0000	.0000	5.0425	1.0000	.0000

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0;\ \frac{1}{T_e^*} = 2.5;\ k = 0.6$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4598	0.0000	0.0000	0.8596
.1	.0023	.0460	.4598	.0043	.0858	.8547
.2	.0092	.0919	.4595	.0171	.1706	.8405
.3	.0207	.1379	.4588	.0384	.2536	.8181
.4	.0368	.1837	.4574	.0678	.3340	.7884
.5	.0574	.2293	.4552	.1051	.4111	.7523
.6	.0826	.2747	.4519	.1499	.4843	.7110
.7	.1123	.3197	.4473	.2018	.5532	.6655
.8	.1465	.3641	.4414	.2603	.6173	.6166
.9	.1851	.4079	.4339	.3251	.6764	.5655
1.0	.2281	.4508	.4249	.3954	.7303	.5132
1.1	.2753	.4928	.4142	.4709	.7790	.4604
1.2	.3266	.5336	.4018	.5511	.8224	.4082
1.3	.3819	.5731	.3878	.6353	.8607	.3573
1.4	.4412	.6111	.3722	.7230	.8940	.3084
1.5	.5041	.6475	.3552	.8139	.9225	.2622
1.6	.5706	.6821	.3370	.9074	.9465	.2191
1.7	.6405	.7149	.3177	1.0031	.9664	.1796
1.8	.7135	.7456	.2976	1.1005	.9826	.1439
1.9	.7895	.7744	.2769	1.1995	.9953	.1121
2.0	.8683	.8010	.2559	1.2995	1.0051	.0844
2.1	.9497	.8255	.2348	1.4004	1.0123	.0605
2.2	1.0334	.8480	.2140	1.5019	1.0174	.0405
2.3	1.1192	.8684	.1935	1.6038	1.0206	.0240
2.4	1.2070	.8867	.1738	1.7060	1.0223	.0108
2.5	1.2965	.9031	.1548	1.8082	1.0228	.0005
2.6	1.3875	.9177	.1369	1.9105	1.0224	-.0072
2.7	1.4799	.9306	.1202	2.0127	1.0214	-.0127
2.8	1.5736	.9418	.1047	2.1148	1.0200	-.0163
2.9	1.6683	.9515	.0904	2.2167	1.0182	-.0184
3.0	1.7638	.9599	.0776	2.3184	1.0163	-.0192
3.1	1.8602	.9671	.0660	2.4199	1.0144	-.0192
3.2	1.9572	.9732	.0557	2.5213	1.0125	-.0184
3.3	2.0548	.9783	.0466	2.6224	1.0107	-.0172
3.4	2.1528	.9825	.0387	2.7234	1.0091	-.0157
3.5	2.2513	.9860	.0319	2.8243	1.0076	-.0140
3.6	2.3500	.9889	.0261	2.9250	1.0063	-.0123
3.7	2.4490	.9913	.0212	3.0255	1.0052	-.0106
3.8	2.5483	.9932	.0170	3.1260	1.0042	-.0090
3.9	2.6477	.9947	.0136	3.2264	1.0034	-.0076
4.0	2.7472	.9959	.0108	3.3267	1.0027	-.0063
4.1	2.8468	.9969	.0085	3.4269	1.0021	-.0051
4.2	2.9466	.9976	.0066	3.5271	1.0016	-.0042
4.3	3.0464	.9982	.0051	3.6272	1.0013	-.0033
4.4	3.1462	.9987	.0039	3.7274	1.0010	-.0026
4.5	3.2461	.9990	.0030	3.8274	1.0007	-.0021
4.6	3.3460	.9993	.0023	3.9275	1.0005	-.0016
4.7	3.4460	.9995	.0017	4.0276	1.0004	-.0012
4.8	3.5459	.9996	.0013	4.1276	1.0003	-.0009
4.9	3.6459	.9997	.0009	4.2276	1.0002	-.0007
5.0	3.7459	.9998	.0007	4.3276	1.0002	-.0005
5.1	3.8458	.9999	.0005	4.4276	1.0001	-.0004
5.2	3.9458	.9999	.0004	4.5277	1.0001	-.0003
5.3	4.0458	.9999	.0003	4.6277	1.0001	-.0002
5.4	4.1458	1.0000	.0002	4.7277	1.0000	-.0002
5.5	4.2458	1.0000	.0001	4.8277	1.0000	-.0001
5.6	4.3458	1.0000	.0001	4.9277	1.0000	-.0001
5.7	4.4458	1.0000	.0001	5.0277	1.0000	-.0001
5.8	4.5458	1.0000	.0000	5.1277	1.0000	.0000
5.9	4.6458	1.0000	.0000	5.2277	1.0000	.0000
6.0	4.7458	1.0000	.0000	5.3277	1.0000	.0000

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CW-4 back

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0; \quad \frac{1}{T_e^*} = 2.5; \quad k = 1.2$

λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5569	0.0000	0.0000	1.0281
.1	.0028	.0557	.5568	.0051	.1025	1.0193
.2	.0111	.1114	.5562	.0205	.2033	.9946
.3	.0251	.1669	.5547	.0457	.3010	.9560
.4	.0445	.2222	.5517	.0805	.3942	.9059
.5	.0695	.2772	.5468	.1243	.4818	.8463
.6	.0999	.3315	.5396	.1767	.5632	.7796
.7	.1358	.3850	.5298	.2368	.6376	.7079
.8	.1769	.4374	.5173	.3039	.7047	.6334
.9	.2232	.4884	.5018	.3774	.7642	.5579
1.0	.2745	.5376	.4834	.4565	.8163	.4834
1.1	.3307	.5849	.4621	.5405	.8610	.4115
1.2	.3914	.6300	.4382	.6285	.8987	.3436
1.3	.4566	.6725	.4120	.7200	.9299	.2808
1.4	.5258	.7123	.3840	.8143	.9551	.2239
1.5	.5989	.7493	.3545	.9108	.9749	.1735
1.6	.6756	.7832	.3242	1.0091	.9900	.1298
1.7	.7555	.8141	.2935	1.1087	1.0011	.0928
1.8	.8383	.8419	.2631	1.2092	1.0088	.0623
1.9	.9237	.8667	.2335	1.3104	1.0138	.0379
2.0	.0115	.8886	.2050	1.4119	1.0166	.0189
2.1	.1014	.9078	.1781	1.5136	1.0177	.0047
2.2	1.1930	.9243	.1531	1.6154	1.0176	-.0054
2.3	1.2862	.9385	.1302	1.7171	1.0167	-.0121
2.4	1.3806	.9504	.1096	1.8187	1.0153	-.0160
2.5	1.4762	.9604	.0912	1.9202	1.0136	-.0179
2.6	1.5727	.9687	.0751	2.0214	1.0118	-.0183
2.7	1.6699	.9755	.0611	2.1225	1.0100	-.0175
2.8	1.7677	.9810	.0492	2.2234	1.0083	-.0161
2.9	1.8660	.9854	.0392	2.3242	1.0068	-.0143
3.0	1.9648	.9889	.0309	2.4248	1.0054	-.0124
3.1	2.0638	.9917	.0241	2.5253	1.0043	-.0105
3.2	2.1631	.9938	.0186	2.6257	1.0033	-.0086
3.3	2.2626	.9954	.0142	2.7260	1.0026	-.0070
3.4	2.3622	.9967	.0107	2.8262	1.0019	-.0056
3.5	2.4619	.9976	.0080	2.9263	1.0014	-.0044
3.6	2.5617	.9983	.0059	3.0265	1.0011	-.0034
3.7	2.6615	.9988	.0043	3.1266	1.0008	-.0025
3.8	2.7614	.9991	.0031	3.2266	1.0005	-.0019
3.9	2.8613	.9994	.0022	3.3267	1.0004	-.0014
4.0	2.9613	.9996	.0016	3.4267	1.0003	-.0010
4.1	3.0613	.9997	.0011	3.5267	1.0002	-.0007
4.2	3.1612	.9998	.0008	3.6267	1.0001	-.0005
4.3	3.2612	.9999	.0005	3.7267	1.0001	-.0004
4.4	3.3612	.9999	.0004	3.8268	1.0000	-.0003
4.5	3.4612	1.0000	.0002	3.9268	1.0000	-.0002
4.6	3.5612	1.0000	.0002	4.0268	1.0000	-.0001
4.7	3.6612	1.0000	.0001	4.1268	1.0000	-.0001
4.8	3.7612	1.0000	.0001	4.2268	1.0000	-.0001
4.9	3.8612	1.0000	.0000	4.3268	1.0000	.0000
5.0	3.9612	1.0000	.0000	4.4268	1.0000	.0000
5.1	4.0612	1.0000	.0000	4.5267	1.0000	.0000
5.2	4.1612	1.0000	.0000	4.6267	1.0000	.0000
5.3	4.2612	1.0000	.0000	4.7267	1.0000	.0000
5.4	4.3612	1.0000	.0000	4.8267	1.0000	.0000
5.5	4.4612	1.0000	.0000	4.9267	1.0000	.0000
5.6	4.5612	1.0000	.0000	5.0267	1.0000	.0000
5.7	4.6612	1.0000	.0000	5.1267	1.0000	.0000
5.8	4.7612	1.0000	.0000	5.2267	1.0000	.0000
5.9	4.8612	1.0000	.0000	5.3267	1.0000	.0000
6.0	4.9612	1.0000	.0000	5.4267	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0;\ \frac{1}{T_e^*} = 5.0;\ k = 0.6$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4815	0.0000	0.0000	1.1422
.1	.0024	.0482	.4815	.0057	.1139	1.1334
.2	.0096	.0963	.4811	.0227	.2261	1.1082
.3	.0217	.1444	.4803	.0508	.3351	1.0687
.4	.0385	.1923	.4785	.0896	.4395	1.0167
.5	.0601	.2400	.4758	.1385	.5381	.9544
.6	.0865	.2874	.4717	.1970	.6301	.8838
.7	.1176	.3343	.4660	.2643	.7146	.8068
.8	.1533	.3806	.4587	.3397	.7913	.7254
.9	.1937	.4260	.4496	.4223	.8596	.6417
1.0	.2385	.4704	.4386	.5113	.9196	.5573
1.1	.2877	.5137	.4257	.6059	.9711	.4740
1.2	.3412	.5555	.4109	.7052	1.0145	.3935
1.3	.3988	.5958	.3943	.8085	1.0500	.3170
1.4	.4603	.6343	.3761	.9150	1.0780	.2457
1.5	.5256	.6710	.3565	1.0239	1.0993	.1805
1.6	.5944	.7056	.3356	1.1346	1.1144	.1221
1.7	.6666	.7380	.3138	1.2466	1.1240	.0710
1.8	.7419	.7683	.2913	1.3593	1.1288	.0273
1.9	.8202	.7963	.2685	1.4722	1.1297	-.0091
2.0	.9011	.8220	.2457	1.5851	1.1272	-.0384
2.1	.9845	.8454	.2231	1.6976	1.1222	-.0609
2.2	1.0701	.8666	.2011	1.8095	1.1152	-.0774
2.3	1.1578	.8857	.1798	1.9206	1.1069	-.0884
2.4	1.2472	.9026	.1596	2.0308	1.0977	-.0947
2.5	1.3382	.9176	.1405	2.1401	1.0881	-.0970
2.6	1.4307	.9308	.1228	2.2485	1.0784	-.0960
2.7	1.5243	.9422	.1064	2.3558	1.0690	-.0925
2.8	1.6191	.9521	.0915	2.4623	1.0600	-.0871
2.9	1.7147	.9606	.0781	2.5678	1.0516	-.0805
3.0	1.8111	.9678	.0661	2.6726	1.0439	-.0731
3.1	1.9082	.9738	.0555	2.7767	1.0370	-.0653
3.2	2.0059	.9789	.0462	2.8800	1.0309	-.0575
3.3	2.1040	.9831	.0382	2.9829	1.0255	-.0499
3.4	2.2025	.9866	.0313	3.0852	1.0209	-.0428
3.5	2.3013	.9894	.0255	3.1870	1.0169	-.0363
3.6	2.4003	.9917	.0206	3.2886	1.0136	-.0304
3.7	2.4996	.9936	.0165	3.3898	1.0108	-.0252
3.8	2.5990	.9950	.0131	3.4908	1.0086	-.0206
3.9	2.6986	.9962	.0103	3.5915	1.0067	-.0167
4.0	2.7983	.9971	.0080	3.6921	1.0052	-.0134
4.1	2.8980	.9978	.0062	3.7926	1.0040	-.0107
4.2	2.9978	.9984	.0048	3.8929	1.0030	-.0084
4.3	3.0977	.9988	.0037	3.9932	1.0023	-.0065
4.4	3.1976	.9991	.0028	4.0934	1.0017	-.0050
4.5	3.2975	.9993	.0021	4.1935	1.0013	-.0039
4.6	3.3974	.9995	.0016	4.2936	1.0009	-.0029
4.7	3.4974	.9997	.0011	4.3937	1.0007	-.0022
4.8	3.5974	.9998	.0008	4.4938	1.0005	-.0016
4.9	3.6973	.9998	.0006	4.5938	1.0004	-.0012
5.0	3.7973	.9999	.0004	4.6938	1.0003	-.0009
5.1	3.8973	.9999	.0003	4.7939	1.0002	-.0006
5.2	3.9973	.9999	.0002	4.8939	1.0001	-.0005
5.3	4.0973	1.0000	.0002	4.9939	1.0001	-.0003
5.4	4.1973	1.0000	.0001	5.0939	1.0001	-.0002
5.5	4.2973	1.0000	.0001	5.1939	1.0000	-.0002
5.6	4.3973	1.0000	.0001	5.2939	1.0000	-.0001
5.7	4.4973	1.0000	.0000	5.3939	1.0000	-.0001
5.8	4.5973	1.0000	.0000	5.4939	1.0000	-.0001
5.9	4.6973	1.0000	.0000	5.5939	1.0000	.0000
6.0	4.7973	1.0000	.0000	5.6939	1.0000	.0000

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

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$\frac{T_w}{T_0} = 0;\ \frac{1}{T_e^*} = 5.0;\ k = 1.2$

λ	f	f' or θ	f'' or θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5898	0.0000	0.0000	1.3634
.1	.0030	.0590	.5897	.0068	.1358	1.3476
.2	.0118	.1179	.5890	.0271	.2686	1.3033
.3	.0265	.1767	.5869	.0603	.3957	1.2350
.4	.0471	.2352	.5830	.1059	.5149	1.1473
.5	.0736	.2932	.5766	.1630	.6246	1.0446
.6	.1058	.3505	.5673	.2305	.7235	.9315
.7	.1436	.4066	.5548	.3073	.8107	.8122
.8	.1870	.4613	.5388	.3922	.8859	.6909
.9	.2358	.5142	.5194	.4841	.9490	.5713
1.0	.2898	.5651	.4965	.5816	1.0003	.4568
1.1	.3488	.6134	.4704	.6838	1.0406	.3499
1.2	.4124	.6591	.4416	.7894	1.0706	.2531
1.3	.4805	.7017	.4106	.8976	1.0916	.1678
1.4	.5526	.7411	.3779	1.0075	1.1046	.0949
1.5	.6286	.7772	.3442	1.1183	1.1110	.0347
1.6	.7080	.8100	.3103	1.2295	1.1119	-.0131
1.7	.7905	.8393	.2767	1.3405	1.1087	-.0492
1.8	.8757	.8653	.2441	1.4511	1.1024	-.0748
1.9	.9634	.8882	.2130	1.5610	1.0941	-.0910
2.0	1.0532	.9080	.1838	1.6699	1.0845	-.0995
2.1	1.1449	.9250	.1569	1.7778	1.0744	-.1018
2.2	1.2382	.9395	.1324	1.8848	1.0643	-.0993
2.3	1.3327	.9516	.1106	1.9907	1.0547	-.0933
2.4	1.4284	.9616	.0913	2.0957	1.0457	-.0852
2.5	1.5250	.9699	.0745	2.1999	1.0377	-.0757
2.6	1.6223	.9766	.0602	2.3033	1.0306	-.0658
2.7	1.7203	.9820	.0481	2.4060	1.0245	-.0561
2.8	1.8187	.9863	.0380	2.5082	1.0194	-.0469
2.9	1.9175	.9897	.0297	2.6099	1.0151	-.0385
3.0	2.0166	.9923	.0229	2.7113	1.0116	-.0311
3.1	2.1160	.9943	.0175	2.8123	1.0088	-.0248
3.2	2.2155	.9958	.0132	2.9131	1.0066	-.0194
3.3	2.3151	.9970	.0099	3.0136	1.0049	-.0150
3.4	2.4148	.9978	.0073	3.1140	1.0036	-.0114
3.5	2.5147	.9985	.0054	3.2144	1.0026	-.0086
3.6	2.6145	.9989	.0039	3.3146	1.0019	-.0064
3.7	2.7144	.9993	.0028	3.4147	1.0013	-.0047
3.8	2.8144	.9995	.0020	3.5149	1.0009	-.0034
3.9	2.9143	.9997	.0014	3.6149	1.0006	-.0024
4.0	3.0143	.9998	.0010	3.7150	1.0004	-.0017
4.1	3.1143	.9998	.0007	3.8150	1.0003	-.0012
4.2	3.2143	.9999	.0004	3.9150	1.0002	-.0008
4.3	3.3143	.9999	.0003	4.0151	1.0001	-.0006
4.4	3.4143	1.0000	.0002	4.1151	1.0001	-.0004
4.5	3.5143	1.0000	.0001	4.2151	1.0001	-.0002
4.6	3.6143	1.0000	.0001	4.3151	1.0000	-.0002
4.7	3.7143	1.0000	.0001	4.4151	1.0000	-.0001
4.8	3.8143	1.0000	.0000	4.5151	1.0000	-.0001
4.9	3.9143	1.0000	.0000	4.6151	1.0000	.0000
5.0	4.0143	1.0000	.0000	4.7151	1.0000	.0000
5.1	4.1143	1.0000	.0000	4.8151	1.0000	.0000
5.2	4.2143	1.0000	.0000	4.9151	1.0000	.0000
5.3	4.3143	1.0000	.0000	5.0151	1.0000	.0000
5.4	4.4143	1.0000	.0000	5.1151	1.0000	.0000
5.5	4.5143	1.0000	.0000	5.2151	1.0000	.0000
5.6	4.6143	1.0000	.0000	5.3151	1.0000	.0000
5.7	4.7143	1.0000	.0000	5.4151	1.0000	.0000
5.8	4.8143	1.0000	.0000	5.5151	1.0000	.0000
5.9	4.9143	1.0000	.0000	5.6151	1.0000	.0000
6.0	5.0143	1.0000	.0000	5.7151	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0.5;\ \frac{1}{T_e^*} = 0;\ k = 0.6$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4468	0.0000	0.0000	0.7888
.1	.0022	.0447	.4467	.0039	.0773	.7564
.2	.0089	.0893	.4465	.0153	.1513	.7229
.3	.0201	.1340	.4459	.0340	.2218	.6885
.4	.0357	.1785	.4446	.0596	.2889	.6533
.5	.0558	.2229	.4426	.0917	.3525	.6177
.6	.0803	.2670	.4397	.1300	.4124	.5818
.7	.1092	.3108	.4356	.1741	.4688	.5459
.8	.1424	.3541	.4303	.2236	.5216	.5101
.9	.1800	.3968	.4237	.2783	.5709	.4747
1.0	.2218	.4388	.4156	.3377	.6166	.4399
1.1	.2677	.4799	.4060	.4015	.6589	.4058
1.2	.3177	.5199	.3950	.4693	.6978	.3727
1.3	.3716	.5588	.3824	.5409	.7334	.3407
1.4	.4294	.5963	.3684	.6159	.7659	.3099
1.5	.4909	.6324	.3530	.6940	.7955	.2805
1.6	.5558	.6669	.3364	.7749	.8221	.2526
1.7	.6242	.6997	.3187	.8583	.8460	.2263
1.8	.6957	.7306	.3001	.9440	.8674	.2016
1.9	.7702	.7597	.2809	1.0317	.8864	.1786
2.0	.8476	.7868	.2612	1.1212	.9032	.1574
2.1	.9275	.8119	.2413	1.2123	.9179	.1379
2.2	1.0099	.8350	.2213	1.3048	.9308	.1200
2.3	1.0945	.8562	.2017	1.3984	.9420	.1039
2.4	1.1811	.8754	.1824	1.4931	.9517	.0894
2.5	1.2695	.8927	.1638	1.5887	.9599	.0764
2.6	1.3595	.9082	.1461	1.6850	.9670	.0649
2.7	1.4510	.9219	.1293	1.7821	.9730	.0548
2.8	1.5439	.9340	.1135	1.8796	.9780	.0460
2.9	1.6378	.9447	.0989	1.9776	.9822	.0383
3.0	1.7327	.9539	.0856	2.0760	.9857	.0317
3.1	1.8285	.9618	.0735	2.1747	.9886	.0260
3.2	1.9251	.9686	.0626	2.2737	.9909	.0213
3.3	2.0222	.9744	.0529	2.3729	.9928	.0172
3.4	2.1199	.9792	.0443	2.4723	.9944	.0139
3.5	2.2180	.9833	.0369	2.5718	.9956	.0111
3.6	2.3165	.9866	.0304	2.6714	.9966	.0088
3.7	2.4153	.9894	.0249	2.7711	.9974	.0069
3.8	2.5144	.9916	.0202	2.8709	.9980	.0054
3.9	2.6137	.9935	.0163	2.9707	.9985	.0042
4.0	2.7131	.9949	.0130	3.0705	.9989	.0033
4.1	2.8126	.9961	.0103	3.1704	.9992	.0025
4.2	2.9123	.9970	.0081	3.2704	.9994	.0019
4.3	3.0120	.9977	.0064	3.3703	.9995	.0014
4.4	3.1118	.9983	.0049	3.4703	.9997	.0011
4.5	3.2117	.9987	.0038	3.5702	.9998	.0008
4.6	3.3116	.9991	.0029	3.6702	.9998	.0006
4.7	3.4115	.9993	.0022	3.7702	.9999	.0004
4.8	3.5114	.9995	.0016	3.8702	.9999	.0003
4.9	3.6114	.9996	.0012	3.9702	.9999	.0002
5.0	3.7113	.9997	.0009	4.0702	1.0000	.0002
5.1	3.8113	.9998	.0007	4.1702	1.0000	.0001
5.2	3.9113	.9999	.0005	4.2702	1.0000	.0001
5.3	4.0113	.9999	.0003	4.3702	1.0000	.0001
5.4	4.1113	.9999	.0003	4.4702	1.0000	.0000
5.5	4.2113	1.0000	.0002	4.5702	1.0000	.0000
5.6	4.3113	1.0000	.0001	4.6702	1.0000	.0000
5.7	4.4113	1.0000	.0001	4.7702	1.0000	.0000
5.8	4.5113	1.0000	.0001	4.8702	1.0000	.0000
5.9	4.6113	1.0000	.0000	4.9702	1.0000	.0000
6.0	4.7113	1.0000	.0000	5.0702	1.0000	.0000

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0.5;\ \frac{1}{T_e^*} = 0;\ k = 1.2$

λ	f	f' or Θ	f" or Θ'	ψ	ψ'	ψ"
0.0	0.0000	0.0000	0.5367	0.0000	0.0000	0.9460
.1	.0027	.0537	.5367	.0047	.0922	.8982
.2	.0107	.1073	.5361	.0183	.1796	.8485
.3	.0241	.1609	.5348	.0404	.2619	.7974
.4	.0429	.2142	.5321	.0705	.3390	.7456
.5	.0670	.2672	.5279	.1080	.4110	.6934
.6	.0963	.3197	.5217	.1525	.4777	.6414
.7	.1309	.3715	.5132	.2034	.5393	.5900
.8	.1706	.4223	.5024	.2602	.5958	.5397
.9	.2153	.4719	.4889	.3224	.6473	.4907
1.0	.2649	.5200	.4729	.3895	.6940	.4435
1.1	.3193	.5664	.4543	.4610	.7360	.3983
1.2	.3781	.6108	.4333	.5366	.7737	.3554
1.3	.4413	.6530	.4101	.6156	.8072	.3150
1.4	.5087	.6927	.3850	.6979	.8368	.2773
1.5	.5798	.7299	.3584	.7829	.8628	.2424
1.6	.6545	.7644	.3307	.8703	.8854	.2104
1.7	.7326	.7961	.3024	.9599	.9049	.1812
1.8	.8137	.8249	.2739	1.0512	.9217	.1549
1.9	.8975	.8508	.2457	1.1441	.9360	.1313
2.0	.9837	.8740	.2183	1.2383	.9481	.1105
2.1	1.0722	.8945	.1919	1.3337	.9582	.0922
2.2	1.1626	.9125	.1671	1.4299	.9666	.0763
2.3	1.2546	.9280	.1439	1.5269	.9735	.0626
2.4	1.3481	.9413	.1227	1.6246	.9792	.0509
2.5	1.4428	.9526	.1035	1.7227	.9838	.0411
2.6	1.5385	.9621	.0864	1.8213	.9874	.0328
2.7	1.6352	.9700	.0713	1.9202	.9904	.0260
2.8	1.7325	.9764	.0583	2.0193	.9927	.0204
2.9	1.8304	.9817	.0471	2.1187	.9945	.0159
3.0	1.9288	.9859	.0376	2.2182	.9959	.0122
3.1	2.0275	.9892	.0297	2.3179	.9969	.0093
3.2	2.1266	.9919	.0233	2.4176	.9978	.0070
3.3	2.2259	.9939	.0180	2.5174	.9984	.0053
3.4	2.3254	.9955	.0138	2.6173	.9988	.0039
3.5	2.4250	.9967	.0104	2.7172	.9992	.0029
3.6	2.5247	.9976	.0078	2.8171	.9994	.0021
3.7	2.6245	.9983	.0058	2.9171	.9996	.0015
3.8	2.7244	.9988	.0042	3.0170	.9997	.0011
3.9	2.8243	.9991	.0031	3.1170	.9998	.0008
4.0	2.9242	.9994	.0022	3.2170	.9999	.0005
4.1	3.0241	.9996	.0016	3.3170	.9999	.0004
4.2	3.1241	.9997	.0011	3.4170	.9999	.0003
4.3	3.2241	.9998	.0008	3.5170	1.0000	.0002
4.4	3.3241	.9999	.0005	3.6169	1.0000	.0001
4.5	3.4241	.9999	.0004	3.7169	1.0000	.0001
4.6	3.5240	1.0000	.0002	3.8169	1.0000	.0001
4.7	3.6240	1.0000	.0002	3.9169	1.0000	.0000
4.8	3.7240	1.0000	.0001	4.0169	1.0000	.0000
4.9	3.8240	1.0000	.0001	4.1169	1.0000	.0000
5.0	3.9240	1.0000	.0000	4.2169	1.0000	.0000
5.1	4.0240	1.0000	.0000	4.3169	1.0000	.0000
5.2	4.1240	1.0000	.0000	4.4169	1.0000	.0000
5.3	4.2240	1.0000	.0000	4.5169	1.0000	.0000
5.4	4.3240	1.0000	.0000	4.6169	1.0000	.0000
5.5	4.4240	1.0000	.0000	4.7169	1.0000	.0000
5.6	4.5240	1.0000	.0000	4.8169	1.0000	.0000
5.7	4.6240	1.0000	.0000	4.9169	1.0000	.0000
5.8	4.7240	1.0000	.0000	5.0169	1.0000	.0000
5.9	4.8240	1.0000	.0000	5.1169	1.0000	.0000
6.0	4.9240	1.0000	.0000	5.2169	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0.5;\ \frac{1}{T_e^*} = 2.5;\ k = 0.6$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4944	0.0000	0.0000	1.5922
.1	.0025	.0494	.4944	.0078	.1536	1.4789
.2	.0099	.0989	.4940	.0303	.2956	1.3617
.3	.0222	.1482	.4929	.0665	.4259	1.2422
.4	.0395	.1974	.4908	.1151	.5441	1.1220
.5	.0617	.2463	.4875	.1749	.6503	1.0024
.6	.0888	.2948	.4826	.2448	.7446	.8847
.7	.1207	.3428	.4760	.3235	.8273	.7703
.8	.1573	.3900	.4676	.4099	.8988	.6604
.9	.1986	.4362	.4571	.5029	.9596	.5559
1.0	.2445	.4814	.4447	.6014	1.0102	.4579
1.1	.2949	.5251	.4302	.7046	1.0514	.3671
1.2	.3495	.5673	.4139	.8114	1.0839	.2841
1.3	.4083	.6078	.3957	.9211	1.1085	.2094
1.4	.4710	.6464	.3759	1.0329	1.1261	.1433
1.5	.5375	.6830	.3548	1.1461	1.1375	.0858
1.6	.6075	.7173	.3325	1.2602	1.1435	.0368
1.7	.6809	.7494	.3095	1.3747	1.1451	-.0040
1.8	.7573	.7792	.2860	1.4891	1.1430	-.0368
1.9	.8366	.8066	.2624	1.6032	1.1380	-.0624
2.0	.9186	.8317	.2390	1.7166	1.1307	-.0814
2.1	1.0029	.8545	.2160	1.8293	1.1219	-.0944
2.2	1.0894	.8749	.1937	1.9410	1.1120	-.1023
2.3	1.1778	.8932	.1724	2.0516	1.1016	-.1058
2.4	1.2680	.9094	.1522	2.1613	1.0910	-.1057
2.5	1.3596	.9237	.1334	2.2698	1.0805	-.1027
2.6	1.4526	.9362	.1160	2.3774	1.0705	-.0976
2.7	1.5468	.9469	.1000	2.4840	1.0611	-.0909
2.8	1.6420	.9562	.0856	2.5896	1.0524	-.0832
2.9	1.7380	.9641	.0727	2.6945	1.0445	-.0750
3.0	1.8348	.9708	.0612	2.7985	1.0374	-.0666
3.1	1.9321	.9764	.0511	2.9020	1.0311	-.0584
3.2	2.0300	.9811	.0424	3.0048	1.0257	-.0505
3.3	2.1283	.9849	.0349	3.1071	1.0210	-.0432
3.4	2.2270	.9881	.0284	3.2090	1.0170	-.0365
3.5	2.3259	.9906	.0230	3.3105	1.0137	-.0305
3.6	2.4251	.9927	.0185	3.4118	1.0109	-.0253
3.7	2.5244	.9943	.0147	3.5127	1.0086	-.0207
3.8	2.6239	.9957	.0116	3.6135	1.0067	-.0168
3.9	2.7235	.9967	.0091	3.7141	1.0052	-.0135
4.0	2.8233	.9975	.0071	3.8146	1.0040	-.0107
4.1	2.9230	.9981	.0055	3.9149	1.0031	-.0084
4.2	3.0229	.9986	.0042	4.0152	1.0023	-.0066
4.3	3.1227	.9990	.0032	4.1154	1.0017	-.0051
4.4	3.2227	.9992	.0024	4.2155	1.0013	-.0039
4.5	3.3226	.9994	.0018	4.3156	1.0010	-.0030
4.6	3.4225	.9996	.0013	4.4157	1.0007	-.0022
4.7	3.5225	.9997	.0010	4.5158	1.0005	-.0017
4.8	3.6225	.9998	.0007	4.6158	1.0004	-.0012
4.9	3.7225	.9999	.0005	4.7159	1.0003	-.0009
5.0	3.8225	.9999	.0004	4.8159	1.0002	-.0007
5.1	3.9224	.9999	.0003	4.9159	1.0001	-.0005
5.2	4.0224	1.0000	.0002	5.0159	1.0001	-.0003
5.3	4.1224	1.0000	.0001	5.1159	1.0001	-.0002
5.4	4.2224	1.0000	.0001	5.2159	1.0000	-.0002
5.5	4.3224	1.0000	.0001	5.3159	1.0000	-.0001
5.6	4.4224	1.0000	.0000	5.4159	1.0000	-.0001
5.7	4.5224	1.0000	.0000	5.5159	1.0000	-.0001
5.8	4.6224	1.0000	.0000	5.6159	1.0000	.0000
5.9	4.7224	1.0000	.0000	5.7159	1.0000	.0000
6.0	4.8224	1.0000	.0000	5.8159	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0.5$; $\frac{1}{T_e^*} = 2.5$; $k = 1.2$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.6092	0.0000	0.0000	1.8998
.1	.0031	.0609	.6091	.0092	.1817	1.7321
.2	.0122	.1218	.6081	.0358	.3462	1.5584
.3	.0274	.1825	.6055	.0779	.4933	1.3824
.4	.0487	.2428	.6006	.1338	.6227	1.2073
.5	.0759	.3025	.5927	.2019	.7349	1.0362
.6	.1091	.3612	.5816	.2802	.8302	.8720
.7	.1481	.4187	.5668	.3674	.9096	.7171
.8	.1928	.4745	.5482	.4617	.9740	.5734
.9	.2430	.5282	.5259	.5617	1.0247	.4428
1.0	.2984	.5795	.5001	.6662	1.0630	.3262
1.1	.3588	.6281	.4711	.7739	1.0904	.2245
1.2	.4239	.6737	.4396	.8840	1.1084	.1379
1.3	.4934	.7160	.4061	.9954	1.1185	.0662
1.4	.5670	.7548	.3713	1.1074	1.1221	.0086
1.5	.6442	.7902	.3359	1.2196	1.1207	-.0357
1.6	.7249	.8220	.3007	1.3314	1.1154	-.0680
1.7	.8085	.8504	.2663	1.4426	1.1074	-.0898
1.8	.8948	.8753	.2333	1.5529	1.0977	-.1028
1.9	.9835	.8971	.2021	1.6621	1.0871	-.1084
2.0	1.0742	.9158	.1732	1.7703	1.0762	-.1083
2.1	1.1666	.9318	.1468	1.8774	1.0656	-.1040
2.2	1.2604	.9453	.1230	1.9834	1.0555	-.0966
2.3	1.3555	.9565	.1020	2.0885	1.0463	-.0874
2.4	1.4517	.9657	.0836	2.1927	1.0381	-.0772
2.5	1.5486	.9733	.0678	2.2962	1.0309	-.0668
2.6	1.6463	.9794	.0544	2.3989	1.0247	-.0567
2.7	1.7445	.9842	.0431	2.5011	1.0195	-.0473
2.8	1.8431	.9881	.0338	2.6029	1.0152	-.0388
2.9	1.9421	.9911	.0262	2.7042	1.0117	-.0313
3.0	2.0413	.9934	.0201	2.8052	1.0089	-.0249
3.1	2.1407	.9951	.0153	2.9060	1.0067	-.0195
3.2	2.2403	.9965	.0115	3.0066	1.0050	-.0151
3.3	2.3400	.9975	.0085	3.1070	1.0037	-.0115
3.4	2.4398	.9982	.0063	3.2073	1.0027	-.0087
3.5	2.5396	.9987	.0045	3.3076	1.0019	-.0064
3.6	2.6395	.9991	.0033	3.4077	1.0014	-.0047
3.7	2.7394	.9994	.0023	3.5078	1.0009	-.0034
3.8	2.8394	.9996	.0016	3.6079	1.0007	-.0025
3.9	2.9393	.9997	.0011	3.7080	1.0005	-.0017
4.0	3.0393	.9998	.0008	3.8080	1.0003	-.0012
4.1	3.1393	.9999	.0005	3.9080	1.0002	-.0008
4.2	3.2393	.9999	.0004	4.0081	1.0001	-.0006
4.3	3.3393	1.0000	.0002	4.1081	1.0001	-.0004
4.4	3.4393	1.0000	.0002	4.2081	1.0001	-.0003
4.5	3.5393	1.0000	.0001	4.3081	1.0000	-.0002
4.6	3.6393	1.0000	.0001	4.4081	1.0000	-.0001
4.7	3.7393	1.0000	.0000	4.5081	1.0000	-.0001
4.8	3.8393	1.0000	.0000	4.6081	1.0000	.0000
4.9	3.9393	1.0000	.0000	4.7081	1.0000	.0000
5.0	4.0393	1.0000	.0000	4.8081	1.0000	.0000
5.1	4.1393	1.0000	.0000	4.9081	1.0000	.0000
5.2	4.2393	1.0000	.0000	5.0081	1.0000	.0000
5.3	4.3393	1.0000	.0000	5.1081	1.0000	.0000
5.4	4.4393	1.0000	.0000	5.2081	1.0000	.0000
5.5	4.5393	1.0000	.0000	5.3081	1.0000	.0000
5.6	4.6393	1.0000	.0000	5.4081	1.0000	.0000
5.7	4.7393	1.0000	.0000	5.5081	1.0000	.0000
5.8	4.8393	1.0000	.0000	5.6081	1.0000	.0000
5.9	4.9393	1.0000	.0000	5.7081	1.0000	.0000
6.0	5.0393	1.0000	.0000	5.8081	1.0000	.0000

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0.5; \quad \frac{1}{T_e^*} = 5.0; \quad k = 0.6$

λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5291	0.0000	0.0000	2.3034
.1	.0027	.0529	.5290	.0112	.2207	2.1090
.2	.0106	.1058	.5284	.0435	.4216	1.9079
.3	.0238	.1586	.5269	.0948	.6022	1.7036
.4	.0423	.2111	.5241	.1632	.7623	1.4990
.5	.0660	.2633	.5195	.2466	.9021	1.2971
.6	.0949	.3150	.5129	.3430	1.0219	1.1006
.7	.1290	.3658	.5040	.4504	1.1224	.9120
.8	.1681	.4157	.4927	.5669	1.2046	.7336
.9	.2121	.4643	.4789	.6907	1.2696	.5673
1.0	.2609	.5114	.4627	.8202	1.3185	.4146
1.1	.3143	.5567	.4441	.9539	1.3530	.2770
1.2	.3721	.6001	.4234	1.0904	1.3745	.1551
1.3	.4342	.6414	.4008	1.2284	1.3846	.0495
1.4	.5003	.6802	.3766	1.3670	1.3849	-.0397
1.5	.5702	.7166	.3512	1.5051	1.3771	-.1130
1.6	.6436	.7504	.3250	1.6422	1.3628	-.1709
1.7	.7202	.7816	.2984	1.7775	1.3434	-.2144
1.8	.7998	.8101	.2718	1.9108	1.3204	-.2448
1.9	.8821	.8360	.2456	2.0415	1.2949	-.2635
2.0	.9669	.8593	.2202	2.1697	1.2680	-.2721
2.1	1.0539	.8800	.1958	2.2951	1.2407	-.2721
2.2	1.1428	.8985	.1726	2.4179	1.2138	-.2652
2.3	1.2335	.9146	.1510	2.5379	1.1879	-.2529
2.4	1.3257	.9287	.1311	2.6555	1.1634	-.2366
2.5	1.4192	.9409	.1128	2.7707	1.1406	-.2177
2.6	1.5138	.9513	.0963	2.8837	1.1199	-.1972
2.7	1.6094	.9602	.0816	2.9947	1.1012	-.1761
2.8	1.7058	.9677	.0685	3.1040	1.0847	-.1551
2.9	1.8029	.9740	.0571	3.2117	1.0702	-.1350
3.0	1.9006	.9792	.0472	3.3181	1.0576	-.1160
3.1	1.9987	.9834	.0387	3.4233	1.0469	-.0986
3.2	2.0972	.9869	.0315	3.5275	1.0379	-.0829
3.3	2.1961	.9898	.0254	3.6309	1.0303	-.0689
3.4	2.2952	.9921	.0203	3.7336	1.0240	-.0567
3.5	2.3945	.9939	.0161	3.8358	1.0189	-.0462
3.6	2.4939	.9953	.0127	3.9374	1.0147	-.0373
3.7	2.5935	.9964	.0099	4.0387	1.0114	-.0298
3.8	2.6932	.9973	.0077	4.1397	1.0087	-.0236
3.9	2.7930	.9980	.0059	4.2405	1.0066	-.0185
4.0	2.8928	.9985	.0045	4.3411	1.0050	-.0143
4.1	2.9927	.9989	.0034	4.4415	1.0037	-.0110
4.2	3.0926	.9992	.0026	4.5418	1.0028	-.0084
4.3	3.1925	.9994	.0019	4.6421	1.0020	-.0064
4.4	3.2925	.9996	.0014	4.7422	1.0015	-.0048
4.5	3.3924	.9997	.0010	4.8424	1.0011	-.0035
4.6	3.4924	.9998	.0008	4.9425	1.0008	-.0026
4.7	3.5924	.9999	.0005	5.0425	1.0006	-.0019
4.8	3.6924	.9999	.0004	5.1426	1.0004	-.0014
4.9	3.7924	.9999	.0003	5.2426	1.0003	-.0010
5.0	3.8923	1.0000	.0002	5.3426	1.0002	-.0007
5.1	3.9923	1.0000	.0001	5.4426	1.0001	-.0005
5.2	4.0923	1.0000	.0001	5.5427	1.0001	-.0003
5.3	4.1923	1.0000	.0001	5.6427	1.0001	-.0002
5.4	4.2923	1.0000	.0000	5.7427	1.0000	-.0002
5.5	4.3923	1.0000	.0000	5.8427	1.0000	-.0001
5.6	4.4923	1.0000	.0000	5.9427	1.0000	-.0001
5.7	4.5923	1.0000	.0000	6.0427	1.0000	-.0001
5.8	4.6923	1.0000	.0000	6.1427	1.0000	.0000
5.9	4.7923	1.0000	.0000	6.2427	1.0000	.0000
6.0	4.8923	1.0000	.0000	6.3427	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 0.5;\ \frac{1}{T_e^*} = 5.0;\ k = 1.2$						
λ	f	f' or θ	f'' or θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.6594	0.0000	0.0000	2.7287
.1	.0033	.0659	.6592	.0132	.2586	2.4409
.2	.0132	.1318	.6578	.0507	.4878	2.1430
.3	.0297	.1974	.6540	.1097	.6871	1.8427
.4	.0527	.2625	.6469	.1872	.8565	1.5470
.5	.0821	.3267	.6358	.2801	.9969	1.2621
.6	.1179	.3895	.6202	.3856	1.1095	.9935
.7	.1600	.4506	.5998	.5011	1.1963	.7458
.8	.2080	.5093	.5746	.6241	1.2595	.5226
.9	.2617	.5653	.5450	.7523	1.3017	.3265
1.0	.3209	.6182	.5114	.8838	1.3257	.1590
1.1	.3852	.6675	.4746	1.0169	1.3345	.0205
1.2	.4543	.7130	.4355	1.1503	1.3308	-.0896
1.3	.5277	.7545	.3950	1.2828	1.3174	-.1728
1.4	.6051	.7920	.3541	1.4136	1.2970	-.2314
1.5	.6860	.8254	.3138	1.5420	1.2719	-.2683
1.6	.7700	.8548	.2748	1.6678	1.2440	-.2867
1.7	.8568	.8804	.2379	1.7908	1.2150	-.2901
1.8	.9460	.9025	.2035	1.9109	1.1864	-.2817
1.9	1.0372	.9212	.1721	2.0281	1.1590	-.2648
2.0	1.1301	.9370	.1438	2.1427	1.1336	-.2422
2.1	1.2245	.9501	.1188	2.2549	1.1107	-.2162
2.2	1.3201	.9608	.0971	2.3649	1.0904	-.1890
2.3	1.4166	.9696	.0784	2.4731	1.0729	-.1620
2.4	1.5139	.9766	.0626	2.5796	1.0580	-.1363
2.5	1.6119	.9822	.0495	2.6847	1.0455	-.1128
2.6	1.7103	.9866	.0386	2.7888	1.0353	-.0919
2.7	1.8092	.9900	.0298	2.8919	1.0270	-.0737
2.8	1.9083	.9926	.0228	2.9942	1.0205	-.0583
2.9	2.0077	.9946	.0172	3.0960	1.0153	-.0454
3.0	2.1072	.9961	.0129	3.1973	1.0113	-.0349
3.1	2.2069	.9972	.0095	3.2983	1.0083	-.0264
3.2	2.3066	.9980	.0069	3.3990	1.0060	-.0198
3.3	2.4065	.9986	.0050	3.4995	1.0043	-.0146
3.4	2.5063	.9990	.0036	3.5999	1.0030	-.0107
3.5	2.6063	.9993	.0025	3.7001	1.0021	-.0077
3.6	2.7062	.9996	.0018	3.8003	1.0014	-.0055
3.7	2.8062	.9997	.0012	3.9004	1.0010	-.0038
3.8	2.9061	.9998	.0008	4.0005	1.0007	-.0027
3.9	3.0061	.9999	.0006	4.1006	1.0004	-.0018
4.0	3.1061	.9999	.0004	4.2006	1.0003	-.0012
4.1	3.2061	1.0000	.0003	4.3006	1.0002	-.0008
4.2	3.3061	1.0000	.0002	4.4006	1.0001	-.0006
4.3	3.4061	1.0000	.0001	4.5006	1.0001	-.0004
4.4	3.5061	1.0000	.0001	4.6006	1.0000	-.0002
4.5	3.6061	1.0000	.0000	4.7006	1.0000	-.0002
4.6	3.7061	1.0000	.0000	4.8006	1.0000	-.0001
4.7	3.8061	1.0000	.0000	4.9006	1.0000	-.0001
4.8	3.9061	1.0000	.0000	5.0006	1.0000	.0000
4.9	4.0061	1.0000	.0000	5.1006	1.0000	.0000
5.0	4.1061	1.0000	.0000	5.2006	1.0000	.0000
5.1	4.2061	1.0000	.0000	5.3006	1.0000	.0000
5.2	4.3061	1.0000	.0000	5.4006	1.0000	.0000
5.3	4.4061	1.0000	.0000	5.5006	1.0000	.0000
5.4	4.5061	1.0000	.0000	5.6006	1.0000	.0000
5.5	4.6061	1.0000	.0000	5.7006	1.0000	.0000
5.6	4.7061	1.0000	.0000	5.8006	1.0000	.0000
5.7	4.8061	1.0000	.0000	5.9006	1.0000	.0000
5.8	4.9061	1.0000	.0000	6.0006	1.0000	.0000
5.9	5.0061	1.0000	.0000	6.1006	1.0000	.0000
6.0	5.1061	1.0000	.0000	6.2006	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1;\ \frac{1}{T_e^*} = 0;\ k = 0.4$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4215	0.0000	0.0000	0.9358
.1	.0021	.0422	.4214	.0046	.0909	.8825
.2	.0084	.0843	.4212	.0180	.1765	.8294
.3	.0190	.1264	.4207	.0397	.2568	.7768
.4	.0337	.1684	.4197	.0692	.3319	.7249
.5	.0526	.2103	.4181	.1059	.4018	.6739
.6	.0758	.2520	.4157	.1494	.4667	.6240
.7	.1030	.2934	.4124	.1991	.5267	.5754
.8	.1344	.3345	.4081	.2546	.5818	.5283
.9	.1699	.3750	.4028	.3153	.6324	.4828
1.0	.2094	.4150	.3962	.3809	.6785	.4392
1.1	.2529	.4542	.3884	.4509	.7203	.3975
1.2	.3002	.4926	.3794	.5248	.7580	.3579
1.3	.3514	.5300	.3691	.6024	.7919	.3205
1.4	.4062	.5664	.3575	.6831	.8222	.2854
1.5	.4646	.6015	.3448	.7667	.8491	.2525
1.6	.5265	.6353	.3310	.8528	.8728	.2221
1.7	.5916	.6677	.3161	.9411	.8936	.1940
1.8	.6599	.6985	.3004	1.0314	.9117	.1684
1.9	.7313	.7277	.2840	1.1234	.9273	.1450
2.0	.8054	.7553	.2669	1.2168	.9408	.1239
2.1	.8823	.7811	.2495	1.3115	.9522	.1051
2.2	.9616	.8052	.2319	1.4072	.9619	.0883
2.3	1.0432	.8275	.2142	1.5038	.9699	.0735
2.4	1.1270	.8480	.1967	1.6011	.9766	.0606
2.5	1.2128	.8668	.1795	1.6991	.9821	.0495
2.6	1.3003	.8839	.1628	1.7975	.9866	.0399
2.7	1.3895	.8994	.1467	1.8964	.9901	.0318
2.8	1.4802	.9133	.1313	1.9955	.9930	.0249
2.9	1.5721	.9257	.1168	2.0949	.9952	.0193
3.0	1.6652	.9367	.1032	2.1946	.9969	.0146
3.1	1.7594	.9464	.0906	2.2943	.9981	.0108
3.2	1.8545	.9548	.0790	2.3942	.9991	.0078
3.3	1.9503	.9622	.0684	2.4941	.9997	.0055
3.4	2.0469	.9685	.0588	2.5941	1.0002	.0036
3.5	2.1440	.9740	.0502	2.6941	1.0004	.0022
3.6	2.2416	.9786	.0426	2.7942	1.0006	.0012
3.7	2.3397	.9825	.0359	2.8943	1.0007	.0005
3.8	2.4381	.9858	.0300	2.9943	1.0007	.0000
3.9	2.5369	.9886	.0250	3.0944	1.0007	-.0004
4.0	2.6358	.9908	.0206	3.1945	1.0006	-.0006
4.1	2.7350	.9927	.0169	3.2945	1.0006	-.0007
4.2	2.8344	.9942	.0137	3.3946	1.0005	-.0007
4.3	2.9338	.9955	.0111	3.4946	1.0004	-.0007
4.4	3.0334	.9965	.0089	3.5947	1.0004	-.0007
4.5	3.1331	.9973	.0071	3.6947	1.0003	-.0006
4.6	3.2329	.9979	.0056	3.7947	1.0003	-.0005
4.7	3.3327	.9984	.0044	3.8947	1.0002	-.0005
4.8	3.4326	.9988	.0034	3.9948	1.0002	-.0004
4.9	3.5325	.9991	.0027	4.0948	1.0001	-.0003
5.0	3.6324	.9993	.0021	4.1948	1.0001	-.0003
5.1	3.7323	.9995	.0016	4.2948	1.0001	-.0002
5.2	3.8323	.9996	.0012	4.3948	1.0001	-.0002
5.3	3.9322	.9997	.0009	4.4948	1.0000	-.0001
5.4	4.0322	.9998	.0007	4.5948	1.0000	-.0001
5.5	4.1322	.9999	.0005	4.6948	1.0000	-.0001
5.6	4.2322	.9999	.0004	4.7948	1.0000	-.0001
5.7	4.3322	1.0000	.0003	4.8948	1.0000	.0000
5.8	4.4322	1.0000	.0002	4.9948	1.0000	.0000
5.9	4.5322	1.0000	.0001	5.0948	1.0000	.0000
6.0	4.6322	1.0000	.0001	5.1948	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1.0;\ \frac{1}{T_e^*} = 0;\ k = 0.8$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4935	0.0000	0.0000	1.0850
.1	.0025	.0493	.4934	.0053	.1048	1.0117
.2	.0099	.0987	.4930	.0207	.2024	.9390
.3	.0222	.1479	.4920	.0455	.2927	.8674
.4	.0395	.1970	.4900	.0790	.3759	.7972
.5	.0616	.2459	.4869	.1205	.4522	.7289
.6	.0886	.2944	.4823	.1692	.5217	.6629
.7	.1205	.3423	.4760	.2246	.5848	.5995
.8	.1571	.3895	.4679	.2860	.6417	.5390
.9	.1983	.4358	.4579	.3528	.6927	.4817
1.0	.2442	.4810	.4459	.4244	.7382	.4278
1.1	.2945	.5249	.4319	.5002	.7784	.3774
1.2	.3491	.5673	.4159	.5799	.8138	.3306
1.3	.4079	.6081	.3981	.6628	.8447	.2876
1.4	.4707	.6469	.3787	.7487	.8714	.2483
1.5	.5372	.6837	.3577	.8370	.8945	.2127
1.6	.6073	.7184	.3356	.9275	.9141	.1807
1.7	.6808	.7508	.3125	1.0197	.9307	.1522
1.8	.7574	.7809	.2889	1.1135	.9446	.1271
1.9	.8369	.8086	.2650	1.2086	.9562	.1051
2.0	.9191	.8339	.2412	1.3047	.9658	.0861
2.1	1.0036	.8569	.2178	1.4017	.9735	.0698
2.2	1.0904	.8775	.1950	1.4993	.9798	.0559
2.3	1.1791	.8959	.1732	1.5976	.9848	.0443
2.4	1.2695	.9122	.1525	1.6963	.9887	.0347
2.5	1.3614	.9265	.1332	1.7953	.9918	.0268
2.6	1.4547	.9389	.1153	1.8946	.9942	.0204
2.7	1.5491	.9496	.0990	1.9941	.9959	.0153
2.8	1.6446	.9587	.0842	2.0938	.9972	.0113
2.9	1.7408	.9665	.0710	2.1935	.9982	.0081
3.0	1.8378	.9730	.0594	2.2934	.9989	.0057
3.1	1.9354	.9784	.0492	2.3933	.9994	.0039
3.2	2.0335	.9828	.0404	2.4933	.9997	.0026
3.3	2.1319	.9865	.0329	2.5932	.9999	.0016
3.4	2.2307	.9895	.0265	2.6932	1.0000	.0010
3.5	2.3298	.9918	.0212	2.7933	1.0001	.0005
3.6	2.4291	.9937	.0168	2.8933	1.0001	.0002
3.7	2.5285	.9952	.0132	2.9933	1.0002	.0000
3.8	2.6281	.9964	.0103	3.0933	1.0001	-.0001
3.9	2.7278	.9973	.0079	3.1933	1.0001	-.0002
4.0	2.8276	.9980	.0061	3.2933	1.0001	-.0002
4.1	2.9274	.9985	.0046	3.3933	1.0001	-.0002
4.2	3.0273	.9989	.0034	3.4933	1.0001	-.0002
4.3	3.1272	.9992	.0026	3.5933	1.0001	-.0001
4.4	3.2271	.9994	.0019	3.6934	1.0001	-.0001
4.5	3.3271	.9996	.0014	3.7934	1.0000	-.0001
4.6	3.4270	.9997	.0010	3.8934	1.0000	-.0001
4.7	3.5270	.9998	.0007	3.9934	1.0000	-.0001
4.8	3.6270	.9999	.0005	4.0934	1.0000	.0000
4.9	3.7270	.9999	.0004	4.1934	1.0000	.0000
5.0	3.8270	.9999	.0003	4.2934	1.0000	.0000
5.1	3.9270	1.0000	.0002	4.3934	1.0000	.0000
5.2	4.0269	1.0000	.0001	4.4934	1.0000	.0000
5.3	4.1269	1.0000	.0001	4.5934	1.0000	.0000
5.4	4.2269	1.0000	.0001	4.6934	1.0000	.0000
5.5	4.3269	1.0000	.0000	4.7934	1.0000	.0000
5.6	4.4269	1.0000	.0000	4.8934	1.0000	.0000
5.7	4.5269	1.0000	.0000	4.9934	1.0000	.0000
5.8	4.6269	1.0000	.0000	5.0934	1.0000	.0000
5.9	4.7269	1.0000	.0000	5.1934	1.0000	.0000
6.0	4.8269	1.0000	.0000	5.2934	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1.0;\ \frac{1}{T_e^*} = 0;\ k = 1.2$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5559	0.0000	0.0000	1.2165
.1	.0028	.0556	.5558	.0059	.1170	1.1233
.2	.0111	.1111	.5551	.0231	.2247	1.0311
.3	.0250	.1666	.5535	.0506	.3233	.9406
.4	.0444	.2218	.5503	.0874	.4129	.8527
.5	.0694	.2766	.5451	.1329	.4939	.7680
.6	.0997	.3307	.5377	.1860	.5666	.6870
.7	.1355	.3840	.5277	.2459	.6315	.6103
.8	.1765	.4362	.5149	.3120	.6889	.5382
.9	.2227	.4869	.4993	.3835	.7393	.4711
1.0	.2738	.5359	.4808	.4596	.7832	.4090
1.1	.3298	.5830	.4597	.5399	.8213	.3523
1.2	.3903	.6278	.4360	.6237	.8539	.3008
1.3	.4552	.6701	.4101	.7105	.8816	.2545
1.4	.5243	.7098	.3825	.7999	.9049	.2134
1.5	.5971	.7466	.3535	.8914	.9244	.1772
1.6	.6735	.7804	.3237	.9847	.9405	.1457
1.7	.7531	.8113	.2937	1.0794	.9537	.1185
1.8	.8356	.8392	.2638	1.1753	.9644	.0954
1.9	.9208	.8641	.2346	1.2722	.9729	.0759
2.0	1.0084	.8861	.2065	1.3698	.9797	.0596
2.1	1.0979	.9054	.1799	1.4681	.9849	.0463
2.2	1.1893	.9222	.1551	1.5668	.9890	.0355
2.3	1.2823	.9365	.1324	1.6658	.9921	.0268
2.4	1.3766	.9487	.1117	1.7652	.9944	.0200
2.5	1.4720	.9589	.0933	1.8647	.9961	.0146
2.6	1.5683	.9674	.0771	1.9644	.9974	.0105
2.7	1.6654	.9744	.0630	2.0642	.9983	.0074
2.8	1.7631	.9801	.0510	2.1640	.9989	.0052
2.9	1.8614	.9847	.0408	2.2639	.9993	.0035
3.0	1.9601	.9883	.0322	2.3639	.9996	.0023
3.1	2.0590	.9912	.0252	2.4639	.9998	.0015
3.2	2.1583	.9934	.0195	2.5639	.9999	.0009
3.3	2.2577	.9951	.0149	2.6638	1.0000	.0005
3.4	2.3573	.9964	.0113	2.7638	1.0000	.0003
3.5	2.4570	.9974	.0085	2.8638	1.0000	.0001
3.6	2.5567	.9981	.0063	2.9639	1.0000	.0000
3.7	2.6566	.9987	.0046	3.0639	1.0000	.0000
3.8	2.7565	.9991	.0033	3.1639	1.0000	-.0001
3.9	2.8564	.9994	.0024	3.2639	1.0000	-.0001
4.0	2.9563	.9996	.0017	3.3639	1.0000	-.0001
4.1	3.0563	.9997	.0012	3.4639	1.0000	.0000
4.2	3.1563	.9998	.0008	3.5639	1.0000	.0000
4.3	3.2563	.9999	.0006	3.6639	1.0000	.0000
4.4	3.3562	.9999	.0004	3.7639	1.0000	.0000
4.5	3.4562	.9999	.0003	3.8639	1.0000	.0000
4.6	3.5562	1.0000	.0002	3.9639	1.0000	.0000
4.7	3.6562	1.0000	.0001	4.0639	1.0000	.0000
4.8	3.7562	1.0000	.0001	4.1639	1.0000	.0000
4.9	3.8562	1.0000	.0001	4.2639	1.0000	.0000
5.0	3.9562	1.0000	.0000	4.3639	1.0000	.0000
5.1	4.0562	1.0000	.0000	4.4639	1.0000	.0000
5.2	4.1562	1.0000	.0000	4.5639	1.0000	.0000
5.3	4.2562	1.0000	.0000	4.6639	1.0000	.0000
5.4	4.3562	1.0000	.0000	4.7639	1.0000	.0000
5.5	4.4562	1.0000	.0000	4.8639	1.0000	.0000
5.6	4.5562	1.0000	.0000	4.9639	1.0000	.0000
5.7	4.6562	1.0000	.0000	5.0639	1.0000	.0000
5.8	4.7562	1.0000	.0000	5.1639	1.0000	.0000
5.9	4.8562	1.0000	.0000	5.2639	1.0000	.0000
6.0	4.9562	1.0000	.0000	5.3639	1.0000	.0000

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1;\ \frac{1}{T_e^*} = 1.0;\ k = 0.4$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4436	0.0000	0.0000	1.4266
.1	.0022	.0444	.4436	.0070	.1373	1.3201
.2	.0089	.0887	.4434	.0271	.2640	1.2142
.3	.0200	.1330	.4427	.0594	.3802	1.1098
.4	.0355	.1772	.4414	.1028	.4861	1.0073
.5	.0554	.2213	.4392	.1563	.5818	.9074
.6	.0797	.2650	.4361	.2188	.6677	.8108
.7	.1084	.3085	.4319	.2895	.7441	.7178
.8	.1414	.3514	.4264	.3673	.8114	.6291
.9	.1787	.3937	.4196	.4515	.8700	.5450
1.0	.2201	.4352	.4113	.5411	.9205	.4660
1.1	.2657	.4759	.4016	.6353	.9634	.3922
1.2	.3153	.5155	.3904	.7335	.9992	.3242
1.3	.3687	.5539	.3779	.8350	1.0284	.2619
1.4	.4260	.5910	.3639	.9390	1.0517	.2055
1.5	.4869	.6267	.3487	1.0451	1.0697	.1550
1.6	.5513	.6607	.3324	1.1528	1.0829	.1104
1.7	.6190	.6931	.3151	1.2616	1.0920	.0716
1.8	.6898	.7237	.2971	1.3711	1.0974	.0384
1.9	.7637	.7525	.2784	1.4810	1.0998	.0104
2.0	.8403	.7794	.2594	1.5909	1.0997	-.0125
2.1	.9195	.8044	.2402	1.7008	1.0975	-.0309
2.2	1.0011	.8275	.2210	1.8104	1.0936	-.0450
2.3	1.0849	.8486	.2021	1.9195	1.0886	-.0554
2.4	1.1708	.8679	.1836	2.0281	1.0827	-.0624
2.5	1.2584	.8854	.1658	2.1360	1.0762	-.0666
2.6	1.3478	.9011	.1487	2.2433	1.0694	-.0684
2.7	1.4386	.9151	.1324	2.3499	1.0626	-.0682
2.8	1.5307	.9276	.1172	2.4558	1.0559	-.0663
2.9	1.6241	.9386	.1030	2.5611	1.0494	-.0633
3.0	1.7184	.9482	.0899	2.6657	1.0432	-.0593
3.1	1.8137	.9566	.0780	2.7697	1.0375	-.0548
3.2	1.9097	.9639	.0671	2.8732	1.0323	-.0499
3.3	2.0064	.9701	.0574	2.9762	1.0276	-.0449
3.4	2.1037	.9754	.0488	3.0788	1.0233	-.0399
3.5	2.2014	.9799	.0411	3.1809	1.0196	-.0350
3.6	2.2996	.9836	.0345	3.2827	1.0163	-.0305
3.7	2.3982	.9868	.0287	3.3842	1.0135	-.0262
3.8	2.4970	.9894	.0237	3.4854	1.0110	-.0224
3.9	2.5960	.9915	.0194	3.5864	1.0090	-.0189
4.0	2.6953	.9933	.0158	3.6872	1.0073	-.0158
4.1	2.7947	.9947	.0128	3.7879	1.0058	-.0131
4.2	2.8942	.9959	.0103	3.8884	1.0046	-.0108
4.3	2.9938	.9968	.0082	3.9888	1.0037	-.0088
4.4	3.0935	.9975	.0065	4.0891	1.0029	-.0071
4.5	3.1933	.9981	.0051	4.1894	1.0022	-.0057
4.6	3.2932	.9986	.0040	4.2896	1.0017	-.0045
4.7	3.3930	.9989	.0031	4.3897	1.0013	-.0036
4.8	3.4929	.9992	.0024	4.4898	1.0010	-.0028
4.9	3.5929	.9994	.0018	4.5899	1.0008	-.0022
5.0	3.6928	.9996	.0014	4.6900	1.0006	-.0017
5.1	3.7928	.9997	.0011	4.7900	1.0004	-.0013
5.2	3.8928	.9998	.0008	4.8901	1.0003	-.0010
5.3	3.9927	.9998	.0006	4.9901	1.0002	-.0007
5.4	4.0927	.9999	.0004	5.0901	1.0002	-.0005
5.5	4.1927	.9999	.0003	5.1901	1.0001	-.0004
5.6	4.2927	1.0000	.0002	5.2901	1.0001	-.0003
5.7	4.3927	1.0000	.0002	5.3901	1.0001	-.0002
5.8	4.4927	1.0000	.0001	5.4901	1.0000	-.0002
5.9	4.5927	1.0000	.0001	5.5901	1.0000	-.0001
6.0	4.6927	1.0000	.0001	5.6901	1.0000	-.0001

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1.0;\ \frac{1}{T_e^*} = 1.0;\ k = 0.8$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5278	0.0000	0.0000	1.6445
.1	.0026	.0528	.5278	.0080	.1571	1.4981
.2	.0106	.1055	.5272	.0309	.2997	1.3533
.3	.0237	.1582	.5258	.0674	.4279	1.2114
.4	.0422	.2106	.5230	.1161	.5421	1.0738
.5	.0659	.2627	.5186	.1754	.6428	.9416
.6	.0947	.3143	.5122	.2442	.7306	.8158
.7	.1287	.3651	.5037	.3211	.8062	.6973
.8	.1677	.4149	.4928	.4050	.8704	.5870
.9	.2116	.4636	.4794	.4948	.9239	.4852
1.0	.2604	.5108	.4636	.5895	.9677	.3926
1.1	.3137	.5562	.4455	.6881	1.0027	.3094
1.2	.3716	.5998	.4252	.7898	1.0299	.2356
1.3	.4336	.6412	.4029	.8938	1.0502	.1711
1.4	.4997	.6803	.3790	.9996	1.0644	.1159
1.5	.5696	.7170	.3538	1.1066	1.0736	.0694
1.6	.6430	.7510	.3277	1.2142	1.0786	.0312
1.7	.7197	.7825	.3011	1.3222	1.0801	.0006
1.8	.7994	.8113	.2743	1.4301	1.0789	-.0230
1.9	.8819	.8374	.2479	1.5379	1.0757	-.0405
2.0	.9668	.8608	.2221	1.6452	1.0710	-.0526
2.1	1.0540	.8818	.1973	1.7520	1.0653	-.0602
2.2	1.1431	.9003	.1737	1.8583	1.0591	-.0640
2.3	1.2340	.9166	.1517	1.9639	1.0526	-.0648
2.4	1.3263	.9307	.1312	2.0688	1.0462	-.0632
2.5	1.4200	.9429	.1126	2.1731	1.0401	-.0599
2.6	1.5149	.9533	.0957	2.2768	1.0343	-.0555
2.7	1.6106	.9621	.0806	2.3800	1.0290	-.0503
2.8	1.7072	.9695	.0673	2.4826	1.0242	-.0448
2.9	1.8045	.9756	.0557	2.5848	1.0200	-.0392
3.0	1.9023	.9807	.0457	2.6867	1.0164	-.0338
3.1	2.0006	.9848	.0372	2.7881	1.0133	-.0287
3.2	2.0993	.9882	.0299	2.8893	1.0106	-.0241
3.3	2.1982	.9908	.0239	2.9903	1.0084	-.0200
3.4	2.2974	.9930	.0189	3.0910	1.0066	-.0163
3.5	2.3968	.9947	.0148	3.1916	1.0051	-.0132
3.6	2.4963	.9960	.0115	3.2921	1.0040	-.0105
3.7	2.5960	.9970	.0089	3.3924	1.0030	-.0083
3.8	2.6957	.9978	.0068	3.4927	1.0023	-.0065
3.9	2.7955	.9984	.0051	3.5929	1.0017	-.0050
4.0	2.8954	.9988	.0039	3.6930	1.0013	-.0039
4.1	2.9953	.9991	.0029	3.7931	1.0009	-.0029
4.2	3.0952	.9994	.0021	3.8932	1.0007	-.0022
4.3	3.1951	.9996	.0015	3.9933	1.0005	-.0016
4.4	3.2951	.9997	.0011	4.0933	1.0004	-.0012
4.5	3.3951	.9998	.0008	4.1933	1.0003	-.0009
4.6	3.4951	.9999	.0006	4.2933	1.0002	-.0006
4.7	3.5950	.9999	.0004	4.3934	1.0001	-.0004
4.8	3.6950	.9999	.0003	4.4934	1.0001	-.0003
4.9	3.7950	1.0000	.0002	4.5934	1.0001	-.0002
5.0	3.8950	1.0000	.0001	4.6934	1.0000	-.0002
5.1	3.9950	1.0000	.0001	4.7934	1.0000	-.0001
5.2	4.0950	1.0000	.0001	4.8934	1.0000	-.0001
5.3	4.1950	1.0000	.0000	4.9934	1.0000	-.0001
5.4	4.2950	1.0000	.0000	5.0934	1.0000	.0000
5.5	4.3950	1.0000	.0000	5.1934	1.0000	.0000
5.6	4.4950	1.0000	.0000	5.2934	1.0000	.0000
5.7	4.5950	1.0000	.0000	5.3934	1.0000	.0000
5.8	4.6950	1.0000	.0000	5.4934	1.0000	.0000
5.9	4.7950	1.0000	.0000	5.5934	1.0000	.0000
6.0	4.8950	1.0000	.0000	5.6934	1.0000	.0000

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1.0;\ \frac{1}{T_e^*} = 1.0;\ k = 1.2$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5995	0.0000	0.0000	1.8393
.1	.0030	.0599	.5993	.0089	.1746	1.6531
.2	.0120	.1198	.5984	.0343	.3307	1.4696
.3	.0270	.1796	.5959	.0744	.4687	1.2912
.4	.0479	.2389	.5912	.1275	.5892	1.1199
.5	.0747	.2977	.5839	.1917	.6930	.9576
.6	.1074	.3556	.5733	.2655	.7810	.8057
.7	.1458	.4123	.5594	.3474	.8545	.6656
.8	.1898	.4674	.5418	.4360	.9146	.5380
.9	.2392	.5205	.5208	.5299	.9626	.4237
1.0	.2938	.5714	.4964	.6281	.9998	.3228
1.1	.3534	.6197	.4689	.7296	1.0276	.2355
1.2	.4177	.6651	.4389	.8334	1.0473	.1613
1.3	.4863	.7074	.4069	.9388	1.0602	.0997
1.4	.5591	.7464	.3735	1.0453	1.0676	.0499
1.5	.6355	.7821	.3394	1.1522	1.0706	.0108
1.6	.7154	.8143	.3052	1.2593	1.0701	-.0185
1.7	.7983	.8431	.2716	1.3661	1.0672	-.0395
1.8	.8839	.8687	.2392	1.4726	1.0625	-.0533
1.9	.9719	.8910	.2084	1.5786	1.0567	-.0613
2.0	1.0620	.9104	.1796	1.6839	1.0504	-.0645
2.1	1.1539	.9270	.1531	1.7887	1.0439	-.0642
2.2	1.2473	.9411	.1291	1.8927	1.0376	-.0613
2.3	1.3420	.9529	.1077	1.9962	1.0317	-.0566
2.4	1.4378	.9627	.0888	2.0991	1.0263	-.0509
2.5	1.5345	.9708	.0725	2.2015	1.0215	-.0447
2.6	1.6319	.9773	.0585	2.3034	1.0174	-.0384
2.7	1.7299	.9826	.0467	2.4050	1.0138	-.0324
2.8	1.8284	.9867	.0369	2.5062	1.0109	-.0269
2.9	1.9272	.9900	.0288	2.6072	1.0084	-.0219
3.0	2.0264	.9925	.0222	2.7079	1.0065	-.0176
3.1	2.1257	.9945	.0170	2.8085	1.0049	-.0139
3.2	2.2252	.9960	.0128	2.9089	1.0037	-.0109
3.3	2.3249	.9971	.0096	3.0092	1.0027	-.0084
3.4	2.4247	.9979	.0071	3.1094	1.0020	-.0063
3.5	2.5245	.9985	.0052	3.2096	1.0014	-.0047
3.6	2.6244	.9990	.0038	3.3097	1.0010	-.0035
3.7	2.7243	.9993	.0027	3.4098	1.0007	-.0026
3.8	2.8242	.9995	.0019	3.5099	1.0005	-.0018
3.9	2.9242	.9997	.0013	3.6099	1.0004	-.0013
4.0	3.0241	.9998	.0009	3.7100	1.0002	-.0009
4.1	3.1241	.9999	.0006	3.8100	1.0002	-.0006
4.2	3.2241	.9999	.0004	3.9100	1.0001	-.0004
4.3	3.3241	.9999	.0003	4.0100	1.0001	-.0003
4.4	3.4241	1.0000	.0002	4.1100	1.0000	-.0002
4.5	3.5241	1.0000	.0001	4.2100	1.0000	-.0001
4.6	3.6241	1.0000	.0001	4.3100	1.0000	-.0001
4.7	3.7241	1.0000	.0001	4.4100	1.0000	-.0001
4.8	3.8241	1.0000	.0000	4.5100	1.0000	.0000
4.9	3.9241	1.0000	.0000	4.6100	1.0000	.0000
5.0	4.0241	1.0000	.0000	4.7100	1.0000	.0000
5.1	4.1241	1.0000	.0000	4.8100	1.0000	.0000
5.2	4.2241	1.0000	.0000	4.9100	1.0000	.0000
5.3	4.3241	1.0000	.0000	5.0100	1.0000	.0000
5.4	4.4241	1.0000	.0000	5.1100	1.0000	.0000
5.5	4.5241	1.0000	.0000	5.2100	1.0000	.0000
5.6	4.6241	1.0000	.0000	5.3100	1.0000	.0000
5.7	4.7241	1.0000	.0000	5.4100	1.0000	.0000
5.8	4.8241	1.0000	.0000	5.5100	1.0000	.0000
5.9	4.9241	1.0000	.0000	5.6100	1.0000	.0000
6.0	5.0241	1.0000	.0000	5.7100	1.0000	.0000

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1;\ \frac{1}{T_e^*} = 2.5;\ k = 0.4$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.4704	0.0000	0.0000	2.1031
.1	.0024	.0470	.4703	.0102	.2010	1.9167
.2	.0094	.0941	.4700	.0396	.3834	1.7319
.3	.0212	.1410	.4691	.0863	.5475	1.5501
.4	.0376	.1878	.4673	.1485	.6936	1.3728
.5	.0587	.2344	.4645	.2244	.8222	1.2012
.6	.0845	.2807	.4603	.3124	.9340	1.0365
.7	.1148	.3265	.4548	.4107	1.0298	.8799
.8	.1498	.3716	.4476	.5178	1.1103	.7322
.9	.1891	.4159	.4388	.6323	1.1765	.5943
1.0	.2329	.4593	.4282	.7527	1.2295	.4669
1.1	.2810	.5015	.4159	.8778	1.2703	.3506
1.2	.3332	.5424	.4019	1.0064	1.3000	.2456
1.3	.3894	.5818	.3864	1.1374	1.3198	.1523
1.4	.4495	.6196	.3694	1.2700	1.3308	.0705
1.5	.5133	.6557	.3511	1.4033	1.3343	.0003
1.6	.5805	.6898	.3317	1.5367	1.3313	-.0588
1.7	.6511	.7220	.3115	1.6694	1.3229	-.1072
1.8	.7249	.7521	.2907	1.8011	1.3102	-.1456
1.9	.8015	.7801	.2696	1.9313	1.2941	-.1746
2.0	.8808	.8060	.2484	2.0598	1.2755	-.1951
2.1	.9626	.8298	.2273	2.1864	1.2553	-.2081
2.2	1.0467	.8515	.2067	2.3109	1.2341	-.2145
2.3	1.1329	.8711	.1867	2.4332	1.2126	-.2152
2.4	1.2209	.8888	.1674	2.5534	1.1913	-.2112
2.5	1.3106	.9047	.1492	2.6715	1.1705	-.2034
2.6	1.4017	.9187	.1320	2.7875	1.1507	-.1928
2.7	1.4942	.9311	.1160	2.9016	1.1320	-.1800
2.8	1.5879	.9419	.1012	3.0140	1.1147	-.1658
2.9	1.6826	.9514	.0877	3.1246	1.0989	-.1509
3.0	1.7781	.9595	.0755	3.2338	1.0845	-.1357
3.1	1.8744	.9665	.0645	3.3416	1.0717	-.1207
3.2	1.9714	.9725	.0548	3.4482	1.0604	-.1063
3.3	2.0689	.9775	.0461	3.5537	1.0504	-.0926
3.4	2.1669	.9817	.0386	3.6583	1.0418	-.0800
3.5	2.2652	.9853	.0321	3.7621	1.0344	-.0684
3.6	2.3639	.9882	.0265	3.8652	1.0281	-.0579
3.7	2.4628	.9906	.0217	3.9678	1.0228	-.0486
3.8	2.5620	.9925	.0177	4.0698	1.0183	-.0405
3.9	2.6613	.9941	.0143	4.1714	1.0146	-.0334
4.0	2.7608	.9954	.0115	4.2727	1.0116	-.0274
4.1	2.8604	.9964	.0091	4.3738	1.0091	-.0222
4.2	2.9601	.9973	.0072	4.4746	1.0071	-.0179
4.3	3.0599	.9979	.0057	4.5752	1.0055	-.0143
4.4	3.1597	.9984	.0044	4.6757	1.0043	-.0113
4.5	3.2595	.9988	.0034	4.7761	1.0033	-.0089
4.6	3.3594	.9991	.0026	4.8764	1.0025	-.0069
4.7	3.4593	.9993	.0020	4.9766	1.0019	-.0054
4.8	3.5593	.9995	.0015	5.0767	1.0014	-.0041
4.9	3.6592	.9996	.0012	5.1769	1.0010	-.0031
5.0	3.7592	.9997	.0009	5.2770	1.0008	-.0024
5.1	3.8592	.9998	.0006	5.3770	1.0005	-.0018
5.2	3.9592	.9999	.0005	5.4771	1.0004	-.0013
5.3	4.0592	.9999	.0004	5.5771	1.0003	-.0010
5.4	4.1592	.9999	.0003	5.6771	1.0002	-.0007
5.5	4.2592	1.0000	.0002	5.7771	1.0001	-.0005
5.6	4.3591	1.0000	.0001	5.8771	1.0001	-.0004
5.7	4.4591	1.0000	.0001	5.9771	1.0001	-.0003
5.8	4.5591	1.0000	.0001	6.0771	1.0000	-.0002
5.9	4.6591	1.0000	.0001	6.1772	1.0000	-.0001
6.0	4.7591	1.0000	.0000	6.2772	1.0000	-.0001

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1;\ \frac{1}{T_e^*} = 2.5;\ k = 0.8$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5675	0.0000	0.0000	2.4026
.1	.0028	.0567	.5673	.0116	.2274	2.1466
.2	.0114	.1134	.5666	.0446	.4294	1.8940
.3	.0255	.1700	.5645	.0966	.6065	1.6480
.4	.0453	.2263	.5606	.1651	.7594	1.4115
.5	.0708	.2821	.5544	.2477	.8892	1.1868
.6	.1017	.3371	.5456	.3422	.9972	.9760
.7	.1381	.3911	.5338	.4465	1.0849	.7809
.8	.1799	.4437	.5191	.5586	1.1539	.6029
.9	.2268	.4948	.5013	.6767	1.2061	.4429
1.0	.2788	.5439	.4807	.7993	1.2431	.3016
1.1	.3355	.5908	.4573	.9249	1.2670	.1791
1.2	.3969	.6353	.4316	1.0523	1.2796	.0752
1.3	.4625	.6771	.4040	1.1805	1.2826	-.0107
1.4	.5322	.7160	.3749	1.3086	1.2780	-.0794
1.5	.6056	.7520	.3450	1.4359	1.2673	-.1323
1.6	.6825	.7850	.3146	1.5619	1.2520	-.1707
1.7	.7625	.8150	.2843	1.6862	1.2336	-.1963
1.8	.8454	.8419	.2547	1.8085	1.2131	-.2109
1.9	.9308	.8659	.2261	1.9288	1.1917	-.2162
2.0	1.0185	.8872	.1989	2.0469	1.1701	-.2140
2.1	1.1081	.9058	.1734	2.1628	1.1491	-.2059
2.2	1.1996	.9219	.1497	2.2767	1.1291	-.1935
2.3	1.2925	.9358	.1282	2.3887	1.1105	-.1782
2.4	1.3866	.9476	.1087	2.4989	1.0935	-.1611
2.5	1.4819	.9576	.0914	2.6074	1.0783	-.1433
2.6	1.5781	.9659	.0761	2.7146	1.0648	-.1255
2.7	1.6751	.9729	.0628	2.8205	1.0532	-.1083
2.8	1.7726	.9786	.0514	2.9253	1.0431	-.0923
2.9	1.8707	.9832	.0416	3.0292	1.0347	-.0776
3.0	1.9692	.9869	.0334	3.1323	1.0276	-.0644
3.1	2.0681	.9899	.0266	3.2347	1.0217	-.0529
3.2	2.1672	.9923	.0210	3.3366	1.0170	-.0429
3.3	2.2665	.9942	.0164	3.4381	1.0131	-.0344
3.4	2.3660	.9956	.0127	3.5393	1.0100	-.0273
3.5	2.4656	.9967	.0098	3.6402	1.0076	-.0214
3.6	2.5654	.9976	.0074	3.7408	1.0057	-.0166
3.7	2.6651	.9982	.0056	3.8413	1.0043	-.0128
3.8	2.7650	.9987	.0042	3.9417	1.0031	-.0097
3.9	2.8649	.9991	.0031	4.0419	1.0023	-.0073
4.0	2.9648	.9993	.0023	4.1421	1.0017	-.0054
4.1	3.0647	.9995	.0017	4.2423	1.0012	-.0040
4.2	3.1647	.9997	.0012	4.3424	1.0008	-.0029
4.3	3.2647	.9998	.0009	4.4425	1.0006	-.0021
4.4	3.3647	.9998	.0006	4.5425	1.0004	-.0015
4.5	3.4646	.9999	.0004	4.6425	1.0003	-.0011
4.6	3.5646	.9999	.0003	4.7426	1.0002	-.0008
4.7	3.6646	1.0000	.0002	4.8426	1.0001	-.0005
4.8	3.7646	1.0000	.0001	4.9426	1.0001	-.0004
4.9	3.8646	1.0000	.0001	5.0426	1.0001	-.0003
5.0	3.9646	1.0000	.0001	5.1426	1.0000	-.0002
5.1	4.0646	1.0000	.0000	5.2426	1.0000	-.0001
5.2	4.1646	1.0000	.0000	5.3426	1.0000	-.0001
5.3	4.2646	1.0000	.0000	5.4426	1.0000	-.0001
5.4	4.3646	1.0000	.0000	5.5426	1.0000	.0000
5.5	4.4646	1.0000	.0000	5.6426	1.0000	.0000
5.6	4.5646	1.0000	.0000	5.7426	1.0000	.0000
5.7	4.6646	1.0000	.0000	5.8426	1.0000	.0000
5.8	4.7646	1.0000	.0000	5.9426	1.0000	.0000
5.9	4.8646	1.0000	.0000	6.0426	1.0000	.0000
6.0	4.9646	1.0000	.0000	6.1426	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1$; $\frac{1}{T_e^*} = 2.5$; k = 1.2						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.6487	0.0000	0.0000	2.6767
.1	.0032	.0649	.6485	.0128	.2514	2.3511
.2	.0130	.1297	.6471	.0492	.4704	2.0315
.3	.0292	.1942	.6435	.1059	.6580	1.7232
.4	.0518	.2583	.6368	.1798	.8156	1.4307
.5	.0808	.3214	.6263	.2681	.9448	1.1577
.6	.1160	.3834	.6115	.3679	1.0479	.9072
.7	.1574	.4436	.5921	.4768	1.1271	.6816
.8	.2047	.5016	.5683	.5926	1.1851	.4822
.9	.2577	.5571	.5402	.7132	1.2244	.3098
1.0	.3160	.6096	.5084	.8370	1.2479	.1644
1.1	.3795	.6587	.4733	.9624	1.2582	.0454
1.2	.4476	.7042	.4360	1.0883	1.2578	-.0488
1.3	.5202	.7458	.3972	1.2137	1.2492	-.1199
1.4	.5967	.7836	.3578	1.3379	1.2345	-.1703
1.5	.6767	.8174	.3187	1.4604	1.2157	-.2027
1.6	.7600	.8473	.2806	1.5810	1.1945	-.2199
1.7	.8461	.8736	.2443	1.6993	1.1722	-.2248
1.8	.9346	.8963	.2103	1.8154	1.1499	-.2200
1.9	1.0252	.9157	.1790	1.9293	1.1284	-.2082
2.0	1.1176	.9322	.1506	2.0411	1.1084	-.1915
2.1	1.2116	.9459	.1253	2.1510	1.0902	-.1720
2.2	1.3068	.9573	.1031	2.2592	1.0740	-.1512
2.3	1.4030	.9666	.0838	2.3659	1.0600	-.1303
2.4	1.5000	.9742	.0674	2.4713	1.0480	-.1103
2.5	1.5978	.9802	.0536	2.5756	1.0379	-.0918
2.6	1.6960	.9850	.0422	2.6789	1.0295	-.0752
2.7	1.7947	.9887	.0328	2.7815	1.0228	-.0607
2.8	1.8937	.9916	.0253	2.8835	1.0173	-.0482
2.9	1.9930	.9938	.0192	2.9850	1.0130	-.0378
3.0	2.0925	.9955	.0145	3.0862	1.0097	-.0292
3.1	2.1921	.9968	.0108	3.1870	1.0071	-.0223
3.2	2.2918	.9977	.0079	3.2876	1.0052	-.0168
3.3	2.3916	.9984	.0058	3.3880	1.0037	-.0125
3.4	2.4915	.9989	.0042	3.4884	1.0027	-.0092
3.5	2.5914	.9992	.0030	3.5886	1.0019	-.0066
3.6	2.6913	.9995	.0021	3.6887	1.0013	-.0048
3.7	2.7913	.9996	.0015	3.7888	1.0009	-.0034
3.8	2.8913	.9998	.0010	3.8889	1.0006	-.0024
3.9	2.9912	.9998	.0007	3.9890	1.0004	-.0016
4.0	3.0912	.9999	.0005	4.0890	1.0003	-.0011
4.1	3.1912	.9999	.0003	4.1890	1.0002	-.0007
4.2	3.2912	1.0000	.0002	4.2891	1.0001	-.0005
4.3	3.3912	1.0000	.0001	4.3891	1.0001	-.0003
4.4	3.4912	1.0000	.0001	4.4891	1.0001	-.0002
4.5	3.5912	1.0000	.0001	4.5891	1.0001	-.0001
4.6	3.6912	1.0000	.0000	4.6891	1.0000	-.0001
4.7	3.7912	1.0000	.0000	4.7891	1.0000	-.0001
4.8	3.8912	1.0000	.0000	4.8891	1.0000	.0000
4.9	3.9912	1.0000	.0000	4.9891	1.0000	.0000
5.0	4.0912	1.0000	.0000	5.0891	1.0000	.0000
5.1	4.1912	1.0000	.0000	5.1891	1.0000	.0000
5.2	4.2912	1.0000	.0000	5.2891	1.0000	.0000
5.3	4.3912	1.0000	.0000	5.3891	1.0000	.0000
5.4	4.4912	1.0000	.0000	5.4891	1.0000	.0000
5.5	4.5912	1.0000	.0000	5.5891	1.0000	.0000
5.6	4.6912	1.0000	.0000	5.6891	1.0000	.0000
5.7	4.7912	1.0000	.0000	5.7891	1.0000	.0000
5.8	4.8912	1.0000	.0000	5.8891	1.0000	.0000
5.9	4.9912	1.0000	.0000	5.9891	1.0000	.0000
6.0	5.0912	1.0000	.0000	6.0891	1.0000	.0000

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TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_W}{T_O} = 1.0; \quad \frac{1}{T_e^*} = 5.0; \quad k = 0.4$

λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.5051	0.0000	0.0000	3.1300
.1	.0025	.0505	.5051	.0151	.2970	2.8106
.2	.0101	.1010	.5046	.0583	.5622	2.4946
.3	.0227	.1514	.5033	.1265	.7962	2.1851
.4	.0404	.2016	.5008	.2166	.9996	1.8851
.5	.0630	.2515	.4968	.3255	1.1736	1.5971
.6	.0907	.3009	.4911	.4503	1.3195	1.3235
.7	.1232	.3497	.4835	.5885	1.4388	1.0663
.8	.1606	.3975	.4737	.7373	1.5333	.8273
.9	.2027	.4443	.4619	.8944	1.6049	.6080
1.0	.2494	.4898	.4479	1.0576	1.6556	.4094
1.1	.3006	.5338	.4318	1.2249	1.6875	.2323
1.2	.3561	.5761	.4138	1.3945	1.7028	.0771
1.3	.4158	.6165	.3940	1.5649	1.7037	-.0564
1.4	.4793	.6549	.3728	1.7348	1.6922	-.1684
1.5	.5467	.6911	.3504	1.9031	1.6707	-.2598
1.6	.6175	.7249	.3271	2.0687	1.6409	-.3315
1.7	.6916	.7565	.3033	2.2310	1.6050	-.3851
1.8	.7687	.7856	.2792	2.3895	1.5645	-.4219
1.9	.8486	.8123	.2552	2.5438	1.5211	-.4439
2.0	.9311	.8366	.2317	2.6937	1.4761	-.4529
2.1	1.0159	.8587	.2088	2.8391	1.4309	-.4508
2.2	1.1027	.8784	.1868	2.9799	1.3863	-.4395
2.3	1.1915	.8961	.1660	3.1164	1.3432	-.4210
2.4	1.2819	.9117	.1464	3.2486	1.3023	-.3968
2.5	1.3737	.9254	.1282	3.3769	1.2640	-.3688
2.6	1.4669	.9374	.1115	3.5015	1.2286	-.3382
2.7	1.5612	.9477	.0962	3.6227	1.1964	-.3064
2.8	1.6564	.9567	.0825	3.7409	1.1673	-.2744
2.9	1.7524	.9643	.0702	3.8563	1.1415	-.2431
3.0	1.8492	.9707	.0593	3.9693	1.1187	-.2131
3.1	1.9466	.9762	.0498	4.0801	1.0988	-.1850
3.2	2.0444	.9807	.0415	4.1891	1.0816	-.1590
3.3	2.1427	.9845	.0343	4.2965	1.0669	-.1354
3.4	2.2413	.9876	.0282	4.4026	1.0544	-.1142
3.5	2.3402	.9902	.0230	4.5075	1.0440	-.0955
3.6	2.4393	.9923	.0186	4.6114	1.0353	-.0792
3.7	2.5386	.9939	.0150	4.7146	1.0281	-.0651
3.8	2.6381	.9953	.0120	4.8171	1.0222	-.0530
3.9	2.7377	.9964	.0095	4.9191	1.0174	-.0429
4.0	2.8373	.9972	.0075	5.0206	1.0135	-.0344
4.1	2.9371	.9979	.0059	5.1218	1.0105	-.0273
4.2	3.0369	.9984	.0045	5.2227	1.0080	-.0216
4.3	3.1368	.9988	.0035	5.3234	1.0061	-.0169
4.4	3.2367	.9991	.0027	5.4239	1.0046	-.0131
4.5	3.3366	.9993	.0020	5.5244	1.0035	-.0101
4.6	3.4365	.9995	.0015	5.6247	1.0026	-.0077
4.7	3.5365	.9996	.0012	5.7249	1.0019	-.0059
4.8	3.6365	.9997	.0009	5.8250	1.0014	-.0044
4.9	3.7364	.9998	.0006	5.9252	1.0010	-.0033
5.0	3.8364	.9999	.0005	6.0252	1.0007	-.0025
5.1	3.9364	.9999	.0003	6.1253	1.0005	-.0018
5.2	4.0364	.9999	.0003	6.2254	1.0004	-.0013
5.3	4.1364	1.0000	.0002	6.3254	1.0003	-.0010
5.4	4.2364	1.0000	.0001	6.4254	1.0002	-.0007
5.5	4.3364	1.0000	.0001	6.5254	1.0001	-.0005
5.6	4.4364	1.0000	.0001	6.6254	1.0001	-.0004
5.7	4.5364	1.0000	.0000	6.7254	1.0000	-.0002
5.8	4.6364	1.0000	.0000	6.8254	1.0000	-.0002
5.9	4.7364	1.0000	.0000	6.9254	1.0000	-.0001
6.0	4.8364	1.0000	.0000	7.0254	1.0000	-.0001

TABLE I. - Continued. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0} = 1;\ \frac{1}{T_e^*} = 5.0;\ k = 0.8$						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.6172	0.0000	0.0000	3.5389
.1	.0031	.0617	.6170	.0170	.3319	3.1003
.2	.0123	.1234	.6158	.0649	.6203	2.6691
.3	.0278	.1848	.6128	.1396	.8662	2.2522
.4	.0493	.2458	.6071	.2368	1.0714	1.8552
.5	.0769	.3061	.5981	.3526	1.2381	1.4831
.6	.1105	.3653	.5855	.4833	1.3690	1.1398
.7	.1499	.4231	.5690	.6253	1.4671	.8285
.8	.1950	.4790	.5485	.7757	1.5358	.5514
.9	.2456	.5327	.5243	.9316	1.5786	.3098
1.0	.3015	.5838	.4967	1.0907	1.5990	.1042
1.1	.3623	.6319	.4662	1.2508	1.6006	-.0661
1.2	.4278	.6769	.4334	1.4103	1.5869	-.2022
1.3	.4976	.7185	.3990	1.5678	1.5612	-.3063
1.4	.5714	.7567	.3637	1.7222	1.5266	-.3811
1.5	.6488	.7913	.3283	1.8729	1.4859	-.4298
1.6	.7295	.8224	.2935	2.0193	1.4414	-.4559
1.7	.8131	.8500	.2597	2.1611	1.3953	-.4630
1.8	.8994	.8744	.2276	2.2984	1.3493	-.4547
1.9	.9879	.8956	.1975	2.4310	1.3048	-.4346
2.0	1.0784	.9139	.1697	2.5594	1.2627	-.4060
2.1	1.1706	.9296	.1445	2.6837	1.2238	-.3716
2.2	1.2643	.9429	.1218	2.8043	1.1885	-.3341
2.3	1.3591	.9541	.1017	2.9215	1.1570	-.2953
2.4	1.4550	.9634	.0842	3.0358	1.1294	-.2572
2.5	1.5517	.9710	.0690	3.1475	1.1055	-.2207
2.6	1.6492	.9772	.0560	3.2570	1.0852	-.1868
2.7	1.7471	.9823	.0451	3.3646	1.0680	-.1561
2.8	1.8456	.9863	.0360	3.4707	1.0538	-.1288
2.9	1.9444	.9895	.0284	3.5755	1.0422	-.1050
3.0	2.0435	.9920	.0222	3.6792	1.0327	-.0846
3.1	2.1428	.9940	.0173	3.7821	1.0251	-.0674
3.2	2.2422	.9955	.0133	3.8843	1.0191	-.0531
3.3	2.3419	.9967	.0101	3.9860	1.0144	-.0414
3.4	2.4416	.9976	.0076	4.0872	1.0108	-.0319
3.5	2.5414	.9982	.0057	4.1881	1.0080	-.0244
3.6	2.6412	.9987	.0042	4.2888	1.0058	-.0184
3.7	2.7411	.9991	.0031	4.3893	1.0042	-.0138
3.8	2.8410	.9994	.0023	4.4897	1.0031	-.0102
3.9	2.9410	.9995	.0016	4.5899	1.0022	-.0075
4.0	3.0409	.9997	.0012	4.6901	1.0015	-.0054
4.1	3.1409	.9998	.0008	4.7903	1.0011	-.0039
4.2	3.2409	.9999	.0006	4.8903	1.0007	-.0028
4.3	3.3409	.9999	.0004	4.9904	1.0005	-.0019
4.4	3.4409	.9999	.0003	5.0905	1.0004	-.0014
4.5	3.5409	1.0000	.0002	5.1905	1.0002	-.0009
4.6	3.6408	1.0000	.0001	5.2905	1.0002	-.0006
4.7	3.7408	1.0000	.0001	5.3905	1.0001	-.0004
4.8	3.8408	1.0000	.0001	5.4905	1.0001	-.0003
4.9	3.9408	1.0000	.0000	5.5905	1.0000	-.0002
5.0	4.0408	1.0000	.0000	5.6905	1.0000	-.0001
5.1	4.1408	1.0000	.0000	5.7905	1.0000	-.0001
5.2	4.2408	1.0000	.0000	5.8905	1.0000	-.0001
5.3	4.3408	1.0000	.0000	5.9905	1.0000	.0000
5.4	4.4408	1.0000	.0000	6.0905	1.0000	.0000
5.5	4.5408	1.0000	.0000	6.1905	1.0000	.0000
5.6	4.6408	1.0000	.0000	6.2905	1.0000	.0000
5.7	4.7408	1.0000	.0000	6.3905	1.0000	.0000
5.8	4.8408	1.0000	.0000	6.4905	1.0000	.0000
5.9	4.9408	1.0000	.0000	6.5905	1.0000	.0000
6.0	5.0408	1.0000	.0000	6.6905	1.0000	.0000

TABLE I. - Concluded. BOUNDARY-LAYER SOLUTIONS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

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$\frac{T_w}{T_0} = 1$; $\frac{1}{T_e^*} = 5.0$; k = 1.2						
λ	f	f' or Θ	f'' or Θ'	ψ	ψ'	ψ''
0.0	0.0000	0.0000	0.7096	0.0000	0.0000	3.9251
.1	.0036	.0710	.7093	.0187	.3646	3.3674
.2	.0142	.1418	.7072	.0711	.6739	2.8227
.3	.0319	.2123	.7018	.1517	.9299	2.3023
.4	.0566	.2820	.6918	.2554	1.1355	1.8152
.5	.0883	.3505	.6765	.3772	1.2943	1.3688
.6	.1267	.4171	.6552	.5128	1.4108	.9686
.7	.1716	.4813	.6279	.6582	1.4897	.6183
.8	.2228	.5425	.5950	.8097	1.5362	.3198
.9	.2800	.6001	.5571	.9645	1.5554	.0733
1.0	.3427	.6538	.5153	1.1200	1.5525	-.1228
1.1	.4106	.7031	.4706	1.2744	1.5324	-.2714
1.2	.4832	.7478	.4244	1.4261	1.4997	-.3767
1.3	.5600	.7880	.3779	1.5741	1.4584	-.4439
1.4	.6406	.8234	.3322	1.7176	1.4120	-.4786
1.5	.7245	.8545	.2884	1.8564	1.3635	-.4869
1.6	.8114	.8812	.2473	1.9903	1.3153	-.4746
1.7	.9007	.9040	.2095	2.1195	1.2691	-.4472
1.8	.9920	.9232	.1753	2.2443	1.2262	-.4096
1.9	1.0852	.9392	.1449	2.3649	1.1874	-.3661
2.0	1.1798	.9523	.1184	2.4819	1.1531	-.3202
2.1	1.2756	.9630	.0956	2.5957	1.1233	-.2745
2.2	1.3723	.9716	.0763	2.7067	1.0981	-.2311
2.3	1.4698	.9784	.0602	2.8154	1.0770	-.1912
2.4	1.5680	.9837	.0470	2.9222	1.0597	-.1557
2.5	1.6665	.9879	.0363	3.0275	1.0457	-.1248
2.6	1.7655	.9911	.0277	3.1315	1.0346	-.0986
2.7	1.8647	.9935	.0209	3.2345	1.0258	-.0768
2.8	1.9642	.9953	.0156	3.3367	1.0191	-.0589
2.9	2.0638	.9966	.0115	3.4383	1.0139	-.0447
3.0	2.1635	.9976	.0084	3.5395	1.0101	-.0334
3.1	2.2633	.9983	.0061	3.6404	1.0072	-.0246
3.2	2.3631	.9988	.0043	3.7410	1.0051	-.0179
3.3	2.4630	.9992	.0031	3.8414	1.0035	-.0129
3.4	2.5630	.9995	.0021	3.9417	1.0024	-.0092
3.5	2.6629	.9996	.0015	4.0419	1.0017	-.0064
3.6	2.7629	.9998	.0010	4.1420	1.0011	-.0045
3.7	2.8629	.9998	.0007	4.2421	1.0007	-.0031
3.8	2.9629	.9999	.0005	4.3422	1.0005	-.0021
3.9	3.0629	.9999	.0003	4.4422	1.0003	-.0014
4.0	3.1628	1.0000	.0002	4.5422	1.0002	-.0009
4.1	3.2628	1.0000	.0001	4.6423	1.0001	-.0006
4.2	3.3628	1.0000	.0001	4.7423	1.0001	-.0004
4.3	3.4628	1.0000	.0001	4.8423	1.0001	-.0003
4.4	3.5628	1.0000	.0000	4.9423	1.0000	-.0002
4.5	3.6628	1.0000	.0000	5.0423	1.0000	-.0001
4.6	3.7628	1.0000	.0000	5.1423	1.0000	-.0001
4.7	3.8628	1.0000	.0000	5.2423	1.0000	.0000
4.8	3.9628	1.0000	.0000	5.3423	1.0000	.0000
4.9	4.0628	1.0000	.0000	5.4423	1.0000	.0000
5.0	4.1628	1.0000	.0000	5.5423	1.0000	.0000
5.1	4.2628	1.0000	.0000	5.6423	1.0000	.0000
5.2	4.3628	1.0000	.0000	5.7423	1.0000	.0000
5.3	4.4628	1.0000	.0000	5.8423	1.0000	.0000
5.4	4.5628	1.0000	.0000	5.9423	1.0000	.0000
5.5	4.6628	1.0000	.0000	6.0423	1.0000	.0000
5.6	4.7628	1.0000	.0000	6.1423	1.0000	.0000
5.7	4.8628	1.0000	.0000	6.2423	1.0000	.0000
5.8	4.9628	1.0000	.0000	6.3423	1.0000	.0000
5.9	5.0628	1.0000	.0000	6.4423	1.0000	.0000
6.0	5.1628	1.0000	.0000	6.5423	1.0000	.0000

TABLE II. - SUMMARY OF SKIN-FRICTION AND HEAT-TRANSFER PARAMETERS FOR MOST WINDWARD STREAMLINE OF A CONE AT ANGLE OF ATTACK WITH PRANDTL NUMBER OF 1

$\frac{T_w}{T_0}$	$\frac{1}{T_e^*}$	k	f''_w or Θ'_w	ψ''_w
0	0	0	0.3321	[a]0.4238
		.6	.4330	.5527
		1.2	.5143	.6570
	2.5	0	0.3321	[a]0.6532
		.6	.4598	.8596
		1.2	.5569	1.0281
	5.0	0	0.3321	[a]0.8826
		.6	.4815	1.1422
		1.2	.5898	1.3634
0.5	0	0	0.3321	[a]0.5923
		.6	.4468	.7888
		1.2	.5367	.9460
	2.5	0	0.3321	[a]1.2430
		.6	.4944	1.5922
		1.2	.6092	1.8998
	5.0	0	0.3321	[a]1.8937
		.6	.5291	2.3034
		1.2	.6594	2.7287

$\frac{T_w}{T_0}$	$\frac{1}{T_e^*}$	k	f''_w or Θ'_w	ψ''_w
1.0	0	0	0.3321	[b]0.7609
		.4	.4215	.9358
		.8	.4935	1.0850
		1.2	.5559	1.2165
	1.0	0	0.3321	[b]1.1897
		.4	.4436	1.4266
		.8	.5278	1.6445
		1.2	.5995	1.8393
	2.5	0	0.3321	[b]1.8329
		.4	.4704	2.1030
		.8	.5675	2.4026
		1.2	.6487	2.6767
	5.0	0	0.3321	[b]2.9049
		.4	.5051	3.1300
		.8	.6172	3.5389
		1.2	.7096	3.9250

[a]Unpublished data obtained at NACA Lewis laboratory.

[b]Ref. 3.

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TABLE III. - HEAT-TRANSFER PARAMETER AND RECOVERY FACTOR FOR PRANDTL NUMBER OF 0.7 AND $1/T_e^* = 0$

Heat transfer		
k	Θ_w'	a
0	*0.2928	0.353
.4	.3697	.366
.8	.4317	.375
1.2	.4857	.379
Recovery factor		
k	r	b
0	*0.8358	0.503
.4	.8398	.489
.8	.8425	.481
1.2	.8438	.476

*Extrapolated from solutions in ref. 12 for Pr = 0.72.

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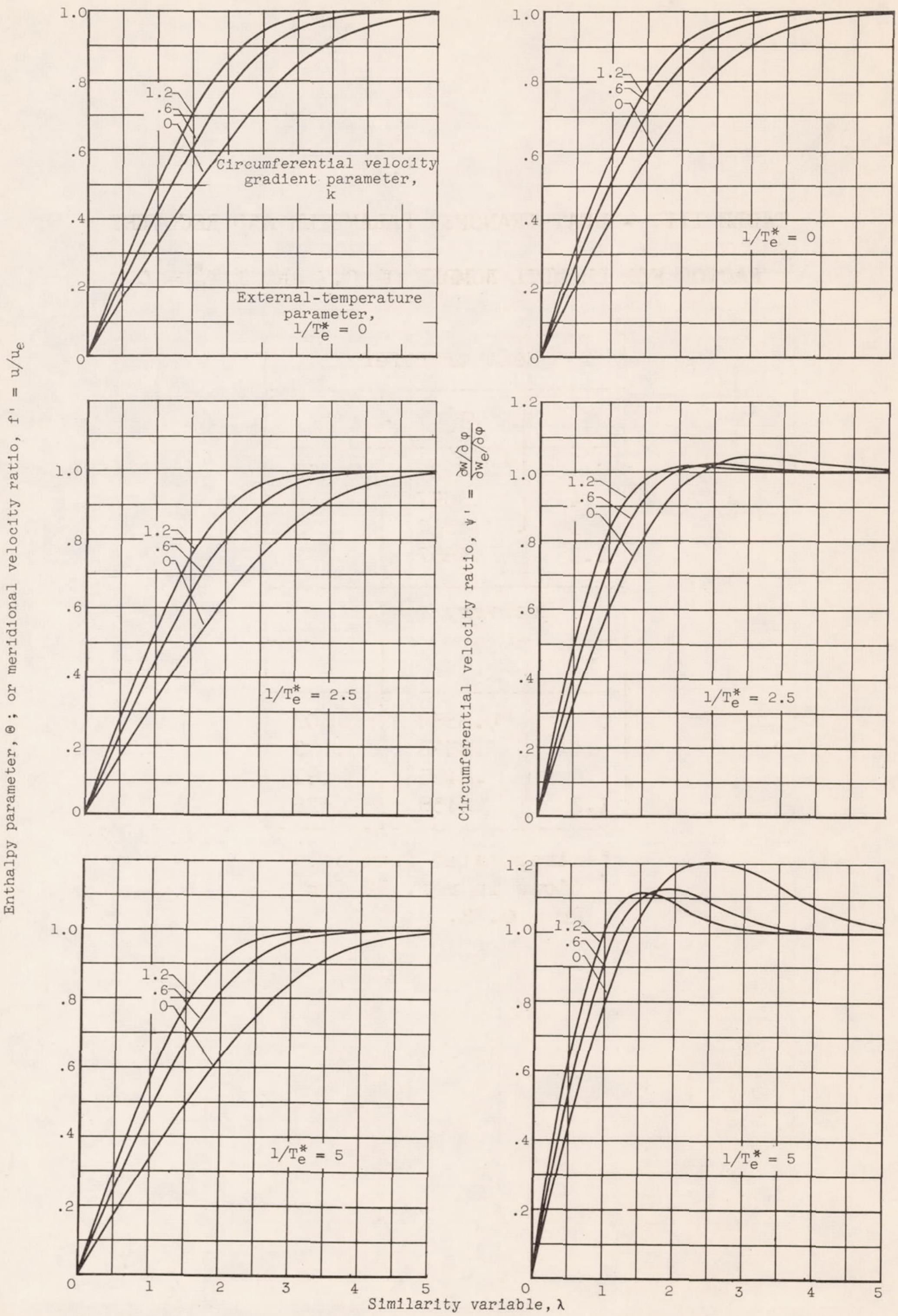
CW-7 back



(a) $T_w/T_0 = 0$.

Figure 1. - Velocity and enthalpy profiles at most windward streamline of yawed cone.

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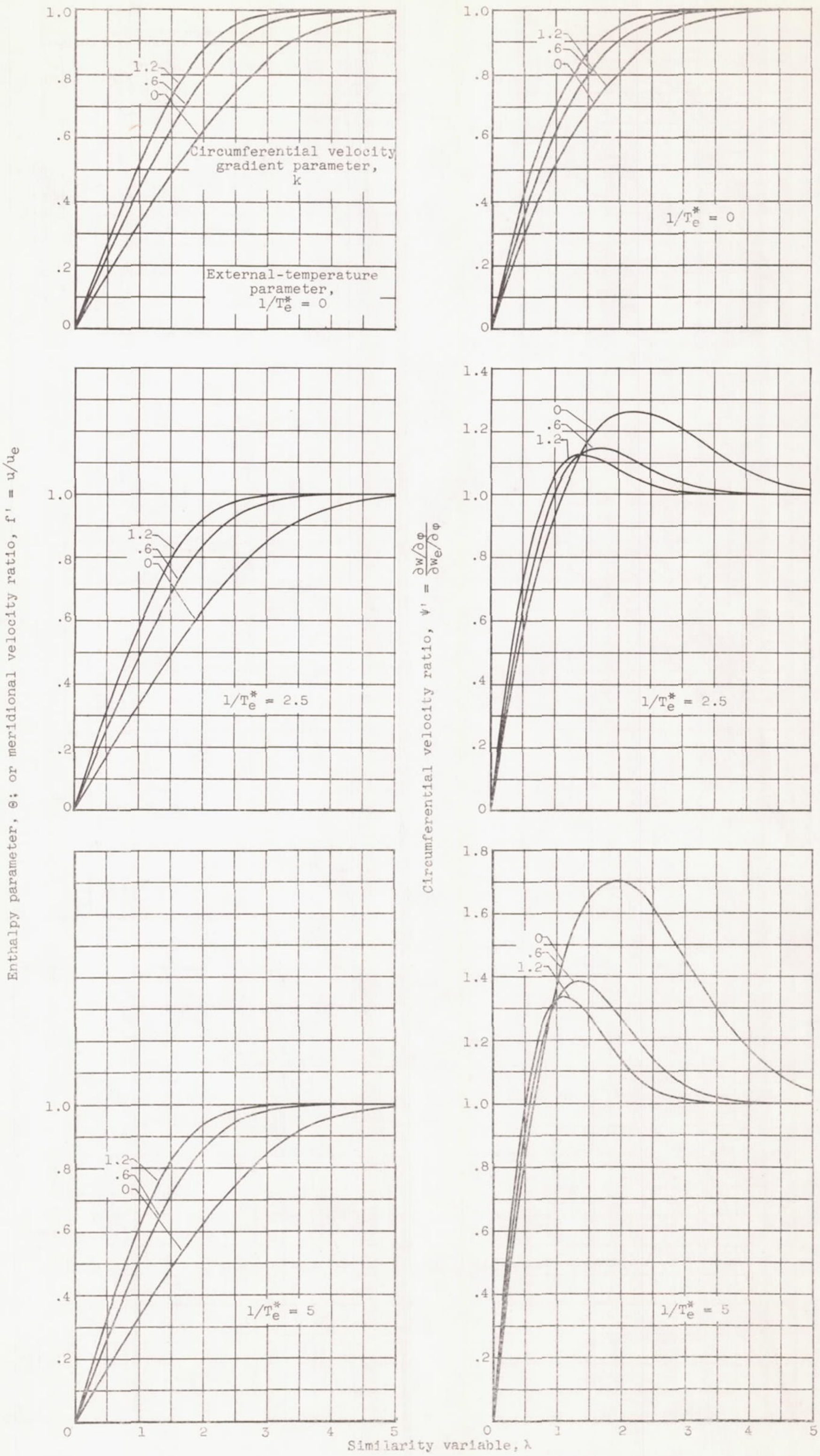

(b) $T_W/T_O = 0.5$.

Figure 1. - Continued. Velocity and enthalpy profiles at most windward streamline of yawed cone.

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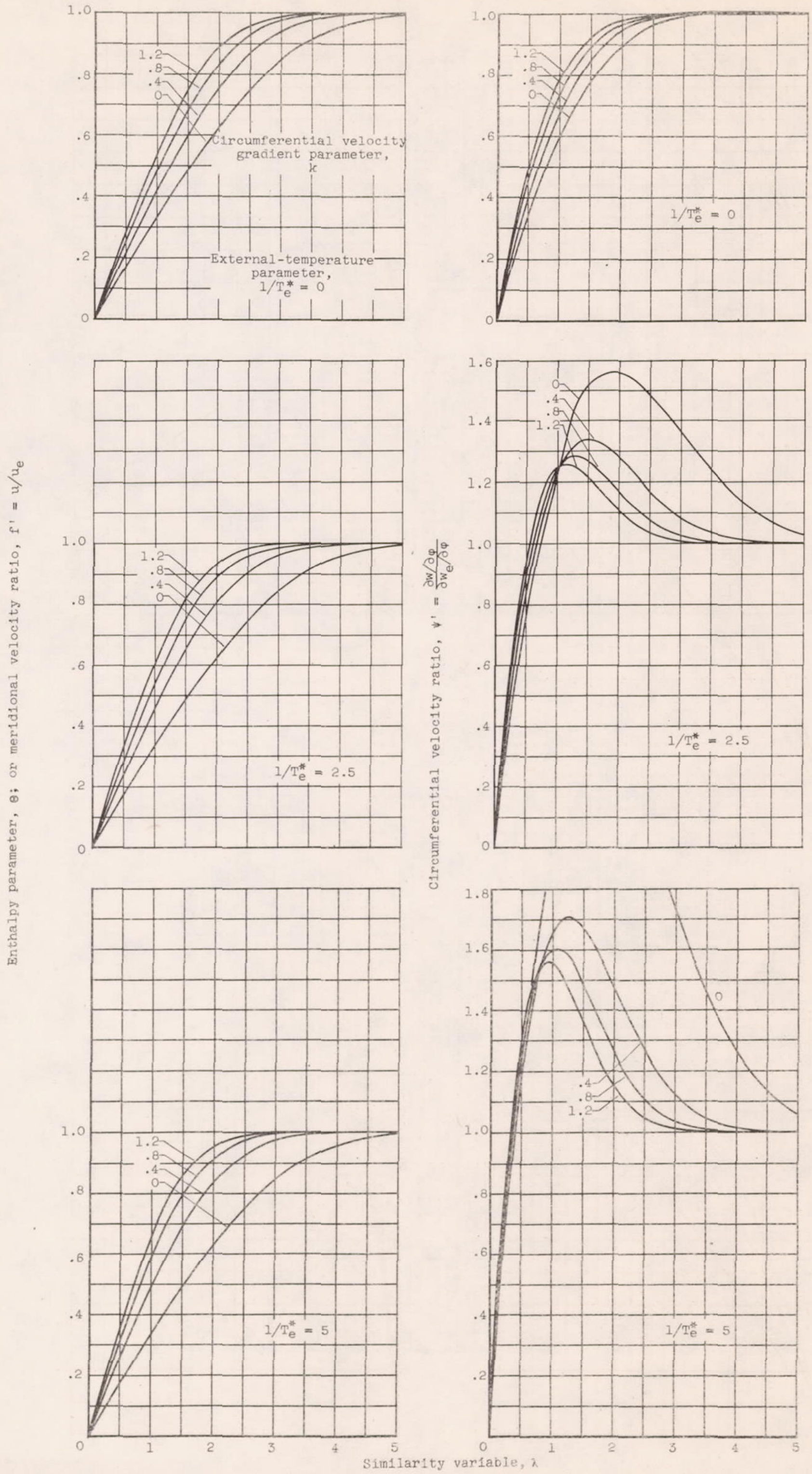
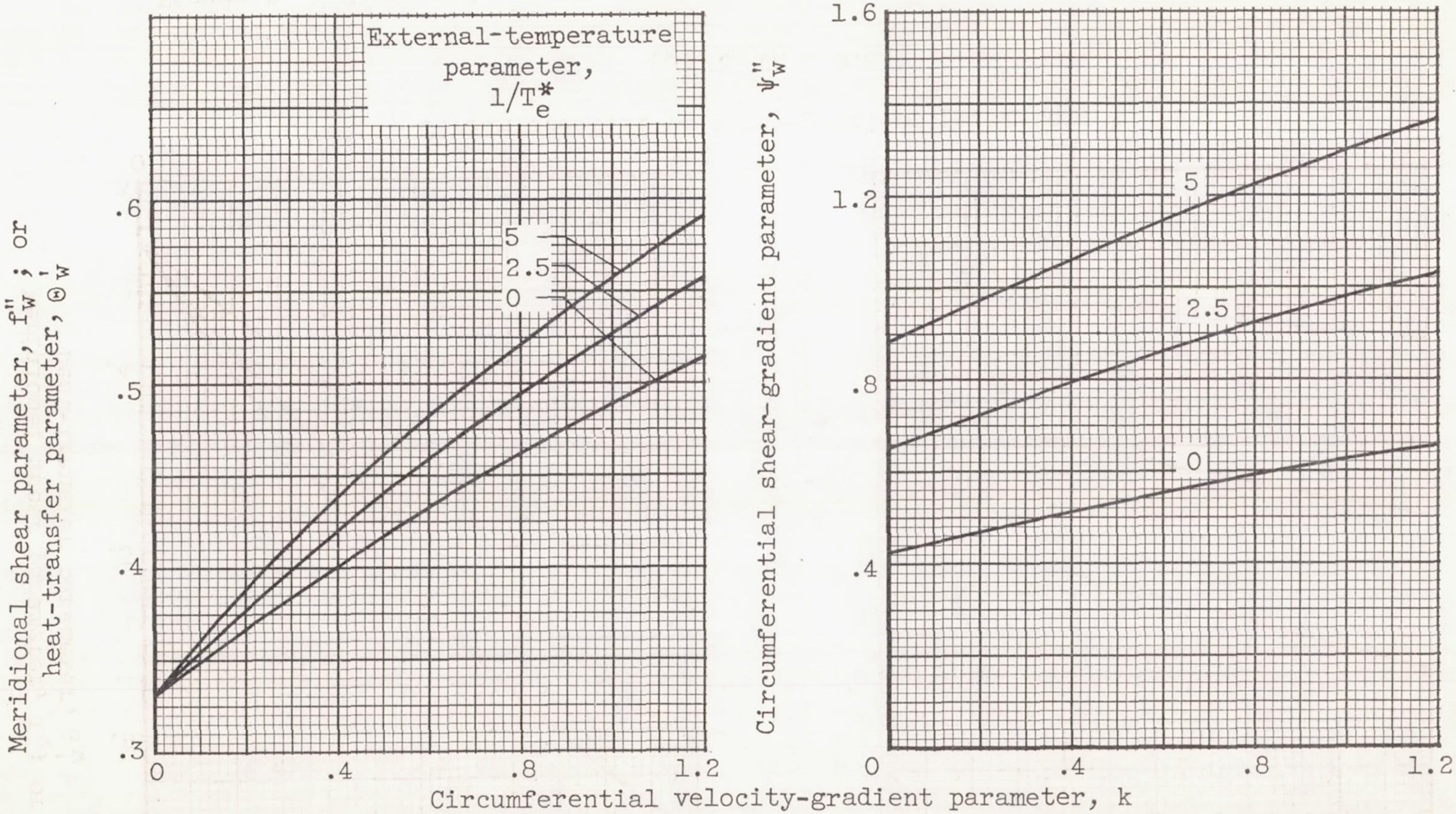


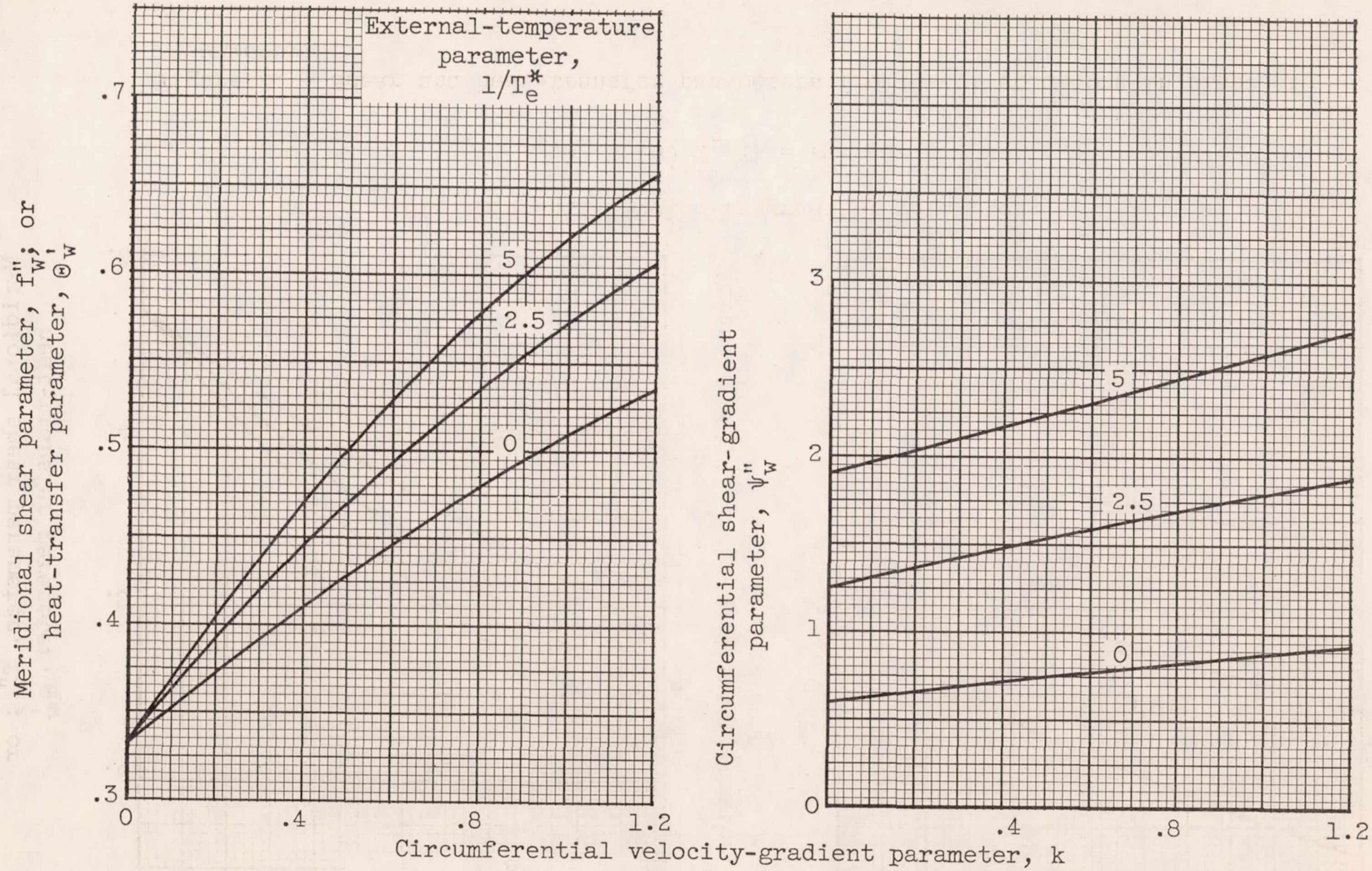
(c) $T_W/T_0 = 1.0$.

Figure 1. - Concluded. Velocity and enthalpy profiles at most windward streamline of yawed cone.



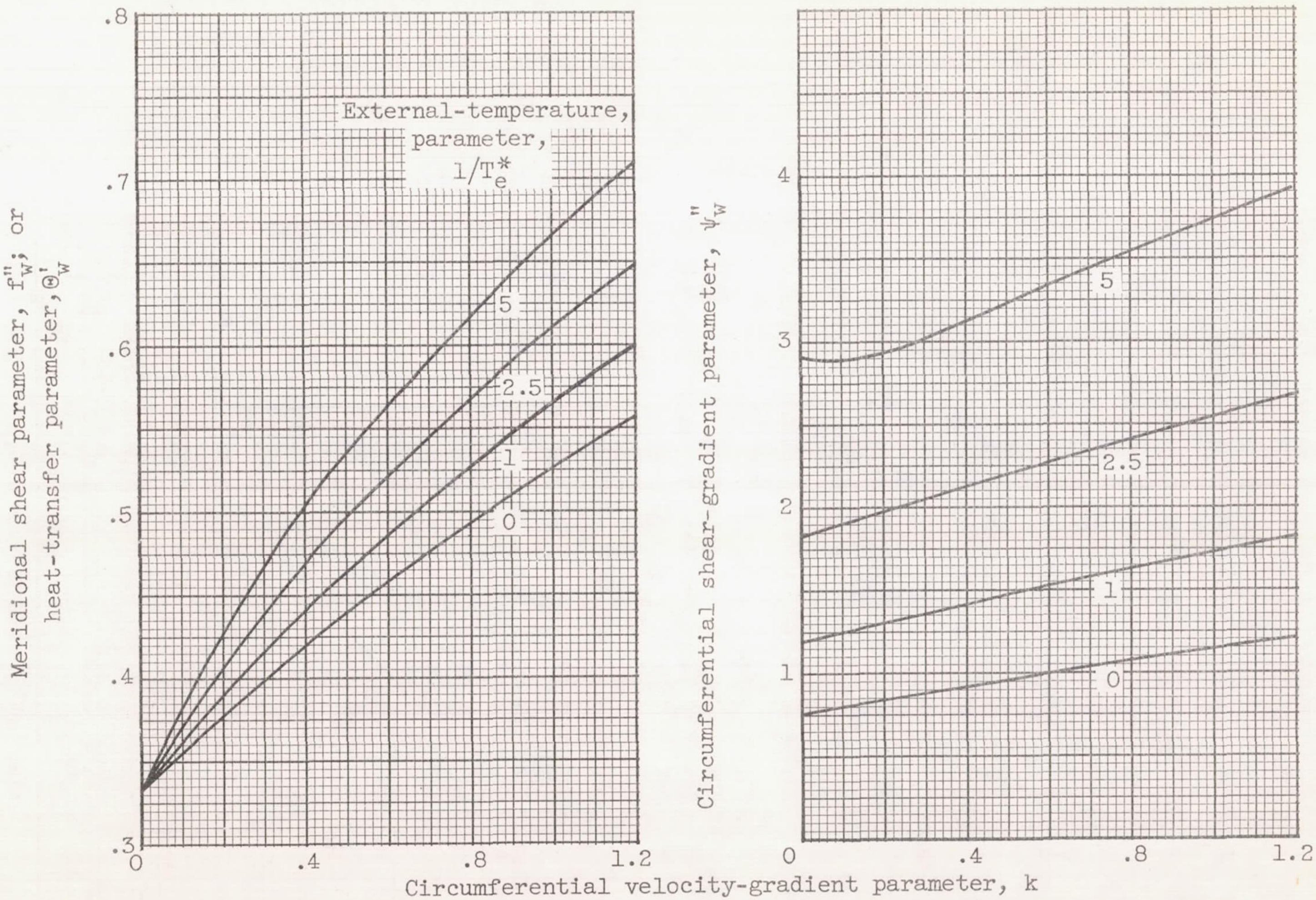
(a) $T_W/T_O = 0$.

Figure 2. - Shear and heat-transfer parameters from exact solutions in plane of symmetry.



(b) $T_w/T_0 = 0.5$.

Figure 2. - Continued. Shear and heat-transfer parameters from exact solutions in plane of symmetry.



(c) $T_w/T_0 = 1.0$.

Figure 2. - Concluded. Shear and heat-transfer parameters from exact solutions in plane of symmetry.

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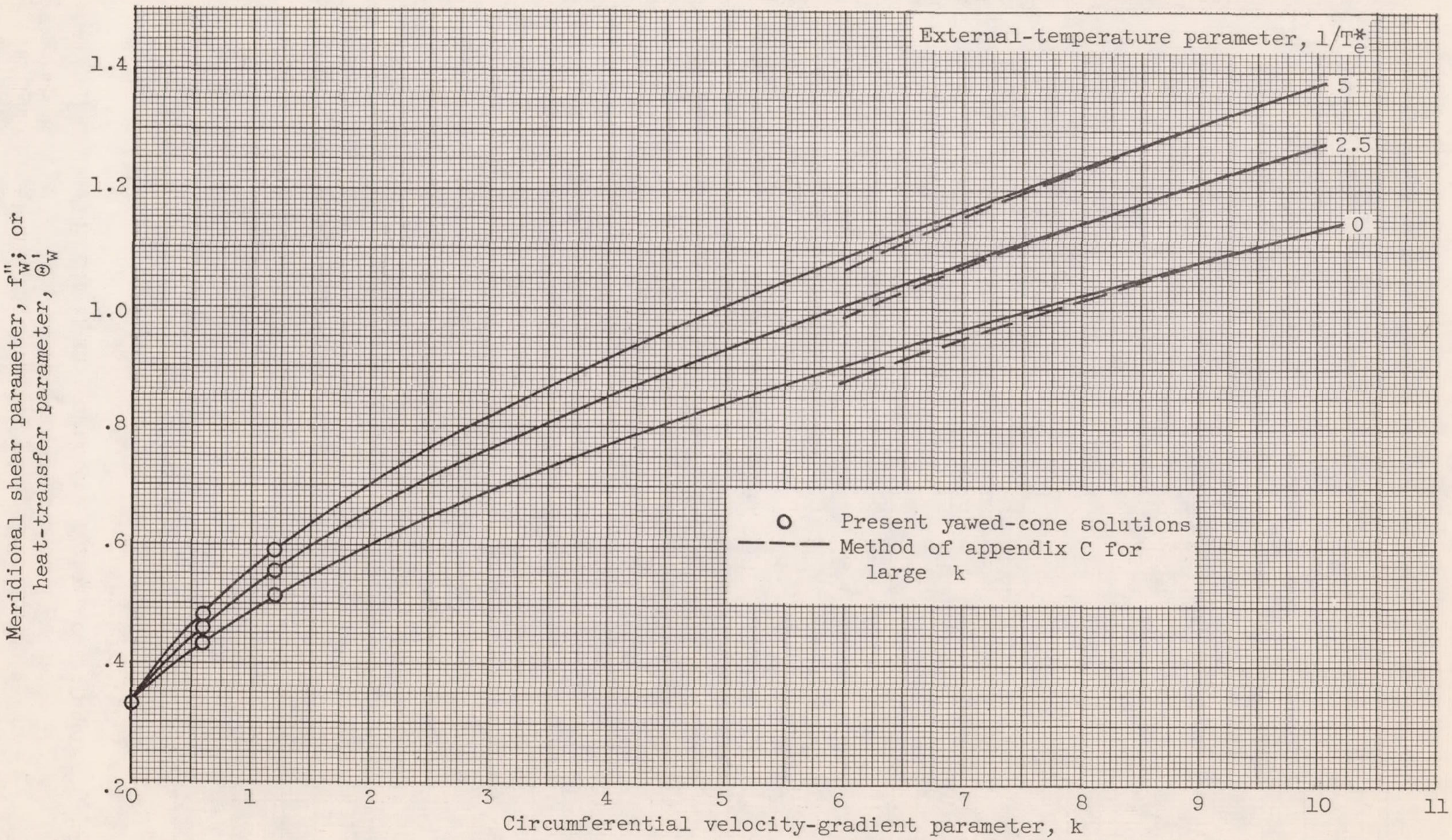
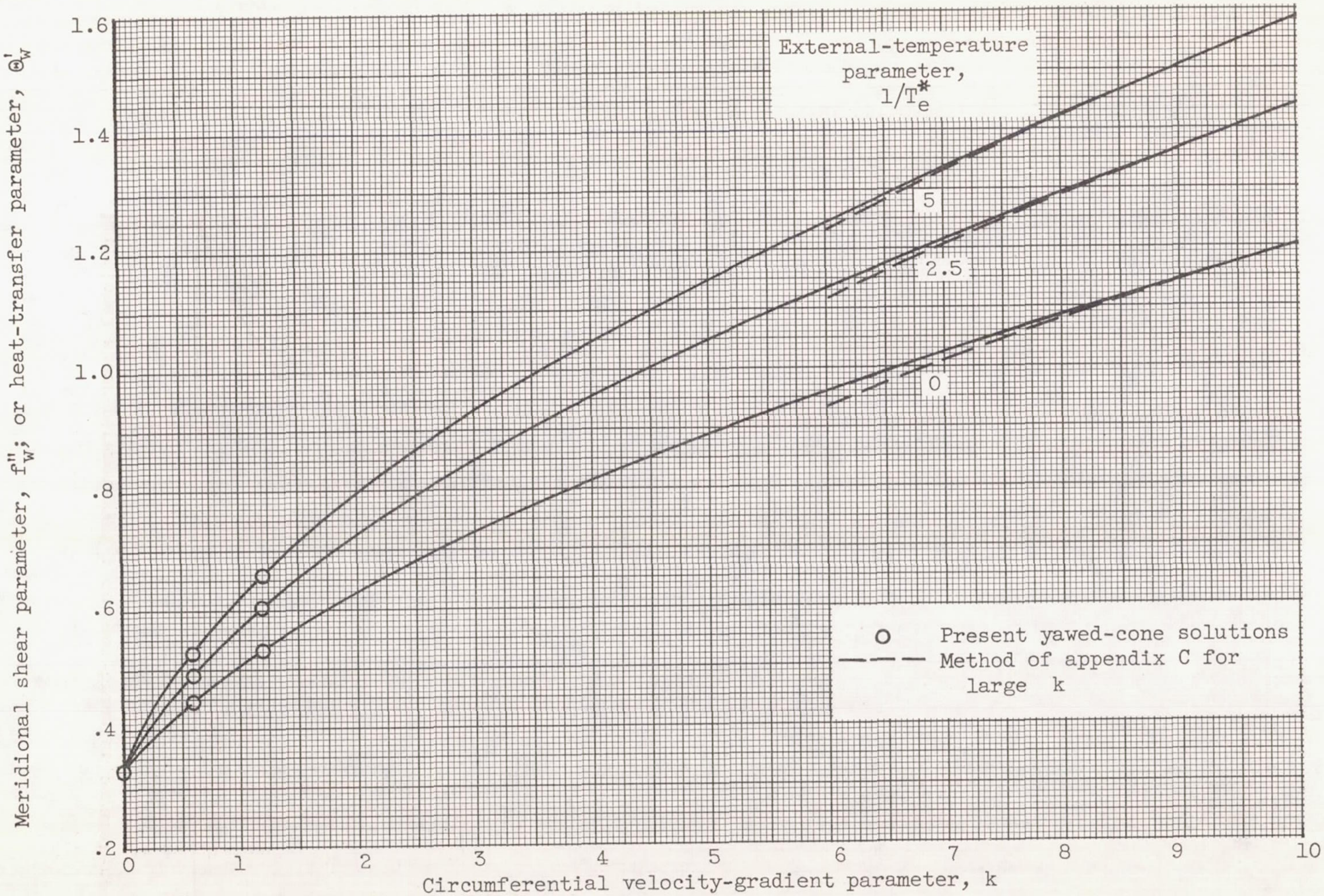


(a) $T_w/T_0 = 0$.

Figure 3. - Extension of meridional shear or heat-transfer parameter to very large yaw.



(b) $T_w/T_0 = 0.5$.

Figure 3. - Continued. Extension of meridional shear or heat-transfer parameter to very large yaw.

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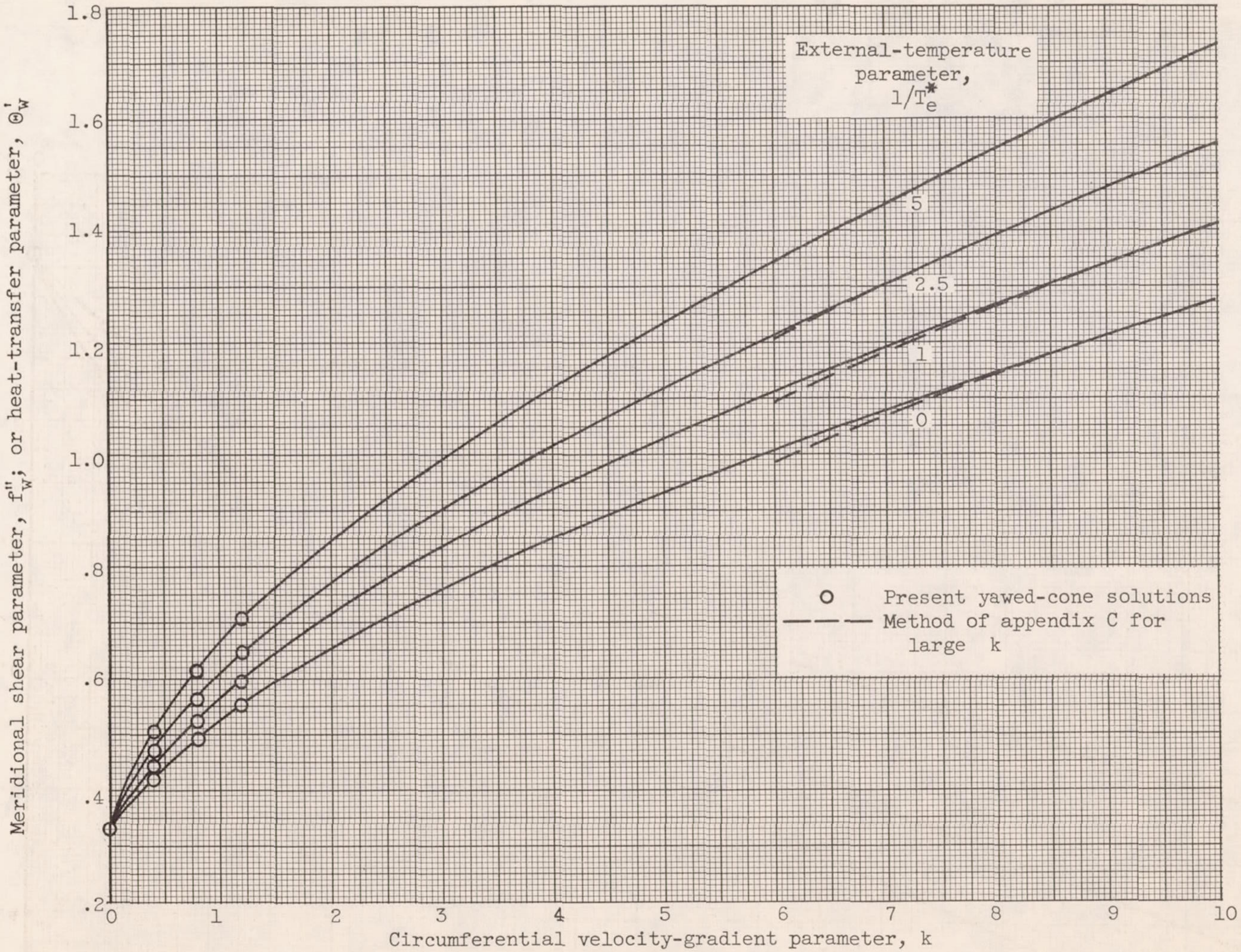

(c) $T_w/T_0 = 1.0$.

Figure 3. - Concluded. Extension of meridional shear or heat-transfer parameter to very large yaw.

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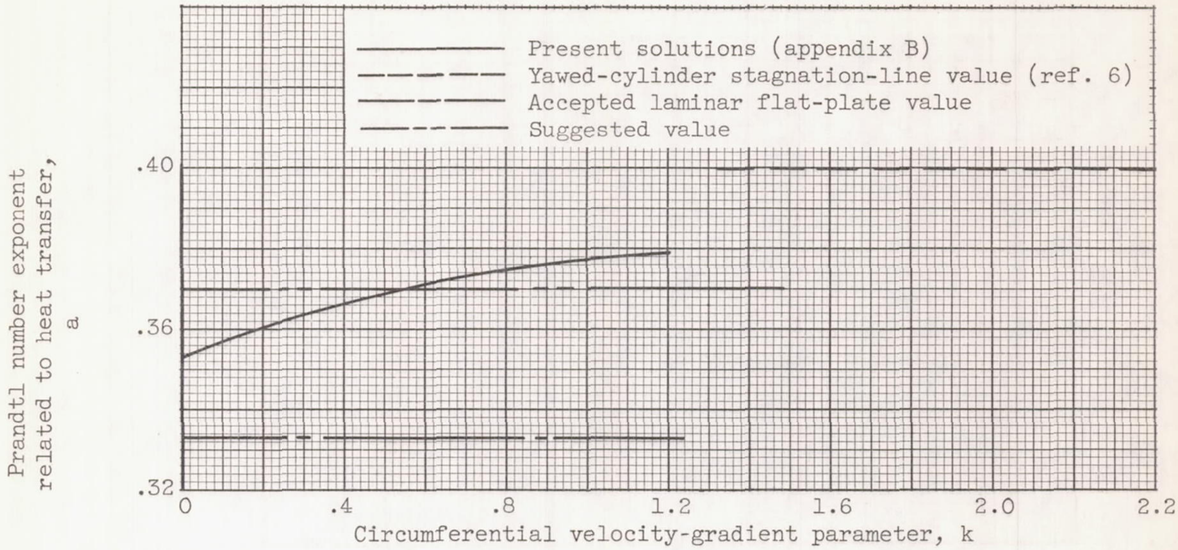


Figure 4. - Prandtl number correction to heat-transfer parameter for yawed cone. $\left[\left(\frac{H_0 - H_w}{H_{a,w} - H_w}\right)\Theta_w'\right]_{Pr\neq 1} = \left[\Theta_w'\right]_{Pr=1} Pr^a$

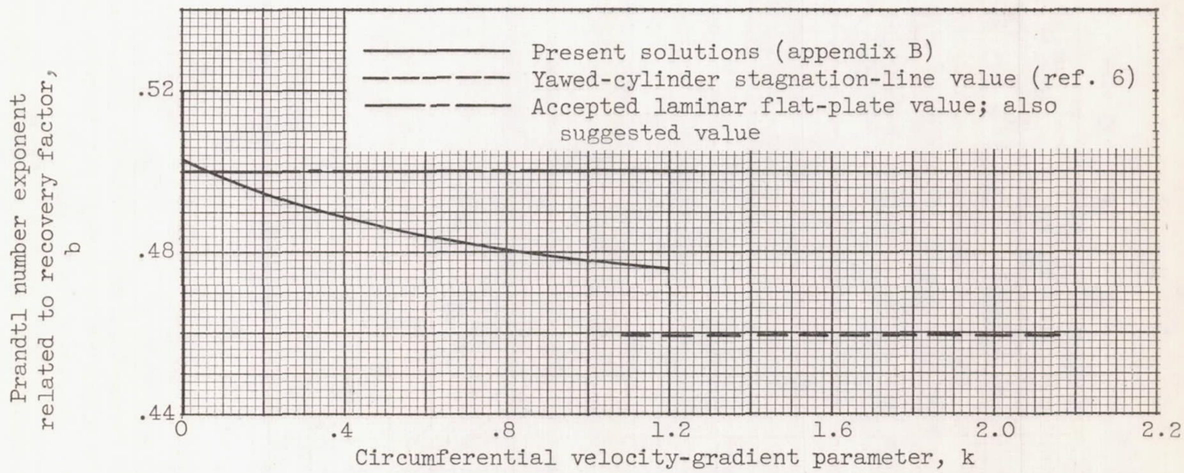
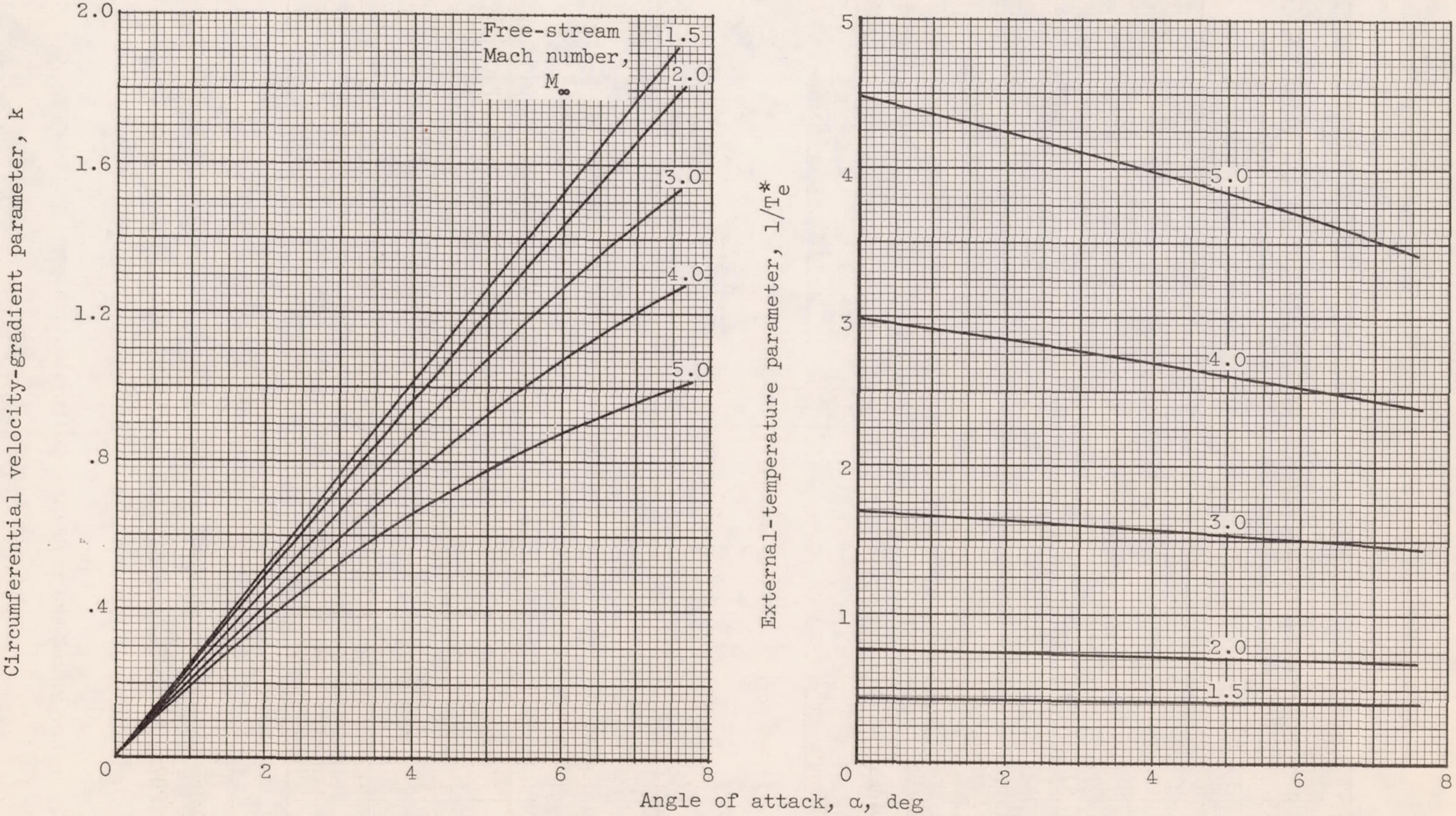
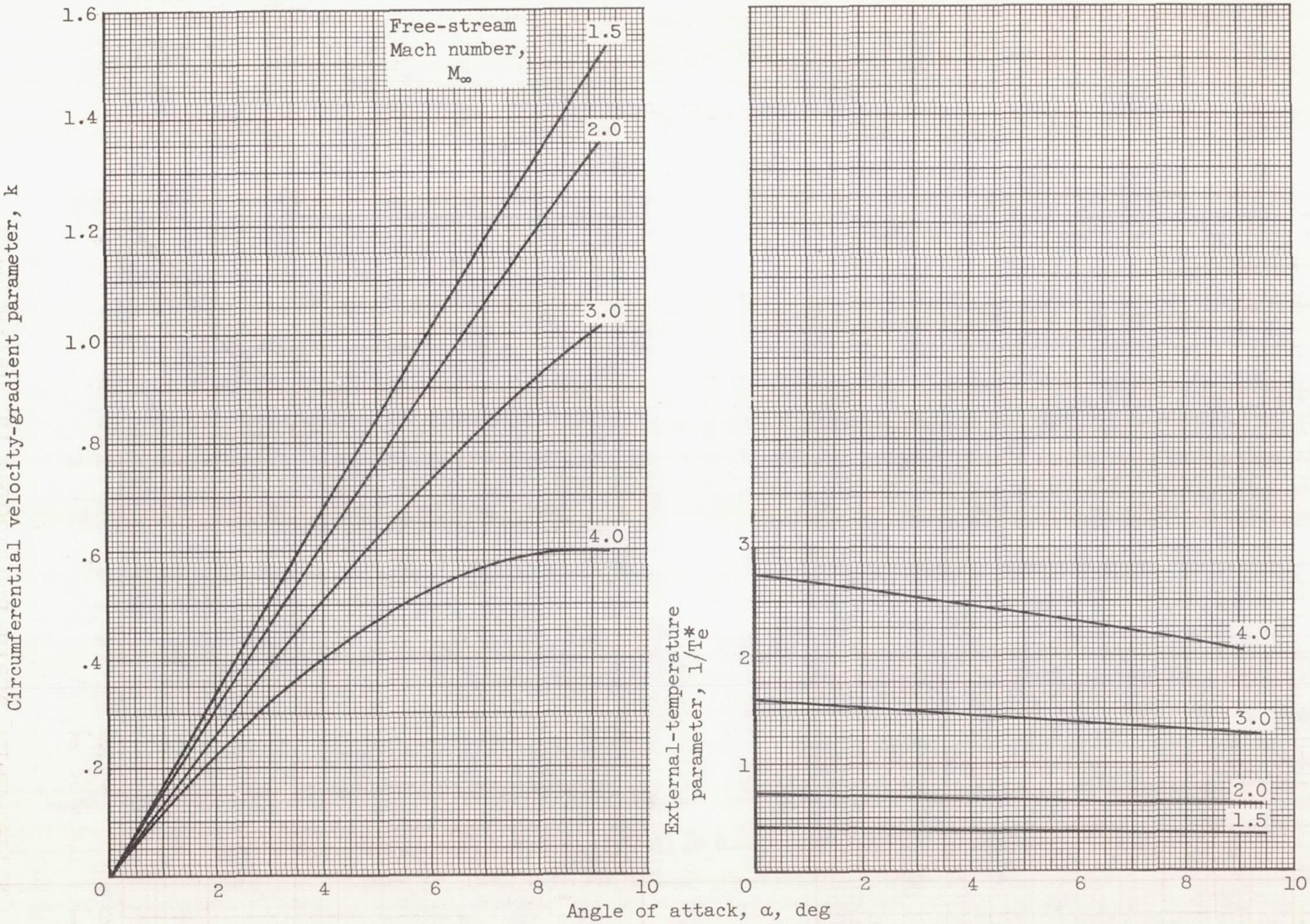


Figure 5. - Dependence of recovery factor r on Prandtl number for yawed cone. $(r = Pr^b)$



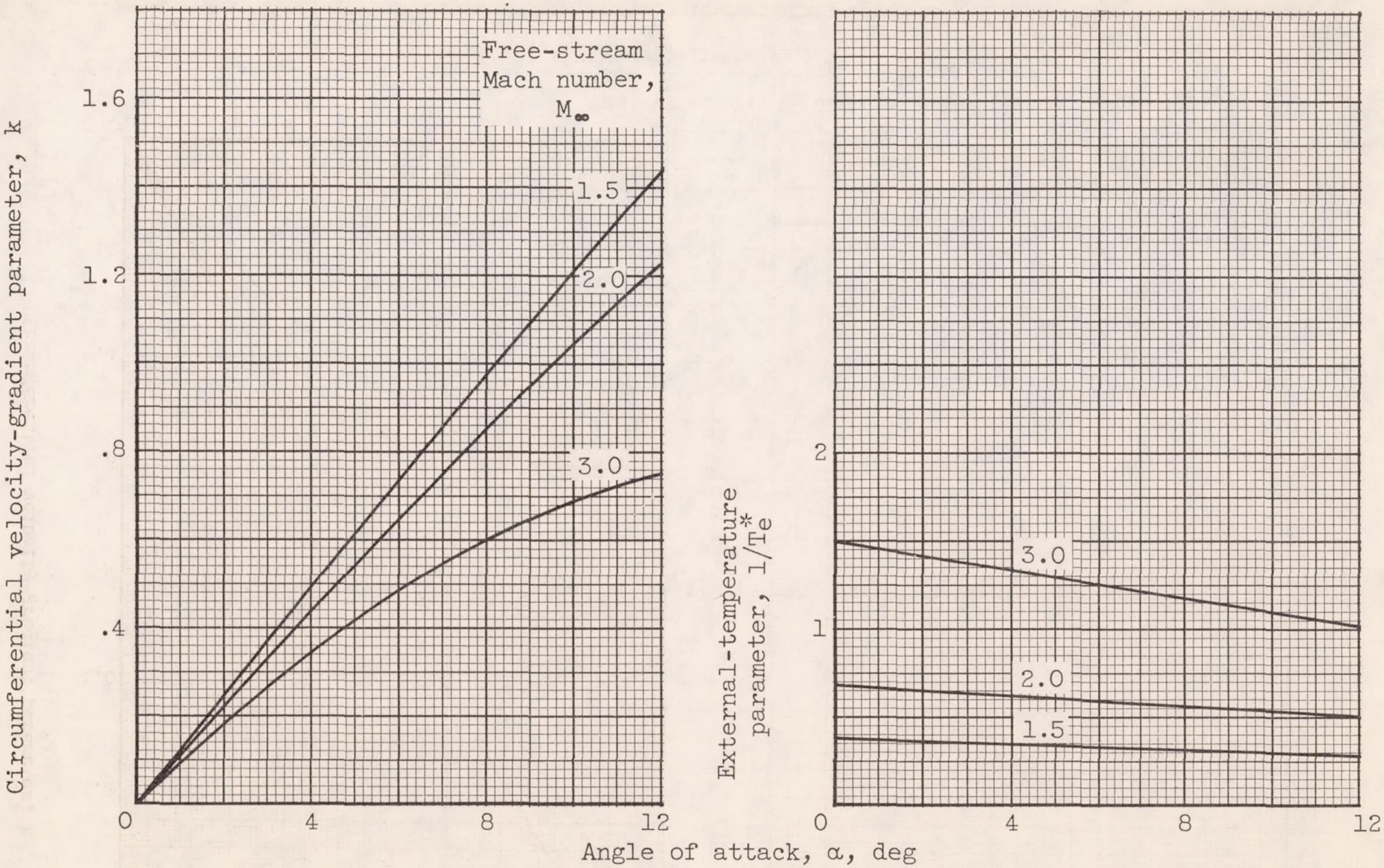
(a) Cone half-angle, 5°.

Figure 6. - Parameters from external inviscid flow required for evaluating viscous effects on windward side of cone in plane of symmetry (M.I.T. tables, refs. 8 to 10).



(b) Cone half-angle, 7.5°.

Figure 6. - Continued. Parameters from external inviscid flow required for evaluating viscous effects on windward side of cone in plane of symmetry (M.I.T. tables, refs. 8 to 10).



(c) Cone half-angle, 10°.

Figure 6. - Concluded. Parameters from external inviscid flow required for evaluating viscous effects on windward side of cone in plane of symmetry (M.I.T. tables, refs. 8 to 10).

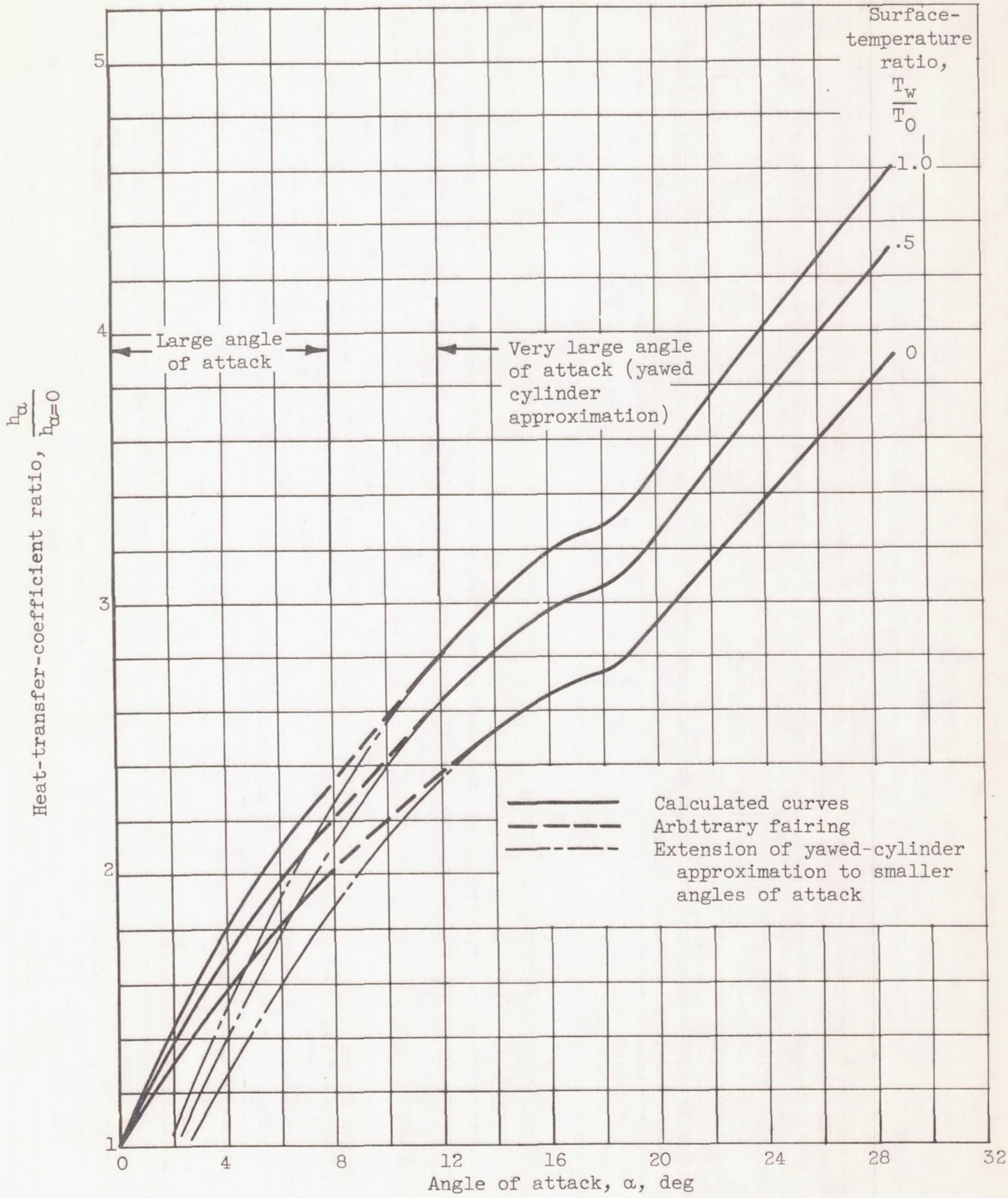


Figure 7. - Effect of angle of attack on heat-transfer coefficient at most windward streamline of a 5° half-angle cone at free-stream Mach number of 3.1.