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Model tests of multiple nozzle exhaust gas educator systems for gas turbine powered ships.

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MODEL TESTS OF MULTIPLE NOZZLE EXHAUST GAS EDUCTOR SYSTEMS FOR GAS TURBINE POWERED SHIPS.

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THESIS REPORT

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Model Tests of Multiple Nozzle Exhaust Gas Eductor Systems for Gas Turbine Powered Ships

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

NOMENCLATURE

English Letter Symbols

A	-	Area, in^2
AR	-	Area Ratio
c	-	Sonic velocity, ft/sec
C	-	Coefficient of discharge
D	-	Diameter, in
f	-	Friction factor
Fa	-	Thermal expansion factor
F_{fr}	-	Wall skin-friction force, lbf/ft^2
g_c	-	Proportionality factor in Newton's Second Law, $g_c = 32.174$ $lbm\text{-}ft/lbf\text{-}sec^2$
h	-	Enthalpy, Btu/lbm
k	-	Ratio of specific heats
K	-	Flow coefficient
K_e	-	Kinetic energy correction factor
K_m	-	Momentum correction factor at the mixing stack exit
K_p	-	Momentum correction factor at the primary nozzle exit
L	-	Length, in
P	-	Pressure, in H_2O
P_a	-	Atmospheric pressure, in Hg
P_v	-	Velocity head, in H_2O
R	-	Gas constant for Air, 53.34 ft-lbf/lbm-°R
s	-	Entropy, Btu/lbm-°R
T	-	Absolute temperature, °R

u - Internal energy, Btu/lbm

U - Velocity, ft/sec

v - Specific volume, lbm/ft^3

W - Mass flow rate, lbm/sec

Y - Expansion factor

Dimensionless Groupings

A* - Secondary flow area to primary flow area ratio

M - Mach number

ΔP* - Pressure coefficient

Re - Reynolds number

T* - Secondary flow absolute temperature to primary flow absolute temperature ratio

W* - Secondary mass flow rate to primary mass flow rate ratio

ρ* - Secondary flow density to primary flow density ratio

Greek Letter Symbols

μ - Absolute viscosity, lbf-sec/ft^2

ρ - Density, lbm/ft^3

Subscripts

0 - Section within secondary air plenum

1 - Section at primary nozzle exit

2 - Section at mixing stack exit

m - Mixed flow or mixing stack

or - Orifice

P - Primary

s - Secondary

u - Uptake

w - Mixing stack inside wall

Tabulated Data

MU - Uptake Mach number

PA-PNZ - Pressure differential across secondary flow nozzles, in H_2O

PA-PS - Static pressure at mixing stack entrance

PTA - Velocity pressure head distribution at mixing stack exit along a diagonal traverse, in H_2O

PTB - Velocity pressure head distribution at mixing stack exit along a horizontal traverse, in H_2O

PU-PA - Static uptake pressure, in H_2O

UM - Average velocity in mixing stack, ft/sec

UP - Primary flow velocity at primary nozzle exit, ft/sec

UU - Primary flow velocity in uptake, ft/sec

VA - Diagonal velocity traverse at mixing stack exit, ft/sec

VB - Horizontal velocity traverse at mixing stack exit, ft/sec

VAV - Average mixing stack exit velocity

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I. INTRODUCTION

One of the unique features which attend the introduction of the gas turbine as a propulsion engine for naval ships is its airbreathing and exhaust characteristics. With air-fuel ratios of four to five times that of a steam plant, relatively large amounts of combustion air are required; and, characteristic of the simple cycle gas turbine engine, exhaust gases of much higher temperature and correspondingly large volume are expelled. New problems inherent with this large volume of high temperature effluent have made reduction of the exhaust gas temperature essential. Newly generated problem areas include the damaging effects of hot gas impingement on mast-mounted equipment within the exhaust gas plume and the infra-red signature of the hot exhaust gas. An effective means of reducing the exhaust gas temperature is to mix it with ambient air prior to its discharge from the stack. Exhaust gas eductor systems presently in service have demonstrated their effectiveness in facilitating such a mixing process.

For the purpose of this investigation, the exhaust gas eductor system is defined as that part of the total gas turbine exhaust system which is located topside and used to induce ambient air to mix with and cool the hot turbine exhaust gas before it discharges from the stack. The primary purpose of an exhaust gas eductor system is to mix ambient cool air with the hot exhaust gas with minimum effect on the performance of the engine. To cool the primary flow effectively requires not only the amount of cooling air to lower the temperature, but also a high degree of mixing. One of the important geometric

influences to be studied is the effect of multi-primary nozzle systems, where several primary nozzles discharge into a single constant area mixing stack. The number, shape and distribution of primary nozzles can have a major effect on eductor performance. Equally important are the geometric properties of the eductor system including the mixing stack area to total primary nozzle area ratio and the existence of adequate secondary (ambient) flow area. Continued application of eductors aboard naval vessels for the purpose just described demands development of systems of lighter weight and better performance. Although a great deal of effort has been expended on the theoretical and experimental analysis of the turbulent mixing of a single primary jet, both axisymmetric and nonconcentric in a secondary air stream, very little has been done on the analysis of an eductor utilizing multiple primary jets.

A Society of Automotive Engineers report [1] identifies basic eductor equations through the analysis of an eductor system used to cool an engine nacelle. The approach taken was to treat the eductor system as a unit, concentrating on the overall flow phenomenon rather than the details of the mixing process within the mixing tube. R.S. Darling [2] combined a computer solution of the equations developed in reference [1] with experimental data to demonstrate the feabibility of using a single nozzle eductor system on naval ship stacks to cool gas turbine exhaust gases. The geometries considered were confined to mixing stack $L/D \leq 1.6$, mixing stack area to primary nozzle area ratios from 1.53 to 2.34 and uptake area to primary nozzle area ratios from 1.0 to 1.5. Darling's study demonstrates that an increase in

mixing stack area to primary nozzle area ratio results in an increased secondary flow rate, a trend that is verified here. It also indicates that a single nozzle eductor system, for the range of area ratios tested and at a primary flow rate equivalent to that used here, produces little or no secondary flow at secondary air pressures equal to or less than atmospheric. For an eductor system utilized aboard ship to cool gas turbine exhaust gases, such secondary air pressures are encountered. R.S. Darling also tested two multiple-eductor systems, not to be confused with multiple-nozzle eductor systems, which showed a slight increase in pumping over a single eductor system but at the expense of a considerable weight increase.

Pucci [3] improved upon the one-dimensional analysis of a single nozzle eductor system with a constant area mixing stack by combining a one-dimensional flow analysis with an experimentally determined momentum correction factor. He demonstrated that the performance of an eductor is dependent upon the completeness of mixing of primary and secondary flows which is a function of mixing stack length, mixing stack area to primary nozzle area ratio and secondary to primary flow rate ratio.

Khanna and Tabakoff [4] consider a theoretical analysis of iso-energetic and non-isoenergetic mixing between two compressible subsonic streams in an axisymmetric duct. A survey of curves representing the decay of initial velocity and temperature nonuniformities along the length of the mixing stack suggests that energy diffuses more rapidly than momentum.

It is the intent of this investigation to obtain data on the behavior of existing and proposed multiple nozzle eductor systems for use aboard naval vessels thus leading to a better understanding of the interdependency of the geometric and flow variables so that an "optimum design" can be approached more closely than is now possible.

A one-dimensional flow analysis of a simple single nozzle eductor system, as a unit, facilitates determination of the non-dimensional parameters which govern the flow phenomenon. An experimental correlation of these non-dimensional parameters is then developed and used in evaluating eductor performance and demonstrating geometric parameter variation effects on performance.

Keeping in mind an eductor's primary purpose, evaluation of its "performance" involves consideration of two things, its ability to induce a flow of ambient air and the degree of mixing between the primary and ambient air streams. In a prototype installation, the flow of ambient air into the eductor is open to the environment and is very sensitive to any restrictions in its flow path, thus eliminating the possible use of any restrictive type measuring device for determining the secondary flow rate. The experimental technique to determine the ambient air flow rate is first to establish the pumping characteristics of the modeled eductor system. This is accomplished by varying the flow of ambient air through a means external to the eductor so as not to disrupt the flow pattern within the eductor. The pumping characteristic curve thus obtained is then extrapolated to the eductor operating point corresponding to its normally unobstructed operating condition.

The degree of mixing is evident in two ways: in the degree of momentum transfer from the high velocity hot exhaust gas to the lower velocity induced ambient air and in the degree of energy transfer from the high temperature exhaust gas to the lower temperature induced ambient air. In this highly turbulent mixing process, the mechanisms for momentum transfer and energy transfer are similar. This permits an investigation dealing with primary and secondary flows at the same temperature since considerable insight into the degree of cooling will be gained from the knowledge of the degree of momentum mixing. A momentum correction factor calculated based on velocity profiles at the mixing stack exit is used as an indication of the degree of momentum mixing. Since ambient air instead of hot gas can be used for the primary flow, a simpler and less expensive experimental facility, which is more adaptable to geometric changes, may be used. It is evident that the number of geometric variations of an eductor configuration is virtually unlimited. The variation of geometric parameters made in this investigation was limited to those most potentially suited for incorporation into the proposed eductor design and which minimize the need for modification of the established basic configuration.

II. THEORY AND ANALYSIS

Evaluation of the effects of geometric parameter variations on prototype eductor system performance through experimentation with models requires the following: assurance of similarity between model and prototype; the identification of the dimensionless groupings controlling the flow phenomenon; a suitable means of data analysis and presentation. Dynamic similarity was maintained by using Mach number similarity to establish the model's primary flow rate. Determination of the dimensionless groupings which govern the flow was accomplished through the analysis of a simple air eductor system. Based on this analysis, an experimental correlation of the non-dimensional parameters was developed and used in presenting and evaluating experimental data.

A. MODELING TECHNIQUE

Dynamic similarity between prototype and model was maintained by duplicating the flow while accounting for differences in fluid properties arising from the use of air at or near ambient temperature in place of hot exhaust gas for the primary flow. For the region of flow velocities considered, the state of the primary flow throughout the eductor is turbulent ($R_e \approx 10^5$). Consequently, momentum exchange is predominant over shear interaction, and the kinetic and internal energy terms are more influential on the flow than are viscous forces. Since Mach number can be shown to represent the ratio of kinetic energy of a flow to its internal energy, it is a more significant parameter than Reynolds number in describing the primary flow through the uptake.

Similarity of Mach number was therefore used to model the primary flow. Mach number is defined as the ratio of flow velocity to sonic velocity in the medium considered. Sonic velocity, represented by c, is calculated using the relation

$$c = (g_c kRT)^{0.5}$$

Neglecting the minor differences in the ratio of specific heats, k, and the gas constant, R, between the hot exhaust gases of the prototype and the ambient air used in the model, Mach number similarity from prototype to model results in the relationship

$$\left(\frac{U_{model}}{U_{prototype}}\right) = \left(\frac{T_{model}}{T_{prototype}}\right)^{0.5}$$

This relationship was used to arrive at the model's primary flow velocity, thereby creating dynamically similar flow from prototype to model.

Geometric similarity was achieved through the use of a dimensional scale factor which is influenced by test facility flow capacities, primary flow velocities and availability of modeling materials.

B. ONE-DIMENSIONAL ANALYSIS OF A SIMPLE EDUCTOR

The theoretical analysis of an eductor may be approached in two ways. One method attempts to analyze the details of the mixing process of the primary and secondary air streams which takes place inside the mixing stack and thereby determines the parameters which describe the

flow. This requires an interpretation of the mixing phenomenon, which, when applied to multiple nozzle systems, becomes extremely complex. The method employed here analyzes the overall performance of the edcutor system as a unit. Since details of the mixing process are not considered in this method, an analysis of the simple single nozzle eductor system shown in Figure 1 leads to a determination of the dimensionless groupings governing the flow. This one-dimensional analysis follows very closely that of reference [3], the details of which are included in Appendix A.

The driving or primary fluid, flowing at a rate W_p and at a velocity U_p, discharges into the throat of the mixing-tube, inducing a secondary flow rate of W_s at velocity U_s. The primary and secondary flows are mixed and leave the mixing-tube at a flow rate of W_m and a bulk-average velocity of U_m.

The one-dimensional flow analysis of the simple eductor system described depends on the simultaneous solution of the equation of continuity, momentum equation, energy balance and the equation of state, compatible with specific boundary conditions.

The idealizations made for simplifying the analysis are as follows:

1. The flow is steady state and incompressible.
2. Adiabatic flow exists throughout the eductor with isentropic flow of the secondary stream from the plenum (at section 0) to the throat or entrance of the mixing-tube (at section 1) and irreversible adiabatic mixing of the primary and secondary streams in the mixing-tube (between sections 1 and 2).

3. The static pressure across the flow at the entrance and exit planes of the mixing-tube (at sections 1 and 2) is uniform.
4. At the mixing-tube entrance (section 1) the primary flow velocity U_p and temperature T_p are uniform across the primary stream, and the secondary flow velocity U_s and temperature T_s are uniform across the secondary stream; but U_p does not equal U_s, and T_p does not equal T_s.
5. Incomplete mixing of the primary and secondary streams in the mixing-tube is accounted for by the use of a non-dimensional momentum correction factor K_m which relates the actual momentum rate to the pseudo-rate based on the bulk-average velocity and density and by the use of a non-dimensional kinetic energy correction factor K_e which relates the actual kinetic energy rate to the pseudo-rate based on the bulk-average velocity and density.
6. Both gas flows behave as perfect gases.
7. Flow potential energy of position changes are negligible.
8. Pressure changes P_{so} to P_{s1} and P_1 to P_a are small relative to the static pressure so that the gas density is essentially dependent upon temperature (and atmospheric pressure).
9. Wall friction in the mixing-tube is accounted for with the conventional pipe friction factor term based on the bulk-average flow velocity U_m and the mixing-tube wall area A_w.

Based on the continuity equation, the conservation of mass principle for steady state flow yields

$$W_m = W_p + W_s \tag{1}$$

where

$$W_p = \rho_p U_p A_p$$

$$W_s = \rho_s U_s A_s \qquad (1a)$$

$$W_m = \rho_m U_m A_m$$

All of the above velocity and density terms, with the exception of ρ_m and U_m, are defined without ambiguity by virtue of idealizations (3) and (4) above. Combining equations (1) and (1a), the bulk average velocity at any point along the mixing stack becomes

$$U_m = \frac{W_s + W_p}{\rho_m A_m} \qquad (1b)$$

The perfect gas equation of state is used to evaluate

$$\rho_m = \frac{P_a}{R T_m} \qquad (2)$$

where T_m is calculated as the bulk average temperature for the mixed flow obtained from the energy equation (9) to follow. The momentum equation stems from Newton's Second and Third Laws of Motion and is the conventional force and momentum-rate balance in fluid mechanics

$$K_p\left[\frac{W_p\,U_p}{g_c}\right]_1 + \left[\frac{W_s\,U_s}{g_c}\right]_1 + P_1A_1 = K_m\left[\frac{W_m\,U_m}{g_c}\right]_2 + P_2A_2 + F_{fr} \qquad (3)$$

with $A_1 = A_2$. Note the introduction of idealizations (3) and (5). To account for a possible non-uniform velocity profile across the primary nozzle exit, the momentum correction factor K_p is introduced here. It is defined in a manner similar to that of K_m and by idealization (4) is equal to unity but is carried through this analysis to illustrate its effect on the final result. The momentum correction factor for the mixing stack exit is defined by the relation

$$K_m = \frac{1}{W_m\,U_m}\int_0^{A_m} U_2^{\,2}\,\rho_2\,dA \qquad (4)$$

where U_m is evaluated as the bulk-average velocity from equation (1b). The actual variable velocity and a weighted average density at section 2 are used in the integrand. The wall skin-friction force F_{fr} can be related to the flow stream velocity by

$$F_{fr} = f\,A_w\left[\frac{U_m^{\,2}\,\rho_m}{2\,g_c}\right] \qquad (5)$$

using idealization (9). As a reasonably good approximation for turbulent flow, the friction factor may be calculated from the Reynolds number

$$f = 0.046\,(Re_m)^{-0.2}\,, \quad \text{where} \quad Re_m = \frac{\rho_m\,U_m\,D_m}{\mu_m} \qquad (6)$$

Applying the conservation of energy principle to the steady flow system in the mixing stack (between sections 1 and 2),

$$W_p \left[h_p + \frac{U_p^2}{2\, g_c} \right]_1 + W_s \left[h_s + \frac{U_s^2}{2\, g_c} \right]_1 = W_m \left[h_m + K_e \frac{U_m^2}{2\, g_c} \right]_2 \tag{7}$$

neglecting potential energy of position changes, idealization (7). Note the introduction of the kinetic energy correction factor K_e which is defined by the relation

$$K_e = \frac{1}{W_m\, U_m^2} \int_0^{A_m} U_2^3\, \rho_2\, dA \quad . \tag{8}$$

It may be demonstrated that for the purpose of evaluating the mixed mean flow temperature T_m, the kinetic energy terms may be neglected to yield

$$h_m = \frac{W_p}{W_m} h_p + \frac{W_s}{W_m} h_s \tag{9}$$

where $T_m = \phi(h_m)$ only with idealization (6).

The energy equation for the isentropic flow of the secondary air from the plenum (section 0) to the entrance of the mixing stack (section 1) may be shown to reduce to

$$\frac{P_0 - P_1}{\rho_s} = \frac{U_s^2}{2\, g_c} \tag{10}$$

This comes from the steady, adiabatic flow, energy equation in differential form

$$dh = -d\left(\frac{U_s^{\;2}}{2\,g_c}\right)$$

with the recognition that $T\,ds = dh - \frac{1}{\rho}\,dP = 0$ for the postulated isentropic conditions. Thus

$$\frac{dP}{\rho} = -\,d\left(\frac{U^2}{2\,g_c}\right) \qquad (10a)$$

But for the small pressure change from the plenum to the mixing stack entrance (section 0 to 1), idealization (8), the temperature and density are essentially constant so that integration of equation (10a) to equation (10) is readily accomplished.

The foregoing equations may be combined to yield the vacuum produced by the eductor in the plenum chamber

$$P_a - P_0 = \frac{1}{g_c\,A_m}\left\{K_P\,\frac{W_P^{\;2}}{A_P\rho_P} + \frac{W_s^{\;2}}{A_s\rho_s}\left[1 - \frac{1}{2}\,\frac{A_m}{A_s}\right] - \frac{W_m^{\;2}}{A_m\rho_m}\left[K_m + \frac{f}{2}\,\frac{A_w}{A_m}\right]\right\} \qquad (11)$$

where it is understood that A_P and ρ_P apply to the primary flow at the entrance to the mixing stack (section 1), A_s and ρ_s apply to the secondary flow at this same section, and A_m and ρ_m apply to the mixed flow at the exit of the mixing stack (section 2). P_a is atmospheric pressure and is equal to the pressure at the exit of the mixing stack P_2. This equation also incorporates the assumption that $(\rho_s)_1 = (\rho_s)_0$ so that ρ_s may be taken as the density of the secondary flow in the plenum.

1. Non-Dimensional Solution of Simple Eductor Analysis

In order to provide the criteria of similarity of flows with geometric similarity, the non-dimensional parameters which govern the flow must be determined. One means of determining these parameters is by normalizing equation (11) which leads to the following terms:

$$\Delta P^* = \frac{\dfrac{P_s - P_0}{\rho_s}}{\dfrac{U_p^2}{2\, g_c}}$$

a pressure coefficient which compares the "pumped head" $\frac{P_a - P_0}{\rho_s}$ for the secondary flow to the "driving head" $\frac{U_p^2}{2\, g_c}$ of the primary flow.

$$W^* = \frac{W_s}{W_p}$$

a flow rate ratio, secondary-to-primary mass flow rate.

$$T^* = \frac{T_s}{T_p}$$

an absolute temperature ratio, secondary-to-primary.

$$\rho^* = \frac{\rho_s}{\rho_p}$$

a flow density ratio. Note that since $P_s = P_p$ and the fluids are perfect gases $\rho^* = \frac{T_p}{T_s} = \frac{1}{T^*}$.

$A^* = \frac{A_s}{A_p}$ area ratio of secondary flow area to primary flow area

$\frac{A_p}{A_m}$ area ratio of primary flow area to mixing stack cross sectional area

$\frac{A_w}{A_m}$ area ratio of wall friction area to mixing stack cross sectional area

K_p momentum correction factor for primary flow

K_m momentum correction factor for mixed flow

f wall friction factor

With these non-dimensional groupings, equation (11) may be written as

$$\frac{\Delta P^*}{T^*} = 2\frac{A_p}{A_m}\left\{\left[K_p - \frac{A_p}{A_m}\beta\right] - W^*\left(1 + T^*\right)\frac{A_p}{A_m}\beta + W^{*2}\,T^*\left[\frac{1}{A^*}\left(1 - \frac{A_m}{2A^*\,A_p}\right) - \frac{A_p}{A_m}\beta\right]\right\} \tag{11a}$$

where $\beta = \left(K_m + \frac{f}{2} \frac{A_w}{A_m} \right)$.

For a given eductor geometry, equation (11a) may be expressed in the form

$$\frac{\Delta P^*}{T^*} = C_1 + C_2 W^* \left(T^* + 1 \right) + C_2 W^{*2} T^* \qquad (11b)$$

where

$$C_1 = 2 \frac{A_p}{A_m} \left(K_p - \frac{A_p}{A_m} \beta \right)$$

$$C_2 = -2 \left(\frac{A_p}{A_m} \right)^2 \beta \qquad (11c)$$

$$C_3 = 2 \frac{A_p}{A_m} \left\{ \frac{1}{A^*} \left(1 - \frac{A_m}{2 A^* A_p} \right) \beta - \frac{A_p}{A_m} \beta \right\}$$

Equation (11b) may be expressed as a simple functional relationship

$$\Delta P^* = F(W^*, T^*) \quad . \qquad (12)$$

2. Dimensional Analysis of Eductor Flow

A second means of determining the governing dimensionless parameters is through a dimensional analysis of the mixing process

within the mixing stack. Using the Buckingham π Theorem with the four primary dimensions,

Mass	M
Length	L
Time	T
Temperature	θ

the seven principle quantities or variables associated with the flow phenomenon,

Pressure	P	M/LT^2
Temperature	T	θ
Viscosity	μ	M/LT
Density	ρ	M/L^3
Gas Constant	R	$L^2/T^2\theta$
Diameter	D	L
Velocity	V	L/T

and velocity, density, gas constant and diameter as repeating variables, three dimensionless groupings are obtained. The first, $P/\rho V^2$, is of the same form as the pressure coefficient, ΔP^*. A second grouping, RT/V^2, in a different form becomes the Mach number; and the third grouping, $\mu/\rho VD$, when inverted, $\rho VD/\mu$, is the Reynolds number, R_e. Since two separate flows, primary and secondary, are involved, ratios of the principle quantities relating to the separate flows will also yield dimensionless groupings. Such ratios include W_s/W_p which is the secondary to primary mass flow ratio designated by W^* and T_s/T_p, the

absolute temperature ratio, designated by T^*. Other ratios are possible but have little significance in the analysis. The five dimensionless groupings thus obtained can be combined in functional relationship form as

$$\Delta P^* = G(W^*, T^*, M, R_e) \qquad (13)$$

For the range of flow velocities encountered, the Mach number is less than 0.20, and compressibility effects are negligible, thus eliminating Mach number as a parameter influencing the flow. The state of the flow within the mixing stack is turbulent, and viscous effects are small. Therefore the pressure coefficient is also independent of Reynolds number, and the functional relationship of equation (13) reduces to that of equation (12).

C. EXPERIMENTAL CORRELATION

It is desirable to make a direct comparison of prototype and model performance on a one-to-one basis so that the effects of changes in geometric parameters on eductor performance may be readily evaluated in terms of expected prototype performance. The ratio of absolute secondary to primary flow temperatures T^* is the only parameter which was not controlled during the model tests. Therefore a means of presenting the experimental data for a given geometric configuration in a form which results in a pseudo-independence of the dimensionless groupings ΔP^* and W^* upon T^* must be developed. From equation (11b), a satisfactory correlation of ΔP^*, T^* and W^* for all temperatures and flow rates takes the form

$$\frac{\Delta P^*}{T^*} = \phi(W^* \, T^{*n}) \qquad (14)$$

where the exponent n is determined to be equal to 0.44. The method used to determine the exponent is detailed in Appendix B. The experimental data is then correlated and analyzed using equation (14), that is $\Delta P^*/T^*$ is plotted as a function of $W^*T^{*.44}$ to yield an eductor's pumping characteristic curve. Variations in geometry will change the appearance of the pumping characteristic curve and facilitate a direct one-to-one comparison of pumping ability between model and prototype. For ease of discussion, $W^*T^{*.44}$ will henceforth be referred to as the pumping coefficient.

III. EXPERIMENTAL APPARATUS

Primary air is supplied to the model by the centrifugal compressor and associated ducting illustrated in Figure 2. The eductor model is located inside the secondary air plenum which facilitates the accurate measurement of the secondary air flow through the use of ASME long radius flow nozzles mounted on the secondary air plenum. An orifice in the inlet duct to the centrifugal compressor permits measurement of primary air flow rates.

A. PRIMARY AIR SYSTEM

The primary air system ducting is constructed of 16-gage steel with 0.635 cm (0.25 inch) thick steel flanges. Assembly of the ducting sections is accomplished using 0.635 cm (0.25 inch) bolts with air drying silicon rubber seals between the flanges of adjacent sections. Entrance to the inlet ducting, shown in Fig. 2, is from the exterior of the building through a 91.44 cm (3.0 ft) square to 30.48 cm (1.0 ft) square reducer (1) each side of which has the curvature of a quarter ellipse. A transition section (2) then changes the 30.48 cm (1.0 ft) square section to a 35.24 cm (13.875 in) diameter circular cross section (3) which runs approximately 9.14 m (30 ft) to the centrifugal compressor inlet. A standard ASME square edged orifice (4) is located 15 diameters down stream of the entrance reducer and 11 diameters up stream of the centrifugal compressor inlet, thus ensuring stabilized flow at both the orifice and centrifugal compressor inlet. Piezometer rings (5) are located one diameter up stream and one-half diameter down stream of the orifice. The duct section just

down stream of the orifice also contains a thermocouple tap (6). The formulae used to calculate the primary and secondary mass flow rates are contained in Appendix C.

A manually operated double sliding plate variable orifice (7) located at the compressor inlet, was designed to constrict the flow symmetrically and facilitate fine control of the primary air flow. It was found that the butterfly valve (9) located at the compressor's discharge provided adequate regulation of primary air flow rates, thus eliminating the necessity of the sliding plate valve for flow regulation.

On the compression discharge side, immediately down stream of the butterfly valve, is a round to square transition (10) followed by two elbows (11) and a straight section of duct (12). All ducting to this point is considered part of the fixed primary air supply system. A transition section (13) is fitted to this last square section which reduces and changes the duct cross section to conform with that of the primary air inlet to the model. The transition is located far enough up stream of the model to ensure that the flow reaching the model is fully developed.

Primary air is induced through this ducting system by a centrifugal compressor (8) rated at 6,000 cfm at 2.5 psi back pressure. The centrifugal compressor is driven by a three-phase, 440 volt, 100 hp motor. Primary air flow is measured by means of a standard ASME square edge orifice designed to the specifications given in the ASME Power Test Code [6]. Type 304 stainless steel plate, 0.635 cm (0.25 inch) thick, is used to make the 17.53 cm (6.902 inch) diameter orifice.

With a duct inside diameter of 35.24 cm (13.875 inch), the corresponding beta ($\beta = \frac{d}{D}$) is 0.497. The primary air flow rate was subject to frequent variations between the extremes of 0.876 kg/sec (1.932 lbm/sec) and 2.573 kg/sec (5.673 lbm/sec) to produce the desired uptake Mach numbers; and since repeated changing of the orifice plate was not desirable, the orifice diameter was chosen to give the best performance over this range in regards to pressure drop and pressure loss across the orifice.

B. SECONDARY AIR PLENUM

The secondary air plenum, pictured in Figure 3, is constructed of 1.905 cm (3/4 inch) plywood and measures 1.22 m x 1.22 m x 2.44 m (4 ft x 4 ft x 8 ft). It serves as an enclosure that completely surrounds the model but allows the model's mixing stacks to protrude through a removable plate placed over the plenum's open end. The purpose of the secondary air plenum is to serve as a boundary through which secondary air induced by the modeled eductor must flow. Long radius ASME flow nozzles designed in accordance with ASME Power Test Code [6] and constructed of fiberglass penetrates the secondary air plenum boundary, thereby providing the sole means for secondary air to reach the eductor. Appendix D outlines the design and construction of the secondary air flow nozzles. By measuring the temperature of the secondary air and its drop in pressure as it flows through the ASME flow nozzles, its mass flow rate is readily obtained. Flexibility is provided this secondary air flow measuring system by the employment of three different flow nozzle sizes: four of 20.32 cm (8 inch) throat

diameter, three of 10.16 cm (4 inch) throat diameter, and three of 5.08 cm (2 inch) throat diameter, various combinations of which produce a wide variety of secondary cross sectional flow areas. Minor adjustments to the model are possible through an access door in the side of the plenum, and the removable end plate makes it possible to change model configurations.

C. INSTRUMENTATION

Pressure instrumentation is provided for measuring gage pressures inside the secondary air plenum, inside the primary air uptake just prior to the model, at various points on the model and across the primary flow orifice. Atmospheric pressure is measured using a mercury barometer. All other pressures are measured with either U-tube water manometers or inclined water manometers with oil of specific gravity 0.834 as the working fluid. A schematic representation of the pressure measurement system for model and secondary air plenum is illustrated in Figure 4. Rapid and frequent monitoring of each of the various pressures was facilitated by the Scanivalve which was used to scan each pressure tap. A multiple valve manifold is then used to link the single output of the Scanivalve to a bank of instruments consisting of 30.48 cm (12 inch), 5.08 cm (2 inch) and 1.27 cm (0.5 inch) inclined water manometers. This permits better matching of the pressure being measured to an instrument of compatible range, thereby improving the degree of accuracy for the lower pressure measurements. Initially a ± 1.0 PSIG pressure transducer coupled with a KAMAN digital display, model number K 3101A23 pictured in Figure 5, was used in conjunction with the Scanivalve. This system was

replaced by the bank of water manometers when it was discovered that the transducer could not measure very low pressures with the desired degree of accuracy. The primary air static pressure just up stream of the model is measured using a 43.18 cm (17 inch) single column water manometer. Figure 6 illustrates the instrumentation for obtaining the data necessary to calculate the primary mass flow rate. A 7.62 cm (3 inch) inclined water manometer is used to measure the static pressure up stream of the orifice, and a 127 cm (50 inch) water U-tube manometer is used to measure the pressure differential across the orifice.

Primary air temperatures at the orifice outlet and just up stream of the model are measured with copper-constantan thermocouples. The thermocouples are in assemblies manufactured by Honeywell under the trade name Megapak. The Megapak consists of a "head" for connecting the extension wires, a "sheath" of 0.318 cm (1/8 inch) stainless steel tubing through which insulated leads pass to the exposed measuring junction at the end of the sheath. Polyvinyl covered 20 gage copper-constantan extension wire is used to connect the thermocouples to a Newport Digital Pyrometer model number 267, pictured in Figure 5, which provides a digital display of the measured temperature in degrees Fahrenheit. Secondary or ambient air temperature is measured with a mercury-glass thermometer and recorded in degrees Fahrenheit.

Velocity profiles at mixing stack exits are obtained using a pitot-static tube mounted so as to facilitate traversing the entire diameter of the mixing stack. Static and stagnation pressure pickups

from the pitot-static tube are connected to opposite ends of a 30.48 cm (12 inch) inclined water manometer which indicates the velocity head in inches of water.

D. MODELS

The multiple nozzle eductor systems studied are designed specifically for service aboard gas turbine powered ships. The specific power plant, for which these eductors are intended, contains two gas turbine engines whose exhaust ducts (uptakes) share a common exhaust trunk within which the uptakes are side-by-side in an athwartships or fore-and-aft arrangement. The exhaust trunk provides a passage for the uptakes from the engine compartment through the ships structure to the eductor located above the ships superstructure.

Three separate eductor configurations are modeled, an existing installation and two proposed configurations. Scale factors for the three configurations were influenced to some extent by availability of modeling materials and consequently differ slightly. Maintaining Mach number similarity in the uptake from prototype to model as well as mixing stack area to primary nozzle area ratios for all three configurations facilitates a direct comparison of performance results of the three configurations when using the experimental data correlation developed in the preceding section.

Time constraints imposed during the course of this investigation precluded the use of a single configuration to determine the effects on eductor performance of all the geometric parameters that were considered. In light of this constraint, the uniqueness of the three

configurations proved to be an asset in that certain of these configurations were more adaptable to some geometric parameter variations than others. Without the non-dimensional experimental data correlation already discussed, a meaningful comparison and analysis of data obtained in this fashion would have been impossible.

Table I contains a summary of key dimensional information pertaining to each configuration while the overall dimensions of the eductor systems are shown in Figures 7, 8, and 9. Once the performance characteristics of a given eductor system had been obtained, the geometry of the configuration was altered, and the resulting effect on eductor performance was noted. Table II relates in matrix form the geometric parameter variations associated with each configuration. Table III summarizes in tabular form the layouts used for positioning the primary nozzles on their respective mounting plates. The five nozzle configuration has its fifth nozzle located at the center of the mounting plate, and for the three nozzle configuration the nozzle centers are located a distance R from the mounting plate center and 120° apart. Materials used in the fabrication of the models consist of copper and aluminum tubing, various types of plastic and PVC tubing and pipe, hardwood and plywood and sheet steel and aluminum. Since material selection was based on dimensional properties rather than material properties, as no adverse temperatures or pressures were encountered, the following discussion will not be concerned with the specific materials used; instead it will address geometric configuration and dimensional proportions only. A detailed description of each of the configurations studied is presented below.

1. Existing Eductor Model

The model of the existing eductor, schematically illustrated in Figure 10, is characterized by the rectangular cross section of its uptake. Located at the discharge of the uptake is the primary air plenum, which serves as a mounting base for the primary flow nozzles. The eccentricity of the primary air plenum with respect to the uptake is necessary to clear structural elements in the prototype. Blockage of the primary nozzles by this eccentricity is illustrated in Figure 11 by the lighter surfaces visible through the primary nozzles. The twelve primary flow nozzles pictured in Figure 12 are mounted on top of the primary air plenum in three clusters of four nozzles each. In each of the eductor configurations, the thickness of the primary nozzles was scaled to approximate that of the full scale prototype. A separate mixing stack of constant cross sectional area is provided for each of the three clusters of nozzles as pictured in Figure 13. Surrounding the eductor system is a low profile enclosure which is open at the top and will be referred to here as the funnel. The eductor system modeled is one of two identical eductor systems located directly athwart-ships from each other and encircled by a common funnel. The second eductor is represented by the dashed lines in Figure 10. Taking advantage of the symmetry of the two adjacent eductor systems, a wall is placed between the two, thus facilitating modeling a single eductor system. Primary air flow, simulating the flow of hot exhaust gases, passes through the uptake, into the primary air plenum and out the primary nozzles. The discharge of the high velocity primary air from the nozzles induces a flow of secondary air which flows down through the open chamber created by the funnel and into the mixing stack where it mixes with the primary

air. The only parameter variation studied in conjunction with the existing eductor was the uptake Mach number which was varied to simulate percentages of full power operation ranging from 50% to 150% in 25% increments.

2. Eductor Proposal A

Eductor Proposal A, schematically illustrated in Figure 14, has many features which distinguish it from the Existing Eductor model. First, the rectangular uptake is replaced with one of circular cross section, and the primary air plenum is eliminated entirely as pictured in Figure 15. Second, a single cluster of primary flow nozzles is mounted directly on the end of the uptake and is served by a single mixing stack of constant circular cross section. Additionally, holes are cut in the funnel sides and covered with screen providing a 30% blockage to simulate the installation of louvers which provide a more direct path for the flow of secondary air into the eductor. The effectiveness of these louvers is demonstrated by a comparison of eductor performances with louvers both open and closed. As illustrated by the dashed lines in Figure 14, a second identical eductor system is within the same funnel enclosure just aft of the system modeled. As with the Existing Eductor model, symmetry has facilitated modeling a single system instead of two.

Uptake Mach number was varied to simulate 50%, 100% and 150% of full power. The effect of the number of primary flow nozzles, as well as their length, on eductor performance was also evaluated using this eductor model. Pictured in Figure 16 are the three, four and five primary nozzle configurations used. The three nozzle configuration was

used to demonstrate the effect of nozzle length on eductor performance. After testing, its individual nozzles were cut to a length equal to that of the four and five nozzle configurations.

3. Eductor Proposal B

Figure 17 schematically illustrates Eductor Proposal B which is similar to Proposal A in that they both have circular uptakes with a single constant area mixing stack. Its funnel, however, has a lower profile and is fitted with large louvered openings, the value of which was demonstrated by tests conducted on Eductor Proposal A. A cover plate, which is pictured in Figure 18, is fitted across the top of the enclosure formed by the funnel to provide lateral support to the mixing stacks. It also creates a small amount of blockage to secondary flow entering through the top of the funnel. Two cover plate designs were considered. The first consisted of a solid plate with oval shaped lightening holes; the second consisted of a truss design. Both are pictured in Figure 19. The advantage of the truss design over the solid plate with lightening holes is its lighter weight and lesser obstruction to secondary flow entering through the top of the funnel. The oval cover plate created a blockage of 75% where the truss design had a blockage of 40% based on the maximum flow area available with no cover plate. In addition, it should be noted that the scantlings located in the plane of the mixing stack entrance create a blockage approximately equal to that of the truss cover plate. In modeling Eductor Proposal B, both eductor systems were included as the shape of the funnel, and stack placement therein did not lend itself to use of symmetry as before. Equal flow rates through the two uptakes is ensured through the use of a splitter in the transition (13), shown in Figure 2, to balance both

the static pressure and the total pressure at the center of each uptake. The number of primary nozzles and the mixing stack area to primary nozzle area ratios were varied during evaluation of the performance of Eductor Proposal B. The separation between the primary nozzle exit plane and the mixing stack entrance plane was varied while maintaining the same relative positioning between the mixing stack and funnel.

IV. EXPERIMENTAL METHOD

Evaluation of an eductor's performance requires determination of the secondary air flow rate as well as the degree of mixing of primary and secondary flows.

The pumping coefficient, $W^* T^{*.44}$, at the eductor's operating point provides the basis for the analysis of parameter variation effects on eductor pumping. Figure 20 graphically illustrates the eductor pumping characteristic curve defined by the experimental data correlation of equation (14). Design of the experimental apparatus facilitates determination of the dimensionless parameters in the experimental correlation with the exception of the secondary flow rate at the operating point. In the prototype, the secondary flow is open to the environment with no restriction other than that imposed by the funnel. Any attempt to equip the model with secondary air flow measurement devices restricts the flow rate and does not yield the dynamically similar flow desired. The technique of determining the pumping coefficient at the operating point is first to establish the pumping characteristics of the eductor system. This is accomplished by varying the secondary air flow rate from zero to its maximum measurable value, using the ASME flow nozzles mounted in the secondary air plenum and recording the temperatures and pressures required to calculate the corresponding dimensionless parameters. The "open to the environment" condition is then simulated by removal of the end plate on the secondary air plenum. Data obtained at this condition determines $\frac{\Delta P^*}{T^*}$ at the operating point and is plotted as a dashed horizontal line on the pumping characteristic plot,

Figure 20. Extrapolation of the characteristic curve to its intersection with this horizontal line locates the operating point of the eductor system under evaluation. The corresponding value of the pumping coefficient, $W^* T^{*.44}$, is obtained by dropping vertically down from the operating point to the horizontal axis.

The momentum correction factor K_m is a measure of the completeness of mixing and provides the basis for evaluating this aspect of eductor performance. The momentum correction factor is evaluated at the exit of the mixing stack by means of two velocity traverses and the definition given in equation (4). Velocity profiles at the mixing stack exit were measured using a pitot-static tube. Since it was impractical to obtain a three-dimensional plot of velocities at the exit plane of the mixing stack, advantage was taken of the symmetry of the velocity surface resulting from the arrangement of the primary nozzles, and only two traverses were made. The first traverse passes directly over the primary nozzles and records the peak velocities while the second traverse passes between the nozzles thus measuring the minimum velocities at the mixing stack exit. An average velocity at the mixing stack exit is obtained by integrating the velocity distribution over the mixing stack area to obtain an integrated volumetric flow rate which, when divided by the mixing stack cross sectional area, yields the average velocity. Appendix E outlines the procedure for calculating the momentum correction factor.

V. DISCUSSION OF EXPERIMENTAL RESULTS

Eductor performance, as defined earlier, considers two things, the amount of secondary air flow induced at a given primary air flow rate, referred to here as pumping, and the degree of mixing of primary and secondary flows within the mixing stack. The eductor systems studied are employed to cool gas turbine exhaust gases through mixing with cooler ambient air, thereby minimizing the danger of overheating mast mounted electronic gear by direct impingement of hot exhaust gases. Maximum pumping is desirable as this lowers the ultimate minimum uniform mixing stack exit temperature obtainable. How closely this minimum is approached is determined by the extent of mixing which occurs within the mixing stack. It is clear, therefore, that an evaluation of the performance of an eductor must consider both its pumping ability and the extent of mixing produced. Data obtained from model tests provides the means of evaluating eductor pumping and mixing as affected by variation of the previously discussed parameters. The approach taken here is to analyze the effect of specific parameters individually on both pumping and mixing; from the results of these analyses, the effect of a specific parameter on total eductor performance is evaluated. Results of the individual analyses are summarized in Table IV.

Values of the pumping coefficient corresponding to an eductor's operating point obtained from plots of experimental data using the correlation

$$\frac{\Delta P^*}{T^*} = \phi(W^* \, T^{*.44})$$

provide the basis for the analysis of parametric variation effects on pumping. Tabulated values of the pumping coefficient for the configurations tested are included in Tables V, VI and VII. Even though W_s is proportional to $W^* T^{*.44}$, it is important to remember that this analysis is based on the non-dimensional parameter $W^* T^{*.44}$ and not on the actual secondary air flow rate, W_s.

By definition, the performance of a given eductor is dependent on the completeness of mixing of the primary and secondary air streams as well as on pumping. Since the momentum correction factor K_m is a measure of the completeness of mixing and is affected to varying extents by the parameters considered here, it provides the basis for evaluating this aspect of eductor performance. Obviously, the closer the momentum correction factor is to unity, the more complete the mixing of the two air streams and the more effective the eductor. Momentum correction factors for the configurations tested are tabulated in Tables V, VI, and VIII. For reference purposes, Tables V, VI, VII and VIII also contain the figure or table numbers from which the parameter values were obtained.

In preparing the performance plots, $\Delta P^*/T^*$ versus $W^*T^{*.44}$, a slight amount of data scatter is encountered as the eductor's operating point is approached. This scatter is attributed to the difficulty in measuring the very small pressure differentials, on the order of 0.254 cm (0.10 inch) of water and less, required for calculation of these last few data points. Consequently, slightly lesser importance was given these scattered points when determining the characteristic curve used in locating an eductor's operating point.

The uncertainties in the pumping coefficient (±1.4%) and the pressure coefficient (±1.9%) are calculated in Appendix F. For some of the

parameter variations to be discussed, changes in the pumping coefficient are within its uncertainty bounds. Caution should therefore be exercised when using these changes for purposes other than to indicate a trend. An uncertainty analysis of the momentum correction factor was not attempted because of the approximations inherent in its development. It is recognized that the uncertainty in the momentum correction factor is likely to exceed its changes; such changes are used, therefore, as indications of trends only.

To minimize repetition of information on the performance curves and velocity profiles, only variations from the model's basic configuration will be noted thereon. Also identified on the plots are the corresponding tables of data from which the plots were prepared. The two circular symbols appearing on the velocity profiles indicate the orientation of the velocity traverses. The set of variables applicable to each model which comprises its basic configuration is listed below.

Existing Eductor,	
uptake Mach number	0.062
Eductor Proposal A,	
uptake Mach number	0.062
number of primary nozzles	4
primary nozzle length	scaled length (short)
louvers	open
Eductor Proposal B,	
uptake Mach number	0.069
number of primary nozzles	4
nozzle-mixing stack separation	0.71"
mixing stack area to primary nozzle area ratio	3.033

Figures illustrating eductor performance characteristic curves and velocity profiles and tables of experimental data associated with each are grouped by eductor model. Figures 21 and 22 pertain to the Existing Eductor model, Figures 23 through 28 apply to Eductor Proposal A and Figures 29 through 37 apply to Eductor Proposal B. Experimental data for the Existing Eductor is listed in Tables IX and X, for Eductor Proposal A in Tables XI and XII, and for Eductor Proposal B in Tables XIII through XX. In the interest of completeness, all characteristic curves, velocity profiles and experimental data obtained during this investigation are included herein. Illustration of some parameter effects on eductor performance is duplicated because of the use of three different eductor models on which similar tests were conducted.

The following discussion addresses the individual parameteric variations and their effects on eductor performance and in so doing references results of tests on each of the three individual eductor models. Since this discussion does not proceed by eductor model and because of the duplication mentioned earlier, each figure and table is not referenced specifically.

A. UPTAKE MACH NUMBER

Primary air flow used in the model tests represents the exhaust gases from the gas turbine engine in the prototype installation. An uptake Mach number of approximately 0.062 corresponds to a primary air mass flow rate of 1.725 kg/sec (3.803 lbm/sec) and represents full power operation of the prototype. The effect of uptake Mach number on eductor performance is evaluated by varying the uptake Mach number from 0.030 to 0.090.

Tests of the Existing Eductor and of the four nozzle configurations of Eductor Proposals A and B indicated that the uptake Mach number has no effect on the pumping coefficient. Any correlation based on tests of the five nozzle configuration of Eductor Proposal A is inconclusive because of the absence of a consistent trend in the pumping coefficient over the range of uptake Mach numbers tested. Comparison of pumping coefficients at eductor operating points as a function of uptake Mach number for the three eductor configurations reveals a very slight and inconsistent variation of the pumping coefficient with uptake Mach number. It is therefore concluded that the pumping ability of an eductor, as represented by its pumping coefficient, is not affected by the uptake Mach number over the range of Mach numbers tested. This independence of uptake Mach number is demonstrated graphically in Figures 21 and 26 by the fact that the pumping characteristic curves for the various uptake Mach numbers all terminate at virtually the same eductor operating point.

The effect of uptake Mach number on mixing is evaluated based on tests of the Existing Eductor and Eductor Proposal B. The decreasing values of the momentum correction factors listed in Tables V and VIII indicate an improvement in mixing corresponding to increases in uptake Mach number. The slight variation of the normalized velocity profiles for various uptake Mach numbers, as plotted in Figures 22 and 35 graphically illustrate this trend. Despite this consistent trend, however, the actual change in the momentum correction factor is less than 1.0%, and it is therefore concluded that the completeness of mixing for a given eductor is essentially independent of uptake Mach number.

It should be noted here that at the outset of this investigation no modifications to the eductor system modeled by the Existing Eductor configuration were being considered. This, coupled with the desire to develop and test a lighter weight eductor whose performance was at least as good as the existing prototype, precluded the Existing Eductor configuration from any further parameter variations. At this point in the study, all effort was directed toward the evaluation of Eductor Proposals A and B.

B. NUMBER OF PRIMARY NOZZLES

During evaluation of the effect of the number of primary nozzles on eductor performance, the mixing stack area to primary nozzle area ratio was maintained as close to 3.0 as possible. Tests using the basic configurations of Eductor Proposals A and B provide the basis for evaluation of the effects of the number of primary nozzles on eductor performance. Comparison of the pumping coefficients listed in Tables VI and VII reveals a positive correlation between pumping coefficient and the number of primary nozzles. An increase in the number of primary nozzles from three to four and from four to five in Eductor Proposal A produces an increase in the pumping coefficient of approximately 2.5% for each case. A 6% increase in the pumping coefficient is obtained when Eductor Proposal B is changed from a four to a five nozzle configuration. This trend is also present for the four and five nozzle configurations of Eductor Proposal A with uptake Mach numbers other than 0.062. The decrease in slope of the characteristic curves in Figures 23 and 32 corresponding to an increase

in the number of primary nozzles graphically illustrates the positive correlation between the pumping coefficient and the number of primary nozzles.

Since different numbers of primary flow nozzles produce entirely different velocity profiles at the mixing stack exit, a comparison of velocity profiles for this parametric variable is impractical. A definite correlation between the number of primary nozzles and the completeness of mixing of primary and secondary air streams is observed, however, when values of the momentum correction factors listed in Tables VI and VIII are compared. The decrease in momentum correction factor corresponding to an increase in the number of primary flow nozzles from four to five for Eductor Proposals A and B is 1.5% and 1.0% respectively. A much more significant decrease of 7.0% in the momentum correction factor is realized when Eductor Proposal A is changed from the three nozzle to a four nozzle configuration. Therefore, even though the momentum correction factor tends to decrease with increasing number of primary nozzles within the range considered here, there is little improvement in mixing beyond that obtained by increasing the number of primary nozzles from three to four.

It can be concluded from the foregoing that the overall performance of an eductor can be improved to varying extent by increasing the number of primary nozzles. The maximum incremental improvement in performance, over the range of numbers of primary nozzles tested, is realized in going from three nozzles to four.

C. PRIMARY NOZZLE LENGTH

The only primary nozzle length variation attempted was with the three nozzle configuration of Eductor Proposal A. Two nozzle lengths were tested; the short nozzle length corresponds to the length found in the prototype modeled by the Existing Eductor and is the length used for all other nozzles tested in this study. The long nozzle length is twice that of the short nozzle. The separation between the primary nozzle exit and mixing stack entrance was maintained at 1.8 cm (0.71 inch) for the long nozzle case by decreasing the uptake penetration through the base of the funnel.

A comparison of the pumping coefficients in Table VI shows a 3.5% decrease in the pumping coefficient when the primary flow nozzles are doubled in length. This change in performance is illustrated by the separation of operating points for the two different nozzle lengths plotted in Figure 25. The momentum correction factors listed in Table VI decrease with increased nozzle length, thus indicating an improvement in mixing for the longer nozzles. Based on the momentum correction factors, the improvement in mixing is relatively small 1.5%. As expected there is little distinction between the normalized velocity profiles for the two cases plotted in Figure 27.

In summary, a slight improvement in mixing is achieved by doubling the primary nozzle length but not without a significant decrease in the pumping coefficient. Caution should be exercised when attempting to apply these results to other than the three nozzle configuration tested as insufficient data was taken to generalize these results to other geometries.

D. PRIMARY NOZZLE TO MIXING STACK SEPARATION

Separation is the distance between the exit plane of the primary nozzles and the entrance plane of the mixing stack. Three separations were tested, 0.7 cm (0.28 inch), 1.8 cm (0.71 inch) and 3.56 cm (1.40 inch) where a separation of 1.8 cm (0.71 inch) corresponds to that presently used on the existing prototype. The four and five nozzle configurations of Eductor Proposal B with an uptake Mach number of 0.069 are used to evaluate the effects of separation on eductor performance.

Comparison of $W^* T^{*.44}$ values listed in Table VII shows an increase in the pumping coefficient corresponding to an increase in separation. Over the total range of separations tested, there is a 1.6% increase in the pumping coefficient for the four nozzle case and a 3.0% increase for the five nozzle case. This correlation is illustrated in Figure 29 by the fact that a distinct operating point exists for each value of separation. It is concluded that an increase in the separation between the primary nozzle exit plane and the mixing stack entrance plane, within the range tested, results in a slight improvement in the pumping coefficient.

The momentum correction factors for this evaluation are listed in Table VIII. As the separation is increased from 0.7 cm (0.28 inch) to 1.8 cm (0.71 inch) and from 1.8 cm (0.71 inch) to 3.56 cm (1.40 inch), the momentum correction factor increases by approximately 1% for each increment thus indicating a trend of decreased mixing with increased separation. This trend is illustrated by the deviations between the normalized velocity profiles for the three different separations which are plotted in Figure 34.

E. SECONDARY FLOW RESTRICTION

A closer look at the operation of an eductor will facilitate a better understanding of the effect on eductor performance of louvered openings in the funnel sides. The high velocity primary air exiting from the primary nozzles induces a flow of secondary or ambient air into the funnel where it enters the mixing stack and mixes with the primary air. Any restriction in the secondary flow created by the funnel or structural supports causes the secondary air pressure to decrease below atmospheric as it enters the funnel. This decrease in secondary air pressure reduces the potential pumping head of the eductor. Any means whereby the restriction to secondary air flow can be reduced should therefore increase the pumping ability of the eductor, other parameters remaining constant.

Eductor Proposal A is used to evaluate one means of reducing the restriction to secondary flow; i.e., placing openings in the funnel sides adjacent to the primary nozzle discharge and mixing stack entrance. The location of these openings is illustrated and pictured in Figures 8 and 15. The presence of actual louvers in a prototype installation is simulated by placing one layer of screen providing a 30% blockage over the openings in the funnel sides. This corresponds to the open louver condition referred to elsewhere in this study. For the closed louver condition, the screens are removed, and the openings through the funnel sides are blocked completely.

The values of the pumping coefficient listed in Table VI show a 10% increase for the open louver case over the closed louver case for each of the three, four, and five nozzle configurations. As

illustrated in Figure 24, this improvement in performance is attributable more to a much lower value of $\Delta P^*/T^*$ at the operating point than it is to a change in the form of the performance curve. This is as expected since ΔP^* contains the term $P_a - P_o$ where P_a is atmospheric pressure and P_o is the pressure of the secondary air available to the eductor. As the resistance to secondary air flow reduces, its pressure increases toward atmospheric thus driving ΔP^* closer to zero. By the methods described in Section IV for locating the operating point of an eductor, this reduction in ΔP^* results in an increase in the pumping coefficient. The influence of louvered openings on the pumping coefficient is further demonstrated by tests of Eductor Proposal B where the screens are removed from the openings in its funnel sides thereby increasing the opening area by approximately 50%. For the four nozzle case, removing the screen from the openings increases the pumping coefficient by 1.5%; a similar increase is obtained for the five nozzle case.

A further demonstration of the sensitivity of the pumping coefficient to secondary air flow restriction is possible by changing the design of the cover plate installed on Eductor Proposal B and pictured in Figure 19. Since secondary air also passes through this cover plate into the funnel, reducing its blockage should improve the pumping characteristics of the eductor. When the oval cover plate which creates a blockage of 75% of the otherwise available flow area is replaced with the truss design having a blockage of approximately 40%, the pumping coefficient of the five nozzle eductor is increased by 1.5%. A slightly smaller increase in the pumping coefficient results with the same variation for the four nozzle case. The effect of varying the cover

plate design on pumping performance is illustrated in Figure 31. It should be noted here that no further improvement in pumping was noted when the truss design cover plate was removed entirely. This is because the blockage to secondary flow through the top of the funnel provided by the mixing stack supports in the plane of the mixing stack entrance is approximately equal to that provided by the truss design. Based on the maximum opening available through the top of the funnel, as determined now by the scantlings, the recalculated blockage presented by the oval cover plate becomes 51%.

It has been demonstrated that any reduction in the restriction to secondary air flow increases the pumping coefficient. Installation of louvered openings in the funnel sides is the most practical means of reducing this restriction.

Not as conclusive, however, is the effect of reduced secondary flow restriction on mixing. This is demonstrated by the momentum correction factors for Eductor Proposal A listed in Table VI. For the three (short) nozzle and four nozzle configuration, the open louver case has a higher value of K_m as compared to the closed louver case which indicates poorer mixing. For the three (long) nozzle configuration the opposite trend exists where the five nozzle configuration shows no change at all in the momentum correction factor. Since the tests conducted here show no consistent relationship between the restriction to secondary flow and the degree of mixing, no correlation between the two is established.

F. MIXING STACK AREA TO PRIMARY NOZZLE AREA RATIO

Eductor Proposal B provides the basic eductor geometry for evaluating the effect of mixing stack area to total primary nozzle area ratio on eductor performance. Variation of the area ratio was accomplished by

varying the total primary nozzle cross section area A_p while holding the mixing stack cross sectional area A_m constant. A decrease in the area ratio therefore corresponds to an increase in the diameter of the individual primary nozzles. A total of three area ratios was tested. The area ratio of 3.033 corresponds to that of the Existing Prototype installation and was maintained throughout all previous tests on all three models. An area ratio of 2.283 was tested to evaluate the effect on performance of an area ratio that would produce a primary nozzle exit velocity of 45.72 m/sec (150 ft/sec), the threshold for excessive noise generation. To establish a better correlation between area ratio and performance an area ratio of 2.639 was also tested.

The substantial change in the pumping coefficient for a given eductor configuration due to a change in its area ratio is vividly illustrated in Figure 33 by the very large changes in slope of respective performance curves. Over the range of area ratios tested, a 35% reduction in area ratio decreases the pumping coefficient by approximately 33%. This indicates that the pumping coefficient has a greater dependence on the mixing stack to primary nozzle area ratio, over the range of area ratios tested, than on any one or combination of other parameters studied. This observation supports the data of Reference 2 in which the area ratio was varied not only by changing A_p, as was done here, but also by varying the mixing stack cross sectional area A_m.

Operating point pumping coefficients versus respective area ratios are plotted in Figure 38. For an eductor of given geometric configuration, this curve indicates the existence of a maximum value of the pumping coefficient as the area ratio is increased. Extrapolation of the

resulting curve indicates that relatively little additional increase in the pumping coefficient can be expected solely from increasing the area ratio beyond 3.03.

Comparison of the momentum correction factors listed in Table VIII indicates a slight increase in mixing accompanying an increase in area ratio. This trend can also be observed from the normalized velocity profiles in Figure 36. In summary, variation of the mixing stack cross sectional area to total primary nozzle cross sectional area ratio has a relatively small effect on the degree of mixing but virtually dominates eductor performance in regards to its pumping capability. There also appears to be a limit to the pumping coefficient obtainable solely through an increase in area ratio.

G. UPTAKE PRESSURE

The uptake pressure influences eductor performance through its direct association with the uptake Mach number, i.e. a given Mach number corresponds to a given primary flow rate which in turn has associated with it a given uptake pressure. Excessive uptake pressures have a significant impact on the gas turbine operating efficiency and for this reason must be taken into consideration during the design of an eductor system.

A brief survey of the tabulated data for Eductor Proposal B reveals that the experimentally determined uptake pressure is very dependent on the uptake area to primary nozzle area ratio. Figure 39 presents a graphical comparison of the experimental values of uptake pressure with their corresponding idealized values as a function of this area ratio for two different uptake Mach numbers. The idealized uptake pressure

is calculated using the actual uptake Mach number, the primary nozzle area to uptake area ratio and the gas tables in Reference 5. Details of this calculation are included in Appendix G. For this calculation, the ratio of specific heats is taken as 1.4. Inherent in the use of the gas tables are the assumptions of uniform velocity profiles throughout the flow and the absence of losses across the primary nozzles. Since losses do occur in the model and prototype, the experimental values of uptake pressure are slightly higher than the ideal values. Recall that Mach number similarity is used in determining model primary flow rates which correspond to prototype exhaust gas flow rates. A family of curves covering a range of uptake Mach numbers can therefore be developed and plotted as in Figure 39 and used to estimate the uptake pressure for a prototype installation.

VI. CONCLUSIONS

The intent of this investigation was to obtain data relating the performance and geometry of multiple nozzle eductors over a region of feasible geometric parameter variations. Trends of interdependency between eductor geometry and performance were discussed in detail in section V; the resulting conclusions are summarized here.

A. Effects of uptake Mach number on the pumping coefficient and the momentum correction factor are very small and inconsistent. It is concluded therefore that the pumping coefficient and degree of mixing between primary and secondary flows are virtually independent of the uptake Mach number over the range tested.

B. A definite improvement in eductor performance is obtained by increasing the number of primary nozzles from three to five. The most significant increase, however, in both pumping and mixing is realized in going from a three to a four nozzle configuration. Because of the added complexity of the five nozzle configuration with its lesser increment of improvement in performance, the four nozzle configuration is considered most desirable.

C. A slight improvement in mixing is obtained by doubling the length of the primary nozzles, but a significant decrease in the pumping coefficient also results.

D. An increase in the primary nozzle exit plane to mixing stack entrance plane separation produces a slight increase in the pumping coefficient and a slight decrease in the completeness of mixing.

E. An increase in louver area reduces the restriction to secondary air flow into the eductor and greatly increases the pumping coefficient but has no significant influence on the completeness of mixing.

F. Of all the geometric parameters considered, the mixing stack area to primary nozzle area ratio has the most significant effect on the pumping coefficient. Increasing the area ratio greatly increases the pumping coefficient but only slightly increases the degree of mixing. Figure 38 indicates the existence of a limit to the pumping coefficient obtainable solely by increasing this area ratio. Considering the severe penalty back pressure has on gas turbine performance, the pumping coefficient corresponding to an area ratio of 3.03 is very close to that limit.

VII. RECOMMENDATIONS

In addition to the insight this project has given into the relationship between eductor geometry and performance, it also has generated an awareness of this investigation's shortcomings. Presented herein are recommendations for improving upon and furthering a productive investigation into the performance of multiple nozzle eductor systems.

A. Variation of the geometric parameters was limited by the restrictions inherent in the configuration of the eductors tested. Cold flow tests using a simpler configuration, e.g., without the complicated funnel, would be more adaptable to changes in geometry and would provide data of a more general nature which would have wider applicability.

B. Although the similarity of momentum and energy mixing phenomena exists, it is not sufficient to predict the effect of the magnitude of the flow temperatures on eductor performance. An experimental facility which independently can vary the primary flow temperature would provide data for correlating the effect of the exhaust gas temperature. Such a facility probably would not have the flexibility to handle as large a variety of geometries as would the simple cold flow facility.

C. Data points for the pumping characteristic curve show a tendency to tail off to the right as the operating point is approached. It is probable that this is attributable to the difficulty in measuring

the secondary flow rate near the operating point where the pressure differential across the long radius flow nozzles is very low. To determine if this is the case, throat-mounted pressure taps should be used to measure this pressure differential rather than a single tap located inside the secondary air plenum as was used here.

D. In the one-dimensional analysis of a simple eductor developed in Section II, the primary nozzle exit and mixing stack entrance are in the same plane and the static pressure at this station is taken to be the same for both the secondary and primary flows. In the actual model tests the pressure tap is located in the plane of the mixing stack entrance which is a variable distance away from the plane of the primary nozzle exit. An investigation of the flow in this vicinity should facilitate a more suitable location of the pressure tap.

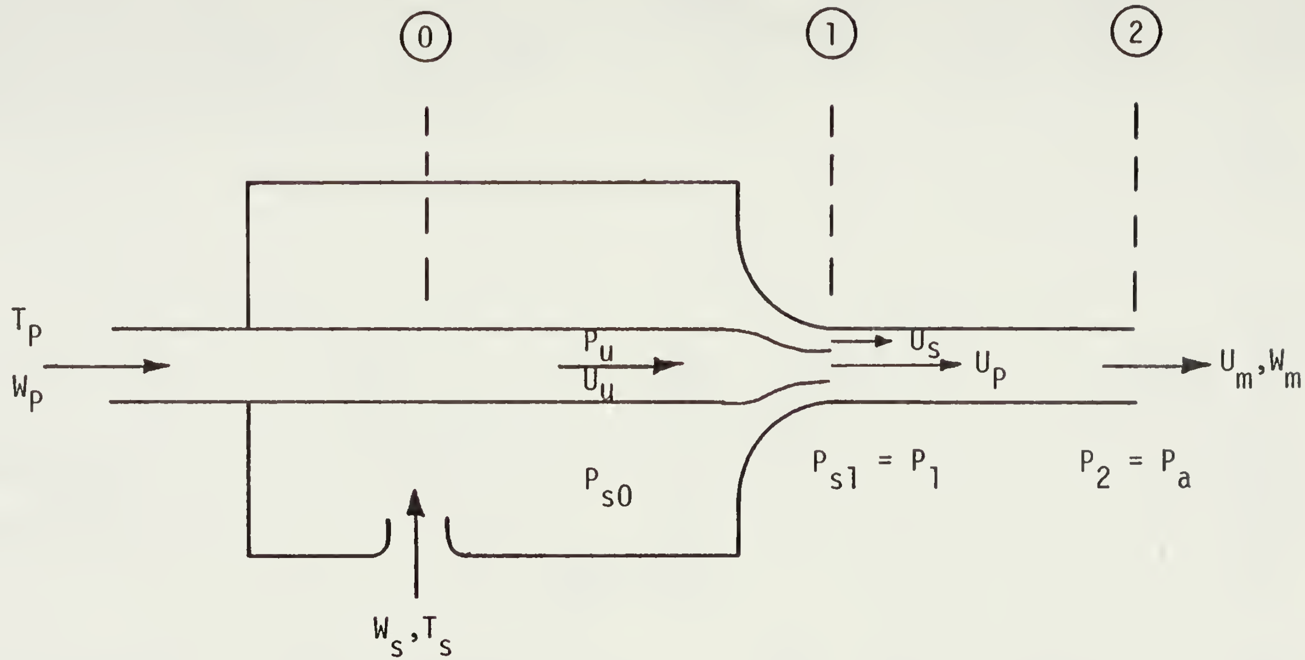
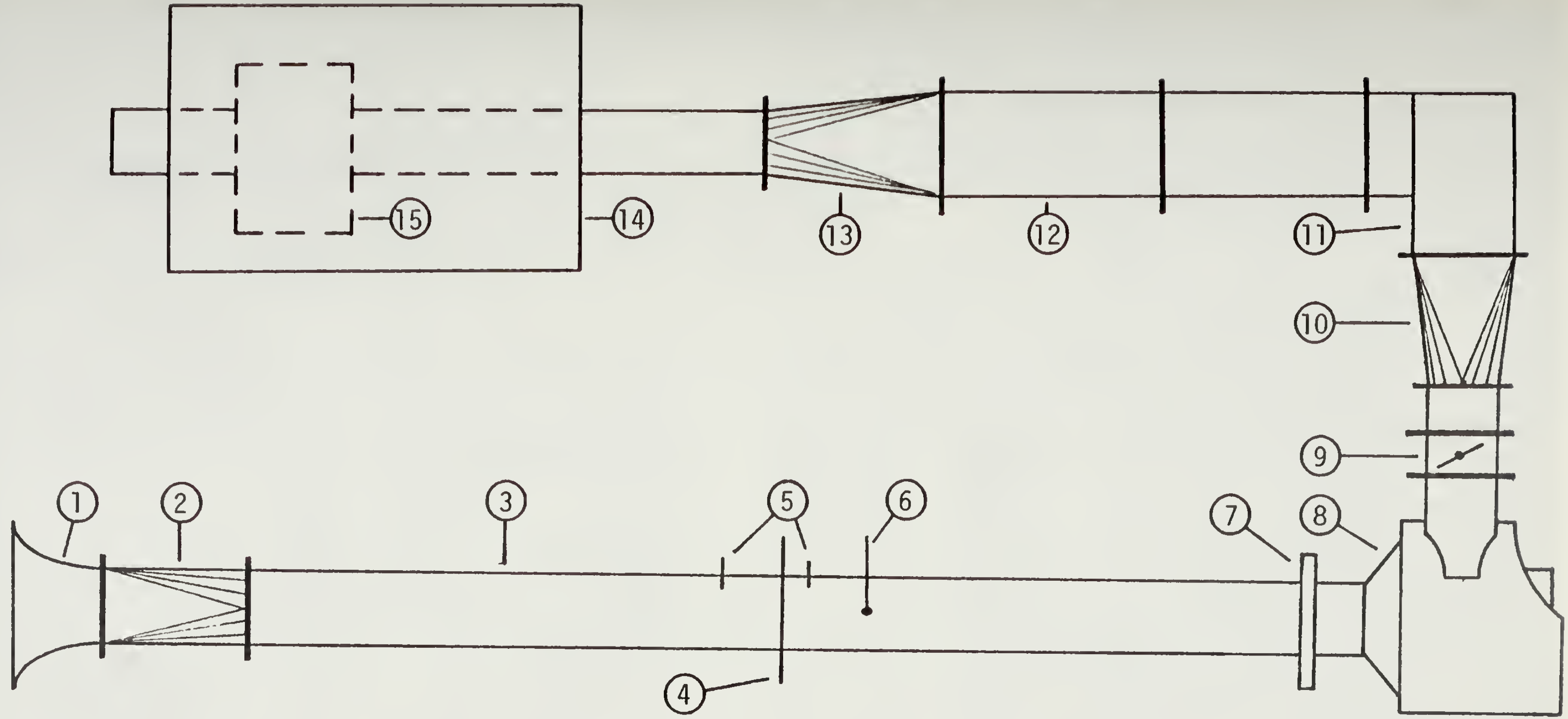


FIGURE 1. Simple Single Nozzle Eductor System.



1 Entrance Reducer
2 Transition
3 Circular Duct
4 Orifice Plate
5 Piezometer Ring
6 Thermocouple
7 Variable Orifice
8 Compressor
9 Butterfly Valve
10 Transition
11 Elbows
12 Square Duct
13 Transition
14 Secondary Air Plenum
15 Eductor Model

FIGURE 2. Eductor Test Facility.

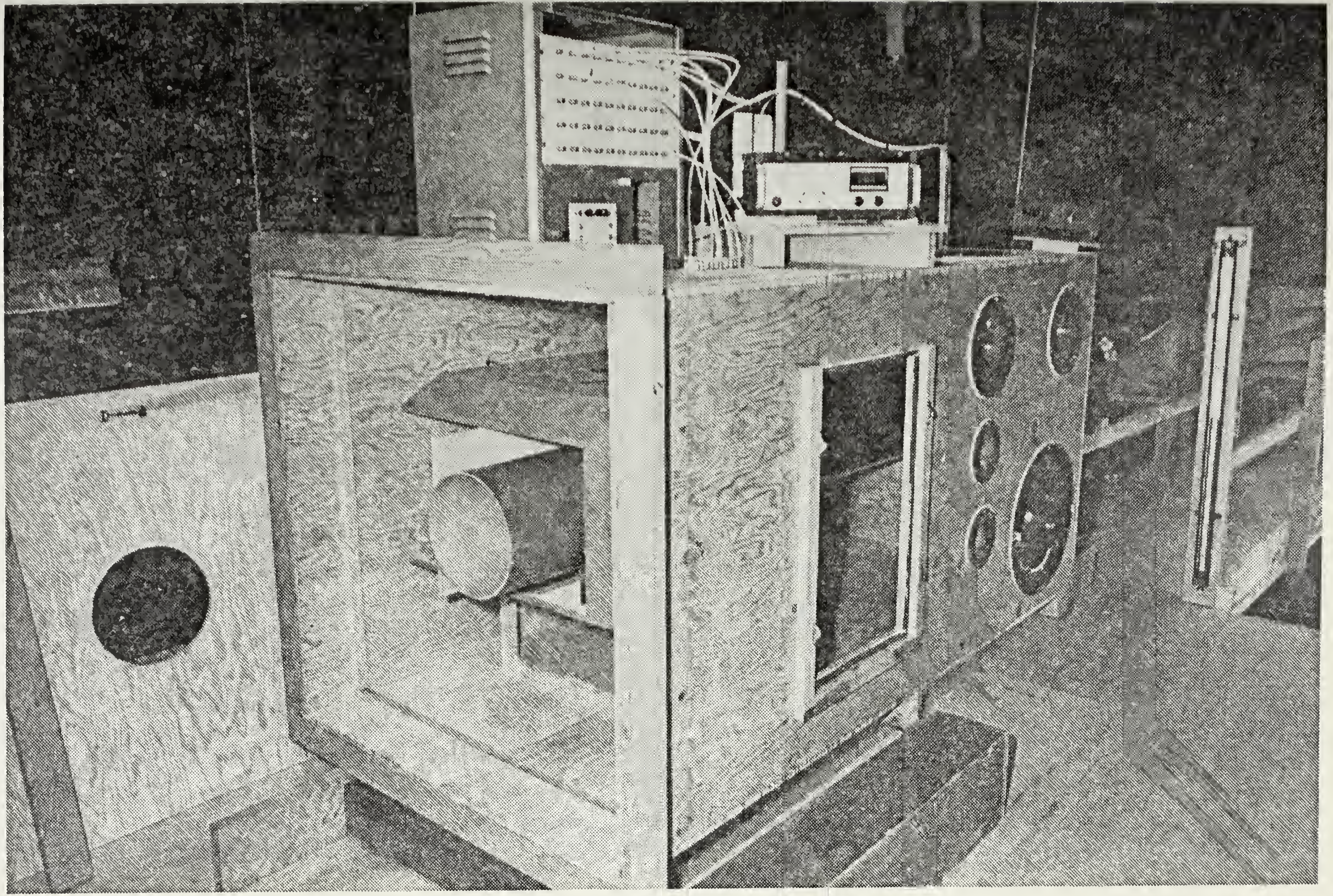


FIGURE 3. Secondary Air Plenum.

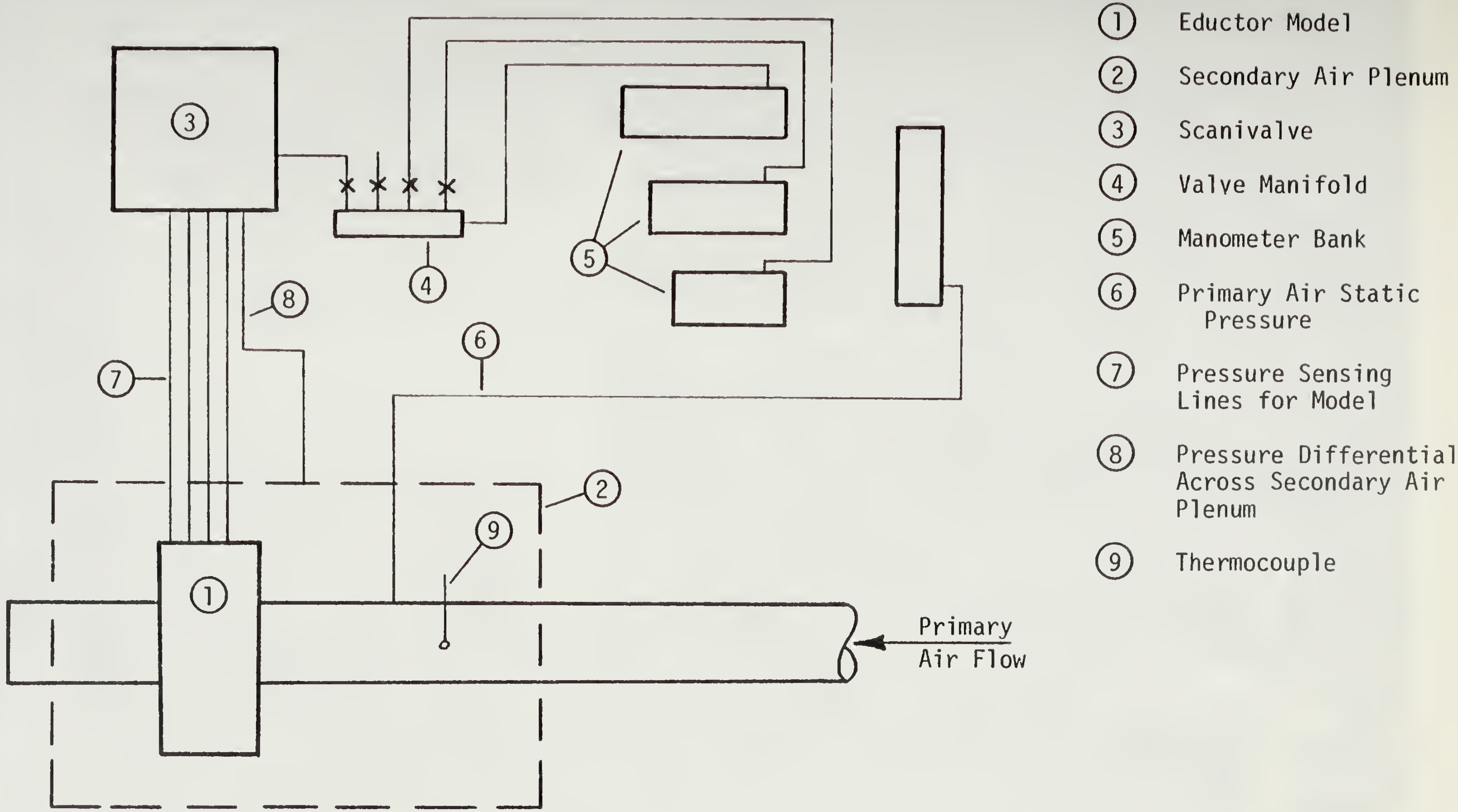


FIGURE 4. Schematic of Instrumentation Hookup for Model and Secondary Air Plenum.

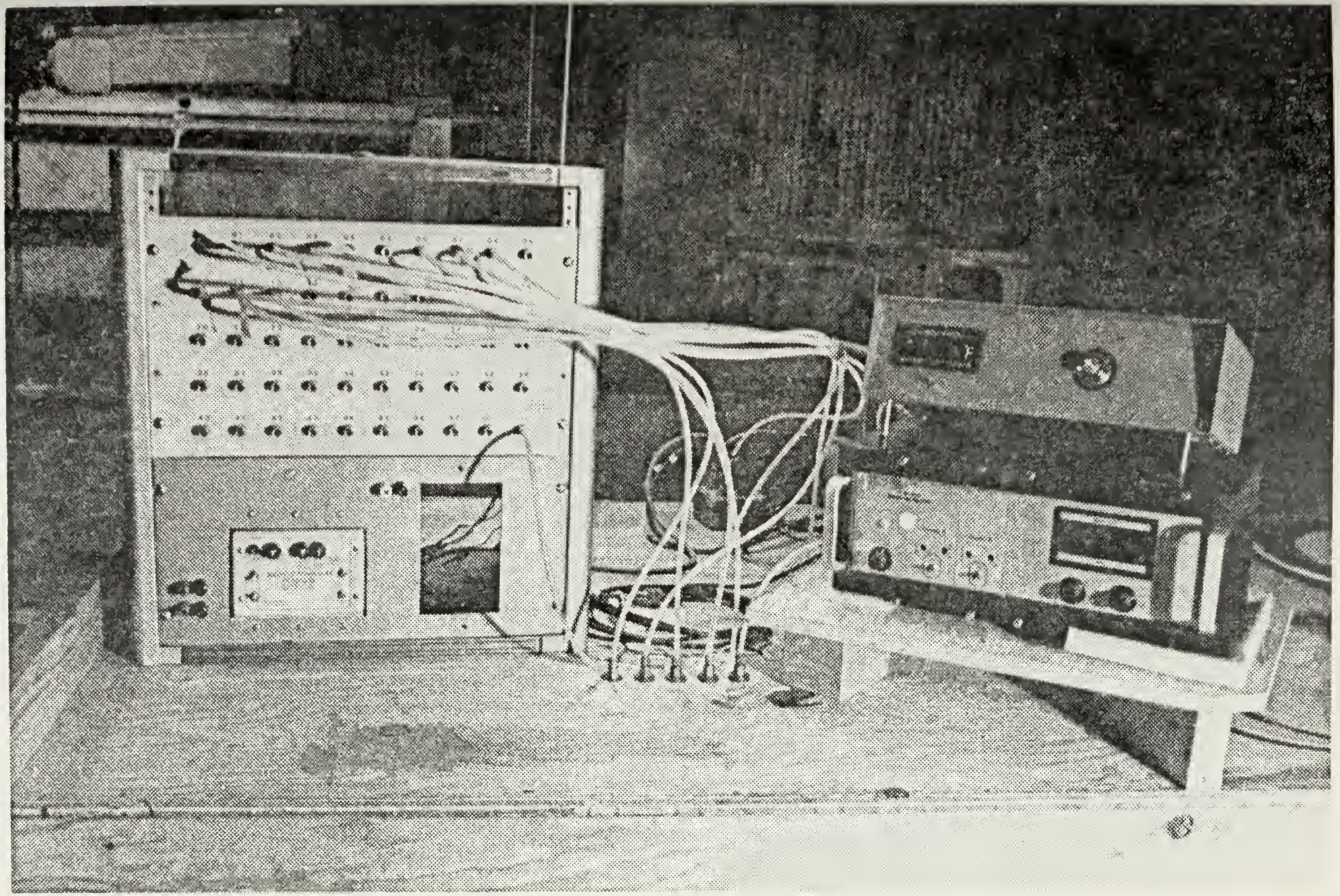


FIGURE 5. Instrumentation for Model and Secondary Air Plenum.

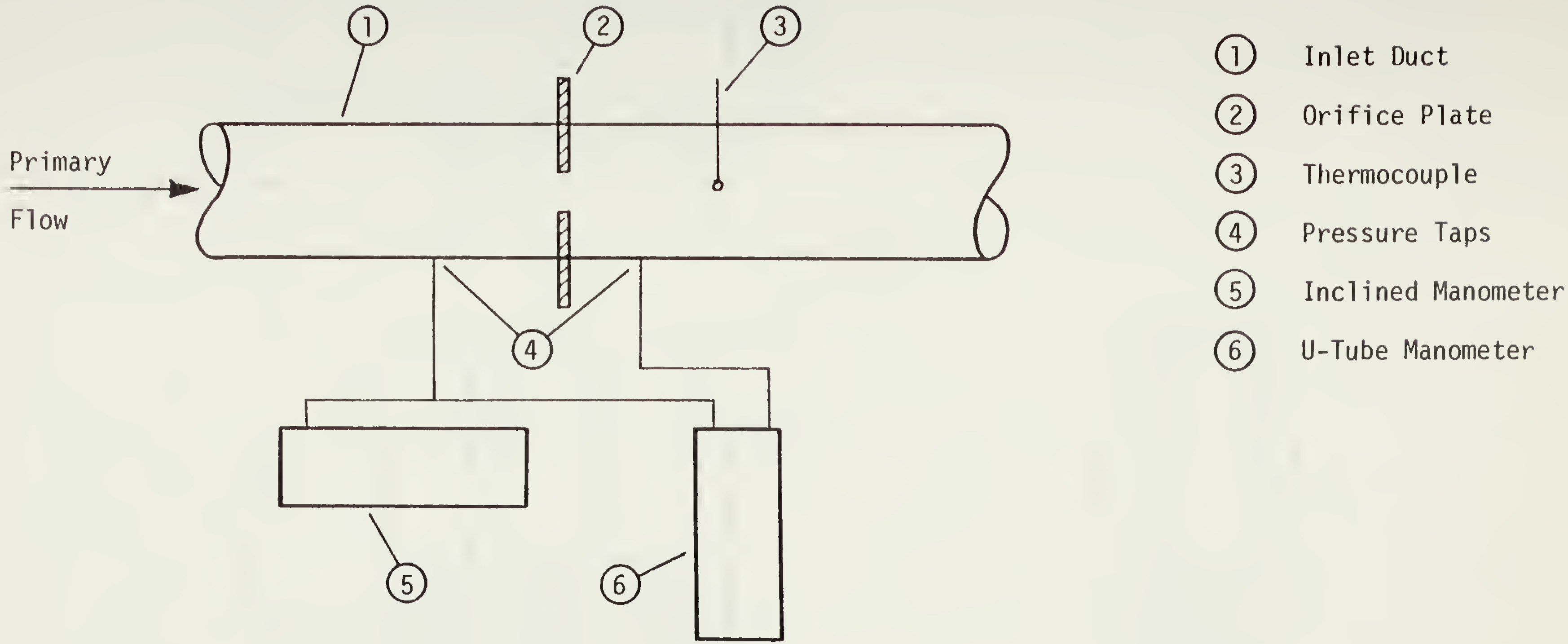


FIGURE 6. Schematic of Instrumentation Hookup for Primary Air Flow Measurement.

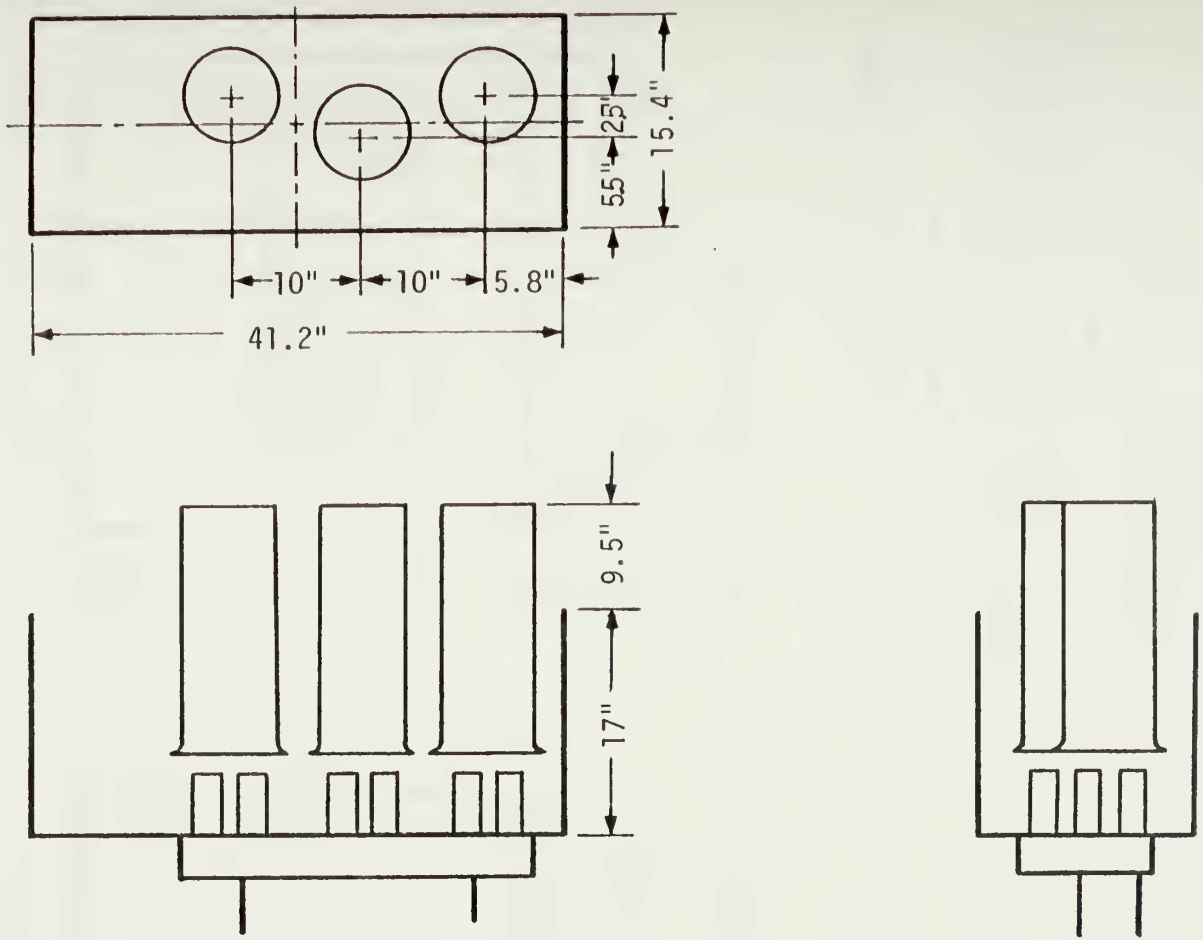


FIGURE 7. Overall Dimensions of the Existing Eductor.

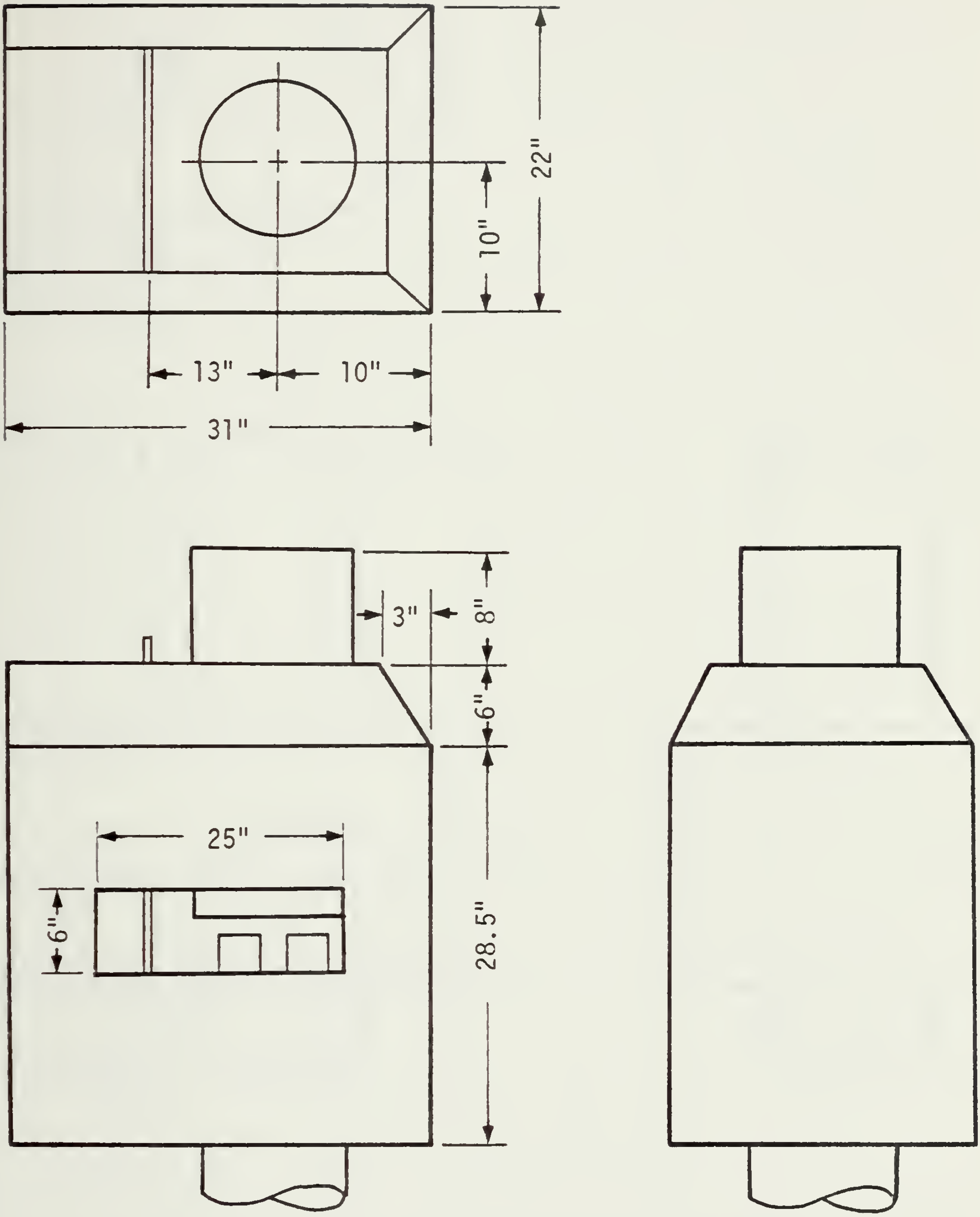


FIGURE 8. Overall Dimensions of Eductor Proposal A.

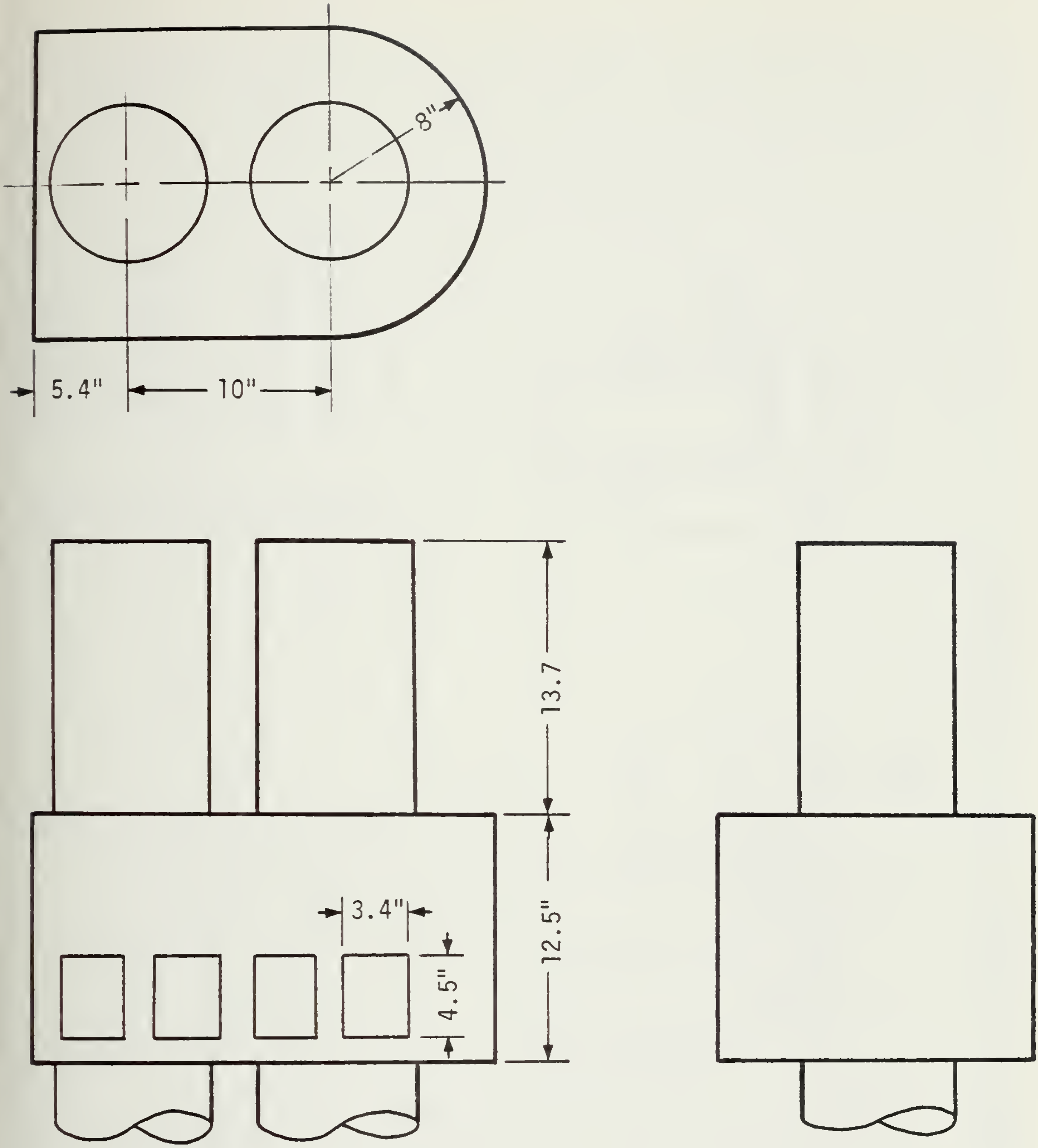


FIGURE 9. Overall Dimensions of Eductor Proposal B.

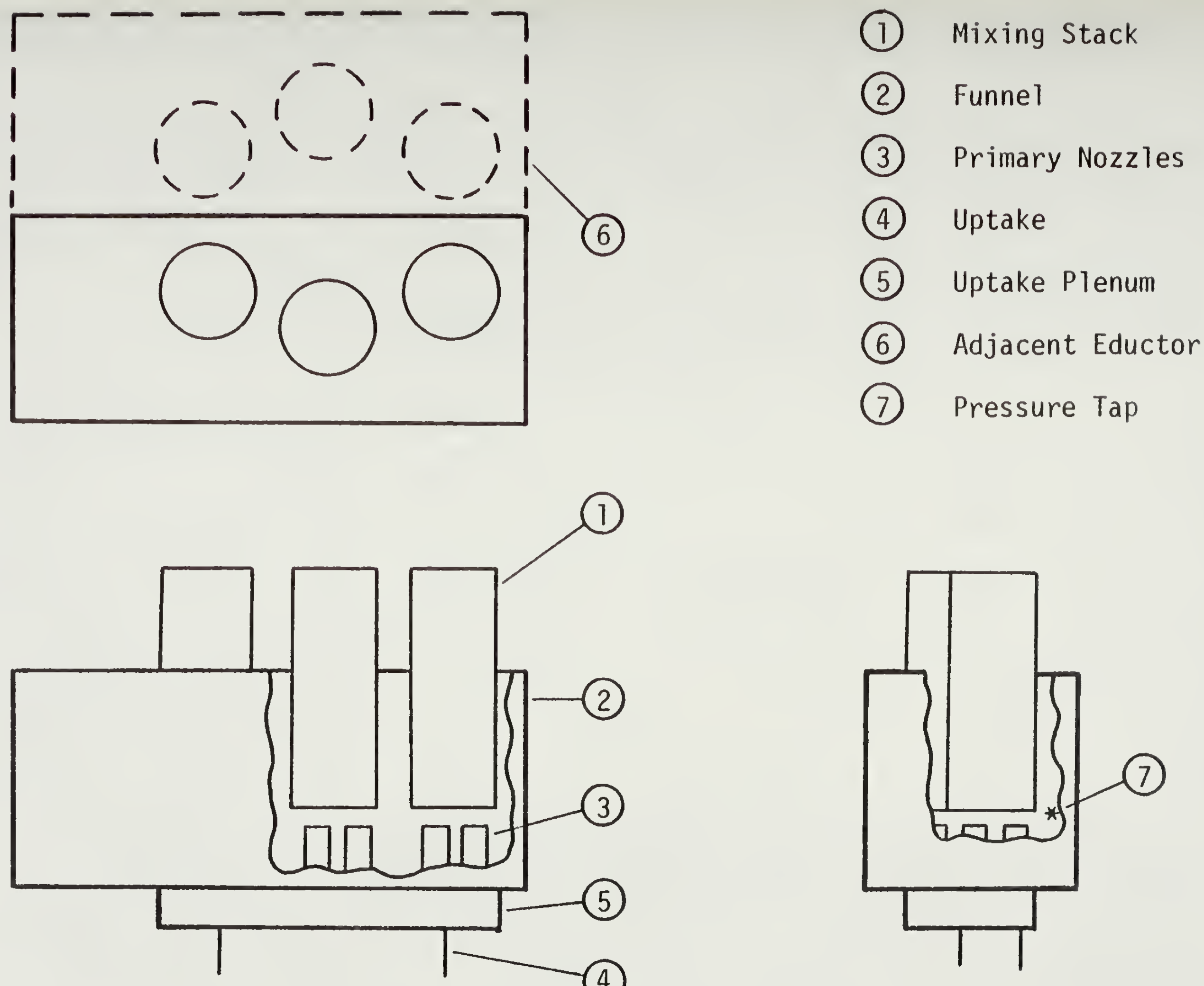


FIGURE 10. Schematic of the Existing Eductor.

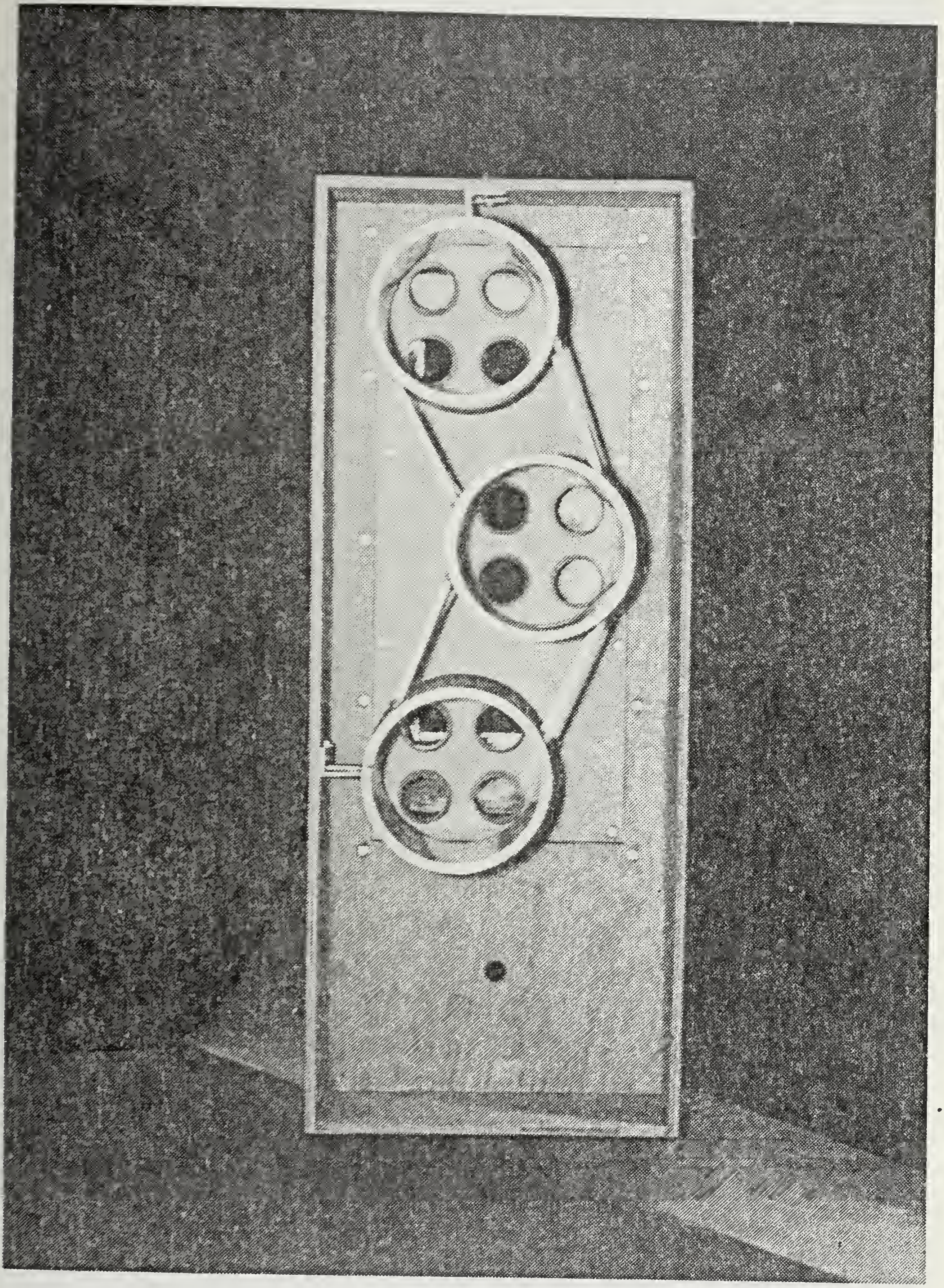


FIGURE 11. Plan View of Existing Eductor.

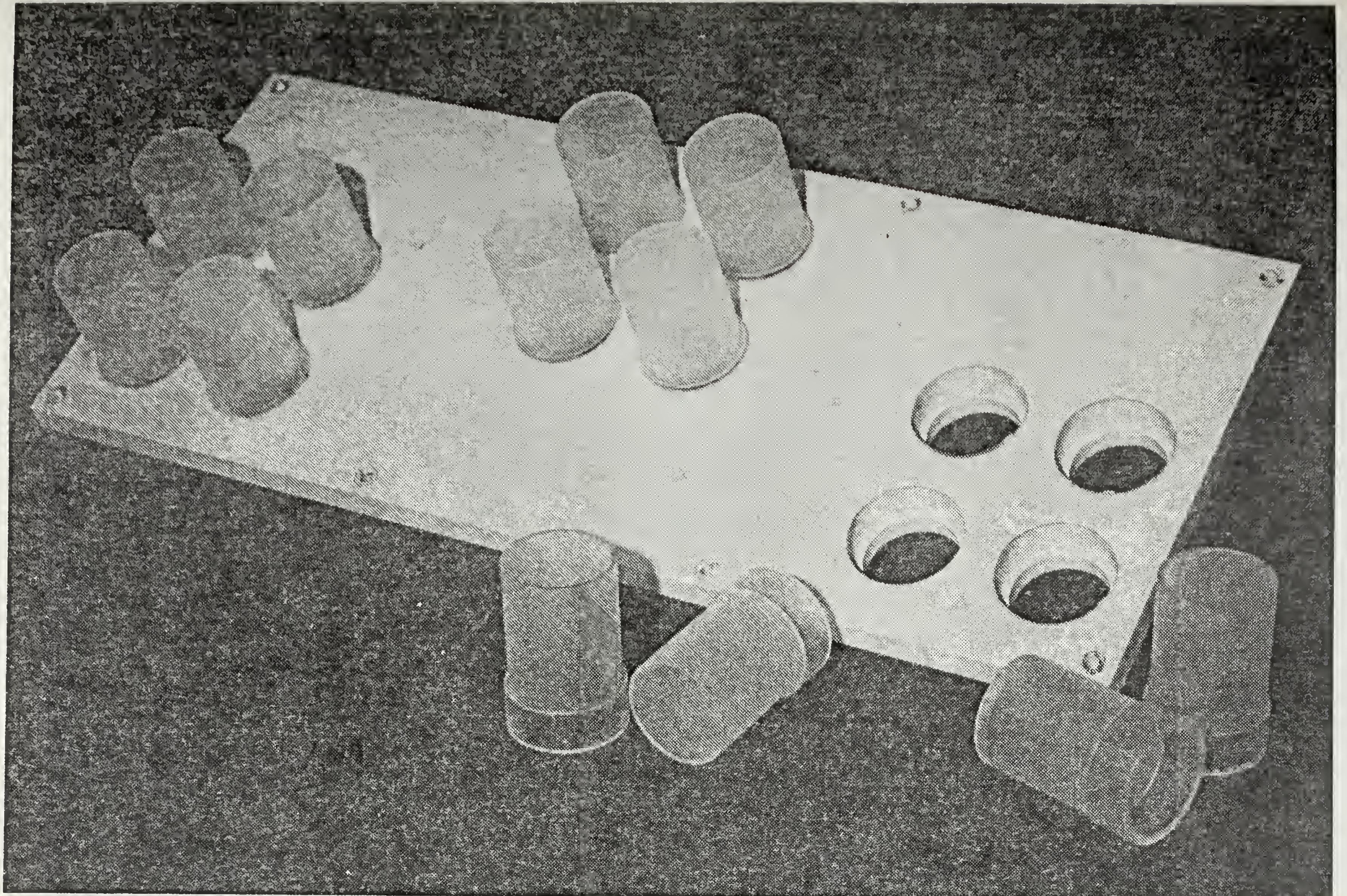


FIGURE 12. Primary Nozzles and Mounting Plate for Existing Eductors.

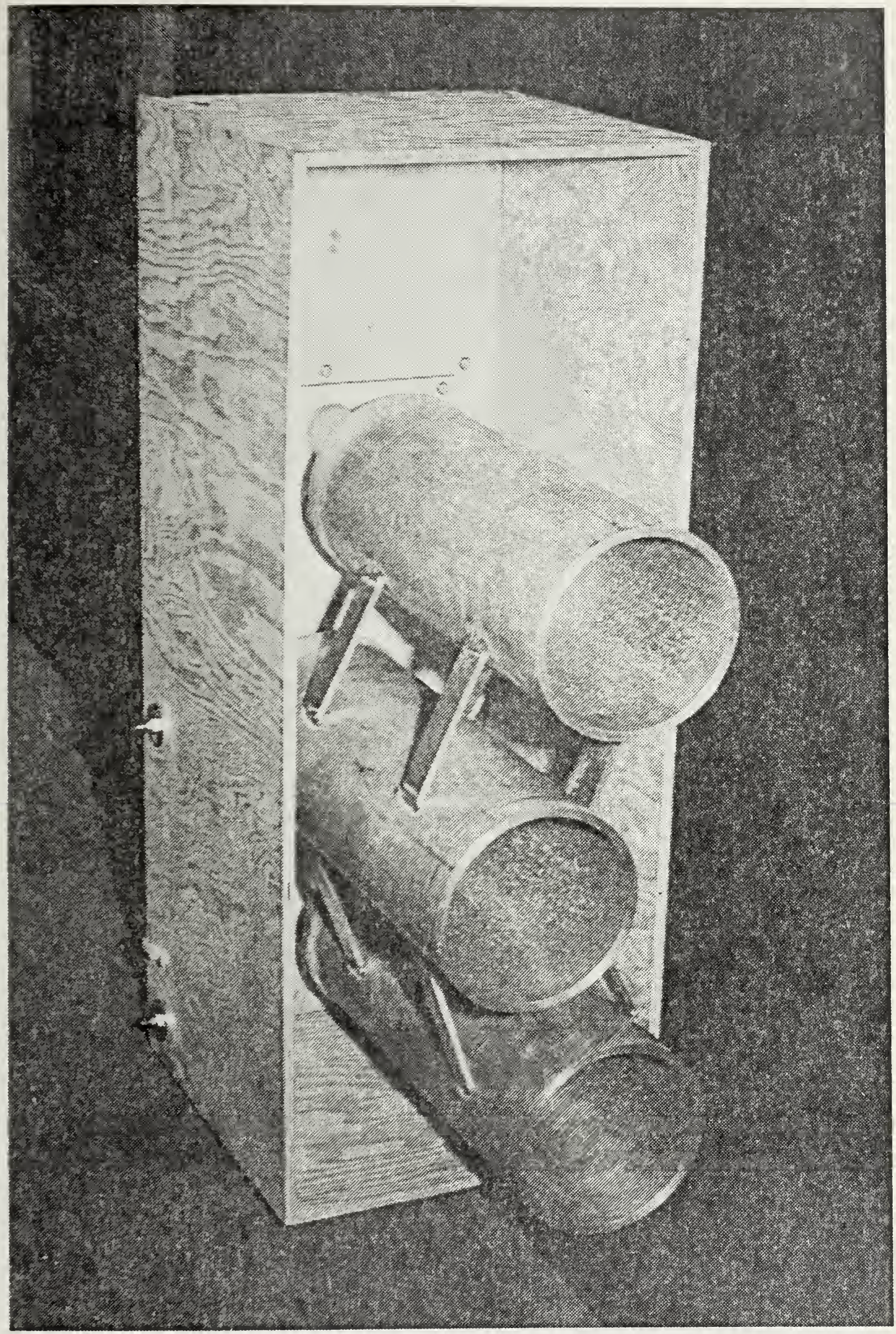
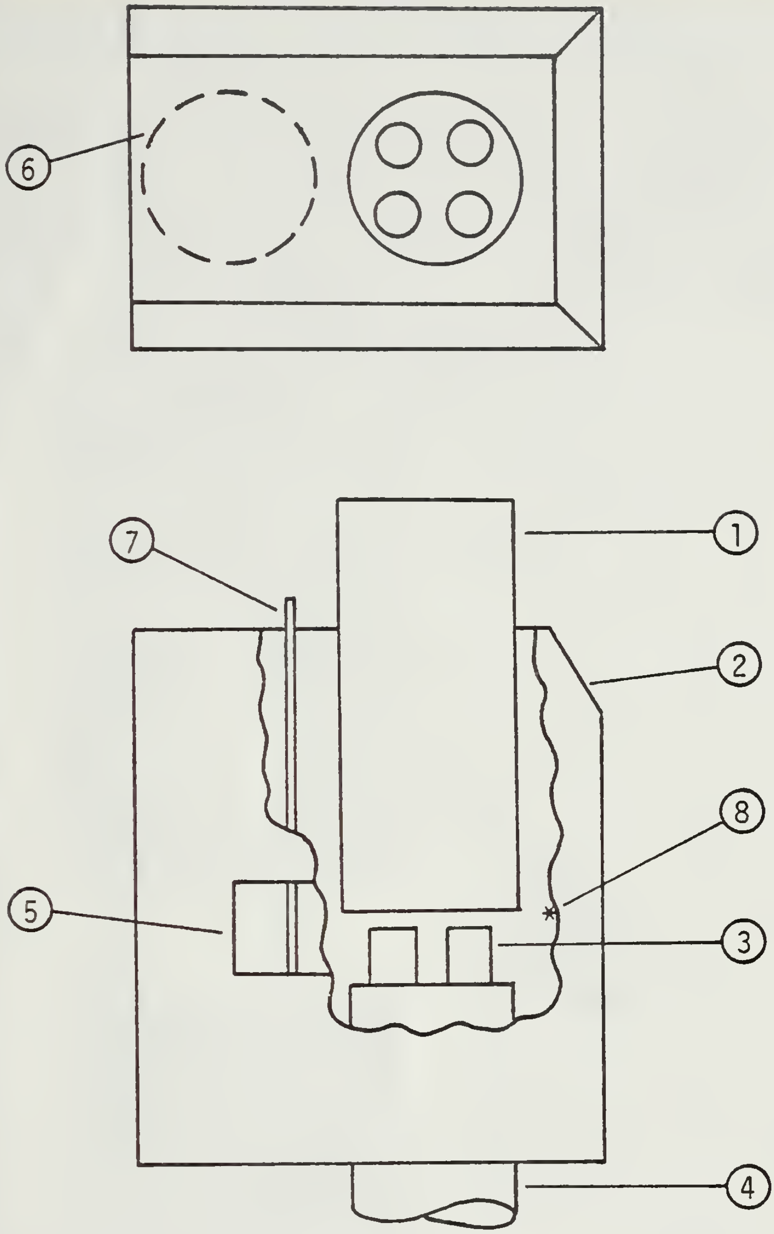


FIGURE 13. Existing Eductor Mixing Stacks.



(1) Mixing Stack
(2) Funnel
(3) Primary Nozzles
(4) Uptake
(5) Louvres
(6) Adjacent Eductor
(7) Bulkhead
(8) Pressure Tap

FIGURE 14. Schematic of Eductor Proposal A.

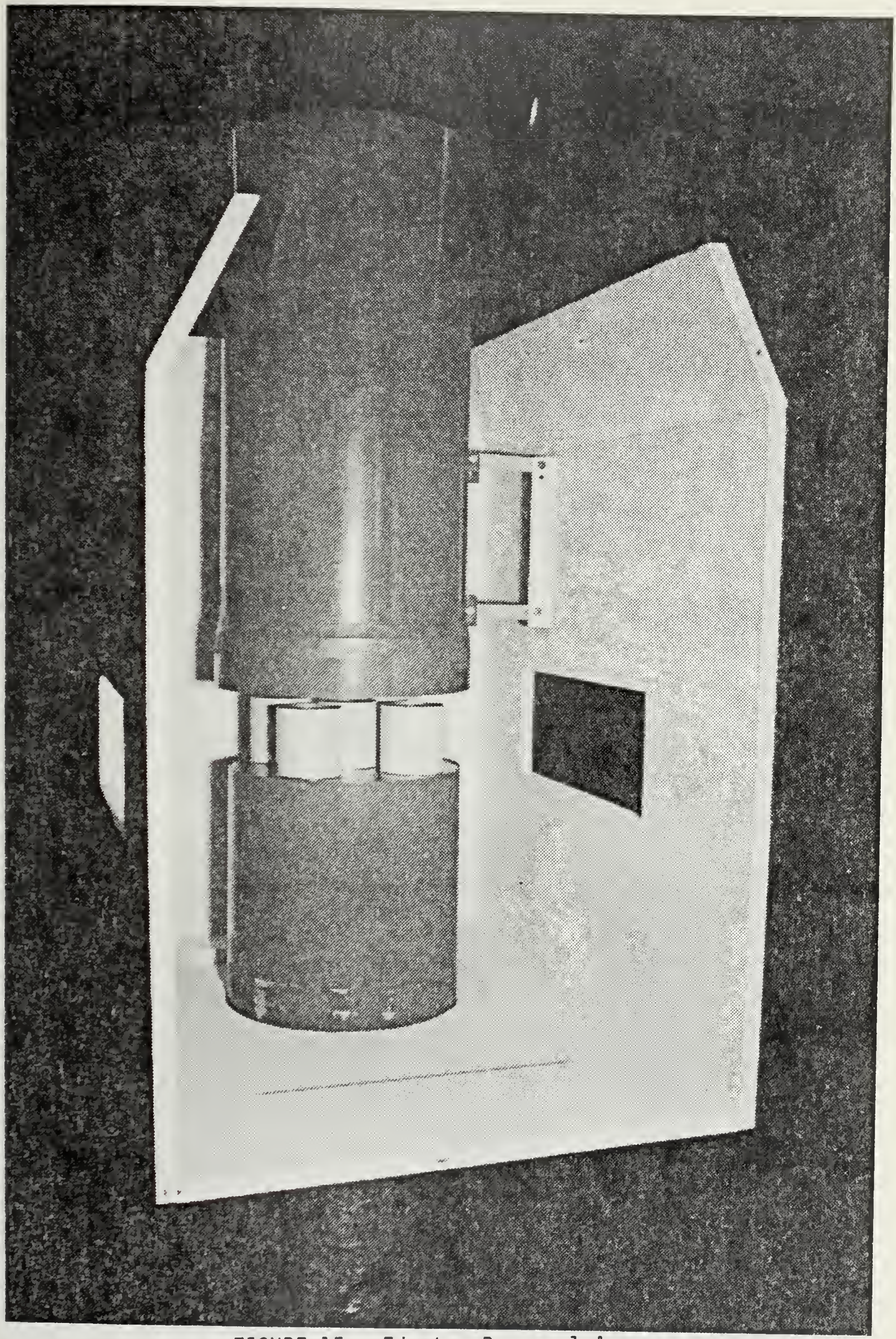


FIGURE 15. Eductor Proposal A.

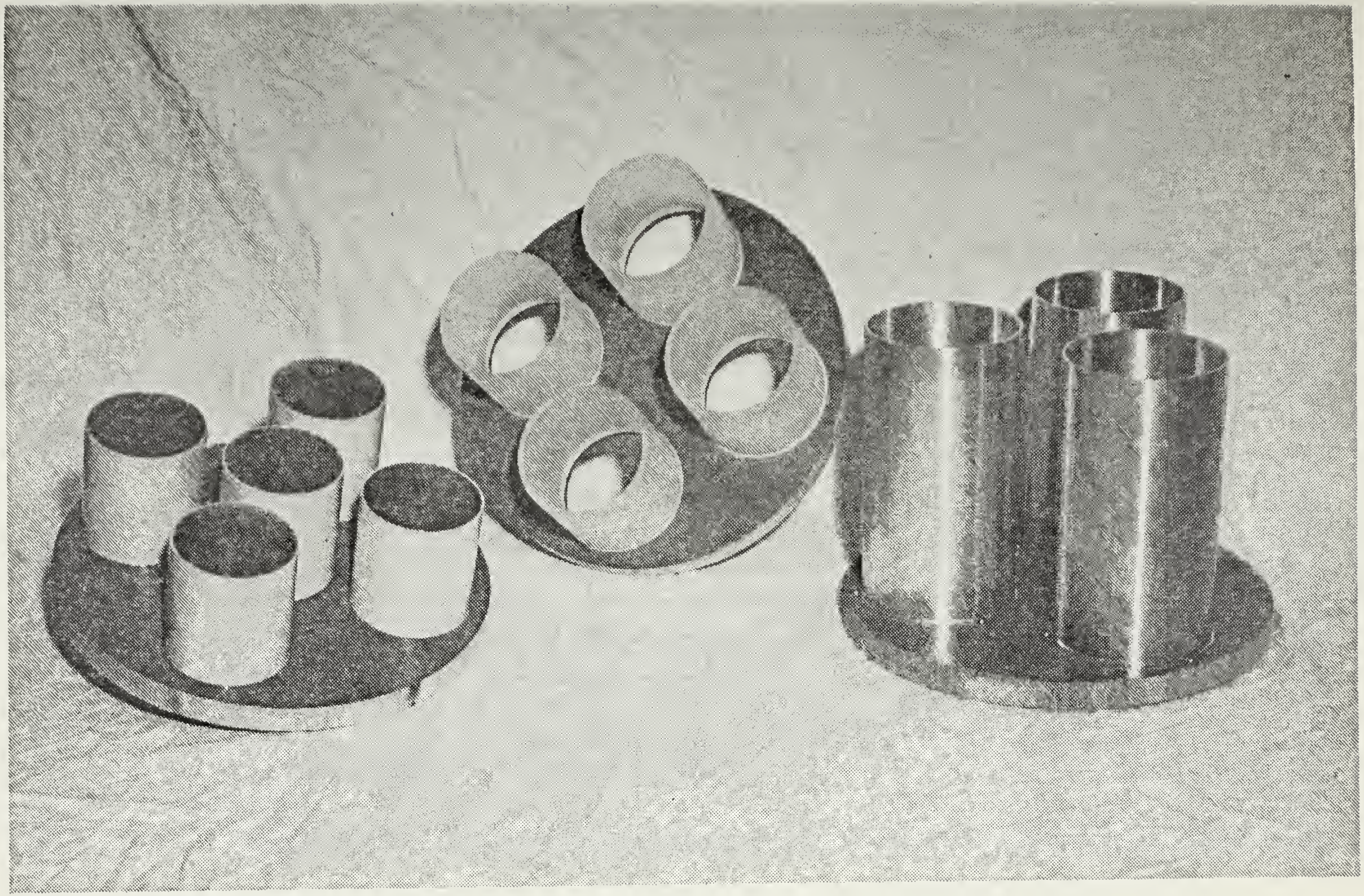
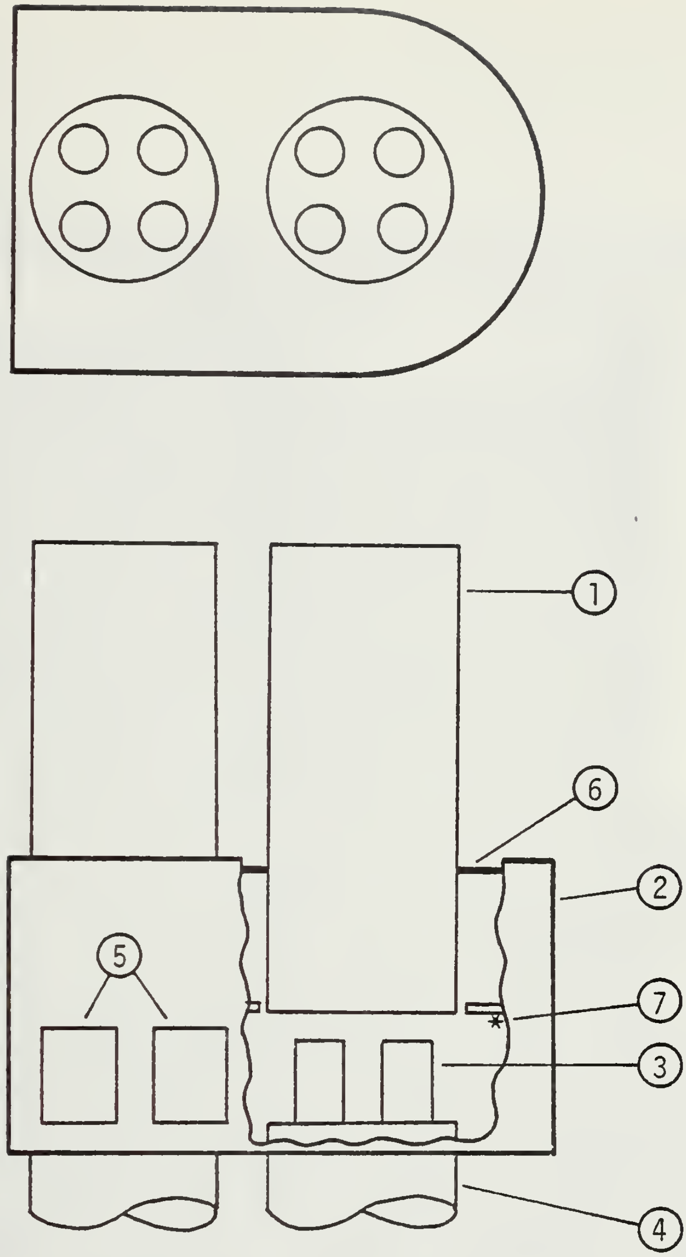


FIGURE 16. Primary Nozzles for Eductor Proposal A.



(1) Mixing Stack
(2) Funnel
(3) Primary Nozzles
(4) Uptake
(5) Louvers
(6) Cover Plate
(7) Pressure Tap

FIGURE 17. Schematic of Eductor Proposal B.

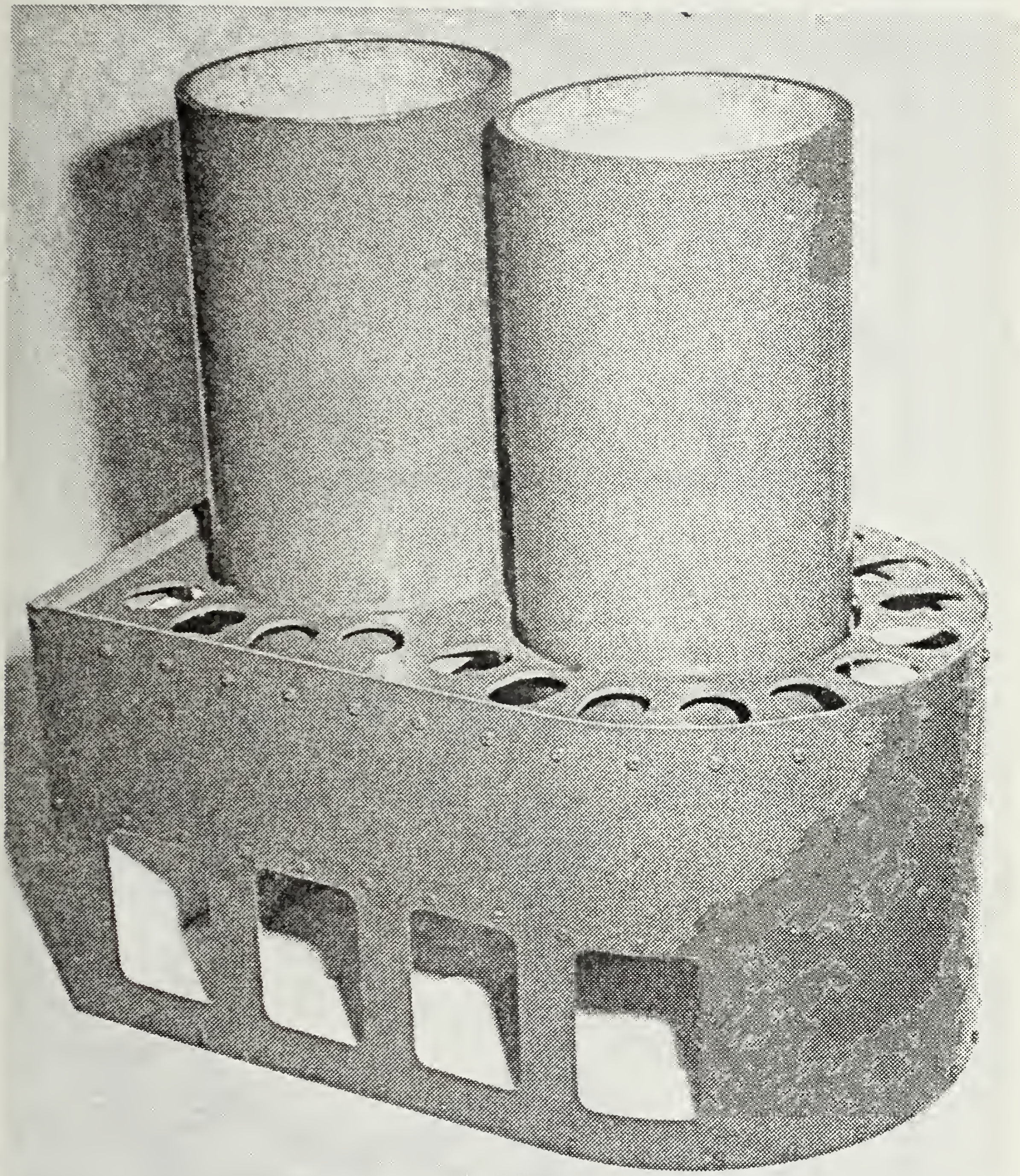


FIGURE 18. Funnel and Mixing Stacks of Eductor Proposal B.

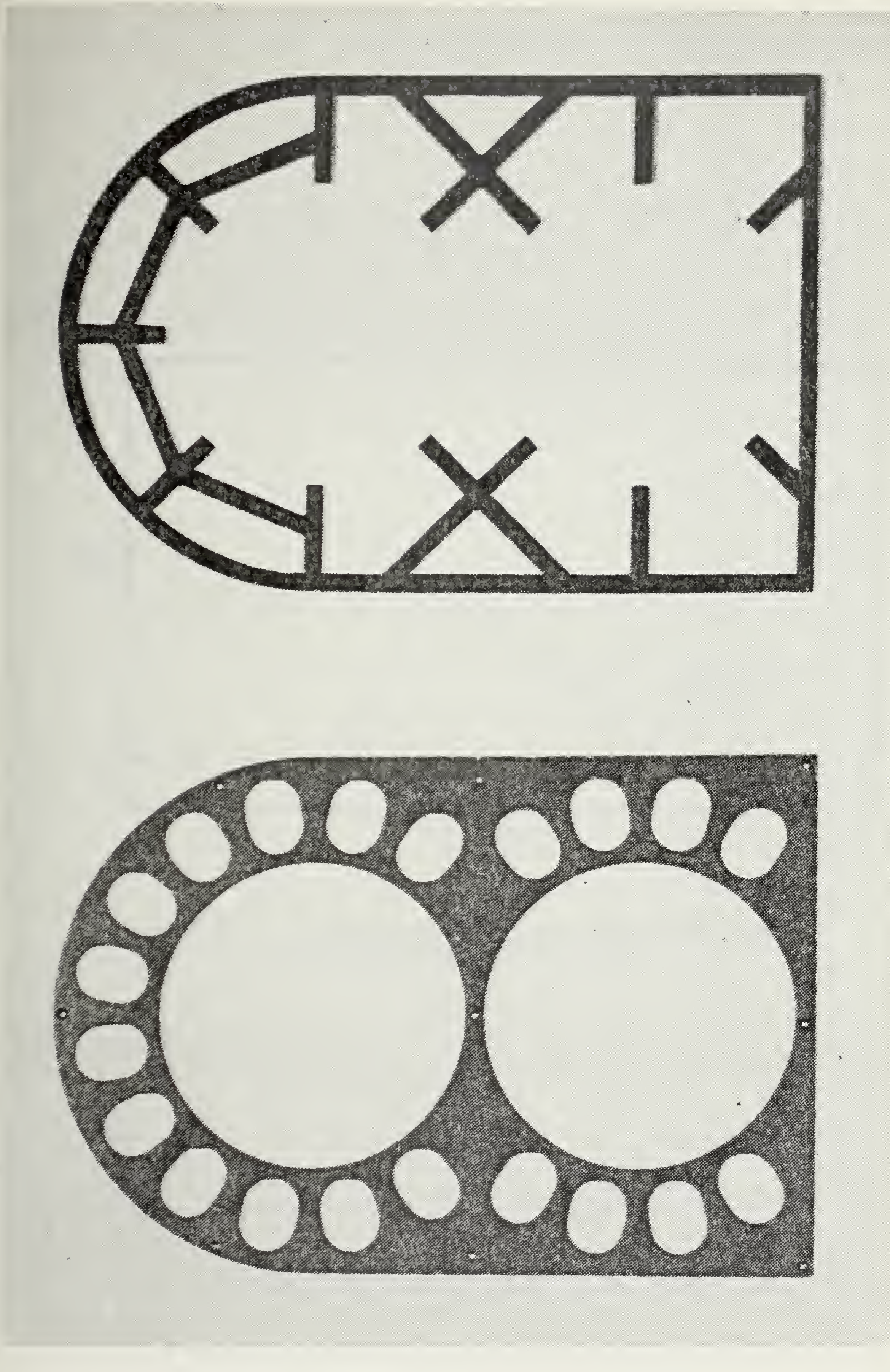


FIGURE 19. Oval and Truss Cover Plate Designs for Eductor Proposal B.

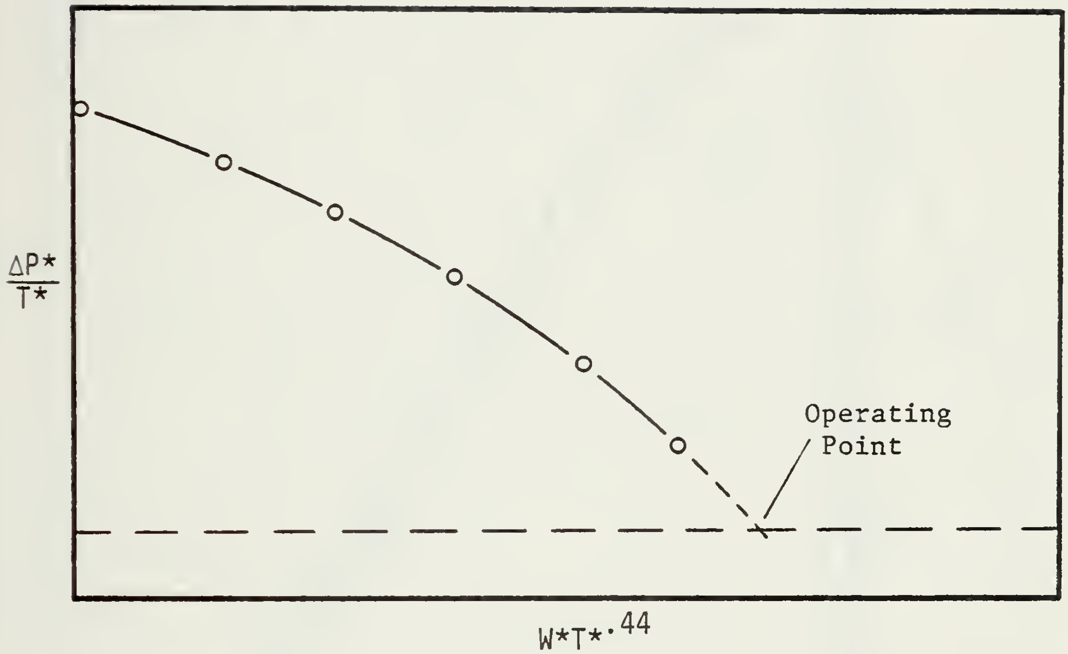


FIGURE 20. Illustrative Plot of the Experimental Data Correlation in Equation (14).

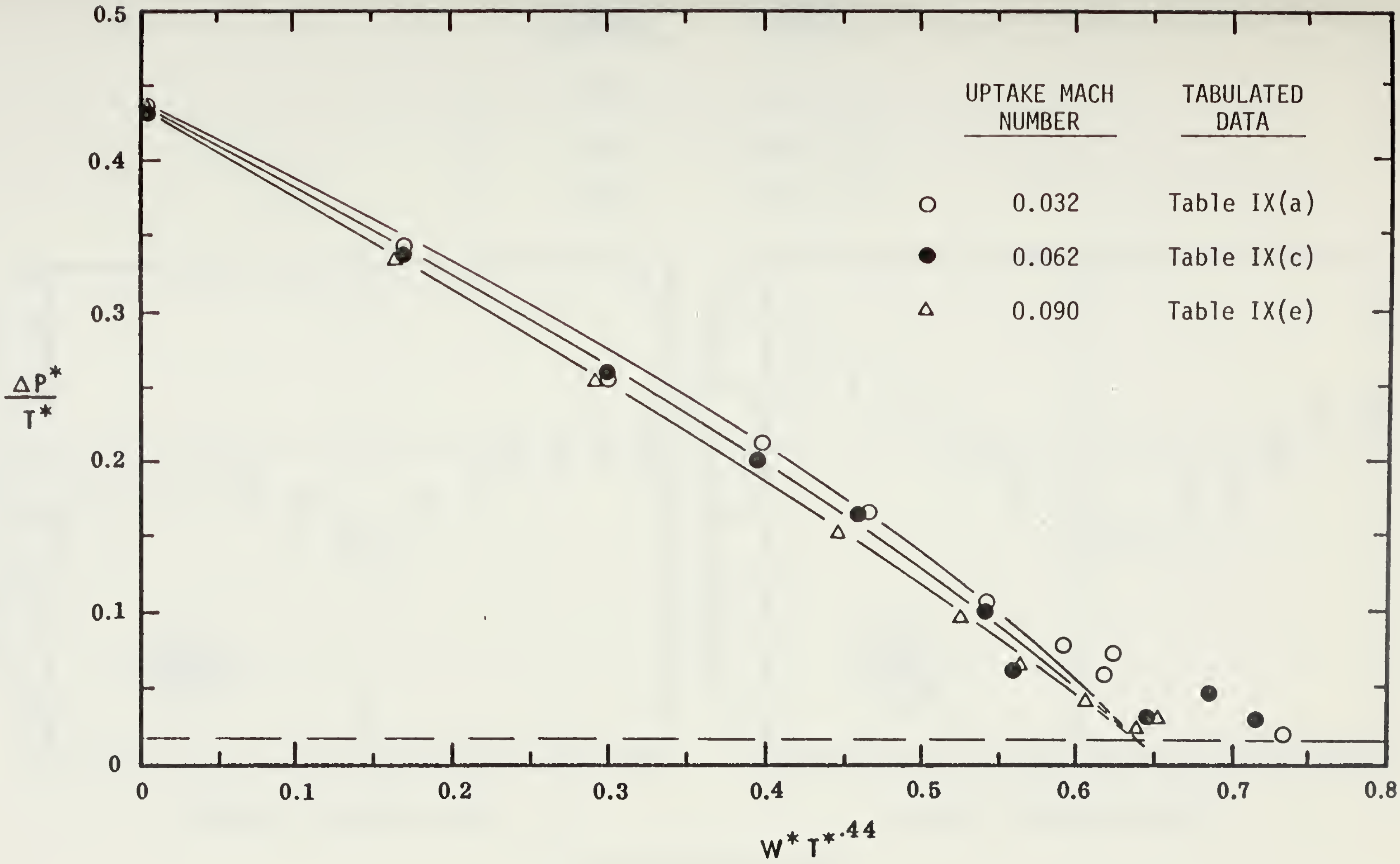
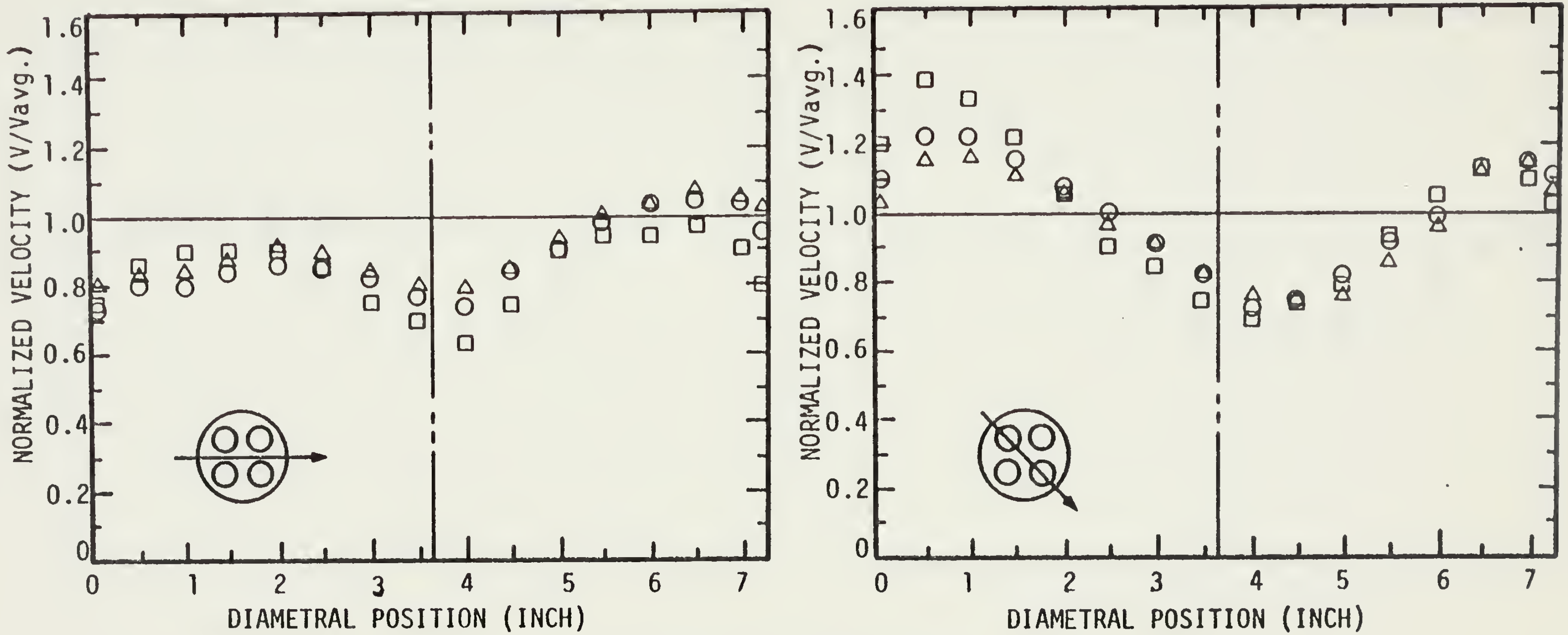


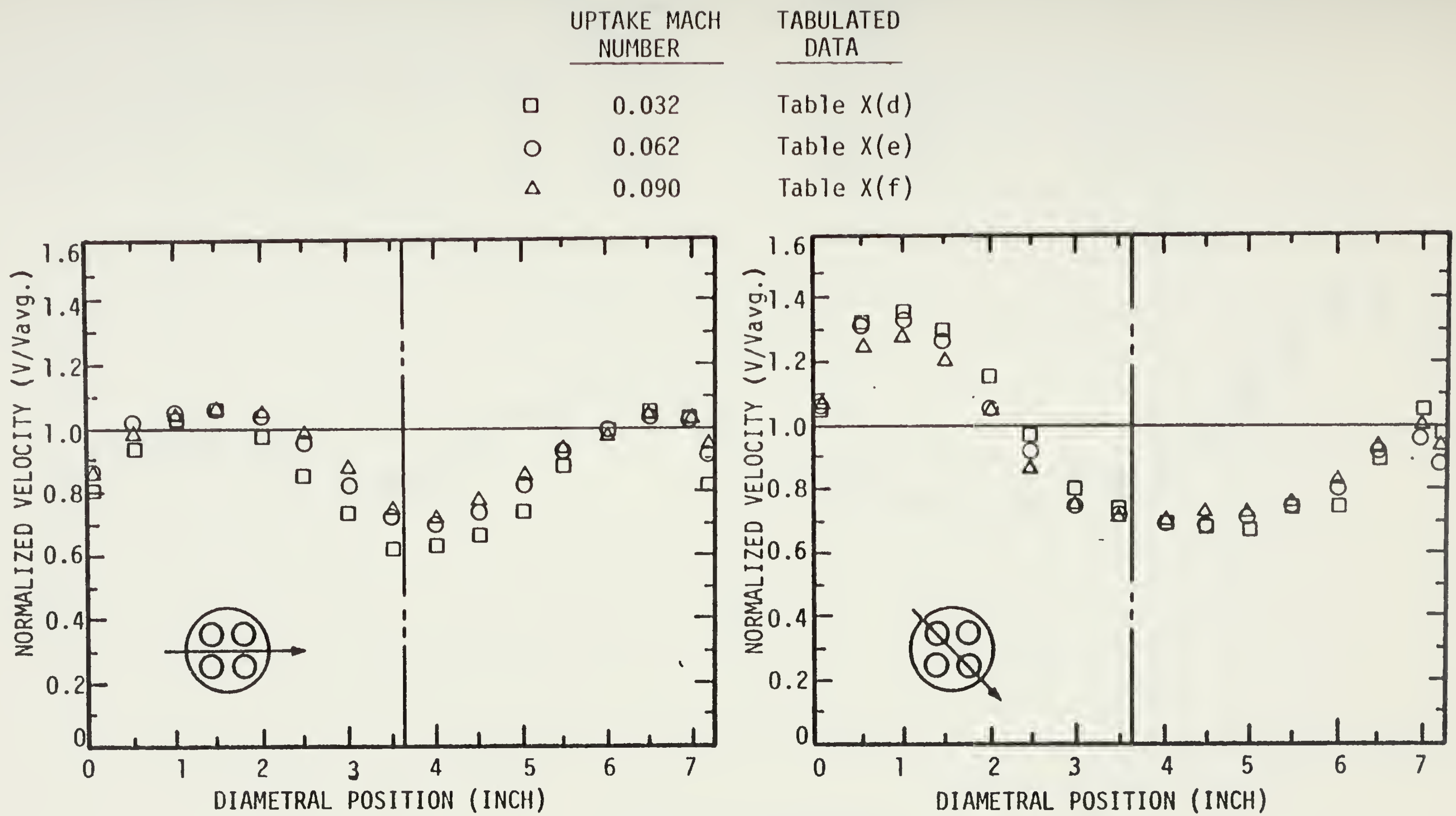
FIGURE 21. Effects of Uptake Mach Number on Performance of the Existing Eductor.

	UPTAKE MACH NUMBER	TABULATED DATA
□	0.032	Table X(a)
○	0.062	Table X(b)
△	0.090	Table X(c)



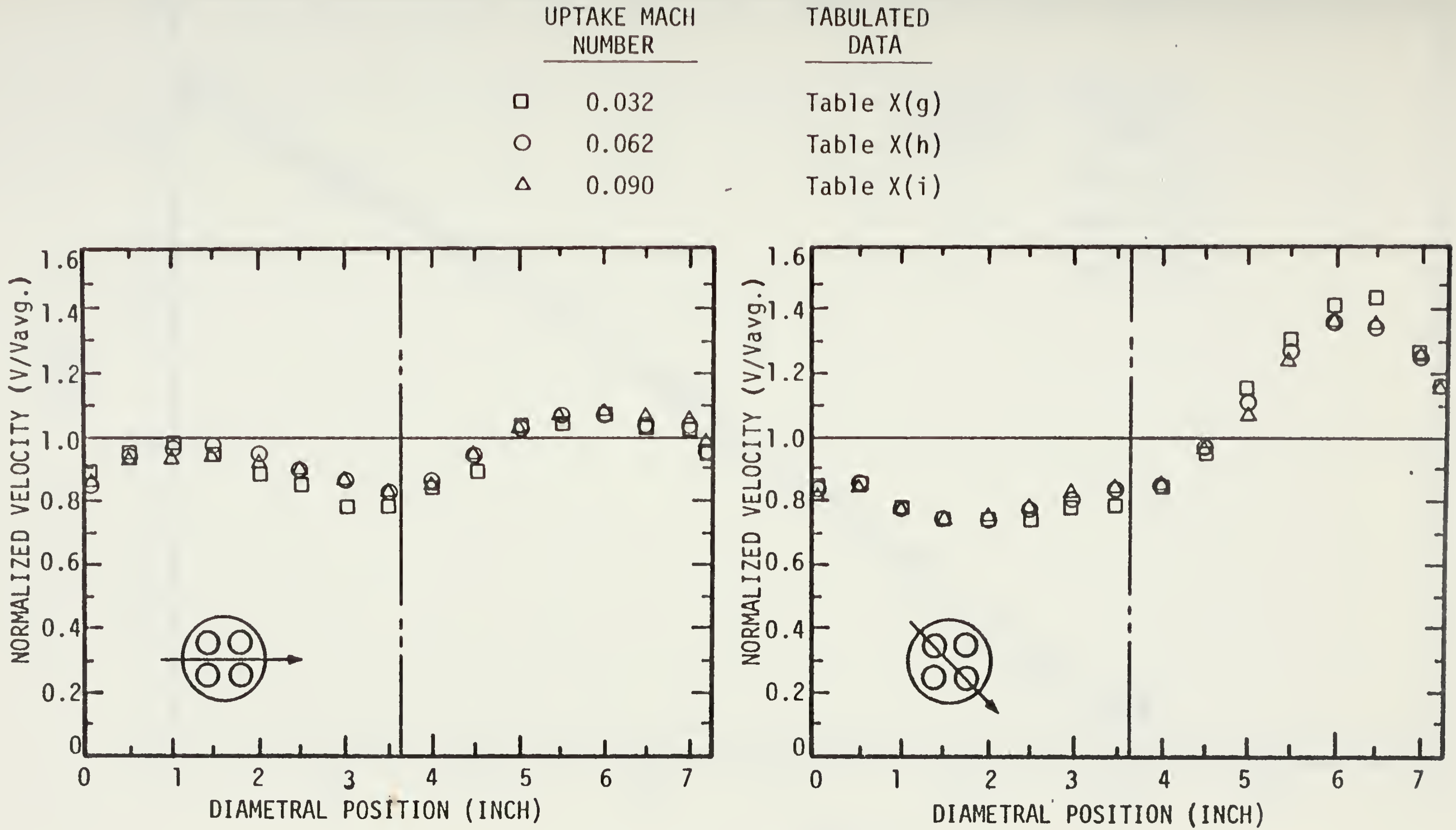
a) Forward Mixing Stack

FIGURE 22. Effect of Uptake Mach Number on Normalized Mixing Stack Exit Velocity Profiles for the Existing Eductor.



(b) Center Mixing Stack

FIGURE 22. Continued.



(c) Aft Mixing Stack

FIGURE 22. Continued.

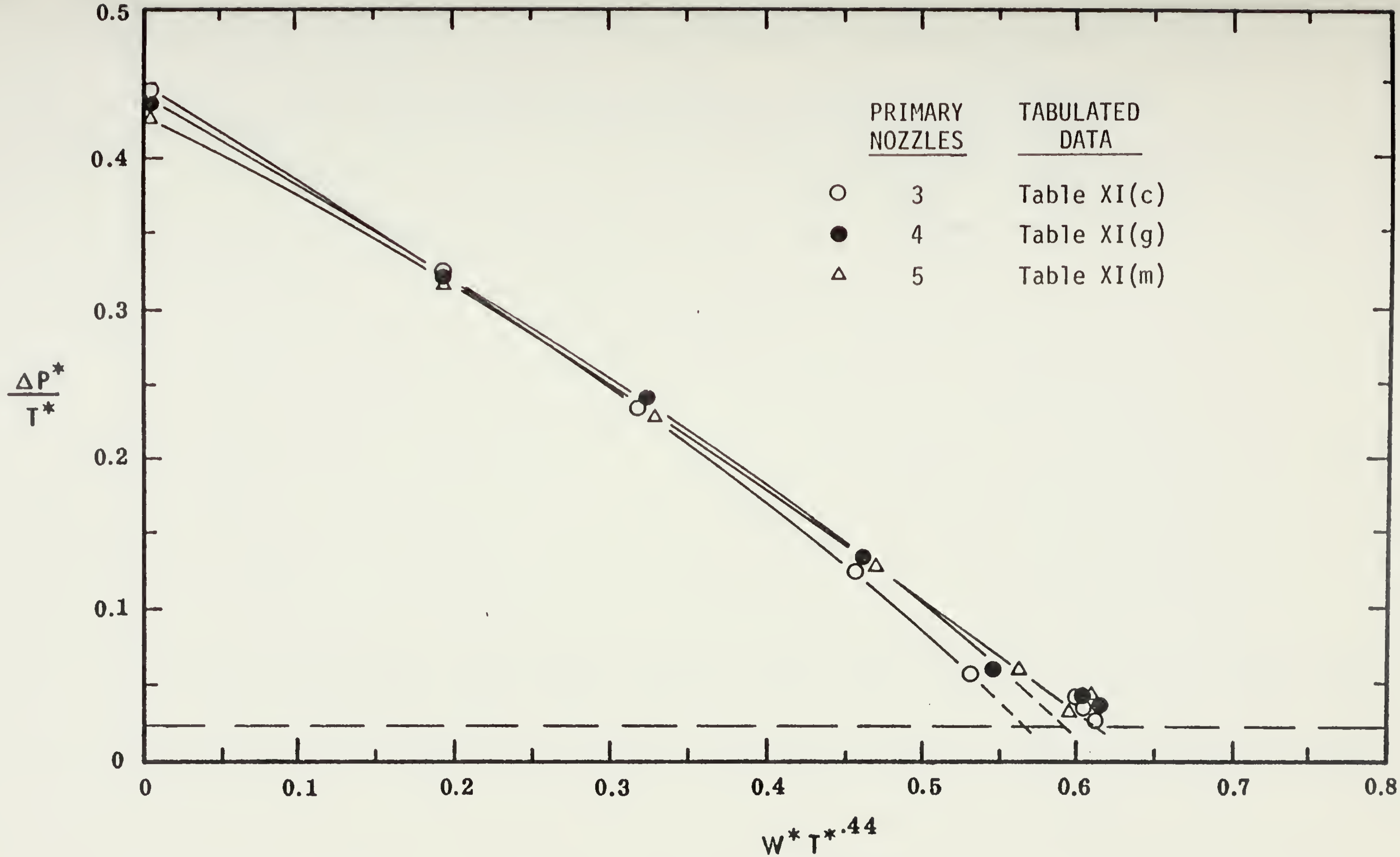
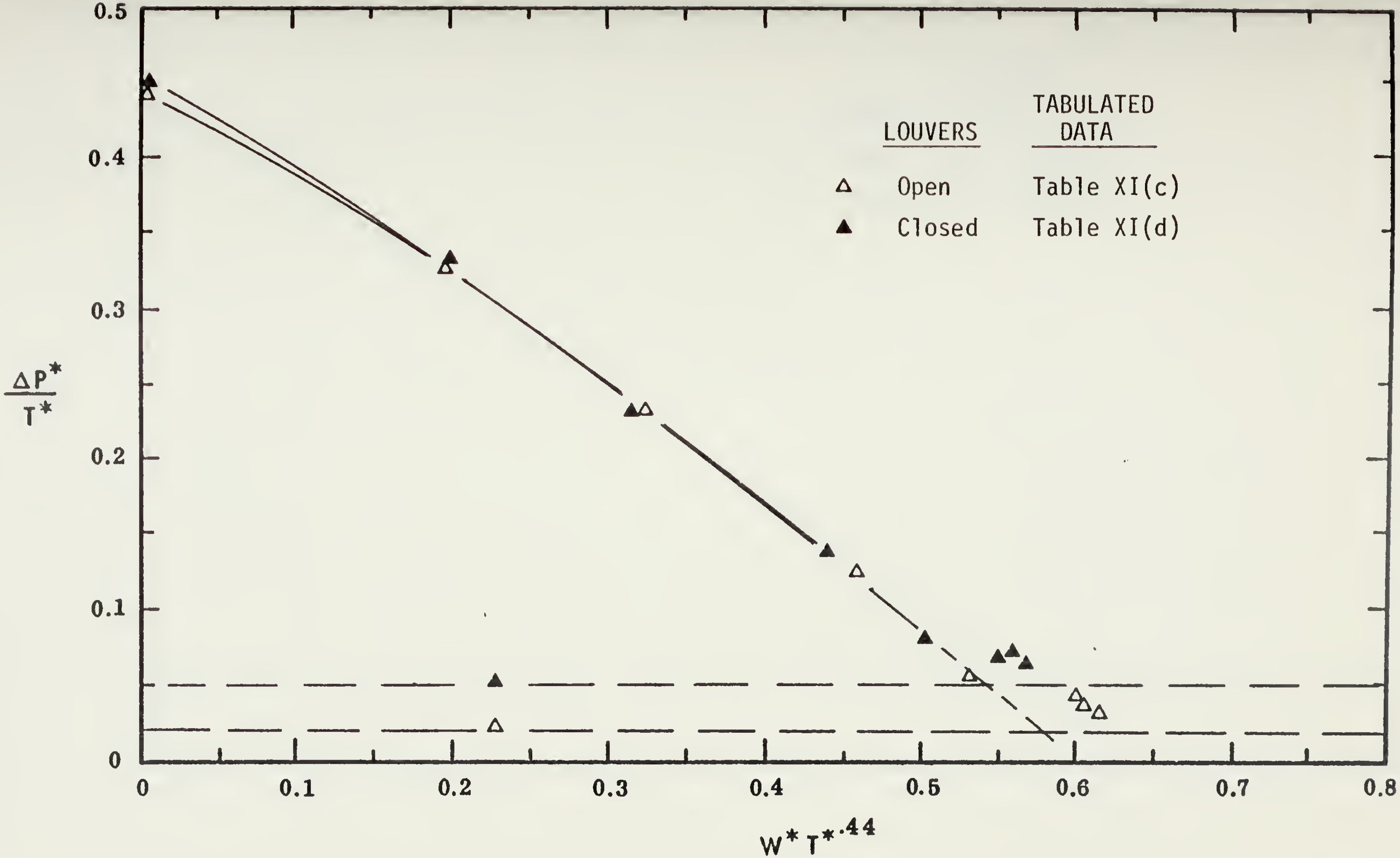
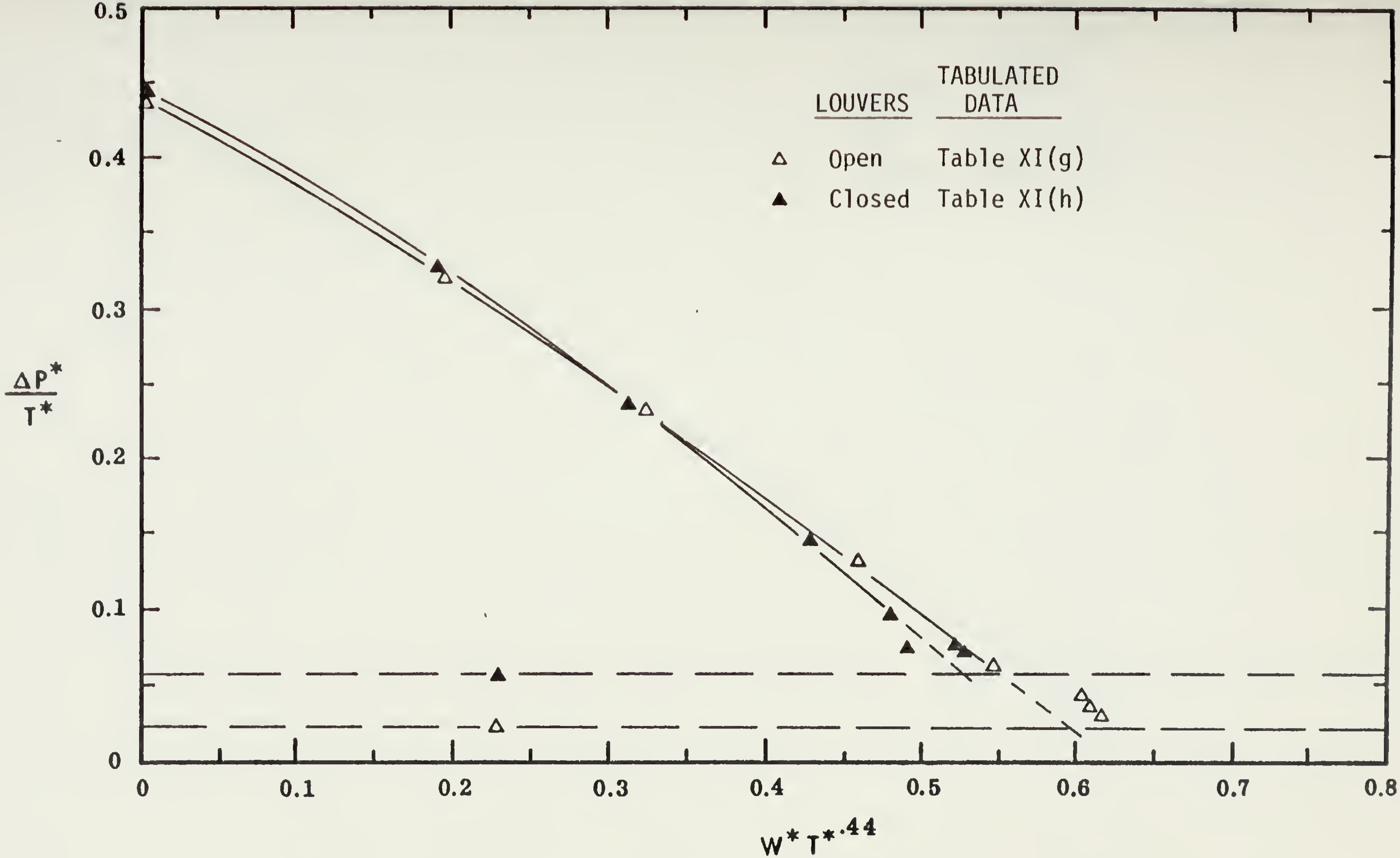


FIGURE 23. Effects of the Number of Primary Nozzles on Performance of Eductor Proposal A.



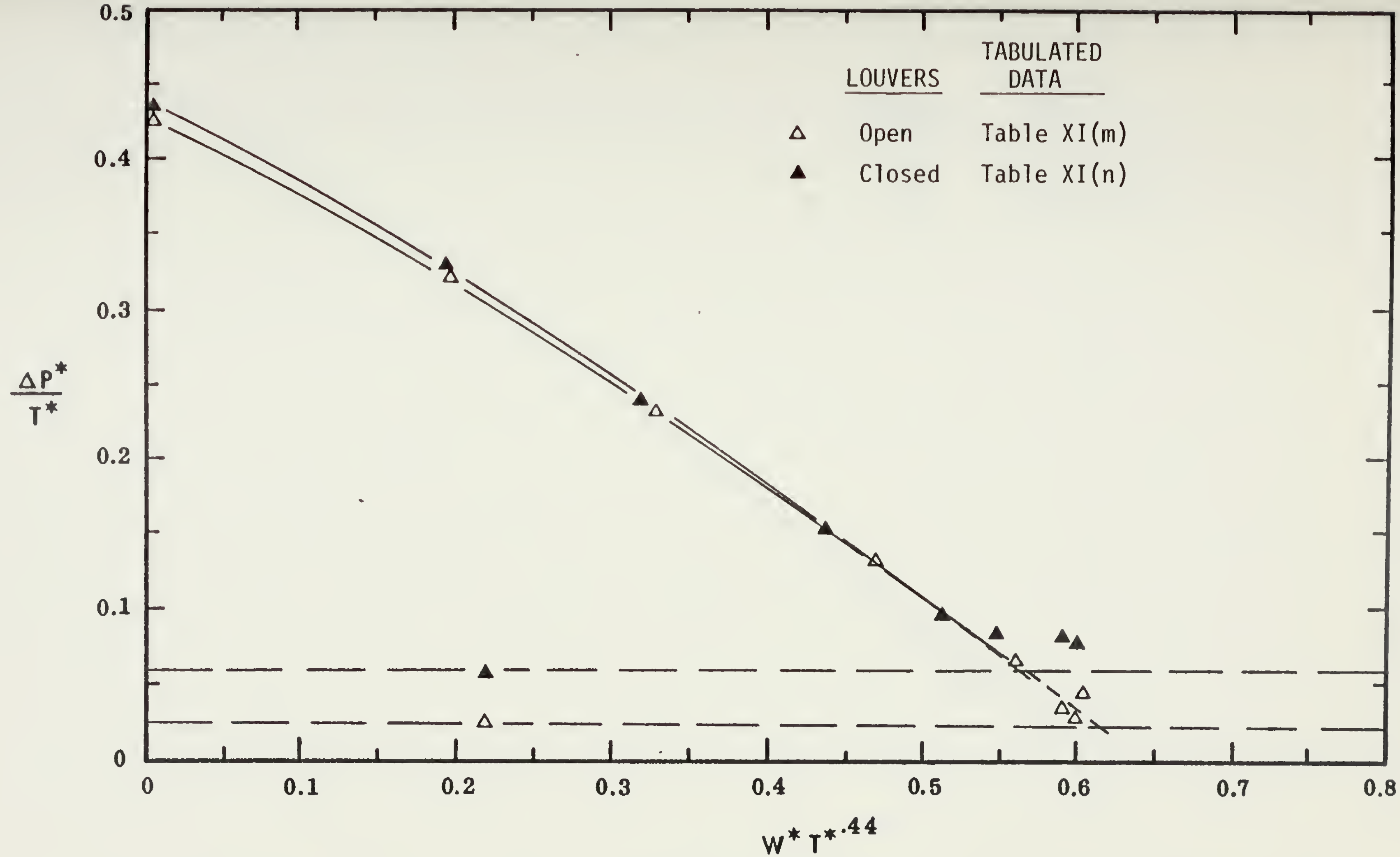
(a) Three Primary Nozzles (Short)

FIGURE 24. Effects of Secondary Flow Restriction on Performance of Eductor Proposal A.



(b) Four Primary Nozzles

FIGURE 24. Continued.



(c) Five Primary Nozzles

FIGURE 24. Continued.

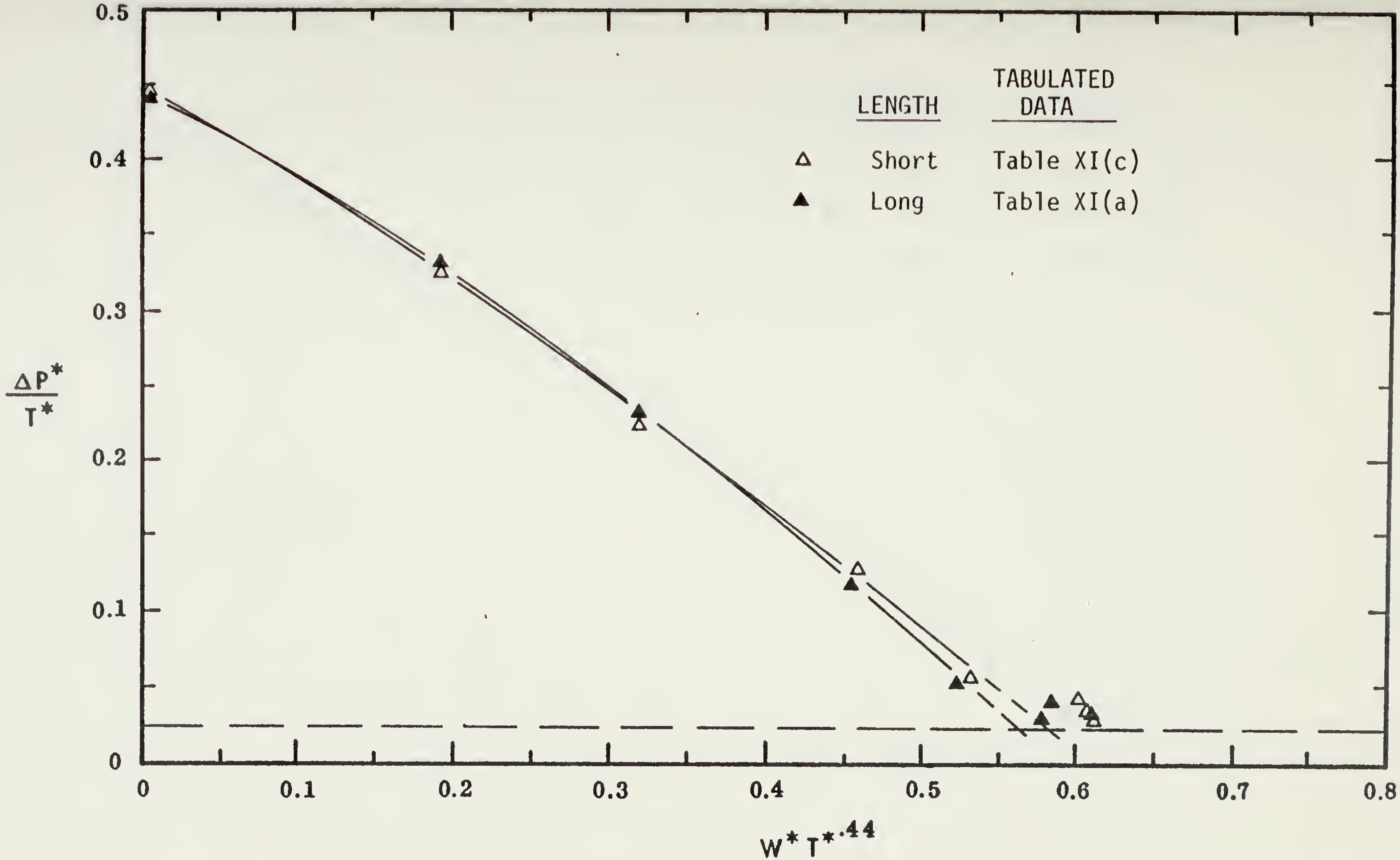
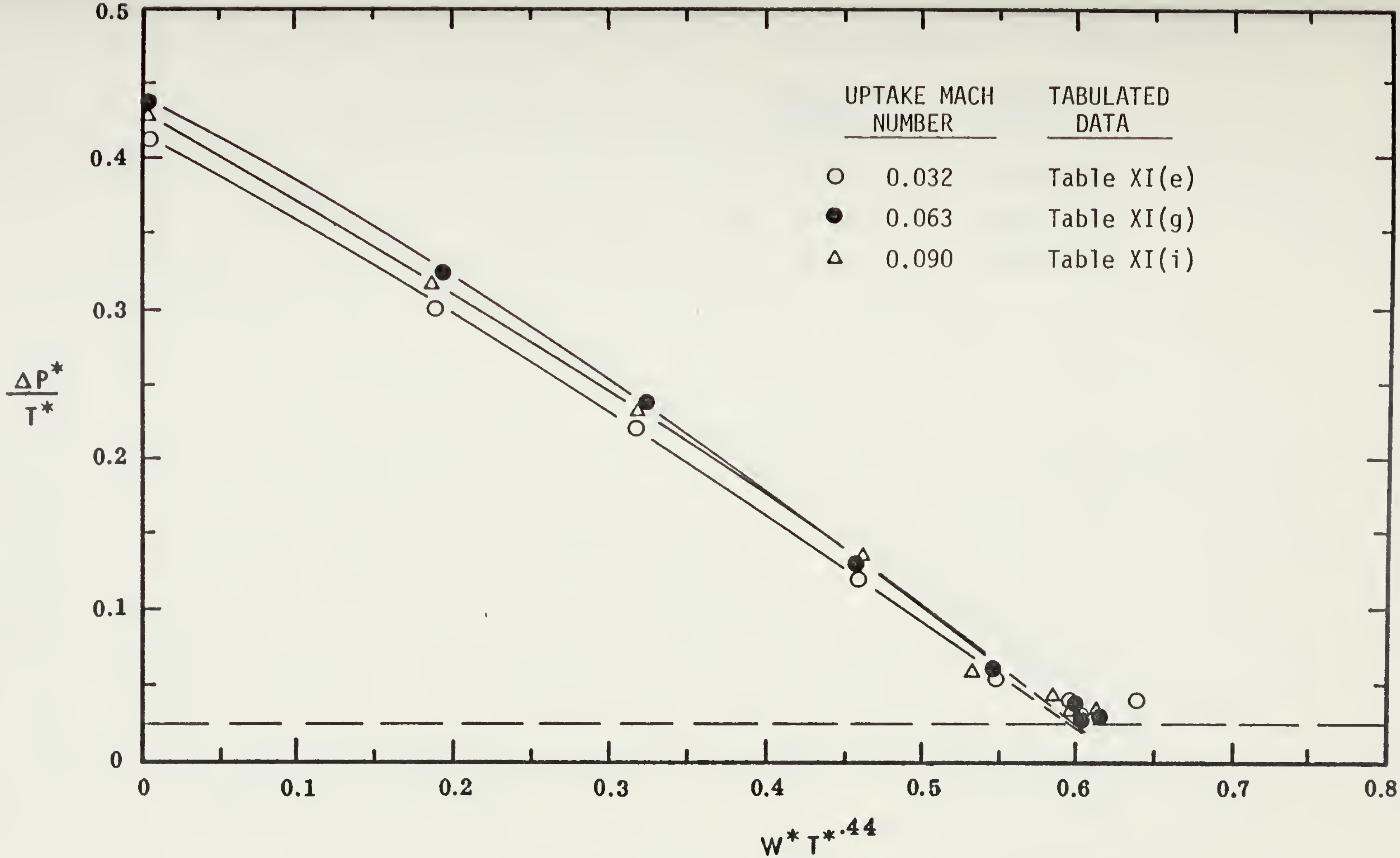
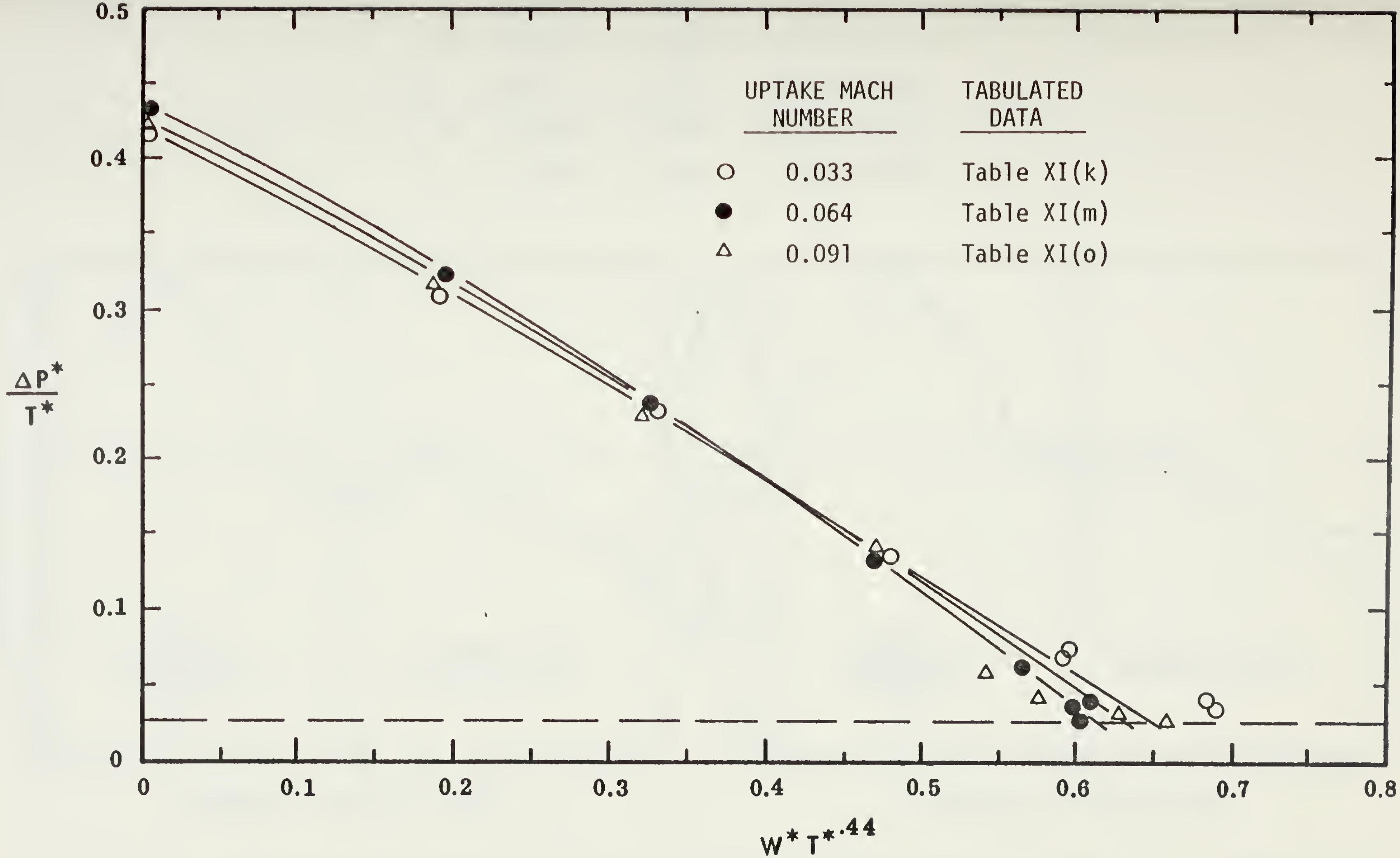


FIGURE 25. Effect of Primary Nozzle Length on Performance of the Three Nozzle Configuration of Eductor Proposal A.



(a) Four Primary Nozzles

FIGURE 26. Effect of Uptake Mach Number on Performance of Eductor Proposal A.



(b) Five Primary Nozzles

FIGURE 26. Continued.

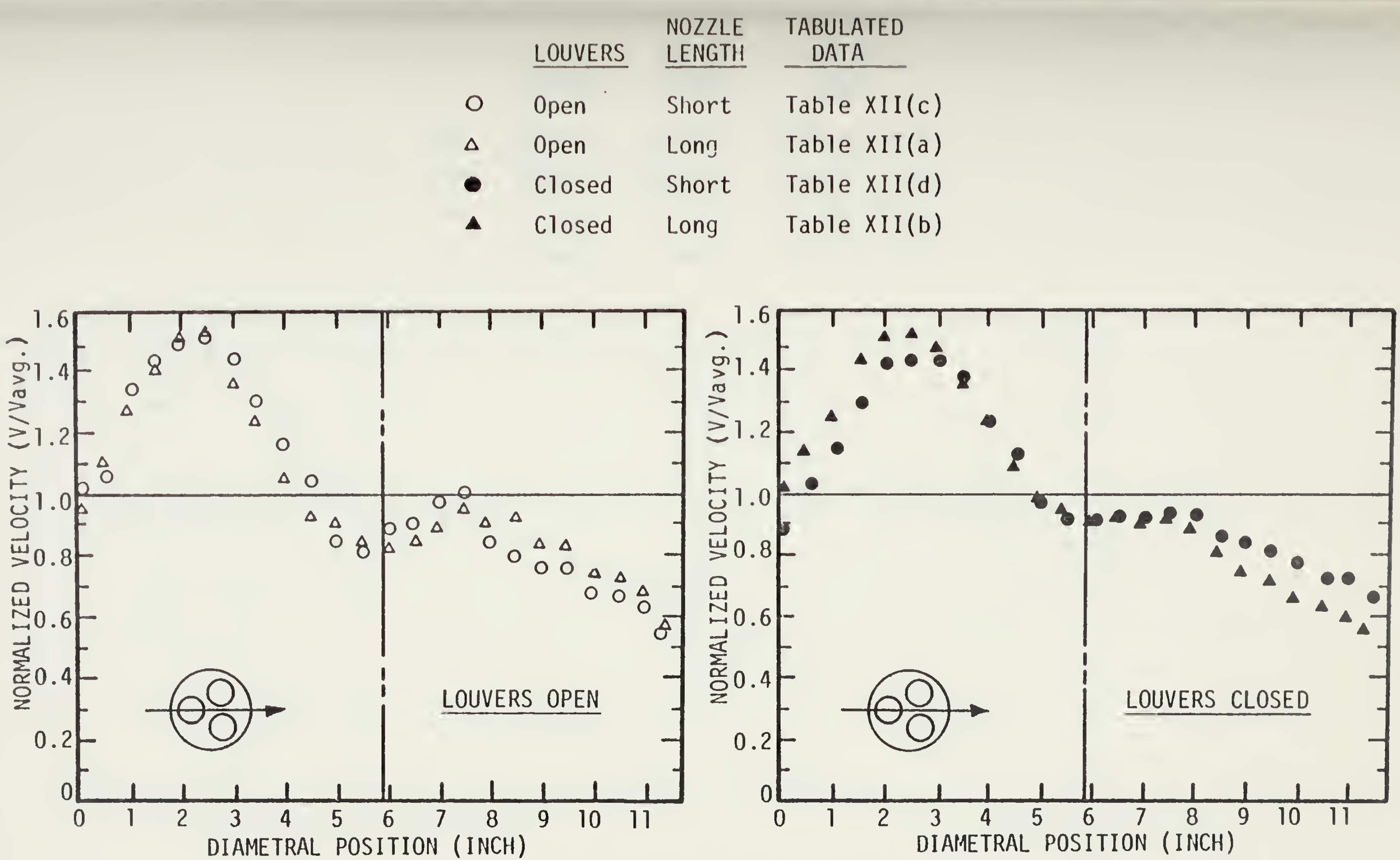
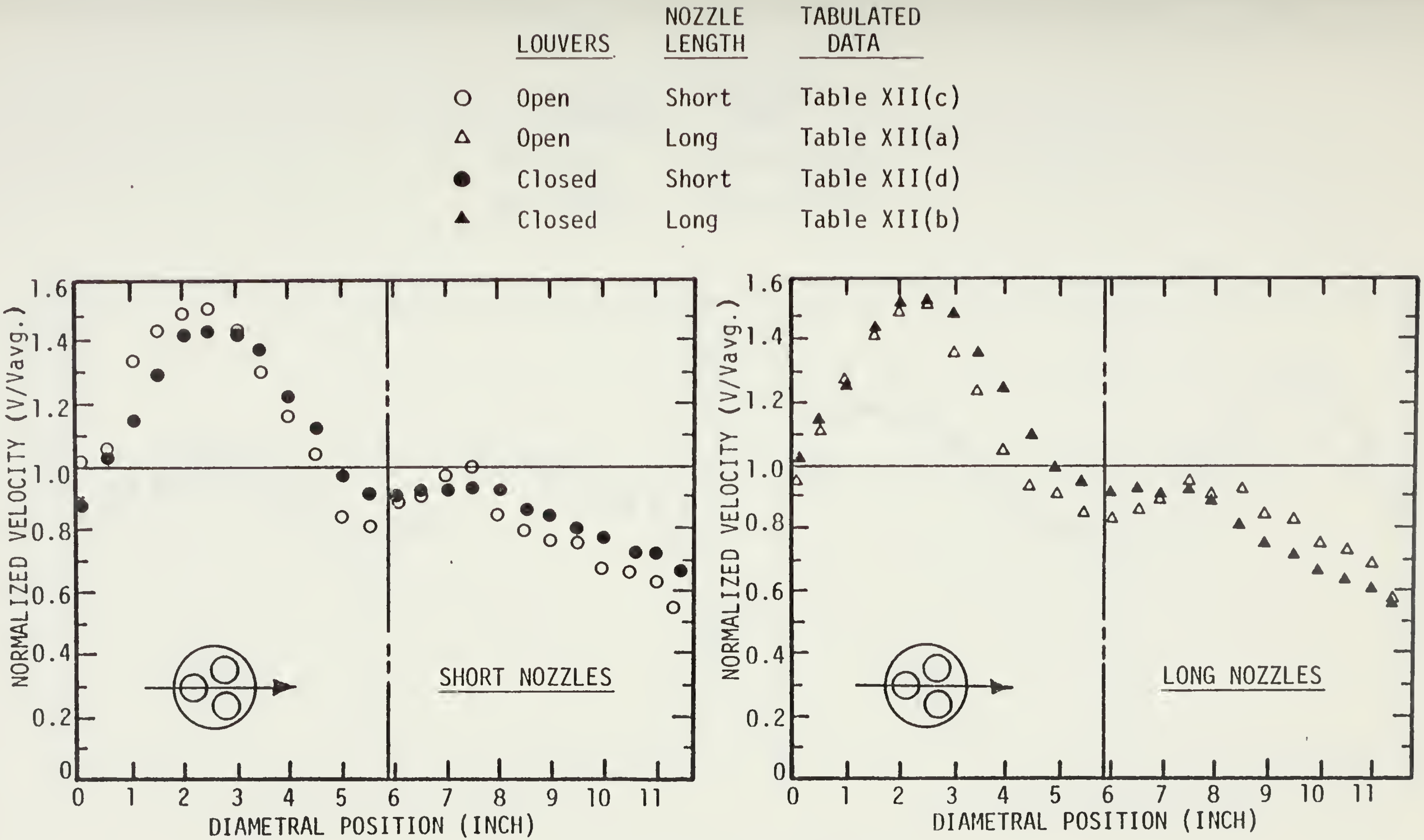


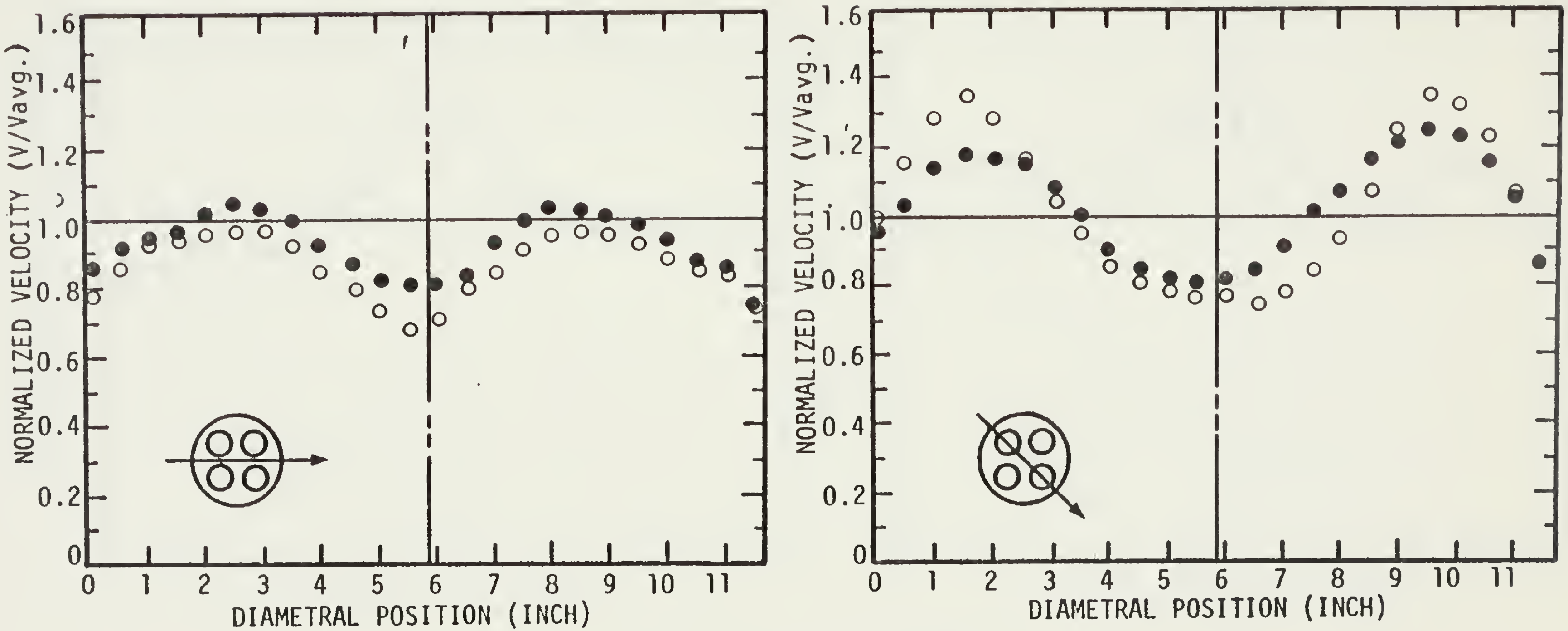
FIGURE 27. Effect of Primary Nozzle Length on Normalized Mixing Stack Exit Velocity Profiles for the Three Nozzle Configuration of Eductor Proposal A.



(a) Three Primary Nozzles

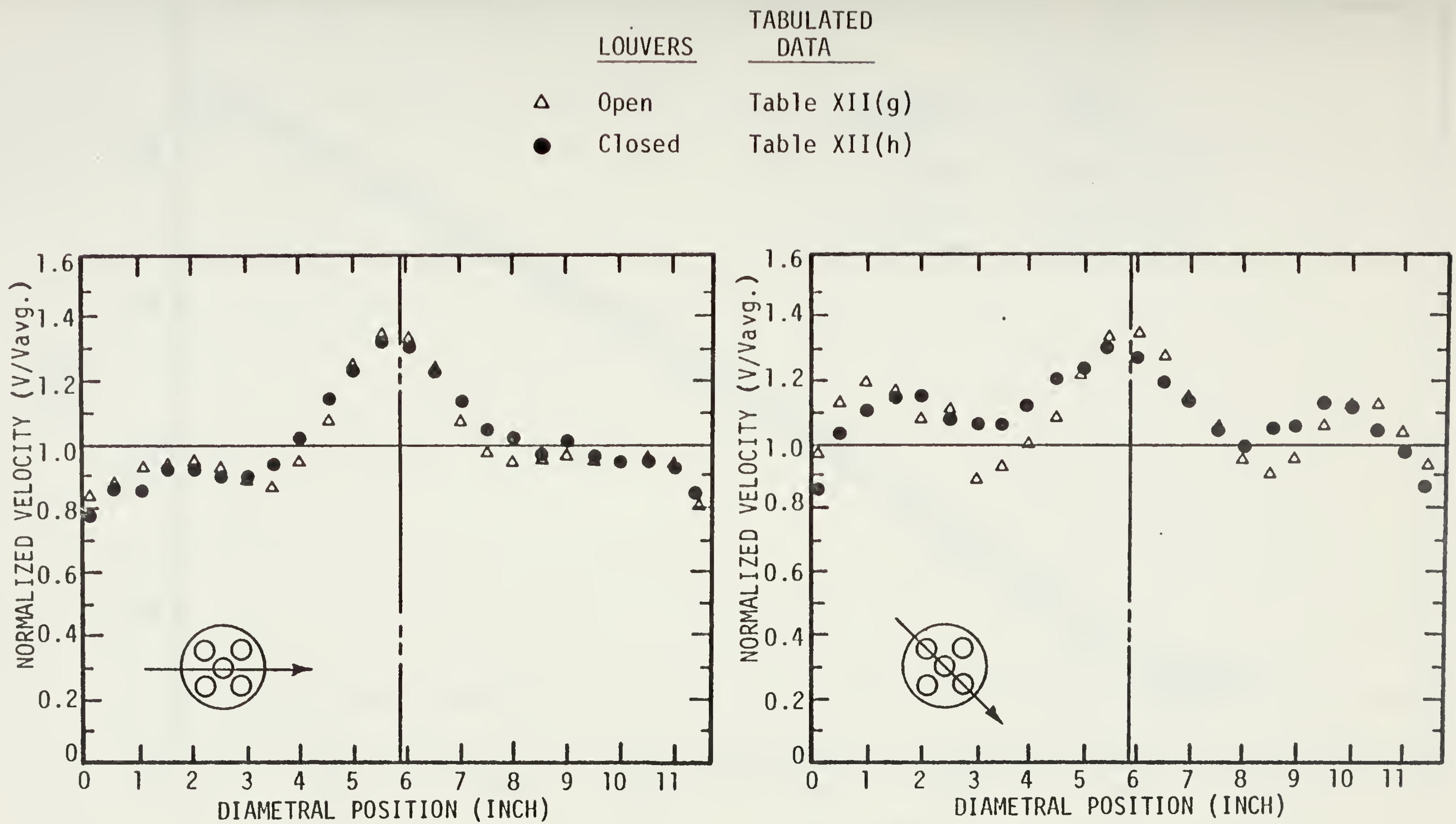
FIGURE 28. Effect of Secondary Flow Restriction on Normalized Mixing Stack Exit Velocity Profiles for Eductor Proposal A.

LOUVERS	TABULATED DATA
○ Open	Table XII(e)
● Closed	Table XII(f)



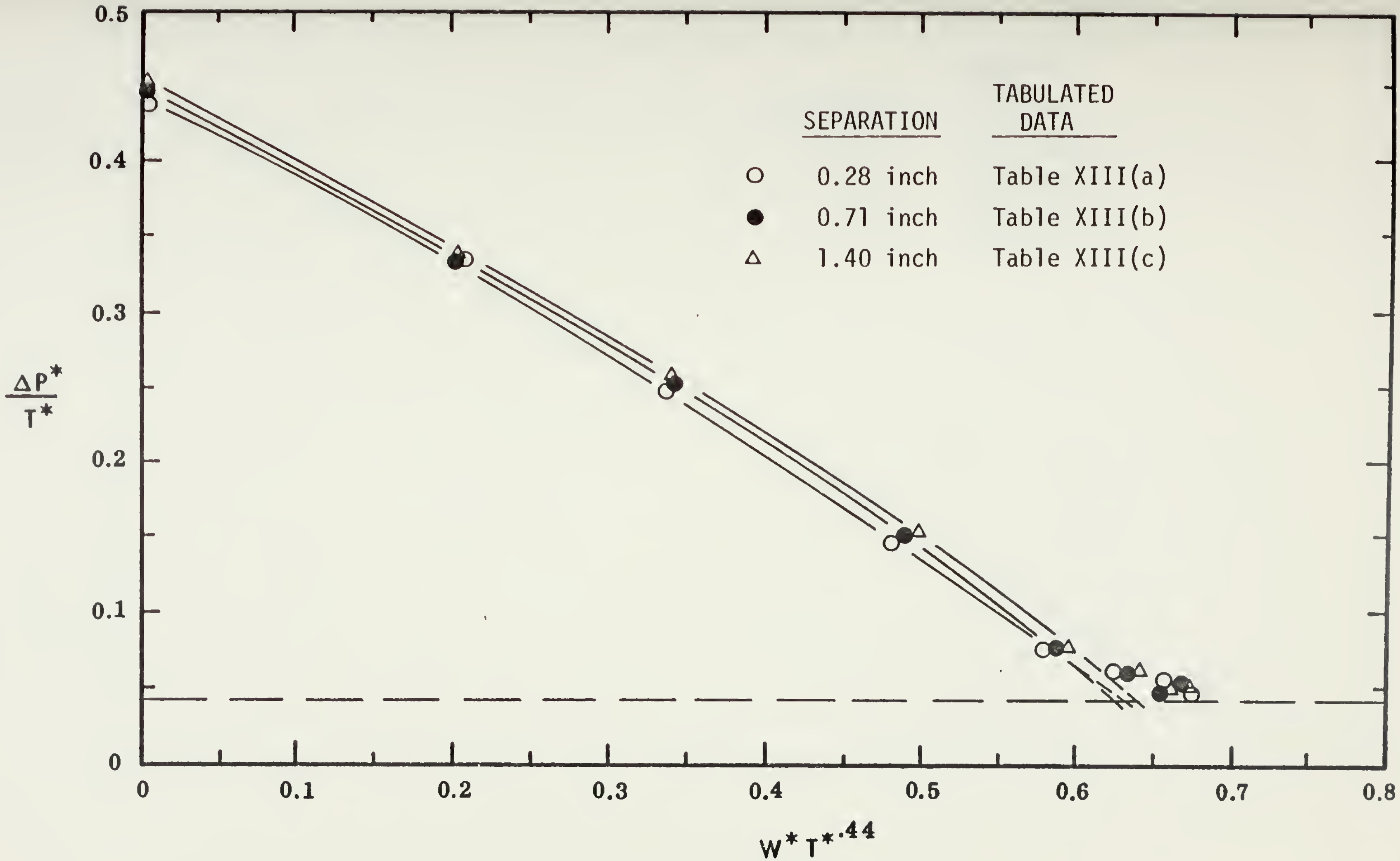
(b) Four Primary Nozzles

FIGURE 28. Continued.



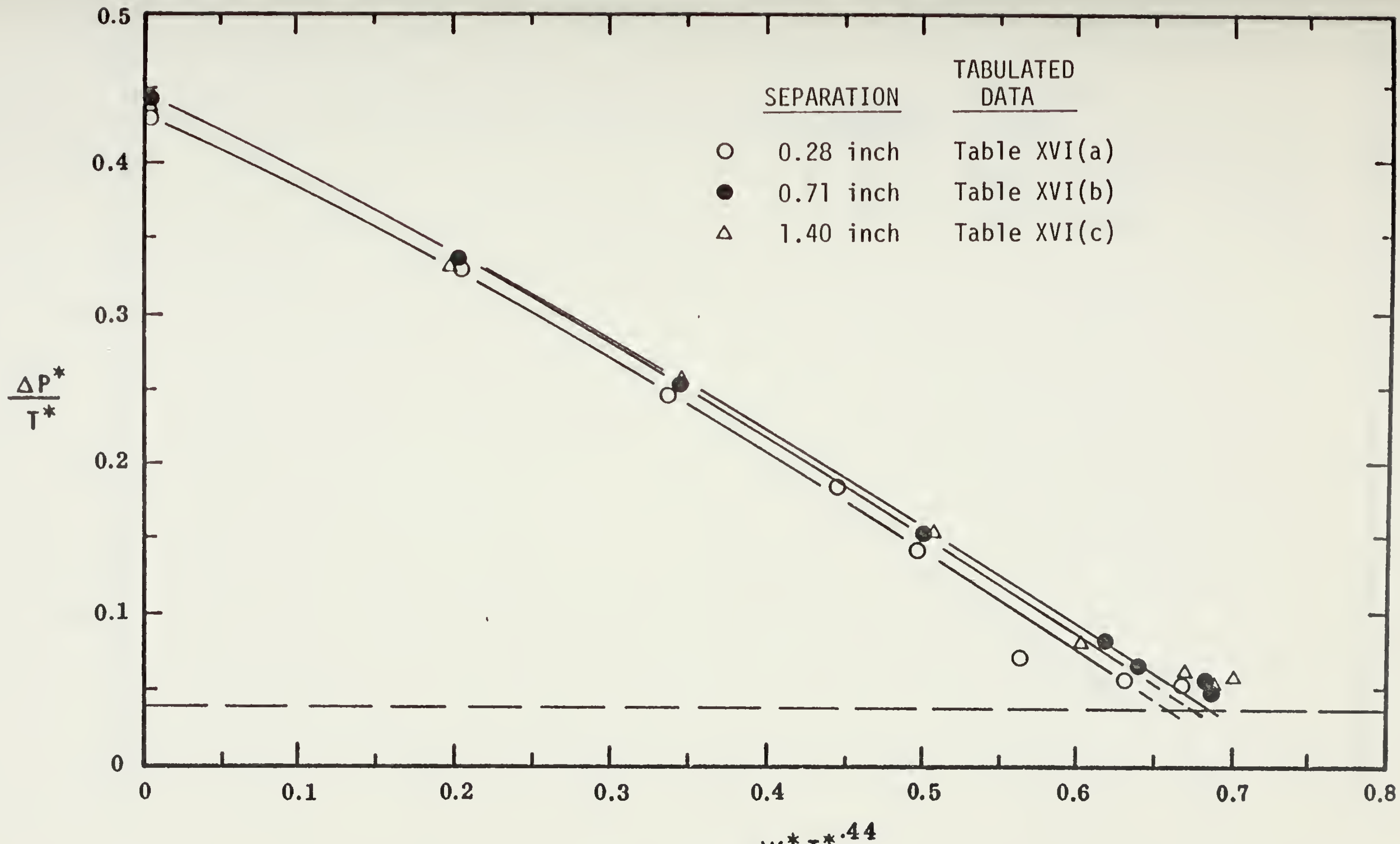
(c) Five Primary Nozzles

FIGURE 28. Continued.



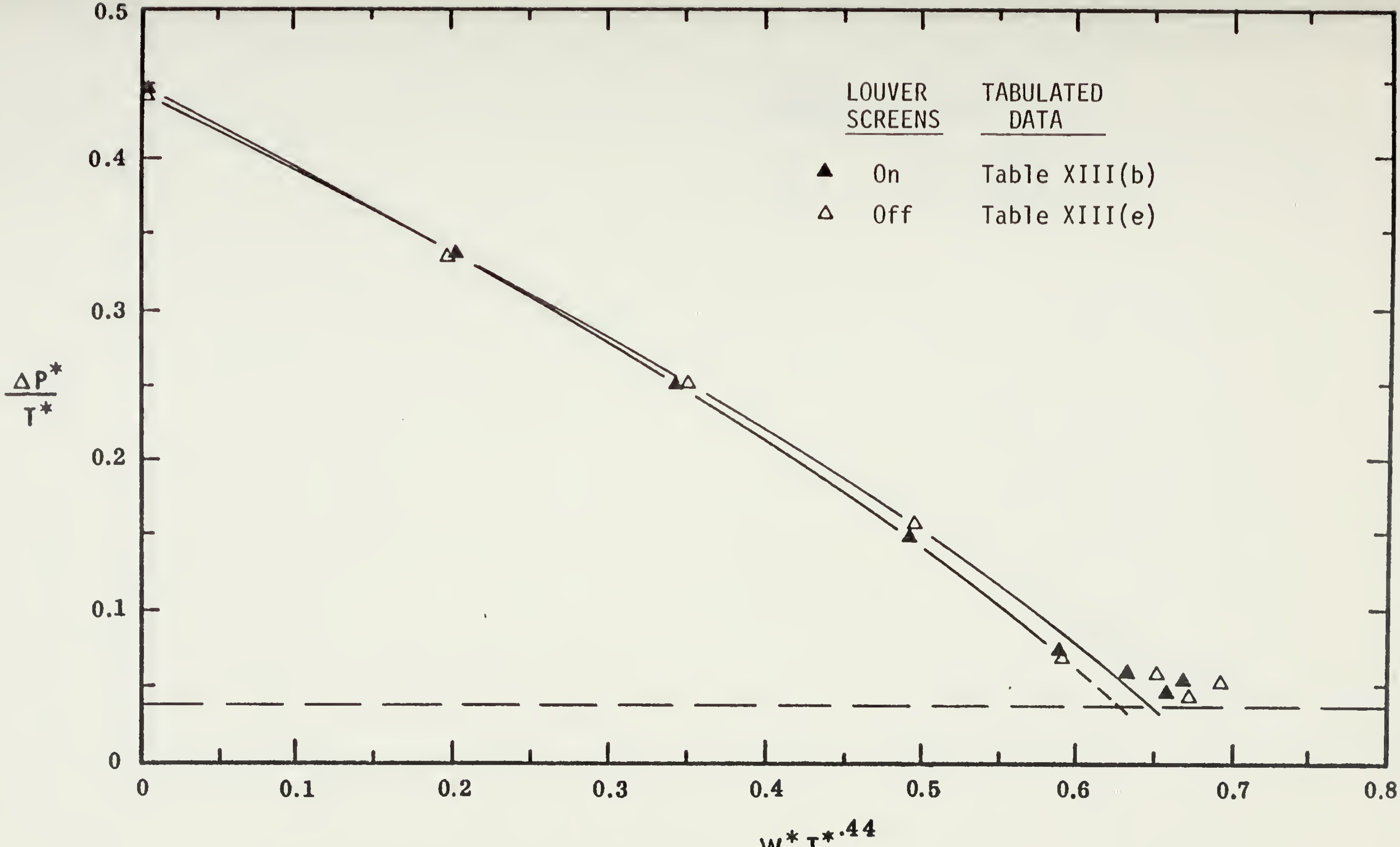
(a) Four Primary Nozzles

FIGURE 29. Effect of Primary Nozzle to Mixing Stack Separation on Performance of Eductor Proposal B.



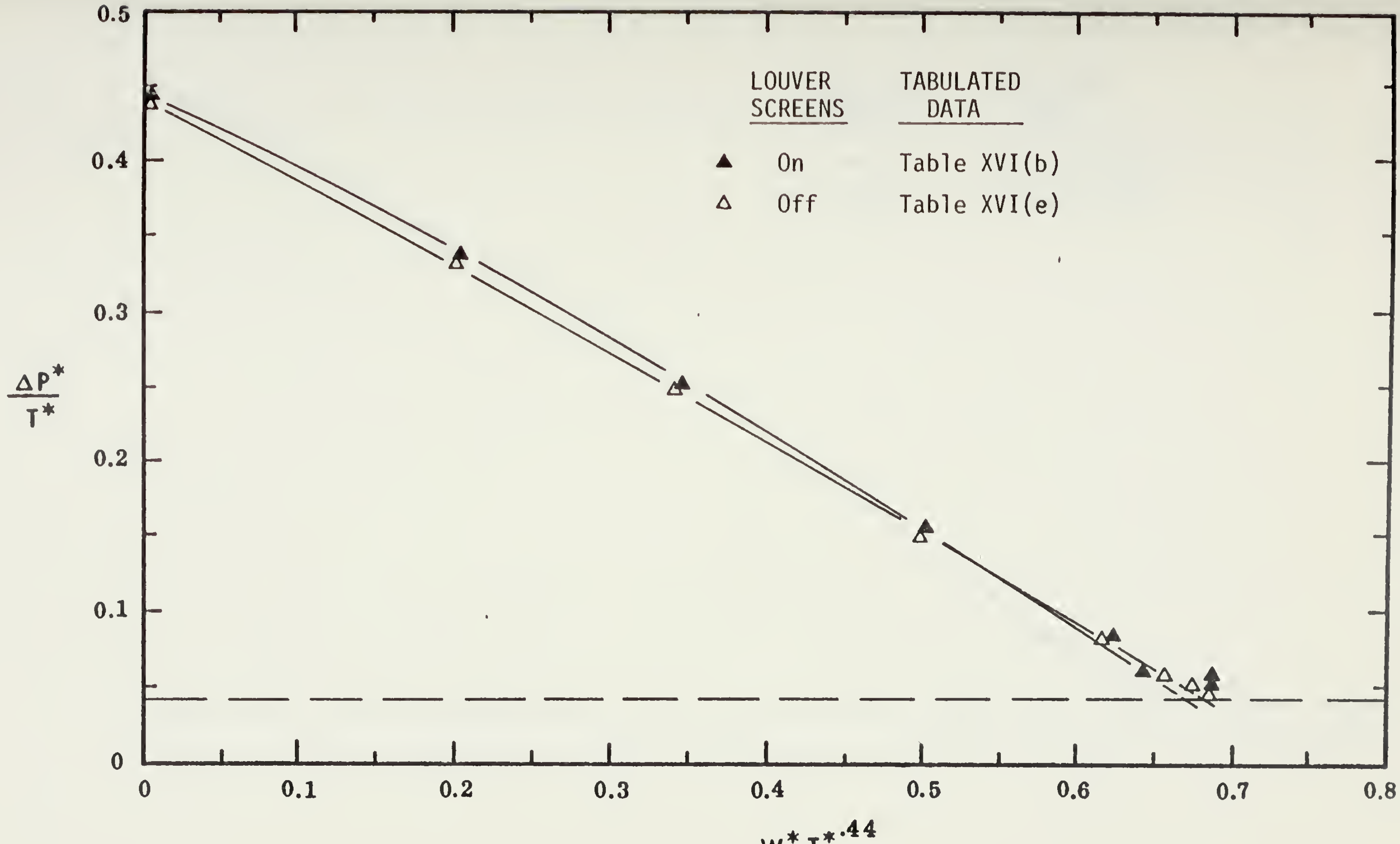
(b) Five Primary Nozzles

FIGURE 29. Continued.



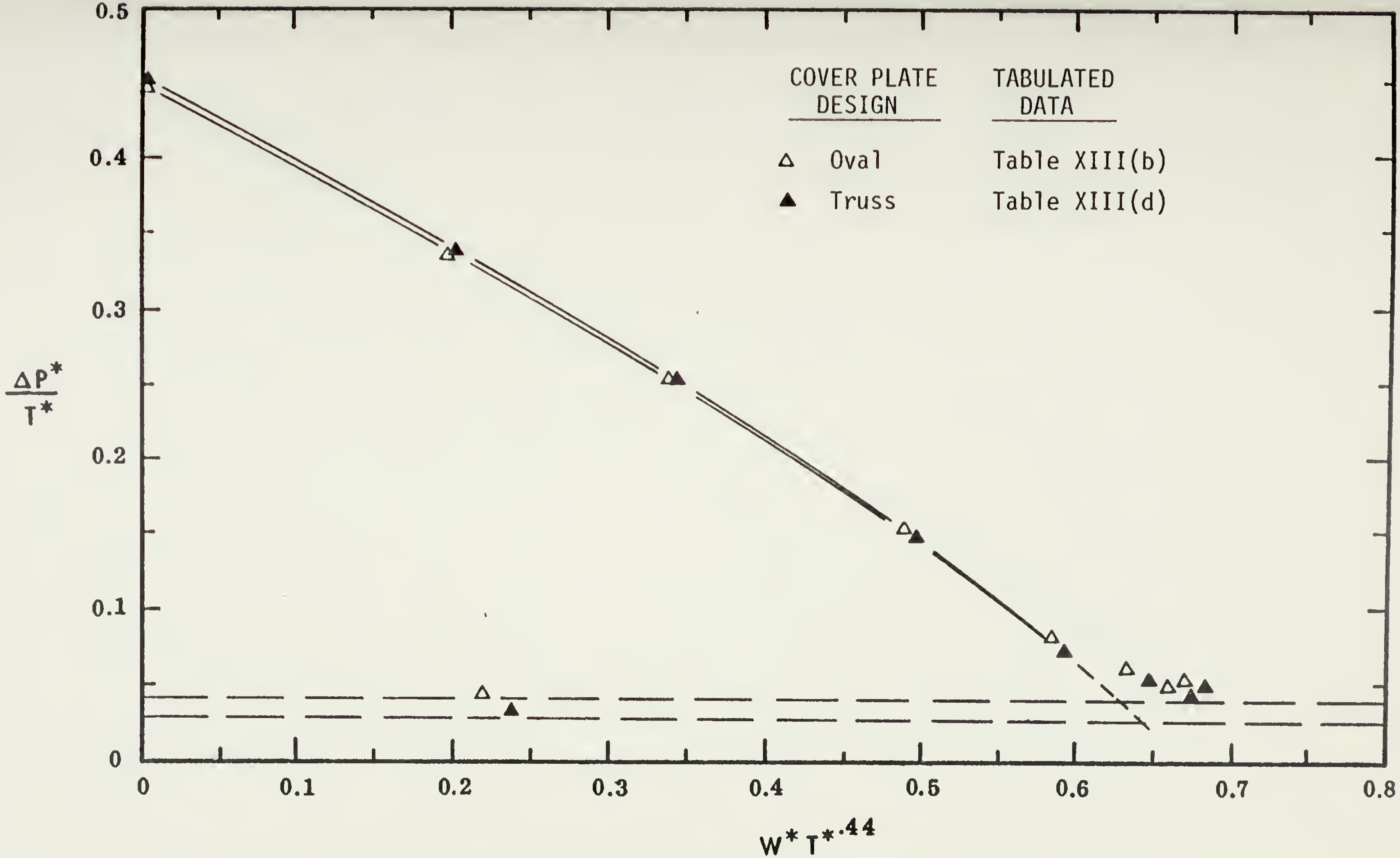
(a) Four Primary Nozzles

FIGURE 30. Effect of Secondary Air Flow Restriction (Louvered Openings) on Performance of Eductor Proposal B.



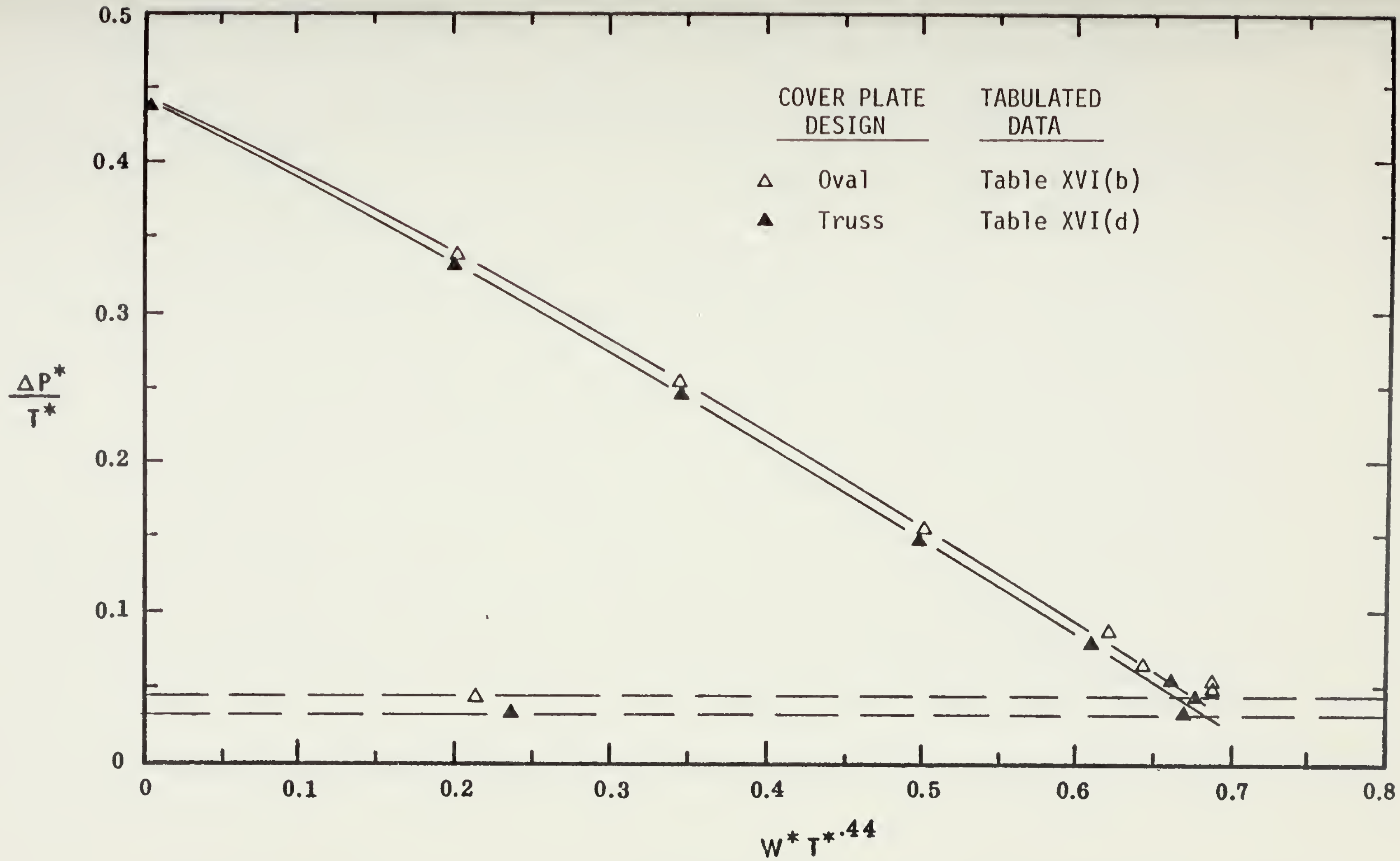
(b) Five Primary Nozzles

FIGURE 30. Continued.



(a) Four Primary Nozzles

FIGURE 31. Effect of Secondary Air Flow Restriction (Cover Plate Design) on Performance of Eductor Proposal B.



(b) Five Primary Nozzles

FIGURE 31. Continued.

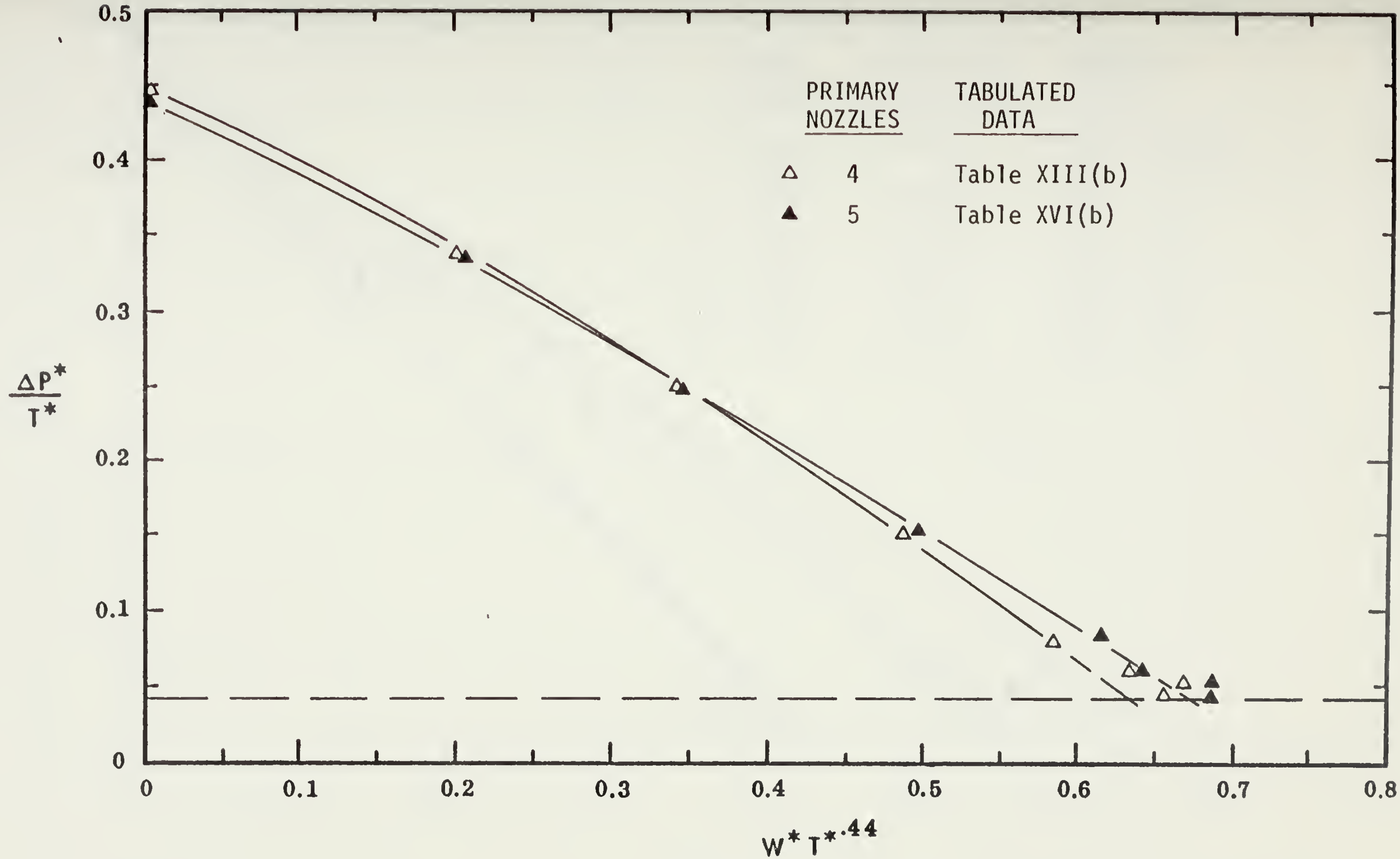


FIGURE 32. Effect of the Number of Primary Nozzles on Performance of Eductor Proposal B.

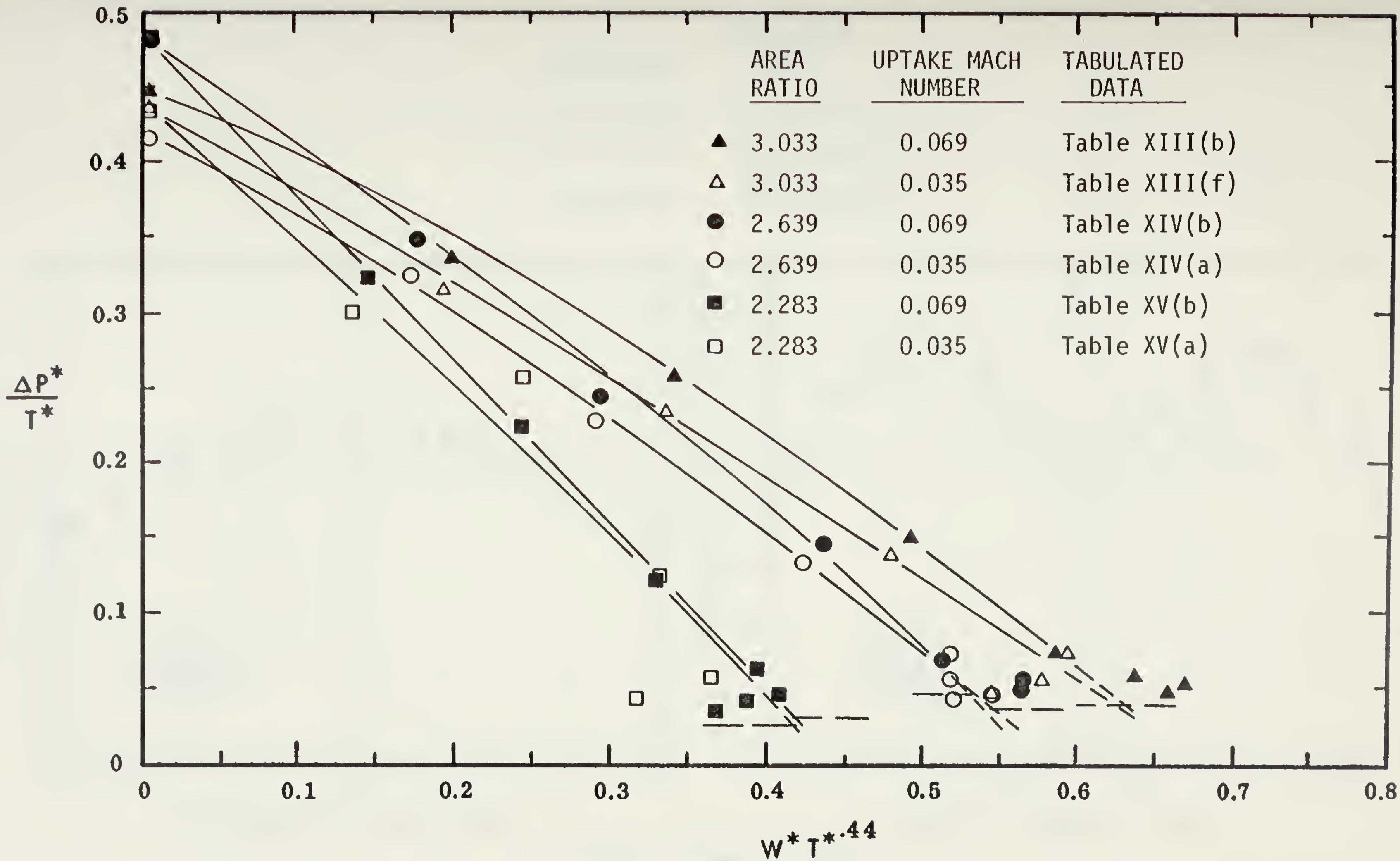
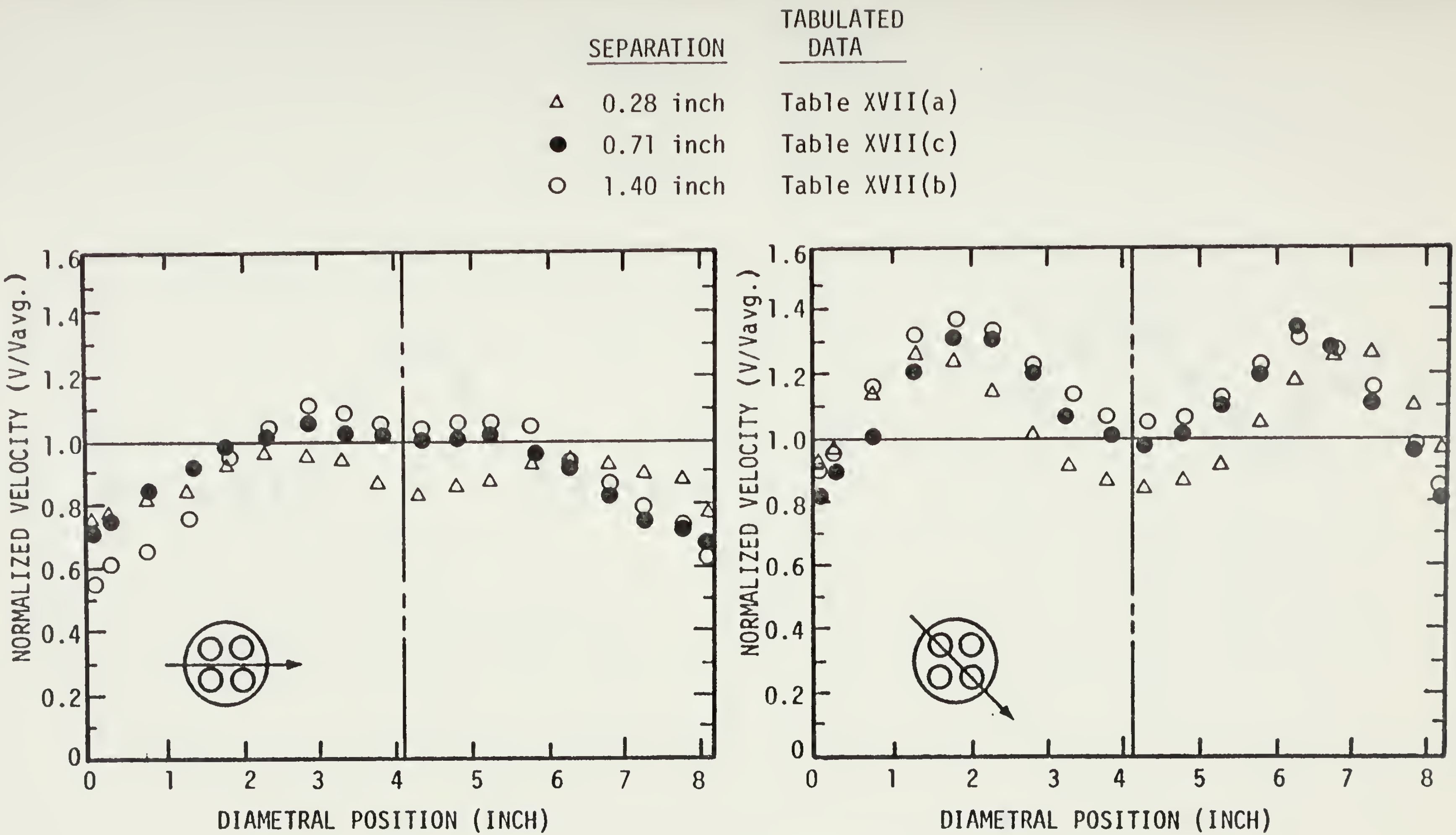
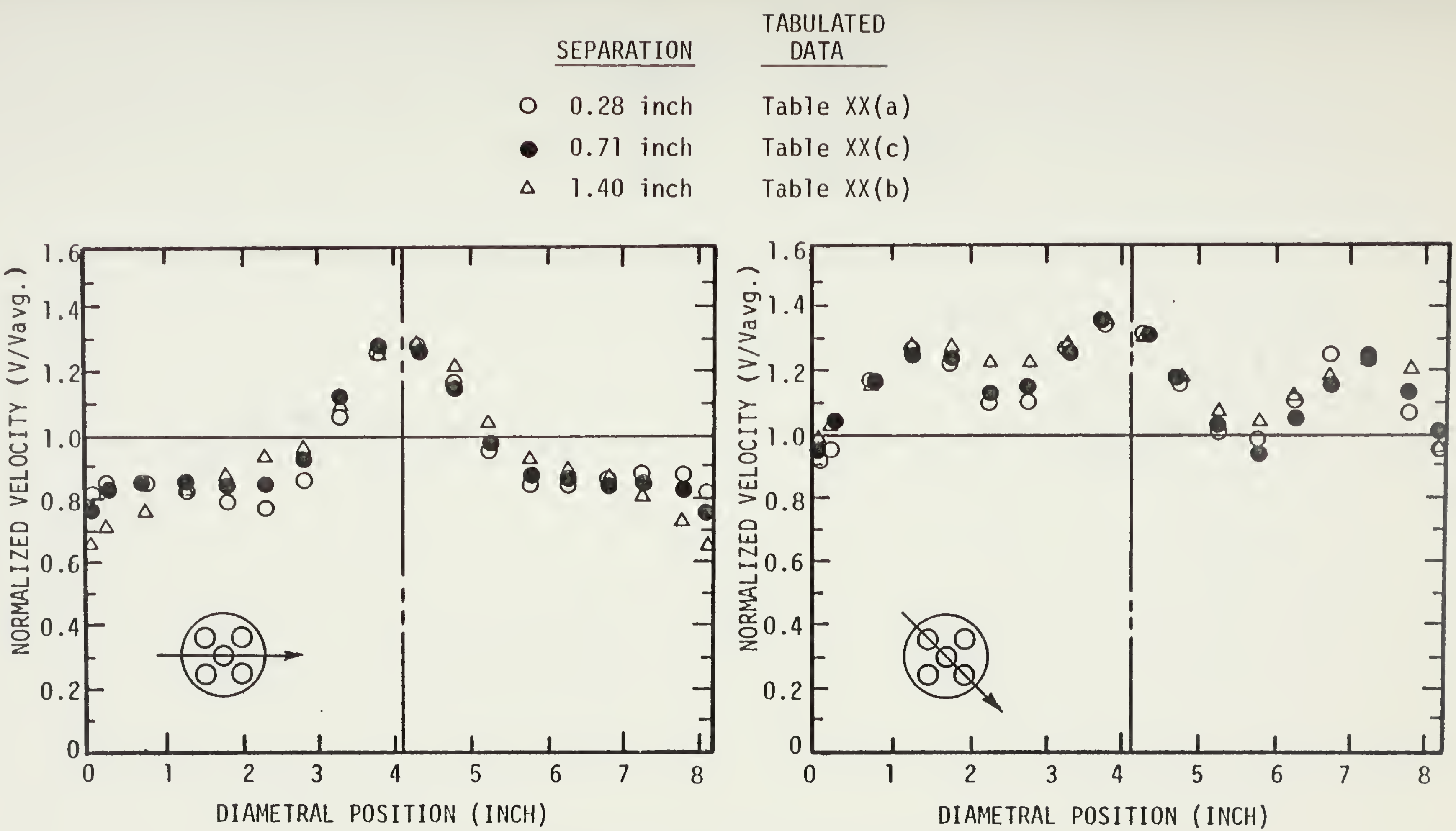


FIGURE 33. Effect of the Ratio of Mixing Stack Area to Primary Nozzle Area on Performance of the Four Nozzle Configuration of Eductor Proposal B.



(a) Four Primary Nozzles

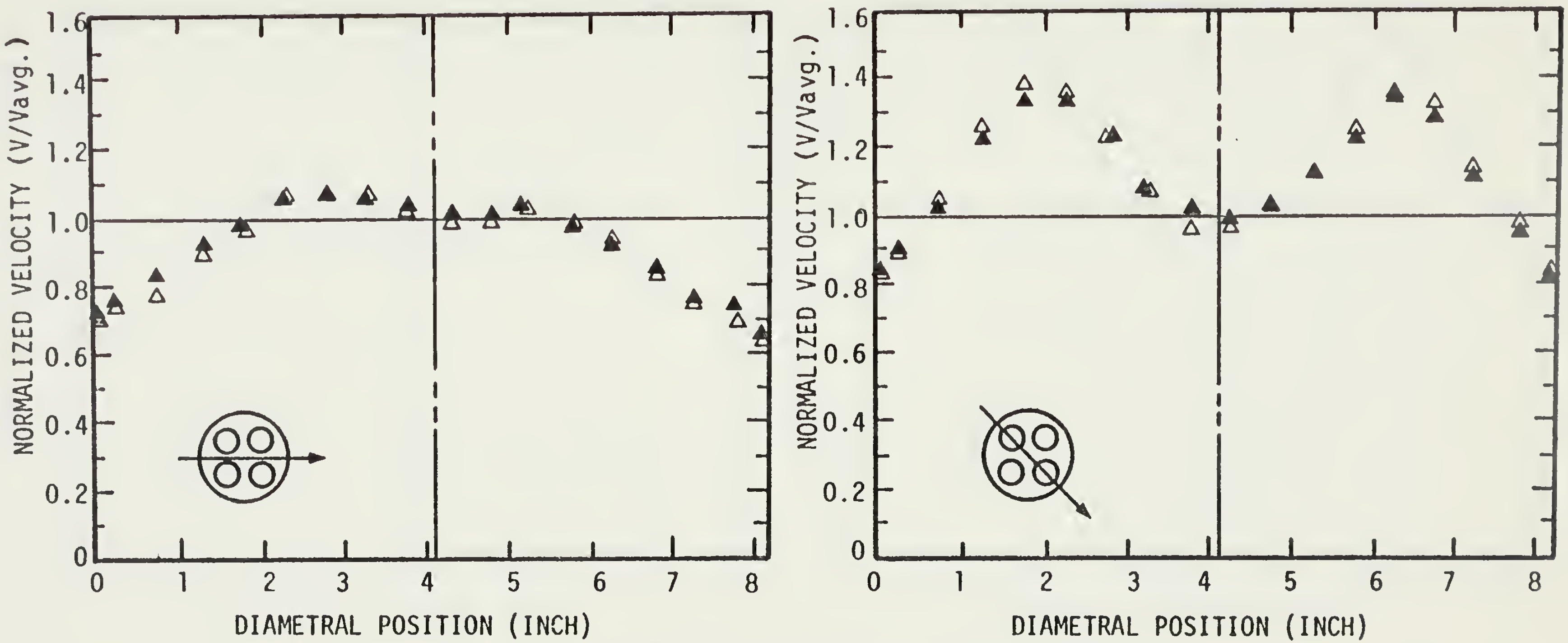
FIGURE 34. Effect of Mixing Stack to Primary Nozzle Separation on Normalized Mixing Stack Exit Velocity Profiles for Eductor Proposal B.



(b) Five Primary Nozzles

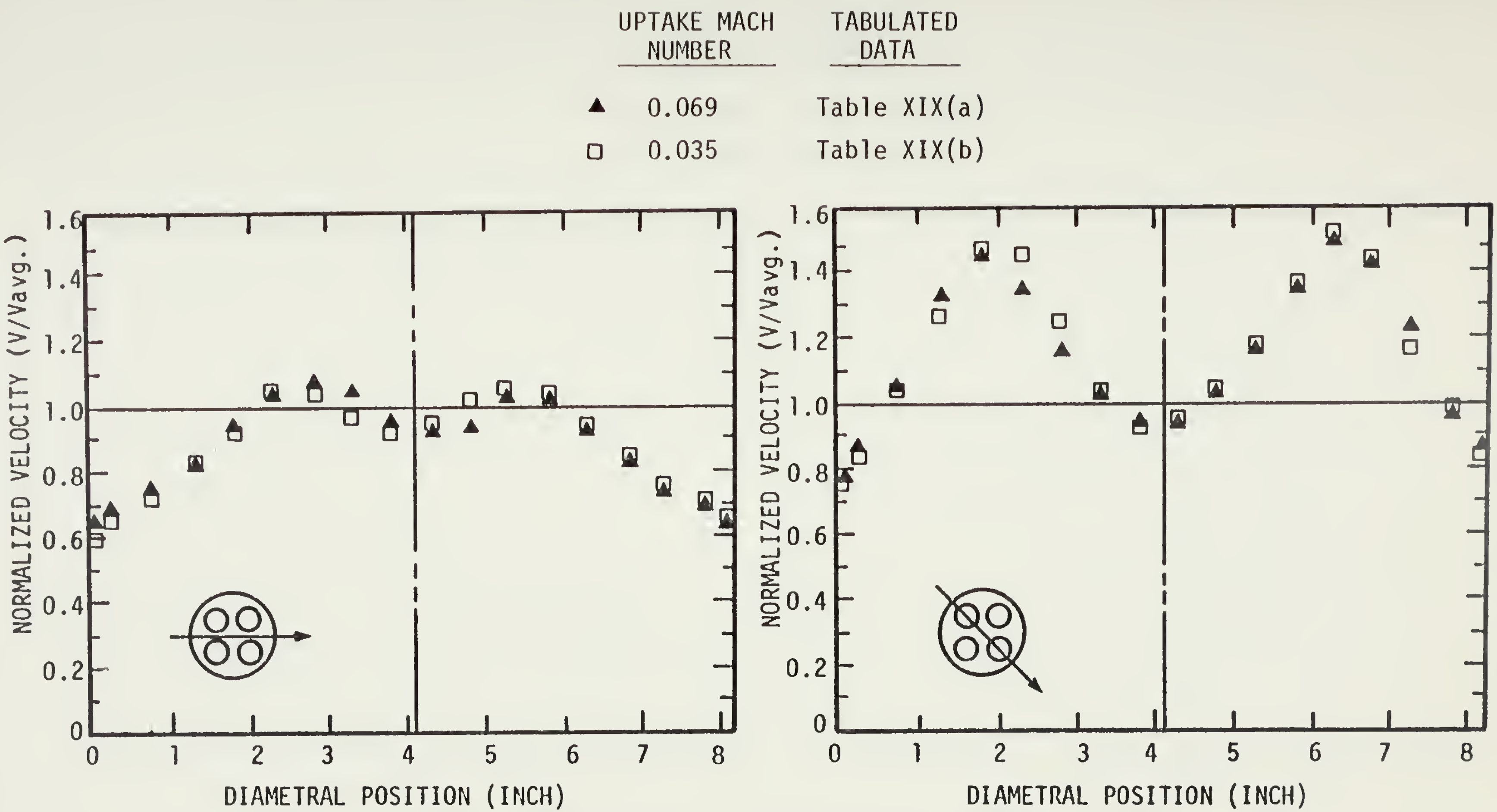
FIGURE 34. Continued.

UPTAKE MACH NUMBER		TABULATED DATA
▲	0.069	Table XVII(c)
△	0.035	Table XVII(d)



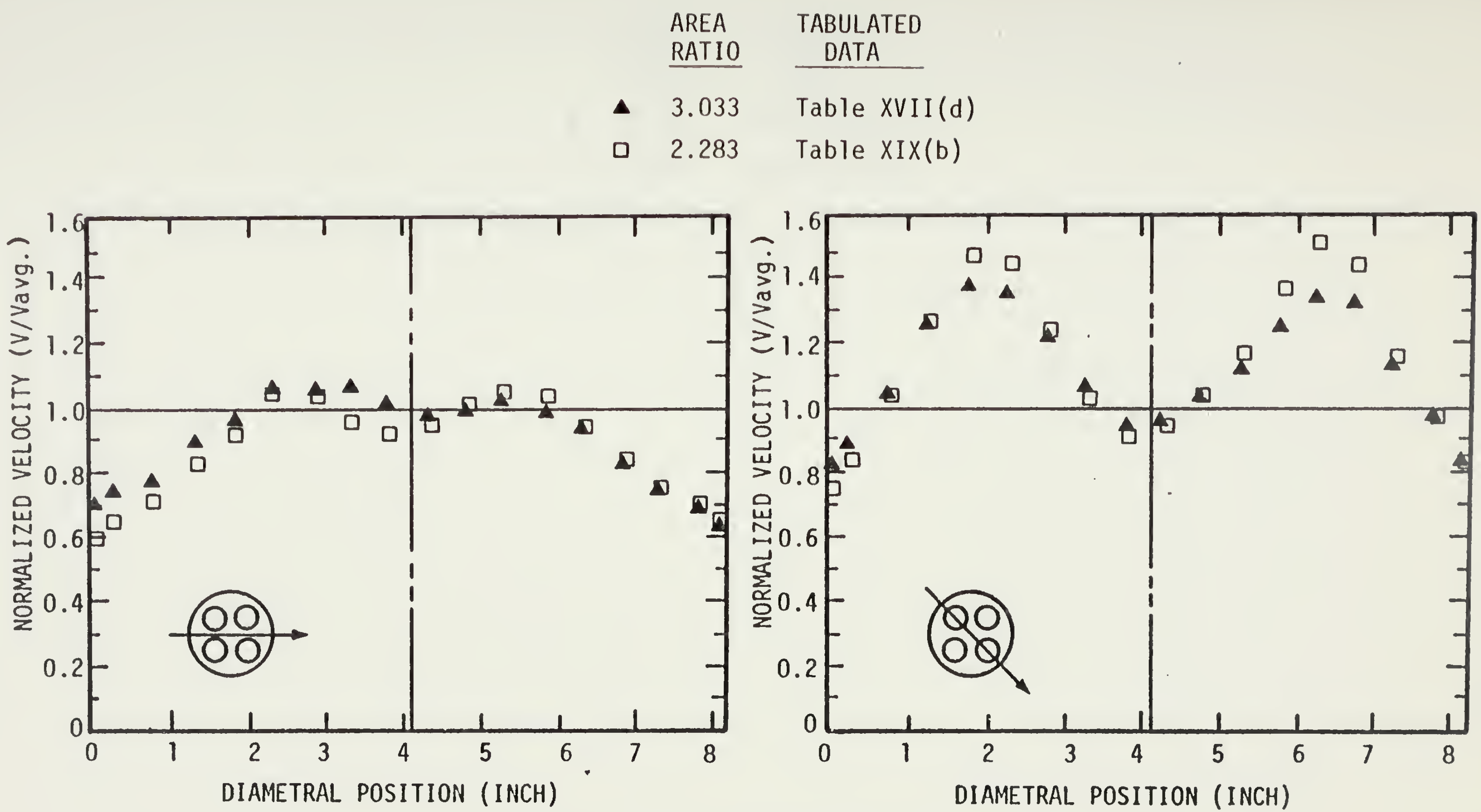
(a) Mixing Stack Area to Primary Nozzle Area Ratio of 3.033.

FIGURE 35. Effect of Uptake Mach Number on Normalized Mixing Stack Exit Velocity Profiles for Eductor Proposal B.



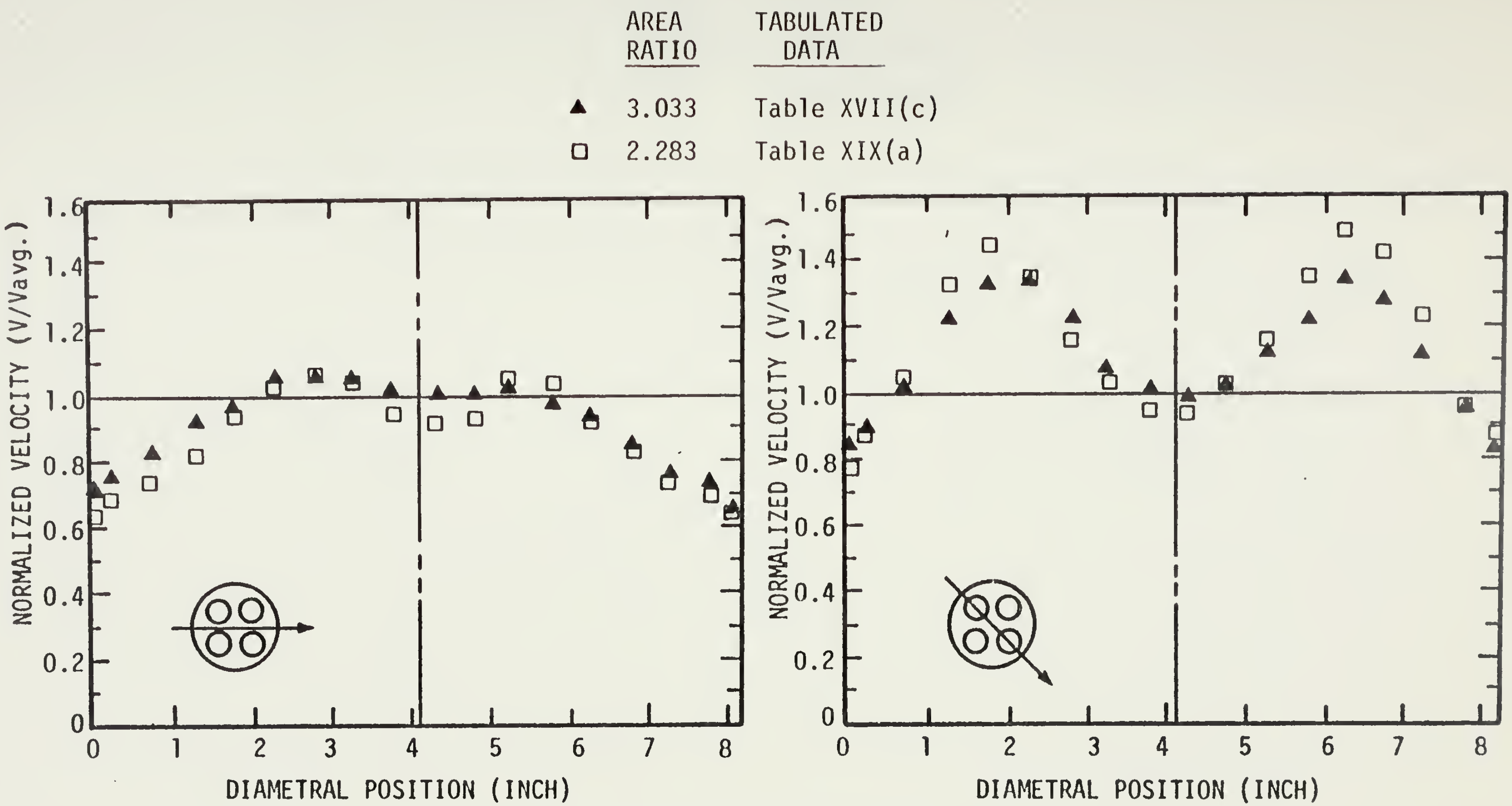
(b) Mixing Stack Area to Primary Nozzle Area Ratio of 2.283.

FIGURE 35. Continued.



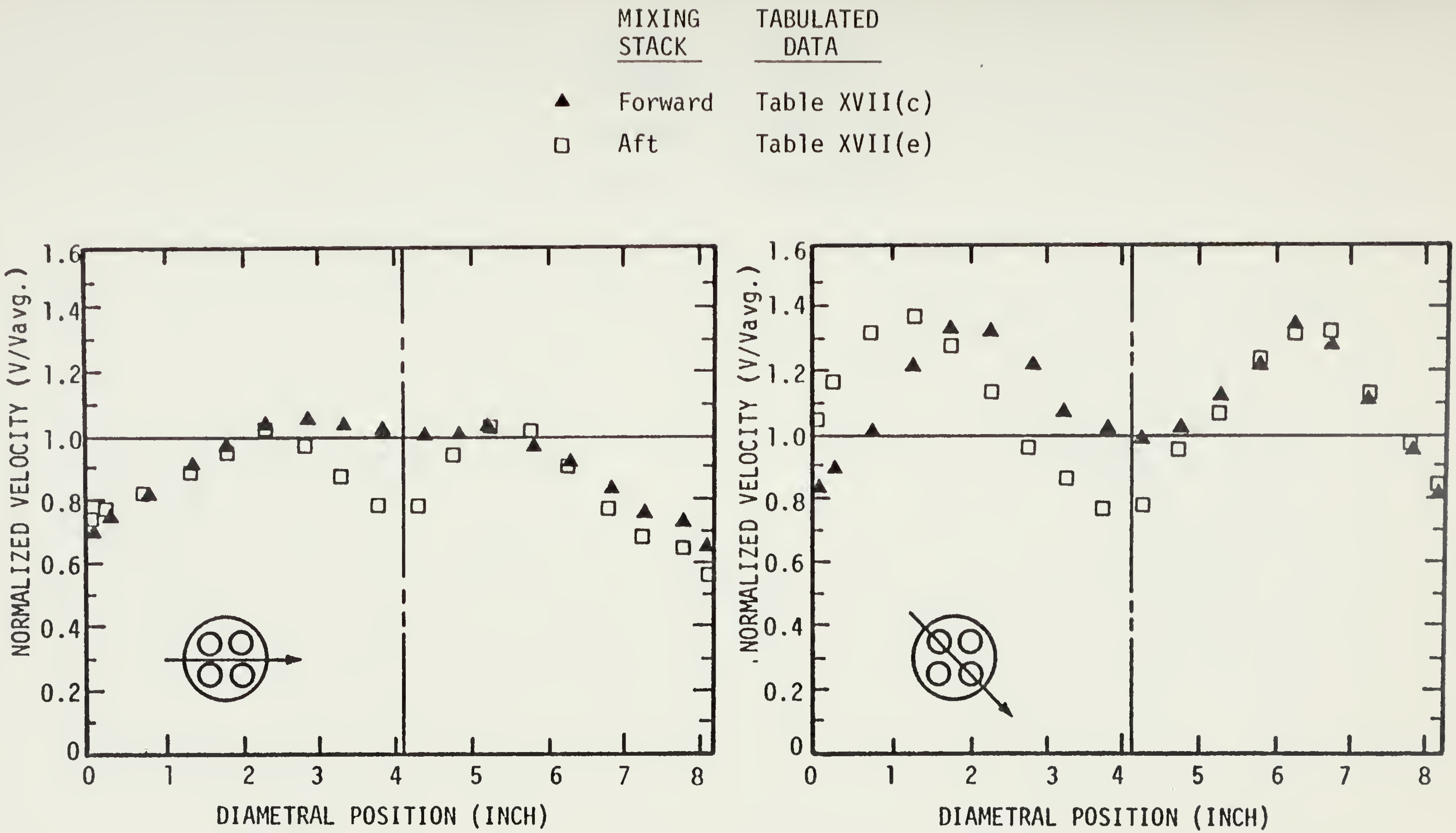
(a) Uptake Mach Number of 0.035

FIGURE 36. Effect of the Ratio of Mixing Stack Area to Primary Nozzle Area on Normalized Mixing Stack Exit Velocity Profiles for Eductor Proposal B.



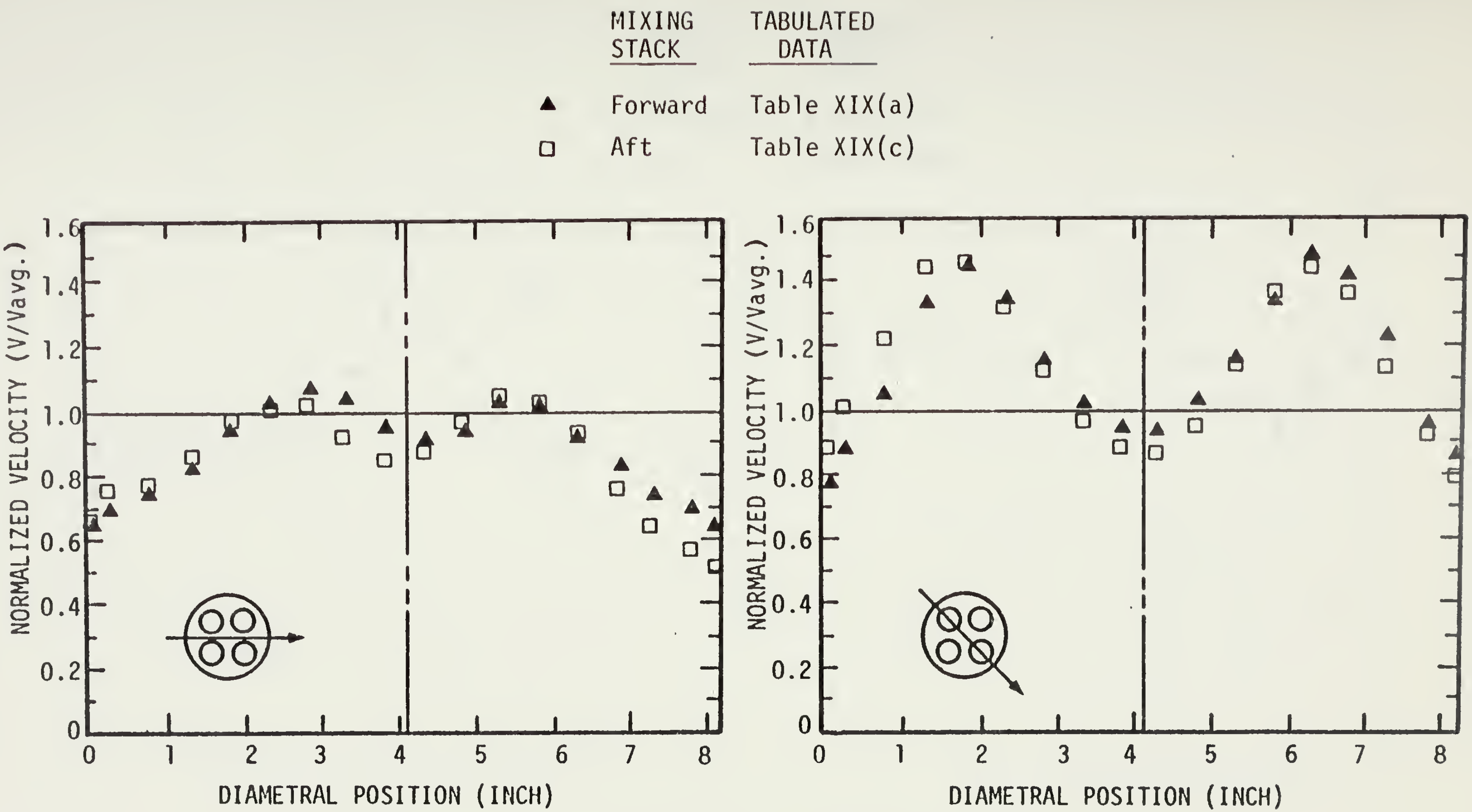
(b) Uptake Mach Number of 0.069

FIGURE 36. Continued.



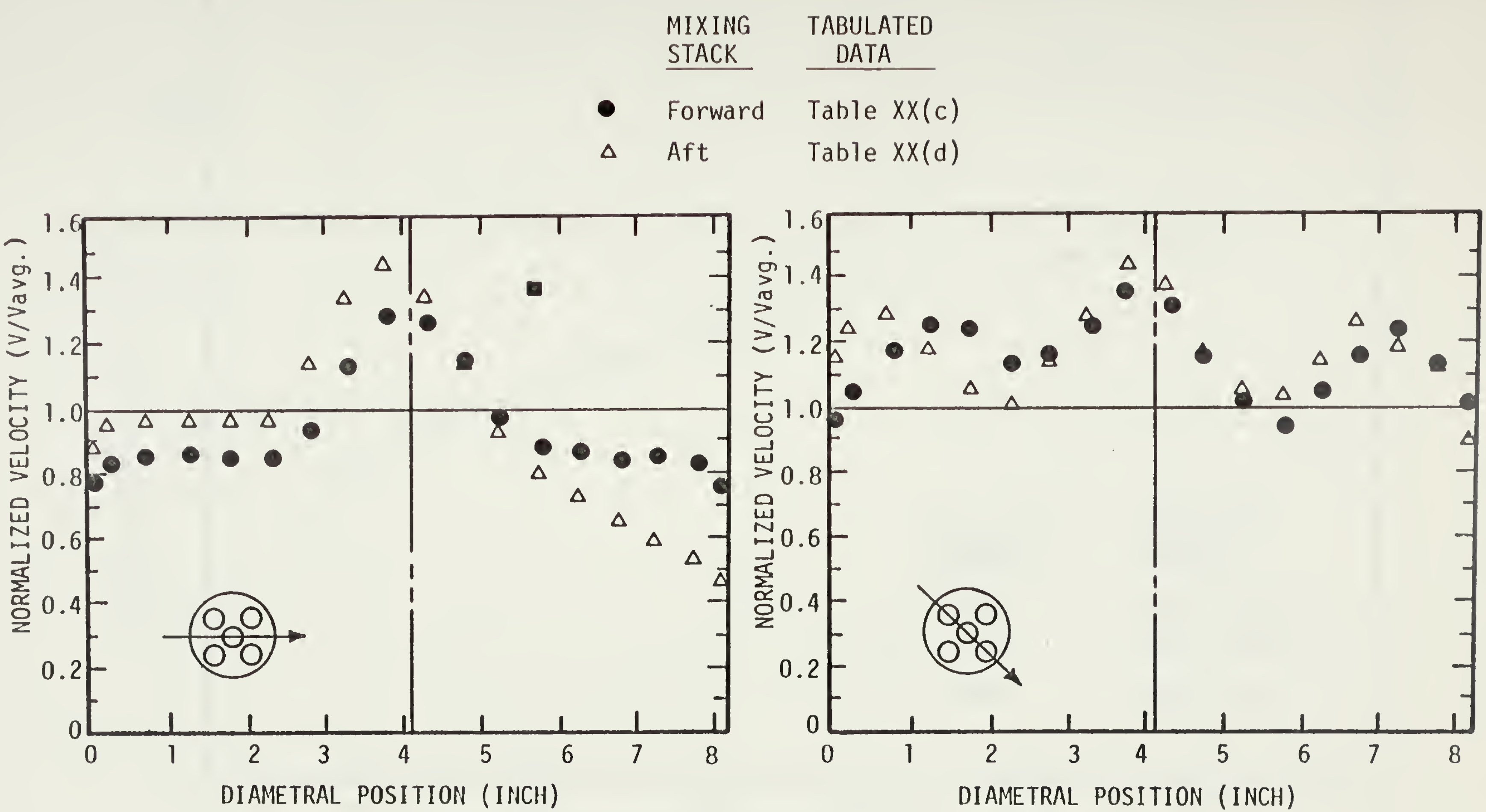
(a) Four Primary Nozzles with an Area Ratio of 3.033

FIGURE 37. Comparison of Normalized Mixing Stack Exit Velocity Profiles for Forward and Aft Mixing Stacks of Eductor Proposal B.



(b) Four Primary Nozzles with an Area Ratio of 2.283

FIGURE 37. Continued.



(c) Five Primary Nozzles with an Area Ratio of 3.033

FIGURE 37. Continued.

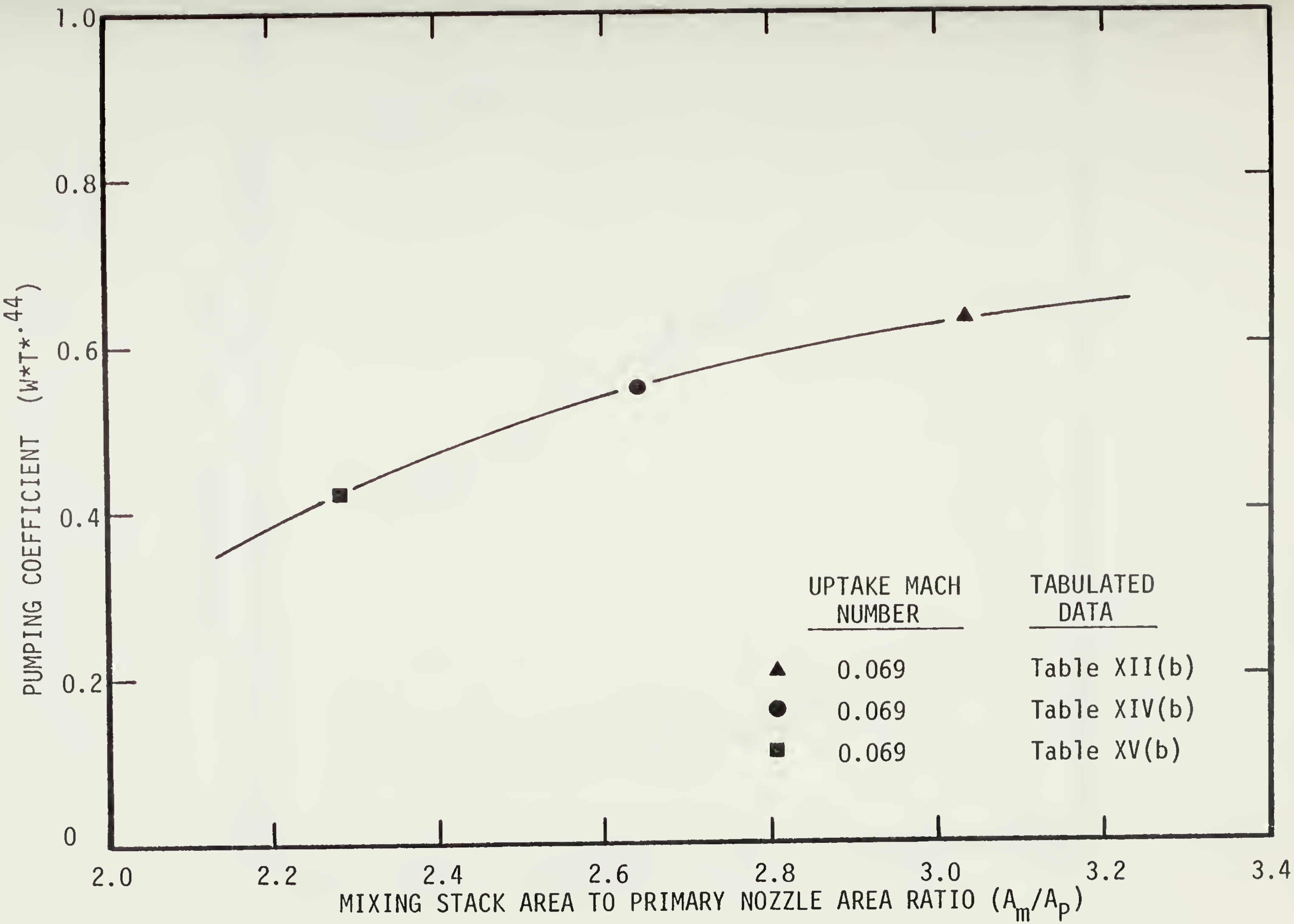


FIGURE 38. Pumping Coefficient Versus Mixing Stack Area to Primary Nozzle Area Ratio for Eductor Proposal B.

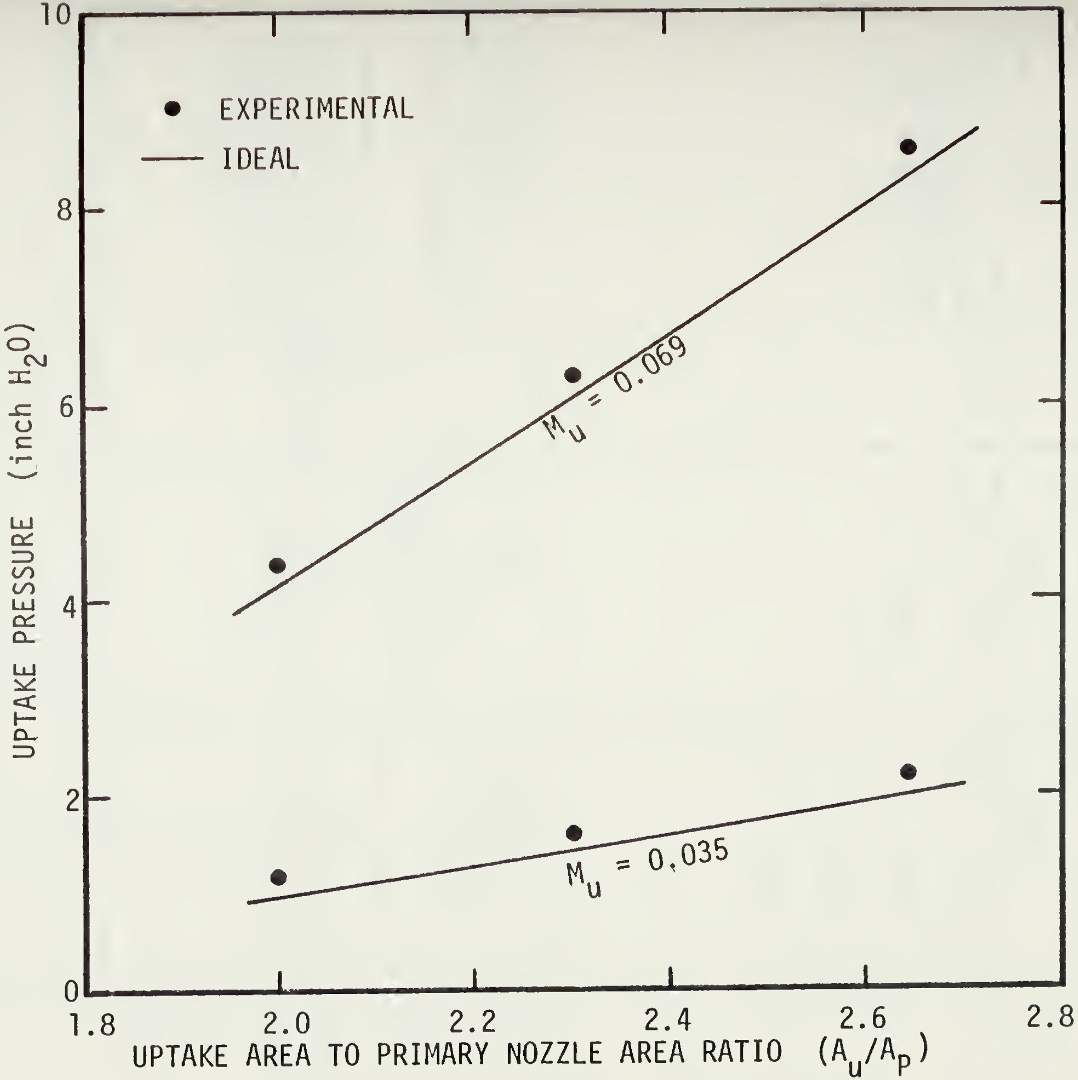


FIGURE 39. Ideal and Experimental Uptake Pressure Versus the Ratio of Uptake Area to Primary Nozzle Area Ratio for Eductor Proposal B.

MODEL / QUANTITY	EXISTING EDUCTOR	EDUCTOR PROPOSAL A	EDUCTOR PROPOSAL B
Mixing Stack Dia. D_m	7.25" (4.5')	11.7" (7.8')	8.22" (7.4')
Mixing Stack Length, L_m	20.6" (13')	26.4" (18')	20.1" (18')
Mixing Stack L_m/D_m	2.8	2.3	2.4
Area Ratio AR = A_m/A_p	3.01	3.00	3.03,2.64,2.28
Primary Nozzles Per Mixing Stack and Nozzle Dia., D_p	AR = 3.01 4 - 2.09"	AR = 3.00 5 - 3.00" 4 - 3.38" 3 - 3.90"	AR = 3.033 5 - 2.10" 4 - 2.36" AR = 2.639 4 - 2.53" AR = 2.283 4 - 2.72"
Scale Factor	7.576	8.174	10.76
Uptake Dimensions	5.8"x18.5" (3.65'x11.65')	11.5" dia.	7.86" dia (7.04' dia)
Area Ratio, AR = A_u/A_p	2.61	2,94	2.65,2.30,1.99
Nozzle-Mixing Stack Separation	0.79"(6.0")	0.75"(6.0")	0.28"(3.0") 0.71"(7.68") 1.40"(15.0")

TABLE I. Dimensional Data Pertaining to Eductor Models. (Parentheses indicate prototype dimensions)

MODEL / PARAMETRIC VARIABLES	EXISTING EDUCTOR	EDUCTOR PROPOSAL A	EDUCTOR PROPOSAL B
Uptake Mach Number	0.032 0.062 0.090	0.032 0.062 0.090	0.035 0.069
Number of Primary Nozzles (Per Mixing Stack)	N.A.	3, 4, 5	4, 5
Primary Nozzle Length (Short = Scaled Length) (Long = Twice Scaled Length)	N.A.	3-Nozzle Case: Short and Long	N.A.
Separation (Between Primary Nozzle Exit and Mixing Stack Entrance)	N.A.	N.A.	0.28" 0.71" 1.40"
Secondary Flow Restriction (Louvers/No Louvers)	N.A.	Louvers Closed and Louvers Open	N.A.
Area Ratio (Mixing Stack to Primary Nozzle)	N.A.	N.A.	3.033 2.639 2.283

TABLE II. Parameter Variations Associated with each Model.

	PRIMARY NOZZLES PER MIXING STACK	AREA RATIO A_m/A_p	d_p	D_u	R
EXISTING EDUCTOR	4	3.01	2.04"	N.A.	2.375"
EDUCTOR PROPOSAL A	3	3.000	3.90"	11.5"	3.125"
	4	2.996	3.38"	11.5"	3.40"
	5	3.042	3.00"	11.5"	3.70"
EDUCTOR PROPOSAL B	4	3.033	2.36"	7.86"	2.32"
		2.639	2.53"	7.86"	2.32"
		2.283	2.72"	7.86"	2.32"
	5	3.033	2.10"	7.86"	2.53"

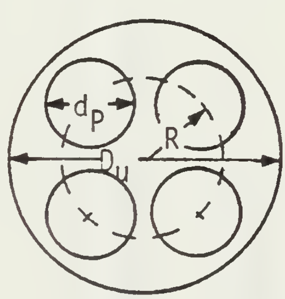


TABLE III. Layout of Primary Nozzles.

PERFORMANCE / PARAMETRIC VARIABLE	PUMPING (based on $W*T*^{.44}$)	MIXING (based on comparison of K_m)
UPTAKE MACH NUMBER	No Effect	No Effect
NUMBER OF PRIMARY NOZZLES	Increases with increase in number of primary nozzles	Improves with increase in number of primary nozzles Most significant improvement in going from 3 to 4 nozzles
PRIMARY NOZZLE LENGTH	Decreases with increase in nozzle length	Improves with increased nozzle length
SEPARATION	Increases with increased separation	Decreases with increased separation
SECONDARY FLOW RESTRICTION	Increases with increased louver area	No Effect
AREA RATIO (A_m/A_p)	Decreases sharply with decrease in area ratio	Decreases slightly with decrease in area ratio

TABLE IV. Summary of Effects of Parameter Variation on Eductor Performance.

		UPTAKE MACH NUMBERS		
		0.0316	0.0623	0.0897
Pumping Coefficient		0.65 Figure 21	0.64 Figure 21	0.64 Figure 21
Momentum Correction Factor	FWD Stack	1.020 Table X(a)	1.013 Table X(b)	1.010 Table X(c)
	CTR Stack	1.029 Table X(d)	1.023 Table X(e)	1.017 Table X(f)
	AFT Stack	1.033 Table X(g)	1.025 Table X(h)	1.028 Table X(i)

TABLE V. Summary of Pumping Coefficients and Momentum Correction Factors Corresponding to Operating Points of the Existing Eductor.

	LOUVER OPENINGS	PUMPING COEFFICIENT			Momentum Correction Factor
		UPTAKE MACH NUMBER (REPRESENTATIVE)			
		0.032	0.062	0.090	0.062
3 PRIMARY NOZZLES (long)	OPEN (screens on)		.56 Figure 25		1.087 Table XII(a)
	CLOSED				1.115 Table XII(b)
3 PRIMARY NOZZLES (short)	OPEN (screens on)		.58 Figure 23		1.104 Table XII(c)
	CLOSED		.54 Figure 24(a)		1.069 Table XII(d)
4 PRIMARY NOZZLES	OPEN (screens on)	.60 Figure 26(a)	.60 Figure 23	.60 Figure 26(a)	1.024 Table XII(e)
	CLOSED		.53 Figure 24(b)		1.019 Table XII(f)
5 PRIMARY NOZZLES	OPEN (screens on)	.65 Figure 26(b)	.61 Figure 23	.63 Figure 26(b)	1.009 Table XII(g)
	CLOSED		.56 Figure 24(c)		1.009 Table XII(h)

TABLE VI. Summary of Pumping Coefficients and Momentum Correction Factors Corresponding to Operating Points of Eductor Proposal A

		COVER-PLATE USED	SCREENS OVER LOUVER OPENINGS	AREA RATIO (A_m/A_p)				
				3.033			2.639	2.283
				SEPARATION				
				0.28"	0.71"	1.40"	0.71"	0.71"
UPTAKE MACH NUMBER (REPRESENTATIVE) 0.069	4 PRIMARY NOZZLES	OVAL	ON	.63 Figure 29(a)	.63 Figure 29(a)	.64 Figure 29(a)	.55 Figure 33	.42 Figure 33
		TRUSS	ON		.635 Figure 31(a)			
		OVAL	OFF		.64 Figure 30(a)			
	5 PRIMARY NOZZLES	OVAL	ON	.66 Figure 29(b)	.67 Figure 29(b)	.68 Figure 29(b)		
		TRUSS	ON		.68 Figure 31(b)			
		OVAL	OFF		.68 Figure 30(b)			

TABLE VII. Summary of Pumping Coefficients Corresponding to Operating Points of Eductor Proposal B

		AREA RATIO A_m/A_p							
		3.033				2.639		2.283	
		SEPARATION							
		0.28"	0.71"		1.40"	0.71"		0.71"	
		UPTAKE MACH NUMBER (REPRESENTATIVE)							
		0.069	0.069	0.035	0.069	0.069	0.035	0.069	0.035
4 NOZZLES	FWD STACK	1.016 Table XVII(a)	1.026 Table XVII(c)	1.031 Table XVII(d)	1.036 Table XVII(b)	1.033 Table XVIII(a)	1.037 Table XVIII(b)	1.041 Table XIX(a)	1.047 Table XIX(b)
	AFT STACK		1.029 Table XVII(e)	1.034 Table XVII(f)		1.040 Table XVIII(c)	1.045 Table XVIII(d)	1.044 Table XIX(c)	1.051 Table XIX(d)
5 NOZZLES	FWD STACK	1.015 Table XX(a)	1.015 Table XX(c)		1.023 Table XX(b)				
	AFT STACK		1.033 Table XX(d)						

TABLE VIII. Summary of Momentum Correction Factors Corresponding to Operating Points of Eductor Proposal B

DATA TAKEN ON 10 NOVEMBER 1976
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 12
PRIMARY NOZZLE DIAMETER = 2.090 INCHES
MIXING STACK DIAMETER = 7.250 INCHES
MIXING STACK LENGTH = 20.600 INCHES
MIXING STACK L/D = 2.841
UPTAKE DIAMETER = 11.700 INCHES
AREA RATIO, AM/AP = 3.008

PRIMARY FLOW RATE = 1.852 LBM/SEC
= 26.995 CFS
ORIFICE PRESSURE DROP = 5.4 IN.H2O
ORIFICE STATIC PRESSURE = 0.18 IN.H2O
ORIFICE TEMPERATURE = 63.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 123.0 DEG.FAHR
AMBIENT PRESSURE = 30.056 IN.HGA
AMBIENT TEMPERATURE = 77.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9219

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4062	0.4406	0.0	1.852	0.0	1.25	0.80	94.42	31.39	36.16	0.0306	0.	0.80
2	0.1796	0.3084	0.3346	0.1733	1.852	0.333	1.41	0.61	94.39	36.56	36.14	0.0305	4.	0.61
3	0.3157	0.2385	0.2587	0.3046	1.852	0.585	1.52	0.47	94.36	40.49	36.13	0.0305	8.	0.47
4	0.4141	0.1965	0.2131	0.3996	1.852	0.767	1.61	0.39	94.34	43.33	36.12	0.0305	12.	0.36
5	0.4843	0.1544	0.1675	0.4673	1.852	0.897	1.66	0.30	94.33	45.35	36.12	0.0305	16.	0.28
6	0.5627	0.0983	0.1066	0.5429	1.852	1.042	1.74	0.19	94.31	47.62	36.11	0.0305	24.	0.17
7	0.6126	0.0702	0.0762	0.5911	1.852	1.135	1.77	0.14	94.30	49.06	36.11	0.0305	32.	0.11
8	0.6497	0.0421	0.0457	0.6269	1.852	1.203	1.80	0.08	94.30	50.13	36.11	0.0305	48.	0.06
9	0.6425	0.0323	0.0350	0.6199	1.852	1.190	1.80	0.06	94.30	49.92	36.11	0.0305	64.	0.03
10	0.7562	0.0211	0.0229	0.7296	1.852	1.400	1.83	0.04	94.29	53.21	36.11	0.0305	79.	0.03
11	********	0.0011	0.0012	********	1.835	*******	1.82	0.00	93.42	********	35.77	0.0302	******	0.0
12	********	0.0146	0.0159	********	1.921	*******	2.05	0.03	97.75	********	37.43	0.0316	******	0.0

(a) Uptake Mach Number of 0.0316.

Table IX. Tabulated Performance Data for the Existing Eductor.

DATA TAKEN ON 10NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 12

PRIMARY NOZZLE DIAMETER = 2.090 INCHES

MIXING STACK DIAMETER = 7.250 INCHES

MIXING STACK LENGTH = 20.600 INCHES

MIXING STACK L/D = 2.841

UPTAKE DIAMETER = 11.700 INCHES

AREA RATIO, AM/AP = 3.008

PRIMARY FLOW RATE = 2.862 LBM/SEC

= 41.239 CFS

ORIFICE PRESSURE DROP = 12.9 IN.H2O

ORIFICE STATIC PRESSURE = 0.42 IN.H2O

ORIFICE TEMPERATURE = 63.5 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 119.0 DEG.FAHR

AMBIENT PRESSURE = 30.056 IN.HGA

AMBIENT TEMPERATURE = 79.5 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9317

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3976	0.4268	0.0	2.862	0.0	3.10	1.83	144.25	47.95	55.23	0.0468	0.	1.85
2	0.1766	0.3078	0.3304	0.1712	2.862	0.505	3.46	1.41	144.12	55.83	55.19	0.0468	4.	1.41
3	0.3049	0.2357	0.2530	0.2956	2.862	0.873	3.77	1.08	144.01	61.56	55.14	0.0468	8.	1.05
4	0.3996	0.1815	0.1948	0.3873	2.862	1.143	3.93	0.83	143.96	65.79	55.12	0.0467	12.	0.80
5	0.4640	0.1332	0.1429	0.4498	2.862	1.328	4.07	0.61	143.91	68.67	55.10	0.0467	16.	0.61
6	0.5552	0.0909	0.0975	0.5382	2.862	1.589	4.21	0.42	143.86	72.75	55.09	0.0467	24.	0.39
7	0.5936	0.0606	0.0650	0.5754	2.862	1.699	4.29	0.28	143.83	74.47	55.07	0.0467	32.	0.25
8	0.5936	0.0364	0.0390	0.5754	2.862	1.699	4.37	0.17	143.80	74.46	55.06	0.0467	48.	0.11
9	0.5596	0.0243	0.0260	0.5425	2.862	1.601	4.40	0.11	143.79	72.93	55.06	0.0467	64.	0.06
10	0.6908	0.0243	0.0260	0.6696	2.862	1.977	4.40	0.11	143.79	78.83	55.06	0.0467	79.	0.06
11	********	0.0121	0.0130	********	2.832	*******	4.54	0.05	142.23	********	54.46	0.0462	******	0.0
12	********	0.0140	0.0150	********	2.893	*******	4.73	0.07	145.23	********	55.61	0.0472	******	0.0

(b) Uptake Mach Number of 0.0471.

Table IX. Continued.

DATA TAKEN ON 10 NOVEMBER 1976

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 12

PRIMARY NOZZLE DIAMETER = 2.090 INCHES

MIXING STACK DIAMETER = 7.250 INCHES

MIXING STACK LENGTH = 20.600 INCHES

MIXING STACK L/D = 2.841

UPTAKE DIAMETER = 11.700 INCHES

AREA RATIO, AM/AP = 3.008

PRIMARY FLOW RATE = 3.801 LBM/SEC

= 54.360 CFS

ORIFICE PRESSURE DROP = 22.9 IN.H2O

ORIFICE STATIC PRESSURE = 0.70 IN.H2O

ORIFICE TEMPERATURE = 66.5 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 118.0 DEG.FAHR

AMBIENT PRESSURE = 30.056 IN.HGA

AMBIENT TEMPERATURE = 80.5 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9351

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4099	0.4384	0.0	3.801	0.0	5.48	3.27	190.14	63.21	72.81	0.0618	0.	3.27
2	0.1764	0.3131	0.3348	0.1712	3.804	0.671	6.09	2.49	190.01	73.71	72.76	0.0618	4.	2.49
3	0.3091	0.2445	0.2615	0.3001	3.801	1.175	6.64	1.94	189.61	81.50	72.60	0.0616	8.	1.91
4	0.4063	0.1889	0.2020	0.3945	3.801	1.544	6.95	1.49	189.47	87.28	72.55	0.0616	12.	1.47
5	0.4707	0.1541	0.1648	0.4570	3.801	1.789	7.17	1.22	189.37	91.09	72.51	0.0616	16.	1.11
6	0.5582	0.0934	0.0999	0.5419	3.801	2.121	4.60	0.75	190.55	96.70	72.96	0.0619	24.	0.69
7	0.5765	0.0556	0.0638	0.5597	3.801	2.191	7.47	0.47	189.23	97.38	72.46	0.0615	32.	0.42
8	0.7060	0.0456	0.0488	0.6855	3.801	2.683	7.50	0.36	189.22	105.12	72.45	0.0615	48.	0.28
9	0.6656	0.0281	0.0300	0.6463	3.801	2.530	7.61	0.22	189.17	102.69	72.44	0.0615	64.	0.14
10	0.7349	0.0281	0.0300	0.7135	3.801	2.793	7.75	0.22	189.11	106.82	72.41	0.0615	79.	0.11
11	********	0.0114	0.0122	********	3.738	*******	7.64	0.09	186.04	********	71.24	0.0605	******	0.0
12	********	0.0131	0.0140	********	3.858	*******	8.31	0.11	191.71	********	73.41	0.0623	******	0.0

(c) Uptake Mach Number of 0.0623

Table IX. Continued.

DATA TAKEN ON 10 NOVEMBER 1976

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 12

PRIMARY NOZZLE DIAMETER = 2.090 INCHES

MIXING STACK DIAMETER = 7.250 INCHES

MIXING STACK LENGTH = 20.600 INCHES

MIXING STACK L/D = 2.841

UPTAKE DIAMETER = 11.700 INCHES

AREA RATIO, AM/AP = 3.008

PRIMARY FLOW RATE = 4.771 LBM/SEC

= 67.431 CFS

ORIFICE PRESSURE DROP = 35.9 IN.H2O

ORIFICE STATIC PRESSURE = 1.18 IN.H2O

ORIFICE TEMPERATURE = 60.0 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 112.0 DEG.FAHR

AMBIENT PRESSURE = 29.875 IN.HGA

AMBIENT TEMPERATURE = 75.0 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9353

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4182	0.4471	0.0	4.771	0.0	8.55	5.15	235.86	78.40	90.32	0.0771	0.	5.15
2	0.1757	0.3185	0.3405	0.1706	4.771	0.838	9.52	3.90	235.31	91.36	90.11	0.0769	4.	3.88
3	0.3044	0.2401	0.2568	0.2955	4.771	1.452	10.16	2.93	234.95	100.86	89.97	0.0768	8.	2.91
4	0.3993	0.1852	0.2023	0.3878	4.791	1.913	10.66	2.33	235.65	108.32	90.23	0.0770	12.	2.24
5	0.4709	0.1474	0.1576	0.4572	4.778	2.250	10.96	1.80	234.83	113.33	89.92	0.0767	16.	1.74
6	0.5557	0.0931	0.0996	0.5396	4.778	2.655	11.32	1.14	234.63	119.62	89.84	0.0767	24.	1.08
7	0.5933	0.0614	0.0657	0.5760	4.778	2.834	11.63	0.75	234.46	122.37	89.78	0.0766	32.	0.69
8	0.6417	0.0387	0.0414	0.6231	4.778	3.066	11.77	0.47	234.38	125.98	89.75	0.0766	48.	0.36
9	0.6712	0.0296	0.0317	0.6517	4.778	3.207	11.82	0.36	234.35	128.18	89.73	0.0766	64.	0.22
10	0.6550	0.0228	0.0244	0.6360	4.778	3.129	11.90	0.28	234.30	126.95	89.72	0.0766	79.	0.14
11	********	0.0114	0.0122	********	4.721	*******	11.60	0.14	231.68	********	88.72	0.0757	******	0.0
12	********	0.0122	0.0131	********	4.798	*******	12.46	0.15	234.99	********	89.98	0.0768	******	0.0

(d) Uptake Mach Number of 0.0767.

Table IX. Continued.

DATA TAKEN ON 10 NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 12
PRIMARY NOZZLE DIAMETER = 2.090 INCHES
MIXING STACK DIAMETER = 7.250 INCHES
MIXING STACK LENGTH = 20.600 INCHES
MIXING STACK L/D = 2.841
UPTAKE DIAMETER = 11.700 INCHES
AREA RATIO, AM/AP = 3.008

PRIMARY FLOW RATE = 5.651 LBM/SEC
= 78.427 CFS

ORIFICE PRESSURE DROP = 50.0 IN.H2O
ORIFICE STATIC PRESSURE = 1.50 IN.H2O
ORIFICE TEMPERATURE = 59.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 109.0 DEG.FAHR
AMBIENT PRESSURE = 30.056 IN.HGA
AMBIENT TEMPERATURE = 77.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9446

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4116	0.4357	0.0	5.651	0.0	11.49	6.87	274.32	91.19	105.04	0.0899	0.	6.87
2	0.1721	0.3172	0.3358	0.1678	5.651	0.972	12.73	5.26	273.51	106.15	104.73	0.0896	4.	5.20
3	0.3022	0.2433	0.2576	0.2947	5.651	1.708	13.81	4.01	272.81	117.44	104.46	0.0894	8.	4.01
4	0.3912	0.1481	0.1568	0.3815	5.651	2.211	14.40	2.44	272.44	125.20	104.32	0.0892	12.	2.99
5	0.4600	0.1485	0.1572	0.4486	5.651	2.600	14.95	2.44	272.08	131.17	104.18	0.0891	16.	2.33
6	0.5377	0.0930	0.0985	0.5244	5.651	3.038	15.42	1.52	271.78	137.95	104.07	0.0890	24.	1.41
7	0.5767	0.0626	0.0663	0.5624	5.651	3.259	15.67	1.02	271.62	141.35	104.01	0.0890	32.	0.91
8	0.6209	0.0390	0.0413	0.6055	5.651	3.508	15.86	0.64	271.50	145.22	103.96	0.0889	48.	0.47
9	0.6659	0.0288	0.0305	0.6494	5.651	3.763	16.06	0.47	271.37	149.17	103.91	0.0889	64.	0.30
10	0.6557	0.0237	0.0251	0.6395	5.651	3.705	16.06	0.39	271.37	148.26	103.91	0.0889	79.	0.19
11	********	0.0117	0.0124	********	5.560	*******	16.11	0.19	266.98	********	102.23	0.0875	******	0.0
12	********	0.0118	0.0125	********	5.713	*******	16.89	0.20	273.81	********	104.34	0.0897	******	0.0

(e) Uptake Mach Number of 0.0897.

Table IX. Continued.

DATA TAKEN ON 19 NOVEMBER 1976

AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 111.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	3.625	0.90	0.35	64.6	40.3	1.2044	0.7511
0.500	3.375	1.20	0.45	74.6	45.7	1.3908	0.8517
1.000	2.875	1.10	0.50	71.4	48.1	1.3315	0.8977
1.500	2.375	0.90	0.50	64.6	48.1	1.2044	0.8977
2.000	1.875	0.70	0.50	57.0	48.1	1.0622	0.8977
2.500	1.375	0.50	0.45	48.1	45.7	0.8977	0.8517
3.000	0.875	0.45	0.35	45.7	40.3	0.8517	0.7511
3.500	0.375	0.35	0.30	40.3	37.3	0.7511	0.6954
4.000	0.125	0.30	0.25	37.3	34.0	0.6954	0.6348
4.500	0.625	0.35	0.35	40.3	40.3	0.7511	0.7511
5.000	1.125	0.40	0.50	43.1	48.1	0.8030	0.8977
5.500	1.625	0.55	0.55	50.5	50.5	0.9415	0.9415
6.000	2.125	0.70	0.55	57.0	50.5	1.0622	0.9415
6.500	2.625	0.80	0.60	60.9	52.7	1.1355	0.9834
7.000	3.125	0.75	0.50	59.0	48.1	1.0995	0.8977
7.250	3.625	0.65	0.40	54.9	43.1	1.0236	0.8030

INTEGRATED FLOW RATE = 15.38 CU.FT/SEC
= 1.110 LBM/SEC

AVERAGE VELOCITY = 53.63 FT/SEC

MOMENTUM FACTOR, KM = 1.020

(a) Forward Mixing Stack with Uptake Mach Number of 0.0316.

Table X. Tabulated Velcoity Profile Data for the Existing Eductor.

DATA TAKEN ON 19 NOVEMBER 1976

AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 104.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	3.625	3.40	1.50	125.1	83.1	1.1025	0.7323
0.500	3.375	4.20	1.80	139.0	91.0	1.2254	0.8022
1.000	2.875	4.20	1.80	139.0	91.0	1.2254	0.8022
1.500	2.375	3.80	2.00	132.3	95.9	1.1655	0.8456
2.000	1.875	3.30	2.10	123.2	98.3	1.0862	0.8665
2.500	1.375	2.80	2.10	113.5	98.3	1.0005	0.8665
3.000	0.875	2.30	1.90	102.9	93.5	0.9068	0.8242
3.500	0.375	1.90	1.70	93.5	88.5	0.8242	0.7796
4.000	0.125	1.50	1.60	83.1	85.8	0.7323	0.7563
4.500	0.625	1.60	2.00	85.8	95.9	0.7563	0.8456
5.000	1.125	1.90	2.30	93.5	102.9	0.8242	0.9068
5.500	1.625	2.30	2.80	102.9	113.5	0.9068	1.0005
6.000	2.125	2.80	3.00	113.5	117.5	1.0005	1.0356
6.500	2.625	3.60	3.10	128.7	119.5	1.1345	1.0527
7.000	3.125	3.80	3.10	132.3	119.5	1.1655	1.0527
7.250	3.625	3.40	2.60	125.1	109.4	1.1025	0.9641

INTEGRATED FLOW RATE = 32.53 CU.FT/SEC
= 2.365 LBM/SEC

AVERAGE VELOCITY = 113.47 FT/SEC

MOMENTUM FACTOR, KM = 1.013

(b) Forward Mixing Stack with Uptake Mach Number of 0.0623.

Table X. Continued.

DATA TAKEN ON 19 NOVEMBER 1976
AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 98.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	3.625	6.20	3.70	168.4	130.1	1.0329	0.7979
0.500	3.375	8.00	4.00	191.3	135.3	1.1733	0.8296
1.000	2.875	8.10	4.10	192.5	136.9	1.1806	0.8399
1.500	2.375	7.20	4.60	181.5	145.1	1.1131	0.8897
2.000	1.875	6.40	4.80	171.1	148.2	1.0494	0.9088
2.500	1.375	5.60	4.70	160.1	146.6	0.9816	0.8993
3.000	0.875	4.70	4.20	146.6	138.6	0.8993	0.8501
3.500	0.375	3.90	3.70	133.6	130.1	0.8192	0.7979
4.000	0.125	3.50	3.70	126.5	130.1	0.7760	0.7979
4.500	0.625	3.40	4.30	124.7	140.2	0.7649	0.8602
5.000	1.125	3.60	5.20	128.3	154.2	0.7871	0.9459
5.500	1.625	4.30	6.00	140.2	165.7	0.8602	1.0161
6.000	2.125	5.60	6.40	160.1	171.1	0.9816	1.0494
6.500	2.625	7.30	6.90	182.7	177.7	1.1208	1.0896
7.000	3.125	7.70	6.70	187.7	175.1	1.1511	1.0737
7.250	3.625	6.70	6.10	175.1	167.0	1.0737	1.0245

INTEGRATED FLOW RATE = 46.74 CU.FT/SEC
= 3.420 LBM/SEC

AVERAGE VELOCITY = 163.05 FT/SEC

MOMENTUM FACTOR, KM = 1.010

(c) Forward Mixing Stack with Uptake Mach Number of 0.0897.

Table X. Continued.

DATA TAKEN ON 19 NOVEMBER 1976
AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 111.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	3.625	0.70	0.40	57.0	43.1	1.0611	0.8021
0.500	3.375	1.10	0.55	71.4	50.5	1.3302	0.9406
1.000	2.875	1.15	0.65	73.0	54.9	1.3601	1.0225
1.500	2.375	1.05	0.70	69.8	57.0	1.2996	1.0611
2.000	1.875	0.85	0.60	62.8	52.7	1.1693	0.9824
2.500	1.375	0.60	0.45	52.7	45.7	0.9824	0.8508
3.000	0.875	0.40	0.35	43.1	40.3	0.8021	0.7503
3.500	0.375	0.35	0.25	40.3	34.0	0.7503	0.6341
4.000	0.125	0.30	0.25	37.3	34.0	0.6947	0.6341
4.500	0.625	0.30	0.30	37.3	37.3	0.6947	0.6947
5.000	1.125	0.30	0.35	37.3	40.3	0.6947	0.7503
5.500	1.625	0.35	0.50	40.3	48.1	0.7503	0.8968
6.000	2.125	0.35	0.62	40.3	53.6	0.7503	0.9986
6.500	2.625	0.50	0.70	48.1	57.0	0.8968	1.0611
7.000	3.125	0.70	0.65	57.0	54.9	1.0611	1.0225
7.250	3.625	0.60	0.40	52.7	43.1	0.9824	0.8021

INTEGRATED FLOW RATE = 15.39 CU.FT/SEC
= 1.111 LBM/SEC

AVERAGE VELOCITY = 53.69 FT/SEC

MOMENTUM FACTOR, KM = 1.029

(d) Center Mixing Stack with Uptake Mach Number of 0.0316.

Table X. Continued.

DATA TAKEN ON 19NOVEMBER 1976
AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 104.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	3.625	3.30	2.20	123.2	100.6	1.0638	0.8686
C.500	3.375	5.00	3.00	151.7	117.5	1.3095	1.0143
1.000	2.875	5.20	3.20	154.7	121.4	1.3354	1.0476
1.500	2.375	4.40	3.30	142.3	123.2	1.2284	1.0638
2.000	1.875	3.30	3.10	123.2	119.5	1.0638	1.0311
2.500	1.375	2.40	2.60	105.1	109.4	0.9072	0.9443
3.000	0.875	1.70	1.90	88.5	93.5	0.7635	0.8072
3.500	0.375	1.50	1.50	83.1	83.1	0.7172	0.7172
4.000	0.125	1.40	1.40	80.3	80.3	0.6929	0.6929
4.500	0.625	1.40	1.60	80.3	85.8	0.6929	0.7407
5.000	1.125	1.50	1.90	83.1	93.5	0.7172	0.8072
5.500	1.625	1.70	2.50	88.5	107.3	0.7635	0.9259
6.000	2.125	1.90	2.90	93.5	115.5	0.8072	0.9973
6.500	2.625	2.50	3.10	107.3	119.5	0.9259	1.0311
7.000	3.125	2.70	3.00	111.5	117.5	0.9623	1.0143
7.250	3.625	2.20	2.40	100.6	105.1	0.8686	0.9072

INTEGRATED FLOW RATE = 33.21 CU.FT/SEC
= 2.415 LBM/SEC

AVERAGE VELOCITY = 115.86 FT/SEC

MOMENTUM FACTOR, KM = 1.022

(e) Center Mixing Stack with Uptake Mach Number of 0.0623.

Table X. Continued.

DATA TAKEN ON 19 NOVEMBER 1976
AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 98.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	3.625	7.20	4.50	181.5	143.5	1.0967	0.8670
0.500	3.375	9.60	5.90	209.6	164.3	1.2663	0.9927
1.000	2.875	10.10	6.30	214.9	169.8	1.2989	1.0258
1.500	2.375	8.60	6.70	198.3	175.1	1.1985	1.0579
2.000	1.875	6.30	6.60	169.8	173.8	1.0258	1.0500
2.500	1.375	4.60	5.80	145.1	162.9	0.8766	0.9843
3.000	0.875	3.40	4.70	124.7	146.6	0.7536	0.8860
3.500	0.375	3.00	3.40	117.1	124.7	0.7079	0.7536
4.000	0.125	3.00	3.10	117.1	119.1	0.7079	0.7196
4.500	0.625	3.10	3.70	119.1	130.1	0.7196	0.7861
5.000	1.125	3.10	4.40	119.1	141.9	0.7196	0.8573
5.500	1.625	3.50	5.30	126.5	155.7	0.7646	0.9409
6.000	2.125	4.00	5.90	135.3	164.3	0.8174	0.9927
6.500	2.625	5.10	6.50	152.7	172.4	0.9230	1.0420
7.000	3.125	5.90	6.30	164.3	169.8	0.9927	1.0258
7.250	3.625	5.20	5.40	154.2	157.2	0.9320	0.9497

INTEGRATED FLOW RATE = 47.44 CU.FT/SEC
= 3.471 LBM/SEC

AVERAGE VELOCITY = 165.49 FT/SEC

MOMENTUM FACTOR, KM = 1.017

(f) Center Mixing Stack with Uptake Mach Number of 0.0897.

Table X. Continued.

DATA TAKEN ON 19 NOVEMBER 1976

AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 111.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	3.625	0.40	0.45	43.1	45.7	0.8478	0.8992
0.500	3.375	0.40	0.50	43.1	48.1	0.8478	0.9479
1.000	2.875	0.35	0.55	40.3	50.5	0.7931	0.9942
1.500	2.375	0.30	0.50	37.3	48.1	0.7342	0.9479
2.000	1.875	0.30	0.45	37.3	45.7	0.7342	0.8992
2.500	1.375	0.30	0.40	37.3	43.1	0.7342	0.8478
3.000	0.875	0.35	0.35	40.3	40.3	0.7931	0.7931
3.500	0.375	0.35	0.35	40.3	40.3	0.7931	0.7931
4.000	0.125	0.40	0.40	43.1	43.1	0.8478	0.8478
4.500	0.625	0.50	0.45	48.1	45.7	0.9479	0.8992
5.000	1.125	0.75	0.60	59.0	52.7	1.1609	1.0384
5.500	1.625	0.95	0.60	66.4	52.7	1.3066	1.0384
6.000	2.125	1.10	0.65	71.4	54.9	1.4059	1.0808
6.500	2.625	1.15	0.60	73.0	52.7	1.4375	1.0384
7.000	3.125	0.90	0.60	64.6	52.7	1.2717	1.0384
7.250	3.625	0.75	0.50	59.0	48.1	1.1609	0.9479

INTEGRATED FLOW RATE = 14.56 CU.FT/SEC
= 1.051 LBM/SEC

AVERAGE VELOCITY = 50.80 FT/SEC

MOMENTUM FACTOR, KM = 1.032

(g) Aft Mixing Stack with Uptake Mach Number of 0.0316.

Table X. Continued.

DATA TAKEN ON 19 NOVEMBER 1976
AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 104.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	3.625	1.70	1.80	88.5	91.0	0.8314	0.8555
0.500	3.375	1.80	2.20	91.0	100.6	0.8555	0.9458
1.000	2.875	1.50	2.30	83.1	102.9	0.7810	0.9671
1.500	2.375	1.40	2.40	80.3	105.1	0.7545	0.9879
2.000	1.875	1.40	2.20	80.3	100.6	0.7545	0.9458
2.500	1.375	1.50	2.00	83.1	95.9	0.7810	0.9018
3.000	0.875	1.60	1.90	85.8	93.5	0.8066	0.8789
3.500	0.375	1.70	1.70	88.5	88.5	0.8314	0.8314
4.000	0.125	1.80	1.90	91.0	93.5	0.8555	0.8789
4.500	0.625	2.40	2.20	105.1	100.6	0.9879	0.9458
5.000	1.125	3.00	2.60	117.5	109.4	1.1045	1.0282
5.500	1.625	4.00	2.80	135.7	113.5	1.2753	1.0670
6.000	2.125	4.60	2.80	145.5	113.5	1.3676	1.0670
6.500	2.625	4.50	2.70	143.9	111.5	1.3527	1.0478
7.000	3.125	3.80	2.70	132.3	111.5	1.2430	1.0478
7.250	3.625	3.30	2.30	123.2	102.9	1.1584	0.9671

INTEGRATED FLOW RATE = 30.50 CU.FT/SEC
= 2.218 LBM/SEC

AVERAGE VELOCITY = 106.40 FT/SEC

MOMENTUM FACTOR, KM = 1.025

(h) Aft Mixing Stack with Uptake Mach Number of 0.0623.

Table X. Continued.

DATA TAKEN ON 19 NOVEMBER 1976
AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 62.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 98.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	3.625	3.30	4.00	122.9	135.3	0.8076	0.8892
0.500	3.375	3.50	4.40	126.5	141.9	0.8318	0.9326
1.000	2.875	3.10	4.40	119.1	141.9	0.7828	0.9326
1.500	2.375	2.80	4.50	113.2	143.5	0.7439	0.9431
2.000	1.875	3.00	4.30	117.1	140.2	0.7701	0.9219
2.500	1.375	3.20	4.10	121.0	136.9	0.7953	0.9002
3.000	0.875	3.40	3.80	124.7	131.8	0.8198	0.8667
3.500	0.375	3.60	3.60	128.3	128.3	0.8436	0.8436
4.000	0.125	3.80	3.80	131.8	131.8	0.8667	0.8667
4.500	0.625	4.90	4.60	149.7	145.1	0.9841	0.9535
5.000	1.125	6.10	5.20	167.0	154.2	1.0981	1.0138
5.500	1.625	7.90	6.00	190.1	165.7	1.2496	1.0890
6.000	2.125	9.50	6.10	208.5	167.0	1.3703	1.0981
6.500	2.625	9.60	5.90	209.6	164.3	1.3775	1.0799
7.000	3.125	8.00	5.80	191.3	162.9	1.2575	1.0707
7.250	3.625	6.70	5.00	175.1	151.2	1.1508	0.9941

INTEGRATED FLOW RATE = 43.61 CU.FT/SEC
= 3.191 LBM/SEC

AVERAGE VELOCITY = 152.12 FT/SEC

MOMENTUM FACTOR, KM = 1.028

(i) Aft Mixing Stack with Uptake Mach Number of 0.0897.

Table X. Continued.

DATA TAKEN ON 09 DECEMBER 1976

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 3

PRIMARY NOZZLE DIAMETER = 3.900 INCHES

MIXING STACK DIAMETER = 11.700 INCHES

MIXING STACK LENGTH = 26.400 INCHES

MIXING STACK L/D = 2.256

UPTAKE DIAMETER = 11.500 INCHES

AREA RATIO, AM/AP = 3.000

PRIMARY FLOW RATE = 3.872 LBM/SEC

= 53.191 CFS

ORIFICE PRESSURE DROP = 22.6 IN.H2O

ORIFICE STATIC PRESSURE = 0.71 IN.H2O

ORIFICE TEMPERATURE = 40.5 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 95.0 DEG.FAHR

AMBIENT PRESSURE = 30.051 IN.HGA

AMBIENT TEMPERATURE = 54.0 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9261

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4050	0.4416	0.0	3.872	0.0	5.45	4.33	213.73	71.24	73.74	0.0639	0.	4.33
2	0.1988	0.2982	0.3220	0.1922	3.872	0.770	6.55	3.14	213.16	84.30	73.55	0.0637	4.	3.12
3	0.3316	0.2134	0.2305	0.3205	3.872	1.284	7.25	2.24	212.80	93.04	73.42	0.0636	8.	2.17
4	0.4678	0.1118	0.1208	0.4523	3.872	1.811	7.90	1.17	212.47	102.03	73.31	0.0635	16.	1.08
5	0.5402	0.0527	0.0569	0.5222	3.872	2.092	8.30	0.55	212.27	106.79	73.24	0.0634	32.	0.36
6	0.6040	0.0383	0.0414	0.5839	3.872	2.339	8.35	0.40	212.24	111.04	73.23	0.0634	48.	0.20
7	0.5972	0.0307	0.0331	0.5774	3.872	2.312	8.40	0.32	212.22	110.58	73.22	0.0634	64.	0.11
8	0.6287	0.0297	0.0321	0.6078	3.872	2.434	8.40	0.31	212.22	112.68	73.22	0.0634	79.	0.08
9	********	0.0220	0.0238	********	3.872	*******	8.40	0.23	212.22	********	73.22	0.0634	******	0.0

(a) Three Primary Nozzles (Long) with an Uptake Mach Number of 0.0634 and Louvers Open.

Table XI. Tabulated Performance Data for Eductor Proposal A.

DATA TAKEN ON 09 DECEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 3
PRIMARY NOZZLE DIAMETER = 3.900 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 3.000

PRIMARY FLOW RATE = 3.871 LBM/SEC
= 53.160 CFS
ORIFICE PRESSURE DROP = 22.6 IN.H2O
ORIFICE STATIC PRESSURE = 0.71 IN.H2O
ORIFICE TEMPERATURE = 41.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 95.0 DEG.FAHR
AMBIENT PRESSURE = 30.056 IN.HGA
AMBIENT TEMPERATURE = 55.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9279

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4093	0.4411	0.0	3.871	0.0	5.45	4.32	213.60	71.20	73.70	0.0638	0.	4.32
2	0.1981	0.2981	0.3213	0.1916	3.871	0.767	6.55	3.13	213.04	84.23	73.50	0.0637	4.	3.10
3	0.3276	0.2131	0.2297	0.3170	3.871	1.268	7.25	2.23	212.68	92.77	73.39	0.0636	8.	2.12
4	0.4499	0.1197	0.1290	0.4354	3.871	1.742	7.75	1.25	212.42	100.86	73.29	0.0635	16.	1.00
5	0.5170	0.0739	0.0796	0.5002	3.871	2.001	8.05	0.77	212.27	105.29	73.24	0.0634	32.	0.33
6	0.5727	0.0555	0.0641	0.5541	3.871	2.217	8.20	0.62	212.19	109.00	73.21	0.0634	48.	0.18
7	0.5691	0.0557	0.0600	0.5507	3.871	2.203	8.15	0.58	212.22	108.77	73.22	0.0634	64.	0.10
8	0.5442	0.0528	0.0569	0.5266	3.871	2.106	8.15	0.55	212.22	107.10	73.22	0.0634	79.	0.06
9	********	0.0461	0.0496	********	3.871	*******	8.15	0.48	212.22	*******	73.22	0.0634	******	0.0

(b) Three Primary Nozzles (Long) with an Uptake Mach Number of 0.0634 and Louvers Closed.

Table XI. Continued.

DATA TAKEN ON 10 DECEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 3
PRIMARY NOZZLE DIAMETER = 3.900 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 3.000

PRIMARY FLOW RATE = 3.869 LBM/SEC
= 52.877 CFS
ORIFICE PRESSURE DROP = 22.5 IN.H2O
ORIFICE STATIC PRESSURE = 0.70 IN.H2O
ORIFICE TEMPERATURE = 40.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 93.0 DEG.FAHR
AMBIENT PRESSURE = 30.111 IN.HGA
AMBIENT TEMPERATURE = 52.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9258

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4105	0.4434	0.0	3.869	0.0	5.30	4.32	212.47	70.82	73.31	0.0636	0.	4.32
2	0.2005	0.3019	0.3261	0.1938	3.869	0.776	6.40	3.16	211.90	83.90	73.11	0.0634	4.	3.15
3	0.3320	0.2156	0.2329	0.3209	3.869	1.285	7.05	2.25	211.57	92.51	73.00	0.0633	8.	2.16
4	0.4739	0.1152	0.1287	0.4581	3.869	1.834	7.70	1.24	211.24	101.81	72.88	0.0633	16.	1.10
5	0.5496	0.0530	0.0572	0.5313	3.869	2.127	8.05	0.55	211.07	106.78	72.82	0.0632	32.	0.37
6	0.6211	0.0385	0.0416	0.6004	3.869	2.403	8.20	0.40	210.99	111.50	72.80	0.0632	48.	0.21
7	0.6260	0.0328	0.0354	0.6052	3.869	2.422	8.20	0.34	210.99	111.82	72.80	0.0632	64.	0.12
8	0.6310	0.0308	0.0333	0.6099	3.869	2.441	8.20	0.32	210.99	112.15	72.80	0.0632	79.	0.08
9	********	0.0231	0.0250	********	3.869	*******	8.30	0.24	210.94	********	72.78	0.0632	******	0.0

(c) Three Primary Nozzles (Short) with an Uptake Mach Number of 0.0632 and Louvers Open.

Table XI. Continued.

DATA TAKEN ON 10 DECEMBER 1976
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 3
PRIMARY NOZZLE DIAMETER = 3.900 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 3.000

PRIMARY FLOW RATE = 3.866 LBM/SEC
= 52.824 CFS
ORIFICE PRESSURE DROP = 22.5 IN.H2O
ORIFICE STATIC PRESSURE = 0.70 IN.H2O
ORIFICE TEMPERATURE = 41.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 93.0 DEG.FAHR
AMBIENT PRESSURE = 30.111 IN.HGA
AMBIENT TEMPERATURE = 54.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9294

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4158	0.4474	0.0	3.866	0.0	5.30	4.35	212.25	70.75	73.23	0.0636	0.	4.35
2	0.1993	0.3056	0.3289	0.1930	3.866	0.770	6.45	3.18	211.67	83.79	73.03	0.0634	4.	3.17
3	0.3247	0.2168	0.2333	0.3144	3.866	1.255	7.00	2.25	211.39	92.04	72.93	0.0633	8.	2.07
4	0.4536	0.1295	0.1393	0.4393	3.866	1.754	7.55	1.34	211.11	100.52	72.84	0.0632	16.	1.01
5	0.5186	0.0774	0.0833	0.5022	3.866	2.005	7.90	0.80	210.93	104.78	72.78	0.0632	32.	0.33
6	0.5745	0.0649	0.0698	0.5563	3.866	2.221	8.00	0.67	210.88	108.49	72.76	0.0631	48.	0.18
7	0.5710	0.0629	0.0677	0.5529	3.866	2.207	8.00	0.65	210.88	108.25	72.76	0.0631	64.	0.10
8	0.5897	0.0571	0.0615	0.5710	3.866	2.279	8.00	0.59	210.88	109.50	72.76	0.0631	79.	0.07
9	********	0.0474	0.0511	********	3.866	********	8.00	0.49	210.88	********	72.76	0.0631	******	0.0

(d) Three Primary Nozzles (Short) with an Uptake Mach Number of 0.0631 and Louvers Closed.

Table XI. Continued.

DATA TAKEN ON 30 NOVEMBER 1976

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4

PRIMARY NOZZLE DIAMETER = 3.380 INCHES

MIXING STACK DIAMETER = 11.700 INCHES

MIXING STACK LENGTH = 26.400 INCHES

MIXING STACK L/D = 2.256

UPTAKE DIAMETER = 11.500 INCHES

AREA RATIO, AM/AP = 2.996

PRIMARY FLOW RATE = 1.936 LBM/SEC

= 27.082 CFS

ORIFICE PRESSURE DROP = 5.6 IN.H2O

ORIFICE STATIC PRESSURE = 0.18 IN.H2O

ORIFICE TEMPERATURE = 39.0 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 102.0 DEG.FAHR

AMBIENT PRESSURE = 30.184 IN.HGA

AMBIENT TEMPERATURE = 54.5 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9154

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3788	0.4138	0.0	1.936	0.0	1.30	1.04	108.66	36.27	37.55	0.0323	0.	1.04
2	0.1966	0.2771	0.3027	0.1891	1.936	0.381	1.55	0.76	108.59	42.76	37.52	0.0323	4.	0.76
3	0.3283	0.2044	0.2232	0.3158	1.935	0.636	1.70	0.56	108.55	47.11	37.51	0.0323	8.	0.53
4	0.4773	0.1132	0.1236	0.4591	1.936	0.924	1.80	0.31	108.53	52.05	37.50	0.0323	16.	0.28
5	0.5704	0.0548	0.0599	0.5487	1.936	1.104	1.90	0.15	108.50	55.13	37.49	0.0323	32.	0.10
6	0.6628	0.0402	0.0439	0.6375	1.936	1.283	1.95	0.11	108.49	58.20	37.49	0.0323	48.	0.06
7	0.6249	0.0365	0.0399	0.6011	1.936	1.210	1.95	0.10	108.49	56.94	37.49	0.0323	64.	0.03
8	0.6298	0.0329	0.0359	0.6058	1.936	1.219	1.95	0.09	108.49	57.10	37.49	0.0323	79.	0.02
9	********	0.0256	0.0280	********	1.936	*******	2.05	0.07	108.46	********	37.49	0.0323	******	0.0

(e) Four Primary Nozzles with Uptake Mach Number of 0.0323 and Louvers Open.

Table XI. Continued.

DATA TAKEN ON 30 NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 3.380 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 2.996

PRIMARY FLOW RATE = 1.941 LBM/SEC
= 27.233 CFS
ORIFICE PRESSURE DROP = 5.7 IN.H2O
ORIFICE STATIC PRESSURE = 0.18 IN.H2O
ORIFICE TEMPERATURE = 43.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 104.0 DEG.FAHR
AMBIENT PRESSURE = 30.196 IN.HGA
AMBIENT TEMPERATURE = 52.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9086

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3730	0.4105	0.0	1.941	0.0	1.30	1.04	109.27	36.48	37.76	0.0324	0.	1.05
2	0.1965	0.2800	0.3082	0.1884	1.941	0.381	1.50	0.78	109.21	42.94	37.74	0.0324	4.	0.76
3	0.3251	0.2084	0.2294	0.3117	1.941	0.631	1.70	0.58	109.16	47.18	37.72	0.0324	8.	0.52
4	0.4509	0.1258	0.1385	0.4322	1.941	0.875	1.80	0.35	109.13	51.33	37.71	0.0324	16.	0.25
5	0.5101	0.0827	0.0910	0.4890	1.941	0.990	1.85	0.23	109.12	53.29	37.71	0.0324	32.	0.08
6	0.5410	0.0719	0.0791	0.5187	1.941	1.050	1.85	0.20	109.12	54.31	37.71	0.0324	48.	0.04
7	0.6247	0.0683	0.0752	0.5989	1.941	1.212	1.85	0.19	109.12	57.09	37.71	0.0324	64.	0.03
8	0.6296	0.0611	0.0673	0.6036	1.941	1.222	1.85	0.17	109.12	57.25	37.71	0.0324	79.	0.02
9	********	0.0504	0.0554	********	1.941	*******	1.90	0.14	109.11	********	37.70	0.0324	******	0.0

(f) Four Primary Nozzles with Uptake Mach Number of 0.0324 and Louvers Closed.

Table XI. Continued.

DATA TAKEN ON 30 NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 3.380 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 2.996

PRIMARY FLOW RATE = 3.872 LBM/SEC
= 52.792 CFS

ORIFICE PRESSURE DROP = 22.4 IN.H2O
ORIFICE STATIC PRESSURE = 0.70 IN.H2O
ORIFICE TEMPERATURE = 38.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 93.0 DEG.FAHR
AMBIENT PRESSURE = 30.196 IN.HGA
AMBIENT TEMPERATURE = 55.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9321

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O		FT/SEC					IN.H2O
1	0.0	0.4070	0.4366	0.0	3.872	0.0	5.10	4.24	211.81	70.71	73.19	0.0635	0.	4.24
2	0.1983	0.3009	0.3229	0.1923	3.872	0.768	6.10	3.12	211.30	83.74	73.01	0.0634	4.	3.10
3	0.3334	0.2196	0.2356	0.3233	3.872	1.291	6.70	2.27	211.00	92.63	72.91	0.0633	8.	2.19
4	0.4747	0.1223	0.1312	0.4603	3.872	1.838	7.35	1.26	210.67	101.94	72.79	0.0632	16.	1.11
5	0.5628	0.0583	0.0625	0.5457	3.872	2.179	7.60	0.60	210.54	107.77	72.75	0.0631	32.	0.39
6	0.6195	0.0408	0.0438	0.6006	3.872	2.399	7.65	0.42	210.52	111.54	72.74	0.0631	48.	0.21
7	0.6244	0.0331	0.0355	0.6054	3.872	2.418	7.80	0.34	210.44	111.84	72.72	0.0631	64.	0.12
8	0.6293	0.0311	0.0334	0.6101	3.872	2.437	7.80	0.32	210.44	112.17	72.72	0.0631	79.	0.08
9	********	0.0243	0.0261	********	3.872	*******	7.90	0.25	210.39	********	72.70	0.0631	******	0.0

(g) Four Primary Nozzles with Uptake Mach Number of 0.0631 and Louvers Open.

Table XI. Continued.

DATA TAKEN ON 30 NOVEMBER 1976

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4

PRIMARY NOZZLE DIAMETER = 3.380 INCHES

MIXING STACK DIAMETER = 11.700 INCHES

MIXING STACK LENGTH = 26.400 INCHES

MIXING STACK L/D = 2.256

UPTAKE DIAMETER = 11.500 INCHES

AREA RATIO, AM/AP = 2.996

PRIMARY FLOW RATE = 3.876 LBM/SEC

= 53.079 CFS

ORIFICE PRESSURE DROP = 22.6 IN.H2O

ORIFICE STATIC PRESSURE = 0.70 IN.H2O

ORIFICE TEMPERATURE = 42.0 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 95.6 DEG.FAHR

AMBIENT PRESSURE = 30.201 IN.HGA

AMBIENT TEMPERATURE = 54.5 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9260

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4075	0.4400	0.0	3.876	0.0	5.15	4.30	212.96	71.09	73.59	0.0637	0.	4.30
2	0.1977	0.3028	0.3270	0.1911	3.876	0.766	6.15	3.18	212.45	84.06	73.41	0.0636	4.	3.08
3	0.3226	0.2214	0.2391	0.3119	3.876	1.250	6.65	2.32	212.20	92.28	73.32	0.0635	8.	2.05
4	0.4438	0.1340	0.1447	0.4290	3.876	1.720	7.20	1.40	211.92	100.25	73.23	0.0634	16.	0.97
5	0.4936	0.0900	0.0972	0.4772	3.876	1.913	7.40	0.94	211.82	103.53	73.19	0.0634	32.	0.30
6	0.5407	0.0709	0.0766	0.5227	3.876	2.096	7.45	0.74	211.79	106.66	73.18	0.0634	48.	0.16
7	0.5098	0.0680	0.0735	0.4928	3.876	1.976	7.45	0.71	211.79	104.60	73.18	0.0634	64.	0.08
8	0.5450	0.0680	0.0735	0.5268	3.876	2.112	7.45	0.71	211.79	106.94	73.18	0.0634	79.	0.06
9	********	0.0527	0.0569	********	3.876	*******	7.50	0.55	211.77	********	73.17	0.0634	******	0.0

(h) Four Primary Nozzles with Uptake Mach Number of 0.0633 and Louvers Closed.

Table XI. Continued.

DATA TAKEN ON 30 NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 3.380 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 2.996

PRIMARY FLOW RATE = 5.681 LBM/SEC
= 75.841 CFS

ORIFICE PRESSURE DROP = 48.3 IN.H2O
ORIFICE STATIC PRESSURE = 1.43 IN.H2O
ORIFICE TEMPERATURE = 38.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 89.0 DEG.FAHR
AMBIENT PRESSURE = 30.196 IN.HGA
AMBIENT TEMPERATURE = 55.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9389

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4037	0.4300	0.0	5.681	0.0	10.85	8.68	304.29	101.58	105.14	0.0916	0.	8.68
2	0.1927	0.2957	0.3192	0.1875	5.681	1.095	12.95	6.38	302.78	119.93	104.62	0.0911	4.	6.30
3	0.3250	0.2197	0.2340	0.3162	5.681	1.846	14.15	4.65	301.92	132.59	104.33	0.0909	8.	4.48
4	0.4728	0.1268	0.1351	0.4599	5.681	2.686	15.30	2.67	301.11	146.78	104.05	0.0906	16.	2.37
5	0.5494	0.0661	0.0640	0.5344	5.681	3.121	16.10	1.26	300.54	154.10	103.85	0.0904	32.	0.80
6	0.6042	0.0429	0.0457	0.5877	5.681	3.432	16.15	0.90	300.51	159.45	103.84	0.0904	48.	0.43
7	0.6143	0.0339	0.0361	0.5975	5.681	3.489	16.20	0.71	300.47	160.42	103.83	0.0904	64.	0.25
8	0.6253	0.0324	0.0345	0.6082	5.681	3.552	16.20	0.68	300.47	161.50	103.83	0.0904	79.	0.17
9	********	0.0239	0.0254	*********	5.681	*******	16.35	0.50	300.37	********	103.79	0.0904	******	0.0

(i) Four Primary Nozzles with Uptake Mach Number of 0.0904 and Louvers Open.

Table XI. Continued.

DATA TAKEN ON 30 NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4

PRIMARY NOZZLE DIAMETER = 3.380 INCHES

MIXING STACK DIAMETER = 11.700 INCHES

MIXING STACK LENGTH = 26.400 INCHES

MIXING STACK L/D = 2.256

UPTAKE DIAMETER = 11.500 INCHES

AREA RATIO, AM/AP = 2.996

PRIMARY FLOW RATE = 5.680 LBM/SEC
= 75.919 CFS

ORIFICE PRESSURE DROP = 48.5 IN.H2O

ORIFICE STATIC PRESSURE = 1.43 IN.H2O

ORIFICE TEMPERATURE = 39.5 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 89.0 DEG.FAHR

AMBIENT PRESSURE = 30.206 IN.HGA

AMBIENT TEMPERATURE = 56.0 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9399

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4055	0.4314	0.0	5.688	0.0	10.80	8.73	304.60	101.68	105.25	0.0917	0.	8.73
2	0.1917	0.3025	0.3219	0.1865	5.688	1.090	12.85	6.45	303.13	119.97	104.74	0.0912	4.	6.25
3	0.3165	0.2259	0.2403	0.3079	5.688	1.800	14.00	4.79	302.31	131.94	104.46	0.0910	8.	4.26
4	0.4380	0.1406	0.1496	0.4262	5.688	2.491	14.80	2.97	301.74	143.67	104.26	0.0908	16.	2.04
5	0.4790	0.0877	0.0934	0.4661	5.688	2.724	15.25	1.85	301.42	147.58	104.15	0.0907	32.	0.61
6	0.5204	0.0783	0.0833	0.5064	5.688	2.960	15.30	1.65	301.38	151.63	104.14	0.0907	48.	0.32
7	0.5058	0.0745	0.0793	0.4921	5.688	2.877	15.40	1.57	301.31	150.17	104.12	0.0907	64.	0.17
8	0.5459	0.0712	0.0757	0.5312	5.688	3.105	15.35	1.50	301.35	154.12	104.13	0.0907	79.	0.13
9	********	0.0546	0.0581	********	5.688	*******	15.60	1.15	301.17	********	104.07	0.0906	******	0.0

(j) Four Primary Nozzles with Uptake Mach Number of 0.0906 and Louvers Closed.

Table XI. Continued.

DATA TAKEN ON 28 NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 3.000 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 3.042

PRIMARY FLOW RATE = 1.936 LBM/SEC
= 27.893 CFS
ORIFICE PRESSURE DROP = 5.8 IN.H2O
ORIFICE STATIC PRESSURE = 0.19 IN.H2O
ORIFICE TEMPERATURE = 58.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 119.5 DEG.FAHR
AMBIENT PRESSURE = 30.215 IN.HGA
AMBIENT TEMPERATURE = 70.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9154

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3772	0.4121	0.0	1.936	0.0	1.45	1.10	113.65	37.36	38.67	0.0328	0.	1.10
2	0.1999	0.2850	0.3113	0.1923	1.936	0.387	1.70	0.83	113.58	44.15	38.65	0.0328	4.	0.81
3	0.3441	0.2130	0.2327	0.3310	1.936	0.666	1.85	0.62	113.54	49.07	38.63	0.0327	8.	0.60
4	0.5026	0.1238	0.1353	0.4834	1.936	0.973	2.05	0.36	113.48	54.47	38.61	0.0327	16.	0.32
5	0.6156	0.0654	0.0714	0.5921	1.936	1.192	2.12	0.19	113.46	58.33	38.61	0.0327	32.	0.12
6	0.7052	0.0413	0.0451	0.6783	1.936	1.366	2.20	0.12	113.44	61.39	38.60	0.0327	48.	0.07
7	0.7108	0.0344	0.0376	0.6837	1.936	1.376	2.20	0.10	113.44	61.58	38.60	0.0327	64.	0.04
8	*****	0.0212	0.0233	******	1.934	******	2.21	0.06	110.12	*****	37.47	0.0322	***	0.0

(k) Five Primary Nozzles with Uptake Mach Number of 0.0327 and Louvers Open.

Table XI. Continued.

DATA TAKEN ON 28 NOVEMBER 1976

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 5

PRIMARY NOZZLE DIAMETER = 3.000 INCHES

MIXING STACK DIAMETER = 11.700 INCHES

MIXING STACK LENGTH = 26.400 INCHES

MIXING STACK L/D = 2.256

UPTAKE DIAMETER = 11.500 INCHES

AREA RATIO, AM/AP = 3.042

PRIMARY FLOW RATE = 1.934 LBM/SEC

= 27.725 CFS

ORIFICE PRESSURE DPOP = 5.8 IN.H2O

ORIFICE STATIC PRESSURE = 0.19 IN.H2O

ORIFICE TEMPERATURE = 58.0 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 116.5 DEG.FAHR

AMBIENT PRESSURE = 30.210 IN.HGA

AMBIENT TEMPERATURE = 66.0 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9124

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3821	0.4188	0.0	1.934	0.0	1.48	1.11	112.96	37.13	38.44	0.0327	0.	1.11
2	0.2022	0.2855	0.3173	0.1942	1.934	0.391	1.70	0.84	112.90	43.94	38.42	0.0327	4.	0.82
3	0.3401	0.2207	0.2419	0.3266	1.934	0.658	1.85	0.64	112.86	48.59	38.40	0.0326	8.	0.58
4	0.4809	0.1415	0.1551	0.4619	1.934	0.930	2.00	0.41	112.82	53.35	38.39	0.0326	16.	0.29
5	0.5924	0.0932	0.1022	0.5690	1.934	1.146	2.08	0.27	112.80	57.12	38.38	0.0326	32.	0.11
6	0.7088	0.0794	0.0870	0.6808	1.934	1.371	2.10	0.23	112.79	61.07	38.38	0.0326	48.	0.07
7	0.7988	0.0725	0.0795	0.7672	1.934	1.545	2.10	0.21	112.79	64.12	38.38	0.0326	64.	0.05
8	******	0.0495	0.0543	******	1.934	*****	2.00	0.14	110.15	*****	37.48	0.0322	***	0.0

(ℓ) Five Primary Nozzles with Uptake Mach Number of 0.0326 and Louvers Closed.

Table XI. Continued.

DATA TAKEN ON 28 NOVEMBER 1976

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 5

PRIMARY NOZZLE DIAMETER = 3.000 INCHES

MIXING STACK DIAMETER = 11.700 INCHES

MIXING STACK LENGTH = 26.400 INCHES

MIXING STACK L/D = 2.256

UPTAKE DIAMETER = 11.500 INCHES

AREA RATIO, AM/AP = 3.042

PRIMARY FLOW RATE = 3.879 LBM/SEC

= 54.366 CFS

ORIFICE PRESSURE DROP = 23.3 IN.H2O

ORIFICE STATIC PRESSURE = 0.72 IN.H2O

ORIFICE TEMPERATURE = 57.0 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 109.5 DEG.FAHR

AMBIENT PRESSURE = 30.220 IN.HGA

AMBIENT TEMPERATURE = 73.5 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9368

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3985	0.4254	0.0	3.879	0.0	5.55	4.39	221.51	72.82	75.37	0.0645	0.	4.40
2	0.2003	0.3028	0.3232	0.1946	3.879	0.777	6.55	3.32	220.98	86.46	75.19	0.0643	4.	3.28
3	0.3376	0.2205	0.2354	0.3280	3.879	1.309	7.20	2.41	220.63	95.82	75.07	0.0642	8.	2.33
4	0.4845	0.1239	0.1323	0.4708	3.879	1.879	7.90	1.35	220.26	105.85	74.95	0.0641	16.	1.20
5	0.5801	0.0558	0.0638	0.5636	3.879	2.250	8.40	0.65	220.00	112.37	74.86	0.0640	32.	0.43
6	0.6224	0.0423	0.0452	0.6047	3.879	2.414	8.50	0.46	219.95	115.27	74.84	0.0640	48.	0.22
7	0.6129	0.0350	0.0373	0.5955	3.879	2.377	8.50	0.38	219.95	114.62	74.84	0.0640	64.	0.12
8	0.6177	0.0322	0.0344	0.6002	3.879	2.396	8.50	0.35	219.95	114.95	74.84	0.0640	79.	0.08
9	******	0.0244	0.0263	******	3.869	*****	8.35	0.26	214.31	******	72.92	0.0631	***	0.00

(m) Five Primary Nozzles with Uptake Mach Number of 0.0640 and Louvers Open.

Table XI. Continued.

DATA TAKEN ON 28 NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 3.000 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 3.042

PRIMARY FLOW RATE = 3.870 LBM/SEC
= 54.548 CFS
ORIFICE PRESSURE DROP = 23.3 IN.H2O
ORIFICE STATIC PRESSURE = 0.73 IN.H2O
ORIFICE TEMPERATURE = 59.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 113.0 DEG.FAHR
AMBIENT PRESSURE = 30.220 IN.HGA
AMBIENT TEMPERATURE = 73.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9310

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4012	0.4309	0.0	3.870	0.0	5.70	4.45	222.25	73.06	75.62	0.0645	0.	4.46
2	0.1995	0.3034	0.3259	0.1933	3.870	0.772	6.64	3.35	221.75	86.62	75.45	0.0643	4.	3.24
3	0.3273	0.2244	0.2411	0.3172	3.870	1.267	7.32	2.47	221.39	95.30	75.33	0.0642	8.	2.18
4	0.4521	0.1412	0.1517	0.4381	3.870	1.750	7.85	1.55	221.11	103.81	75.24	0.0641	16.	1.04
5	0.5320	0.0912	0.0980	0.5156	3.870	2.059	8.10	1.00	220.98	109.27	75.19	0.0641	32.	0.36
6	0.5643	0.0794	0.0852	0.5468	3.870	2.184	8.15	0.87	220.95	111.48	75.18	0.0641	48.	0.18
7	0.6143	0.0748	0.0803	0.5953	3.870	2.377	8.10	0.82	220.98	114.94	75.19	0.0641	64.	0.12
8	0.6192	0.0740	0.0795	0.6000	3.870	2.396	8.50	0.81	220.77	115.20	75.12	0.0640	79.	0.08
9	******	0.0543	0.0585	******	3.869	*****	8.00	0.58	214.49	******	72.98	0.0632	***	0.00

(n) Five Primary Nozzles with Uptake Mach Number of 0.0640 and Louvers Closed.

Table XI. Continued.

DATA TAKEN ON 28 NOVEMBER 1976
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 3.000 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 3.042

PRIMARY FLOW RATE = 5.682 LBM/SEC
= 77.407 CFS
ORIFICE PRESSURE DROP = 49.4 IN.H2O
ORIFICE STATIC PRESSURE = 1.45 IN.H2O
ORIFICE TEMPERATURE = 50.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 101.5 DEG.FAHR
AMBIENT PRESSURE = 30.220 IN.HGA
AMBIENT TEMPERATURE = 74.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9510

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3957	0.4161	0.0	5.682	0.0	11.50	8.83	315.39	103.68	107.31	0.0924	0.	8.83
2	0.1938	0.3022	0.3178	0.1896	5.682	1.101	13.50	6.68	313.90	122.83	106.81	0.0920	4.	6.60
3	0.3296	0.2235	0.2350	0.3224	5.682	1.873	14.80	4.91	312.94	136.27	106.48	0.0917	8.	4.77
4	0.4810	0.1310	0.1378	0.4705	5.682	2.733	16.20	2.86	311.91	151.28	106.13	0.0914	16.	2.54
5	0.5532	0.0589	0.0620	0.5411	5.682	3.143	17.20	1.28	311.19	158.37	105.89	0.0912	32.	0.84
6	0.5868	0.0438	0.0460	0.5740	5.682	3.334	17.40	0.95	311.04	161.72	105.84	0.0911	48.	0.42
7	0.6388	0.0364	0.0383	0.6249	5.682	3.630	17.40	0.79	311.04	166.99	105.84	0.0911	64.	0.28
8	0.6664	0.0327	0.0344	0.6519	5.682	3.787	17.40	0.71	311.04	169.79	105.84	0.0911	79.	0.20
9	******	0.0250	0.0267	******	5.680	*****	17.50	0.54	305.07	******	103.80	0.0902	***	0.00

(o) Five Primary Nozzles with Uptake Mach Number of 0.0911 and Louvers Open.

Table XI. Continued.

DATA TAKEN ON 28 NOVEMBER 1976
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 3.000 INCHES
MIXING STACK DIAMETER = 11.700 INCHES
MIXING STACK LENGTH = 26.400 INCHES
MIXING STACK L/D = 2.256
UPTAKE DIAMETER = 11.500 INCHES
AREA RATIO, AM/AP = 3.042

PRIMARY FLOW RATE = 5.682 LBM/SEC
= 78.465 CFS
ORIFICE PRESSURE DROP = 50.3 IN.H2O
ORIFICE STATIC PRESSURE = 1.48 IN.H2O
ORIFICE TEMPERATURE = 59.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 110.0 DEG.FAHR
AMBIENT PRESSURE = 30.230 IN.HGA
AMBIENT TEMPERATURE = 79.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9456

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4067	0.4301	0.0	5.682	0.0	11.95	9.24	319.69	105.09	108.78	0.0931	0.	9.24
2	0.1946	0.3074	0.3251	0.1899	5.682	1.106	13.90	6.92	318.23	124.50	108.28	0.0926	4.	6.71
3	0.3236	0.2332	0.2466	0.3158	5.682	1.839	15.10	5.22	317.33	137.40	107.98	0.0923	8.	4.64
4	0.4547	0.1482	0.1567	0.4437	5.682	2.583	16.25	3.30	316.48	150.53	107.69	0.0920	16.	2.29
5	0.4956	0.0923	0.0976	0.4835	5.682	2.816	16.75	2.05	316.11	154.58	107.56	0.0919	32.	0.68
6	0.5099	0.0779	0.0824	0.4975	5.682	2.897	16.85	1.73	316.03	156.03	107.53	0.0919	48.	0.32
7	0.5099	0.0743	0.0786	0.4975	5.682	2.897	16.90	1.65	316.00	156.02	107.52	0.0919	64.	0.18
8	0.4921	0.0725	0.0767	0.4801	5.682	2.796	16.95	1.61	315.96	154.18	107.51	0.0919	79.	0.11
9	******	0.0567	0.0605	******	5.680	*****	16.55	1.23	305.75	******	104.03	0.0904	***	0.00

(p) Five Primary Nozzles with Uptake Mach Number of 0.0919 and Louvers Closed.

Table XI. Continued.

DATA TAKEN ON C9 DECEMBER 1976

UPTAKE MACH NUMBER 0.063
AMBIENT PRESSURE = 30.051 IN.HGA, TEMPERATURE = 54.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 95.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	2.50	0.0	106.3	116.0	0.9589	1.0468
C.500	5.375	3.50	0.0	125.7	124.4	1.1346	1.1227
1.000	4.875	4.50	0.0	142.6	141.0	1.2865	1.2720
1.500	4.375	5.40	0.0	156.2	155.0	1.4093	1.3983
2.000	3.875	6.20	0.0	167.4	162.4	1.5101	1.4658
2.500	3.375	6.30	0.0	168.7	159.6	1.5223	1.4399
3.000	2.875	5.10	0.0	151.8	153.2	1.3696	1.3826
3.500	2.375	4.20	0.0	137.7	134.1	1.2429	1.2100
4.000	1.875	3.00	0.0	116.4	120.9	1.0505	1.0912
4.500	1.375	2.40	0.0	104.1	109.2	0.9396	0.9851
5.0CC	0.875	2.30	0.0	101.9	98.4	0.9198	0.8878
5.500	0.375	1.90	0.0	92.6	96.1	0.8360	0.8667
6.000	0.125	1.80	0.0	90.2	92.6	0.8137	0.8360
6.500	0.625	1.90	0.0	92.6	94.9	0.8360	0.8566
7.000	1.125	2.20	0.0	99.7	99.5	0.8996	0.8975
7.50C	1.625	2.50	0.0	106.3	99.7	0.9589	0.8996
8.000	2.125	2.20	0.0	99.7	104.1	0.8996	0.9394
8.500	2.625	2.30	0.0	101.9	96.2	0.9198	0.8678
9.000	3.125	1.90	0.0	92.6	97.3	0.8360	0.8779
9.500	3.625	1.90	0.0	92.6	87.5	0.8360	0.7894
10.000	4.125	1.50	0.0	82.3	86.1	0.7428	0.7768
10.500	4.625	1.40	0.0	79.5	79.5	0.7176	0.7171
11.000	5.125	1.30	0.0	76.6	71.6	0.6915	0.6465
11.50C	5.625	0.90	0.0	63.8	63.8	0.5754	0.5754
11.750	5.875	0.90	0.0	63.8	63.8	0.5754	0.5754

INTEGRATED FLOW RATE = 83.45 CU.FT/SEC
= 6.183 LBM/SEC

AVERAGE VELOCITY = 110.82 FT/SEC

MOMENTUM FACTOR, KM = 1.087

(a) Three Primary Nozzles (Long) with Louvers Open.

Table XII. Tabulated Velocity Profile Data for Eductor Proposal A.

DATA TAKEN ON 9 DECEMBER 1976

UPTAKE MACH NUMBER 0.063

AMBIENT PRESSURE = 30.056 IN.HGA, TEMPERATURE = 55.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 95.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	2.50	0.0	106.3	113.3	1.0134	1.0799
0.500	5.375	3.20	0.0	120.3	119.5	1.1465	1.1395
1.000	4.875	3.90	0.0	132.8	135.3	1.2657	1.2898
1.500	4.375	5.00	0.0	150.3	147.3	1.4331	1.4046
2.000	3.875	5.80	0.0	161.9	156.8	1.5435	1.4949
2.500	3.375	5.90	0.0	163.3	159.8	1.5568	1.5233
3.000	2.875	5.50	0.0	157.7	153.7	1.5031	1.4657
3.500	2.375	4.60	0.0	144.2	144.4	1.3746	1.3762
4.000	1.875	3.80	0.0	131.1	129.3	1.2494	1.2330
4.500	1.375	2.90	0.0	114.5	117.6	1.0914	1.1211
5.000	0.875	2.40	0.0	104.2	107.1	0.9929	1.0210
5.500	0.375	2.20	0.0	99.7	99.6	0.9506	0.9496
6.000	0.125	2.00	0.0	95.1	98.6	0.9064	0.9397
6.500	0.625	2.10	0.0	97.4	95.1	0.9288	0.9064
7.000	1.125	2.00	0.0	95.1	97.4	0.9064	0.9288
7.500	1.625	2.10	0.0	97.4	95.1	0.9288	0.9064
8.000	2.125	2.00	0.0	95.1	91.2	0.9064	0.8697
8.500	2.625	1.60	0.0	85.0	87.3	0.8107	0.8324
9.000	3.125	1.40	0.0	79.5	80.8	0.7583	0.7707
9.500	3.625	1.30	0.0	76.7	75.0	0.7307	0.7153
10.000	4.125	1.10	0.0	70.5	71.9	0.6722	0.6858
10.500	4.625	1.00	0.0	67.2	67.1	0.6409	0.6401
11.000	5.125	0.90	0.0	63.8	63.7	0.6080	0.6071
11.500	5.625	0.80	0.0	60.1	60.1	0.5732	0.5732
11.750	5.875	0.80	0.0	60.1	60.1	0.5732	0.5732

INTEGRATED FLOW RATE = 78.99 CU.FT/SEC
= 5.849 LBM/SEC

AVERAGE VELOCITY = 104.90 FT/SEC

MOMENTUM FACTOR, KM = 1.115

(b) Three Primary Nozzles (Long) with Louvers Closed.

Table XII. Continued.

DATA TAKEN ON 10 DECEMBER 1976

UPTAKE MACH NUMBER = 0.063

AMBIENT PRESSURE = 30.111 IN.HGA, TEMPERATURE = 52.5 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 93.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	2.60	0.0	108.1	111.1	1.0264	1.0552
0.500	5.375	2.90	0.0	114.2	124.3	1.0840	1.1808
1.000	4.875	4.40	0.0	140.6	132.8	1.3353	1.2608
1.500	4.375	5.10	0.0	151.4	150.3	1.4376	1.4275
2.000	3.875	5.70	0.0	160.0	156.4	1.5198	1.4853
2.500	3.375	5.80	0.0	161.4	156.4	1.5330	1.4857
3.000	2.875	5.20	0.0	152.9	149.4	1.4516	1.4188
3.500	2.375	4.20	0.0	137.4	138.2	1.3046	1.3127
4.000	1.875	3.40	0.0	123.6	123.8	1.1738	1.1753
4.500	1.375	2.70	0.0	110.1	106.8	1.0460	1.0139
5.000	0.875	1.80	0.0	89.9	97.5	0.8540	0.9256
5.500	0.375	1.60	0.0	84.8	92.4	0.8052	0.8771
6.000	0.125	2.00	0.0	94.8	89.8	0.9002	0.8527
6.500	0.625	2.00	0.0	94.8	99.3	0.9002	0.9432
7.000	1.125	2.40	0.0	103.8	100.4	0.9862	0.9534
7.500	1.625	2.50	0.0	106.0	96.9	1.0065	0.9201
8.000	2.125	1.80	0.0	89.9	95.4	0.8540	0.9058
8.500	2.625	1.60	0.0	84.8	86.0	0.8052	0.8168
9.000	3.125	1.50	0.0	82.1	83.4	0.7796	0.7924
9.500	3.625	1.50	0.0	82.1	77.8	0.7796	0.7385
10.000	4.125	1.20	0.0	73.4	77.8	0.6973	0.7385
10.500	4.625	1.20	0.0	73.4	70.2	0.6973	0.6669
11.000	5.125	1.00	0.0	67.0	66.7	0.6366	0.6333
11.500	5.625	0.80	0.0	60.0	60.0	0.5694	0.5694
11.750	5.875	0.80	0.0	60.0	60.0	0.5694	0.5694

INTEGRATED FLOW RATE = 79.29 CU.FT/SEC
= 5.907 LBM/SEC

AVERAGE VELOCITY = 105.30 FT/SEC

MOMENTUM FACTOR, KM = 1.104

(c) Three Primary Nozzles (Short) with Louvers Open.

Table XII. Continued.

DATA TAKEN ON 10 DECEMBER 1976

UPTAKE MACH NUMBER = 0.063
AMBIENT PRESSURE = 30.111 IN.HGA, TEMPERATURE = 54.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 93.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	1.90	0.0	92.5	100.3	0.8786	0.9532
0.500	5.375	2.60	0.0	108.1	107.1	1.0278	1.0183
1.000	4.875	3.30	0.0	121.8	122.8	1.1579	1.1670
1.500	4.375	4.20	0.0	137.5	135.9	1.3063	1.2916
2.000	3.875	5.00	0.0	150.0	145.2	1.4253	1.3799
2.500	3.375	5.20	0.0	152.9	150.7	1.4535	1.4324
3.000	2.875	5.10	0.0	151.5	149.9	1.4395	1.4250
3.500	2.375	4.80	0.0	146.9	141.1	1.3965	1.3410
4.000	1.875	3.80	0.0	130.7	132.5	1.2425	1.2594
4.500	1.375	3.10	0.0	118.1	117.3	1.1223	1.1150
5.000	0.875	2.40	0.0	103.9	107.6	0.9875	1.0230
5.500	0.375	2.10	0.0	97.2	99.4	0.9237	0.9444
6.000	0.125	2.00	0.0	94.9	97.2	0.9014	0.9237
6.500	0.625	2.10	0.0	97.2	96.0	0.9237	0.9126
7.000	1.125	2.10	0.0	97.2	98.3	0.9237	0.9346
7.500	1.625	2.20	0.0	99.5	97.2	0.9454	0.9237
8.000	2.125	2.10	0.0	97.2	96.0	0.9237	0.9120
8.500	2.625	1.90	0.0	92.5	92.3	0.8786	0.8774
9.000	3.125	1.70	0.0	87.5	88.6	0.8311	0.8424
9.500	3.625	1.60	0.0	84.8	84.8	0.8063	0.8059
10.000	4.125	1.50	0.0	82.1	80.7	0.7807	0.7665
10.500	4.625	1.30	0.0	76.5	79.3	0.7268	0.7537
11.000	5.125	1.30	0.0	76.5	73.4	0.7268	0.6976
11.500	5.625	1.10	0.0	70.3	70.3	0.6685	0.6685
11.750	5.875	1.10	0.0	70.3	70.3	0.6685	0.6685

INTEGRATED FLOW RATE = 79.24 CU.FT/SEC
= 5.895 LBM/SEC

AVERAGE VELOCITY = 105.23 FT/SEC

MOMENTUM FACTOR, KM = 1.069

(d) Three Primary Nozzles (Short) with Louvers Closed.

Table XII. Continued.

DATA TAKEN ON 1 DECEMBER 1976

UPTAKE MACH NUMBER = 0.063
AMBIENT PRESSURE = 30.196 IN.HGA, TEMPERATURE = 55.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 93.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	3.10	1.90	118.0	92.4	0.9968	0.7804
0.500	5.375	4.20	2.40	137.3	103.8	1.1603	0.8771
1.000	4.875	5.20	2.60	152.8	108.0	1.2911	0.9129
1.500	4.375	5.60	2.70	158.6	110.1	1.3398	0.9303
2.000	3.875	5.20	2.90	152.8	114.1	1.2911	0.9642
2.500	3.375	4.40	3.00	140.5	116.1	1.1876	0.9806
3.000	2.875	3.40	3.00	123.5	116.1	1.0440	0.9806
3.500	2.375	2.80	2.60	112.1	108.0	0.9474	0.9129
4.000	1.875	2.20	2.30	99.4	101.6	0.8398	0.8586
4.500	1.375	2.00	2.00	94.8	94.8	0.8007	0.8007
5.000	0.875	1.90	1.70	92.4	87.4	0.7804	0.7382
5.500	0.375	1.80	1.50	89.9	82.1	0.7596	0.6934
6.000	0.125	1.80	1.60	89.9	84.8	0.7596	0.7162
6.500	0.625	1.70	2.00	87.4	94.8	0.7382	0.8007
7.000	1.125	1.90	2.30	92.4	101.6	0.7804	0.8586
7.500	1.625	2.20	2.60	99.4	108.0	0.8398	0.9129
8.000	2.125	2.60	2.80	108.0	112.1	0.9129	0.9474
8.500	2.625	3.70	2.90	128.9	114.1	1.0891	0.9642
9.000	3.125	4.90	2.90	148.3	114.1	1.2533	0.9642
9.500	3.625	5.60	2.70	158.6	110.1	1.3398	0.9303
10.000	4.125	5.50	2.50	157.1	105.9	1.3278	0.8952
10.500	4.625	4.70	2.30	145.3	101.6	1.2274	0.8586
11.000	5.125	3.60	2.20	127.1	99.4	1.0742	0.8398
11.500	5.625	2.40	1.60	103.8	84.8	0.8771	0.7162
11.750	5.875	2.40	1.60	103.8	84.8	0.8771	0.7162

INTEGRATED FLOW RATE = 89.12 CU.FT/SEC
= 6.644 LBM/SEC

AVERAGE VELOCITY = 118.35 FT/SEC

MOMENTUM FACTOR, KM = 1.024

(e) Four Primary Nozzles with Louvers Open.

Table XII. Continued.

DATA TAKEN ON 1 DECEMBER 1976

UPTAKE MACH NUMBER = 0.063
AMBIENT PRESSURE = 30.201 IN.HGA, TEMPERATURE = 55.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 95.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	2.70	2.20	110.2	99.5	0.9496	0.8572
0.500	5.375	3.20	2.50	120.0	106.0	1.0338	0.9138
1.000	4.875	3.80	2.80	130.7	112.2	1.1266	0.9670
1.500	4.375	4.20	2.90	137.5	114.2	1.1844	0.9841
2.000	3.875	4.20	3.10	137.5	118.1	1.1844	1.0175
2.500	3.375	4.00	3.30	134.1	121.8	1.1558	1.0498
3.000	2.875	3.60	3.20	127.3	120.0	1.0965	1.0338
3.500	2.375	3.00	3.00	116.2	116.2	1.0010	1.0010
4.000	1.875	2.50	2.60	106.0	108.1	0.9138	0.9318
4.500	1.375	2.20	2.30	99.5	101.7	0.8572	0.8764
5.000	0.875	2.00	2.10	94.9	97.2	0.8173	0.8375
5.500	0.375	2.00	2.00	94.9	94.9	0.8173	0.8173
6.000	0.125	2.00	2.00	94.9	94.9	0.8173	0.8173
6.500	0.625	2.20	2.10	99.5	97.2	0.8572	0.8375
7.000	1.125	2.50	2.60	106.0	108.1	0.9138	0.9318
7.500	1.625	3.10	3.00	118.1	116.2	1.0175	1.0010
8.000	2.125	3.50	3.20	125.5	120.0	1.0812	1.0338
8.500	2.625	4.10	3.10	135.8	118.1	1.1702	1.0175
9.000	3.125	4.50	3.10	142.3	118.1	1.2259	1.0175
9.500	3.625	4.80	2.90	146.9	114.2	1.2661	0.9841
10.000	4.125	4.60	2.70	143.8	110.2	1.2395	0.9496
10.500	4.625	4.10	2.40	135.8	103.9	1.1702	0.8953
11.000	5.125	3.30	2.30	121.8	101.7	1.0498	0.8764
11.500	5.625	2.20	1.60	99.5	84.8	0.8572	0.7310
11.750	5.875	0.0	1.60	0.0	84.8	0.0	0.7310

INTEGRATED FLOW RATE = 87.39 CU.FT/SEC
= 6.503 LBM/SEC

AVERAGE VELOCITY = 116.06 FT/SEC

MOMENTUM FACTOR, KM = 1.019

(f) Four Primary Nozzles with Louvers Closed.

Table XII. Continued.

DAYA TAKEN ON 30 NOVEMBER 1976

UPTAKE MACH NUMBER = 0.063

AMBIENT PRESSURE = 30.210 IN.HGA, TEMPERATURE = 56.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 96.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	3.50	2.50	125.6	106.1	0.9864	0.8336
0.500	5.375	4.60	2.90	144.0	114.3	1.1308	0.8979
1.000	4.875	5.20	3.20	153.1	120.1	1.2023	0.9432
1.500	4.375	4.90	3.20	148.6	120.1	1.1671	0.9432
2.000	3.875	4.30	3.30	139.2	121.9	1.0933	0.9578
2.500	3.375	4.40	3.20	140.8	120.1	1.1060	0.9432
3.000	2.875	2.90	2.90	114.3	114.3	0.8979	0.8979
3.500	2.375	3.10	2.80	118.2	112.3	0.9283	0.8822
4.000	1.875	3.60	3.20	127.4	120.1	1.0004	0.9432
4.500	1.375	4.30	4.30	139.2	139.2	1.0933	1.0933
5.000	0.875	5.60	5.80	158.8	161.7	1.2477	1.2698
5.500	0.375	6.60	6.50	172.4	171.1	1.3545	1.3442
6.000	0.125	6.70	6.40	173.7	169.8	1.3647	1.3338
6.500	0.625	6.00	5.50	164.4	157.4	1.2915	1.2365
7.000	1.125	4.60	4.30	144.0	139.2	1.1308	1.0933
7.500	1.625	4.00	3.50	134.2	125.6	1.0545	0.9864
8.000	2.125	3.30	3.30	121.9	121.9	0.9578	0.9578
8.500	2.625	3.00	3.40	116.3	123.8	0.9132	0.9722
9.000	3.125	3.40	3.40	123.8	123.8	0.9722	0.9722
9.500	3.625	4.10	3.40	135.9	123.8	1.0676	0.9722
10.000	4.125	4.40	3.20	140.8	120.1	1.1060	0.9432
10.500	4.625	4.50	3.10	142.4	118.2	1.1185	0.9283
11.000	5.125	3.90	3.10	132.6	118.2	1.0412	0.9283
11.500	5.625	3.20	2.30	120.1	101.8	0.9432	0.7996
11.750	5.875	3.20	2.30	120.1	101.8	0.9432	0.7996

INTEGRATED FLOW RATE = 95.86 CU.FT/SEC
= 7.122 LBM/SEC

AVERAGE VELOCITY = 127.31 FT/SEC

MOMENTUM FACTOR, KM = 1.009

(g) Five Primary Nozzles with Louvers Open.

Table XII. Continued.

DATA TAKEN ON 30 NOVEMBER 1976

UPTAKE MACH NUMBER = 0.063

AMBIENT PRESSURE = 30.210 IN.HGA, TEMPERATURE = 56.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 96.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	2.40	1.90	104.0	92.5	0.8682	0.7725
0.500	5.375	3.40	2.50	123.8	106.1	1.0334	0.8861
1.000	4.875	3.90	2.40	132.6	104.0	1.1067	0.8682
1.500	4.375	4.20	2.70	137.6	110.3	1.1485	0.9209
2.000	3.875	4.30	2.70	139.2	110.3	1.1621	0.9209
2.500	3.375	3.80	2.60	130.8	108.2	1.0925	0.9037
3.000	2.875	3.60	2.60	127.4	108.2	1.0633	0.9037
3.500	2.375	3.60	2.90	127.4	114.3	1.0633	0.9544
4.000	1.875	3.90	3.30	132.6	121.9	1.1067	1.0181
4.500	1.375	4.60	4.20	144.0	137.6	1.2020	1.1485
5.000	0.875	5.00	4.90	150.1	148.6	1.2531	1.2405
5.500	0.375	5.40	5.50	156.0	157.4	1.3023	1.3143
6.000	0.125	5.20	5.40	153.1	156.0	1.2780	1.3023
6.500	0.625	4.60	4.80	144.0	147.1	1.2020	1.2278
7.000	1.125	4.00	4.10	134.2	135.9	1.1208	1.1348
7.500	1.625	3.50	3.60	125.6	127.4	1.0485	1.0633
8.000	2.125	3.20	3.40	120.1	123.8	1.0025	1.0334
8.500	2.625	3.50	3.10	125.6	118.2	1.0485	0.9867
9.000	3.125	3.60	3.20	127.4	120.1	1.0633	1.0025
9.500	3.625	3.90	3.00	132.6	116.3	1.1067	0.9707
10.000	4.125	3.90	2.90	132.6	114.3	1.1067	0.9544
10.500	4.625	3.50	2.90	125.6	114.3	1.0485	0.9544
11.000	5.125	3.10	2.80	118.2	112.3	0.9867	0.9378
11.500	5.625	2.30	2.20	101.8	99.6	0.8499	0.8312
11.750	5.875	2.30	2.20	101.8	99.6	0.8499	0.8312

INTEGRATED FLOW RATE = 90.19 CU.FT/SEC
= 6.700 LBM/SEC

AVERAGE VELOCITY = 119.77 FT/SEC

MOMENTUM FACTOR, KM = 1.009

(h) Five Primary Nozzles with Louvers Closed.

Table XII. Continued.

DATA TAKEN ON 03 JANUARY 1977

OVAL COVER PLATE ON LOUVER SCREENS ON

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4

PRIMARY NOZZLE DIAMETER = 2.360 INCHES

MIXING STACK DIAMETER = 8.220 INCHES

MIXING STACK LENGTH = 20.100 INCHES

MIXING STACK L/D = 2.445

UPTAKE DIAMETER = 7.860 INCHES

AREA RATIO, AM/AP = 3.033

PRIMARY FLOW RATE = 3.863 LBM/SEC

= 54.070 CFS

ORIFICE PRESSURE DROP = 23.2 IN.H2O

ORIFICE STATIC PRESSURE = 0.71 IN.H2O

ORIFICE TEMPERATURE = 55.0 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 104.0 DEG.FAHR

AMBIENT PRESSURE = 29.975 IN.HGA

AMBIENT TEMPERATURE = 65.0 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9308

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4124	0.4430	0.0	3.863	0.0	5.35	4.62	222.49	73.36	80.23	0.0689	0.	4.62
2	0.2077	0.3150	0.3384	0.2012	3.863	0.802	6.45	3.51	221.90	87.49	80.02	0.0688	4.	3.47
3	0.3483	0.2313	0.2485	0.3375	3.863	1.345	7.10	2.57	221.55	97.09	79.89	0.0687	8.	2.44
4	0.4986	0.1354	0.1454	0.4831	3.863	1.926	7.65	1.50	221.26	107.38	79.79	0.0686	16.	1.25
5	0.5916	0.0715	0.0768	0.5732	3.863	2.285	8.15	0.79	220.99	113.72	79.69	0.0685	32.	0.44
6	0.6485	0.0570	0.0612	0.6284	3.863	2.505	8.20	0.63	220.97	117.65	79.68	0.0685	48.	0.24
7	0.6792	0.0471	0.0506	0.6582	3.863	2.624	8.25	0.52	220.94	119.76	79.67	0.0685	64.	0.15
8	0.6963	0.0453	0.0486	0.6747	3.863	2.690	8.28	0.50	220.92	120.93	79.67	0.0685	79.	0.10
9	********	0.0398	0.0428	********	3.863	*******	8.32	0.44	220.90	********	79.66	0.0685	******	0.0

(a) Separation of 0.28 inch and Uptake Mach Number of 0.0684.

Table XIII. Tabulated Performance Data for the Four Nozzle Configuration of Eductor Proposal B With an Area Ratio of 3.033.

DATA TAKEN ON 02 JANUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS ON

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4

PRIMARY NOZZLE DIAMETER = 2.360 INCHES

MIXING STACK DIAMETER = 8.220 INCHES

MIXING STACK LENGTH = 20.100 INCHES

MIXING STACK L/D = 2.445

UPTAKE DIAMETER = 7.860 INCHES

AREA RATIO, AM/AP = 3.033

PRIMARY FLOW RATE = 3.868 LBM/SEC
= 54.006 CFS

ORIFICE PRESSURE DROP = 23.1 IN.H2O

ORIFICE STATIC PRESSURE = 0.71 IN.H2O

ORIFICE TEMPERATURE = 48.5 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 99.5 DEG.FAHR

AMBIENT PRESSURE = 29.805 IN.HGA

AMBIENT TEMPERATURE = 58.0 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9258

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4146	0.4478	0.0	3.868	0.0	5.40	4.67	222.23	73.27	80.14	0.0691	0.	4.67
2	0.2076	0.3113	0.3363	0.2007	3.868	0.803	6.40	3.49	221.69	87.32	79.94	0.0690	4.	3.45
3	0.3527	0.2346	0.2534	0.3410	3.868	1.364	7.15	2.62	221.29	97.14	79.80	0.0688	8.	2.49
4	0.5078	0.1384	0.1494	0.4908	3.868	1.964	7.85	1.54	220.91	107.66	79.66	0.0687	16.	1.29
5	0.6064	0.0720	0.0778	0.5862	3.868	2.346	8.35	0.80	220.64	114.35	79.57	0.0686	32.	0.46
6	0.6571	0.0559	0.0603	0.6351	3.868	2.541	8.47	0.62	220.58	117.80	79.54	0.0686	48.	0.24
7	0.6926	0.0478	0.0516	0.6695	3.868	2.679	8.50	0.53	220.56	120.24	79.54	0.0686	64.	0.15
8	0.6804	0.0446	0.0482	0.6577	3.868	2.632	8.55	0.50	220.54	119.39	79.53	0.0686	79.	0.10
9	********	0.0388	0.0419	********	3.868	********	8.60	0.43	220.51	********	79.52	0.0686	******	0.0

(b) Separation of 0.71 inch and Uptake Mach Number of 0.0686.

Table XIII. Continued.

DATA TAKEN ON 03 JANUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 2.360 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 3.033

PRIMARY FLOW RATE = 3.877 LBM/SEC
= 54.566 CFS
ORIFICE PRESSURE DROP = 23.4 IN.H2O
ORIFICE STATIC PRESSURE = 0.72 IN.H2O
ORIFICE TEMPERATURE = 55.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 107.0 DEG.FAHR
AMBIENT PRESSURE = 29.965 IN.HGA
AMBIENT TEMPERATURE = 74.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9426

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4258	0.4517	0.0	3.877	0.0	5.40	4.77	224.53	74.03	80.97	0.0694	0.	4.77
2	0.2062	0.3185	0.3379	0.2009	3.877	0.799	6.50	3.55	223.94	88.39	80.75	0.0692	4.	3.51
3	0.3509	0.2414	0.2561	0.3419	3.877	1.360	7.30	2.68	223.51	98.47	80.60	0.0691	8.	2.54
4	0.5097	0.1447	0.1535	0.4966	3.877	1.976	8.10	1.60	223.08	109.55	80.44	0.0689	16.	1.34
5	0.6101	0.0744	0.0789	0.5944	3.877	2.365	8.70	0.82	222.75	116.55	80.33	0.0688	32.	0.48
6	0.6604	0.0581	0.0616	0.6435	3.877	2.560	8.78	0.64	222.71	120.09	80.31	0.0688	48.	0.25
7	0.6934	0.0490	0.0520	0.6756	3.877	2.688	8.85	0.54	222.67	122.41	80.30	0.0688	64.	0.16
8	0.6875	0.0472	0.0501	0.6698	3.877	2.665	8.90	0.52	222.65	121.98	80.29	0.0688	79.	0.10
9	********	0.0391	0.0414	********	3.877	*******	9.00	0.43	222.59	********	80.27	0.0688	******	0.0

(c) Separation of 1.40 inch and Uptake Mach Number of 0.0688.

Table XIII. Continued.

DATA TAKEN ON 02 JANUARY 1977
TRUSS COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 2.360 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 3.033

PRIMARY FLOW RATE = 3.866 LBM/SEC
= 54.018 CFS
ORIFICE PRESSURE DROP = 23.1 IN.H2O
ORIFICE STATIC PRESSURE = 0.72 IN.H2O
ORIFICE TEMPERATURE = 49.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 100.5 DEG.FAHR
AMBIENT PRESSURE = 29.840 IN.HGA
AMBIENT TEMPERATURE = 59.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9259

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMPO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4156	0.4489	0.0	3.866	0.0	5.40	4.68	222.28	73.29	80.16	0.0691	0.	4.68
2	0.2088	0.3133	0.3384	0.2019	3.866	0.807	6.45	3.51	221.71	87.41	79.95	0.0689	4.	3.49
3	0.3542	0.2329	0.2515	0.3424	3.866	1.369	7.15	2.60	221.34	97.26	79.82	0.0688	8.	2.51
4	0.5137	0.1367	0.1476	0.4966	3.866	1.986	7.95	1.52	220.91	108.08	79.66	0.0687	16.	1.32
5	0.6130	0.0658	0.0710	0.5926	3.866	2.370	8.40	0.73	220.67	114.82	79.58	0.0686	32.	0.47
6	0.6706	0.0487	0.0526	0.6483	3.866	2.593	8.50	0.54	220.61	118.76	79.56	0.0686	48.	0.25
7	0.7041	0.0433	0.0467	0.6806	3.866	2.722	8.50	0.48	220.61	121.06	79.56	0.0686	64.	0.16
8	0.6981	0.0392	0.0424	0.6748	3.866	2.699	8.55	0.44	220.59	120.64	79.55	0.0686	79.	0.10
9	********	0.0302	0.0326	********	3.866	*******	8.60	0.34	220.56	********	79.54	0.0686	******	0.0

(d) Separation of 0.71 inch, Uptake Mach Number of 0.0685 with Truss Cover Plate.

Table XIII. Continued.

DATA TAKEN ON 02 JANUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS OFF
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 2.360 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.862 INCHES
AREA RATIO, AM/AP = 3.033

PRIMARY FLOW RATE = 3.867 LBM/SEC
= 54.014 CFS
ORIFICE PRESSURE DROP = 23.1 IN.H2O
ORIFICE STATIC PRESSURE = 0.72 IN.H2O
ORIFICE TEMPERATURE = 49.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 100.0 DEG.FAHR
AMBIENT PRESSURE = 29.820 IN.HGA
AMBIENT TEMPERATURE = 58.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9250

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4134	0.4469	0.0	3.867	0.0	5.40	4.66	222.26	73.28	80.11	0.0691	0.	4.66
2	0.2083	0.3121	0.3374	0.2013	3.867	0.805	6.45	3.50	221.69	87.36	79.90	0.0689	4.	3.47
3	0.3550	0.2349	0.2540	0.3431	3.867	1.373	7.60	2.62	221.08	97.21	79.68	0.0687	8.	2.52
4	0.5100	0.1401	0.1514	0.4928	3.867	1.972	7.90	1.56	220.92	107.79	79.62	0.0687	16.	1.30
5	0.6100	0.0693	0.0749	0.5895	3.867	2.359	8.35	0.77	220.68	114.57	79.54	0.0686	32.	0.47
6	0.6776	0.0522	0.0565	0.6548	3.867	2.620	8.50	0.58	220.60	119.18	79.51	0.0686	48.	0.26
7	0.7157	0.0468	0.0506	0.6915	3.867	2.767	8.55	0.52	220.57	121.79	79.50	0.0686	64.	0.16
8	0.6984	0.0432	0.0467	0.6748	3.867	2.701	8.58	0.48	220.55	120.60	79.49	0.0686	79.	0.10
9	********	0.0365	0.0394	********	3.867	*******	8.60	0.41	220.54	********	79.45	0.0685	******	0.0

(e) Separation of 0.71 inch, Uptake Mach Number of 0.0685 with Louver Screens Off.

Table XIII. Continued.

DATA TAKEN ON 21 JANUARY 1977
OVAL COVER PLATE ON LOUVER SCREENS ON
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 2.360 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 3.033

PRIMARY FLOW RATE = 1.924 LBM/SEC
= 27.847 CFS
ORIFICE PRESSURE DROP = 5.8 IN.H2O
ORIFICE STATIC PRESSURE = 0.19 IN.H2O
ORIFICE TEMPERATURE = 59.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 117.0 DEG.FAHR
AMBIENT PRESSURE = 29.950 IN.HGA
AMBIENT TEMPERATURE = 70.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9185

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4012	0.4368	0.0	1.924	0.0	1.40	1.18	114.59	37.78	41.32	0.0351	0.	1.18
2	0.2053	0.2893	0.3150	0.1977	1.924	0.395	1.63	0.85	114.52	44.87	41.30	0.0351	4.	0.85
3	0.3478	0.2146	0.2337	0.3350	1.924	0.669	1.80	0.63	114.47	49.79	41.28	0.0351	8.	0.61
4	0.4958	0.1262	0.1374	0.4776	1.924	0.954	2.00	0.37	114.42	54.91	41.26	0.0351	16.	0.31
5	0.6170	0.0665	0.0724	0.5943	1.924	1.187	2.13	0.20	114.38	59.11	41.25	0.0350	32.	0.12
6	0.5974	0.0495	0.0539	0.5755	1.924	1.150	2.17	0.15	114.37	58.43	41.24	0.0350	48.	0.05
7	0.5632	0.0427	0.0464	0.5426	1.924	1.084	2.18	0.13	114.37	57.24	41.24	0.0350	64.	0.03
8	0.4397	0.0393	0.0427	0.4236	1.924	0.846	2.19	0.12	114.37	52.95	41.24	0.0350	79.	0.01
9	*******	0.0324	0.0353	********	1.924	*******	2.20	0.10	114.36	*******	41.24	0.0350	******	0.0

(f) Separation of 0.71 inch and Uptake Number of 0.0350.

Table XIII. Continued.

DATA TAKEN ON 08 MARCH 1977
OVAL COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 2.530 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 2.639

PRIMARY FLOW RATE = 1.927 LBM/SEC
= 27.530 CFS
ORIFICE PRESSURE DROP = 5.7 IN.H2O
ORIFICE STATIC PRESSURE = 0.19 IN.H2O
ORIFICE TEMPERATURE = 51.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 111.5 DEG.FAHR
AMBIENT PRESSURE = 30.080 IN.HGA
AMBIENT TEMPERATURE = 62.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9133

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3785	0.4144	0.0	1.927	0.0	0.90	0.84	98.57	37.35	40.85	0.0349	0.	0.90
2	0.1810	0.2977	0.3260	0.1740	1.927	0.349	1.15	0.66	98.51	43.47	40.83	0.0349	4.	0.65
3	0.3013	0.2077	0.2274	0.2895	1.927	0.580	1.30	0.46	98.48	47.55	40.81	0.0348	8.	0.45
4	0.4400	0.1219	0.1335	0.4228	1.927	0.848	1.40	0.27	98.45	52.27	40.80	0.0348	16.	0.24
5	0.5389	0.0678	0.0742	0.5178	1.927	1.038	1.50	0.15	98.43	55.63	40.79	0.0348	32.	0.09
6	0.5389	0.0542	0.0594	0.5178	1.927	1.038	1.50	0.12	98.43	55.63	40.79	0.0348	48.	0.04
7	0.5681	0.0429	0.0470	0.5458	1.927	1.094	1.60	0.10	98.40	56.61	40.78	0.0348	64.	0.03
8	0.5431	0.0384	0.0421	0.5219	1.927	1.046	1.60	0.09	98.40	55.76	40.78	0.0348	79.	0.02
9	*******	0.0362	0.0396	********	1.927	*******	1.60	0.08	98.40	********	40.78	0.0348	******	0.0

(a) Separation of 0.71 inch and Uptake Mach Number of 0,0348.

Table XIV. Tabulated Performance Data for the Four Nozzle Configuration of Eductor Proposal B With an Area Ratio of 2.639.

DATA TAKEN ON 23 FEBRUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 2.530 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 2.639

PRIMARY FLOW RATE = 3.877 LBM/SEC
= 54.199 CFS

ORIFICE PRESSURE DROP = 23.1 IN.H2O
ORIFICE STATIC PRESSURE = 0.73 IN.H2O
ORIFICE TEMPERATURE = 51.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 103.5 DEG.FAHR
AMBIENT PRESSURE = 30.124 IN.HGA
AMBIENT TEMPERATURE = 65.5 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9325

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4487	0.4812	0.0	3.877	0.0	3.50	3.84	194.06	73.53	80.43	0.0691	0.	3.84
2	0.1849	0.3264	0.3501	0.1793	3.877	0.717	4.50	2.78	193.59	86.11	80.23	0.0690	4.	2.76
3	0.3036	0.2284	0.2449	0.2944	3.877	1.177	5.00	1.94	193.36	94.21	80.13	0.0689	8.	1.86
4	0.4452	0.1346	0.1444	0.4317	3.877	1.726	5.70	1.14	193.03	103.86	80.00	0.0688	16.	1.00
5	0.5268	0.0663	0.0711	0.5108	3.877	2.042	6.10	0.56	192.85	109.43	79.92	0.0687	32.	0.35
6	0.5822	0.0545	0.0584	0.5645	3.877	2.257	6.20	0.46	192.80	113.24	79.90	0.0687	48.	0.19
7	0.5906	0.0485	0.0521	0.5727	3.877	2.290	6.20	0.41	192.80	113.82	79.90	0.0687	64.	0.11
8	0.5816	0.0462	0.0495	0.5640	3.877	2.255	6.20	0.39	192.80	113.20	79.90	0.0687	79.	0.07
9	********	0.0379	0.0406	********	3.877	*******	6.30	0.32	192.75	********	79.88	0.0687	******	0.0

(b) Separation of 0.71 inch and Uptake Mach Number of 0.0687.

Table XIV. Continued

DATA TAKEN ON 24 JANUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4
PRIMARY NOZZLE DIAMETER = 2.720 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 2.283

PRIMARY FLOW RATE = 1.932 LBM/SEC
= 28.001 CFS
ORIFICE PRESSURE DROP = 5.8 IN.H2O
ORIFICE STATIC PRESSURE = 0.19 IN.H2O
ORIFICE TEMPERATURE = 57.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 119.0 DEG.FAHR
AMBIENT PRESSURE = 30.060 IN.HGA
AMBIENT TEMPERATURE = 72.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9188

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMPO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3976	0.4327	0.0	1.932	0.0	0.60	0.67	86.74	37.99	41.55	0.0352	0.	0.67
2	0.1512	0.2762	0.3006	0.1457	1.932	0.292	0.80	0.47	86.70	43.22	41.53	0.0352	4.	0.47
3	0.2509	0.2377	0.2587	0.2417	1.932	0.485	0.91	0.40	86.67	46.68	41.52	0.0352	8.	0.32
4	0.3436	0.1100	0.1197	0.3310	1.932	0.664	1.04	0.19	86.65	49.90	41.51	0.0352	16.	0.15
5	0.3764	0.0535	0.0583	0.3626	1.932	0.727	1.09	0.09	86.64	51.03	41.50	0.0352	32.	0.04
6	0.3260	0.0387	0.0421	0.3140	1.932	0.630	1.12	0.07	86.63	49.29	41.50	0.0352	48.	0.02
7	0.0	0.0297	0.0324	0.0	1.932	0.0	1.13	0.05	86.63	37.94	41.50	0.0352	64.	0.0
8	0.0	0.0268	0.0291	0.0	1.932	0.0	1.13	0.04	86.63	37.94	41.50	0.0352	79.	0.0
9	********	0.0208	0.0227	********	1.932	*******	1.13	0.03	86.63	********	41.50	0.0352	******	0.0

(a) Separation of 0.71 inch and Uptake Mach Number of 0.0352.

Table XV. Tabulated Performance Data for the Four Nozzle Configuration of Eductor Proposal B With an Area Ratio of 2.283.

DATA TAKEN ON 24 JANUARY 1977

OVAL COVER PLATE ON LOUVER SCREENS ON

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 4

PRIMARY NOZZLE DIAMETER = 2.720 INCHES

MIXING STACK DIAMETER = 8.220 INCHES

MIXING STACK LENGTH = 20.100 INCHES

MIXING STACK L/D = 2.445

UPTAKE DIAMETER = 7.869 INCHES

AREA RATIO, AM/AP = 2.283

PRIMARY FLOW RATE = 3.869 LBM/SEC

= 55.094 CFS

ORIFICE PRESSURE DROP = 23.4 IN.H2O

ORIFICE STATIC PRESSURE = 0.73 IN.H2O

ORIFICE TEMPERATURE = 58.0 DEG.FAHR

ORIFICE DIAMETER = 6.902 INCHES

ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 111.0 DEG.FAHR

AMBIENT PRESSURE = 30.060 IN.HGA

AMBIENT TEMPERATURE = 72.0 DEG.FAHR

TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9317

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4491	0.4821	0.0	3.869	0.0	2.25	2.93	170.67	74.75	81.75	0.0698	0.	2.93
2	0.1534	0.3001	0.3221	0.1487	3.869	0.594	3.05	1.95	170.34	85.31	81.59	0.0697	4.	1.92
3	0.2495	0.2066	0.2218	0.2419	3.869	0.966	3.50	1.34	170.15	91.94	81.50	0.0696	8.	1.27
4	0.3402	0.1113	0.1194	0.3297	3.869	1.316	3.95	0.72	169.96	98.19	81.42	0.0695	16.	0.59
5	0.4059	0.0588	0.0631	0.3935	3.869	1.571	4.30	0.38	169.82	102.72	81.35	0.0695	32.	0.21
6	0.4201	0.0434	0.0465	0.4073	3.869	1.626	4.35	0.28	169.30	103.71	81.34	0.0695	48.	0.10
7	0.3961	0.0372	0.0399	0.3840	3.869	1.533	4.35	0.24	169.80	102.03	81.34	0.0695	64.	0.05
8	0.3787	0.0341	0.0366	0.3671	3.869	1.465	4.38	0.22	169.79	100.81	81.33	0.0695	79.	0.03
9	*******	0.0287	0.0308	********	3.869	*******	4.40	0.19	169.78	********	81.33	0.0695	******	0.0

(b) Separation of 0.71 inch and Uptake Mach Number of 0.0695.

Table XV. Continued.

DATA TAKEN ON 01 JANUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 2.100 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 3.064

PRIMARY FLOW RATE = 3.864 LBM/SEC
= 53.971 CFS

ORIFICE PRESSURE DROP = 23.0 IN.H2O
ORIFICE STATIC PRESSURE = 0.72 IN.H2O
ORIFICE TEMPERATURE = 48.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502

PRIMARY FLOW (UPTAKE) TEMPERATURE = 101.5 DEG.FAHR
AMBIENT PRESSURE = 29.870 IN.HGA
AMBIENT TEMPERATURE = 60.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9260

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.3995	0.4314	0.0	3.864	0.0	5.80	4.58	224.39	73.23	80.09	0.0690	0.	4.58
2	0.2086	0.3087	0.3334	0.2016	3.864	0.806	6.95	3.52	223.76	87.32	79.86	0.0689	4.	3.48
3	0.3528	0.2305	0.2489	0.3411	3.864	1.363	7.55	2.62	223.44	97.12	79.75	0.0687	8.	2.49
4	0.4437	0.1762	0.1903	0.4289	3.864	1.714	7.90	2.00	223.25	103.30	79.68	0.0686	12.	1.75
5	0.5079	0.1359	0.1467	0.4910	3.864	1.962	8.20	1.54	223.09	107.66	79.62	0.0686	16.	1.29
6	0.5831	0.0672	0.0726	0.5637	3.864	2.253	8.60	0.76	222.87	112.75	79.55	0.0685	32.	0.43
7	0.6572	0.0540	0.0583	0.6354	3.864	2.539	8.70	0.61	222.82	117.83	79.53	0.0685	48.	0.24
8	0.6928	0.0478	0.0516	0.6698	3.864	2.677	8.75	0.54	222.79	120.26	79.52	0.0685	64.	0.15
9	0.6982	0.0460	0.0497	0.6750	3.864	2.698	8.75	0.52	222.79	120.64	79.52	0.0685	79.	0.10
10	********	0.0376	0.0406	*******	3.864	*******	8.75	0.43	222.79	********	79.52	0.0685	******	0.0

(a) Separation of 0.28 inch and Uptake Mach Number of 0.0685.

Table XVI. Tabulated Performance Data for the Five Nozzle Configuration of Eductor Proposal B With an Area Ratio of 3.064.

DATA TAKEN ON 02 JANUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 2.100 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 3.064

PRIMARY FLOW RATE = 3.866 LBM/SEC
= 54.818 CFS
ORIFICE PRESSURE DPOP = 23.5 IN.H2O
ORIFICE STATIC PRESSURE = 0.73 IN.H2O
ORIFICE TEMPERATURE = 56.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 107.5 DEG.FAHR
AMBIENT PRESSURE = 29.725 IN.HGA
AMBIENT TEMPERATURE = 69.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9321

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4071	0.4368	0.0	3.866	0.0	5.95	4.71	227.91	74.37	81.34	0.0697	0.	4.71
2	0.2085	0.3138	0.3366	0.2022	3.866	0.806	7.10	3.61	227.27	88.80	81.12	0.0695	4.	3.56
3	0.3550	0.2362	0.2534	0.3442	3.866	1.372	7.70	2.71	226.94	98.98	81.00	0.0694	8.	2.58
4	0.5136	0.1426	0.1530	0.4980	3.866	1.985	8.40	1.63	226.55	110.00	80.86	0.0693	16.	1.35
5	0.6376	0.0772	0.0828	0.6181	3.866	2.465	9.00	0.88	226.22	118.61	80.74	0.0692	32.	0.52
6	0.6631	0.0588	0.0631	0.6429	3.866	2.563	9.10	0.67	226.17	120.39	80.72	0.0692	48.	0.25
7	0.7073	0.0492	0.0527	0.6858	3.866	2.734	9.15	0.56	226.14	123.49	80.71	0.0691	64.	0.16
8	0.7073	0.0465	0.0499	0.6857	3.866	2.734	9.20	0.53	226.11	123.47	80.70	0.0691	79.	0.11
9	********	0.0395	0.0424	********	3.866	*******	9.25	0.45	226.09	*******	80.69	0.0691	******	0.0

(b) Separation of 0.71 inch and Uptake Mach Number of 0.0691.

Table XVI. Continued.

DATA TAKEN ON 02 JANUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY

NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 2.100 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 3.064

PRIMARY FLOW RATE = 3.861 LBM/SEC
= 54.130 CFS
ORIFICE PRESSURE DROP = 23.1 IN.H2O
ORIFICE STATIC PRESSURE = 0.72 IN.H2O
ORIFICE TEMPERATURE = 50.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 102.0 DEG.FAHR
AMBIENT PRESSURE = 29.795 IN.HGA
AMBIENT TEMPERATURE = 61.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9270

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	HU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4041	0.4360	0.0	3.861	0.0	5.75	4.64	225.04	73.44	80.32	0.0691	0.	4.64
2	0.2082	0.3083	0.3326	0.2014	3.861	0.804	6.90	3.52	224.42	87.57	80.10	0.0690	4.	3.48
3	0.3572	0.2364	0.2550	0.3454	3.861	1.379	7.60	2.69	224.04	97.71	79.96	0.0688	8.	2.56
4	0.5226	0.1448	0.1562	0.5054	3.861	2.018	8.50	1.64	223.55	108.96	79.79	0.0687	16.	1.37
5	0.6250	0.0770	0.0831	0.6045	3.861	2.414	9.10	0.87	223.22	115.92	79.67	0.0686	32.	0.49
6	0.6959	0.0593	0.0640	0.6731	3.861	2.687	9.20	0.67	223.17	120.80	79.65	0.0686	48.	0.27
7	0.7254	0.0532	0.0573	0.7016	3.861	2.801	9.25	0.60	223.14	122.82	79.64	0.0686	64.	0.17
8	0.7143	0.0479	0.0516	0.6909	3.861	2.758	9.30	0.54	223.12	122.05	79.63	0.0686	79.	0.11
9	********	0.0421	0.0454	********	3.861	*******	9.35	0.48	223.09	********	79.62	0.0685	******	0.0

(c) Separation of 1.40 and Uptake Mach Number of 0.0685.

Table XVI. Continued.

DATA TAKEN ON 02 JANUARY 1977
TRUSS COVER PLATE ON   LOUVER SCREENS ON
GEOMETRY
NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 2.100 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 3.064

PRIMARY FLOW RATE = 3.866 LBM/SEC
= 54.919 CFS
ORIFICE PRESSURE DROP = 23.6 IN.H2O
ORIFICE STATIC PRESSURE = 0.73 IN.H2O
ORIFICE TEMPERATURE = 58.0 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 108.0 DEG.FAHR
AMBIENT PRESSURE = 29.700 IN.HGA
AMBIENT TEMPERATURE = 70.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9331

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMBO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4093	0.4387	0.0	3.866	0.0	6.00	4.74	228.33	74.51	81.49	0.0698	0.	4.74
2	0.2076	0.3081	0.3302	0.2014	3.866	0.803	7.00	3.55	227.77	88.94	81.29	0.0696	4.	3.54
3	0.3538	0.2325	0.2492	0.3432	3.866	1.368	7.70	2.67	227.38	99.12	81.16	0.0695	8.	2.57
4	0.5185	0.1381	0.1480	0.5029	3.866	2.005	8.45	1.58	226.97	110.59	81.01	0.0694	16.	1.38
5	0.6304	0.0701	0.0751	0.6115	3.866	2.437	8.90	0.80	226.72	118.40	80.92	0.0693	32.	0.51
6	0.6816	0.0500	0.0536	0.6611	3.866	2.635	9.10	0.57	226.61	121.98	80.88	0.0693	48.	0.27
7	0.6950	0.0417	0.0446	0.6742	3.866	2.687	9.15	0.48	226.58	122.92	80.87	0.0692	64.	0.16
8	0.6891	0.0403	0.0432	0.6684	3.866	2.664	9.18	0.46	226.57	122.49	80.86	0.0692	79.	0.10
9	*******	0.0294	0.0315	*******	3.866	*******	9.22	0.34	226.55	*******	80.86	0.0692	******	0.0

(d) Separation of 0.71 inch, Uptake Mach Number of 0.0692 with Truss Cover Plate.

Table XVI. Continued.

DATA TAKEN ON 02 JANUARY 1977
OVAL COVER PLATE ON   LOUVER SCREENS OFF

GEOMETRY

NUMBER OF PRIMARY NOZZLES = 5
PRIMARY NOZZLE DIAMETER = 2.100 INCHES
MIXING STACK DIAMETER = 8.220 INCHES
MIXING STACK LENGTH = 20.100 INCHES
MIXING STACK L/D = 2.445
UPTAKE DIAMETER = 7.860 INCHES
AREA RATIO, AM/AP = 3.064

PRIMARY FLOW RATE = 3.869 LBM/SEC
= 54.888 CFS
ORIFICE PRESSURE DROP = 23.6 IN.H2O
ORIFICE STATIC PRESSURE = 0.73 IN.H2O
ORIFICE TEMPERATURE = 57.5 DEG.FAHR
ORIFICE DIAMETER = 6.902 INCHES
ORIFICE BETA = 0.502
PRIMARY FLOW (UPTAKE) TEMPERATURE = 107.5 DEG.FAHR
AMBIENT PRESSURE = 29.710 IN.HGA
AMBIENT TEMPERATURE = 70.0 DEG.FAHR
TEMPERATURE RATIO, TS/TP (T-STAR) = 0.9339

N	W*	P*	P*/T*	W*T**.44	WP	WS	PU-PA	PA-PS	UP	UM	UU	MU	COMPO	PA-PNZ
					LBM/SEC		IN.H2O			FT/SEC				IN.H2O
1	0.0	0.4053	0.4340	0.0	3.869	0.0	6.00	4.69	228.20	74.47	81.45	0.0698	0.	4.69
2	0.2078	0.3102	0.3321	0.2016	3.869	0.804	7.10	3.57	227.59	88.90	81.23	0.0696	4.	3.55
3	0.3529	0.2336	0.2501	0.3424	3.869	1.365	7.75	2.68	227.23	99.01	81.10	0.0695	8.	2.56
4	0.5142	0.1406	0.1505	0.4989	3.885	1.998	8.60	1.62	227.72	110.70	81.28	0.0696	16.	1.37
5	0.6362	0.0763	0.0817	0.6174	3.869	2.462	9.00	0.87	226.54	118.77	80.86	0.0693	32.	0.52
6	0.6748	0.0562	0.0601	0.6548	3.869	2.611	9.15	0.64	226.46	121.47	80.83	0.0692	48.	0.26
7	0.6947	0.0483	0.0517	0.6741	3.869	2.688	9.20	0.55	226.43	122.86	80.82	0.0692	64.	0.16
8	0.7058	0.0448	0.0479	0.6849	3.869	2.731	9.25	0.51	226.40	123.63	80.81	0.0692	79.	0.11
9	********	0.0351	0.0376	********	3.869	*******	9.30	0.40	226.37	********	80.80	0.0692	******	0.0

(e) Separation of 0.71 inch, Uptake Mach Number of 0.0692 with Louver Screens Off.

Table XVI. Continued.

DATA TAKEN ON 3 JANUARY 1977

OVAL COVER PLATE ON LOUVER SCREENS ON
AMBIENT PRESSURE = 29.960 IN.HGA, TEMPERATURE = 72.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 107.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	4.125	3.00	1.90	118.2	94.0	0.9359	0.7448
0.250	3.875	3.20	2.10	122.0	98.9	0.9666	0.7830
0.750	3.375	4.60	2.20	146.3	101.2	1.1589	0.8014
1.250	2.875	5.50	2.40	160.0	105.7	1.2672	0.8371
1.750	2.375	5.50	2.80	160.0	114.2	1.2672	0.9042
2.250	1.875	4.50	3.20	144.7	122.0	1.1462	0.9666
2.750	1.375	3.50	3.20	127.6	122.0	1.0109	0.9666
3.250	0.875	2.80	3.00	114.2	118.2	0.9042	0.9359
3.750	0.375	2.60	2.60	110.0	110.0	0.8713	0.8713
4.250	0.125	2.50	2.40	107.9	105.7	0.8543	0.8371
4.750	0.625	2.70	2.50	112.1	107.9	0.8879	0.8543
5.250	1.125	2.90	2.60	116.2	110.0	0.9202	0.8713
5.750	1.625	3.80	3.00	133.0	118.2	1.0533	0.9359
6.250	2.125	4.90	3.10	151.0	120.1	1.1961	0.9514
6.750	2.625	5.60	3.00	161.4	118.2	1.2787	0.9359
7.250	3.125	5.60	2.80	161.4	114.2	1.2787	0.9042
7.750	3.625	4.20	2.70	139.8	112.1	1.1074	0.8879
8.250	4.125	3.20	2.10	122.0	98.9	0.9666	0.7830

INTEGRATED FLOW RATE = 46.87 CU.FT/SEC
= 3.371 LBM/SEC

AVERAGE VELOCITY = 126.25 FT/SEC

MOMENTUM FACTOR, KM = 1.016

(a) Separation of 0.28 inch, Forward Mixing Stack with Uptake Mach Number of 0.0685.

Table XVII. Tabulated Velocity Profile Data for the Four Nozzle Configuration of Eductor Proposal B with an Area Ratio of 3.033.

DATA TAKEN ON 3 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON

AMBIENT PRESSURE = 29.970 IN.HGA, TEMPERATURE = 66.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 110.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	4.125	2.70	1.00	112.0	68.2	0.9114	0.5547
0.250	3.875	3.10	1.20	120.0	74.7	0.9766	0.6076
0.750	3.375	4.30	1.50	141.3	83.5	1.1502	0.6793
1.250	2.875	5.60	2.00	161.3	96.4	1.3126	0.7844
1.750	2.375	6.20	2.90	169.7	116.1	1.3811	0.9446
2.250	1.875	5.80	3.60	164.1	129.3	1.3358	1.0524
2.750	1.375	4.90	4.00	150.9	136.3	1.2278	1.1093
3.250	0.875	4.20	3.90	139.7	134.6	1.1367	1.0954
3.750	0.375	3.90	3.80	134.6	132.9	1.0954	1.0812
4.250	0.125	3.60	3.60	129.3	129.3	1.0524	1.0524
4.750	0.625	3.70	3.70	131.1	131.1	1.0669	1.0669
5.250	1.125	4.00	3.80	136.3	132.9	1.1093	1.0812
5.750	1.625	4.80	3.70	149.3	131.1	1.2152	1.0669
6.250	2.125	5.60	3.10	161.3	120.0	1.3126	0.9766
6.750	2.625	5.40	2.50	158.4	107.8	1.2889	0.8770
7.250	3.125	4.40	2.10	143.0	98.8	1.1635	0.8038
7.750	3.625	3.20	1.70	121.9	88.9	0.9922	0.7232
8.250	4.125	2.40	1.30	105.6	77.7	0.8593	0.6324

INTEGRATED FLOW RATE = 45.61 CU.FT/SEC
= 3.287 LBM/SEC

AVERAGE VELOCITY = 122.87 FT/SEC

MOMENTUM FACTOR, KM = 1.036

(b) Separation of 1.40 inch, Forward Mixing Stack with Uptake Mach Number of 0.0688.

Table XVII. Continued.

DATA TAKEN ON 23 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON

AMBIENT PRESSURE = 30.150 IN.HGA, TEMPERATURE = 70.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 109.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	4.125	2.30	1.70	103.2	88.7	0.8450	0.7265
0.250	3.875	2.60	1.80	109.7	91.3	0.8985	0.7476
0.750	3.375	3.40	2.30	125.4	103.2	1.0274	0.8450
1.250	2.875	4.80	2.70	149.0	111.8	1.2208	0.9156
1.750	2.375	5.80	3.20	163.8	121.7	1.3419	0.9968
2.250	1.875	5.80	3.70	163.8	130.8	1.3419	1.0718
2.750	1.375	4.80	3.80	149.0	132.6	1.2208	1.0862
3.250	0.875	3.80	3.70	132.6	130.8	1.0862	1.0718
3.750	0.375	3.30	3.30	123.6	123.6	1.0122	1.0122
4.250	0.125	3.10	3.30	119.8	123.6	0.9811	1.0122
4.750	0.625	3.30	3.30	123.6	123.6	1.0122	1.0122
5.250	1.125	4.00	3.50	136.0	127.3	1.1144	1.0424
5.750	1.625	5.10	3.20	153.6	121.7	1.2583	0.9968
6.250	2.125	5.80	2.80	163.8	113.8	1.3419	0.9324
6.750	2.625	5.40	2.20	158.1	103.2	1.2948	0.8450
7.250	3.125	4.00	1.90	136.0	93.8	1.1144	0.7680
7.750	3.625	3.00	1.80	117.8	91.3	0.9651	0.7476
8.250	4.125	2.20	1.50	100.9	83.3	0.8265	0.6824

INTEGRATED FLOW RATE = 45.32 CU.FT/SEC
= 3.278 LBM/SEC

AVERAGE VELOCITY = 122.08 FT/SEC

MOMENTUM FACTOR, KM = 1.026

(c) Separation of 0.71 inch, Forward Mixing Stack with Uptake Mach Number of 0.0686.

Table XVII. Continued.

DATA TAKEN ON 23 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON
AMBIENT PRESSURE = 30.150 IN.HGA,   TEMPERATURE = 70.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 120.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	4.125	0.55	0.40	50.7	43.3	0.8255	0.7039
0.250	3.875	0.65	0.45	55.1	45.9	0.8974	0.7466
0.750	3.375	0.90	0.50	64.9	48.4	1.0559	0.7870
1.250	2.875	1.30	0.65	78.0	55.1	1.2691	0.8974
1.750	2.375	1.55	0.75	85.2	59.2	1.3857	0.9639
2.250	1.875	1.50	0.95	83.8	66.7	1.3632	1.0849
2.750	1.375	1.20	0.95	74.9	66.7	1.2193	1.0849
3.250	0.875	0.95	0.95	66.7	66.7	1.0849	1.0849
3.750	0.375	0.75	0.85	59.2	63.1	0.9639	1.0262
4.250	0.125	0.75	0.80	59.2	61.2	0.9639	0.9955
4.750	0.625	0.85	0.80	63.1	61.2	1.0262	0.9955
5.250	1.125	1.00	0.85	68.4	63.1	1.1130	1.0262
5.750	1.625	1.30	0.80	78.0	61.2	1.2691	0.9955
6.250	2.125	1.50	0.70	83.8	57.2	1.3632	0.9312
6.750	2.625	1.40	0.55	80.9	50.7	1.3170	0.8255
7.250	3.125	1.05	0.45	70.1	45.9	1.1405	0.7466
7.750	3.625	0.80	0.40	61.2	43.3	0.9955	0.7039
8.250	4.125	0.55	0.35	50.7	40.5	0.8255	0.6585

INTEGRATED FLOW RATE = 22.81 CU.FT/SEC
                     = 1.632 LBM/SEC

AVERAGE VELOCITY = 61.46 FT/SEC

MOMENTUM FACTOR, KM =   1.031

(d) Separation of 0.71 inch, Forward Mixing Stack with Uptake Mach Number of 0.0350.

Table XVII. Continued.

DATA TAKEN ON 23 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON

AMBIENT PRESSURE = 30.150 IN.HGA, TEMPERATURE = 70.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 109.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	4.125	3.70	1.80	130.8	91.3	1.0519	0.7337
0.250	3.875	4.60	2.00	145.9	96.2	1.1729	0.7734
0.750	3.375	5.70	2.20	162.4	100.9	1.3057	0.8112
1.250	2.875	6.30	2.60	170.7	109.7	1.3727	0.8818
1.750	2.375	5.50	3.20	159.5	121.7	1.2826	0.9783
2.250	1.875	4.20	3.50	139.4	127.3	1.1208	1.0231
2.750	1.375	3.20	3.20	121.7	121.7	0.9783	0.9783
3.250	0.875	2.60	2.60	109.7	109.7	0.8818	0.8818
3.750	0.375	2.10	2.10	98.6	98.6	0.7925	0.7925
4.250	0.125	2.10	2.10	98.6	98.6	0.7925	0.7925
4.750	0.625	3.10	3.00	119.8	117.8	0.9629	0.9472
5.250	1.125	4.00	3.40	136.0	125.4	1.0938	1.0084
5.750	1.625	5.10	3.40	153.6	125.4	1.2350	1.0084
6.250	2.125	5.90	2.70	165.2	111.8	1.3284	0.8986
6.750	2.625	5.80	2.00	163.8	96.2	1.3171	0.7734
7.250	3.125	4.40	1.60	142.7	86.0	1.1471	0.6918
7.750	3.625	3.30	1.50	123.6	83.3	0.9935	0.6698
8.250	4.125	2.40	1.00	105.4	68.0	0.8472	0.5469

INTEGRATED FLOW RATE = 46.17 CU.FT/SEC
= 3.340 LBM/SEC

AVERAGE VELOCITY = 124.38 FT/SEC

MOMENTUM FACTOR, KM = 1.029

(e) Separation of 0.71 inch, Aft Mixing Stack with Uptake Mach Number of 0.0686.

Table XVII. Continued.

DATA TAKEN ON 23 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON

AMBIENT PRESSURE = 30.150 IN.HGA, TEMPERATURE = 70.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 120.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	4.125	0.90	0.40	64.9	43.3	1.0454	0.6969
0.250	3.875	1.05	0.45	70.1	45.9	1.1292	0.7392
0.750	3.375	1.45	0.55	82.4	50.7	1.3269	0.8172
1.250	2.875	1.65	0.65	87.9	55.1	1.4155	0.8884
1.750	2.375	1.40	0.80	80.9	61.2	1.3038	0.9856
2.250	1.875	1.10	0.85	71.7	63.1	1.1557	1.0159
2.750	1.375	0.80	0.80	61.2	61.2	0.9856	0.9856
3.250	0.875	0.60	0.60	53.0	53.0	0.8536	0.8536
3.750	0.375	0.50	0.50	48.4	48.4	0.7792	0.7792
4.250	0.125	0.50	0.55	48.4	50.7	0.7792	0.8172
4.750	0.625	0.70	0.65	57.2	55.1	0.9219	0.8884
5.250	1.125	0.90	0.80	64.9	61.2	1.0454	0.9856
5.750	1.625	1.30	0.80	78.0	61.2	1.2564	0.9856
6.250	2.125	1.55	0.65	85.2	55.1	1.3719	0.8884
6.750	2.625	1.50	0.50	83.8	48.4	1.3496	0.7792
7.250	3.125	1.15	0.40	73.4	43.3	1.1817	0.6969
7.750	3.625	0.80	0.35	61.2	40.5	0.9856	0.6519
8.250	4.125	0.55	0.25	50.7	34.2	0.8172	0.5510

INTEGRATED FLOW RATE = 23.04 CU.FT/SEC
= 1.648 LBM/SEC

AVERAGE VELOCITY = 62.08 FT/SEC

MOMENTUM FACTOR, KM = 1.034

(f) Separation of 0.71 inch, Aft Mixing Stack with Uptake Mach Number of 0.0350.

Table XVII. Continued.

DATA TAKEN ON 25 FEBRUARY 1977

OVAL COVER PLATE ON LOUVER SCREENS ON

AMBIENT PRESSURE = 30.281 IN.HGA, TEMPERATURE = 78.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 111.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	4.125	1.10	2.10	71.5	98.8	0.6252	0.8638
0.250	3.875	1.20	2.40	74.7	105.6	0.6530	0.9234
0.750	3.375	1.50	3.00	83.5	118.0	0.7300	1.0324
1.250	2.875	1.80	4.80	91.4	149.3	0.7997	1.3059
1.750	2.375	2.30	5.40	103.4	158.4	0.9040	1.3851
2.250	1.875	3.00	5.20	118.0	155.4	1.0324	1.3592
2.750	1.375	2.80	4.00	114.0	136.3	0.9974	1.1921
3.250	0.875	2.20	2.60	101.1	109.9	0.8841	0.9611
3.750	0.375	2.10	2.10	98.8	98.8	0.8638	0.8638
4.250	0.125	2.20	2.40	101.1	105.6	0.8841	0.9234
4.750	0.625	2.60	2.80	109.9	114.0	0.9611	0.9974
5.250	1.125	2.70	3.40	112.0	125.7	0.9794	1.0991
5.750	1.625	2.80	4.30	114.0	141.3	0.9974	1.2360
6.250	2.125	2.50	5.30	107.8	156.9	0.9425	1.3722
6.750	2.625	2.20	5.40	101.1	158.4	0.8841	1.3851
7.250	3.125	1.80	4.40	91.4	143.0	0.7997	1.2503
7.750	3.625	1.90	3.20	93.9	121.9	0.8216	1.0663
8.250	4.125	1.40	2.40	80.6	105.6	0.7053	0.9234

INTEGRATED FLOW RATE = 42.45 CU.FT/SEC
= 3.059 LBM/SEC

AVERAGE VELOCITY = 114.34 FT/SEC

MOMENTUM FACTOR, KM = 1.033

(a) Separation of 0.71 inch, Forward Mixing Stack with Uptake Mach Number of 0.0687.

Table XVIII. Tabulated Velocity Profile Data for the Four Nozzle Configuration of Eductor Proposal B with an Area Ratio of 2.639.

DATA TAKEN ON 08 MARCH 1977

OVAL COVER PLATE ON LOUVER SCREENS ON
AMBIENT PRESSURE = 30.080 IN.HGA, TEMPERATURE = 64.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 113.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	4.125	0.28	0.40	36.0	43.1	0.6425	0.7679
0.250	3.875	0.32	0.50	38.5	48.1	0.6868	0.8586
0.750	3.375	0.37	0.67	41.4	55.7	0.7386	0.9938
1.250	2.875	0.44	1.07	45.2	70.4	0.8054	1.2560
1.750	2.375	0.57	1.27	51.4	79.7	0.9167	1.4212
2.250	1.875	0.65	1.22	54.9	78.2	0.9789	1.3950
2.750	1.375	0.62	1.02	53.6	68.8	0.9560	1.2263
3.250	0.875	0.55	0.63	50.5	54.0	0.9005	0.9637
3.750	0.375	0.50	0.50	48.1	48.1	0.8586	0.8586
4.250	0.125	0.52	0.52	49.1	49.1	0.8756	0.8756
4.750	0.625	0.60	0.65	52.7	54.9	0.9405	0.9789
5.250	1.125	0.65	0.83	54.9	62.0	0.9789	1.1062
5.750	1.625	0.68	1.08	56.1	70.8	1.0012	1.2618
6.250	2.125	0.60	1.33	52.7	78.5	0.9405	1.4003
6.750	2.625	0.52	1.38	49.1	80.0	0.8756	1.4263
7.250	3.125	0.47	1.15	46.7	73.0	0.8324	1.3021
7.750	3.625	0.41	0.80	43.6	60.9	0.7775	1.0860
8.250	4.125	0.34	0.58	39.7	51.8	0.7080	0.9247

INTEGRATED FLOW RATE = 20.81 CU.FT/SEC
= 1.503 LBM/SEC

AVERAGE VELOCITY = 56.07 FT/SEC

MOMENTUM FACTOR, KM = 1.037

(b) Separation of 0.71 inch, Aft Mixing Stack with Uptake Mach Number of 0.0348.

Table XVIII. Continued.

DATA TAKEN ON 25 FEBRUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON
AMBIENT PRESSURE = 30.281 IN.HGA, TEMPERATURE = 78.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 111.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTE	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	4.125	1.20	2.70	74.7	112.0	0.6609	0.9914
0.250	3.875	1.40	3.10	80.6	120.0	0.7139	1.0623
0.750	3.375	1.70	4.30	88.9	141.3	0.7867	1.2511
1.250	2.875	2.10	5.60	98.8	161.3	0.8743	1.4277
1.750	2.375	2.70	5.50	112.0	159.8	0.9914	1.4149
2.250	1.875	2.90	4.30	116.1	141.3	1.0274	1.2511
2.750	1.375	2.60	3.10	109.9	120.0	0.9728	1.0623
3.250	0.875	2.10	2.20	98.8	101.1	0.8743	0.8949
3.750	0.375	1.80	1.90	91.4	93.9	0.8095	0.8316
4.250	0.125	1.90	1.80	93.9	91.4	0.8316	0.8095
4.750	0.625	2.20	2.40	101.1	105.6	0.8949	0.9347
5.250	1.125	2.80	3.30	114.0	123.8	1.0096	1.0960
5.750	1.625	2.80	4.70	114.0	147.8	1.0096	1.3080
6.250	2.125	2.20	5.50	101.1	159.8	0.8949	1.4149
6.750	2.625	1.70	5.20	88.9	155.4	0.7867	1.3758
7.250	3.125	1.20	3.80	74.7	132.9	0.6609	1.1761
7.750	3.625	1.10	2.50	71.5	107.8	0.6328	0.9540
8.250	4.125	0.90	2.00	64.7	96.4	0.5724	0.8532

INTEGRATED FLOW RATE = 41.93 CU.FT/SEC
= 3.022 LBM/SEC

AVERAGE VELOCITY = 112.96 FT/SEC

MOMENTUM FACTOR, KM = 1.040

(c) Separation of 0.71 inch, Forward Mixing Stack with Uptake Mach Number of 0.0687.

Table XVIII. Continued.

DATA TAKEN ON 08 MARCH 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON
AMBIENT PRESSURE = 30.080 IN.HGA,   TEMPERATURE = 64.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 113.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	4.125	0.30	0.62	37.3	53.6	0.6704	0.9638
0.250	3.875	0.32	0.72	38.5	57.8	0.6924	1.0386
0.750	3.375	0.39	1.07	42.5	70.4	0.7644	1.2662
1.250	2.875	0.50	1.40	48.1	80.6	0.8655	1.4483
1.750	2.375	0.64	1.33	54.5	78.5	0.9792	1.4116
2.250	1.875	0.70	1.02	57.0	68.8	1.0241	1.2362
2.750	1.375	0.68	0.77	56.1	59.7	1.0094	1.0741
3.250	0.875	0.56	0.62	50.9	53.6	0.9160	0.9638
3.750	0.375	0.48	0.50	47.2	48.1	0.8480	0.8655
4.250	0.125	0.48	0.48	47.2	47.2	0.8480	0.8480
4.750	0.625	0.56	0.60	50.9	52.7	0.9160	0.9481
5.250	1.125	0.65	0.92	54.9	65.3	0.9869	1.1741
5.750	1.625	0.67	1.15	55.7	73.0	1.0019	1.3126
6.250	2.125	0.58	1.44	51.8	81.7	0.9322	1.4688
6.750	2.625	0.43	1.30	44.6	77.6	0.8027	1.3956
7.250	3.125	0.30	0.90	37.3	64.6	0.6704	1.1612
7.750	3.625	0.22	0.60	31.9	52.7	0.5741	0.9481
8.250	4.125	0.20	0.45	30.4	45.7	0.5474	0.8211

INTEGRATED FLOW RATE = 20.65 CU.FT/SEC
                     = 1.491 LBM/SEC

AVERAGE VELOCITY = 55.62 FT/SEC

MOMENTUM FACTOR, KM =   1.045

(d) Separation of 0.71 inch, Aft Mixing Stack with Uptake Mach Number of 0.0348.

Table XVIII. Continued.

DATA TAKEN ON 26 JANUARY 1977

OVAL COVER PLATE ON LOUVER SCREENS ON

AMBIENT PRESSURE = 30.000 IN.HGA, TEMPERATURE = 78.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 112.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	4.125	1.40	1.00	81.1	68.5	0.7906	0.6682
0.250	3.875	1.70	1.10	89.3	71.9	0.8712	0.7008
0.750	3.375	2.50	1.30	108.3	78.1	1.0565	0.7618
1.250	2.875	3.90	1.50	135.3	83.9	1.3196	0.8184
1.750	2.375	4.70	2.00	148.5	96.9	1.4486	0.9450
2.250	1.875	4.10	2.40	138.7	106.1	1.3530	1.0351
2.750	1.375	3.00	2.70	118.7	112.6	1.1573	1.0979
3.250	0.875	2.30	2.50	103.9	108.3	1.0133	1.0565
3.750	0.375	2.00	2.10	96.9	99.3	0.9450	0.9683
4.250	0.125	2.00	1.90	96.9	94.4	0.9450	0.9210
4.750	0.625	2.30	2.00	103.9	96.9	1.0133	0.9450
5.250	1.125	3.10	2.30	120.6	103.9	1.1765	1.0133
5.750	1.625	4.10	2.30	138.7	103.9	1.3530	1.0133
6.250	2.125	4.90	1.90	151.6	94.4	1.4791	0.9210
6.750	2.625	4.50	1.50	145.3	83.9	1.4174	0.8184
7.250	3.125	3.30	1.20	124.4	75.0	1.2138	0.7320
7.750	3.625	2.10	1.10	99.3	71.9	0.9683	0.7008
8.250	4.125	1.60	0.90	86.7	65.0	0.8452	0.6339

INTEGRATED FLOW RATE = 38.06 CU.FT/SEC
= 2.714 LBM/SEC

AVERAGE VELOCITY = 102.53 FT/SEC

MOMENTUM FACTOR, KM = 1.041

(a) Separation of 0.71 inch, Forward Mixing Stack with Uptake Mach Number of 0.0695.

Table XIX. Tabulated Velocity Profile Data for the Four Nozzle Configuration of Eductor Proposal B with an Area Ratio of 2.283.

DATA TAKEN ON 26 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON
AMBIENT PRESSURE = 30.000 IN.HGA,   TEMPERATURE = 76.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 120.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	4.125	0.35	0.21	40.7	31.5	0.7844	0.6076
0.250	3.875	0.40	0.25	43.5	34.4	0.8385	0.6629
0.750	3.375	0.62	0.29	54.1	37.0	1.0439	0.7140
1.250	2.875	0.93	0.38	66.3	42.4	1.2786	0.8173
1.750	2.375	1.26	0.49	77.2	48.1	1.4882	0.9281
2.250	1.875	1.22	0.61	75.9	53.7	1.4644	1.0355
2.750	1.375	0.88	0.62	64.5	54.1	1.2437	1.0439
3.250	0.875	0.58	0.54	52.3	50.5	1.0097	0.9743
3.750	0.375	0.50	0.49	48.6	48.1	0.9375	0.9281
4.250	0.125	0.51	0.51	49.1	49.1	0.9468	0.9468
4.750	0.625	0.61	0.59	53.7	52.8	1.0355	1.0184
5.250	1.125	0.79	0.66	61.1	55.8	1.1784	1.0771
5.750	1.625	1.09	0.62	71.8	54.1	1.3842	1.0439
6.250	2.125	1.30	0.49	78.4	48.1	1.5116	0.9281
6.750	2.625	1.16	0.38	74.0	42.4	1.4279	0.8173
7.250	3.125	0.78	0.33	60.7	39.5	1.1709	0.7616
7.750	3.625	0.54	0.30	50.5	37.6	0.9743	0.7262
8.250	4.125	0.41	0.25	44.0	34.4	0.8489	0.6629

INTEGRATED FLOW RATE = 19.25 CU.FT/SEC
= 1.363 LBM/SEC

AVERAGE VELOCITY = 51.84 FT/SEC

MOMENTUM FACTOR, KM = 1.047

(b) Separation of 0.71 inch, Forward Mixing Stack with Uptake Mach Number of 0.0352.

Table XIX. Continued.

DATA TAKEN ON 26 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON
AMBIENT PRESSURE = 30.000 IN.HGA, TEMPERATURE = 78.0 DEG.FAHR
PRIMARY (UPTAKE) TEMPERATURE = 112.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	4.125	2.00	1.10	96.9	71.9	0.9201	0.6824
0.250	3.875	2.40	1.40	106.1	81.1	1.0080	0.7699
0.750	3.375	3.50	1.50	128.2	83.9	1.2172	0.7969
1.250	2.875	4.90	1.80	151.6	91.9	1.4403	0.8729
1.750	2.375	5.00	2.20	153.2	101.6	1.4549	0.9651
2.250	1.875	4.10	2.40	138.7	106.1	1.3175	1.0080
2.750	1.375	3.00	2.40	118.7	106.1	1.1269	1.0080
3.250	0.875	2.30	2.00	103.9	96.9	0.9868	0.9201
3.750	0.375	1.90	1.70	94.4	89.3	0.8969	0.8483
4.250	0.125	1.80	1.80	91.9	91.9	0.8729	0.8729
4.750	0.625	2.20	2.30	101.6	103.9	0.9651	0.9868
5.250	1.125	3.10	2.50	120.6	108.3	1.1456	1.0288
5.750	1.625	4.30	2.40	142.1	106.1	1.3492	1.0080
6.250	2.125	5.00	2.00	153.2	96.9	1.4549	0.9201
6.750	2.625	4.40	1.40	143.7	81.1	1.3648	0.7699
7.250	3.125	3.00	1.00	118.7	68.5	1.1269	0.6506
7.750	3.625	2.00	0.80	96.9	61.3	0.9201	0.5820
8.250	4.125	1.50	0.60	83.9	53.1	0.7969	0.5040

INTEGRATED FLOW RATE = 39.09 CU.FT/SEC
= 2.788 LBM/SEC

AVERAGE VELOCITY = 105.29 FT/SEC

MOMENTUM FACTOR, KM = 1.044

(c) Separation of 0.71 inch, Aft Mixing Stack with Uptake Mach Number of 0.0695.

Table XIX. Continued.

DATA TAKEN ON 26 JANUARY 1977

OVAL COVER PLATE ON LOUVER SCREENS ON

AMBIENT PRESSURE = 30.000 IN.HGA, TEMPERATURE = 76.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 120.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	4.125	0.46	0.29	46.6	37.0	0.8742	0.6941
0.250	3.875	0.55	0.31	51.0	38.3	0.9559	0.7177
0.750	3.375	0.74	0.39	59.1	42.9	1.1088	0.8050
1.250	2.875	1.18	0.48	74.7	47.6	1.4002	0.8930
1.750	2.375	1.35	0.61	79.9	53.7	1.4977	1.0067
2.250	1.875	1.10	0.71	72.1	57.9	1.3519	1.0861
2.750	1.375	0.78	0.70	60.7	57.5	1.1384	1.0784
3.250	0.875	0.60	0.55	53.2	51.0	0.9984	0.9559
3.750	0.375	0.47	0.48	47.1	47.6	0.8837	0.8930
4.250	0.125	0.47	0.50	47.1	48.6	0.8837	0.9114
4.750	0.625	0.56	0.62	51.4	54.1	0.9646	1.0149
5.250	1.125	0.83	0.71	62.6	57.9	1.1743	1.0861
5.750	1.625	1.18	0.71	74.7	57.9	1.4002	1.0861
6.250	2.125	1.35	0.53	79.9	50.0	1.4977	0.9384
6.750	2.625	1.12	0.38	72.7	42.4	1.3641	0.7946
7.250	3.125	0.72	0.27	58.3	35.7	1.0937	0.6698
7.750	3.625	0.48	0.18	47.6	29.2	0.8930	0.5469
8.250	4.125	0.36	0.17	41.2	28.3	0.7734	0.5315

INTEGRATED FLOW RATE = 19.80 CU.FT/SEC
= 1.402 LBM/SEC

AVERAGE VELOCITY = 53.33 FT/SEC

MOMENTUM FACTOR, KM = 1.051

(d) Separation of 0.71 inch, Aft Mixing Stack with Uptake Mach Number of 0.0352.

Table XIX. Continued.

DATA TAKEN ON 1 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON

AMBIENT PRESSURE = 29.870 IN.HGA, TEMPERATURE = 60.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 102.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	4.125	2.80	2.30	113.5	102.9	0.9022	0.8177
0.250	3.875	3.20	2.50	121.3	107.2	0.9645	0.8525
0.750	3.375	4.80	2.50	148.6	107.2	1.1812	0.8525
1.250	2.875	5.60	2.40	160.5	105.1	1.2759	0.8353
1.750	2.375	5.10	2.20	153.2	100.6	1.2176	0.7997
2.250	1.875	4.20	2.10	139.0	98.3	1.1050	0.7813
2.750	1.375	4.20	2.60	139.0	109.4	1.1050	0.8694
3.250	0.875	5.60	4.00	160.5	135.6	1.2759	1.0783
3.750	0.375	6.20	5.50	168.9	159.1	1.3425	1.2644
4.250	0.125	5.90	5.70	164.7	161.9	1.3096	1.2872
4.750	0.625	4.60	4.70	145.5	147.0	1.1564	1.1689
5.250	1.125	3.50	3.10	126.9	119.4	1.0087	0.9493
5.750	1.625	3.40	2.50	125.1	107.2	0.9942	0.8525
6.250	2.125	4.20	2.50	139.0	107.2	1.1050	0.8525
6.750	2.625	5.30	2.60	156.1	109.4	1.2412	0.8694
7.250	3.125	5.20	2.70	154.7	111.4	1.2295	0.8859
7.750	3.625	4.00	2.70	135.6	111.4	1.0783	0.8859
8.250	4.125	3.10	2.30	119.4	102.9	0.9493	0.8177

INTEGRATED FLOW RATE = 46.70 CU.FT/SEC
= 3.398 LBM/SEC

AVERAGE VELOCITY = 125.80 FT/SEC

MOMENTUM FACTOR, KM = 1.015

(a) Separation of 0.28 inch, Forward Mixing Stack with Uptake Mach Number of 0.0685.

Table XX. Tabulated Velocity Profile Data for the Five Nozzle Configuration of Eductor Proposal B with an Area Ratio of 3.064.

DATA TAKEN ON 2 JANUARY 1977

OVAL COVER PLATE ON LOUVER SCREENS ON

AMBIENT PRESSURE = 29.795 IN.HGA, TEMPERATURE = 66.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 106.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	4.125	3.20	1.40	122.0	80.7	0.9971	0.6595
0.250	3.875	3.40	1.60	125.8	86.3	1.0277	0.7050
0.750	3.375	4.40	1.90	143.1	94.0	1.1691	0.7683
1.250	2.875	5.40	2.20	158.5	101.2	1.2952	0.8267
1.750	2.375	5.30	2.50	157.0	107.9	1.2832	0.8813
2.250	1.875	4.80	2.80	149.4	114.1	1.2211	0.9327
2.750	1.375	4.80	3.00	149.4	118.1	1.2211	0.9654
3.250	0.875	5.40	3.90	158.5	134.7	1.2952	1.1007
3.750	0.375	5.90	4.90	165.7	151.0	1.3538	1.2338
4.250	0.125	5.50	5.40	160.0	158.5	1.3071	1.2952
4.750	0.625	4.50	4.70	144.7	147.9	1.1824	1.2083
5.250	1.125	3.80	3.50	133.0	127.6	1.0865	1.0427
5.750	1.625	3.50	2.80	127.6	114.1	1.0427	0.9327
6.250	2.125	4.00	2.60	136.4	110.0	1.1147	0.8987
6.750	2.625	4.60	2.40	146.3	105.7	1.1954	0.8635
7.250	3.125	4.80	2.10	149.4	98.8	1.2211	0.8077
7.750	3.625	3.90	1.70	134.7	88.9	1.1007	0.7267
8.250	4.125	3.00	1.40	118.1	80.7	0.9654	0.6595

INTEGRATED FLOW RATE = 45.43 CU.FT/SEC
= 3.268 LBM/SEC

AVERAGE VELOCITY = 122.38 FT/SEC

MOMENTUM FACTOR, KM = 1.023

(b) Separation of 1.40 inch, Forward Mixing Stack with Uptake Mach Number of 0.0685.

Table XX. Continued.

DATA TAKEN ON 2 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON

AMBIENT PRESSURE = 29.765 IN.HGA,   TEMPERATURE = 67.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 108.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	4.125	3.00	2.00	118.4	96.7	0.9414	0.7686
0.250	3.875	3.50	2.30	127.9	103.6	1.0168	0.8243
0.750	3.375	4.60	2.40	146.6	105.9	1.1657	0.8420
1.250	2.875	5.40	2.40	158.8	105.9	1.2630	0.8420
1.750	2.375	5.00	2.40	152.8	105.9	1.2153	0.8420
2.250	1.875	4.30	2.40	141.7	105.9	1.1270	0.8420
2.750	1.375	4.50	2.90	145.0	116.4	1.1529	0.9255
3.250	0.875	5.50	4.40	160.3	143.4	1.2746	1.1401
3.750	0.375	6.10	5.60	168.8	161.7	1.3423	1.2862
4.250	0.125	5.80	5.70	164.6	163.2	1.3089	1.2976
4.750	0.625	4.50	4.50	145.0	145.0	1.1529	1.1529
5.250	1.125	3.40	3.20	126.0	122.3	1.0022	0.9722
5.750	1.625	3.10	2.50	120.3	108.1	0.9569	0.8593
6.250	2.125	3.80	2.50	133.2	108.1	1.0595	0.8593
6.750	2.625	4.70	2.50	148.2	108.1	1.1783	0.8593
7.250	3.125	5.10	2.50	154.3	108.1	1.2274	0.8593
7.750	3.625	4.20	2.40	140.1	105.9	1.1138	0.8420
8.250	4.125	3.40	2.00	126.0	96.7	1.0022	0.7686

INTEGRATED FLOW RATE = 46.68 CU.FT/SEC
= 3.345 LBM/SEC

AVERAGE VELOCITY = 125.75 FT/SEC

MOMENTUM FACTOR, KM = 1.015

(c) Separation of 0.71 inch, Forward Mixing Stack with Uptake Mach Number of 0.0691.

Table XX. Continued.

DATA TAKEN ON 2 JANUARY 1977

OVAL COVER PLATE ON   LOUVER SCREENS ON

AMBIENT PRESSURE = 29.765 IN.HGA, TEMPERATURE = 67.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 108.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	4.125	4.60	2.70	146.6	112.3	1.1558	0.8855
0.250	3.875	5.20	3.10	155.8	120.3	1.2288	0.9488
0.750	3.375	5.80	3.20	164.6	122.3	1.2978	0.9640
1.250	2.875	4.90	3.20	151.3	122.3	1.1929	0.9640
1.750	2.375	3.80	3.20	133.2	122.3	1.0505	0.9640
2.250	1.875	3.50	3.20	127.9	122.3	1.0082	0.9640
2.750	1.375	4.50	4.50	145.0	145.0	1.1431	1.1431
3.250	0.875	5.80	6.20	164.6	170.2	1.2978	1.3418
3.750	0.375	7.10	7.10	182.1	182.1	1.4359	1.4359
4.250	0.125	6.60	6.10	175.6	168.8	1.3844	1.3309
4.750	0.625	4.70	4.30	148.2	141.7	1.1683	1.1174
5.250	1.125	3.80	2.90	133.2	116.4	1.0505	0.9177
5.750	1.625	3.60	2.20	129.7	101.4	1.0225	0.7993
6.250	2.125	4.50	1.90	145.0	94.2	1.1431	0.7428
6.750	2.625	5.60	1.50	161.7	83.7	1.2752	0.6600
7.250	3.125	4.90	1.20	151.3	74.9	1.1929	0.5903
7.750	3.625	3.60	1.00	129.7	68.3	1.0225	0.5389
8.250	4.125	2.70	0.80	112.3	61.1	0.8855	0.4820

INTEGRATED FLOW RATE = 47.08 CU.FT/SEC
= 3.374 LBM/SEC

AVERAGE VELOCITY = 126.83 FT/SEC

MOMENTUM FACTOR, KM = 1.033

(d) Separation of 0.71 inch, Aft Mixing Stack with Uptake Mach Number of 0.0691.

Table XX. Continued.

APPENDIX A

ONE-DIMENSIONAL ANALYSIS OF A SIMPLE EDUCTOR

This appendix supplements Section II.B. by presenting a portion of the one-dimensional analysis of a simple eductor in more detail. Section II.B. provides adequate information on the development of equations (1) through (9); the development presented here will begin with the energy equation for isentropic flow of the secondary air from the plenum to the entrance of the mixing stack which leads to equation (10). The idealizations used in this analysis are listed in Section II, and Figure 1 illustrates the simplified eductor with section locations.

Consider the flow of secondary air from the plenum (section 0) to the mixing stack entrance (section 1) to be isentropic and adiabatic. The Gibbs equation in differential form is

$$Tds = du + Pdv. \tag{a}$$

Enthalpy as a function of temperature is defined in differential form as

$$dh = du + Pdv + vdP. \tag{b}$$

Combining equations (a) and (b) yields

$$Tds = dh - vdP \tag{c}$$

which for isentropic flow reduces to

$$dh = \frac{1}{\rho} dP. \tag{d}$$

The energy equation for steady, adiabatic flow in differential form is

$$dh = - d\left(\frac{U^2}{2 g_c}\right) \tag{e}$$

which when combined with equation (d) yields

$$\frac{1}{\rho} dP = - d\left(\frac{U^2}{2 g_c}\right) \tag{f}$$

By idealization (8), the pressure and density from station 0 to station 1 remains constant. Taking the secondary flow velocity at station 0 U_{so} to be negligible, integration of equation (f) yields equation (10).

$$\frac{1}{\rho_s} (P_0 - P_1) = \frac{1}{2 g_c} U_s^2 \tag{10}$$

The vacuum produced within the plenum by the eductor, equation (11), is obtained by combining the foregoing equations. Taking $A_1 = A_2 = A_m$ and $P_2 = P_a$, equation (3) of Section II is rewritten as

$$(P_a - P_1) A_m = K_P \frac{W_P U_P}{g_c} + \frac{W_s U_s}{g_c} - K_m \frac{W_m U_m}{g_c} - F_{fr} \tag{g}$$

Substituting $U = \frac{W}{\rho A}$ for the primary, secondary and mixed flows and the definition of F_{fr} into equation (g) yields

$$(P_a - P_1)A_m = \frac{K_p\, W_p^{\,2}}{g_c\, \rho_p\, A_p} + \frac{W_s^{\,2}}{g_c\, \rho_s\, A_s} - \frac{K_m\, W_m^{\,2}}{g_c\, \rho_m\, A_m} - \frac{f\, A_w\, \rho_m}{2\, g_c} \left(\frac{W_m^{\,2}}{\rho_m^{\,2}\, A_m^{\,2}} \right) \quad \text{(h)}$$

Substituting $U_s = \frac{W_s}{\rho_s\, A_s}$ into equation (10) and subtracting the result from equation (h) yields equation (11)

$$(P_a - P_0) = \frac{1}{A_m\, g_c} \left\{ \frac{K_p\, W_p^{\,2}}{\rho_p\, A_p} + \frac{W_s^{\,2}}{\rho_s\, A_s} \left[1 - \frac{A_m}{2\, A_s} \right] - \frac{W_m^{\,2}}{\rho_m\, A_m} \left[K_m + \frac{f}{2} \frac{A_w}{A_m} \right] \right\} \quad \text{(11)}$$

Equation (11b) is obtained from equation (11) as follows:

Factor the first term on the right out of the entire right-hand side.

$$(P_a - P_0) = \frac{1}{A_m\, g_c}\, \frac{W_p^{\,2}}{\rho_p\, A_p} \left\{ K_p + \frac{W_s^{\,2}}{W_p^{\,2}} \frac{\rho_p}{\rho_s} \frac{A_p}{A_s} \left[1 - \frac{A_m}{2\, A_s} \right] \right.$$

$$\left. - \frac{W_m^{\,2}}{W_p^{\,2}} \frac{\rho_p}{\rho_m} \frac{A_p}{A_m} \left[K_m + \frac{f}{2} \frac{A_w}{A_m} \right] \right\} \quad \text{(i)}$$

Multiply both sides of equation (i) by $\frac{1}{\rho_s}$, multiply the right side by $\frac{A_p\, \rho_p}{A_p\, \rho_p}$ and arrange the factor outside of the brackets on the right-hand side as follows:

$$\frac{A_p\, \rho_p}{A_m\, g_c\, \rho_s}\, \frac{W_p^{\,2}}{A_p^{\,2}\, \rho_p^{\,2}} = \frac{A_p}{A_m}\, \frac{\rho_p}{\rho_s}\, \frac{1}{g_c} \left(\frac{W_p}{\rho_p\, A_p} \right)^2 \quad \text{(j)}$$

Recalling that $\frac{\rho_p}{\rho_s} = T^*$ and that $U_p = \frac{W_p}{\rho_p A_p}$, the factor in equation (j) becomes

$$\frac{A_p}{A_m} (2T^*) \frac{U_p^2}{2 g_c} \qquad \text{(k)}$$

Substituting equation (k) into equation (i) and expressing $\frac{W_s}{W_p}$ as W* and $\frac{A_s}{A_p}$ as A* yields

$$\frac{\dfrac{(P_a - P_0)}{\rho_s}}{\dfrac{U_p^2}{2 g_c}} = \left(\frac{A_p}{A_m}\right) (2T^*) \left\{ K_p + \frac{W^{*2} T^*}{A^*} \left[1 - \frac{1}{2A^* \left(\frac{A_p}{A_m}\right)} \right] - \frac{W_m^2}{W_p^2} \frac{\rho_p}{\rho_m} \frac{A_p}{A_m} \left[K_m + \frac{f}{2} \frac{A_w}{A_m} \right] \right\} \qquad (\ell)$$

The next step is to express part of the last factor on the right-hand side of equation (ℓ) $\frac{W_m^2 \rho_p}{W_p^2 \rho_m}$ in terms of W* and T*. Combining equation (9) with the definition of enthalpy for a perfect gas, $h = c_p T$, yields

$$W_m T_m = W_p T_p + W_s T_s \qquad \text{(m)}$$

which when divided through by $W_p T_p$ results in the relation

$$\frac{W_m T_m}{W_p T_p} = 1 + \frac{W_s T_s}{W_p T_p} = (1 + W^* T^*) \qquad \text{(n)}$$

Density is essentially a function of temperature; therefore

$$T_m \rho_m \approx T_p \rho_p \quad . \tag{o}$$

The ratio $\frac{W_m}{W_p}$ may be expressed as

$$\frac{W_m}{W_p} = \frac{W_p + W_s}{W_p} = (1 + W^*) \quad . \tag{p}$$

Combining equations (n), (o) and (p) yields

$$\frac{W_m}{W_p}\left(\frac{W_m \rho_p}{W_p \rho_m}\right) = (1 + W^*)(1 + W^* T^*) \tag{q}$$

which when expanded is

$$\frac{W_m^2 \rho_p}{W_p^2 \rho_m} = 1 + W^* + W^*T^* + W^{*2}T^* \tag{r}$$

By introducing the definition of the pressure coefficient ΔP^*, the two quantities

$$\alpha = \left[1 - \frac{1}{2A^*\left(\frac{A_p}{A_m}\right)}\right] \quad \text{and} \quad \beta = \left[K_m + \frac{f}{2}\frac{A_w}{A_m}\right]$$

and the relationship in equation (r), equation (ℓ) may be expressed as

$$\Delta P^* = 2T^* \frac{A_p}{A_m} \left\{ \left[K_p - \beta \frac{A_p}{A_m} \right] - W^* \left[1 + T^* \right] \frac{A_p}{A_m} \beta \right.$$

$$\left. + W^{*2} T^* \left[\frac{\alpha}{A^*} - \frac{A_p}{A_m} \beta \right] \right\} \qquad \text{(s)}$$

Introducing the constants defined by equation (11c) and equation (s) yields equation (11b),

$$\frac{\Delta P^*}{T^*} = C_1 + C_2 W^*(T^* + 1) + C_3 W^{*2} T^* \qquad \text{(11b)}$$

APPENDIX B

DETERMINATION OF THE EXPONENT IN THE NONDIMENSIONAL PUMPING COEFFICIENT

The method used to determine the value of the exponent n in equation (14) is outlined below.

(1) Select a given geometry, assume reasonable values for K_p, K_m and f, and calculate C_1, C_2 and C_3 for use in equation (11b).

(2) Set T* = 1.0, ΔP* = 0, and solve from W*max. Equation (11b) plots as indicated in Figure 20; for ΔP* = 0 and T* = 1.0, the intersection of the curve with the W^*T^{*n} axis yields the value of W*max. Note that for each value of T* < 1.0 ($T^* = T_s/T_p$ and $T_s < T_p$ therefore T* < 1.0) a different curve will result.

(3) For the same geometric configuration and other values assumed and calculated in step (1), calculate ΔP*/T* using equation (11b) with W^*T^{*n} for different values of T* in each case varying W* from 0 to W*max in equal increments of W*max. For each new value of T* tried, vary n until the resulting plots of ΔP*/T* vs W^*T^{*n} for T* < 1.0 come close enough to the initial plot obtained in step (2) where T* = 1.0 that, for all practical purposes, all such plots can be represented by a single curve.

(4) The value of n which most effectively collapses all performance curves onto the T* = 1.0 case is n = 0.44.

APPENDIX C

FORMULAE

Presented here are the formulae used to obtain the primary and secondary mass flow rates. According to the ASME Power Test Code [6], the general equation for mass flow rate appearing in equation (a)

$$W(\text{lbm/sec}) = (0.12705)\ K\,A\,Y\,F_a \left[\rho\ \Delta P\right]^{0.5} \qquad \text{(a)}$$

may be used with flow nozzles and square edge orifices provided the flow is subsonic. In the above equation, K (dimensionless) represents the flow coefficient for the metering device and is defined as $K = C\left(1 - \beta^4\right)^{-0.5}$ where C is the coefficient of discharge and β is the ratio of throat to inlet diameters; $A(\text{in}^2)$ is the total cross sectional area of the metering device; Y (dimensionless) is the expansion factor for the flow; F_a (dimensionless) is the area thermal-expansion factor; $\rho(\text{lbm/ft}^3)$ is the flow mass density; and ΔP (inches H_2O) is the differential pressure across the metering device. Each of these quantities are evaluated, according to the guide lines set forth in Reference [6], for the specific type of flow measuring device used.

Using a square edge orifice for measurement of the primary mass flow rate, the quantities in equation (a) are defined as follows:

1. The flow coefficient K is 0.62 based on a β of 0.502 and a constant coefficient of discharge over the range of flows considered of 0.60.

2. The orifice area is 37.4145 in^2.
3. Corresponding to the range of pressure ratios encountered across the orifice, the expansion factor Y is 0.98.
4. Since the temperature of the metered air is nearly ambient temperature, the thermal expansion factor is essentially 1.0.
5. The primary air mass density ρ_{or} is calculated using the perfect gas relationship with pressure and temperature evaluated upstream of the orifice.

Substituting these values into equation (a) yields

$$W_p \text{ (lbm/sec)} = (2.8882) \left[\rho_{or} \, \Delta P_{or} \right]^{0.5} \qquad \text{(b)}$$

The secondary mass flow rate is measured using long radius flow nozzles for which case the quantities in equation (a) become:

1. For a flow nozzle installed in a plenum, β is approximately zero in which case the flow coefficient is approximately equal to the coefficient of discharge. For the range of secondary flows encountered, the flow coefficient becomes 0.98.
2. A is the sum of the throat areas of the flow nozzles in use.
3. Since the pressure ratios across the flow nozzles are very close to unity, the expansion coefficient Y is 1.0.
4. Since the temperature of the metered air is nearly ambient temperature, the thermal expansion factor is essentially 1.0.
5. The secondary air mass density ρ_s is evaluated using the perfect gas relationship at ambient conditions.

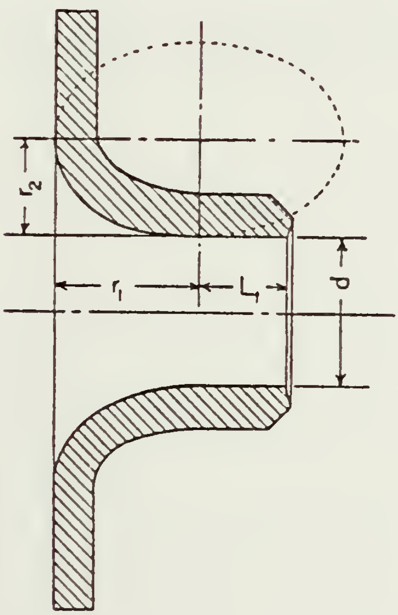
Substituting these values into equation (a) yields the equation for the secondary mass flow rate measured using long radius flow nozzles.

$$W_s \text{ (lbm/sec)} = (0.12451)\ A \left[\rho_s \ \Delta P_s\right]^{0.5} \qquad \text{(c)}$$

APPENDIX D

DESIGN AND CONSTRUCTION OF THE SECONDARY AIR FLOW NOZZLES

Measurement of the secondary air flow was facilitated through the use of standard long-radius flow nozzles fabricated to ASME Power Test Code, Reference [6], specifications. The contoured entrance to the nozzle is defined by the quadrant of an ellipse whose curvature is defined in relation to the nozzle's throat diameter. For low flow rates and where the nozzle entrance diameter is virtually unlimited, low throat to inlet diameter ratios ($\beta = \frac{d}{D}$) are recommended. The proportions of the nozzle with respect to its throat diameter are shown in Figure 40 for a low β nozzle.



$\beta \leq 0.5$

$r_1 = d$

$r_2 = 0.65d$

$L_t = 0.60d$

FIGURE 40. Proportions of Low β ASME Long-Radius Flow Nozzles

The numbers and sizes of the nozzles were chosen to give good total throat cross sectional area coverage over the expected range of secondary flow rates without encountering excessively high pressure drops across the nozzle. A computer solution of the equation for an ellipse whose axes are defined by the relations in the preceding figure was used to obtain nozzle contours for various throat diameters.

Fiber glass was selected as the material for the nozzles because of ease of fabrication and the fact that the molding process used made it possible to produce several nozzles of the same size with good dimensional control. The fabrication process involved machining a wooden form slightly smaller than the inside dimensions of the nozzle, coating it with an epoxy base resin and polishing it to the desired degree of smoothness. The form was then treated with a mold release agent, and sufficient layers of fiber glass were applied to obtain a thickness sufficient to ensure dimensional rigidity.

APPENDIX E

CALCULATION OF THE MOMENTUM CORRECTION FACTOR

The momentum correction factor is defined as the ratio of the actual momentum rate to the pseudo-rate based on the bulk-average velocity. Defining the actual momentum as that obtained by integrating over the velocity surface, the momentum correction factor may be written as

$$K_m = \frac{1}{W_m U_m} \int_0^{A_m} U_2^2 \rho_2 \, dA \ . \tag{4}$$

The density of the air at the mixing stack exit ρ_2 is a weighted average of the densities of the primary and secondary air flows. Assuming a secondary to primary mass flow rate ratio of 0.65, which is consistent with experimental results, ρ_2 is expressed as

$$\rho_2 = \rho_{avg.} = \frac{\rho_s}{1.65} \left[0.65 + \frac{T_s}{T_p} \right] \ . \tag{a}$$

Using this average density of the mixed flow, the mass flow rate leaving the mixing stack may be expressed as

$$W_m = \rho_{avg.} U_m A_m \ . \tag{b}$$

Combining equations (4) and (b) results in an equation for the momentum correction factor in terms of the experimentally determined

mixing stack exit velocity profiles,

$$K_m = \frac{1}{U_m^2 A_m} \int_0^{A_m} U_2^2 \, dA \, . \qquad \text{(c)}$$

Figure 41 illustrates the orientation of the two velocity traverses.

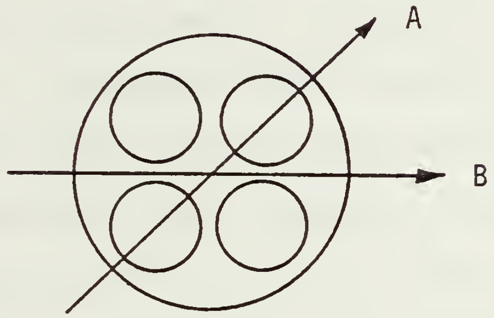


FIGURE 41. Orientation of Mixing Stack Exit Velocity Traverses.

To integrate the mixing stack exit velocity over the three-dimensional velocity surface using only the two traverses requires making some approximations:

1. Traverses A and B represent the maximum and minimum values of the velocity surface respectively.
2. The three-dimensional velocity surface is symmetrical, i.e. a velocity traverse passing above the other two primary nozzles, perpendicular to traverse A, is equal to that of traverse A and likewise for traverse B.
3. The circumferential variation of the velocity surface is sinusoidal with the maximum and minimum values at a given radius occurring at traverses A and B respectively.

The velocity traverse obtained experimentally consists of discrete points rather than a continuous curve. Each of these point values of velocity is representative of a radial element of the velocity traverse of length equal to the spacing between successive points. The procedure is to fit a circumferential sinusoidal curve through the maximum and minimum velocities of traverses A and B respectively. Then treat this circumferential band as representing a segment of the velocity surface of incremental width dr equal to the spacing between the data points and integrate circumferentially over successive radial elements. Completion of the integration yields the actual momentum of the mixed gases leaving the exit of the mixing stack.

The details of the integration are varied slightly for the three primary nozzle configuration, but the basic principles are the same.

APPENDIX F

UNCERTAINTY ANALYSIS

The experimentally determined pressure coefficient and pumping coefficient are used in determining eductor operating points which in turn provide the basis for comparison and evaluation of eductor system performance. A determination of the uncertainties in these coefficients was made using the method described by Kline and McClintock [7]. Data for the eductor configuration described in Table XIII(b) is considered a representative case and is used to calculate representative uncertainties in the pumping and pressure coefficients.

For a single sample measurement the value of a specific variable should be given in the format:

$$x = \overline{x} \pm \delta x$$

where

$\overline{x}$ = mean value of the variable x

δx = estimated uncertainty in x.

Variations for the variables in the defining equations for the two coefficients are listed at the end of this appendix. Having described the uncertainties in the basic variables of a relationship, it is now

necessary to determine how these uncertainties propagate into the result. Consider the relation where the result R is the product of a sequence of terms.

$$R = x_1^{a}\, x_2^{b}\, x_3^{c} \qquad \text{(a)}$$

A reasonable prediction of the uncertainty in the result R is obtained by using the Second Order Equation suggested by Kline and McClintock [7].

$$\delta R = \left[\left(\frac{\partial R}{\partial x_1}\,\delta x_1\right)^2 + \left(\frac{\partial R}{\partial x_2}\,\delta x_2\right)^2 + \left(\frac{\partial R}{\partial x_2}\,\delta x_3\right)^2\right]^{1/2} \qquad \text{(b)}$$

Evaluating the partial derivatives appearing in equation (b) and normalizing by dividing through by R yields the simplified form of equation (b) which will be used in this analysis.

$$\frac{\delta R}{R} = \left[\left(\frac{a\ \delta x_1}{x_1}\right)^2 + \left(\frac{b\ \delta x_2}{x_2}\right)^2 + \left(\frac{c\ \delta x_3}{x_3}\right)^2\right]^{1/2} \qquad \text{(c)}$$

Determination of the uncertainty in the pressure coefficient is facilitated by writing it as the product of a series of terms,

$$\frac{\Delta P^*}{T^*} = (\rho_s)^{-1}\,(\Delta P)\,(U_p)^{-2}\,(T^*)^{-1} \qquad \text{(d)}$$

where ΔP represents the pressure difference $(P_a - P_0)$. Constants such as $2g_c$ in the equation for the pressure coefficient will be cancelled out when used in equation (c) and are therefore not included in this analysis. Applying equation (c) to the pumping coefficient in equation (d) yields the following expression for its uncertainty:

$$\frac{\delta \frac{\Delta P^*}{T^*}}{\frac{\Delta P^*}{T^*}} = \left[\left(\frac{(-1)\ \delta\rho_s}{\rho_s} \right)^2 + \left(\frac{(\ 1)\ \delta(\Delta P)}{\Delta P} \right)^2 + \left(\frac{(-2)\ \delta U_p}{U_p} \right)^2 + \left(\frac{(-1)\ \delta T^*}{T^*} \right)^2 \right]^{1/2} \qquad \text{(e)}$$

Taking into account the respective equations defining the individual variables, the terms of equation (e) are expanded as follows:

$$\rho_s = \frac{P_a}{R\ T_s} \quad , \quad \left[\frac{\delta\rho_s}{\rho_s} \right]^2 = \left[\frac{\delta P_a}{P_a} \right]^2 + \left[\frac{\delta T_s}{T_s} \right]^2$$

$$U_p{}^2 = \frac{2\ g_c\ P_v}{\rho_p} = \frac{2\ g_c\ R\ P_v\ T_p}{P_u} \quad ,$$

$$\left[\frac{(-2)\ \delta U_p}{U_p} \right]^2 = \left[\frac{(-2)\ \delta P_v}{P_v} \right]^2 + \left[\frac{(-2)\ \delta T_p}{T_p} \right]^2 + \left[\frac{(-2)\ \delta P_u}{P_u} \right]^2$$

$$T^* = \frac{T_s}{T_p} \quad , \quad \left[\frac{\delta T^*}{T^*}\right]^2 = \left[\frac{\delta T_s}{T_s}\right]^2 + \left[\frac{\delta T_p}{T_p}\right]^2$$

Using the values of the variables and their respective uncertainties listed in Table XXI, the uncertainty in the pressure coefficient is estimated to be

$$\frac{\delta\left(\frac{\Delta P^*}{T^*}\right)}{\frac{\Delta P^*}{T^*}} = 0.019 = \pm 1.9\%$$

By a similar process, the uncertainty in the pumping coefficient is estimated to be

$$\frac{\delta(W^* T^{*.44})}{W^* T^{*.44}} = 0.014 = \pm 1.4\% \quad .$$

VARIABLE	VALUE	UNCERTAINTY
T_s	518 °R	± 1 °R
T_p	560 °R	± 1 °R
P_a	14.64 psia	± 0.01 psia
ΔP	0.43 in. H_2O	± 0.01 in. H_2O
P_v	1.38 in. H_2O	± 0.01 in. H_2O
P_u	8.60 in. H_2O	± 0.05 in. H_2O
ΔP_s (†),(††)	0.45 in. H_2O	± 0.01 in. H_2O
P_{or} (†)	0.71 in. H_2O	± 0.01 in. H_2O
ΔP_{or} (†)	23.1 in. H_2O	± 0.20 in. H_2O
T_{or} (†)	509 °R	± 1 °R

(†) These quantities were used in calculation of the uncertainty in the pumping coefficient.

(††) The pressure differential across the secondary flow nozzles ΔP_s is zero at the operating point. It is the major source of uncertainty in the pumping coefficient however and is therefore included here with a representative value.

TABLE XXI. Variables With Corresponding Uncertainties Taken from Table XIII(b).

APPENDIX G

CALCULATION OF IDEALIZED UPTAKE PRESSURE

In determination of the idealized uptake pressure, the multiple primary nozzle configuration was assumed to be replaced by a single converging nozzle with the same overall area ratio as that of the multiple nozzle system. Figure 42 illustrates the idealized nozzle with the key stations identified as A^*, the throat area for which

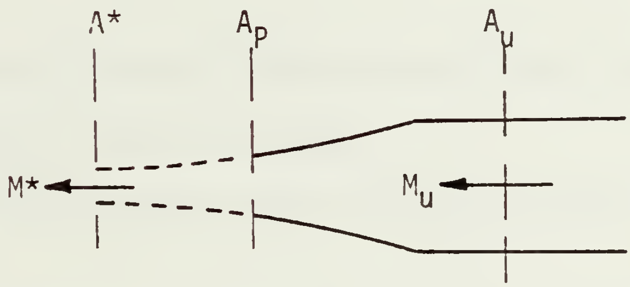


FIGURE 42. Schematic of Idealized Nozzle Representing a Multiple Primary Nozzle System.

choked flow occurs; A_p, the total primary nozzle cross sectional area; and A_u, the uptake cross sectional area. The assumptions made in this analysis are:

1. no losses occur in the nozzle,
2. velocity profiles are uniform throughout the one-dimensional flow, and
3. isentropic flow of a perfect gas with constant specific heat of 1.40.

The gas tables, Reference [5], contain the idealized relationships between Mach number, pressure, temperature and nozzle throat area in tabular form. For the flow condition described, the gas tables may be used to determine the pressure in the uptake for a given uptake Mach number. The procedure is as follows:

(1) Calculate the uptake Mach number, M_u.

(2) Enter the gas tables for the flow condition described with the uptake Mach number, and obtain the ratios A_u/A^* and P_u/P_t where P_t represents the stagnation pressure of the flow.

(3) Calculate the total primary nozzle area to uptake cross sectional area ratio, A_p/A_u.

(4) Multiply the ratios A_p/A_u and A_u/A^* to obtain the ratio A_p/A^*.

(5) Enter the gas tables with the ratio A_p/A^*, and obtain values for M_p and P_p/P_t.

(6) Divide the ratio P_u/P_t by P_p/P_t to obtain P_u/P_p.

(7) With the assumption that the pressure at the primary nozzle discharge is atmospheric, $P_p = P_a$, multiply the ratio obtained in step (6) by P_a to obtain the idealized absolute pressure in the uptake, P_u.

(8) The uptake pressure relative to atmospheric is obtained by subtracting P_a from P_u.

Table XXII contains the numerical results of the above procedure when used to calculate the data for Figure 38 for Eductor Proposal B. All pressures in this calculation are measured in inches of water. Notice

that the actual dimensions of the nozzle do not enter into the calculation of the idealized uptake pressure. This procedure can also be used to estimate the uptake pressure for a prototype installation.

A_m/A_p	M_u	A_u/A^*	P_u/P_t	A_p/A_u	A_p/A^*	M_p	P_p/P_t	P_u/P_a	P_a	P_u-P_a Ideal	P_u-P_a Actual
3.033				.3777	3.1768	.1860	.97616	1.02101	408.89	8.59	8.60
2.639	0.069	8.41099	0.99667	.4341	3.6512	.1610	.98206	1.01488	409.08	6.09	6.30
2.283				.5017	4.2198	.1387	.98664	1.01017	408.76	4.16	4.40
3.033				.3777	6.2496	.0931	.99396	1.0052	406.72	2.11	2.20
2.639	0.035	16.54655	0.99914	.4341	7.1829	.0809	.99543	1.00372	408.49	1.52	1.60
2.283				.5017	8.3014	.0699	.99659	1.00256	408.21	1.04	1.13

Table XXII. Idealized Uptake Pressure Calculations for Eductor Proposal B

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