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Effect of inlet swirl on annular diffuser performance.

Uwe H. Schneider
University of Windsor

EFFECT OF INLET SWIRL ON ANNULAR DIFFUSER PERFORMANCE

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Uwe H. Schneider

B.A.Sc., University of Windsor

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ABSTRACT

Four Equiangular Annular Diffusers were investigated with an inlet flow having swirl. The total expansion angles of the inner and outer cones of the diffusers were 40° and the area ratios were 1.25, 1.50, 2.00, 3.00 respectively. The performance of each of these diffusers was studied at various amounts of inlet swirl. The mean swirl angle at the inlet was varied from approximately zero (axial flow) to a value of about 25°. The performance of the diffuser was studied at five different inlet swirl angles with the aim of finding the effect of inlet swirl on the performance. It was found that the Equiangular Annular Diffuser performance was good at axial flow, decreased at low swirl and increased at higher swirl.

The performance of the present diffuser geometry was compared to a set of annular diffusers whose inner cone converged and outer cone diverged. The Equiangular Divergent Annular Diffuser performed better than the Equiangular Divergent-Convergent Annular Diffuser.

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NOTATION

A	Flow Area
A_t	Throat Area
AR	Area Ratio
B	Inlet Opening of Swirl Vane Unit
C_{PR}	Pressure Recovery Factor Based on Mass-Weighted Average Value of Dynamic Head
C_{PR_I}	Ideal Pressure Recovery Factor Based on Free Vortex Flow
D	Diffusion Factor
h	Height of the Annular Passage
L	Length of the Diffuser Measured Along the Wall
M	Mass Flow Rate
P_S	Static Pressure
P_T	Total Pressure
r	Radius
r_i	Hub Radius
r_o	Tip Radius
V	Absolute Velocity
V_a	Axial Velocity
V_r	Radial Velocity
V_t	Tangential Velocity
y	Distance from Inner Surface of Outer Wall
η	Diffuser Effectiveness
ψ	Swirl Angle
ρ	Density

θ Diffuser Divergence Angle or Diffuser Expansion Angle

Θ Sweep Angle of Flow Contour for Design of Swirl Vane Unit

Subscripts

i Inner Wall

0 Outer Wall

I Ideal

1 Diffuser Inlet

2 Diffuser Outlet

Bar over the symbol means mass-weighted average quantity except where it is otherwise stated.

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CHAPTER I

INTRODUCTION

Plane-walled and conical diffusers have been extensively investigated at least, in the absence of swirl; annular diffusers, however, have not yet been thoroughly investigated. Since the flow in turbomachinery is largely through annuli this type of duct is of great interest.

In investigating the performance of a diffuser it is important to measure certain performance parameters, such as pressure recovery and diffuser efficiency, and also to determine the effect if any, of the various geometric and flow variables on the performance parameters.

A comparatively simple type of annular diffuser of practical interest is that in which the mean flow surface is a cone of increasing radius. For such a configuration there are four basic geometrical variables, the inlet hub/tip ratio, the over-all area ratio, the angle of the inner wall, and the angle of the outer wall.

It is also essential that several aerodynamic parameters be carefully measured if a meaningful analysis of diffuser performance is sought. For the inlet, these parameters are the inlet profile shape, turbulence and inlet swirl.

Defects in mass flux and momentum flux at the inlet may be of several kinds, associated with the boundary layer or with the radial or circumferential variations in flow velocity and pressure. In order to reduce the number of experimental configurations, it was desired to establish a flow that is axisymmetric and to employ a fully developed flow, which would establish a "thick" boundary layer. Repeatability is best achieved if the boundary layer builds up in a long constant area duct.

In practical applications of annular diffusers the flow enters the diffuser with a swirl. The effect of inlet swirl is of major importance, and no performance data on this type of diffuser can be considered complete unless it includes the effect of inlet swirl.

The aim of this research is to investigate the effects of inlet swirl on the performance of a number of annular diffusers of equal divergent angles, but different area ratios.

CHAPTER 2

LITERATURE SURVEY

The material covered in this chapter summarizes briefly the existing literature and also, introduces some of the terminology used in diffuser research.

2.1.0 General Remarks on Diffusers

The diffuser is a device which converts the kinetic energy of a moving stream of fluid into static pressure. Continuity is satisfied by the corresponding reduction in mean velocity. The mean velocity reduction is accompanied by a pressure rise; however, this relationship, between decreasing velocity and increasing pressure is complex. The axial momentum is reduced not only because of the increased pressure, but also because of mixing processes occurring and the shear forces developed on the diffuser walls. With a diffuser a wide variation in axial velocity occurs across the outlet section, the flow separating from the walls if the diffuser expansion angle is sufficiently large.

The simplest flow passing through a diffuser may be considered as one-dimensional. As the flow enters, the streamlines diverge and the fluid experiences a deacceleration, velocity decreasing as the flow continues through the diffuser, but static pressure increasing. Most of the analysis on diffuser performance in the past has been done using one dimensional flow through the diffuser.

Diffusers are classified into three general groups-plane-walled, conical and annular. The various types of diffusers are in Figure (1).

2.2.0 Diffuser Performance

The performance parameters most commonly used in the analysis of diffuser performance are the pressure recovery factor, C_{PR} and the diffuser effectiveness, η .

The pressure-recovery factor relates the actual pressure rise of a diffuser to the dynamic pressure at the diffuser inlet, i.e.,

$$\overline{C}_{PR} = \frac{\Delta P}{\overline{q}_{i}} = \frac{\overline{P}_{S_2} - \overline{P}_{S_1}}{\overline{q}_{i}} \qquad (2\text{-}1)$$

The overall diffuser effectiveness is the ratio of actual pressure rise to that achievable from the same diffuser with, one dimensional ideal fluid flow at the same flow rate, i.e.,

$$\eta = \frac{\overline{C}_{PR}}{C_{PR_i}} \qquad (2\text{-}2)$$

where the ideal pressure recovery factor can be readily shown to be a function of only the area ratio of the diffuser, i.e.,

$$C_{PR_i} = 1 - \frac{1}{AR^2} \qquad (2\text{-}3)$$

Often in the diffuser literature, the term diffuser efficiency is used, rather than effectiveness. Efficiency implies losses, whereas, η , as defined here, is more representative of the effectiveness with which the area change of a diffuser is used for diffusion purposes than it is of the loss which occurs within the device.

When swirl is introduced into the flow, the maximum pressure rise may be obtained at an optimum swirl angle and the effectiveness could be greater than unity. An expression for the pressure recovery factor for ideal fluid flow through an annular diffuser with a free vortex swirl is derived and presented in Appendix B.

2.3.0. Previous Investigations of Diffusers

2.3.1. Conical and Plane Walled Diffusers

Although diffuser research dates back to the eighteenth century, it was not until the early twentieth century that serious, extensive investigations were carried out by Gibson and Eiffel (ref. 3). Both men investigated conical diffusers, the former using air the latter water. McDonald and Fox (ref. 9) did further investigations on conical diffusers, obtaining performance and flow regimes information for a wide range of diffuser geometries. Later Patterson and Peters (ref. 10 and 11) correlated diffuser losses with the angle of expansion of the diffuser, the shape of the diffuser and the area ratio of the diffuser.

Professor Kline (ref. 7) and his associates investigated extensively the performance and design of straight two-dimensional diffusers (Plane walled). Kline found four primary flow regimes, regions of unstalled flow, large transitory stall flow, two-dimensional stall flow, and jet flow and presented these as functions of overall diffuser geometry. The performance of both stalled and unstalled diffuser was mapped for a wide range of geometries and inlet boundary layer thicknesses. In analyzing the diffuser performance, two performance parameters were found- the pressure recovery factor, C_{PR}, and the diffuser effectiveness, η . Using these values, performance plots were obtained. It was found that in the region of unstalled flow, C_{PR} is determined by the area ratio, the diffuser effectiveness is determined by the diffuser expansion angle. In the region of large transitory stall, C_{PR} is determined by the expansion angle. In the two-dimensional stall flow and in the jet flow C_{PR} remains fairly constant.

2.3.2. Annular Diffusers

Johnston (ref. 6) investigated the effect of inlet conditions on the flow, in annular diffusers.

The expansion angles of his annular diffuser varied from 6.5° to 15°. For a variety of inlet velocity distributions the performance of each diffuser was measured. He found that diffuser efficiency deteriorated as inlet conditions become more non-uniform, this tendency increasing with diffuser angle.

Hensler and Howard (ref. 5) investigated equiangular annular diffusers (converging inner cone, diverging outer cone) with angles ranging between 7° and 20°. They were able to establish the flow regimes and performance as functions of the geometrical parameters of the diffusers. The flow was fully developed at the inlet, without swirl, and it was noticed that the behaviour of the equiangular diffuser was similar to that of two dimensional diffusers.

Thornton-Trump (ref. 15) investigating annular diffusers with a straight inner concentric core and a diverging outer cone found that the performance of the diffuser laid between two-dimensional diffusers and conical diffusers.

Sovran and Klomp (ref. 13) studied the performance of a wide variety of annular diffusers, for flow without swirl, using thin boundary layers and different inner and outer wall angles to obtain a performance chart. They concluded that wall angles and the inlet radius ratio did not affect the performance appreciably; however, the area ratio and the non-dimensional diffuser length, were important controlling factors.

2.4.0. Specification of Inlet Swirl

In most practical applications of annular diffuser the fluid motion is not one-dimensional, but possesses also a swirl motion. Such a motion in a flow may be set up by means of a swirl vane, turbine blades or compressor blades. Due to the swirl motion, the flow entering the diffuser now has an axial velocity component and also a tangential velocity component. A swirl angle, ψ, the angle of the flow measured relative to a plane through the center line of the duct, is defined. If the swirl angle distribution has a profile of its own, it becomes necessary to find an overall average value of the swirl angle. Schwartz defined a mass weighted average value of the swirl angle denoted by $\overline{\psi}$.

2.4.1. Previous Investigations of Diffusers-With Inlet Swirl

In 1953, Schwartz (ref. 12) investigated the effects of swirl on the annular diffusers with constant outer diameters and effective angles of 8° and 16°. He found that regions of maximum efficiency occurred when the angle of inflow (swirl angle) equalled the conical angle of expansion and also when the flow was axial. There are sharp reductions in efficiency at high angles of swirl.

The effect of swirl on the Flow Regimes and Performance of Equiangular, Divergent-Convergent Annular Diffuser was investigated by Srinath (ref. 14). It was found that the diffuser performed most efficiently when the mean inlet swirl angle was close to the total expansion angle of the diffuser. Swirl removed stall completely from the outer wall and transitory stall set in almost immediately on the inner wall. At higher swirl angles, there was great reduction in the efficiency of the diffuser.

2.5.0. Aims of Present Investigation

In view of the need for a better understanding of the effect of swirl on annular diffuser performance and of its importance in numerous practical applications, the present work aims to investigate the effects of inlet swirl on the performance of a number of annular diffusers, of equal inner and outer divergent angles.

CHAPTER 3

TEST FACILITIES AND EXPERIMENTAL PROCEDURE

3.1.0. Test Facilities

A schematic diagram is given in Figure (2) showing the letter code used in the following description of the test facilities. Figure (3) to (8) show a series of photos of the test facilities.

3.1.1. Air Supply and Flow-Calibration Pipe

Air was supplied by a type E, size 7 Canadian Buffalo blower, B, with a rating of 2000 C.F.M., 56.1 inches of water S.P., 3500 R.P.M. and 31.9 B.H.P.. This blower was driven by a 40 H.P., 550 volts and 3500 R.P.M. General Electric induction motor. The air flow could be varied by a 10 inch blast plate and a damper, A, fitted at the intake of the blower.

The flow entered a short converging section and then passed into a 30 inch long cold rolled seamless steel pipe, C, with 5 inch O.D.. This pipe served as a flow measuring section. A standard pitot-static probe mounted on a traversing mechanism was able to traverse across the pipe and the air flow thus could be determined by knowing the velocity profiles inside the pipe.

3.1.2. Expansion Cone and Plenum Chamber

The expansion cone, D, approximately eight feet long, was constructed out of 1/8 inch plywood sheets. The inner surface was sanded and varnished to ensure a smooth surface.

The plenum chamber, E, consists of four cylindrical sections, 38 inches diameter, built out of 1/16 inch plexiglass, supported by 3/4 inch plywood frames. These sections were joined to form a six foot long settling chamber which contained also a one foot honeycomb section, G, and three screens, H, (30x30 mesh). A fibre glass filter, F, was mounted at the front of the chamber. The plexiglass wall provides a smooth inner surface and also allows for flow visualization at the inlet of the swirl vane unit.

By means of a velometer the velocity profile at the exit of the plenum chamber was measured. The profile showed that a uniform flow had been achieved.

3.1.3. Swirl Vane Unit

A swirl vane unit (or swirl generator), I, was mounted in the last section of the plenum chamber. The unit consisted of two machined pieces of wood (axisymmetric),the outer piece mounted on the outer tube of the annulus,the inner piece mounted on the inner tube and suspended in the chamber by a spider. The inner and outer flow contours were obtained after a detailed analysis to achieve the best flow conditions. This analysis was carried out with the help of United Aircraft of Canada Limited (ref. 16).

According to the analysis, presented briefly in Appendix C, the flow in the swirl unit is continuously accelerated with minimum losses and enters the annular passage at the end. If inlet flow conditions are as specified in the analysis, no flow separation should occur at the walls.

Between the outer and inner parts of the swirl unit a 1.6 inch gap allows the mounting of twenty-four NACA 0012 airfoils (3 inch chord). By means of a ring mechanism, all twenty-four vanes can be turned through the same angle and different degrees of swirl introduced into the flow.

3.1.4. Annular Pipes

From the swirl vane unit, the air passed through the annular space between two twelve-foot aluminum pipes, J, the inner pipe being 5 inch O.D., the outer pipe 8 inch I.D.. Spacers were not used to separate the annular pipes in order to reduce distortion of the swirl asit passed down the annular passage. To ensure concentricity of the pipes and keep vibrations to a minimum, considerable work was done to suspend the inner pipe firmly at one end by a spider located in the plenum chamber, at the other end by a solid-angle stand. The outer pipe was cradled firmly by two solid stands, which also allowed levelling of the outer pipe to ensure concentricity of the inner and outer pipes. The last foot of the outer pipe was replaced by a plexiglass section, K, of the same diameter. The section was threaded and flanged on, so that the probe attached to it could be rotated about the inner pipe.

3.1.5. The Test Section: The Diffuser

From the annular passage, the flow entered the test section-the annular diffuser,L. The annular diffuser, shown in Figure (9) consisted of two cones, total expansion angle of each cone being 40°. The cones were machined from laminated pieces of basswood and were assembled out of four cone sections, thereby, allowing the study of four annular diffusers, of the same divergent angle but of different lengths. The lengths were chosen, to give area ratios of 1.25, 1.50, 2.0 and 3.0.

At the diffuser inlet, the inner diameter of the outer pipe was 8.0 inches and the inner pipe had an outer diameter of 5.0 inches, resulting in an annular height of 1.5 inches. The hub to tip radius ratio was 0.6., typical of turbine outlet annuli.

The following table gives the area ratios and the corresponding non-dimensional length for the diffusers tested.

Total Expansion Angle = 40°	
L/h	AR
1.60	1.25
3.13	1.50
6.35	2.00
12.65	3.00

TABLE 3-1

3.2.0. Experimental Procedure

The following measurements were made for each diffuser, the largest diffuser being analyzed first.

Each annular diffuser was studied for five different swirl conditions, approximately zero swirl to a maximum swirl of about 25°. For each swirl condition, pressure variations along the diffuser and the flow conditions at the inlet and the outlet of the diffuser were measured. The degree of swirl was set, by turning the external control knob, which rotated all of the twenty-four vanes simultaneously through the same angle (0° to 45°).

Initially, the airfoils were turned to a neutral position, allowing zero swirl or axial flow to be introduced into the flow. Two inches upstream of the diffuser inlet, a yaw probe was inserted, and measurements were made at ten positions, radially across the annular gap. The probe also allowed measurements of static pressure and total pressure at these positions. It should be noted that first, the probe was rotated to the null direction and then swirl angle and pressure readings were taken.

The inlet flow conditions were measured at three different radial locations 120° apart, by rotating the plexiglass section about the inner pipe.

The flow was adjusted for each swirl condition by adjustment of the damper, to ensure a constant flow rate of approximately 1900 cfm at a Reynold's Number of 2×10^5.

Following the inlet swirl and pressure measurements, the yaw probe was removed and replaced by a hot wire probe to measure the inlet turbulence level. Care was taken to locate the hot wire at the same position as the yaw probe and for each position to rotate the hot wire to the same angle as was measured, with the yaw probe at the corresponding position. Once the hot wire was properly aligned average D.C. voltage and RMS voltage readings were recorded.

Care was taken not to bring the hot wire probe too close to the wall, in order to reduce the chances of damaging the hot wire. This precaution allowed turbulent measurements only at eight positions, instead of ten.

At the exit, another yaw probe was mounted and similar measurements were made at ten positions; however, only one traverse was made. No static pressure measurements were made, assuming that the exit static pressure was atmospheric. Also, no turbulence measurements were made at the exit.

The pressure variations in the diffuser were noted by means of three rows (120° apart) of static pressure taps, fourteen per row, along the diffuser wall. These pressure taps were hooked up to a thirty-six tube sloping bank manometer.

In Figure (10), the stations at which measurements were taken are shown.

3.3.0. Instrumentation

The inlet conditions were measured with a probe that contained a cobra yaw probe, a circular stainless steel hypodermic tube (0.06 in O. D.) to measure total pressure and a similar hypodermic tube of the same outer dimensions with two small holes on the side to measure static pressure. The yaw probe was aligned for zero swirl by placing it in a uniform velocity field of a windtunnel. The static pressure and total pressure tubes were calibrated with a standard Kiel Probe in a windtunnel.

Outlet conditions were measured with another cobra yaw probe, whose central hypodermic tube measured the total pressure. The probe was aligned and calibrated in the windtunnel. Static pressure was assumed atmospheric at the exit.

Thirty static pressure taps, .040 in. diameter, were drilled into the outer wall and allowed measurement of the static pressure rise in the diffuser.

A NPL-Type Multitube Tilting Manometer was utilized in making all pressure measurements.

The relative inlet turbulence was measured with a Disa, Constant-Temperature Anemoneter, 55A01, using a Type 55A36 Miniature Hot Wire Probe. The cold resistance of this probe was approximately 3.40 ohms. Calibration of the hot wire was done periodically in the windtunnel and the test apparatus itself.

CHAPTER 4

RESULTS AND DISCUSSION

4.1.0. Experimental Results

Before measurements were taken, it was shown that the flow, for zero swirl, was fully developed. Since the length of the annulus was 80 times the hydraulic diameter, it was reasonable to assume that the flow at the diffuser inlet was fully developed. Also the velocity profile at the diffuser inlet was compared with the velocity profiles of Brighton and Jones (ref. 1) for fully developed turbulent flow, Figure 11, showing very good agreement. It was observed that the inlet velocity profile could be repeated well and at zero swirl did not vary considerably for different flow rates. The last observation showed that the Reynold's Number effects were quite small, within the range of experimentation.

4.2.0. Inlet Conditions

Inlet measurements, taken at three traverses, 120° apart, indicated a good circumferential uniformity. The flow was, therefore, assumed to be a function of radial distance only (axisymmetric).

In order to check the magnitude of three-dimensional effects, a three-dimensional five-hole yaw probe was employed and a traverse made at the diffuser inlet. The pressure difference in the pitch plane was small; therefore, the flow in the radial direction was considered to be negligibly small.

Inlet data and calculated results are given in Table I.

4.2.1. Swirl and Tangential Velocity Distributions

Figure (13) shows the various inlet swirl distributions at which the diffusers were tested. It is seen that for low and medium swirl, the swirl angle is nearly constant across the core of the annulus. At higher swirl, the swirl angle increases toward the outer wall, the slope of the profile increasing as the swirl angle increases. The same trend is evident for all four diffusers.

Figure (14) shows the various inlet tangential velocity distributions for the four diffusers. A trend similar to the swirl angle distributions is evident. For low and medium swirl, the profiles are flat, the tangential velocity being nearly constant across the core of the annulus. At higher swirl, the tangential velocity increases towwards the outer wall.

From the tangential velocity profiles across the annulus, it is evident that the inlet swirl distribution does not follow a free vortex pattern. This can be attributed to the fact that the flow is fully developed at the entry to the diffuser and also that the annulus is quite small. Therefore, the whole flow region is affected by shear stresses and hence there is no non-viscous flow region for the free vortex pattern of swirl to develop.

At higher swirl angles, the slope of the swirl angle and the tangential velocity distributions increase, because the flow is being shifted outwards.

4.2.2. Velocity and Dynamic Pressure Distributions

Figure (15) shows the dynamic pressure distributions for the four diffusers, and Figures (16 and 17) show the absolute and axial velocity profiles are almost identical. As the swirl angle increases, the absolute velocity profile becomes increasingly affected by both the tangential velocity and the axial velocity. The figures show, however, that the trend of the axial velocity distribution is also dominant in the corresponding absolute velocity distribution. Both profiles show that with increasing swirl, the profile becomes more skewed towards the outer wall (the point of maximum velocity shifts toward the outer wall). This trend becomes even more pronounced in the dynamic pressure distributions where the velocity is squared and plotted.

4.2.3 Static Pressure Distribution

The inlet static pressure distribution for the four diffuser studied are shown in Figure (18).

It is seen that as the swirl increases the static pressure decreases, becoming more negative at the diffuser inlet. Note that this condition is a favorable condition, for it causes the diffuser to be more efficient. A decreasing static pressure at the inlet increases the flow rate.

The static pressure distributions show the static pressure to be generally constant near the inner wall and increasing towards the outer wall. In the outer region, the static pressure becomes increasingly affected by a combination of the boundary layer effects and the centrifugal forces created by the swirl flow.

As the the diffuser length increases, it is observed that the inlet static pressure decreases. This could be explained by the fact that the exit static pressure for all diffusers is equal to ambient pressure.

4.3.0. Diffuser Duct and Outlet

Outlet data and calculated results are given in Table II.

4.3.1. Swirl and Tangential Velocity Distributions

Swirl angle and tangential velocity distributions at the diffuser outlet are shown in Figures (19 and 20). The profiles are not as smooth as the inlet profiles; however, do show the same trend as was evident for high inlet swirl, the swirl angle increasing towards the outer wall. For all swirl conditions, the mass-weighted swirl angle decreases from the diffuser inlet to the diffuser outlet.

For low and medium swirl the reduction in mean swirl angle from inlet to the outlet, is accompanied by a change in distribution from a relatively uniform rotation in the inlet to a non-uniform gradient with maximum swirl angle at the outer wall at the exit.

The tangential velocity distributions show the tangential velocity to be constant across the core of the annulus for all swirl conditions.

4.3.2. Velocity and Pressure Distributions

Dynamic pressure and velocity distributions for the diffuser outlet are presented in Figures (21,22, and 23). The distributions for the dynamic pressure, absolute velocity and axial velocity show similar trends, greater skewness towards the outer wall as the swirl angle increases. The outward shift is more pronounced at the diffuser exit. For low swirl, the maximum velocity is near the inner wall; and at high swirl, it has shifted considerably towards the outer wall. Comparison of the curves of the dynamic pressure at the diffuser inlet to that at the outlet, shows the curves to be steeper at the exit, having a more pronounced maximum point. The diffuser magnifies any distortion of the flow parameters. This amplification is due to the diffusing action which occurs.

With increasing swirl, the absolute velocity distribution changes significantly; static pressure and flow-angle distributions on the contrary were essentially constant from inlet to exit of the diffuser.

4.3.3. Static Pressure Rise in Diffuser

The static pressure distribution along the diffuser length is shown in figure (24) for the four annular diffuser investigated. It is seen that as the diffuser length increases the static pressure rise increases accordingly. Swirl appears to have no appreciable effect on the distributions.

4.4.0. Effect of Turbulence

Kline (ref.7) his associates have done extensive investigations on plane walled diffusers and they concluded that for Mach number less than unity and for Reynold's Number greater than $5x10^5$, the most important inlet conditions affecting performance are inlet velocity profile and turbulence level. Other researchers have also mentioned turbulence as a prime influence on diffuser performance.

In turbomachines, the boundary layer builds up and often occupies a considerable portion of the annular space of the flow. In swirl flow, because of the tangential mean velocity, neither the turbulence level nor the radial pressure variation need be small in the boundary layer.

Yeh (ref. 17) investigated the development of incompressible turbulent boundary layers along concave and convex stationary annular walls, analytically and experimentally for a swirling flow. He concluded that large-scale turbulence eddies "roam" radially back and forth in the outer half of the annular passage; while, such motion is very much reduced in the inner half. The strong radial turbulent motion near the outer wall pulls the immediate adjacent mean velocity taut, creating a larger velocity gradient and shear stress at the outer wall.

For flow with swirl, the boundary layer near the inner wall is very much like the one for flow with no swirl-approaching the equilibrium profile for fully-developed turbulent flow without swirl. For the outer wall region, the boundary layer departs much more than for flow with no swirl. The turbulence intensity is generally larger near the outer wall. This is shown to be true for the results found in the present investigation,as shown in Figure (15). The transverse component of turbulence intensity is produced near the outer or concave wall (where the tangential velocity decreases with radius) but is suppressed near the inner or convex wall (where the tangential velocity increases with radius), resulting in a larger intensity near the outer wall.

At the inlet to the annular pipes, the swirl generator sets up a swirling flow; that is, flow with both tangential and axial mean velocities. The turbulence present in the flow decays the turbulent swirl in the flow and also evens out the velocity profile. Kreith and Sonju (ref. 8) observed that swirl in a turbulent pipe flow decays to about 10-20% of its initial value in a distance of about 50 pipe diameters. In the present investigation it was found that a swirl of

45° set up by the swirl generator at the inlet of the annulus, decayed to 26° at the diffuser inlet and to 18° at the diffuser exit. This trend was true for all swirl conditions.

4.5.0. Discussion of Performance Parameters

The performance of the four annular diffusers and the effect of inlet swirl on the performance was determined by plotting the parameters--the diffuser effectiveness and the pressure recovery factor. The plots were also compared to the findings of other researchers.

4.5.1. Pressure Recovery Factor

For the four diffusers, the pressure recovery factor was plotted against the non-dimensional length for different inlet swirl conditions, shown in Figure (26). In order to find an optium swirl angle, if possible, the pressure recovery factor was plotted against mass weighted average swirl angle $\overline{\psi}$, Figure (27), for each diffuser.

The plots show that the introduction of a certain amount of swirl into the flow has an effect on the performance of the diffuser.

In the plot of CPR versus the non-dimensional diffuser length, the curves are approximately parallel to the curve for zero swirl, indicating that the general trend of the CPR variation with the non-dimensional length is not affected by the swirl. The pressure recovery factor increases as the diffuser length increases and levels off at higher values of non-dimensional diffuser length.

Srinath who investigated an equiangular divergent convergent annular diffuser, found that the curves of constant swirl angle levelled off and then decreased at higher non-dimensional diffuser lengths, Figure (24). The curves of the C_{PR} versus L/h plot were also quite flat, compared to the ones of this investigation.

Sovran and Klomp conducted an extensive investigation of a wide variety of annular diffuser configurations, for flow with no inlet swirl. The geometric characteristics were specified by four parameters-the two wall angles, the inlet radius ratio and a non-dimensional length. From their results, several types of diffusers wre chosen, and a plot of pressure recovery factor versus area ratio was made, shown in Figure (28).

Each curve in this plot represents a set of diffusers of the same wall angle but of different lengths. The particular type of annular diffuser is identified by its outer wall angle (which has a positive value if the cone is diverging, negative if the cone is converging), the inner wall angle, the inlet radius ratio and the non dimensional diffuser length. For comparison, the four diffusers of the present investigation have also been plotted. Note that the identification expression for this set of diffusers is 20°, 20°, 0.6, (1.25,1.50,2.00,3.00).

Two sets of diffusers studied by Sovran and Klomp, (30°, $29\frac{1}{2}^\circ$, 0.7, L/h and 15°, 15°, 0.7, L/h) have a geometry similar to those of the present investigation and show a similar performance trend. Results of the current investigation, for the case of flow with no swirl, are supported strongly by the results of Sovran and Klomp.

Referring to Figure (28) again, it is observed that if the outer wall angle is left at 20°, as the inner wall angle becomes less divergent, the pressure recovery factor for a constant value of area ratio decreases. The profile of pressure recovery factor versus area ratio, tends to become flater.

Sovran and Klomp unfortunately did not include any results for a set of diffusers, which had a diverging outer cone and a converging inner cone. The trend of Figure (26) and the results obtained by Srinath predicts that such a set would have had a flat profile.

In the second performance plot Figure (27) pressure recovery factor is plotted against mass-weighted swirl angle for constant diffuser length. For the largest diffuser, swirl apparently has no effect on the pressure recovery factor, for smaller diffuser lengths, however, the inlet swirl has a small effect on the pressure recovery factor. When a small amount of swirl is introduced into the flow, the pressure recovery factor decreases, and as more swirl is added, the pressure recovery factor slowly increases. For the two shorter diffuser lengths the increased swirl produces pressure recovery factors greater than for no-swirl flow. The diffuser with non-dimensional diffuser length equal to 6.35 (Diffuser B) shows the same trend.

The point of minimum pressure recovery factor shifts to a higher swirl angle as the non-diminsional diffuser lengths increases. The curves of C_{PR} versus $\bar{\Psi}$ flatten out as the diffuser length increases.

In general, an increase in swirl angle causes sharp radial pressure gradients to develope which will cause better mixing of the outer wall boundary layer with fluid having higher kinetic energy. This delays or even washes off completely the stall or flow separation from the outer wall. The divergence of the flow is thus brought closer to an ideal flow process. The pressure recovery therefore tends to increase.

The profiles, Figure (30), obtained by Srinath for C_{PR} versus $\bar{\Psi}$ for the equiangular divergent-convergent annular diffuser show an opposite trend. When swirl is introduced into the flow, the pressure recovery increases to a maximum value and then further increase in swirl decreases it. Srinath concluded that any increase in inlet swirl beyond the optimum value will bring down the diffuser performance.

The geometry of the present annular diffuser; that is the divergence of the inner cone, favors also the divergence of the flow. In the diffuser studied by Srinath, the converging inner cone, allowed early flow separation on the inner wall, especially at higher swirl angles. Here, the radial pressure gradients also leads to an adverse condition resulting from the centripetal flow of low energy air which in turn causes separation of the flow on the inner wall. This separation of flow on the inner wall causes considerable losses especially in the exit portions of the diffuser.

4.5.2. Diffuser Effectiveness

Two additional plots have been included in the performance plots, to show the distribution of the diffuser effectiveness, which has been redefined for the case of flow with inlet swirl. These plots are shown in Figures (31 and 32). The effect of inlet swirl is evident in both plots.

First consider the plot of diffuser effectiveness versus non-dimensional diffuser length. For low swirl, the trend is similar to that shown in the plot of pressure recovery factor versus non-dimensional diffuser length. As the diffuser length increases the diffuser effectiveness increases and tends to flatten out.

For higher swirl, it appears that as the diffuser length increases the diffuser effectiveness decreases sharply, reaches a minimum and then with further increase the effectiveness increases again. The effect of the inlet swirl becomes more pronounced in the plot of diffuser effectiveness versus mass-weighted inlet swirl angle for constant non-dimensional diffuser length.

For the largest diffuser, the diffuser effectiveness remains constant, swirl having no effect. For the other three diffusers, the presence of some swirl decreased the diffuser effectiveness and reached a minimum value. As the inlet swirl was further increased the effectiveness also increased, the increase being more rapid as the diffuser became shorter.

CHAPTER 5

CONCLUSIONS

1. The Pressure Recovery Factor, C_{Pr}, increases with dffuser length, L/h, and tends to flatten out at higher values of diffuser length.

2. For a given Equiangular Divergent Annular Diffuser, C_{PR} initially decreases with swirl, $\bar{\Psi}$, and then increases.

3. The effect of swirl on Diffuser Effectiveness is similar to its effect on C_{PR}. However, the swirl effect on Diffuser Effectiveness, η , is more pronounced for shorter diffuser lengths.

4. Equiangular Divergent Annular Diffusers perform better than Equiangular Divergent-Convergent Annular Diffusers, the diffuser effectiveness of the Divergent Annular Diffuser being considerably higher at increased inlet swirl.

APPENDIX A-1

```
C      INLET SWIRL ANGLE PROFILES
       DIMENSION IBUF(1000),DARRAY(12),VARRAY(12),VAARRA(12),VTARRA(12),P
      1SARRA(12),PHIARR(12)
    10 CALL PLOTS (IBUF,1000)
    20 CALL PLOT (0.0,1.5,-3)
       DO 60 L=1,4
       DARRAY(11)=0.0
       DARRAY(12)=0.20
       PHIARR(11)=0.0
       PHIARR(12)=0.20
    21 CALL AXIS (0.0,0.0,20H(R-RINR)/(ROTR-RINR),-20,5.0,0.0,DARRAY(11),
      2DARRAY(12))
    22 CALL AXIS (0.0,0.0,23HSWIRL ANG/MAX SWIRL ANG,+23,5.0,90.0,PHIARR(
      311),PHIARR(12))
       DA=2.17E-03
       DL=1.94
       A=DL/DA-1.0
       G=32.174
    25 CALL SYMBOL (1.5,5.5,0.14,11HINLET SWIRL,0.0,11)
    23 CALL SYMBOL (1.5,5.25,0.14,14HANGLE PROFILES,0.0,14)
       PRINT 16
    16 FORMAT (10H  DIFFUSER)
       DO 50 K=1,5
       PRINT 17
    17 FORMAT (21H  SWIRL ANGLE SETTING)
       DO 30 I=1,10
       READ 26,DIST,ANG,PS,PT,UV,UVA,UVT,RM,RI
    26 FORMAT (9F8.3)
       DR=(RM-RI)/1.5
       S=PS+PT
       PST=PS*0.73711
       PD=S*0.73711/12.0
       V=SQRT(2.0*G*PD*A)
       VA=V*COS(ANG*3.142/180.0)
       VT=V*SIN(ANG*3.142/180.0)
       DV=V/UV
       DVA=VA/UVA
       DVT=VT/UVT
       PRINT 27,DIST,ANG,PS,PT,UV,UVA,UVT,RM
    27 FORMAT (8F8.3)
       PRINT 28,DIST,DR,V,VA,VT,DV,DVA,DVT
    28 FORMAT (8F8.3,/)
       DARRAY(I)=DR
       VARRAY(I)=DV
       VAARRA(I)=DVA
       VTARRA(I)=DVT
       PSARRA(I)=PST
       PHIARR(I)=ANG
    30 CONTINUE
    35 CALL LINE (DARRAY,PHIARR,10,1,1,K)
    50 CONTINUE
    55 CALL PLOT (7.0,0.0,-3)
    60 CONTINUE
    90 CALL SYMBOL (8.0,0.0,0.14,22HUWE SCHNEIDER JOB PLOT,90.0,22)
   100 CALL PLOT (10.0,0.0,-3)
   105 CALL PLOT (0.0,0.0,999)
   110 CALL EXIT
       END
```

APPENDIX A-2

```
C     INLET TANGENTIAL VELOCITY PROFILES
      DIMENSION IBUF(1000),DARRAY(12),VARRAY(12),VAARRA(12),VTARRA(12),P
     1SARRA(12),PHIARR(12)
   10 CALL PLOTS (IBUF,1000)
   20 CALL PLOT (0.0,1.5,-3)
      DO 60 L=1,4
      DARRAY(11)=0.0
      DARRAY(12)=0.20
      VTARRA(11)=0.0
      VTARRA(12)=0.25
   21 CALL AXIS (0.0,0.0,20H(R-RINR)/(RCTR-RINR),-20,5.0,0.0,DARRAY(11),
     2DARRAY(12))
   22 CALL AXIS (0.0,0.0,19HTAN VEL/MAX TAN VEL,+19,5.0,90.0,VTARRA(11),
     2VTARRA(12))
      DA=2.175-03
      DL=1.942
      A=DL/DA-1.0
      G=32.174
   25 CALL SYMBOL (1.5,5.5,0.14,16HINLET TANGENTIAL,0.0,16)
   23 CALL SYMBOL (1.5,5.25,0.14,17HVELOCITY PROFILES,0.0,17)
      PRINT 16
   16 FORMAT (11H  DIFFUSER)
      DO 50 K=1,5
      PRINT 17
   17 FORMAT (20H  SWIRL ANGLE SETTING)
      DO 30 I=1,10
      READ 26,DIST,ANG,PS,PT,UV,UVA,UVT,RM,RI
   26 FORMAT (9F8.3)
      DR=(RM-RI)/1.5
      S=PS+PT
      PST=PS*0.73711
      PD=S*0.73711/12.0
      V=SQRT(2.0*G*PD*A)
      VA=V*COS(ANG*3.142/180.0)
      VT=V*SIN(ANG*3.142/180.0)
      DV=V/UV
      DVA=VA/UVA
      DVT=VT/UVT
      PRINT 27,DIST,ANG,PS,PT,UV,UVA,UVT,RM
   27 FORMAT (8F8.3)
      PRINT 28,DIST,DR,V,VA,VT,DV,DVA,DVT
   28 FORMAT (8F8.3,/)
      DARRAY(I)=DR
      VARRAY(I)=DV
      VAARRA(I)=DVA
      VTARRA(I)=DVT
      PSARRA(I)=PST
      PHIARR(I)=ANG
   30 CONTINUE
   35 CALL LINE (DARRAY,VTARRA,10,1,1,K)
   50 CONTINUE
   55 CALL PLOT (7.0,0.0,-3)
   60 CONTINUE
   90 CALL SYMBOL (8.0,0.0,0.14,22HUWE SCHNEIDER JOB PLOT,90.0,22)
  100 CALL PLOT (10.0,0.0,-3)
  105 CALL PLOT (0.0,0.0,999)
  110 CALL EXIT
      END
```

```
C       EXIT AXIAL VELOCITY PROFILES
        DIMENSION IBUF(1000),DARRAY(12),VARRAY(12),VAARRA(12),VTARRA(12),P
       1SARRA(12),PHIARR(12),PDARRA(12),RI(5)
     10 CALL PLOTS (IBUF,1000)
     20 CALL PLOT (0.0,1.5,-3)
        DO 60 L=1,4
        DARRAY(11)=0.0
        DARRAY(12)=0.20
        VAARRA(11)=0.70
        VAARRA(12)=0.20
        RI(1)=8.99
        RI(2)=5.75
        RI(3)=4.12
        RI(4)=3.31
     21 CALL AXIS (0.0,0.0,20H(R-RINR)/(ROTR-RINR),-20,5.0,0.0,DARRAY(11),
       2DARRAY(12))
     22 CALL AXIS (0.0,0.0,23HAXIAL VEL/MAX AXIAL VEL,+23,5.0,90.0,VAARRA(
       311),VAARRA(12))
        DA=2.1703
        DL=1.94
        A=DL/DA-1.0
        G=32.174
     25 CALL SYMBOL (1.5,5.5,0.14,10HEXIT AXIAL,0.0,10)
     23 CALL SYMBOL (1.5,5.25,0.14,17HVELOCITY PROFILES,0.0,17)
        PRINT 16
     16 FORMAT (11H  DIFFUSER)
        DO 50 K=1,5
        PRINT 17
     17 FORMAT (20H  SWIRL ANGLE SETTING)
        DO 30 I=1,10
        READ 26,DIST,ANG,PS,PT,UV,UVA,UVT
     26 FORMAT (7F8.3)
        RM=RI(L)+DIST
        DR=(RM-RI(L))/1.5
        S=PS+PT
        PST=PS*0.07711
        PDS=S*0.07711
        PD=S*0.07711
        PDS=S*0.07711/12.0
        V=SQRT(2.0*G*PDS*A)
        VA=V*COS(ANG*3.142/180.0)
        VT=V*SIN(ANG*3.142/180.0)
        PDM=6.0*(UV**2)/(G*A)
        DV=V/UV
        DVA=VA/UVA
        DVT=VT/UVT
        DPDM=PDS/PDM
        PRINT 27,DIST,ANG,PS,PT,UV,UVA,UVT,RM,PDS
     27 FORMAT (9F8.3)
        PRINT 28,DIST,DR,V,VA,VT,DV,DVA,DVT,DPDM
     28 FORMAT (9F8.3)
        DARRAY(I)=DR
        VARRAY(I)=DV
        VAARRA(I)=DVA
        VTARRA(I)=DVT
        PSARRA(I)=PST
        PHIARR(I)=ANG
        PDARRA(I)=DPDM
```

APPENDIX A-3

```
   30 CONTINUE
   35 CALL LINE (DARRAY,VAARRA,10,1,1,K)
   50 CONTINUE
   55 CALL PLOT (7.0,0.0,-3)
   60 CONTINUE
   90 CALL SYMBOL (8.0,0.0,0.14,22HUWE SCHNEIDER JOB PLOT,90.0,22)
  100 CALL PLOT (10.0,0.0,-3)
  105 CALL PLOT (0.0,0.0,999)
  110 CALL EXIT
      END
```

APPENDIX A-4

```
C       INLET TURBULENCE PROFILE
        DIMENSION IBUF(1000),DARRAY(10),TARRAY(10)
     10 CALL PLOTS (IBUF,1000)
     20 CALL PLOT (0.0,1.5,-3)
        DO 60 L=1,4
        DARRAY(9)=0.0
        DARRAY(10)=0.20
        TARRAY(9)=0.0
        TARRAY(10)=5.0
     21 CALL AXIS (0.0,0.0,20H(R-RINR)/(ROTR-RINR),-20,5.0,0.0,DARRAY(9),D
       2ARRAY(10))
     22 CALL AXIS (0.0,0.0,21HPERCENTAGE TURBULENCE,+21,6.0,90.0,TARRAY(9)
       1,TARRAY(10))
     25 CALL SYMBOL (1.5,6.5,0.14,16HINLET TURBULENCE,0.0,16)
     23 CALL SYMBOL (1.5,6.25,0.14,12HDISTRIBUTION,0.0,12)
        PRINT 16
     16 FORMAT (10H  DIFFUSER)
        DO 50 K=1,5
        PRINT 17
     17 FORMAT (21H  SWIRL ANGLE SETTING)
        DO 30 I=1,8
        READ 18,DIST,VDC,VRMS
     18 FORMAT (3F8.3)
        SQRTV=(VDC**2-29.0)/5.27
        PERCTU=75.8*VDC*VRMS/SQRTV
        PRINT 15,DIST,VDC,VRMS,SQRTV,PERCTU
     15 FORMAT (5F8.2)
        RI=2.5
        RM=RI+DIST
        DR=(RM-RI)/1.5
        DARRAY(I)=DR
        TARRAY(I)=PERCTU
     30 CONTINUE
     35 CALL LINE (DARRAY,TARRAY,8,1,1,K)
     50 CONTINUE
     55 CALL PLOT (3.0,0.0,-3)
     60 CONTINUE
     90 CALL SYMBOL (8.0,0.0,0.14,22HUWE SCHNEIDER JOB PLOT,90.0,22)
    100 CALL PLOT (10.,0.0,-3)
    105 CALL PLOT (0.0,0.0,999)
    110 CALL EXIT
        END
```

APPENDIX A-5

```
C     STATIC PRESSURE RISE IN DIFFUSER
      DIMENSION IBUF(1000),DARRAY(12),PARRAY(12)
   10 CALL PLOTS (IBUF,1000)
   20 CALL PLOT (0.0,1.5,-3)
      DARRAY(11)=0.0
      DARRAY(12)=4.0
      PARRAY(11)=0.0
      PARRAY(12)=1.0
   21 CALL AXIS (0.0,0.0,8HDISTANCE,-8,5.0,0.0,DARRAY(11),DARRAY(12))
   22 CALL AXIS (0.0,0.0,15HSTATIC PRESSURE,+15,6.0,90.0,PARRAY(11),PARR
     1AY(12))
   25 CALL SYMBOL (1.5,6.5,0.14,33HSTATIC PRESSURE RISE DISTRIBUTION,0.0
     2,33)
      PRINT 16
   16 FORMAT (10H DIFFUSER)
      DO 50 K=1,5
      PRINT 17
   17 FORMAT (21H  SWIRL ANGLE SETTING)
      DO 30 I=1,10
      READ 26,DIST,PSA,PSB,PSC
   26 FORMAT (5F8.3)
      PAV=((PSA+PSB+PSC)/3.0)*0.70711
      PRINT 11,DIST,PSA,PSB,PSC,PAV
   11 FORMAT (5F8.3)
      DARRAY(I)=DIST
      PARRAY(I)=PAV
   30 CONTINUE
   35 CALL LINE (DARRAY,PARRAY,10,1,1,K)
   50 CONTINUE
   55 CALL PLOT (10.,0.0,-3)
   90 CALL SYMBOL (8.1,0.0,0.14,22HUWE SCHNEIDER JOB PLOT,90.0,22)
  100 CALL PLOT (10.0,0.0,-3)
  105 CALL PLOT (0.0,0.0,999)
  110 CALL EXIT
      END
```

APPENDIX A-6

```
C     MASS-WEIGHTED VALUES FOR INLET AND EXIT DATA
      DIMENSION SARRA(12),PSARRA(12),PDARRA(12),VARRA(12),VAARRA(12),VTA
     1RRA(12)
      DO 40 J=1,40
      DO 10 I=1,10
      DL=1.94
      DA=2.17E-03
      A=DL/DA*1.0
      G=32.174
      READ 6,DIST,ANG,PS,PT
    6 FORMAT (4F8.3)
      S=PS+PT
      PST=PS*0.7*711
      PDS=S*0.7*711
      PD=S*0.7*713/12.
      V=SQRT(2.*G*PD/A)
      VA=V*COS(ANG*3.142/180.)
      VT=V*SIN(ANG*3.142/180.)
      PRINT 9,DIST,ANG,PST,PT,PD,V,VA,VT
    9 FORMAT (8F8.3,//)
      SARRA(I)=ANG
      PSARRA(I)=PST
      PDARRA(I)=PDS
      VARRA(I)=V
      VAARRA(I)=VA
      VTARRA(I)=VT
   10 CONTINUE
      DO 30 I=1,1
      PRCS=VAARRA(I)*SARRA(I)
      PRCPS=VAARRA(I)*PSARRA(I)
      PROPD=VAARRA(I)*PDARRA(I)
      PROV=VAARRA(I)*VARRA(I)
      PROVA=VAARRA(I)*VAARRA(I)
      PROVT=VAARRA(I)*VTARRA(I)
      PRINT 12,SARRA(I),PSARRA(I),PDARRA(I),VARRA(I),VAARRA(I),VTARRA(I)
   12 FORMAT (/F12.2,//)
      PRINT 13,SARRA(I),PRCS,PRCPS,PROPD,PROV,PROVA,PROVT
   13 FORMAT (7F12.2,//)
   30 CONTINUE
      VAS=0.0
      VAP=0.0
      VAPD=0.0
      VAV=0.0
      VAVA=0.0
      VAVT=0.0
      VASUM=0.0
      DO 4[illegible] I=1,[illegible]
      VAS=VAS+VAARRA(I)*SARRA(I)
      VAP=VAP+VAARRA(I)*PSARRA(I)
      VAPD=VAPD+VAARRA(I)*PDARRA(I)
      VAV=VAV+VAARRA(I)*VARRA(I)
      VAVA=VAVA+VAARRA(I)*VAARRA(I)
      VAVT=VAVT+VAARRA(I)*VTARRA(I)
      VASUM=VASUM+VAARRA(I)
      WS=VAS/VASUM
      WP=VAP/VASUM
      WPD=VAPD/VASUM
      WV=VAV/VASUM
```

APPENDIX A-6 continued

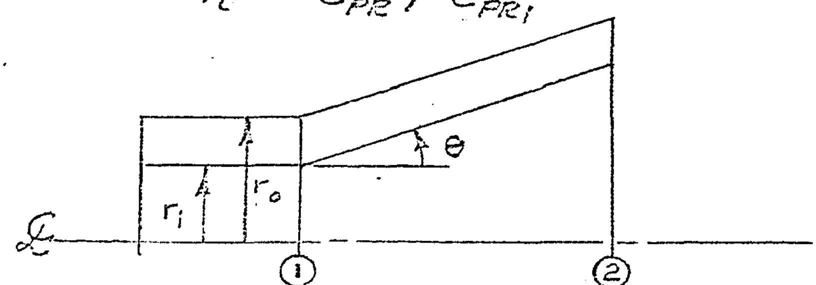
```
      WVT=VAVT/VASUM
      PRF=WP/WPD
      PRINT 35,SIGMA(I),VAS,VAP,VAPD,VAV,VAVA,VAVT,VASUM
   35 FORMAT ([illegible],//)
      PRINT 34,WS,WP,WPD,WV,WVA,WVT
   34 FORMAT (6F12.3)
      PRINT 37
   37 FORMAT (31H  PRESSURE RECOVERY COEFFICIENT)
      PRINT 38,PRF
   38 FORMAT ([illegible]3)
   40 CONTINUE
   60 CONTINUE
      CALL EXIT
      END
```

APPENDIX B.

DIFFUSER EFFECTIVENESS

The diffuser effectiveness is defined as the ratio of the actual pressure recovery factor to the ideal pressure recovery factor.

$$\eta = \bar{C}_{PR} / C_{PR_I} \qquad (B\text{-}1)$$



The actual pressure recovery factor is defined as the ratio of the mass weighted static pressure rise from the inlet to the diffuser outlet to the average dynamic pressure at the inlet.

$$C_{PR} = \frac{P_{S_2} - P_{S_1}}{P_{Dyn_1}} = \frac{\text{STATIC PRESSURE RISE}}{\text{DYNAMIC HEAD AT INLET}} \qquad (B\text{-}2)$$

In the present study, the ideal pressure recovery factor has been defined on three assumptions. First, the flow is considered to be a free vortex. The streamlines in a free vortex flow are concentric circles about the center of the vortex and the velocity at any point in such a flow field is given by the following two components.

$$V_t = K/r \qquad (B\text{-}3)$$
$$V_r = 0$$

The free vortex motion is irrotational except at the centre, wher V_t approachs infinity. Secondly, the flow is in radial equilibrium and, thirdly, there are no losses. Then from continuity

$$A_1 V_{a_1} = A_2 V_{a_2} \qquad (B-4)$$

from Bernoulli

$$\frac{P_1}{\rho} + \frac{1}{2} V_1^2 = \frac{P_2}{\rho} + \frac{1}{2} V_2^2 = C \qquad (B-5)$$

from Free Vortex Condition

$$r_1 V_{t_1} = r_2 V_{t_2} \qquad (B-6)$$

The absolute velocity can easily be written in terms of its components: the axial velocity and the tangential velocity. The axial velocity is independent of radius; (assuming uniform flow); the tangential velocity is dependent on radius. Therefore,

$$V^2 = V_a^2 + V_t(r)^2 \qquad (B-7)$$

Equation B-5 becomes,

$$\frac{P_1(r)}{\rho} + \frac{1}{2}\left(V_{a_1}^2 + V_{t_1}(r)^2\right) = \frac{P_2(r)}{\rho} + \frac{1}{2}\left(V_{a_2}^2 + V_{t_2}(r)^2\right) \qquad (B-8)$$

Rewritting,

$$\frac{P_2(r)-P_1(r)}{\rho} = \frac{1}{2}\left\{(V_{a_1}^{\,2}-V_{a_2}^{\,2})+(V_{t_1}(r)^2-V_{t_2}(r)^2)\right\} \qquad (B\text{-}9)$$

$$\doteq \frac{1}{2}\left\{V_{a_1}^{\,2}\left(1-\frac{V_{a_2}^{\,2}}{V_{a_1}^{\,2}}\right)+V_{t_1}(r)^2\left(1-\frac{V_{t_2}(r)^2}{V_{t_1}(r)^2}\right)\right\} \qquad (B\text{-}10)$$

From Equation (B-4)

$$V_{a_2} = \frac{A_1}{A_2}\, V_{a_2}$$

From Equation (B-6)

$$V_{t_2}(r) = \frac{r_1}{r_2}\, V_{t_1}(r)$$

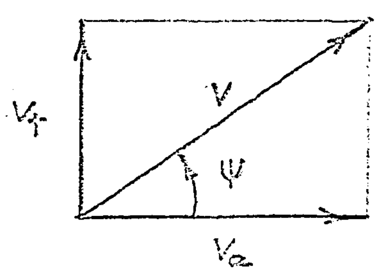
Substituting these values into Equation (B-10)

$$\frac{P_2(r)-P_1(r)}{\rho} = \frac{1}{2}\left\{V_{a_1}^{\,2}\left(1-\frac{A_1^{\,2}}{A_2^{\,2}}\right)+V_{t_1}(r)^2\left(1-\frac{r_1^{\,2}}{r_2^{\,2}}\right)\right\} \qquad (B\text{-}11)$$

The mass-weighted and non dimensional form of Equation (B-11) is

$$\frac{\bar{P}_2(r)-\bar{P}_1(r)}{\frac{1}{2}\rho \bar{V}_1^{\,2}} = \left\{\left(\frac{\bar{V}_{a_1}}{\bar{V}_1}\right)^2\left(1-\frac{A_1^{\,2}}{A_2^{\,2}}\right)+\left(\frac{\overline{V_{t_1}(r)}}{\bar{V}_1}\right)^2\left(1-\frac{r_{1m}^{\,2}}{r_{2m}^{\,2}}\right)\right\} \qquad (B\text{-}12)$$

where r_{1m} and r_{2m} are mean radii.



From the typical velocity triangle shown in Figure, where is defined as a swirl angle, it is readily shown that

Va=Vcos (B-13)

V_t=Vsin (B-14)

Substituting these values into Equation (B-12)

$$\frac{\bar{P}_2(r) - \bar{P}_1(r)}{\frac{1}{2}\rho \bar{V}_1^2} = \cos^2\bar{\psi}_1\left(1 - \frac{A_1^2}{A_2^2}\right) + \sin^2\bar{\psi}_1\left(1 - \frac{r_{1m}^2}{r_{2m}^2}\right) \qquad (B\text{-}15)$$

Equation B-15 is the final expression for the ideal pressure recovery factor, based on the condition of a free vortex flow. The expression differs considerably from the one for ideal one-dimensional flow, because it is not expressed wholly in terms of the diffuser geometry, but also contains the mass-weigthed inlet swirl angle. However, at zero-swirl, the expression reduces to the expression for ideal one-dimensional flow.

$$\frac{\bar{P}_2(r) - \bar{P}_1(r)}{\frac{1}{2}\rho V_1^2} = 1 - \frac{1}{AR^2} \qquad (B\text{-}16)$$

In order to be able to apply the expression, an expression has to be found for the mean radii, r_{1m} and r_{2m}.

Consider the variation in the radial direction, in a typical cross-sectional plane.

From Bernoulli,

$$\frac{P(r)}{\rho} + \frac{1}{2}V^2 = \text{constant} = C \qquad (B\text{-}17)$$

From which

$$P(r) = C\rho - \frac{\rho}{2}V^2$$
$$= C\rho - \frac{\rho}{2}(V_a^2 + V_t(r)^2) \qquad (B\text{-}18)$$

From Free Vortex Flow

$$V_t\, r = K \qquad (B\text{-}19)$$

Substituting Equation B-19 into Equation B-18,

$$P(r) = C\gamma - \frac{\gamma}{2}\left(V_a^2 + \frac{K}{r^2}\right)$$

$$= C\gamma - \frac{\rho V_a^2}{2} - \frac{\gamma}{2}\frac{K^2}{r^2} \qquad (B\text{-}20)$$

Defining

$$M = C\gamma - \frac{\rho V_a^2}{2} \qquad (B\text{-}21a)$$

$$N = \rho K^2/2 \qquad (B\text{-}21b)$$

Equation B-20 then becomes

$$P(r) = M - \frac{N}{r^2} \qquad (B\text{-}22)$$

The mass-weighted value of P(r) is found in the plane,

$$\overline{P} = \frac{\int_{r_{in}}^{r_{out}} P(r)\, 2\pi r\, dr\, V_a \rho}{\int_{r_{in}}^{r_{out}} 2\pi r\, dr\, V_a \gamma} = \frac{\int_{r_{in}}^{r_{out}} P(r)\, 2\pi r\, dr}{\pi (r_{out}^2 - r_{in}^2)} \qquad (B\text{-}23)$$

$$\overline{P} = 2\pi \frac{\int_{r_{in}}^{r_{out}} \left(M - \frac{N}{r^2}\right) r\, dr}{\pi (r_{out}^2 - r_{in}^2)}$$

$$= M - N \frac{2 \ln(r_{out}/r_{in})}{(r_{out}^2 - r_{in}^2)} \qquad (B\text{-}24)$$

However from Equation B-22

$$\overline{P} = M - N/r_m^2 \qquad (B\text{-}25)$$

Equating Equations B-24 and B-25

$$r_m^2 = \frac{(r_{out}^2 - r_{in}^2)}{2 \ln(r_{out}/r_{in})} \qquad (B\text{-}26)$$

Therefore, summarizing

$$C_{PRF} = \frac{\overline{P}_2 - \overline{P}_1}{\frac{1}{2}\rho \overline{V}_1^2} = \cos^2\overline{\varphi}_1\left(1 - \frac{B_1^2}{B_2^2}\right) + \sin^2\overline{\varphi}_1\left(1 - \frac{r_{1m}^2}{r_{2m}^2}\right) \qquad (B\text{-}27)$$

$$\text{where} \quad r_m^2 = \frac{(r_{out}^2 - r_{in}^2)}{2 \ln(r_{out}/r_{in})}$$

APPENDIX C

DESIGN OF THE SWIRL GENERATOR

The swirl in the annulus is created by a set of vanes arranged radially at the inlet to the annulus. The vanes have an NACA 0012 cross-section and a three inch chord. The angle of the airfoils to the incoming flow may be varied from 0 degrees (no swirl) to 45 degrees. The vane arrangement and the inlet contours are shown in the figure on the next page. This type of arrangement introduces a vortex, similar to a free vortex, into the entering flow.

The vanes have a maximum tip diameter of twenty-four inches.

In order to establish a well behaved swirl or vortex, it was necessary to design a flow contour block. The incoming flow must be continuously accelerated up to the annulus velocity in order to avoid separation and consquent disruption of the swirl.

An analysis was carried out and was subsequently modified by United Aircraft of Canada Limited.

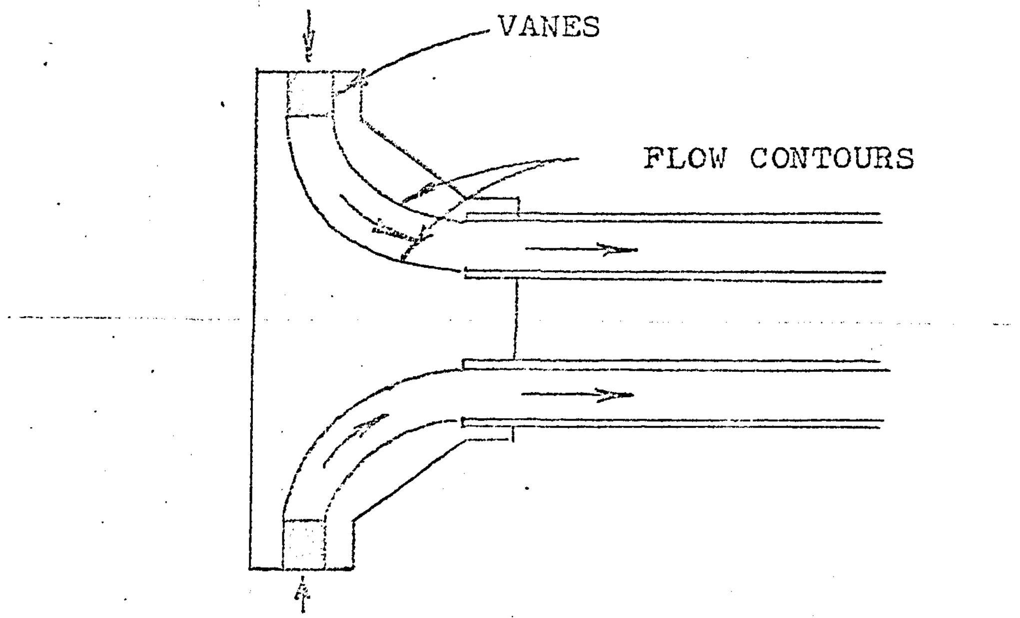


FIGURE C-1 SWIRL VANE UNIT

DESIGN ANALYSIS

The Schneider Analysis

Design Conditions: Using geometric conditions required for the annulus.

(a) hub radius (r_1HUB)= 2.5"

(b) tip radius (r_1TIP)= 4.0"

(c) mass flow rate (Q) =1867 cfm

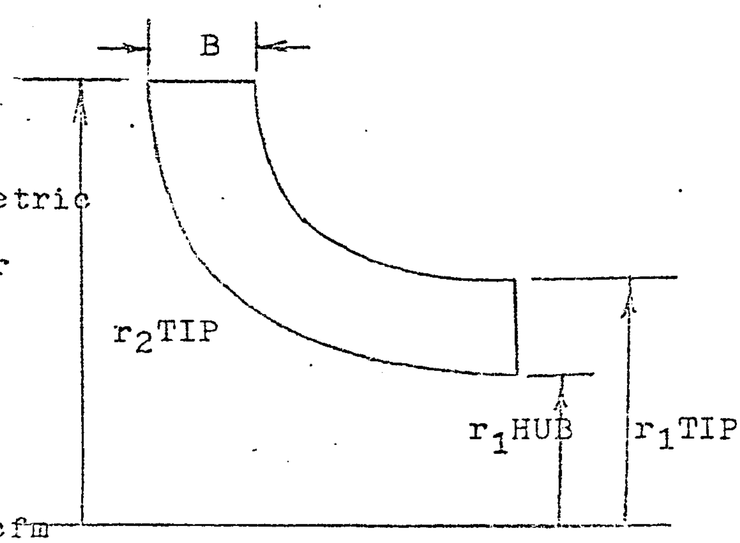


FIGURE C-2 FLOW CONTOURS

By the continuity equation $Q = VA$

$$\frac{1867}{60} = V \times \pi (4.0^2 - 2.5^2) \qquad (C-1)$$

$$V = \frac{1867 \times 144}{60 \times 30.7} = 146 \text{ ft/sec} \qquad (C-2)$$

$\therefore$ the velocity at the exit plane is to be 146.0 ft/sic

From these conditions and supposing an inlet radius (r_2TIP) of 11" the angular momentum and continuity equations are used to find the inlet opening "B".

$$T = \rho Q (r_2 V_2 \cos\alpha_2 - r_1 V_1 \cos\alpha_1) \qquad (C-3)$$

where T becomes zero as in passages where there are no vanes.

$$\therefore \quad \rho Q r_2 V_2 \cos\alpha_2 = \rho Q r_1 V_1 \cos\alpha_1 \qquad (C-4)$$

with

$$\alpha_2 = \alpha_1 = 0^\circ \quad (\alpha \text{ is the swirl angle})$$

$$r_2 V_2 = r_1 V_1 \qquad (C-5)$$

This rV = constant, which is free vortex motion with the tangential component of velocity varying inversely with radius.

Taking the mean value for r_2 of 3.25"

$$V_1 = 3.25 \times 146 \times 12 / (11 \times 12) = 43.044 \text{ ft/sec}$$

and $A = \frac{Q}{V} = \frac{1867 \times 144}{60 \times 43.044} = 2\pi r B \qquad (C-6)$

with r = 11" $B = \frac{1867 \times 144}{60 \times 43.044 \times 2\pi \times 11}$

= 1.503 inches

similar calculations for r = 13" yeild B = 1.503".

The duct profile submitted by the writer (called "Schneider analysis") was put through the U.A.C.I.

computer without any changes. The program used was UACL-D1118 :MULTIPLE PLANE COMPLETE RADIAL EQUILIBRIUM.

From the program output the velocity and pressure distributions were plotted versus sweep angle 0° for various planes as seen on profile (1), Figure (12A). The velocity distribution, for 0° swirl, Figure (12B), shows a fairly smooth acceleration along the tip contour which by itself would be acceptable. The hub velocity, on the other hand shows a peak at plane 4 and a sharp drop at plane 5. This drop is accompanied by a sharp increase in static pressure at plane 5 as seen in Figure (12C). The increase in static pressure is due mostly to the high curvature change from plane 4 to 5 (increase in curvature) hence the velocity in this region is lower (decreased).

Although the acceleration along the tip contour is smooth, the diffusion factor, defined as

$$D_{TIP} = 1 - \frac{\text{Velocity out}}{\text{Velocity max}} \qquad \text{(C-7)}$$

has a value of 0.0232.

This in itself is far from critical but in view of the flow conditions at the hub there is a possibility of flow distortion in the exit portion of the duct.

In the case of 45° swirl at the inlet, with the same profile, the flow conditions are greatly improved. As can be seen from Figure (12D), the velocity along both walls increases smoothly and the hump on the duct hub contour velocity curve disappears resulting in much improved flow conditions.

The Modified Analysis by United Aircraft Limited

The analysis in this case considers the same flow parameters and geometric conditions as in the Schneider analysis but differs in the duct profile. It was felt that the Schneider profile did not turn the flow early enough upstream but rather turned very late, as shown by the high curvatures at planes 4 and 5.

A comparison of the UACL profile, Profile 2, Figure (12F), and Profile 1, Figure (12A), show earlier turning in Profile 2 resulting in a continuous acceleration throughout the entire length of the duct. The advantage of early turning of the flow is that if any imperfections in the contours occur in a region of high curvature, the flow will feel these effects much more than in a region where curvatures are low. Therefore, with early turning, the flow can use the rest of the duct to stabalize itself, whereas when the flow is turned in the late stages there is no time for stabalization. Again this analysis was done for both 0^{0} and 45^{o} swirl angles at the inlet.

APPENDIX D

ERROR ANALYSIS

Accuracy of Measurements

The multitube tilting manometer used in the present investigation had a reading accuracy of 0.10 inches of water, and the radial position of the probe could be read to an accuracy of 0.01 inch. From wind tunnel calibration tests, using the test probe and a standard pitot static probe calibration curves were obtained for the static pressure and total pressure readings taken with the two probes.

Due to some inevitable fluctuations of the manometer readings, it was sometimes necessary to select an average reading. Secondly the manometer had sometimes slow response to the applied pressures. Care was taken to wait for some time before taking the readings. The static pressure tube was susceptible to greater error as non-alignment with the flow could cause greater error. It was more sensitive to non- alignment than the total pressure tube. It was estimated that the accuracy of the total pressure measurements was ± 0.20"H_2O and that of the static pressure measurements was ± 0.30"H_2O.

The error in the pressure recovery factor is analyzed below by incorporating the Uncertainity Analysis Standard Equation:

$$w_R = \left\{ \left(\frac{\partial R}{\partial x_1} w_1 \right)^2 + \left(\frac{\partial R}{\partial x_2} w_2 \right)^2 + ---- \left(\frac{\partial R}{\partial x_n} w_n \right)^2 \right\}^{\frac{1}{2}} \quad (D\text{-}1)$$

where R is a given function of the independent variable x_1, x_2, x_3 ----- x_n

w_R is the uncertainity in the result

w_1, w_2, w_3 ------ w_n are the uncertainities in the independent variables.

Equation for the Pressure Recovery Factor:

$$C_{PR} = \frac{P_{S_2} - P_{S_1}}{P_{Dyn_1}} = \frac{P_{S_2} - P_{S_1}}{P_{T_1} - P_{S_1}} \qquad (D-2)$$

Since P_{s2} was assumed to be equal to the ambient pressure,

$$P_{S2} = 0 \text{ gauge}$$

Therefore,

$$C_{PR} = -\frac{P_{S_1}}{P_{T_1} - P_{S_1}} \qquad (D-3)$$

Then, applying the General Equation for the Uncertainity Analysis,

$$w_{C_{PR}} = \left\{ \left(\frac{\partial C_{PR}}{\partial P_{S_1}} w_{P_{S_1}} \right)^2 + \left(\frac{\partial C_{PR}}{\partial P_{T_1}} w_{P_{T_1}} \right)^2 \right\}^{1/2} \qquad (D-4)$$

Upon differentiation:

$$\frac{\partial C_{PR}}{\partial P_{S_1}} = \frac{\partial}{\partial P_{S_1}} \left(-\frac{P_{S_1}}{P_{T_1} - P_{S_1}} \right) = -\frac{P_{T_1}}{(P_{T_1} - P_{S_1})^2} \qquad (D-5)$$

$$\frac{\partial C_{PR}}{\partial P_{T_1}} = \frac{\partial}{\partial P_{T_1}} \left(-\frac{P_{S_1}}{P_{T_1} - P_{S_1}} \right) = \frac{P_{S_1}}{(P_{T_1} - P_{S_1})^2} \qquad (D-6)$$

As an example, consider Diffuser A at maximum swirl condition: P_{s1}= -6.017" H_2O, P_{s2}= 0, and P_{T1}= 2.433" H_2O. Then

$$\frac{\partial C_{PR}}{\partial P_{S_1}} = \frac{-2.433(.707)}{[(2.433)(.707) - (-6.017)(.707)]^2} = -\frac{2.433}{50.5}$$

$$\frac{\partial C_{PR}}{\partial P_{T_1}} = \frac{(-6.017)(.707)}{[(2.433)(.707) - (-6.017)(.707)]^2} = -\frac{4.26}{50.5}$$

And the Uncertainity Values are:

$$w_{P_{S_1}} = \pm .10 \pm .20 = \pm .30 ''$$
$$w_{P_{T_1}} = \pm .10 \pm .10 = \pm .20 ''$$

The error in the Pressure Recovery Factor is

$$w_{C_{PR}} = \left\{ \left(-\frac{2.433}{50.5} \times .30 \right)^2 + \left(-\frac{4.26}{50.5} \times .20 \right)^2 \right\}^{\frac{1}{2}}$$
$$= 2.2 \%$$

From windtunnel calibration tests it was found that the accuracy of the yaw probes was approximately $\pm 2.0^{\circ}$.

A similar error analysis was carried out for the axial velocity.

$$V_a = V \cos\alpha \qquad (D-7)$$
$$= \left(\frac{2g}{12} (P_T - P_S) \left(\frac{\gamma_{H_2O}}{\gamma_{air}} - 1 \right) \right)^{\frac{1}{2}} \cos\alpha$$
$$= 70 (P_T - P_S)^{\frac{1}{2}} \cos\alpha$$

where P_T and P_S were measured in inches of water in a manometer.

Applying the Uncertainity Analysis, one obtains

$$w_{V_a} = \left\{ \left(\frac{\partial V_a}{\partial P_S} w_{P_S} \right)^2 + \left(\frac{\partial V_a}{\partial P_T} w_{P_T} \right)^2 + \left(\frac{\partial V_a}{\partial \alpha} w_{\alpha} \right)^2 \right\}^{\frac{1}{2}} \qquad (D-8)$$

where

$$\frac{\partial V_a}{\partial P_S} = -70 \cos\alpha \, \frac{1}{2} (P_T - P_S)^{-\frac{1}{2}} \qquad (D-9)$$
$$\frac{\partial V_a}{\partial P_T} = 70 \cos\alpha \, \frac{1}{2} (P_T - P_S)^{-\frac{1}{2}} \qquad (D-10)$$
$$\frac{\partial V_a}{\partial \alpha} = -70 (P_T - P_S)^{\frac{1}{2}} \sin\alpha \qquad (D-11)$$

Considering again Diffuser A at maximum swirl condition it is found that

$$\frac{\partial V_a}{\partial P_S} = -12.8 \quad , \quad \frac{\partial V_a}{\partial P_T} = 12.8 \quad , \quad \frac{\partial V_a}{\partial \alpha} = -68.0$$

And the Uncertainity Values are

$$w_{P_S} = \pm .30''$$

$$w_{P_T} = \pm .20''$$

$$w_{\alpha} = \pm 2^{\circ}$$

The error in the Axial Velocity is

$$w_{V_a} = \left\{ \left(-12.8 \times .30\right)^2 + \left(12.8 \times .20\right)^2 + \left(-\frac{68.0}{57.0} \times 2.0\right)^2 \right\}^{\frac{1}{2}}$$

$$= 5.2\%$$

APPENDIX-E

MASS-WEIGHTED AVERAGES

The mass weighted average Q is defined as

$$\overline{Q} = \frac{\int_{0}^{2\pi}\int_{r_i}^{r_o} Q\, dm}{\int_{0}^{2\pi}\int_{r_i}^{r_o} dm} \qquad (E-1)$$

where Q could be $\frac{P}{\gamma}$, $\frac{P}{\rho}$ or ψ and m is the mass flow across any section.

or

$$\overline{Q} = \frac{\int_{A} \gamma (VQ)\, dA}{\int_{A} \gamma V\, dA} \qquad (E-2)$$

For incompressible and axisymmetric flow

$$\overline{Q} = \frac{\int_{r_i}^{r_o} VQ\, r\, dr}{\int_{r_i}^{r_o} V\, r\, dr} \qquad (E-3)$$

where V is the velocity in the axial direction.

From the measured value of $\frac{P}{\gamma}$, $\frac{P}{\rho}$ and ψ, the mass weighted averages were obtained by a step by step numerical integration. A computer program was prepared to carry out this integration.

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INLET EXPERIMENTAL DATA

DIFFUSER A , L/H= 12.65
FLOW TEMPERATURE= 110°F
ROOM TEMPERATURE= 81.5°F
BAROMETRIC PRESSURE= 29.62"Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.[illegible]	1.833	4.73[illegible]	0.55[illegible]
0.28[illegible]	2.167	4.817	1.767
0.45[illegible]	2.067	5.067	2.367
0.610	2.167	5.30[illegible]	2.633
0.760	2.500	5.467	2.583
0.910	2.233	5.467	2.317
1.060	2.333	5.317	1.917
1.180	2.167	5.217	1.283
1.310	1.333	5.167	0.650
1.44[illegible]	[illegible].467	4.467	[illegible]

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	13[illegible]	13[illegible].321	1.552
0.28[illegible]	149.3[illegible]	149.311	1.738
0.45[illegible]	158.657	158.646	1.847
0.61[illegible]	163.395	163.384	1.9[illegible]8
0.76[illegible]	165.1[illegible]	165.[illegible]88	1.922
0.91[illegible]	162.349	162.338	1.89[illegible]
1.05[illegible]	156.5[illegible]9	156.498	1.822
1.18[illegible]	148.356	148.346	1.727
1.31[illegible]	139.134	139.124	1.62[illegible]
1.44	122.[illegible]	122.978	1.432

EXIT EXPERIMENTAL DATA

DIFFUSER B , L/H= 12.68
FLOW TEMPERATURE= 110 °F
ROOM TEMPERATURE= 81.5 °F
BAROMETRIC PRESSURE= 29.62 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.080	[illegible]	0.07[illegible]	1.3[illegible]
0.240	0.0	0.07[illegible]	1.3[illegible]
0.400	0.0	0.078	1.5[illegible]
0.550	0.0	0.07[illegible]	1.4[illegible]
0.700	0.0	0.07[illegible]	1.2[illegible]
0.850	0.0	0.074	0.95[illegible]
1.0[illegible]	0.0	[illegible]7[illegible]	[illegible]
1.150	0.0	0.07[illegible]	0.55[illegible]
1.290	0.0	0.07[illegible]	0.4[illegible]
1.430	[illegible]	0.07[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
0.24[illegible]	68.21[illegible]	6[illegible].[illegible]09	1.18[illegible]
0.4[illegible]	72.912	72.9[illegible]	1.273
0.55[illegible]	7[illegible].5[illegible]	7[illegible].54[illegible]	[illegible]
0.7[illegible]	65.[illegible]77	65.[illegible]57	1.[illegible]
0.85[illegible]	58.76[illegible]	58.74[illegible]	1.[illegible]26
1.0[illegible]	51.[illegible]	51.[illegible]54	[illegible]
1.15[illegible]	45.81[illegible]	45.[illegible]12	[illegible]
1.29[illegible]	39.[illegible]	39.[illegible]87	[illegible]
1.43[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER A L/H 12.65
FLOW TEMPERATURE 110 °F
ROOM TEMPERATURE 81.5°F
BAROMETRIC PRESSURE 29.62 "Hg
MASS WEIGHTED SWIRL ANGLE 1.976 °

COLD RESISTANCE OF HOT WIRE= 3.40 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.400	0.250
0.450	9.550	0.160
0.610	9.600	0.130
0.760	9.650	0.105
0.910	9.650	0.085
1.050	9.650	0.095
1.180	9.550	0.136
1.310	9.450	0.183

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	15.814
0.450	9.813
0.610	7.893
0.760	6.312
0.910	5.110
1.050	5.711
1.180	8.341
1.310	11.456

INLET EXPERIMENTAL DATA

DIFFUSER A , L/H=12.65
FLOW TEMPERATURE= 110 °F
ROOM TEMPERATURE= 82°F
BAROMETRIC PRESSURE= 29.6 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	4.167	4.817	0.267
0.280	5.833	4.883	1.683
0.450	5.433	5.117	2.367
0.610	5.333	5.350	2.650
0.760	5.600	5.567	2.733
0.910	5.333	5.583	2.567
1.050	5.167	5.500	2.133
1.180	5.000	5.400	1.450
1.310	4.500	5.217	0.867
1.440	4.[illegible]	4.950	0.017

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.090	132.489	132.166	9.243
0.280	149.107	148.744	10.413
0.450	159.19[illegible]	158.802	11.106
0.630	164.586	164.135	11.482
0.760	167.644	167.235	11.696
0.910	166.122	165.717	11.590
1.05	16[illegible].767	16[illegible].375	11.216
1.180	152.296	151.927	10.625
1.310	143.530	143.18[illegible]	10.013
1.440	[illegible]	[illegible]	9.[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER B , L/H= 12.62
FLOW TEMPERATURE= 110°F
ROOM TEMPERATURE= 82°F
BAROMETRIC PRESSURE= 22.6" Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.080	1.[illegible]	0.[illegible]7[illegible]	[illegible].95[illegible]
[illegible].24[illegible]	1.[illegible]	0.[illegible]7[illegible]	1.2[illegible]
[illegible].4[illegible]	1.5[illegible]	0.[illegible]7[illegible]	1.35[illegible]
[illegible].55[illegible]	1.8[illegible]	[illegible]7[illegible]	1.25[illegible]
[illegible].7[illegible]	2.8[illegible]	[illegible]7[illegible]	1.[illegible]
[illegible].85[illegible]	3.[illegible]	[illegible]7[illegible]	[illegible].85[illegible]
[illegible]	4.[illegible]	[illegible]7[illegible]	[illegible].6[illegible]
1.15[illegible]	4.[illegible]	[illegible]7[illegible]	[illegible].5[illegible]
1.29[illegible]	6.5[illegible]	[illegible]7[illegible]	[illegible].35[illegible]
[illegible].4[illegible]	[illegible]	[illegible]7[illegible]	[illegible].3[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
[illegible].24	55.977	55.[illegible]	7.4[illegible]
[illegible].4[illegible]	6[illegible].34[illegible]	62.[illegible]	7.851
[illegible].55	66.955	66.42[illegible]	7.[illegible]
[illegible].7[illegible]	6[illegible].[illegible]	61.186	6.97[illegible]
[illegible].85[illegible]	55.[illegible]4	55.456	6.31[illegible]
[illegible]	47.[illegible]3	47.3[illegible]	5.3[illegible]
[illegible].15	4[illegible]	4[illegible]	4.974
[illegible].29	37.7[illegible]	37.44[illegible]	4.27
[illegible].4[illegible]	[illegible]	[illegible]	[illegible]7

INLET TURBULENCE DATA

DIFFUSER A , L/H 12.65
FLOW TEMPERATURE 110.0°F
ROOM TEMPERATURE 82.0°F
BAROMETRIC PRESSURE 29.60" Hg
MASS WEIGHTED SWIRL ANGLE 3.532°

COLD RESISTANCE OF HOT WIRE 3.40 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.600	0.172
0.450	9.650	0.144
0.610	9.700	0.117
0.760	9.750	0.097
0.910	9.750	0.090
1.050	9.750	0.109
1.180	9.650	0.137
1.310	9.550	0.197

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	10.443
0.450	8.657
0.610	6.965
0.760	5.719
0.910	5.306
1.050	6.426
1.180	8.236
1.310	12.082

INLET EXPERIMENTAL DATA

DIFFUSER A , L/H=12.65
FLOW TEMPERATURE= 110.0°F
ROOM TEMPERATURE= 82.0°F
BAROMETRIC PRESSURE= 29.62 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.098	8.733	5.133	0.867
0.280	9.733	5.200	1.500
0.450	10.000	5.350	2.150
0.610	9.933	5.550	2.467
0.760	10.500	5.750	2.617
0.910	10.600	5.883	2.617
1.050	10.667	5.800	2.367
1.180	11.067	5.717	2.017
1.310	10.567	5.533	1.350
1.440	10.567	5.017	0.417

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.098	132.696	130.443	24.237
0.280	150.621	148.066	27.625
0.450	159.360	156.657	29.228
0.610	164.761	161.966	30.219
0.760	168.319	165.464	30.871
0.910	169.651	166.774	31.116
1.050	166.295	163.474	30.5[illegible]
1.180	161.827	159.082	29.68[illegible]
1.310	152.664	150.074	28.[illegible]
1.44[illegible]	135.[illegible]	13[illegible].[illegible]45	24.[illegible]70

EXIT EXPERIMENTAL DATA

DIFFUSER A , L/H= 12.65
FLOW TEMPERATURE= 110.0 °F
ROOM TEMPERATURE= 88.0 °F
BAROMETRIC PRESSURE= 29.62 "Hg

DIST FROM INNER SURF INCHES	[illegible]	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.[illegible]8[illegible]	4.[illegible]	0.07[illegible]	[illegible].8[illegible]
0.240	4.5[illegible]	[illegible].[illegible]7[illegible]	1.[illegible]5[illegible]
0.400	5.8[illegible]	0.07[illegible]	1.3[illegible]
0.550	5.8[illegible]	0.070	1.4[illegible]
0.7[illegible]	6.[illegible]	0.07[illegible]	1.350
0.850	7.0[illegible]	0.070	1.15[illegible]
1.0[illegible]	8.5[illegible]	0.07[illegible]	0.950
1.150	9.5[illegible]	0.07[illegible]	[illegible].75[illegible]
1.290	11.5[illegible]	0.07[illegible]	[illegible].5[illegible]
1.43[illegible]	11.5[illegible]	0.07[illegible]	[illegible].45[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	[illegible] VELOCITY FT/SEC	[illegible] VELOCITY FT/SEC	[illegible] VELOCITY FT/SEC
[illegible].24[illegible]	6[illegible].5[illegible]	4[illegible].[illegible]46	12.279
[illegible].4[illegible]	6[illegible].1[illegible]	64.742	13.59[illegible]
[illegible].55[illegible]	7[illegible]	69.[illegible]25	14.[illegible]67
[illegible].7[illegible]	[illegible]	67.969	13.[illegible]26
[illegible].85	64.27[illegible]	62.992	12.616
[illegible]	5[illegible].76[illegible]	57.[illegible]39	11.71[illegible]
[illegible].15[illegible]	5[illegible].6[illegible]	5[illegible].635	1[illegible].5[illegible]7
[illegible].2[illegible]	4[illegible]	4[illegible].[illegible]5	[illegible].74[illegible]
[illegible]	4[illegible]	4[illegible]	[illegible]7

INLET TURBULENCE DATA

DIFFUSER A ,L/H 12.65
FLOW TEMPERATURE 110.0 °F
ROOM TEMPERATURE 82.0 °F
BAROMETRIC PRESSURE 29.62 "Hg
MASS WEIGHTED SWIRL ANGLE 10.267 °

COLD RESISTANCE OF HOT WIRE= 3.40 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.500	0.183
0.450	9.600	0.135
0.610	9.650	0.110
0.760	9.700	0.098
0.910	9.700	0.110
1.050	9.670	0.127
1.180	9.650	0.165
1.310	9.550	0.280

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	11.338
0.450	8.197
0.610	6.613
0.760	5.834
0.910	6.548
1.050	7.605
1.180	9.919
1.310	17.172

INLET EXPERIMENTAL DATA

DIFFUSER A , L/H= 12.65
FLOW TEMPERATURE= 110.0°F
ROOM TEMPERATURE= 82.0°F
BAROMETRIC PRESSURE= 29.62 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	11.667	5.250	0.133
0.280	13.900	5.350	1.533
0.450	14.667	5.483	2.100
0.610	14.933	5.567	2.317
0.760	15.667	5.717	2.383
0.910	16.167	5.833	2.367
1.050	16.667	5.867	2.283
1.180	17.167	5.733	2.083
1.310	17.333	5.567	1.617
1.440	17.333	5.083	0.79[illegible]

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.090	[illegible]	[illegible].376	4[illegible].227
0.280	152.664	145.73[illegible]	45.488
0.450	16[illegible].239	152.961	47.745
0.610	16[illegible].388	155.967	48.684
0.760	165.612	159.[illegible]89	49.346
0.910	166.631	159.[illegible]62	49.65[illegible]
1.050	16[illegible].122	158.576	49.498
1.180	162.[illegible]82	155.293	48.473
1.310	155.966	148.882	46.472
1.440	13[illegible].934	13[illegible].578	4[illegible].695

EXIT EXPERIMENTAL DATA

DIFFUSER A , L/H= 12.65
FLOW TEMPERATURE= 110.0 °F
ROOM TEMPERATURE= 82.0 °F
BAROMETRIC PRESSURE= 29.62 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER [illegible] SLOPE	PT TOTAL PRESSURE INCHES WATER [illegible] SLOPE
0.080	9.[illegible]	0.[illegible]7[illegible]	[illegible].7[illegible]
0.240	9.500	0.07[illegible]	1.[illegible]
0.400	9.[illegible]	0.07[illegible]	1.250
0.55[illegible]	9.[illegible]	[illegible].07[illegible]	1.4[illegible]
0.7[illegible]	1[illegible].2[illegible]	[illegible].[illegible]7	1.45[illegible]
0.850	1[illegible]	0.[illegible]7[illegible]	1.4[illegible]
1.0[illegible]	12.[illegible]	0.[illegible]7[illegible]	1.2[illegible]
1.150	13.5[illegible]	0.07[illegible]	1.[illegible]
1.29[illegible]	16.500	0.07[illegible]	[illegible].7[illegible]
1.4[illegible]	17.[illegible]	[illegible]7	[illegible].6[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	[illegible] VELOCITY FT/SEC	[illegible] VELOCITY FT/SEC	[illegible] VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible].[illegible]	62.[illegible]	10.[illegible]
[illegible].55	7[illegible].5[illegible]	67.44[illegible]	[illegible].6[illegible]
[illegible].7	7[illegible].74[illegible]	6[illegible].6[illegible]6	[illegible].[illegible]7[illegible]
[illegible]	7[illegible].5[illegible]	67.44[illegible]	[illegible].6[illegible]
[illegible]	65.[illegible]77	62.72[illegible]	1[illegible].17[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	4[illegible]	1[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER A ,L/H 12.65
FLOW TEMPERATURE 110.0 °F
ROOM TEMPERATURE 82.0 °F
BAROMETRIC PRESSURE 29.62 "Hg
MASS WEIGHTED SWIRL ANGLE 15.603 °

COLD RESISTANCE OF HOT WIRE= 3.40 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.750	0.145
0.450	9.850	0.108
0.610	9.850	0.090
0.760	9.850	0.087
0.910	9.850	0.105
1.050	9.850	0.122
1.180	9.800	0.162
1.310	9.750	0.260

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	8.549
0.450	6.247
0.610	5.206
0.760	5.032
0.910	6.074
1.050	7.057
1.180	9.460
1.310	15.329

INLET EXPERIMENTAL DATA

DIFFUSER A , L/H= 12.65
FLOW TEMPERATURE= 110.0°F
ROOM TEMPERATURE= 82.0°F
BAROMETRIC PRESSURE= 29.62 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	19.833	5.767	0.833
0.280	21.433	5.950	1.600
0.450	22.167	6.050	2.217
0.610	22.900	6.000	2.350
0.760	24.000	6.017	2.433
0.910	24.667	6.067	2.433
1.050	25.833	6.083	2.433
1.180	26.333	6.050	2.400
1.310	26.333	5.917	2.117
1.440	26.833	5.333	1.283

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.090	14[illegible].14[illegible]	125.[illegible]47	63.266
0.290	159.89[illegible]	142.67[illegible]	72.182
0.450	167.31[illegible]	149.291	75.531
0.610	168.149	15[illegible].[illegible]38	75.91[illegible]
0.760	169.152	15[illegible].934	76.363
0.910	169.651	151.38[illegible]	76.588
1.050	169.911	151.532	76.660
1.180	169.152	15[illegible].934	76.363
1.310	164.935	147.172	74.459
1.440	149.674	133.558	67.57[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER A , L/H= 12.65
FLOW TEMPERATURE= 110.0 °F
ROOM TEMPERATURE= 82.0 °F
BAROMETRIC PRESSURE= 29.62 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.[illegible]8[illegible]	15.[illegible]	[illegible]	[illegible].6[illegible]
[illegible].240	16.50[illegible]	[illegible]	[illegible].8[illegible]
[illegible].4[illegible]	16.50[illegible]	[illegible]	1.[illegible]
0.550	14.[illegible]	[illegible]	1.2[illegible]
[illegible].7[illegible]	15.2[illegible]	[illegible]	1.4[illegible]
[illegible].850	14.[illegible]	[illegible]	1.45[illegible]
1.[illegible]	16.[illegible]	[illegible]	1.4[illegible]
1.150	17.5[illegible]	[illegible]	1.2[illegible]
1.29[illegible]	21.[illegible]	2.0	[illegible].9[illegible]
1.43[illegible]	2[illegible].[illegible]	[illegible]	[illegible].9[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
[illegible].240	5[illegible].[illegible]47	48.[illegible]	1[illegible].[illegible]54
[illegible].4[illegible]	5[illegible].[illegible]9[illegible]	54.[illegible]	2[illegible].[illegible]56
[illegible].55[illegible]	[illegible].7[illegible]	5[illegible]	2[illegible].[illegible]
[illegible].7[illegible]	6[illegible]	6[illegible].[illegible]77	[illegible].677
[illegible].85[illegible]	7[illegible]7[illegible]	6[illegible]	2[illegible]
1.[illegible]	6[illegible].[illegible]5[illegible]	[illegible]4.277	24.677
1.15[illegible]	65.[illegible]	6[illegible].[illegible]	2[illegible]
1.2[illegible]	5[illegible].[illegible]	5[illegible].5[illegible]6	1[illegible].7[illegible]
1.4[illegible]	5[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER A , L/H 12.65
FLOW TEMPERATURE 110.0 °F
ROOM TEMPERATURE 82.0 °F
BAROMETRIC PRESSURE 29.62 "Hg
MASS WEIGHTED SWIRL ANGLE 24.065 °

COLD RESISTANCE OF HOT WIRE= 3.40 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.750	0.168
0.450	9.850	0.121
0.610	9.850	0.105
0.760	9.900	0.098
0.910	9.900	0.112
1.050	9.900	0.125
1.180	9.850	0.155
1.310	9.800	0.255

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	9.905
0.450	6.999
0.610	6.074
0.760	5.616
0.910	6.418
1.050	7.163
1.180	8.966
1.310	14.891

INLET EXPERIMENTAL DATA

DIFFUSER *B* , L/H= *6.35*
FLOW TEMPERATURE= *110.0°F*
ROOM TEMPERATURE= *80.0°F*
BAROMETRIC PRESSURE= *29.80"Hg*

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	1.333	3.617	1.300
0.280	1.767	3.667	2.283
0.451	1.600	3.817	3.217
0.610	1.800	3.967	3.450
0.760	2.033	4.000	3.467
0.910	1.733	3.967	3.217
1.050	1.933	3.867	2.817
1.190	1.667	3.750	2.267
1.310	1.167	3.617	1.650
1.440	0.533	3.183	0.767

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
0.280	141.943	141.935	1.239
0.450	154.330	154.324	1.347
0.610	158.476	158.469	1.383
0.760	159.[illegible]9	159.[illegible]3	1.398
0.910	155.966	155.961	1.361
1.050	15[illegible].441	15[illegible].435	1.313
1.190	142.738	142.732	1.246
1.310	132.9[illegible]	132.9[illegible]5	1.16[illegible]
1.440	115.65[illegible]	115.64[illegible]	[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER *B* , L/H= *6.35*
FLOW TEMPERATURE= *110.0°F*
ROOM TEMPERATURE= *80.0°F*
BAROMETRIC PRESSURE= *29.80"Hg*

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.080	[illegible].5[illegible]	0.3[illegible]	1.55[illegible]
0.250	1.500	0.3[illegible]	2.70[illegible]
0.410	1.500	0.30[illegible]	3.25[illegible]
0.57[illegible]	2.5[illegible]	0.3[illegible]	3.7[illegible]
0.72[illegible]	2.[illegible]	0.3[illegible]	3.7[illegible]
0.87[illegible]	1.[illegible]	0.2[illegible]	2.[illegible]
1.0[illegible]	1.[illegible]	0.3[illegible]	2.[illegible]
1.160	1.[illegible]	0.3[illegible]	1.2[illegible]
1.3[illegible]	0.5[illegible]	0.2[illegible]	0.5[illegible]
1.4[illegible]	0.5[illegible]	[illegible].3[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	.6[illegible]
.25[illegible]	[illegible].788	[illegible].784	[illegible]
.41[illegible]	[illegible].68[illegible]	[illegible].634	.957
.57[illegible]	[illegible].38[illegible]	[illegible]6.375	[illegible]
.72[illegible]	[illegible].3[illegible]	[illegible]6.375	[illegible]
.87[illegible]	[illegible]6.[illegible]5	[illegible]6.5[illegible]	.9[illegible]
[illegible]	[illegible].26[illegible]	[illegible].2[illegible]	.77
[illegible].16[illegible]	7[illegible]	7[illegible]	.6[illegible]
[illegible]	[illegible].47	[illegible]	.454
[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER B , L/H 6.35
FLOW TEMPERATURE 110.0 °F
ROOM TEMPERATURE 80.0 °F
BAROMETRIC PRESSURE 29.20 "Hg
MASS WEIGHTED SWIRL ANGLE 1.582 °

COLD RESISTANCE OF HOT WIRE= 3.38 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.750	0.145
0.450	9.800	0.108
0.610	9.850	0.084
0.760	9.820	0.094
0.910	9.800	0.122
1.050	9.720	0.155
1.180	9.650	0.250
1.310	9.600	0.255

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	8.549
0.450	6.307
0.610	4.975
0.760	5.468
0.910	7.124
1.050	9.191
1.180	15.029
1.310	15.483

INLET EXPERIMENTAL DATA

DIFFUSER B , L/H= 6.35"
FLOW TEMPERATURE= 110.0 °F
ROOM TEMPRATURE= 70.0 °F
BAROMETRIC PRESSURE= 29.443 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	4.167	3.950	1.583
0.280	4.333	3.983	2.400
0.450	4.500	4.100	3.000
0.610	4.500	4.267	3.350
0.760	5.033	4.433	3.500
0.910	4.867	4.550	3.483
1.050	4.667	4.567	3.2[illegible]
1.180	4.667	4.432	2.583
1.310	4.500	4.117	2.017
1.440	4.500	3.733	[illegible].950

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	136.876	136.456	10.741
0.29[illegible]	147.[illegible]15	146.561	11.536
0.45[illegible]	155.[illegible]52	154.574	12.167
0.61[illegible]	16[illegible].598	16[illegible].[illegible]3	12.602
0.76[illegible]	162.895	163.39[illegible]	12.861
0.91[illegible]	164.925	164.417	12.942
1.05[illegible]	162.172	161.672	12.725
1.18[illegible]	154.132	153.657	12.095
1.31[illegible]	144.119	143.674	11.319
1.44	[illegible]	125.536	9.881

EXIT EXPERIMENTAL DATA

DIFFUSER *B* , L/H= *6.35*
FLOW TEMPERATURE= *110.0 °F*
ROOM TEMPERATURE= *73.0 °F*
BAROMETRIC PRESSURE= *29.43 "Hg*

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.18[illegible]	3.[illegible]	0.35[illegible]	2.25[illegible]
0.25[illegible]	3.5[illegible]	[illegible].35[illegible]	2.7[illegible]
0.410	3.50[illegible]	0.35[illegible]	3.[illegible]
0.570	3.5[illegible]	0.35[illegible]	2.35[illegible]
0.72[illegible]	3.5[illegible]	[illegible].35[illegible]	3.35[illegible]
0.87[illegible]	3.[illegible]	[illegible].35[illegible]	2.[illegible]
1.01[illegible]	4.[illegible]	[illegible].35[illegible]	2.5[illegible]
1.15[illegible]	3.5[illegible]	[illegible].35[illegible]	2.[illegible]
1.3[illegible]	3.5[illegible]	[illegible].35[illegible]	[illegible].7[illegible]
1.43[illegible]	[illegible].5[illegible]	[illegible].35[illegible]	[illegible].55[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
[illegible].25[illegible]	[illegible].4[illegible]	[illegible].435	6.2[illegible]5
[illegible].41[illegible]	[illegible].17[illegible]	[illegible].966	6.7[illegible]
[illegible].57[illegible]	[illegible]	[illegible].722	6.8[illegible]
[illegible].72[illegible]	[illegible]	[illegible]	[illegible]
[illegible].87[illegible]	[illegible]	[illegible]	6.[illegible]
1.[illegible]	[illegible].2[illegible]6	[illegible]	5.[illegible]
1.1[illegible]	[illegible]	[illegible].[illegible]27	[illegible].64[illegible]
1.3[illegible]	[illegible]	[illegible].16	5.[illegible]7
1.4[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER B , L/H 4.35
FLOW TEMPERATURE 110.0 °F
ROOM TEMPERATURE 78.0 °F
BAROMETRIC PRESSURE 29.43 "Hg
MASS WEIGHTED SWIRL ANGLE 4.285 °

COLD RESISTANCE OF HOT WIRE= 3.56 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.750	0.128
0.450	9.750	0.090
0.610	9.800	0.098
0.760	9.750	0.127
0.910	9.700	0.152
1.050	9.650	0.177
1.180	9.550	0.275
1.310	9.400	0.280

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	7.546
0.450	5.306
0.610	5.723
0.760	7.487
0.910	9.049
1.050	10.641
1.180	16.866
1.310	17.712

INLET EXPERIMENTAL DATA

DIFFUSER B , L/H= 6.35
FLOW TEMPERATURE= 118 °F
ROOM TEMPERATURE= 86.0 °F
BAROMETRIC PRESSURE= 29.46 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	9.767	3.550	1.500
0.280	10.833	3.633	3.317
0.450	11.167	3.683	4.050
0.610	11.500	3.7[illegible]	4.283
0.760	11.933	3.817	4.350
0.910	12.033	3.883	4.267
1.050	11.933	3.833	4.083
1.180	12.233	3.817	3.717
1.310	12.500	3.733	3.017
1.440	12.7[illegible]	3.[illegible]50	1.750

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.090	13[illegible].766	127.566	28.752
0.280	153.4[illegible]5	149.659	33.73[illegible]
0.450	161.816	157.856	35.579
0.610	164.411	16[illegible].388	36.15[illegible]
0.760	166.295	162.226	36.564
0.910	166.122	162.057	36.526
1.050	163.72[illegible]	159.712	35.998
1.180	159.721	155.812	35.118
1.310	151.182	147.482	33.241
1.440	127.4[illegible]3	124.[illegible]	28.[illegible]33

EXIT EXPERIMENTAL DATA

DIFFUSER B , L/H= 6.35
FLOW TEMPERATURE= 110.0°F
ROOM TEMPERATURE= 86.0°F
BAROMETRIC PRESSURE= 29.[illegible] "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER ABOVE SLOPE	PT TOTAL PRESSURE INCHES WATER ABOVE SLOPE
0.08[illegible]	5.5[illegible]	0.37[illegible]	1.4[illegible]
0.25[illegible]	4.5[illegible]	0.37[illegible]	2.25[illegible]
0.41[illegible]	5.0[illegible]	0.37[illegible]	3.2[illegible]
0.57[illegible]	4.5[illegible]	0.37[illegible]	3.7[illegible]
0.72[illegible]	5.[illegible]	0.37[illegible]	3.7[illegible]
0.87[illegible]	5.7[illegible]	0.37[illegible]	3.7[illegible]
1.0[illegible]	6.2[illegible]	0.37[illegible]	3.4[illegible]
1.16[illegible]	7.5[illegible]	0.37[illegible]	2.3[illegible]
1.3[illegible]	1[illegible].5[illegible]	0.37[illegible]	1.4[illegible]
1.4[illegible]	[illegible]	[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
[illegible].25[illegible]	[illegible]	[illegible]	[illegible]
0.41[illegible]	[illegible].967	[illegible]4.264	34.[illegible]
[illegible].57	[illegible]7.[illegible]	[illegible].326	37.2[illegible]4
[illegible].72	[illegible]7.[illegible]	[illegible]	37.[illegible]
[illegible].87	[illegible]	[illegible].326	37.2[illegible]4
[illegible]	[illegible]	[illegible]7.144	3[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
1.[illegible]	77.4[illegible]7	7[illegible].415	24.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER B , L/H 6.35
FLOW TEMPERATURE 118.0 °F
ROOM TEMPERATURE 86.0°F
BAROMETRIC PRESSURE 28.44 "Hg
MASS WEIGHTED SWIRL ANGLE 11.680 °

COLD RESISTANCE OF HOT WIRE= 3.44 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.750	0.165
0.450	9.850	0.125
0.610	9.870	0.098
0.760	9.870	0.094
0.910	9.870	0.106
1.050	9.850	0.135
1.180	9.820	0.170
1.310	9.750	0.260

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	9.728
0.450	7.231
0.610	5.648
0.760	5.417
0.910	6.109
1.050	7.809
1.180	9.889
1.310	15.329

INLET EXPERIMENTAL DATA

DIFFUSER B , L/H= 6.85
FLOW TEMPERATURE= 119.0°F
ROOM TEMPERATURE= 84.0°F
BAROMETRIC PRESSURE= 29.46 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	13.867	3.750	1.283
0.280	15.333	3.867	3.233
0.450	16.233	3.917	3.867
0.610	16.500	3.917	4.083
0.760	17.133	3.900	4.133
0.910	17.733	3.900	4.133
1.050	17.933	3.883	4.033
1.180	18.833	3.933	3.833
1.310	19.333	3.733	3.283
1.440	19.5[illegible]	3.25[illegible]	2.217

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS. VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.090	13[illegible].545	12[illegible].[illegible]56	43.582
0.290	155.[illegible]52	146.156	53.764
0.450	162.349	153.035	54.2[illegible]
0.610	164.586	155.143	54.947
0.760	164.925	155.463	55.06[illegible]
0.910	164.925	155.463	55.06[illegible]
1.050	163.72[illegible]	154.327	54.658
1.1[illegible]	162.161	152.857	54.137
1.310	154.132	145.289	51.457
1.44[illegible]	137.[illegible]56	129.419	45.856

EXIT EXPERIMENTAL DATA

DIFFUSER B , L/H= 6.35
FLOW TEMPERATURE= 119.0 °F
ROOM TEMPERATURE= 84.0 °F
BAROMETRIC PRESSURE= 28.446 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45 DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45 DEG SLOPE
[illegible]	11.0[illegible]	0.42[illegible]	1.[illegible]5[illegible]
0.25[illegible]	[illegible]	[illegible]42[illegible]	1.85[illegible]
0.41[illegible]	1[illegible]	0.42[illegible]	2.45[illegible]
0.57[illegible]	10.5[illegible]	[illegible]42[illegible]	3.4[illegible]
0.72[illegible]	[illegible]	0.42[illegible]	3.75[illegible]
0.87[illegible]	11.5[illegible]	[illegible]42[illegible]	3.65[illegible]
1.01[illegible]	13.[illegible]	0.42[illegible]	2.75[illegible]
1.16[illegible]	16.[illegible]	[illegible]42[illegible]	2.[illegible]
1.30[illegible]	19.50[illegible]	[illegible]42[illegible]	[illegible]
1.42[illegible]	2[illegible].5[illegible]	[illegible]42[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	GAS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]25[illegible]	87.471	[illegible]	34.962
[illegible]41[illegible]	[illegible]	[illegible]	39.3[illegible]
[illegible]57[illegible]	11[illegible]	[illegible]	45.35[illegible]
[illegible]72[illegible]	[illegible]	[illegible]	67.35[illegible]
[illegible]87[illegible]	[illegible]	[illegible]	44.9[illegible]
[illegible]	[illegible]	[illegible]	41.317
[illegible]16[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER 5 , L/H 6.35
FLOW TEMPERATURE 119.0 °F
ROOM TEMPERATURE 84.0 °F
BAROMETRIC PRESSURE 29.44 "Hg
MASS WEIGHTED SWIRL ANGLE 17.269 °

COLD RESISTANCE OF HOT WIRE= 5.42 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.850	0.146
0.450	9.950	0.110
0.610	9.970	0.094
0.760	9.970	0.100
0.910	9.950	0.117
1.050	9.920	0.142
1.180	9.900	0.175
1.310	9.850	0.250

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	8.445
0.450	6.246
0.610	5.318
0.760	5.657
0.910	6.643
1.050	8.107
1.180	10.029
1.310	14.461

INLET EXPERIMENTAL DATA

DIFFUSER *B* , L/H= *6.35*
FLOW TEMPERATURE= *119.5 °F*
ROOM TEMPERATURE= *87.0 °F*
BAROMETRIC PRESSURE= *29.41 "Hg*

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	20.333	4.233	0.800
0.280	22.333	4.400	3.200
0.450	23.700	4.417	3.933
0.610	24.667	4.317	4.167
0.760	25.667	4.200	4.283
0.910	26.067	4.250	4.317
1.050	26.667	4.267	4.350
1.180	27.067	4.183	4.300
1.310	27.733	4.050	3.917
1.440	28.667	3.633	3.[illegible]83

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	114.539	62.032
0.280	16[illegible].419	14[illegible].75	76.965
0.450	168.148	147.532	81.673
0.610	169.492	148.711	81.318
0.760	170.478	149.576	81.791
0.910	17[illegible].319	149.436	81.715
1.050	17[illegible].815	149.972	81.953
1.180	169.482	148.732	81.313
1.310	164.266	144.108	78.821
1.44	[illegible]	132.211	72.35[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER B , L/H=6.35
FLOW TEMPERATURE= 119.5 °F
ROOM TEMPERATURE= 82.0 °F
BAROMETRIC PRESSURE= 29.41 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.18[illegible]	16.[illegible]	0.42[illegible]	0.8[illegible]
0.25[illegible]	16.[illegible]	0.42[illegible]	2.15[illegible]
0.41[illegible]	15.[illegible]	0.42[illegible]	2.45[illegible]
0.57[illegible]	15.[illegible]	0.42[illegible]	3.15[illegible]
0.72[illegible]	16.[illegible]	0.42[illegible]	3.4[illegible]
0.87[illegible]	17.[illegible]	0.42[illegible]	3.45[illegible]
1.0[illegible]	19.[illegible]	0.42[illegible]	3.15[illegible]
1.16[illegible]	2[illegible]	0.42[illegible]	2.8[illegible]
1.3[illegible]	22.[illegible]	0.42[illegible]	2.40[illegible]
1.43[illegible]	28.5[illegible]	0.42[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]517
[illegible]41	[illegible]	8[illegible]	47.[illegible]44
[illegible]57	[illegible]	[illegible]5.[illegible]57	[illegible]
[illegible]72	[illegible]12.73[illegible]	[illegible]	[illegible]274
[illegible]87	[illegible]4.473	[illegible]07	[illegible]
[illegible]	[illegible]	[illegible]57	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]872	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER B , L/H 6.35
FLOW TEMPERATURE 119.5 °F
ROOM TEMPERATURE 87.0 °F
BAROMETRIC PRESSURE 29.41 "Hg
MASS WEIGHTED SWIRL ANGLE 28.357°

COLD RESISTANCE OF HOT WIRE= 3.42 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.900	0.148
0.450	9.970	0.108
0.610	10.000	0.096
0.760	10.000	0.098
0.910	9.970	0.105
1.050	9.950	0.125
1.180	9.950	0.148
1.310	9.900	0.235

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	8.481
0.450	6.110
0.610	5.401
0.760	5.514
0.910	5.940
1.050	7.097
1.180	8.403
1.310	13.467

INLET EXPERIMENTAL DATA.

DIFFUSER C , L/H= 3.13
FLOW TEMPERATURE= 100.0 °F
ROOM TEMPERATURE= 70.0 °F
BAROMETRIC PRESSURE= 29.60 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	1.733	2.533	2.467
0.280	0.900	2.633	3.783
0.450	0.833	2.767	4.367
0.610	0.667	3.000	4.683
0.760	0.833	3.133	4.683
0.910	0.833	3.167	4.450
1.050	0.833	3.117	4.050
1.190	0.633	3.017	3.517
1.310	0.400	2.950	2.850
1.440	0.333	2.533	1.950

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.090	[illegible]	[illegible]	0.756
0.280	147.394	147.392	0.857
0.450	155.423	155.420	0.903
0.610	161.292	161.290	0.938
0.760	162.682	162.631	0.946
0.910	160.599	160.595	0.934
1.050	155.782	155.779	0.956
1.190	148.743	148.741	0.865
1.310	139.535	139.532	0.811
1.440	[illegible]	[illegible]	0.716

EXIT EXPERIMENTAL DATA

DIFFUSER C , L/H=3.13
FLOW TEMPERATURE=100.0 °F
ROOM TEMPERATURE= 70.0 °F
BAROMETRIC PRESSURE=29.68 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45 DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45 DEG SLOPE
0.090	0.5[illegible]	0.650	4.[illegible]
0.260	0.5[illegible]	0.65[illegible]	4.[illegible]
0.420	0.5[illegible]	0.65[illegible]	5.2[illegible]
0.53[illegible]	0.5[illegible]	0.65[illegible]	5.25[illegible]
0.73[illegible]	0.[illegible]	0.65[illegible]	4.65[illegible]
0.880	0.[illegible]	0.65[illegible]	3.6[illegible]
1.[illegible]20	0.[illegible]	0.65[illegible]	2.[illegible]
1.1[illegible]	0.[illegible]	0.65[illegible]	[illegible].4[illegible]
1.3[illegible]	0.[illegible]	0.65[illegible]	1.[illegible]
1.43[illegible]	[illegible]	[illegible].65[illegible]	[illegible].7[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	RS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
[illegible].26[illegible]	135.946	135.944	[illegible]
[illegible].42[illegible]	14[illegible].74[illegible]	141.743	[illegible]
[illegible].58[illegible]	[illegible]	141.343	[illegible]
[illegible].73[illegible]	13[illegible].9[illegible]3	13[illegible].962	[illegible]
[illegible].88[illegible]	119.962	119.962	[illegible]
1.[illegible]	94.72[illegible]	94.726	[illegible]
1.[illegible]	83.31[illegible]	83.315	[illegible]
1.3	74.71[illegible]	74.714	[illegible]
1.4[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER C , L/H 3.13
FLOW TEMPERATURE 100.0 °F
ROOM TEMPERATURE 70.0 °F
BAROMETRIC PRESSURE 29.68 "Hg
MASS WEIGHTED SWIRL ANGLE 10.785

COLD RESISTANCE OF HOT WIRE= 3.33 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.800	0.128
0.450	9.850	0.091
0.610	9.850	0.087
0.760	9.850	0.110
0.910	9.800	0.132
1.050	9.700	0.167
1.180	9.600	0.255
1.310	9.500	0.260

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	7.474
0.450	5.264
0.610	5.032
0.760	6.363
0.910	7.708
1.050	9.942
1.180	15.483
1.310	16.109

INLET EXPERIMENTAL DATA

DIFFUSER *C* , L/H= *3.13*
FLOW TEMPERATURE= *106.0 °F*
ROOM TEMPERATURE= *73.0 °F*
BAROMETRIC PRESSURE= *29.57 "Hg*

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	2.500	2.450	2.600
0.280	3.000	2.567	4.167
0.450	3.300	2.650	4.700
0.610	3.667	2.767	4.917
0.760	3.933	2.867	4.933
0.910	3.667	2.917	4.767
1.050	3.833	2.850	4.417
1.180	3.933	2.750	3.833
1.310	3.923	2.650	3.033
1.440	3.500	2.633	2.200

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	7.984
0.280	[illegible]	150.721	9.22[illegible]
0.450	157.758	157.464	9.632
0.610	161.302	161.0[illegible]2	9.849
0.760	162.516	162.213	9.923
0.910	161.3[illegible]3	161.[illegible]2	9.849
1.050	156.865	156.572	9.578
1.180	149.3[illegible]	149.[illegible]22	9.116
1.310	138.719	138.461	8.470
1.44	127.925	127.687	7.811

EXIT EXPERIMENTAL DATA

DIFFUSER C , L/H=3.18
FLOW TEMPERATURE=106.0 °F
ROOM TEMPERATURE= 78.0 °F
BAROMETRIC PRESSURE=29.57 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	0.0	0.6[illegible]	1.500
0.260	2.500	0.6[illegible]	3.9[illegible]
0.420	2.5[illegible]	0.600	4.45[illegible]
0.590	3.[illegible]	0.6[illegible]	4.95
0.730	3.[illegible]	0.6[illegible]	4.95[illegible]
0.890	3.[illegible]	0.600	4.6[illegible]
1.0[illegible]0	3.[illegible]	0.600	3.80[illegible]
1.160	3.200	0.6[illegible]	2.4[illegible]
1.300	3.2[illegible]	0.6[illegible]	1.[illegible]
1.430	3.2[illegible]	[illegible].6[illegible]	[illegible].45[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
.26	123.44[illegible]	123.[illegible]47	6.991
.42	13[illegible].756	[illegible]3[illegible].562	7.7[illegible]
.59	137.[illegible]	136.877	7.65[illegible]
.73	137.[illegible]86	136.873	7.650
.89	13[illegible].[illegible]	13[illegible].487	7.4[illegible]
1.[illegible]	12[illegible].[illegible]	[illegible]21.97[illegible]	6.914
[illegible]	[illegible].7[illegible]	[illegible].6[illegible]	5.627
1.30	73.[illegible]	73.4[illegible]	4.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER C , L/H 3.13
FLOW TEMPERATURE 106.0 °F
ROOM TEMPERATURE 73.0 °F
BAROMETRIC PRESSURE 29.51 " Hg
MASS WEIGHTED SWIRL ANGLE 3.532 °

COLD RESISTANCE OF HOT WIRE= 3.34 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.650	0.168
0.450	9.700	0.115
0.610	9.750	0.086
0.760	9.750	0.092
0.910	9.720	0.117
1.050	9.700	0.140
1.180	9.650	0.172
1.310	9.600	0.198

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	10.100
0.450	6.846
0.610	5.070
0.760	5.424
0.910	6.938
1.050	8.334
1.180	10.340
1.310	12.022

INLET EXPERIMENTAL DATA

DIFFUSER C , L/H=3.13
FLOW TEMPERATURE= 104.0 °F
ROOM TEMPERATURE= 74.0 °F
BAROMETRIC PRESSURE= 29.47 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	6.333	2.617	2.333
0.280	7.000	2.667	3.867
0.450	7.667	2.750	4.500
0.610	7.667	2.833	4.783
0.760	8.000	2.933	4.900
0.917	8.000	3.050	4.817
1.050	7.833	2.983	4.633
1.180	8.167	2.933	4.300
1.310	8.167	2.833	3.567
1.440	8.000	2.800	2.633

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
0.280	149.743	147.295	21.704
0.450	156.681	155.156	21.809
0.610	161.597	159.024	22.352
0.760	162.859	161.274	22.669
0.910	163.212	161.622	22.718
1.050	161.597	159.024	22.352
1.180	156.497	154.974	21.783
1.310	147.219	145.777	20.498
1.440	[illegible]	[illegible]	[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER C , L/H= 3.48
FLOW TEMPERATURE= 104.0°F
ROOM TEMPERATURE= 74.0°F
BAROMETRIC PRESSURE= 29.47 "Hg

DIST	SWIRL ANGLE	PS	PT
FROM INNER SURF INCHES		STATIC PRESSURE INCHES WATER 45DEG SLOPE	TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.09[illegible]	5.[illegible]	0.7[illegible]	2.[illegible]
0.26[illegible]	5.[illegible]	0.7[illegible]	3.25[illegible]
0.42[illegible]	5.5[illegible]	0.7[illegible]	4.1[illegible]
0.58[illegible]	6.0[illegible]	0.7[illegible]	4.7[illegible]
0.73[illegible]	6.5[illegible]	0.7[illegible]	4.9[illegible]
0.88[illegible]	7.0[illegible]	0.7[illegible]	4.8[illegible]
1.0[illegible]	7.2[illegible]	0.7[illegible]	4.3[illegible]
1.16[illegible]	9.[illegible]	0.7[illegible]	2.55[illegible]
1.3[illegible]	12.[illegible]	0.7[illegible]	1.[illegible]
1.43[illegible]	13.5[illegible]	0.7[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST	ABS VELOCITY	AXIAL VELOCITY	TAN VELOCITY
FROM INNER SURF INCHES	FT/SEC	FT/SEC	FT/SEC
0.0[illegible]	[illegible]	[illegible]	[illegible]
0.26[illegible]	1[illegible]7.1[illegible]5	[illegible]13.969	27.341
0.42[illegible]	1[illegible]7.4[illegible]	[illegible]23.964	[illegible]9.765
0.58[illegible]	13[illegible].2[illegible]	131.494	31.971
0.73[illegible]	1[illegible]7.7[illegible]	[illegible]	3[illegible]
0.88[illegible]	1[illegible]4.46[illegible]	[illegible]32.696	3[illegible]
1.0[illegible]	13[illegible].117	126.521	3[illegible].379
1.16[illegible]	[illegible]1.172	1[illegible]5.[illegible]	25.[illegible]6
1.3[illegible]	75.87[illegible]	[illegible]2.774	17.714
1.43[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER C , L/H 3.13
FLOW TEMPERATURE 104.0°F
ROOM TEMPERATURE 74.0°F
BAROMETRIC PRESSURE 29.47"Hg
MASS WEIGHTED SWIRL ANGLE 7.497°

COLD RESISTANCE OF HOT WIRE= 3.34 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.600	0.175
0.450	9.700	0.135
0.610	9.750	0.105
0.760	9.770	0.090
0.910	9.780	0.105
1.050	9.750	0.125
1.180	9.700	0.162
1.310	9.650	0.245

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	10.625
0.450	8.037
0.610	6.190
0.760	5.286
0.910	6.155
1.050	7.370
1.180	9.644
1.310	14.729

INLET EXPERIMENTAL DATA

DIFFUSER C , L/H= 3.18
FLOW TEMPERATURE= 104.0 °F
ROOM TEMPERATURE= 74.0 °F
BAROMETRIC PRESSURE= 29.465 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	11.167	3.150	2.100
0.280	12.500	3.233	3.783
0.450	13.067	3.283	4.450
0.610	13.733	3.350	4.650
0.760	14.500	3.383	4.733
0.910	15.233	3.433	4.700
1.050	15.733	3.500	4.617
1.180	16.167	3.467	4.400
1.310	16.367	3.383	3.967
1.440	17.000	3.150	2.983

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.090	[illegible]	[illegible]	[illegible]
0.280	154.132	147.395	45.069
0.450	161.816	154.744	47.316
0.610	164.586	157.393	48.126
0.760	165.775	158.531	48.474
0.910	165.949	158.696	48.525
1.050	165.785	158.539	48.477
1.180	163.212	156.079	47.725
1.310	157.759	150.863	46.131
1.440	[illegible]	[illegible]	42.138

EXIT EXPERIMENTAL DATA

DIFFUSER C , L/W= 3.13
FLOW TEMPERATURE= 104.0 °F
ROOM TEMPERATURE= 74.0 °F
BAROMETRIC PRESSURE= 29.465 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGL.	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.09[illegible]	9.5[illegible]	0.77[illegible]	1.7[illegible]
0.26[illegible]	9.5[illegible]	0.77[illegible]	3.2[illegible]
0.42[illegible]	1[illegible]	0.77[illegible]	4.[illegible]
0.58[illegible]	1[illegible].5[illegible]	0.77[illegible]	4.45[illegible]
0.73[illegible]	11.5[illegible]	0.77[illegible]	4.6[illegible]
0.89[illegible]	12.[illegible]	0.77[illegible]	4.6[illegible]
1.[illegible]2[illegible]	13.[illegible]	0.77[illegible]	4.4[illegible]
1.1[illegible]	15.[illegible]	0.77[illegible]	3.2[illegible]
1.3[illegible]	19.5[illegible]	0.77[illegible]	1.65[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.26[illegible]	1[illegible]	[illegible]	42.49[illegible]
0.42[illegible]	1[illegible]	118.243	46.524
0.58[illegible]	[illegible]	123.[illegible]	4[illegible].737
0.73[illegible]	134.[illegible]	125.[illegible]	49.[illegible]27
0.89[illegible]	134.[illegible]	125.[illegible]	49.427
1.[illegible]	[illegible]	12[illegible]	4[illegible].49[illegible]
1.1[illegible]	[illegible]	1[illegible]7.[illegible]	4[illegible]
1.3[illegible]	[illegible]	[illegible]	[illegible]
1.4[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER C , L/H 3.13
FLOW TEMPERATURE 104.0 °F
ROOM TEMPERATURE 74.0 °F
BAROMETRIC PRESSURE 29.45 "Hg
MASS WEIGHTED SWIRL ANGLE 14.564°

COLD RESISTANCE OF
HOT WIRE= 3.34 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.670	0.185
0.450	9.750	0.130
0.610	9.800	0.102
0.760	9.800	0.092
0.910	9.800	0.100
1.050	9.800	0.115
1.180	9.800	0.140
1.310	9.750	0.170

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	11.078
0.450	7.664
0.610	5.956
0.760	5.372
0.910	5.839
1.050	6.715
1.180	8.175
1.310	10.023

INLET EXPERIMENTAL DATA

DIFFUSER C , L/H= 3.13
FLOW TEMPERATURE= 103.0 °F
ROOM TEMPERATURE= 78.0 °F
BAROMETRIC PRESSURE= 29.37 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.290	18.733	3.817	3.917
0.280	21.167	3.950	3.917
0.450	21.900	3.950	4.617
0.610	22.833	3.850	4.817
0.760	23.833	3.800	4.883
0.910	24.500	3.817	4.950
1.050	25.333	3.833	4.967
1.180	25.667	3.867	4.883
1.310	26.500	3.700	4.617
1.440	27.333	3.333	3.733

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	139.56[illegible]	12[illegible]	[illegible]
[illegible].28[illegible]	163.212	144.985	74.95[illegible]
[illegible].45[illegible]	17[illegible].339	151.298	78.213
[illegible]	171.31[illegible]	152.179	78.668
[illegible].76[illegible]	173.468	152.319	78.741
[illegible].91[illegible]	172.295	153.154	79.123
1.05[illegible]	172.619	153.342	79.27[illegible]
1.1[illegible]	172.12[illegible]	152.9[illegible]6	79.[illegible]44
1.31[illegible]	167.815	149.[illegible]74	77.[illegible]63
[illegible]	[illegible]	[illegible]	[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER C , L/H= 2.18
FLOW TEMPERATURE= 102.0 °F
ROOM TEMPERATURE= 73.0 °F
BAROMETRIC PRESSURE= 29.37 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	16.300	0.920	0.750
0.260	16.500	0.820	2.700
0.420	17.500	0.820	3.650
0.590	18.500	0.820	4.500
0.730	19.000	0.820	4.750
0.880	20.500	0.820	4.900
1.020	21.500	0.820	4.900
1.160	23.000	0.820	4.400
1.300	27.000	0.820	2.800
1.430	[illegible]	[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
0.26	[illegible]	[illegible]	55.416
0.42	[illegible]	[illegible]	62.449
0.59	124.214	[illegible]	[illegible]
0.73	[illegible]	[illegible]	[illegible]
0.88	[illegible]	[illegible]	[illegible]
1.02	[illegible]	[illegible]	[illegible]
1.16	[illegible]	[illegible]	67.484
1.30	[illegible]	[illegible]	[illegible]
1.43	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER C , L/H 3-13
FLOW TEMPERATURE 103.0 °F
ROOM TEMPERATURE 73.0 °F
BAROMETRIC PRESSURE 29.37 "Hg
MASS WEIGHTED SWIRL ANGLE 23.808°

COLD RESISTANCE OF HOT WIRE= 3.34 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.700	0.195
0.450	9.820	0.127
0.610	9.850	0.100
0.760	9.850	0.097
0.910	9.820	0.107
1.050	9.820	0.117
1.180	9.800	0.140
1.310	9.770	0.170

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	11.608
0.450	7.388
0.610	5.784
0.760	5.611
0.910	6.225
1.050	6.806
1.180	8.175
1.310	9.984

INLET EXPERIMENTAL DATA

DIFFUSER D , L/H=1.60
FLOW TEMPERATURE=106.0 °F
ROOM TEMPERATURE= 74.0 °F
BAROMETRIC PRESSURE= 29.06 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	0.500	1.567	3.700
0.280	0.500	1.517	5.083
0.450	0.167	1.683	5.717
0.610	0.067	1.833	5.933
0.760	0.033	1.967	5.850
0.910	0.267	2.017	5.617
1.050	0.0	1.950	5.183
1.180	0.0	1.800	4.567
1.310	0.0	1.717	3.800
1.440	0.0	1.700	2.950

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
0.280	149.493	149.493	0.0
0.450	158.294	158.294	0.0
0.610	162.167	162.161	0.0
0.760	162.693	162.693	0.0
0.910	161.777	161.777	0.0
1.050	155.412	155.412	0.0
1.180	146.83[illegible]	146.83[illegible]	0.0
1.310	136.678	136.678	0.0
1.440	125.48[illegible]	125.48[illegible]	[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER D , L/H = 1.60
FLOW TEMPERATURE = 106.0 °F
ROOM TEMPERATURE = 74.0 °F
BAROMETRIC PRESSURE = 29.03 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	0.500	1.200	3.80[illegible]
0.250	0.500	1.200	4.400
0.430	0.500	1.200	5.55[illegible]
0.590	0.500	1.2[illegible]	6.75[illegible]
0.740	0.0	1.2[illegible]	6.75[illegible]
0.890	0.500	1.2[illegible]	6.3[illegible]
1.030	0.0	1.200	5.45[illegible]
1.170	0.500	1.200	4.3[illegible]
1.310	0.500	1.200	2.5[illegible]
1.430	0.50[illegible]	1.2[illegible]	1.5[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	1.[illegible]
0.25	[illegible]57.7[illegible]	[illegible]7.5[illegible]	1.2[illegible]
0.431	153.1[illegible]	15[illegible].776	1.319
0.59	164.[illegible]7[illegible]	[illegible]64.[illegible]65	1.432
0.74	164.[illegible]71	164.[illegible]65	1.432
0.89	159.[illegible]84	159.254	1.39[illegible]
1.03	[illegible]	[illegible]52	1.5[illegible]
1.17	136.[illegible]	136.43[illegible]	1.30[illegible]
1.31	11[illegible].[illegible]	11[illegible].926	0.977
1.43	95.616	95.612	0.83[illegible]

INLET TURBULENCE DATA

DIFFUSER D , L/H 1.60
FLOW TEMPERATURE 106.0 °F
ROOM TEMPERATURE 72.0 °F
BAROMETRIC PRESSURE 29.06 "Hg
MASS WEIGHTED SWIRL ANGLE 0.151 °

COLD RESISTANCE OF HOT WIRE= 3.37 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.750	0.152
0.450	9.800	0.112
0.610	9.870	0.087
0.760	9.870	0.090
0.910	9.820	0.115
1.050	9.750	0.147
1.180	9.700	0.175
1.310	9.620	0.255

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	8.961
0.450	6.540
0.610	5.014
0.760	5.187
0.910	6.690
1.050	8.667
1.180	10.418
1.310	15.421

INLET EXPERIMENTAL DATA

DIFFUSER D , L/H= 160
FLOW TEMPERATURE= 104.6 °F
ROOM TEMPERATURE= 78.0 °F
BAROMETRIC PRESSURE= 29.10 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	3.167	1.467	3.817
0.280	3.000	1.567	5.267
0.450	3.000	1.667	5.833
0.610	3.167	1.800	6.133
0.760	3.533	1.967	6.140
0.910	3.667	2.067	5.967
1.050	3.500	2.150	5.617
1.180	3.667	1.933	5.067
1.310	3.400	1.800	4.333
1.440	3.833	1.717	3.350

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	155.7[illegible]	155.4[illegible]	8.942
0.280	152.320	151.779	10.175
0.450	159.363	159.003	10.654
0.610	163.895	163.529	10.958
0.760	165.683	165.312	11.077
0.910	164.935	164.566	11.027
1.050	161.124	160.764	10.772
1.180	153.954	153.612	10.293
1.31[illegible]	144.107	143.784	9.635
1.44[illegible]	13[illegible].096	13[illegible].693	8.757

EXIT EXPERIMENTAL DATA

DIFFUSER D , L/W=1.60
FLOW TEMPERATURE= 106.5 °F
ROOM TEMPERATURE= 75.0 °F
BAROMETRIC PRESSURE= 29.10 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	2.[illegible]	1.3[illegible]	3.85[illegible]
0.260	2.50[illegible]	1.3[illegible]	5.3[illegible]
0.430	1.80[illegible]	1.3[illegible]	6.25[illegible]
0.590	2.[illegible]	1.3[illegible]	6.65[illegible]
0.740	2.300	1.3[illegible]	6.5[illegible]
0.890	2.500	1.3[illegible]	5.95[illegible]
1.030	3.[illegible]	1.3[illegible]	5.25[illegible]
1.170	1.500	1.3[illegible]	4.25[illegible]
1.310	2.300	1.3[illegible]	2.25[illegible]
1.430	3.[illegible]	1.3[illegible]	1.5[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	7.[illegible]
.260	149.603	149.345	9.6[illegible]7
.430	159.89[illegible]	159.625	9.2[illegible]
.590	164.[illegible]71	163.799	9.446
.74	16[illegible]	16[illegible].766	9.354
.890	156.681	156.421	9.[illegible]2
1.030	148.925	148.679	8.574
1.170	127.[illegible]86	126.959	7.892
1.31	1[illegible]9.679	1[illegible]9.456	6.212
1.43	[illegible]67.[illegible]	67.[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER D , L/H 1.60
FLOW TEMPERATURE 104.0 °F
ROOM TEMPERATURE 79.0 °F
BAROMETRIC PRESSURE 29.42 "Hg
MASS WEIGHTED SWIRL ANGLE 3.392 °

COLD RESISTANCE OF HOT WIRE= 3.37 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.800	0.152
0.450	9.850	0.105
0.610	9.900	0.092
0.760	9.900	0.094
0.910	9.900	0.102
1.050	9.880	0.117
1.180	9.850	0.132
1.310	9.850	0.175

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	8.876
0.450	6.074
0.610	5.272
0.760	5.387
0.910	5.845
1.050	6.730
1.180	7.635
1.310	10.123

INLET EXPERIMENTAL DATA

DIFFUSER D , L/H= 1.60
FLOW TEMPERATURE= 100.0 °F
ROOM TEMPERATURE= 76.0 °F
BAROMETRIC PRESSURE= 29.12 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	7.500	1.467	3.583
0.280	7.833	1.700	5.183
0.450	7.567	1.817	5.733
0.610	7.833	1.923	6.117
0.760	8.367	2.050	6.033
0.910	8.500	2.150	5.967
1.050	8.500	2.167	5.767
1.180	8.667	2.067	5.350
1.310	8.833	1.950	4.600
1.440	9.[illegible]	1.883	3.567

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
0.090	13[illegible].766	129.155	2[illegible].459
0.280	152.664	15[illegible].784	23.885
0.450	159.891	157.921	25.016
0.610	163.968	161.948	25.652
0.760	165.438	163.400	25.883
0.910	165.785	163.744	25.938
1.050	163.916	161.887	25.644
1.180	158.476	156.524	24.794
1.310	148.925	147.091	23.[illegible]
1.[illegible]	1[illegible].[illegible]44	1[illegible].173	21.[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER D , L/H=1.60
FLOW TEMPERATURE= 100.0 °F
ROOM TEMPERATURE= 76.0 °F
BAROMETRIC PRESSURE= 29.12 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	0.0	1.410	3.1[illegible]
0.260	0.0	1.400	4.500
0.430	0.500	1.400	5.530
0.590	2.000	1.410	5.950
0.740	2.100	1.400	6.[illegible]
0.890	3.000	1.400	5.800
1.030	3.500	1.400	5.440
1.170	4.200	1.400	4.500
1.310	5.000	1.400	2.150
1.430	5.[illegible]	1.4[illegible]	[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
0.24	1[illegible].243	14[illegible].566	14.776
0.43	152.852	15[illegible].[illegible]15	15.979
0.59	157.758	156.994	16.692
0.74	158.294	157.426	16.548
0.89	156.1[illegible]	155.294	16.323
1.03	15[illegible].742	15[illegible].9[illegible]6	15.962
1.17	14[illegible].345	14[illegible].[illegible]58	14.772
1.31	1[illegible]9.658	1[illegible]9.[illegible]18	11.462
1.43	95.[illegible]16	[illegible].97	[illegible]

INLET TURBULENCE DATA

DIFFUSER D , L/H 1.60
FLOW TEMPERATURE 106.5 °F
ROOM TEMPERATURE 75.0 °F
BAROMETRIC PRESSURE 29.10 "Hg
MASS WEIGHTED SWIRL ANGLE 3.250 °

COLD RESISTANCE OF HOT WIRE= 3.37 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.750	0.165
0.450	9.820	0.132
0.610	9.850	0.100
0.760	9.900	0.083
0.910	9.870	0.095
1.050	9.850	0.130
1.180	9.750	0.172
1.310	9.700	0.195

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	9.723
0.450	7.679
0.610	5.734
0.760	4.756
0.910	5.475
1.050	7.520
1.180	10.140
1.310	11.608

INLET EXPERIMENTAL DATA

DIFFUSER D , L/H=1.60
FLOW TEMPERATURE=109.0°F
ROOM TEMPERATURE= 76.0°F
BAROMETRIC PRESSURE= 29.18 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	12.000	2.050	3.133
0.280	12.833	2.100	4.917
0.450	12.667	2.217	5.583
0.610	13.333	2.283	5.817
0.760	14.333	2.400	5.883
0.910	14.500	2.533	5.933
1.050	15.000	2.583	5.867
1.180	15.333	2.517	5.633
1.310	15.967	2.383	5.050
1.440	16.500	2.183	4.067

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	13[illegible].476	127.[illegible]	[illegible]
0.280	154.143	147.794	43.784
0.450	162.516	155.822	46.163
0.610	165.612	158.790	47.042
0.760	167.472	160.574	47.571
0.910	169.312	162.338	48.093
1.050	169.152	162.184	48.048
1.180	166.122	159.279	47.187
1.310	158.646	152.112	45.064
1.44[illegible]	145.475	139.483	4[illegible].322

EXIT EXPERIMENTAL DATA

DIFFUSER D , L/H= 1.60
FLOW TEMPERATURE= 109.0 °F
ROOM TEMPERATURE= 76.0 °F
BAROMETRIC PRESSURE= 29.14 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.19[illegible]	2.5[illegible]	1.55[illegible]	3.[illegible]
0.26[illegible]	3.6[illegible]	1.55[illegible]	4.7[illegible]
0.430	5.5[illegible]	1.550	5.9[illegible]
0.59[illegible]	4.[illegible]	1.55[illegible]	6.35[illegible]
0.74[illegible]	6.7[illegible]	1.55[illegible]	6.45[illegible]
0.89[illegible]	7.9[illegible]	1.55[illegible]	6.4[illegible]
1.03[illegible]	8.[illegible]	1.55[illegible]	6.2[illegible]
1.17[illegible]	9.5[illegible]	1.55[illegible]	5.5[illegible]
1.33[illegible]	1[illegible]	1.55[illegible]	2.4[illegible]
1.43[illegible]	12.[illegible]	[illegible].55[illegible]	[illegible].75[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
0.26[illegible]	345.475	342.295	3[illegible].25[illegible]
0.43[illegible]	[illegible].828	355.356	33.[illegible]26
0.59	343.[illegible]	35[illegible].[illegible]70	34.[illegible]
0.74[illegible]	[illegible]	[illegible]	34.[illegible]
0.89[illegible]	36[illegible].[illegible]73	36[illegible].[illegible]	34.117
1.0[illegible]	361.904	[illegible]	33.685
1.17[illegible]	35[illegible]	35[illegible]	[illegible].127
1.33[illegible]	[illegible]	[illegible]	26.9[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

INLET TURBULENCE DATA

DIFFUSER D , L/H 1.60
FLOW TEMPERATURE 108.0 °F
ROOM TEMPERATURE 74.0 °F
BAROMETRIC PRESSURE 29.12 "Hg
MASS WEIGHTED SWIRL ANGLE 14.274°

COLD RESISTANCE OF HOT WIRE= 3.37OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.800	0.157
0.450	9.870	0.115
0.610	9.870	0.094
0.760	9.870	0.098
0.910	9.870	0.100
1.050	9.850	0.142
1.180	9.800	0.180
1.310	9.770	0.260

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	9.168
0.450	6.627
0.610	5.417
0.760	5.640
0.910	5.763
1.050	8.214
1.180	10.511
1.310	15.270

INLET EXPERIMENTAL DATA

DIFFUSER D , L/H= 1.60
FLOW TEMPERATURE= 104.0 °F
ROOM TEMPERATURE= 79.0 °F
BAROMETRIC PRESSURE= 29.42 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	19.567	2.633	2.783
0.280	21.167	2.783	4.783
0.450	21.567	2.817	5.367
0.610	22.4[illegible]	2.767	5.533
0.760	23.5[illegible]	2.733	5.633
0.910	24.233	2.733	5.650
1.050	24.5[illegible]	2.783	5.650
1.180	25.167	2.833	5.600
1.310	25.9[illegible]	2.650	5.267
1.440	26.233	2.283	4.450

INLET CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]
0.280	16[illegible]59	143.57[illegible]	7[illegible].758
0.450	166.468	149.318	73.591
0.610	167.644	150.373	74.111
0.760	168.3[illegible]	150.969	74.415
0.910	168.48[illegible]	151.123	74.481
1.050	168.982	151.572	74.703
1.180	168.982	151.573	74.703
1.310	163.73[illegible]	146.862	72.381
1.44[illegible]	15[illegible]	13[illegible].636	66.75[illegible]

EXIT EXPERIMENTAL DATA

DIFFUSER D , L/D=1.60
FLOW TEMPERATURE= 104.0 °F
ROOM TEMPERATURE= 79.0 °F
BAROMETRIC PRESSURE= 29.482 "Hg

DIST FROM INNER SURF INCHES	SWIRL ANGLE	PS STATIC PRESSURE INCHES WATER 45DEG SLOPE	PT TOTAL PRESSURE INCHES WATER 45DEG SLOPE
0.090	7.7[illegible]	1.6[illegible]	2.[illegible]
0.260	9.8[illegible]	1.6[illegible]	4.35[illegible]
0.430	11.5[illegible]	1.6[illegible]	5.55[illegible]
0.59[illegible]	13.2[illegible]	1.6[illegible]	6.[illegible]
0.74[illegible]	14.5[illegible]	1.6[illegible]	6.1[illegible]
0.890	16.[illegible]	1.6[illegible]	6.2[illegible]
1.030	16.5[illegible]	1.6[illegible]	6.15[illegible]
1.170	17.5[illegible]	1.6[illegible]	5.75[illegible]
1.310	19.5[illegible]	1.6[illegible]	[illegible].55[illegible]
1.43[illegible]	21.5[illegible]	1.6[illegible]	2.[illegible]

EXIT CALCULATED RESULTS

DIST FROM INNER SURF INCHES	ABS VELOCITY FT/SEC	AXIAL VELOCITY FT/SEC	TAN VELOCITY FT/SEC
[illegible]	[illegible]	[illegible]	4[illegible].47
0.26[illegible]	141.9[illegible]	122.[illegible]1	52.[illegible]
0.43[illegible]	155.937	144.767	57.[illegible]33
0.59	16[illegible].419	149.259	59.8[illegible]
0.74[illegible]	16[illegible].471	15[illegible].232	59.[illegible]86
0.89[illegible]	162.516	151.[illegible]5	59.57
1.[illegible]	16[illegible].9[illegible]4	15[illegible].71[illegible]	59.279
1.[illegible]7	[illegible]57.7[illegible]	146.778	57.[illegible]26
1.3[illegible]	12[illegible].[illegible]54	122.[illegible]	49.[illegible]4
1.4[illegible]	[illegible]	[illegible]	42.[illegible]

INLET TURBULENCE DATA

DIFFUSER D , L/H 1.60
FLOW TEMPERATURE 109.0 °F
ROOM TEMPERATURE 76.0 °F
BAROMETRIC PRESSURE 29.14 "Hg
MASS WEIGHTED SWIRL ANGLE 23.463 °

COLD RESISTANCE OF HOT WIRE= 3.37 OHMS

DISTANCE FROM INNER SURFACE INCHES	DC VOLTAGE VOLTS	RMS VOLTAGE MILLIVOLTS
0.280	9.800	0.157
0.450	9.850	0.100
0.610	9.900	0.090
0.760	9.900	0.100
0.910	9.870	0.112
1.050	9.870	0.142
1.180	9.820	0.172
1.310	9.800	0.250

RELATIVE TURBULENCE

DISTANCE FROM INNER SURFACE INCHES	PERCENTAGE TURBULENCE
0.280	9.168
0.450	5.784
0.610	5.158
0.760	5.731
0.910	6.454
1.050	8.183
1.180	10.006
1.310	14.599

TABLE IV

MASS WEIGHTED VALUES

SWIRL CONDITION		DIFFUSER A		DIFFUSER B	
		INLET	EXIT	INLET	EXIT
Minimum Swirl ○	$\overline{\Psi}$	1.976	0.132	1.582	1.354
	$\overline{P_s}$	-3.691		- 2.729	
	$\overline{V}$	152.340	59.585	146.428	95.482
	$\overline{V_a}$	152.241	59.584	146.367	95.445
	$\overline{V_t}$	5.329	0.087	4.109	2.454
△	$\overline{\Psi}$	5.071	2.824	4.585	3.442
	$\overline{P_s}$	-3.783		-3.086	
	$\overline{V}$	154.638	56.808	153.894	98.023
	$\overline{V_a}$	154.018	56.731	153.398	97.846
	$\overline{V_t}$	13.756	2.485	12.336	5.873
+	$\overline{\Psi}$	10.267	7.078	11.680	6.552
	$\overline{P_s}$	-3.981		-2.663	
	$\overline{V}$	158.412	60.189	156.529	101.893
	$\overline{V_a}$	155.853	59.719	153.263	101.212
	$\overline{V_t}$	28.313	7.143	31.741	10.828
×	$\overline{\Psi}$	15.603	11.368	17.269	12.854
	$\overline{P_s}$	-4.009		-2.757	
	$\overline{V}$	158.694	62.783	157.629	98.028
	$\overline{V_a}$	152.742	61.541	150.434	95.564
	$\overline{V_t}$	42.829	12.128	46.877	20.991
Maximum Swirl ◇	$\overline{\Psi}$	24.065	16.754	25.357	18.145
	$\overline{P_s}$	-4.253		-3.044	
	$\overline{V}$	164.146	61.191	164.267	100.559
	$\overline{V_a}$	149.694	58.584	148.207	95.493
	$\overline{V_t}$	67.061	17.531	70.547	30.956

TABLE IV CONTINUED

MASS WEIGHTED VALUES

SWIRL CONDITION		DIFFUSER C		DIFFUSER D	
		INLET	EXIT	INLET	EXIT
Minimum Swirl ⬡	$\bar{\Psi}$	0.795	0.243	0.151	0.398
	$\bar{P}_s$	-2.107		-1.306	
	$\bar{V}$	150.530	118.449	150.903	143.366
	$\bar{V}_a$	150.513	118.447	150.901	143.361
	$\bar{V}_t$	2.078	0.578	0.393	0.943
△	$\bar{\Psi}$	3.532	2.697	3.392	2.261
	$\bar{P}_s$	-1.960		-1.329	
	$\bar{V}$	151.333	116.815	154.719	145.100
	$\bar{V}_a$	151.039	116.673	154.446	144.984
	$\bar{V}_t$	9.362	5.581	9.154	5.613
+	$\bar{\Psi}$	7.697	7.193	8.280	2.475
	$\bar{P}_s$	-2.040		-1.411	
	$\bar{V}$	153.380	118.802	153.180	141.985
	$\bar{V}_a$	151.985	117.872	149.832	141.799
	$\bar{V}_t$	20.602	14.254	31.892	5.859
×	$\bar{\Psi}$	14.564	12.592	14.274	7.048
	$\bar{P}_s$	-2.390		-1.698	
	$\bar{V}$	158.738	119.044	160.589	149.876
	$\bar{V}_a$	153.540	116.170	155.565	148.633
	$\bar{V}_t$	40.023	25.263	39.673	18.214
Maximum Swirl ◇	$\bar{\Psi}$	23.808	20.790	23.463	14.717
	$\bar{P}_s$	-2.685		-1.965	
	$\bar{V}$	166.082	123.370	163.254	148.448
	$\bar{V}_a$	151.742	115.132	149.595	143.291
	$\bar{V}_t$	67.166	43.574	65.130	37.685

TABLE V

DIVERGENT-DIVERGENT ANNULAR DIFFUSER
EXPERIMENTALLY MEASURED C_{PR}, $\overline{\Psi}$, η VALUES

SWIRL CONDITION	L/h	1.60 DIFFUSER D	3.13 DIFFUSER C	6.35 DIFFUSER B	12.65 DIFFUSER A
Minimum Swirl ○	$\overline{\Psi}$	0.151	0.793	1.582	1.976
	C_{PR}	0.266	0.435	0.599	0.752
	η	0.739	0.783	0.799	0.846
△	$\overline{\Psi}$	3.349	3.531	4.582	5.077
	C_{PR}	0.258	0.403	0.613	0.749
	η	0.717	0.725	0.817	0.843
+	$\overline{\Psi}$	8.280	7.697	11.688	10.867
	C_{PR}	0.269	0.410	0.512	0.751
	η	0.747	0.738	0.683	0.845
X	$\overline{\Psi}$	14.274	14.564	17.269	15.603
	C_{PR}	0.308	0.449	0.524	0.750
	η	0.856	0.808	0.698	0.844
Maximum Swirl ◇	$\overline{\Psi}$	23.463	23.808	25.357	24.065
	C_{PR}	0.346	0.464	0.534	0.754
	η	0.963	0.834	0.709	0.848

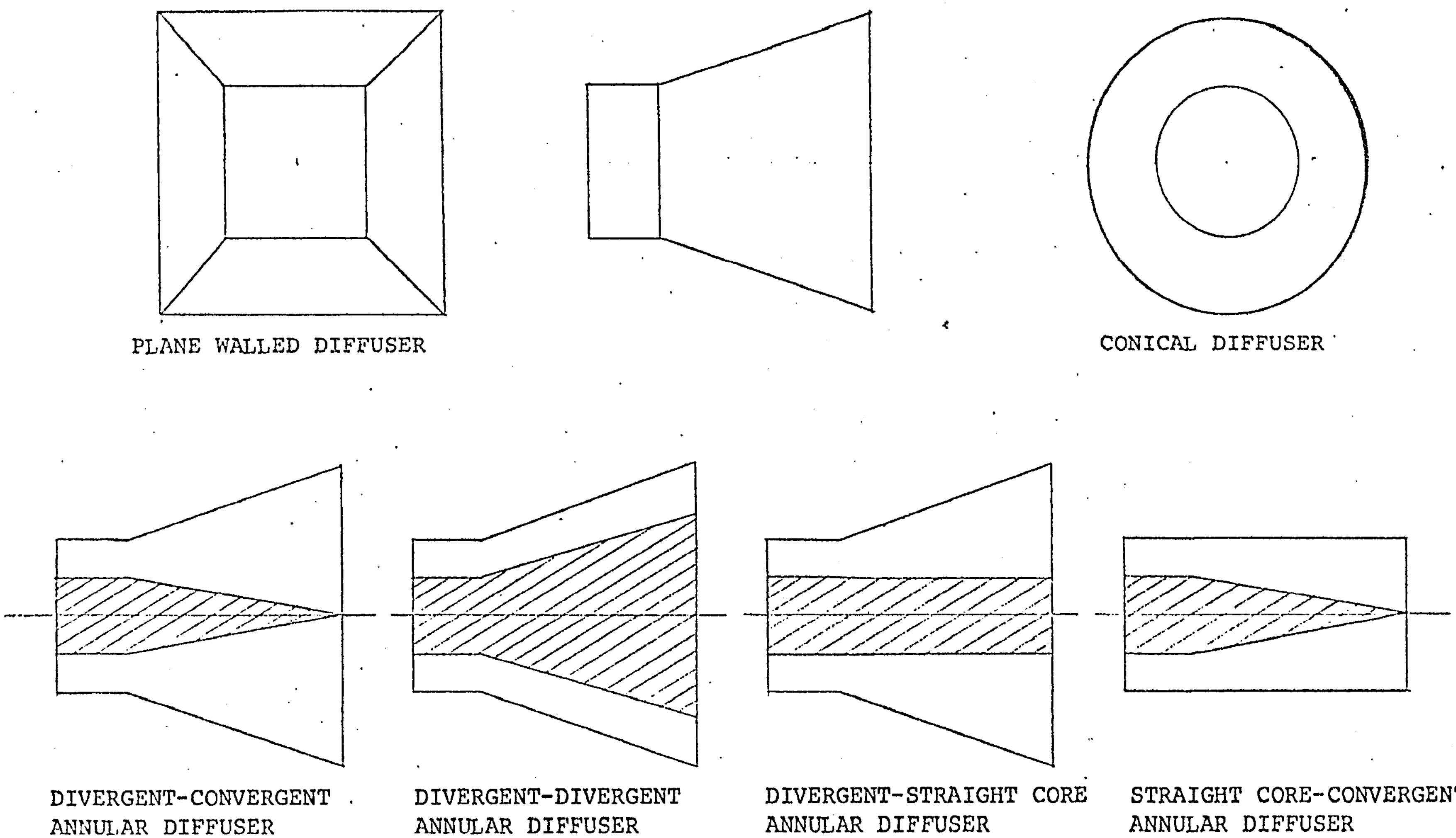
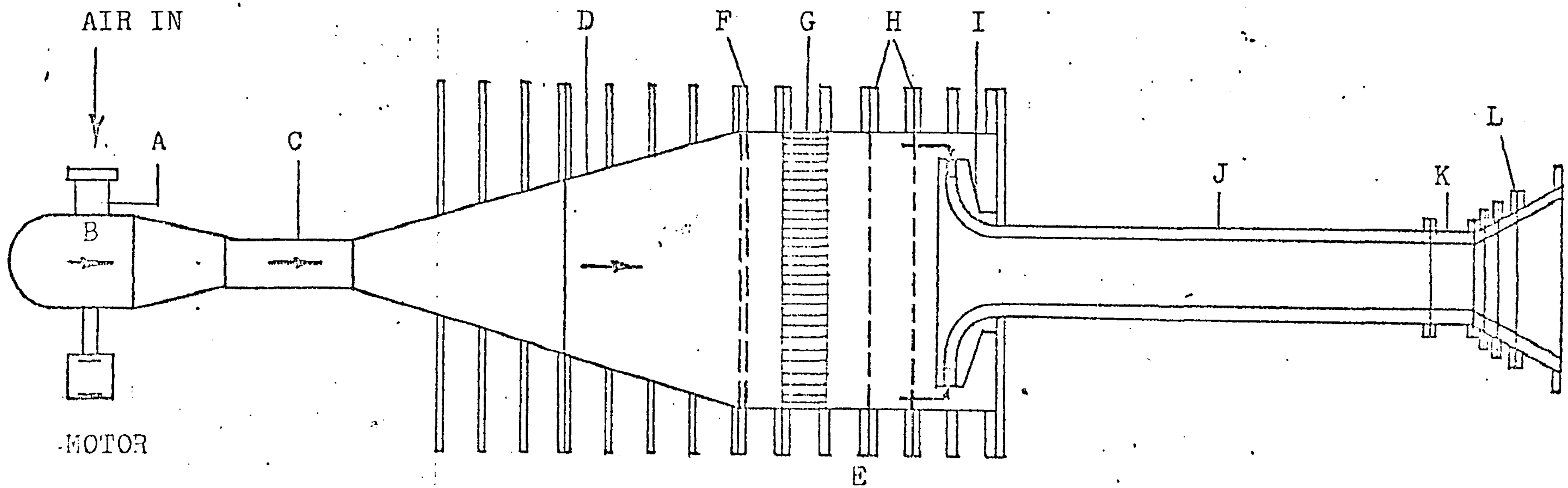


FIGURE | DIFFUSER CLASSIFICATION



A - BLAST PLATE
B - BLOWER
C - FLOW-CALIBRATION PIPE
D - EXPANSION CONE
E - PLENUM CHAMBER
F - FILTER
G - HONEYCOMB
H - SCREENS
I - SWIRL VANE UNIT
J - ANNULAR PIPES
K - ROTATABLE OUTER PIPE
L - ANNULAR DIFFUSER

FIGURE 2 SCHEMATIC DIAGRAM OF THE TEST FACILITIES

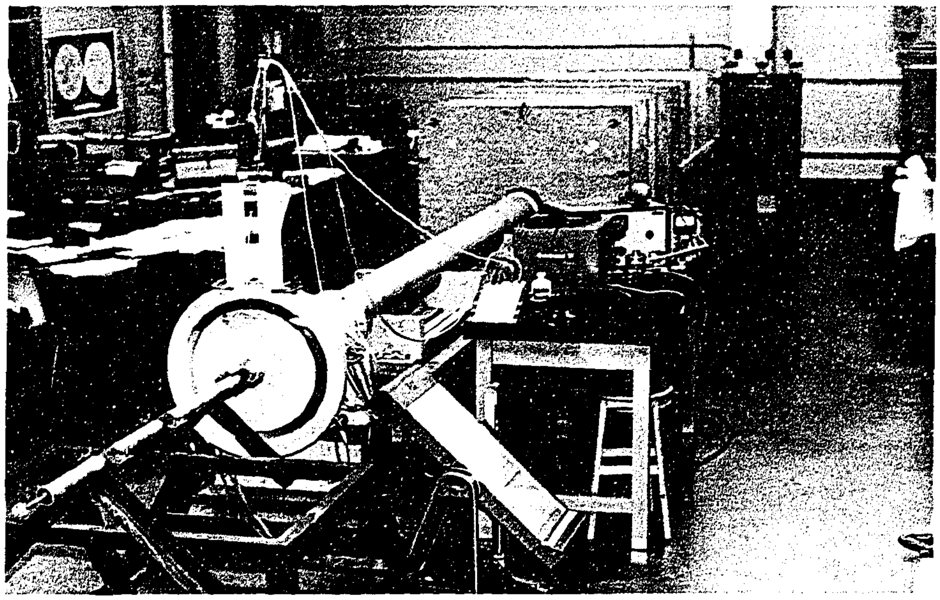


FIGURE 3 APPARATUS LAYOUT

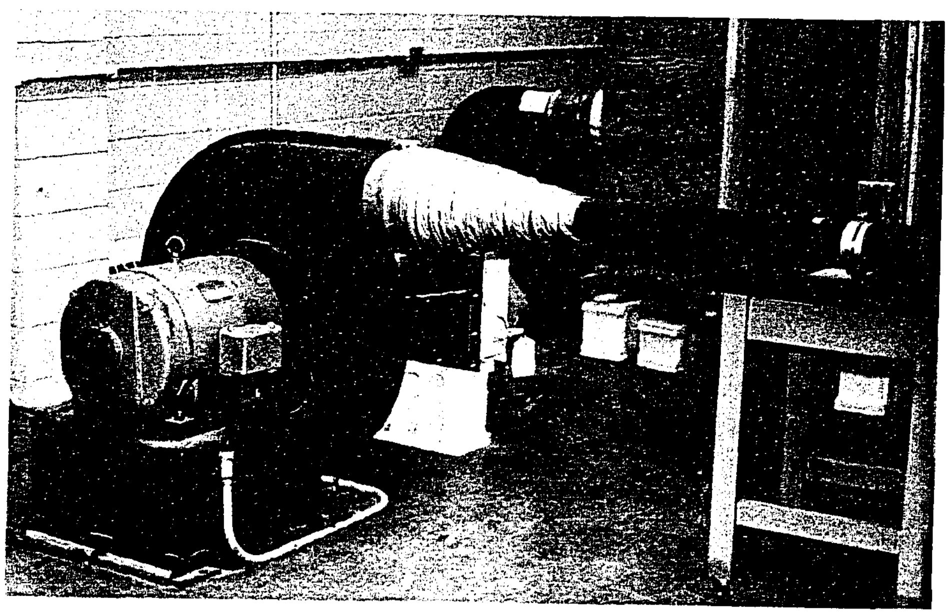


FIGURE 4 CENTRIFUGAL BLOWER

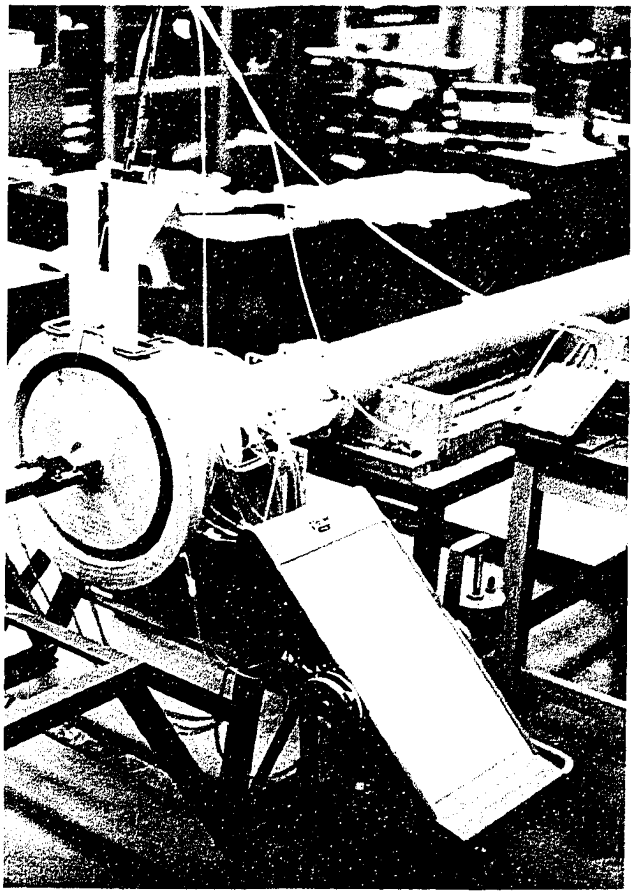


FIGURE 5 DIFFUSER TEST SECTION

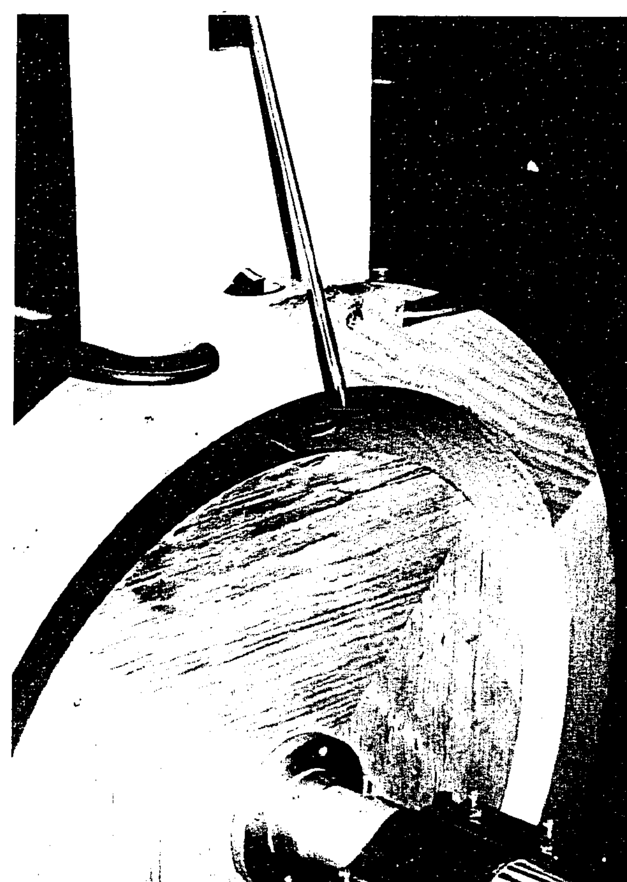


FIGURE 6 YAWPROBE AT DIFFUSER EXIT

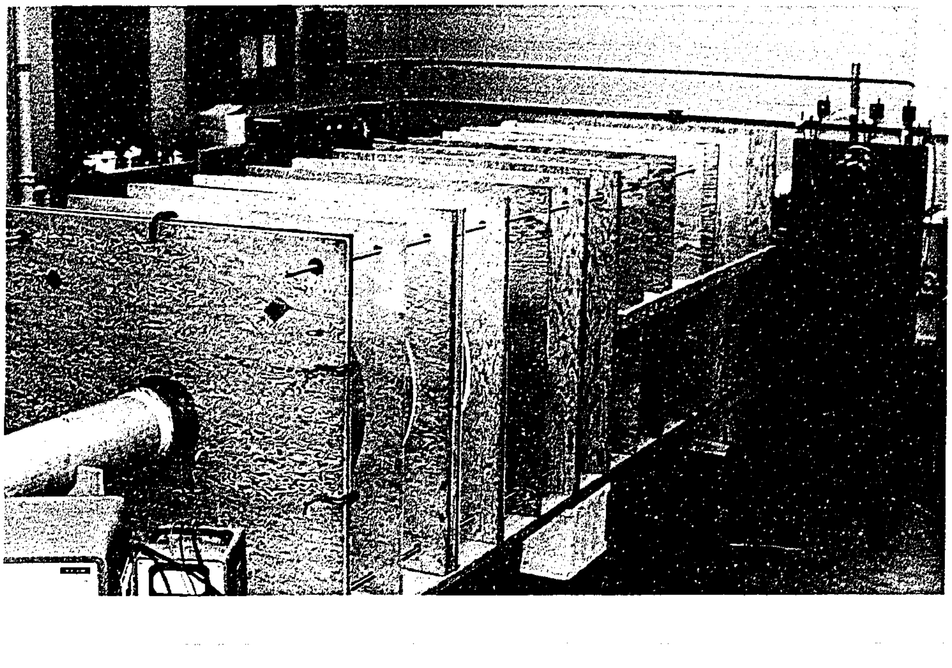


FIGURE 7 SETTLING CHAMBER

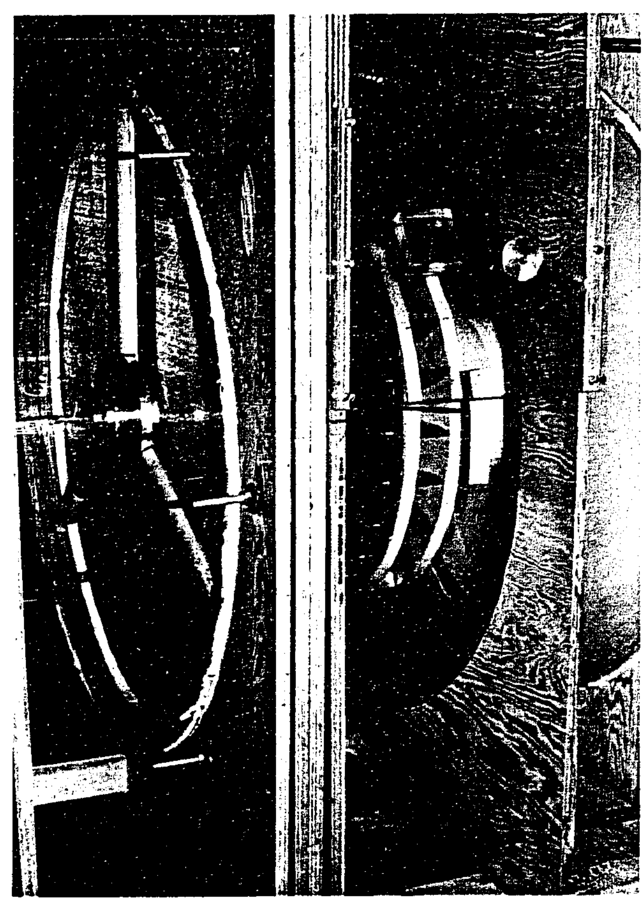
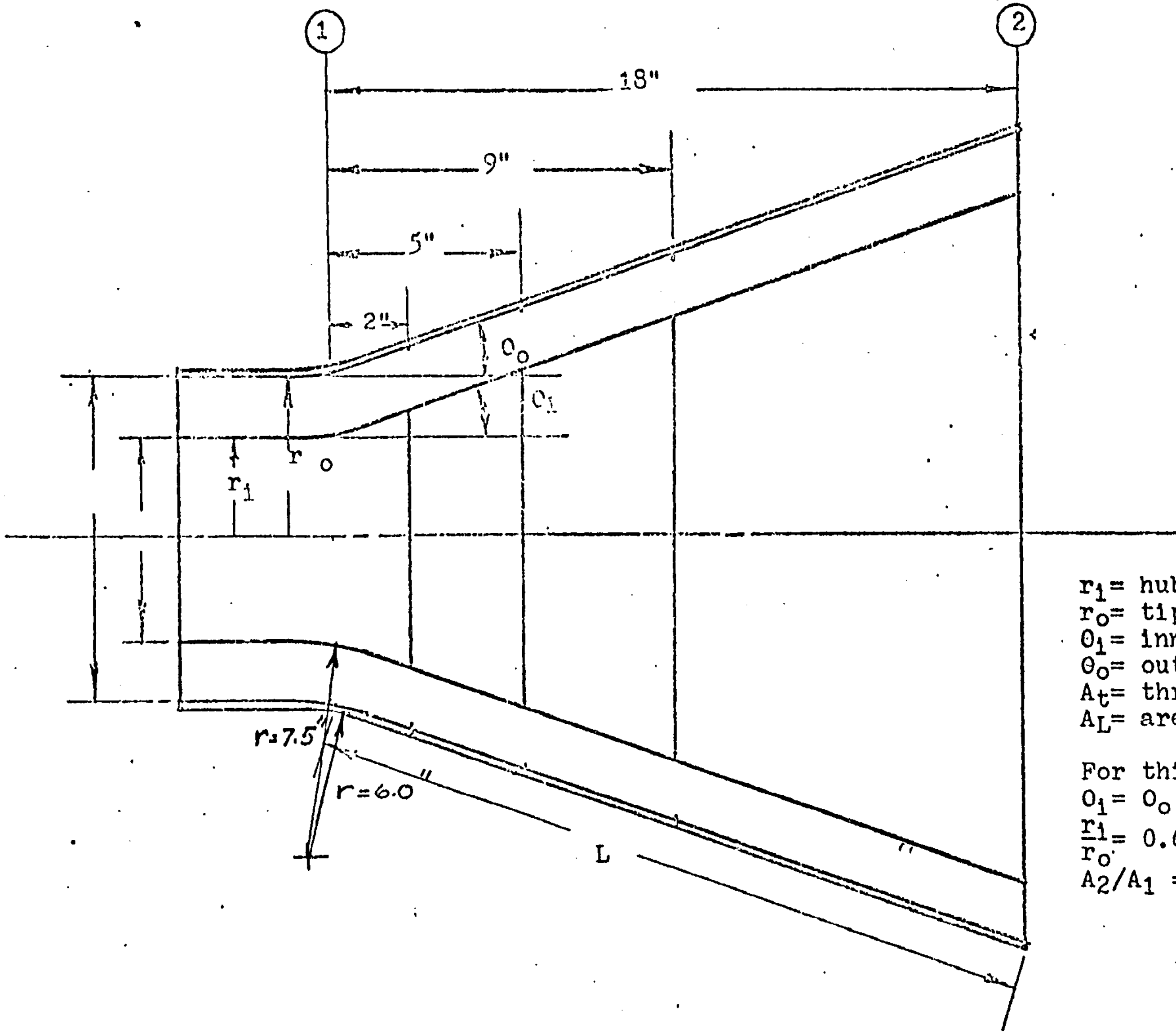


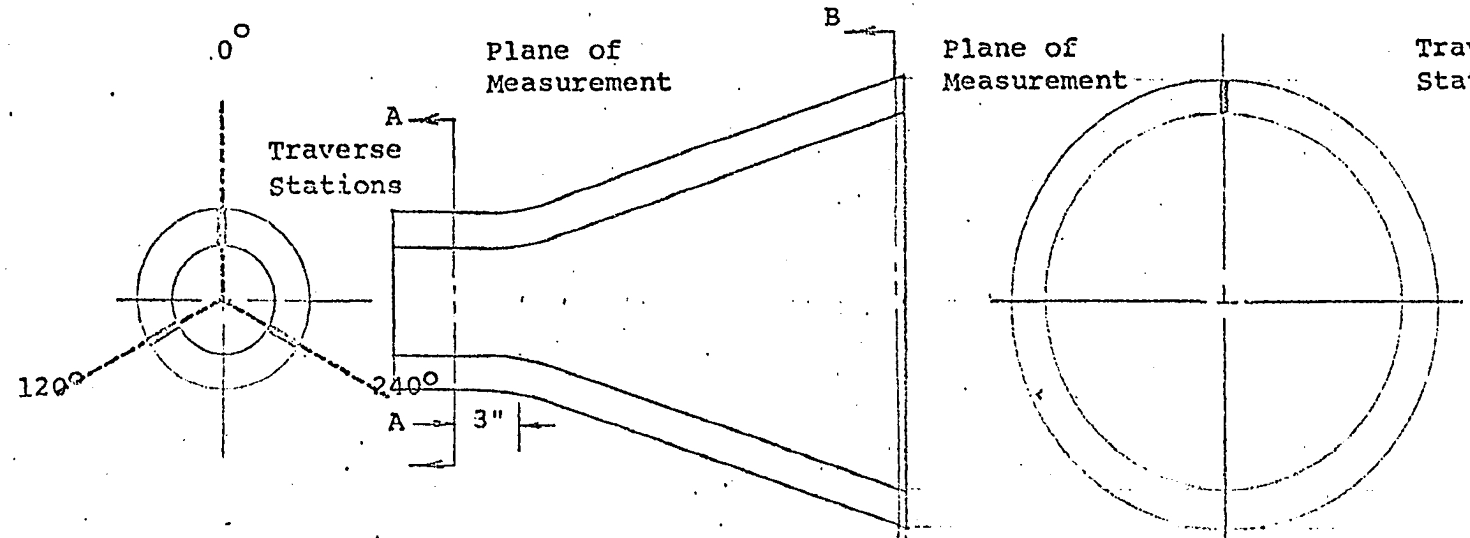
FIGURE 8 SWIRL VANE UNIT



r_i= hub radius
r_o= tip radius
θ_i= inner wall angle
θ_o= outer wall angle
A_t= throat area = A_1
A_L= area at L = A_2

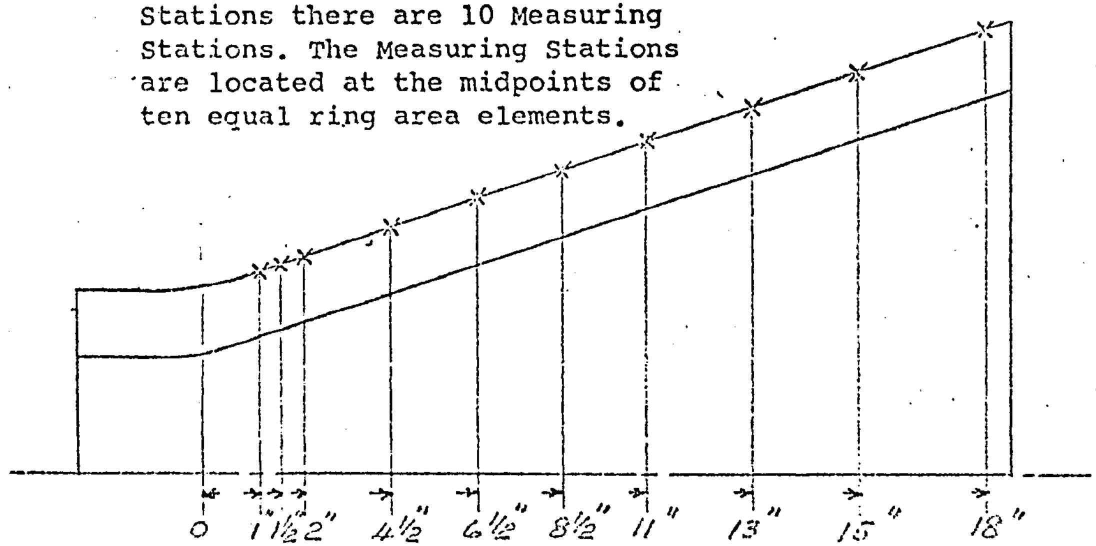
For this investigation
$\theta_i = \theta_o = 20^\circ$
$\frac{r_i}{r_o} = 0.6$ at 1
A_2/A_1 = 1.25, 1.50, 2.00, 3.00

FIGURE 9 DIFFUSER GEOMETRY



At each one of the 3 Traverse Stations there are 10 Measuring Stations. The Measuring Stations are located at the midpoints of ten equal ring area elements.

There are 10 Measuring Stations at the 1 Traverse Station. The Measuring Stations are located at the midpoints of ten equal ring area elements.

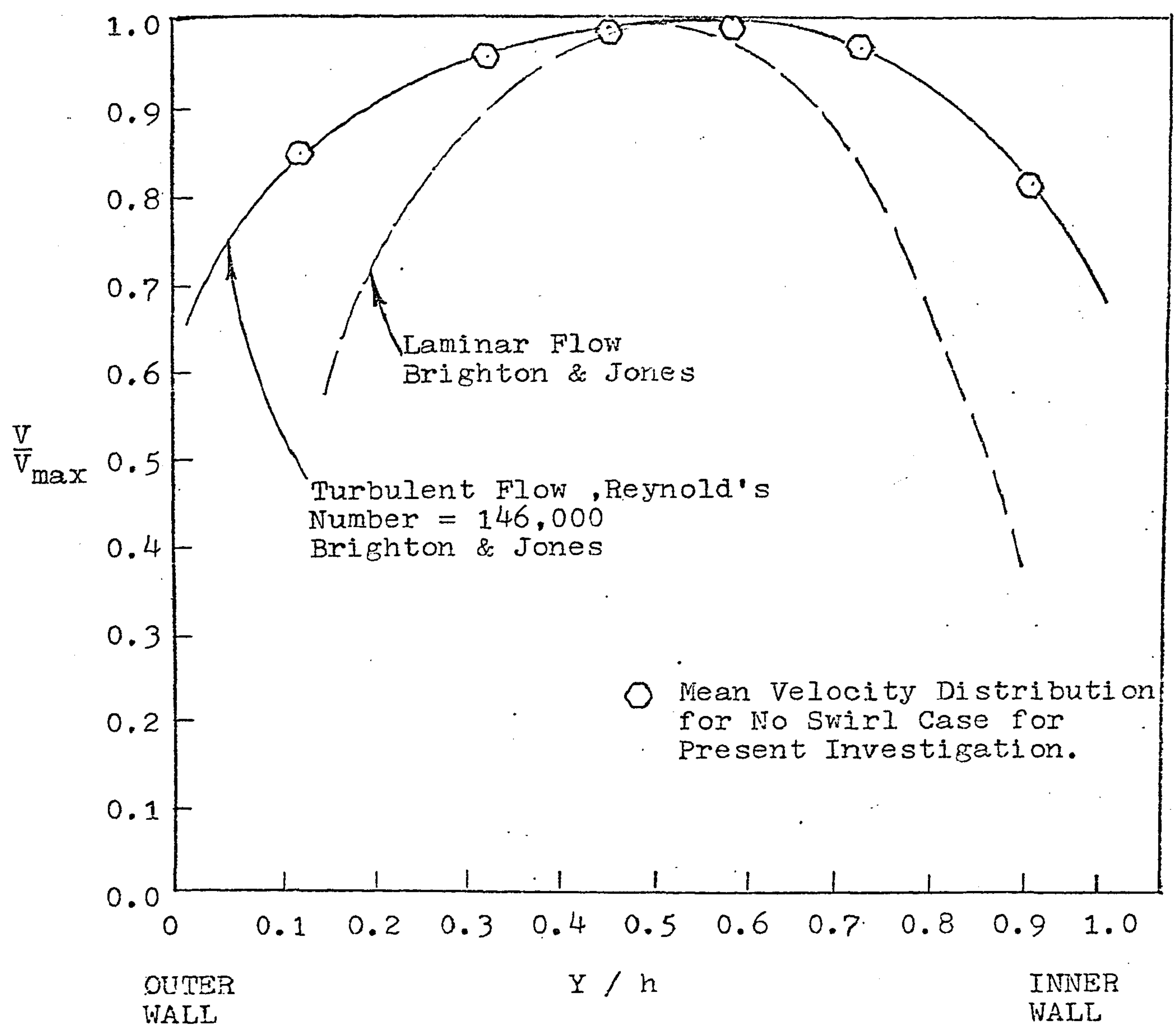


DIFFUSER WALLS -3 rows of 10 Static Pressure Taps are located on the outer wall at 0°, 120°, and 240°.

FIGURE 10 _ MEASUREMENT STATIONS

FIGURE 11

COMPARISON OF MEAN VELOCITY DISTRIBUTION WITH RESULTS OF BRIGHTON & JONES



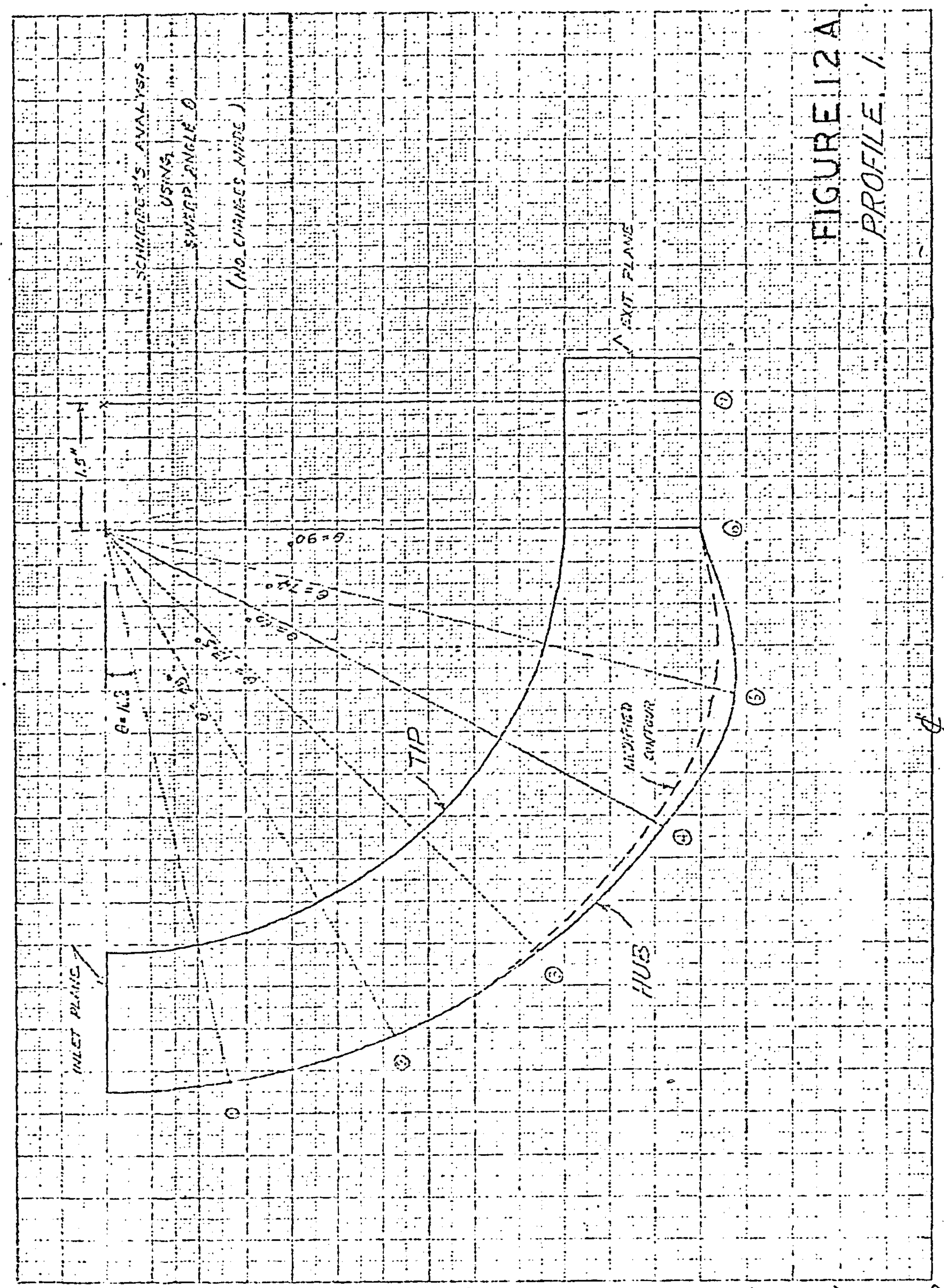


FIGURE 12 A
PROFILE 1

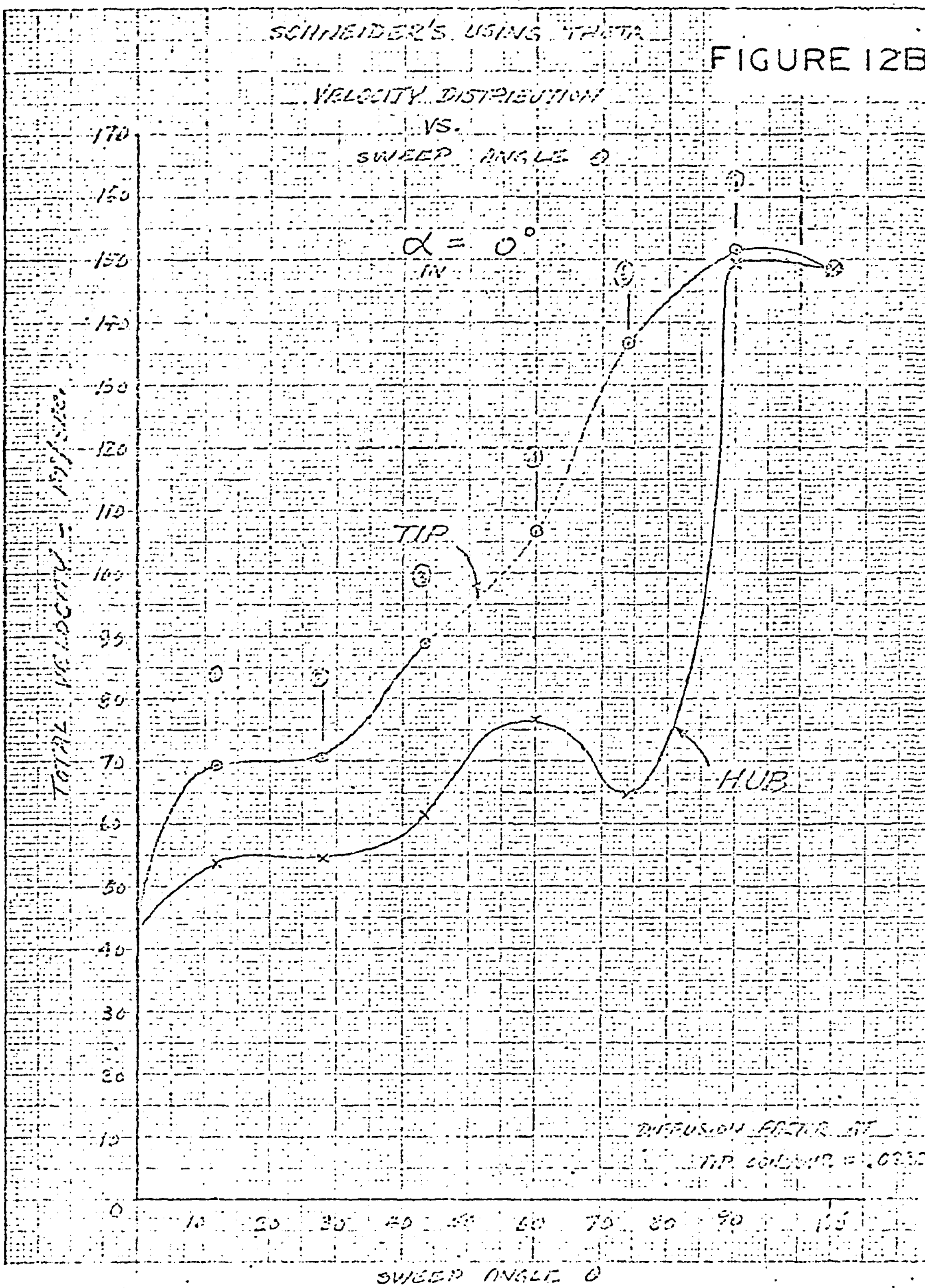
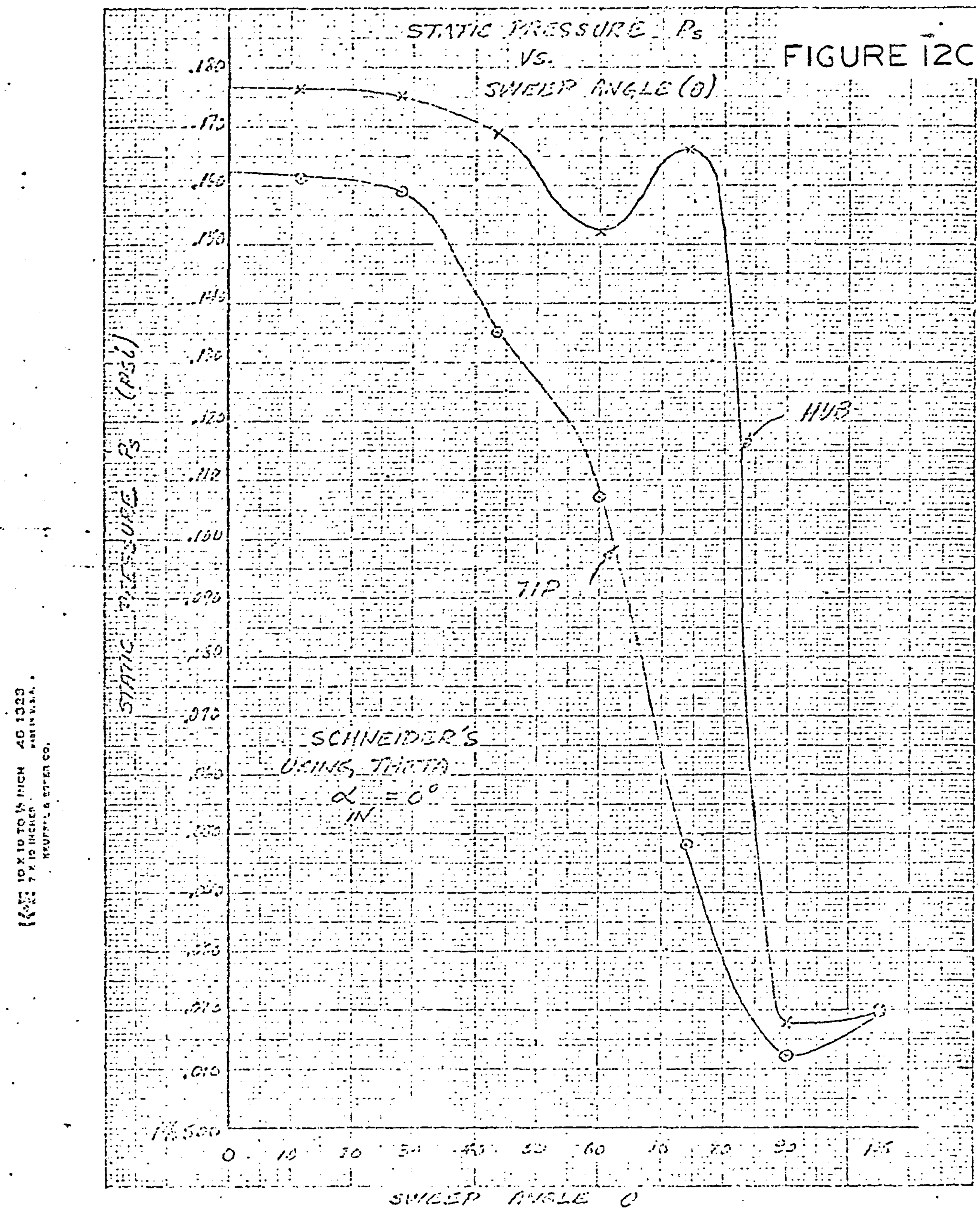

SCHNEIDER'S USING THETA
VELOCITY DISTRIBUTION
VS.
SWEEP ANGLE θ
FIGURE 12B
α = 0°
TIP
HUB
TOTAL VELOCITY - FT/SEC.
SWEEP ANGLE θ
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
60
70
80
90

FIGURE 12C


STATIC PRESSURE Ps
VS.
SWEEP ANGLE (θ)
STATIC PRESSURE Ps (PSI)
SWEEP ANGLE θ
HUB
TIP
SCHNEIDER'S
USING THETA
α = 0°
IN
0
10
20
30
40
50
60
70
80
90
100

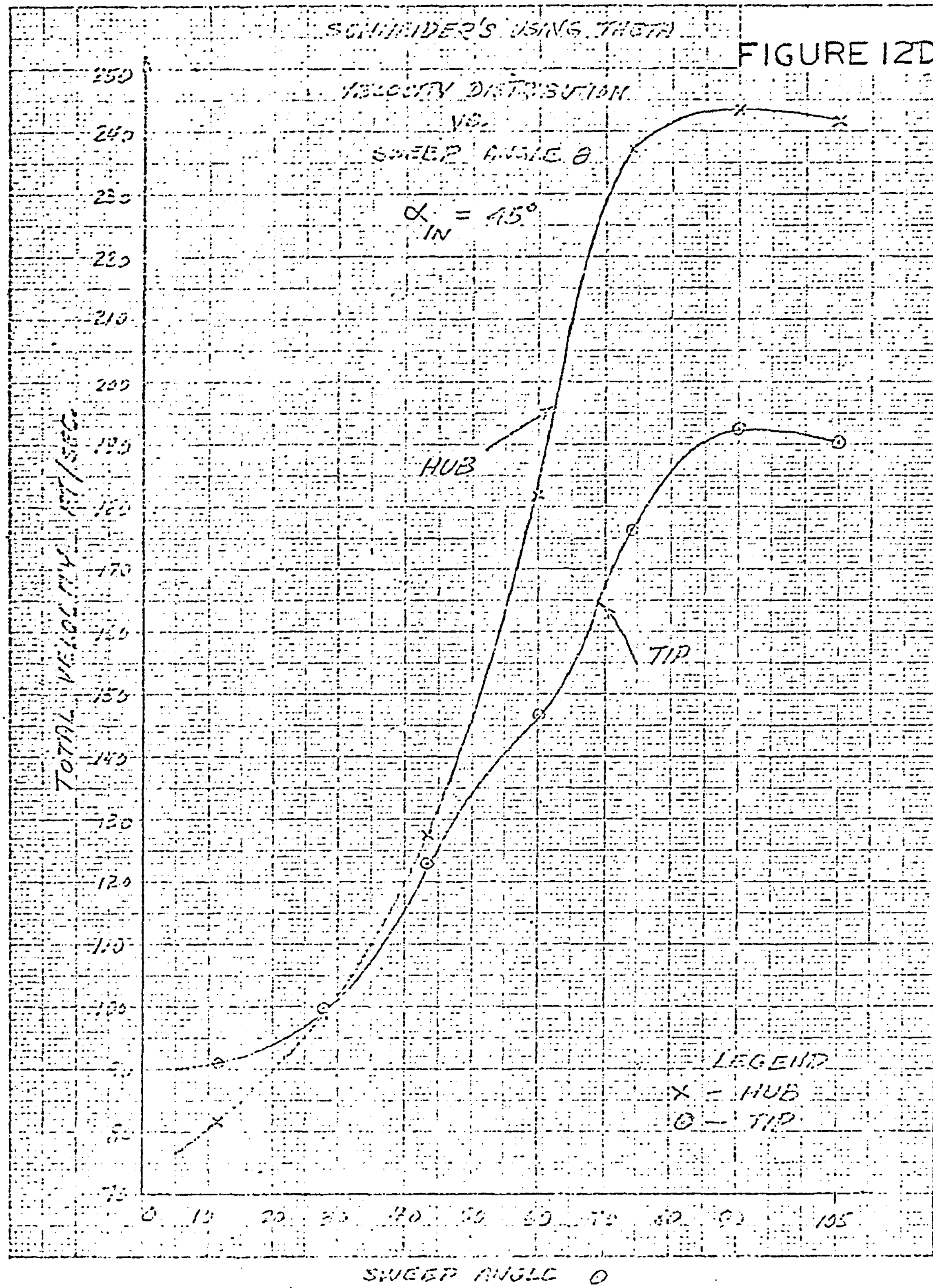

VELOCITY DISTRIBUTION
VS.
SWEEP ANGLE θ
α IN = 45°
HUB
TIP
LEGEND
X — HUB
O — TIP
TOTAL VELOCITY FT/SEC
SWEEP ANGLE θ

FIGURE 12D

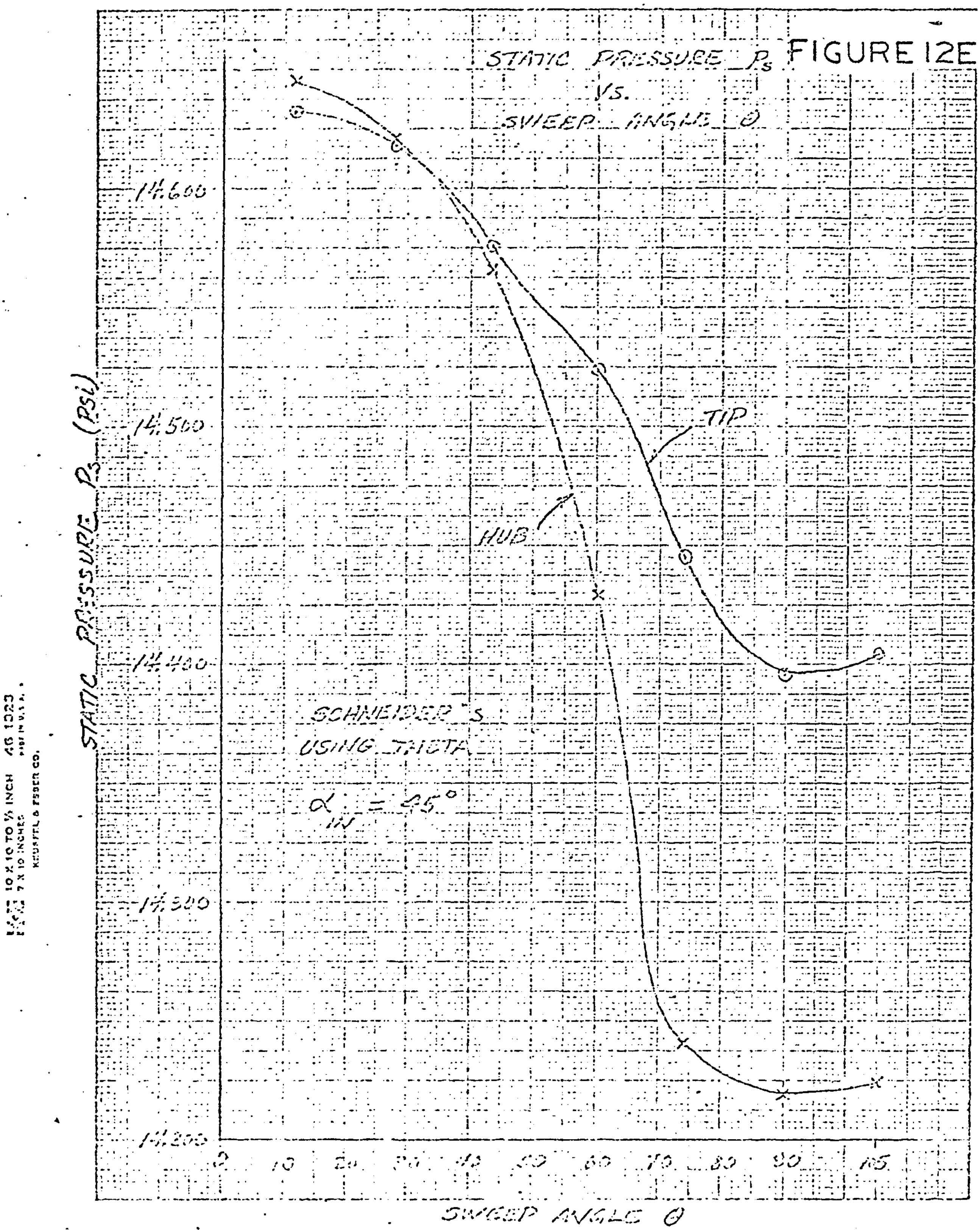


FIGURE 12E
STATIC PRESSURE P_s
VS.
SWEEP ANGLE θ
14.600
14.500
14.400
14.300
14.200
STATIC PRESSURE P_s (PSI)
TIP
HUB
SCHNEIDER'S
USING THETA
$\alpha_{IN} = 45°$
0
10
20
30
40
50
60
70
80
90
95
SWEEP ANGLE θ

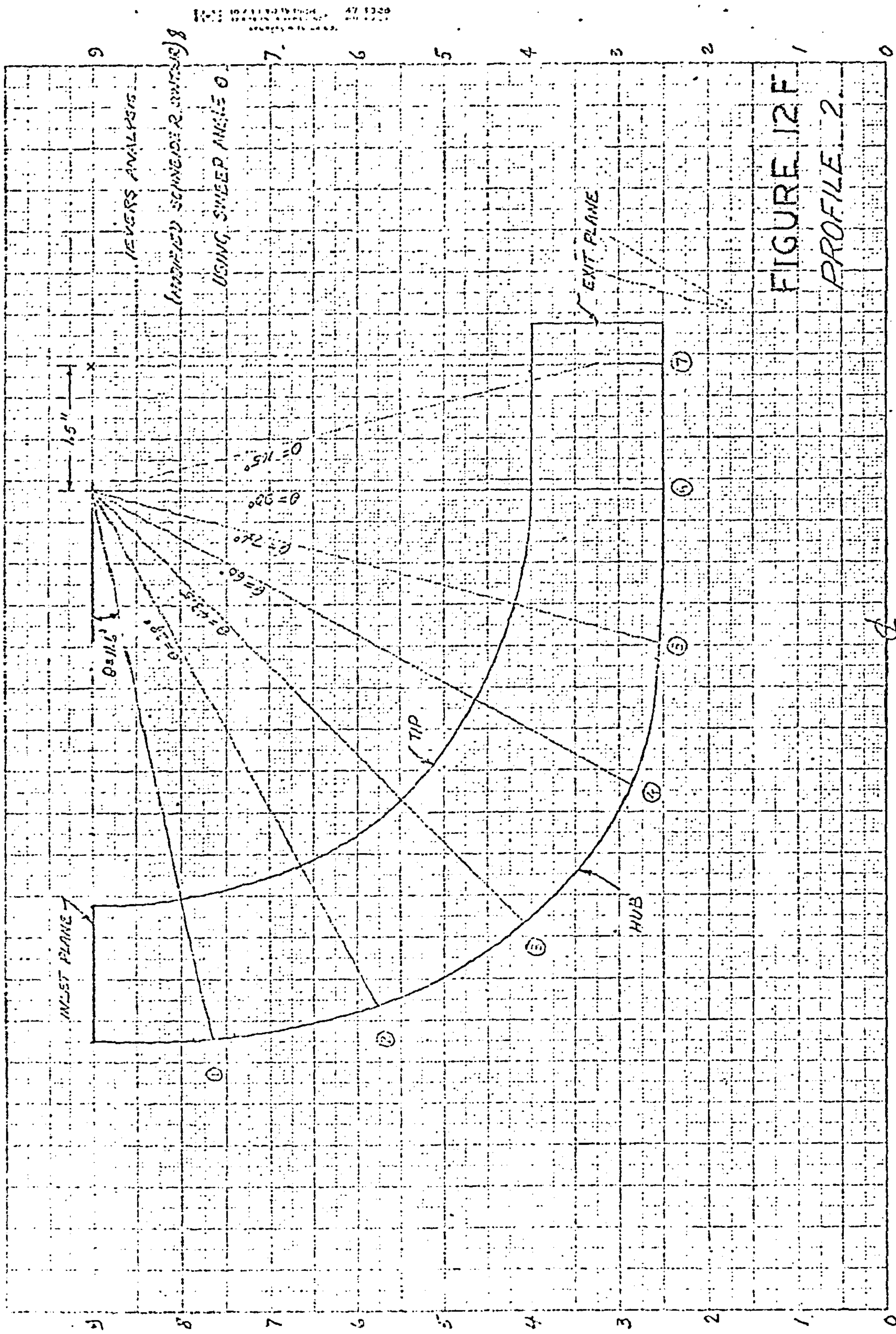


FIGURE 12 F
PROFILE 2

FIGURE 12G

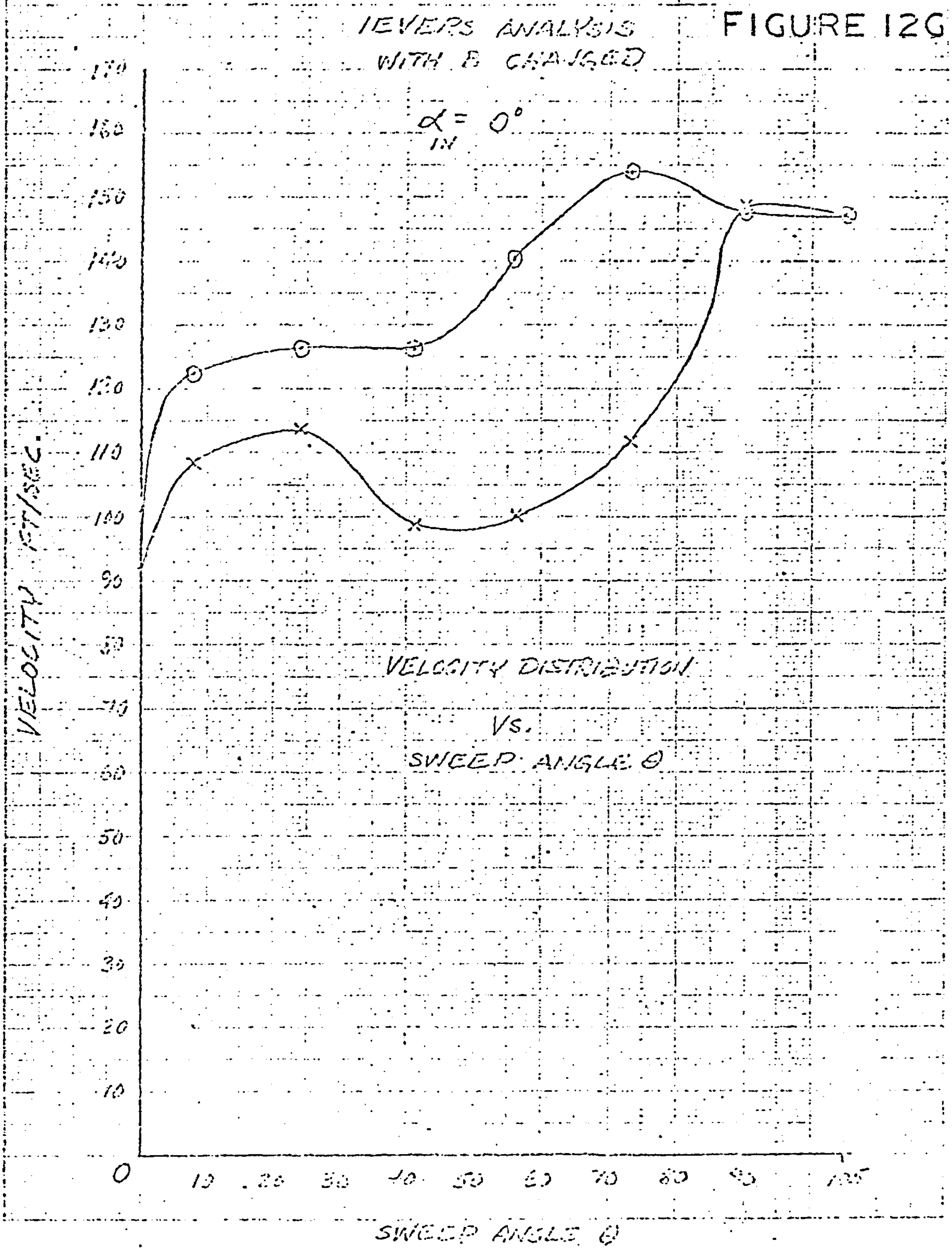
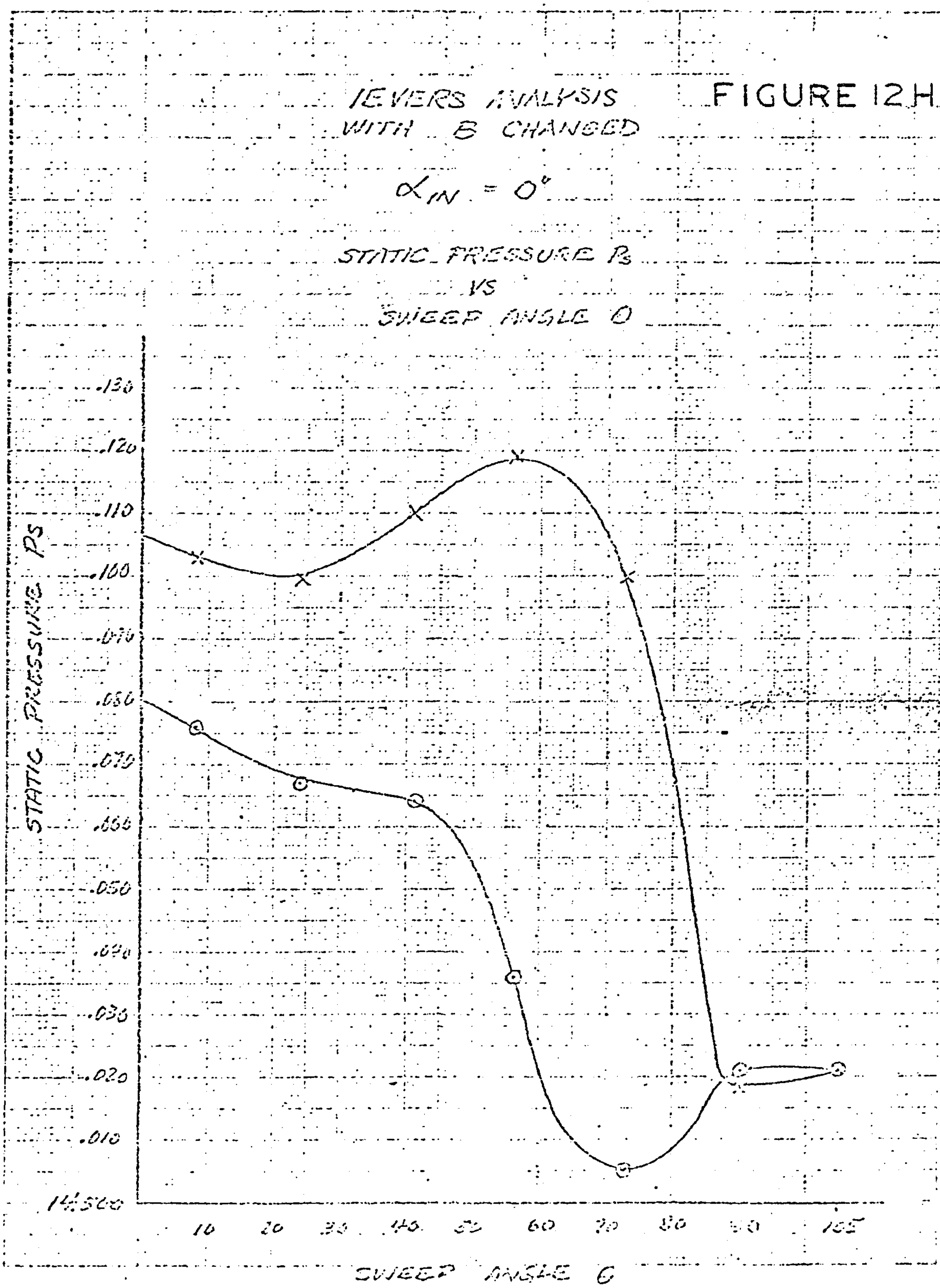

IEVERS ANALYSIS
WITH B CHANGED
α IN = 0°
VELOCITY FT/SEC.
VELOCITY DISTRIBUTION
VS.
SWEEP ANGLE θ
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
SWEEP ANGLE θ

FIGURE 12H


IEVERS ANALYSIS
WITH B CHANGED
α_{IN} = 0°
STATIC PRESSURE Ps
VS
SWEEP ANGLE θ
STATIC PRESSURE Ps
.130
.120
.110
.100
.090
.080
.070
.060
.050
.040
.030
.020
.010
14.500
10
20
30
40
50
60
70
80
90
100
SWEEP ANGLE θ

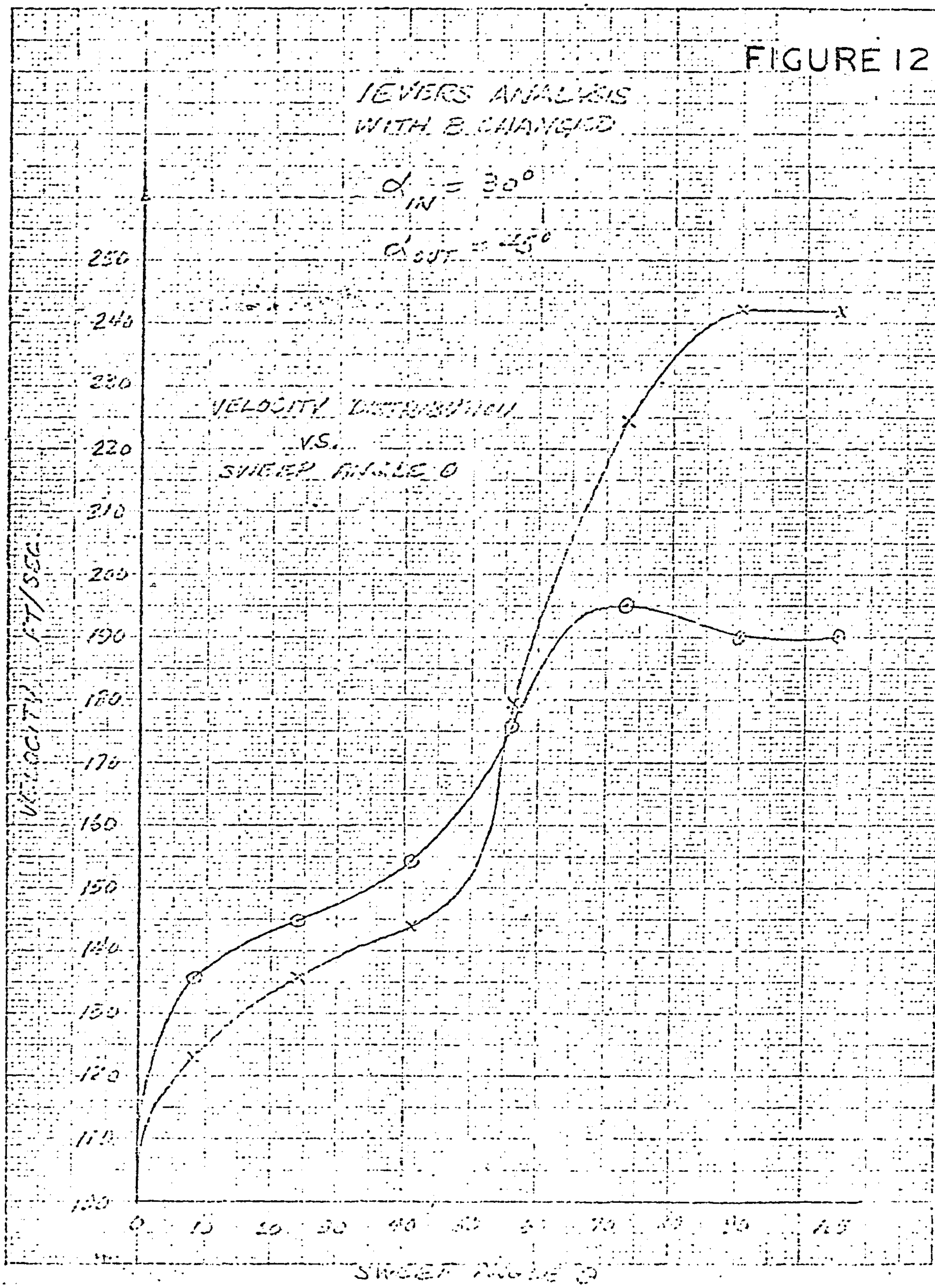


FIGURE 121
IEVERS ANALYSIS
WITH B CHANGED
$\alpha_{IN} = 30^\circ$
VELOCITY DISTRIBUTION
VS.
SWEEP ANGLE θ
VELOCITY FT/SEC.
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
0
10
20
30
40
50
60
70
80
90
SWEEP ANGLE θ

FIGURE 12J

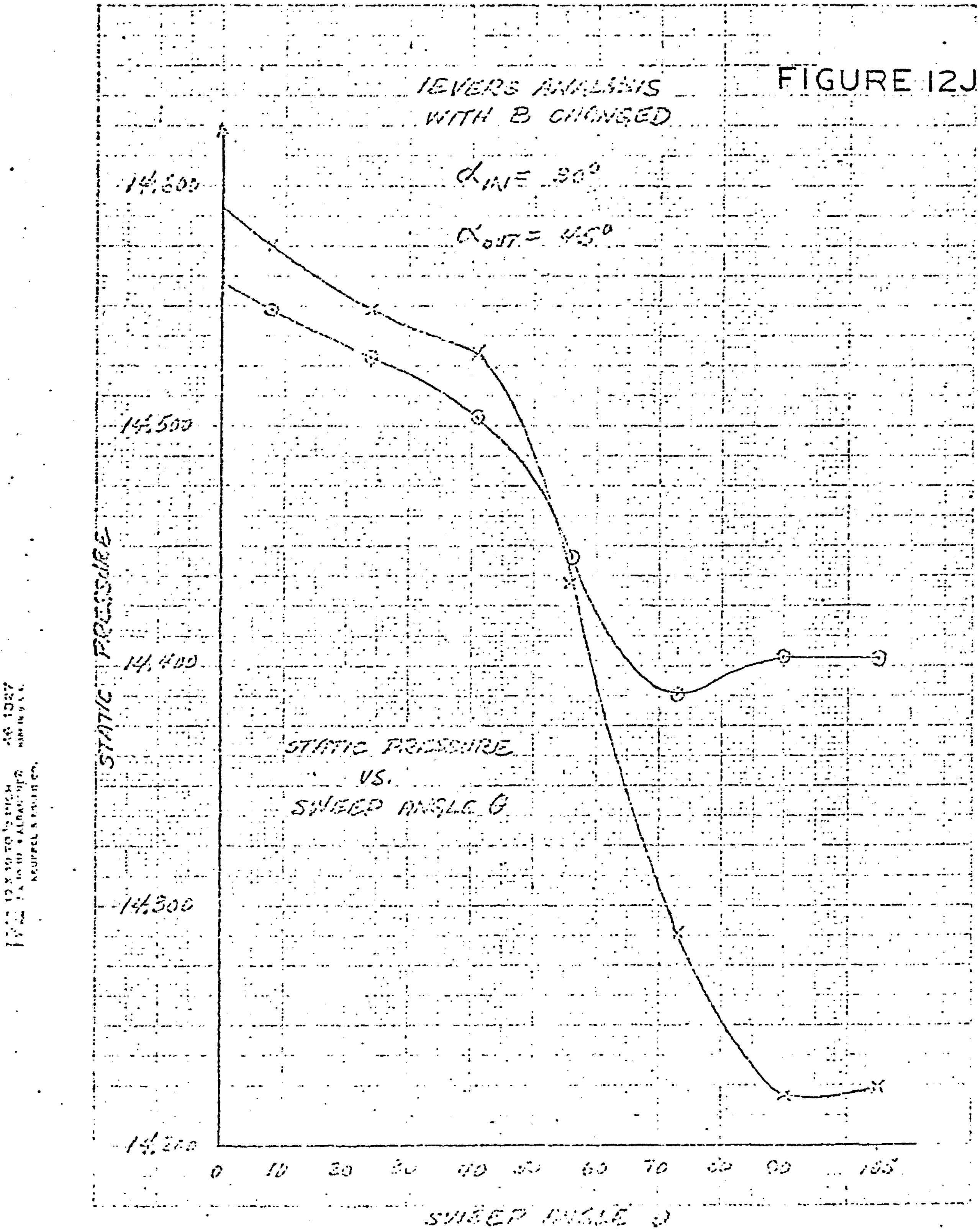

IEVERS ANALYSIS
WITH B CHANGED
$\alpha_{IN} = 30°$
$\alpha_{OUT} = 45°$
14,600
14,500
14,400
14,300
STATIC PRESSURE
STATIC PRESSURE
VS.
SWEEP ANGLE θ
0
10
60
70
90
100
SWEEP ANGLE θ

FIGURE 13A

INLET SWIRL ANGLE PROFILES

DIFFUSER A

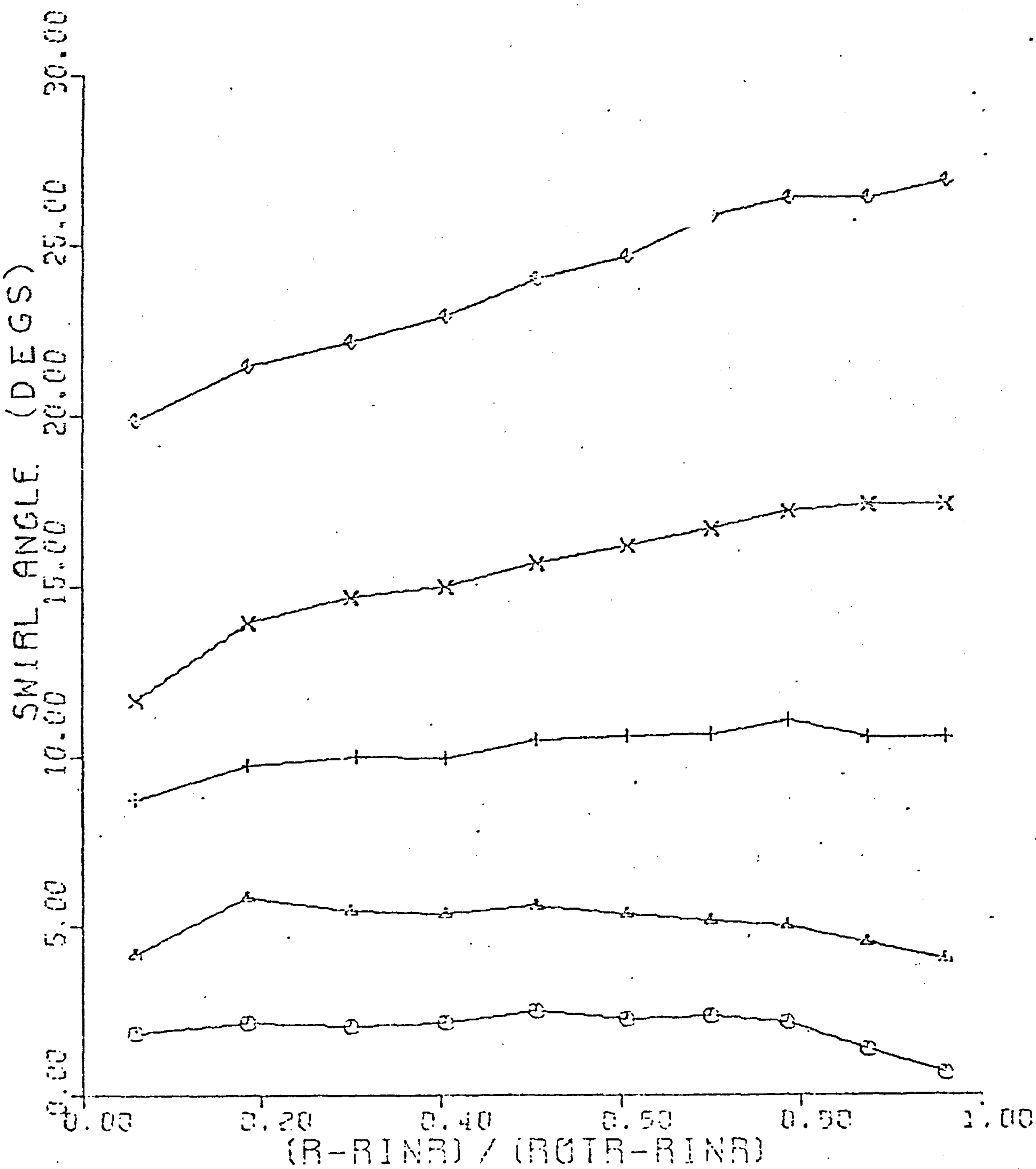


FIGURE 13B

INLET SWIRL ANGLE PROFILES

DIFFUSER B

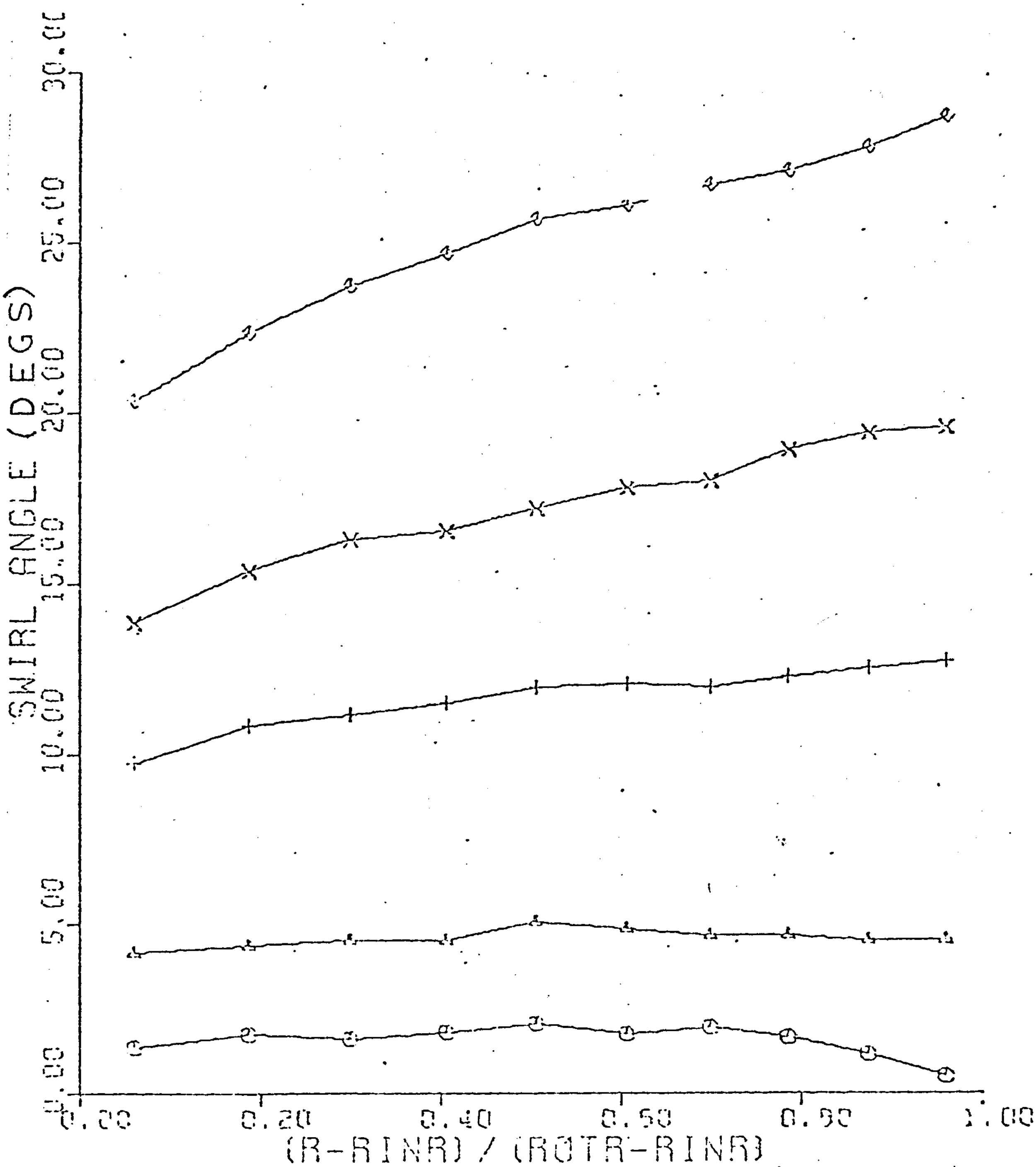


FIGURE 13 C.

INLET SWIRL ANGLE PROFILES

DIFFUSER C

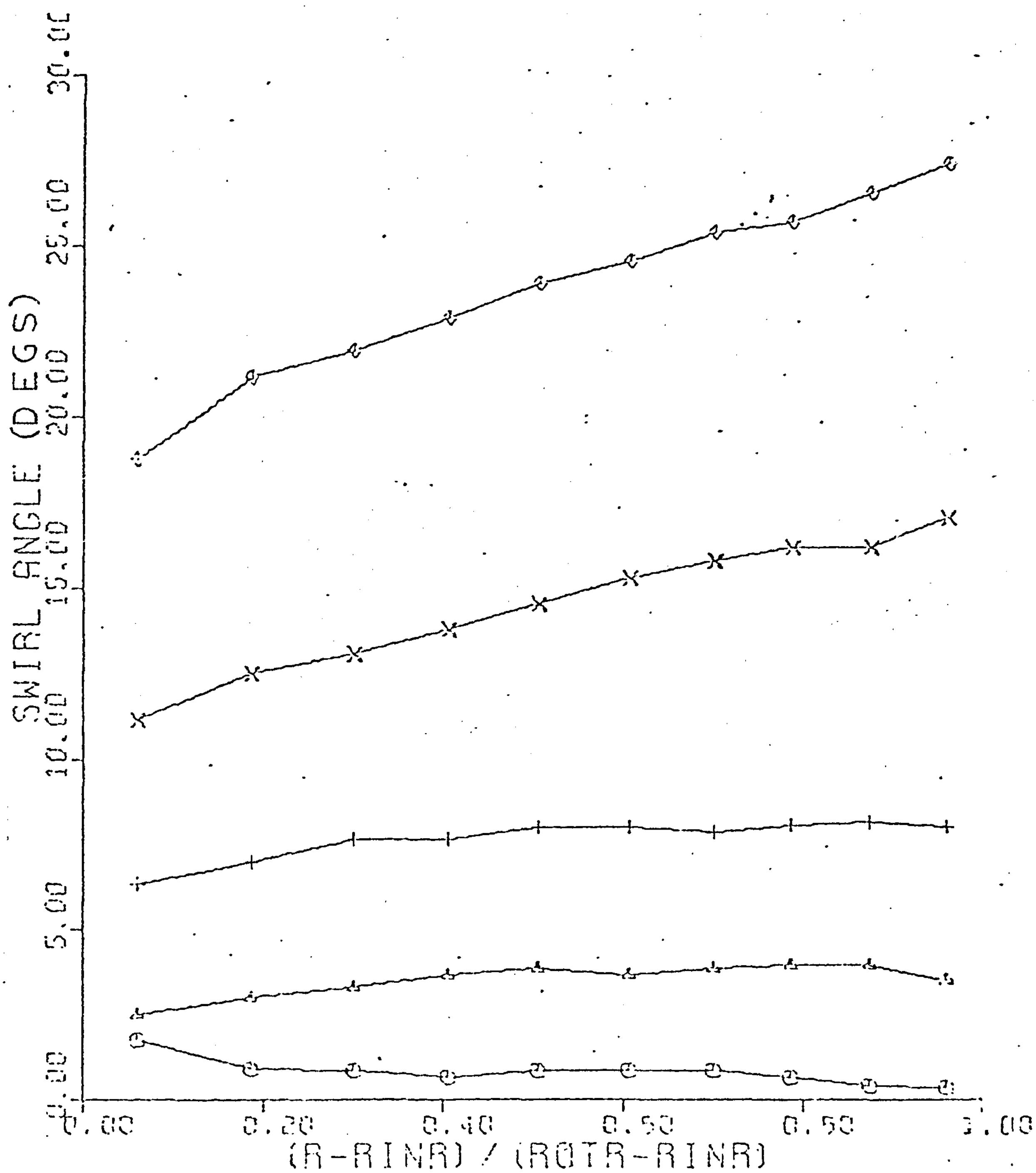


FIGURE 13 D.

INLET SWIRL ANGLE PROFILES

DIFFUSER D

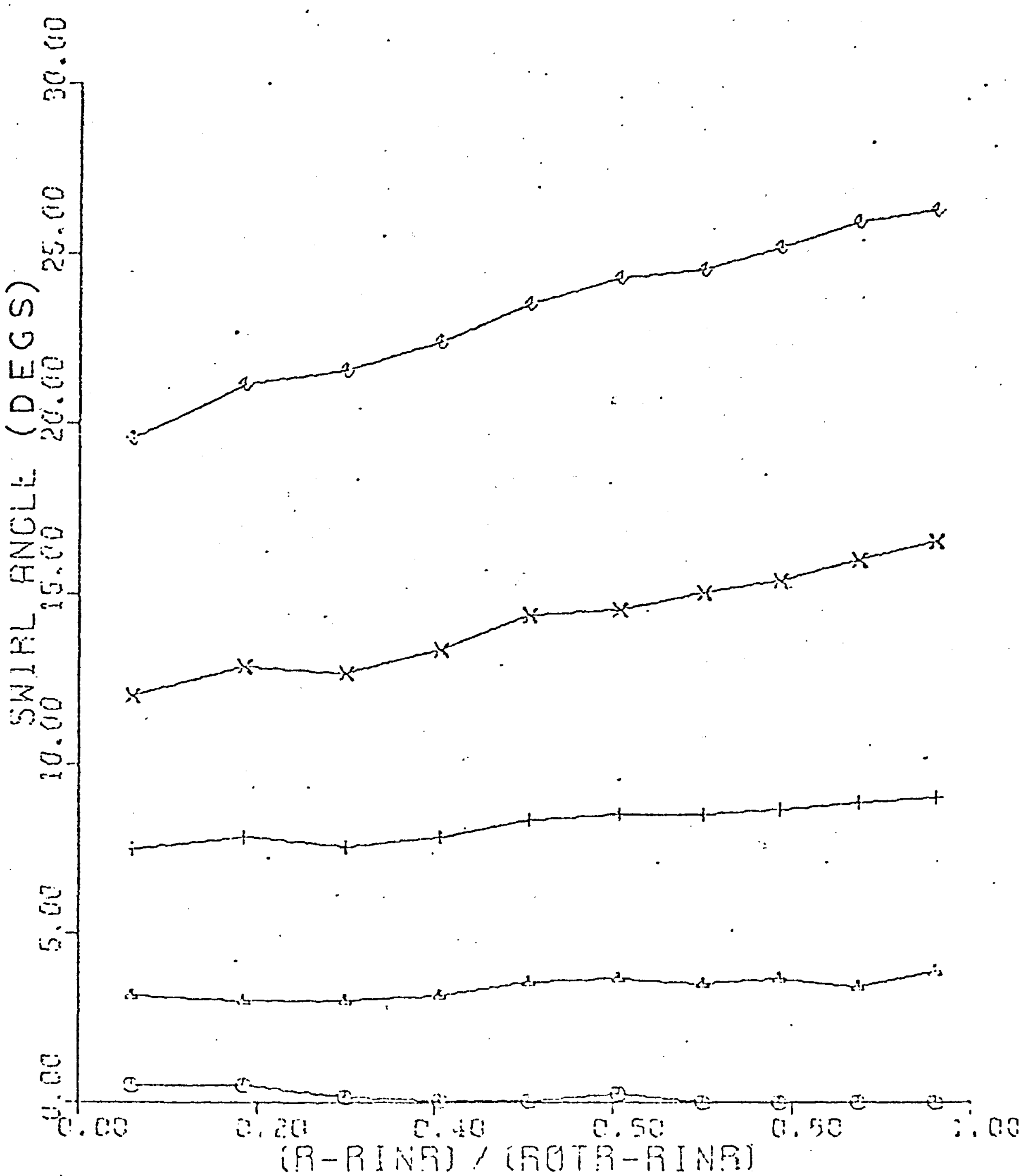


FIGURE 14A.

INLET TANGENTIAL VELOCITY PROFILES

DIFFUSER A

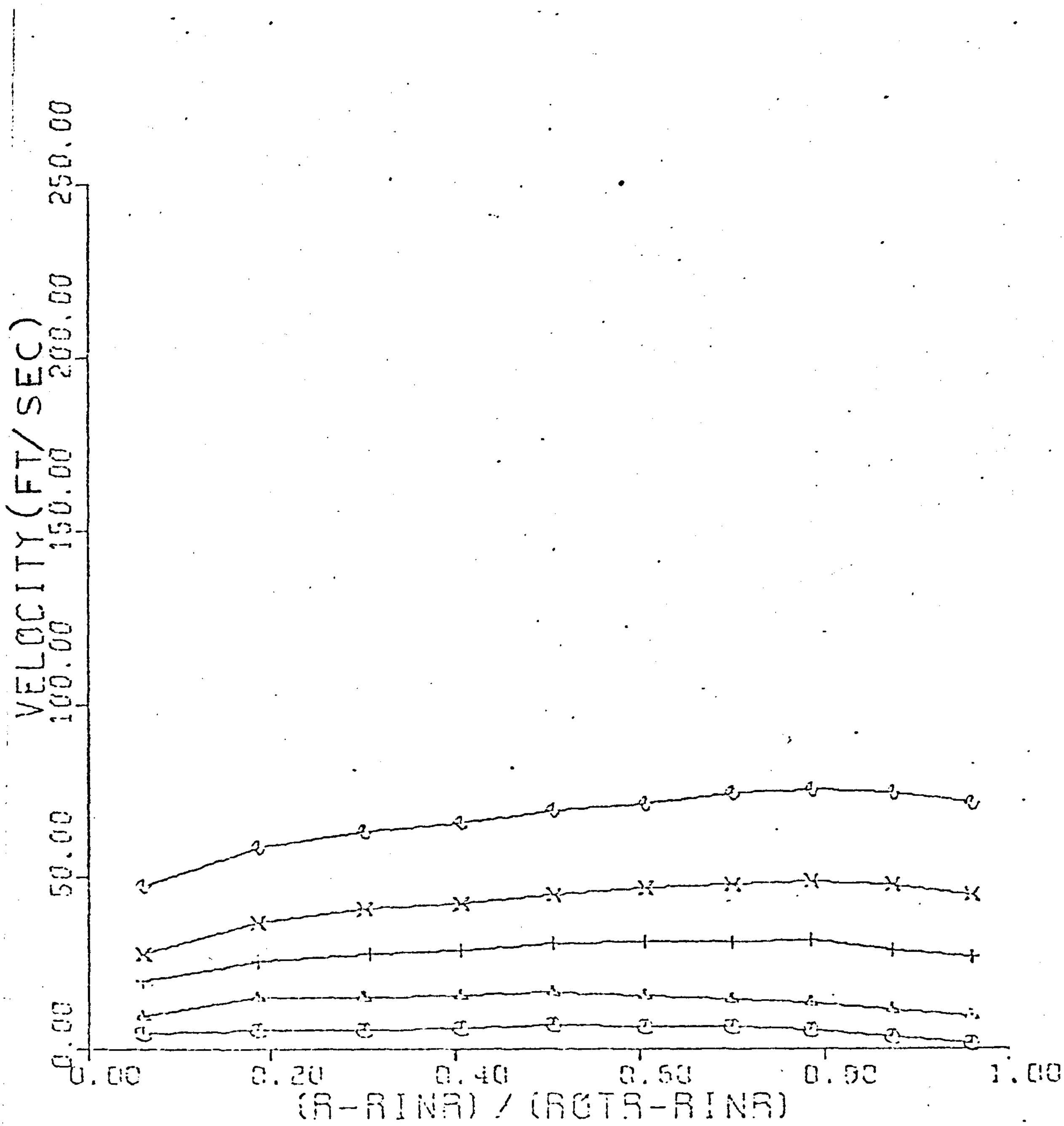


FIGURE 14B

INLET TANGENTIAL VELOCITY PROFILES

DIFFUSERB

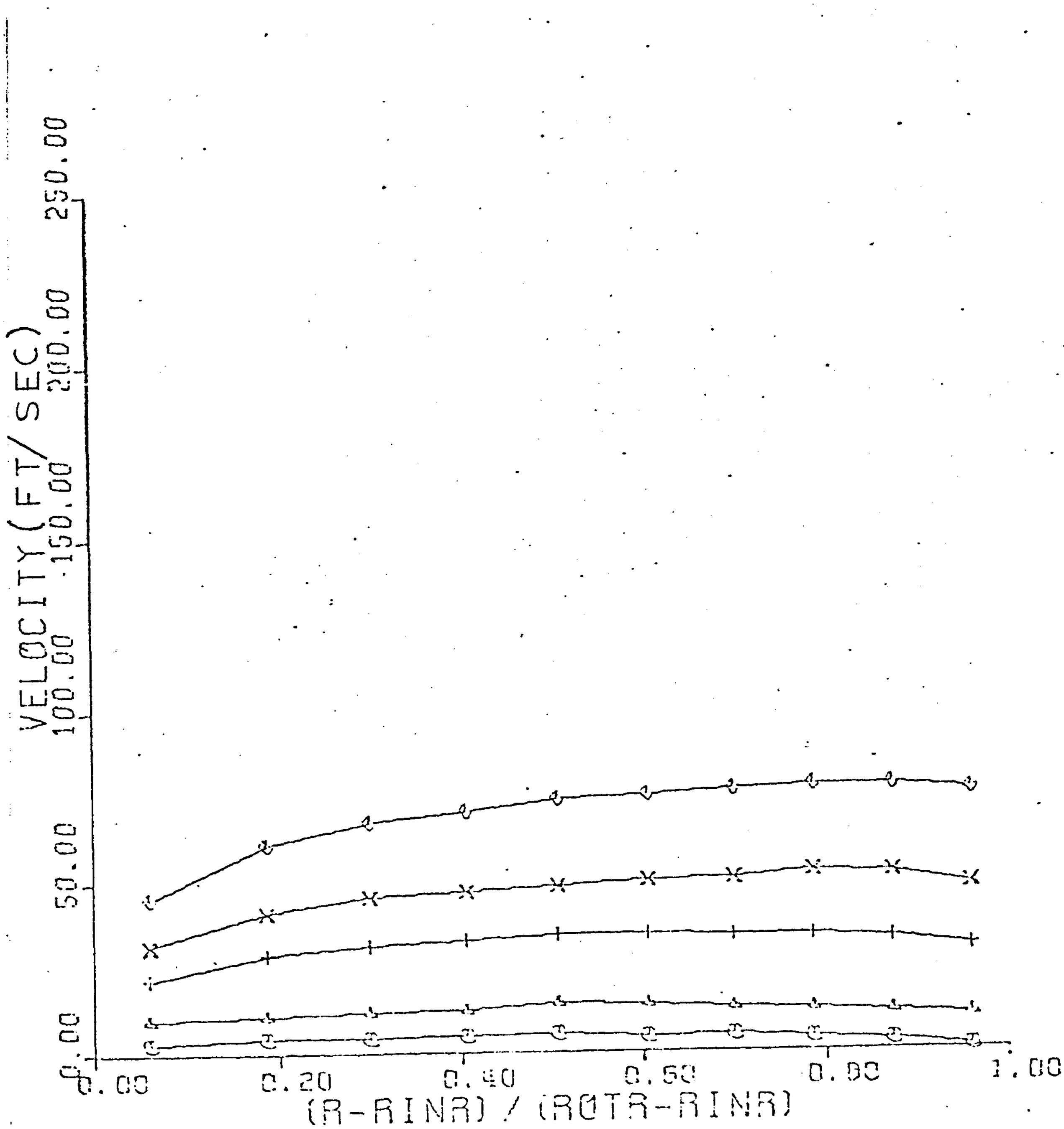


FIGURE 14C

INLET TANGENTIAL VELOCITY PROFILES

DIFFUSER C

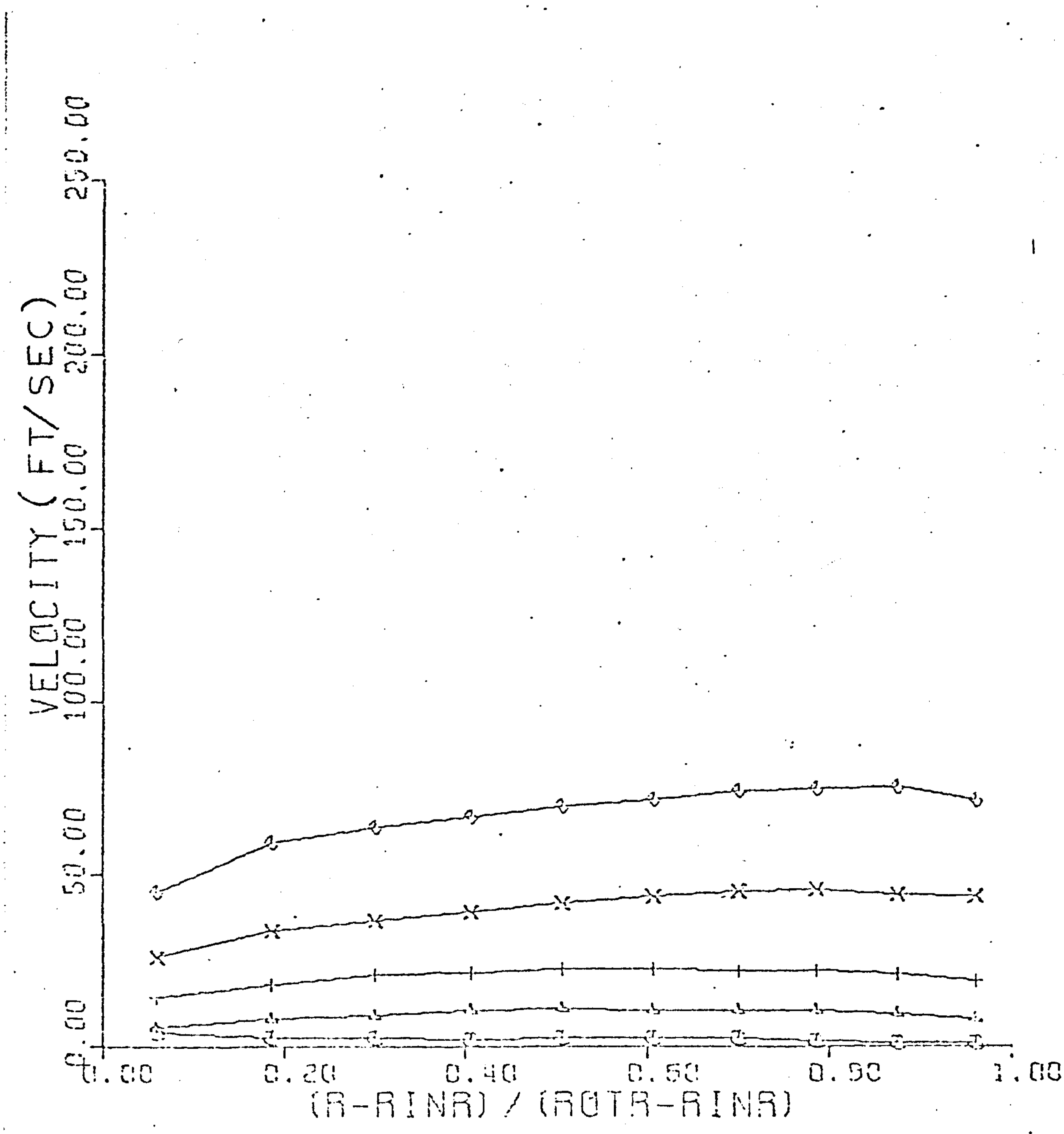


FIGURE 14D.

INLET TANGENTIAL VELOCITY PROFILES

DIFFUSERD

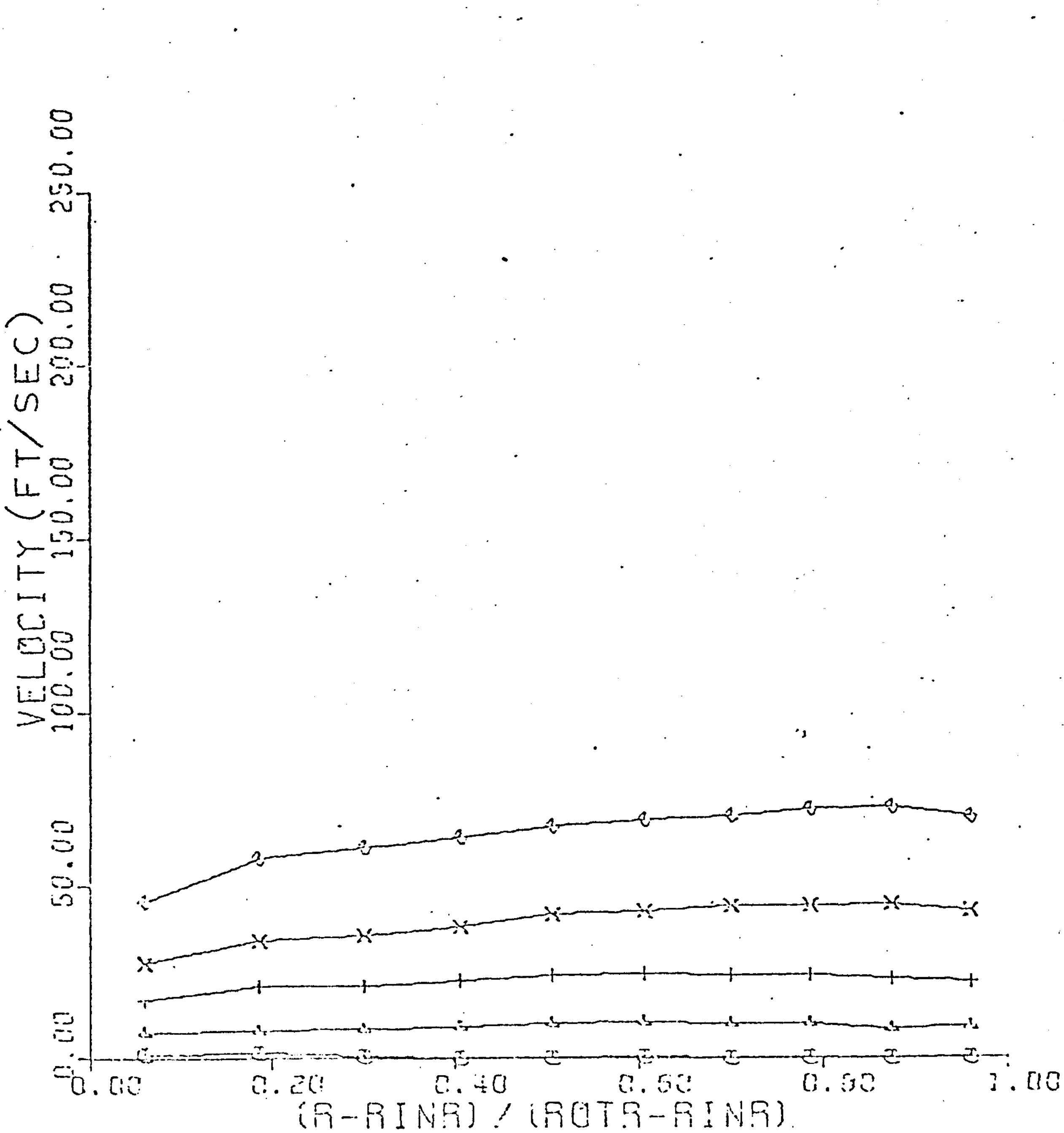


FIGURE 15A

INLET DYNAMIC PRESSURE PROFILES

DIFFUSER A

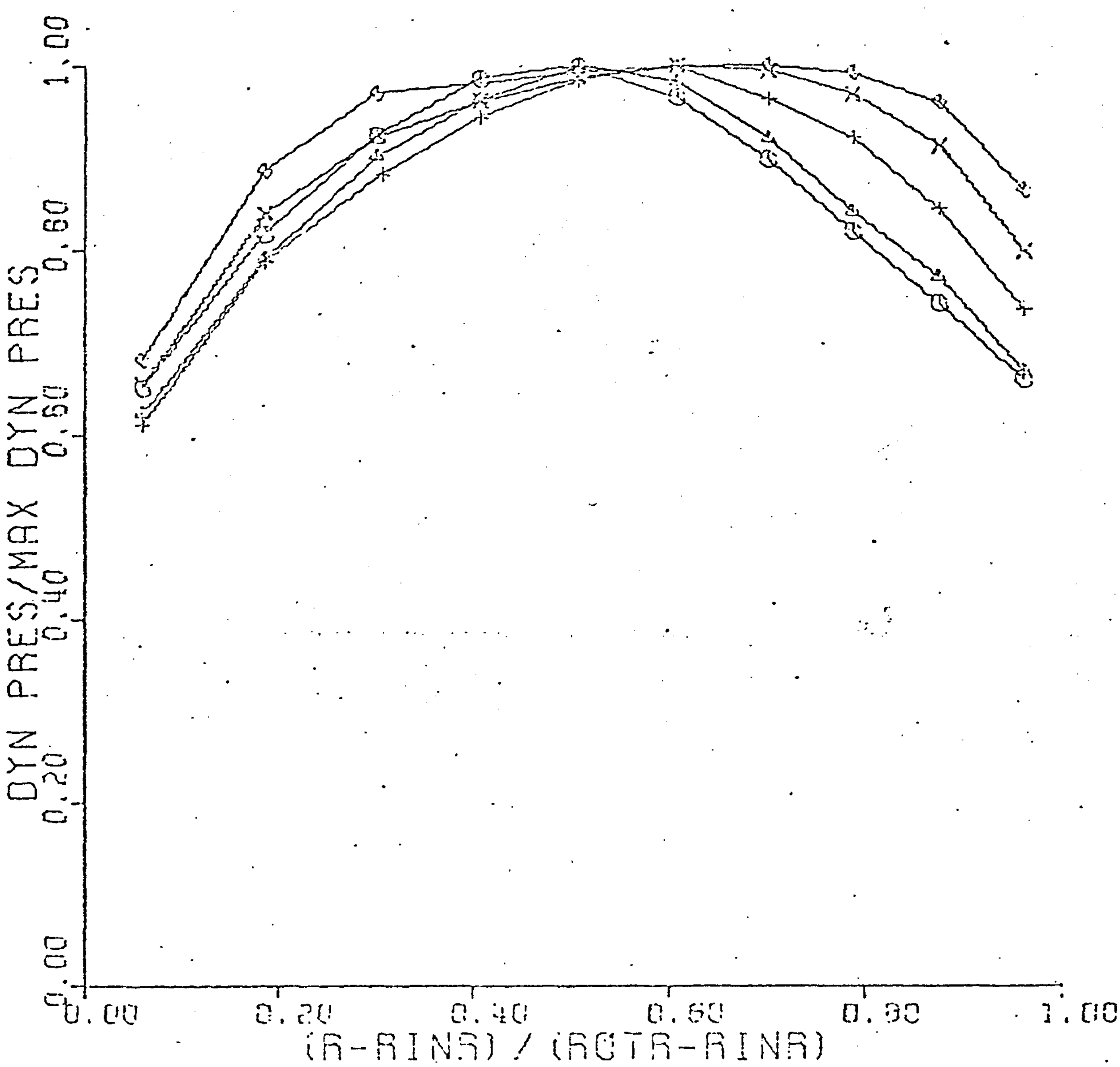


FIGURE 15 B

INLET DYNAMIC PRESSURE PROFILES

DIFFUSER B

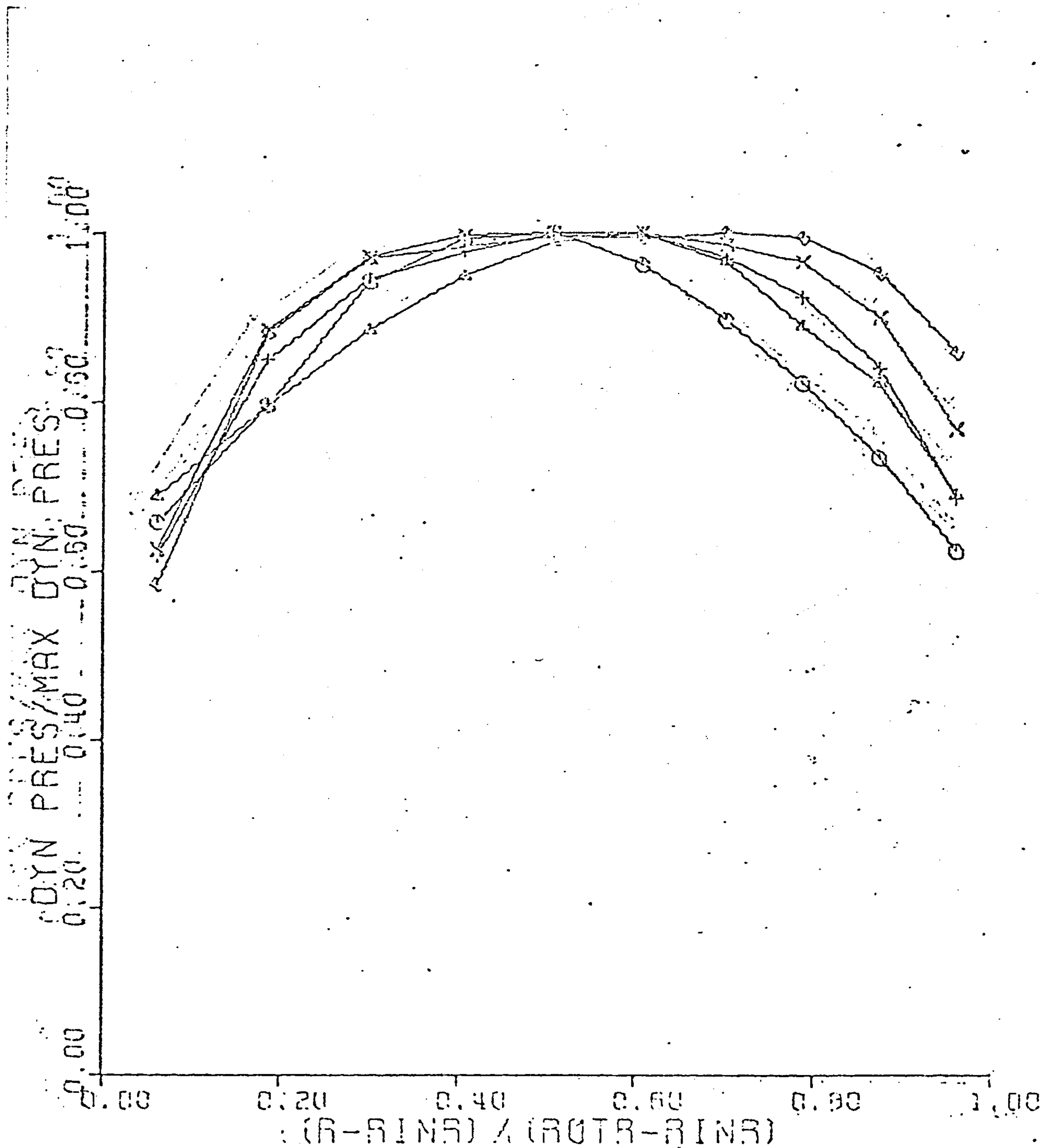


FIGURE 15C

INLET DYNAMIC PRESSURE PROFILES

DIFFUSER C

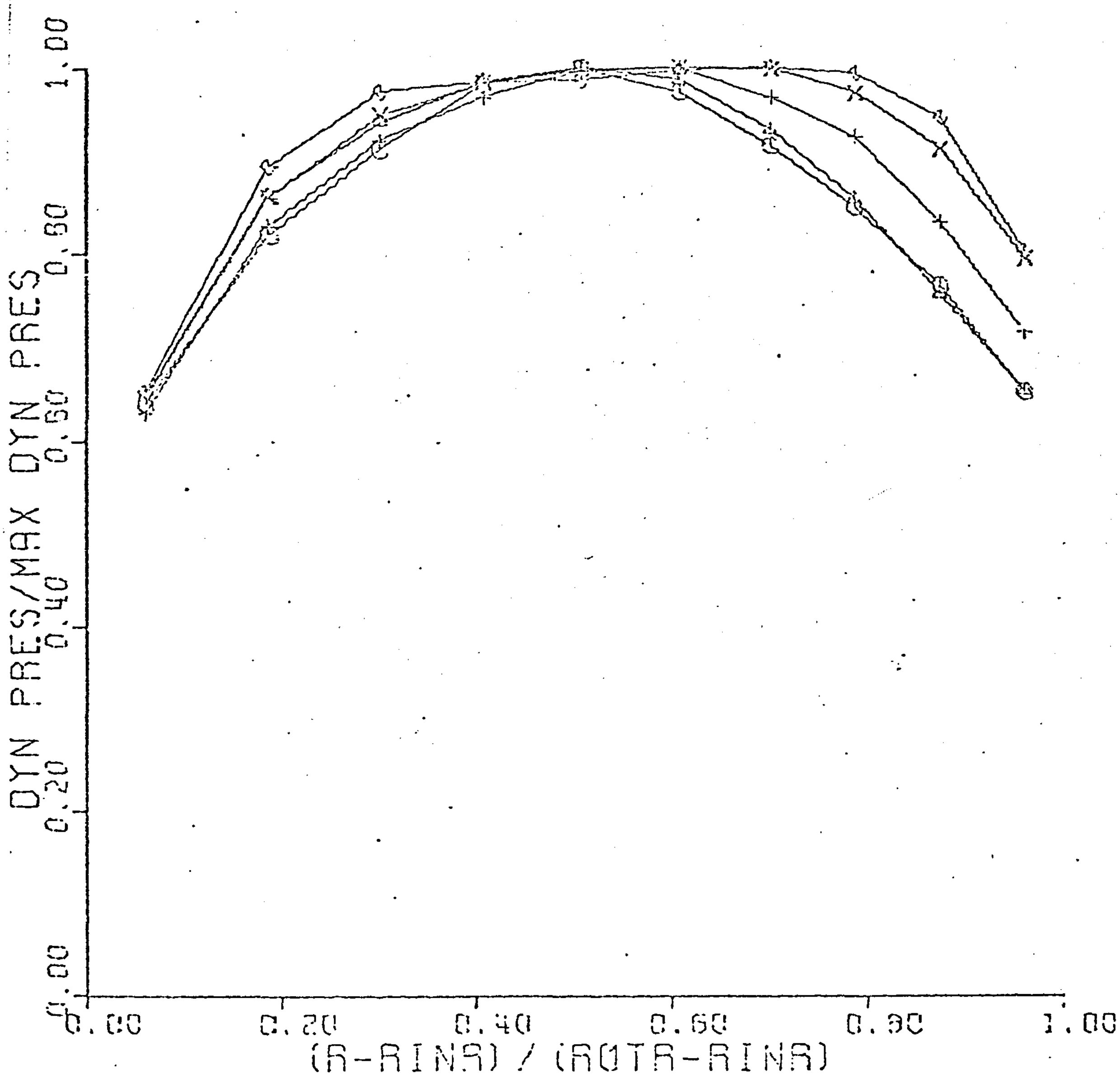


FIGURE 15D

INLET DYNAMIC PRESSURE PROFILES

DIFFUSER D

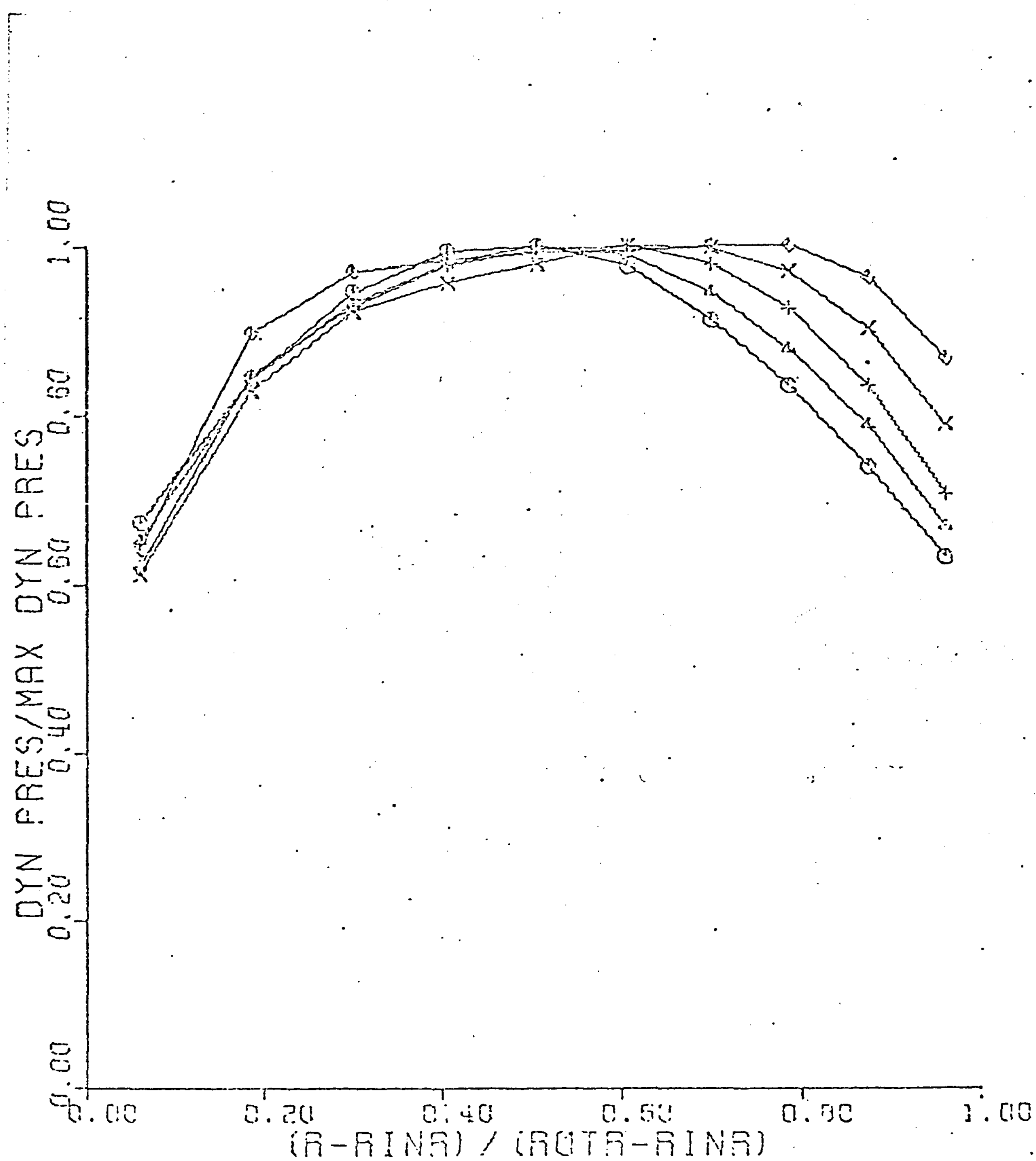


FIGURE 16A

INLET ABSOLUTE VELOCITY PROFILES

DIFFUSER A

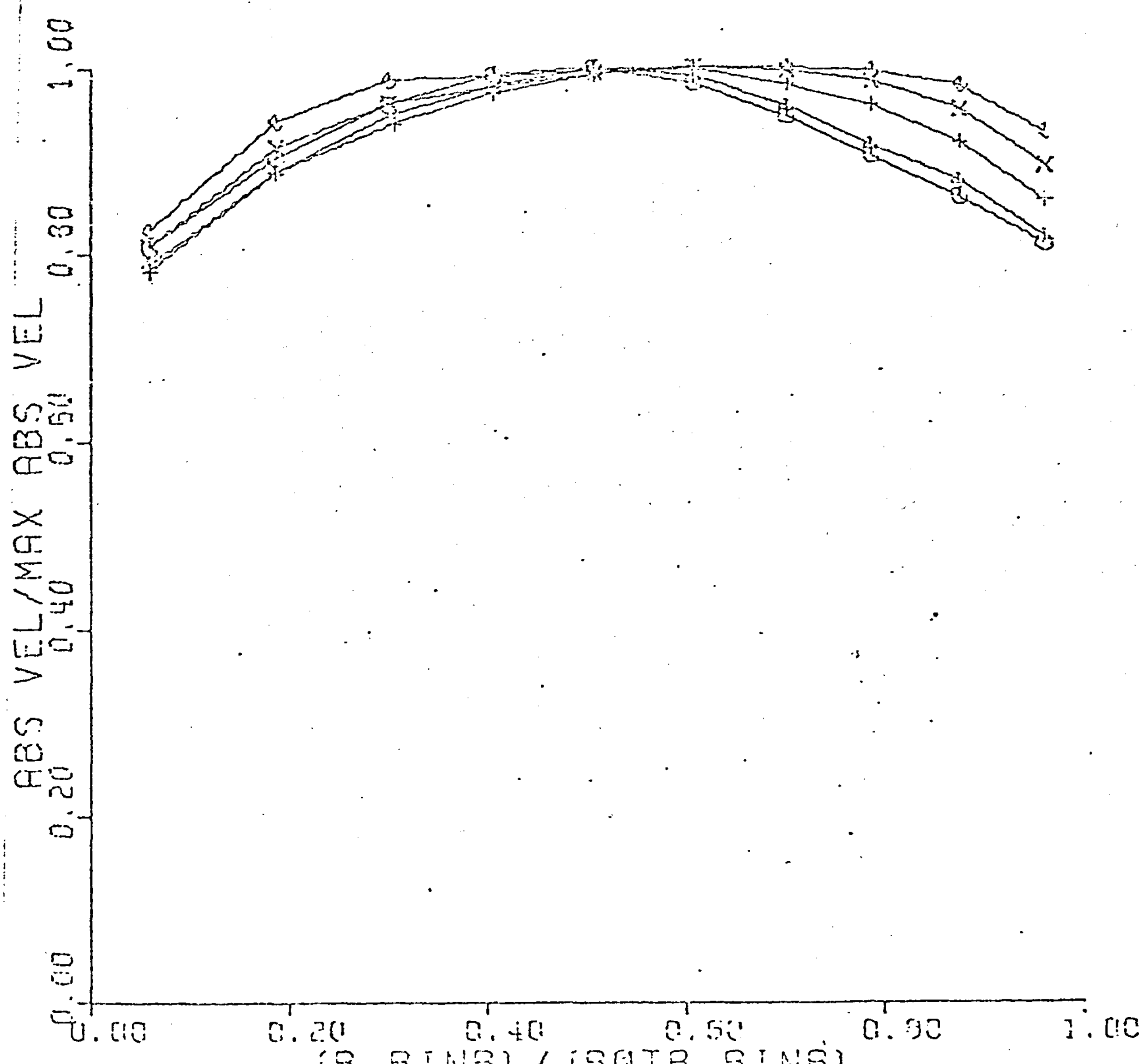


FIGURE 16B

INLET ABSOLUTE VELOCITY PROFILES

DIFFUSER B

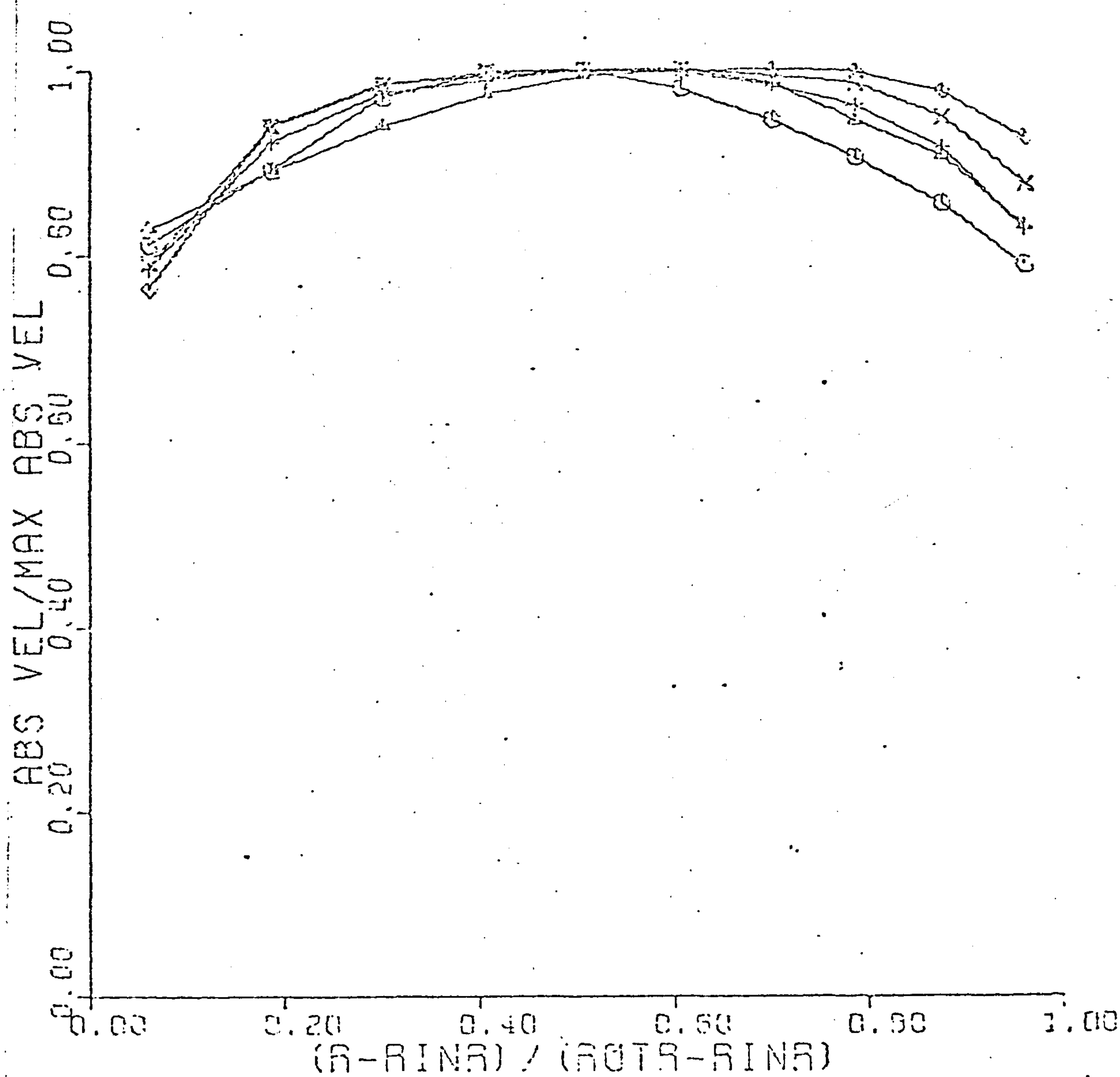


FIGURE 16C.

INLET ABSOLUTE VELOCITY PROFILES

DIFFUSER C

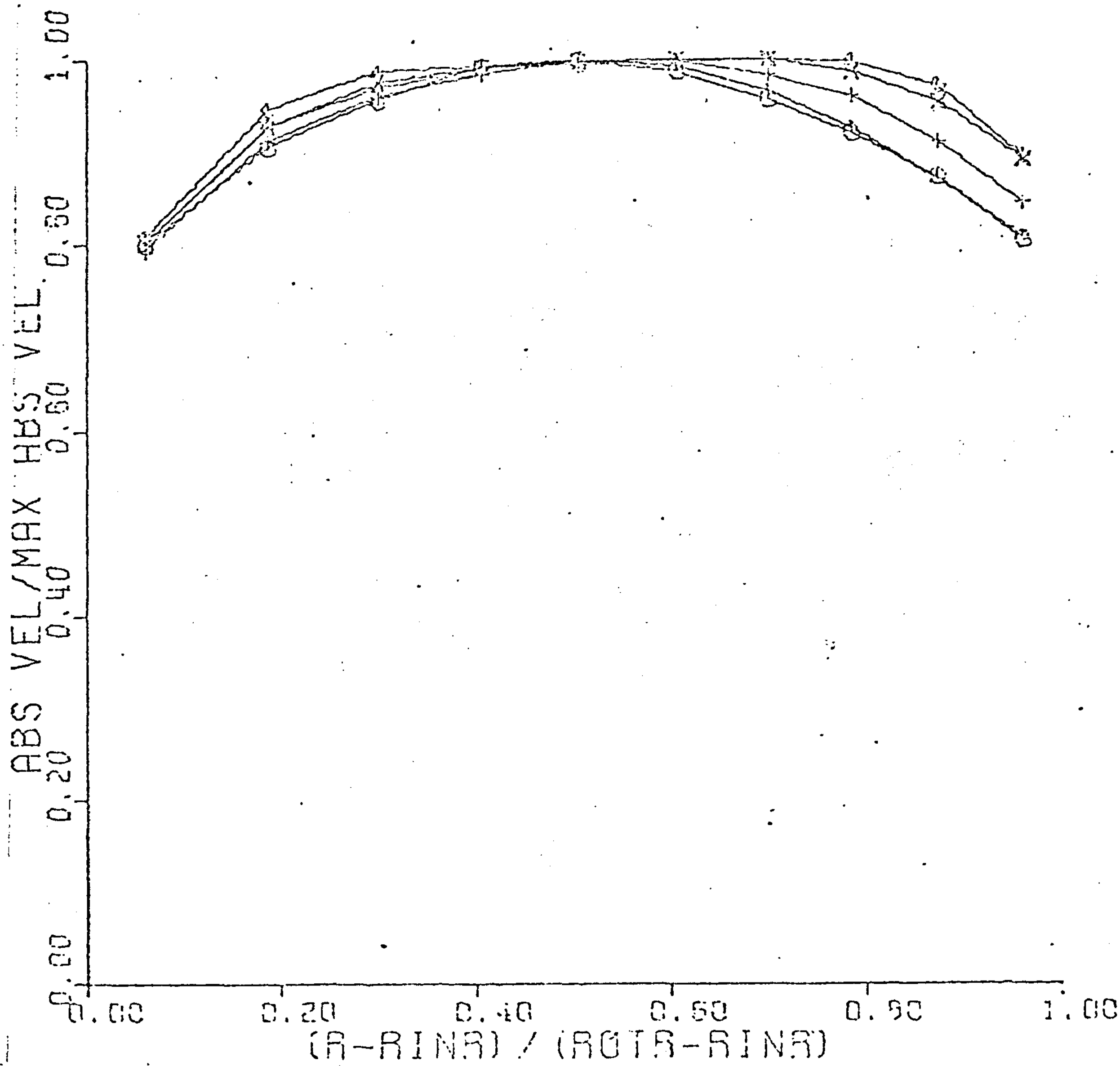


FIGURE 16 D.

INLET ABSOLUTE VELOCITY PROFILES

DIFFUSER D

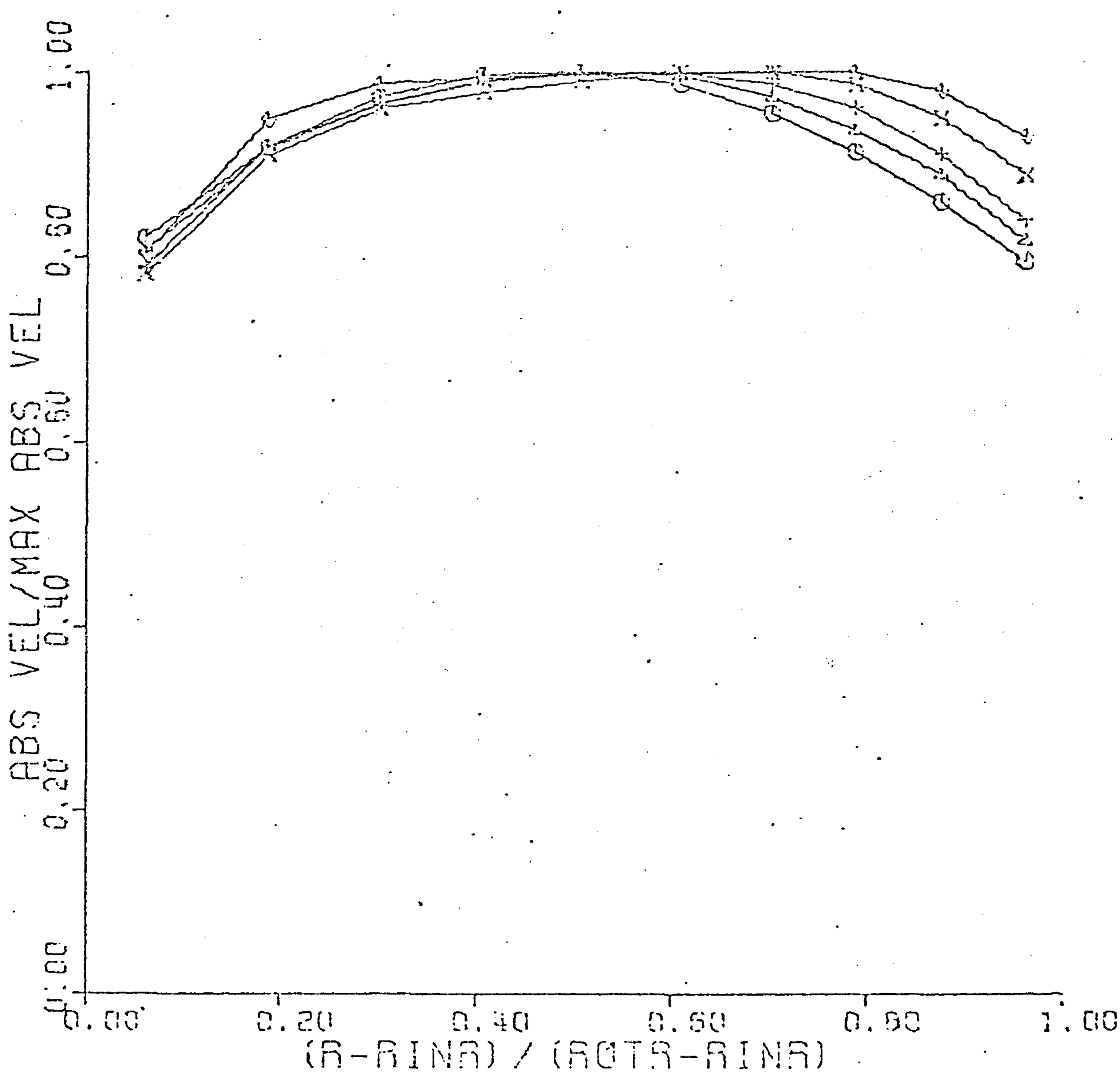


FIGURE 17A.

INLET AXIAL VELOCITY PROFILES

DIFFUSER A

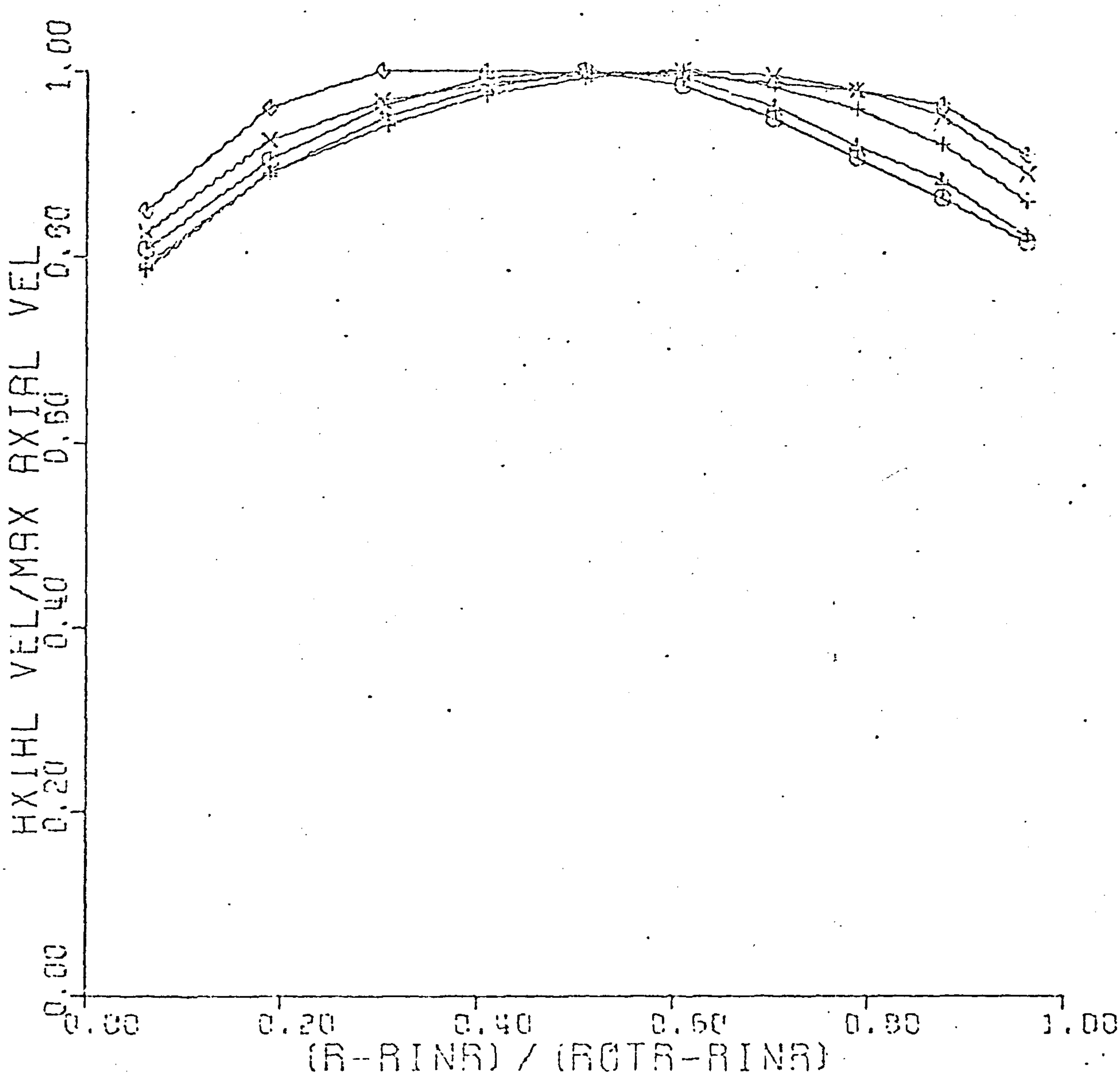


FIGURE 17B.

INLET AXIAL VELOCITY PROFILES

DIFFUSERB

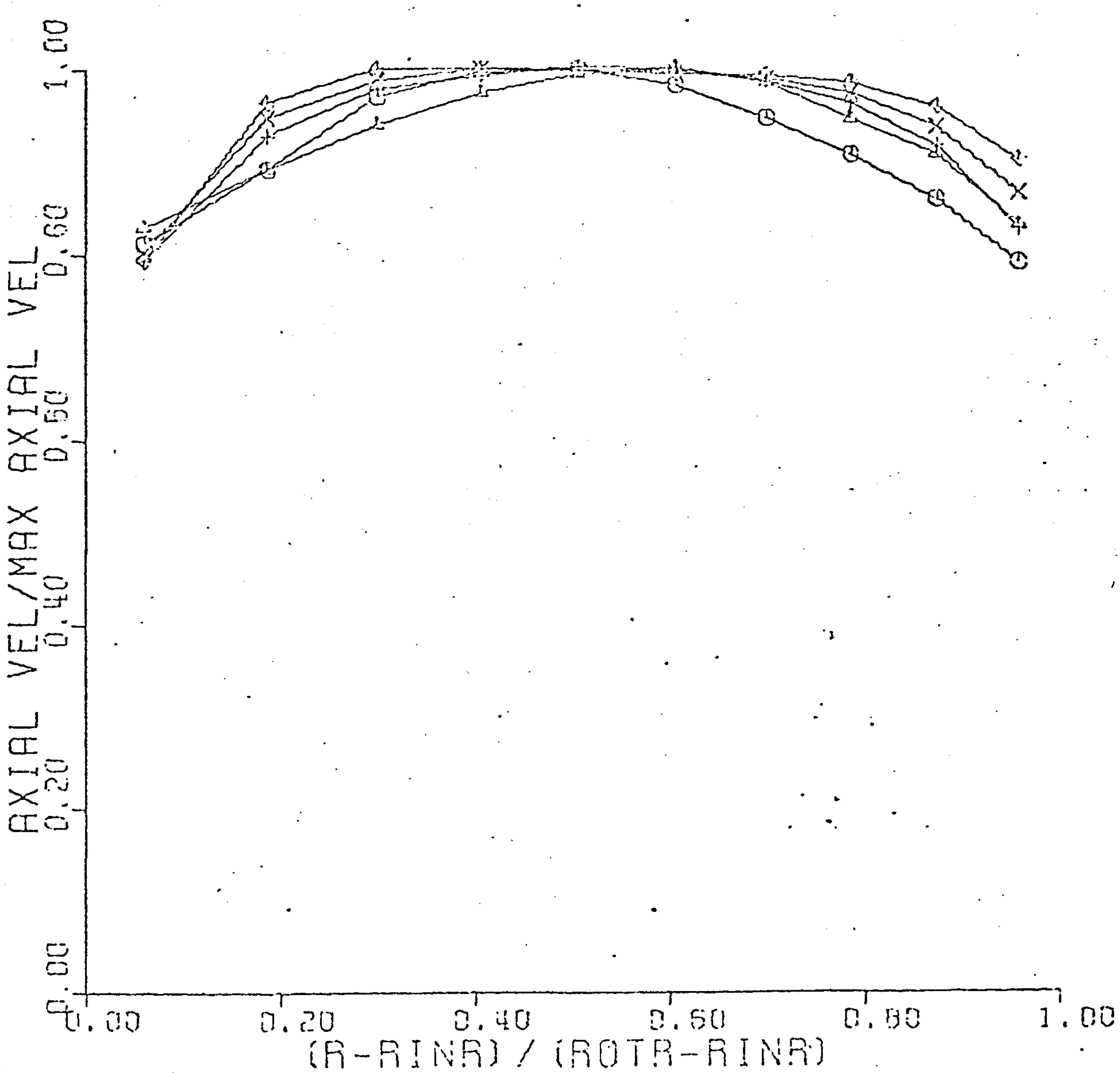


FIGURE 17C.

INLET AXIAL VELOCITY PROFILES

DIFFUSER C

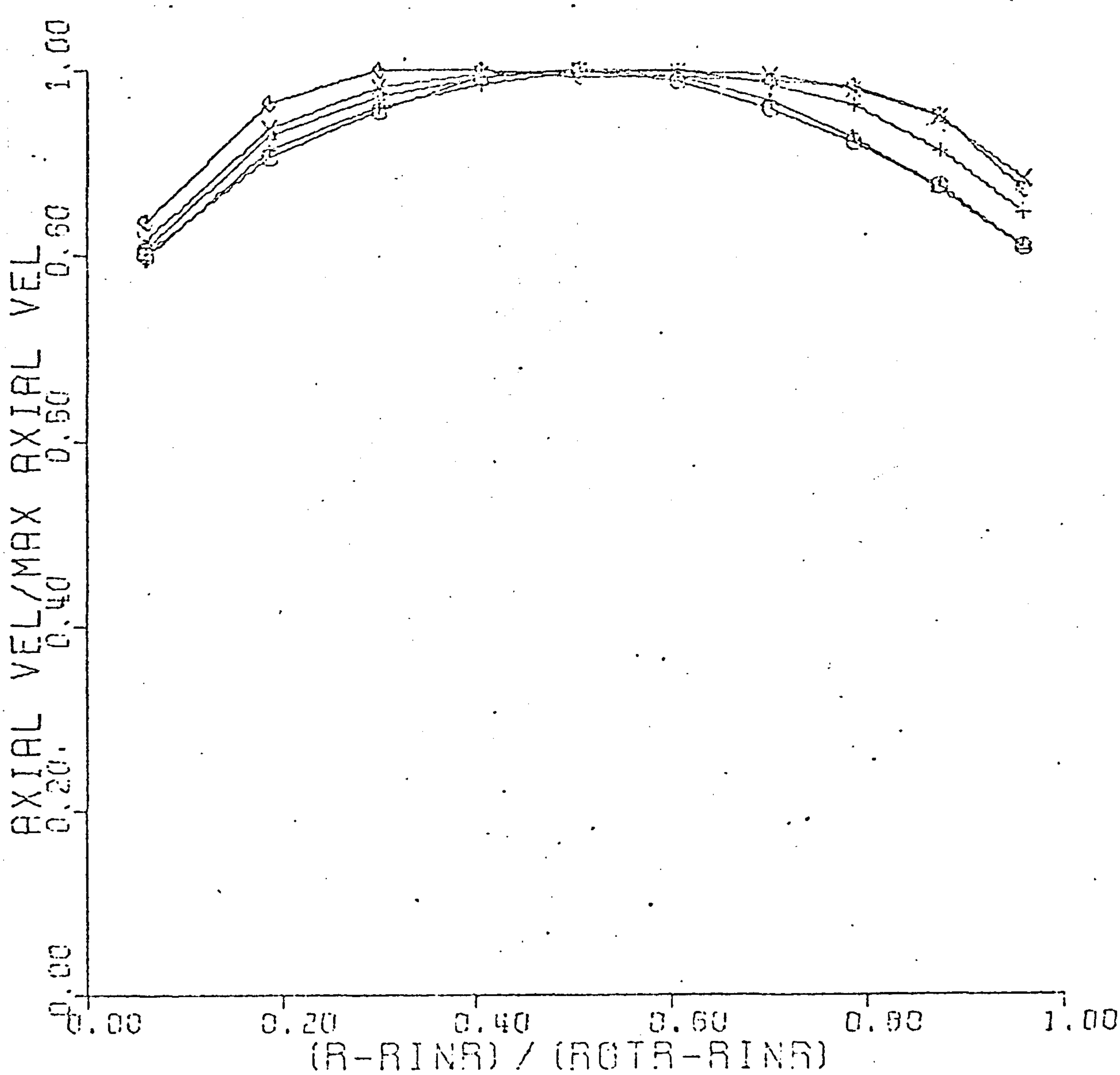


FIGURE 17 D

INLET AXIAL VELOCITY PROFILES

DIFFUSER D

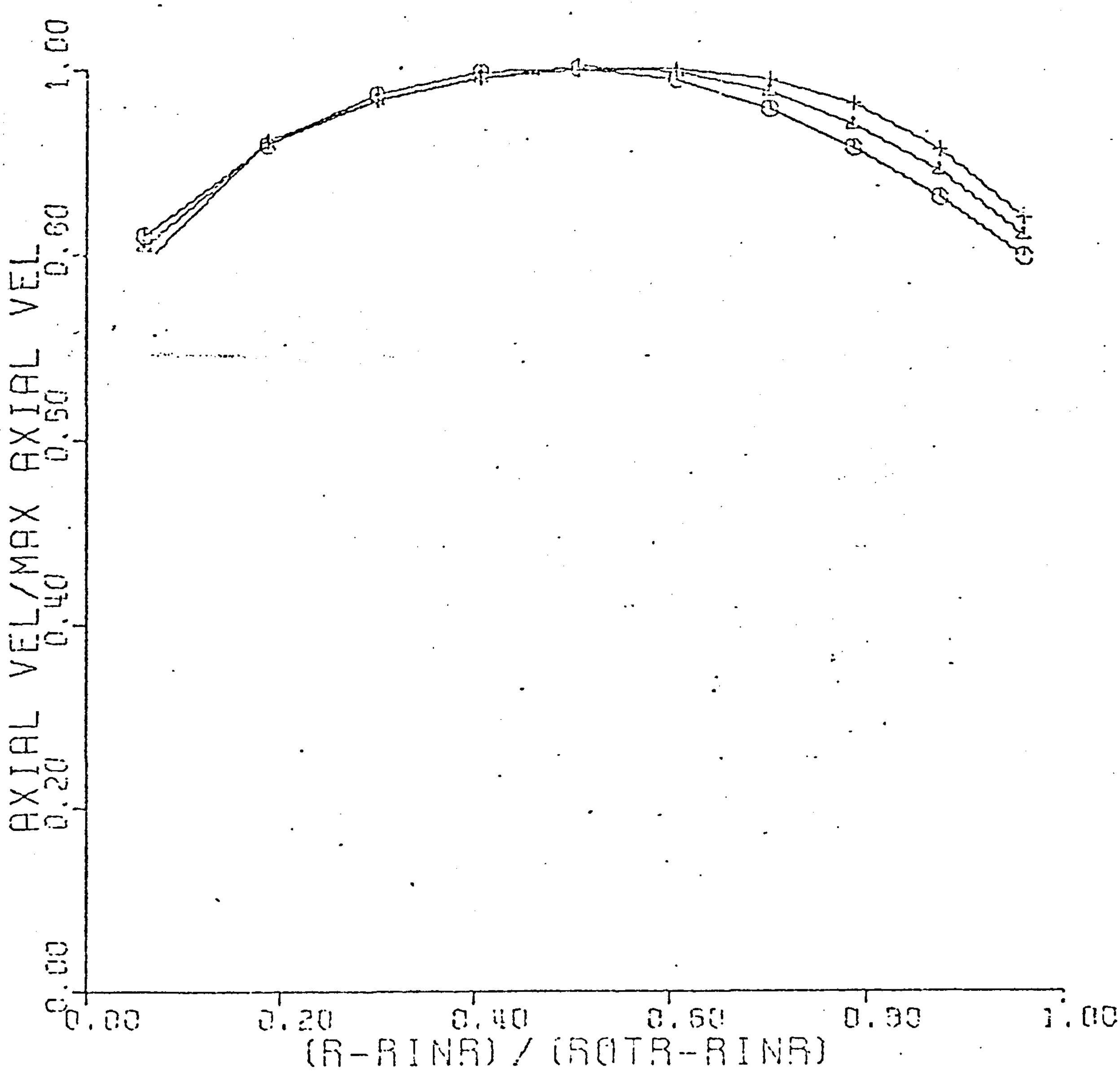


FIGURE 18A

INLET STATIC PRESSURE PROFILES

DIFFUSER A

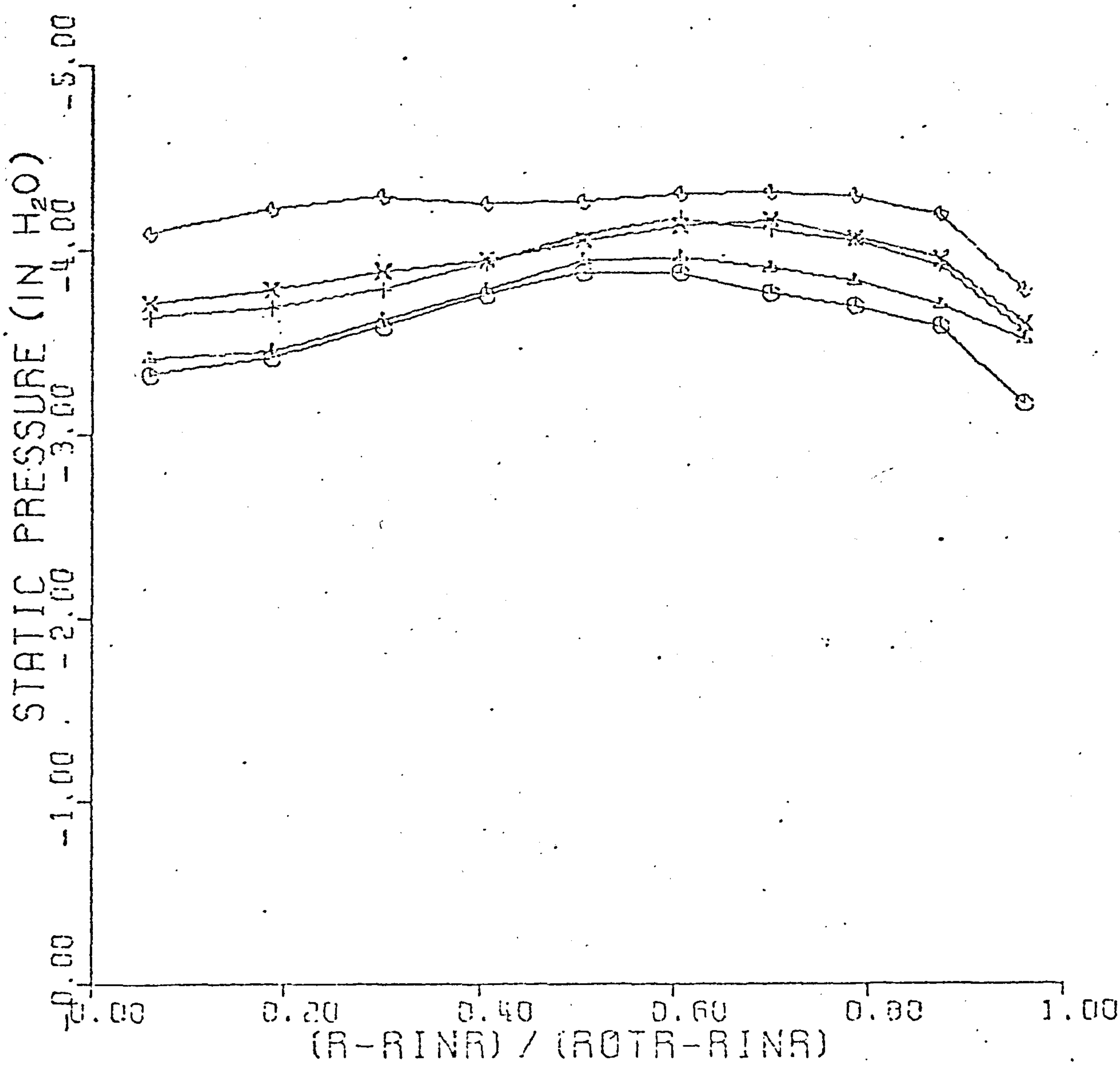


FIGURE 18B

INLET STATIC PRESSURE PROFILES

DIFFUSER B

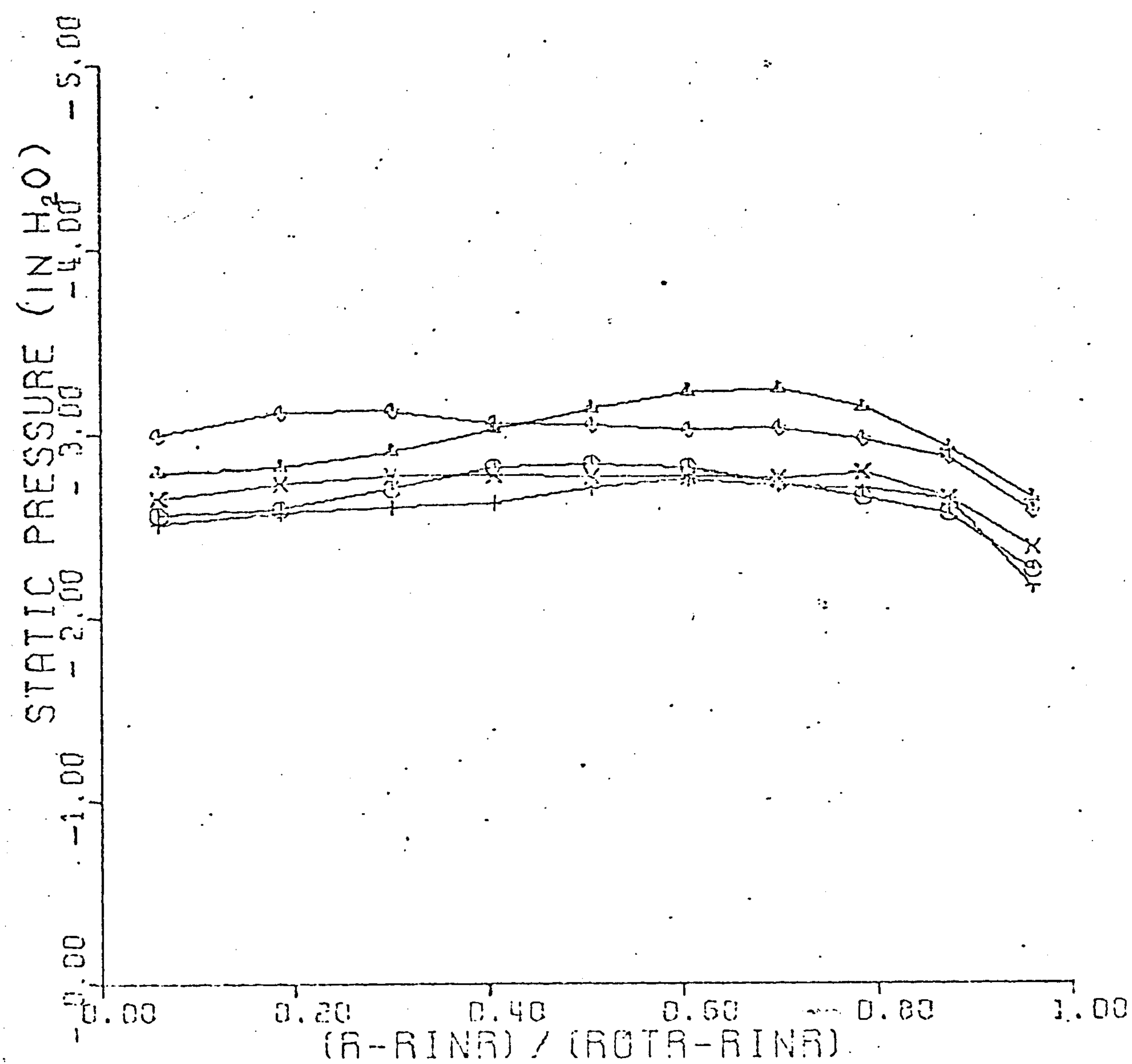


FIGURE 18C

INLET STATIC PRESSURE PROFILES

DIFFUSER C

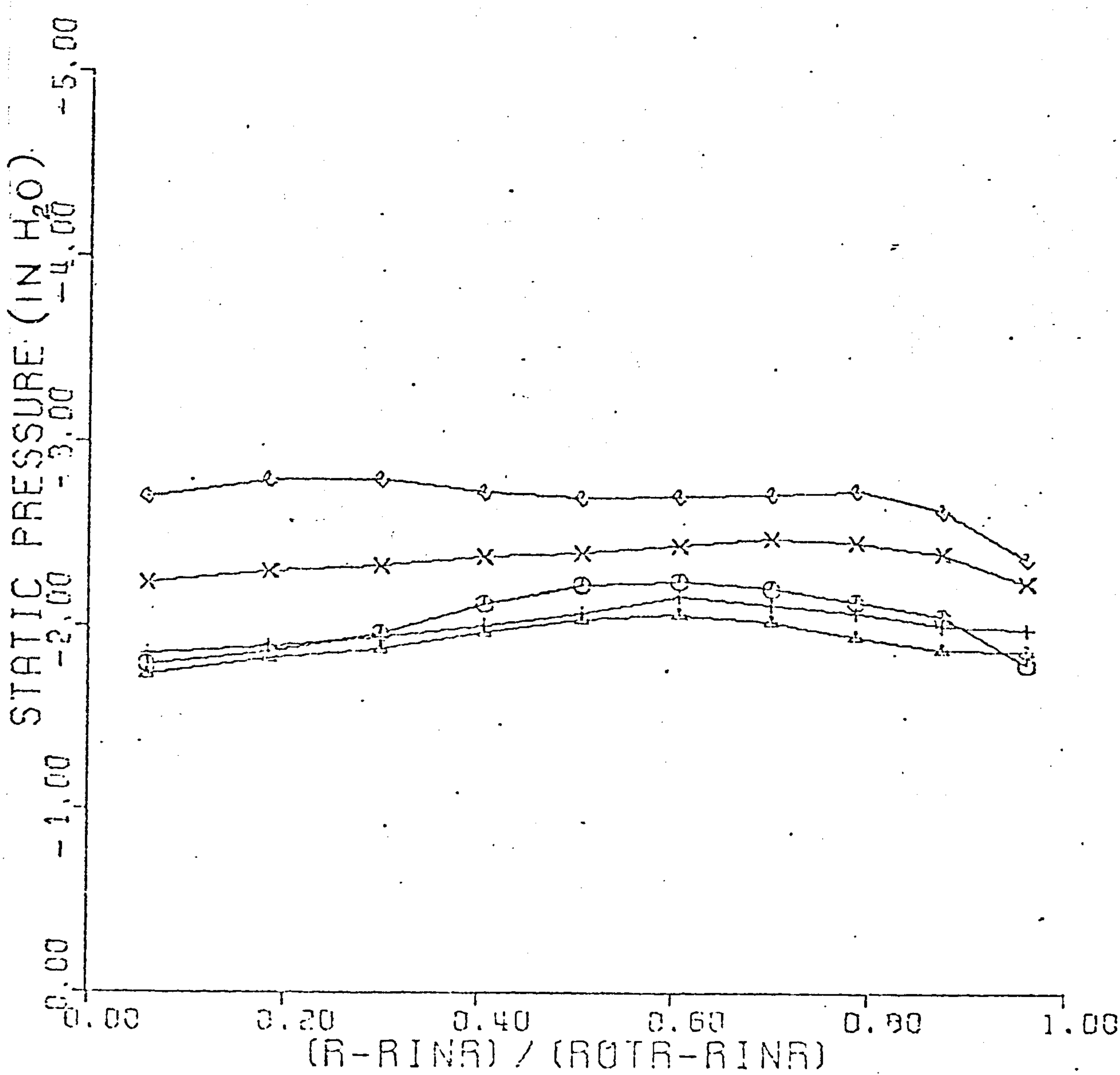


FIGURE 18D

INLET STATIC PRESSURE PROFILES

DIFFUSER D

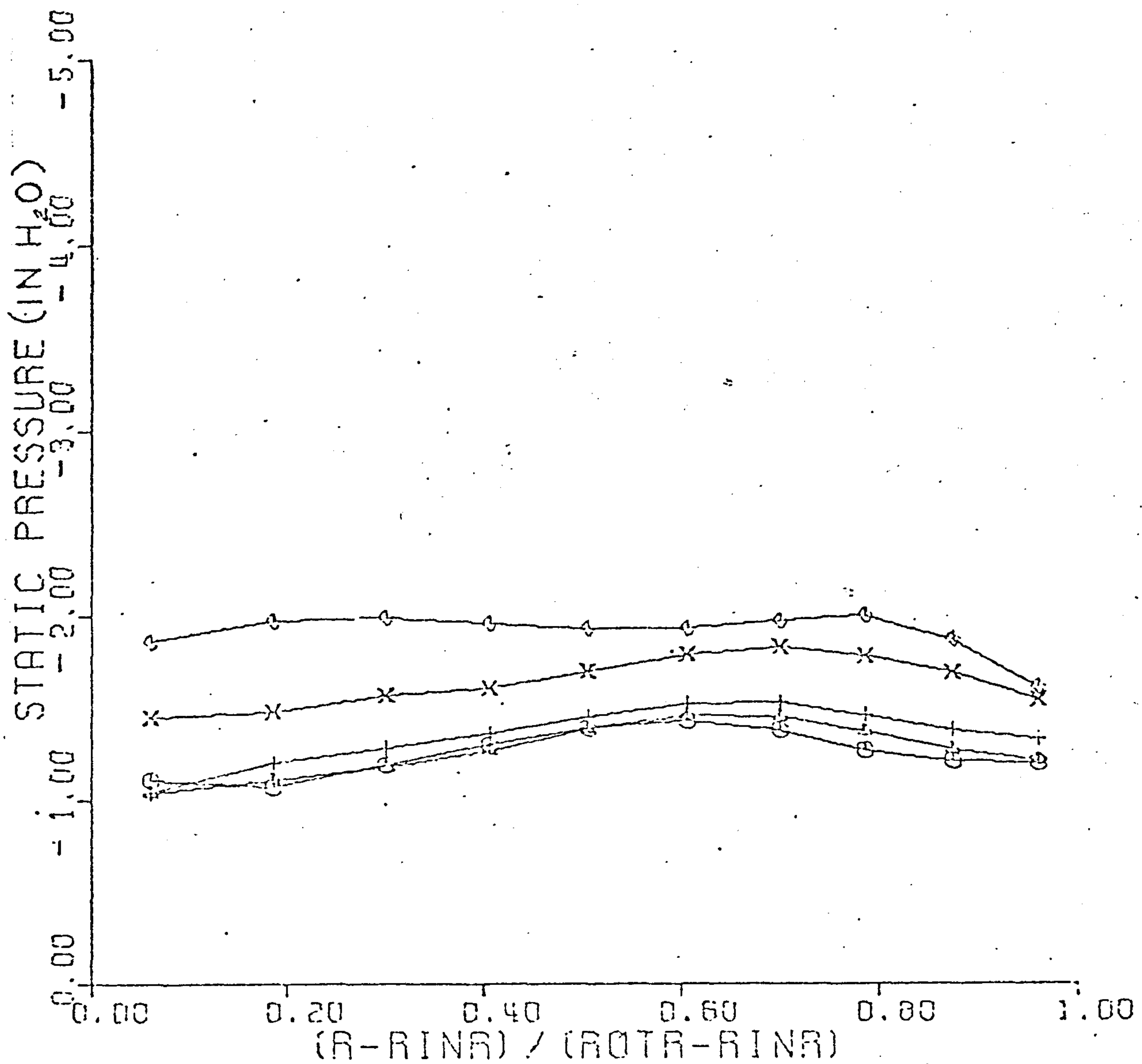


FIGURE 1.9A.

EXIT SWIRL ANGLE PROFILES

DIFFUSER A

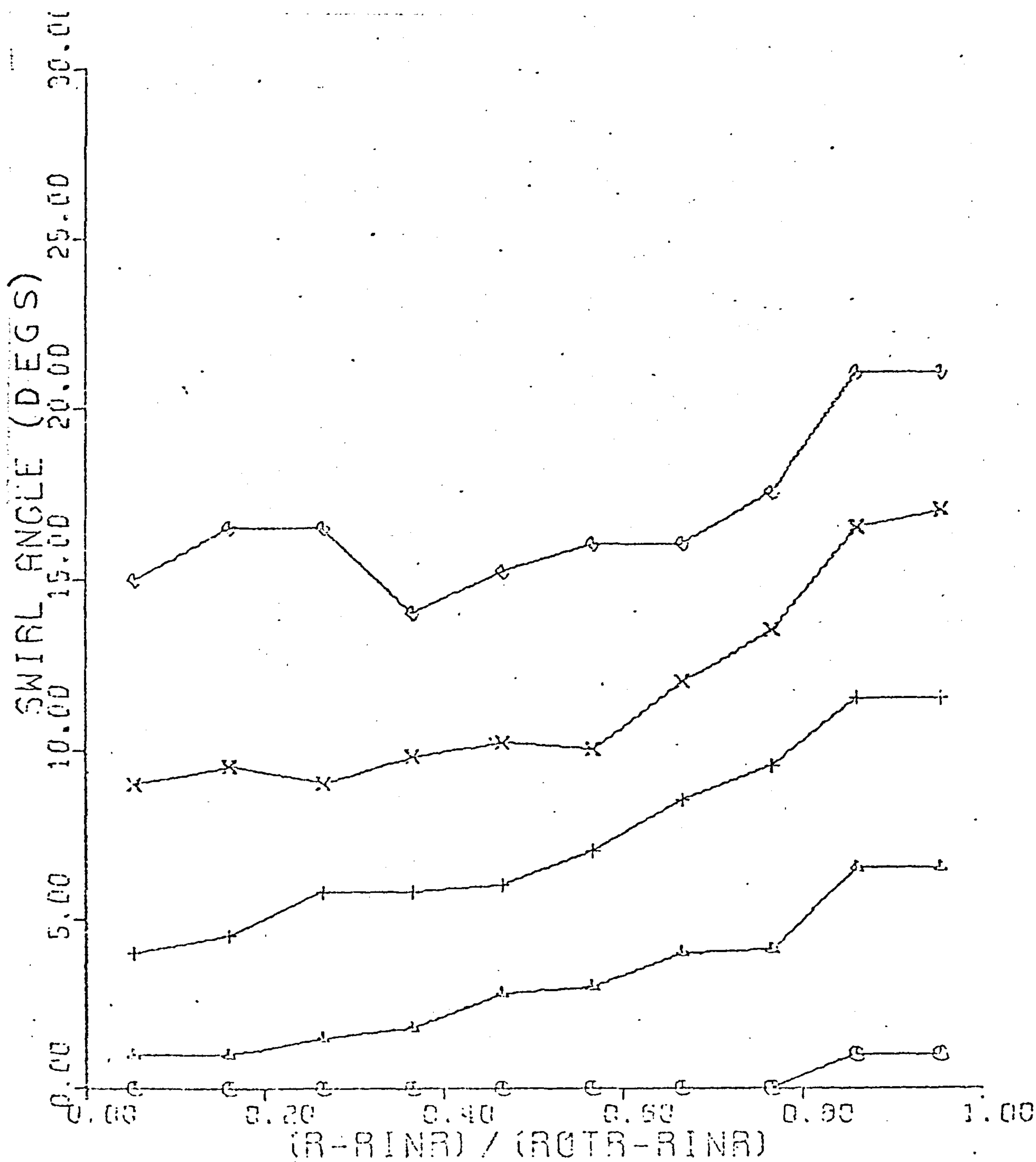


FIGURE 19B.

EXIT SWIRL ANGLE PROFILES

DIFFUSER B

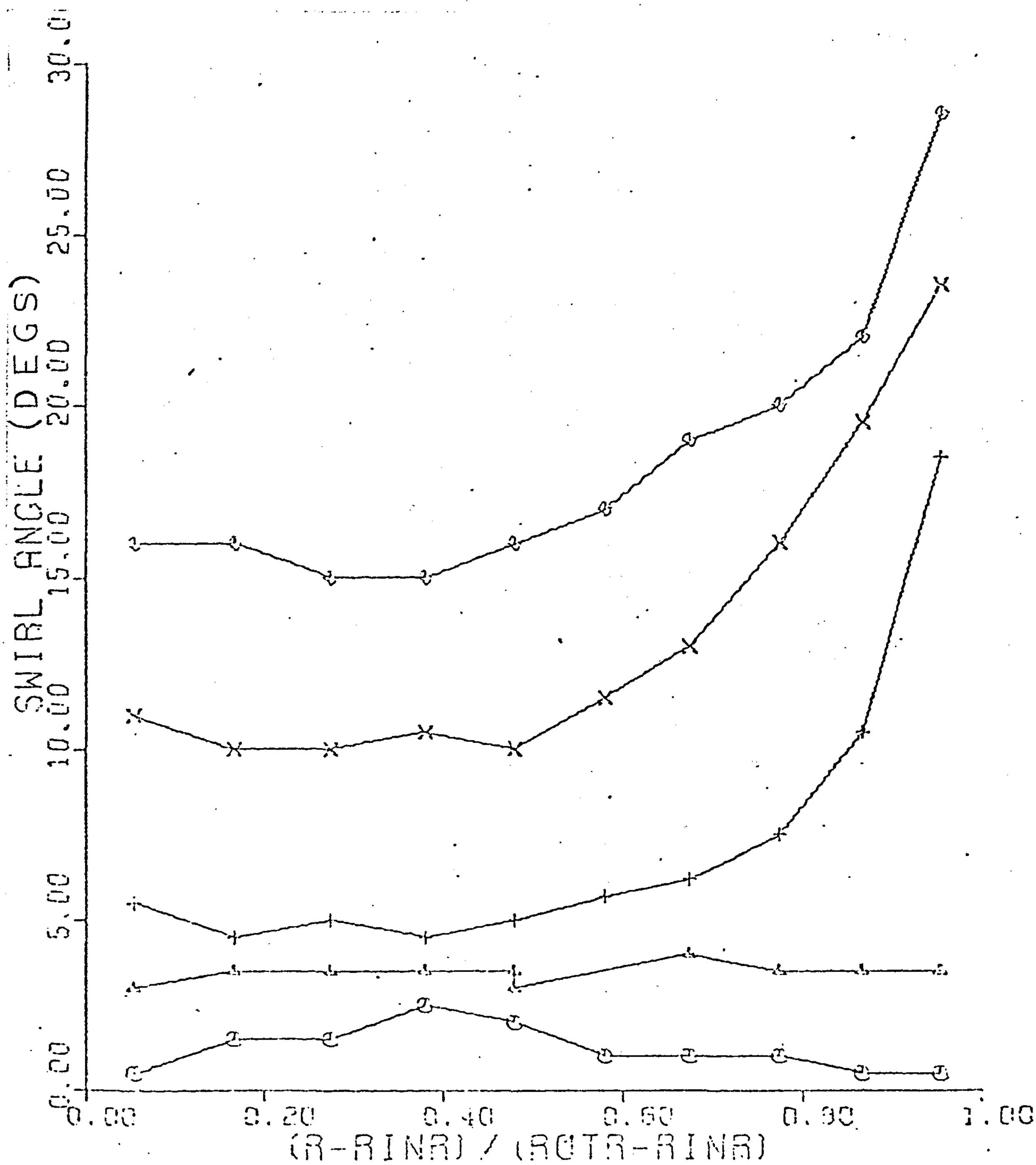


FIGURE 19C

EXIT SWIRL ANGLE PROFILES

DIFFUSERC

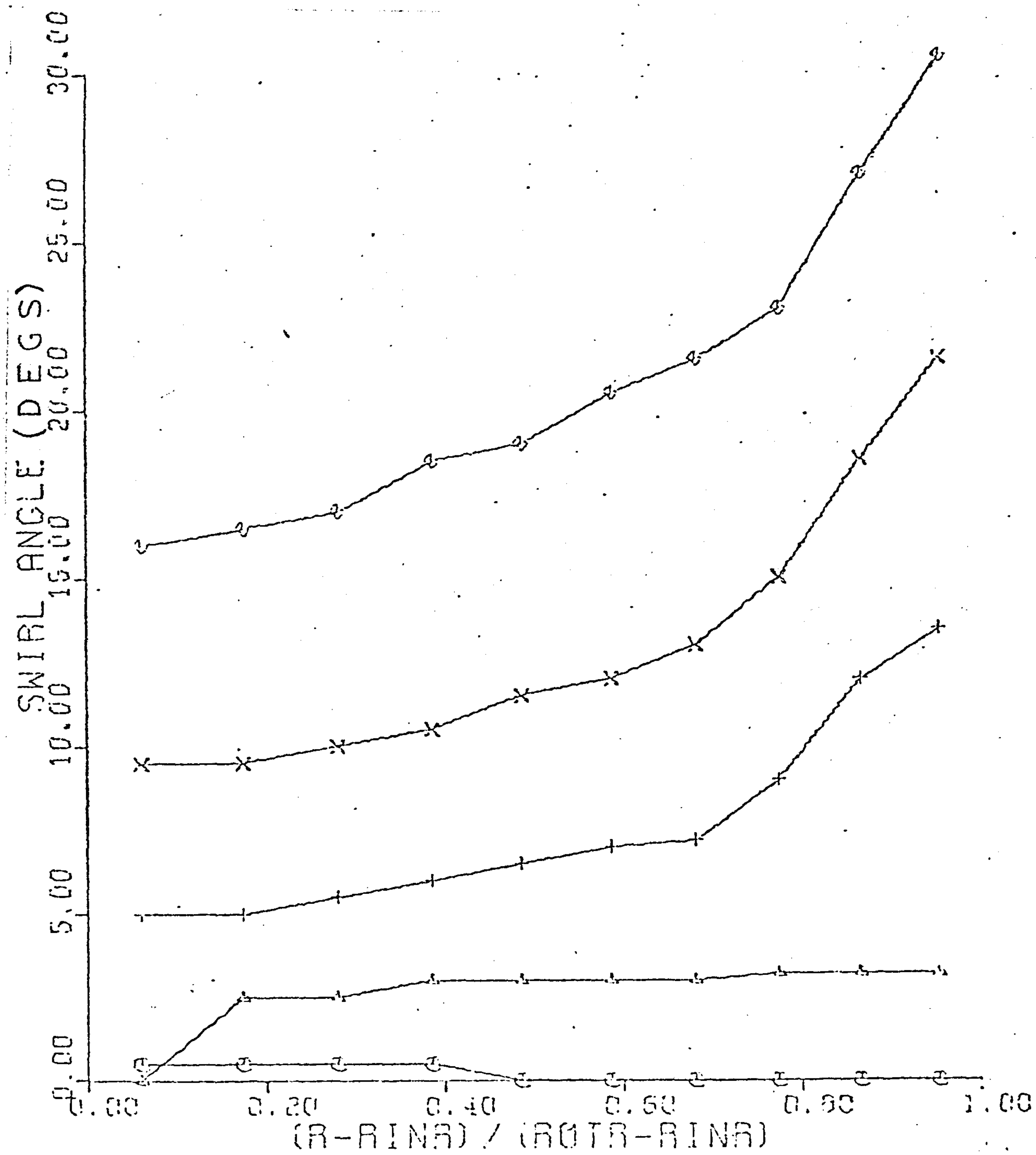


FIGURE 19D.

EXIT SWIRL ANGLE PROFILES

DIFFUSERD

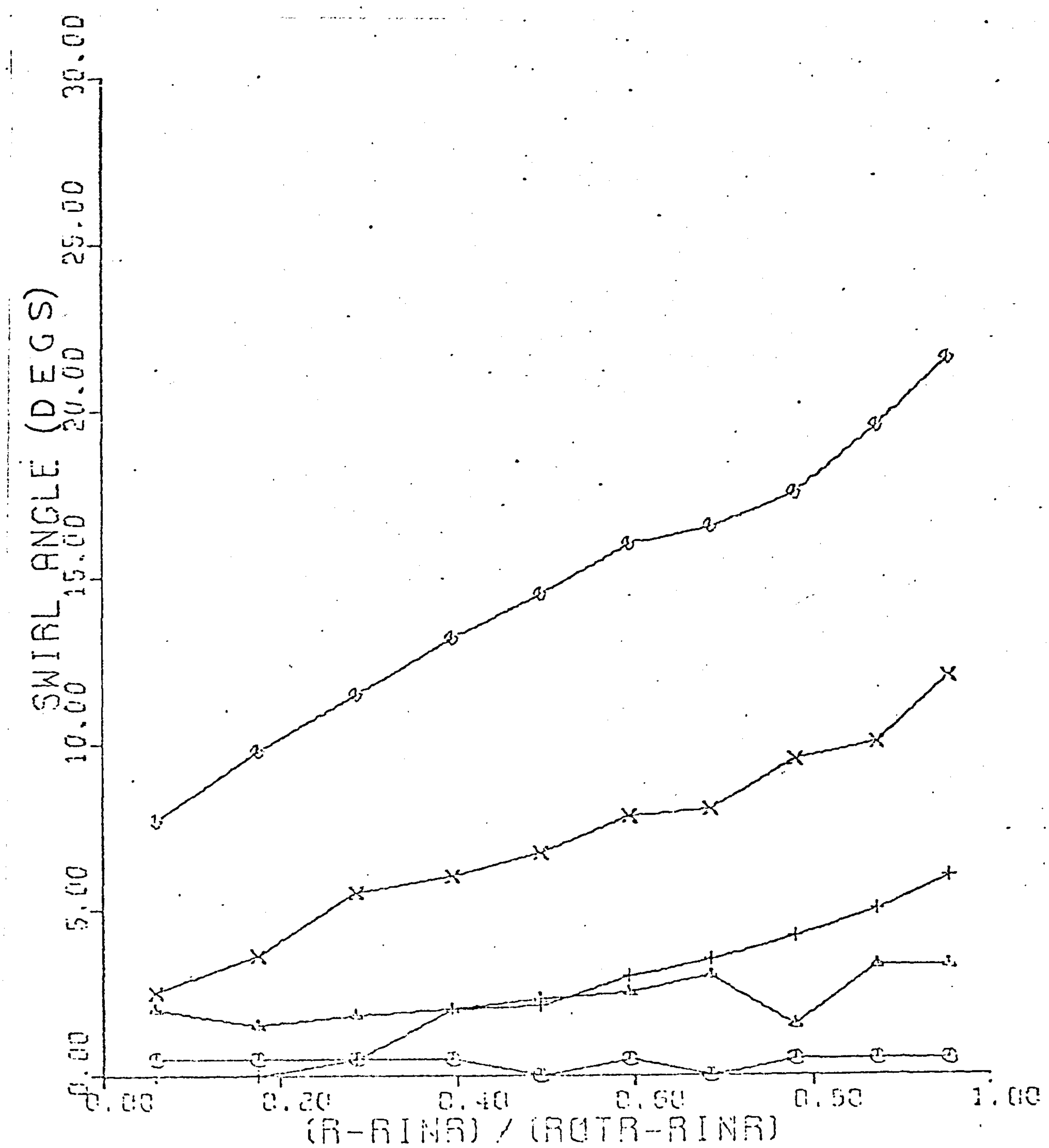


FIGURE 20A

EXIT TANGENTIAL VELOCITY PROFILES

DIFFUSERA

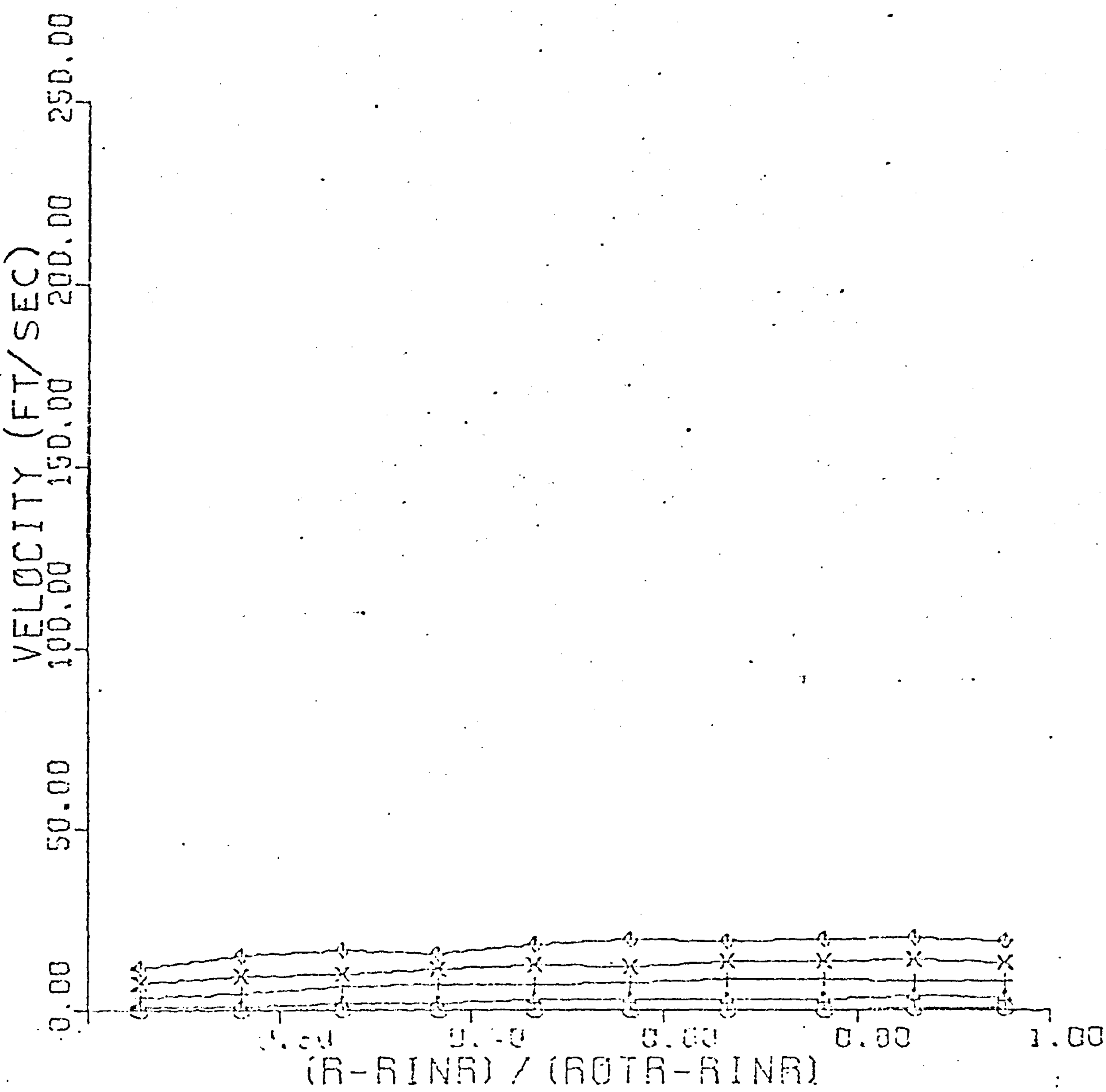


FIGURE 20B

EXIT TANGENTIAL VELOCITY PROFILES

DIFFUSERB

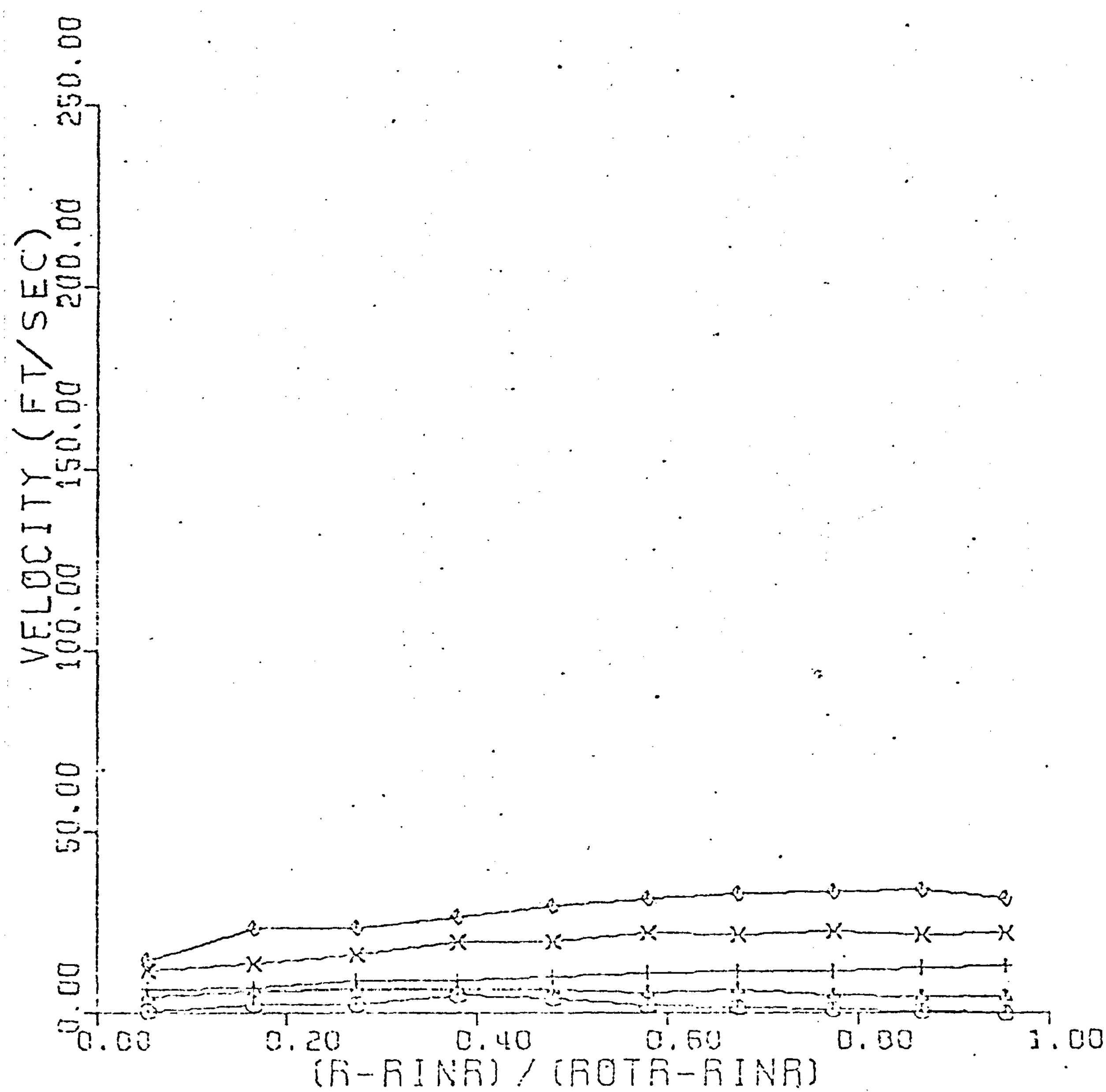


FIGURE 20C

EXIT TANGENTIAL VELOCITY PROFILES

DIFFUSERC

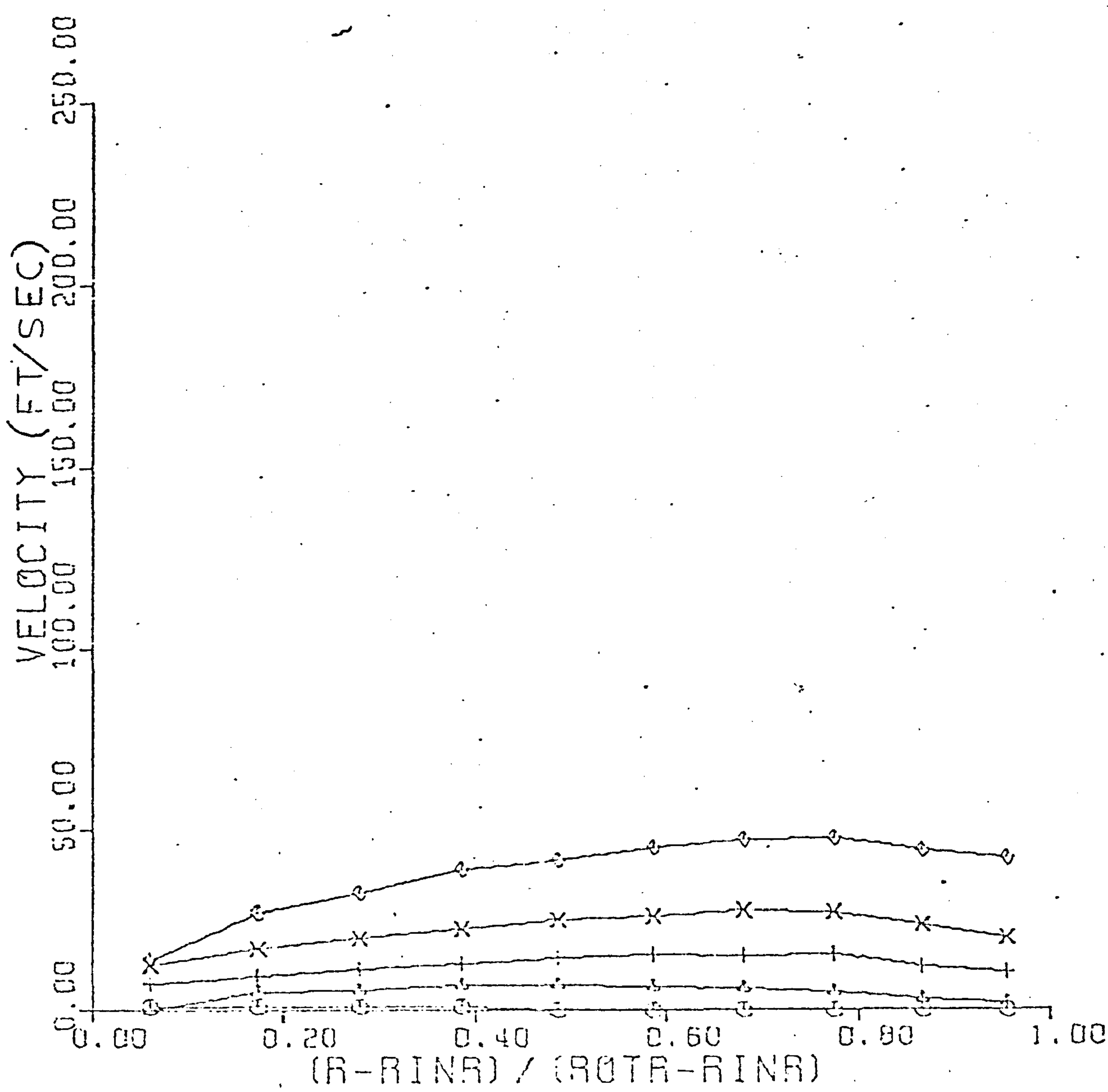


FIGURE 20D

EXIT TANGENTIAL VELOCITY PROFILES

DIFFUSER D

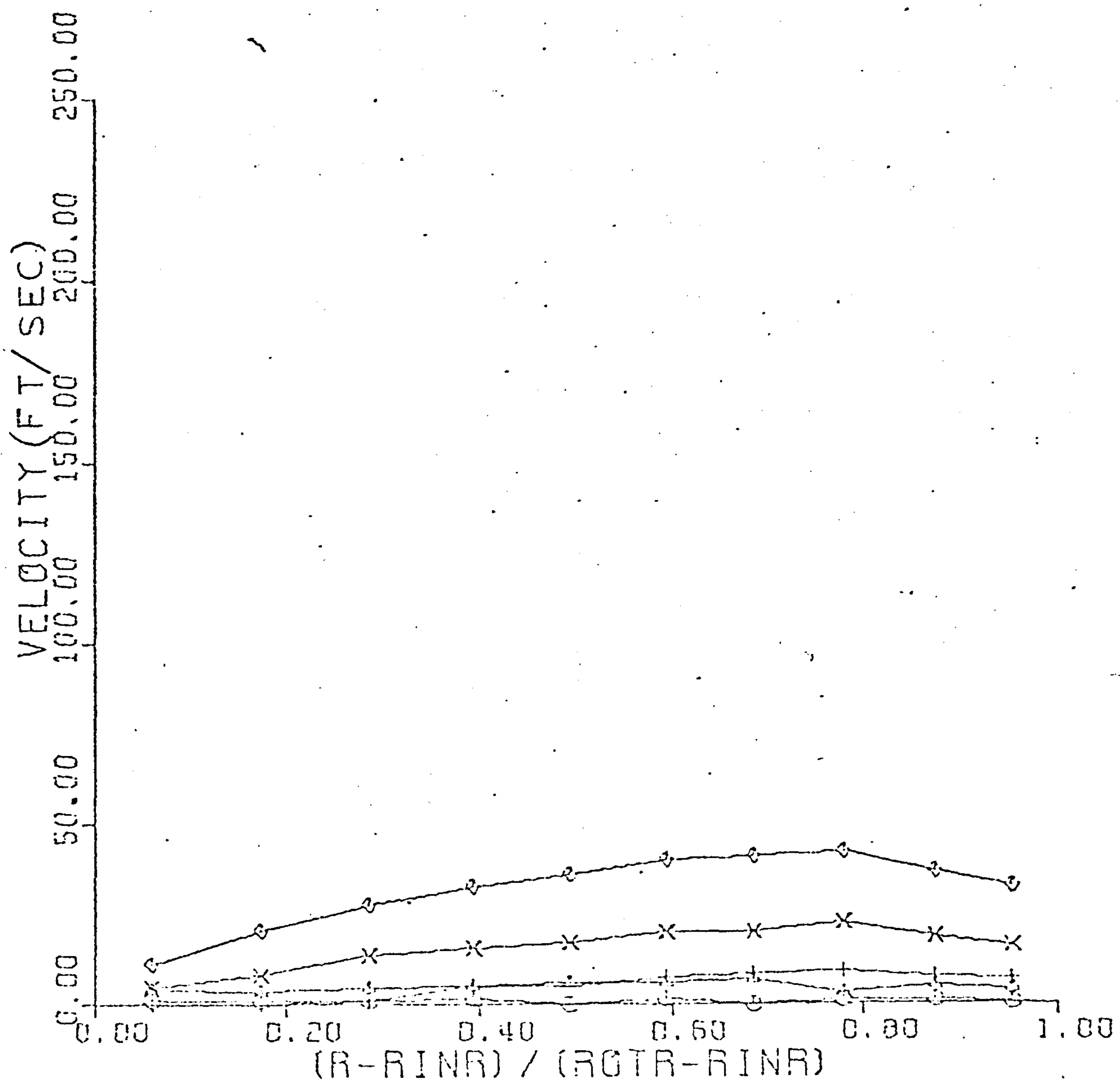


FIGURE 21A

EXIT DYNAMIC PRESSURE PROFILES

DIFFUSER A

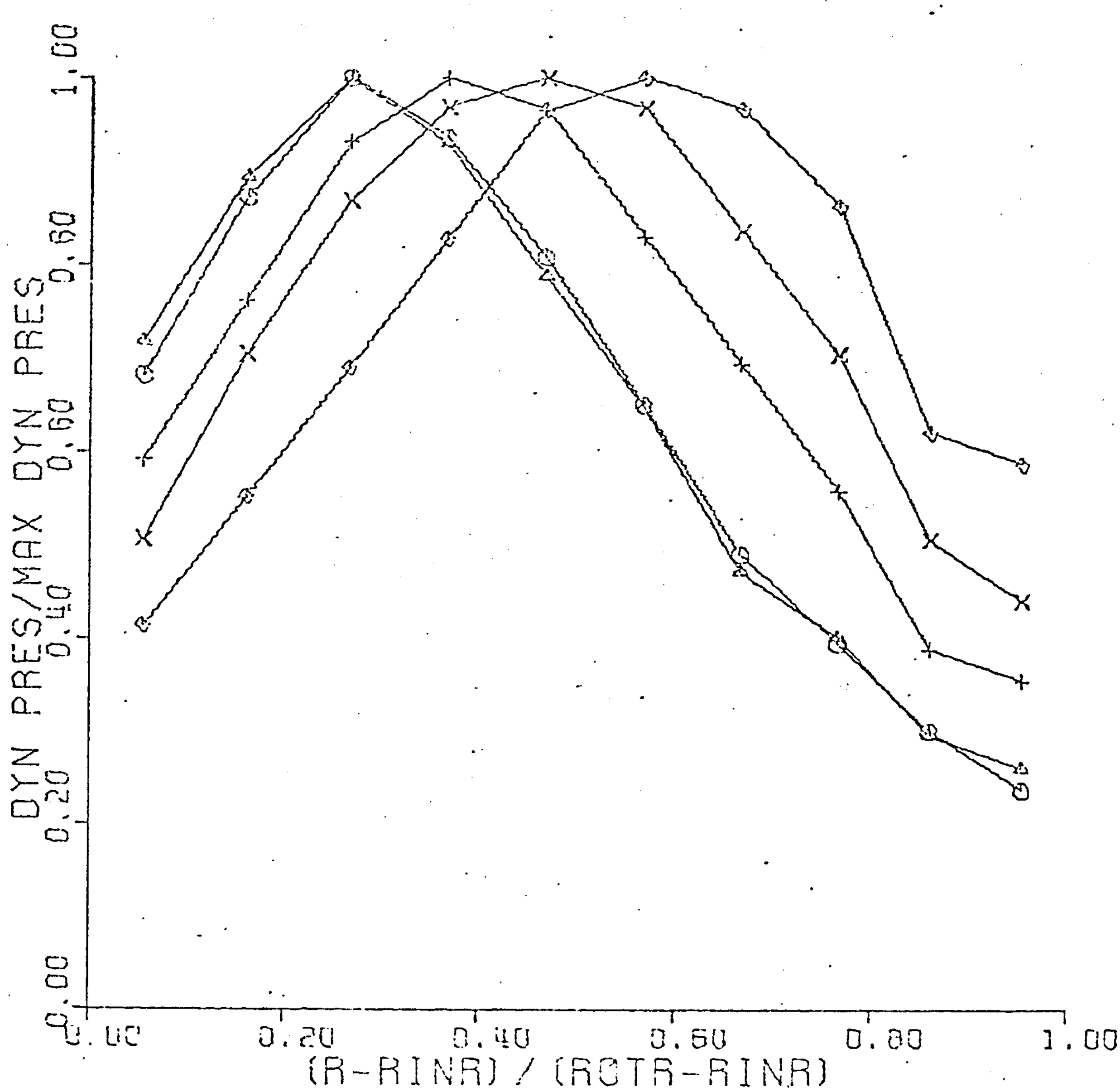


FIGURE 21B

EXIT DYNAMIC PRESSURE PROFILES

DIFFUSER B

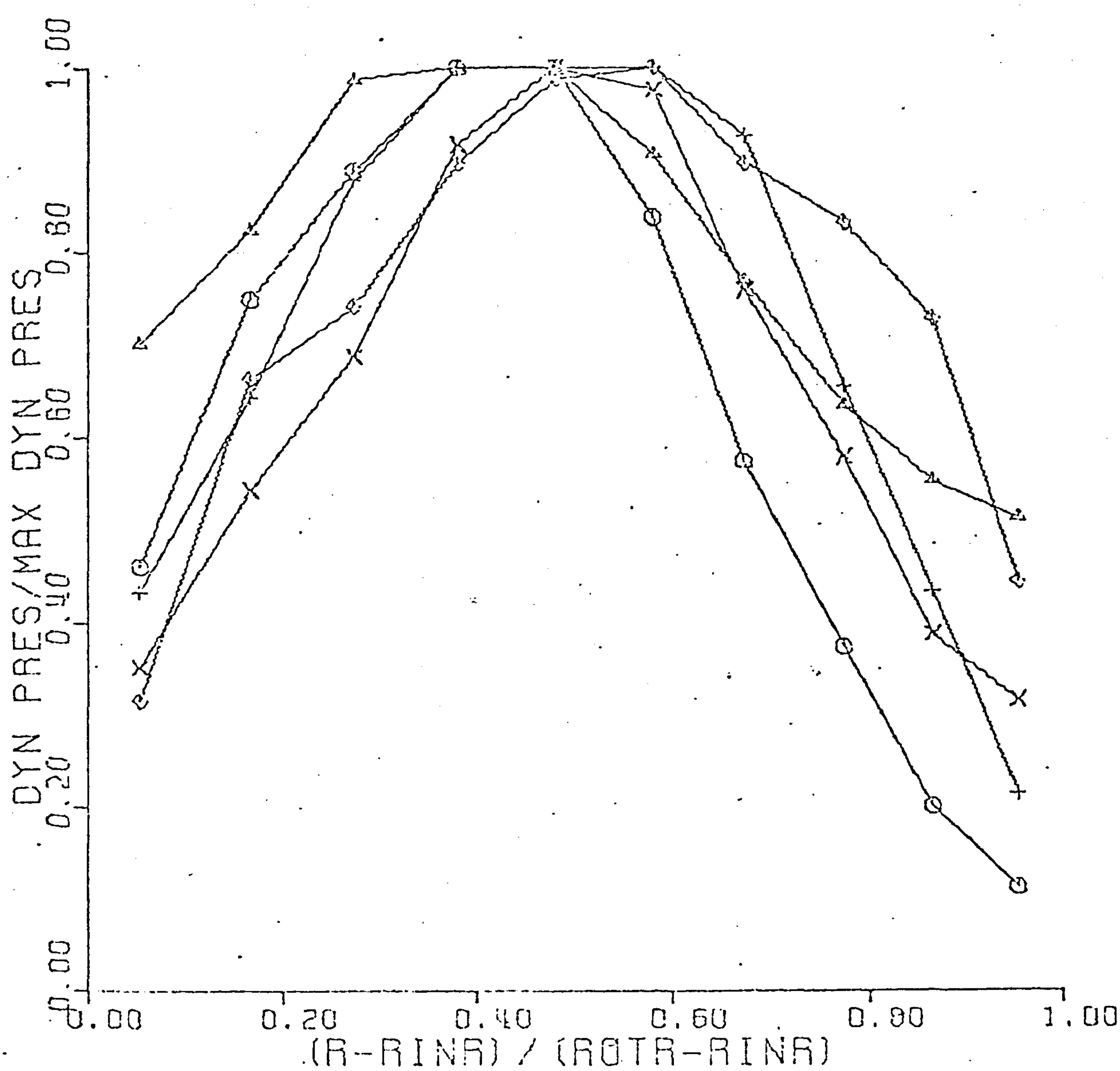


FIGURE 21C

EXIT DYNAMIC PRESSURE PROFILES

DIFFUSER C

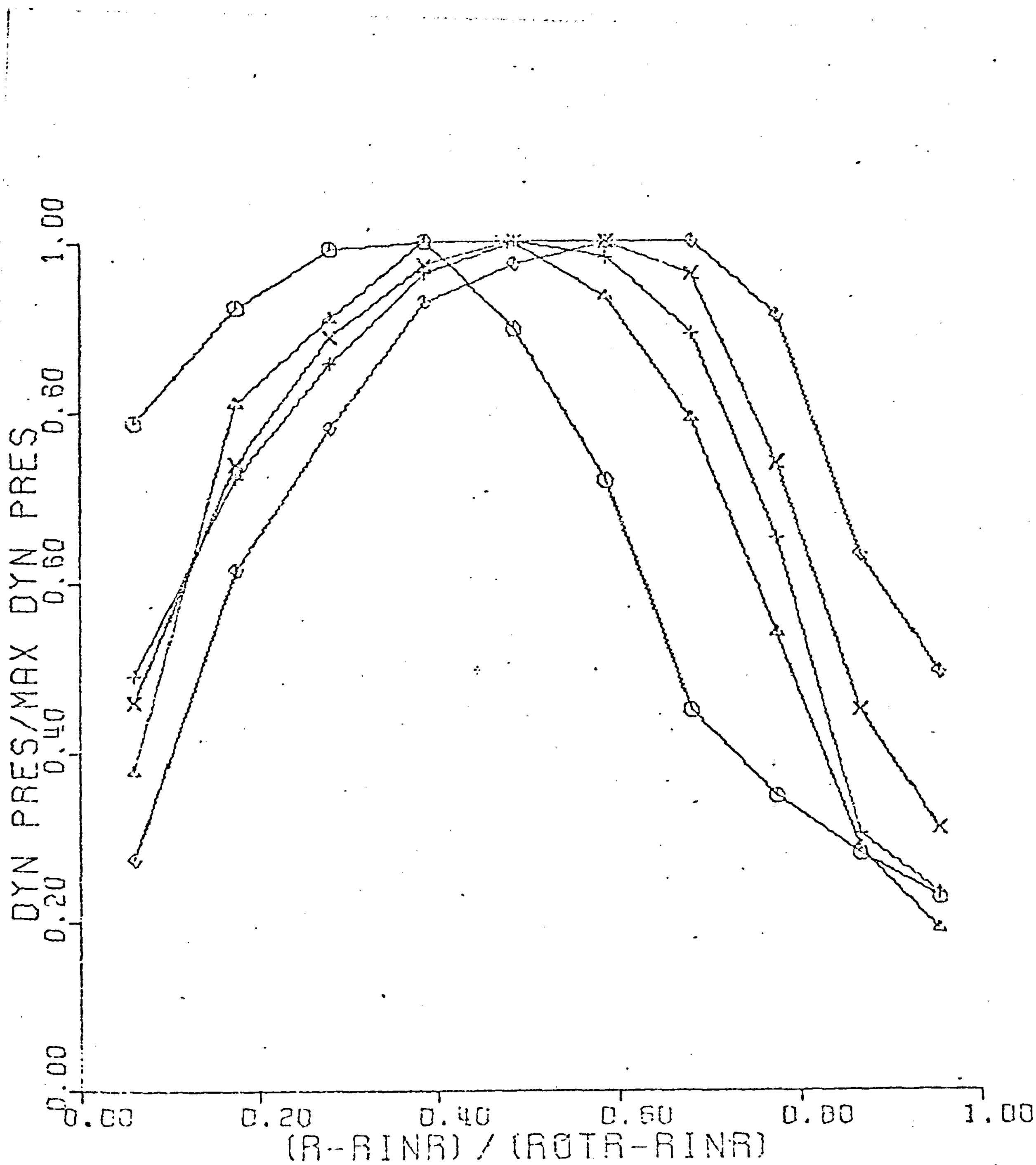


FIGURE 21 D

EXIT DYNAMIC PRESSURE PROFILES

DIFFUSER D

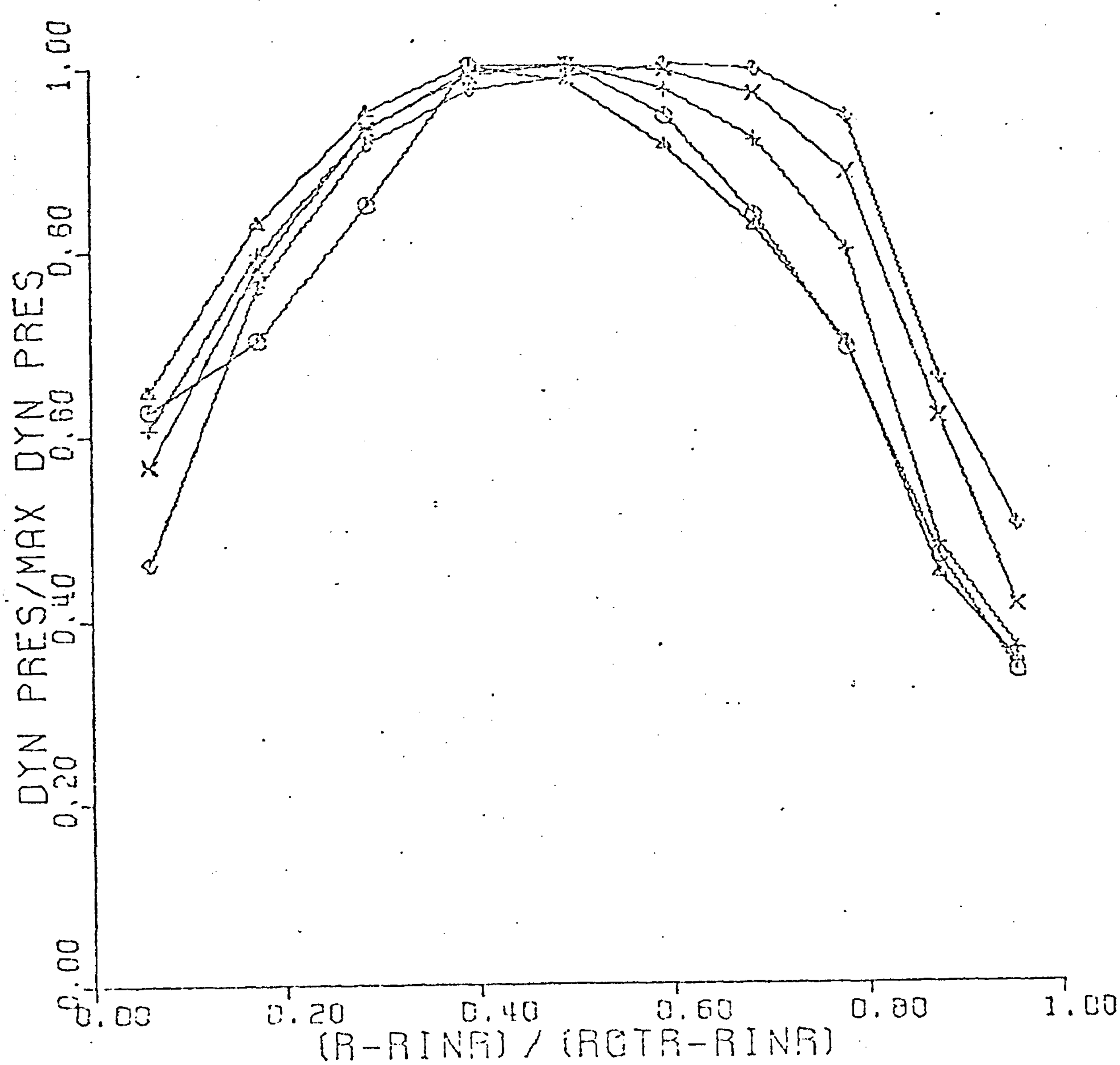


FIGURE 22A

EXIT ABSOLUTE VELOCITY PROFILES

DIFFUSER A

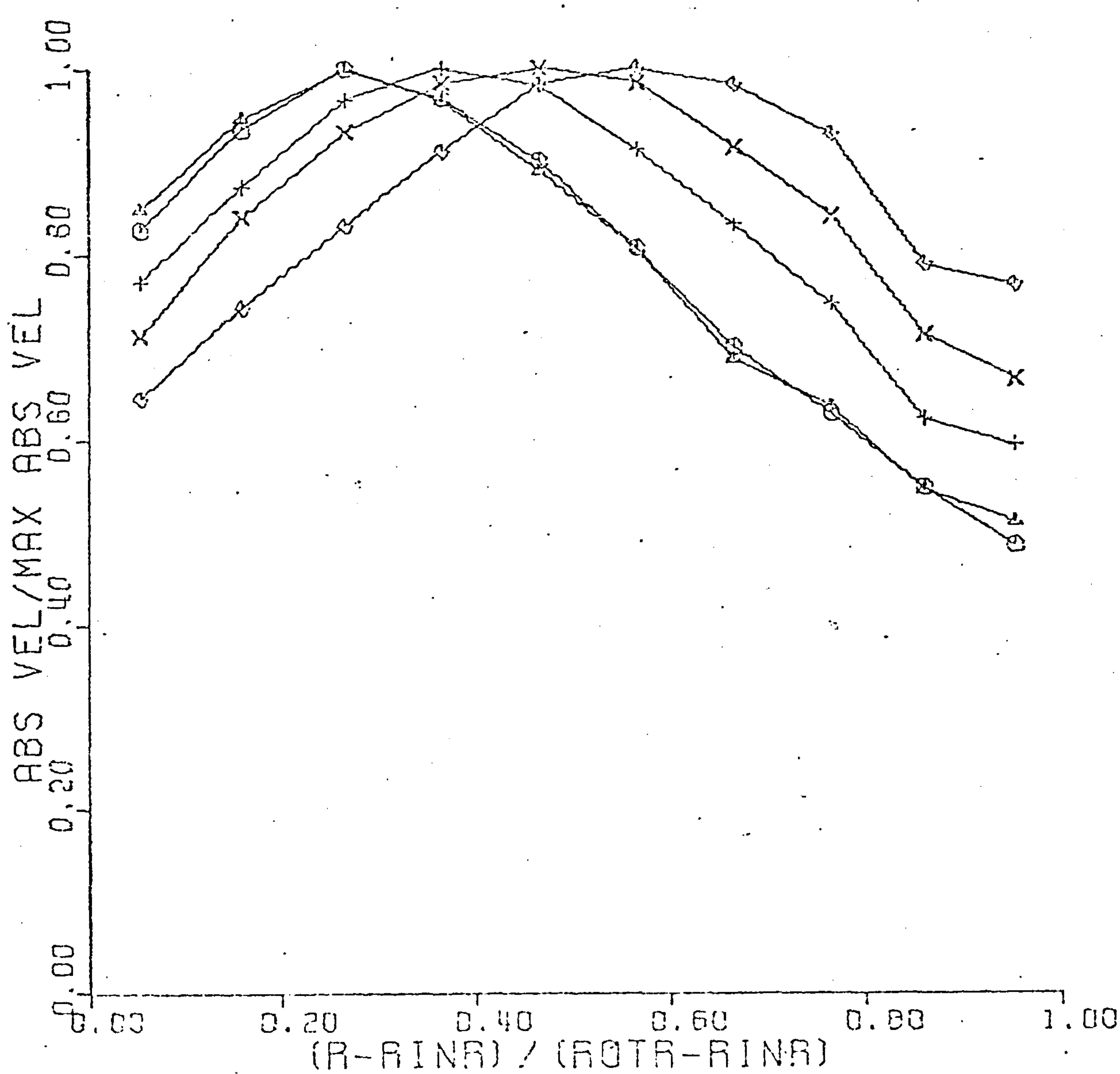


FIGURE 22 B

EXIT ABSOLUTE VELOCITY PROFILES

DIFFUSER B

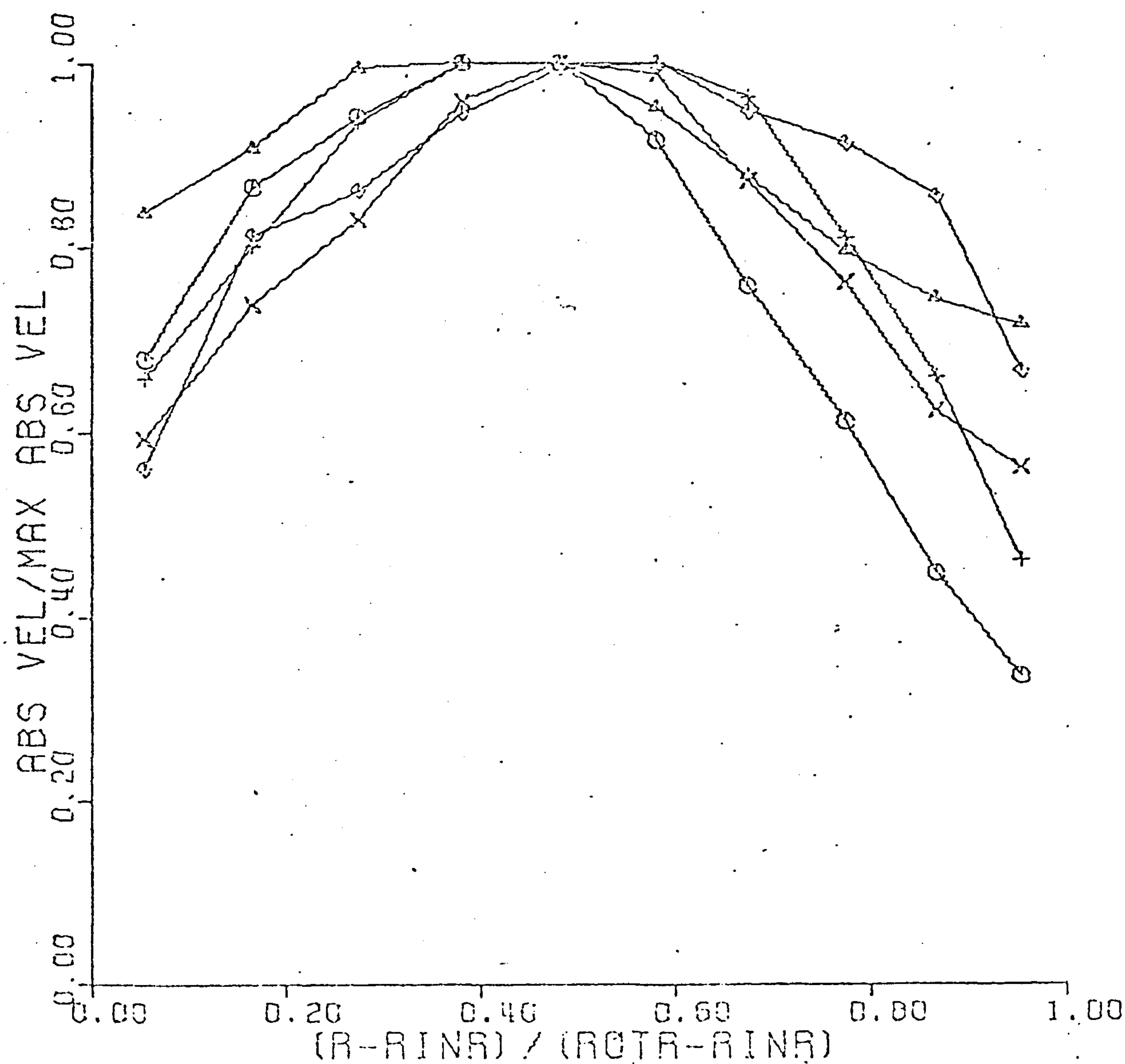


FIGURE 22C

EXIT ABSOLUTE VELOCITY PROFILES

DIFFUSER C

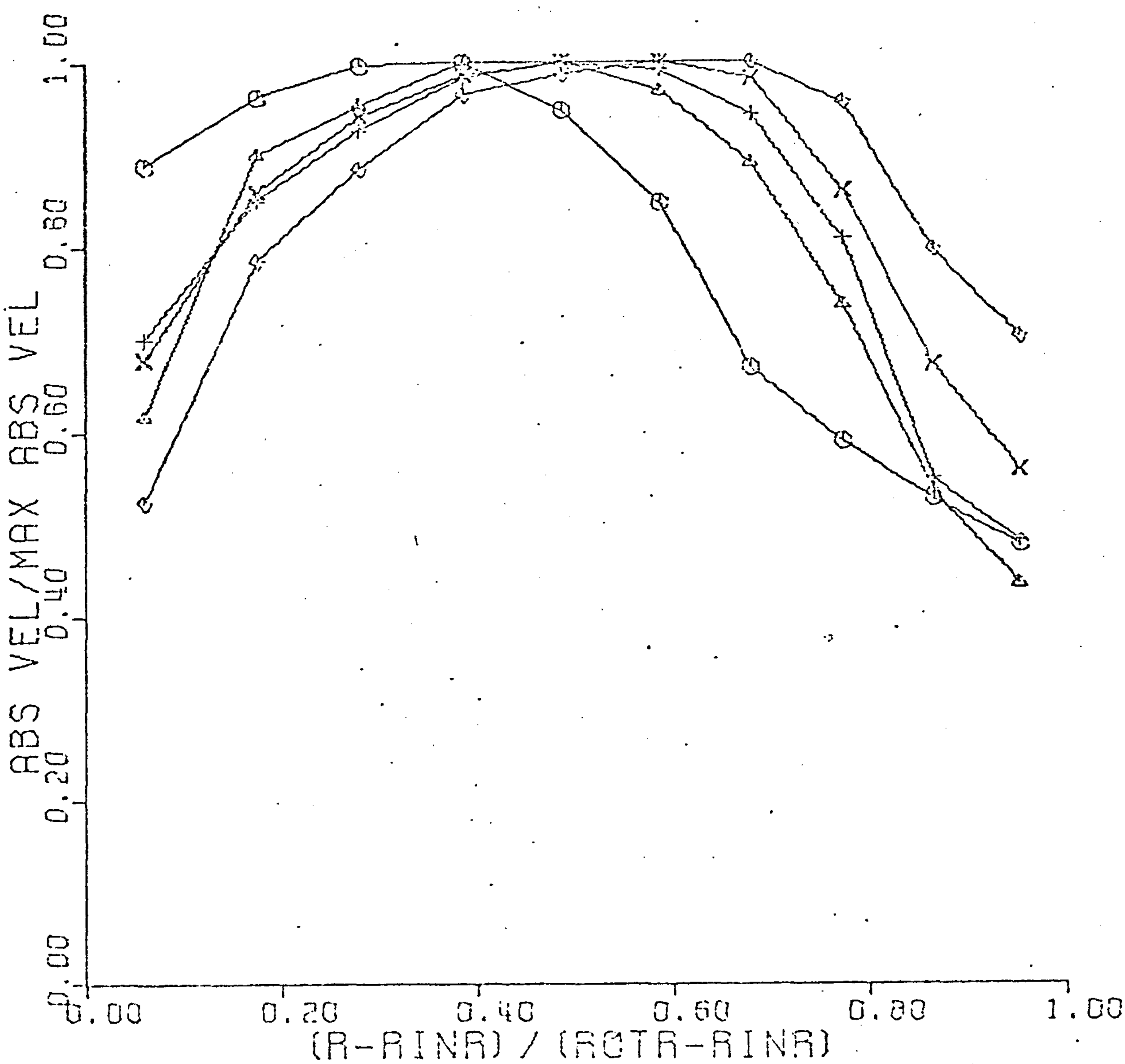


FIGURE 22 D

EXIT ABSOLUTE VELOCITY PROFILES

DIFFUSER D

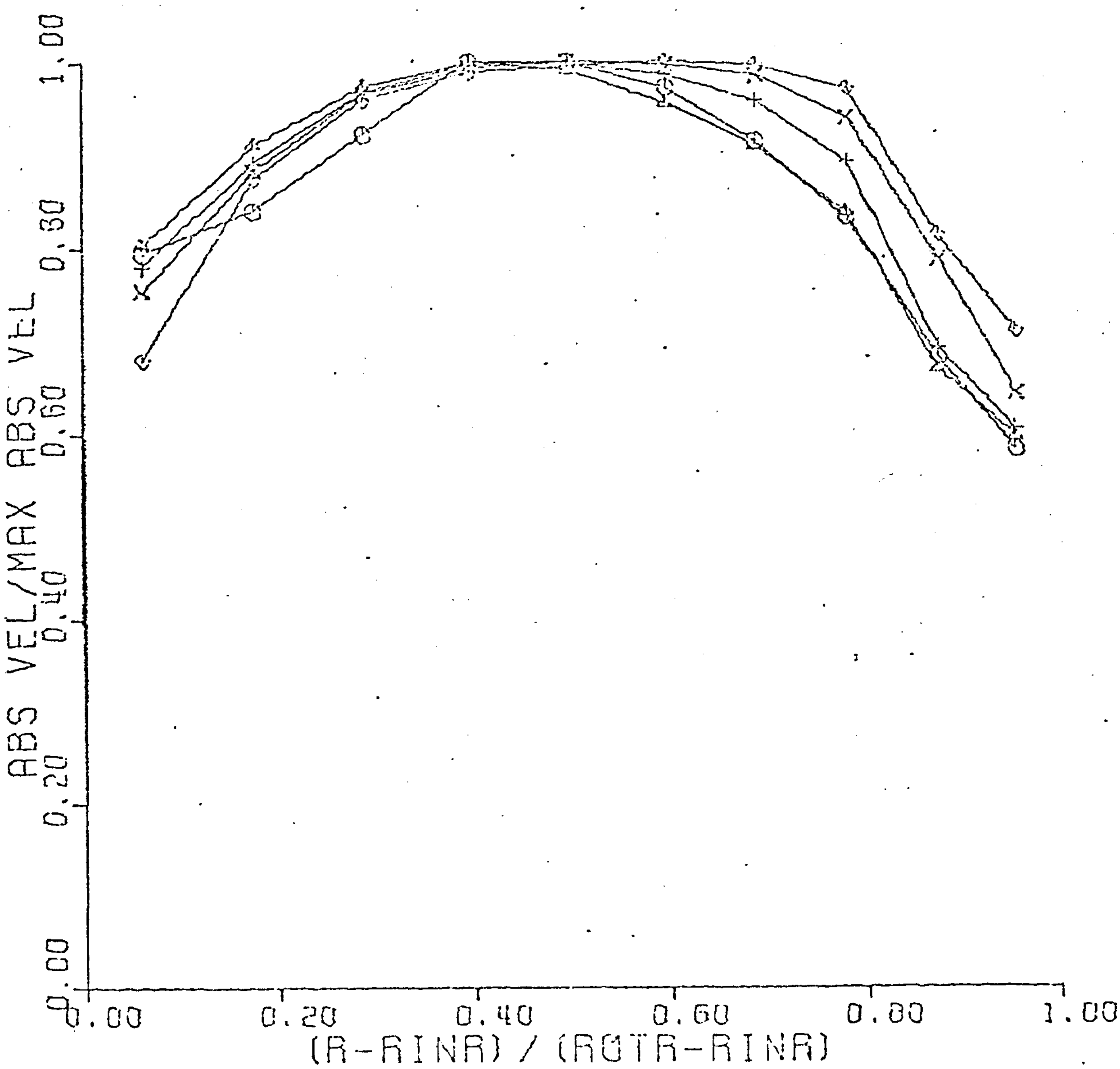


FIGURE 23A

EXIT AXIAL VELOCITY PROFILES

DIFFUSERA

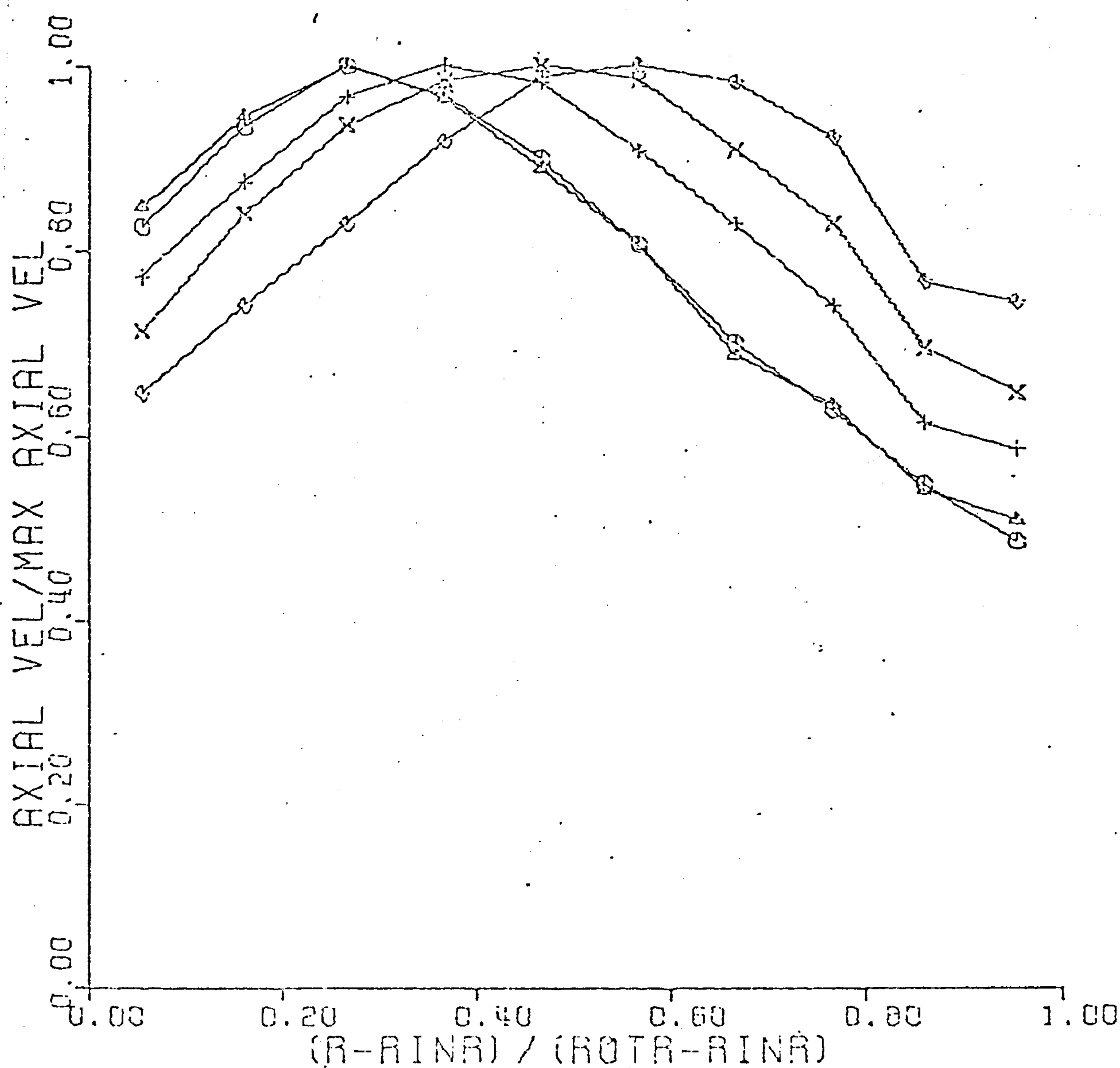


FIGURE 23 B

EXIT AXIAL VELOCITY PROFILES

DIFFUSER B

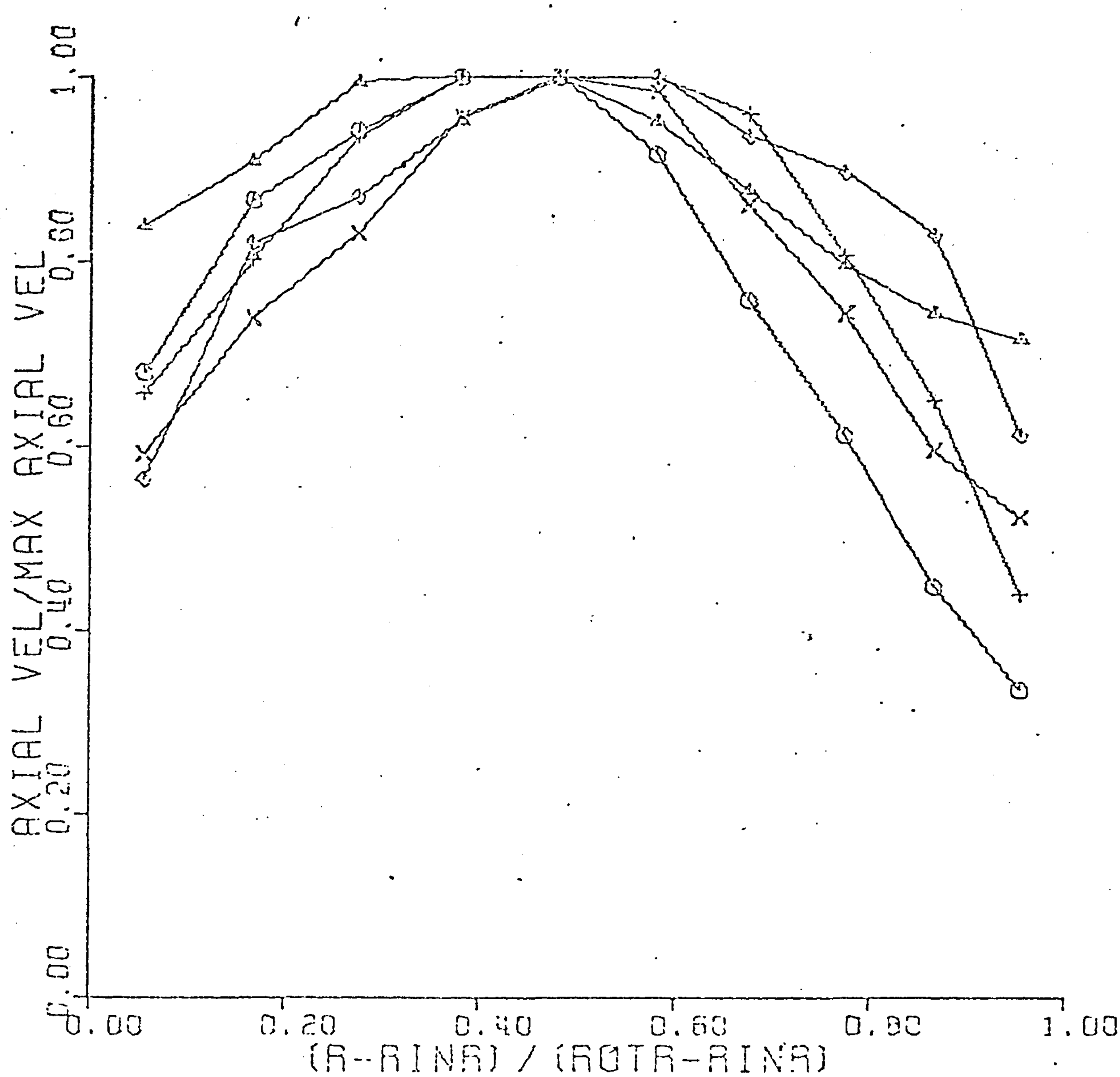


FIGURE 23C

EXIT AXIAL VELOCITY PROFILES

DIFFUSER C

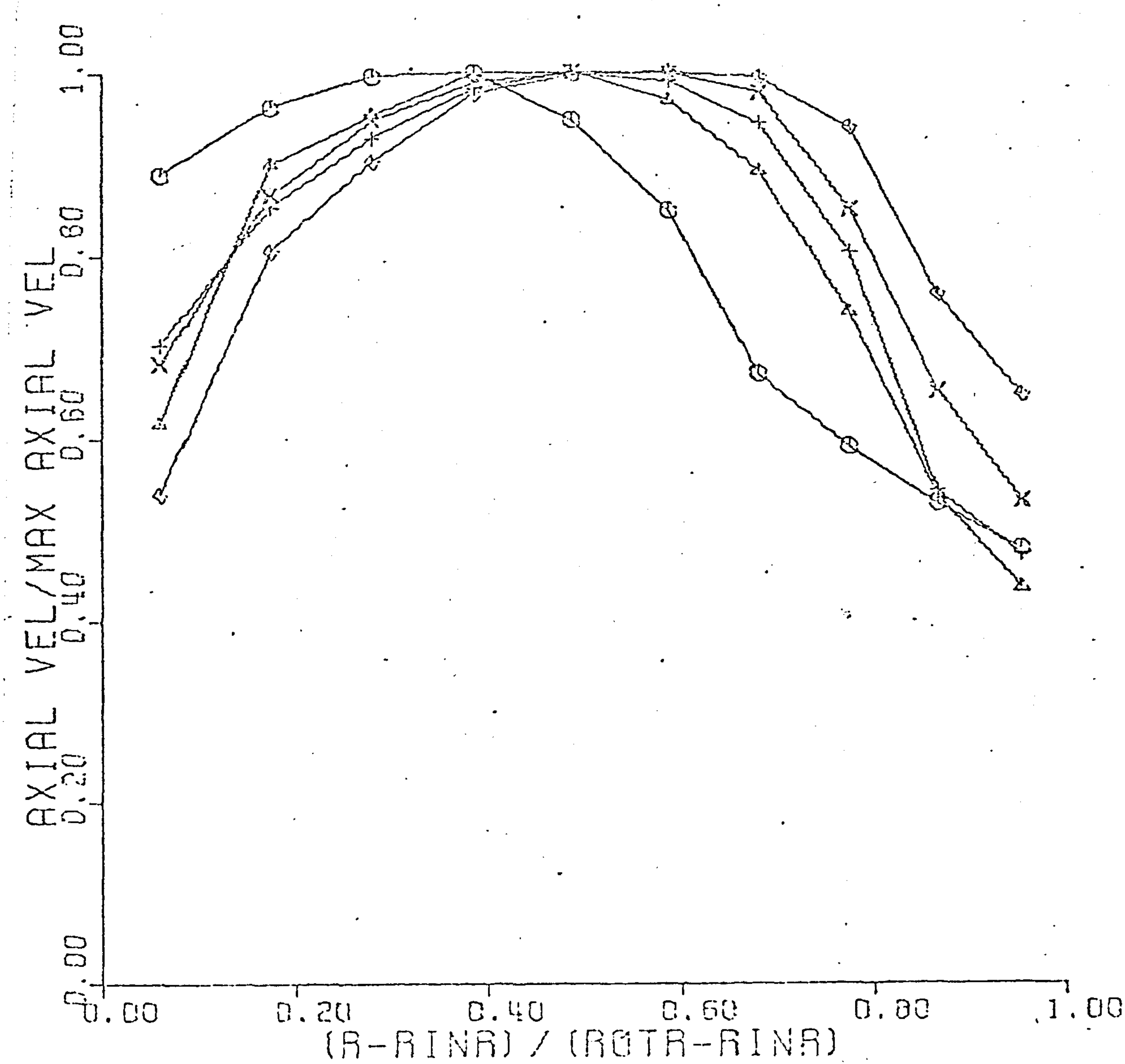


FIGURE 23D

EXIT AXIAL VELOCITY PROFILES

DIFFUSER D

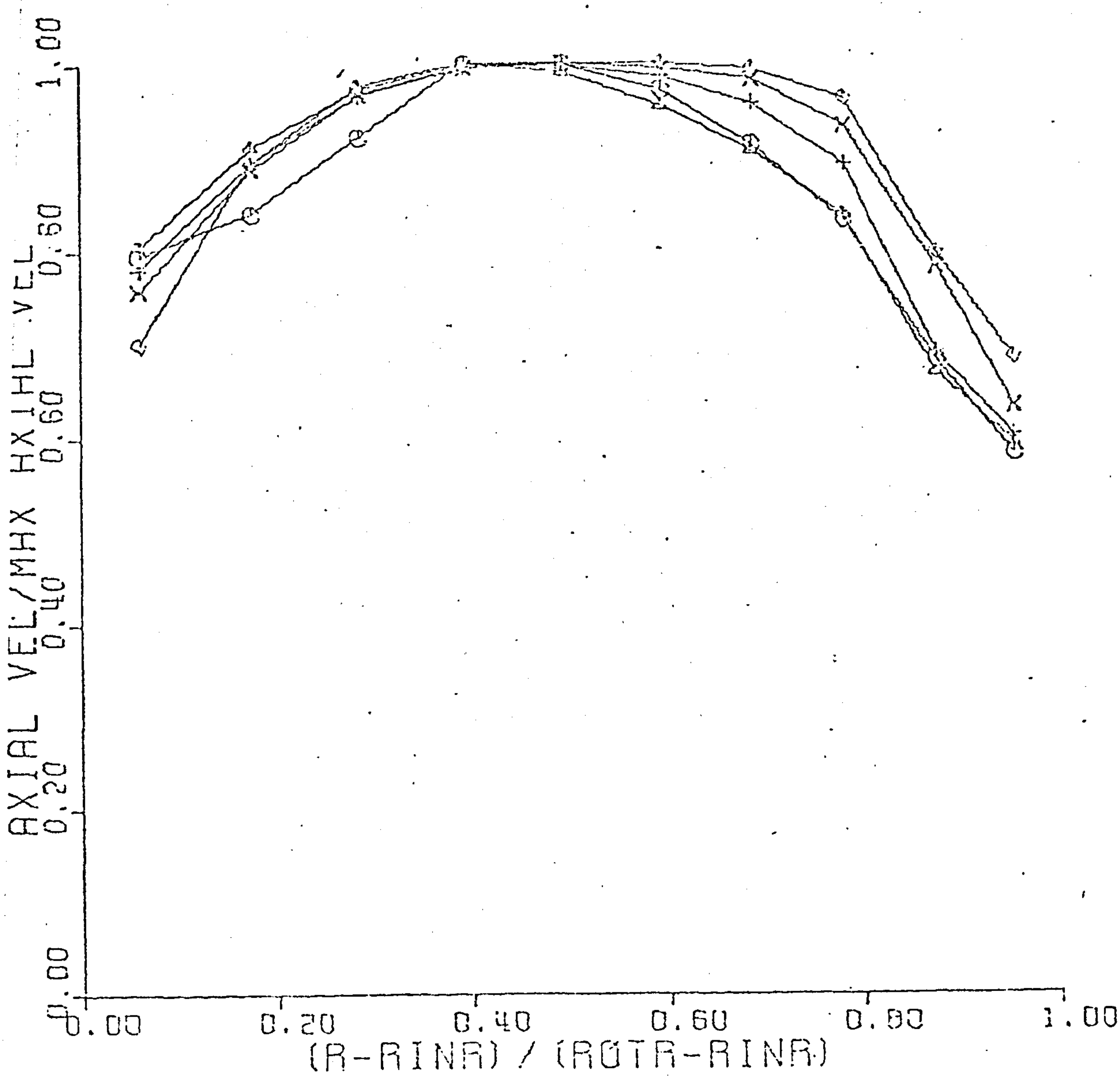


FIGURE 24A

STATIC PRESSURE RISE

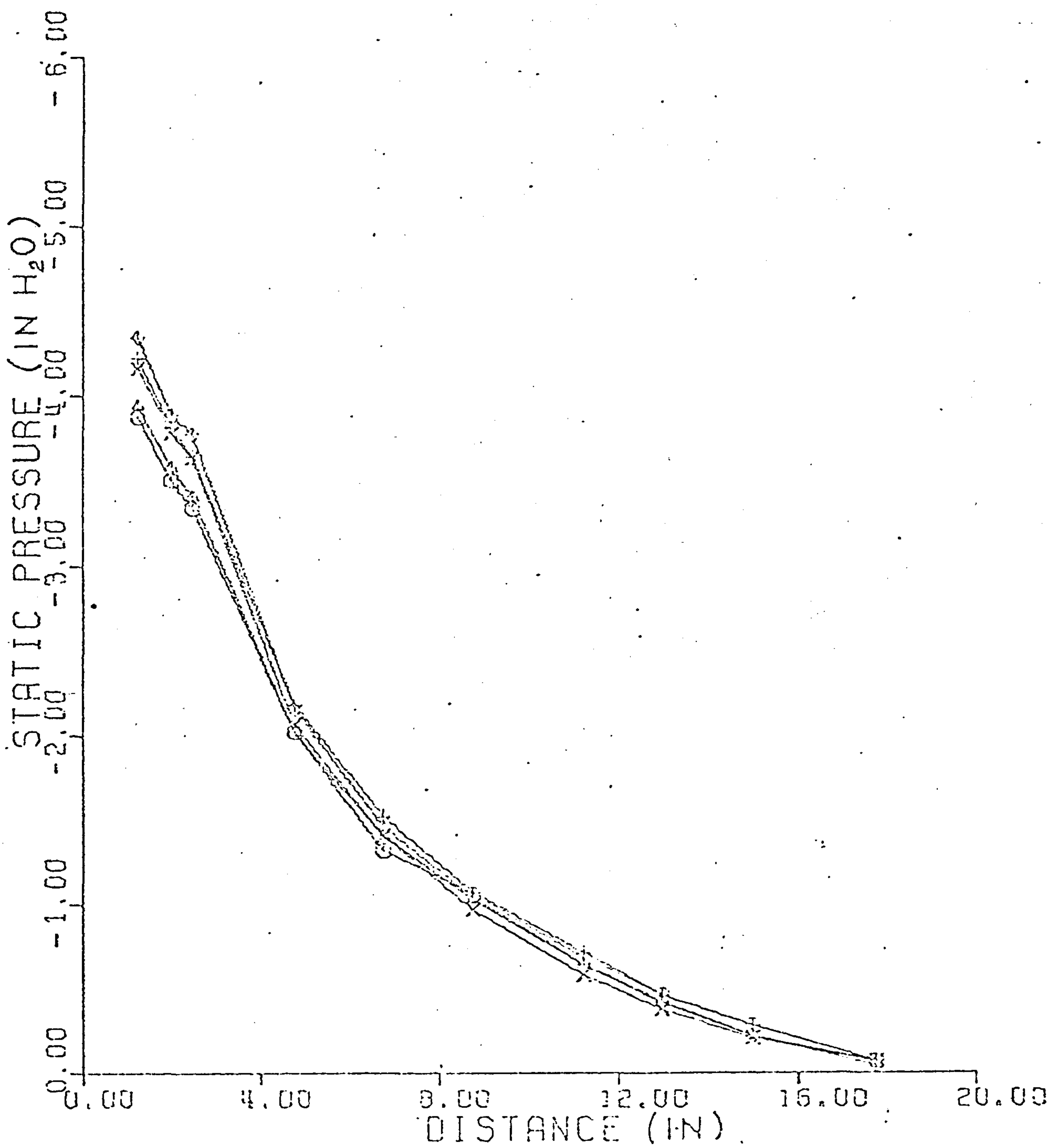


FIGURE 24B

STATIC PRESSURE RISE

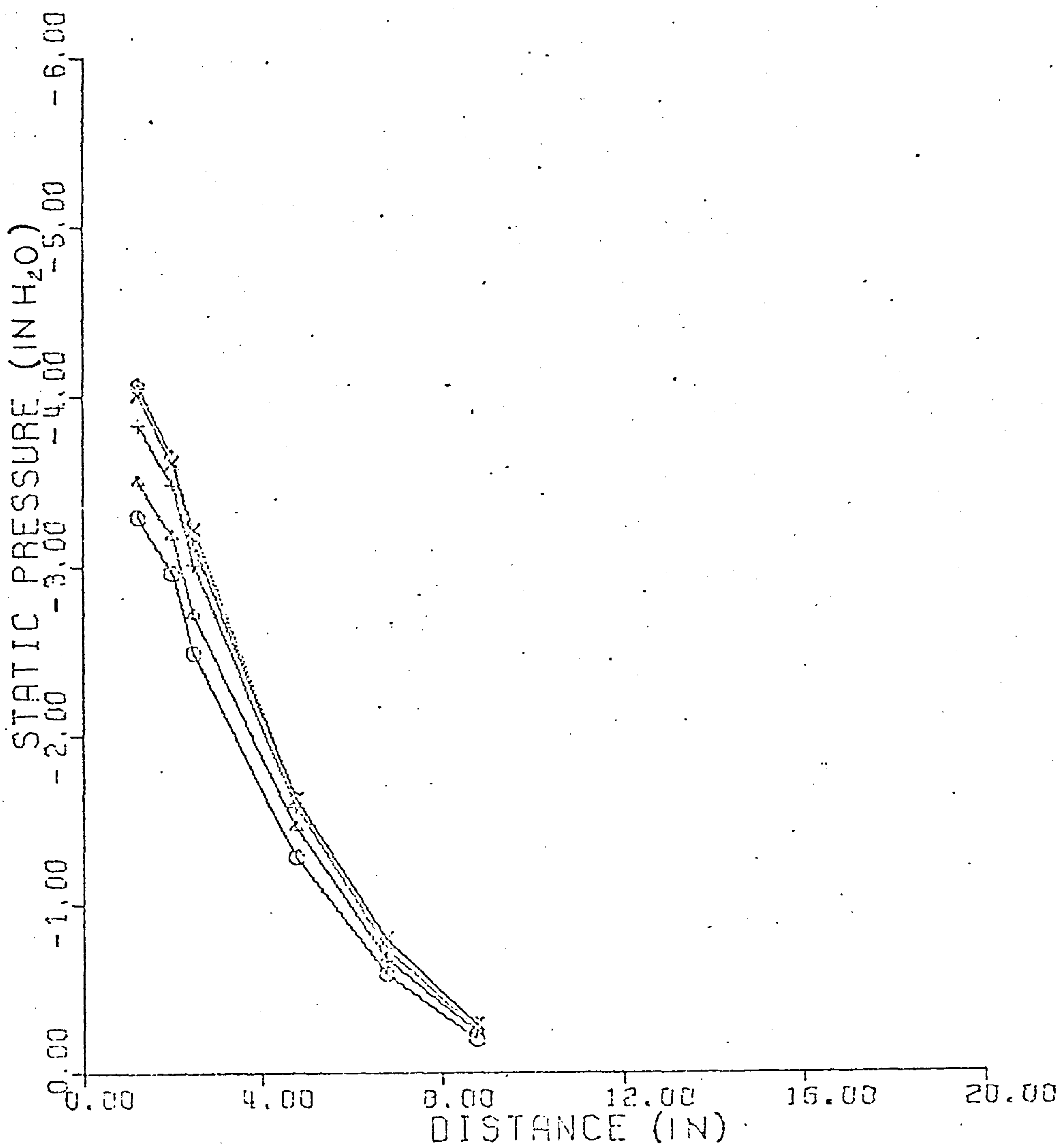


FIGURE 24C

STATIC PRESSURE RISE

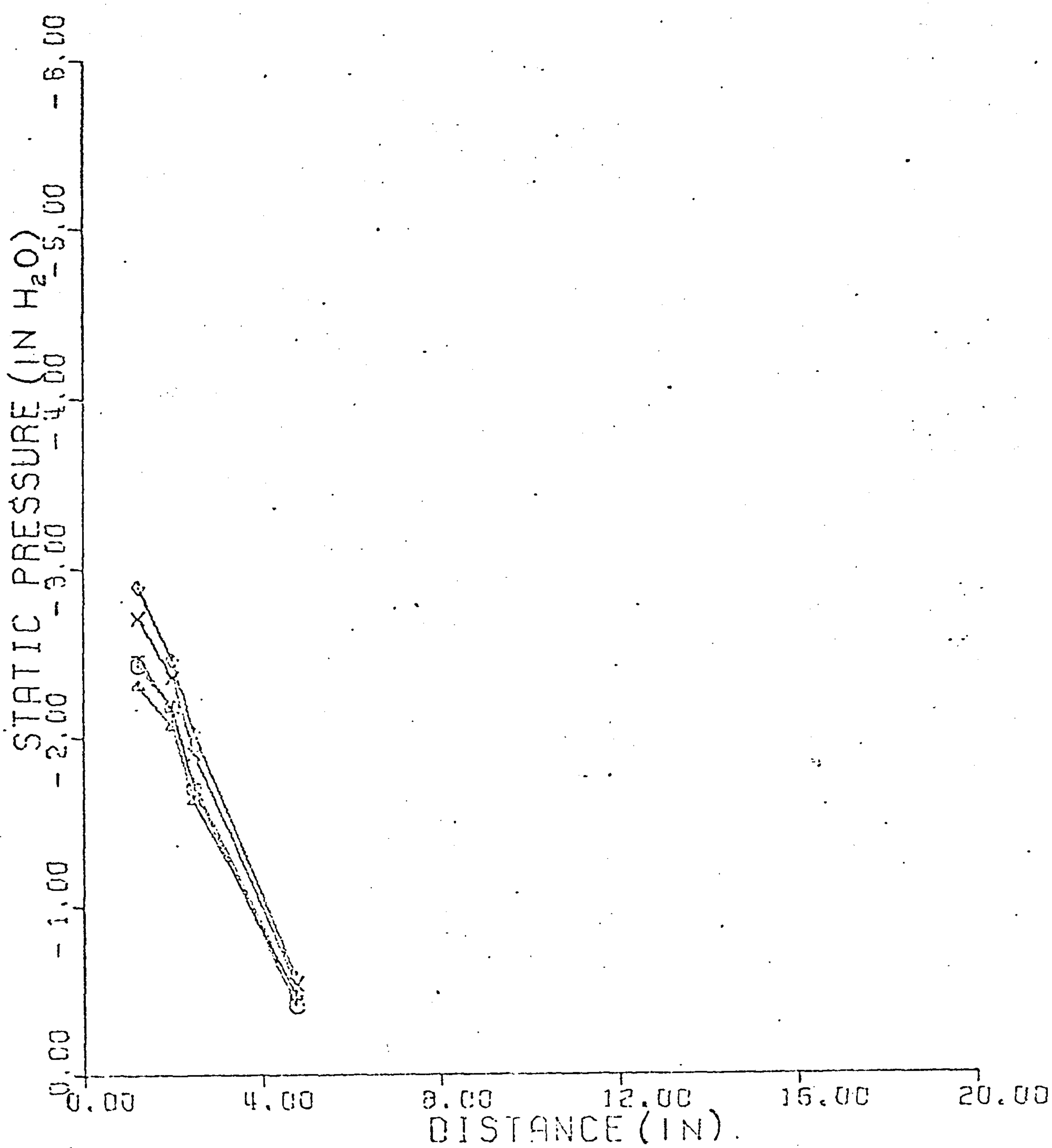


FIGURE 24D

STATIC PRESSURE RISE

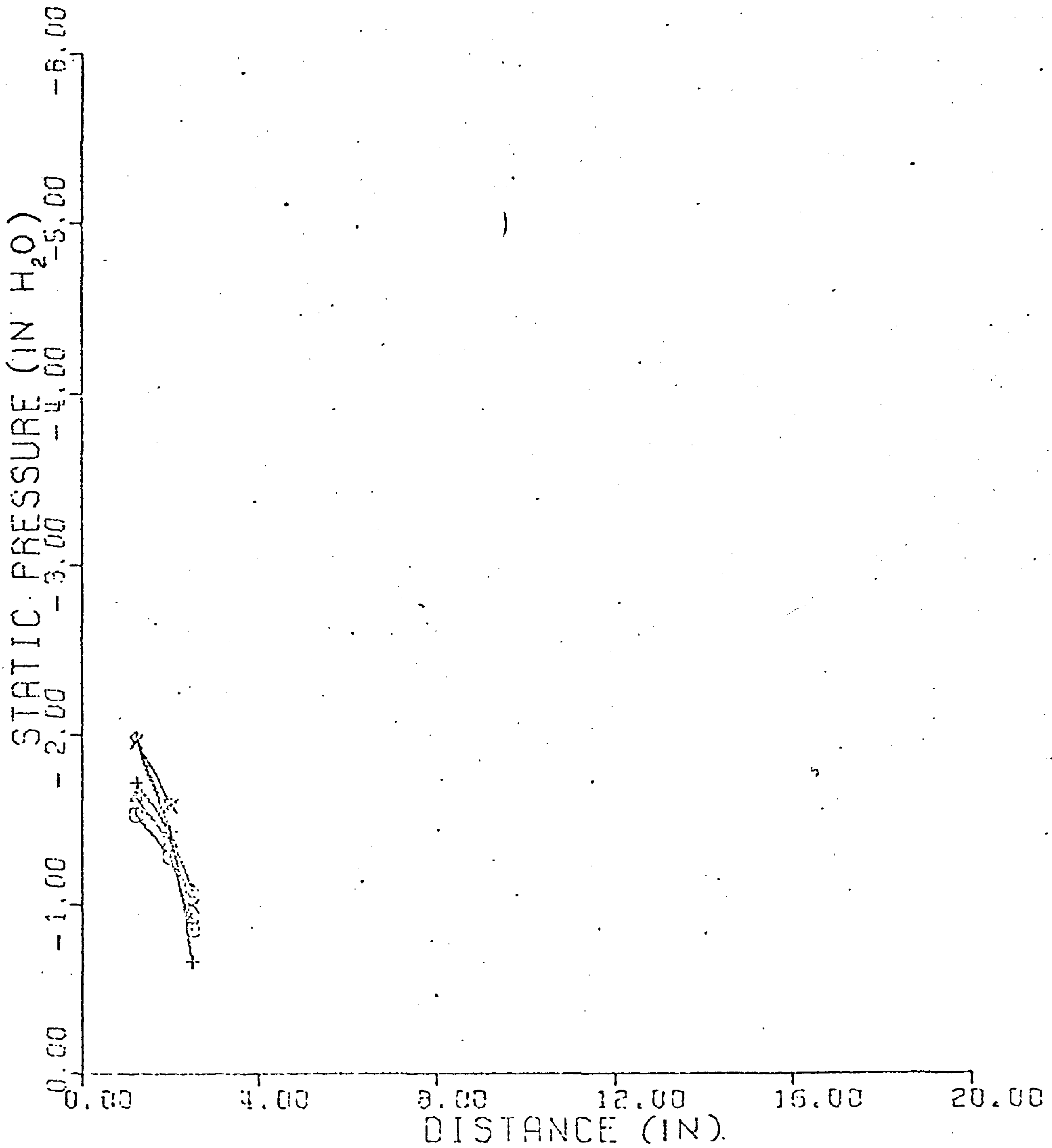


FIGURE 25A

INLET TURBULENCE

DIFFUSER A

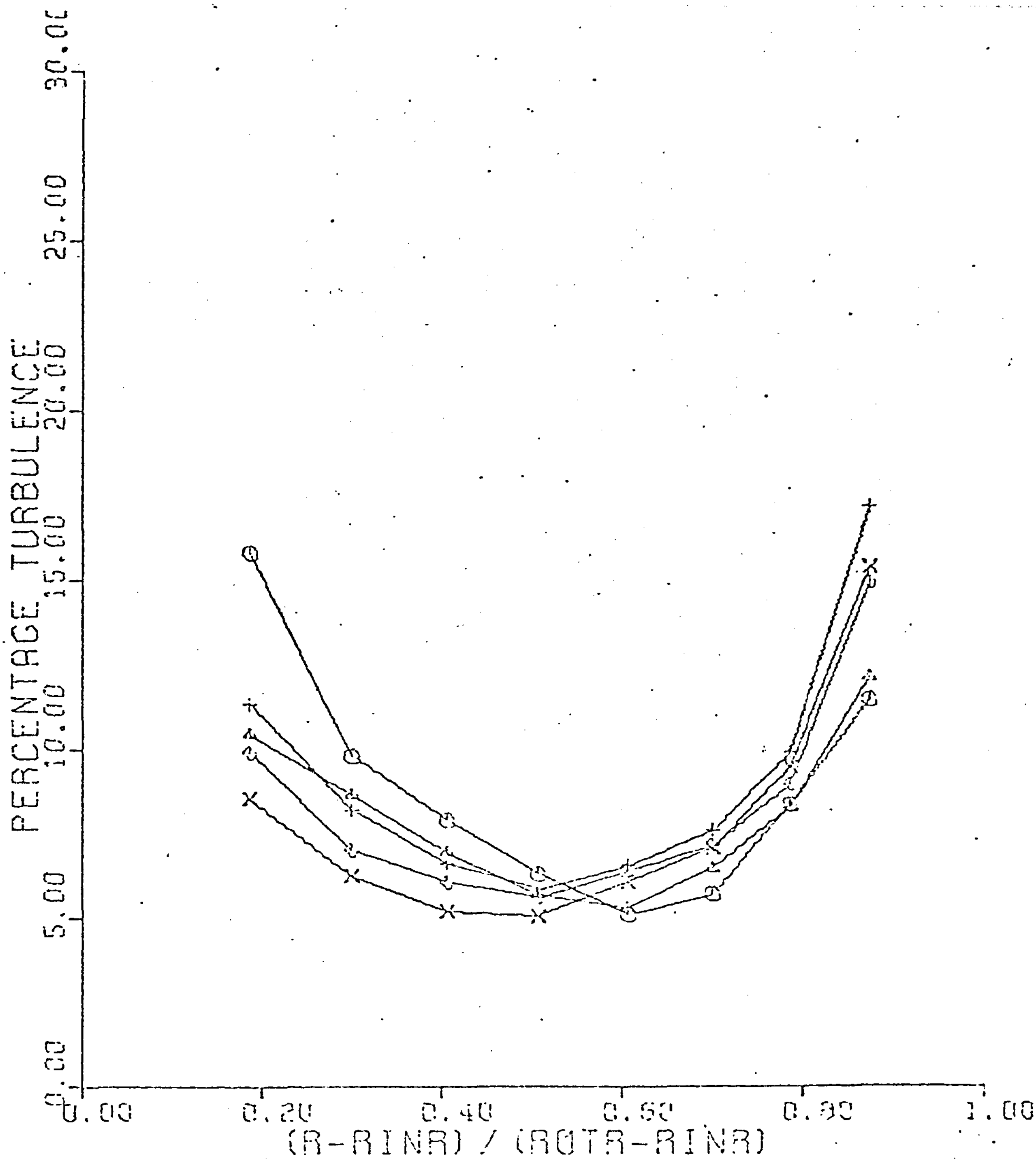


FIGURE 25B

INLET TURBULENCE

DIFFUSER B

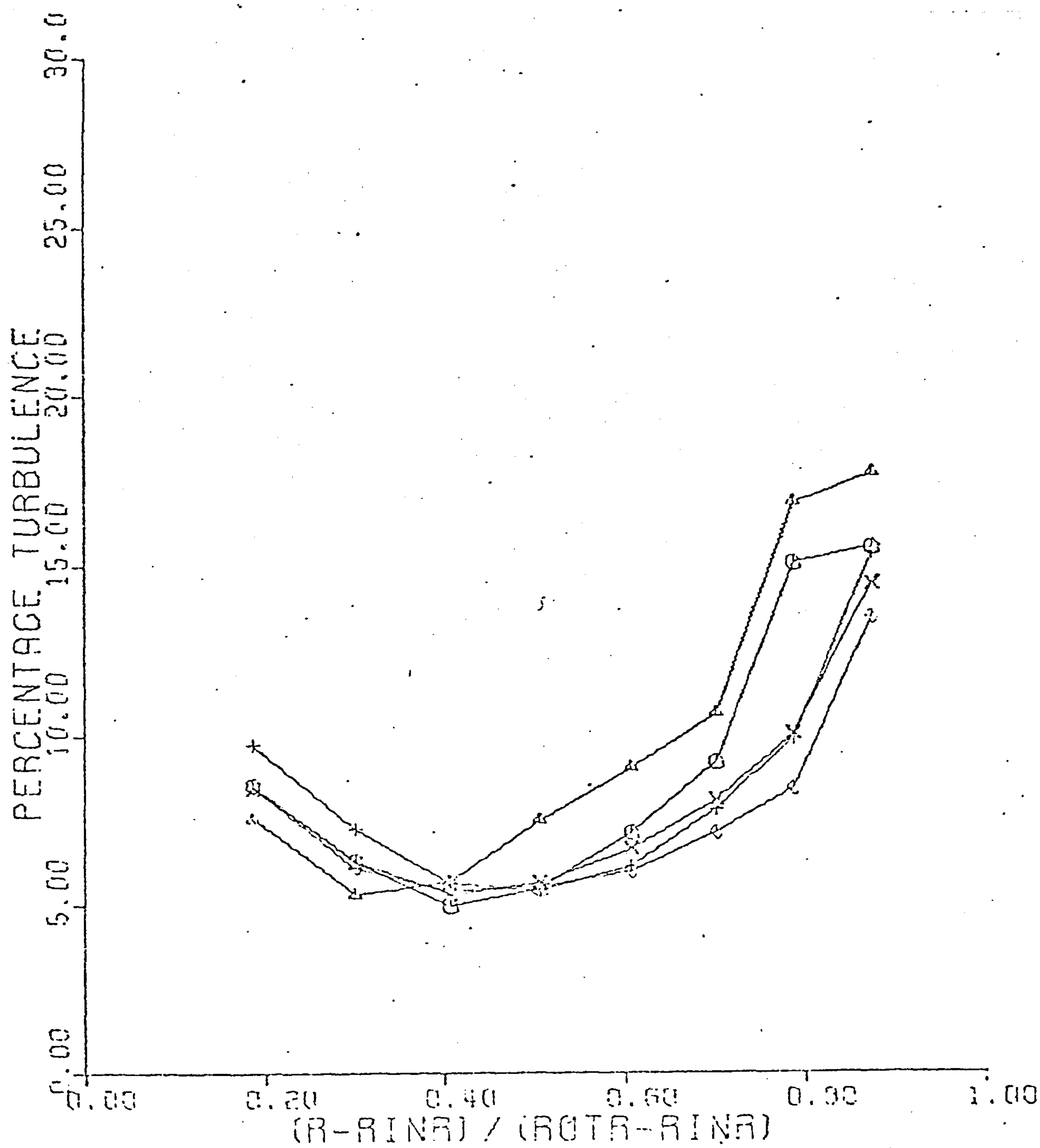


FIGURE 25C

INLET TURBULENCE

DIFFUSER C

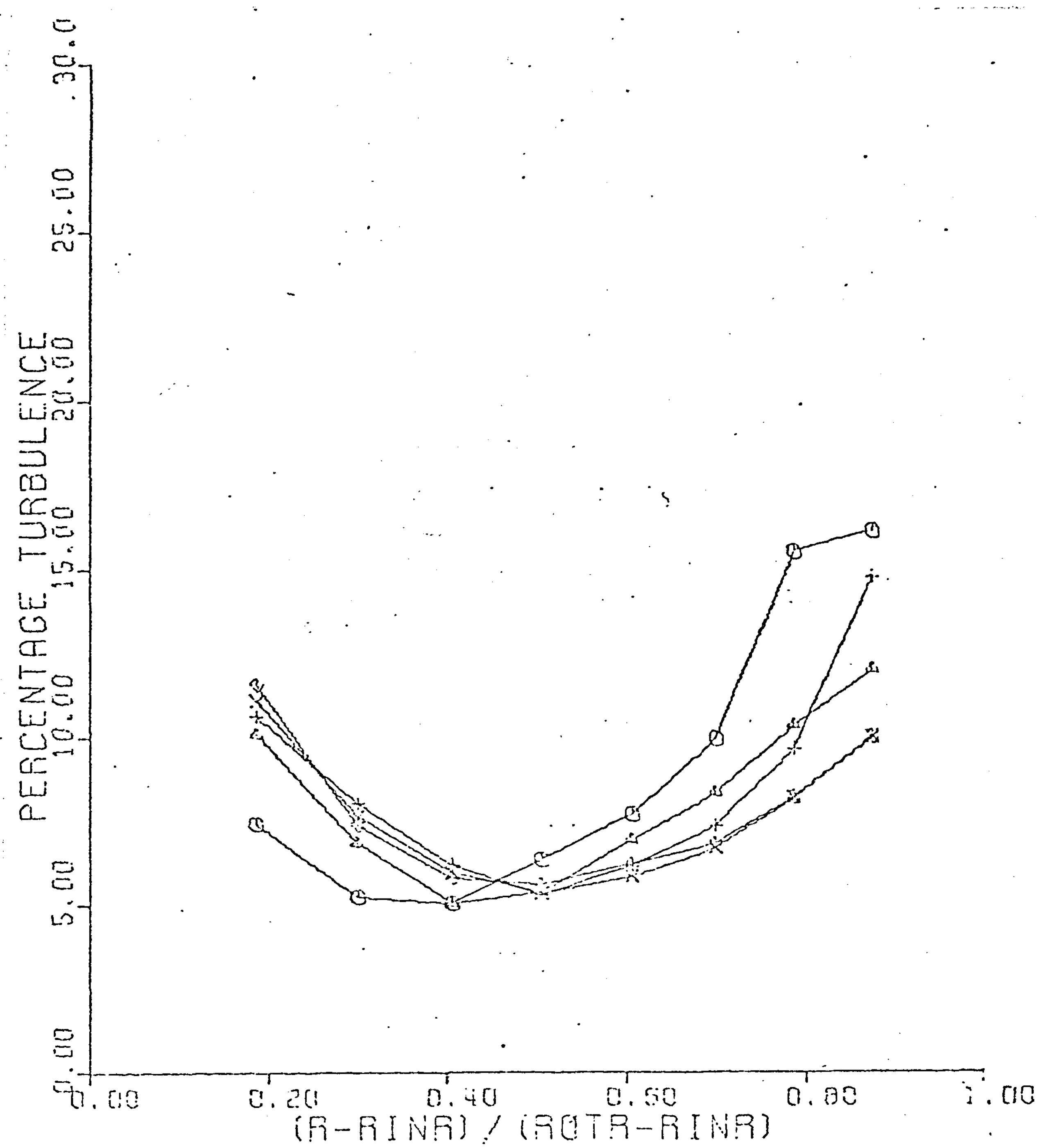


FIGURE 25D

INLET TURBULENCE

DIFFUSER D

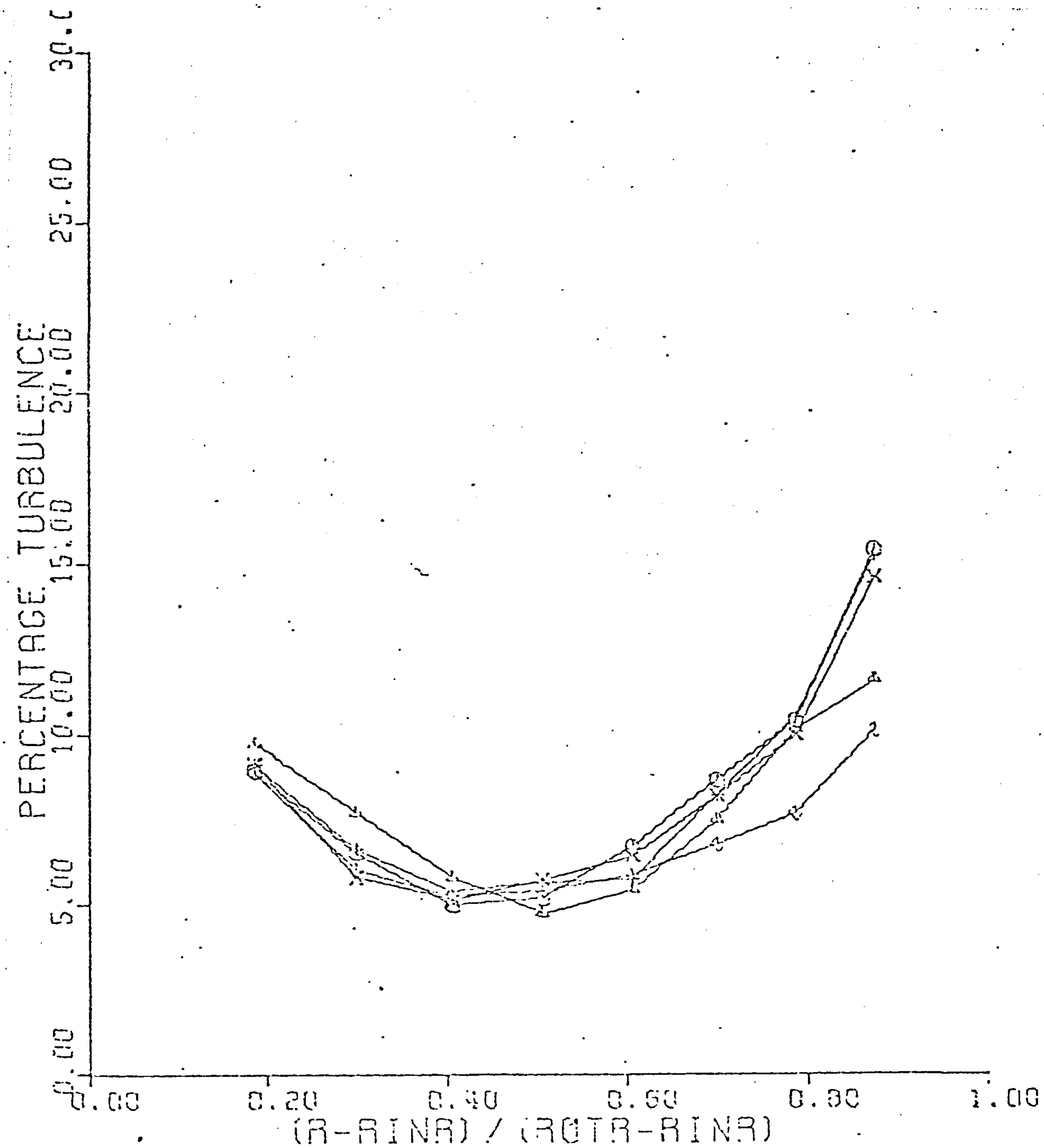


FIGURE 26

C_{PR} VERSUS L/h
CONSTANT Ψ (SWIRL ANGLE)

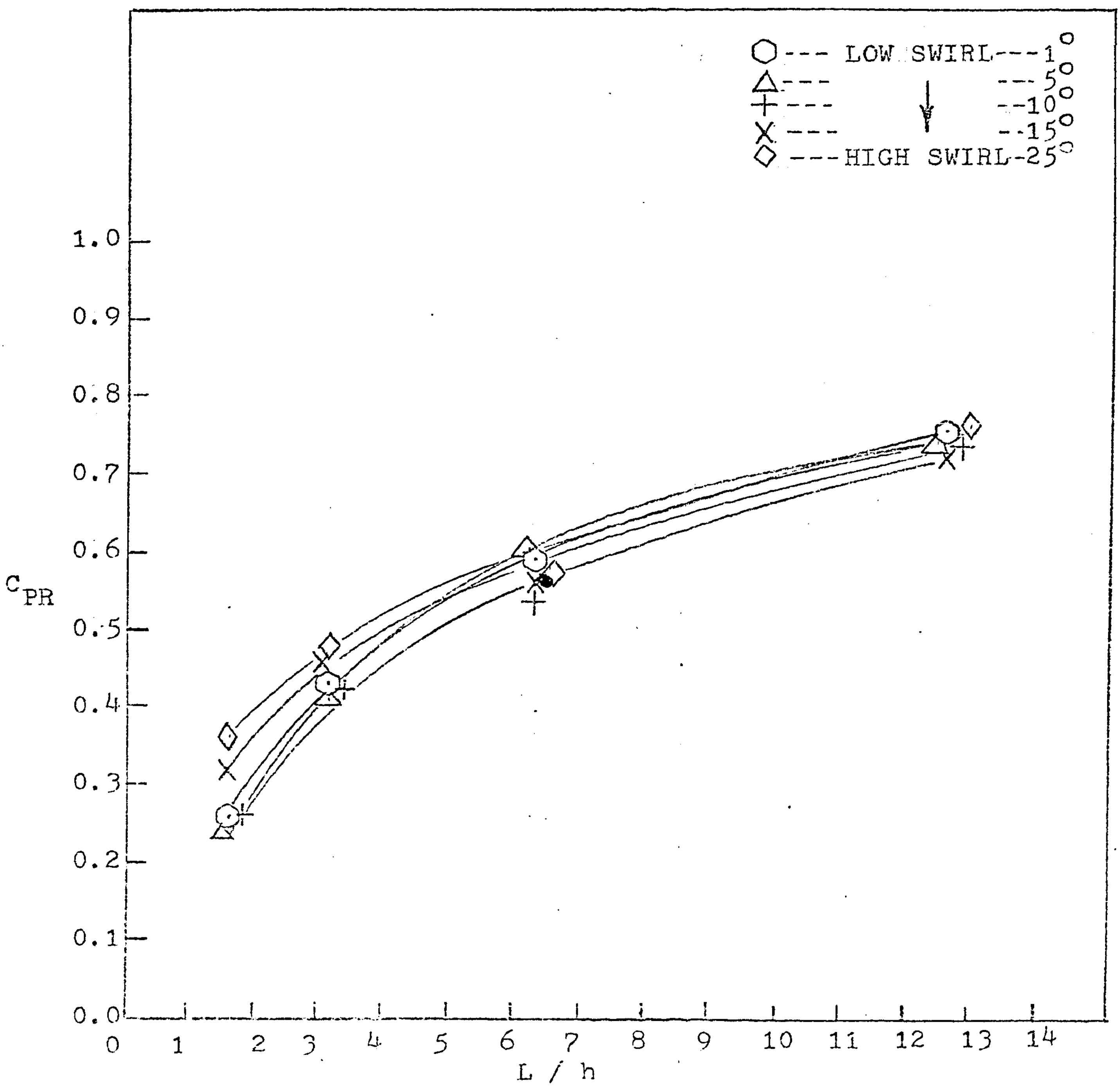


FIGURE 27

C_{PR} VERSUS $\overline{\psi}$
CONSTANT L / h

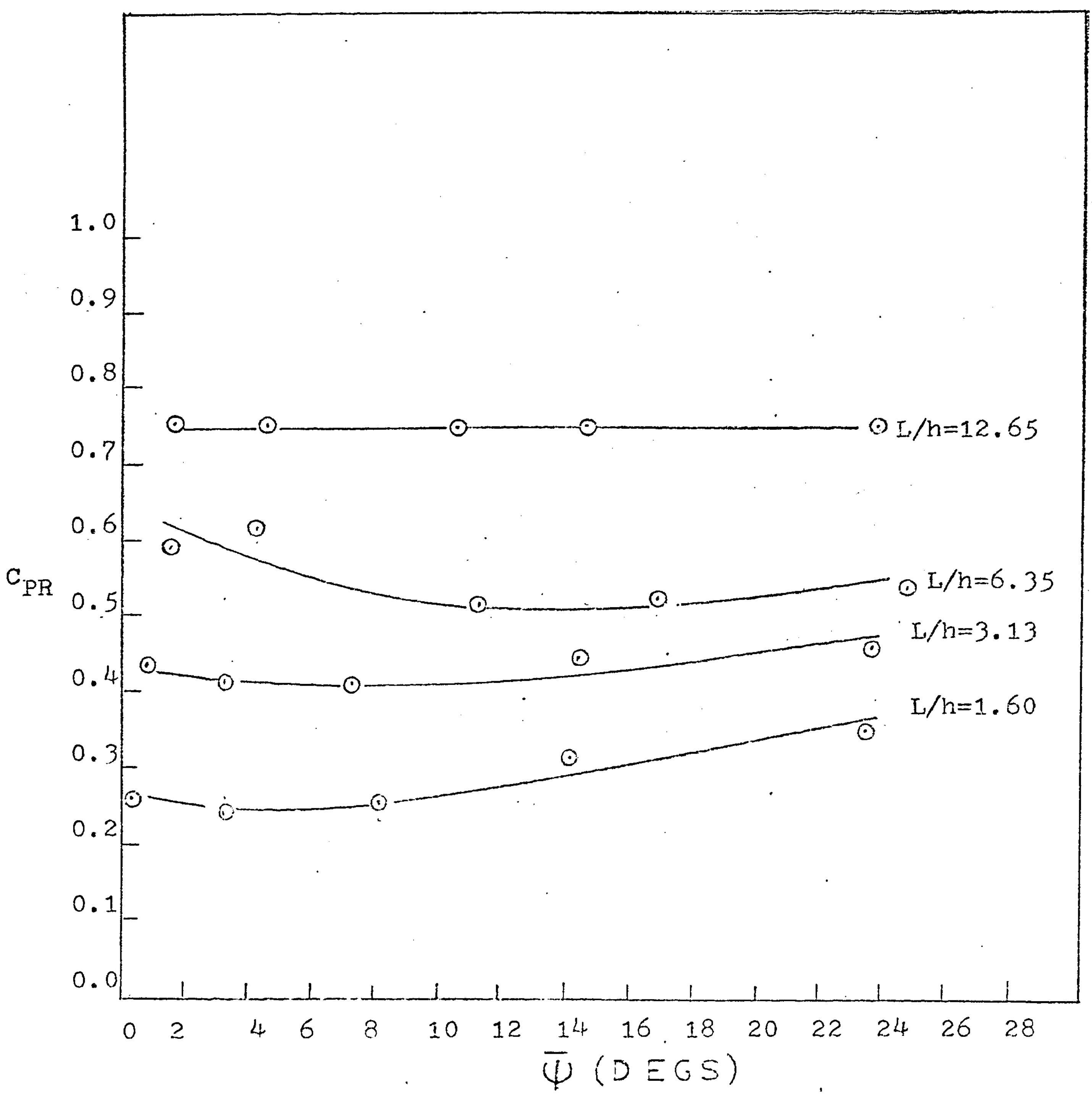
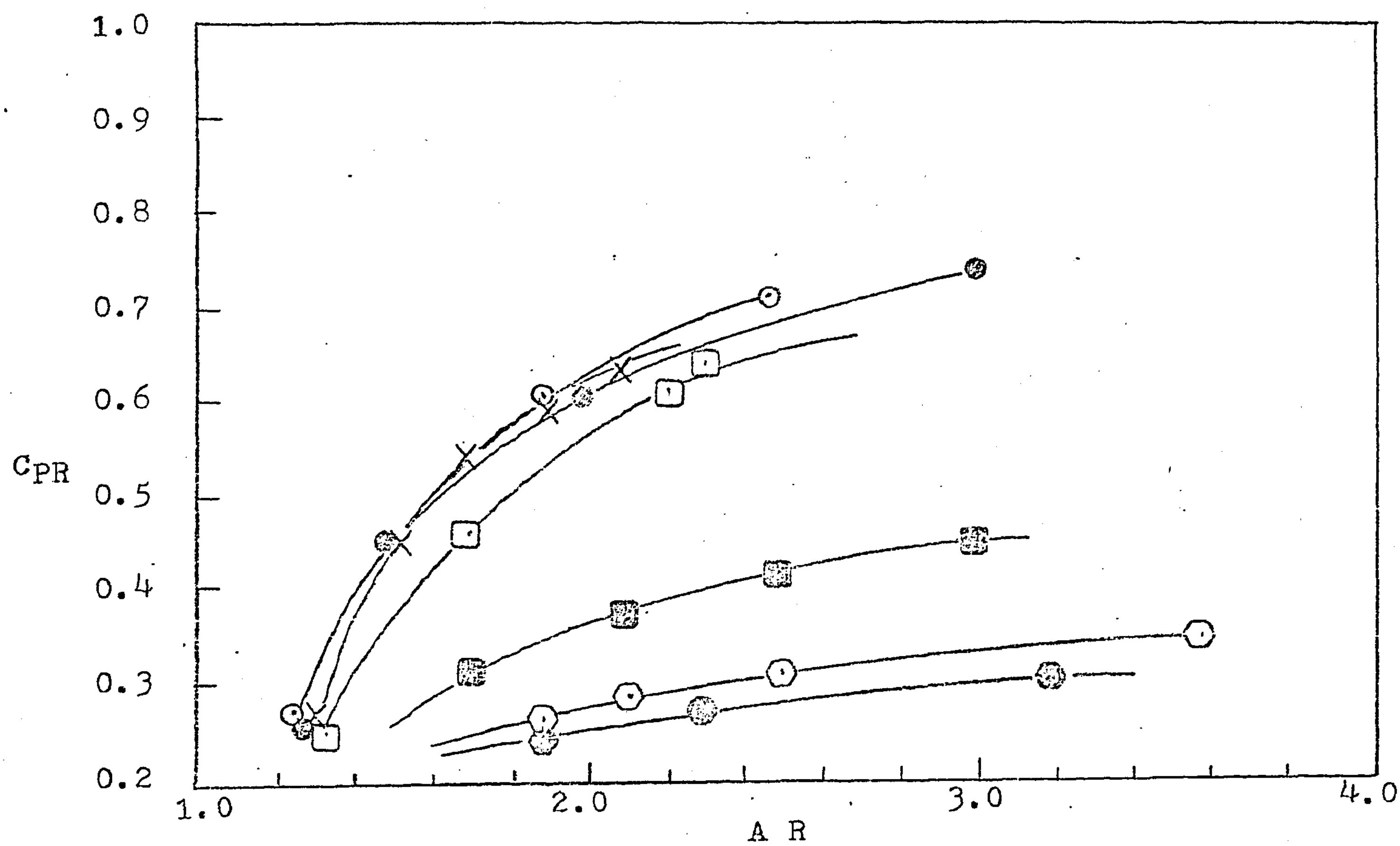


FIGURE 28

COMPARISON OF PRESENT RESULTS TO RESULTS OF SOVRAN & KLOMP



TYPES OF DIFFUSERS

SYMBOL	θ_o	θ_i	r_h/r_t
○	30.0°	29.5°	0.70
● (shaded circle, small)	20.0	20.0	0.60
X	15.0	15.0	0.70
□	20.0	15.0	0.70
■ (shaded square)	20.0	10.0	0.70
⬡	20.0	5.0	0.70
● (shaded circle, large)	20.0	0.0	0.55

FIGURE 29

ANNULAR EQUIANGULAR DIFFUSER

PRESSURE RECOVERY FACTOR VARIATION WITH LENGTH FOR VARIOUS SWIRL DISTRIBUTIONS

UNIVERSITY OF WATERLOO

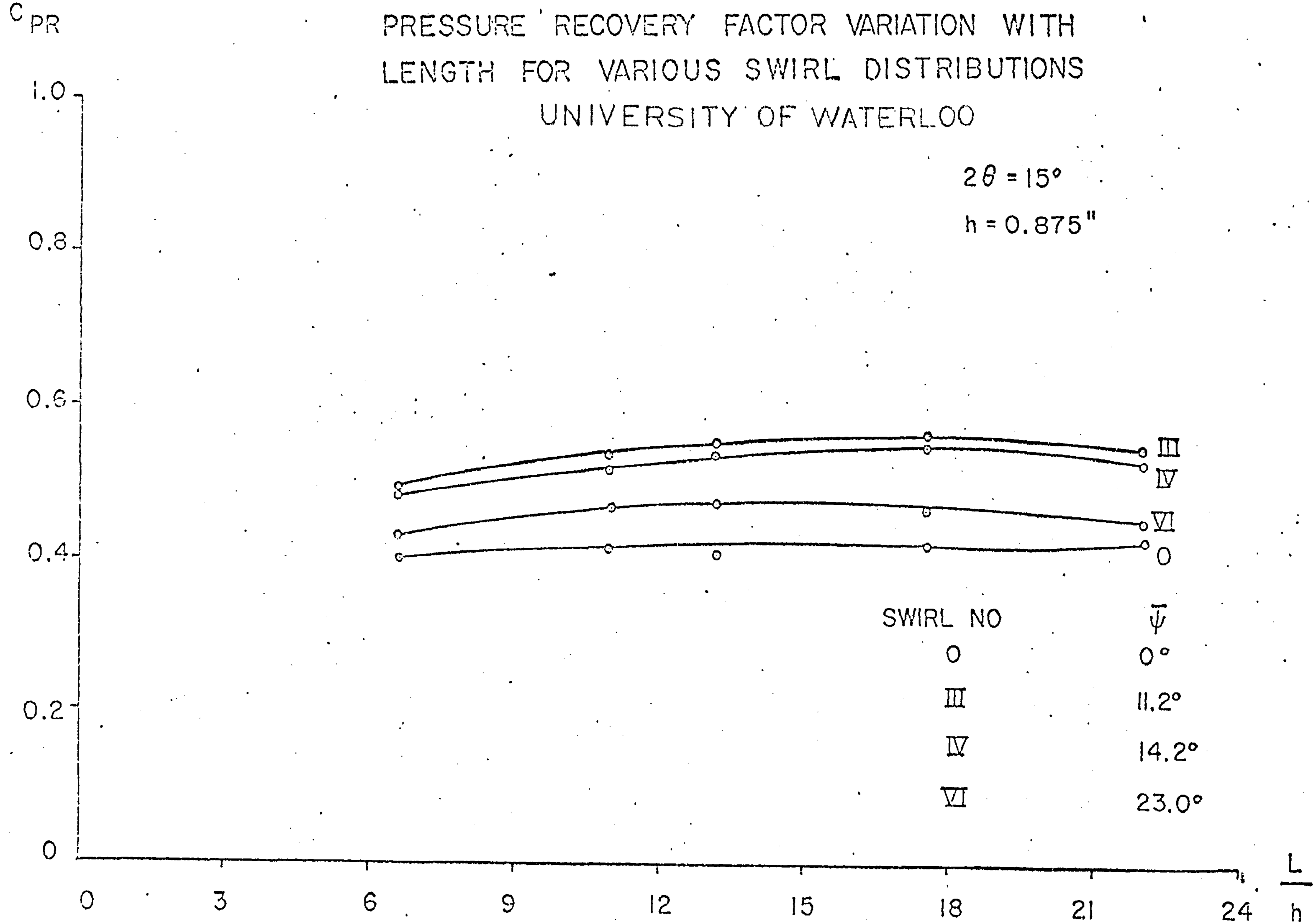


FIGURE 30

ANNULAR EQUIANGULAR DIFFUSER

PRESSURE RECOVERY FACTOR VARIATION WITH INLET SWIRL FOR CONSTANT LENGTH

UNIVERSITY OF WATERLOO

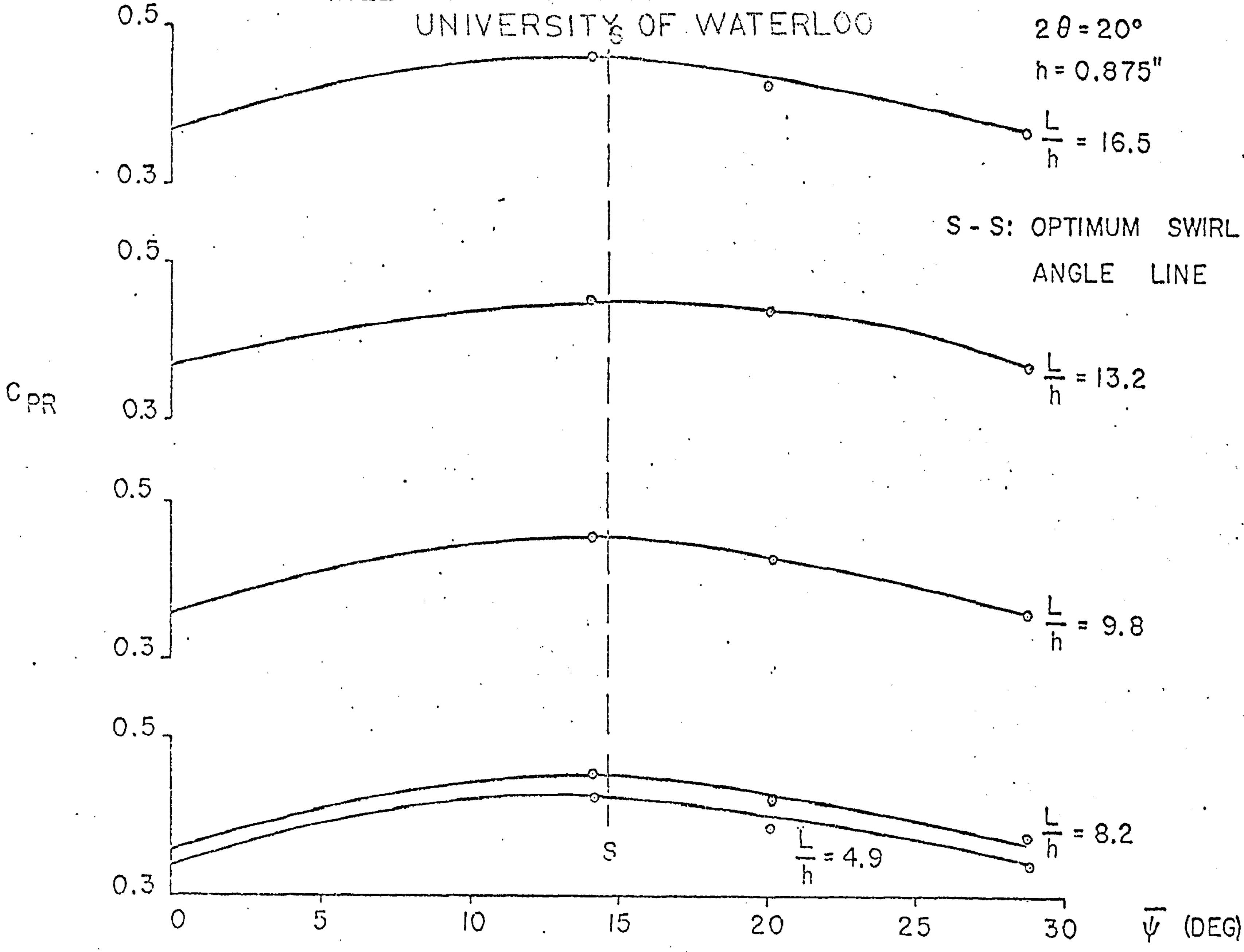


FIGURE 31

η VERSUS L / h
CONSTANT Ψ (SWIRL ANGLE)

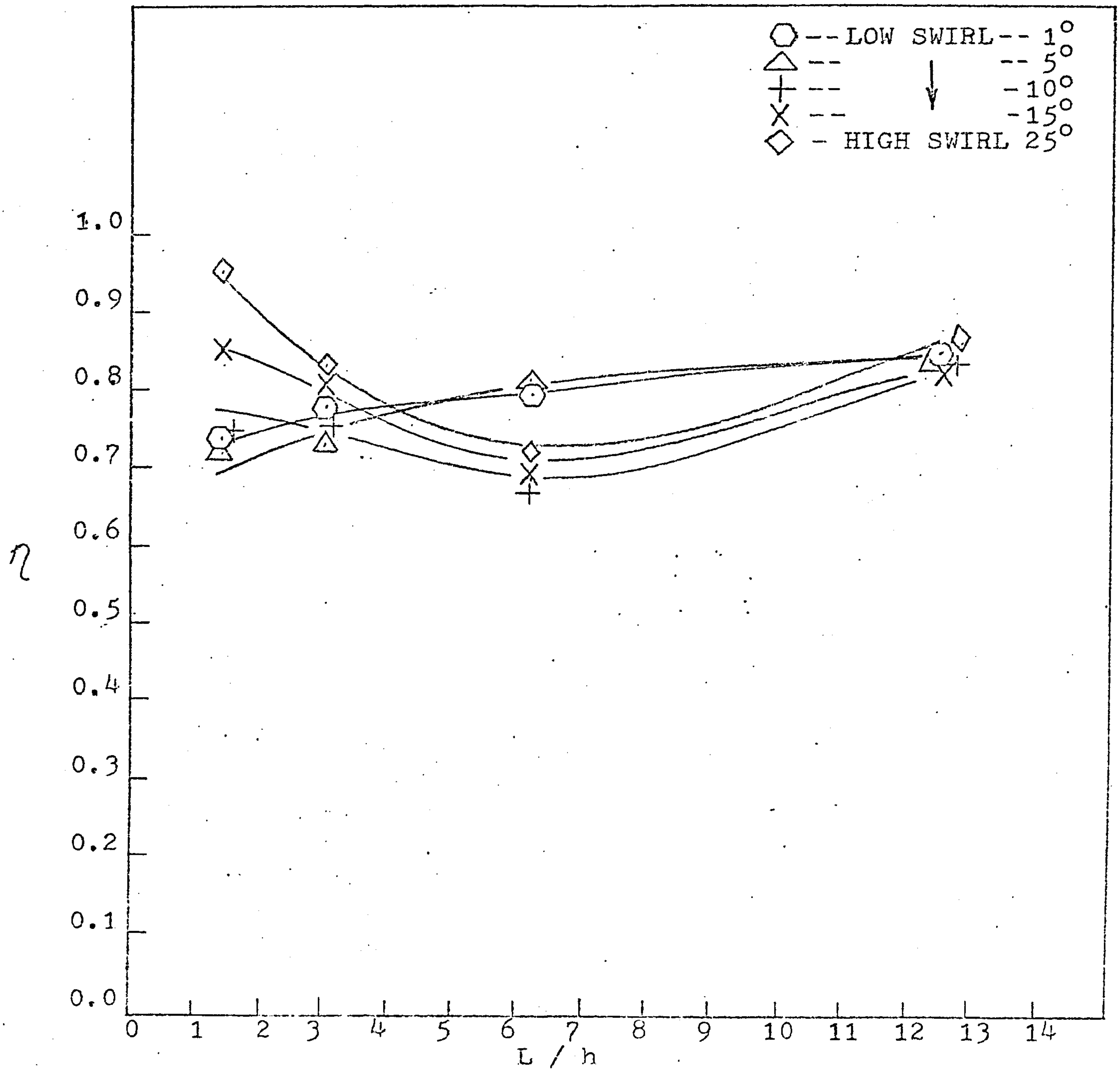
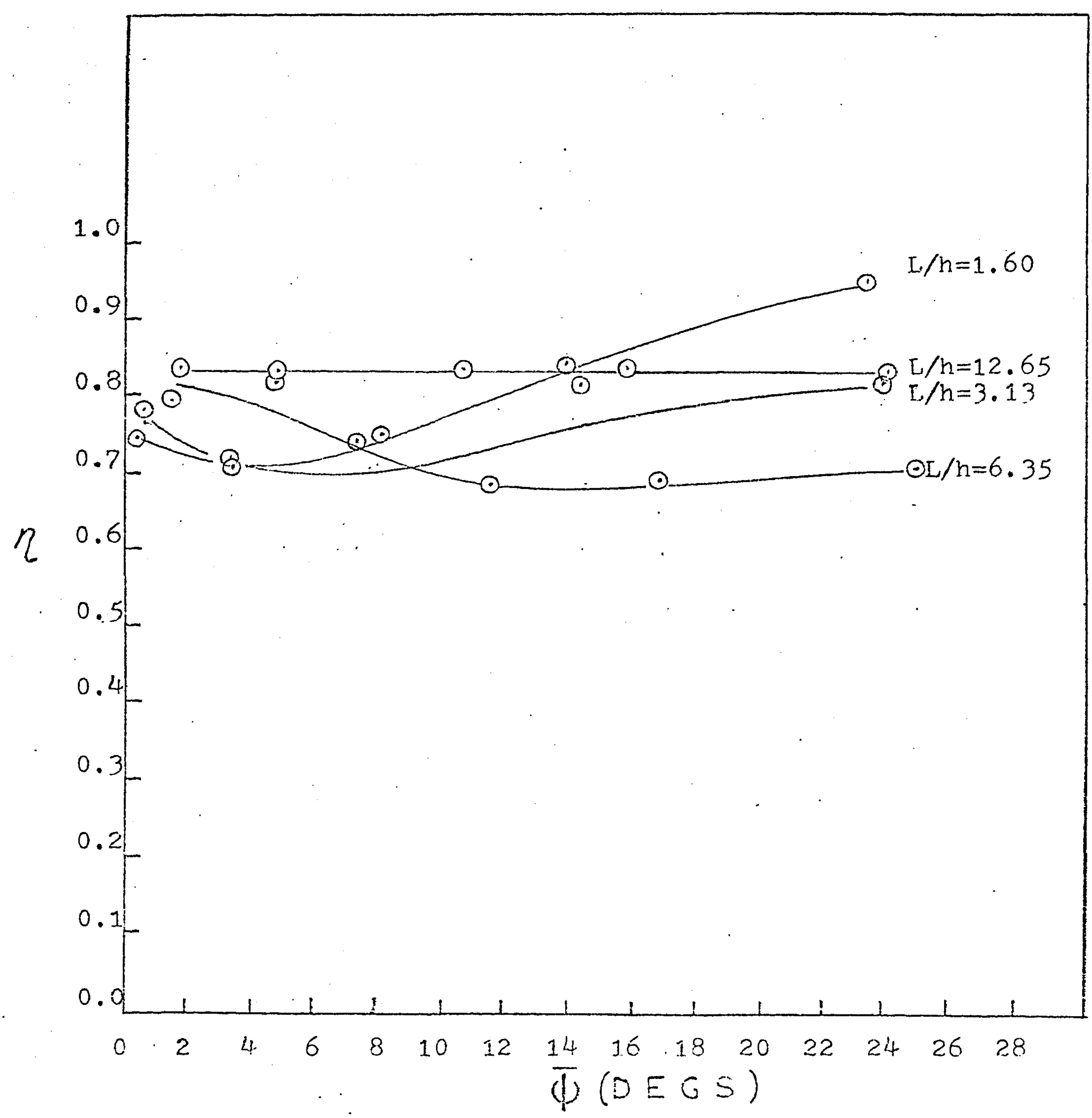


FIGURE 32

η VERSUS $\overline{\Phi}$
CONSTANT L / h



VITA AUCTORIS

1946 Born in Frankfurt am Main, West Germany on May 17.

1965 Completed High School at Vincent Massey Collegiate Institute, Windsor, Ontario in June.

1969 Received the Degree of Bachelor of Applied Science in Mechanical Engineering from the University of Windsor, Windsor, Ontario.

1971 Currently a candidate for the Degree of Master of Applied Science in Mechanical Engineering at the University of Windsor.