APPENDIX 1

ARTIFICIALLY GENERATED PROFILES

ARTIFICIALLY GENERATED PROFILES

The methods available are primarily intended to produce some specified velocity profile in a two-dimensional duct, and most are based on some form of graded flow blockage operating on the upstream flow to give a particular type of profile.

The most general theory for generation of a velocity profile was given by Elder (21). A grid or gauze of varying flow resistance was specified with a varying angle to the main flow; the general principle is illustrated in Fig. A.1.1. This theory has lately been re-examined by Turner (75) who, after some modification, applied numerical analysis techniques to the problem of designing a gauze to produce a given velocity distribution.

An earlier theory of Owen and Zienkiewitz (49) is actually a special case of Elder's analysis, and employs a graded grid to produce a stable uniform shear flow. The experimental application of their method has been independently verified by Livesey and Turner (39).

A simpler principle, using a wall flow spoiler as shown in Fig. A.1.2, was applied by Livesey and Turner (38) to the production of peaked velocity profiles with a high degree of turbulent mixing in a two-dimensional duct.

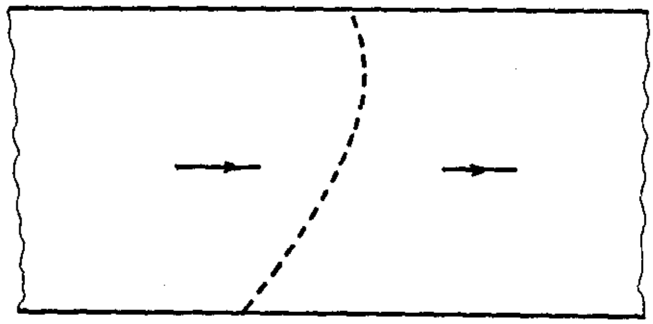
The artificial thickening of boundary layers has been experimentally investigated by Brighton (8) and Stevens and Markland (68), for circular and annular pipes respectively (see Fig. A.1.3), Brighton noted the use of a circular screen of rods while Stevens and Markland employed gauze screen rings. Both papers note that a 'trial and error' approach was necessary to produce a specific velocity profile.

These last examples serve to illustrate one of the main problems in that two-dimensional methods cannot easily be applied in the case where there is transverse wall curvature.

A further problem is that none of the methods considers the generated turbulence structure. The possible beneficial effects of inlet turbulent mixing on diffuser flow have been indicated in Section 1.4. Since diffuser inlet velocity profile effects are fairly well understood, and in view of the highly turbulent nature of many engineering flows, it was felt that the effects of a high level of turbulent mixing at inlet should be quantified experimentally by applying increased flow mixing to particular inlet velocity profiles.

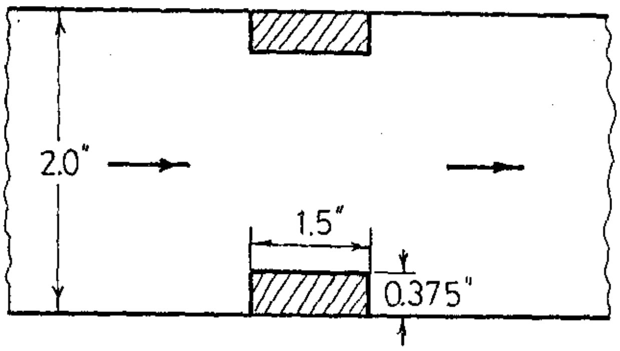
To this end, having regard to the limitations imposed by the annular test diffuser geometry, coarse gauze and flow spoiler methods were used; these are described in detail in Section 2.3 of the main text.

FIGURE A.1.1



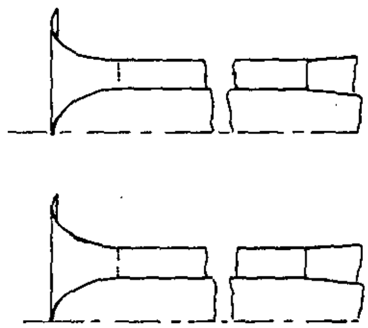
TWO-DIMENSIONAL GAUZE GRID SYSTEM — ELDER(21)

FIGURE A.1.2

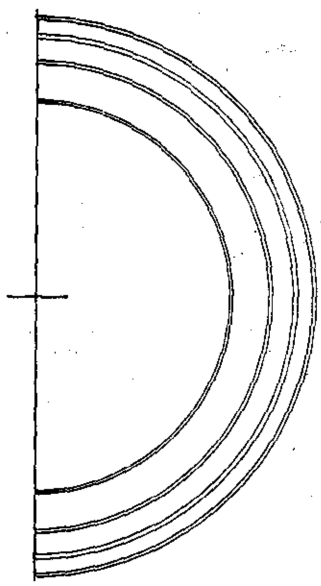


PEAKED VELOCITY PROFILE GENERATOR — LIVESEY & TURNER(38)

FIGURE A.1.3



STEVENS & MARKLAND(68)
GAUZE RINGS



BRIGHTON(8)CIRCULAR SCREEN

APPENDIX 2

MEAN VELOCITY MEASUREMENTS

MEAN VELOCITY MEASUREMENTS

A.2.1. Mean Velocity Data Analysis

The non-dimensional mean velocity profile $(\frac{u}{U})$ data was analysed by a computer program using numerical integration techniques to give the following parameters:

Inner and Outer Wall Boundary Layers

δ^*_{2-D} , δ^*	two-dimensional and axi-symmetric displacement thicknesses
θ_{2-D} , θ	two-dimensional and axi-symmetric momentum thicknesses
δ^{**}_{2-D} , δ^{**}	two-dimensional and axi-symmetric energy thicknesses
H_{2-D} , H	two-dimensional and axi-symmetric shape parameter
$\overline{H}_{2-D}$, $\overline{H}$	two-dimensional and axi-symmetric shape parameter
$R_{\theta_{2-D}}$, R_θ	Reynolds number based on momentum thickness

Velocity Profile

α	kinetic energy flux coefficient
β	momentum flux coefficient
$(\overline{u}/U)$	mass mean velocity ratio
Q	total volume flow in annulus

The calculation of these parameters required the use of area integration techniques and in this case the trapezoidal rule was applied.

For each station a smooth curve was drawn through all the velocity experimental data points; in the event of marked asymmetry each profile was analysed separately.

Each boundary layer velocity profile was divided into a number of equal intervals (dR), see Fig. A.2.1, such that there was a sufficiently accurate 'near wall' representation of the velocity profile. Further to this end the first data point was taken at a variable distance (DISP) from the adjacent wall. This $(\frac{u}{U}) \sim R$ data was encoded onto punch cards for computer input.

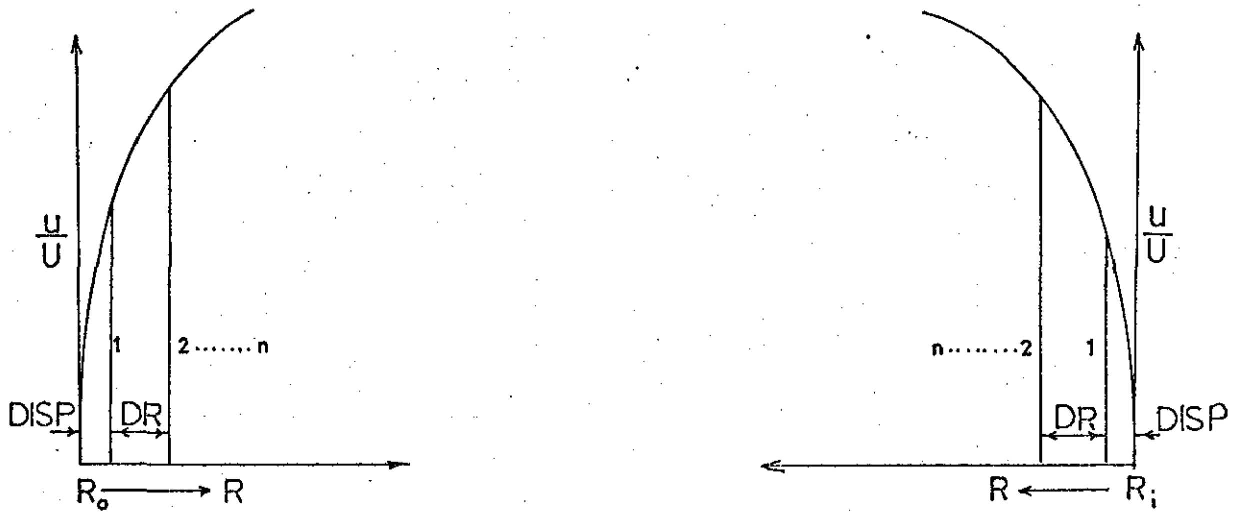


Figure A.2.1

Taking the two-dimensional value of displacement thickness as an example we have:

$$\delta^*_{2-D} = \int_{R_o-\delta_o}^{R_o} (1 - \frac{u}{U})\, dR = f_1 \cdot \frac{DISP}{2} + \sum_{BL} (f_n + f_{n+1}) \frac{dR}{2}$$

where $f_n = (1 - \frac{u}{U})_n$

$f_{n+1} = (1 - \frac{u}{U})_{n+1}$

The flow chart shown in Fig. A.2.2 outlines the computation procedure used.

A graphical check was carried out on the program computation, through area integrations performed by planimeter. Checks were made at several stations; a typical comparison shown below confirms the accuracy of the numerical analysis computer program, within the accuracy limits of the planimeter technique.

$\overline{L}/\Delta R_1 = 10.0$, $L_e/D_{h_1} = 2.0$, $AR_{1-2} = 2.0$

Naturally developed inlet conditions

$X/N = 0.145$ Outer wall

	Planimeter**	Computed
δ^*_{2-D}	0.0408 in.	0.0406 in.
θ_{2-D}	0.0270 in.	0.0267 in.

** mean of three integrations

A.2.2 Accuracy of Velocity Measurement

The measurement system used consisted of wall static tappings combined with radial total pressure traverses. The dynamic head ($\frac{1}{2}\rho u^2$) so measured was recorded on a Betz micromanometer reading pressures of up to 10.00 in. water gauge with an accuracy of 0.005 in.

To minimise the effect of flow distortion on the static pressure measurement, the tappings were kept to a diameter of 0.030 in. The flattened end pitot tube, when corrected for total pressure gradient, gave an effective wall displacement, applying the correction of Young and Maas (85), of 0.015 in. No correction was applied to take account of the wall proximity effect as the effect is minimal, typically 0.25% of the dynamic pressure, and there is no generally applicable criterion.

Correct probe positioning was essential in this series of tests; measurements of inlet velocity near the wall for thin boundary layers could be 2% in error for a positioning error of 0.001 in., this being the worst case. Hence great care was taken to ensure correct probe positioning.

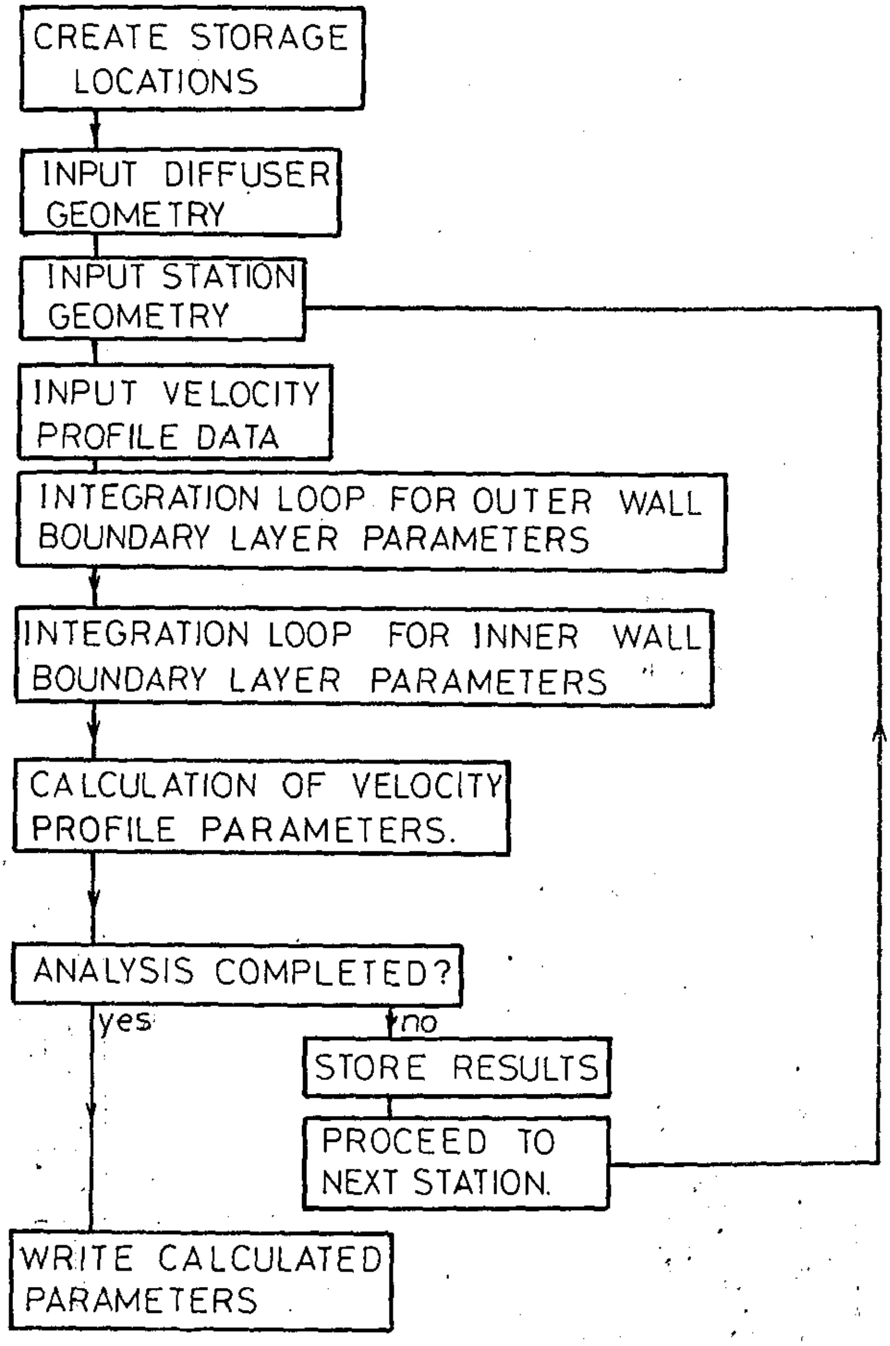
Probe alignment was less critical as yaw angles of at least $\pm$ 5^o were tolerated with negligible effect on total pressure measurement.

Turbulence effects on velocity measurement were similarly considered to be negligible for low local levels of turbulence in the region of

$(\sqrt{\overline{u'^2}}/u) = 0.10$; however, where very high local turbulence levels $(\sqrt{\overline{u'^2}}/u > 0.30)$ occurred, typically in near stall conditions, the mean velocity measured may have been overestimated in the order of 10-15% due to the high turbulent energy contribution to the total pressure measurement.

FIGURE A.2.2.

MEAN VELOCITY PROFILE—ANALYSIS PROCEDURE



APPENDIX 3

TURBULENCE MEASUREMENTS

Supplementary nomenclature list for Appendix 3.

I	Current through hot-wire.
E	Bridge voltage (mean).
e	Bridge voltage (a.c.).
R_w	Electrical resistance of hot-wire.
R_g	Wire resistance at gas temperature.
R_o	Wire resistance at reference temperature.
ρ	Resistivity of wire.
ℓ	Length of wire.
d	Diameter of wire.
ε	Power conversion factor.
π	Constant.
A	Constant.
B	Constant.
k_f	Thermal conductivity at film temperature.
μ_f	Dynamic viscosity at film temperature.
ρ_f	Gas density at film temperature.
$(Pr)_f$	Prandtl number at film temperature.
$(Re)_f$	Reynolds number at film temperature.

A.3.1 Operation of Hot-Wire Anemometer at Constant Temperature

The basic relationship for wire heat transfer can be found from the concept of thermal equilibrium. The heat loss per unit time must be equal to the heat generated per unit time by the electric current through the wire, see Hinze (28). This gives:

$$I^2 R_w = \frac{\varepsilon \pi k_f \ell}{\rho} \cdot \frac{R_w - R_g}{R_o} \left(0.42(Pr)_f^{0.2} + 0.57(Pr)_f^{0.33}(Re)_f^{0.50}\right) \qquad \text{A.3.1}$$

This relation is usually written in the form known as King's Law

$$\frac{I^2 R_w}{R_w - R_g} = A + B\sqrt{u_i} \qquad \text{A.3.2}$$

where A and B are constants and u_i is the instantaneous velocity.

For constant temperature operation the wire temperature is held constant by an electronic feedback system, thus we may write:

$$E^2 = A' + B'\sqrt{u_i}$$

$$\text{or } E^2 - E_o^2 = B'\sqrt{u_i} \qquad \text{A.3.3}$$

where E_o is the zero flow voltage, measured at the mid-annulus position.

An incompressible flow of mean velocity u is assumed with a turbulence component u' in the same direction and v' in the lateral direction, as shown in Fig. A.3.1. For the orientation shown the hot-wire is relatively insensitive to yaw caused by the fluctuation velocity w', and making the further assumption that the fluctuation velocities are small compared with u we may carry out the following analysis of hot-wire operation.

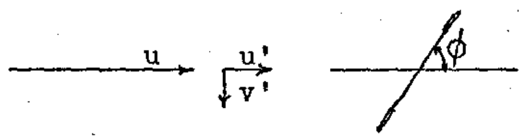


Figure A.3.1

w' is into the plane of the paper.

With $\phi = 90^0$, assuming the flow approaches the wire in a normal direction, we define the axial turbulence intensity as:

$$\sqrt{\overline{u'^2}} = \frac{\sqrt{(\overline{e}^2)_{90}}}{dE/du} \qquad \text{A.3.4}$$

where the suffix 90 here refers to the $\phi = 90^\circ$ case, differentiating A.3.3 we get

$$2E\,\frac{dE}{du} = \frac{B'}{2\sqrt{u}}$$

so
$$\frac{dE}{du} = \frac{E^2-E_o^2}{4Eu} \qquad \text{A.3.5}$$

substituting in A.3.4 gives

$$\sqrt{\overline{u'^2}} = \frac{\sqrt{(\overline{e}^2)_{90}}\,4Eu}{(E^2-E_o^2)}$$

which we can write as

$$S_{90}\sqrt{\overline{u'^2}} = \sqrt{(\overline{e}^2)_{90}} \qquad \text{A.3.6}$$

where
$$S_{90} = \frac{E^2-E_o^2}{4Eu} \qquad \text{A.3.7}$$

If the wire is inclined at an angle ϕ and we assume the cosine law of cooling, such that the wire is only cooled by the normal velocity component, we have:

$$E^2-E_o^2 = B'\sqrt{u\sin\phi} \qquad \text{A.3.8}$$

from which it may readily be shown that again

$$S_\phi = \frac{E^2-E_o^2}{4Eu} \qquad \text{A.3.9}$$

Now if the wire is aligned so that $\phi = 45^\circ$ the wire is equally sensitive to both the u' and v' velocity fluctuations, and considering Fig. A.3.2 we may write:

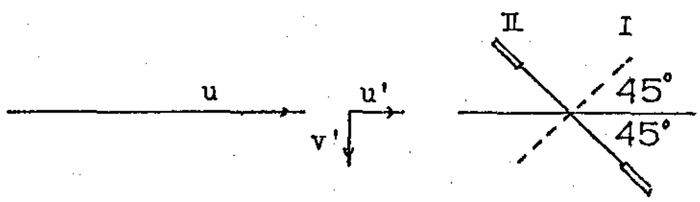


Figure A.3.2

Orientation I $\quad (e)_I = S_I(u' + v')$

Orientation II $\quad (e)_{II} = S_{II}(u' - v')$

whence

$$(\bar{e}^2)_I = S_I^2(\overline{u'^2} + 2\overline{u'v'} + \overline{v'^2}) \qquad \text{A.3.10}$$

$$(\bar{e}^2)_{II} = S_{II}^2(\overline{u'^2} - 2\overline{u'v'} + \overline{v'^2}) \qquad \text{A.3.11}$$

Noting $S_I = S_{II} = S$ and subtracting A.3.11 from A.3.10 gives

$$\boxed{(\bar{e}^2)_I - (\bar{e}^2)_{II} = S^2 4\overline{u'v'}} \qquad \text{A.3.12}$$

addition of A.3.10 and A.3.11 gives

$$(\bar{e}^2)_I + (\bar{e}^2)_{II} = 2S^2(\overline{u'^2} + \overline{v'^2})$$

Now from A.3.6

$$(\bar{e}^2)_{90} = S_{90}^2(\overline{u'^2})$$

so $$\frac{1}{2S^2}\left((\bar{e}^2)_I + (\bar{e}^2)_{II}\right) = \bar{v}'^2 + \frac{(\bar{e}^2)_{90}}{S_{90}^2}$$

whence

$$\boxed{\overline{v'^2} = \frac{1}{2S^2}\left((\bar{e}^2)_I + (\bar{e}^2)_{II}\right) - \frac{(\bar{e}^2)_{90}}{S_{90}^2}} \qquad \text{A.3.13}$$

a similar analysis in the $u' - w'$ plane yields relationships for $\overline{w'^2}$ and $\overline{u'w'}$.

Measurements may be taken by the 45° slant wire method described, as used by Goldberg (25) and Lee (35), or by an X-array of two identical wires. In the latter case the exact matching of two hot-wires in the correct geometry increases experimental complication, and further the X-wires commercially available did not meet the resolution requirements for the present work. Thus the 45° slant wire method was adopted using D.I.S.A. miniature probe elements which gave the resolution required.

A.3.2 Turbulence Data Analysis

The turbulence data was analysed using a computer program which employed, where necessary, the numerical integration technique described in Appendix 2 A.2.1. The following parameters were calculated over the inner and outer wall boundary layers:

$\overline{u'v'}$, $\overline{u'w'}$	turbulent shear stress in u-v and u-w planes.
$\sqrt{\overline{u'^2}}$, $\sqrt{\overline{v'^2}}$, $\sqrt{\overline{w'^2}}$	r.m.s. turbulent fluctuation velocities in the u, v, w directions.
$\int_0^{\delta} \left(\frac{\overline{u'^2}}{U^2}\right) dR$ and $\int_0^{\delta} \left(\frac{\overline{v'^2}}{U^2}\right) dR$	* integral of Reynolds normal stress over boundary layer.
$\mathfrak{D} = \int_0^{\delta} \frac{\tau}{\frac{1}{2}\rho U^2} \frac{d}{dR} \left(\frac{u}{U}\right) dR$	shear work integral
$\ell = \left\{ -\overline{u'v'} \Big/ \frac{du}{dR} \left\lvert \frac{du}{dR} \right\rvert \right\}^{\frac{1}{2}}$	Prandtl mixing length
$\varepsilon = \left\{ -\overline{u'v'} \Big/ \frac{du}{dR} \right\}$	Eddy viscosity

---

* Two-dimensional definitions are used because the experimental accuracy does not warrant the inclusion of minor effects due to transverse curvature.

A curve using the minimum necessary smoothing was drawn through the experimental points for mean bridge voltage (E) and r.m.s. fluctuation voltage $(\sqrt{\overline{e^2}})$. These were then encoded on to punch data cards as described in Appendix 2, Section A.2.1. Local mean velocity (u) and $(\frac{du}{dR})$ were derived from the pitot-static velocity measurements, using the previously encoded $(\frac{u}{U})$ data. The values of $(\frac{du}{dR})$ calculated from this data proved liable to oscillation above $(\frac{u}{U}) \simeq 0.95$, which similarly affected the calculated values of mixing length and eddy viscosity. Thus for $(\frac{u}{U}) > 0.95$ a smoothing curve fit technique was applied to the calculated values of $(\frac{du}{dR})$ reducing these oscillations to a minimal level.

The flow chart shown in Fig. A.3.3 illustrates the computation technique used; again hand calculation and planimeter checks made on the calculated parameters gave satisfactory agreement.

A.3.3 Accuracy of Turbulence Measurements

Full accounts of the several aspects of hot-wire anemometry are given in References (7), (20), (28), (52). A summary of the main limitations of the hot-wire instrumentation used is given here.

The design of a hot-wire probe always represents a compromise between aerodynamic, sensitivity, and mechanical considerations. The wires used in the present tests were D.I.S.A. sub-miniature probe elements types 55A53 (straight wire) and 55A54 (slant wire).

Probe positioning and wire alignment can give rise to serious errors if not carefully controlled, and great care was taken to ensure correct probe positioning. The probe was traversed radially normal to the adjacent wall with resulting misalignment with the mean flow in the region of maximum velocity. The analysis of Goldberg (25) indicates maximum errors of 20% in $\overline{u'v'}$ in the region of maximum velocity due to this effect. The value of $\overline{u'}$ should be unaffected. Misalignment of the slant wires themselves could again give rise to errors in $\overline{u'v'}$; however, the wire angles were carefully checked and it is not felt that errors due to this source should exceed 6%.

The correction of readings for wall proximity effects shown by Wills (82) was not applied since no readings were taken in the affected region.

The susceptibility of the calculated values of $\overline{u'}$, $\overline{v'}$, $\overline{u'v'}$, etc. to reading errors can be investigated by consideration of the calculation equations A.3.6, A.3.12, A.3.13.

The value of u used is that from pitot-static measurements and this is liable to the errors outlined in Appendix 2, A.2.2. Thus this will only markedly affect the turbulence parameters when the local turbulence level is high ($\frac{\overline{u'}}{u} > 0.30$), and at this condition will give rise to errors of the order 10% of $\overline{u'}$ and 20% of $\overline{u'v'}$.

The possible reading error in $\bar{e}$ is typically 1.5% in the early stages of diffusion and 3% in the latter stages. The value of *E is subject to 1% error at all stages.

Considering equations A.3.6, A.3.12, A.3.13 and assuming the worst case of the near wall position with non-cancelling errors we get the following maximum possible errors:

$$\left.\begin{array}{ll} \overline{u'} & 3\% \\ \overline{u'v'} & 10\% \end{array}\right\} \text{early stages of diffusion}$$

$$\left.\begin{array}{ll} \overline{u'} & 10\% \\ \overline{u'v'} & 40\% \end{array}\right\} \text{latter stages of diffusion}$$

Due to the algebraic nature of equation A.3.13 the combination of possible reading errors gives rise to a maximum error in $\overline{v'}$ of 70%.

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* Initial measurements from the mean bridge volts meter of the D.I.S.A. 55A01 anemometer proved liable to unacceptable reading error and a Digital Volt Meter was used to ensure greater reading accuracy.

The hot-wire probes used for this investigation had an ℓ/d ratio of 100, hence some deviation from the cosine law assumed in the simple analysis of A.3.2 must be expected. Champagne and Sleicher (12) show that the cosine law holds for an ℓ/d ratio of 600 and above but note increasing deviation down to an ℓ/d value of 100.

Another simplifying assumption in the analysis is that the fluctuation velocities are small in comparison with the local mean velocity; in the latter stages of diffusion this condition is not satisfied. This problem has been considered by, among others, Hinze (28), and Sandborn and Liu (57). The former shows that a measured value of $u'/u = 0.20$ is liable to errors of the order 15% while Sandborn and Liu indicate possible errors of 40% in the near wall measurement of $\overline{u'v'}$ in separating flow. It is interesting to note that the measurements of Sandborn and Liu give a maximum value of $\frac{\overline{u'}}{u} \approx 0.45$ in the separating region, and Spangenberg et al (64) quote a value of 0.33 as indicative of transitory stall. Hence turbulence intensity measurements in excess of $\frac{\overline{u'}}{u} \approx 0.40$ must be regarded with reservation and do not represent classical turbulence, but highly three-dimensional fluctuating flow with near zero mean velocity.

In the light of the above review the following accuracy limits are placed on the measured turbulence parameters; it must be emphasized that the values quoted are pessimistic:

$\overline{u'}$	5%	early stages of diffusion
$\overline{u'v'}$	10%	
$\overline{v'}$	30%	
$\overline{u'}$	10-15%	latter stages of diffusion (where $(\frac{\overline{u'}}{u} > 0.20)$
$\overline{u'v'}$	40%	
$\overline{v'}$	60%	

A.3.4 Asymmetry and Verification of King's Law Checks

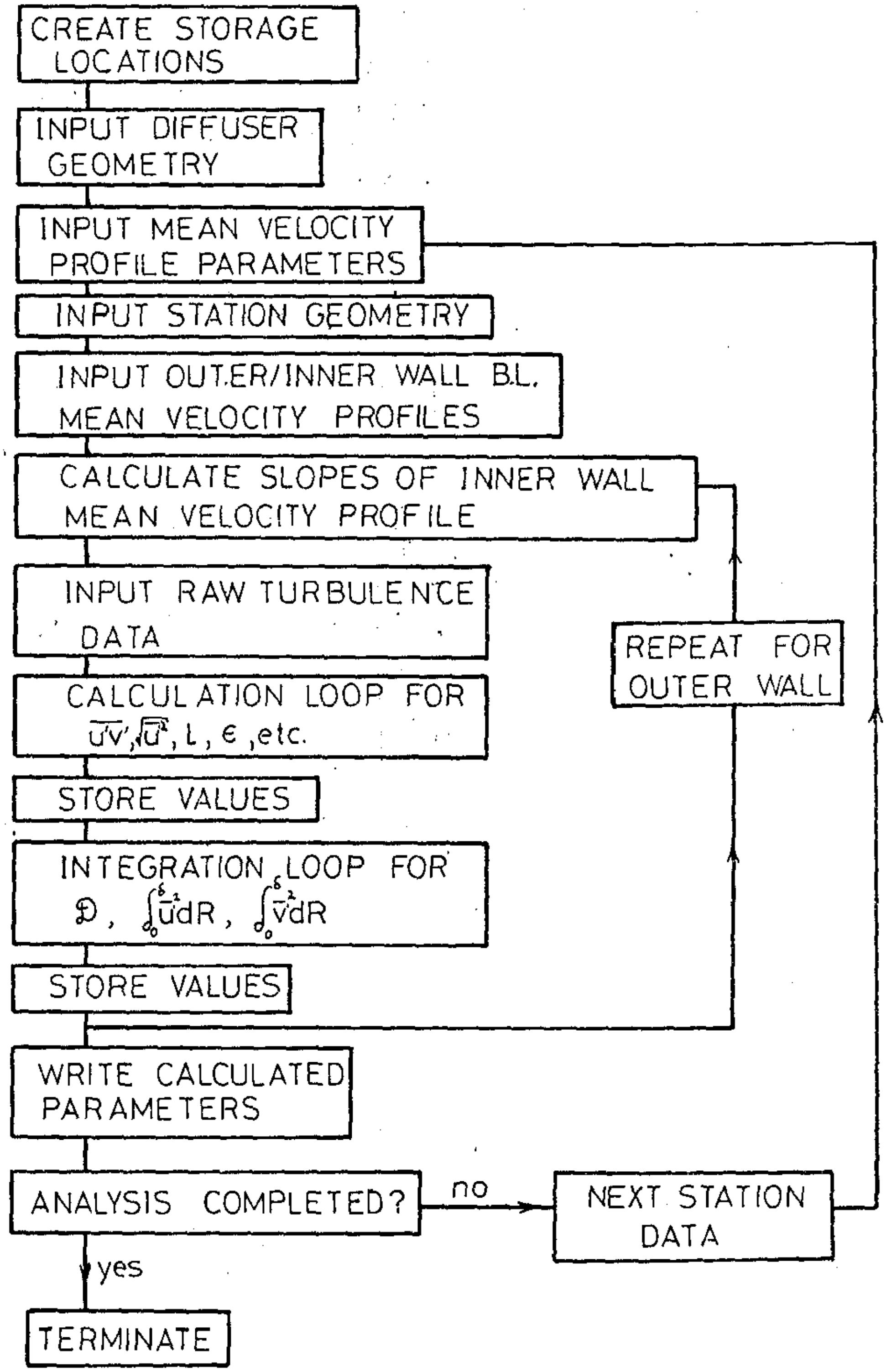
Traverses were taken along each diffuser for one circumferential position with checks for the dgree of asymmetry at appropriate stations. Fig. A.3.4 shows a typical example which indicates that, for the circumferential measurement positions, the differences are within the possible levels of accuracy quoted in Section A.3.3.

As shown in Section A.3.1 a 'basic' analysis of the hot-wire data was carried out by assuming King's law of cooling with the cosine law of directional sensitivity. The validity of King's law has been verified using typical examples from the present data as shown in Fig. A.3.5.

The raw experimental turbulence data has, as stated in Section A.3.2, been subjected to the minimum necessary amount of smoothing. A typical comparison between the smoothed data analysis and a direct analysis of the raw data is given in Fig. A.3.6.

FIGURE A.3.3

TURBULENCE DATA—ANALYSIS PROCEDURE



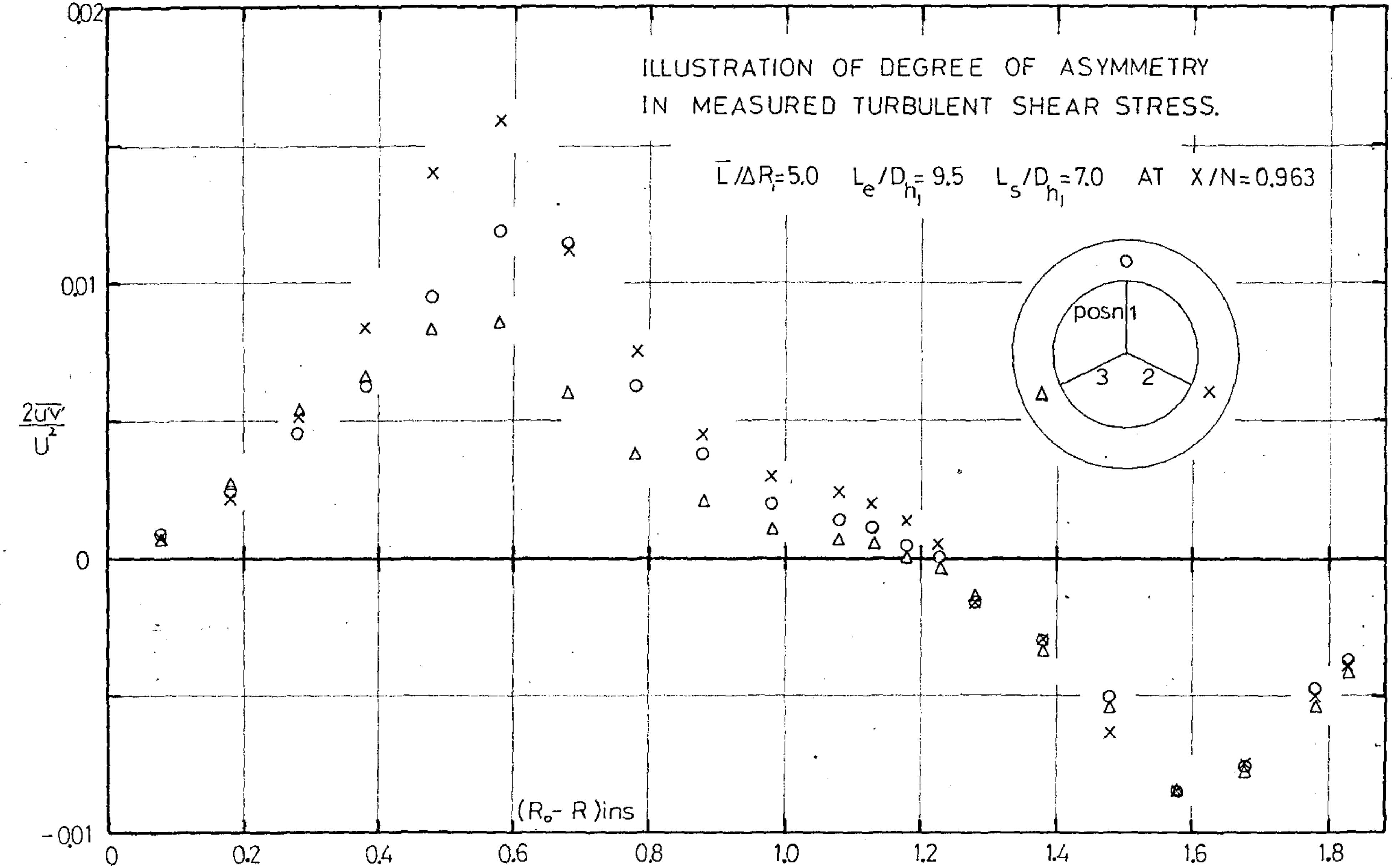


ILLUSTRATION OF DEGREE OF ASYMMETRY
IN MEASURED TURBULENT SHEAR STRESS.
$\overline{L}/\Delta R_i = 5.0$ $L_e/D_{h_1} = 9.5$ $L_s/D_{h_1} = 7.0$ AT $X/N = 0.963$
posn 1
3
2
$\frac{2\overline{u'v'}}{U^2}$
$(R_o - R)$ ins
0.02
0.01
0
-0.01
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8

FIGURE A.34

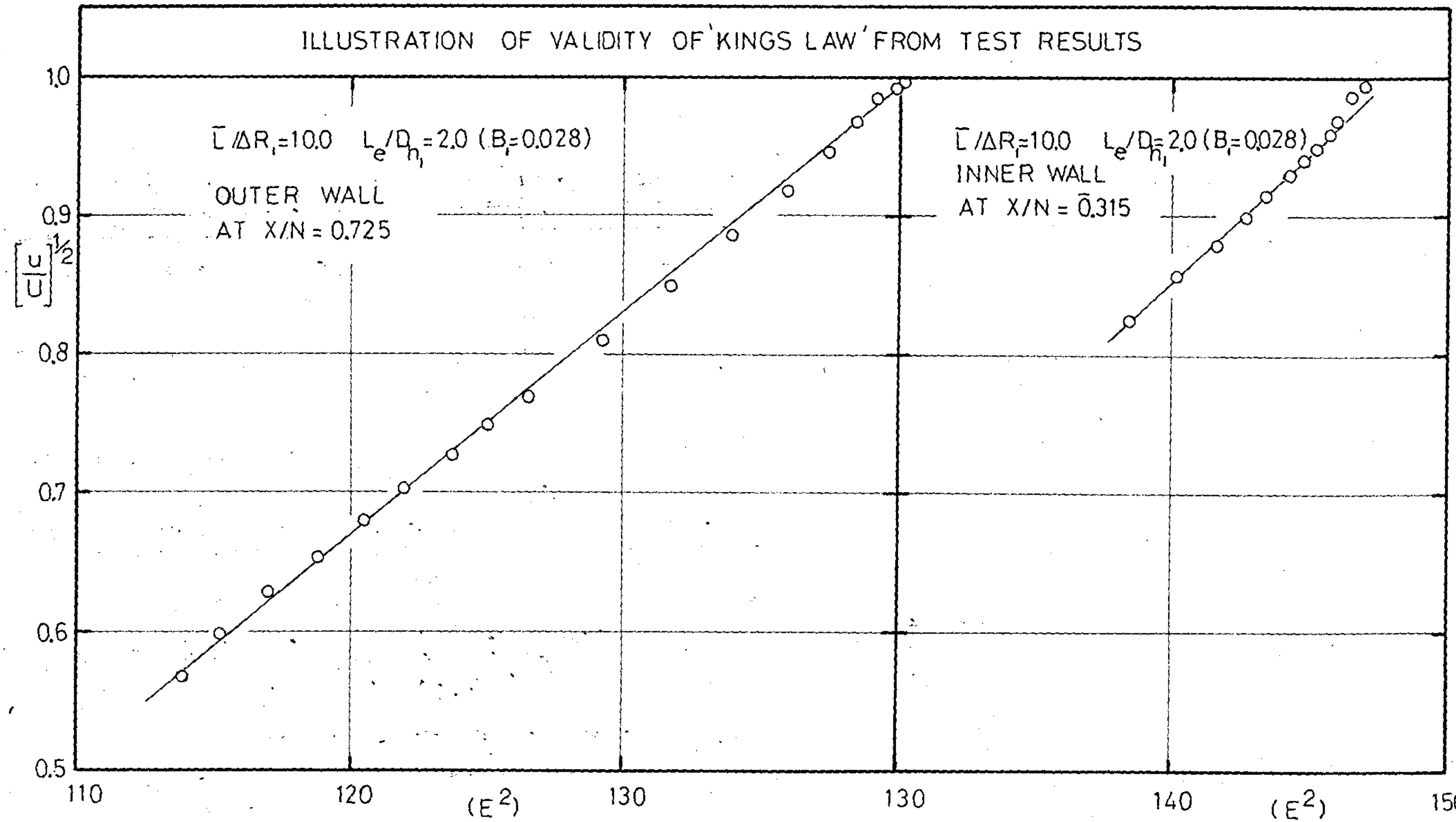


ILLUSTRATION OF VALIDITY OF 'KINGS LAW' FROM TEST RESULTS
$\bar{L}/\Delta R_i = 10.0$ $L_e/D_{h_i} = 2.0$ $(B_i = 0.028)$
OUTER WALL
AT X/N = 0.725
$\bar{L}/\Delta R_i = 10.0$ $L_e/D_{h_i} = 2.0$ $(B_i = 0.028)$
INNER WALL
AT X/N = 0.315
$\left[\frac{u}{U}\right]^{1/2}$
1.0
0.9
0.8
0.7
0.6
0.5
110
120
130
130
140
150
(E^2)
(E^2)

FIGURE A.3.5

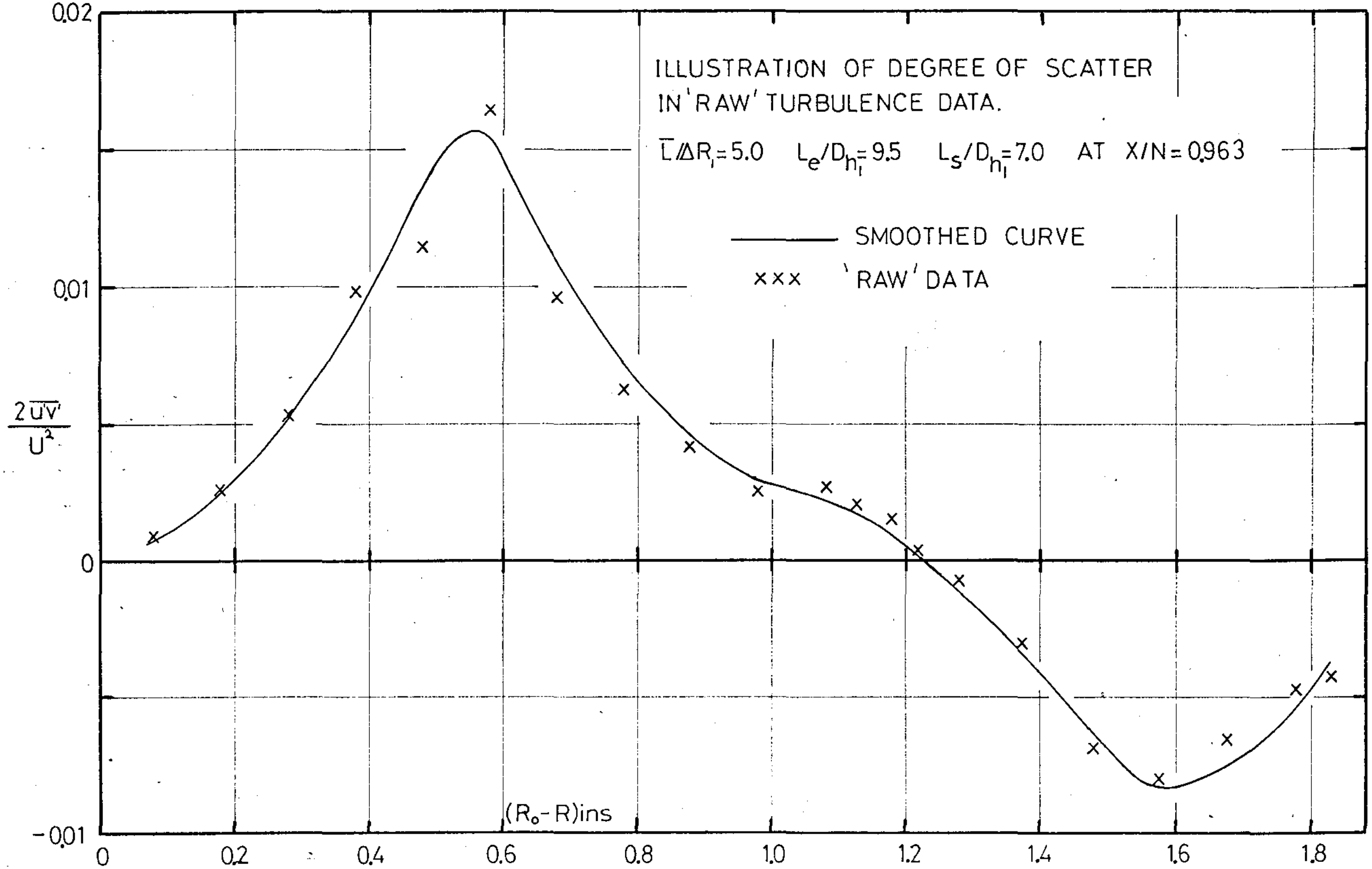


ILLUSTRATION OF DEGREE OF SCATTER
IN 'RAW' TURBULENCE DATA.
$\overline{L}/\Delta R_i = 5.0$ $L_e/D_{h_1} = 9.5$ $L_s/D_{h_1} = 7.0$ AT X/N = 0.963
SMOOTHED CURVE
××× 'RAW' DATA
0.02
0.01
0
-0.01
$\frac{2\overline{u'v'}}{U^2}$
$(R_o - R)$ ins
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8

FIGURE A.3.6.

APPENDIX 4

MOMENTUM INTEGRAL EQUATION IN THE AXI-SYMMETRIC CO-ORDINATE SYSTEM

Momentum Integral Equation in the Axi-symmetric Co-ordinate System

The Navier-Stokes equations for axi-symmetric flow (general radius R, axial direction x) are given in standard texts such as Schlichting (59). For incompressible flow, as shown by Chaturvedi (13), if the following assumptions are made:

(i) Mean and fluctuation velocities in the angular direction are neglected.

(ii) The mean flow is steady.

(iii) The viscous stresses are negligible in comparison with the Reynolds stresses.

Then the mean flow equations may be written as follows:

x - direction

$$\rho u \frac{\partial u}{\partial x} + \rho v \frac{\partial u}{\partial R} = - \frac{\partial p}{\partial x} - \rho \left\{ \frac{\partial}{\partial x} (\overline{u'^2}) + \frac{\partial}{\partial R} (\overline{u'v'}) + \frac{\overline{u'v'}}{R} \right\} \qquad A.4.1$$

R - direction

$$\rho u \frac{\partial v}{\partial x} + \rho v \frac{\partial v}{\partial R} = - \frac{\partial p}{\partial R} - \rho \left\{ \frac{\partial}{\partial x} (\overline{u'v'}) + \frac{\partial}{\partial R} (\overline{v'^2}) \right\} \qquad A.4.2$$

Further in the axi-symmetric co-ordinate system the continuity relationship may be written:

$$\frac{\partial}{\partial x} (Ru) + \frac{\partial}{\partial R} (Rv) = 0 \qquad A.4.3$$

Now noting that $\tau = -\rho\overline{u'v'}$ it can be seen from equation A.4.1 that:

$$\rho u \frac{\partial u}{\partial x} + \rho v \frac{\partial u}{\partial R} = - \frac{\partial p}{\partial x} - \rho \frac{\partial}{\partial x} (\overline{u'^2}) + \frac{1}{R} \frac{\partial}{\partial R} (\tau R) \qquad A.4.4$$

and from equation A.4.2, neglecting second order terms:

$$- \frac{\partial p}{\partial R} - \rho \frac{\partial}{\partial R} (\overline{v'^2}) = 0$$

thus

$$\frac{\partial p}{\partial R} = - \rho \frac{\partial}{\partial R} (\overline{v'^2})$$

which upon integration gives

$$p = -\rho \overline{v'^2} + \text{const}$$

Now if the suffix δ indicates the edge of the boundary layer, then

$$p = p_\delta \text{ when } \overline{v'^2} = \overline{v'^2_\delta}$$

thus

$$p = p_\delta + \rho\left(\overline{v'^2_\delta} - \overline{v'^2}\right)$$

and therefore

$$\frac{\partial p}{\partial x} = \frac{\partial p_\delta}{\partial x} + \frac{\partial}{\partial x}\rho\left(\overline{v'^2_\delta} - \overline{v'^2}\right) \qquad \text{A.4.5}$$

Bernoulli's equation gives

$$P_\delta = p_\delta + \tfrac{1}{2}\rho U^2 \qquad \text{A.4.6}$$

Thus substituting equations A.4.5 and A.4.6 in equation A.4.4, we get:

$$\rho u \frac{\partial u}{\partial x} + \rho v \frac{\partial u}{\partial R} = -\frac{dP_\delta}{dx} + \rho U \frac{dU}{dx} - \rho\frac{\partial}{\partial x}\left(\overline{u'^2} + \overline{v'^2_\delta} - \overline{v'^2}\right) + \frac{1}{R}(\tau R) \qquad \text{A.4.7}$$

The continuity relationship of equation A.4.3 upon integration gives:

$$Rv = -\int \frac{\partial}{\partial x}(Ru)\partial R$$

and if now the specific case of the inner wall (radius R_i, boundary layer thickness δ_i) is considered then we may say, at general radius R:

$$Rv = -\int_{R_i}^{R} \frac{\partial}{\partial x}(Ru)\partial R \qquad \text{A.4.8}$$

Thus if we now isolate the L.H.S. of equation A.4.7, and multiply through by R, we have, upon integration across the boundary layer and substituting equation A.4.8.

$$\text{L.H.S.} = \int_{R_i}^{R_i+\delta_i} \rho R u \frac{\partial u}{\partial x}\partial R - \int_{R_i}^{R_i+\delta_i} \rho\frac{\partial u}{\partial R}\int_{R_i}^{R} \frac{\partial}{\partial x}(Ru)\partial R \qquad \text{A.4.9}$$

and integrating by parts for the second term in equation A.4.9 gives:

$$\int_{R_i}^{R_i+\delta_i} \rho R u \frac{\partial u}{\partial x}\partial R - \int_{R_i}^{R_i+\delta_i} \rho U\frac{\partial}{\partial x}(Ru)\partial R + \int_{R_i}^{R_i+\delta_i} \rho u\frac{\partial}{\partial x}(Ru)\partial R$$

which reduces to:

$$\text{L.H.S.} = \int_{R_i}^{R_i+\delta_i} \rho R u \frac{\partial u}{\partial x}\, \partial R + \int_{R_i}^{R_i+\delta_i} \rho \left\{ \frac{\partial}{\partial x} (Ru) \right\} (u - U)\partial R \qquad \text{A.4.10}$$

Now considering the R.H.S. of equation A.4.7 and integrating over the boundary layer, on adopting the convention $R_i + \delta_i = R_\delta$, we get:

$$\text{R.H.S.} = -\frac{dP_\delta}{dx}\tfrac{1}{2}(R_\delta^2 - R_i^2) - \int_{R_i}^{R} \rho R \frac{\partial}{\partial x}(\overline{u'^2} + \overline{v_\delta'^2} - \overline{v'^2})dR$$

$$- \tau_i R_i + \int_{R_i}^{R_\delta} \rho U R \frac{dU}{dx}\, dR \qquad \text{A.4.11}$$

and combining equations A.4.10 and A.4.11 gives, after re-arrangement of terms:

$$\rho \frac{dU}{dx} \int_{R_i}^{R_\delta} (U - u)R dR + \rho \int_{R_i}^{R_\delta} \frac{d}{dx} \left\{ (U - u)Ru \right\} dR$$

$$= \tau_i R_i + \int_{R_i}^{R_\delta} \rho R \frac{\partial}{\partial x}(\overline{u'^2} + \overline{v_\delta'^2} - \overline{v'^2})dR + \frac{dP_\delta}{dx}\tfrac{1}{2}(R_\delta^2 - R_i^2) \qquad \text{A.4.12}$$

Now in axi-symmetric co-ordinates the momentum (θ) and displacement (δ^*) thicknesses are defined thus:

$$\theta_i = \int_{R_i}^{R_\delta} (1 - \frac{u}{U}) \frac{u}{U} \frac{R}{R_i}\, dR \qquad \text{A.4.13}$$

$$\delta_i^* = \int_{R_i}^{R_\delta} \left(1 - \frac{u}{U}\right) \frac{R}{R_i}\, dR \qquad \text{A.4.14}$$

and from these two equations we get:

$$\theta_i R_i U^2 = \int_{R_i}^{R_\delta} (U - u) R u\, dR \qquad \text{A.4.15}$$

$$\delta_i^* R_i U = \int_{R_i}^{R_\delta} (U - u) R\, dR \qquad \text{A.4.16}$$

If equations A.4.15 and A.4.16 are now substituted in equation A.4.12 the following relationship is seen to hold:

$$\rho \frac{d}{dx} (\theta_i R_i U^2) + \rho \frac{dU}{dx} (\delta_i^* R_i U)$$

$$= \tau_i R_i + \rho \int_{R_i}^{R_\delta} R \frac{\partial}{\partial x} (\overline{u'^2} + \overline{v_\delta'^2} - \overline{v'^2}) dR + \frac{dP_\delta}{dx} (R_\delta^2 - R_i^2) \qquad \text{A.4.17}$$

If equation A.4.17 is expanded and divided throughout by $\rho R_i U^2$ the following form of the Momentum Integral Equation results:

$$\frac{d\theta_i}{dx} + \frac{\theta_i}{U} \frac{dU}{dx} \left\{ \frac{\delta_i^*}{\theta_i} + 2 \right\} + \frac{\theta_i}{R_i} \frac{dR_i}{dx}$$

$$= \frac{\tau_i}{\rho U^2} + \frac{1}{U^2} \int_{R_i}^{R_\delta} \frac{R}{R_i} \frac{\partial}{\partial x} (\overline{u'^2} + \overline{v_\delta'^2} - \overline{v'^2}) dR + \frac{dP_\delta}{dx} \frac{(R_\delta^2 - R_i^2)}{2 \rho U^2 R_i} \qquad \text{A.4.18}$$

and a similar process for the outer wall of the annular diffuser gives:

$$\frac{d\theta_o}{dx} + \frac{\theta_o}{U} \frac{dU}{dx} \left\{ \frac{\delta_o^*}{\theta_o} + 2 \right\} + \frac{\theta_o}{R_o} \frac{dR_o}{dx}$$

$$= \frac{\tau_o}{\rho U^2} + \frac{1}{U^2} \int_{R_\delta}^{R_o} \frac{R}{R_o} \frac{\partial}{\partial x} (\overline{u'^2} + \overline{v_\delta'^2} - \overline{v'^2}) dR + \frac{dP_\delta}{dx} \frac{(R_o^2 - R_\delta^2)}{2 \rho U^2 R_o}$$

A.4.19

In equations A.4.18 and A.4.19, if the diffuser flow has a potential core, then:

$$\frac{dP_\delta}{dx} = 0 \qquad \text{and} \qquad \overline{v'^2_\delta} = 0$$

and the momentum equation on the inner wall reduces to:

$$\frac{d\theta_i}{dx} + \frac{\theta_i}{U}\frac{dU}{dx}\left\{\frac{\delta^*_i}{\theta_i} + 2\right\} + \frac{\theta_i}{R_i}\frac{dR_i}{dx}$$

$$= \frac{\tau_i}{\rho U^2} + \frac{1}{U^2}\int_{R_i}^{R_\delta} \frac{R}{R_i}\frac{\partial}{\partial x}\left(\overline{u'^2} - \overline{v'^2}\right)dR$$

and similarly for the outer wall.

Where the gradient of the Reynolds normal stress term has been evaluated in Chapter 4 the weighting due to $\frac{R}{R_i}$, $\frac{R}{R_o}$ has been omitted on the grounds of the high diffuser radius ratio and the relative inaccuracy in the experimental determination of the $\rho\overline{v'^2}$ component of Reynolds normal stress.

APPENDIX 5

HEAD'S ENTRAINMENT METHOD

HEAD'S ENTRAINMENT METHOD

A.5.1 Application of Head's Entrainment Method to Internal Axi-symmetric Flows

Diffuser Flow - Power Law Velocity Profile

Assuming an annular diffuser where the flow has a potential core, and denoting the flow in the inner and outer wall boundary layers Q_i and Q_o respectively, referring to Fig. A.5.1, we may write:

$$Q_i = \int_{R_i}^{R_i+\delta_i} 2\pi uRdR \qquad \text{A.5.1}$$

and

$$Q_o = \int_{R_o-\delta_o}^{R_o} 2\pi uRdR \qquad \text{A.5.2}$$

If a power law profile is assumed then the inner wall boundary layer:

$$\frac{u}{U} = \left\{\frac{R-R_i}{\delta_i}\right\}^{\frac{1}{2}(H_i-1)} \qquad \text{A.5.3}$$

and similarly for the outer wall

$$\frac{u}{U} = \left\{\frac{R_o-R}{\delta_o}\right\}^{\frac{1}{2}(H_o-1)} \qquad \text{A.5.4}$$

Thus

$$Q_i = \frac{2\pi U}{\delta_i^{\frac{1}{2}(H_i-1)}} \int_{R_i}^{R_i+\delta_i} (R-R_i)^{\frac{1}{2}(H_i-1)}dR \qquad \text{A.5.5}$$

and

$$Q_o = \frac{2\pi U}{\delta_o^{\frac{1}{2}(H_o-1)}} \int_{R_o-\delta_o}^{R_o} (R_o-R)^{\frac{1}{2}(H_o-1)}dR \qquad \text{A.5.6}$$

Integration of equations A.5.5 and A.5.6 gives:

$$Q_i = 4\pi U \left\{ \frac{R_i \delta_i}{H_i + 1} + \frac{\delta_i^2}{H_i + 3} \right\} \quad \text{A.5.7}$$

$$Q_o = 4\pi U \left\{ \frac{R_o \delta_o}{H_o + 1} - \frac{\delta_o^2}{H_o + 3} \right\} \quad \text{A.5.8}$$

and thus the total flow in the diffuser may be written:

$$Q = 4\pi U \left\{ \frac{R_i \delta_i}{H_i + 1} + \frac{\delta_i^2}{H_i + 3} + \frac{((R_o - \delta_o)^2 - (R_i + \delta_i)^2)}{4} + \frac{R_o \delta_o}{H_o + 1} - \frac{\delta_o^2}{H_o + 3} \right\} \quad \text{A.5.9}$$

This equation allows evaluation of the flow in terms of the necessary integral, geometrical, and flow parameters in prediction methods as shown in Chapter 5, Section 5.3.3

Auxiliary Equation

For annular diffuser flow, as shown in Chapter 5, Section 5.3.3, the Head auxiliary equation assumes the form:

$$\frac{dQ_i}{dx} = 2\pi R_{i_{eff.}} UF(H_i') \quad \text{A.5.10}$$

$$\frac{dQ_o}{dx} = 2\pi R_{o_{eff.}} UF(H_o') \quad \text{A.5.11}$$

where $R_{i_{eff.}}$ and $R_{o_{eff.}}$ are the effective radii of entrainment on the inner and outer walls respectively, and H_i' and H_o' are representative shape parameters.

Now

$$Q_i = \int_{R_i}^{R_i + \delta_i} 2\pi R u dR \quad \text{A.5.12}$$

and noting that

$$\delta_i^* = \int_{R_i}^{R_i+\delta_i} (1 - \frac{u}{U}) \frac{R}{R_i} dR$$

which gives

$$\int_{R_i}^{R_i+\delta_i} u 2\pi R dR = 2\pi U R_i (\delta_i + \frac{\delta_i^2}{2R_i} - \delta_i^*)$$

then

$$Q_i = 2\pi U R_i \ (\delta_i + \frac{\delta_i^2}{2R_i} - \delta_i^*) \qquad \text{A.5.13}$$

and similarly for the outer wall.

$$Q_o = 2\pi U R_o \ (\delta_o - \frac{\delta_o^2}{2R_o} - \delta_o^*) \qquad \text{A.5.14}$$

From A.5.13

$$\frac{dQ_i}{dx} = \frac{d}{dx} \left\{ 2\pi U R_i (\delta_i + \frac{\delta_i^2}{2R_i} - \delta_i^*) \right\}$$

which on expansion gives

$$\frac{dQ_i}{dx} = 2\pi \left\{ U R_i \frac{d}{dx} (\delta_i + \frac{\delta_i^2}{2R_i} - \delta_i^*) + (\delta_i + \frac{\delta_i^2}{2R_i} - \delta_i^*) U \frac{dR_i}{dx} \right.$$

$$\left. + (\delta_i + \frac{\delta_i^2}{2R_i} - \delta_i^*) R_i \frac{dU}{dx} \right\}$$

combining with equation A.5.10 and denoting $(\delta_i + \frac{\delta_i^2}{2R_i} - \delta_i^*) = DI$ the following relationship is found

$$2\pi R_{i_{eff.}} U F(H_i') = 2\pi \left\{ U R_i \frac{d}{dx} (DI) + (DI) U \frac{dR_i}{dx} + (DI) R_i \frac{dU}{dx} \right\} \qquad \text{A.5.15}$$

where $H_i' = DI/\theta_i$, chosen as a representative shape parameter.

Re-arrangement of equation A.5.15 gives

$$\frac{d}{dx}(DI) = \frac{1}{R_i}\left\{R_{i_{eff.}} F(H_i') - (DI)\frac{R_i}{U}\frac{dU}{dx} - (DI)\frac{dR_i}{dx}\right\} \qquad \text{A.5.16}$$

and similarly for the outer wall

$$\frac{d}{dx}(DO) = \frac{1}{R_o}\left\{R_{o_{eff.}} F(H_o') - (DO)\frac{R_o}{U}\frac{dU}{dx} - (DO)\frac{dR_o}{dx}\right\} \qquad \text{A.5.17}$$

where $H_o' = DO/\theta_o$.

Equations A.5.16 and A.5.17 form the auxiliary equation in this application of Head's method, as fully described in Chapter 5, Section 5.3.3.

A.5.2 Theoretical Predictions - Computer Program Output

TABLE A.5.1 CONSTANT CORE DIAMETER ANNULAR DIFFUSER HEADS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)=10.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_{h_1}/\nu$)=184092.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\overline{C}_p$	ζ	λ	α	OUTER WALL θ (IN)	OUTER WALL H	OUTER WALL C_f	INNER WALL θ (IN)	INNER WALL H	INNER WALL C_f
3.150	6.000	5.000	177.7	0.0	0.000	0.000	0.000	1.022	.0103	1.380	.00451	.0097	1.370	.00466
2.000	6.000	5.000	178.6	8.9	−.010	0.000	0.000	1.025	.0125	1.380	.00426	.0120	1.370	.00439
1.000	6.000	5.000	179.3	8.5	−.019	0.000	0.000	1.028	.0143	1.380	.00409	.0139	1.370	.00419
0.000	6.000	5.000	180.0	8.5	−.027	0.000	0.000	1.030	.0161	1.380	.00399	.0157	1.370	.00408
1.000	6.087	5.000	168.7	−135.7	0.106	0.633	0.032	1.061	.0217	1.567	.00333	.0215	1.557	.00340
2.000	6.175	5.000	157.7	−131.1	0.227	0.761	0.036	1.081	.0287	1.630	.00258	.0289	1.619	.00262
3.000	6.262	5.000	148.6	−109.0	0.321	0.800	0.041	1.103	.0364	1.693	.00222	.0372	1.661	.00229
4.000	6.350	5.000	141.0	−91.7	0.396	0.818	0.045	1.126	.0448	1.749	.00193	.0463	1.690	.00206
5.000	6.437	5.000	134.5	−78.4	0.457	0.828	0.050	1.151	.0538	1.804	.00171	.0563	1.707	.00191
6.000	6.525	5.000	128.8	−67.8	0.508	0.835	0.054	1.175	.0635	1.857	.00152	.0670	1.719	.00180
7.000	6.612	5.000	124.0	−57.5	0.549	0.838	0.058	1.202	.0733	1.917	.00135	.0781	1.724	.00172
8.000	6.700	5.000	119.8	−50.2	0.583	0.840	0.063	1.229	.0835	1.978	.00120	.0896	1.728	.00166
9.000	6.787	5.000	116.2	−44.0	0.613	0.842	0.067	1.257	.0939	2.032	.00106	.1015	1.731	.00160
10.000	6.875	5.000	112.9	−38.9	0.638	0.844	0.071	1.284	.1045	2.092	.00096	.1137	1.733	.00156

TABLE A.5.2 CONSTANT CORE DIAMETER ANNULAR DIFFUSER HEADS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 7.50 ENTRY LENGTH(L_e/D_{H_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_{H_1}/\nu$)=173945.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\overline{C}_p$	ζ	λ	α	OUTER WALL θ (IN)	OUTER WALL H	OUTER WALL C_f	INNER WALL θ (IN)	INNER WALL H	INNER WALL C_f
3.150	6.000	5.000	167.9	0.0	0.000	0.000	0.000	1.022	.0102	1.395	.00449	.0097	1.375	.00469
2.500	6.000	5.000	168.4	8.7	-.006	0.000	0.000	1.024	.0115	1.395	.00433	.0111	1.375	.00452
2.000	6.000	5.000	168.7	8.4	-.010	0.000	0.000	1.026	.0125	1.395	.00423	.0121	1.375	.00440
1.500	6.000	5.000	169.1	8.4	-.015	0.000	0.000	1.027	.0134	1.395	.00414	.0130	1.375	.00431
1.000	6.000	5.000	169.4	8.4	-.019	0.000	0.000	1.028	.0143	1.395	.00406	.0140	1.375	.00422
0.500	6.000	5.000	169.8	8.3	-.024	0.000	0.000	1.029	.0152	1.395	.00399	.0149	1.375	.00414
0.000	6.000	5.000	170.1	8.3	-.028	0.000	0.000	1.031	.0160	1.395	.00396	.0158	1.375	.00410
0.500	6.058	5.000	163.0	-170.6	0.061	0.528	0.030	1.054	.0194	1.539	.00346	.0193	1.533	.00354
1.000	6.117	5.000	155.5	-180.9	0.153	0.711	0.032	1.067	.0235	1.598	.00284	.0236	1.591	.00287
1.500	6.175	5.000	148.8	-159.6	0.229	0.770	0.033	1.082	.0280	1.651	.00250	.0284	1.637	.00254
2.000	6.233	5.000	143.0	-140.7	0.294	0.797	0.036	1.098	.0327	1.709	.00223	.0335	1.673	.00230
2.500	6.291	5.000	137.8	-124.6	0.350	0.811	0.039	1.115	.0378	1.762	.00199	.0390	1.705	.00212
3.000	6.350	5.000	133.1	-111.7	0.398	0.821	0.041	1.132	.0431	1.814	.00178	.0449	1.722	.00197
3.500	6.408	5.000	129.0	-99.3	0.439	0.826	0.044	1.150	.0486	1.876	.00159	.0510	1.735	.00189
4.000	6.466	5.000	125.4	-86.0	0.473	0.827	0.047	1.173	.0542	1.945	.00140	.0571	1.740	.00181
4.500	6.525	5.000	122.1	-77.6	0.504	0.828	0.050	1.195	.0599	2.014	.00123	.0634	1.745	.00176
5.000	6.583	5.000	119.2	-69.9	0.530	0.829	0.053	1.219	.0658	2.084	.00108	.0699	1.748	.00171
5.500	6.641	5.000	116.6	-63.1	0.554	0.829	0.056	1.244	.0717	2.154	.00095	.0764	1.751	.00167
6.000	6.700	5.000	114.2	-58.2	0.575	0.829	0.059	1.269	.0779	2.217	.00084	.0831	1.753	.00164
6.500	6.758	5.000	112.0	-53.5	0.594	0.829	0.061	1.295	.0841	2.277	.00075	.0900	1.756	.00160
7.000	6.816	5.000	109.9	-49.4	0.612	0.830	0.064	1.320	.0905	2.333	.00068	.0969	1.758	.00157
7.500	6.874	5.000	108.0	-45.7	0.627	0.830	0.066	1.346	.0971	2.385	.00062	.1038	1.759	.00155

TABLE A.5.3 CONSTANT CORE DIAMETER ANNULAR DIFFUSER HEADS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_{h_1}/\nu$)=171268.0

NATURALLY DEVELOPED INLET CONDITIONS

									OUTER WALL			INNER WALL		
X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\bar{C}_p$	ξ	λ	α	θ (IN)	H	C_f	θ (IN)	H	C_f
3.150	6.000	5.000	165.2	-150.0	0.000	0.000	0.000	1.021	.0099	1.390	.00458	.0097	1.355	.00486
2.500	6.000	5.000	165.6	8.0	-.006	0.000	0.000	1.023	.0113	1.390	.00450	.0112	1.355	.00477
2.000	6.000	5.000	166.0	8.3	-.010	0.000	0.000	1.024	.0123	1.390	.00437	.0122	1.355	.00462
1.500	6.000	5.000	166.3	8.1	-.014	0.000	0.000	1.025	.0133	1.390	.00427	.0133	1.355	.00451
1.000	6.000	5.000	166.7	8.1	-.019	0.000	0.000	1.027	.0142	1.390	.00419	.0143	1.355	.00442
0.500	6.000	5.000	167.0	8.0	-.023	0.000	0.000	1.028	.0151	1.390	.00411	.0153	1.355	.00433
0.000	6.000	5.000	167.3	8.0	-.028	0.000	0.000	1.029	.0160	1.390	.00401	.0162	1.355	.00422
0.500	6.088	5.000	156.7	-255.2	0.107	0.635	0.031	1.063	.0209	1.590	.00332	.0214	1.578	.00340
1.000	6.176	5.000	146.2	-251.4	0.231	0.772	0.032	1.083	.0272	1.684	.00251	.0283	1.654	.00257
1.500	6.264	5.000	137.9	-199.0	0.324	0.802	0.035	1.112	.0340	1.802	.00203	.0357	1.733	.00217
2.000	6.353	5.000	131.3	-158.8	0.393	0.808	0.039	1.148	.0410	1.967	.00157	.0435	1.774	.00189
2.500	6.441	5.000	126.1	-124.6	0.446	0.804	0.043	1.195	.0480	2.187	.00112	.0512	1.788	.00174
3.000	6.529	5.000	121.7	-106.2	0.489	0.800	0.048	1.245	.0554	2.388	.00078	.0590	1.797	.00166
3.500	6.617	5.000	117.8	-93.0	0.525	0.799	0.052	1.297	.0632	2.568	.00061	.0672	1.801	.00158
4.000	6.705	5.000	114.4	-81.5	0.556	0.798	0.055	1.350	.0716	2.710	.00042	.0755	1.805	.00155
4.500	6.793	5.000	111.4	-72.6	0.583	0.799	0.059	1.403	.0804	2.833	.00034	.0840	1.810	.00151
5.000	6.882	5.000	108.7	-64.9	0.606	0.799	0.063	1.457	.0895	2.932	.00028	.0926	1.814	.00147

TABLE A.5.4 CONSTANT CORE DIAMETER ANNULAR DIFFUSER HEADS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_i$)=10.00 ENTRY LENGTH(L_e/D_{h_i})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_i)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_{h_i}/\nu$)=184092.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\overline{C}_p$	ζ	λ	α	OUTER WALL θ (IN)	OUTER WALL H	OUTER WALL C_f	INNER WALL θ (IN)	INNER WALL H	INNER WALL C_f
1.000	6.087	5.000	168.5	0.0	0.000	0.000	0.000	1.056	.0230	1.510	.00301	.0225	1.440	.00338
2.000	6.174	5.000	157.8	-128.6	0.143	0.913	0.004	1.077	.0302	1.591	.00274	.0300	1.526	.00306
3.000	6.262	5.000	148.7	-109.1	0.257	0.916	0.008	1.100	.0382	1.655	.00233	.0386	1.595	.00257
4.000	6.349	5.000	141.1	-91.2	0.347	0.912	0.012	1.124	.0469	1.722	.00201	.0479	1.645	.00223
5.000	6.437	5.000	134.6	-77.4	0.420	0.909	0.017	1.150	.0561	1.782	.00175	.0580	1.682	.00200
6.000	6.524	5.000	129.1	-66.8	0.480	0.907	0.022	1.176	.0659	1.837	.00155	.0688	1.708	.00184
7.000	6.612	5.000	124.3	-56.9	0.529	0.904	0.027	1.204	.0759	1.902	.00137	.0800	1.720	.00173
8.000	6.699	5.000	120.2	-49.1	0.570	0.902	0.032	1.232	.0861	1.968	.00121	.0915	1.726	.00166
9.000	6.787	5.000	116.6	-43.4	0.606	0.900	0.037	1.260	.0966	2.028	.00107	.1034	1.730	.00160
10.000	6.874	5.000	113.4	-38.2	0.636	0.899	0.042	1.289	.1072	2.090	.00095	.1154	1.732	.00156

TABLE A.5.5 CONSTANT CORE DIAMETER ANNULAR DIFFUSER HEADS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 7.50 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_{h_1}/\nu$)=173945.0

NATURALLY DEVELOPED INLET CONDITIONS

									OUTER WALL			INNER WALL		
X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\overline{C_p}$	ζ	λ	α	θ (IN)	H	C_f	θ (IN)	H	C_f
0.500	6.058	5.000	163.0	0.0	0.000	0.000	0.000	1.048	.0210	1.480	.00326	.0190	1.420	.00368
1.000	6.116	5.000	155.5	-179.2	0.102	0.922	0.002	1.062	.0254	1.541	.00304	.0233	1.485	.00342
1.500	6.175	5.000	148.9	-160.4	0.190	0.925	0.003	1.076	.0301	1.598	.00268	.0280	1.540	.00300
2.000	6.233	5.000	142.9	-142.5	0.265	0.924	0.005	1.091	.0352	1.651	.00238	.0331	1.592	.00266
2.500	6.291	5.000	137.7	-125.1	0.328	0.920	0.007	1.109	.0406	1.710	.00212	.0385	1.634	.00239
3.000	6.349	5.000	133.1	-111.4	0.382	0.917	0.009	1.127	.0462	1.768	.00188	.0442	1.669	.00219
3.500	6.408	5.000	129.0	-98.5	0.428	0.912	0.012	1.146	.0520	1.824	.00168	.0502	1.701	.00202
4.000	6.466	5.000	125.4	-86.4	0.468	0.907	0.015	1.168	.0579	1.893	.00149	.0562	1.719	.00190
4.500	6.524	5.000	122.2	-75.3	0.501	0.900	0.018	1.193	.0637	1.973	.00130	.0623	1.729	.00182
5.000	6.583	5.000	119.4	-67.9	0.530	0.895	0.022	1.218	.0697	2.051	.00113	.0684	1.735	.00176
5.500	6.641	5.000	116.8	-61.1	0.556	0.890	0.025	1.245	.0757	2.131	.00098	.0746	1.739	.00172
6.000	6.699	5.000	114.5	-56.1	0.580	0.887	0.028	1.272	.0819	2.204	.00086	.0809	1.741	.00168
6.500	6.758	5.000	112.4	-51.8	0.601	0.884	0.031	1.300	.0882	2.271	.00076	.0873	1.744	.00165
7.000	6.816	5.000	110.4	-47.9	0.620	0.882	0.034	1.327	.0946	2.334	.00067	.0938	1.746	.00162
7.500	6.874	5.000	108.5	-44.5	0.637	0.881	0.037	1.354	.1012	2.392	.00061	.1003	1.747	.00159

TABLE A.5.6 CONSTANT CORE DIAMETER ANNULAR DIFFUSER HEADS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

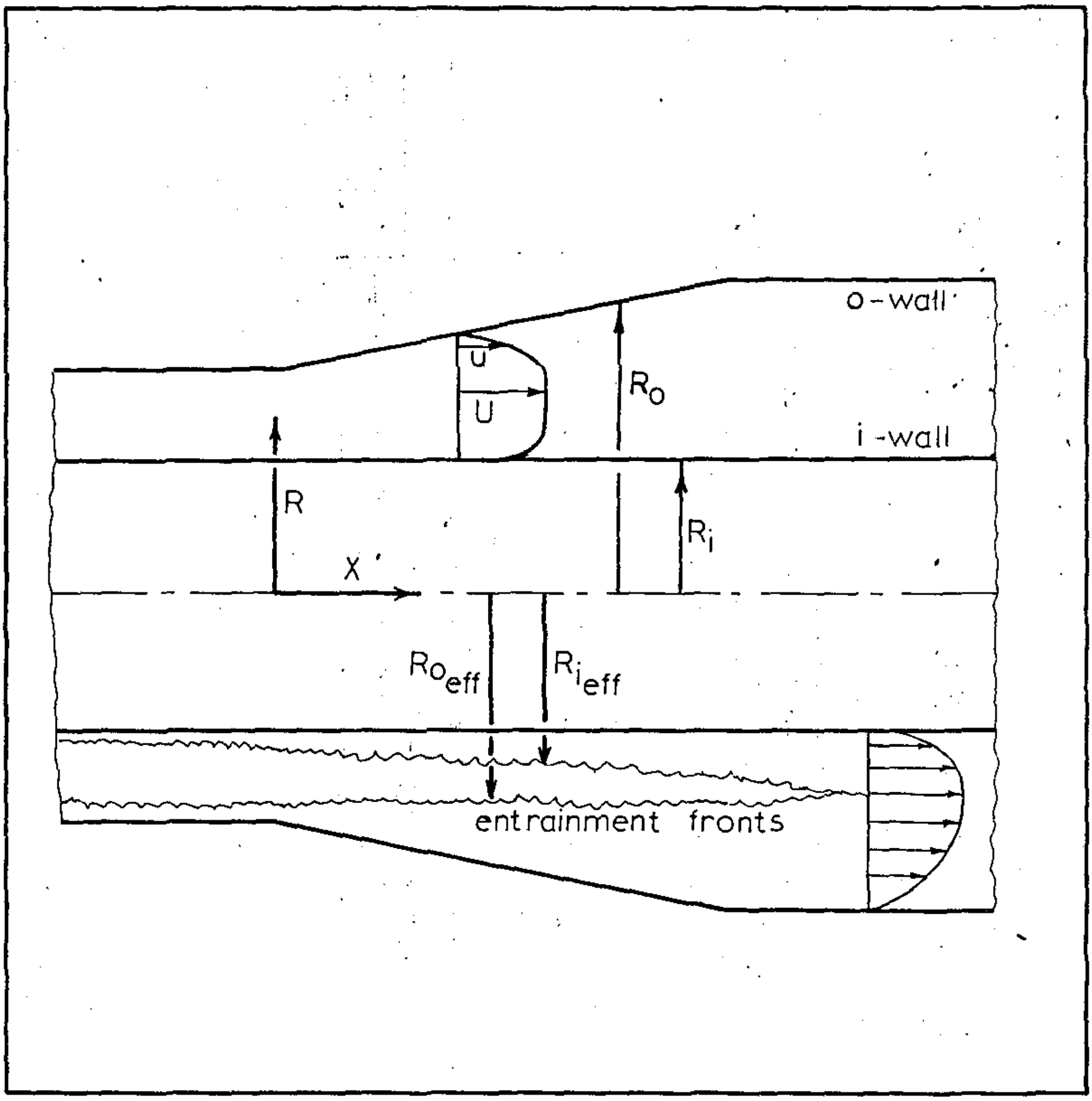
AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_{h_1}/\nu$)=171263.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\overline{C}_p$	ζ	λ	α	OUTER WALL θ (IN)	OUTER WALL H	OUTER WALL C_f	INNER WALL θ (IN)	INNER WALL H	INNER WALL C_f
0.500	6.088	5.000	157.5	0.0	0.000	0.000	0.000	1.053	.0210	1.570	.00286	.0220	1.400	.00368
1.000	6.176	5.000	147.1	-249.3	0.147	0.931	0.002	1.074	.0272	1.667	.00258	.0288	1.491	.00333
1.500	6.264	5.000	138.7	-201.3	0.258	0.914	0.004	1.102	.0340	1.785	.00208	.0362	1.588	.00274
2.000	6.352	5.000	131.8	-165.3	0.345	0.901	0.007	1.137	.0413	1.953	.00160	.0442	1.639	.00234
2.500	6.441	5.000	126.6	-124.7	0.407	0.877	0.012	1.185	.0483	2.171	.00114	.0518	1.694	.00208
3.000	6.529	5.000	122.2	-105.7	0.458	0.861	0.016	1.236	.0557	2.371	.00080	.0596	1.734	.00187
3.500	6.617	5.000	118.4	-92.2	0.501	0.852	0.021	1.289	.0635	2.543	.00058	.0677	1.762	.00173
4.000	6.705	5.000	115.0	-81.2	0.537	0.847	0.025	1.343	.0718	2.688	.00044	.0759	1.782	.00163

DIAGRAM OF STRAIGHT-CORE DIFFUSER FLOW SHOWING NOMENCLATURE USED IN HEAD'S METHOD



APPENDIX 6

THOMPSON'S ENTRAINMENT METHOD

A.6.1 Application of Thompson's Entrainment Method to Internal Axi-symmetric Flow

Diffuser Flow - Two-Part Velocity Profile

The basic form of Thompson's two-part velocity profile is given in Chapter 5, Section 5.2.1. The velocity profile is presented in terms of contours of (y/θ) on $H \sim \log_{10}R_\theta$ axes for fixed values of $(\frac{u}{U})$, a typical example being shown in Fig. A.6.1. Thus for given H and R_θ the velocity profile can be built up from some 14 charts for the following fixed values of $(\frac{u}{U})$:

$(\frac{u}{U})$ = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95, 0.98, 0.99, 0.995, 1.000.

In order to generate a computer program for the evaluation of annular diffuser flow, using this velocity profile representation, it was necessary to curvefit each individual contour. As Fig. A.6.1 shows, the contours were not in a suitable form and it was found that re-plotting in the form of H contours on $(y/\theta) \sim \log_{10} R_\theta$ axes gave a form more amenable to curve fitting technqiues, as Fig. A.6.2 illustrates. Thus each of the H contours for each fixed value of $(\frac{u}{U})$ was curvefitted, using a fifth order polynomial representation, and the resulting curvefits formed the basis of a computer sub-routine for the evaluation of flow in an annular diffuser (denoted QUANTITY). The basis of operation of the sub-routine was as follows:

For specified values of H_o, H_i, R_{θ_o} and R_{θ_i} the velocity profiles were generated by interpolation between the curvefits representing the contour plots at each particular value of $(\frac{u}{U})$. Then, noting that the flow in the outer wall boundary layer (Q_o):

$$Q_o = \int_{R_o-\delta_o}^{R_o} 2\pi R u dR$$

the function R.u. $\sim$ R was generated in the form of a curvefit, which was integrated to give the outer wall boundary layer flow.

A similar process was carried out for the inner wall boundary layer flow (Q_i), and the total flow then evaluated by combining Q_o, Q_i, and any potential core contribution.

Auxiliary Equation

As shown in Chapter 5, Section 5.4.1, Thompson's (71) entrainment method is based upon the property of intermittency in the turbulent boundary layer.

The flux of turbulent fluid (Q_t) in the boundary layer is given thus:

$$Q_t = \int_0^{\delta} \gamma u_t dy = Ut \qquad \text{A.6.1}$$

where γ is the intermittency factor i.e. the fraction of time for which the flow is turbulent at a particular position, and t is the turbulence flux thickness.

The rate of increase of turbulent flux is then:

$$\frac{dQ_t}{dx} = \frac{d}{dx}(Ut) = \nu \frac{d}{dx}(R_\theta \cdot t/\theta) = v_{\overline{et}} \qquad \text{A.6.2}$$

where $v_{\overline{et}}$ is the overall entrainment rate, defined as the entrainment velocity. Thompson postulated that the overall entrainment rate was proportional to some suitable scale of defect to the turbulent region (Δu).

Thus $$v_{\overline{et}} = \alpha_e \Delta u \qquad \text{A.6.3}$$

where α_e is a 'universal' entrainment constant giving

$$\frac{d}{dx}(R_\theta \cdot t/\theta) = \alpha_e \frac{\Delta u}{U} \frac{U}{\nu} \qquad \text{A.6.4}$$

From assumptions of the form of the intermittency distribution etc. (as detailed in Chapter 5) Thompson was able to construct a family of turbulence flux profiles, corresponding to his velocity profile family, and to plot t/θ

and $\Delta u/U$ as a function of R_θ and H, as shown in Fig. A.6.3.

To take account of departures from the equilibrium layer it was then assumed that:

$$\alpha_e = \alpha + \beta\theta \frac{d}{dx}(t/\theta) \qquad \text{A.6.5}$$

and equation A.6.4 then took the form

$$\frac{d}{dx}(t/\theta) = \frac{\alpha \frac{U}{\nu}\frac{\Delta u}{U} - (t/\theta)\frac{dR_\theta}{dx}}{R_\theta(1 - \beta\frac{\Delta u}{U})} \qquad \text{A.6.6}$$

Equation A.6.6 is the basic form of the auxiliary equation in Thompson's method and may be applied, with the momentum integral equation, to the prediction of the boundary layer growth in an annular diffuser, as briefly described:

Considering the outer wall of an annular diffuser, equation A.6.6 may be written:

$$\frac{d}{dx}\left\{\frac{t}{\theta}\right\}_o = \frac{\alpha\frac{U}{\nu}\left\{\frac{\Delta u}{U}\right\}_o - \left\{\frac{t}{\theta}\right\}_o \frac{dR_{\theta_o}}{dx}}{R_{\theta_o}\left\{1 - \beta\left(\frac{\Delta u}{U}\right)_o\right\}} \qquad \text{A.6.7}$$

Over a step length dx all parameters are written for the mean position $\frac{dx}{2}$ and, for a given value of $\frac{dR_{\theta_o}}{dx}$, $\frac{d}{dx}\left\{\frac{t}{\theta}\right\}_o$ is predicted. Thus the value of $\left\{\frac{t}{\theta}\right\}_o$ at the upstream station is found, from which, through Fig. A.6.3 ($\log_{10}\frac{t}{\theta} \sim \log_{10}R_\theta$, H contours), it is possible to find the downstream value of H_o. A similar process is carried for the inner wall, and continuity then checked using the QUANTITY sub-routine. If necessary the values of $\frac{dU}{dx}$ i.e. $\frac{dR_{\theta_o}}{dx}$, $\frac{dR_{\theta_i}}{dx}$ and the mean position parameters are re-estimated and iteration continued until continuity of flow in the diffuser is satisfied.

A.6.2 Theoretical Predictions - Computer Program Output

TABLE A.6.1 CONSTANT CORE DIAMETER ANNULAR DIFFUSER THOMPSONS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)=10.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_{h_1}/\nu$)=184092.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\bar{C}_p$	ζ			OUTER WALL θ (IN)	H	C_f	INNER WALL θ (IN)	H	C_f
1.000	50.100	49.000	168.5	0.0	0.106	0.000	0.000	0.000	.0230	1.510	.00305	.0225	1.440	.00349
2.000	50.201	49.000	157.2	-135.7	0.230	0.747	0.000	0.000	.0310	1.584	.00279	.0304	1.483	.00321
3.000	50.301	49.000	147.9	-111.8	0.325	0.791	0.000	0.000	.0399	1.671	.00228	.0393	1.545	.00271
4.000	50.402	49.000	140.4	-89.6	0.398	0.806	0.000	0.000	.0507	1.716	.00133	.0497	1.604	.00187
5.000	50.502	49.000	134.2	-74.9	0.455	0.814	0.000	0.000	.0609	1.786	.00169	.0598	1.688	.00201
6.000	50.602	49.000	128.8	-64.5	0.502	0.820	0.000	0.000	.0718	1.851	.00149	.0705	1.764	.00173
7.000	50.703	49.000	124.2	-55.6	0.541	0.824	0.000	0.000	.0832	1.898	.00128	.0818	1.830	.00145
8.000	50.803	49.000	120.3	-46.8	0.573	0.826	0.000	0.000	.0949	1.922	.00113	.0934	1.877	.00127
9.000	50.904	49.000	116.4	-45.8	0.604	0.832	0.000	0.000	.1081	1.995	.00106	.1065	1.951	.00116
10.000	51.004	49.000	113.3	-37.7	0.628	0.834	0.000	0.000	.1209	2.040	.00091	.1192	2.000	.00099

TABLE A.6.1 CONT. NON-DIMENSIONAL MEAN VELOCITY PROFILES

X																
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 1.00IN	(R_o-R) TNS=	0.000	0.001	0.002	0.002	0.004	0.009	0.021	0.043	0.074	0.112	0.136	0.157	0.171	0.176	0.198
	$(R-R_i)$ TNS=	0.000	0.001	0.001	0.002	0.003	0.007	0.015	0.033	0.064	0.111	0.143	0.172	0.191	0.197	0.226
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 2.00IN	(R_o-R) TNS=	0.000	0.001	0.002	0.003	0.006	0.017	0.038	0.070	0.106	0.146	0.171	0.196	0.211	0.218	0.241
	$(R-R_i)$ TNS=	0.000	0.001	0.002	0.003	0.005	0.010	0.025	0.055	0.096	0.148	0.182	0.210	0.231	0.237	0.267
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 3.00IN	(R_o-R) TNS=	0.000	0.001	0.003	0.005	0.011	0.031	0.064	0.102	0.142	0.185	0.212	0.239	0.255	0.266	0.289
	$(R-R_i)$ TNS=	0.000	0.001	0.002	0.004	0.007	0.018	0.043	0.084	0.132	0.187	0.221	0.253	0.273	0.283	0.313
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 4.00IN	(R_o-R) TNS=	0.000	0.002	0.003	0.006	0.016	0.047	0.090	0.137	0.184	0.233	0.264	0.296	0.315	0.328	0.355
	$(R-R_i)$ TNS=	0.000	0.001	0.003	0.005	0.010	0.029	0.068	0.119	0.174	0.232	0.267	0.306	0.327	0.340	0.373
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 5.00IN	(R_o-R) TNS=	0.000	0.002	0.004	0.009	0.027	0.070	0.121	0.173	0.225	0.279	0.314	0.349	0.370	0.383	0.412
	$(R-R_i)$ TNS=	0.000	0.002	0.003	0.006	0.016	0.051	0.102	0.159	0.215	0.276	0.313	0.352	0.374	0.390	0.423
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 6.00IN	(R_o-R) TNS=	0.000	0.002	0.005	0.012	0.042	0.097	0.154	0.211	0.269	0.326	0.369	0.406	0.429	0.444	0.476
	$(R-R_i)$ TNS=	0.000	0.002	0.004	0.009	0.028	0.077	0.137	0.198	0.260	0.322	0.364	0.405	0.430	0.446	0.479
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 7.00IN	(R_o-R) TNS=	0.000	0.003	0.006	0.016	0.059	0.124	0.187	0.250	0.314	0.377	0.428	0.468	0.492	0.509	0.546
	$(R-R_i)$ TNS=	0.000	0.002	0.005	0.012	0.044	0.106	0.172	0.239	0.305	0.372	0.420	0.463	0.490	0.507	0.544
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 8.00IN	(R_o-R) TNS=	0.000	0.003	0.007	0.020	0.074	0.149	0.219	0.288	0.359	0.428	0.487	0.532	0.559	0.579	0.618
	$(R-R_i)$ TNS=	0.000	0.003	0.006	0.016	0.061	0.135	0.207	0.278	0.351	0.422	0.479	0.525	0.553	0.572	0.613

TABLE A.6.1 CONT. NON-DIMENSIONAL MEAN VELOCITY PROFILES

	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 9.00IN	(R_o-R) INS=	0.000	0.003	0.008	0.030	0.107	0.191	0.266	0.338	0.413	0.487	0.554	0.604	0.634	0.658	0.694
	$(R-R_i)$ INS=	0.000	0.003	0.008	0.025	0.092	0.175	0.252	0.327	0.404	0.480	0.546	0.596	0.625	0.648	0.689
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X=10.00IN	(R_o-R) INS=	0.000	0.004	0.010	0.042	0.135	0.226	0.306	0.384	0.464	0.544	0.619	0.675	0.707	0.735	0.775
	$(R-R_i)$ INS=	0.000	0.004	0.009	0.033	0.119	0.212	0.294	0.373	0.455	0.536	0.611	0.665	0.698	0.725	0.764

TABLE A.6.2 CONSTANT CORE DIAMETER ANNULAR DIFFUSER THOMPSONS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)= 7.50 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_{h_1}/\nu$)=173945.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\bar{C}_p$	ξ			OUTER WALL θ (IN)	OUTER WALL H	OUTER WALL C_f	INNER WALL θ (IN)	INNER WALL H	INNER WALL C_f
0.500	50.067	49.000	163.0	0.0	0.061	0.834	0.000	0.000	.0210	1.480	.00336	.0190	1.420	.00388
1.000	50.134	49.000	155.7	-174.9	0.148	0.663	0.000	0.000	.0255	1.515	.00313	.0233	1.442	.00368
1.500	50.201	49.000	148.1	-181.6	0.235	0.761	0.000	0.000	.0311	1.582	.00283	.0285	1.470	.00337
2.000	50.268	49.000	142.2	-142.3	0.299	0.787	0.000	0.000	.0366	1.662	.00242	.0336	1.503	.00303
2.500	50.335	49.000	136.7	-132.7	0.357	0.810	0.000	0.000	.0428	1.764	.00204	.0393	1.561	.00273
3.000	50.402	49.000	132.2	-107.0	0.402	0.815	0.000	0.000	.0489	1.845	.00167	.0449	1.620	.00241
3.500	50.469	49.000	128.4	-93.0	0.439	0.817	0.000	0.000	.0552	1.913	.00145	.0506	1.687	.00213
4.000	50.536	49.000	124.7	-88.3	0.475	0.821	0.000	0.000	.0622	1.995	.00120	.0569	1.763	.00182
4.500	50.603	49.000	121.6	-75.0	0.503	0.822	0.000	0.000	.0691	2.069	.00102	.0631	1.825	.00158
5.000	50.670	49.000	118.8	-66.4	0.528	0.822	0.000	0.000	.0759	2.135	.00097	.0693	1.879	.00148
5.500	50.737	49.000	116.2	-62.9	0.551	0.823	0.000	0.000	.0833	2.203	.00081	.0759	1.930	.00129
6.000	50.804	49.000	113.8	-56.4	0.572	0.823	0.000	0.000	.0908	2.290	.00073	.0825	1.979	.00118
6.500	50.871	49.000	111.7	-49.6	0.590	0.823	0.000	0.000	.0984	2.357	.00058	.0891	2.021	.00101
7.000	50.938	49.000	109.8	-46.1	0.606	0.823	0.000	0.000	.1062	2.428	.00050	.0958	2.067	.00093
7.500	51.005	49.000	108.1	-41.5	0.620	0.823	0.000	0.000	.1141	2.467	.00042	.1025	2.099	.00084

TABLE A62 CONT NON-DIMENSIONAL MEAN VELOCITY PROFILES

	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 0.50 IN	(R_o-R) INS=	0.000	0.001	0.001	0.002	0.004	0.007	0.016	0.035	0.064	0.103	0.129	0.152	0.168	0.172	0.196
	$(R-R_i)$ INS=	0.000	0.001	0.001	0.002	0.003	0.005	0.011	0.025	0.049	0.095	0.125	0.155	0.174	0.180	0.209
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 1.00 IN	(R_o-R) INS=	0.000	0.001	0.002	0.003	0.005	0.010	0.024	0.048	0.082	0.124	0.150	0.173	0.189	0.194	0.217
	$(R-R_i)$ INS=	0.000	0.001	0.001	0.002	0.004	0.007	0.015	0.034	0.066	0.115	0.148	0.178	0.199	0.204	0.235
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 1.50 IN	(R_o-R) INS=	0.000	0.001	0.002	0.003	0.007	0.017	0.038	0.069	0.106	0.147	0.173	0.197	0.212	0.220	0.243
	$(R-R_i)$ INS=	0.000	0.001	0.002	0.003	0.004	0.009	0.022	0.048	0.087	0.140	0.174	0.204	0.225	0.231	0.262
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 2.00 IN	(R_o-R) INS=	0.000	0.001	0.003	0.005	0.010	0.027	0.057	0.092	0.130	0.171	0.196	0.221	0.236	0.246	0.268
	$(R-R_i)$ INS=	0.000	0.001	0.002	0.003	0.006	0.012	0.030	0.064	0.109	0.163	0.197	0.225	0.247	0.253	0.283
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 2.50 IN	(R_o-R) INS=	0.000	0.002	0.003	0.007	0.018	0.045	0.081	0.119	0.157	0.197	0.223	0.248	0.264	0.274	0.296
	$(R-R_i)$ INS=	0.000	0.001	0.002	0.004	0.007	0.019	0.045	0.085	0.133	0.187	0.220	0.252	0.272	0.281	0.311
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 3.00 IN	(R_o-R) INS=	0.000	0.002	0.004	0.009	0.028	0.063	0.103	0.143	0.183	0.224	0.253	0.279	0.295	0.305	0.328
	$(R-R_i)$ INS=	0.000	0.001	0.003	0.005	0.010	0.028	0.063	0.108	0.157	0.210	0.242	0.276	0.295	0.307	0.336
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 3.50 IN	(R_o-R) INS=	0.000	0.002	0.005	0.013	0.041	0.082	0.124	0.166	0.208	0.252	0.285	0.312	0.328	0.340	0.364
	$(R-R_i)$ INS=	0.000	0.002	0.003	0.006	0.014	0.042	0.085	0.133	0.182	0.234	0.266	0.300	0.319	0.333	0.361
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 4.00 IN	(R_o-R) INS=	0.000	0.003	0.006	0.019	0.060	0.106	0.151	0.193	0.237	0.283	0.320	0.350	0.368	0.381	0.403
	$(R-R_i)$ INS=	0.000	0.002	0.004	0.008	0.023	0.060	0.109	0.159	0.209	0.262	0.295	0.329	0.350	0.363	0.391

TABLE A.6.2 CONT. NON-DIMENSIONAL MEAN VELOCITY PROFILES

	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 4.50IN	(R_o-R)INS=	0.000	0.003	0.008	0.028	0.080	0.131	0.177	0.221	0.266	0.315	0.356	0.388	0.407	0.423	0.448
	$(R-R_i)$INS=	0.000	0.002	0.005	0.011	0.033	0.079	0.131	0.183	0.235	0.288	0.325	0.360	0.381	0.394	0.423
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 5.00IN	(R_o-R)INS=	0.000	0.004	0.010	0.041	0.101	0.154	0.202	0.248	0.295	0.346	0.391	0.427	0.446	0.465	0.492
	$(R-R_i)$INS=	0.000	0.002	0.005	0.013	0.045	0.098	0.152	0.206	0.260	0.315	0.357	0.392	0.413	0.427	0.459
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 5.50IN	(R_o-R)INS=	0.000	0.004	0.013	0.059	0.122	0.179	0.229	0.278	0.329	0.381	0.429	0.469	0.490	0.510	0.539
	$(R-R_i)$INS=	0.000	0.003	0.006	0.017	0.060	0.118	0.175	0.231	0.287	0.344	0.391	0.427	0.449	0.465	0.497
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 6.00IN	(R_o-R)INS=	0.000	0.005	0.017	0.082	0.148	0.207	0.258	0.312	0.364	0.420	0.470	0.514	0.537	0.558	0.591
	$(R-R_i)$INS=	0.000	0.003	0.007	0.023	0.076	0.140	0.199	0.255	0.314	0.374	0.424	0.463	0.487	0.505	0.535
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 6.50IN	(R_o-R)INS=	0.000	0.006	0.023	0.102	0.172	0.234	0.287	0.344	0.400	0.459	0.512	0.560	0.585	0.608	0.643
	$(R-R_i)$INS=	0.000	0.004	0.008	0.029	0.093	0.160	0.222	0.280	0.341	0.403	0.458	0.499	0.524	0.544	0.574
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 7.00IN	(R_o-R)INS=	0.000	0.007	0.033	0.125	0.198	0.261	0.319	0.379	0.437	0.501	0.558	0.608	0.636	0.660	0.697
	$(R-R_i)$INS=	0.000	0.004	0.010	0.038	0.112	0.182	0.246	0.306	0.369	0.434	0.492	0.537	0.562	0.585	0.618
	U/U=	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 7.50IN	(R_o-R)INS=	0.000	0.008	0.042	0.142	0.219	0.285	0.347	0.412	0.474	0.542	0.601	0.655	0.685	0.711	0.751
	$(R-R_i)$INS=	0.000	0.004	0.011	0.046	0.130	0.203	0.269	0.331	0.396	0.464	0.526	0.574	0.600	0.625	0.661

TABLE A.6.3 CONSTANT CORE DIAMETER ANNULAR DIFFUSER THOMPSONS PREDICTION METHOD

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.030

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.(UD_{h_1}/ν)=171265.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	R_o (IN)	R_i (IN)	U FT/SEC	DU/DX /SEC	$\overline{C_p}$	ζ			OUTER WALL θ (IN)	H	C_f	INNER WALL θ (IN)	H	C_f
0.500	50.101	49.000	157.5	0.0	0.096	0.823	0.000	0.000	.0210	1.570	.00298	.0220	1.400	.00386
1.000	50.202	49.000	145.5	-237.7	0.237	0.766	0.000	0.000	.0288	1.761	.00245	.0299	1.446	.00355
1.500	50.303	49.000	137.4	-193.8	0.326	0.789	0.000	0.000	.0362	1.962	.00169	.0373	1.492	.00307
2.000	50.404	49.000	130.7	-162.2	0.396	0.800	0.000	0.000	.0447	2.230	.00107	.0453	1.569	.00263
2.500	50.506	49.000	125.6	-122.7	0.447	0.797	0.000	0.000	.0534	2.518	.00062	.0529	1.662	.00222
3.000	50.607	49.000	121.3	-101.3	0.488	0.793	0.000	0.000	.0626	2.761	.00040	.0606	1.768	.00184

TABLE A.6.3 CONT. NON-DIMENSIONAL MEAN VELOCITY PROFILES

	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 0.50IN	(R_o-R) INS=	0.000	0.001	0.002	0.003	0.005	0.011	0.023	0.044	0.070	0.101	0.120	0.138	0.149	0.154	0.170
	$(R-R_i)$ INS=	0.000	0.001	0.001	0.002	0.003	0.006	0.011	0.027	0.056	0.110	0.146	0.182	0.204	0.211	0.246
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 1.00IN	(R_o-R) INS=	0.000	0.001	0.003	0.005	0.012	0.029	0.053	0.079	0.105	0.134	0.151	0.169	0.180	0.187	0.201
	$(R-R_i)$ INS=	0.000	0.001	0.002	0.003	0.004	0.009	0.021	0.047	0.087	0.147	0.187	0.222	0.246	0.253	0.288
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 1.50IN	(R_o-R) INS=	0.000	0.002	0.004	0.011	0.031	0.057	0.084	0.111	0.138	0.166	0.188	0.206	0.217	0.225	0.239
	$(R-R_i)$ INS=	0.000	0.001	0.002	0.003	0.006	0.013	0.032	0.070	0.120	0.181	0.220	0.253	0.276	0.284	0.318
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 2.00IN	(R_o-R) INS=	0.000	0.004	0.009	0.034	0.067	0.096	0.123	0.150	0.178	0.208	0.232	0.254	0.266	0.276	0.293
	$(R-R_i)$ INS=	0.000	0.001	0.003	0.004	0.009	0.023	0.054	0.101	0.155	0.214	0.250	0.286	0.308	0.320	0.353
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 2.50IN	(R_o-R) INS=	0.000	0.006	0.026	0.070	0.105	0.135	0.164	0.195	0.225	0.258	0.285	0.311	0.325	0.337	0.357
	$(R-R_i)$ INS=	0.000	0.002	0.003	0.006	0.014	0.040	0.084	0.135	0.189	0.246	0.280	0.317	0.338	0.352	0.383
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 3.00IN	(R_o-R) INS=	0.000	0.011	0.060	0.105	0.143	0.176	0.210	0.244	0.278	0.314	0.345	0.377	0.394	0.407	0.430
	$(R-R_i)$ INS=	0.000	0.002	0.004	0.009	0.025	0.065	0.117	0.170	0.223	0.278	0.314	0.349	0.371	0.385	0.415
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 3.50IN	(R_o-R) INS=	0.000	0.012	0.076	0.128	0.170	0.210	0.250	0.289	0.329	0.370	0.406	0.444	0.464	0.480	0.506
	$(R-R_i)$ INS=	0.000	0.003	0.006	0.015	0.050	0.103	0.155	0.208	0.261	0.315	0.358	0.391	0.411	0.425	0.457
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 4.00IN	(R_o-R) INS=	0.000	0.003	0.006	0.019	0.060	0.106	0.151	0.193	0.237	0.283	0.320	0.350	0.368	0.381	0.403
	$(R-R_i)$ INS=	0.000	0.002	0.004	0.008	0.023	0.060	0.109	0.159	0.209	0.262	0.295	0.329	0.350	0.363	0.391
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 4.50IN	(R_o-R) INS=	0.000	0.003	0.003	0.028	0.080	0.131	0.177	0.221	0.266	0.315	0.356	0.388	0.407	0.423	0.448
	$(R-R_i)$ INS=	0.000	0.002	0.005	0.011	0.033	0.079	0.131	0.183	0.235	0.288	0.325	0.360	0.381	0.394	0.423
	u/U =	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.950	0.980	0.990	0.995	1.000
X= 5.00IN	(R_o-R) INS=	0.000	0.004	0.010	0.041	0.101	0.154	0.202	0.248	0.295	0.346	0.391	0.427	0.446	0.465	0.492
	$(R-R_i)$ INS=	0.000	0.002	0.005	0.013	0.045	0.098	0.152	0.206	0.260	0.315	0.357	0.392	0.413	0.427	0.459

FIGURE A.6.1

THOMPSON(73) — VELOCITY PROFILE CHART

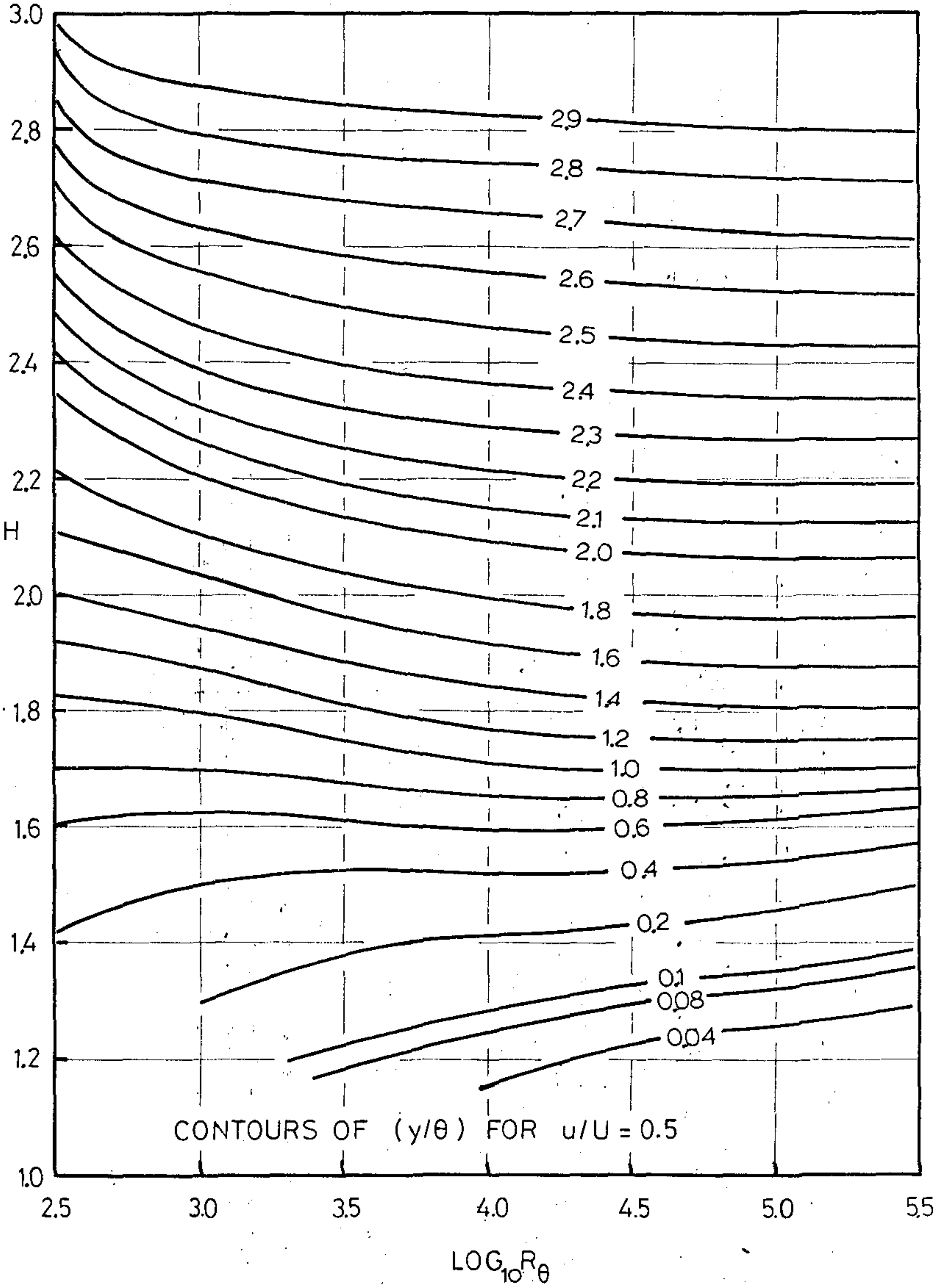


FIGURE A.6.2

THOMPSON(73) —VELOCITY PROFILE CHART (RE-PLOTTED FORM)

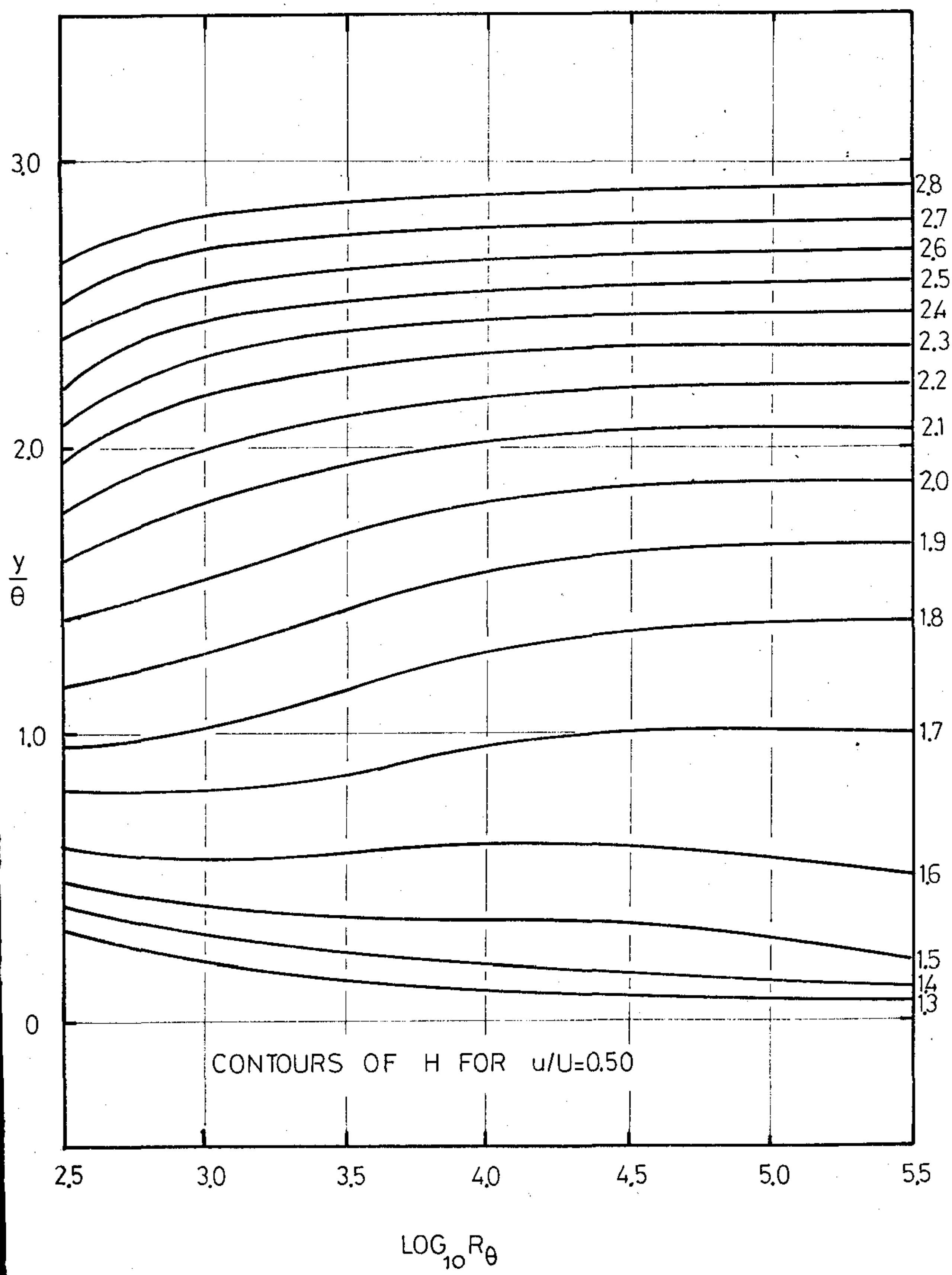
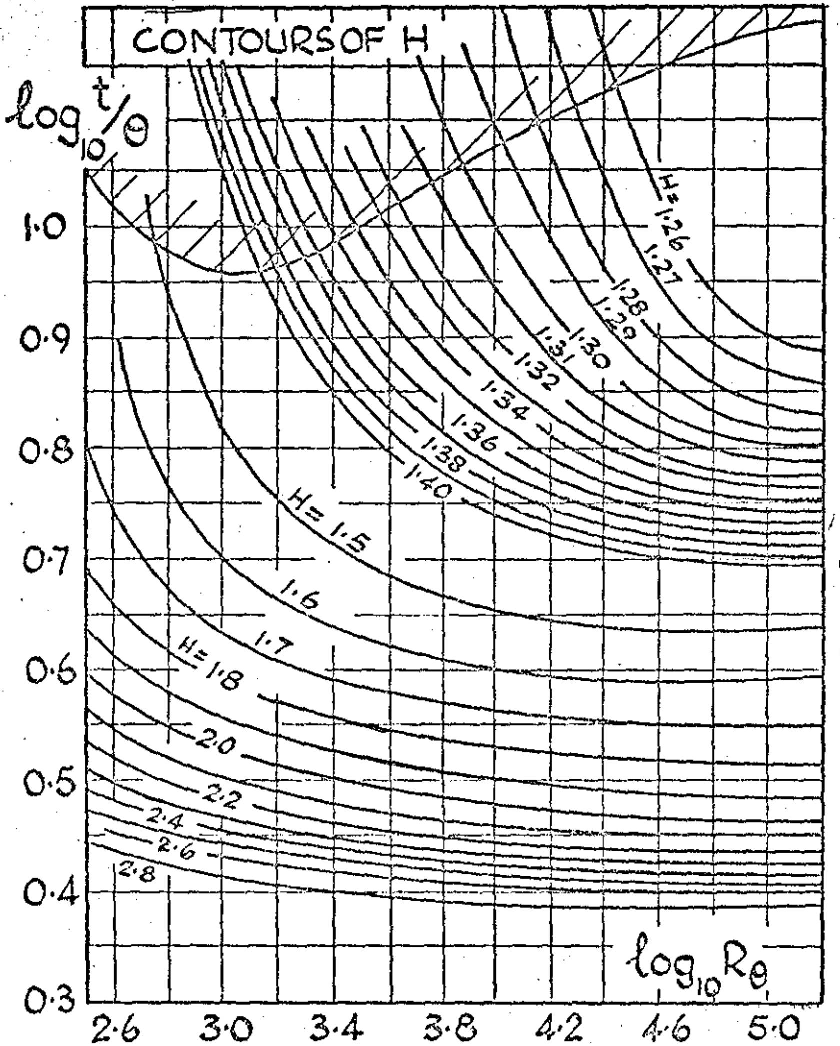
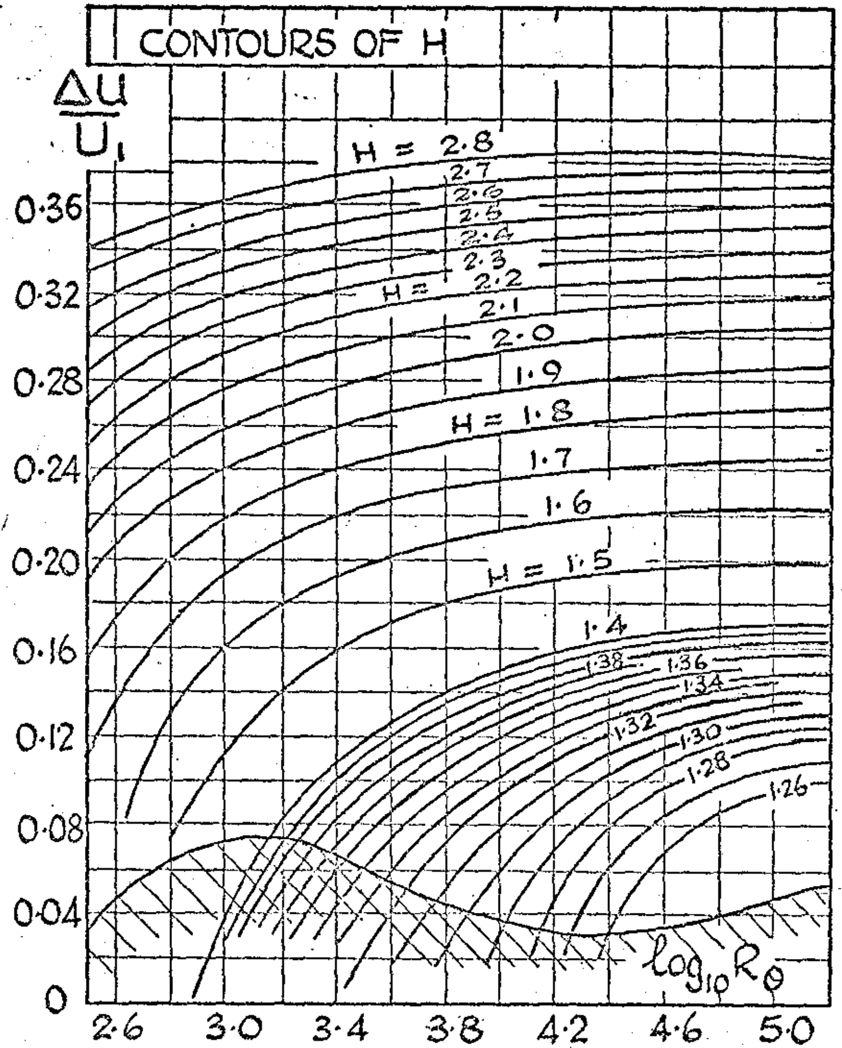


FIGURE A.6.3

THOMPSON(71) — PARAMETERS USED IN ENTRAINMENT EQUATION



Shape-factor relationships for use in the new entrainment equation. Turbulence flux thickness parameter



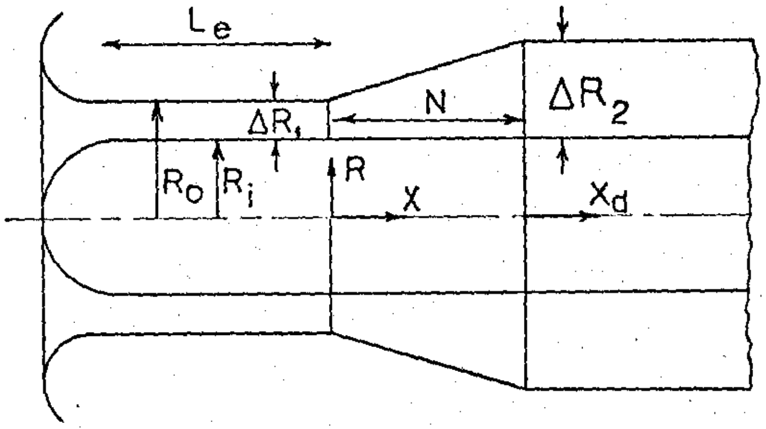
Shape-factor relationships for use in the new entrainment equation. Velocity-defect parameter

APPENDIX 7

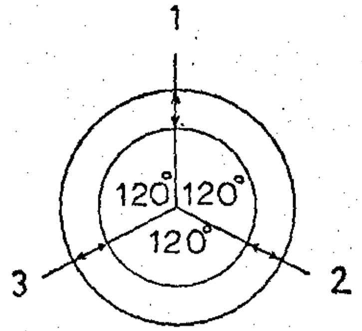
DIFFUSER INTERNAL FLOW DEVELOPMENT UNDER NATURALLY DEVELOPED INFLOW CONDITIONS

$\bar{L}/\Delta R_1 = 10.0$ $\qquad AR_{1\text{-}2} = 2.0$ $\qquad [R_i/R_o]_1 = 0.833$

TRAVERSE STATIONS		
X/N	SYMBOL	STN
0.315	●	1
0.030	○	2
0.075	▲	3
0.145	△	4
0.215	X	5
0.270	◐	6
0.370	▽	7
0.470	▼	8
0.590	⊗	9
0.770	◑	10
0.985	Ø	11
$X_d/\Delta R_2 = 1$	-	S1
2	-	S2
3	-	S3



GEOMETRY.	
$\phi_o = 5.0°$	$N = 10.0$ IN.
$R_{o_1} = 6.0$ IN.	$R_{i_1} = 5.0$ IN.
$R_{o_2} = 6.875$ IN.	$R_{i_2} = 5.0$ IN.



TRAVERSE POSITIONS.

symbols as noted unless otherwise indicated

FIGURE A.7.1


MEAN VELOCITY PROFILE DEVELOPMENT — L/ΔR=10.0 B=0028
posn 1
2
3
OUTER WALL
INNER WALL
(R₀-R)ins
(R-Rᵢ)ins
u/U
STN1
S1
S2
S3
0
0.5
1.0

FIGURE A.7.2

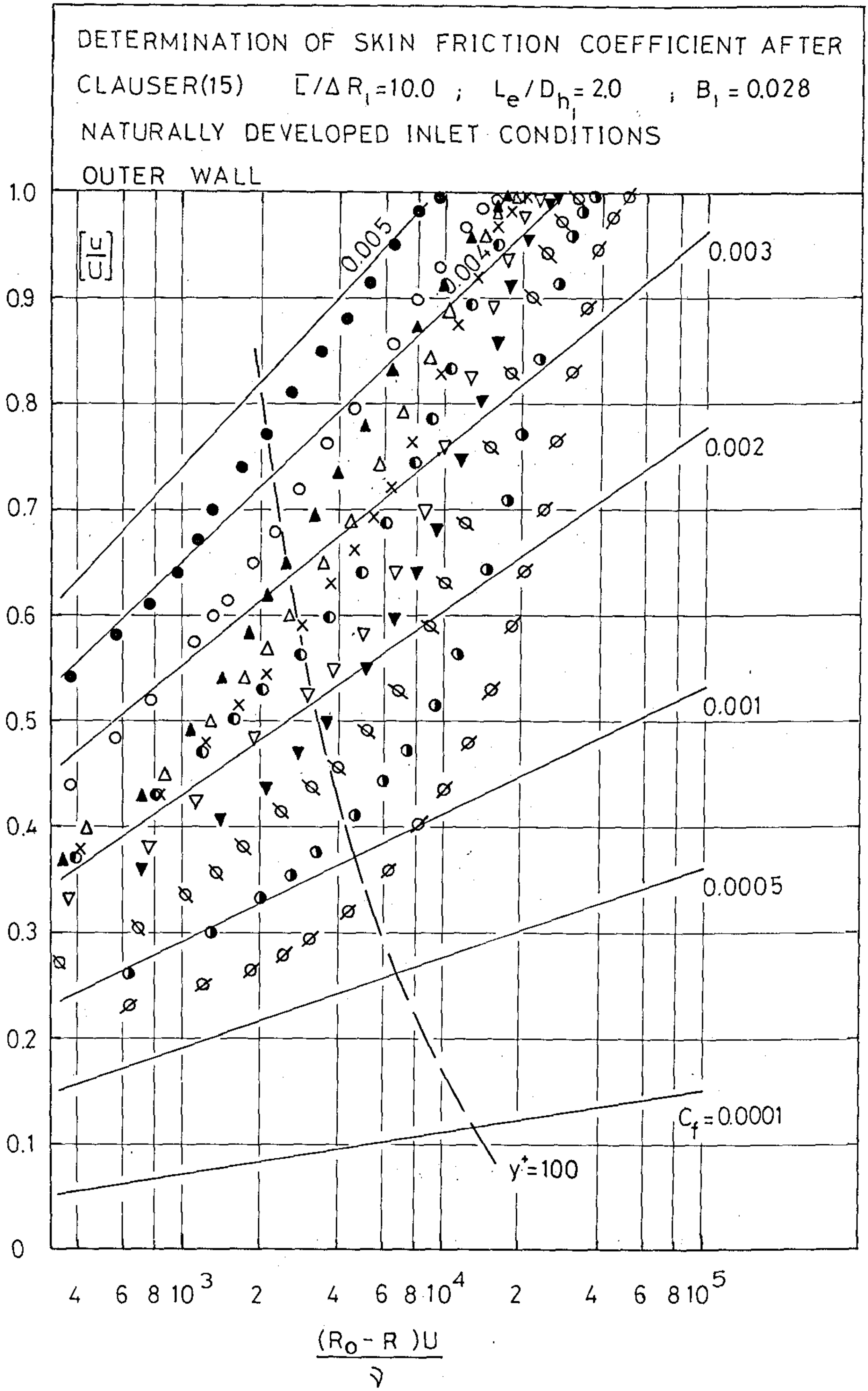

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1 = 10.0$; $L_e/D_{h_1} = 2.0$; $B_1 = 0.028$
NATURALLY DEVELOPED INLET CONDITIONS
OUTER WALL
$\left[\frac{u}{U}\right]$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
4
6
8
10^3
2
4
6
8
10^4
2
4
6
8
10^5
$\frac{(R_o - R)U}{\nu}$

FIGURE A.7.3

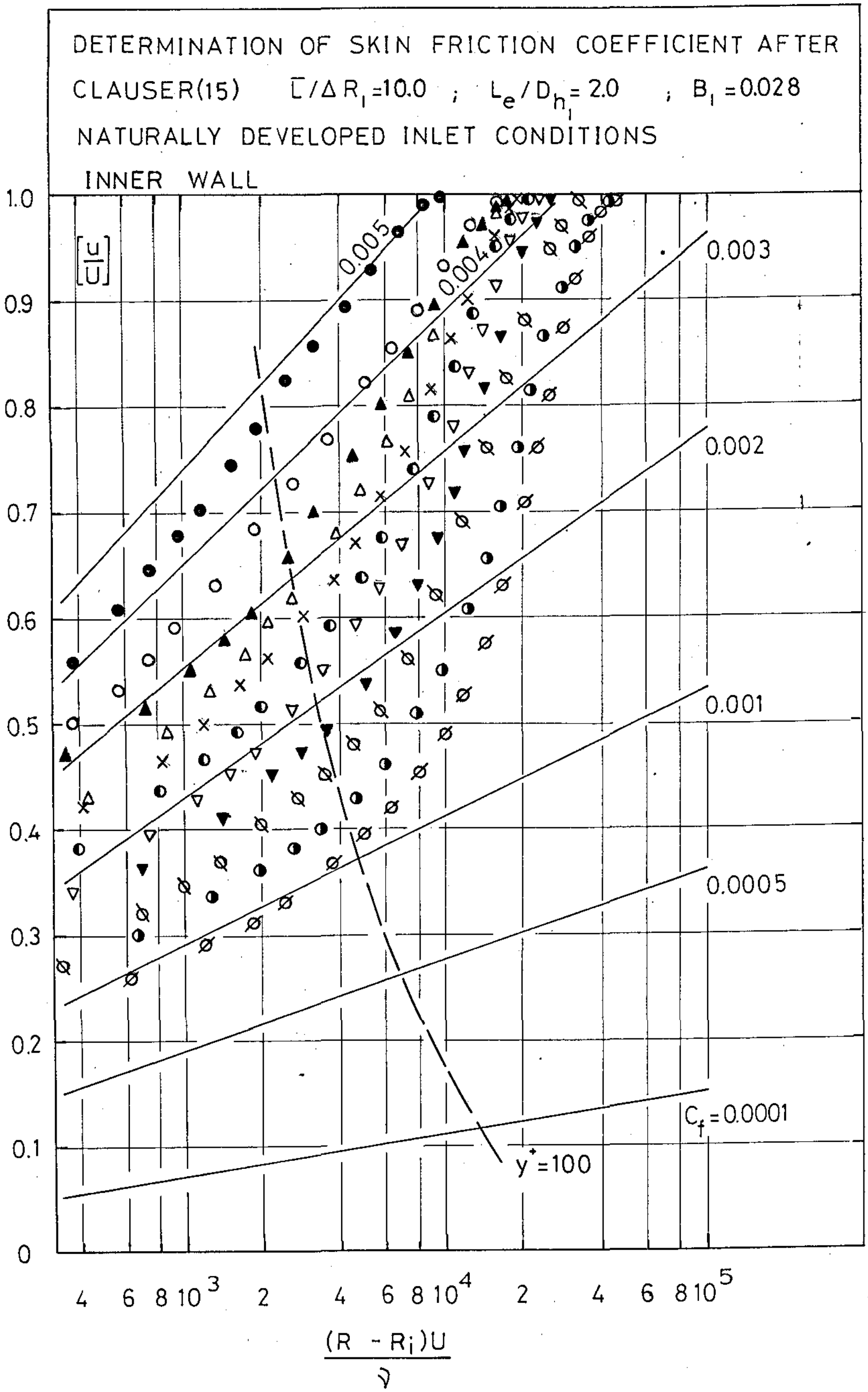

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1=10.0$; $L_e/D_{h_1}=2.0$; $B_1=0.028$
NATURALLY DEVELOPED INLET CONDITIONS
INNER WALL
$\left[\frac{u}{U}\right]$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f=0.0001$
$y^+=100$
4
6
8 10^3
2
4
6
8 10^4
2
4
6
8 10^5
$\frac{(R-R_i)U}{\nu}$

TABLE A.7.1 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)=10.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu$)$_1$=184091

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}$.147	$\bar{0}$.315	.0142	.0103	.0181	1.381	1.758	.0133	.0097	.0172	1.371	1.770
0.300	0.030	.0255	.0180	.0314	1.420	1.745	.0251	.0184	.0324	1.364	1.763
0.750	0.075	.0324	.0216	.0371	1.502	1.720	.0316	.0222	.0385	1.428	1.737
1.450	0.145	.0402	.0263	.0448	1.529	1.701	.0390	.0262	.0450	1.488	1.714
2.150	0.215	.0483	.0313	.0530	1.545	1.693	.0481	.0319	.0542	1.511	1.702
2.700	0.270	.0542	.0345	.0580	1.571	1.682	.0570	.0365	.0614	1.562	1.683
3.700	0.370	.0716	.0437	.0725	1.639	1.659	.0710	.0442	.0738	1.607	1.670
4.700	0.470	.0884	.0523	.0859	1.690	1.643	.0933	.0555	.0913	1.680	1.644
5.900	0.590	.1164	.0662	.1077	1.759	1.628	.1202	.0702	.1155	1.711	1.644
7.700	0.770	.1600	.0852	.1361	1.879	1.598	.1688	.0959	.1563	1.761	1.630
9.850	0.985	.2395	.1195	.1882	2.004	1.575	.2162	.1160	.1859	1.864	1.602
13.750	1.375	.2103	.1288	.2123	1.633	1.649	.2535	.1455	.2366	1.742	1.626
17.500	1.750	.1802	.1221	.2085	1.476	1.708	.1858	.1265	.2172	1.470	1.717
21.250	2.125	.1068	.0856	.1557	1.248	1.819	.1388	.1004	.1770	1.382	1.762

TABLE A7.2 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)=10.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu)_1$=184091

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	X/N	U FT/SEC	$\bar{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
-3.147	-0.315	177.66	.972	41.459	1.019	1.007	972.1	921.3
0.300	0.030	177.28	.951	41.595	1.034	1.013	1698.3	1735.2
0.750	0.075	169.61	.940	41.026	1.047	1.018	1948.4	2001.7
1.450	0.145	163.24	.930	41.516	1.058	1.022	2288.5	2281.1
2.150	0.215	156.33	.919	41.649	1.068	1.026	2606.4	2653.9
2.700	0.270	151.50	.910	41.785	1.079	1.029	2782.5	2944.1
3.700	0.370	143.63	.892	41.916	1.101	1.037	3344.5	3382.0
4.700	0.470	135.14	.872	41.378	1.127	1.047	3766.6	3996.2
5.900	0.590	130.64	.844	42.009	1.159	1.059	4607.8	4889.2
7.700	0.770	122.90	.804	42.145	1.213	1.078	5575.9	6279.3
9.850	0.985	115.72	.753	42.007	1.292	1.104	7366.1	7154.3
13.750	1.375	109.83	.756	40.346	1.200	1.069	7535.9	8514.1
17.500	1.750	103.92	.805	40.649	1.109	1.038	6759.4	7002.1
21.250	2.125	98.35	.872	41.644	1.051	1.018	4483.8	5262.8

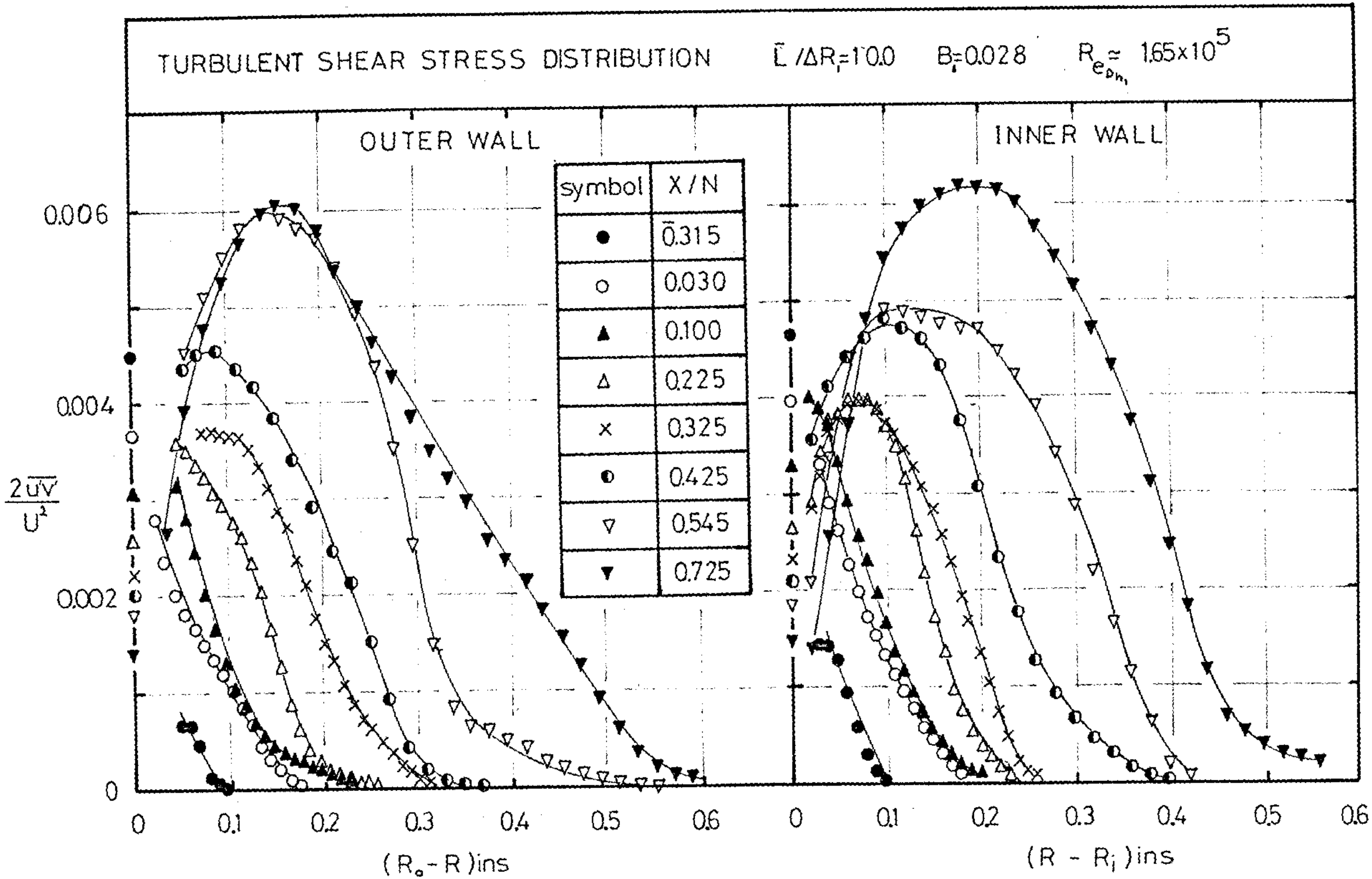
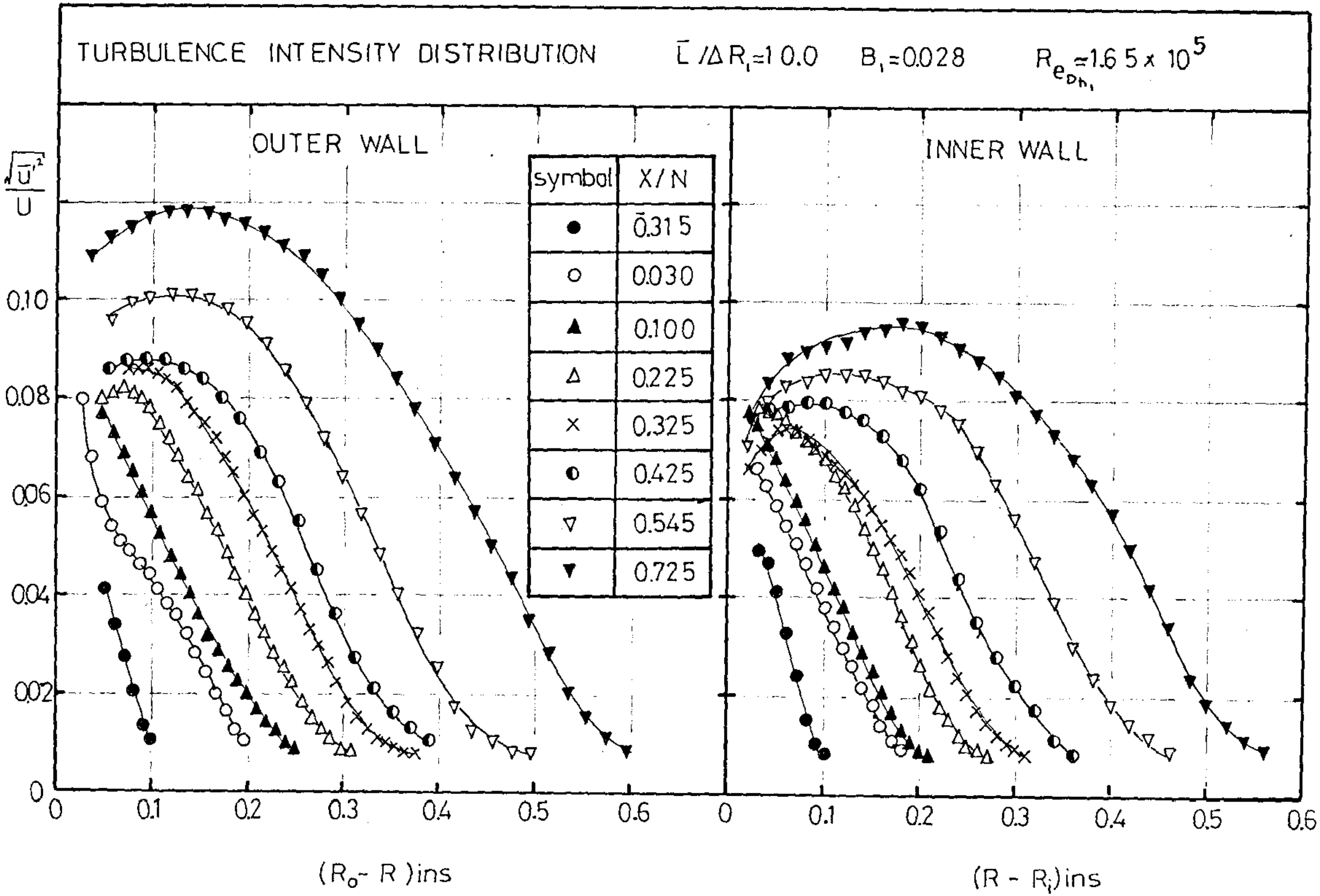

TURBULENT SHEAR STRESS DISTRIBUTION
L̄/ΔRᵢ=10.0
Bᵢ=0.028
Re ≃ 1.65x10^5
OUTER WALL
INNER WALL
symbol
X/N
0.315
0.030
0.100
0.225
0.325
0.425
0.545
0.725
0.006
0.004
0.002
0
2uv/U²
0
0.1
0.2
0.3
0.4
0.5
0.6
(Rₒ - R) ins
(R - Rᵢ) ins

FIGURE A.7.4



TURBULENCE INTENSITY DISTRIBUTION
$\bar{L}/\Delta R_1 = 10.0$
$B_1 = 0.028$
$R_{e_{Dh_1}} = 1.65 \times 10^5$
OUTER WALL
INNER WALL
$\frac{\sqrt{\bar{u}'^2}}{U}$
symbol
X/N
0.315
0.030
0.100
0.225
0.325
0.425
0.545
0.725
0
0.02
0.04
0.06
0.08
0.10
0.1
0.2
0.3
0.4
0.5
0.6
$(R_o - R)$ ins
$(R - R_i)$ ins

FIGURE A.7.5

TABLE A.7.3 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_1)$=10.00 (L_e/D_{h_1})= 2.0 (AR)=2.000 (B_1)=0.028 INLET REYNOLDS NO.$(\bar{u}D_{h_1}/\nu)$=163500.0

STN. X_1= 3.147 X/N=0.315 GREEN POSITION(2) $H_{o_{2-D}}$=1.380 $H_{i_{2-D}}$=1.372 $\delta^*_{o_{2-D}}$=.0142" $\delta^*_{i_{2-D}}$=.0133" U=157.91FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	R-R (IN)	$\frac{R-R}{R-R}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.050	.950	.898	.00032	.041	.0068	0.380	0.030	.030	.837	.00069	.050	.0130	0.494
0.060	.940	.930	.00032	.034	.0077	0.430	0.040	.040	.877	.00070	.047	.0141	0.532
0.070	.930	.957	.00023	.027	.0069	0.453	0.050	.050	.910	.00062	.041	.0143	0.576
0.080	.920	.977	.00009	.020	.0039	0.410	0.060	.060	.938	.00044	.033	.0124	0.585
0.090	.910	.989	.00005	.013	.0033	0.468	0.070	.070	.962	.00027	.024	.0096	0.582
0.100	.900	.997	.00003	.010	.0060	1.037	0.080	.080	.981	.00013	.015	.0066	0.576
0.000	.000	.000	.00000	.000	.0000	0.000	0.090	.090	.992	.00005	.010	.0047	0.636
0.000	.000	.000	.00000	.000	.0000	0.000	0.100	.100	.999	.00002	.008	.0066	1.414

OUTER WALL: *REYNOLDS STRESS INTEGRAL(J)= .00007099IN

DISSIPATION INTEGRAL$(\frac{\mathcal{D}}{2})$= 0.000256

INNER WALL: REYNOLDS STRESS INTEGRAL(J)= .00002692IN

DISSIPATION INTEGRAL$(\frac{\mathcal{D}}{2})$= 0.000377

$$* \quad J = \int_0^{\delta} (\overline{u'^2} - \overline{v'^2})\, dR$$

TABLE A.7.4 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\overline{L}/\Delta R_1)$=10.00 (L_e/D_{h_1})= 2.0 (AR)=2.000 (B_1)=0.028 INLET REYNOLDS NO.$(\overline{u}D_h/\nu)$=163500.0

STN. X= 0.300" X/N=0.030 GREEN POSITION(2) $H_{o_{2\text{-}D}}$=1.418 $H_{i_{2\text{-}D}}$=1.366 $\delta^*_{o_{2\text{-}D}}$=.0257" $\delta^*_{i_{2\text{-}D}}$=.0248" U=158.34FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2\text{-}D}}}$	$\frac{\ell}{\delta^*_{o_{2\text{-}D}}}$
0.026	.975	.694	.00139	.080	.0078	0.208
0.036	.965	.753	.00117	.068	.0101	0.296
0.046	.955	.795	.00100	.059	.0111	0.352
0.056	.945	.828	.00090	.054	.0117	0.390
0.066	.936	.853	.00082	.051	.0122	0.425
0.076	.926	.875	.00074	.049	.0127	0.469
0.086	.916	.897	.00067	.046	.0131	0.504
0.096	.906	.917	.00059	.044	.0122	0.502
0.106	.897	.935	.00050	.041	.0110	0.496
0.116	.887	.951	.00041	.038	.0105	0.523
0.126	.877	.965	.00032	.036	.0095	0.530
0.136	.867	.976	.00020	.032	.0072	0.508
0.146	.858	.983	.00014	.028	.0060	0.518
0.156	.848	.990	.00009	.024	.0052	0.549
0.166	.838	.994	.00007	.020	.0057	0.693
0.176	.828	.998	.00005	.016	.0074	1.074
0.186	.819	.999	.00004	.012	.0341	5.640

REYNOLDS STRESS INTEGRAL(J)= .00028848IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$= 0.000493

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2\text{-}D}}}$	$\frac{\ell}{\delta^*_{i_{2\text{-}D}}}$
0.020	.019	.682	.00186	.070	.0115	0.267
0.030	.029	.736	.00166	.066	.0149	0.366
0.040	.039	.775	.00146	.063	.0168	0.440
0.050	.049	.808	.00131	.059	.0177	0.488
0.060	.058	.836	.00115	.055	.0185	0.546
0.070	.068	.859	.00098	.051	.0176	0.561
0.080	.078	.881	.00085	.047	.0172	0.589
0.090	.088	.901	.00076	.042	.0174	0.634
0.100	.097	.921	.00065	.038	.0157	0.618
0.110	.107	.940	.00055	.034	.0126	0.538
0.120	.117	.956	.00048	.030	.0144	0.659
0.130	.127	.968	.00038	.026	.0135	0.691
0.140	.136	.978	.00028	.022	.0120	0.717
0.150	.146	.984	.00021	.018	.0113	0.780
0.160	.156	.990	.00014	.014	.0100	0.856
0.170	.166	.995	.00008	.011	.0095	1.042
0.180	.175	.998	.00004	.009	.0114	1.710

REYNOLDS STRESS INTEGRAL(J)= .00008416IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$= 0.000623

TABLE A.7.5 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i)$=10.00 (L_e/D_{h_i})= 2.0 (AR)=2.000 (B)=0.028 INLET REYNOLDS NO. $(\bar{u}D_{h_i}/\nu)$=163500.0

STN. X= 1.000" X/N=0.100 GREEN POSITION(2) $H_{o_{2-D}}$=1.477 $H_{i_{2-D}}$=1.395 $\delta^*_{o_{2-D}}$=.0390" $\delta^*_{i_{2-D}}$=.0353" U=148.34FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.048	.956	.698	.00157	.077	.0090	0.228	0.020	.018	.616	.00199	.078	.0099	0.221
0.058	.947	.740	.00141	.073	.0094	0.252	0.030	.028	.664	.00194	.075	.0122	0.277
0.068	.938	.775	.00122	.069	.0094	0.268	0.040	.037	.705	.00184	.072	.0131	0.304
0.078	.928	.806	.00100	.065	.0092	0.290	0.050	.046	.743	.00166	.069	.0134	0.329
0.088	.919	.833	.00082	.061	.0076	0.266	0.060	.055	.775	.00145	.064	.0132	0.347
0.098	.910	.859	.00065	.057	.0071	0.276	0.070	.064	.806	.00128	.060	.0125	0.350
0.108	.901	.881	.00051	.053	.0064	0.286	0.080	.074	.832	.00114	.056	.0140	0.415
0.118	.892	.901	.00043	.048	.0058	0.280	0.090	.083	.855	.00096	.051	.0124	0.400
0.128	.882	.918	.00034	.044	.0058	0.319	0.100	.092	.874	.00083	.047	.0130	0.452
0.138	.873	.931	.00027	.040	.0056	0.339	0.110	.101	.892	.00067	.042	.0112	0.432
0.148	.864	.942	.00022	.036	.0058	0.384	0.120	.110	.907	.00057	.038	.0108	0.452
0.158	.855	.951	.00019	.032	.0058	0.425	0.130	.119	.922	.00045	.033	.0091	0.429
0.168	.846	.959	.00016	.029	.0060	0.470	0.140	.129	.936	.00036	.029	.0078	0.412
0.178	.836	.966	.00015	.026	.0064	0.528	0.150	.138	.948	.00027	.025	.0069	0.421
0.188	.827	.972	.00012	.023	.0063	0.571	0.160	.147	.959	.00021	.021	.0060	0.418
0.198	.818	.977	.00010	.020	.0064	0.628	0.170	.156	.967	.00015	.017	.0050	0.410
0.208	.809	.981	.00008	.017	.0057	0.654	0.180	.165	.973	.00010	.013	.0038	0.397
0.218	.800	.985	.00006	.014	.0055	0.725	0.190	.175	.978	.00006	.010	.0029	0.375
0.228	.790	.989	.00004	.012	.0056	0.835	0.200	.184	.981	.00004	.009	.0021	0.350

TABLE A.7.5 CONT.

OUTER WALL $R_o - R$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.238	.781	.992	.00003	.010	.0055	0.980
0.248	.772	.995	.00002	.009	.0046	1.100
0.258	.763	.997	.00001	.008	.0034	1.210
0.268	.754	.999	.00000	.007	.0028	1.680
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00040715IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.000547

INNER WALL $R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.210	.193	.983	.00001	.008	.0005	0.190
0.220	.202	.985	.00000	.007	.0000	0.000
0.230	.211	.987	.00000	.006	.0000	0.000
0.240	.221	.989	.00000	.006	.0000	0.000
0.250	.230	.991	.00000	.005	.0000	0.000
0.260	.239	.992	.00000	.005	.0000	0.000
0.270	.248	.993	.00000	.005	.0000	0.000
0.280	.257	.994	.00000	.005	.0000	0.000
0.290	.267	.995	.00000	.005	.0000	0.000
0.300	.276	.996	.00000	.005	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00001257IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.000760

TABLE A.7.6 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i)$=10.00 (L_e/D_{h_i})= 2.0 (AR)=2.000 (B_i)=0.028 INLET REYNOLDS NO.$(\bar{u}D_{h_i}/\nu)$=163500.0

STN. X= 2.250" X/N=0.225 GREEN POSITION(2) $H_{o_{2-D}}$=1.554 $H_{i_{2-D}}$=1.515 $\delta^*_{o_{2-D}}$=.0590" $\delta^*_{i_{2-D}}$=.0531" U=135.97FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.047	.961	.593	.00179	.080	.0095	0.225	0.020	.017	.530	.00146	.078	.0055	0.144
0.057	.952	.625	.00174	.081	.0090	0.216	0.030	.025	.568	.00171	.079	.0092	0.223
0.067	.944	.657	.00168	.082	.0088	0.214	0.040	.033	.600	.00185	.079	.0120	0.280
0.077	.936	.690	.00161	.081	.0087	0.218	0.050	.042	.626	.00190	.077	.0138	0.316
0.087	.927	.719	.00153	.080	.0094	0.241	0.060	.050	.655	.00197	.076	.0138	0.310
0.097	.919	.747	.00147	.078	.0091	0.238	0.070	.058	.681	.00197	.074	.0128	0.289
0.107	.911	.772	.00138	.075	.0090	0.243	0.080	.067	.709	.00198	.072	.0143	0.322
0.117	.902	.798	.00129	.072	.0088	0.245	0.090	.075	.736	.00192	.070	.0134	0.305
0.127	.894	.820	.00118	.068	.0086	0.250	0.100	.084	.761	.00183	.068	.0138	0.322
0.137	.886	.841	.00103	.064	.0078	0.246	0.110	.092	.786	.00173	.065	.0130	0.313
0.147	.877	.861	.00083	.061	.0068	0.238	0.120	.100	.812	.00155	.062	.0117	0.297
0.157	.869	.880	.00063	.056	.0062	0.246	0.130	.109	.836	.00128	.059	.0096	0.270
0.167	.860	.897	.00043	.053	.0049	0.233	0.140	.117	.860	.00104	.054	.0089	0.276
0.177	.852	.913	.00030	.048	.0038	0.219	0.150	.125	.882	.00082	.050	.0075	0.260
0.187	.844	.926	.00020	.044	.0030	0.205	0.160	.134	.904	.00064	.046	.0066	0.260
0.197	.835	.938	.00014	.040	.0023	0.197	0.170	.142	.924	.00048	.041	.0059	0.268
0.207	.827	.949	.00010	.036	.0017	0.207	0.180	.150	.938	.00037	.036	.0058	0.302
0.217	.819	.957	.00008	.032	.0017	0.207	0.190	.159	.950	.00026	.031	.0051	0.318
0.227	.810	.962	.00005	.028	.0013	0.195	0.200	.167	.957	.00017	.026	.0042	0.320

TABLE A.7.6 CONT.

OUTER WALL

$R_o - R$ (IN)	$\frac{R - R_i}{R_o - R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.237	.802	.967	.00003	.025	.0009	0.190
0.247	.794	.971	.00003	.022	.0009	0.204
0.257	.785	.975	.00002	.018	.0007	0.195
0.267	.777	.978	.00001	.015	.0005	0.175
0.277	.769	.981	.00001	.013	.0005	0.181
0.287	.760	.984	.00000	.010	.0003	0.187
0.297	.752	.986	.00000	.008	.0000	0.000
0.307	.744	.988	.00000	.008	.0000	0.000
0.317	.735	.989	.00000	.007	.0001	0.071
0.327	.727	.991	.00000	.006	.0000	0.050
0.337	.718	.993	.00000	.006	.0000	0.000
0.347	.710	.995	.00000	.006	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00055960IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.000704

INNER WALL

$R - R_i$ (IN)	$\frac{R - R_i}{R_o - R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.210	.175	.964	.00012	.022	.0039	0.358
0.220	.184	.969	.00007	.018	.0031	0.355
0.230	.192	.975	.00003	.015	.0020	0.360
0.240	.201	.980	.00002	.012	.0015	0.365
0.250	.209	.984	.00002	.010	.0018	0.386
0.260	.217	.987	.00001	.009	.0010	0.284
0.270	.226	.990	.00001	.007	.0008	0.280
0.280	.234	.992	.00001	.006	.0008	0.280
0.290	.242	.995	.00000	.006	.0000	0.000
0.300	.251	.997	.00000	.005	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00016779IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.000844

TABLE A.7.7 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i)$=10.00 (L_e/D_{h_1})= 2.0 (AR)=2.000 (B_i)=0.028 INLET REYNOLDS NO. $(\bar{u}D_{h_1}/\nu)$=163500.0

STN. X=3.250" X/H=0.325 GREEN POSITION(2) $H_{o_{2-D}}$=1.645 $H_{i_{2-D}}$=1.606 $\delta^*_{o_{2-D}}$=.0766 $\delta^*_{i_{2-D}}$=.0771 U=128.82FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\epsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\epsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.074	.942	.587	.00186	.086	.0096	0.222	0.020	.016	.425	.00141	.066	.0028	0.074
0.084	.935	.613	.00185	.086	.0092	0.213	0.030	.023	.477	.00168	.070	.0047	0.116
0.094	.927	.640	.00183	.086	.0092	0.214	0.040	.031	.517	.00180	.072	.0062	0.147
0.104	.919	.665	.00184	.085	.0094	0.220	0.050	.039	.552	.00188	.074	.0074	0.170
0.114	.911	.691	.00182	.084	.0095	0.222	0.060	.047	.583	.00195	.074	.0089	0.201
0.124	.903	.715	.00176	.082	.0094	0.225	0.070	.055	.609	.00198	.073	.0105	0.235
0.134	.896	.739	.00166	.079	.0087	0.213	0.080	.062	.632	.00192	.072	.0111	0.253
0.144	.888	.765	.00154	.077	.0080	0.204	0.090	.070	.654	.00192	.071	.0113	0.258
0.154	.880	.790	.00142	.075	.0076	0.203	0.100	.078	.676	.00184	.069	.0106	0.247
0.164	.872	.814	.00134	.072	.0073	0.200	0.110	.086	.699	.00179	.067	.0103	0.244
0.174	.864	.837	.00117	.068	.0066	0.192	0.120	.093	.721	.00170	.065	.0100	0.243
0.184	.857	.860	.00104	.065	.0064	0.197	0.130	.101	.743	.00162	.063	.0096	0.238
0.194	.849	.880	.00087	.060	.0063	0.212	0.140	.109	.765	.00152	.061	.0088	0.225
0.204	.841	.897	.00074	.056	.0061	0.223	0.150	.117	.788	.00141	.058	.0078	0.207
0.214	.833	.912	.00065	.053	.0058	0.227	0.160	.125	.812	.00127	.055	.0075	0.211
0.224	.826	.925	.00053	.049	.0052	0.225	0.170	.132	.832	.00113	.052	.0075	0.223
0.234	.818	.936	.00043	.045	.0047	0.224	0.180	.140	.851	.00096	.049	.0067	0.217
0.244	.810	.946	.00035	.041	.0042	0.224	0.190	.148	.869	.00082	.045	.0065	0.225
0.254	.802	.954	.00029	.037	.0040	0.233	0.200	.156	.884	.00063	.041	.0056	0.221

TABLE A.7.7 CONT.

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.264	.794	.962	.00023	.033	.0035	0.232	0.210	.164	.899	.00050	.037	.0048	0.214
0.274	.787	.968	.00017	.030	.0030	0.230	0.220	.171	.911	.00036	.033	.0040	0.213
0.284	.779	.973	.00011	.026	.0022	0.212	0.230	.179	.922	.00022	.028	.0039	0.195
0.294	.771	.978	.00007	.022	.0016	0.215	0.240	.187	.932	.00011	.024	.0016	0.158
0.304	.763	.983	.00004	.018	.0013	0.211	0.250	.195	.942	.00005	.020	.0009	0.123
0.314	.755	.986	.00002	.015	.0009	0.195	0.260	.202	.950	.00002	.017	.0005	0.108
0.324	.748	.989	.00001	.013	.0008	0.205	0.270	.210	.957	.00001	.014	.0002	0.092
0.334	.740	.992	.00000	.011	.0002	0.165	0.280	.218	.963	.00001	.012	.0002	0.107
0.344	.732	.994	.00000	.010	.0000	0.000	0.290	.226	.968	.00000	.010	.0000	0.000
0.354	.724	.996	.00000	.009	.0000	0.000	0.300	.234	.973	.00000	.009	.0000	0.000
0.364	.717	.998	.00000	.008	.0000	0.000	0.310	.241	.977	.00000	.008	.0000	0.000
0.374	.709	.999	.00000	.008	.0000	0.000	0.320	.249	.979	.00000	.007	.0001	0.039
0.000	.000	.000	.00000	.000	.0000	0.000	0.330	.257	.981	.00000	.006	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000	0.340	.265	.983	.00000	.006	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000	0.350	.273	.984	.00000	.006	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000	0.360	.280	.986	.00000	.006	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000	0.370	.288	.987	.00000	.006	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000	0.380	.296	.989	.00000	.006	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000	0.390	.304	.990	.00000	.006	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000	0.400	.312	.991	.00000	.057	.0000	0.000

OUTER WALL:

REYNOLDS STRESS INTEGRAL(J)= .00058669IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.000789

INNER WALL:

REYNOLDS STRESS INTEGRAL(J)= .00007924IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.000917

TABLE A.7.8 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i)$=10.00 (L_e/D_{h_i})= 2.0 (AR)=2.000 (B_i)=0.028 INLET REYNOLDS NO. $(\bar{U}D_{h_i}/\nu)$=163500.0

STN. X= 4.250" X/N=0.425 GREEN POSITION(2) $H_{o_{2-D}}$=1.694 $H_{i_{2-D}}$=1.657 $\delta^*_{o_{2-D}}$=.0889" $\delta^*_{i_{2-D}}$=.0913" U=122.90FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.052	.962	.499	.00217	.086	.0101	0.218	0.020	.015	.424	.00178	.076	.0073	0.174
0.072	.948	.547	.00226	.087	.0110	0.231	0.040	.029	.470	.00205	.078	.0098	0.216
0.092	.933	.595	.00227	.088	.0108	0.226	0.060	.044	.515	.00221	.079	.0105	0.224
0.112	.918	.640	.00218	.088	.0108	0.232	0.080	.058	.562	.00231	.080	.0110	0.229
0.132	.904	.685	.00207	.086	.0104	0.229	0.100	.073	.609	.00239	.080	.0114	0.233
0.152	.889	.729	.00191	.084	.0100	0.229	0.120	.087	.652	.00235	.078	.0112	0.231
0.172	.875	.772	.00169	.080	.0091	0.221	0.140	.102	.700	.00230	.076	.0109	0.228
0.192	.860	.814	.00146	.076	.0079	0.206	0.160	.117	.743	.00215	.073	.0112	0.242
0.212	.845	.854	.00122	.069	.0071	0.204	0.180	.131	.785	.00187	.068	.0098	0.226
0.232	.831	.889	.00104	.063	.0072	0.222	0.200	.146	.827	.00153	.062	.0086	0.219
0.252	.816	.921	.00074	.055	.0057	0.209	0.220	.160	.862	.00116	.054	.0080	0.234
0.272	.802	.946	.00044	.045	.0042	0.202	0.240	.175	.892	.00087	.044	.0070	0.239
0.292	.787	.968	.00021	.036	.0028	0.190	0.260	.190	.916	.00063	.035	.0060	0.239
0.312	.773	.981	.00008	.027	.0016	0.170	0.280	.204	.939	.00046	.028	.0048	0.224
0.332	.758	.989	.00005	.021	.0014	0.205	0.300	.219	.956	.00033	.022	.0050	0.223
0.352	.743	.993	.00003	.016	.0015	0.276	0.320	.233	.967	.00022	.017	.0035	0.228
0.372	.729	.997	.00002	.013	.0014	0.395	0.340	.248	.978	.00014	.011	.0028	0.236
0.392	.714	.999	.00001	.010	.0020	0.588	0.360	.262	.985	.00007	.008	.0017	0.211
0.000	.000	.000	.00000	.000	.0000	0.000	0.380	.277	.991	.00004	.006	.0012	0.203

TABLE A.7.8 CONT.

OUTER WALL

$R_o - R$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00027530IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001029

INNER WALL

$R - R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U^2}$	$\frac{\overline{u'v'}}{U}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.400	.292	.995	.00002	.005	.0008	0.199
0.420	.306	.997	.00001	.005	.0008	0.253
0.440	.321	.999	.00001	.005	.0017	0.631

REYNOLDS STRESS INTEGRAL(J)= .00010887IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001148

TABLE A.7.9 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\overline{L}/\Delta R_i)$=10.00 (L_e/D_{h_i})= 2.0 (AR)=2.000 (B_i)=0.028 INLET REYNOLDS NO. $(\bar{u}D_{h_i}/\nu)$=163500.0

STN. X= 5.450" X/N=0.545 GREEN POSITION(2) $H_{o_{2-D}}$=1.751 $H_{i_{2-D}}$=1.772 $\delta^*_{o_{2-D}}$=.1167" $\delta^*_{i_{2-D}}$=.1163" U=116.69FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.057	.961	.454	.00226	.096	.0095	0.199	0.020	.014	.350	.00102	.071	.0019	0.061
0.077	.948	.497	.00255	.099	.0103	0.204	0.040	.027	.418	.00167	.080	.0055	0.135
0.097	.934	.537	.00275	.100	.0118	0.225	0.060	.041	.464	.00220	.083	.0095	0.202
0.117	.921	.577	.00289	.101	.0124	0.231	0.080	.054	.500	.00240	.084	.0118	0.241
0.137	.907	.619	.00298	.101	.0127	0.234	0.100	.068	.536	.00245	.085	.0111	0.224
0.157	.894	.657	.00295	.100	.0128	0.236	0.120	.081	.574	.00244	.085	.0114	0.230
0.177	.880	.696	.00291	.098	.0128	0.237	0.140	.095	.612	.00240	.085	.0103	0.211
0.197	.867	.735	.00284	.095	.0127	0.238	0.160	.108	.651	.00237	.084	.0102	0.209
0.217	.853	.772	.00271	.091	.0128	0.247	0.180	.122	.692	.00236	.082	.0097	0.199
0.237	.840	.804	.00246	.086	.0125	0.250	0.200	.135	.734	.00235	.081	.0092	0.190
0.257	.826	.835	.00217	.079	.0120	0.257	0.220	.149	.779	.00222	.078	.0091	0.193
0.277	.812	.864	.00174	.072	.0105	0.251	0.240	.162	.822	.00211	.075	.0089	0.193
0.297	.799	.891	.00125	.064	.0085	0.241	0.260	.176	.860	.00194	.070	.0096	0.217
0.317	.785	.915	.00073	.056	.0055	0.208	0.280	.190	.891	.00171	.063	.0096	0.233
0.337	.772	.939	.00039	.048	.0034	0.171	0.300	.203	.915	.00142	.056	.0094	0.250
0.357	.758	.959	.00030	.040	.0030	0.172	0.320	.217	.935	.00109	.047	.0089	0.268
0.377	.745	.977	.00029	.032	.0032	0.187	0.340	.230	.952	.00081	.039	.0079	0.278
0.397	.731	.986	.00024	.025	.0033	0.210	0.360	.244	.965	.00055	.030	.0065	0.272
0.417	.718	.989	.00019	.017	.0030	0.220	0.380	.257	.974	.00029	.024	.0041	0.242

TABLE A.7.9 CONT.

OUTER WALL

$R_o - R$ (IN)	$\frac{R - R_i}{R_o - R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U \delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.437	.704	.991	.00012	.012	.0024	0.220
0.457	.691	.993	.00009	.010	.0022	0.234
0.477	.677	.995	.00006	.008	.0020	0.257
0.497	.664	.996	.00004	.008	.0017	0.285
0.517	.650	.997	.00003	.007	.0015	0.357
0.537	.636	.998	.00002	.007	.0024	0.472
0.557	.623	.999	.00001	.007	.0020	0.529
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00053206IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001412

INNER WALL

$R - R_i$ (IN)	$\frac{R - R_i}{R_o - R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U \delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.400	.271	.979	.00008	.018	.0014	0.160
0.420	.234	.984	.00002	.014	.0006	0.120
0.440	.298	.988	.00000	.011	.0002	0.090
0.460	.311	.992	.00000	.008	.0000	0.000
0.480	.325	.994	.00000	.006	.0000	0.000
0.500	.339	.996	.00000	.006	.0000	0.000
0.520	.352	.998	.00000	.005	.0000	0.000
0.540	.366	.999	.00000	.005	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00015869IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001324

TABLE A.7.10 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i)$=10.00 (L_e/D_{h_i})= 2.0 (AR)=2.000 (B_i)=0.028 INLET REYNOLDS NO. $(\bar{u}D_{h_i}/\nu)$=163500.0

STN. X= 7.250" X/N=0.725 GREEN POSITION(2) $H_{o_{2-D}}$=1.919 $H_{i_{2-D}}$=1.930 $\delta^*_{o_{2-D}}$=.1681" $\delta^*_{i_{2-D}}$=.1646" U=109.31FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\,\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\,\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.034	.979	.324	.00133	.109	.0035	0.095	0.020	.012	.283	.00069	.077	.0010	0.040
0.054	.967	.361	.00194	.113	.0069	0.156	0.040	.024	.342	.00128	.084	.0031	0.087
0.074	.955	.395	.00237	.115	.0084	0.173	0.060	.037	.384	.00186	.089	.0064	0.150
0.094	.942	.429	.00263	.117	.0094	0.184	0.080	.049	.416	.00241	.090	.0094	0.192
0.114	.930	.461	.00283	.118	.0099	0.186	0.100	.061	.445	.00273	.091	.0110	0.212
0.134	.918	.495	.00297	.118	.0109	0.200	0.120	.073	.476	.00287	.092	.0116	0.217
0.154	.906	.528	.00303	.118	.0109	0.198	0.140	.086	.509	.00300	.094	.0107	0.196
0.174	.894	.560	.00302	.117	.0114	0.208	0.160	.098	.539	.00306	.095	.0124	0.224
0.194	.881	.592	.00288	.116	.0106	0.197	0.180	.110	.570	.00311	.096	.0126	0.226
0.214	.869	.625	.00268	.114	.0098	0.189	0.200	.122	.600	.00308	.095	.0117	0.211
0.234	.857	.656	.00248	.111	.0094	0.190	0.220	.135	.632	.00308	.093	.0121	0.217
0.254	.845	.689	.00230	.109	.0083	0.172	0.240	.147	.665	.00301	.091	.0111	0.202
0.274	.832	.721	.00212	.105	.0080	0.173	0.260	.159	.697	.00288	.088	.0106	0.198
0.294	.820	.752	.00192	.100	.0078	0.177	0.280	.171	.730	.00272	.085	.0100	0.192
0.314	.808	.781	.00176	.095	.0068	0.161	0.300	.184	.762	.00258	.081	.0098	0.193
0.334	.796	.813	.00160	.090	.0063	0.158	0.320	.196	.797	.00236	.077	.0075	0.155
0.354	.783	.842	.00148	.084	.0064	0.166	0.340	.208	.832	.00214	.073	.0081	0.176
0.374	.771	.868	.00128	.078	.0058	0.163	0.360	.220	.865	.00188	.068	.0074	0.170
0.394	.759	.894	.00118	.071	.0062	0.181	0.380	.233	.893	.00155	.063	.0073	0.184

TABLE A.7.10 CONT.

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.414	.747	.915	.00107	.064	.0058	0.178
0.434	.734	.935	.00091	.057	.0061	0.201
0.454	.722	.952	.00078	.050	.0056	0.200
0.474	.710	.968	.00063	.044	.0051	0.205
0.494	.698	.979	.00046	.035	.0044	0.206
0.514	.685	.986	.00030	.028	.0035	0.203
0.534	.673	.991	.00018	.020	.0026	0.194
0.554	.661	.995	.00011	.015	.0021	0.206
0.574	.649	.997	.00007	.011	.0021	0.257
0.594	.636	.999	.00004	.009	.0028	0.438

REYNOLDS STRESS INTEGRAL(J)= .00384678IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.001492

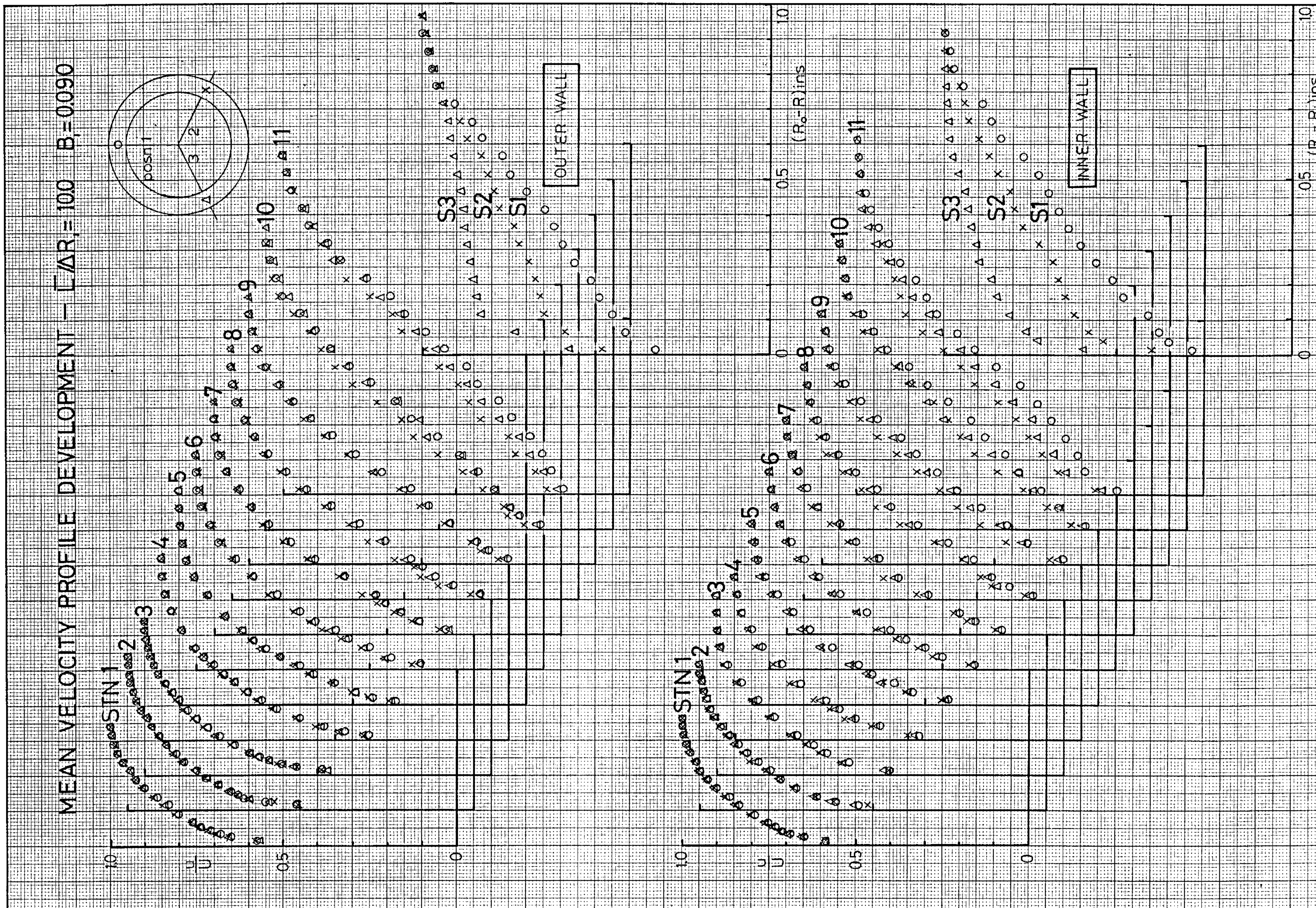
INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.400	.245	.917	.00123	.057	.0071	0.203
0.420	.257	.938	.00090	.050	.0050	0.166
0.440	.269	.957	.00058	.042	.0044	0.182
0.460	.282	.970	.00033	.034	.0030	0.163
0.480	.294	.980	.00024	.023	.0026	0.170
0.500	.306	.987	.00019	.018	.0027	0.195
0.520	.318	.993	.00016	.014	.0031	0.249
0.540	.330	.997	.00012	.011	.0040	0.361
0.560	.343	.999	.00009	.009	.0088	0.935
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00032926IN

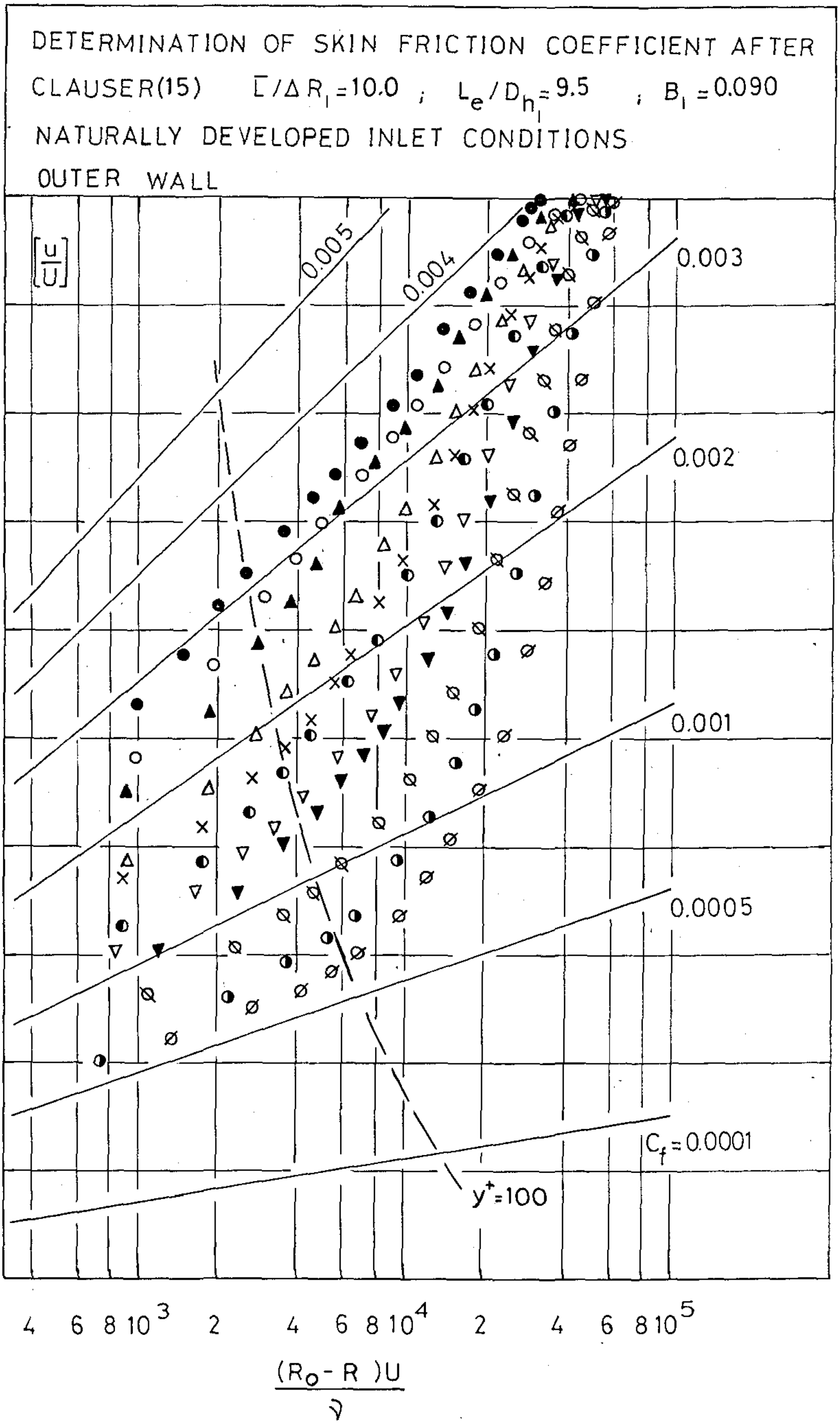
DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.001625

FIGURE A.7.6



MEAN VELOCITY PROFILE DEVELOPMENT – L/ΔR_i = 10.0 B_i = 0.090
posn 1
OUTER WALL
INNER WALL
STN 1
S1
S2
S3
u/U
(R_o - R) ins
(R - R_i) ins

FIGURE A.7.7



DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER
CLAUSER(15) L̄/ΔR1 = 10.0 ; Le/Dh1 = 9.5 ; B1 = 0.090
NATURALLY DEVELOPED INLET CONDITIONS
OUTER WALL
[u/U]
0.005
0.004
0.003
0.002
0.001
0.0005
Cf = 0.0001
y+=100
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4 6 8 10^3 2 4 6 8 10^4 2 4 6 8 10^5
(Ro - R)U / ν

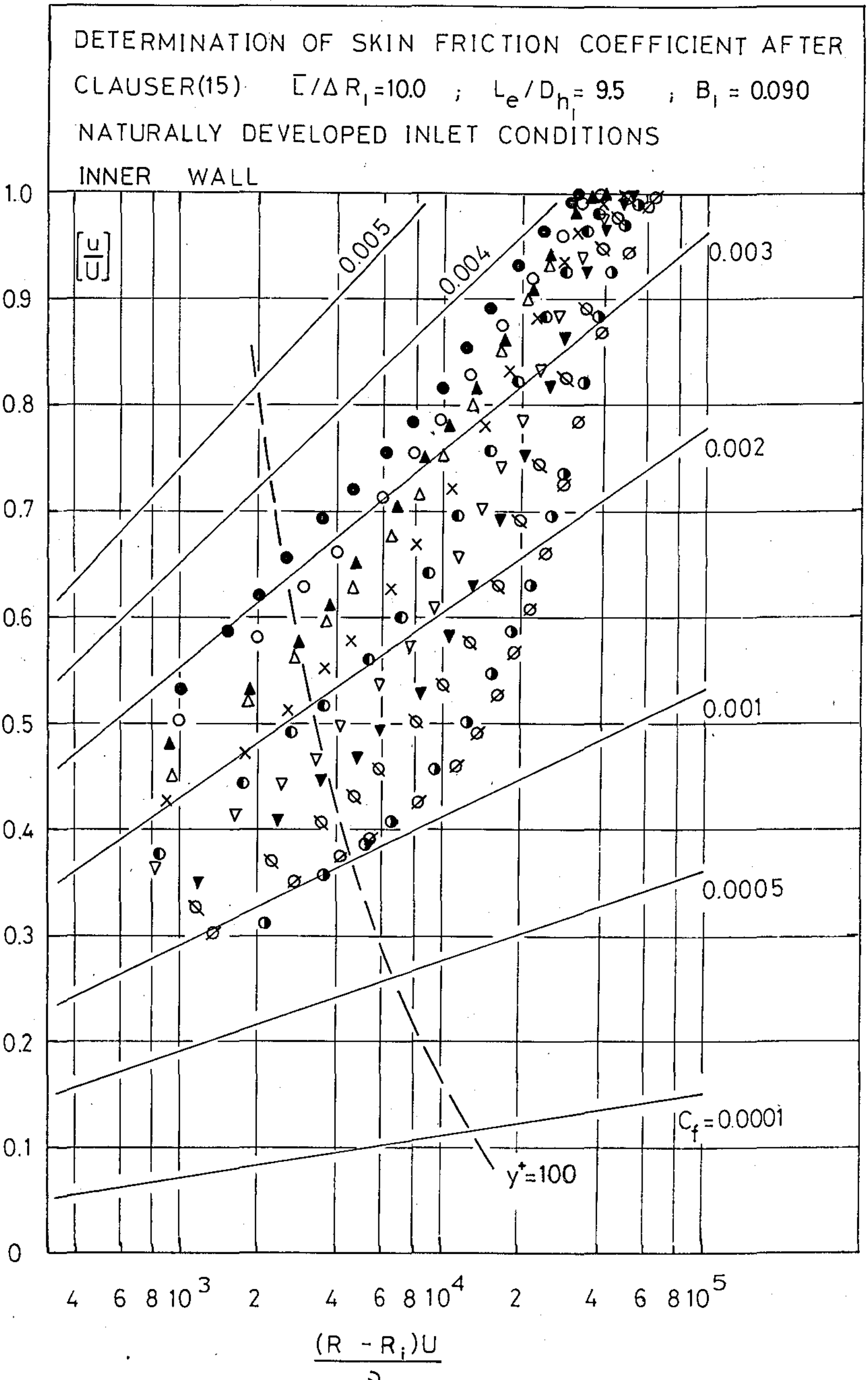

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_i=10.0$; $L_e/D_{h_i}=9.5$; $B_i=0.090$
NATURALLY DEVELOPED INLET CONDITIONS
INNER WALL
$\left[\frac{u}{U}\right]$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f=0.0001$
$y^+=100$
4
6
8
10^3
2
4
6
8
10^4
2
4
6
8
10^5
$\frac{(R-R_i)U}{\nu}$

TABLE A7.11 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)=10.00 ENTRY LENGTH(L_e/D_{h_1})= 9.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.090

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($(\bar{U}D_h/\nu)_1$)=182575

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}$.147	$\bar{0}$.315	.0450	.0333	.0588	1.352	1.769	.0456	.0338	.0599	1.349	1.772
0.300	0.030	.0566	.0414	.0729	1.369	1.763	.0571	.0417	.0733	1.372	1.760
0.750	0.075	.0614	.0431	.0751	1.426	1.742	.0651	.0462	.0807	1.407	1.745
1.450	0.145	.0823	.0538	.0918	1.529	1.706	.0717	.0500	.0869	1.433	1.736
2.150	0.215	.0959	.0608	.1026	1.578	1.687	.0878	.0595	.1023	1.475	1.719
2.700	0.270	.1090	.0674	.1131	1.617	1.678	.1014	.0660	.1123	1.535	1.701
3.700	0.370	.1331	.0778	.1282	1.711	1.649	.1234	.0780	.1311	1.583	1.681
4.700	0.470	.1573	.0892	.1458	1.763	1.634	.1516	.0912	.1513	1.662	1.659
5.900	0.590	.1983	.1036	.1651	1.914	1.594	.1793	.1041	.1709	1.722	1.641
7.700	0.770	.2527	.1231	.1937	2.053	1.573	.2373	.1277	.2061	1.858	1.614
9.850	0.985	.3297	.1513	.2323	2.179	1.535	.2759	.1513	.2449	1.823	1.618
13.750	1.375	.2666	.1487	.2384	1.792	1.603	.2980	.1673	.2705	1.782	1.617
17.500	1.750	.1954	.1353	.2320	1.444	1.715	.1961	.1351	.2322	1.452	1.719
21.250	2.125	.1124	.0913	.1671	1.231	1.831	.0812	.0652	.1190	1.245	1.825

TABLE A.7.12 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_i$)=10.00 ENTRY LENGTH(L_e/D_{h_i})= 9.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_i)=0.090

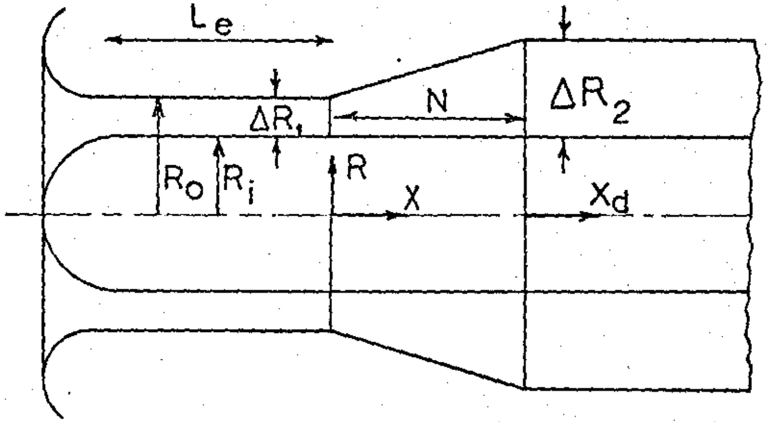
INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D/\nu$)$_i$=182575

NATURALLY DEVELOPED INLET CONDITIONS

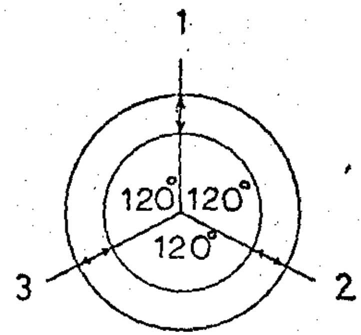
X (IN)	X/N	U FT/SEC	$\bar{U}$/U	Q FT³/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\bar{3}$.147	$\bar{0}$.315	188.38	.910	41.118	1.051	1.019	3337.5	3390.3
0.300	0.030	185.12	.889	40.624	1.062	1.022	4079.3	4108.2
0.750	0.075	177.03	.882	40.167	1.074	1.027	4064.5	4361.6
1.450	0.145	173.16	.862	40.357	1.097	1.035	4965.5	4616.6
2.150	0.215	167.88	.845	41.116	1.115	1.042	5437.0	5325.9
2.700	0.270	163.11	.829	40.976	1.134	1.049	5856.7	5739.7
3.700	0.370	156.76	.805	41.299	1.167	1.060	6496.4	6511.1
4.700	0.470	149.40	.781	40.964	1.200	1.072	7102.4	7259.9
5.900	0.590	144.80	.749	41.326	1.256	1.091	7989.7	8031.7
7.700	0.770	136.79	.706	41.171	1.331	1.117	8971.8	9309.1
9.850	0.985	127.41	.670	41.146	1.378	1.130	10271.2	10273.9
13.750	1.375	117.75	.702	40.127	1.254	1.086	9330.5	10494.7
17.500	1.750	104.78	.791	40.273	1.097	1.033	7535.8	7543.3
21.250	2.125	90.96	.894	39.509	1.032	1.011	4423.2	3160.1

$\bar{L}/\Delta R_1 = 7.5$ $AR_{1\text{-}2} = 2.0$ $[R_i/R_o]_1 = 0.833$

TRAVERSE STATIONS		
X/N	SYMBOL	STN
$\bar{0}.420$	●	1
0.040	○	2
0.100	▲	3
0.167	△	4
0.293	×	5
0.420	◐	6
0.547	▽	7
0.673	▼	8
0.800	⊘	9
0.963	◑	10
$X_d/\Delta R_2 = 1$	-	S1
2	-	S2
3	-	S3



GEOMETRY.	
$\phi_o = 6.65^\circ$	N = 7.5 IN.
$R_{o_1} = 6.0$ IN.	$R_{i_1} = 5.0$ IN.
$R_{o_2} = 6.875$ IN.	$R_{i_2} = 5.0$ IN.



TRAVERSE POSITIONS.

symbols as noted unless otherwise indicated

FIGURE A.7.9

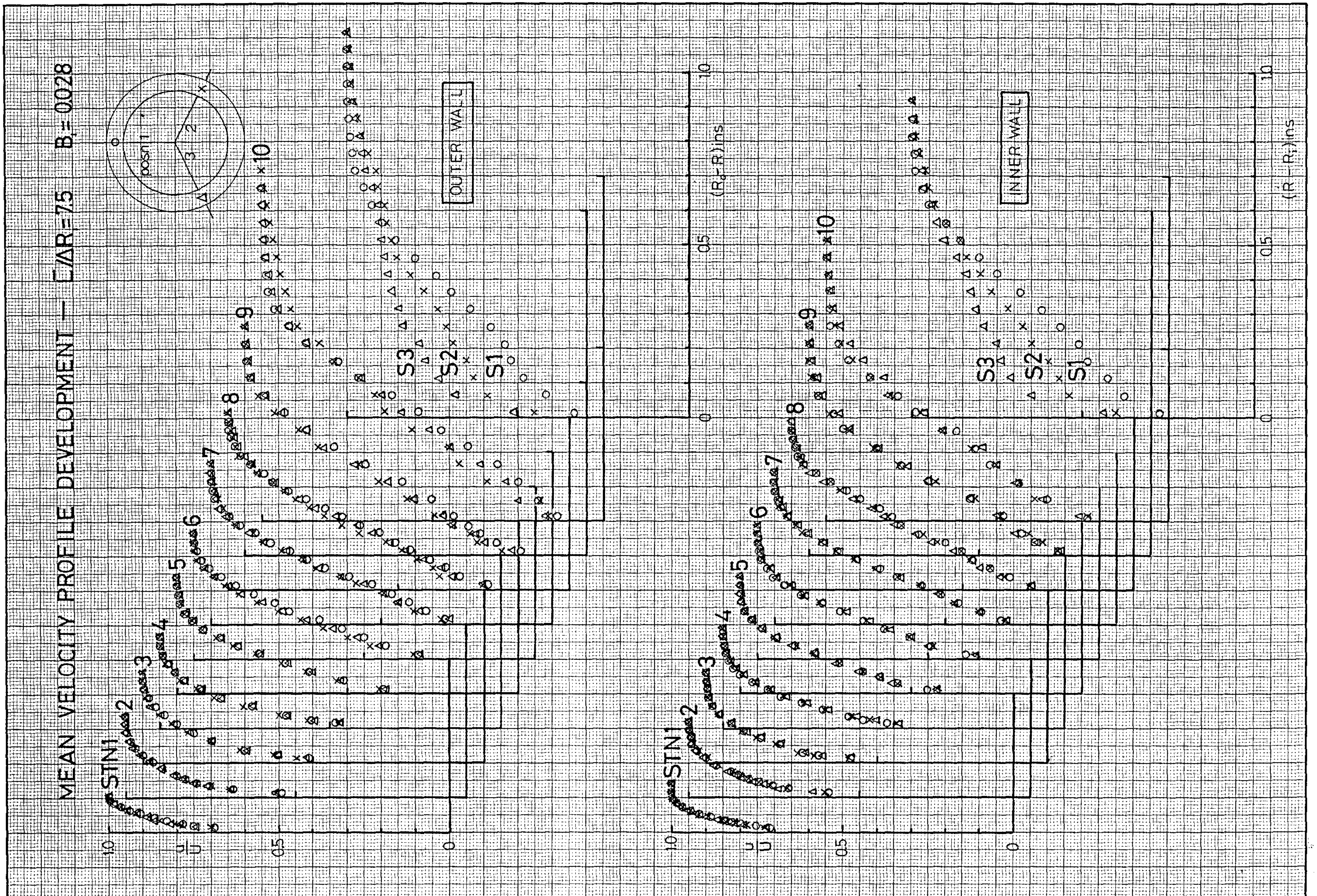
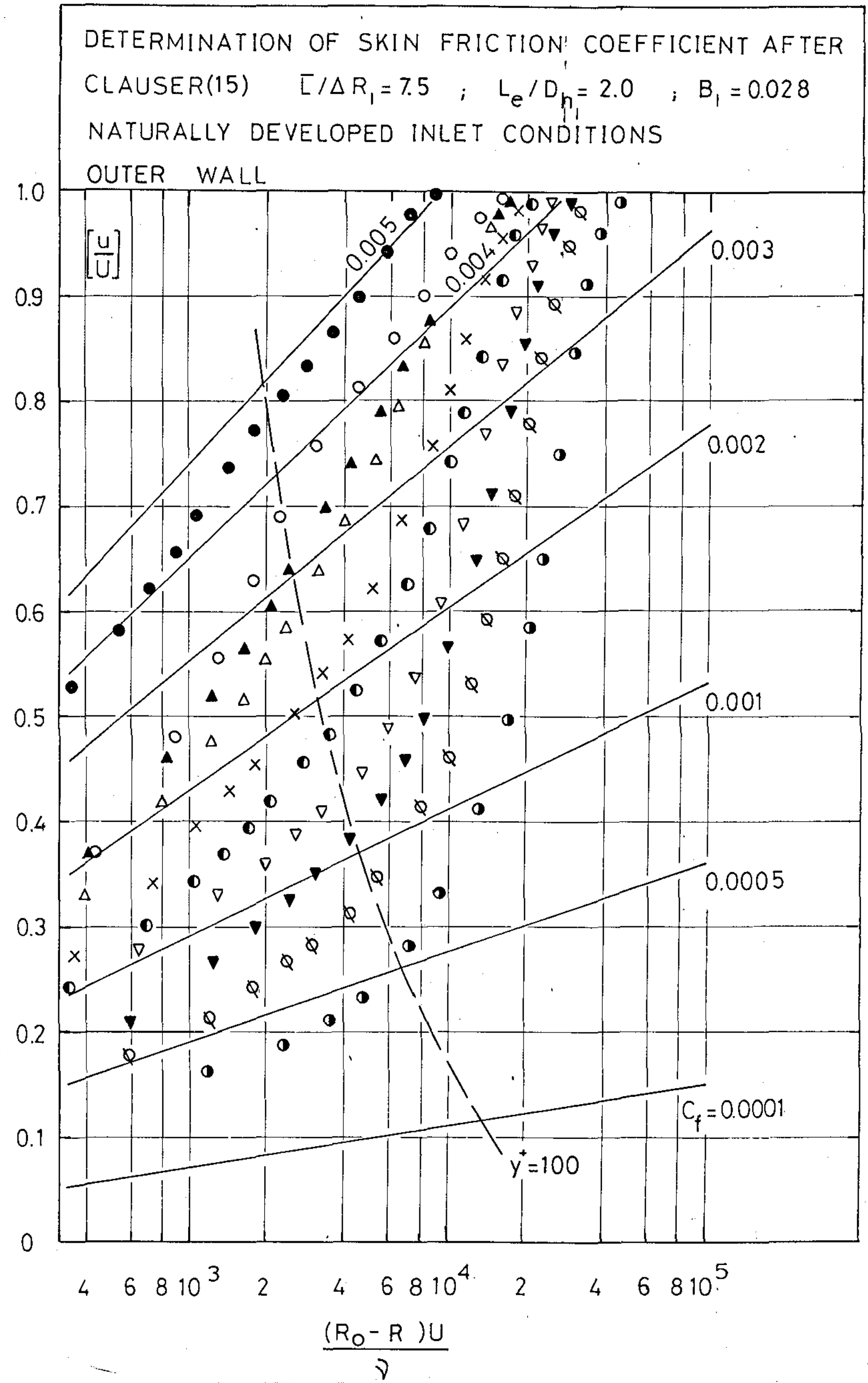

MEAN VELOCITY PROFILE DEVELOPMENT — E/ΔR=7.5 B = 0.028
posn 1
2
3
OUTER WALL
INNER WALL
(R_o-R) ins
$(R-R_i)$ ins
$\frac{u}{U}$
1.0
0.5
0
STN1
2
3
4
5
6
7
8
9
10
S1
S2
S3

FIGURE A.7.10



DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1 = 7.5$; $L_e/D_{h_1} = 2.0$; $B_1 = 0.028$
NATURALLY DEVELOPED INLET CONDITIONS
OUTER WALL
$\left[\frac{u}{U}\right]$
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
$\frac{(R_o - R)U}{\nu}$

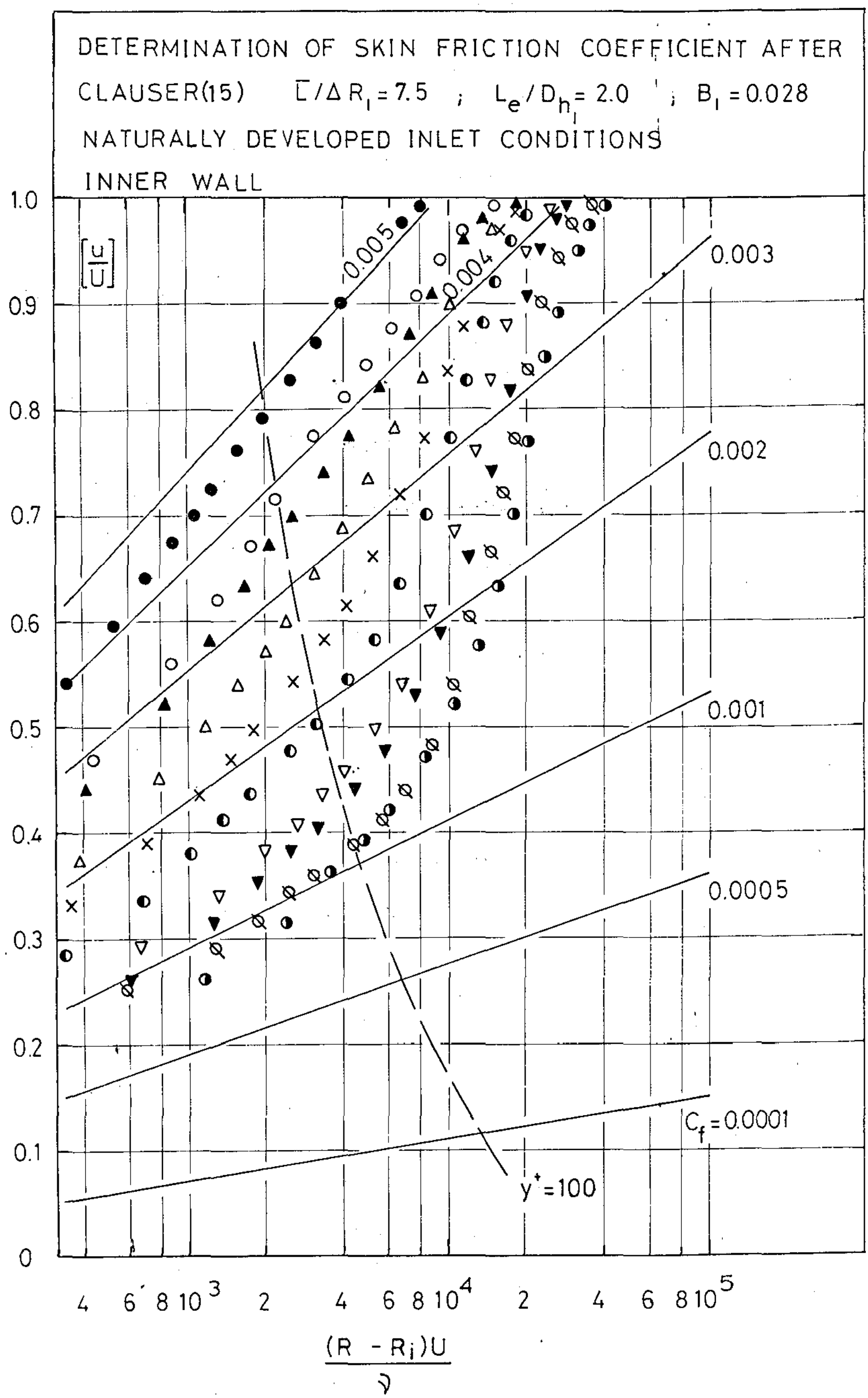

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_i = 7.5$; $L_e/D_{h_i} = 2.0$; $B_i = 0.028$
NATURALLY DEVELOPED INLET CONDITIONS
INNER WALL
$\left[\frac{u}{U}\right]$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
4
6
8
10^3
2
4
6
8
10^4
2
4
6
8
10^5
$\frac{(R - R_i)U}{\nu}$

TABLE A.7.13 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($L/\Delta R_1$)= 7.50 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu)_1$=173944

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}$.147	$\bar{0}$.420	.0142	.0102	.0179	1.396	1.759	.0134	.0097	.0172	1.376	1.766
0.300	0.040	.0277	.0184	.0320	1.504	1.740	.0244	.0172	.0302	1.415	1.755
0.750	0.100	.0357	.0233	.0402	1.528	1.721	.0305	.0213	.0372	1.433	1.744
1.250	0.167	.0417	.0263	.0447	1.586	1.698	.0431	.0283	.0483	1.524	1.707
2.200	0.293	.0640	.0377	.0624	1.699	1.656	.0590	.0367	.0615	1.608	1.676
3.150	0.420	.0837	.0467	.0759	1.792	1.625	.0802	.0472	.0776	1.700	1.646
4.100	0.547	.1137	.0602	.0962	1.890	1.599	.1093	.0597	.0962	1.831	1.612
5.050	0.673	.1452	.0722	.1140	2.010	1.579	.1352	.0724	.1160	1.867	1.602
5.050	0.673	.1356	.0711	.1134	1.908	1.596	.1352	.0724	.1160	1.867	1.602
5.050	0.673	.1452	.0722	.1140	2.010	1.579	.1352	.0724	.1160	1.867	1.602
6.000	0.800	.1881	.0867	.1347	2.170	1.554	.1695	.0874	.1391	1.938	1.591
6.000	0.800	.1760	.0863	.1360	2.038	1.575	.1695	.0874	.1391	1.938	1.591
6.000	0.800	.1760	.0863	.1360	2.038	1.575	.1695	.0874	.1391	1.938	1.591
7.400	0.987	.2727	.1114	.1694	2.447	1.520	.2017	.1050	.1679	1.920	1.599
7.400	0.987	.2686	.1267	.2010	2.120	1.587	.2017	.1050	.1679	1.920	1.599
7.400	0.987	.2727	.1114	.1694	2.447	1.520	.2017	.1050	.1679	1.920	1.599
11.250	1.500	.2191	.1231	.1981	1.779	1.609	.2434	.1289	.2053	1.888	1.593
15.000	2.000	.1772	.1241	.2146	1.428	1.729	.1977	.1289	.2176	1.533	1.688
18.750	2.500	.1203	.0924	.1656	1.301	1.791	.1469	.1068	.1880	1.375	1.761

TABLE A.7.14 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 7.50 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.028

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu$)$_1$=173944.

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
3.147	0.420	167.88	.972	39.174	1.019	1.007	908.6	869.1
0.300	0.040	166.53	.949	39.394	1.039	1.015	1633.8	1527.2
0.750	0.100	156.48	.939	38.657	1.049	1.019	1946.2	1776.4
1.250	0.167	150.60	.926	38.865	1.064	1.024	2111.3	2270.6
2.200	0.293	139.25	.902	38.761	1.095	1.036	2796.7	2720.6
3.150	0.420	130.90	.880	39.043	1.127	1.048	3257.1	3289.6
4.100	0.547	125.09	.849	39.293	1.175	1.066	4009.8	3976.5
5.050	0.673	117.66	.823	38.887	1.218	1.081	4528.5	4537.8
5.050	0.673	118.23	.830	39.402	1.201	1.074	4476.8	4559.9
5.050	0.673	117.85	.823	38.950	1.218	1.081	4535.8	4545.2
6.000	0.800	114.75	.788	39.241	1.282	1.104	5299.9	5345.9
6.000	0.800	114.55	.796	39.580	1.257	1.095	5269.1	5336.7
6.000	0.800	114.75	.796	39.648	1.257	1.095	5278.1	5345.9
7.400	0.987	111.36	.739	39.696	1.381	1.139	6612.1	6232.6
7.400	0.987	111.15	.742	39.762	1.325	1.119	7503.5	6221.3
7.400	0.987	111.36	.739	39.696	1.381	1.139	6612.1	6232.6
11.250	1.500	104.03	.755	38.173	1.255	1.089	6825.0	7143.2
15.000	2.000	98.69	.802	38.437	1.109	1.038	6526.2	6778.6
18.750	2.500	94.25	.860	39.361	1.059	1.021	4642.4	5362.7

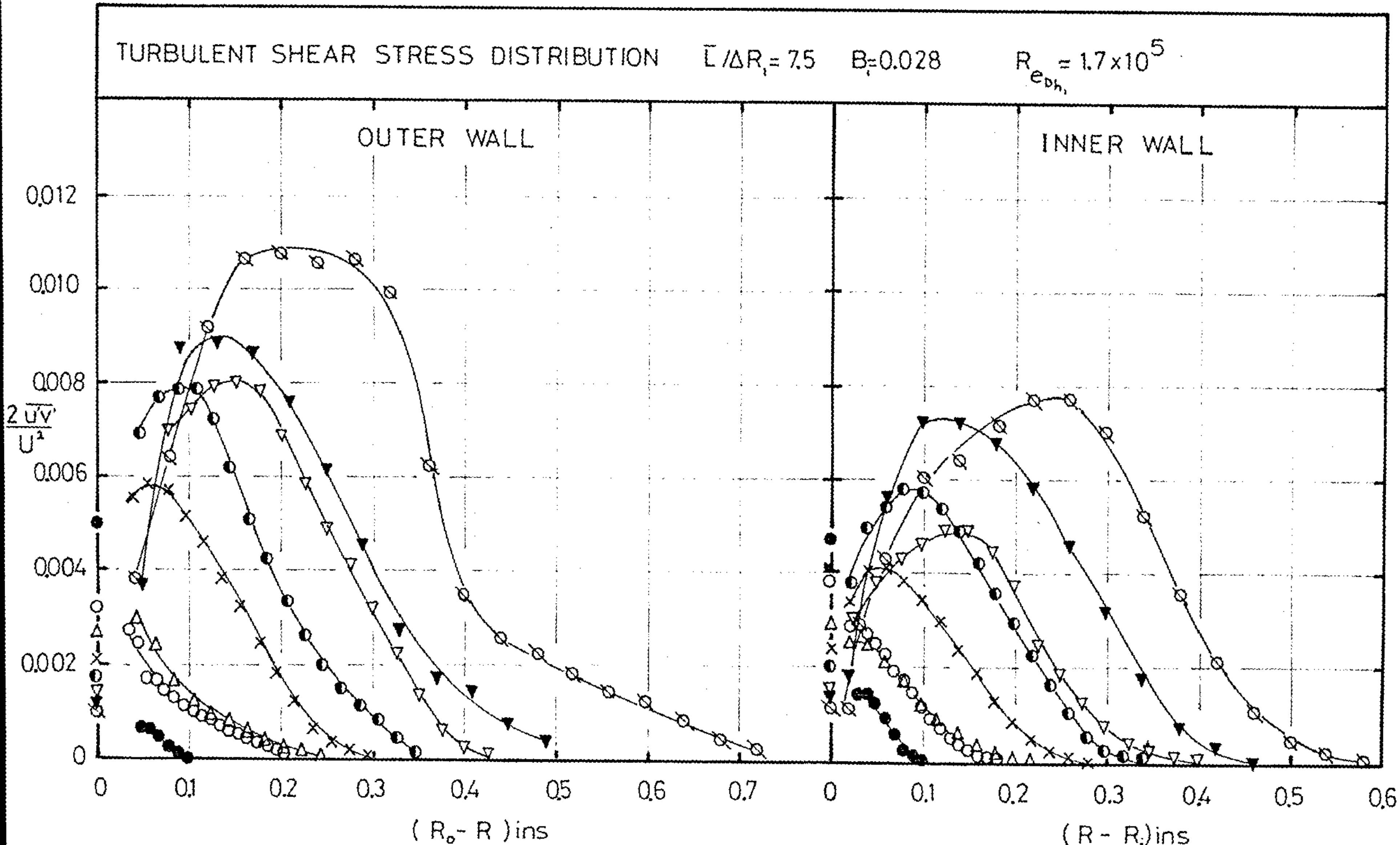

TURBULENT SHEAR STRESS DISTRIBUTION $\bar{L}/\Delta R_i = 7.5$ $B_i = 0.028$ $R_{e_{Dh_i}} = 1.7\times10^5$
OUTER WALL
INNER WALL
$\frac{2\overline{u'v'}}{U^2}$
0.012
0.010
0.008
0.006
0.004
0.002
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
$(R_o - R)$ ins
$(R - R_i)$ ins

FIGURE A.7.12

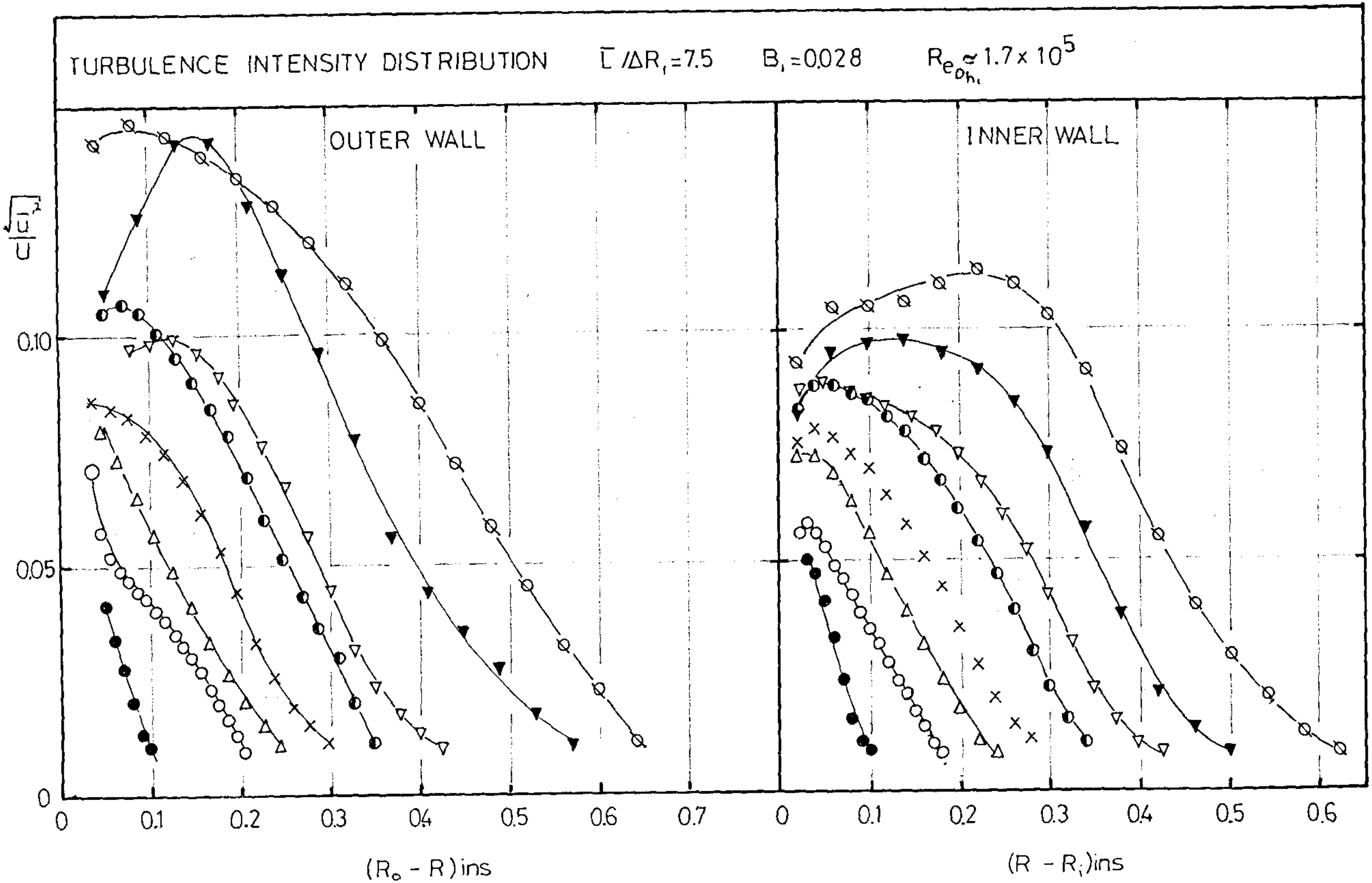

TURBULENCE INTENSITY DISTRIBUTION
$\bar{L}/\Delta R_1 = 7.5$
$B_1 = 0.028$
$Re_{D_{h_1}} \simeq 1.7 \times 10^5$
OUTER WALL
INNER WALL
$\frac{\sqrt{\overline{u'^2}}}{U}$
0.10
0.05
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
$(R_o - R)$ ins
0 0.1 0.2 0.3 0.4 0.5 0.6
$(R - R_i)$ ins

FIGURE A.7.13

TABLE A.7.15 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\overline{L}/\Delta R_i)$= 7.50 (L_e/D_{h_i})= 2.0 (AR)=2.000 (B_i)=0.028 INLET REYNOLDS NO. $(\overline{U}D_{h_i}/\nu)$=173944.0

STN. X= 3.147" X/N=0.420 GREEN POSITION(2) $H_{o_{2-D}}$=1.395 $H_{i_{2-D}}$=1.378 $\delta^*_{o_{2-D}}$=.0142" $\delta^*_{i_{2-D}}$=.0133" U=167.88FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.050	.950	.898	.00032	.041	.0068	0.380
0.060	.940	.930	.00032	.034	.0077	0.430
0.070	.930	.957	.00023	.027	.0069	0.453
0.080	.920	.977	.00009	.020	.0039	0.410
0.090	.910	.989	.00005	.013	.0033	0.463
0.100	.900	.997	.00003	.010	.0060	1.037
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00007099IN

DISSIPATION INTEGRAL$(\frac{\mathcal{D}}{2})$= 0.000256

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.030	.030	.837	.00069	.050	.0130	0.494
0.040	.040	.877	.00070	.047	.0141	0.532
0.050	.050	.910	.00062	.041	.0143	0.576
0.060	.060	.938	.00044	.033	.0124	0.585
0.070	.070	.962	.00027	.024	.0096	0.582
0.080	.080	.981	.00013	.015	.0066	0.576
0.090	.090	.992	.00005	.010	.0047	0.636
0.100	.100	.999	.00002	.008	.0066	1.414

REYNOLDS STRESS INTEGRAL(J)= .00002692IN

DISSIPATION INTEGRAL$(\frac{\mathcal{D}}{2})$= 0.000377

TABLE A.7.16 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i) = 7.50$ $(L_e/D_{h_i}) = 2.0$ $(AR) = 2.000$ $(B_i) = 0.028$ INLET REYNOLDS NO. $(\bar{u}D_{h_i}/\nu) = 173944.0$

STN. $X = 0.300''$ $X/N = 0.040$ GREEN POSITION(2) $H_{o_{2-D}} = 1.501$ $H_{i_{2-D}} = 1.418$ $\delta^*_{o_{2-D}} = .0279''$ $\delta^*_{i_{2-D}} = .0242''$ U=166.53FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL

$R_o - R$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.035	.966	.760	.00136	.071	.0104	0.281
0.045	.957	.795	.00119	.057	.0119	0.344
0.055	.947	.828	.00082	.052	.0109	0.381
0.065	.937	.850	.00080	.049	.0123	0.436
0.075	.928	.872	.00070	.047	.0120	0.458
0.085	.918	.892	.00063	.044	.0121	0.482
0.095	.908	.910	.00056	.043	.0118	0.500
0.105	.899	.927	.00050	.040	.0113	0.500
0.115	.889	.941	.00044	.038	.0110	0.532
0.125	.879	.955	.00039	.035	.0107	0.542
0.135	.870	.967	.00034	.033	.0106	0.576
0.145	.860	.974	.00029	.030	.0106	0.617
0.155	.850	.981	.00025	.027	.0106	0.672
0.165	.841	.988	.00021	.023	.0108	0.750
0.175	.831	.991	.00016	.020	.0107	0.847
0.185	.821	.994	.00011	.016	.0105	0.993
0.195	.812	.997	.00008	.013	.0118	1.360
0.205	.802	.998	.00005	.009	.0231	3.287

REYNOLDS STRESS INTEGRAL(J)= .00010777IN

DISSIPATION INTEGRAL($\frac{D}{2}$)= 0.000551

INNER WALL

$R - R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.020	.019	.670	.00142	.056	.0062	0.164
0.030	.029	.747	.00143	.058	.0102	0.269
0.040	.039	.793	.00136	.056	.0152	0.412
0.050	.048	.825	.00126	.053	.0174	0.489
0.060	.058	.851	.00112	.049	.0201	0.601
0.070	.068	.876	.00098	.046	.0187	0.600
0.080	.077	.897	.00085	.043	.0175	0.602
0.090	.087	.915	.00071	.039	.0162	0.610
0.100	.097	.933	.00058	.035	.0141	0.585
0.110	.106	.950	.00046	.032	.0126	0.589
0.120	.116	.963	.00035	.028	.0111	0.590
0.130	.126	.973	.00026	.024	.0097	0.596
0.140	.135	.981	.00019	.021	.0084	0.610
0.150	.145	.987	.00013	.017	.0070	0.619
0.160	.155	.991	.00008	.014	.0058	0.652
0.170	.164	.995	.00005	.010	.0057	0.793
0.180	.174	.998	.00003	.007	.0063	1.175
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00005058IN

DISSIPATION INTEGRAL($\frac{D}{2}$)= 0.000681

TABLE A.7.17 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\overline{L}/\Delta R_i)$ = 7.50 (L_e/D_{h_i}) = 2.0 (AR)=2.000 (B_i)=0.028 INLET REYNOLDS NO. $(\overline{u}D_{h_i}/\nu)$=173944.0

STN. X= 1.250" X/N=0.167 GREEN POSITION(2) $H_{o_{2-D}}$=1.583 $H_{i_{2-D}}$=1.528 $\delta^*_{o_{2-D}}$=.0421" $\delta^*_{i_{2-D}}$=.0426" U=150.60FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.046	.960	.665	.00151	.080	.0080	0.206	0.020	.017	.540	.00125	.073	.0042	0.118
0.066	.942	.746	.00121	.073	.0078	0.223	0.040	.035	.645	.00127	.073	.0075	0.209
0.086	.925	.813	.00081	.065	.0064	0.225	0.060	.052	.720	.00105	.069	.0077	0.238
0.106	.908	.866	.00057	.057	.0055	0.228	0.080	.070	.780	.00082	.063	.0069	0.241
0.126	.890	.909	.00046	.049	.0065	0.304	0.100	.087	.831	.00064	.056	.0066	0.259
0.146	.873	.939	.00037	.041	.0071	0.371	0.120	.105	.877	.00045	.047	.0051	0.238
0.166	.855	.959	.00030	.033	.0079	0.460	0.140	.122	.915	.00030	.039	.0041	0.238
0.186	.838	.974	.00020	.026	.0069	0.494	0.160	.140	.946	.00017	.032	.0030	0.234
0.206	.820	.985	.00012	.020	.0063	0.568	0.180	.157	.969	.00010	.024	.0023	0.227
0.226	.803	.993	.00007	.015	.0067	0.793	0.200	.175	.983	.00005	.018	.0017	0.233
0.246	.785	.999	.00002	.011	.0123	2.704	0.220	.192	.993	.00003	.011	.0015	0.278
0.000	.000	.000	.00000	.000	.0000	0.000	0.240	.209	.998	.00001	.007	.0018	0.542

OUTER WALL: REYNOLDS STRESS INTEGRAL(J)= 00024778IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$= 0.000588

INNER WALL: REYNOLDS STRESS INTEGRAL(J)= .00040167IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$= 0.000584

TABLE A.7.18 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_1)$ = 7.50 (L_e/D_{h_1}) = 2.0 (AR)=2.000 (B_1)=0.028 INLET REYNOLDS NO. $(\bar{u}D_{h_1}/\nu)$=173944.0

STN. X= 2.200" X/N=0.293 GREEN POSITION(2) $H_{o_{2-D}}$=1.694 $H_{i_{2-D}}$=1.613 $\delta^*_{o_{2-D}}$=.0648" $\delta^*_{i_{2-D}}$=.0581" U=139.25FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.037	.971	.510	.00275	.086	.0107	0.204
0.057	.955	.580	.00290	.084	.0128	0.237
0.077	.939	.647	.00286	.082	.0132	0.247
0.097	.923	.708	.00256	.078	.0131	0.260
0.117	.907	.765	.00228	.074	.0134	0.280
0.137	.891	.816	.00191	.068	.0129	0.294
0.157	.875	.863	.00159	.061	.0117	0.294
0.177	.859	.902	.00122	.053	.0110	0.317
0.197	.843	.934	.00087	.044	.0095	0.321
0.217	.827	.958	.00060	.033	.0082	0.334
0.237	.811	.974	.00033	.025	.0060	0.330
0.257	.796	.986	.00015	.019	.0040	0.326
0.277	.780	.992	.00008	.015	.0030	0.331
0.297	.764	.997	.00004	.012	.0033	0.511

REYNOLDS STRESS INTEGRAL(J)= *-.00018366IN

DISSIPATION INTEGRAL$(\frac{\mathcal{D}}{2})$= 0.001395

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.020	.016	.468	.00169	.076	.0047	0.114
0.040	.032	.562	.00202	.079	.0087	0.194
0.060	.048	.630	.00205	.077	.0114	0.251
0.080	.064	.690	.00192	.073	.0114	0.260
0.100	.080	.747	.00172	.070	.0106	0.255
0.120	.095	.798	.00147	.064	.0098	0.254
0.140	.111	.845	.00118	.058	.0085	0.247
0.160	.127	.887	.00089	.051	.0075	0.250
0.180	.143	.921	.00063	.044	.0064	0.254
0.200	.159	.951	.00041	.035	.0053	0.260
0.220	.175	.971	.00023	.027	.0041	0.270
0.240	.191	.983	.00011	.020	.0027	0.259
0.260	.207	.992	.00004	.014	.0016	0.260
0.280	.223	.998	.00003	.011	.0033	0.635

REYNOLDS STRESS INTEGRAL(J)= .00026488IN

DISSIPATION INTEGRAL$(\frac{\mathcal{D}}{2})$= 0.000988

TABLE A.7.19 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i) = 7.50$ $(L_e/D_{h_i}) = 2.0$ $(AR) = 2.000$ $(B_i) = 0.028$ INLET REYNOLDS NO. $(\bar{u}D_{h_i}/\nu) = 173944.0$

STN. X = 3.150" X/N=0.420 GREEN POSITION(2) $H_{o_{2-D}} = 1.785$ $H_{i_{2-D}} = 1.706$ $\delta^*_{o_{2-D}} = .0848"$ $\delta^*_{i_{2-D}} = .0788"$ U=130.90FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL

$R_o - R$ (IN)	$\frac{R - R_i}{R_o - R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.047	.966	.473	.00346	.105	.0146	0.248
0.067	.951	.532	.00382	.107	.0160	0.259
0.087	.936	.588	.00392	.105	.0165	0.264
0.107	.922	.643	.00392	.100	.0172	0.274
0.127	.907	.695	.00360	.095	.0164	0.274
0.147	.892	.746	.00307	.090	.0151	0.272
0.167	.878	.793	.00253	.084	.0129	0.257
0.187	.863	.836	.00212	.078	.0121	0.264
0.207	.849	.876	.00166	.069	.0106	0.260
0.227	.834	.911	.00130	.060	.0095	0.263
0.247	.819	.941	.00097	.051	.0081	0.258
0.267	.805	.964	.00072	.043	.0087	0.324
0.287	.790	.984	.00056	.036	.0109	0.458
0.307	.775	.996	.00043	.030	.0211	1.017
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00022897IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$= 0.001849

INNER WALL

$R - R_i$ (IN)	$\frac{R - R_i}{R_o - R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.020	.015	.410	.00190	.083	.0042	0.095
0.040	.029	.490	.00247	.088	.0116	0.233
0.060	.044	.542	.00271	.088	.0137	0.264
0.080	.059	.594	.00287	.086	.0135	0.252
0.100	.073	.647	.00286	.085	.0134	0.251
0.120	.088	.698	.00268	.081	.0136	0.263
0.140	.102	.750	.00245	.078	.0124	0.251
0.160	.117	.794	.00208	.072	.0120	0.263
0.180	.132	.840	.00178	.067	.0103	0.243
0.200	.146	.880	.00144	.061	.0092	0.241
0.220	.161	.920	.00111	.054	.0074	0.222
0.240	.176	.947	.00081	.047	.0068	0.240
0.260	.190	.965	.00051	.039	.0057	0.264
0.280	.205	.977	.00025	.030	.0040	0.255
0.300	.219	.987	.00012	.022	.0031	0.287
0.320	.234	.994	.00007	.015	.0033	0.380
0.340	.249	.999	.00006	.010	.0080	1.034

REYNOLDS STRESS INTEGRAL(J)= .00046488IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$= 0.001463

TABLE A.7.20 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_1) = 7.50$ $(L_e/D_{h_1}) = 2.0$ $(AR) = 2.000$ $(B_1) = 0.028$ INLET REYNOLDS NO. $(\bar{u}D_{H_1}/\nu) = 173944.0$

STN $X = 4.100''$ $X/N = 0.547$ GREEN POSITION(2) $H_{o_{2-D}} = 1.881$ $H_{i_{2-D}} = 1.841$ $\delta^*_{o_{2-D}} = .1157''$ $\delta^*_{i_{2-D}} = .1070''$ $U = 125.09$ FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL

$R_o - R$ (IN)	$\frac{R - R_i}{R_o - R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.078	.947	.464	.00352	.097	.0136	0.228
0.103	.930	.519	.00371	.098	.0134	0.221
0.128	.913	.582	.00394	.099	.0136	0.217
0.153	.896	.643	.00398	.096	.0140	0.221
0.178	.880	.700	.00389	.091	.0147	0.236
0.203	.863	.756	.00342	.085	.0144	0.246
0.228	.846	.808	.00293	.076	.0120	0.222
0.253	.829	.856	.00245	.067	.0114	0.230
0.278	.812	.898	.00204	.056	.0111	0.245
0.303	.795	.932	.00158	.044	.0110	0.275
0.328	.778	.959	.00110	.031	.0095	0.287
0.353	.761	.977	.00066	.023	.0078	0.305
0.378	.744	.988	.00028	.017	.0054	0.326
0.403	.727	.995	.00011	.013	.0041	0.400
0.428	.710	.999	.00004	.010	.0031	0.518
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= *-.00072174IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.002013

INNER WALL

$R - R_i$ (IN)	$\frac{R - R_i}{R_o - R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.025	.017	.362	.00148	.087	.0037	0.096
0.050	.034	.432	.00191	.089	.0074	0.170
0.075	.051	.483	.00215	.086	.0097	0.210
0.100	.068	.538	.00229	.085	.0095	0.199
0.125	.085	.596	.00242	.083	.0092	0.187
0.150	.101	.658	.00244	.081	.0086	0.174
0.175	.118	.725	.00223	.078	.0080	0.169
0.200	.135	.785	.00172	.073	.0072	0.172
0.225	.152	.836	.00120	.067	.0061	0.176
0.250	.169	.880	.00090	.060	.0048	0.160
0.275	.186	.918	.00062	.052	.0043	0.172
0.300	.203	.950	.00035	.042	.0032	0.171
0.325	.220	.969	.00017	.032	.0021	0.160
0.350	.237	.982	.00006	.022	.0011	0.142
0.375	.254	.991	.00004	.015	.0011	0.175
0.400	.271	.996	.00004	.010	.0016	0.252
0.425	.288	.999	.00003	.007	.0079	1.463

REYNOLDS STRESS INTEGRAL(J)= .00059922IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.001213

TABLE A.7.21 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i) = 7.50$ $(L_e/D_{h_i}) = 2.0$ $(AR) = 2.000$ $(B_i) = 0.028$ INLET REYNOLDS NO. $(\bar{u}D_{h_i}/\nu) = 173944.0$

STN. X= 5.050" X/N=0.673 GREEN POSITION(2) $H_{o_{2-D}} = 1.898$ $H_{i_{2-D}} = 1.879$ $\delta^*_{o_{2-D}} = .1384"$ $\delta^*_{i_{2-D}} = .1318"$ U=118.23FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.049	.969	.381	.00182	.109	.0063	0.149
0.089	.944	.454	.00437	.126	.0155	0.235
0.129	.919	.529	.00440	.141	.0156	0.235
0.169	.894	.615	.00433	.142	.0156	0.237
0.209	.868	.698	.00380	.128	.0141	0.228
0.249	.843	.774	.00304	.113	.0137	0.248
0.289	.818	.838	.00225	.096	.0108	0.227
0.329	.793	.892	.00136	.077	.0081	0.221
0.369	.768	.937	.00086	.056	.0062	0.211
0.409	.743	.973	.00072	.044	.0070	0.260
0.449	.717	.990	.00036	.035	.0055	0.289
0.489	.692	.998	.00020	.027	.0068	0.487

REYNOLDS STRESS INTEGRAL(J)= 00107798IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.002132

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.020	.013	.315	.00090	.082	.0015	0.049
0.060	.038	.425	.00277	.095	.0113	0.216
0.100	.063	.493	.00361	.097	.0156	0.260
0.140	.088	.570	.00359	.098	.0144	0.239
0.180	.113	.644	.00340	.095	.0136	0.233
0.220	.138	.722	.00292	.091	.0120	0.222
0.260	.164	.800	.00228	.084	.0094	0.196
0.300	.189	.875	.00158	.073	.0073	0.183
0.340	.214	.935	.00087	.057	.0057	0.195
0.380	.239	.969	.00038	.038	.0041	0.207
0.420	.264	.987	.00016	.021	.0026	0.209
0.460	.289	.996	.00006	.013	.0023	0.296

REYNOLDS STRESS INTEGRAL(J)= .00025963IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.001737

TABLE A.7.22 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\overline{L}/\Delta R_i)$= 7.50 (L_e/D_{h_i})= 2.0 (AR)=2.000 (B_i)=0.028 INLET REYNOLDS NO. $(\overline{u}D_{h_i}/\nu)$=173944.0

STN. X= 6.000" X/N=0.800 GREEN POSITION(2) $H_{o_{2-D}}$=2.023 $H_{i_{2-D}}$=1.954 $\delta^*_{o_{2-D}}$=.1802" $\delta^*_{i_{2-D}}$=.1645" U=114.55FT/SEC

NATURALLY DEVELOPED INLET CONDITIONS

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.040	.976	.300	.00189	.142	.0044	0.101
0.080	.953	.370	.00320	.146	.0111	0.196
0.120	.929	.435	.00458	.143	.0164	0.242
0.160	.906	.502	.00531	.139	.0168	0.231
0.200	.882	.571	.00536	.134	.0161	0.220
0.240	.859	.642	.00526	.128	.0167	0.230
0.280	.835	.713	.00537	.120	.0170	0.232
0.320	.812	.785	.00496	.111	.0168	0.246
0.360	.788	.841	.00310	.099	.0130	0.232
0.400	.765	.888	.00173	.085	.0091	0.220
0.440	.741	.929	.00127	.072	.0079	0.220
0.480	.718	.960	.00111	.058	.0098	0.294
0.520	.694	.979	.00091	.045	.0112	0.372
0.560	.671	.991	.00073	.032	.0149	0.554
0.600	.647	.998	.00056	.022	.0347	1.462
0.000	.000	.000	.00000	.000	.0000	0.000

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.020	.012	.288	.00055	.093	.0010	0.044
0.060	.035	.371	.00214	.105	.0090	0.194
0.100	.059	.423	.00302	.105	.0131	0.239
0.140	.082	.481	.00319	.106	.0121	0.215
0.180	.106	.560	.00357	.110	.0112	0.196
0.220	.129	.644	.00385	.113	.0111	0.180
0.260	.153	.720	.00382	.110	.0126	0.203
0.300	.176	.788	.00353	.103	.0126	0.212
0.340	.200	.853	.00262	.091	.0099	0.194
0.380	.224	.910	.00177	.074	.0093	0.220
0.420	.247	.943	.00104	.055	.0084	0.260
0.460	.271	.963	.00053	.040	.0063	0.277
0.500	.294	.977	.00023	.029	.0041	0.269
0.540	.318	.987	.00011	.020	.0028	0.268
0.580	.341	.994	.00006	.012	.0026	0.349
0.620	.365	.999	.00003	.007	.0069	1.265

REYNOLDS STRESS INTEGRAL(J)= x-.00248215IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$= 0.002890

REYNOLDS STRESS INTEGRAL(J)= .00207537IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$= 0.001997

FIGURE A.7.14

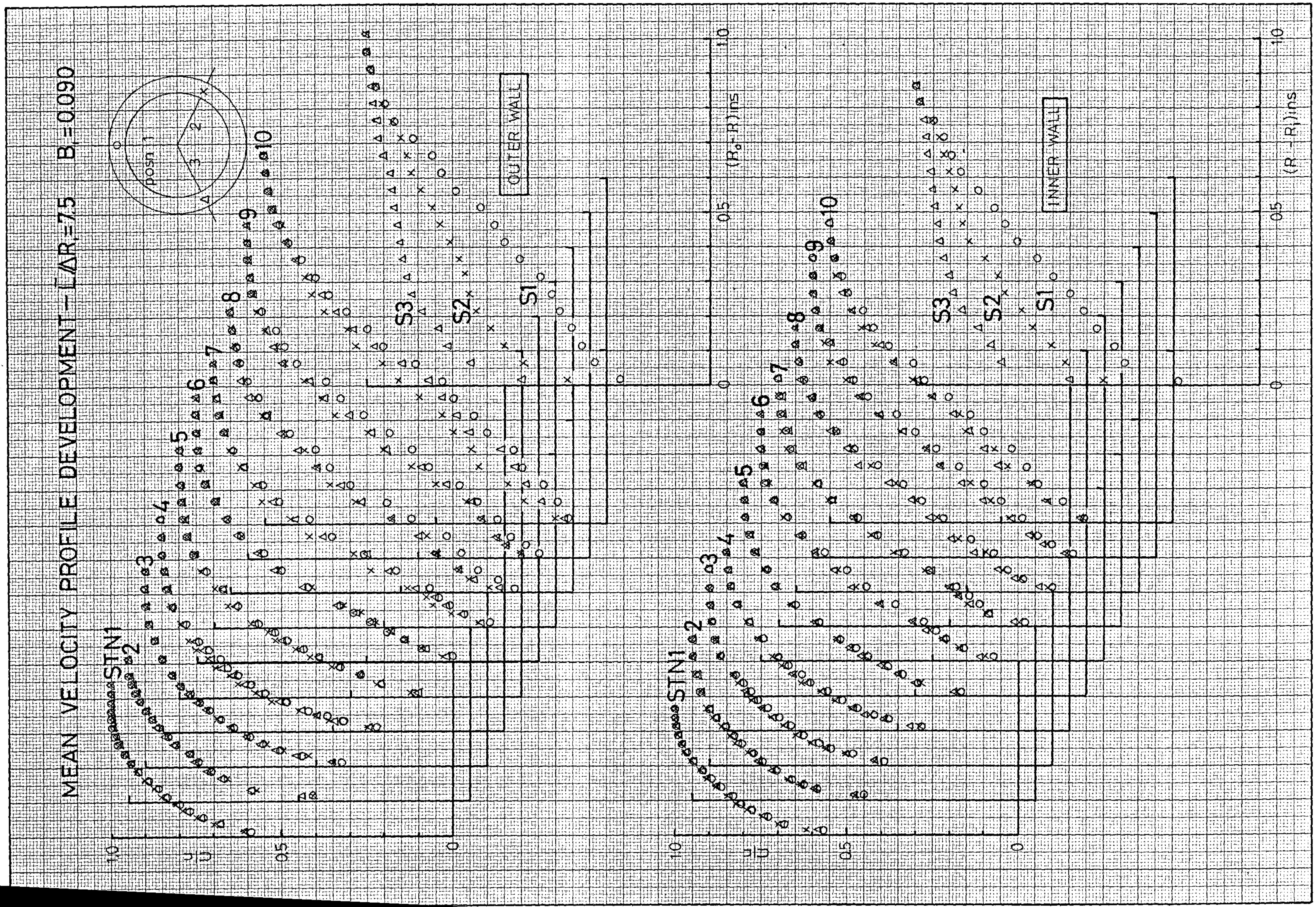
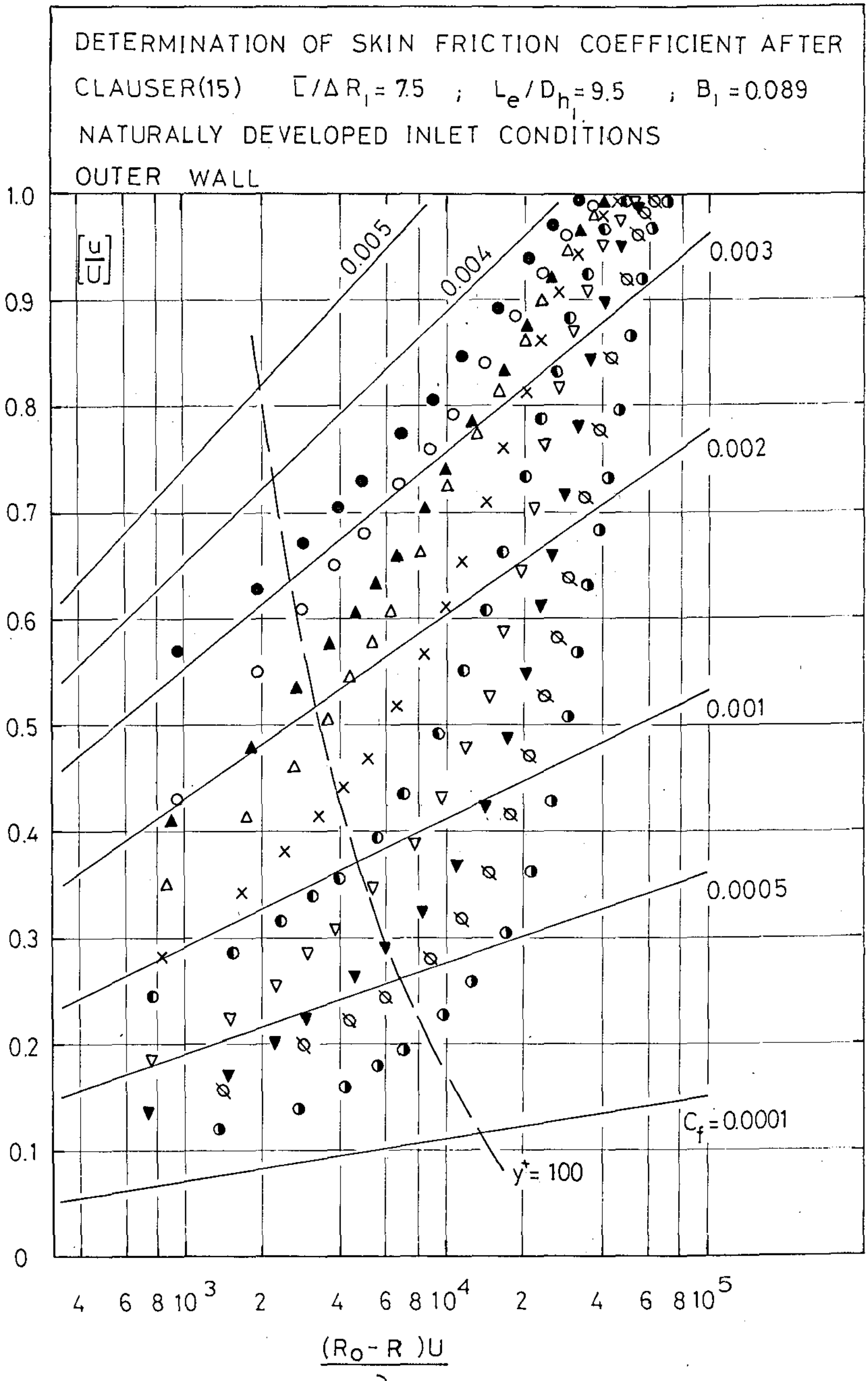

MEAN VELOCITY PROFILE DEVELOPMENT — L/ΔR=7.5 B=0.090
posn 1
OUTER WALL
INNER WALL
STN1
S1
S2
S3
u/U
$(R_o - R)$ ins
$(R - R_i)$ ins
0
0.5
1.0

FIGURE A.7.15



DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1 = 7.5$; $L_e/D_{h_1} = 9.5$; $B_1 = 0.089$
NATURALLY DEVELOPED INLET CONDITIONS
OUTER WALL
$\left[\frac{u}{U}\right]$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
4
6
8
10^3
2
4
6
8
10^4
2
4
6
8
10^5
$\frac{(R_o - R)U}{\nu}$

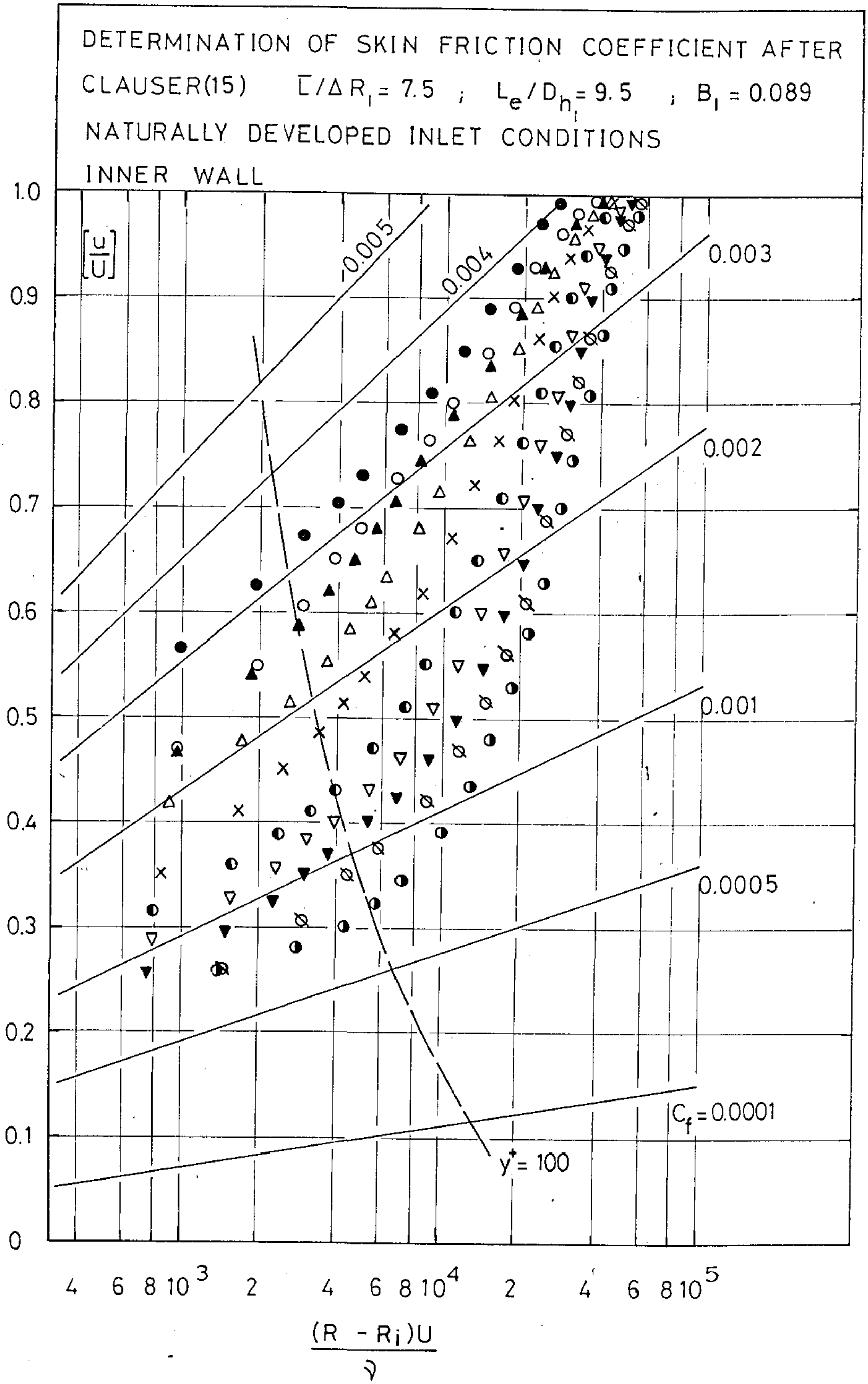

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1 = 7.5$; $L_e/D_{h_1} = 9.5$; $B_1 = 0.089$
NATURALLY DEVELOPED INLET CONDITIONS
INNER WALL
$\left[\frac{u}{U}\right]$
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
4 6 8 10^3 2 4 6 8 10^4 2 4 6 8 10^5
$\frac{(R - R_i)U}{\nu}$

TABLE A7.23 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH$(L/\Delta R_i)$= 7.50 ENTRY LENGTH(L_e/D_{h_i})= 9.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_i)=0.089

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.$(\bar{U}D_h/\nu)_i$=176022

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}$.147	$\bar{0}$.420	.0448	.0338	.0600	1.327	1.778	.0440	.0329	.0584	1.338	1.772
0.300	0.040	.0597	.0418	.0731	1.431	1.749	.0600	.0427	.0748	1.405	1.754
0.750	0.100	.0754	.0508	.0876	1.483	1.724	.0677	.0479	.0838	1.412	1.749
1.250	0.167	.0857	.0545	.0927	1.572	1.700	.0838	.0564	.0969	1.486	1.717
2.200	0.293	.1184	.0696	.1156	1.700	1.660	.1093	.0695	.1172	1.573	1.687
3.150	0.420	.1559	.0832	.1342	1.874	1.612	.1438	.0858	.1419	1.676	1.654
4.100	0.547	.1891	.0934	.1483	2.025	1.588	.1720	.0980	.1598	1.756	1.631
5.050	0.673	.2448	.1098	.1702	2.230	1.551	.2036	.1111	.1788	1.832	1.609
5.050	0.673	.2141	.1087	.1729	1.969	1.590	.2036	.1111	.1788	1.832	1.609
5.050	0.673	.2110	.1059	.1676	1.992	1.582	.2036	.1111	.1788	1.832	1.609
6.000	0.800	.2980	.1263	.1935	2.359	1.531	.2337	.1224	.1954	1.909	1.596
6.000	0.800	.2686	.1233	.1914	2.178	1.552	.2337	.1224	.1954	1.909	1.596
6.000	0.800	.2686	.1233	.1914	2.178	1.552	.2337	.1224	.1954	1.909	1.596
7.400	0.987	.3836	.1453	.2188	2.640	1.506	.2758	.1391	.2199	1.983	1.581
7.400	0.987	.3332	.1490	.2315	2.235	1.553	.2402	.1296	.2080	1.853	1.605
7.400	0.987	.3836	.1453	.2188	2.640	1.506	.2402	.1296	.2080	1.853	1.605
11.250	1.500	.3303	.1631	.2538	2.025	1.556	.2984	.1584	.2525	1.834	1.594
15.000	2.000	.1524	.1119	.1965	1.363	1.756	.2132	.1418	.2412	1.504	1.701
18.750	2.500	.0924	.0746	.1360	1.240	1.824	.1307	.1003	.1796	1.302	1.790

TABLE A.7.24 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_i$) = 7.50 ENTRY LENGTH(L_e/D_{h_i}) = 9.5 HYDRAULIC DIAMETERS

AREA RATIO(AR) = 2.000 BLOCKAGE(B_i) = 0.089

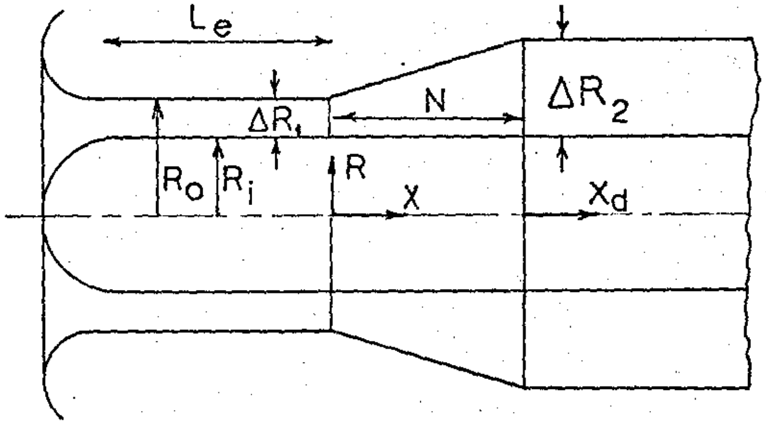
INLET RADIUS RATIO = 0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu_i$) = 176022

NATURALLY DEVELOPED INLET CONDITIONS

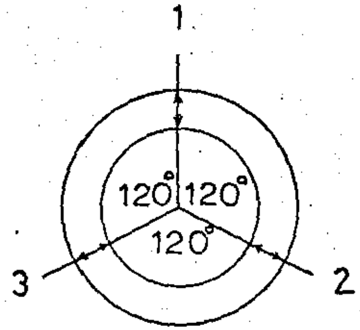
X (IN)	X/N	U FT/SEC	$\bar{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\bar{3}$.147	$\bar{0}$.420	181.31	.911	39.642	1.048	1.017	3260.4	3180.4
0.300	0.040	179.56	.884	39.567	1.072	1.027	3995.3	4082.0
0.750	0.100	171.59	.368	39.194	1.086	1.031	4644.5	4382.4
1.250	0.167	165.44	.852	39.275	1.111	1.041	4805.6	4973.5
2.200	0.293	156.04	.818	39.407	1.156	1.057	5789.7	5776.0
3.150	0.420	147.27	.780	38.926	1.220	1.080	6529.7	6731.3
4.100	0.547	142.45	.754	39.762	1.274	1.099	7089.1	7434.7
5.050	0.673	139.57	.714	40.050	1.359	1.128	8162.4	8762.9
5.050	0.673	136.96	.736	40.511	1.292	1.103	7932.4	8108.4
5.050	0.673	136.13	.738	40.386	1.295	1.105	7684.0	8059.6
6.000	0.800	136.63	.682	40.419	1.430	1.151	9196.5	8913.5
6.000	0.800	132.61	.702	40.368	1.374	1.132	8713.5	8651.3
6.000	0.800	133.29	.702	40.574	1.374	1.132	8758.0	8695.5
7.400	0.987	130.90	.637	40.201	1.554	1.192	10133.8	9698.9
7.400	0.987	125.98	.684	41.574	1.393	1.138	10004.6	8700.8
7.400	0.987	127.41	.653	40.118	1.519	1.182	9863.6	8799.1
11.250	1.500	119.56	.662	38.445	1.351	1.118	10390.0	10090.3
15.000	2.000	99.60	.810	39.194	1.092	1.032	5936.2	7525.0
18.750	2.500	93.29	.884	40.069	1.041	1.014	3706.5	4986.9

$\bar{L}/\Delta R_1 = 5.0$ $AR_{1\text{-}2} = 2.0$ $[R_i/R_o]_1 = 0.833$

TRAVERSE STATIONS		
X/N	SYMBOL	STN
$\bar{0}.630$	◉	1
0.060	○	2
0.150	▲	3
0.270	△	4
0.390	×	5
0.510	◐	6
0.630	▽	7
0.750	▼	8
0.856	⊘	9
0.963	◑	10
$X_d/\Delta R_2 = 1$	-	S1
2	-	S2
3	-	S3

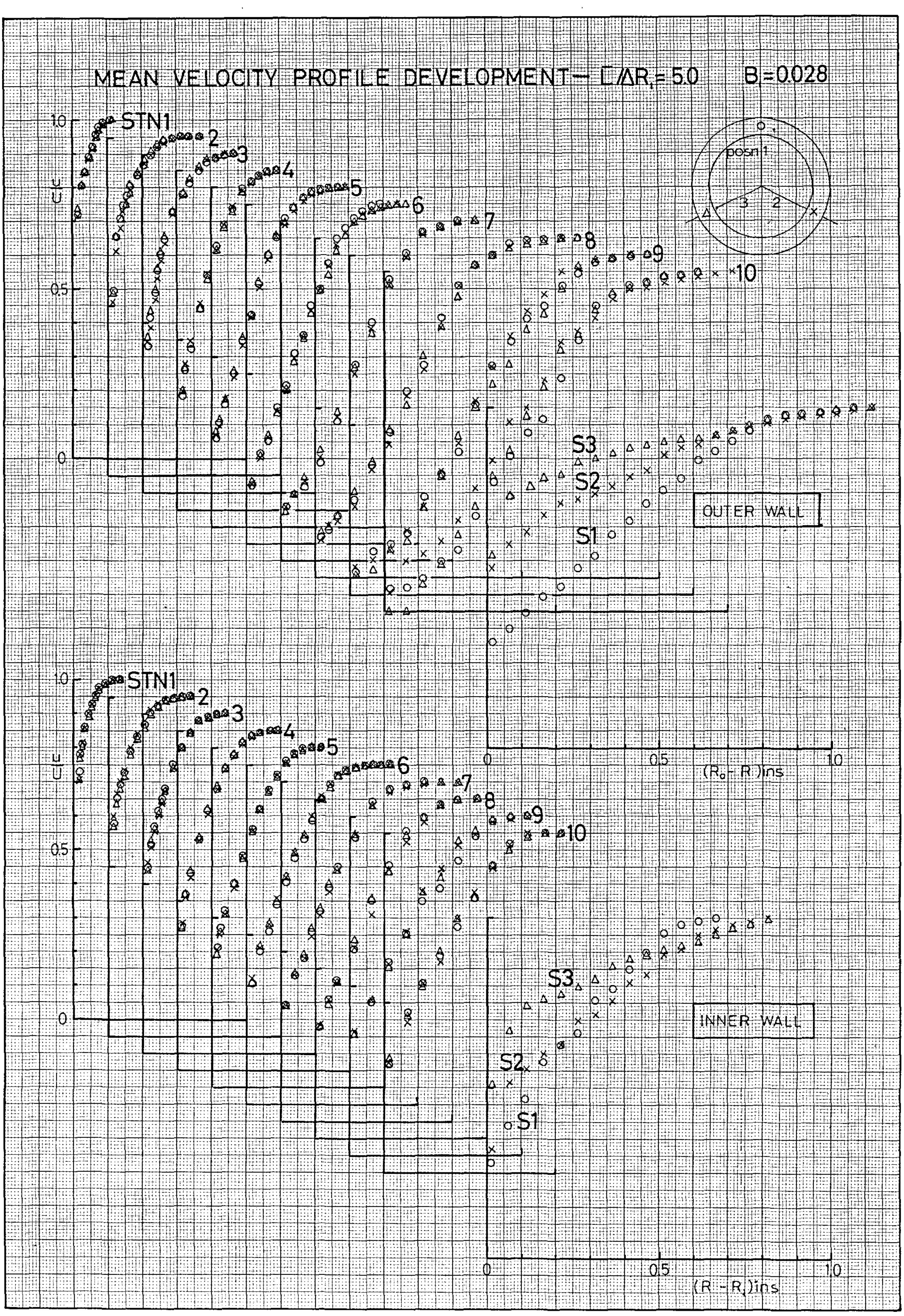


GEOMETRY.	
$\phi_o = 10.0^\circ$	$N = 4.96$ IN.
$R_{o_1} = 6.0$ IN.	$R_{i_1} = 5.0$ IN.
$R_{o_2} = 6.875$ IN.	$R_{i_2} = 5.0$ IN.



TRAVERSE POSITIONS.

symbols as noted unless otherwise indicated



MEAN VELOCITY PROFILE DEVELOPMENT — L/ΔR_i = 5.0 B = 0.028
posn 1
1
2
3
STN1
2
3
4
5
6
7
8
9
10
S3
S2
S1
OUTER WALL
INNER WALL
u/U
1.0
0.5
0
0.5
1.0
(R_o - R) ins
(R - R_i) ins

FIGURE A.7.17

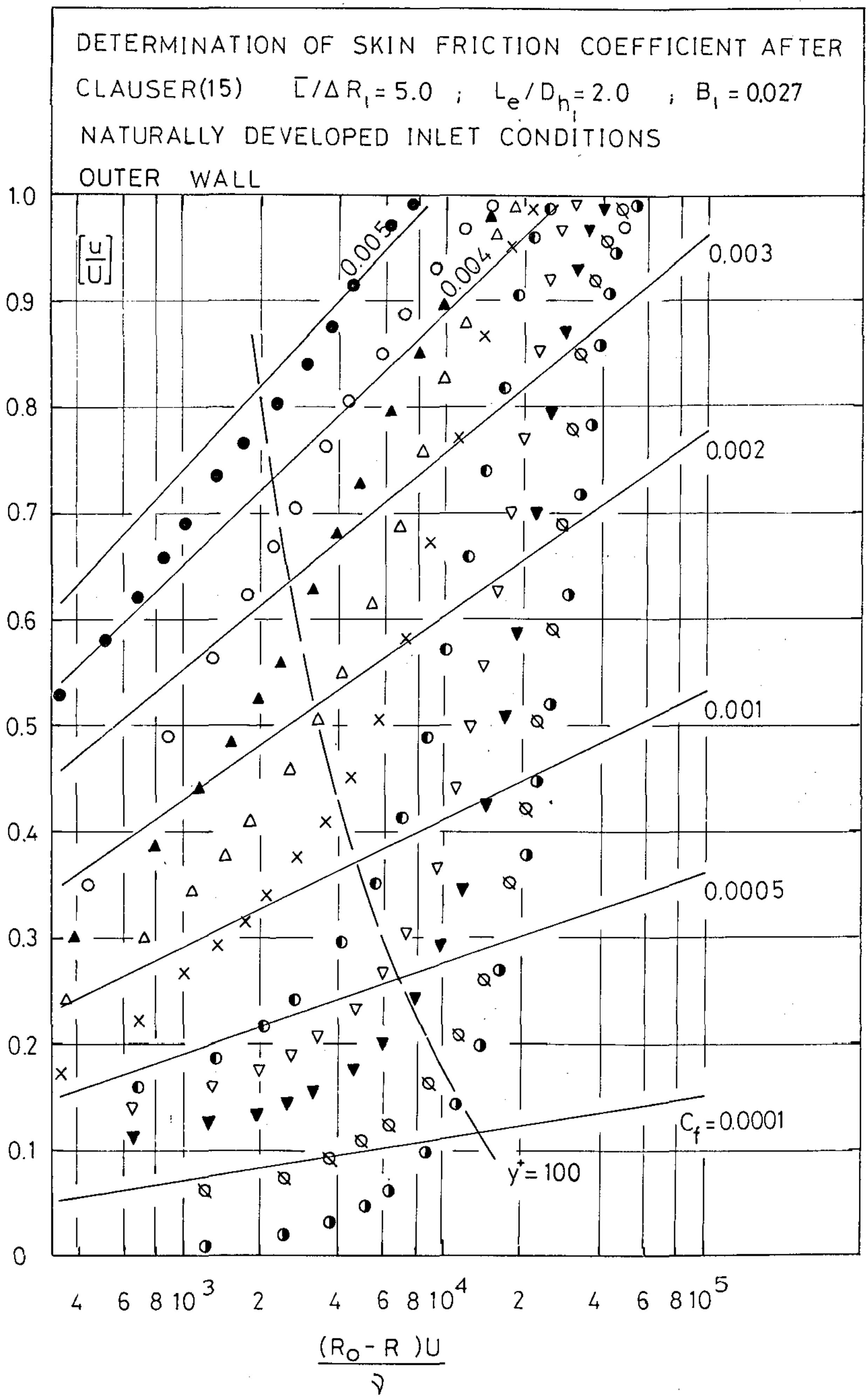

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1 = 5.0$; $L_e/D_{h_1} = 2.0$; $B_1 = 0.027$
NATURALLY DEVELOPED INLET CONDITIONS
OUTER WALL
$\left[\frac{u}{U}\right]$
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4 6 8 10^3 2 4 6 8 10^4 2 4 6 8 10^5
$\frac{(R_o - R)U}{\nu}$

FIGURE A.7.19

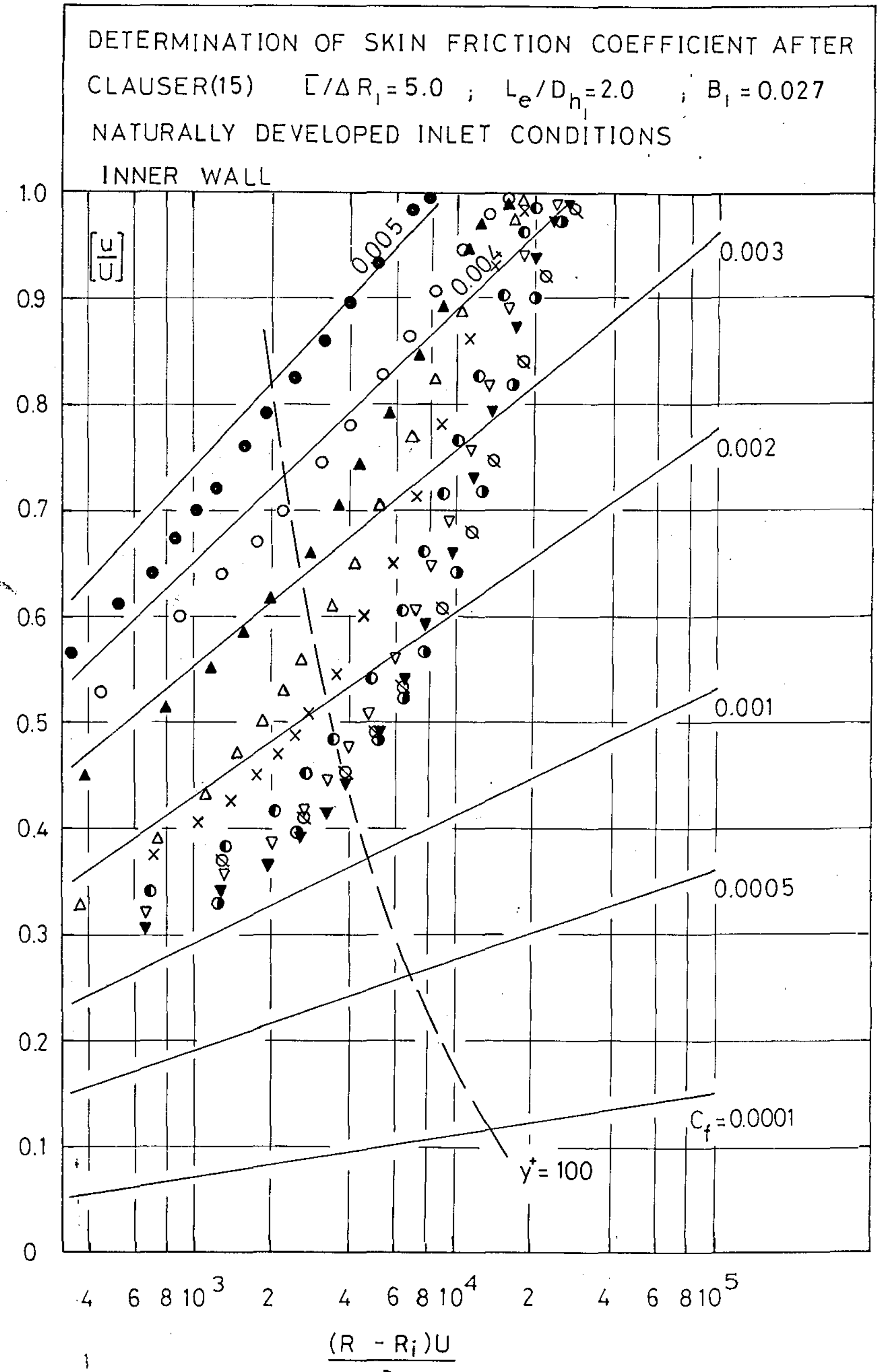

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1 = 5.0$; $L_e/D_{h_1} = 2.0$; $B_1 = 0.027$
NATURALLY DEVELOPED INLET CONDITIONS
INNER WALL
$\left[\frac{u}{U}\right]$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
4
6
8
10^3
2
4
6
8
10^4
2
4
6
8
10^5
$\frac{(R - R_i)U}{\nu}$

TABLE A7.25 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$) = 5.00 ENTRY LENGTH(L_e/D_{h_1}) = 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.027

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu)_1$=171265

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}.147$	$\bar{0}.629$	.0137	.0099	.0173	1.392	1.756	.0131	.0097	.0173	1.346	1.771
0.300	0.060	.0282	.0182	.0317	1.547	1.737	.0263	.0193	.0341	1.362	1.764
0.750	0.150	.0430	.0261	.0441	1.647	1.690	.0358	.0245	.0423	1.460	1.723
1.350	0.270	.0646	.0359	.0588	1.800	1.638	.0513	.0320	.0537	1.605	1.681
1.950	0.390	.0916	.0458	.0730	1.999	1.593	.0662	.0397	.0657	1.668	1.655
2.550	0.510	.1338	.0575	.0890	2.326	1.547	.0841	.0484	.0791	1.739	1.634
3.150	0.630	.1865	.0730	.1106	2.555	1.514	.0976	.0553	.0901	1.765	1.629
3.750	0.750	.2438	.0891	.1344	2.736	1.509	.1132	.0628	.1018	1.802	1.621
4.282	0.856	.3312	.0995	.1472	3.330	1.480	.1273	.0732	.1193	1.739	1.630
4.813	0.963	.3816	.1047	.1582	3.645	1.511	.1270	.0710	.1150	1.790	1.620
4.813	0.963	.3408	.1188	.1789	2.870	1.506	.1270	.0710	.1150	1.790	1.620
4.813	0.963	.3816	.1047	.1582	3.645	1.511	.1270	.0710	.1150	1.790	1.620
8.750	1.750	.2829	.1489	.2364	1.900	1.588	.1937	.1049	.1689	1.845	1.609
12.500	2.500	.1758	.1255	.2180	1.401	1.737	.1946	.1221	.2039	1.594	1.671
16.250	3.250	.1200	.0953	.1728	1.259	1.813	.1298	.0982	.1750	1.322	1.782

TABLE A.7.26 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.027

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu)_1$=171265

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\overline{3}$.147	$\overline{0}$.629	165.17	.973	38.570	1.019	1.007	869.1	857.3
0.300	0.060	167.07	.948	40.217	1.040	1.015	1623.9	1719.7
0.750	0.150	150.30	.930	38.419	1.062	1.024	2088.8	1965.4
1.350	0.270	141.17	.905	38.787	1.097	1.037	2700.9	2404.2
1.950	0.390	133.96	.880	39.226	1.138	1.053	3271.2	2834.9
2.550	0.510	129.34	.845	39.604	1.206	1.080	3963.9	3333.8
3.150	0.630	125.09	.810	39.732	1.279	1.107	4865.6	3686.8
3.750	0.750	122.90	.774	40.191	1.357	1.136	5833.8	4114.8
4.282	0.856	119.93	.721	38.943	1.511	1.193	6355.6	4675.4
4.813	0.963	118.99	.703	40.006	1.586	1.224	6637.9	4499.3
4.813	0.963	117.66	.729	40.994	1.458	1.171	7444.2	4448.9
4.813	0.963	118.61	.703	39.879	1.586	1.224	6616.7	4485.0
8.750	1.750	104.78	.738	37.582	1.283	1.099	8310.7	5858.6
12.500	2.500	95.91	.804	37.459	1.112	1.039	6411.7	6237.4
16.250	3.250	91.09	.868	38.386	1.045	1.016	4626.6	4766.8

FIGURE A.7.20

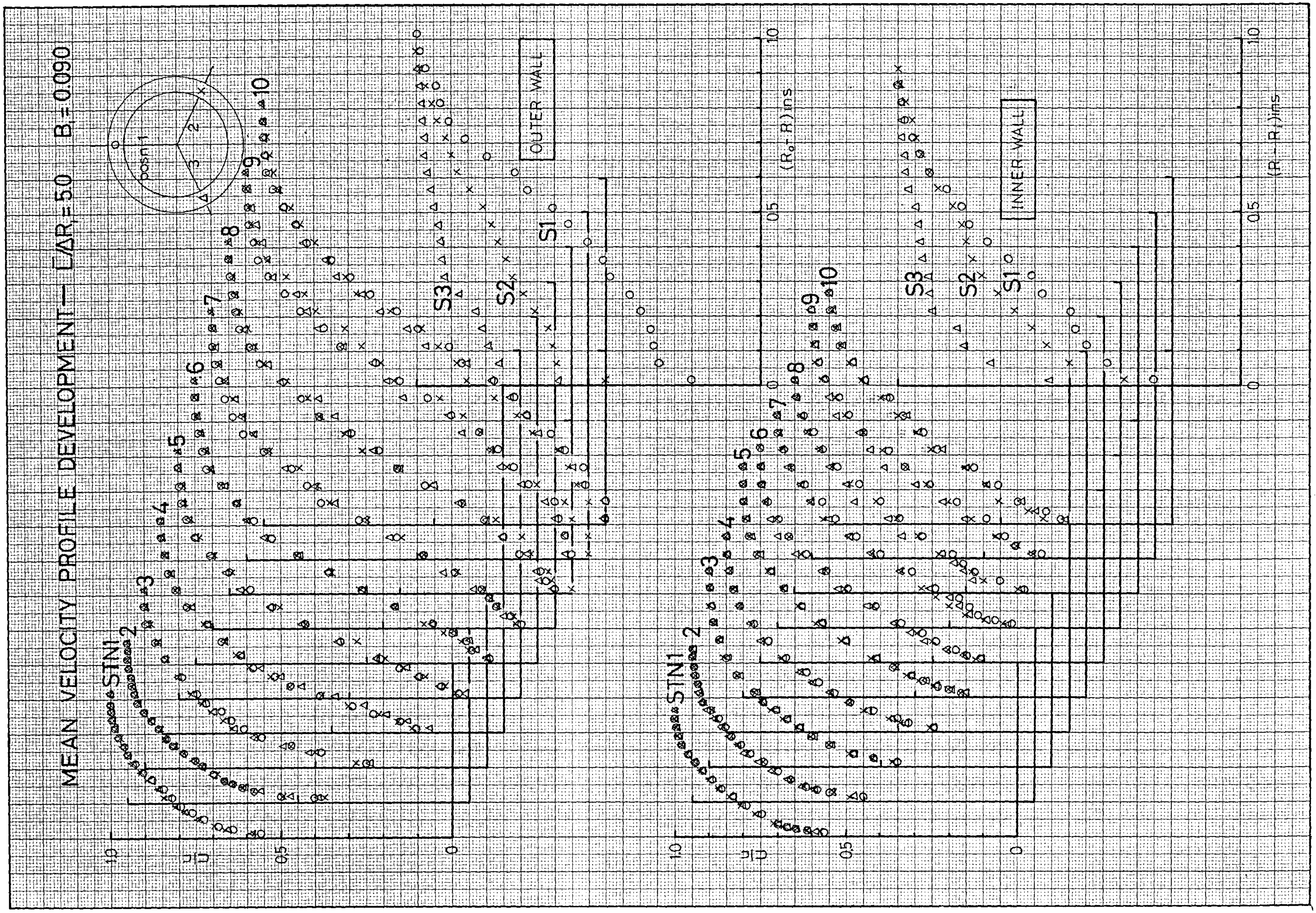
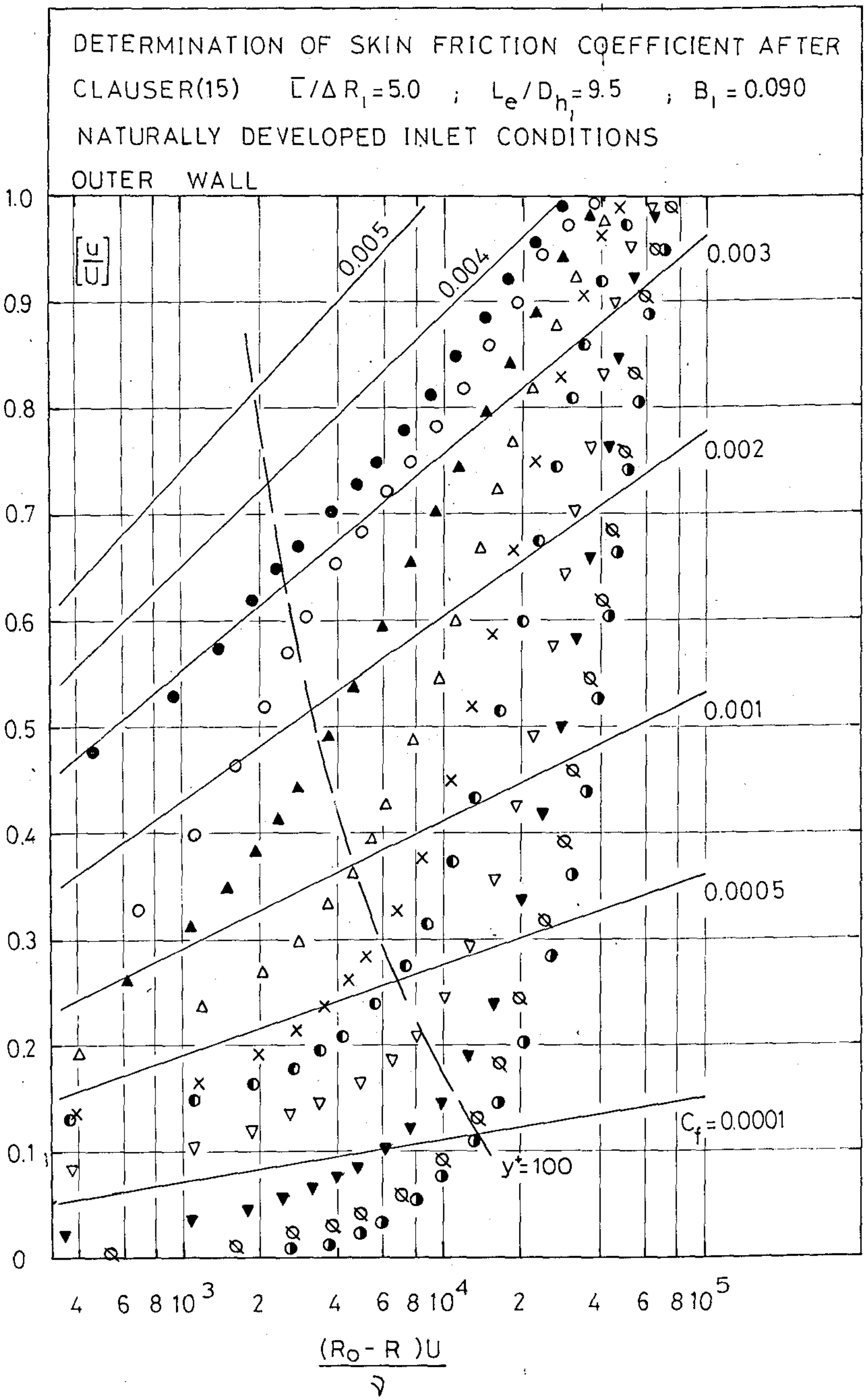

MEAN VELOCITY PROFILE DEVELOPMENT — L/ΔR = 5.0 B = 0.090
OUTER WALL
INNER WALL
STN1
S1
S2
S3
posn 1
(R₀ - R) ins
(R - Rᵢ) ins
u/U

FIGURE A.7.21


DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1 = 5.0$; $L_e/D_{h_1} = 9.5$; $B_1 = 0.090$
NATURALLY DEVELOPED INLET CONDITIONS
OUTER WALL
$\left[\frac{u}{U}\right]$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
4
6
8
10^3
2
4
6
8
10^4
2
4
6
8
10^5
$\frac{(R_O - R)U}{\nu}$

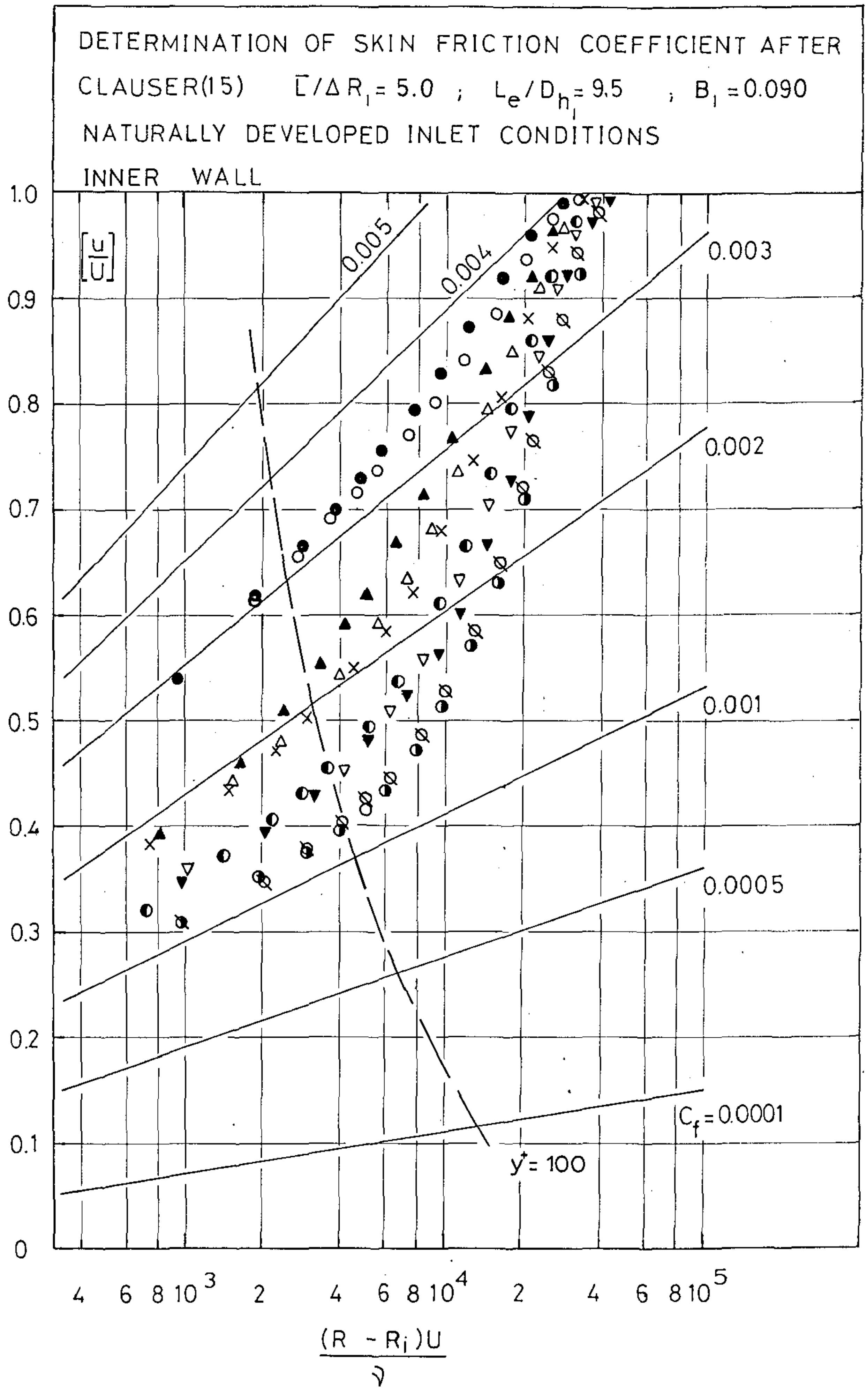

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_i = 5.0$; $L_e/D_{h_i} = 9.5$; $B_i = 0.090$
NATURALLY DEVELOPED INLET CONDITIONS
INNER WALL
$\left[\frac{u}{U}\right]$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
4 6 8 10^3 2 4 6 8 10^4 2 4 6 8 10^5
$\frac{(R - R_i)U}{\nu}$

TABLE A.7.27 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_i$)= 5.00 ENTRY LENGTH(L_e/D_{h_i})= 9.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_i)=0.090

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu_i$)=172777

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$
$\overline{3}$.147	$\overline{0}$.629	.0450	.0333	.0588	1.352	1.769	.0456	.0338	.0599	1.349	1.772
0.300	0.060	.0606	.0407	.0711	1.488	1.745	.0612	.0430	.0755	1.423	1.755
0.750	0.150	.0885	.0545	.0923	1.625	1.694	.0820	.0554	.0957	1.481	1.729
1.350	0.270	.1347	.0717	.1172	1.879	1.635	.0967	.0619	.1055	1.562	1.705
1.950	0.390	.1798	.0835	.1324	2.154	1.586	.1229	.0758	.1275	1.622	1.682
2.550	0.510	.2261	.0985	.1543	2.295	1.567	.1265	.0757	.1260	1.671	1.664
3.150	0.630	.2935	.1137	.1747	2.580	1.536	.1430	.0843	.1396	1.697	1.656
3.750	0.750	.3737	.1204	.1820	3.104	1.512	.1431	.0861	.1431	1.663	1.663
4.282	0.856	.4531	.1285	.1929	3.526	1.501	.1632	.0957	.1580	1.707	1.652
4.813	0.963	.5047	.1366	.2049	3.694	1.500	.1623	.0949	.1566	1.711	1.651
8.750	1.750	.3633	.1608	.2431	2.259	1.512	.2587	.1421	.2286	1.821	1.609
12.500	2.500	.1927	.1321	.2257	1.458	1.709	.2035	.1329	.2257	1.531	1.698
16.250	3.250	.0842	.0678	.1236	1.243	1.825	.0814	.0652	.1189	1.249	1.826

TABLE A.7.28 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 9.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.090

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu_1$)=172777

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\overline{3}$.147	$\overline{0}$.629	178.27	.910	38.911	1.051	1.019	3158.4	3208.4
0.300	0.060	174.96	.884	39.287	1.078	1.029	3798.6	4011.5
0.750	0.150	163.49	.849	38.154	1.117	1.044	4744.3	4822.2
1.350	0.270	154.23	.810	37.905	1.184	1.069	5891.0	5084.2
1.950	0.390	149.47	.770	38.271	1.263	1.098	6646.9	6036.0
2.550	0.510	143.50	.748	38.886	1.319	1.118	7531.6	5790.1
3.150	0.630	143.19	.706	39.682	1.422	1.155	8677.1	6430.5
3.750	0.750	137.35	.669	38.835	1.569	1.210	8808.9	6298.2
4.282	0.856	136.40	.624	38.318	1.732	1.267	9338.3	6951.5
4.813	0.963	133.71	.610	39.010	1.807	1.293	9732.7	6758.1
8.750	1.750	121.06	.659	38.779	1.418	1.141	10370.9	9163.4
12.500	2.500	100.73	.790	38.634	1.113	1.040	7090.2	7133.2
16.250	3.250	85.60	.911	37.899	1.032	1.012	3090.0	2971.4

APPENDIX 8

DIFFUSER PERFORMANCE OVER A RANGE OF NATURALLY DEVELOPED INLET VELOCITY PROFILES

FIGURE A.8.1

DIFFUSER EXIT VELOCITY PROFILES — $\bar{L}/\Delta R_i$ = 10.0, 7.5, 5.0

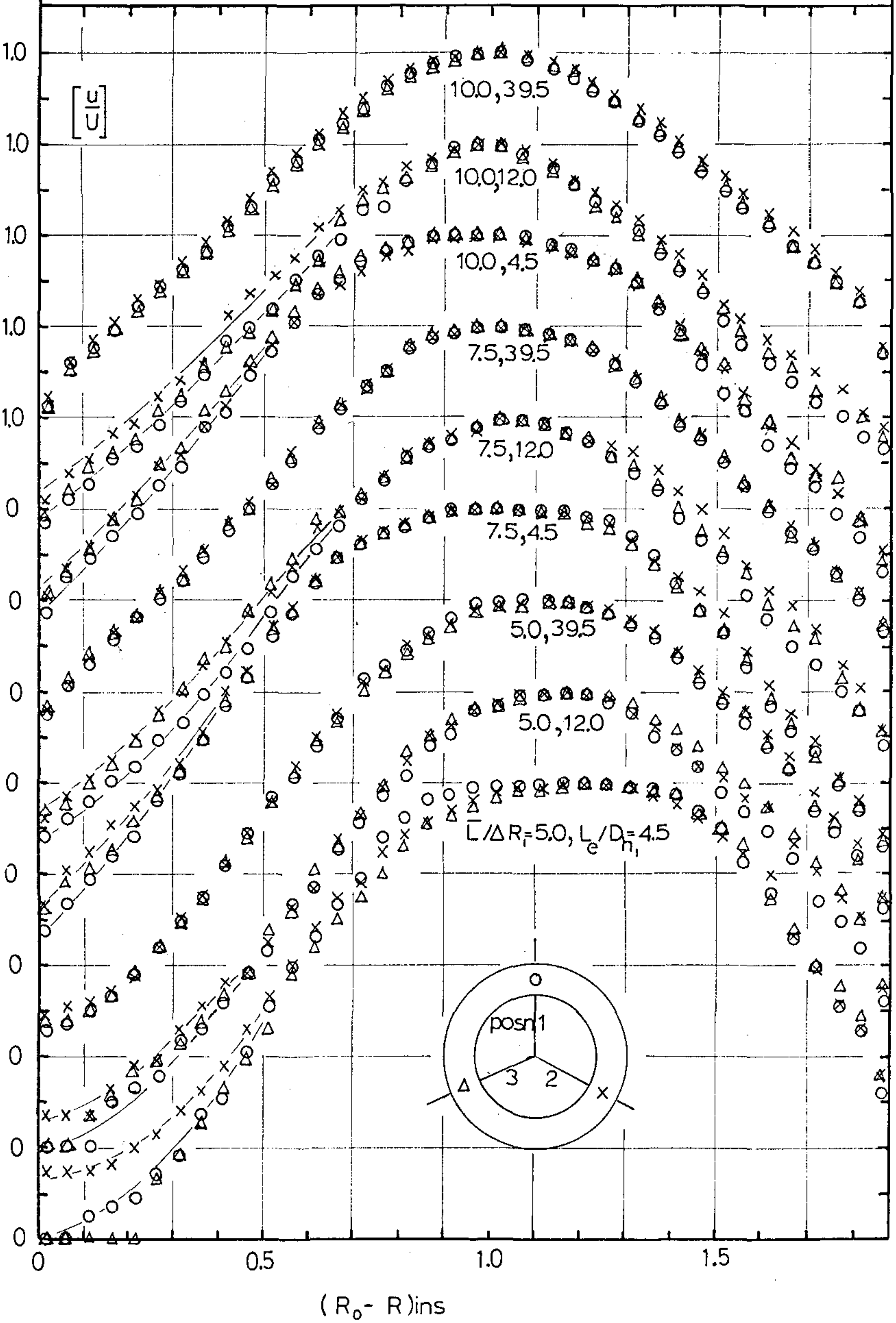


TABLE A.8.1 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)=10.00 ENTRY LENGTH(L_e/D_{h_1})= 4.3 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.053

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu)_1$=175248.9

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$
$\overline{3}$.147	$\overline{0}$.315	.0253	.0189	.0337	1.336	1.779	.0280	.0205	.0362	1.367	1.764
9.850	0.985	.3039	.1350	.2075	2.251	1.537	.2527	.1387	.2241	1.822	1.615

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\overline{3}$.147	$\overline{0}$.315	173.68	.947	39.468	1.033	1.012	1753.3	1898.1
9.850	0.985	116.31	.697	39.047	1.379	1.133	8367.0	8596.2

TABLE A.8.2 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)=10.00 ENTRY LENGTH(L_e/D_{h_1})=12.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.109

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu$)$_1$=174331.3

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$
$\overline{3}$.147	$\overline{0}$.315	.0523	.0389	.0689	1.346	1.773	.0571	.0416	.0734	1.371	1.762
9.850	0.985	.3651	.1566	.2392	2.332	1.527	.2987	.1619	.2586	1.845	1.598
9.850	0.985	.3139	.1479	.2297	2.123	1.553	.2603	.1542	.2527	1.688	1.638
9.850	0.985	.3651	.1566	.2392	2.332	1.527	.2603	.1542	.2527	1.688	1.638

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\overline{3}$.147	$\overline{0}$.315	183.60	.891	39.261	1.059	1.021	3802.9	4071.7
9.850	0.985	126.52	.638	38.891	1.434	1.148	10555.6	10912.4
9.850	0.985	119.65	.687	39.614	1.326	1.113	9426.8	9831.4
9.850	0.985	123.82	.655	39.097	1.394	1.137	10330.2	10173.8

TABLE A.8.3 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_i$)=10.00 ENTRY LENGTH(L_e/D_{h_i})=39.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_i)=0.101

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu_i$)=173706.2

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}$.147	$\bar{0}$.315	.0520	.0402	.0724	1.293	1.802	.0486	.0382	.0689	1.275	1.806
9.850	0.985	.3081	.1519	.2379	2.029	1.566	.2341	.1426	.2357	1.642	1.653

X (IN)	X/N	U FT/SEC	$\bar{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\bar{3}$.147	$\bar{0}$.315	181.31	.899	39.120	1.042	1.015	3881.8	3685.4
9.850	0.985	115.33	.703	39.046	1.292	1.101	9333.0	8760.1

TABLE A.8.4 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)= 7.50 ENTRY LENGTH(L_e/D_{h_1})= 4.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.057

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu$)$_1$=174994.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	X/N	OUTER WALL δ^* (IN)	Θ (IN)	δ^{**} (IN)	H	$\bar{H}$	INNER WALL δ^* (IN)	Θ (IN)	δ^{**} (IN)	H	$\bar{H}$
3.147	0.420	.0269	.0201	.0356	1.338	1.773	.0300	.0216	.0377	1.391	1.748
7.400	0.987	.3470	.1310	.1987	2.650	1.517	.2367	.1240	.1979	1.909	1.596

X (IN)	X/N	$\bar{U}$ FT/SEC	$\bar{u}/U$	Q FT^3/SEC	α	β	OUTER WALL R_Θ	INNER WALL R_Θ
3.147	0.420	174.07	.943	39.410	1.036	1.013	1862.3	2000.5
7.400	0.987	121.98	.677	39.841	1.494	1.177	8512.2	8058.3

TABLE A.8.5 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_i$)= 7.50 ENTRY LENGTH(L_e/D_{h_i})=12.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_i)=0.110

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu$)$_i$=178144.0

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}$.147	$\bar{0}$.420	.0517	.0392	.0698	1.319	1.782	.0505	.0385	.0688	1.312	1.785
7.400	0.987	.4102	.1511	.2273	2.714	1.504	.2403	.1332	.2155	1.805	1.618

X (IN)	X/N	U FT/SEC	$\bar{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\bar{3}$.147	$\bar{0}$.420	184.14	.890	39.669	1.049	1.017	3845.1	3778.0
7.400	0.987	126.88	.636	38.938	1.543	1.191	10216.4	9001.6

TABLE A.8.6 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_i$) = 7.50 ENTRY LENGTH(L_e/D_{h_i}) = 39.5 HYDRAULIC DIAMETERS

AREA RATIO(AR) = 2.00 BLOCKAGE(B_i) = 0.102

INLET RADIUS RATIO = 0.833 INLET REYNOLDS NO ($\bar{u}D_H/\nu$)$_i$ = 175750.0

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	X/N	OUTER WALL δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	INNER WALL δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}$.147	$\bar{0}$.420	.0534	.0419	.0756	1.276	1.805	.0483	.0378	.0682	1.278	1.805
7.400	0.987	.3580	.1520	.2320	2.350	1.530	.2250	.1410	.2410	1.710	1.620

X (IN)	X/N	U FT/SEC	$\bar{u}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\bar{3}$.147	$\bar{0}$.420	183.80	.898	39.600	1.041	1.015	4090.0	3710.0
7.400	0.987	124.50	.669	40.100	1.406	1.142	10100.0	9350.0

TABLE A.8.7 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 4.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.053

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu$)$_1$=175248.9

NATURALLY DEVELOPED INLET CONDITIONS

X (IN)	X/N	Outer wall δ^* (IN)	Outer wall Θ (IN)	Outer wall δ^{**} (IN)	Outer wall H	Outer wall $\overline{H}$	Inner wall δ^* (IN)	Inner wall Θ (IN)	Inner wall δ^{**} (IN)	Inner wall H	Inner wall $\overline{H}$
$\overline{3}$.147	$\overline{0}$.629	.0253	.0189	.0337	1.336	1.779	.0280	.0205	.0362	1.367	1.764
4.813	0.963	.4918	.1125	.1679	4.370	1.492	.1499	.0867	.1419	1.729	1.636
4.813	0.963	.4632	.1533	.2264	3.021	1.477	.1499	.0867	.1419	1.729	1.636
4.813	0.963	.4953	.1275	.1955	3.885	1.533	.1499	.0867	.1419	1.729	1.636

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_Θ	INNER WALL R_Θ
$\overline{3}$.147	$\overline{0}$.629	173.68	.947	39.468	1.033	1.012	1753.3	1898.1
4.813	0.963	131.33	.624	39.175	1.869	1.320	7874.6	6067.9
4.813	0.963	130.04	.642	39.902	1.647	1.229	10622.3	6008.1
4.813	0.963	130.12	.622	38.678	1.808	1.300	8838.3	6012.1

TABLE A.8.8 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})=12.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.109

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu$)$_1$=174331.3

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$
$\overline{3}$.147	$\overline{0}$.629	.0523	.0389	.0689	1.346	1.773	.0571	.0416	.0734	1.371	1.762
4.813	0.963	.5115	.1380	.2043	3.706	1.481	.1885	.1098	.1796	1.717	1.636
4.813	0.963	.5115	.1380	.2043	3.706	1.481	.1630	.1019	.1706	1.600	1.674
4.813	0.963	.5115	.1380	.2043	3.706	1.481	.1630	.1019	.1706	1.600	1.674

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\overline{3}$.147	$\overline{0}$.629	183.60	.891	39.261	1.059	1.021	3802.9	4071.7
4.813	0.963	142.45	.594	40.453	1.833	1.297	10474.5	8329.8
4.813	0.963	137.21	.606	39.729	1.800	1.289	10089.2	7449.1
4.813	0.963	135.97	.606	39.370	1.800	1.289	9998.1	7381.9

TABLE A.8.9 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})=39.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.102

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu$)$_1$=173345.6

NATURALLY DEVELOPED INLET CONDITIONS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$
$\overline{3}$.147	$\overline{0}$.629	.0534	.0419	.0756	1.276	1.805	.0483	.0378	.0682	1.278	1.805
4.813	0.963	.4551	.1405	.2098	3.239	1.493	.1849	.1107	.1827	1.671	1.651

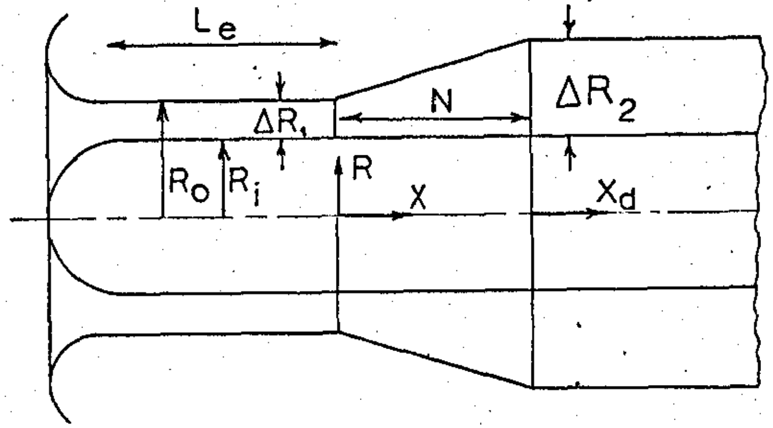
X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\overline{3}$.147	$\overline{0}$.629	181.18	.898	39.039	1.041	1.015	4040.4	3645.2
4.813	0.963	131.07	.631	39.535	1.657	1.237	9813.5	7730.0

APPENDIX 9

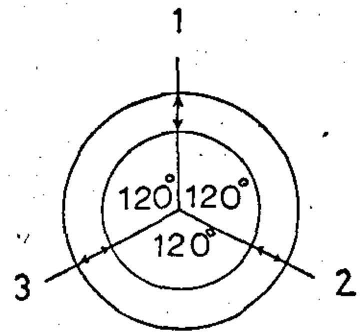
DIFFUSER INTERNAL FLOW DEVELOPMENT AT OPTIMUM SPOILER POSITION

$\bar{L}/\Delta R_1 = 5.0$ $AR_{1-2} = 2.0$ $[R_i/R_o]_1 = 0.833$

TRAVERSE STATIONS		
X/N	SYMBOL	STN
0.630	●	1
0.060	○	2
0.150	▲	3
0.270	△	4
0.390	×	5
0.510	◐	6
0.630	▽	7
0.750	▼	8
0.856	⊘	9
0.963	◑	10
$X_d/\Delta R_2 = 1$	-	S1
2	-	S2
3	-	S3



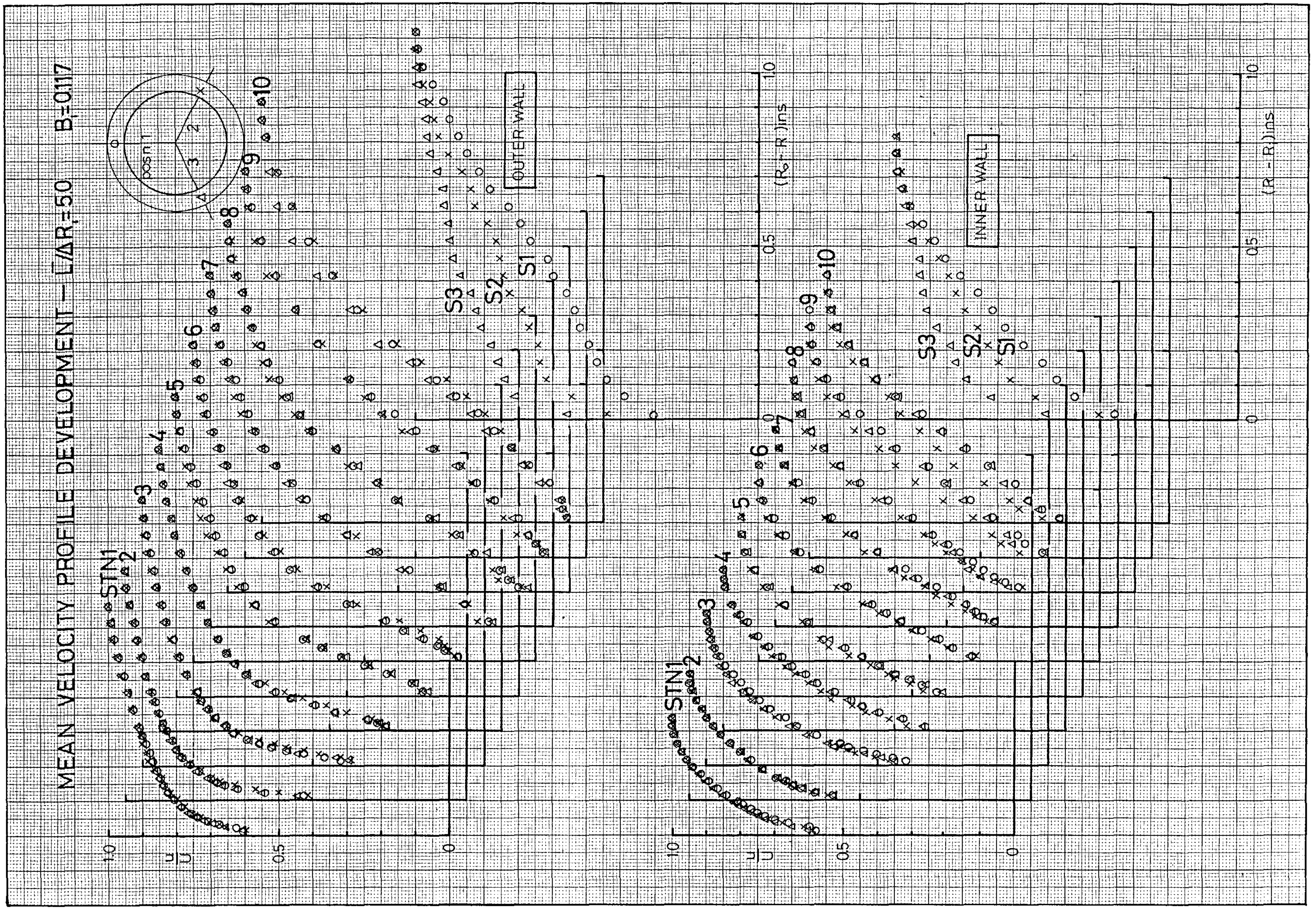
GEOMETRY.	
$\phi_o = 10.0°$	$N = 4.96$ IN.
$R_{o_1} = 6.0$ IN.	$R_{i_1} = 5.0$ IN.
$R_{o_2} = 6.875$ IN.	$R_{i_2} = 5.0$ IN.



TRAVERSE POSITIONS.

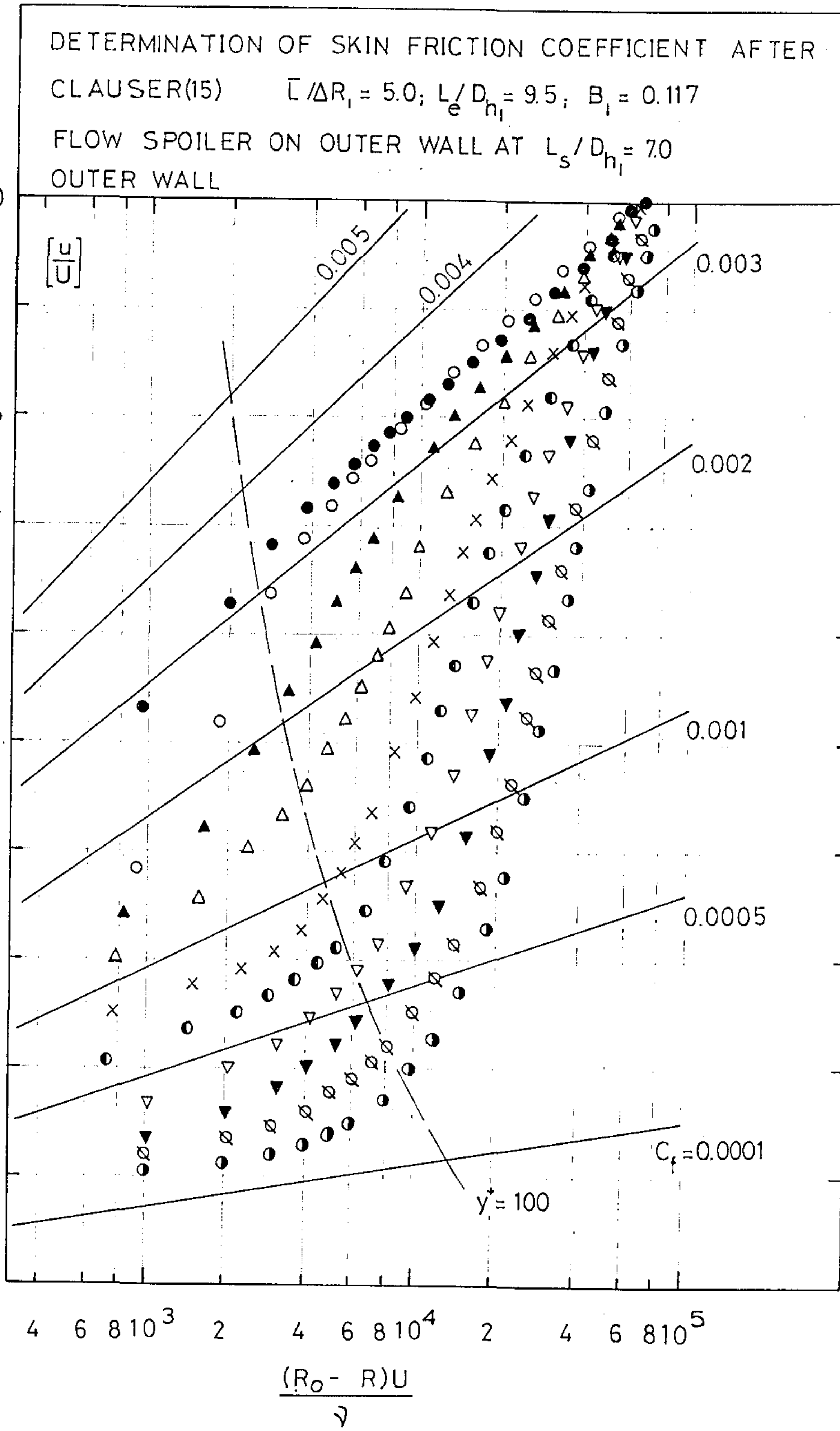
symbols as noted unless otherwise indicated

FIGURE A.9.1



MEAN VELOCITY PROFILE DEVELOPMENT – L/ΔR=50   B=0.117
posn 1
2
3
STN1
2
3
4
5
6
7
8
9
10
S1
S2
S3
OUTER WALL
INNER WALL
(R₀-R)ins
(R-Rᵢ)ins
u/U
1.0
0.5
0

FIGURE A.9.2



DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_1 = 5.0$; $L_e/D_{h_1} = 9.5$; $B_1 = 0.117$
FLOW SPOILER ON OUTER WALL AT $L_s/D_{h_1} = 7.0$
OUTER WALL
$\left[\frac{u}{U}\right]$
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4 6 8 10^3 2 4 6 8 10^4 2 4 6 8 10^5
$\frac{(R_o - R)U}{\nu}$

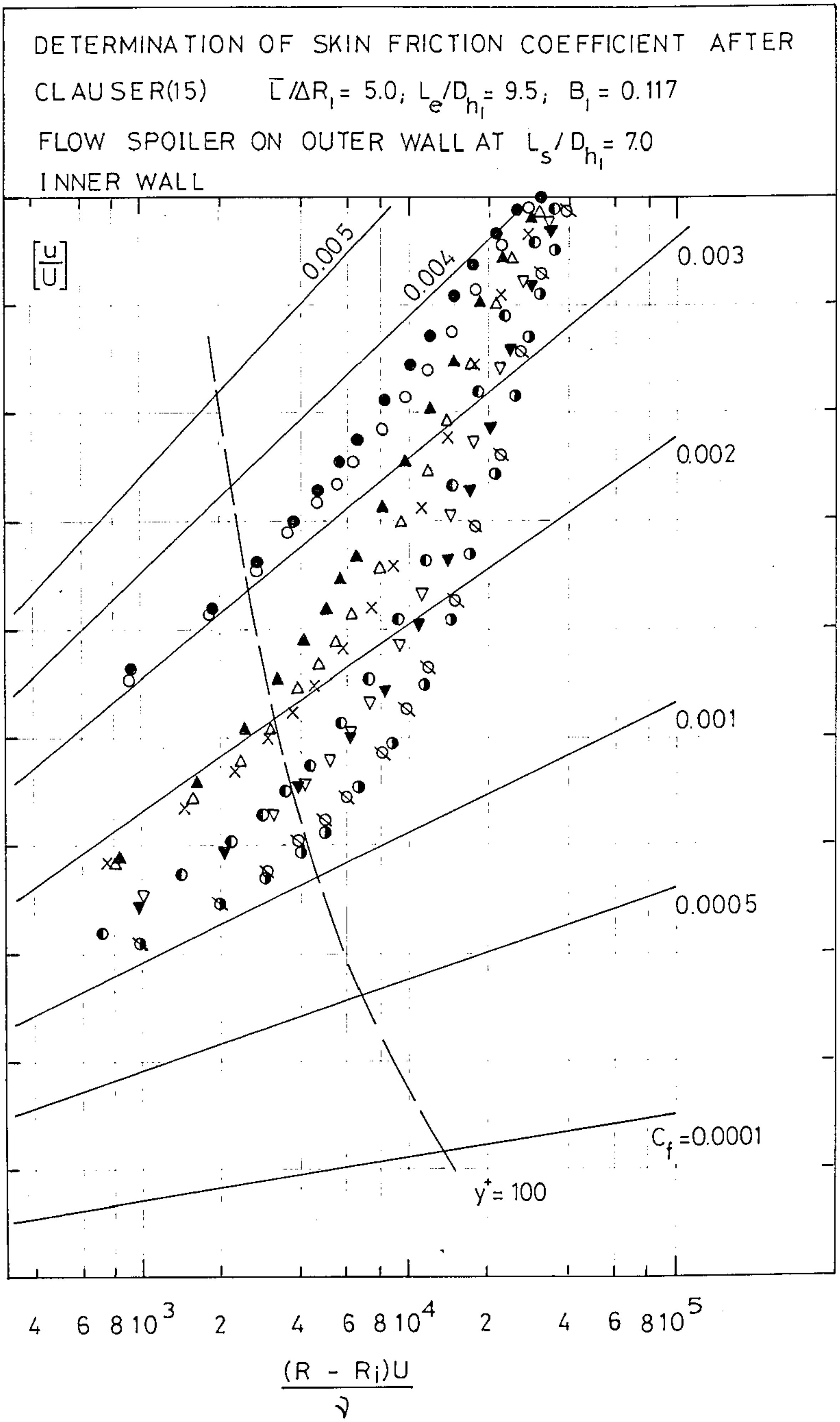

DETERMINATION OF SKIN FRICTION COEFFICIENT AFTER CLAUSER(15) $\bar{L}/\Delta R_I = 5.0$; $L_e/D_{h_I} = 9.5$; $B_I = 0.117$
FLOW SPOILER ON OUTER WALL AT $L_s/D_{h_I} = 7.0$
INNER WALL
$\left[\frac{u}{U}\right]$
0.005
0.004
0.003
0.002
0.001
0.0005
$C_f = 0.0001$
$y^+ = 100$
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
4 6 8 10^3 2 4 6 8 10^4 2 4 6 8 10^5
$\frac{(R - R_i)U}{\nu}$

TABLE A.9.1 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH$(\bar{L}/\Delta R_1)$= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 9.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.117

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.$(\bar{U}D_h/\nu)_1$=167922

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT(L_e/D_{h_1})=7.0HYDRAULIC DIAMETERS

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
$\bar{3}$.147	$\bar{0}$.629	.0702	.0550	.0999	1.277	1.816	.0443	.0321	.0568	1.379	1.767
0.300	0.060	.0705	.0520	.0934	1.354	1.794	.0514	.0376	.0666	1.366	1.768
0.750	0.150	.0968	.0670	.1176	1.444	1.755	.0754	.0497	.0851	1.517	1.711
1.350	0.270	.1297	.0833	.1429	1.557	1.715	.0910	.0585	.0989	1.557	1.692
1.950	0.390	.1698	.0972	.1619	1.748	1.666	.1011	.0644	.1082	1.571	1.682
2.550	0.510	.2062	.1089	.1779	1.894	1.634	.1252	.0747	.1234	1.677	1.653
3.150	0.630	.2536	.1226	.1963	2.068	1.601	.1403	.0828	.1362	1.694	1.645
3.750	0.750	.3050	.1358	.2139	2.246	1.575	.1561	.0916	.1504	1.704	1.642
4.282	0.856	.3703	.1515	.2338	2.444	1.543	.1793	.0990	.1599	1.811	1.614
4.313	0.963	.4282	.1630	.2495	2.627	1.531	.1938	.1080	.1744	1.795	1.615
8.750	1.750	.3218	.1738	.2862	1.799	1.600	.1950	.1199	.1991	1.626	1.660
12.500	2.500	.2236	.1512	.2576	1.479	1.704	.1543	.1073	.1856	1.438	1.730
16.250	3.250	.1356	.1057	.1900	1.283	1.798	.0903	.0708	.1278	1.277	1.807

TABLE A.9.2 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

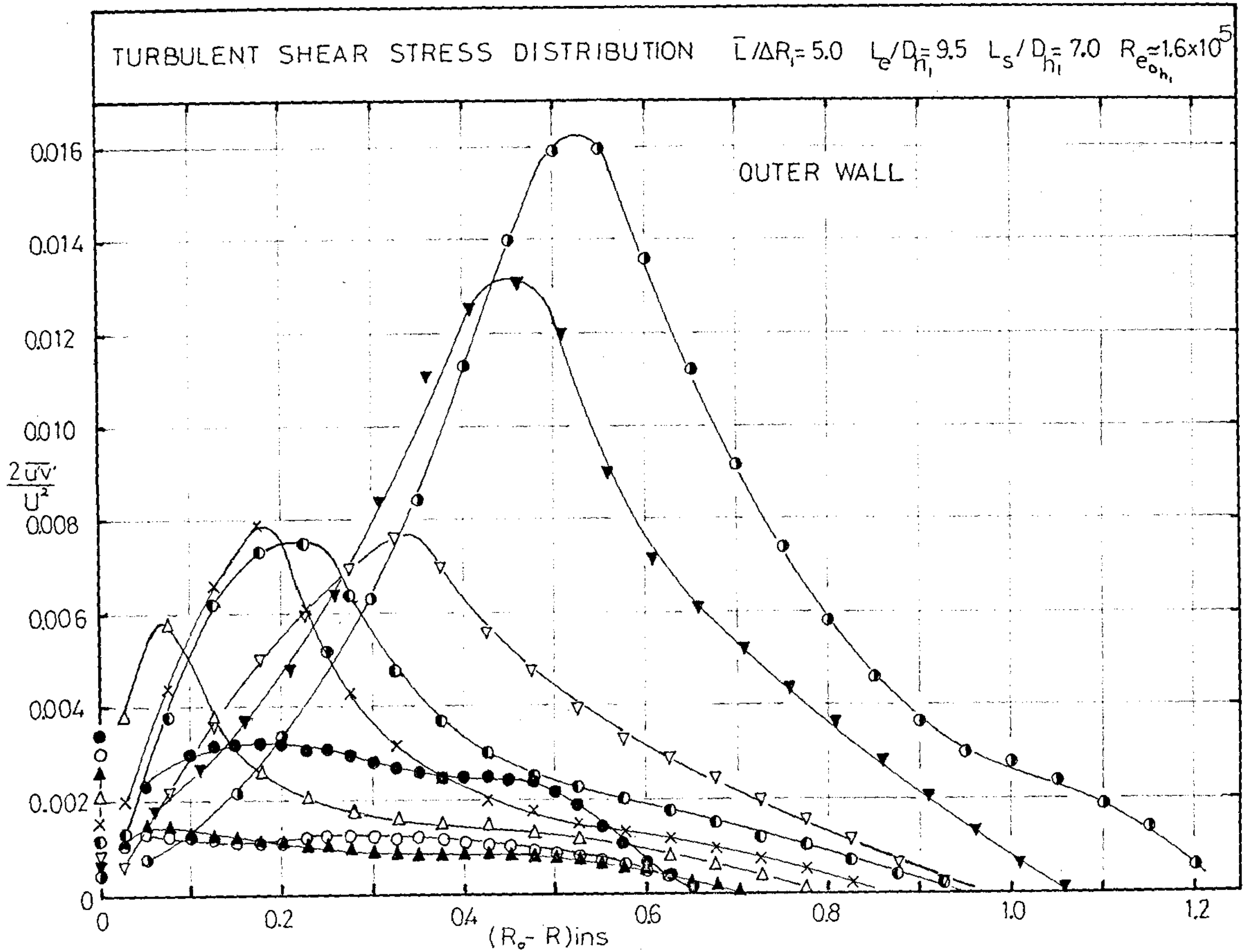
NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 9.5 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.117

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu_1$)=167922

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT(L_e/D_{h_1})=7.0HYDRAULIC DIAMETERS

X	X/N	U	$\bar{U}/U$	Q	α	β	OUTER WALL	INNER WALL
(IN)		FT/SEC		FT^3/SEC			R_θ	R_θ
$\overline{3}.147$	$\overline{0}.629$	178.45	.883	37.818	1.049	1.018	5229.4	3056.0
0.300	0.060	171.96	.883	38.534	1.059	1.022	4768.2	3448.7
0.750	0.150	156.99	.846	36.511	1.097	1.036	5607.1	4160.8
1.350	0.270	150.41	.818	37.355	1.130	1.048	6675.4	4685.5
1.950	0.390	143.31	.792	37.771	1.179	1.066	7420.6	4914.3
2.550	0.510	137.24	.764	37.995	1.236	1.087	7961.2	5459.1
3.150	0.630	132.32	.737	38.260	1.294	1.107	8645.0	5836.3
3.750	0.750	129.34	.710	38.783	1.357	1.130	9360.7	6311.7
4.282	0.856	126.56	.671	38.194	1.459	1.164	10218.1	6676.6
4.813	0.963	123.22	.644	37.915	1.530	1.189	10700.5	7089.3
8.750	1.750	110.54	.714	38.322	1.231	1.079	10533.3	7063.6
12.500	2.500	99.03	.793	38.128	1.105	1.036	7978.4	5660.7
16.250	3.250	88.58	.876	37.680	1.044	1.015	4987.0	3339.3



TURBULENT SHEAR STRESS DISTRIBUTION $\bar{L}/\Delta R_i = 5.0$ $L_e/D_{h_i} = 9.5$ $L_s/D_{h_i} = 7.0$ $R_{e_{D_{h_i}}} \approx 1.6 \times 10^5$
OUTER WALL
$\frac{2\overline{u'v'}}{U^2}$
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0
0
0.2
0.4
0.6
0.8
1.0
1.2
$(R_o - R)$ ins

FIGURE A.9.4

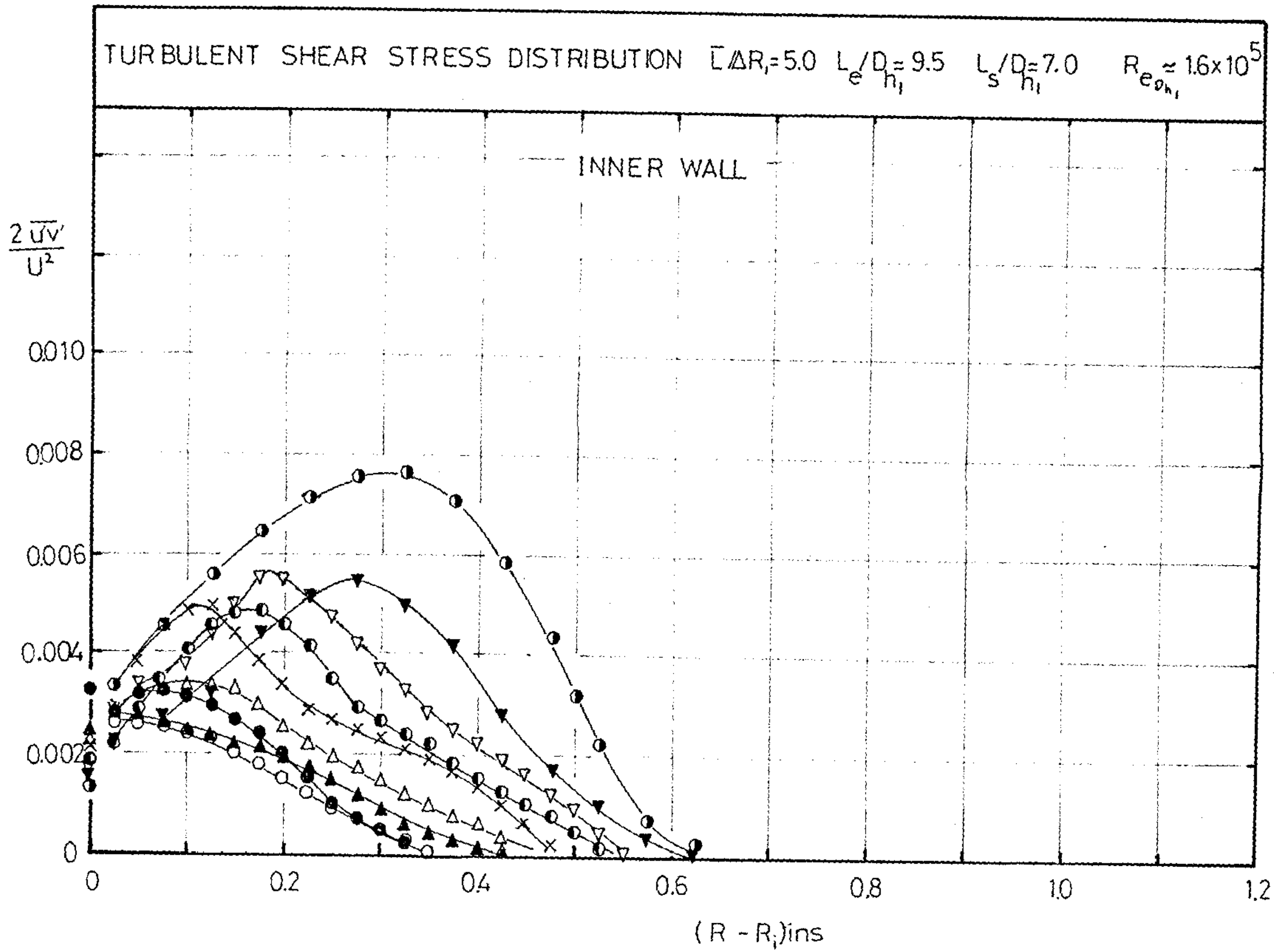

TURBULENT SHEAR STRESS DISTRIBUTION $\overline{L}/\Delta R_i = 5.0$ $L_e/D_{h_1} = 9.5$ $L_s/D_{h_1} = 7.0$ $R_{e_{D_{h_1}}} \simeq 1.6 \times 10^5$
INNER WALL
$\frac{2\overline{u'v'}}{U^2}$
0.010
0.008
0.006
0.004
0.002
0
0
0.2
0.4
0.6
0.8
1.0
1.2
$(R - R_i)$ins

FIGURE A.9.5

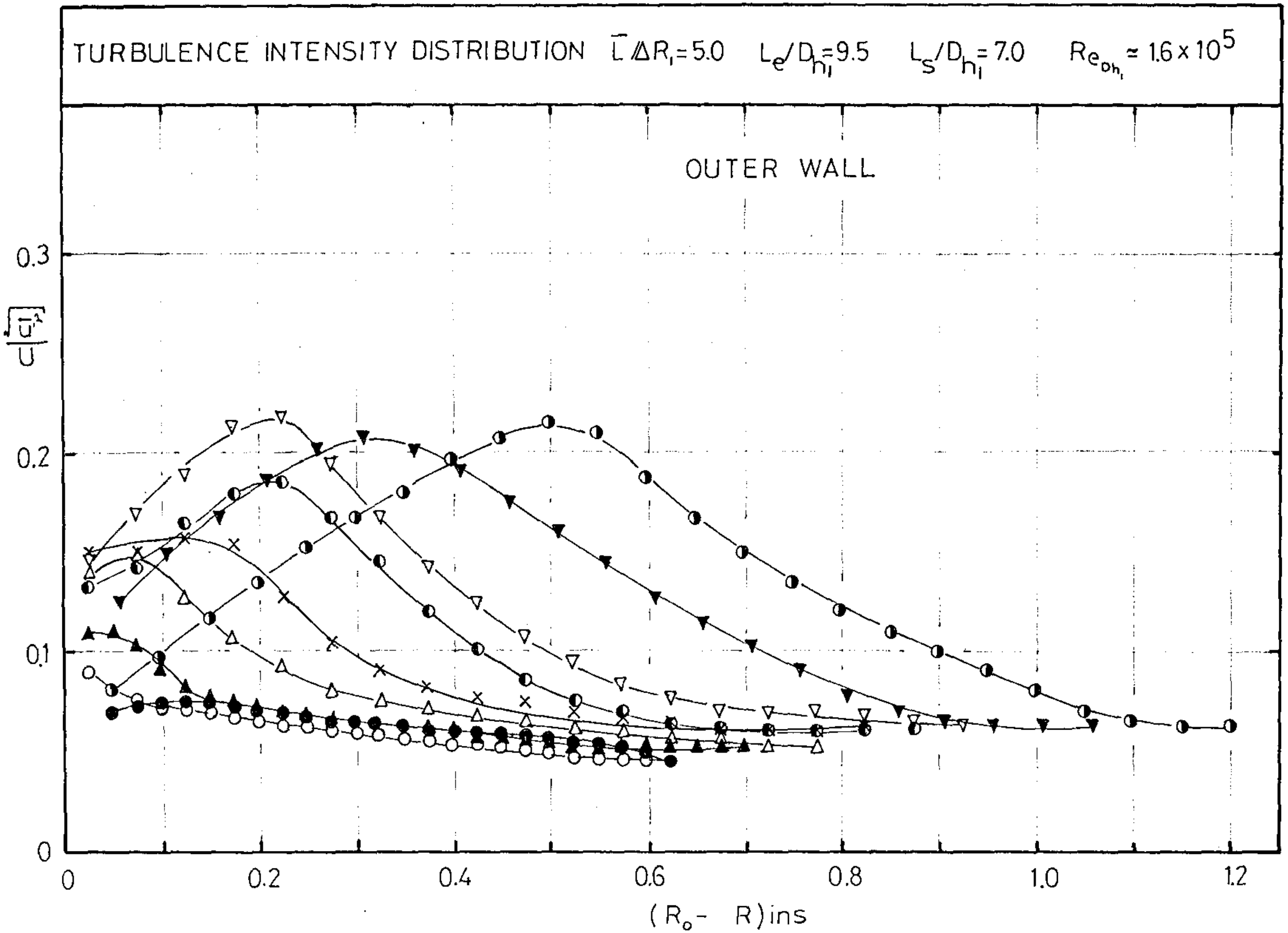

TURBULENCE INTENSITY DISTRIBUTION $\bar{L}/\Delta R_1 = 5.0$ $L_e/D_{h_1} = 9.5$ $L_s/D_{h_1} = 7.0$ $Re_{D_{h_1}} \simeq 1.6 \times 10^5$
OUTER WALL
$\frac{\sqrt{\overline{u'^2}}}{U}$
0
0.1
0.2
0.3
0
0.2
0.4
0.6
0.8
1.0
1.2
$(R_o - R)$ ins

FIGURE A.9.6

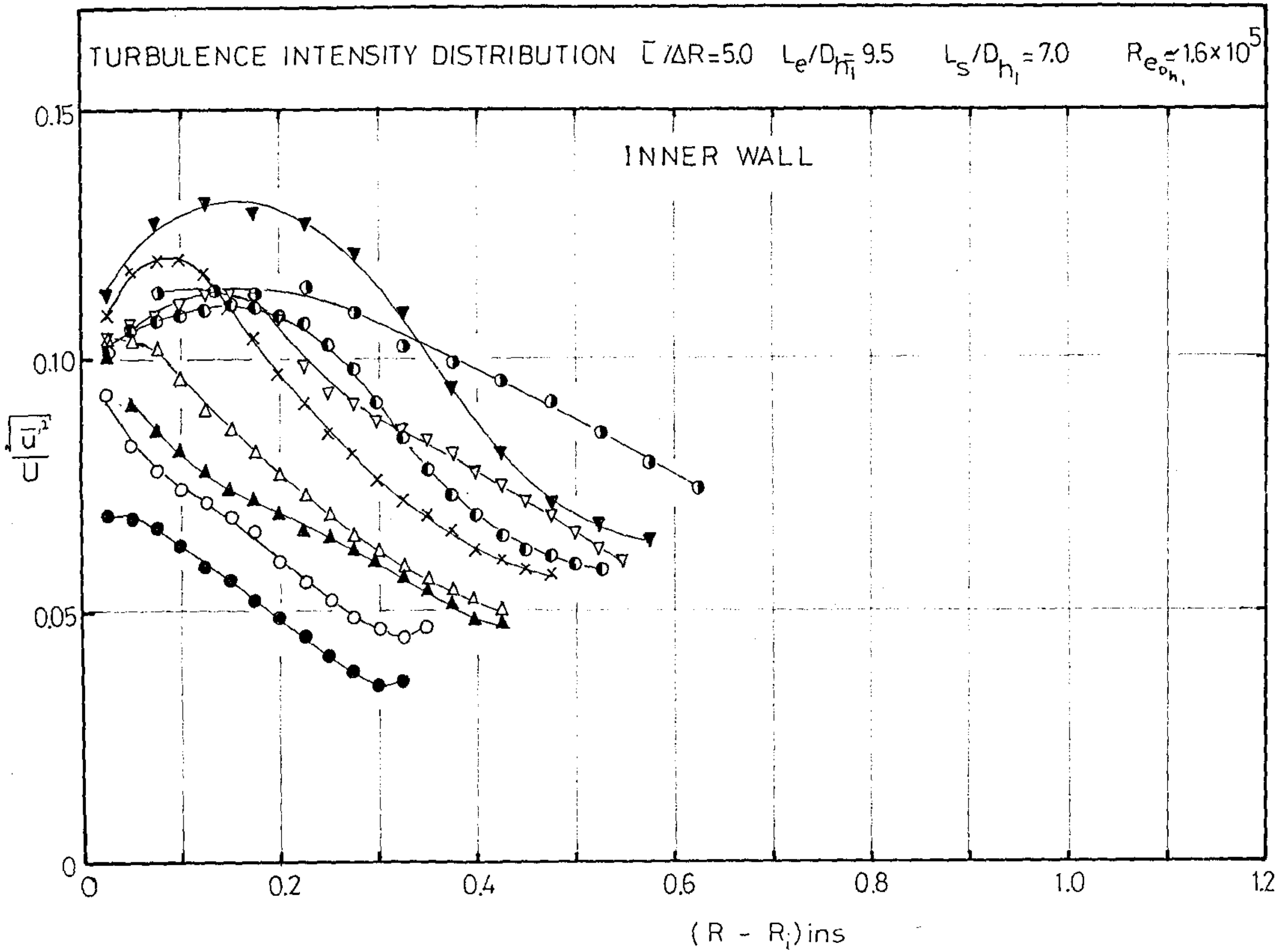

TURBULENCE INTENSITY DISTRIBUTION $\bar{L}/\Delta R = 5.0$ $L_e/D_{h_1} = 9.5$ $L_s/D_{h_1} = 7.0$ $Re_{D_{h_1}} \simeq 1.6 \times 10^5$
INNER WALL
$\frac{\sqrt{\overline{u'^2}}}{U}$
0.15
0.10
0.05
0
0
0.2
0.4
0.6
0.8
1.0
1.2
$(R - R_i)$ ins

FIGURE A.9.7

TABLE A.9.3 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\overline{L}/\Delta R)$= 5.00 (L_e/D_{h_i})= 9.5 (AR)=2.000 (B_i)=0.117 INLET REYNOLDS NO.$(\bar{u}D_{h_i}/\nu)$=160521.0

STN. X= 3.147" X/N=0.629 GREEN POSITION(2) $H_{o_{2-D}}$=1.289 $H_{i_{2-D}}$=1.365 $\delta^*_{o_{2-D}}$=.0732" $\delta^*_{i_{2-D}}$=.0433" U=170.58FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT(L_s/D_{h_i})=7.0HYDRAULIC DIAMETERS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.050	.950	.738	.00115	.070	.0073	0.216	0.025	.025	.645	.00140	.069	.0071	0.189
0.075	.925	.778	.00134	.073	.0136	0.372	0.050	.050	.730	.00162	.069	.0136	0.338
0.100	.900	.806	.00150	.075	.0228	0.588	0.075	.075	.786	.00166	.067	.0201	0.492
0.125	.875	.827	.00159	.076	.0277	0.697	0.100	.100	.830	.00158	.063	.0228	0.573
0.150	.850	.843	.00162	.075	.0370	0.918	0.125	.125	.867	.00150	.059	.0263	0.678
0.175	.825	.858	.00163	.073	.0403	0.998	0.150	.150	.898	.00136	.056	.0262	0.711
0.200	.800	.870	.00163	.071	.0460	1.140	0.175	.175	.924	.00119	.052	.0282	0.816
0.225	.775	.880	.00161	.069	.0555	1.383	0.200	.200	.946	.00100	.049	.0328	1.041
0.250	.750	.890	.00154	.068	.0600	1.531	0.225	.225	.963	.00075	.045	.0280	1.021
0.275	.725	.900	.00149	.067	.0637	1.653	0.250	.250	.978	.00053	.041	.0252	1.096
0.300	.700	.908	.00141	.066	.0625	1.660	0.275	.275	.986	.00036	.038	.0239	1.257
0.325	.675	.916	.00135	.065	.0616	1.675	0.300	.300	.993	.00024	.035	.0254	1.649
0.350	.650	.923	.00129	.064	.0587	1.635	0.325	.325	.997	.00010	.037	.0279	2.823
0.375	.625	.931	.00126	.063	.0573	1.615	0.000	.000	.000	.00000	.000	.0000	0.000
0.400	.600	.938	.00125	.062	.0568	1.608	0.000	.000	.000	.00000	.000	.0000	0.000
0.425	.575	.946	.00125	.061	.0563	1.593	0.000	.000	.000	.00000	.000	.0000	0.000
0.450	.550	.952	.00123	.060	.0702	2.005	0.000	.000	.000	.00000	.000	.0000	0.000
0.475	.525	.959	.00118	.059	.0768	2.234	0.000	.000	.000	.00000	.000	.0000	0.000
0.500	.500	.966	.00109	.057	.0820	2.482	0.000	.000	.000	.00000	.000	.0000	0.000

TABLE A.9.3 CONT.

OUTER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\,\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.525	.475	.972	.00096	.056	.0853	2.756
0.550	.450	.979	.00072	.054	.0783	2.926
0.575	.425	.984	.00050	.052	.0704	3.155
0.600	.400	.990	.00033	.049	.0655	3.623
0.625	.375	.995	.00017	.046	.0572	4.434

REYNOLDS STRESS INTEGRAL(J)= .00067764IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.000662

INNER WALL						
$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\,\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00014572IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.000821

TABLE A.9.4 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i)$= 5.00 (L_e/D_{h_1})= 9.5 (AR)=2.000 (B_1)=0.117 INLET REYNOLDS NO. $(\bar{u}D_{h_1}/\nu)$=160521.0

STN. X= 0.300" X/N=0.060 GREEN POSITION(2) $H_{o_{2-D}}$=1.380 $H_{i_{2-D}}$=1.380 $\delta^*_{o_{2-D}}$=.0735" $\delta^*_{i_{2-D}}$=.0510" U=164.39FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT(L_s/D_{h_1})=7.0HYDRAULIC DIAMETERS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.025	.976	.580	.00053	.090	.0007	0.029	0.025	.024	.637	.00133	.093	.0069	0.190
0.050	.953	.716	.00065	.081	.0033	0.131	0.050	.047	.715	.00129	.083	.0112	0.313
0.075	.929	.765	.00062	.076	.0052	0.210	0.075	.071	.762	.00127	.078	.0152	0.426
0.100	.905	.800	.00059	.073	.0067	0.275	0.100	.095	.800	.00122	.074	.0164	0.471
0.125	.881	.827	.00057	.071	.0085	0.355	0.125	.119	.834	.00114	.072	.0170	0.505
0.150	.858	.849	.00055	.069	.0100	0.426	0.150	.142	.863	.00103	.069	.0168	0.525
0.175	.834	.865	.00056	.067	.0120	0.509	0.175	.166	.892	.00090	.066	.0159	0.529
0.200	.810	.879	.00058	.065	.0158	0.656	0.200	.190	.916	.00076	.060	.0156	0.568
0.225	.786	.891	.00060	.063	.0182	0.740	0.225	.214	.938	.00061	.056	.0151	0.610
0.250	.763	.901	.00062	.062	.0209	0.845	0.250	.237	.958	.00046	.052	.0129	0.601
0.275	.739	.911	.00063	.060	.0230	0.920	0.275	.261	.973	.00036	.049	.0127	0.671
0.300	.715	.920	.00062	.059	.0255	1.020	0.300	.285	.984	.00025	.046	.0118	0.753
0.325	.691	.929	.00061	.058	.0270	1.090	0.325	.309	.993	.00015	.045	.0111	0.912
0.350	.668	.935	.00061	.056	.0263	1.150	0.350	.332	.998	.00003	.047	.0054	0.949
0.375	.644	.942	.00058	.055	.0296	1.230	0.000	.000	.000	.00000	.000	.0000	0.000
0.400	.620	.949	.00056	.054	.0306	1.290	0.000	.000	.000	.00000	.000	.0000	0.000
0.425	.596	.954	.00054	.053	.0315	1.351	0.000	.000	.000	.00000	.000	.0000	0.000
0.450	.573	.961	.00052	.051	.0339	1.487	0.000	.000	.000	.00000	.000	.0000	0.000
0.475	.549	.967	.00048	.050	.0358	1.635	0.000	.000	.000	.00000	.000	.0000	0.000

TABLE A9.4 CONT.

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o2-D}}$	$\frac{\ell}{\delta^*_{o2-D}}$
0.500	.525	.973	.00045	.049	.0393	1.850
0.525	.501	.980	.00041	.048	.0430	2.119
0.550	.478	.986	.00037	.047	.0485	2.517
0.575	.454	.991	.00033	.046	.0578	3.172
0.600	.430	.996	.00026	.045	.0684	4.226
0.625	.406	.999	.00017	.045	.0901	6.861

REYNOLDS STRESS INTEGRAL(J)= .00197093IN

DISSIPATION INTEGRAL($\frac{D}{2}$)= 0.000387

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i2-D}}$	$\frac{\ell}{\delta^*_{i2-D}}$
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00138423IN

DISSIPATION INTEGRAL($\frac{D}{2}$)= 0.000690

TABLE A.9.5 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_1) = 5.00$ $(L_e/D_{h_1}) = 9.5$ $(AR) = 2.000$ $(B_1) = 0.117$ INLET REYNOLDS NO. $(\bar{u}D_h/\nu) = 160521.0$

STN. $X = 0.750''$ $X/N = 0.150$ GREEN POSITION(2) $H_{o_{2-D}} = 1.444$ $H_{i_{2-D}} = 1.519$ $\delta^*_{o_{2-D}} = .0999''$ $\delta^*_{i_{2-D}} = .0738''$ $U = 150.08$ FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT $(L_s/D_{h_1}) = 7.0$ HYDRAULIC DIAMETERS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.025	.978	.455	.00055	.109	.0008	0.036	0.025	.022	.487	.00146	.101	.0038	0.099
0.050	.956	.588	.00075	.111	.0018	0.066	0.050	.044	.590	.00143	.091	.0060	0.158
0.075	.934	.672	.00075	.102	.0028	0.103	0.075	.066	.660	.00134	.086	.0074	0.203
0.100	.912	.726	.00062	.089	.0035	0.142	0.100	.088	.715	.00124	.082	.0082	0.233
0.125	.890	.763	.00059	.082	.0046	0.192	0.125	.110	.763	.00117	.078	.0091	0.266
0.150	.867	.792	.00058	.077	.0058	0.241	0.150	.133	.804	.00113	.074	.0102	0.303
0.175	.845	.814	.00056	.074	.0069	0.294	0.175	.155	.840	.00108	.072	.0108	0.329
0.200	.823	.832	.00052	.071	.0074	0.326	0.200	.177	.871	.00101	.069	.0114	0.358
0.225	.801	.847	.00051	.069	.0089	0.394	0.225	.199	.897	.00088	.066	.0118	0.400
0.250	.779	.861	.00051	.066	.0092	0.410	0.250	.221	.920	.00075	.065	.0120	0.437
0.275	.757	.874	.00049	.065	.0102	0.463	0.275	.243	.940	.00059	.062	.0110	0.454
0.300	.735	.884	.00045	.063	.0101	0.474	0.300	.265	.956	.00044	.060	.0098	0.470
0.325	.713	.895	.00044	.062	.0104	0.497	0.325	.287	.971	.00031	.057	.0087	0.492
0.350	.691	.906	.00042	.061	.0110	0.535	0.350	.309	.981	.00021	.054	.0075	0.525
0.375	.669	.914	.00042	.058	.0119	0.584	0.375	.331	.988	.00014	.051	.0073	0.624
0.400	.647	.923	.00041	.056	.0118	0.582	0.400	.353	.995	.00008	.048	.0083	0.897
0.425	.625	.931	.00042	.054	.0132	0.641	0.425	.375	.999	.00001	.047	.0071	2.169
0.450	.602	.940	.00039	.053	.0131	0.662	0.000	.000	.000	.00000	.000	.0000	0.000
0.475	.580	.948	.00039	.052	.0130	0.658	0.000	.000	.000	.00000	.000	.0000	0.000

TABLE A.9.5 CONT.

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o2-D}}$	$\frac{\ell}{\delta^*_{o2-D}}$
0.500	.558	.955	.00037	.051	.0130	0.674
0.525	.536	.963	.00034	.051	.0136	0.739
0.550	.514	.969	.00031	.051	.0144	0.820
0.575	.492	.977	.00027	.052	.0150	0.918
0.600	.470	.983	.00024	.052	.0168	1.084
0.625	.448	.989	.00019	.052	.0177	1.287
0.650	.426	.993	.00013	.052	.0184	1.606
0.675	.404	.997	.00009	.053	.0243	2.607
0.700	.382	.999	.00002	.053	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00272530IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.000426

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i2-D}}$	$\frac{\ell}{\delta^*_{i2-D}}$
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00199709IN

DISSIPATION INTEGRAL($\frac{\mathfrak{D}}{2}$)= 0.000758

TABLE A.9.6 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_1) = 5.00$ $(L_e/D_{h_1}) = 9.5$ $(AR) = 2.000$ $(B_1) = 0.117$ INLET REYNOLDS NO. $(\bar{u}D_h/\nu) = 160521.0$

STN $X = 1.350''$ $X/N = 0.270$ GREEN POSITION(2) $H_{o_{2-D}} = 1.545$ $H_{i_{2-D}} = 1.564$ $\delta^*_{o_{2-D}} = .1337''$ $\delta^*_{i_{2-D}} = .0890''$ $U = 143.79$ FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT $(L_s/D_{h_1}) = 7.0$ HYDRAULIC DIAMETERS

OUTER WALL							INNER WALL							
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.025	.980	.379	.00195	.140	.0036	0.081	0.025	.020	.464	.00152	.101	.0044	0.114
0.075	.939	.535	.00287	.149	.0072	0.135	0.050	.040	.542	.00157	.104	.0065	0.165
0.125	.899	.670	.00191	.128	.0070	0.159	0.075	.061	.602	.00163	.102	.0081	0.200
0.175	.859	.747	.00133	.107	.0083	0.227	0.100	.081	.658	.00173	.096	.0091	0.218
0.225	.818	.797	.00104	.092	.0101	0.315	0.125	.101	.708	.00170	.090	.0110	0.267
0.275	.778	.831	.00087	.081	.0104	0.352	0.150	.121	.750	.00168	.086	.0114	0.279
0.325	.737	.859	.00079	.075	.0111	0.396	0.175	.141	.789	.00150	.081	.0114	0.293
0.375	.697	.882	.00075	.071	.0125	0.457	0.200	.162	.822	.00126	.077	.0113	0.319
0.425	.657	.903	.00074	.067	.0138	0.508	0.225	.182	.854	.00111	.073	.0109	0.327
0.475	.616	.922	.00066	.064	.0141	0.549	0.250	.202	.880	.00098	.069	.0105	0.334
0.525	.576	.940	.00059	.061	.0138	0.570	0.275	.222	.907	.00086	.065	.0096	0.329
0.575	.536	.956	.00052	.059	.0138	0.605	0.300	.242	.930	.00074	.062	.0092	0.340
0.625	.495	.969	.00042	.056	.0144	0.701	0.325	.263	.950	.00060	.059	.0099	0.404
0.675	.455	.980	.00031	.054	.0146	0.836	0.350	.283	.966	.00047	.056	.0094	0.434
0.725	.414	.989	.00017	.051	.0135	1.040	0.375	.303	.978	.00038	.054	.0102	0.521
0.775	.374	.997	.00000	.052	.0000	0.000	0.400	.323	.987	.00027	.052	.0108	0.658
0.000	.000	.000	.00000	.000	.0000	0.000	0.425	.343	.993	.00014	.050	.0115	0.958

OUTER WALL: REYNOLDS STRESS INTEGRAL(J) = .0052122 8IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$ = 0.001229

INNER WALL: REYNOLDS STRESS INTEGRAL(J) = .0019347 7IN

DISSIPATION INTEGRAL$(\frac{\mathfrak{D}}{2})$ = 0.000809

TABLE A9.7 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i)$= 5.00 (L_e/D_{h_i})= 9.5 (AR)=2.000 (B_i)=0.117 INLET REYNOLDS NO.$(\bar{u}D_h/\nu)$=160521.0

STN. X= 1.950" X/N=0.390 GREEN POSITION(2) $H_{o_{2-D}}$=1.732 $H_{i_{2-D}}$=1.583 $\delta^*_{o_{2-D}}$= .1754" $\delta^*_{i_{2-D}}$= .0989" U=136.99FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT(L_s/D_{h_i})=7.0HYDRAULIC DIAMETERS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_i}$	$\frac{\ell}{\delta^*_i}$
0.025	.981	.286	.00100	.151	.0041	0.128	0.025	.019	.454	.00144	.109	.0040	0.106
0.075	.944	.394	.00222	.149	.0046	0.098	0.050	.037	.524	.00194	.118	.0082	0.185
0.125	.907	.526	.00332	.158	.0075	0.130	0.075	.056	.573	.00229	.120	.0124	0.258
0.175	.870	.645	.00396	.154	.0110	0.175	0.100	.074	.620	.00246	.120	.0131	0.264
0.225	.833	.726	.00304	.127	.0141	0.257	0.125	.093	.668	.00248	.117	.0131	0.263
0.275	.795	.777	.00214	.104	.0150	0.329	0.150	.112	.712	.00222	.110	.0140	0.298
0.325	.758	.816	.00160	.089	.0130	0.326	0.175	.130	.753	.00196	.104	.0122	0.275
0.375	.721	.847	.00123	.082	.0121	0.345	0.200	.149	.791	.00169	.097	.0122	0.297
0.425	.684	.874	.00101	.077	.0109	0.344	0.225	.167	.826	.00146	.091	.0114	0.298
0.475	.647	.897	.00087	.074	.0116	0.395	0.250	.186	.857	.00134	.085	.0113	0.308
0.525	.609	.916	.00076	.070	.0107	0.390	0.275	.205	.886	.00124	.081	.0117	0.332
0.575	.572	.935	.00064	.067	.0109	0.434	0.300	.223	.911	.00117	.076	.0125	0.365
0.625	.535	.951	.00057	.064	.0103	0.431	0.325	.242	.933	.00105	.072	.0127	0.393
0.675	.498	.966	.00047	.061	.0107	0.493	0.350	.260	.950	.00094	.069	.0158	0.516
0.725	.461	.977	.00036	.059	.0111	0.589	0.375	.279	.965	.00081	.066	.0168	0.592
0.775	.423	.987	.00025	.060	.0124	0.785	0.400	.298	.977	.00066	.062	.0181	0.705
0.825	.386	.995	.00008	.064	.0100	1.094	0.425	.316	.988	.00050	.060	.0200	0.893
0.000	.000	.000	.00000	.000	.0000	0.000	0.450	.335	.994	.00028	.058	.0203	1.218
0.000	.000	.000	.00000	.000	.0000	0.000	0.475	.353	.999	.00008	.057	.0418	4.577

REYNOLDS STRESS INTEGRAL(J)= .00784644IN

DISSIPATION INTEGRAL$(\frac{\mathcal{D}}{2})$= 0.001692

REYNOLDS STRESS INTEGRAL(J)= .00324527IN

DISSIPATION INTEGRAL$(\frac{\mathcal{D}}{2})$= 0.001081

TABLE A.9.8 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_1) = 5.00$ $(L_e/D_{h_1}) = 9.5$ $(AR) = 2.000$ $(B_1) = 0.117$ INLET REYNOLDS NO. $(\bar{u}D_h/\nu) = 160521.0$

STN. X= 2.550" X/N=0.510 GREEN POSITION(2) $H_{o_{2-D}} = 1.873$ $H_{i_{2-D}} = 1.691$ $\delta^*_{o_{2-D}} = .2134"$ $\delta^*_{i_{2-D}} = .1220"$ U=131.19FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT $(L_s/D_{h_1}) = 7.0$ HYDRAULIC DIAMETERS

OUTER WALL

$R_o - R$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.025	983	.244	.00059	.132	.0015	0.060
0.075	948	.319	.00188	.142	.0052	0.119
0.125	914	.428	.00309	.164	.0058	0.104
0.175	879	.540	.00365	.179	.0084	0.139
0.225	845	.639	.00376	.185	.0109	0.178
0.275	810	.710	.00323	.168	.0134	0.235
0.325	776	.761	.00239	.144	.0137	0.281
0.375	741	.802	.00184	.120	.0120	0.280
0.425	707	.836	.00151	.100	.0108	0.279
0.475	672	.865	.00124	.084	.0106	0.302
0.525	638	.891	.00114	.075	.0113	0.333
0.575	603	.913	.00102	.069	.0120	0.374
0.625	569	.932	.00087	.063	.0107	0.365
0.675	534	.948	.00075	.061	.0099	0.363
0.725	500	.964	.00061	.060	.0102	0.413
0.775	466	.978	.00051	.060	.0116	0.514
0.825	431	.988	.00035	.062	.0126	0.675
0.875	397	.995	.00020	.064	.0175	1.242
0.000	000	.000	.00000	.000	.0000	0.000

INNER WALL

$R - R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.025	.017	.390	.00107	.102	.0025	0.077
0.050	.034	.452	.00145	.105	.0055	0.145
0.075	.052	.504	.00176	.108	.0071	0.169
0.100	.069	.552	.00205	.109	.0088	0.195
0.125	.086	.601	.00232	.110	.0101	0.211
0.150	.103	.647	.00243	.111	.0108	0.219
0.175	.121	.690	.00245	.110	.0116	0.235
0.200	.138	.732	.00231	.109	.0118	0.246
0.225	.155	.772	.00208	.107	.0112	0.245
0.250	.172	.809	.00176	.103	.0103	0.246
0.275	.190	.842	.00145	.098	.0097	0.254
0.300	.207	.870	.00134	.091	.0105	0.286
0.325	.224	.895	.00119	.084	.0100	0.289
0.350	.241	.918	.00109	.078	.0112	0.338
0.375	.259	.935	.00091	.073	.0106	0.351
0.400	.276	.952	.00071	.069	.0097	0.363
0.425	.293	.965	.00062	.065	.0101	0.408
0.450	.310	.977	.00051	.062	.0104	0.462
0.475	.328	.986	.00038	.061	.0103	0.529

TABLE A9.8 CONT.

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o2-D}}$	$\frac{\ell}{\delta^*_{o2-D}}$
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .01117763IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001846

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i2-D}}$	$\frac{\ell}{\delta^*_{i2-D}}$
0.500	.345	.994	.00023	.059	.0092	0.615
0.525	.362	.999	.00006	.058	.0046	0.614

REYNOLDS STRESS INTEGRAL(J)= .00371503IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001161

TABLE A.9.9 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\overline{L}/\Delta R_1)$= 5.00 (L_e/D_{h_1})= 9.5 (AR)=2.000 (B_1)=0.117 INLET REYNOLDS NO. $(\bar{u}D_{h_1}/\nu)$=160521.0

STN. X= 3.150" X/N=0.630 GREEN POSITION(2) $H_{o_{2-D}}$=2.035 $H_{i_{2-D}}$=1.693 $\delta^*_{o_{2-D}}$=.2629" $\delta^*_{i_{2-D}}$=.1356" U=126.48FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT(L_s/D_{h_1})=7.0HYDRAULIC DIAMETERS

OUTER WALL R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o2-D}}$	$\frac{\ell}{\delta^*_{o2-D}}$	INNER WALL $R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i2-D}}$	$\frac{\ell}{\delta^*_{i2-D}}$
0.025	.984	.191	.00031	.147	.0005	0.029	0.025	.016	.388	.00188	.104	.0044	0.102
0.075	.952	.267	.00112	.171	.0028	0.085	0.050	.032	.437	.00171	.105	.0067	0.161
0.125	.920	.344	.00178	.189	.0038	0.090	0.075	.048	.482	.00173	.108	.0072	0.174
0.175	.888	.436	.00253	.212	.0055	0.109	0.100	.064	.526	.00188	.111	.0079	0.182
0.225	.855	.526	.00299	.218	.0067	0.122	0.125	.080	.568	.00223	.113	.0101	0.214
0.275	.823	.607	.00349	.193	.0093	0.157	0.150	.096	.609	.00252	.113	.0114	0.227
0.325	.791	.674	.00382	.167	.0114	0.185	0.175	.112	.650	.00277	.112	.0125	0.237
0.375	.759	.728	.00353	.143	.0139	0.234	0.200	.129	.690	.00277	.108	.0133	0.252
0.425	.727	.770	.00283	.125	.0130	0.245	0.225	.145	.727	.00257	.098	.0126	0.249
0.475	.695	.807	.00239	.108	.0130	0.265	0.250	.161	.765	.00237	.093	.0121	0.250
0.525	.663	.840	.00197	.094	.0118	0.267	0.275	.177	.799	.00212	.091	.0120	0.261
0.575	.630	.871	.00167	.083	.0108	0.263	0.300	.193	.829	.00185	.088	.0121	0.280
0.625	.598	.899	.00145	.075	.0101	0.264	0.325	.209	.857	.00167	.086	.0108	0.265
0.675	.566	.924	.00125	.070	.0102	0.288	0.350	.225	.885	.00142	.084	.0100	0.266
0.725	.534	.946	.00103	.070	.0099	0.309	0.375	.241	.910	.00125	.081	.0095	0.270
0.775	.502	.964	.00081	.070	.0096	0.336	0.400	.257	.932	.00112	.078	.0112	0.334
0.825	.470	.978	.00053	.067	.0091	0.375	0.425	.273	.948	.00098	.075	.0111	0.356
0.875	.438	.989	.00033	.062	.0077	0.420	0.450	.289	.963	.00080	.072	.0107	0.380
0.925	.406	.995	.00013	.061	.0058	0.504	0.475	.305	.976	.00062	.069	.0102	0.409

TABLE A.9.9 CONT.

OUTER WALL

R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o2-D}}$	$\frac{\ell}{\delta^*_{o2-D}}$
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .01478913IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001841

INNER WALL

$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i2-D}}$	$\frac{\ell}{\delta^*_{i2-D}}$
0.500	.321	.984	.00045	.065	.0095	0.446
0.525	.337	.991	.00022	.062	.0065	0.433
0.550	.353	.996	.00003	.060	.0015	0.267

REYNOLDS STRESS INTEGRAL(J)= .00313623IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001310

TABLE A.9.10 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\overline{L}/\Delta R_i)$= 5.00 (L_e/D_{h_i})= 9.5 (AR)=2.000 (B_i)=0.117 INLET REYNOLDS NO. $(\bar{u}D_{h_i}/\nu)$=160521.0

STN. X= 3.750" X/N=0.750 GREEN POSITION(2) $H_{o_{2-D}}$=2.202 $H_{i_{2-D}}$=1.701 $\delta^*_{o_{2-D}}$=.3173" $\delta^*_{i_{2-D}}$=.1504" U=123.60FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT (L_s/D_{h_i})=7.0HYDRAULIC DIAMETERS

OUTER WALL							INNER WALL							
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.061	.963	.202	.00090	.126	.0020	0.066	0.025	.015	.384	.00189	.113	.0031	0.070
0.111	.933	.266	.00135	.149	.0037	0.101	0.075	.045	.478	.00134	.127	.0059	0.162
0.161	.903	.325	.00185	.167	.0047	0.109	0.125	.075	.547	.00162	.131	.0081	0.201
0.211	.873	.394	.00242	.186	.0051	0.103	0.175	.105	.615	.00223	.129	.0110	0.232
0.261	.843	.477	.00320	.202	.0062	0.110	0.225	.135	.685	.00258	.127	.0123	0.241
0.311	.813	.554	.00419	.208	.0093	0.143	0.275	.166	.754	.00276	.121	.0139	0.265
0.361	.783	.620	.00554	.201	.0142	0.191	0.325	.196	.819	.00252	.109	.0130	0.260
0.411	.753	.680	.00628	.189	.0169	0.213	0.375	.226	.877	.00207	.094	.0129	0.284
0.461	.722	.734	.00656	.174	.0195	0.241	0.425	.256	.924	.00137	.081	.0121	0.327
0.511	.692	.782	.00597	.159	.0226	0.293	0.475	.286	.954	.00086	.071	.0108	0.367
0.561	.662	.821	.00451	.144	.0206	0.306	0.525	.316	.977	.00048	.067	.0092	0.420
0.611	.632	.852	.00358	.127	.0184	0.307	0.575	.346	.991	.00016	.064	.0063	0.504
0.661	.602	.879	.00308	.114	.0172	0.310	0.000	.000	.000	.00000	.000	.0000	0.000
0.711	.572	.903	.00261	.103	.0169	0.331	0.000	.000	.000	.00000	.000	.0000	0.000
0.761	.542	.925	.00221	.090	.0162	0.345	0.000	.000	.000	.00000	.000	.0000	0.000
0.811	.512	.944	.00180	.078	.0143	0.336	0.000	.000	.000	.00000	.000	.0000	0.000
0.861	.482	.962	.00139	.070	.0142	0.382	0.000	.000	.000	.00000	.000	.0000	0.000
0.911	.452	.976	.00102	.065	.0141	0.441	0.000	.000	.000	.00000	.000	.0000	0.000
0.961	.421	.986	.00064	.062	.0135	0.534	0.000	.000	.000	.00000	.000	.0000	0.000

TABLE A.9.10 CONT.

OUTER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
1.011	.391	.995	.00033	.061	.0148	0.818
1.061	.361	.997	.00000	.063	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .01584229IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.002844

INNER WALL						
$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00488990IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001362

TABLE A.9.11 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

$(\bar{L}/\Delta R_i)$= 5.00 (L_e/D_{h_i})= 9.5 (AR)=2.000 (B_i)=0.117 INLET REYNOLDS NO. $(\bar{u}D_{h_i}/\nu)$=160521.0

STN. X= 4.813" X/N=0.963 GREEN POSITION(2) $H_{o_{2-D}}$=2.563 $H_{i_{2-D}}$=1.802 $\delta^*_{o_{2-D}}$=.4497" $\delta^*_{i_{2-D}}$=.1864" U=117.79FT/SEC

INLET CONDITIONS ARTIFICIALLY GENERATED BY STEP BLOCKAGE AT (L_s/D_{h_i})=7.0 HYDRAULIC DIAMETERS

OUTER WALL							INNER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$	$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.049	.973	.121	.00038	.080	.0015	0.078	0.025	.014	.344	.00170	.133	.0035	0.086
0.099	.946	.155	.00063	.097	.0019	0.077	0.075	.041	.415	.00231	.113	.0098	0.204
0.149	.919	.199	.00109	.118	.0027	0.081	0.125	.068	.479	.00281	.111	.0113	0.213
0.199	.892	.244	.00170	.136	.0041	0.099	0.175	.095	.544	.00324	.112	.0135	0.238
0.249	.865	.294	.00260	.153	.0058	0.113	0.225	.122	.610	.00357	.114	.0144	0.241
0.299	.838	.344	.00314	.167	.0070	0.125	0.275	.149	.677	.00378	.109	.0152	0.247
0.349	.811	.400	.00421	.181	.0079	0.122	0.325	.176	.742	.00382	.102	.0168	0.272
0.399	.784	.462	.00566	.196	.0097	0.128	0.375	.203	.804	.00354	.099	.0158	0.266
0.449	.757	.529	.00703	.208	.0130	0.155	0.425	.230	.859	.00294	.095	.0154	0.284
0.499	.730	.589	.00795	.214	.0163	0.183	0.475	.257	.907	.00218	.091	.0136	0.292
0.549	.703	.646	.00803	.210	.0168	0.188	0.525	.284	.943	.00112	.085	.0101	0.300
0.599	.676	.696	.00679	.188	.0161	0.196	0.575	.311	.970	.00035	.079	.0056	0.300
0.649	.649	.739	.00560	.167	.0147	0.196	0.000	.000	.000	.00000	.000	.0000	0.000
0.699	.622	.779	.00461	.149	.0137	0.202	0.000	.000	.000	.00000	.000	.0000	0.000
0.749	.595	.813	.00372	.134	.0120	0.197	0.000	.000	.000	.00000	.000	.0000	0.000
0.799	.568	.846	.00291	.121	.0104	0.193	0.000	.000	.000	.00000	.000	.0000	0.000
0.849	.541	.875	.00230	.111	.0093	0.194	0.000	.000	.000	.00000	.000	.0000	0.000
0.899	.514	.902	.00180	.101	.0086	0.202	0.000	.000	.000	.00000	.000	.0000	0.000
0.949	.487	.925	.00151	.091	.0074	0.191	0.000	.000	.000	.00000	.000	.0000	0.000

TABLE A.9.11 CONT.

OUTER WALL						
R_o-R (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\,\delta^*_{o_{2-D}}}$	$\frac{\ell}{\delta^*_{o_{2-D}}}$
0.999	.460	.947	.00140	.080	.0083	0.223
1.049	.433	.964	.00119	.071	.0093	0.270
1.099	.406	.980	.00095	.064	.0105	0.341
1.149	.379	.989	.00072	.063	.0136	0.508
1.199	.352	.995	.00030	.069	.0192	1.107

REYNOLDS STRESS INTEGRAL(J)= .02156214IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.003562

INNER WALL						
$R-R_i$ (IN)	$\frac{R-R_i}{R_o-R_i}$	$\frac{u}{U}$	$\frac{\overline{u'v'}}{U^2}$	$\frac{\sqrt{\overline{u'^2}}}{U}$	$\frac{\varepsilon}{U\,\delta^*_{i_{2-D}}}$	$\frac{\ell}{\delta^*_{i_{2-D}}}$
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000
0.000	.000	.000	.00000	.000	.0000	0.000

REYNOLDS STRESS INTEGRAL(J)= .00345436IN

DISSIPATION INTEGRAL($\frac{\mathcal{D}}{2}$)= 0.001949

APPENDIX 10

DIFFUSER PERFORMANCE WITH GRID GENERATED INLET TURBULENCE

TABLE A.10.1 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)=10.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.044

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu_1$)=166256.1

INLET CONDITIONS ARTIFICIALLY GENERATED BY COARSE GRID IN ENTRY FLARE

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$
$\overline{3}$.147	$\overline{0}$.315	.0255	.0182	.0318	1.402	1.747	.0181	.0134	.0238	1.346	1.773
9.850	0.985	.1333	.0902	.1545	1.478	1.713	.2228	.1491	.2554	1.494	1.713

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\overline{3}$.147	$\overline{0}$.315	163.24	.956	37.442	1.030	1.011	1580.9	1169.0
9.850	0.985	96.03	.816	37.772	1.112	1.040	4613.7	7628.5

TABLE A.10.2 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\overline{L}/\Delta R_1$)= 7.50 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.044

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\overline{U}D_h/\nu)_1$=166256.1

INLET CONDITIONS ARTIFICIALLY GENERATED BY COARSE GRID IN ENTRY FLARE

X (IN)	X/N	OUTER WALL δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$	INNER WALL δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\overline{H}$
$\overline{3}$.147	$\overline{0}$.420	.0255	.0182	.0318	1.402	1.747	.0181	.0134	.0238	1.346	1.773
7.400	0.987	.2038	.1184	.1936	1.721	1.634	.1439	.0980	.1689	1.468	1.723

X (IN)	X/N	U FT/SEC	$\overline{U}$/U	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
$\overline{3}$.147	$\overline{0}$.420	163.24	.956	37.442	1.030	1.011	1580.9	1169.0
7.400	0.987	100.05	.808	38.994	1.158	1.057	6313.0	5224.4

TABLE A.10.3 CONSTANT CORE DIAMETER ANNULAR DIFFUSER

NON-DIMENSIONAL LENGTH($\bar{L}/\Delta R_1$)= 5.00 ENTRY LENGTH(L_e/D_{h_1})= 2.0 HYDRAULIC DIAMETERS

AREA RATIO(AR)=2.000 BLOCKAGE(B_1)=0.044

INLET RADIUS RATIO=0.833 INLET REYNOLDS NO.($\bar{U}D_h/\nu$)$_1$=166256.1

INLET CONDITIONS ARTIFICIALLY GENERATED BY COARSE GRID IN ENTRY FLARE

		OUTER WALL					INNER WALL				
X (IN)	X/N	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$	δ^* (IN)	θ (IN)	δ^{**} (IN)	H	$\bar{H}$
3.147	0.629	.0255	.0182	.0318	1.402	1.747	.0181	.0134	.0238	1.346	1.773
4.813	0.963	.1937	.1026	.1637	1.888	1.596	.1028	.0694	.1189	1.481	1.713

X (IN)	X/N	U FT/SEC	$\bar{U}/U$	Q FT^3/SEC	α	β	OUTER WALL R_θ	INNER WALL R_θ
3.147	0.629	163.24	.956	37.442	1.030	1.011	1580.9	1169.0
4.813	0.963	108.28	.832	43.058	1.173	1.064	5918.5	4002.9

APPENDIX 11

MOMENTUM INTEGRAL EQUATION BALANCE

Momentum Integral Equation Balance

The momentum integral equation, derived in Appendix 4, is written as follows for the inner and outer walls respectively:

$$\frac{d\theta_i}{dx} + \frac{\theta_i}{U}\frac{dU}{dx}(H_i + 2) + \frac{\theta_i}{R_i}\frac{dR_i}{dx}$$

$$= \frac{\tau_i}{\rho U^2} + \frac{1}{U^2}\int_{R_i}^{R_\delta} \frac{\partial}{\partial x}(\overline{u'^2} + \overline{v_\delta'^2} - v'^2)dR + \frac{dP_\delta}{dx}\frac{(R_\delta^2 - R_i^2)}{2\rho U^2 R_i} \qquad \text{A.4.18}$$

$$\frac{d\theta_o}{dx} + \frac{\theta_o}{U}\frac{dU}{dx}(H_o + 2) + \frac{\theta_o}{R_o}\frac{dR_o}{dx}$$

$$= \frac{\tau_o}{\rho U^2} + \frac{1}{U^2}\int_{R_\delta}^{R_o} \frac{\partial}{\partial x}(\overline{u'^2} + \overline{v_\delta'^2} - \overline{v'^2})dR + \frac{dP_\delta}{dx}\frac{(R_o^2 - R_\delta^2)}{2\rho U^2 R_o} \qquad \text{A.4.19}$$

These equations were used to check the experimental data for three-dimensional effects by comparing the two sides of each equation evaluated from the measured data.

For flow with a potential core in the straight-core annular diffuser geometry we have the following

$$v'_\delta = 0 \qquad \frac{dP_\delta}{dx} = 0 \qquad \frac{dR_i}{dx} = 0$$

Thus the inner wall equation reduces to:

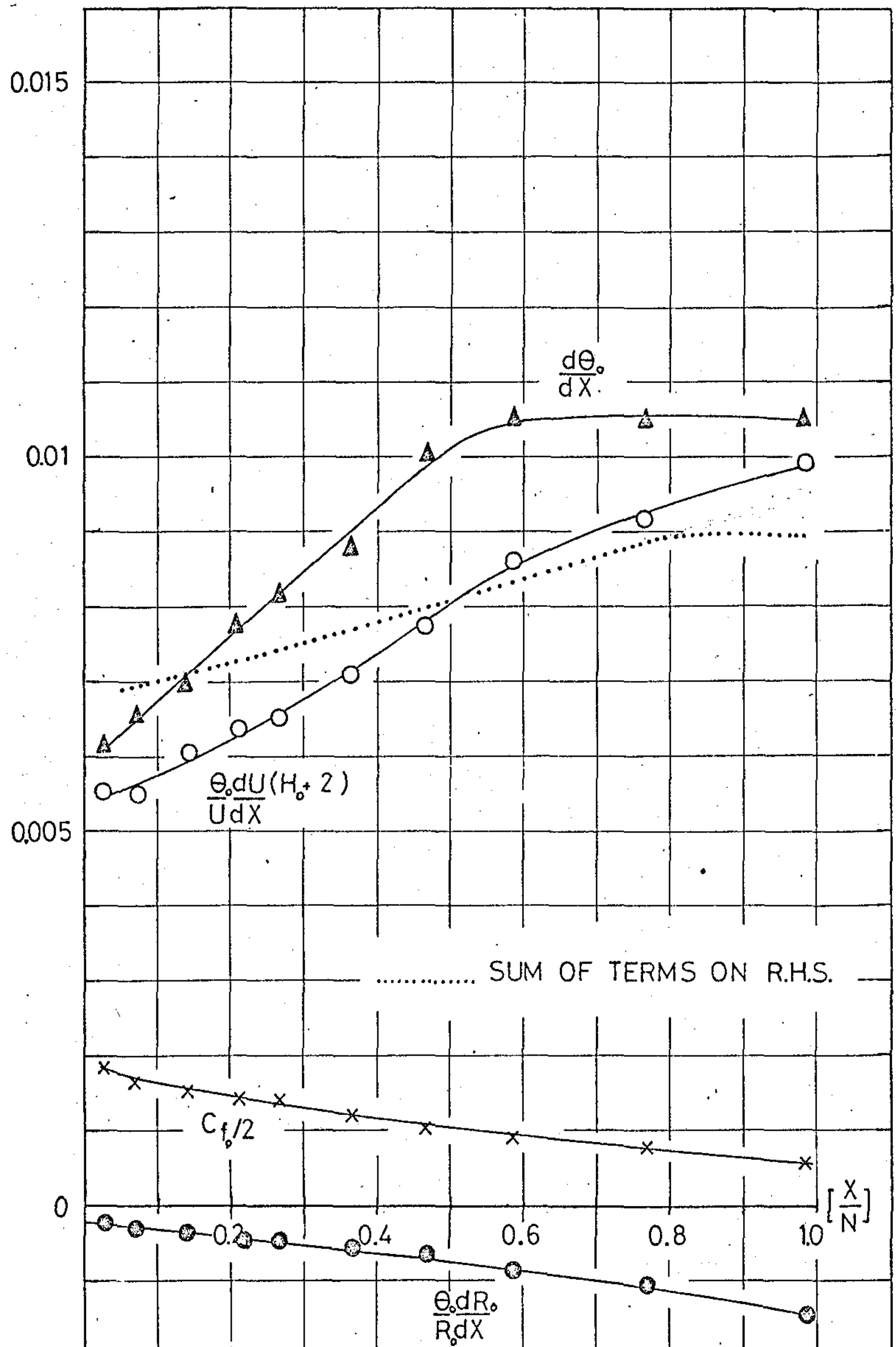
$$\frac{d\theta_i}{dx} = \frac{\tau_i}{\rho U^2} - \frac{\theta_i}{U}\frac{dU}{dx}(H_i + 2) + \frac{1}{U^2}\int_{R_i}^{R_\delta}\frac{\partial}{\partial x}(\overline{u'^2} - \overline{v'^2})dR \qquad \text{A.11.1}$$

and similarly for the outer wall:

$$\frac{d\theta_o}{dx} = \frac{\tau_o}{\rho U^2} - \frac{\theta_o}{U}\frac{dU}{dx}(H_o + 2) - \frac{\theta_o}{R_o}\frac{dR_o}{dx} + \frac{1}{U^2}\int_{R_\delta}^{R_o}\frac{\partial}{\partial x}(\overline{u'^2} - \overline{v'^2})dR \qquad \text{A.11.2}$$

Where it was necessary to measure gradients the experimental data i.e. U, θ_i etc. was plotted against the axial distance down the diffuser and the slopes read off at the necessary stations by drawing tangents to the curve. Great care was taken to obtain the true tangent in each case, each tangent being measured several times and the mean value taken. Thus each side of equations A.11.1 and A.11.2 was evaluated and the comparisons are shown in Figs. A.11.1 → A.11.6.

Comparison is also made for the spoiler generated inflow in Figs. A.11.7 and A.11.8 where in this case the values of $\frac{dP_\delta}{dx}$ and v'_δ are significant.

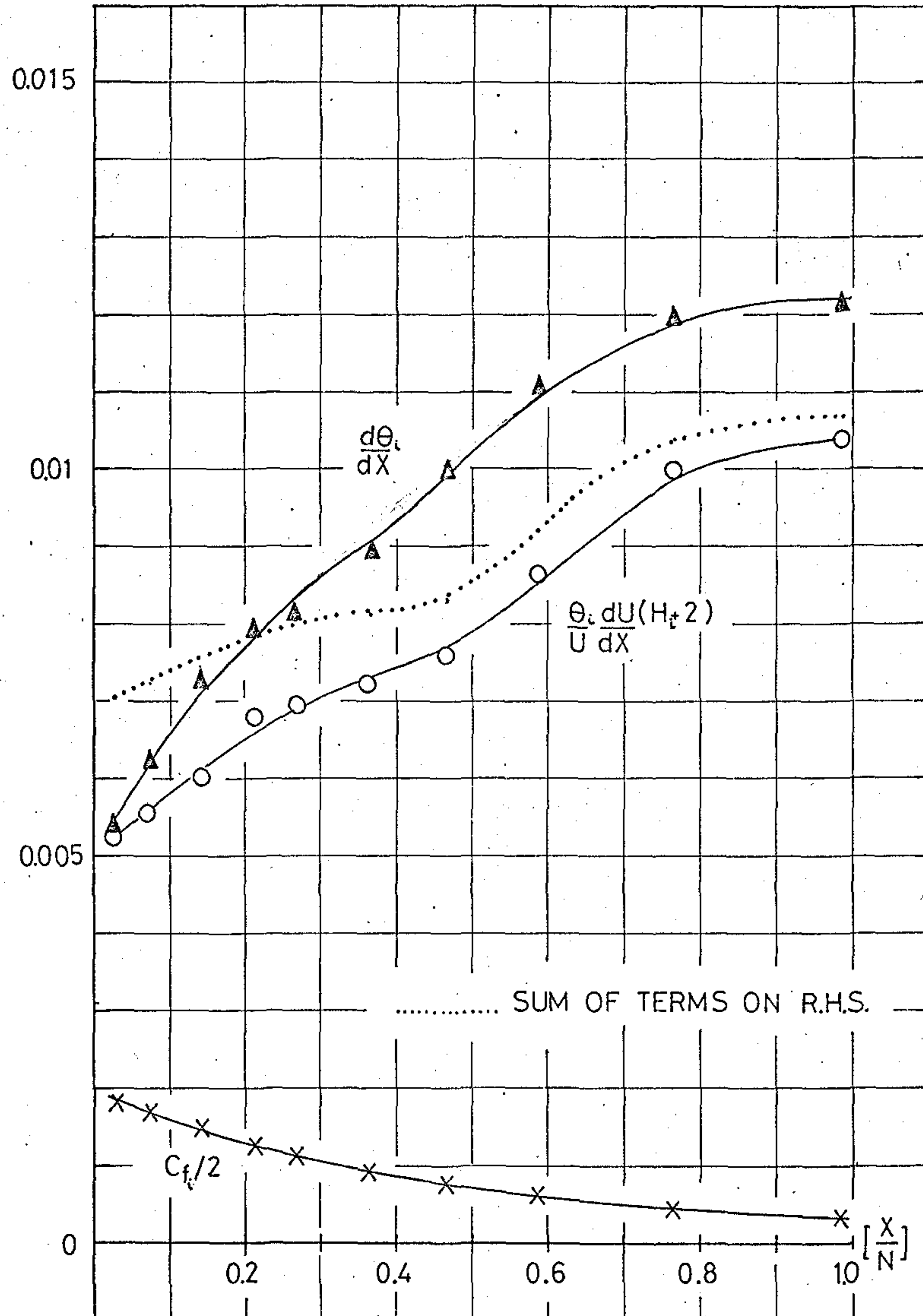


MOMENTUM INTEGRAL EQUATION BALANCE

$\overline{L}/\Delta R_1 = 10.0$ $L_e/D_{h_1} = 2.0$ $B_1 = 0.028$

OUTER WALL $\frac{d\Theta_o}{dX} = \frac{C_{f_o}}{2} - \frac{\Theta_o}{U}\frac{dU}{dX}(H_o+2) - \frac{\Theta_o}{R_o}\frac{dR_o}{dX}$

FIGURE A.11.2

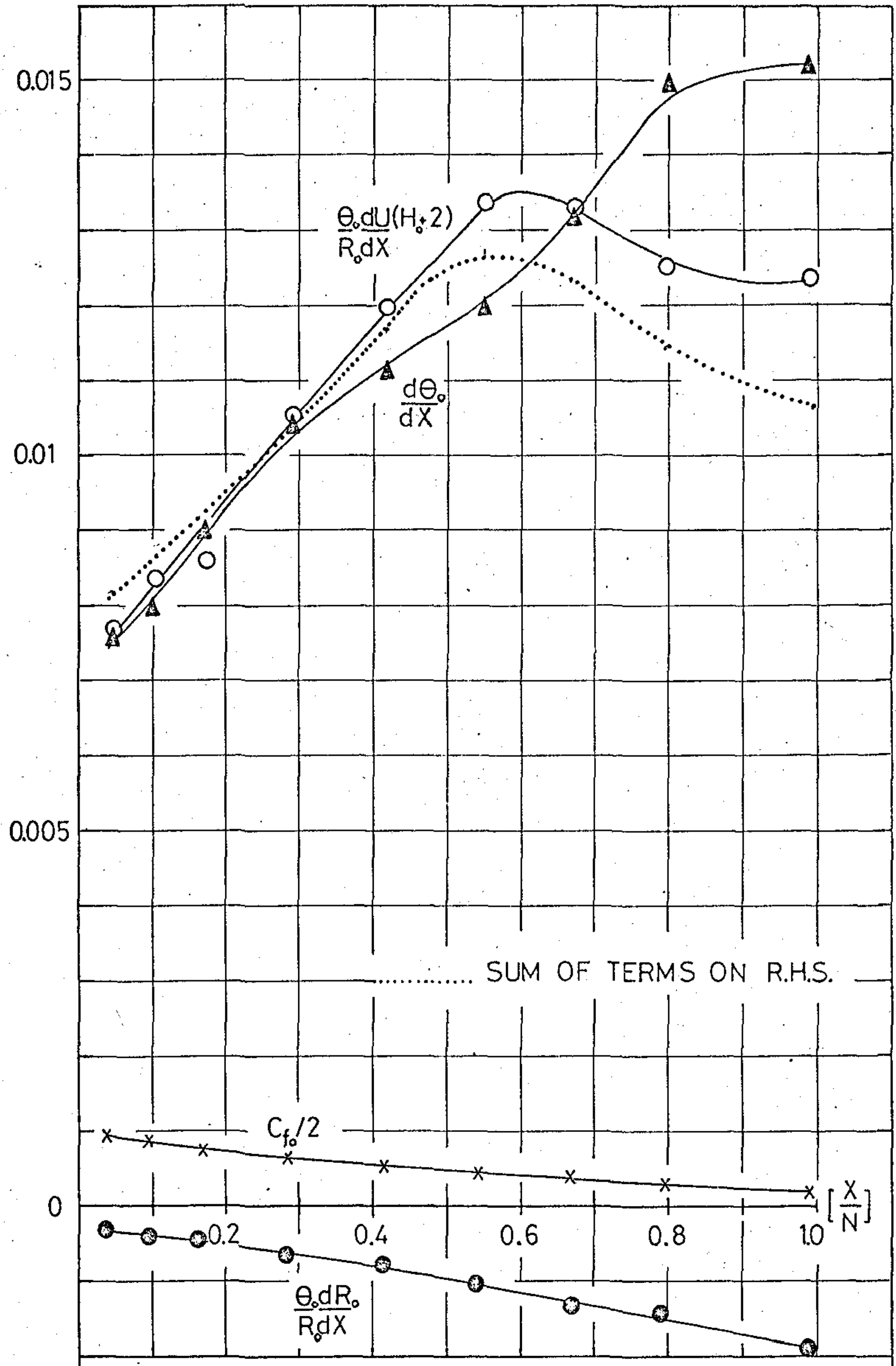


MOMENTUM INTEGRAL EQUATION BALANCE

$\bar{L}/\Delta R_1 = 10.0$ $L_e/D_{h_1} = 2.0$ $B_1 = 0.028$

INNER WALL $\frac{d\theta_i}{dX} = \frac{C_{f_i}}{2} - \frac{\theta_i}{U}\frac{dU}{dX}(H_i+2) - \frac{\theta_i}{R_i}\frac{dR_i}{dX}$

FIGURE A.11.3

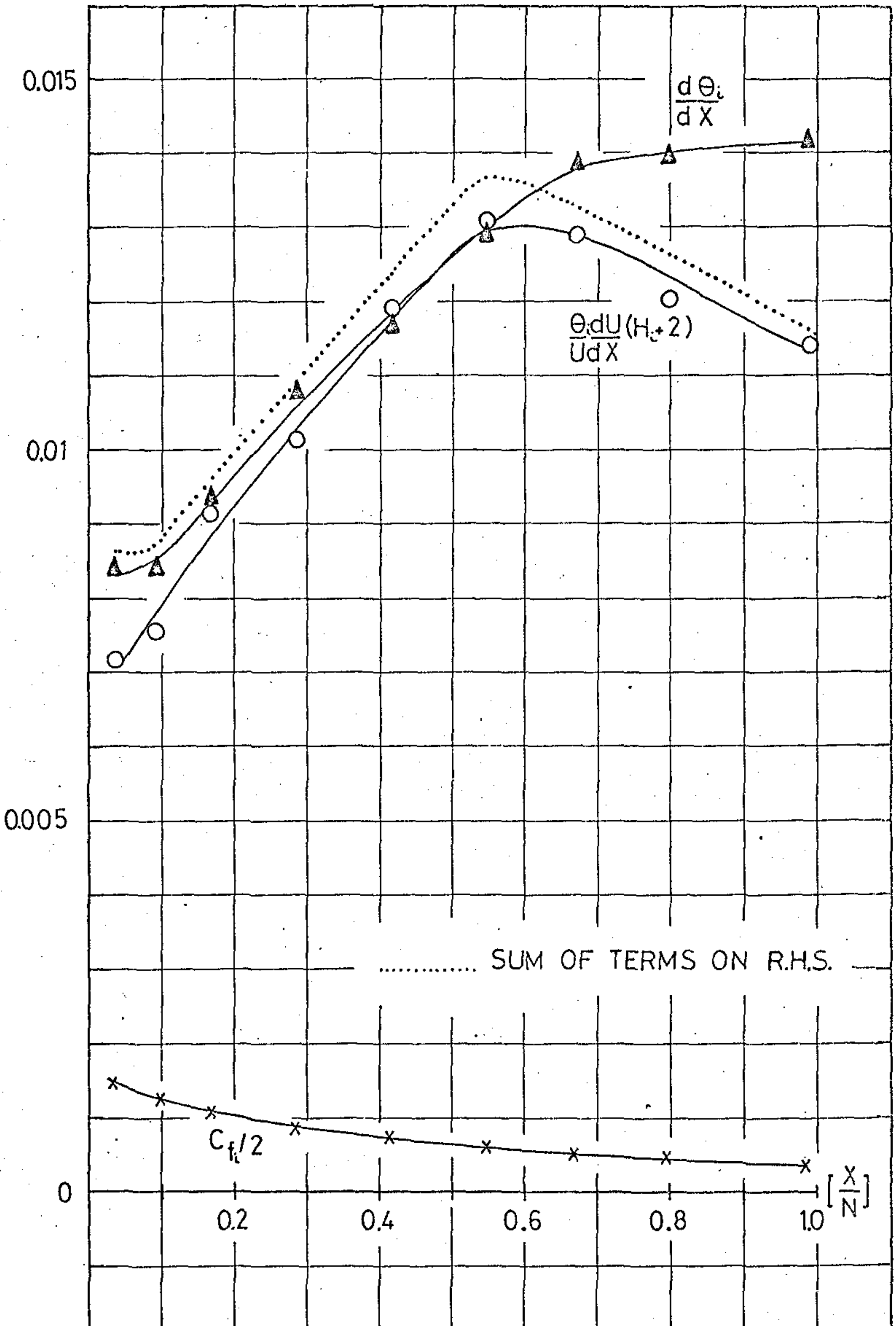


MOMENTUM INTEGRAL EQUATION BALANCE

$\overline{L}/\Delta R_1 = 7.5$ $L_e/D_{h_1} = 20$ $B_1 = 0.028$

OUTER WALL $\frac{d\theta_o}{dX} = \frac{C_{f_o}}{2} - \frac{\theta_o}{U}\frac{dU}{dX}(H_o + 2) - \frac{\theta_o}{R_o}\frac{dR_o}{dX}$

FIGURE A.11.4

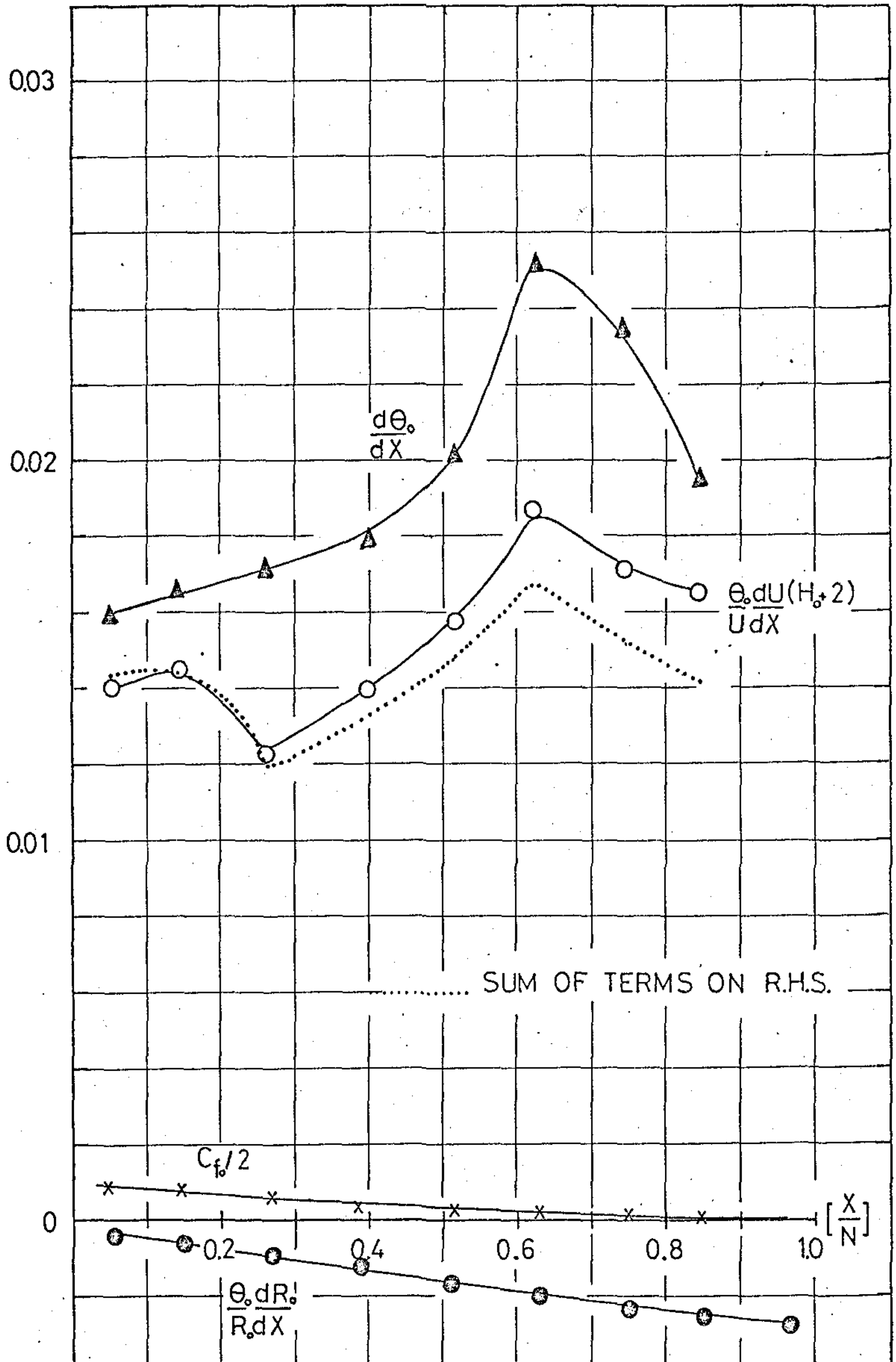


MOMENTUM INTEGRAL EQUATION BALANCE

$\overline{L}/\Delta R_1 = 7.5$ $L_e/D_{h_1} = 2.0$ $B_1 = 0.028$

INNER WALL $\frac{d\theta_i}{dX} = \frac{C_{f_i}}{2} - \frac{\theta_i}{U}\frac{dU}{dX}(H_i+2) - \frac{\theta_i}{R_i}\frac{dR_i}{dX}$

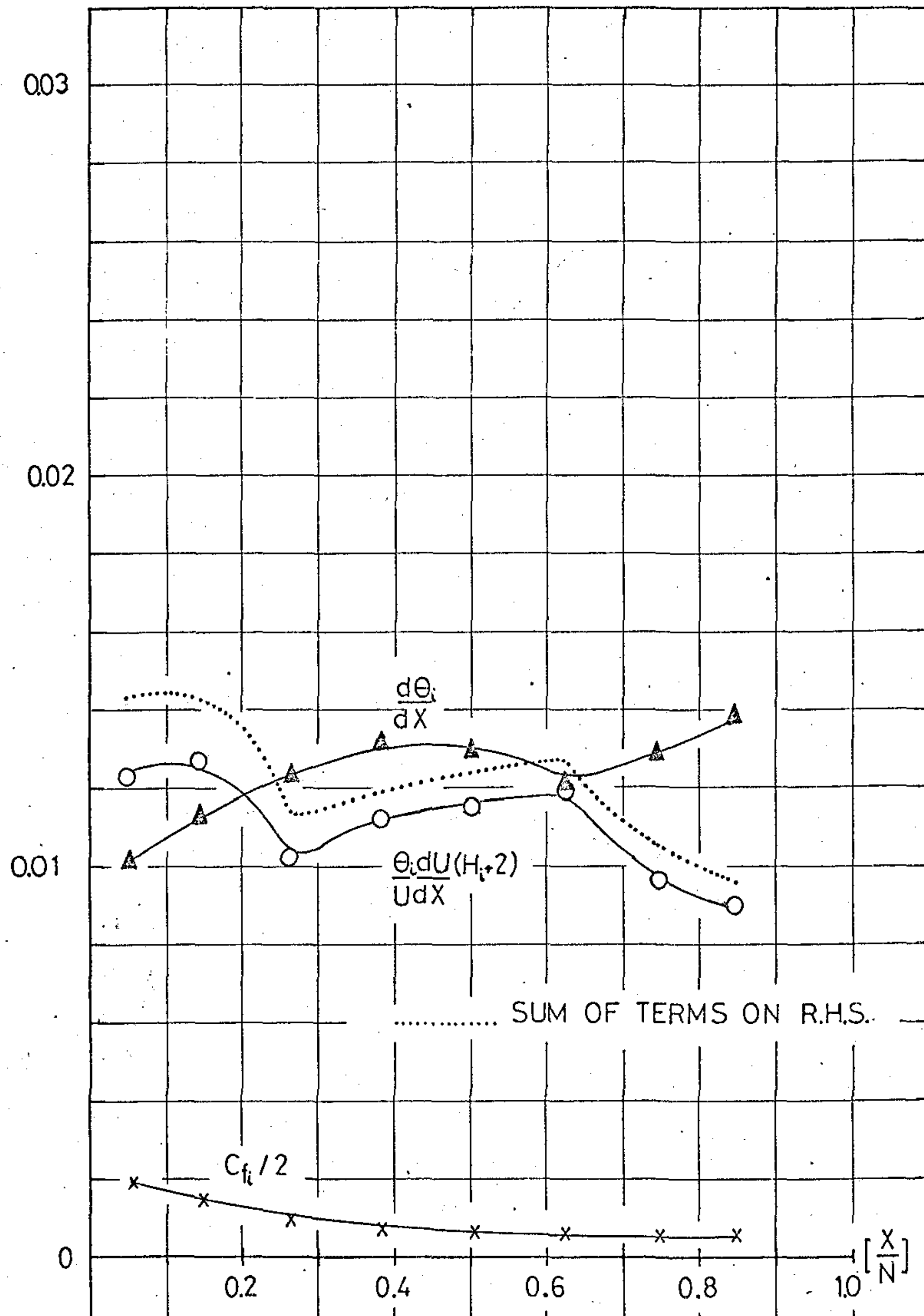
FIGURE A.11.5



MOMENTUM INTEGRAL EQUATION BALANCE

$\overline{L}/\Delta R_1 = 5.0$ $L_e/D_{h_1} = 2.0$ $B_1 = 0.028$

OUTER WALL $\frac{d\Theta_o}{dX} = \frac{C_{f_o}}{2} - \frac{\Theta_o}{U}\frac{dU}{dX}(H_o + 2) - \frac{\Theta_o}{R_o}\frac{dR_o}{dX}$

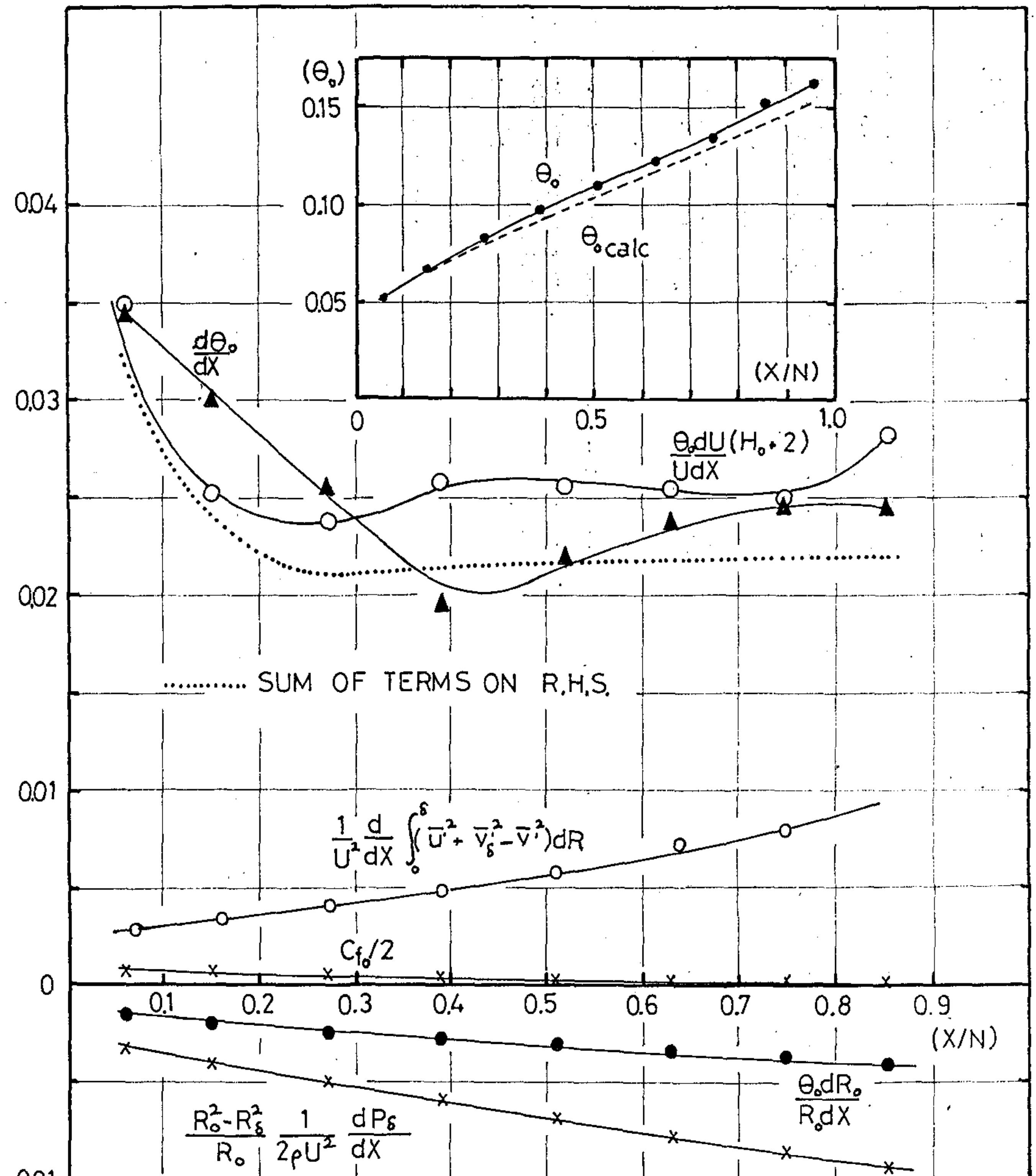


MOMENTUM INTEGRAL EQUATION BALANCE

$\overline{L}/\Delta R_1 = 5.0$ $L_e/D_{h_1} = 2.0$ $B_1 = 0.028$

INNER WALL $\frac{d\theta_i}{dX} = \frac{C_{f_i}}{2} - \frac{\theta_i}{U}\frac{dU}{dX}(H_i + 2) - \frac{\theta_i}{R_i}\frac{dR_i}{dX}$

FIGURE A.11.7

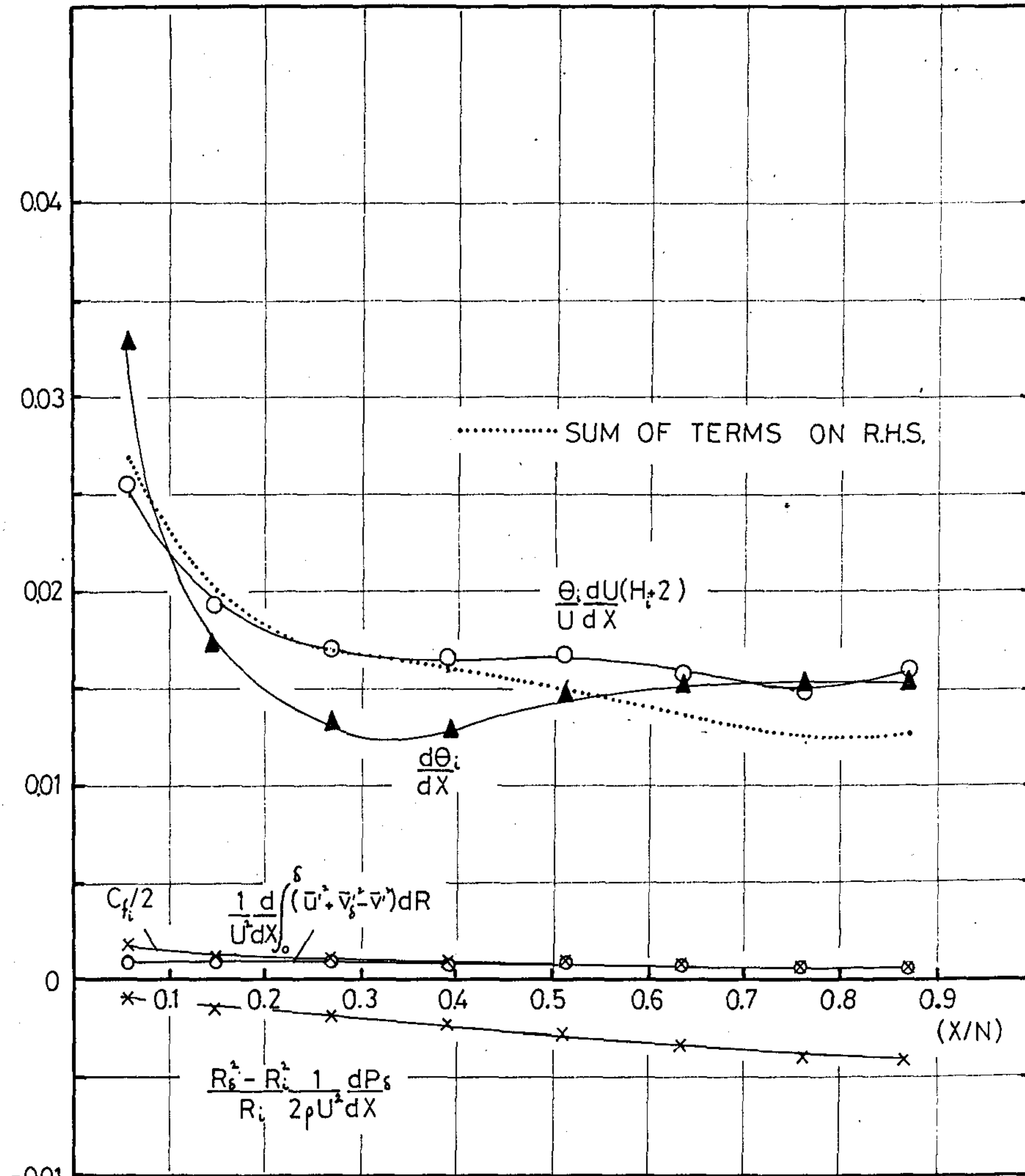


MOMENTUM EQUATION BALANCE — OUTER WALL, $E/\Delta R_1 = 5.0$

$B_1 = 0.117$, FLOW SPOILER AT $L_s/D_{h_1} = 7.0$ WITH $L_e/D_{h_1} = 9.5$

$$\frac{d\Theta_o}{dX} = \frac{C_{f_o}}{2} - \frac{\Theta_o dR_o}{R_o dX} - \frac{\Theta_o dU}{UdX}(H_o+2) + \frac{R_o^2-R_\delta^2}{R_o}\frac{1}{2\rho U^2}\frac{dP_\delta}{dX} + \frac{1}{U^2}\frac{d}{dX}\int_0^\delta(\overline{u'^2}+\overline{v_\delta'^2}-\overline{v'^2})dR$$

FIGURE A.11.8



MOMENTUM EQUATION BALANCE — INNER WALL, $\bar{L}/\Delta R_i = 5.0$

$B_i = 0.117$, FLOW SPOILER AT $L_s/D_{h_i} = 7.0$ WITH $L_e/D_{h_i} = 9.5$

$$\frac{d\theta_i}{dX} = \frac{C_{f_i}}{2} - \frac{\theta_i}{R_i}\frac{dR_i}{dX} - \frac{\theta_i}{U}\frac{dU}{dX}(H_i+2) + \frac{R_\delta^2 - R_i^2}{R_i}\frac{1}{2\rho U^2}\frac{dP_\delta}{dX} + \frac{1}{U^2}\frac{d}{dX}\int_0^\delta(\overline{u'^2} + \overline{v_\delta'^2} - \overline{v'^2})\,dR$$

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