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National Aeronautics
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Scientific and Technical
Information Branch

Summary

In an effort to explain an unusual flow separation phenomenon encountered while studying flows through a three-step seal configuration, choked flow rate and pressure profile data were taken and studied for configurations consisting of four axially aligned, sequential orifice inlets of 0.5 length-diameter ratio with separation distances of 0.66 and 32 diameters. The flow rates were related to a flow coefficient by using the homogeneous and nonequilibrium two-phase-flow models. A flow coefficient–reduced-temperature plot was then used to represent the flow rate data for the two separation distances.

An analytic model was effective in predicting the mass flow rates and recovered pressure drops for the sequential inlets for gas or liquid flows but failed to converge properly when property variations became large. Work continues on this problem.

At a separation distance of 32 diameters the pressure profiles dropped sharply at the entrance and partially recovered within each orifice—the exception being at low temperatures, where fluid jetting through the last orifice occurred. At a separation distance of 0.66 diameter fluid jetting was prevalent throughout the configuration at the lower inlet temperatures.

These results are in qualitative agreement with previously acquired data for four axially aligned, sequential Borda inlets and for tubes with single sharp-edge orifice or Borda inlets to L/D's of 105 and with a water flow visualization study reported herein and one previously reported for Borda inlets.

Introduction

Sharp-edge as well as contoured inlet configurations are common to fluid machinery components and heat transfer devices. In many cases the details of the flow dynamics in these configurations are not well understood. Such a situation occurred during the investigation of the flow of cryogens (hydrogen and nitrogen) through a high-pressure, three-step shaft seal configuration for the shuttle engine, when an unusual separation phenomenon was encountered (ref. 2, see ref. 1 for comparison). With the seal configuration set in the fully eccentric position, the flow appeared to separate and jet—like a free jet—throughout the third-stage length in the maximum-clearance channel.

Such unusual results provoked a series of choked fluid flow tests. As the seal passage was neither of the Borda nor orifice type but some combination of the two and was also a multiple-inlet passage, it was necessary first to study multiple Borda and orifice inlets. This has been done in a systematic way by using axisymmetric flows rather than combinations of concentric and eccentric annular flows, which are much more complex.

Single Borda inlets were examined to illustrate the dependence of the seal configuration on a geometric protrusion into the "reservoir region." These tests were followed by an effort to determine how the flow responded to a sharp-edge[1] orifice inlet. Here jetting refers to a dense, high-velocity core acting rather independently of its boundaries, in this case the tube walls. Then the nature of the flow through sequential Borda inlets was assessed, and in this report we investigate the flow through sequential sharp-edge orifice inlets. These tests are discussed in more detail in the following paragraphs.

In tubes with single sharp-edge Borda and orifice inlets (refs. 3 to 6), tests demonstrated that a jetting phenomenon could occur over a rather wide range of fluid-state conditions. Flow jetting occurred principally at low temperatures and high pressures and was nearly independent of the inlet cross-sectional geometry. Data were taken for single Borda and orifice inlet tube lengths to 105 L/D (refs. 3 and 4). (Symbols are defined in the appendix.)

Flow jetting was found to be inhibited (1) by high inlet stagnation temperature ($T_r > 1$) and, to a lesser extent, by low pressure, (2) by high L/D at one extreme, (3) by the saturated liquid locus at low L/D, where the liquid-like jet tended toward reattachment because of rapid vapor release,[2] and (4) by tube roughness. Another unusual feature was that for a given inlet stagnation isotherm,[3] as the flow changed from the jetting to the no-jetting condition, the pressure profiles were significantly altered but the flow rates were unaffected. The jetting condition indicates choked flow to be controlled at the inlet rather than at the outlet. It was also found that the flow rates followed the extended corresponding-states principle (refs. 7 to 9) but that the locus of change between jetting and no jetting did not follow the principle as well.

These tests established that jetting could occur in the passage. But the major issues that continued to block understanding of the flow phenomenon of the three-step seal configuration were whether jetting could occur in highly roughened passages and/or when discontinuities existed in the geometry.

In reference 10 the effects of four sequential, axially aligned Borda inlets were studied, as a first look at

[1]Sharp edge implies a leading-edge corner where the derivative of the streamline is discontinuous.

[2]Similar to the problem of establishing a supersonic liquid.

[3]Herein, constant temperature and isotherm are used interchangeably.

discontinuities. The authors found from a water table flow visualization study that for length-diameter ratios L/D less than 1 jetting could occur. For L/D greater than 20 the flow appeared to be nearly independent of the reservoir. For the range of $1 < L/D < 20$ flow instabilities were pronounced. Subsequent experimental tests were then conducted with Borda inlets ($l/D = 1.9$) and fluid nitrogen over a wide range of inlet stagnation pressures (to 7 MPa) and inlet stagnation temperatures (86 K to 300 K). The pressure profiles and flow rates at selected isotherms for a separation distance of 30 L/D demonstrated the flow to be nearly independent of the upstream Bordas and reservoirs, but jetting did occur in the fourth Borda at lower inlet stagnation temperatures. The pressure profiles dropped sharply at the entrance and recovered within each Borda tube—the exception being the last Borda, where the profile was flat. At a separation distance of 0.8 L/D jetting was commonplace at low inlet temperatures, and with the exception of the first Borda inlet the flow appeared to be independent of the configuration. The pressure dropped sharply at the first inlet and remained constant at lower temperatures throughout, an indication of jetting.

To characterize the flow rates for these four Borda configurations, flow coefficients C_f were given at selected isotherms. The 53-L/D single Borda inlet data were provided as a reference. At 30 L/D the flow was disrupted the most (low C_f), and at 0.8 L/D the least (high C_f) with the single inlet at 53 L/D somewhere in between. In both the 30-L/D and 0.8-L/D cases the variation of the flow coefficient locus with reduced inlet stagnation temperature $T_{r,0}$ was similar to that of a 53-L/D single Borda inlet tube (ref. 6). For the 30-L/D separation distance a thermodynamic model was postulated and used to predict liquid or gas flow rates with reasonable agreement to experimental data.

With these findings one could begin to understand the more complex flow phenomenon of the three-step seal (ref. 2) even though the annular passage of the seal geometry in the fully eccentric position does not have the symmetry of the tube.

Because the Borda inlet geometry represents the most severe case of simple flow reversal, the issue now centers on the effects of orifice inlet geometry, which more closely approximates that of the three-step seal (ref. 2). The queston is, Will changing the four sequential inlets from the Borda type to the orifice type yield essentially the same results as noted in references 3 and 4, or does the Borda inlet tend to direct jetting and the orifice inlet to obstruct jetting?

The authors only found a few studies in the open literature on flow phenomena in axially aligned, sequential orifice inlets. One such study is that of Boscole, Martin, and Dennis (ref. 11), who were primarly interested in the improvement of flowmeters. They varied parameters such as orifice diameter, axial spacing, and Reynolds number and concluded that a double orifice could be devised to give the same available head as a single orifice but with improved pressure recovery. It would appear that the analysis of reference 10 could be applied to these data to predict first-order effects.

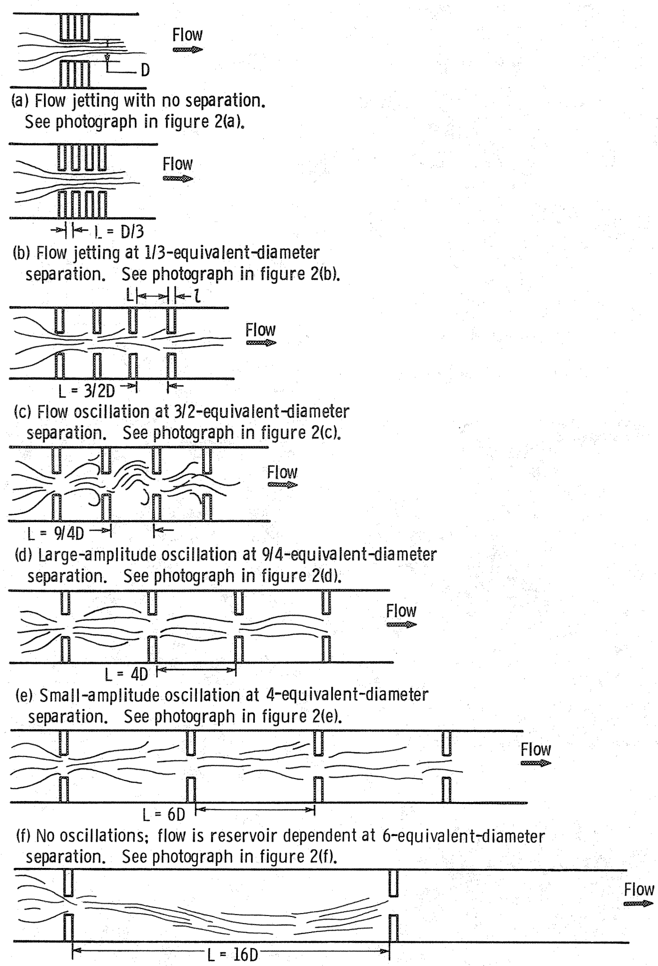
There are studies available on labyrinth seals, which in many respects are similar to the sequential orifice inlets. For example, Komotori and Mori (ref. 12) present a systematic study of one-dimensional ideal gas flow through labyrinth seals. The calculations appear to be in good agreement with limited, but adequate, data. Recently Benchert and Wachter (ref. 13) presented a thorough experimental study of see-through and leaved labyrinth seals. Their results show significant effects of inlet swirl on stability, which is modulated by rotation and the number of labyrinth cavities. Iwatsubo (ref. 14) also studied the stability of flows in labyrinth seal cavities. His results appear to be nearly the analytical complement to the experimental work of Benchert and Wachter (ref. 13). Although the annulus of a shaft seal configuration differs from sequential orifice inlets, the similarities are felt to be significant, and the concepts presented primarily in reference 12 will be applied in this report.

The need to study sequential inlets of the orifice type is necessary because of their commonplace usage and the similarity to the seal inlet of references 1 and 2. The results should apply to a larger class of problems, as sequential inlets are common to axial-fluid-flow machinery components, labyrinth seals, and seal dynamics in particular. Furthermore sequential orifice inlets represent one of the worst types of "roughened surfaces." Although the results could serve as a guide to studies on selected surface roughness, such effects were not covered in this study.

With so little information available on sequential inlets a flow visualization study to quantify some parameters was undertaken herein and in the study of reference 10. The purpose of this report is to provide some flow rate and pressure profile characteristics for four sequential, axially aligned orifice inlets separated by distances of 0.66 and 32 diameters over a range of fluid pressure and temperature as well as some results of the flow visualization study.

Flow Visualization Study

A flow visualization study was carried out on a water table to determine some characteristics of flows through sequential orifice inlets. In previous attempts to model flows through inlets such as the orifice, Borda, and other modifications (refs. 3 to 6 and 10), the water table observations were found to be in good correspondence to the potential flow one would intuitively anticipate for these inlets. Thus, to gain some insight as to flows in sequential inlets, Lucite models with L/D similar to those the authors expected to apply to the test apparatus were made of the orifice inlets. The models were then run on the water table and selected observations sketched as figure 1. The inlet water level was maintained at nearly two channel widths, and a red dye was used to mark the fluid paths. As the dye was ejected from a tube, vortex street patterns were prevalent, rather than uniform lamina. This, however, presented no difficulties as our interest was simply in marking the flow and the nature of



(a) Flow jetting with no separation. See photograph in figure 2(a).

(b) Flow jetting at 1/3-equivalent-diameter separation. See photograph in figure 2(b).

(c) Flow oscillation at 3/2-equivalent-diameter separation. See photograph in figure 2(c).

(d) Large-amplitude oscillation at 9/4-equivalent-diameter separation. See photograph in figure 2(d).

(e) Small-amplitude oscillation at 4-equivalent-diameter separation. See photograph in figure 2(e).

(f) No oscillations; flow is reservoir dependent at 6-equivalent-diameter separation. See photograph in figure 2(f).

(g) Flow nearly independent of reservoir at 16-equivalent-diameter separation. See photograph in figure 2(g).

Figure 1. - Schematic of water table visualization of flow in four sequential, axially aligned orifice inlets.

dye penetration within the body cavities. The average water level was maintained at about 1 channel width to provide a nominal-hydraulic square fluid passage, and a mirror was used to provide a 90° view of the water level through one of the inlets. Sketches of the dye traces of figure 1 correspond to the photographs of figure 2. The first sketch and photograph (figs. 1(a) and 2(a)) show four orifice models placed in such a way that they touched each other to form a continuous channel. After passing the *vena contracta* the flow continued uninterrupted through this configuration. The models were then placed with spacings of 1/3 of the channel passage width (figs. 1(b) and 2(b)). The flow continued in a nearly uninterrupted manner after the *vena contracta* with a very small amount of dye entering the fluid cavities. The models were then placed with spacings of 3/2 of the channel passage (figs. 1(c) and (2(c)). At this separation part of the flow entered the cavities and slight oscillations could be observed. At a separation of 2 to 3 channel passage widths a very strong oscillation was observed: The exhaust of one passage would "fan" the flow across the inlet of the subsequent orifice passage (figs. 1(d) and 2(d)). These oscillations weakened somewhat when the separation was increased to 4 channel passage widths (figs. 1(e) and 2(e)). At a separation of 6 channel widths no appreciable oscillations were observed, but the dye flow patterns were still perturbed by the body cavities (figs. 1(f) and 2(f)). At a distance of 16 channel widths the flow through each orifice passage appeared to be weakly dependent on the preceding orifice body cavity flow (figs. 1(g) and 2(g)). In essence the body cavities functioned as nearly independent reservoirs at large spacings.

Apparatus and Instrumentation

From the water table visualization studies and those of reference 10 it became apparent that stable flow could be anticipated at small separation distances (<1 diameter) and at large separation distances (>20 diameters). The orifice inlets were therefore designed with a sharp corner for the flow leading edge, similar to those used in reference 4, with spacers of 15.2 and 0.32 centimeters (6 and 0.125 in.). This provided two fixed separation distances between the orifice inlets of 32 and 0.66 diameter, respectively.

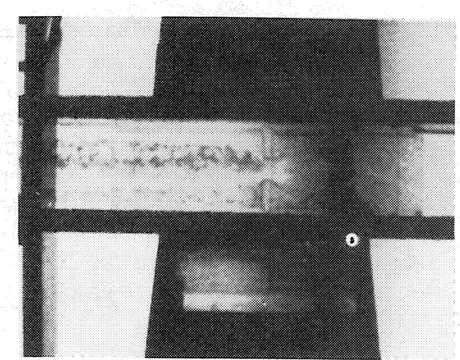
The flow facility (fig. 3) was basically that described in reference 15 but modified to accommodate the sequential inlet configurations of reference 10.

A schematic of the four-sequential-inlet geometry with 15.2-centimeter (6-in.) spacers is illustrated in figure 4. A disassembled view of this geometry is given as figure 5, and the test section installation is shown as figure 6. The 15.2-centimeter (6 in.) spacers were instrumented to measure the pressure profiles between the sequential orifice inlets. The locations of these pressure taps are given in figure 4.

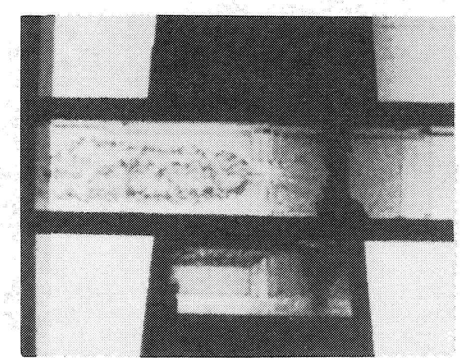
A schematic of the four-sequential-inlet geometry with 0.32-centimeter (0.125-in.) spacers is illustrated in figure 7, which also provides details of the orifice inlet geometry and pressure tap locations. A more detailed view of the orifice inlet is given as figure 8, a disassembled view of this configuration is given as figure 9, and the test installation is shown in figure 10.

The configuration was "sandwiched" between the inlet and outlet flange adaptors in order to accommodate the multiple lengths, with the multiple surfaces being satisfactorily sealed by thin Mylar gaskets between the flat faces.

The pressure data were recorded on the Lewis low-speed analog-to-digital data system and subsequently processed as described in reference 15. The runs were monitored with information displayed on a cathode-ray tube with 2-second updating. However, there were insufficient available pressure channels to accommodate all the simultaneous recording of the pressures within and between the four sequential orifice inlets. Only limited data were taken on the instrumented spacers in view of the nearly isobaric conditions found in the spacers between the sequential Borda inlets (ref. 10).

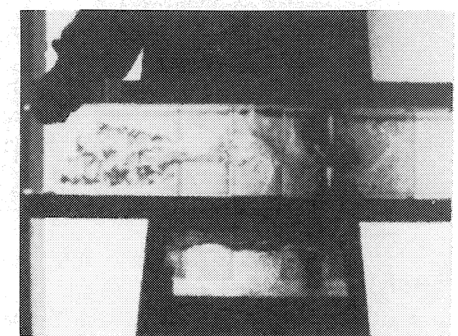


(a) Flow jetting with no separation.

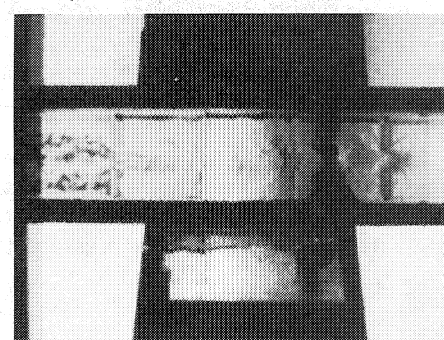


(b) Flow jetting at 1/3-equivalent-diameter separation.

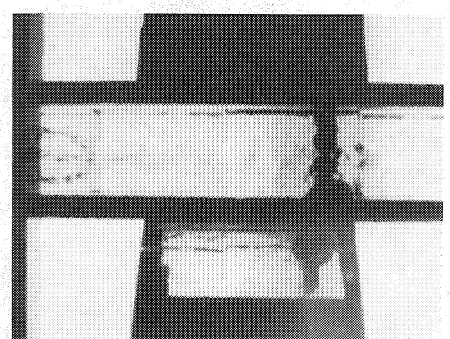
(c) Flow oscillation at 3/2-equivalent-diameter separation.



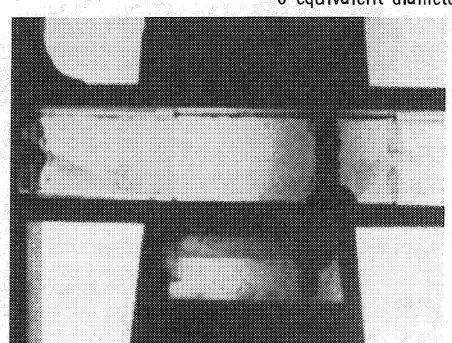
(d) Large-amplitude oscillation at 9/4-equivalent-diameter separation.



(e) Small-amplitude oscillation at 4-equivalent-diameter separation.



(f) No oscillation; flow is reservoir dependent at 6-equivalent-diameter separation.



(g) Flow nearly independent of reservoir at 16-equivalent-diameter separation.

Figure 2. - Water table visualization of flow in four sequential, axially aligned orifice inlets.

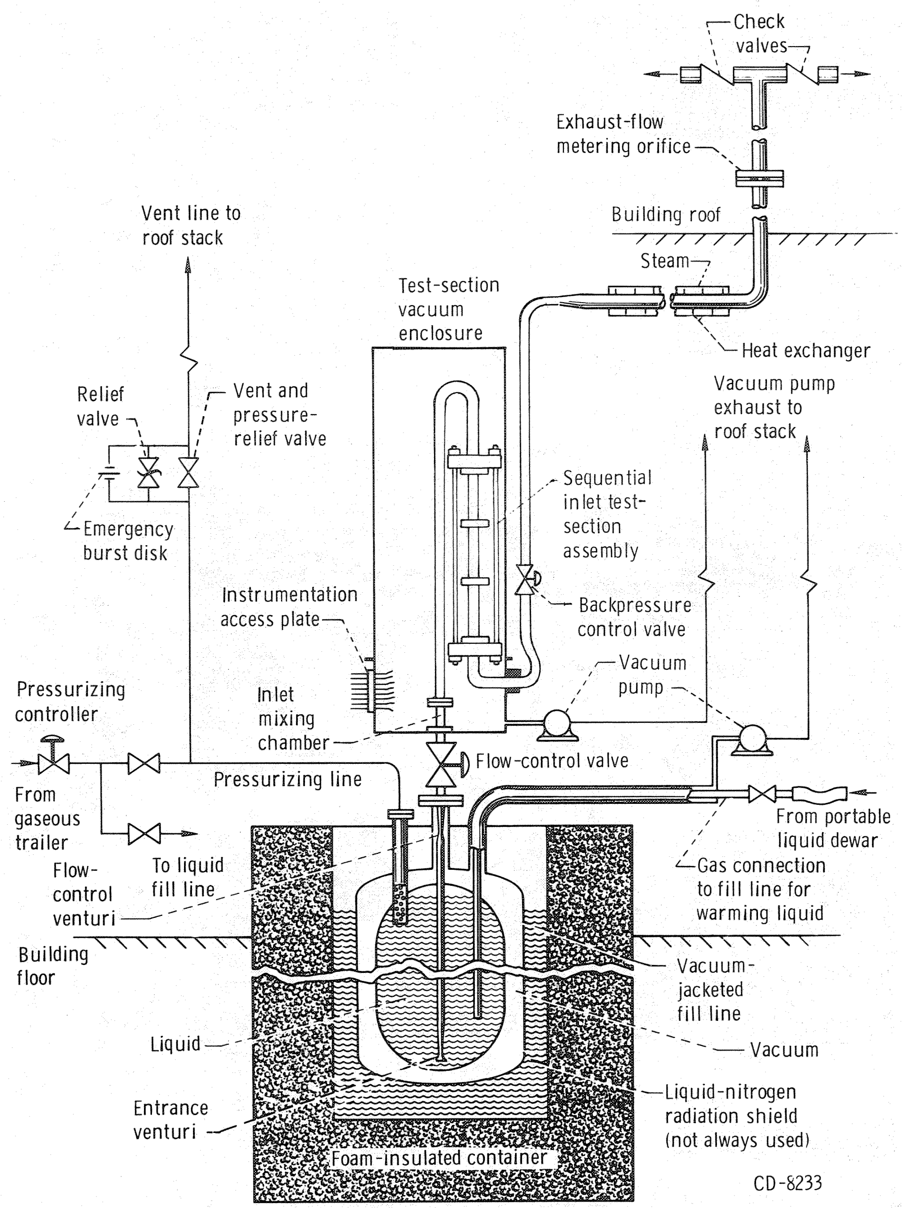


Figure 3. - Schematic diagram of high-pressure liquid-flow apparatus.

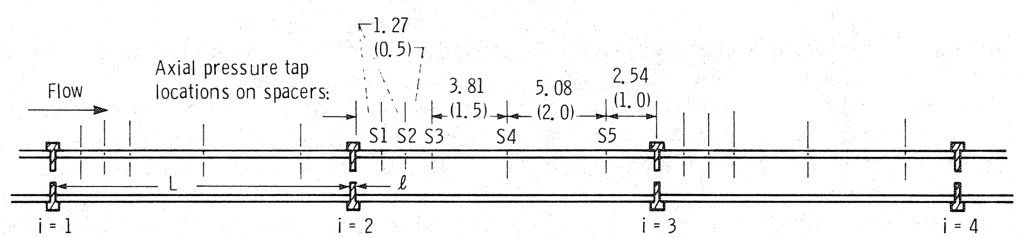


Figure 4. - Schematic of four-sequential-orifice-inlet geometry with 15.2-cm (6-in.) spacers. (See fig. 7 for details. Dimensions are in cm(in.).)

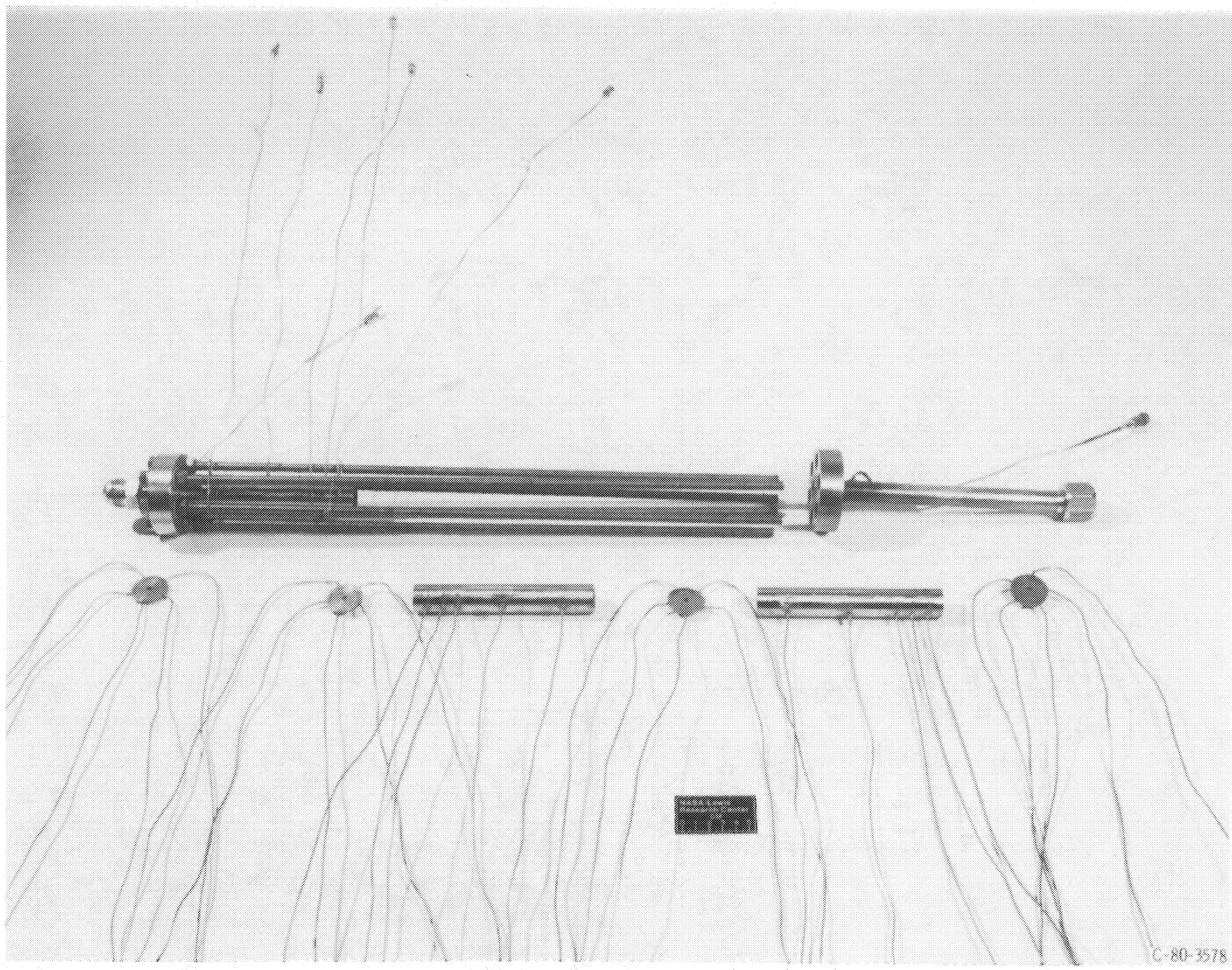


Figure 5. - Disassembled view of four-sequential-orifice-inlet geometry with 15.2-cm (6-in.) spacers.

The working fluid was nitrogen, and the temperature ranged from $0.68 < T_r < 2.5$ (liquid to gas), with pressure to $P_r < 2.5$.

Analysis

Axial-flow compressors, turbines, stage pumps, and seals are common examples of sequential inlet configurations. Notwithstanding the difficulties in describing the flow through these devices we wish to consider some treatment of flow through elementary axially aligned, sequential inlets.

The treatment even of the simplest set of sequential inlets is quite complicated. The expansion involves fluid separation, jetting, oscillations, turbulence, vortex streets, dissipation, and (for $S_{0,i} < S_c$) a change of phase. Sequential expansions are perturbed in a complex way and are quite difficult to assess either experimentally or theoretically. One fundamental problem is that the pressure ratio across the initial stage (or subsequent stages) is unknown; the choking conditions are also unknown. Consequently even the most idealized treatment is not closed and requires some iteration.

As an attempt to treat the sequential inlet problem analytically, suppose we assume the entire process to be adiabatic, with a series of isentropic expansions across each inlet followed by an isobaric recovery in a "mixing chamber" to the adiabatic locus as illustrated in figure 11. Such a procedure was used to predict the flow rates and pressure ratios of the four Borda inlet configurations with some success (ref. 10). The procedure is also quite similar to the approach given by Komotori and Mori (ref. 12) for flow through labyrinth seals.

At the present time we will consider only the simplest cases, marked "gas" and "liquid" in figure 11, where all fluid properties are evaluated by using the code GASP, (ref. 16). The process at the i^{th} inlet is described in reference 10:

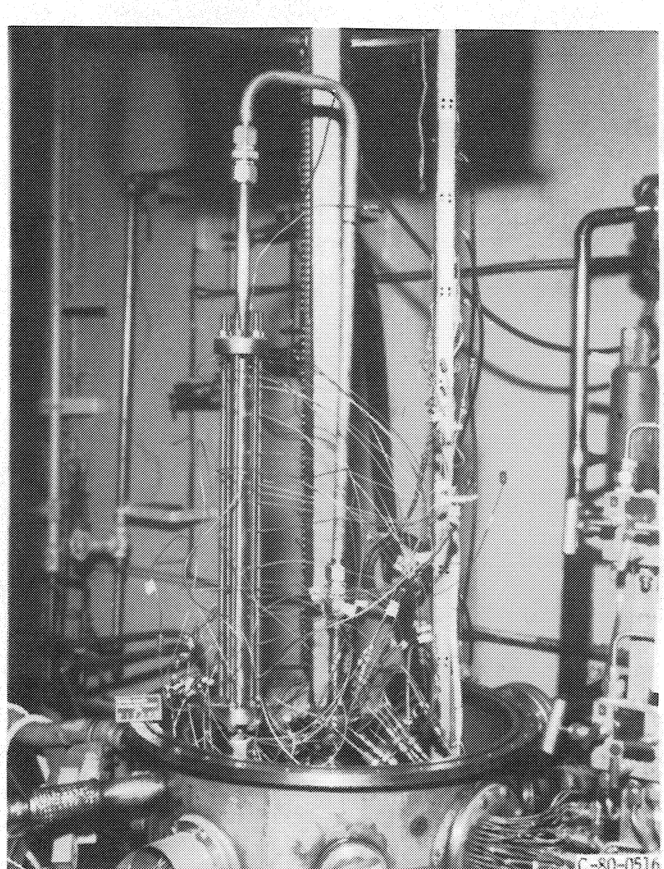


Figure 6. - Test installation of four-sequential-orifice-inlet geometry with 15.2-cm (6-in.) spacers.

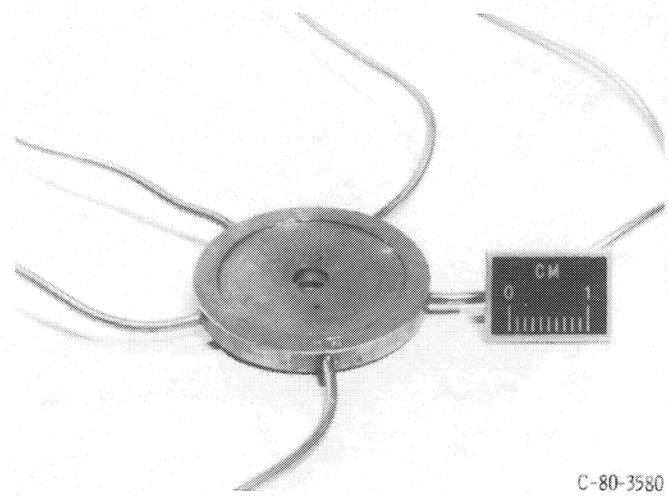


Figure 8. - Orifice inlet.

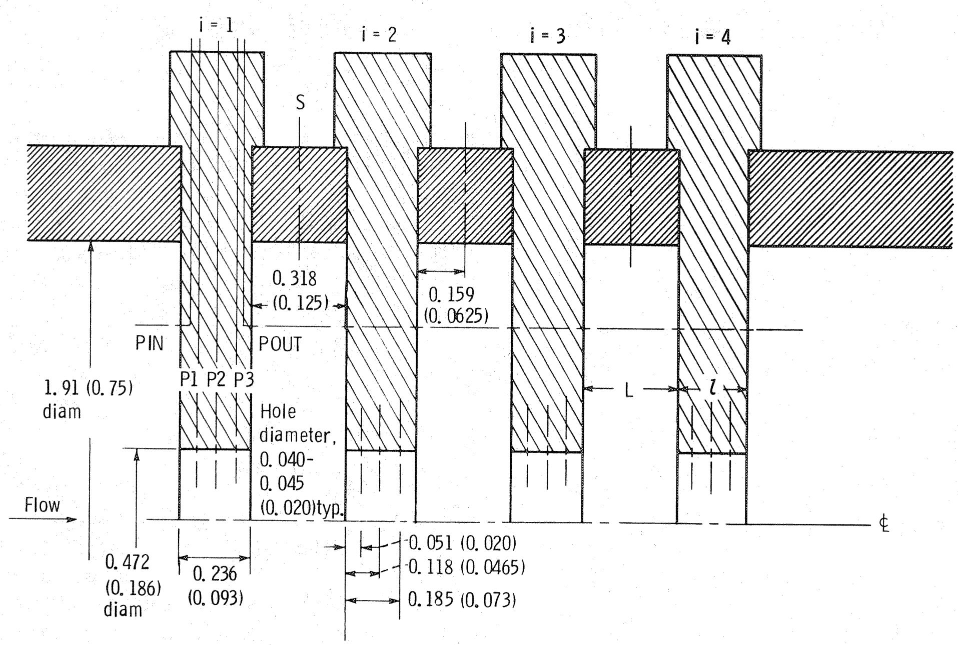


Figure 7. - Schematic of four-sequential-orifice-inlet geometry with 0.32-cm (0.125-in.) spacers. (Dimensions are in cm (in.).)

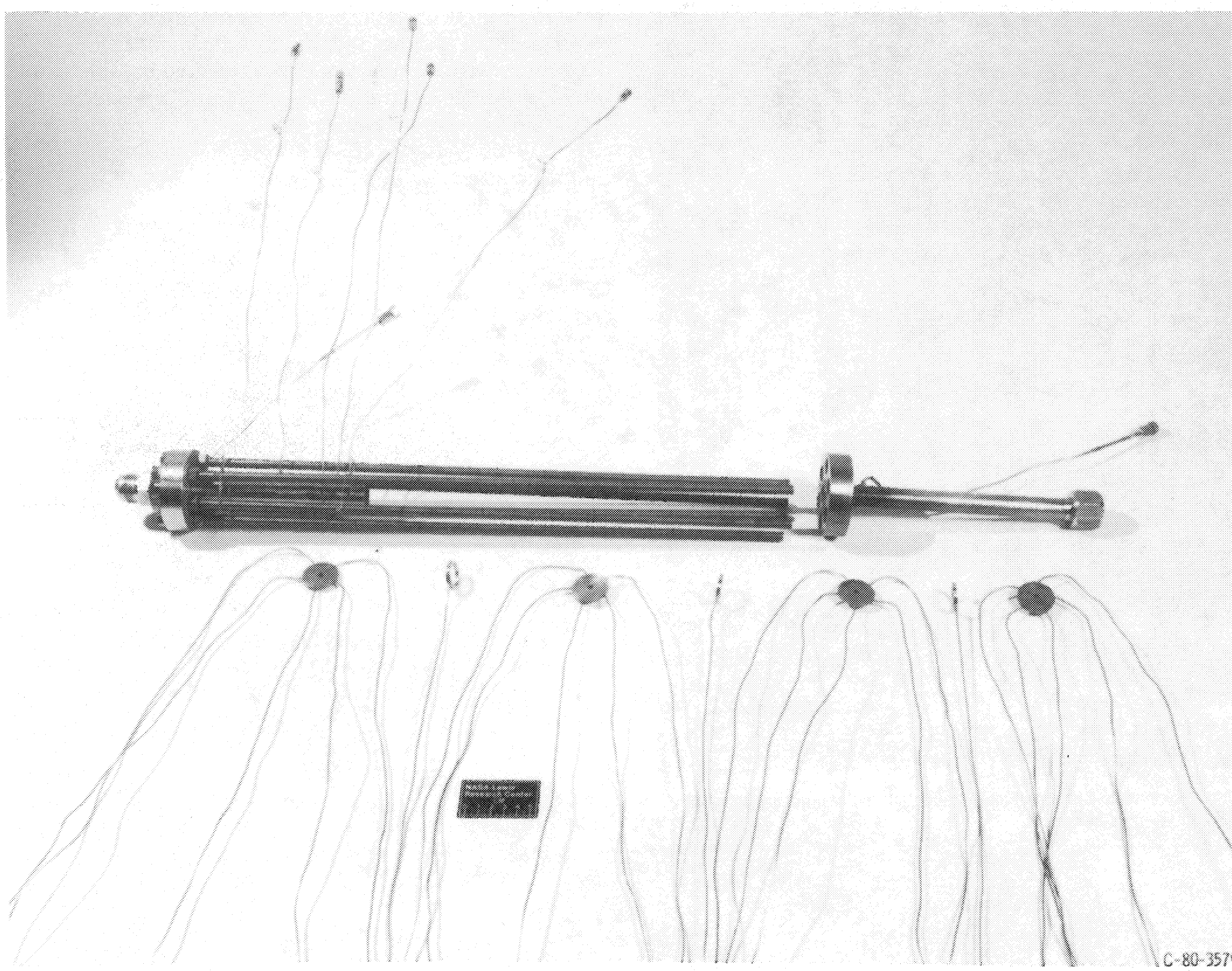


Figure 9. - Disassembled view of four-sequential-orifice-inlet geometry with 0.32-cm (0.125-in.) spacers.

$G^2 = 2\rho_i^2(H_0 - H_i)$

The constraints are as follows:

Isentropic

$S_0(P_0, T_0),\ i = S_e(P_e, T_e),\ i$

Isobaric

$P_{e,i} = P_{0,i+1}$

Critical flow (choked)

$$G_m^2 \left(\frac{dV}{dP}\right)_e \bigg|_{i=4} = -1$$

where

$$G_m^2 = \left(\frac{2}{V^2}\right) \int_{P_e}^{P_0} V\,dp,\ i = 4$$

Upon convergence, G approaches G_m.

Although the governing equations appear to be straightforward, their solution is not. The computational procedure initiated in reference 10 is still being developed, and a limited number of data points for the four-sequential-orifice-inlet configuration spaced at 32 diameters are compared in table I and discussed in the following section.

Results

Experimental Comparisons

The results will be separated into those for the 32-diameter separation distance and those for the 0.66-diameter separation distance, asserting that each represents a limiting case. At 32 diameters the flow through one inlet appears to be nearly independent of the other inlets, but at 0.66 diameter the flow appears to "recognize" the configuration as one inlet. Because the system instrumentation used in this work is for steady

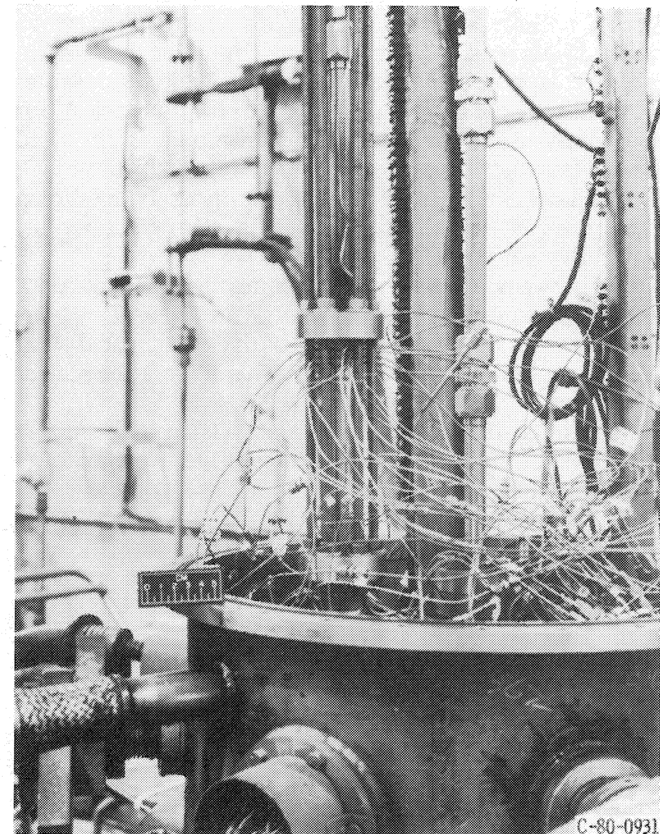


Figure 10. - Test installation of four-sequential-orifice-inlet geometry with 0.32-cm (0.125-in.) spacers.

flows and flow instabilities are anticipated within this range of L/D, spacings ranging from 1 diameter to less 32 diameters were not run. Data are presented in table II for the 32-diameter separation distance and in table III for the 0.66-diameter separation distance.

Four Sequential Inlets at 32-Diameter Separation Distance

The four sequential inlets at the 32-diameter separation distance were heard to whistle at multiple frequencies. The frequencies were noted but not measured.

In references 3, 4, and 10 the flow rates were ratioed to those predicted for two-phase choked flow through a venturi. This ratio is defined as the flow coefficient. Even though in this experiment four such orifice inlets were aligned axially and it belies further understanding of the flow details, we will apply the same technique.

The flow coefficient for the four-orifice-inlet configuration becomes

$$C_f = \frac{G_r}{G_{r,\ \text{venturi}}}$$

where $G_r = G/G^*$ represents the reduced flow rate and G^* can be determined from the extended corresponding-states principle (refs. 8 and 9 and the appendix of ref. 10). Although no verification of the extension of results herein to other fluids is presented, references 7 to 9 and 17 suggest that the principle can be applied.

Reduced flow rate data as a function of reduced inlet stagnation pressure for selected isotherms are presented as figure 12. For the 0.68 reduced inlet stagnation

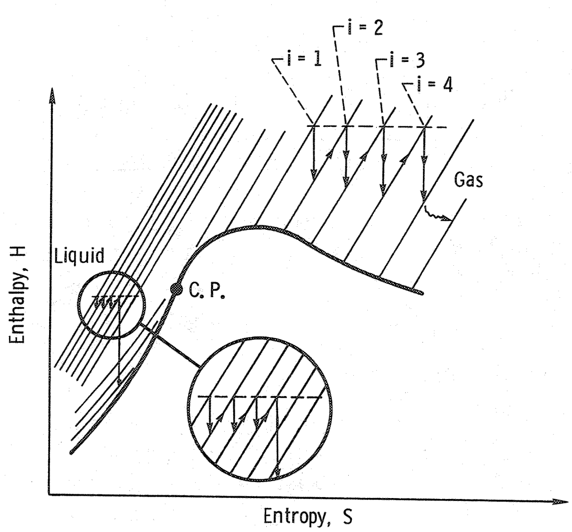


Figure 11. - Process path for four-sequential-orifice-inlet configuration on enthalpy-entropy diagram.

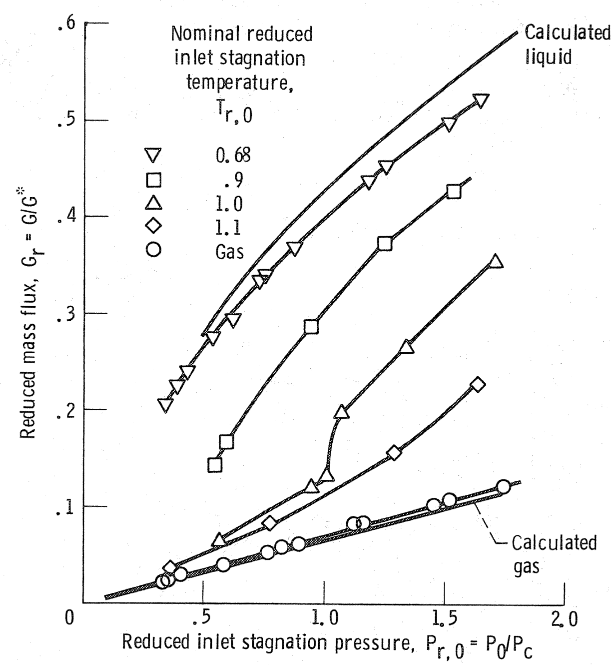


Figure 12. - Reduced mass flux as a function of reduced inlet stagnation pressure for four sequential, axially aligned orifice inlets - 32-diameter separation distance.

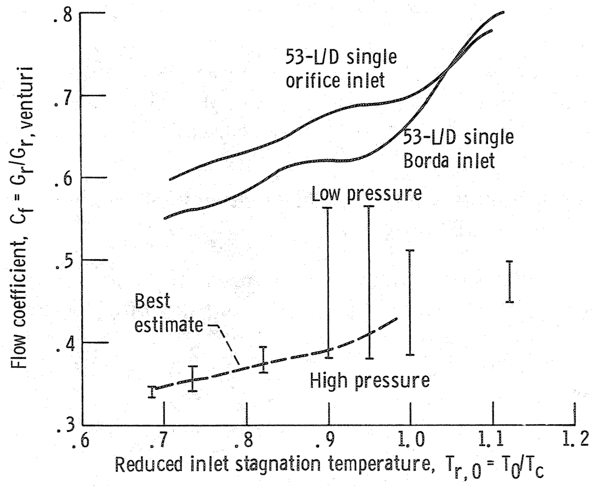


Figure 13. - Flow coefficient as a function of reduced inlet stagnation temperature for four sequential, axially aligned orifice inlets spaced at 32 diameters - equilibrium properties.

temperature isotherm, C_f equals 0.345; for gas the value of C_f increases to 0.51, as illustrated in figure 13. This trend is not unusual. It was found for the four sequential, axially aligned Borda inlets (ref. 10) and for tubes with single Borda and orifice inlets to 105 L/D (refs. 3 to 6). In reference 3 the flow coefficient locus was shown to be practically the same for both the orifice and Borda inlets. With the C_f locus for a 53-L/D tube with a single Borda inlet (ref. 6) and for a 53-L/D tube with a single orifice inlet (ref. 4) as background or reference curves, the C_f variation based on the homogeneous equilibrium model for the four-orifice configuration with reduced stagnation temperature is given as figure 13. The deviation bars represent uncertainties (with pressure, e.g.) at the selected isotherms. The nonequilibrium model (ref. 17) allows a certain degree of metastability, which becomes increasingly important for inlet stagnation pressures approaching saturation, and higher flow rates are predicted over those of the equilibrium model in this region. By using the nonequilibrium model in the fluid regime (a rather broad region around the critical point), the deviation bars can be reduced significantly, as shown in figure 14; however, the deviations still persist, especially near the critical point.

The flow coefficient curve recommended for these data is given in figure 14. The curve is dashed near $T_r = 1$ for two reasons: Our understanding of the near-critical fluid behavior is limited, and for flows where $T_r > 1$ the scatter appears to be substantially reduced.

As pointed out earlier the flow coefficient technique does little to promote understanding of the complex four-sequential-inlet flow phenomenon, but it is expedient and characterizes the black-box nature of the system.

An insight into the complex nature of the flow through the four sequential inlets is provided by the pressure profiles given in figures 15 and 16. If one were unaware of the four orifice inlets spaced at 32 diameters and had only the stagnation pressures at the inlet (or outlet) of each and connected these points, one would presume that the profiles were those of a tube with substantial surface roughness (fig. 15). It is quite apparent from the details that such is not the case. There exists a rather sharp drop in pressure near the entrance of each of the four sequential orifice inlets, as given in more detail in figures 15 and 16. The pressure drop is generally followed by a recovery; but, in the case of the liquid-like flows, jetting is assumed to occur in the last inlet configuration from the nature of the "flat" pressure profile. Such behavior is quite similar to that of the seal configuration for the shuttle engine (ref. 1), which instigated the study. The spacer pressure profiles exhibited in reference 11 for water flow through two aligned orifices are quite similar to those found within the sequential orifice inlets of this

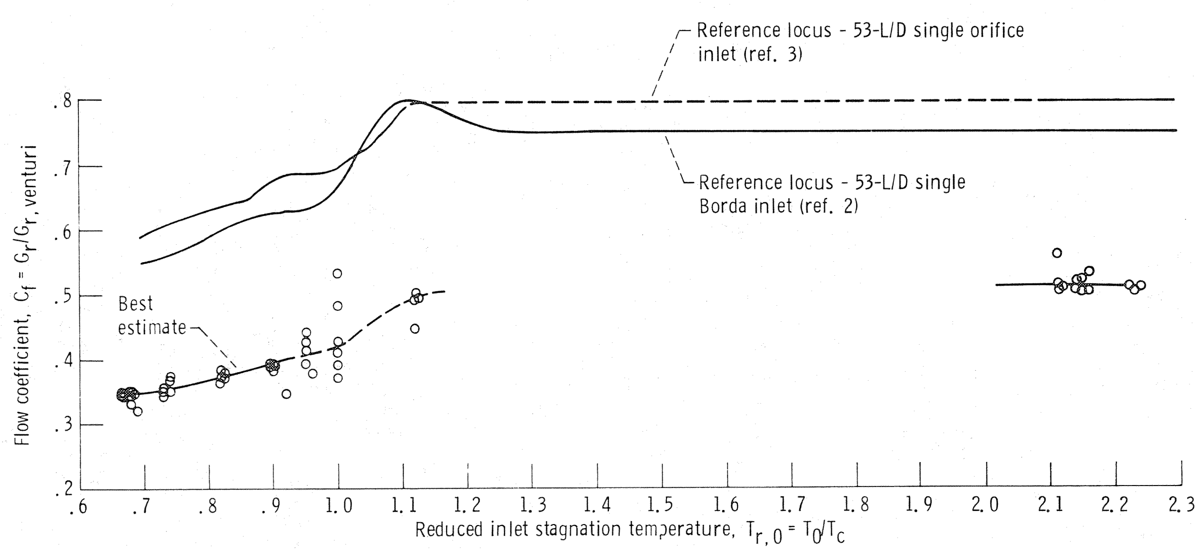


Figure 14. - Flow coefficient as a function of reduced inlet stagnation temperature for four sequential, axially aligned orifice inlets spaced at 32 diameters - nonequilibrium properties.

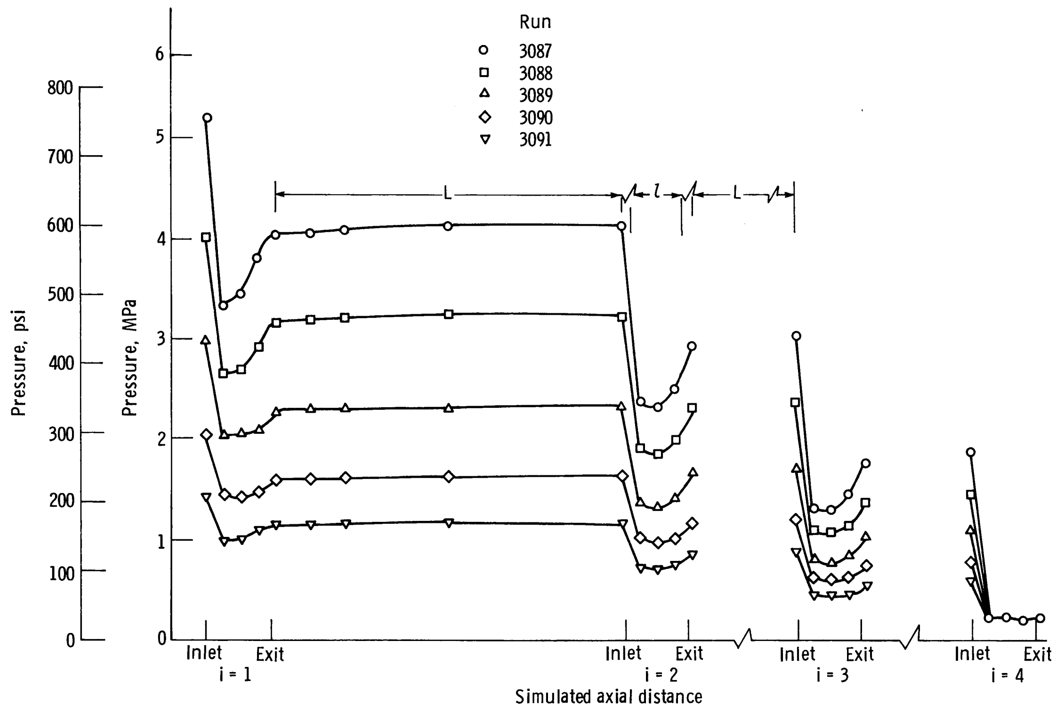


Figure 15. - Pressure profiles for four sequential, axially aligned orifice inlets at reduced inlet stagnation temperature $T_{r,0}$ of 0.68. Separation distance, L, 15.2 cm (6 in.), or 32 diameters; length of orifice, l, 0.236 cm (0.093 in.).

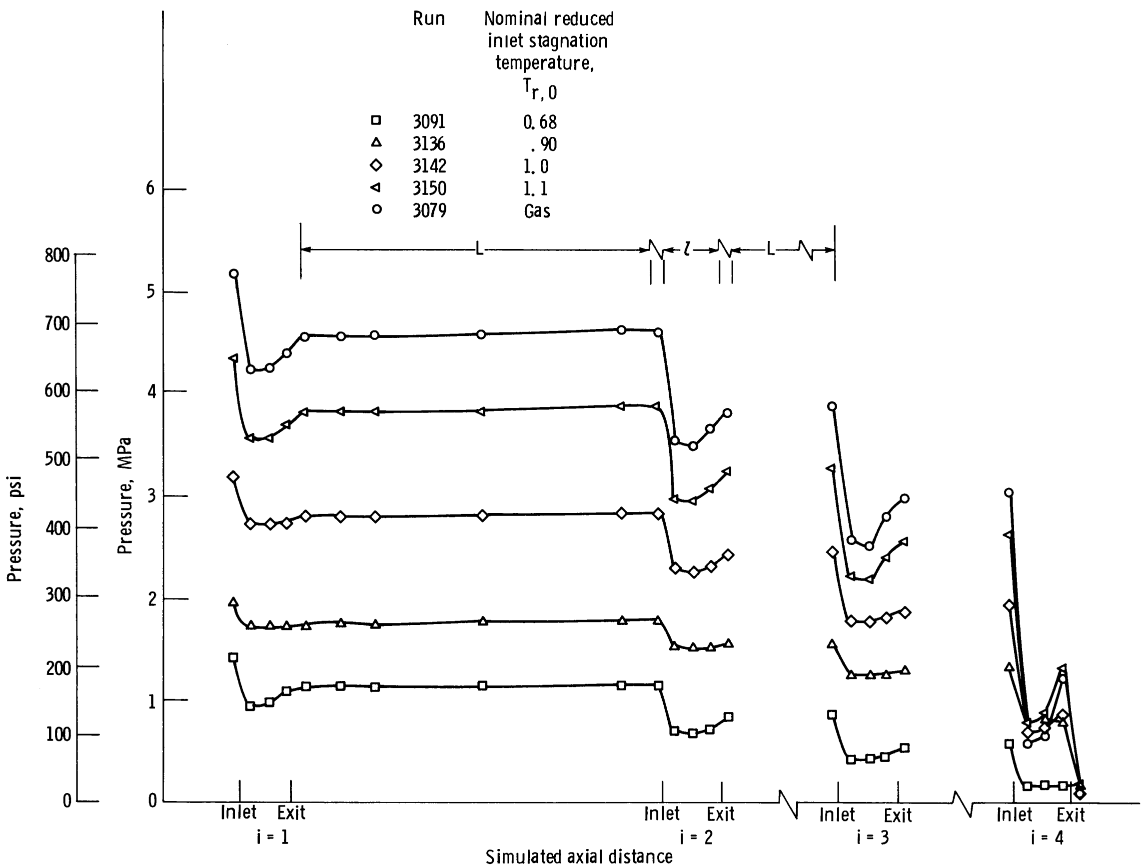


Figure 16. - Pressure profiles for four sequential, axially aligned orifice inlets at various reduced inlet stagnation temperatures. Separation distance, 15.2 cm (6 in.), or 32 diameters; length of orifice, l, 0.236 cm (0.093 in.).

study. This is in contrast to small variations in spacer pressure profiles taken with one of the 15.2-centimeter (6-in.) instrumented spacers (fig. 15). The results were much as anticipated from reference 10, and the effect appears to signal the presence of vortex flow.

The variation of pressure profiles with inlet stagnation temperatures is illustrated in figure 16. As anticipated from previous work the pressure level of the "flat" profile in the last sequential inlet is very close to the saturation pressure as determined by the inlet stagnation temperature (refs. 1 to 4). As the inlet stagnation temperature is increased, the saturation pressure is increased and so the minimum pressure level of the "flat" profile is increased.

Backpressure Effects at 32-Diameter Separation Distance

Backpressure was applied at various inlet stagnation temperatures. Some of the results are shown in figure 17. At lower inlet stagnation temperatures jetting appears to occur over a range of backpressures. As the backpressure is increased, the profile throughout the configuration begins to shift. This behavior is typical of orifice geometries, which really never choke but approach some asymptotic limit. The effect is more pronounced at higher inlet stagnation temperatures, where small changes in backpressure affect the profile, as noted in figure 18.

Four Sequential Inlets at 0.66-Diameter Separation Distance

The authors assumed from the flow visualization studies and the results of references 3, 4, and 10 that at 0.66 diameter the fluid could flow undisturbed by the spacer discontinuities; that is, flow jetting would be a distinct possibility. Although in general this was found to be the case, minor disturbances and acoustic noise, which was not detected in Borda-type inlets (ref. 10), did seem to have little influence on the flows. An audible frequency of several kilohertz was noted for the four sequential inlets and was estimated but not measured.

As with the 32-diameter separation distance again we first look at the flow rates. The reduced flow rate for the four sequential inlets with 0.66-diameter separation distance as a function of reduced pressure for selected isotherms is given as figure 19. As for the 32-diameter separation distance the flow coefficient varies. With the 53-L/D single Borda inlet and the 53-L/D orifice inlet as background curves and with the homogeneous equilibrium model used in calculating the value of G_r, the variations in C_f with reduced inlet stagnation temperatures are given as figure 20. The deviations in C_f were reduced by using the nonequilibrium model for the calculated value of G_r, as illustrated in figure 21. The dashed line represents the recommended locus for C_f.

The data marked "Teflon spacers" were taken with two Teflon washers used back to back as a spacer.

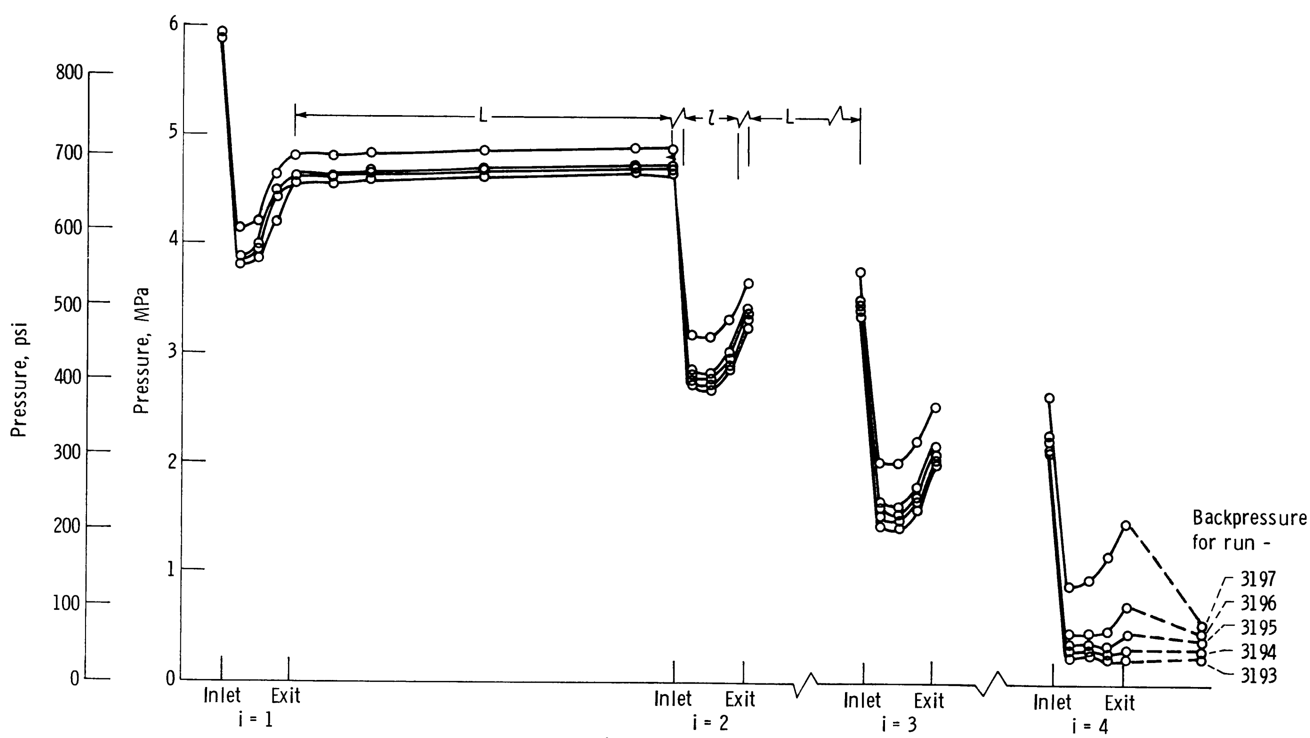


Figure 17. - Backpressure effects on four sequential, axially aligned orifice inlets at reduced inlet stagnation temperature $T_{r,0}$ of 0.7. Separation distance, L, 15.2 cm (6 in.), or 32 diameters; length of orifice, l, 0.236 cm (0.093 in.).

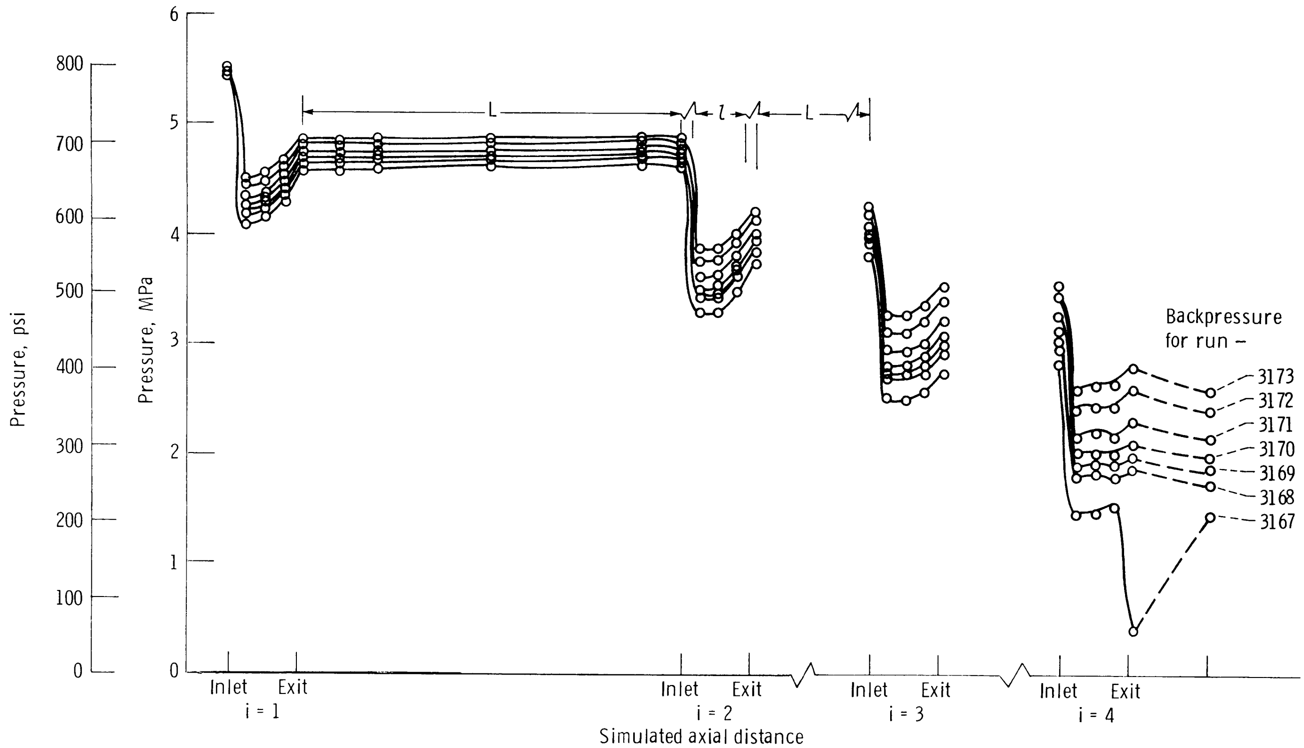


Figure 18. - Backpressure effects on four sequential, axially aligned orifice inlets at reduced inlet stagnation temperature $T_{r,0}$ of 1.0. Separation distance, L, 15.2 cm (6 in.), or 32 diameters; length of orifice, l, 0.236 cm (0.093 in.).

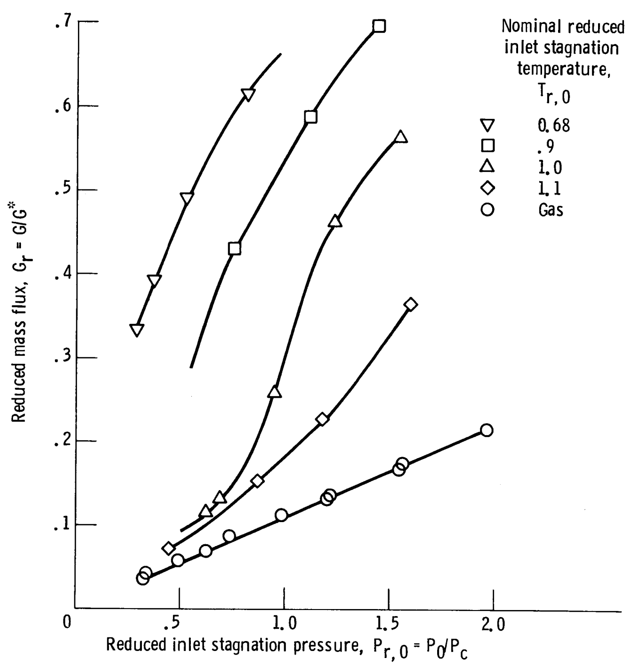


Figure 19. - Reduced mass flux as a function of reduced inlet stagnation pressure for four sequential, axially aligned orifice inlets - 0.66-diameter separation distance.

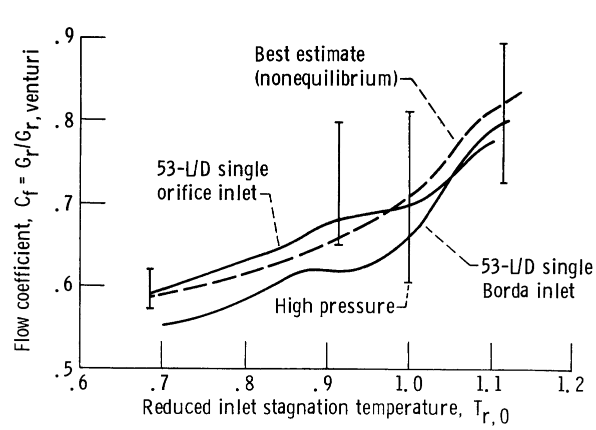


Figure 20. - Flow coefficient as a function of reduced inlet stagnation temperature for four sequential, axially aligned orifice inlets spaced at 0.66 diameter - equilibrium properties.

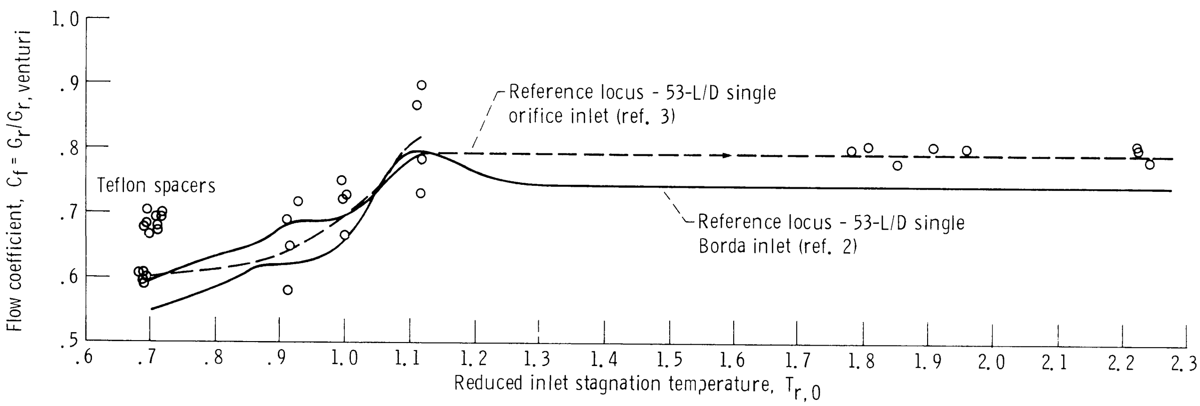


Figure 21. - Flow coefficient as a function of reduced inlet stagnation temperature for four sequential, axially aligned orifice inlets spaced at 0.66 diameter - nonequilibrium properties.

Although the nominal separation distance was 0.30 centimeter (0.12 in.), the Teflon was expected to cold flow (extrude), which it did, leaving the L/D unknown; but the results properly reflect a higher C_f at an $L/D<0.66$. Although the level changes from 0.6 to 0.8 in the gas, the trends appear to be similar to those of figure 13 and that of a tube with a single Borda or orifice inlet (refs. 3, 4, and 6).

A most dramatic change due to spacing (L/D) occurred in the pressure profiles for both gas and liquid as well as the fluid states in between. As can be seen from figures 22 and 23 the pressure profiles through the first inlet exhibit a sharp drop at the entrance, recover through the first and second inlets, drop somewhat in the third and fourth inlets, and show a sharp drop at the exit of the last inlet depending on the fluid structure. At lower inlet stagnation temperatures there is a flat profile.

Note the higher-inlet-temperature liquid and gas pressure profiles, which give the appearance of a flow that is nearly choked at *both* the inlet and the outlet.

At the lower inlet stagnation temperatures the pressure profiles resemble those of a free jet, analogous to those noted for the four sequential, axially aligned Borda inlets and single Borda and orifice inlets. This of course means that under these conditions the fluid can flow virtually unimpeded from the entrance through the four sequential inlets, even though they are separated by spacer lengths of 0.66 diameter.

Backpressure Effects at 0.66-Diameter Separation Distance

To determine how the profiles respond to backpressure, several data sets were taken. Backpressure

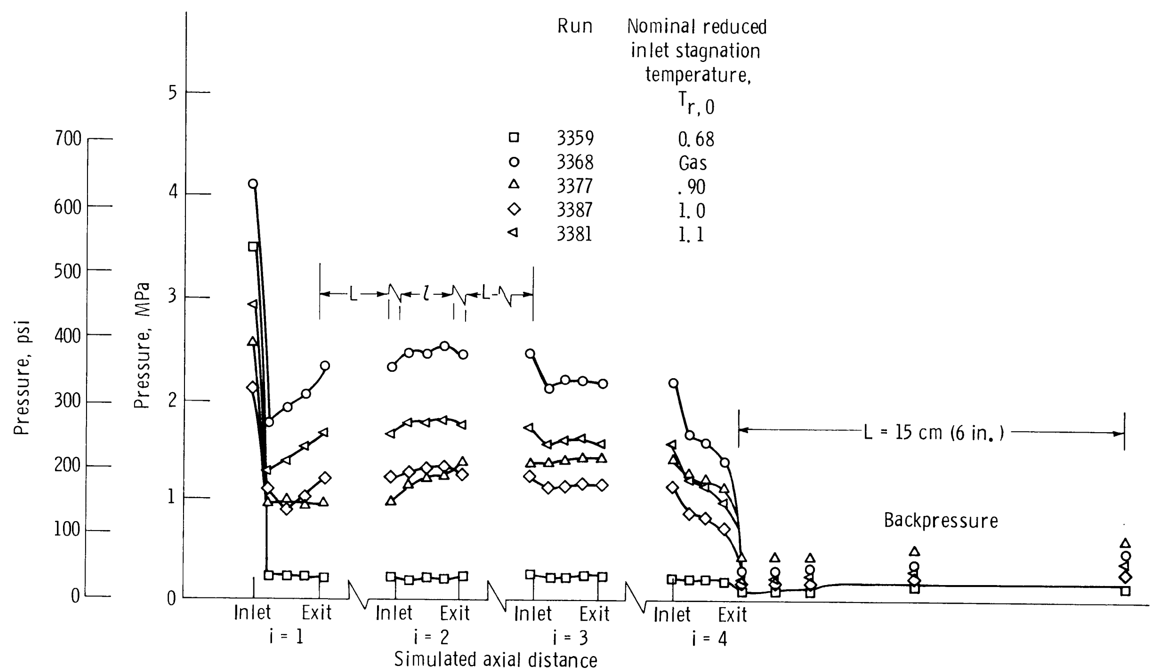


Figure 22. - Pressure profiles for four sequential, axially aligned orifice inlets at various reduced inlet stagnation temperatures. Separation distance, L, 0.318 cm (0.125 in.), or 0.66 diameter; length of orifice, l, 0.236 cm (0.093 in.).

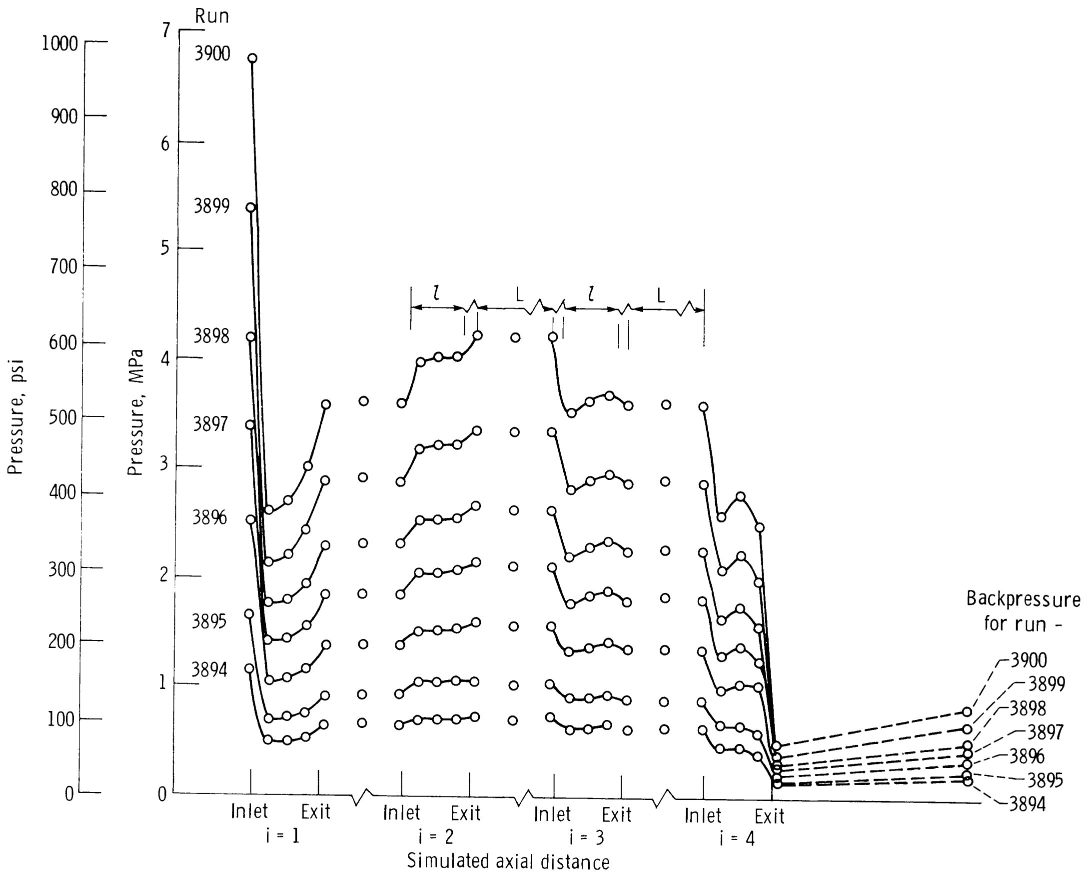
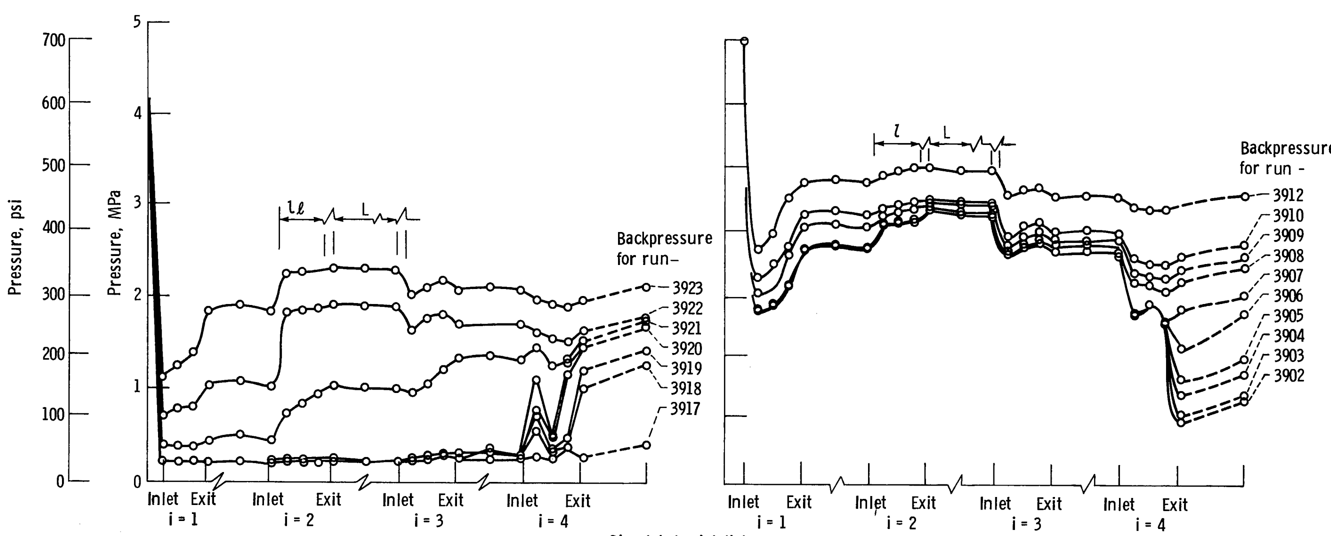


Figure 23. - Backpressure effects on four sequential, axially aligned orifice inlets at reduced inlet stagnation temperature $T_{r,0}$ of 2.18 (gas). Separation distance, L, 0.318 cm (0.125 in.), or 0.66 diameter; length of orifice, l, 0.236 cm (0.093 in.).



(a) Reduced inlet stagnation temperature, $T_{r,0}$, 0.68 (86 K).

(b) Reduced inlet stagnation temperature, $T_{r,0}$, 2.18 (gas).

Figure 24. - Backpressure effects on four sequential, axially aligned orifice inlets at reduced inlet stagnation temperatures $T_{r,0}$ of 0.68 and 2.18. Separation distance, L, 0.318 cm (0.125 in.), or 0.66 diameter; length of orifice, l, 0.236 cm (0.093 in.).

control profiles for the 0.66-diameter separation distance are given as figure 24 for two cases, liquid and gas. For liquid (fig. 24(a)) the flow remains choked at the inlet even when significant backpressure is applied, up to a point sometimes near 0.4 P_0, after which of course the flow is unchoked.

For gas (fig. 24(b)) significant variations in backpressure must be made before the profiles in the first, second, and third inlets are altered. Above that point, however, the pressure profile throughout the first orifice appears to be altered, and significant variations in flow are expected.

Noted also that for gas at the small separation distance significant backpressure variation can be applied without significantly altering the upstream pressure profiles. This should be contrasted to the large separation distance where small changes in backpressure alter the profiles (figs. 17 and 18).

These results demonstrate that jetting can occur even with disjoint sequential inlets and elevated backpressures and further define the nature of the flow separation in the three-step seal (ref. 1). Such controlled separations can be quite useful in providing high seal stiffness, high blade loading, fluidic control, ejector flow, etc.; however, they can be equally harmful when uncontrolled.

Analytical Comparisons

The 32-diameter separation distance was considered first when assuming each orifice to act independently of the previous one. In general the gas data were easier to handle than the liquid; however, for either fluid regime, one must make three assumptions (1) the pressure ratio across the first inlet, (2) that the choking condition applies at the last orifice inlet, and (3) that the iteration will converge to the solution. The results of selected computations are given as table I. For these cases a flow coefficient of 0.75 was chosen as representative of the system and held constant for each inlet. This of course is a crude assumption but expedient at this point in the development of a solution for the system. The calculated liquid and gas loci are presented in figure 12 and are in somewhat close agreement with the experimental values.

The calculated values of table I show a good correspondence with experimental values: The pressure ratios are similar and the flow rates are in somewhat good agreement. These results may be improved if a different value is used for the flow coefficient.

For the limiting case of a perfect gas the results of this analysis are in good agreement with the results of Komotori and Mori (ref. 12). In many cases Komotori and Mori's approach can be applied even though there are real gas effects, and better solution stability is achieved.

A great deal of effort must be applied here before we can achieve a solution. For example, the failure of the code to handle the near-critical and low-inlet-pressure data could be improved with an improved iteration procedure and a better flow model to handle the significant property variations that occur close to the saturation locus and in the near-critical region. In the meantime the black-box approach will serve as a guide.

For the 0.66-diameter separation distance, since jetting can be established at the first orifice inlet, the implication from references 3, 4, and 10 is that jetting will continue throughout the remaining three orifice inlets. This was indeed noted experimentally. The flow rate and pressure ratio behavior are essentially defined as though the sequential configuration were only *one* orifice inlet.

When the liquid is jetting through the orifice, the influence of the orifice length l/D is minimal and one should expect a C_f of about 0.6. For the gas the effect of orifice length (0.5 l/D) becomes significant, increasing C_f to about 0.7. Sudden contraction gives a C_f of 0.83, so we use $C_f = 0.75$ in the analysis.

For gas and for the larger separation distance the agreement between the analysis of Komotori and Mori (ref. 12) and the results presented herein indicates direct applicability of axisymmetric results to the concentric labyrinth seal geometry, provided the proper similarity rules are followed.

Concluding Remarks

Choked flow rate and pressure profile data for four axially aligned, sequential orifice inlet configurations separated by spacers of 0.66 and 32 diameters have been taken and studied.

Analytic modeling is quite complex and an extensive effort will be required; however, a simplistic model of the 32-diameter-separation-distance case, currently being developed, appears to give reasonable agreement with a limited set of gas and liquid data. Furthermore agreement with the labyrinth seal analysis of Komotori and Mori for the limiting case of a perfect gas indicates that axisymmetric results can be applied to axisymmetric annular passage flows of labyrinth seals. Implications drawn from the model appear to apply to the 0.66-diameter case although flow rate and pressure ratio behavior are essentially similar to that of a single orifice-type inlet. In either case it was found that a flow coefficient plot as a function of reduced temperature could be used for preliminary prediction purposes. However, such practice adds little to the understanding of flow details. The deviations with pressure are not yet explained.

At a separation distance of 32 diameters the pressure profiles within each of the four sequential inlets dropped sharply at the entrance, followed by a recovery—the exception being the last orifice inlet, where the pressure profile at low fluid temperatures and elevated pressures can be flat. Such a flat profile is indicative of fluid jetting.

At a separation distance of 0.66 diameter, and at lower fluid temperatures, fluid jetting through all four sequential orifice inlets was somewhat prevalent, with choking controlled at the entrance of the first orifice inlet. Even for gas flows the pressure dropped very sharply at the entrance of the first orifice and at the exit of the last orifice to the point of being nearly choked at either place. Application of various backpressures, significantly higher than the pressures within the four sequential orifice inlets, did not alter fluid jetting.

These results agree with previously published data for jetting in tubes with sharp-edge orifice or Borda inlets. They are also in qualitative agreement with water table flow visualization studies used to delineate regions of fluid stability and instability, although stability was not covered in this study. In general the calculations and observations of flow and pressure profiles were similar for single or sequential sharp-edge orifice or Borda inlets.

Lewis Research Center
National Aeronautics and Space Administration
Cleveland, Ohio, March 12, 1981

Appendix—Symbols

A area
C_f flow coefficient
D tube diameter
G mass flow rate
G^* flow normalizing parameter, 6010 g/cm^2 sec for nitrogen, $\sqrt{P_c \rho_c / Z_c}$
H enthalpy
L separation distance
l length of orifice
P pressure
S entropy
T temperature
u velocity
V specific volume
X pressure ratio
Z compressibility
ρ density, $1/V$

Subscripts:

c thermodynamic critical
calc calculated
e exit
exp experimental
i i^{th} sequential inlet
m mass flow rate at choking
r reduced by normalizing parameter
T total
0 stagnation, or reference
1 inlet 1
2 inlet 2
3 inlet 3
4 inlet 4

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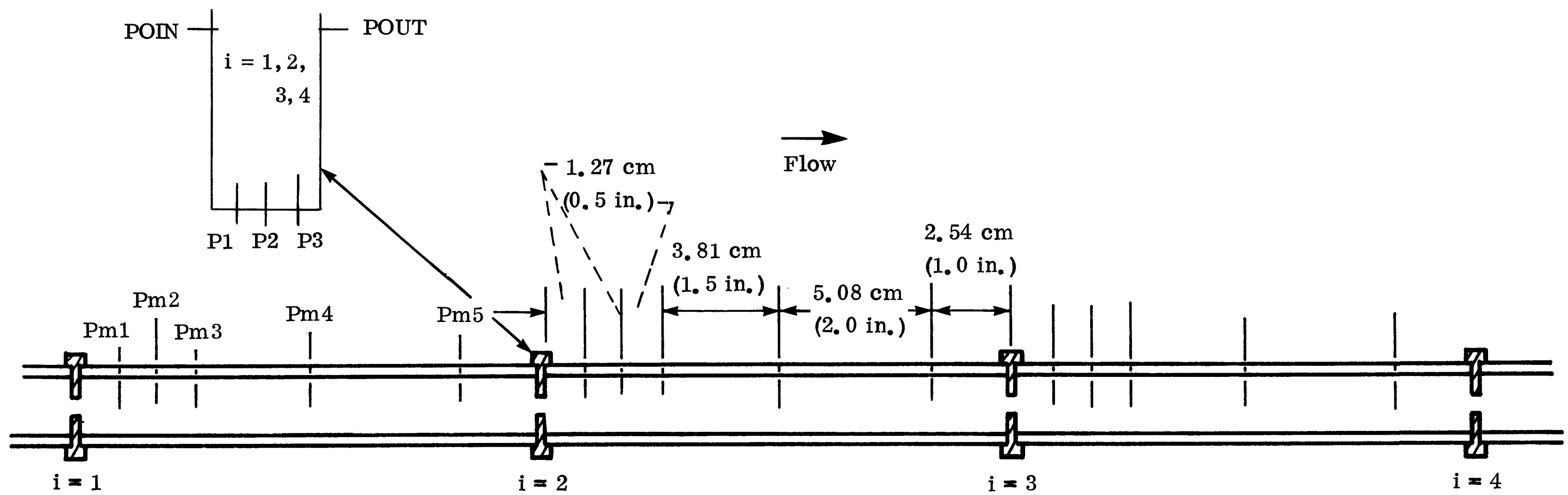
TABLE I. - CALCULATED AND EXPERIMENTAL VALUES FOR FOUR SEQUENTIAL ORIFICE INLETS SPACED AT 32 DIAMETERS

Run	Reduced inlet stagnation pressure, $P_{r,0}$	Reduced inlet stagnation tempera- ture, $T_{r,0}$	Reduced mass flow rate		Pressure ratio							
					For inlet 1		For inlet 2		For inlet 3		For inlet 4	
			Exper- imental, $G_{r,exp}$	Calcu- lated, $G_{r,calc}$	Exper- imental, $X_{1,exp}$	Calcu- lated, $X_{1,calc}$	Exper- imental, $X_{2,exp}$	Calcu- lated, $X_{2,calc}$	Exper- imental, $X_{3,exp}$	Calcu- lated, $X_{3,calc}$	Exper- imental, $X_{4,exp}$	Calcu- lated, $X_{4,calc}$
3077	1.453	2.146	0.101	0.093	0.88	0.89	0.84	0.86	0.76	0.79	----	0.52
3086	1.145	2.225	.078	.072	.87	↓	.83	↓	.76	↓	----	.53
3076	.897	2.138	.062	.057	.87	↓	.84	↓	.76	↓	----	.53
3075	.399	2.155	.027	.025	.87	↓	.84	↓	.77	↓	----	.53
3091	.428	.686	.243	.267	.89	.80	.74	.75	.63	.66	----	.49
3089	.876	.684	.370	.399	.77	.78	.73	.71	.60	.59	----	.32
3088	1.176	.687	.437	.458	.79	.77	.72	.71	.58	.58	----	.30
3027	1.249	.672	.455	.467	.79	.77	.71	.70	.58	.57	----	.30

TABLE II. - DATA FOR FOUR SEQUENTIAL, AXIALLY ALIGNED ORIFICE INLETS - 32-DIAMETER SEPARATION DISTANCE



Schematic illustrating table notation and pressure tap location

(a) Normal backpressure and first spacer instrumented

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3074	25.4	273.0	1.200	0.000	0.351	0.024	2.162
3075	29.1	272.0	1.363	0.000	0.399	0.027	2.154
3076	66.6	270.0	3.064	0.000	0.897	0.062	2.138
3077	109.0	271.0	4.964	0.000	1.453	0.101	2.146
3078	129.8	273.0	5.959	0.000	1.744	0.121	2.162
3079	113.8	270.0	5.185	0.000	1.517	0.106	2.138
3080	87.7	268.0	3.988	0.000	1.167	0.082	2.122
3081	61.6	267.0	2.822	0.000	0.826	0.057	2.114
3082	43.1	266.0	1.989	0.000	0.582	0.040	2.106
3083	24.3	266.0	1.127	0.000	0.330	0.023	2.106

RUN	ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
3074	1	1.20		0.98		0.98		1.00		1.04
			1.05		1.04		1.05		1.05	
	2	1.05		0.82		0.80		0.82		0.89
	3	0.89		0.60		0.58		0.64		0.69
	4	0.71		0.13		0.21		0.29		0.12
3075	1	1.36		1.12		1.11		1.13		1.18
			1.20		1.18		1.20		1.20	
	2	1.20		0.93		0.91		0.94		1.01
	3	1.01		0.68		0.66		0.73		0.78
	4	0.81		0.15		0.23		0.33		0.11
3076	1	3.09		2.52		2.53		2.61		2.70
			2.71		2.71		2.73		2.73	
	2	2.73		2.12		2.09		2.17		2.29
	3	2.31		1.53		1.51		1.66		1.77
	4	1.82		0.36		0.49		0.74		0.13
3077	1	5.02		4.08		4.13		4.28		4.42
			4.42		4.43		4.44		4.48	
	2	4.46		3.44		3.40		3.56		3.73
	3	3.78		2.50		2.46		2.73		2.89
	4	2.95		0.58		0.68		1.21		0.18
3078	1	6.03		4.91		4.95		5.09		5.29
			5.29		5.31		5.33		5.36	
	2	5.34		4.11		4.06		4.24		4.45
	3	4.52		2.98		2.94		3.25		3.45
	4	3.53		0.69		0.97		1.44		0.21
3079	1	5.24		4.27		4.30		4.45		4.60
			4.60		4.62		4.63		4.66	
	2	4.65		3.58		3.54		3.70		3.89
	3	3.93		2.60		2.56		2.83		3.01
	4	3.08		0.61		0.71		1.26		0.19
3080	1	4.02		3.28		3.30		3.43		3.54
			3.55		3.55		3.57		3.59	
	2	3.58		2.76		2.73		2.84		2.99
	3	3.03		2.01		1.98		2.18		2.32
	4	2.38		0.47		0.71		0.97		0.15
3081	1	2.83		2.33		2.33		2.39		2.48
			2.49		2.49		2.50		2.51	
	2	2.51		1.94		1.91		1.99		2.10
	3	2.13		1.41		1.39		1.53		1.63
	4	1.68		0.33		0.40		0.68		0.12
3082	1	1.99		1.64		1.63		1.66		1.73
			1.74		1.73		1.75		1.75	
	2	1.75		1.36		1.33		1.39		1.47
	3	1.49		0.98		0.97		1.07		1.14
	4	1.18		0.23		0.29		0.48		0.11
3083	1	1.12		0.92		0.91		0.93		0.97
			0.98		0.97		0.98		0.98	
	2	0.98		0.77		0.74		0.77		0.82
	3	0.83		0.55		0.54		0.60		0.64
	4	0.67		0.12		0.18		0.27		0.11

TABLE II. - Continued.

(a) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3084	28.4	283.0	1.356	0.000	0.397	0.026	2.241
3085	55.8	280.0	2.619	0.000	0.766	0.052	2.217
3086	83.6	281.0	3.913	0.000	1.145	0.078	2.225
3087	538.4	86.6	5.175	0.000	1.514	0.500	0.686
3088	469.8	86.8	4.018	0.000	1.176	0.437	0.687
3089	397.6	86.4	2.992	0.000	0.876	0.370	0.684
3090	316.6	86.4	2.063	0.000	0.604	0.294	0.684
3091	261.6	86.6	1.461	0.000	0.428	0.243	0.686
3092	224.0	87.0	1.152	0.000	0.337	0.208	0.689
3093	529.7	92.2	5.368	0.000	1.571	0.492	0.730

RUN	ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
3084	1	1.35	1.18	1.11	1.17	1.10	1.18	1.12	1.19	1.17
	2	1.18		0.91		0.91		0.93		1.00
	3	1.00		0.66		0.66		0.72		0.77
	4	0.80		0.15		0.18		0.33		0.11
3085	1	2.62	2.33	2.15	2.30	2.15	2.31	2.20	2.33	2.29
	2	2.32		1.78		1.78		1.84		1.95
	3	1.96		1.30		1.28		1.42		1.51
	4	1.55		0.31		0.35		0.64		0.12
3086	1	3.95	3.45	3.22	3.46	3.23	3.47	3.32	3.50	3.45
	2	3.49		2.68		2.66		2.76		2.91
	3	2.95		1.93		1.92		2.13		2.25
	4	2.31		0.46		0.52		0.95		0.15
3087	1	5.20	4.04	3.33	4.06	3.46	4.10	3.82	4.14	4.04
	2	4.13		2.38		2.33		2.53		2.95
	3	3.04		1.32		1.31		1.46		1.78
	4	1.89		0.23		0.24		0.22		0.25
3088	1	4.02	3.16	2.65	3.18	2.68	3.21	2.93	3.24	3.17
	2	3.24		1.91		1.86		2.01		2.33
	3	2.40		1.09		1.09		1.15		1.38
	4	1.47		0.20		0.32		0.18		0.20
3089	1	2.98	2.28	2.04	2.29	2.02	2.32	2.09	2.33	2.28
	2	2.33		1.37		1.33		1.43		1.69
	3	1.73		0.80		0.78		0.84		1.04
	4	1.11		0.19		0.21		0.18		0.19
3090	1	2.04	1.60	1.44	1.60	1.42	1.62	1.47	1.63	1.60
	2	1.63		1.02		1.00		1.04		1.18
	3	1.21		0.62		0.61		0.63		0.73
	4	0.79		0.19		0.23		0.18		0.20
3091	1	1.44	1.15	0.99	1.15	1.00	1.17	1.10	1.18	1.15
	2	1.17		0.74		0.72		0.76		0.87
	3	0.89		0.47		0.46		0.49		0.56
	4	0.61		0.20		0.20		0.19		0.20
3092	1	1.13	0.92	0.80	0.91	0.80	0.93	0.87	0.93	0.92
	2	0.93		0.62		0.60		0.63		0.71
	3	0.72		0.42		0.41		0.42		0.47
	4	0.51		0.20		0.20		0.19		0.20
3093	1	5.39	4.22	3.55	4.25	3.66	4.29	4.05	4.32	4.23
	2	4.32		2.60		2.55		2.73		3.09
	3	3.19		1.49		1.46		1.59		1.91
	4	2.02		0.36		0.35		0.34		0.39

TABLE II. - Continued.

(a) Continued.

RUN	MASS FLOW G/S	TIN K	ORIFICE INLET	POIN MPA	PIN MPA / Pm1	P1 MPA	PBACK MPA / Pm2	P2 MPA	PR / Pm3	P3 MPA	GR / Pm4	POUT MPA	TR
3094	463.4	92.6			4.194		0.000		1.227		0.431		0.733
			1	4.20		2.79		2.92		3.21		3.35	
					3.35		3.35		3.38		3.40		
			2	3.41		2.08		2.04		2.15		2.44	
			3	2.51		1.22		1.17		1.24		1.48	
			4	1.56		0.28		0.28		0.27		0.28	
3095	406.3	92.9			3.258		0.000		0.953		0.378		0.736
			1	3.25		2.18		2.20		2.35		2.51	
					2.57		2.58		2.61		2.62		
			2	2.63		1.59		1.55		1.67		1.92	
			3	1.97		0.95		0.93		0.99		1.18	
			4	1.26		0.26		0.26		0.25		0.26	
3096	352.6	92.5			2.508		0.000		0.734		0.328		0.732
			1	2.49		1.69		1.71		1.82		2.00	
					2.01		2.02		2.04		2.04		
			2	2.04		1.27		1.24		1.30		1.50	
			3	1.54		0.78		0.76		0.80		0.93	
			4	1.00		0.25		0.25		0.24		0.25	
3097	282.6	93.0			1.768		0.000		0.517		0.263		0.736
			1	1.74		1.25		1.24		1.27		1.35	
					1.36		1.36		1.38		1.39		
			2	1.39		0.89		0.86		0.90		1.03	
			3	1.05		0.57		0.55		0.58		0.67	
			4	0.72		0.24		0.24		0.22		0.24	
3098	228.0	93.4			1.276		0.000		0.373		0.212		0.740
			1	1.25		0.90		0.90		0.95		1.01	
					1.02		1.01		1.02		1.02		
			2	1.03		0.70		0.67		0.70		0.79	
			3	0.80		0.48		0.47		0.48		0.51	
			4	0.55		0.22		0.22		0.21		0.22	

RUN	MASS FLOW G/S	TIN K	ORIFICE INLET	POIN MPA	PIN MPA / Pm1	P1 MPA	PBACK MPA / Pm2	P2 MPA	PR / Pm3	P3 MPA	GR / Pm4	POUT MPA	TR
3099	519.1	104.0			5.519		0.000		1.615		0.482		0.823
			1	5.53		3.63		3.76		4.00		4.36	
					4.35		4.39		4.42		4.46		
			2	4.46		2.61		2.61		2.87		3.25	
			3	3.35		1.52		1.54		1.77		2.04	
			4	2.15		0.40		0.40		0.38		0.40	
3100	452.6	104.0			4.334		0.000		1.268		0.421		0.823
			1	4.33		2.89		2.94		3.13		3.45	
					3.45		3.47		3.50		3.53		
			2	3.53		2.15		2.11		2.29		2.59	
			3	2.66		1.29		1.28		1.40		1.61	
			4	1.71		0.37		0.37		0.35		0.37	
3101	368.2	103.9			3.126		0.000		0.915		0.342		0.823
			1	3.11		2.13		2.20		2.42		2.50	
					2.51		2.52		2.54		2.55		
			2	2.55		1.64		1.61		1.67		1.88	
			3	1.92		1.03		1.01		1.04		1.15	
			4	1.22		0.33		0.32		0.32		0.34	
3102	308.9	103.3			2.342		0.000		0.685		0.287		0.818
			1	2.32		1.64		1.66		1.78		1.91	
					1.91		1.92		1.93		1.94		
			2	1.94		1.29		1.27		1.31		1.46	
			3	1.49		0.87		0.86		0.86		0.91	
			4	0.97		0.30		0.28		0.30		0.30	
3103	223.3	103.2			1.677		0.000		0.491		0.208		0.817
			1	1.65		1.32		1.31		1.33		1.40	
					1.41		1.41		1.42		1.43		
			2	1.43		1.09		1.07		1.09		1.18	
			3	1.19		0.86		0.85		0.86		0.88	
			4	0.92		0.49		0.47		0.52		0.24	

TABLE II. - Continued.

(a) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	P1 MPA	P2 MPA	P3 MPA	POUT MPA
				Pm1	Pm2	Pm3	Pm4
3126	564.8	84.7	5.611	0.000	1.642	0.525	0.671
		1	5.63	3.62	3.70	4.07	4.37
				4.36	4.39	4.43	4.47
		2	4.46	2.55	2.51	2.72	3.19
		3	3.29	1.42	1.39	1.55	1.91
		4	2.02	0.22	0.23	0.22	0.26
3127	489.9	84.9	4.269	0.000	1.249	0.455	0.672
		1	4.26	2.74	2.86	3.13	3.37
				3.37	3.38	3.41	3.44
		2	3.44	2.01	1.96	2.09	2.45
		3	2.53	1.13	1.11	1.19	1.45
		4	1.55	0.18	0.19	0.17	0.18
3128	370.5	85.0	2.566	0.000	0.751	0.344	0.673
		1	2.55	1.71	1.71	1.85	2.04
				2.05	2.06	2.08	2.09
		2	2.09	1.29	1.26	1.31	1.49
		3	1.53	0.82	0.73	0.76	0.89
		4	0.95	0.16	0.17	0.16	0.16
3129	360.0	84.7	2.457	0.000	0.719	0.335	0.671
		1	2.43	1.66	1.64	1.72	1.89
				1.89	1.90	1.92	1.93
		2	1.93	1.15	1.11	1.20	1.42
		3	1.46	0.70	0.68	0.72	0.86
		4	0.93	0.18	0.19	0.17	0.18
3130	299.4	85.0	1.806	0.000	0.529	0.278	0.673
		1	1.78	1.22	1.21	1.31	1.39
				1.40	1.40	1.42	1.42
		2	1.42	0.88	0.86	0.90	1.03
		3	1.06	0.53	0.52	0.55	0.65
		4	0.71	0.18	0.20	0.17	0.18

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	P1 MPA	P2 MPA	P3 MPA	POUT MPA
				Pm1	Pm2	Pm3	Pm4
3131	246.6	85.1	1.308	0.000	0.383	0.229	0.674
		1	1.28	0.89	0.89	0.98	1.03
				1.04	1.04	1.05	1.05
		2	1.06	0.68	0.66	0.69	0.78
		3	0.80	0.44	0.43	0.45	0.51
		4	0.55	0.18	0.19	0.18	0.19
3132	458.4	114.1	5.222	0.000	1.528	0.426	0.903
		1	5.25	3.65	3.71	3.83	4.19
				4.18	4.22	4.25	4.29
		2	4.28	2.74	2.71	2.84	3.13
		3	3.22	1.71	1.70	1.73	1.89
		4	1.99	0.46	0.45	0.44	0.46
3133	403.2	113.8	4.239	0.000	1.241	0.375	0.901
		1	4.24	2.97	3.04	3.16	3.42
				3.42	3.44	3.46	3.49
		2	3.49	2.24	2.24	2.37	2.62
		3	2.69	1.51	1.50	1.51	1.62
		4	1.71	0.48	0.49	0.49	0.41
3134	310.3	113.7	3.223	0.000	0.943	0.288	0.900
		1	3.22	2.49	2.49	2.55	2.69
				2.69	2.70	2.71	2.73
		2	2.74	2.00	1.98	2.05	2.22
		3	2.26	1.55	1.55	1.56	1.62
		4	1.68	0.86	0.86	0.90	0.32
3135	207.8	115.9	2.457	0.000	0.719	0.193	0.918
		1	2.44	2.09	2.09	2.13	2.18
				2.18	2.19	2.20	2.21
		2	2.21	1.85	1.84	1.85	1.90
		3	1.92	1.55	1.55	1.57	1.60
		4	1.64	1.01	1.01	1.00	0.22

TABLE II. - Continued.

(a) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR	ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
3136	180.5	113.8	2.017	0.000	0.590	0.168	0.901										
								1	2.00	1.78	1.75	1.78	1.75	1.80	1.75	1.80	1.78
								2	1.80		1.55		1.54		1.55		1.58
								3	1.60		1.28		1.27		1.30		1.32
								4	1.36		0.85		0.84		0.83		0.20
3137	156.0	114.4	1.850	0.000	0.541	0.145	0.906										
								1	1.84	1.66	1.65	1.66	1.64	1.67	1.65	1.68	1.66
								2	1.69		1.44		1.43		1.45		1.48
								3	1.49		1.18		1.18		1.20		1.22
								4	1.25		0.77		0.77		0.73		0.18
3138	378.0	126.8	5.826	0.000	1.705	0.351	1.004										
								1	5.86	4.93	4.60	4.98	4.66	5.00	4.79	5.04	4.94
								2	5.02		3.75		3.78		3.95		4.16
								3	4.24		2.93		2.94		3.09		3.29
								4	3.36		1.82		2.00		1.93		0.37
3139	285.6	127.1	4.541	0.000	1.329	0.265	1.006										
								1	4.56	4.01	3.75	4.03	3.79	4.04	3.90	4.07	4.01
								2	4.06		3.25		3.24		3.33		3.49
								3	3.53		2.75		2.73		2.75		2.83
								4	2.89		1.42		1.46		1.49		0.28
3140	212.4	126.7	3.638	0.000	1.065	0.197	1.003										
								1	3.64	3.26	3.16	3.28	3.18	3.29	3.20	3.31	3.26
								2	3.31		2.78		2.76		2.79		2.86
								3	2.89		2.22		2.20		2.23		2.28
								4	2.33		1.15		1.18		1.15		0.22
3141	141.0	127.0	3.427	0.000	1.003	0.131	1.006										
								1	3.44	3.04	3.00	3.05	3.00	3.06	3.02	3.08	3.04
								2	3.08		2.55		2.53		2.56		2.61
								3	2.64		1.98		1.96		1.99		2.02
								4	2.08		0.90		0.93		0.95		0.17
3142	129.4	126.8	3.213	0.000	0.940	0.120	1.004										
								1	3.22	2.83	2.76	2.84	2.75	2.85	2.78	2.87	2.83
								2	2.86		2.31		2.29		2.34		2.45
								3	2.49		1.82		1.80		1.84		1.90
								4	1.96		0.74		0.77		0.89		0.15
3143	68.5	126.4	1.916	0.000	0.561	0.064	1.001										
								1	1.90	1.67	1.58	1.67	1.57	1.69	1.62	1.69	1.67
								2	1.70		1.31		1.29		1.34		1.42
								3	1.44		0.95		0.94		1.04		1.10
								4	1.14		0.25		0.29		0.48		0.12
3144	445.5	120.6	5.890	0.000	1.724	0.414	0.955										
								1	5.91	4.86	4.26	4.90	4.34	4.93	4.50	4.97	4.87
								2	4.95		3.31		3.31		3.55		3.87
								3	3.96		2.38		2.36		2.44		2.68
								4	2.78		1.15		1.15		1.18		0.52
3145	372.3	120.2	4.656	0.000	1.363	0.346	0.952										
								1	4.66	3.92	3.53	3.94	3.55	3.96	3.64	3.99	3.92
								2	3.98		2.84		2.82		2.95		3.22
								3	3.29		2.18		2.17		2.19		2.31
								4	2.38		1.24		1.24		1.26		0.43

TABLE II. - Continued.

(a) Concluded.

ORIFICE INLET

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3146	289.6	119.4	3.592	0.000	1.051	0.269	0.945
3147	194.9	120.4	2.696	0.000	0.789	0.181	0.953
3148	187.3	120.2	2.589	0.000	0.758	0.174	0.952
3149	240.0	141.6	5.589	0.000	1.636	0.223	1.121
3150	168.4	141.8	4.377	0.000	1.281	0.157	1.123
3151	88.3	142.0	2.641	0.000	0.773	0.082	1.124
3152	38.7	142.0	1.240	0.000	0.363	0.036	1.124

RUN		POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
3146	1	3.59	3.13	2.87	3.14	2.90	3.15	2.99	3.17	3.13
	2	3.17		2.46		2.45		2.52		2.67
	3	2.71		2.04		2.02		2.04		2.09
	4	2.15		1.29		1.30		1.35		0.30
3147	1	2.69	2.40	2.37	2.40	2.37	2.40	2.38	2.42	2.40
	2	2.42		2.07		2.06		2.08		2.13
	3	2.15		1.69		1.67		1.71		1.74
	4	1.09		1.02		1.04		0.98		0.41
3148	1	2.60	2.33	2.31	2.33	2.30	2.34	2.31	2.35	2.33
	2	2.35		2.00		2.00		2.02		2.06
	3	2.09		1.64		1.62		1.66		1.69
	4	1.73		1.00		1.00		0.95		0.20
3149	1	5.62	4.91	4.63	4.94	4.64	4.95	4.74	5.00	4.92
	2	4.98		3.90		3.86		4.04		4.26
	3	4.33		3.08		3.06		3.22		3.41
	4	3.49		1.20		1.31		1.77		0.24
3150	1	4.39	3.86	3.61	3.87	3.61	3.88	3.73	3.91	3.86
	2	3.91		3.01		3.00		3.11		3.28
	3	3.33		2.24		2.22		2.43		2.59
	4	2.65		0.82		0.91		1.34		0.18
3151	1	2.65	2.33	2.19	2.33	2.18	2.35	2.26	2.36	2.33
	2	2.36		1.82		1.80		1.87		1.98
	3	2.00		1.32		1.29		1.44		1.52
	4	1.57		0.33		0.38		0.67		0.13
3152	1	1.21	1.07	1.01	1.06	1.00	1.08	1.04	1.08	1.06
	2	1.08		0.83		0.82		0.85		0.90
	3	0.91		0.61		0.59		0.66		0.70
	4	0.77		0.15		0.23		0.30		0.12

TABLE II. - Continued.

(b) Applied backpressure and first spacer instrumented

RUN	MASS FLOW G/S	TIN K	ORIFICE INLET	PIN MPA / POIN MPA	Pm1	PBACK MPA / P1 MPA	Pm2	PR / P2 MPA	Pm3	GR / P3 MPA	Pm4	TR / POUT MPA
3159	567.5	86.0		5.606		0.196		1.641		0.527		0.681
			1	5.65	4.37	3.67	4.41	3.72	4.43	4.06	4.47	4.38
			2	4.46		2.55		2.52		2.73		3.17
			3	3.26		1.40		1.37		1.51		1.89
			4	2.00		0.20		0.29		0.19		0.20
3160	550.9	86.4		5.630		0.493		1.648		0.512		0.684
			1	5.69	4.49	3.75	4.52	3.85	4.55	4.26	4.59	4.50
			2	4.57		2.76		2.72		2.93		3.35
			3	3.44		1.67		1.64		1.82		2.15
			4	2.26		0.50		0.53		0.66		0.90
3161	544.4	86.7		5.640		0.610		1.651		0.506		0.686
			1	5.69	4.52	3.80	4.55	3.91	4.58	4.27	4.62	4.53
			2	4.61		2.84		2.80		3.01		3.41
			3	3.51		1.77		1.74		1.91		2.25
			4	2.34		0.60		0.64		0.84		1.13
3162	533.5	87.2		5.654		0.789		1.655		0.496		0.690
			1	5.71	4.58	3.90	4.62	3.98	4.64	4.29	4.68	4.59
			2	4.66		2.95		2.93		3.13		3.51
			3	3.60		1.91		1.91		2.09		2.41
			4	2.49		0.80		0.92		1.02		1.33
3163	515.4	87.6		5.686		1.113		1.664		0.479		0.694
			1	5.74	4.69	4.06	4.71	4.13	4.74	4.40	4.78	4.69
			2	4.76		3.18		3.15		3.35		3.65
			3	3.74		2.13		2.12		2.33		2.63
			4	2.71		1.10		1.15		1.34		1.65
3164	497.8	88.1		5.719		1.465		1.674		0.463		0.698
			1	5.78	4.78	4.22	4.82	4.28	4.83	4.51	4.87	4.80
			2	4.86		3.35		3.35		3.53		3.82
			3	3.91		2.40		2.39		2.59		2.89
			4	2.97		1.46		1.50		1.70		2.01
3165	483.1	88.6		5.743		1.775		1.681		0.449		0.702
			1	5.80	4.88	4.33	4.91	4.41	4.93	4.59	4.96	4.89
			2	4.95		3.54		3.52		3.70		3.99
			3	4.06		2.64		2.64		2.82		3.11
			4	3.18		1.78		1.93		1.98		2.28
3166	407.3	89.4		4.500		2.092		1.317		0.379		0.708
			1	5.84	4.96	4.50	5.00	4.56	5.01	4.69	5.04	4.97
			2	5.02		3.73		3.71		3.86		4.15
			3	4.22		2.92		2.26		2.40		2.61
			4	2.65		1.64		1.77		1.81		2.02
3167	396.0	122.8		5.378		1.513		1.574		0.368		0.972
			1	5.43	4.58	4.08	4.60	4.14	4.62	4.30	4.64	4.58
			2	4.63		3.31		3.32		3.50		3.77
			3	3.84		2.56		2.54		2.60		2.78
			4	2.86		1.51		1.52		1.55		0.41
3168	386.8	123.2		5.393		1.810		1.578		0.359		0.975
			1	5.44	4.63	4.16	4.66	4.22	4.68	4.37	4.71	4.64
			2	4.69		3.44		3.44		3.64		3.87
			3	3.94		2.72		2.70		2.77		2.95
			4	3.02		1.80		1.83		1.80		1.89

TABLE II. - Continued.

(b) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3169	381.6	123.5	5.400	1.899	1.580	0.355	0.978
3170	375.8	123.8	5.411	2.037	1.584	0.349	0.980
3171	367.2	124.1	5.422	2.210	1.587	0.341	0.983
3172	354.0	124.4	5.446	2.451	1.594	0.329	0.985
3173	343.5	124.8	5.461	2.623	1.598	0.319	0.988
3174	309.0	125.2	5.516	3.099	1.614	0.287	0.991
3175	499.1	115.4	5.858	0.505	1.714	0.464	0.914
3176	473.8	116.9	5.895	1.079	1.725	0.440	0.926
3177	465.8	117.5	5.905	1.230	1.728	0.433	0.930
3178	461.8	117.9	5.910	1.299	1.730	0.429	0.933

RUN	ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
3169	1	5.45	4.66	4.19	4.68	4.26	4.69	4.40	4.72	4.66
	2	4.71		3.46		3.47		3.67		3.91
	3	3.97		2.77		2.76		2.83		3.03
	4	3.09		1.90		1.93		1.90		1.99
3170	1	5.46	4.68	4.24	4.71	4.30	4.72	4.43	4.75	4.69
	2	4.73		3.54		3.55		3.73		3.97
	3	4.02		2.84		2.84		2.93		3.13
	4	3.20		2.04		2.06		2.04		2.15
3171	1	5.49	4.73	4.31	4.76	4.36	4.77	4.48	4.80	4.74
	2	4.78		3.63		3.65		3.82		4.04
	3	4.10		3.35		2.97		3.06		3.26
	4	3.32		2.20		2.24		2.22		2.35
3172	1	5.51	4.80	4.42	4.83	4.46	4.84	4.58	4.87	4.82
	2	4.85		3.78		3.79		3.95		4.16
	3	4.22		3.15		3.15		3.25		3.44
	4	3.49		2.45		2.49		2.49		2.63
3173	1	5.52	4.85	4.49	4.87	4.55	4.89	4.65	4.91	4.86
	2	4.90		3.89		3.90		4.06		4.24
	3	4.30		3.30		3.30		3.39		3.57
	4	3.62		2.62		2.67		2.69		2.85
3174	1	5.59	5.02	4.74	5.05	4.79	5.05	4.90	5.07	5.02
	2	5.05		4.25		4.24		4.33		4.47
	3	4.52		3.71		3.69		3.76		3.91
	4	3.95		3.11		3.22		3.23		3.39
3175	1	5.91	4.73	4.04	4.76	4.08	4.79	4.25	4.83	4.73
	2	4.81		2.98		2.95		3.20		3.62
	3	3.71		1.92		1.89		1.96		2.18
	4	2.31		0.51		0.50		0.49		0.51
3176	1	5.95	4.84	4.24	4.88	4.27	4.90	4.42	4.94	4.85
	2	4.92		3.22		3.22		3.45		3.82
	3	3.91		2.23		2.22		2.35		2.63
	4	2.73		1.09		1.20		1.06		1.12
3177	1	5.95	4.87	4.29	4.91	4.33	4.94	4.47	4.98	4.89
	2	4.95		3.31		3.31		3.53		3.88
	3	3.96		2.32		2.32		2.46		2.73
	4	2.83		1.23		1.24		1.21		1.28
3178	1	5.96	4.89	4.31	4.92	4.38	4.95	4.50	4.98	4.89
	2	4.96		3.33		3.34		3.55		3.91
	3	3.99		2.36		2.36		2.51		2.78
	4	2.87		1.29		1.31		1.27		1.35

TABLE II. - Continued.

(b) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3179	454.9	118.4	5.918	1.437	1.732	0.423	0.937
3180	440.5	119.4	5.944	1.706	1.740	0.409	0.945
3181	556.7	99.4	5.924	0.369	1.734	0.517	0.787
3182	542.7	100.2	5.946	0.619	1.740	0.504	0.793
3183	539.5	100.6	5.945	0.657	1.740	0.501	0.797
3184	532.7	101.2	5.955	0.761	1.743	0.495	0.801
3185	508.7	102.4	5.995	1.148	1.754	0.473	0.811
3186	507.4	103.1	6.002	1.161	1.757	0.472	0.816
3187	488.8	103.9	6.030	1.520	1.765	0.454	0.823
3188	284.6	141.3	6.178	1.472	1.808	0.264	1.119

ORIFICE INLET

RUN	ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
3179	1	5.98		4.38		4.42		4.57		4.93
	Pm		4.92		4.95		4.98		5.02	
	2	5.00		3.42		3.42		3.62		3.97
	3	4.04		2.45		2.46		2.61		2.89
	4	2.98		1.43		1.44		1.42		1.53
3180	1	6.01		4.49		4.54		4.69		5.01
	Pm		5.00		5.03		5.05		5.09	
	2	5.07		3.59		3.58		3.80		4.09
	3	4.17		2.66		2.66		2.83		3.11
	4	3.17		1.71		1.73		1.72		1.86
3181	1	5.97		3.89		4.02		4.22		4.71
	Pm		4.70		4.73		4.76		4.81	
	2	4.80		2.81		2.80		3.05		3.51
	3	3.60		1.67		1.65		1.79		2.13
	4	2.26		0.37		0.37		0.35		0.37
3182	1	6.00		4.01		4.11		4.31		4.81
	Pm		4.80		4.83		4.86		4.90	
	2	4.89		2.98		2.97		3.20		3.64
	3	3.73		1.89		1.85		1.98		2.31
	4	2.42		0.62		0.62		0.59		0.66
3183	1	6.00		4.03		4.13		4.33		4.80
	Pm		4.80		4.83		4.86		4.91	
	2	4.89		3.00		3.00		3.24		3.64
	3	3.74		1.90		1.89		2.02		2.34
	4	2.45		0.66		0.66		0.63		0.71
3184	1	6.00		4.04		4.17		4.38		4.83
	Pm		4.82		4.86		4.88		4.93	
	2	4.91		3.06		3.05		3.29		3.70
	3	3.80		1.99		1.95		2.09		2.41
	4	2.52		0.75		0.75		0.73		0.84
3185	1	6.05		4.34		4.40		4.51		4.84
	Pm		4.83		4.88		4.90		4.94	
	2	4.92		3.24		3.22		3.41		3.77
	3	3.86		2.11		2.10		2.40		2.76
	4	2.85		1.15		1.25		1.40		1.66
3186	1	6.05		4.34		4.40		4.53		4.82
	Pm		4.81		4.85		4.87		4.91	
	2	4.90		3.21		3.19		3.40		3.78
	3	3.86		2.11		2.11		2.39		2.75
	4	2.84		1.15		1.26		1.37		1.62
3187	1	6.09		4.49		4.49		4.64		4.93
	Pm		4.92		4.97		5.00		5.03	
	2	5.01		3.38		3.42		3.68		4.00
	3	4.07		2.51		2.51		2.67		2.98
	4	3.06		1.51		1.53		1.69		1.96
3188	1	6.26		5.09		5.11		5.23		5.44
	Pm		5.42		5.45		5.46		5.51	
	2	5.49		4.25		4.24		4.39		4.66
	3	4.73		3.35		3.31		3.52		3.80
	4	3.86		1.42		1.52		2.00		0.29

TABLE II. - Continued.

(b) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3189	277.6	142.8	6.180	1.651	1.809	0.258	1.131
3190	267.9	143.3	6.200	2.272	1.814	0.249	1.135
3191	255.2	144.0	6.220	2.837	1.820	0.237	1.140
3192	10.0	200.0	6.402	6.435	1.874	0.009	1.584
3193	575.6	86.9	5.791	0.203	1.695	0.535	0.688
3194	571.4	87.1	5.788	0.283	1.694	0.531	0.690
3195	565.9	87.6	5.798	0.356	1.697	0.526	0.694
3196	560.8	88.4	5.808	0.440	1.700	0.521	0.700
3197	532.7	89.6	5.860	0.888	1.715	0.495	0.709
3198	544.0	102.0	5.844	0.398	1.710	0.506	0.808

RUN	ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
3189	1	6.26	5.46	5.10	5.49	5.13	5.50	5.28	5.54	5.47
	2	5.51		4.29		4.29		4.45		4.71
	3	4.78		3.41		3.33		3.57		3.82
	4	3.89		1.64		1.72		2.26		2.53
3190	1	6.27	5.51	5.18	5.55	5.20	5.55	5.33	5.60	5.53
	2	5.57		4.42		4.40		4.54		4.78
	3	4.84		3.57		3.53		3.71		3.96
	4	4.02		2.29		2.36		2.53		2.75
3191	1	6.30	5.50	5.29	5.53	5.32	5.55	5.38	5.58	5.52
	2	5.56		4.49		4.47		4.62		4.85
	3	4.91		3.73		3.70		3.94		4.15
	4	4.20		2.84		2.91		2.95		3.12
3192	1	6.51	6.49	6.47	6.52	6.51	6.50	6.52	6.52	6.50
	2	6.49		6.49		6.49		6.50		6.48
	3	6.49		6.49		6.47		6.46		6.46
	4	6.44		6.44		6.56		6.45		6.44
3193	1	5.83	4.51	3.78	4.56	3.84	4.59	4.17	4.62	4.53
	2	4.61		2.69		2.64		2.83		3.22
	3	3.33		1.42		1.39		1.57		1.98
	4	2.08		0.21		0.26		0.20		0.21
3194	1	5.82	4.53	3.79	4.58	3.90	4.61	4.39	4.65	4.54
	2	4.64		2.73		2.69		2.89		3.29
	3	3.38		1.51		1.45		1.63		2.00
	4	2.12		0.27		0.28		0.26		0.30
3195	1	5.84	4.58	3.81	4.62	3.95	4.65	4.45	4.69	4.45
	2	4.67		2.79		2.76		2.94		3.34
	3	3.44		1.58		1.53		1.68		2.06
	4	2.18		0.35		0.36		0.34		0.44
3196	1	5.84	4.60	3.86	4.64	3.96	4.67	4.45	4.71	4.61
	2	4.70		2.84		2.81		3.00		3.38
	3	3.48		1.65		1.61		1.78		2.16
	4	2.26		0.44		0.44		0.48		0.70
3197	1	5.91	4.78	4.12	4.81	4.20	4.84	4.60	4.88	4.79
	2	4.86		3.16		3.14		3.31		4.06
	3	3.73		2.02		2.01		2.20		2.51
	4	2.61		0.89		0.93		1.15		1.46
3198	1	5.88	4.63	3.86	4.66	4.00	4.69	4.25	4.74	4.64
	2	4.73		2.80		2.78		3.04		3.46
	3	3.56		1.65		1.64		1.81		2.13
	4	2.24		0.40		0.41		0.39		0.39

TABLE II. - Continued.

(b) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3200	524.2	103.2	5.861	0.745	1.715	0.487	0.817
3202	503.2	104.5	5.890	1.120	1.724	0.468	0.827
3203	486.3	105.4	5.924	1.396	1.734	0.452	0.835
3204	491.0	116.7	5.865	0.536	1.716	0.456	0.924
3205	475.5	118.4	5.880	0.768	1.721	0.442	0.937
3206	470.1	118.7	5.885	0.968	1.722	0.437	0.940
3208	450.8	119.8	5.914	1.389	1.731	0.419	0.949
3209	459.1	120.2	5.897	1.051	1.726	0.427	0.952
3210	431.7	120.7	5.948	1.823	1.741	0.401	0.956
3211	394.0	127.3	6.050	1.823	1.771	0.366	1.008

RUN	ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
3200	1	5.91	4.73	4.00	4.77	4.12	4.80	4.35	4.83	4.75
	2	4.81		2.99		2.98		3.22		3.62
	3	3.71		1.93		1.91		2.06		2.36
	4	2.47		0.74		0.74		0.72		0.79
3202	1	5.93	4.84	4.19	4.88	4.29	4.90	4.50	4.94	4.85
	2	4.93		3.26		3.24		3.44		3.82
	3	3.89		2.22		2.20		2.35		2.67
	4	2.76		1.12		1.13		1.18		1.42
3203	1	5.97	4.84	4.35	4.89	4.44	4.91	4.55	4.95	4.86
	2	4.93		3.37		3.35		3.54		3.86
	3	3.94		2.31		2.29		2.58		2.90
	4	2.98		1.39		1.49		1.65		1.91
3204	1	5.91	4.73	4.07	4.78	4.13	4.81	4.31	4.85	4.75
	2	4.83		3.01		3.02		3.22		3.64
	3	3.73		1.97		1.95		1.99		2.19
	4	2.31		0.52		0.52		0.52		0.50
3205	1	5.92	4.79	4.18	4.83	4.22	4.86	4.40	4.90	4.81
	2	4.88		3.13		3.13		3.33		3.73
	3	3.83		2.14		2.11		2.15		2.38
	4	2.48		0.76		0.76		0.78		0.50
3206	1	5.93	4.82	4.20	4.87	4.26	4.89	4.44	4.93	4.84
	2	4.91		3.20		3.20		3.42		3.80
	3	3.89		2.21		2.18		2.26		2.53
	4	2.64		0.97		0.97		0.95		1.00
3208	1	5.96	4.93	4.35	4.97	4.40	4.99	4.57	5.03	4.94
	2	5.01		3.42		3.42		3.64		3.98
	3	4.06		2.47		2.46		2.58		2.84
	4	2.93		1.39		1.44		1.38		1.44
3209	1	5.94	4.86	4.24	4.90	4.31	4.93	4.58	4.97	4.88
	2	4.94		3.27		3.29		3.50		3.84
	3	3.93		2.31		2.29		2.36		2.60
	4	2.70		1.04		1.05		1.08		0.49
3210	1	6.00	5.03	4.51	5.08	4.57	5.09	4.71	5.13	5.05
	2	5.11		3.65		3.65		3.87		4.15
	3	4.24		2.77		2.76		2.91		3.16
	4	3.25		1.82		1.84		1.82		1.95
3211	1	6.11	5.11	4.76	5.15	4.82	5.17	4.98	5.21	5.13
	2	5.19		3.84		3.88		4.06		4.29
	3	4.37		2.98		2.98		3.13		3.36
	4	3.44		1.82		1.91		1.94		0.42

TABLE II. - Concluded.

(b) Concluded.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3212	386.3	127.8	6.054	2.030	1.772	0.359	1.012

ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
1	6.11	5.14	4.80	5.18	4.86	5.20	5.00	5.24	5.16
2	5.22		3.91		3.95		4.12		4.33
3	4.41		3.05		3.06		3.22		3.44
4	3.52		2.02		2.05		2.11		2.28

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3213	355.0	128.3	6.107	2.830	1.787	0.330	1.016

ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
1	6.17	5.35	5.06	5.39	5.09	5.40	5.24	5.44	5.37
2	5.42		4.31		4.32		4.46		4.66
3	4.72		3.58		3.57		3.73		3.92
4	3.98		2.83		2.89		2.94		3.14

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3214	274.2	142.8	6.119	1.313	1.791	0.255	1.131

ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
1	6.18	5.38	5.03	5.42	5.06	5.43	5.22	5.46	5.40
2	5.44		4.23		4.22		4.36		4.60
3	4.67		3.29		3.24		3.47		3.73
4	3.80		1.32		1.43		1.97		0.28

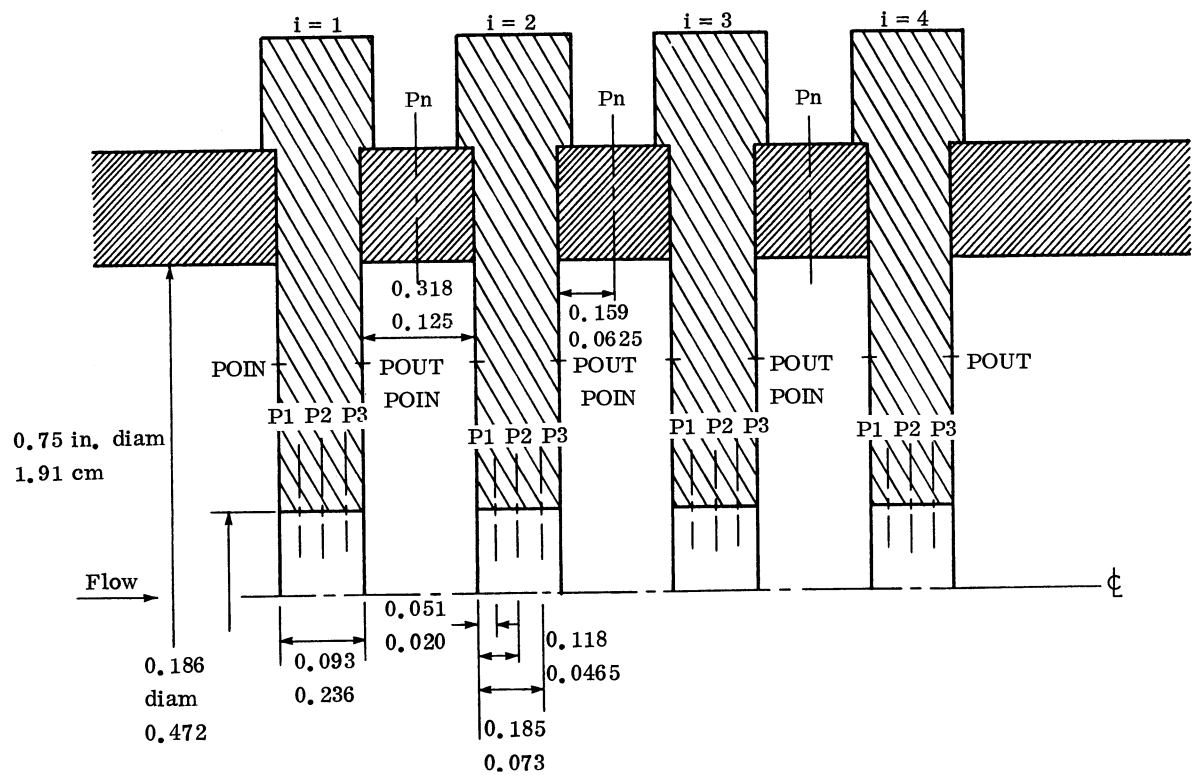
RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3216	247.1	144.1	6.165	3.023	1.804	0.230	1.141

ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
1	6.23	5.53	5.26	5.57	5.31	5.58	5.42	5.61	5.55
2	5.59		4.58		4.55		4.71		4.91
3	4.97		3.86		3.84		4.04		4.24
4	4.29		3.03		3.09		3.18		3.39

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3215	261.0	143.7	6.132	2.272	1.795	0.243	1.138

ORIFICE INLET	POIN MPA	Pm1	P1 MPA	Pm2	P2 MPA	Pm3	P3 MPA	Pm4	POUT MPA
1	6.23	5.43	5.13	5.47	5.15	5.48	5.27	5.52	5.45
2	5.49		4.36		4.35		4.48		4.71
3	4.78		3.52		3.47		3.66		3.91
4	3.97		2.27		2.31		2.50		2.71

TABLE III. - DATA FOR FOUR SEQUENTIAL, AXIALLY ALIGNED ORIFICE INLETS - 0.66-DIAMETER SEPARATION DISTANCE



(a) Normal backpressure and instrumented spacers.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3894	44.3	221.0	1.179	0.000	0.345	0.041	1.750
3895	62.6	230.2	1.677	0.000	0.491	0.058	1.823
3896	93.2	240.6	2.530	0.000	0.740	0.087	1.905
3897	123.2	249.6	3.389	0.000	0.992	0.114	1.976
3898	150.3	258.1	4.199	0.000	1.229	0.140	2.044
3899	190.8	267.8	5.360	0.000	1.569	0.177	2.120
3900	235.5	275.9	6.715	0.000	1.965	0.219	2.184
3901	182.9	280.7	5.273	0.000	1.543	0.170	2.222

RUN	ORIFICE INLET	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3894	1	1.15	0.66	0.51	0.51	0.54	0.64
	2	0.64	0.72	0.69	0.70	0.72	0.74
	3	0.72	0.63	0.62	0.63	0.68	0.63
	4	0.63	0.20	0.46	0.47	0.39	0.11
3895	1	1.65	0.93	0.71	0.72	0.77	0.91
	2	0.91	1.03	1.00	1.01	1.03	1.06
	3	1.04	0.90	0.90	0.91	0.95	0.89
	4	0.89	0.25	0.66	0.68	0.58	0.13
3896	1	2.51	1.39	1.06	1.07	1.16	1.38
	2	1.37	1.58	1.51	1.53	1.54	1.60
	3	1.58	1.37	1.35	1.38	1.42	1.35
	4	1.35	0.34	0.98	1.04	0.92	0.18
3897	1	3.38	1.86	1.42	1.44	1.55	1.84
	2	1.84	2.13	2.04	2.06	2.09	2.15
	3	2.13	1.83	1.78	1.85	1.89	1.82
	4	1.82	0.44	1.31	1.40	1.24	0.24
3898	1	4.20	2.31	1.77	1.80	1.94	2.28
	2	2.28	2.63	2.52	2.55	2.57	2.66
	3	2.64	2.26	2.22	2.29	2.34	2.24
	4	2.24	0.53	1.62	1.75	1.55	0.30
3899	1	5.38	2.91	2.14	2.21	2.43	2.89
	2	2.89	3.35	3.18	3.22	3.24	3.37
	3	3.35	2.89	2.82	2.91	2.96	2.87
	4	2.86	0.67	2.07	2.22	1.98	0.39
3900	1	6.75	3.61	2.59	2.71	3.01	3.58
	2	3.58	4.18	3.97	4.02	4.03	4.22
	3	4.19	3.62	3.53	3.64	3.70	3.60
	4	3.59	0.83	2.58	2.78	2.49	0.50
3901	1	5.29	2.86	2.06	2.14	2.38	2.83
	2	2.83	3.29	3.12	3.16	3.18	3.31
	3	3.29	2.85	2.78	2.86	2.93	2.82
	4	2.81	0.66	2.03	2.18	1.95	0.39

TABLE III. - Continued.

(a) Concluded.

ORIFICE INLET

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3914	62.5	282.5	1.833	0.000	0.536	0.058	2.237

	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
1	1.80	0.99	0.75	0.75	0.82	0.98
2	0.98	1.13	1.08	1.09	1.11	1.14
3	1.13	0.98	0.95	0.98	1.02	0.98
4	0.98	0.26	0.72	0.75	0.64	0.13

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3915	111.3	283.8	3.239	0.000	0.948	0.103	2.247

	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
1	3.22	1.76	1.29	1.32	1.46	1.75
2	1.75	2.01	1.92	1.94	1.96	2.03
3	2.02	1.76	1.71	1.75	1.81	1.73
4	1.73	0.42	1.26	1.35	1.18	0.23

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3916	177.4	285.5	5.143	0.000	1.505	0.165	2.260

	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
1	5.15	2.79	2.01	2.09	2.33	2.77
2	2.77	3.20	3.04	3.09	3.10	3.23
3	3.21	2.78	2.71	2.79	2.85	2.75
4	2.74	0.65	1.98	2.13	1.95	0.38

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3956	65.5	268.1	1.876	0.000	0.549	0.061	2.123

	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
1	1.83	1.01	0.76	0.76	0.84	1.01
2	1.00	1.15	1.10	1.11	1.18	1.16
3	1.15	1.03	0.98	1.00	1.06	1.00
4	1.00	0.27	0.73	0.77	0.66	0.14

ORIFICE INLET

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3957	108.8	273.9	3.121	0.000	0.913	0.101	2.169

	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
1	3.09	1.69	1.24	1.27	1.42	1.69
2	1.69	1.93	1.84	1.87	1.88	1.95
3	1.94	1.69	1.64	1.69	1.74	1.66
4	1.67	0.41	1.21	1.30	1.18	0.23

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3958	182.3	279.6	5.233	0.000	1.531	0.169	2.214

	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
1	5.23	2.83	2.04	2.12	2.38	2.82
2	2.82	3.26	3.10	3.14	3.15	3.28
3	3.26	2.83	2.76	2.84	2.91	2.80
4	2.80	0.66	2.01	2.16	1.94	0.38

TABLE III. - Continued.

(b) Uninstrumented spacers

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE INLET		POIN MPA	P1 MPA	P2 MPA	P3 MPA	POUT MPA	
		Pn1	Pn2	Pn3	Pn4		
3366	37.8	282.5	1.124	0.000	0.329	0.035	2.237
	1	1.09	0.49	0.52	0.57	0.63	
	2	0.63	0.66	0.65	0.67	0.66	
	3	0.65	0.58	0.58	0.60	0.59	
	4	0.59	0.44	0.43	0.37	0.15	
		0.14	0.17	0.16	0.19		
3367	73.5	280.6	2.149	0.000	0.629	0.068	2.222
	1	2.13	0.93	0.99	1.06	1.20	
	2	1.20	1.28	1.27	1.30	1.28	
	3	1.27	1.11	1.15	1.16	1.14	
	4	1.14	0.87	0.84	0.73	0.20	
		0.19	0.22	0.23	0.29		
3368	141.0	281.4	4.111	0.000	1.203	0.131	2.228
	1	4.11	1.77	1.91	2.05	2.32	
	2	2.32	2.46	2.46	2.53	2.47	
	3	2.47	2.15	2.22	2.24	2.20	
	4	2.20	1.66	1.60	1.40	0.34	
		0.32	0.35	0.39	0.52		
3369	211.0	86.5	5.106	0.000	1.494	0.196	0.685
	1	5.05	0.15	0.16	0.15	0.15	
	2	0.15	0.15	0.16	0.16	0.17	
	3	0.16	0.17	0.18	0.18	0.20	
	4	0.20	0.19	0.20	0.18	0.00	
		0.00	0.14	0.13	0.18		
3370	795.0	86.8	3.849	0.000	1.126	0.739	0.687
	1	3.79	0.16	0.16	0.16	0.16	
	2	0.16	0.16	0.16	0.16	0.17	
	3	0.17	0.17	0.18	0.19	0.20	
	4	0.20	0.19	0.20	0.18	0.00	
		0.00	0.15	0.14	0.17		

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE INLET		POIN MPA	P1 MPA	P2 MPA	P3 MPA	POUT MPA	
		Pn1	Pn2	Pn3	Pn4		
3371	664.0	87.0	2.762	0.000	0.808	0.617	0.689
	1	2.71	0.17	0.17	0.17	0.17	
	2	0.17	0.17	0.17	0.17	0.18	
	3	0.18	0.18	0.19	0.20	0.21	
	4	0.21	0.20	0.21	0.19	0.13	
		0.12	0.16	0.13	0.17		
3372	529.0	86.3	1.793	0.000	0.525	0.492	0.683
	1	1.73	0.17	0.17	0.17	0.17	
	2	0.17	0.17	0.17	0.17	0.18	
	3	0.17	0.18	0.19	0.19	0.20	
	4	0.20	0.19	0.20	0.18	0.16	
		0.16	0.19	0.16	0.17		
3373	423.0	86.6	1.265	0.000	0.370	0.393	0.686
	1	1.22	0.18	0.19	0.18	0.18	
	2	0.18	0.18	0.18	0.18	0.19	
	3	0.18	0.19	0.19	0.20	0.20	
	4	0.20	0.20	0.20	0.19	0.18	
		0.18	0.22	0.18	0.19		
3374	360.0	87.2	1.003	0.000	0.294	0.335	0.690
	1	0.95	0.20	0.20	0.20	0.19	
	2	0.20	0.20	0.20	0.20	0.20	
	3	0.19	0.20	0.20	0.21	0.21	
	4	0.21	0.20	0.21	0.20	0.20	
		0.19	0.29	0.20	0.20		
3375	753.0	115.8	4.918	0.000	1.439	0.700	0.917
	1	4.89	0.75	0.75	0.74	0.75	
	2	0.75	0.87	0.94	0.97	1.11	
	3	1.10	1.17	1.28	1.38	1.53	
	4	1.53	1.48	1.49	1.34	5.86	
		0.65	0.68	0.72	0.83		

TABLE III. - Continued.

(b) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	P1 MPA	P2 MPA	P3 MPA	POUT MPA
			Pn1	Pn2	Pn3	Pn4	
3376	630.0	115.1	3.806	0.000	1.114	0.586	0.911
		1	3.78	0.89	0.89	0.89	0.89
		2	0.89	1.05	1.13	1.16	1.29
		3	1.29	1.39	1.51	1.58	1.64
		4	1.64	1.52	1.50	1.35	0.59
			0.57	0.60	0.65	0.72	
3377	464.0	117.1	2.588	0.000	0.757	0.431	0.927
		1	2.56	0.97	0.96	0.97	0.97
		2	0.98	1.17	1.24	1.26	1.35
		3	1.34	1.37	1.40	1.42	1.42
		4	1.42	1.24	1.22	1.10	0.45
			0.43	0.47	0.51	0.55	
3378	217.0	115.0	1.902	0.000	0.557	0.202	0.911
		1	1.89	1.35	1.38	1.41	1.42
		2	1.43	1.33	1.33	1.33	1.30
		3	1.31	1.19	1.19	1.18	1.15
		4	1.15	1.00	0.97	0.87	0.27
			0.24	0.32	0.30	0.33	
3379	394.0	140.5	5.444	0.000	1.593	0.366	1.112
		1	5.47	2.35	2.60	2.81	3.24
		2	3.24	3.56	3.57	3.65	3.59
		3	3.59	3.38	3.44	3.43	3.38
		4	3.38	2.90	2.82	2.49	0.53
			0.49	0.57	0.66	0.77	
3380	243.0	141.3	4.058	0.000	1.188	0.226	1.119
		1	4.06	1.76	1.91	2.05	2.31
		2	2.31	2.45	2.46	2.50	2.44
		3	2.44	2.20	2.24	2.25	2.21
		4	2.20	1.75	1.75	1.58	0.35
			0.33	0.39	0.44	0.53	

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	P1 MPA	P2 MPA	P3 MPA	POUT MPA
			Pn1	Pn2	Pn3	Pn4	
3381	161.3	141.3	2.946	0.000	0.862	0.150	1.119
		1	2.94	1.28	1.40	1.50	1.67
		2	1.68	1.78	1.78	1.80	1.77
		3	1.76	1.58	1.61	1.62	1.58
		4	1.58	1.20	1.18	1.01	0.26
			0.25	0.29	0.31	0.39	
3382	78.5	141.3	1.544	0.000	0.452	0.073	1.119
		1	1.52	0.65	0.72	0.78	0.86
		2	0.87	0.92	0.91	0.94	0.92
		3	0.91	0.81	0.82	0.84	0.82
		4	0.82	0.63	0.61	0.52	0.17
			0.16	0.19	0.18	0.23	
3383	608.0	126.3	5.272	0.000	1.543	0.565	1.000
		1	5.26	1.97	1.96	1.96	2.11
		2	2.11	2.29	2.29	2.30	2.37
		3	2.37	2.37	2.42	2.47	2.56
		4	2.55	2.38	2.32	2.09	0.69
			0.65	0.76	0.82	0.91	
3384	469.0	125.8	4.207	0.000	1.231	0.436	0.996
		1	4.21	2.12	2.12	2.14	2.33
		2	2.33	2.44	2.51	2.58	2.62
		3	2.62	2.53	2.55	2.55	2.54
		4	2.54	2.22	2.15	1.95	0.56
			0.53	0.78	0.64	0.72	
3385	278.0	126.0	3.261	0.000	0.954	0.258	0.998
		1	3.27	1.73	1.84	1.89	1.95
		2	1.95	2.00	2.00	2.03	2.02
		3	2.02	1.90	1.91	1.91	1.89
		4	1.89	1.62	1.57	1.41	0.37
			0.34	0.42	0.43	0.49	

TABLE III. - Continued.

(b) Concluded.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3386	141.0	126.6	2.364	0.000	0.692	0.131	1.002
3387	124.0	126.2	2.124	0.000	0.622	0.115	0.999
3388	24.7	234.0	0.685	0.000	0.200	0.023	1.853
3389	49.7	225.0	1.311	0.000	0.384	0.046	1.781
3390	82.4	229.8	2.167	0.000	0.634	0.077	1.819
3391	149.0	241.5	3.970	0.000	1.162	0.138	1.912
3392	237.0	247.4	6.372	0.000	1.865	0.220	1.959

Run 3386

ORIFICE INLET	POIN MPA	Pn1	P1 MPA	Pn2	P2 MPA	Pn3	P3 MPA	Pn4	POUT MPA
1	2.35		1.06		1.15		1.24		1.37
2	1.37		1.43		1.44		1.46		1.44
3	1.44		1.30		1.31		1.32		1.30
4	1.30		1.03		1.00		0.89		0.23
		0.21		0.25		0.27		0.33	

Run 3387

ORIFICE INLET	POIN MPA	Pn1	P1 MPA	Pn2	P2 MPA	Pn3	P3 MPA	Pn4	POUT MPA
1	2.11		1.11		0.94		1.02		1.22
2	1.22		1.29		1.29		1.30		1.27
3	1.26		1.13		1.15		1.17		1.14
4	1.14		0.88		0.85		0.76		0.21
		0.20		0.23		0.25		0.30	

Run 3388

ORIFICE INLET	POIN MPA	Pn1	P1 MPA	Pn2	P2 MPA	Pn3	P3 MPA	Pn4	POUT MPA
1	0.66		0.29		0.31		0.34		0.37
2	0.37		0.40		0.39		0.41		0.40
3	0.38		0.36		0.35		0.36		0.35
4	0.36		0.27		0.26		0.22		0.14
		0.13		0.12		0.14		0.16	

Run 3389

ORIFICE INLET	POIN MPA	Pn1	P1 MPA	Pn2	P2 MPA	Pn3	P3 MPA	Pn4	POUT MPA
1	1.29		0.55		0.59		0.65		0.73
2	0.73		0.77		0.77		0.79		0.77
3	0.76		0.69		0.69		0.71		0.69
4	0.69		0.52		0.50		0.44		0.16
		0.15		0.14		0.17		0.21	

Run 3390

ORIFICE INLET	POIN MPA	Pn1	P1 MPA	Pn2	P2 MPA	Pn3	P3 MPA	Pn4	POUT MPA
1	2.15		0.91		0.99		1.08		1.21
2	1.21		1.29		1.28		1.32		1.29
3	1.28		1.14		1.16		1.18		1.15
4	1.16		0.87		0.84		0.74		0.21
		0.20		0.18		0.23		0.30	

Run 3391

ORIFICE INLET	POIN MPA	Pn1	P1 MPA	Pn2	P2 MPA	Pn3	P3 MPA	Pn4	POUT MPA
1	3.98		1.64		1.82		1.97		2.22
2	2.22		2.38		2.35		2.42		2.37
3	2.36		2.09		2.15		2.16		2.13
4	2.13		1.60		1.55		1.35		0.33
		0.31		0.31		0.38		0.50	

Run 3392

ORIFICE INLET	POIN MPA	Pn1	P1 MPA	Pn2	P2 MPA	Pn3	P3 MPA	Pn4	POUT MPA
1	6.41		2.64		2.93		3.15		3.55
2	3.56		3.82		3.78		3.91		3.82
3	3.81		3.35		3.44		3.45		3.40
4	3.41		2.55		2.46		2.13		0.51
		0.48		0.48		0.58		0.77	

TABLE III. - Continued.

(c) Uninstrumented Teflon spacers.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE	INLET		POIN MPA	P1 MPA	P2 MPA	P3 MPA	POUT MPA
				Pn1	Pn2	Pn3	Pn4
3355	685.0	87.9	2.300	0.000	0.673	0.637	0.696
		1	2.24	0.20	0.20	0.21	0.20
		2	0.21	0.20	0.21	0.21	0.21
		3	0.22	0.20	0.20	0.21	0.22
		4	0.22	0.22	0.24	0.26	0.36
				0.34	0.36	0.38	0.49
3356	573.0	87.6	1.700	0.000	0.498	0.533	0.694
		1	1.64	0.20	0.19	0.21	0.20
		2	0.21	0.20	0.21	0.21	0.22
		3	0.22	0.19	0.20	0.20	0.22
		4	0.20	0.19	0.20	0.17	0.20
				0.19	0.22	0.21	0.23
3357	486.0	87.5	1.318	0.000	0.386	0.452	0.693
		1	1.26	0.20	0.20	0.21	0.20
		2	0.21	0.21	0.21	0.21	0.22
		3	0.22	0.19	0.20	0.21	0.22
		4	0.21	0.19	0.20	0.21	0.22
				0.19	0.22	0.20	0.21
3358	406.0	87.6	1.006	0.000	0.294	0.377	0.694
		1	0.96	0.20	0.20	0.21	0.20
		2	0.21	0.21	0.21	0.21	0.22
		3	0.22	0.20	0.20	0.21	0.22
		4	0.22	0.19	0.20	0.19	0.21
				0.19	0.24	0.21	0.22
3359	852.0	90.3	3.563	0.000	1.043	0.792	0.715
		1	3.49	0.21	0.21	0.22	0.22
		2	0.22	0.20	0.23	0.23	0.24
		3	0.24	0.23	0.24	0.24	0.25
		4	0.26	0.24	0.24	0.21	0.16
				0.14	0.17	0.16	0.20
3360	752.0	90.3	2.836	0.000	0.830	0.699	0.715
		1	2.76	0.22	0.22	0.23	0.22
		2	0.24	0.22	0.24	0.26	0.25
		3	0.24	0.23	0.25	0.24	0.26
		4	0.26	0.24	0.24	0.22	0.19
				0.17	0.18	0.19	0.20
3361	587.0	90.3	1.841	0.000	0.539	0.546	0.715
		1	1.79	0.21	0.22	0.27	0.22
		2	0.24	0.23	0.24	0.23	0.24
		3	0.24	0.22	0.24	0.24	0.24
		4	0.25	0.23	0.23	0.21	0.22
				0.20	0.23	0.21	0.21
3362	455.0	90.1	1.233	0.000	0.361	0.423	0.713
		1	1.19	0.23	0.23	0.24	0.23
		2	0.24	0.23	0.24	0.24	0.24
		3	0.24	0.23	0.23	0.24	0.24
		4	0.25	0.23	0.23	0.22	0.22
				0.21	0.22	0.22	0.23
3363	335.0	90.6	0.815	0.000	0.239	0.311	0.717
		1	0.78	0.24	0.24	0.25	0.24
		2	0.25	0.24	0.25	0.25	0.25
		3	0.24	0.23	0.24	0.24	0.25
		4	0.26	0.22	0.23	0.22	0.23
				0.21	0.24	0.23	0.23

TABLE III. - Continued.

(d) Applied backpressure with instrumented spacers

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR	ORIFICE INLET	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3902	166.8	276.7	4.733	0.913	1.385	0.155	2.191							
								1	4.73	2.57	1.86	1.93	2.14	2.55
								2	2.54	2.94	2.80	2.84	2.86	2.98
								3	2.95	2.54	2.49	2.57	2.62	2.53
								4	2.53	0.91	1.82	1.96	1.74	0.68
3903	166.2	277.8	4.725	0.975	1.383	0.154	2.200							
								1	4.73	2.57	1.86	1.93	2.14	2.55
								2	2.54	2.95	2.80	2.84	2.86	2.98
								3	2.95	2.54	2.49	2.57	2.62	2.53
								4	2.53	0.98	1.82	1.96	1.74	0.75
3904	165.8	278.3	4.726	1.196	1.383	0.154	2.203							
								1	4.73	2.57	1.86	1.92	2.13	2.54
								2	2.54	2.95	2.80	2.84	2.86	2.98
								3	2.95	2.54	2.49	2.57	2.63	2.53
								4	2.53	1.20	1.82	1.96	1.74	0.97
3905	165.7	278.6	4.725	1.375	1.383	0.154	2.206							
								1	4.73	2.57	1.85	1.92	2.13	2.55
								2	2.54	2.95	2.80	2.84	2.86	2.98
								3	2.95	2.54	2.49	2.57	2.62	2.53
								4	2.52	1.38	1.82	1.96	1.74	1.15
3906	165.5	278.9	4.724	1.686	1.382	0.154	2.208							
								1	4.73	2.57	1.85	1.92	2.13	2.55
								2	2.54	2.94	2.80	2.84	2.85	2.97
								3	2.95	2.54	2.49	2.57	2.62	2.53
								4	2.53	1.69	1.83	1.96	1.75	1.49
3907	165.2	279.2	4.722	2.079	1.382	0.154	2.211							
								1	4.73	2.57	1.85	1.92	2.14	2.54
								2	2.54	2.95	2.80	2.84	2.86	2.98
								3	2.95	2.54	2.49	2.57	2.62	2.53
								4	2.53	2.08	1.87	1.98	1.77	1.90
3908	164.5	279.5	4.729	2.375	1.384	0.153	2.213							
								1	4.74	2.60	1.89	1.95	2.16	2.57
								2	2.57	2.98	2.84	2.86	2.89	3.00
								3	2.98	2.62	2.54	2.62	2.67	2.60
								4	2.60	2.38	2.21	2.17	2.11	2.22
3909	160.7	279.6	4.747	2.486	1.389	0.149	2.214							
								1	4.76	2.82	2.06	2.15	2.49	2.80
								2	2.79	3.05	2.91	2.95	2.98	3.07
								3	3.04	2.67	2.62	2.69	2.75	2.66
								4	2.66	2.49	2.33	2.28	2.26	2.35

TABLE III. - Continued.

(d) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE INLET		POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3910	158.2	279.8	4.767	2.623	1.395	0.147	2.215
1		4.78	2.97	2.24	2.36	2.59	2.93
2		2.94	3.09	3.01	3.04	3.09	3.11
3		3.09	2.78	2.71	2.82	2.86	2.75
4		2.75	2.62	2.48	2.42	2.41	2.49
3911	152.5	280.1	4.814	3.134	1.409	0.142	2.218
1		4.84	3.30	2.52	2.71	3.10	3.28
2		3.28	3.40	3.33	3.40	3.43	3.44
3		3.40	3.13	3.14	3.21	3.24	3.12
4		3.11	3.13	3.01	2.96	3.03	3.03
3912	152.0	280.2	4.819	3.168	1.410	0.141	2.219
1		4.83	3.31	2.54	2.73	3.11	3.30
2		3.29	3.42	3.35	3.42	3.44	3.45
3		3.42	3.15	3.16	3.23	3.26	3.15
4		3.15	3.17	3.04	3.00	3.00	3.06
3917	820.4	88.3	4.149	0.390	1.214	0.762	0.699
1		4.08	0.17	0.18	0.17	0.17	0.17
2		0.17	0.17	0.18	0.18	0.20	0.19
3		0.19	0.23	0.19	0.20	0.24	0.22
4		0.23	0.39	0.25	0.23	0.35	0.24

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
ORIFICE INLET		POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3918	816.6	88.5	4.131	1.258	1.209	0.759	0.701
1		4.06	0.17	0.18	0.18	0.17	0.17
2		0.17	0.17	0.18	0.18	0.20	0.19
3		0.19	0.59	0.20	0.21	0.25	0.23
4		0.24	1.26	0.53	0.29	0.32	1.02
3919	812.2	88.9	4.117	1.430	1.205	0.755	0.704
1		4.04	0.18	0.19	0.18	0.18	0.18
2		0.18	0.18	0.18	0.19	0.21	0.20
3		0.20	0.34	0.20	0.22	0.26	0.24
4		0.25	1.43	0.69	0.33	0.45	1.20
3920	807.3	89.6	4.109	1.672	1.203	0.750	0.709
1		4.04	0.19	0.20	0.19	0.19	0.19
2		0.19	0.19	0.19	0.19	0.22	0.21
3		0.21	0.26	0.22	0.23	0.27	0.26
4		0.26	1.67	1.10	0.43	0.81	1.46
3921	782.3	89.9	4.166	1.720	1.219	0.727	0.712
1		4.08	0.47	0.36	0.36	0.36	0.42
2		0.42	1.00	0.73	0.82	0.93	1.00
3		1.00	1.35	0.95	1.03	1.20	1.33
4		1.32	1.72	1.45	1.24	1.32	1.53

TABLE III. - Continued.

(d) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR

ORIFICE INLET	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA

RUN	MASS FLOW	TIN	PIN	PBACK	PR	GR	TR
3922	805.6	90.2	4.098	1.706	1.199	0.749	0.714

ORIFICE INLET	POIN	Pn	P1	P2	P3	POUT
1	4.03	0.20	0.21	0.20	0.20	0.20
2	0.19	0.20	0.20	0.20	0.22	0.22
3	0.21	0.29	0.23	0.24	0.28	0.27
4	0.28	1.71	1.11	0.46	0.94	1.50

RUN	MASS FLOW	TIN	PIN	PBACK	PR	GR	TR
3923	757.2	91.2	4.219	1.796	1.235	0.704	0.722

ORIFICE INLET	POIN	Pn	P1	P2	P3	POUT
1	4.17	1.07	0.68	0.76	0.80	1.03
2	1.02	1.91	1.83	1.86	1.86	1.91
3	1.89	0.00	1.64	1.77	1.82	1.71
4	1.71	1.80	1.62	1.56	1.54	1.62

RUN	MASS FLOW	TIN	PIN	PBACK	PR	GR	TR
3924	713.1	92.6	4.328	2.127	1.267	0.663	0.733

ORIFICE INLET	POIN	Pn	P1	P2	P3	POUT
1	4.29	1.91	1.12	1.26	1.40	1.87
2	1.86	2.33	2.26	2.27	2.29	2.33
3	2.30	2.11	2.02	2.12	2.18	2.09
4	2.07	2.13	1.98	1.93	1.91	1.98

RUN	MASS FLOW	TIN	PIN	PBACK	PR	GR	TR
3925	653.1	113.3	3.924	0.757	1.148	0.607	0.897

ORIFICE INLET	POIN	Pn	P1	P2	P3	POUT
1	3.87	0.78	0.80	0.78	0.78	0.78
2	0.78	1.09	0.91	0.96	1.04	1.11
3	1.10	1.50	1.22	1.32	1.43	1.48
4	1.48	0.76	1.40	1.43	1.35	0.58

RUN	MASS FLOW	TIN	PIN	PBACK	PR	GR	TR
3926	650.1	113.8	3.921	0.961	1.147	0.604	0.901

ORIFICE INLET	POIN	Pn	P1	P2	P3	POUT
1	3.86	0.80	0.81	0.80	0.80	0.80
2	0.80	1.12	0.93	0.99	1.06	1.14
3	1.13	1.53	1.26	1.35	1.46	1.51
4	1.51	0.96	1.42	1.46	1.37	0.81

RUN	MASS FLOW	TIN	PIN	PBACK	PR	GR	TR
3927	646.5	114.1	3.921	1.051	1.147	0.601	0.903

ORIFICE INLET	POIN	Pn	P1	P2	P3	POUT
1	3.86	0.82	0.83	0.82	0.82	0.82
2	0.82	1.15	0.95	1.02	1.09	1.17
3	1.15	0.00	1.30	1.40	1.51	1.55
4	1.55	1.05	1.46	1.49	1.42	0.90

RUN	MASS FLOW	TIN	PIN	PBACK	PR	GR	TR
3928	642.4	114.5	3.919	1.106	1.147	0.597	0.907

ORIFICE INLET	POIN	Pn	P1	P2	P3	POUT
1	3.86	0.84	0.85	0.84	0.84	0.84
2	0.84	1.18	0.98	1.04	1.12	1.20
3	1.19	1.60	1.33	1.43	1.54	1.58
4	1.58	1.11	1.47	1.52	1.44	0.96

RUN	MASS FLOW	TIN	PIN	PBACK	PR	GR	TR
3929	639.8	114.7	3.917	1.154	1.146	0.595	0.908

ORIFICE INLET	POIN	Pn	P1	P2	P3	POUT
1	3.86	0.86	0.86	0.85	0.85	0.86
2	0.85	1.21	1.00	1.06	1.14	1.22
3	1.22	1.62	1.35	1.46	1.57	1.60
4	1.60	1.15	1.49	1.54	1.46	1.00

TABLE III. - Continued.

(d) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA		PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3930	636.4	115.0	3.914		1.265	1.145	0.591	0.911
		1	3.86	0.88	0.89	0.87	0.87	0.87
		2	0.87	1.24	1.02	1.09	1.18	1.26
		3	1.24	1.66	1.40	1.50	1.60	1.64
		4	1.64	1.26	1.51	1.57	1.49	1.11
3931	630.9	115.5	3.921		1.306	1.147	0.586	0.914
		1	3.87	0.91	0.92	0.91	0.91	0.91
		2	0.91	1.30	1.07	1.15	1.23	1.32
		3	1.31	1.71	1.46	1.56	1.67	1.69
		4	1.69	1.31	1.56	1.62	1.53	1.15
3932	577.3	118.9	3.997		1.506	1.170	0.537	0.941
		1	3.93	1.20	1.18	1.18	1.18	1.19
		2	1.19	1.74	1.46	1.56	1.66	1.76
		3	1.75	2.10	1.89	1.96	2.06	2.09
		4	2.09	1.51	1.82	1.93	1.80	1.35
3933	493.6	126.7	4.536		0.803	1.327	0.459	1.003
		1	4.51	2.29	2.11	2.10	2.11	2.27
		2	2.26	2.71	2.26	2.36	2.40	2.74
		3	2.72	2.89	2.66	2.69	2.76	2.71
		4	2.71	0.80	2.29	2.44	2.29	0.59
3934	489.8	127.0	4.538		1.127	1.328	0.455	1.006
		1	4.52	2.30	2.11	2.10	2.11	2.29
		2	2.28	2.78	2.31	2.44	2.49	2.80
		3	2.78	2.91	2.71	2.73	2.80	2.74
		4	2.74	1.13	2.31	2.46	2.33	0.93
3935	487.6	127.2	4.540		1.189	1.329	0.453	1.007
		1	4.51	2.31	2.11	2.10	2.11	2.29
		2	2.29	2.81	2.35	2.50	2.54	2.84
		3	2.82	2.78	2.73	2.75	2.82	2.76
		4	2.75	1.19	2.33	2.48	2.35	0.99
3936	483.6	127.4	4.534		1.299	1.327	0.449	1.009
		1	4.51	2.31	2.11	2.10	2.11	2.30
		2	2.29	2.84	2.41	2.55	2.60	2.86
		3	2.85	2.79	2.75	2.78	2.84	2.78
		4	2.78	1.30	2.35	2.50	2.37	1.11
3937	480.9	127.6	4.534		1.437	1.327	0.447	1.010
		1	4.51	2.32	2.10	2.10	2.11	2.31
		2	2.30	2.86	2.45	2.59	2.63	2.89
		3	2.88	2.81	2.76	2.79	2.86	2.80
		4	2.80	1.44	2.38	2.51	2.46	1.26

TABLE III. - Continued.

(d) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR	
ORIFICE INLET			POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3938	478.5	127.7	4.532	1.603	1.326	0.445	1.011	
		1	4.51	2.33	2.10	2.09	2.11	2.31
		2	2.31	2.89	2.49	2.62	2.66	2.91
		3	2.90	2.82	2.78	2.81	2.88	2.82
		4	2.81	1.60	2.40	2.53	2.41	1.42
3940	471.1	128.1	4.540	2.217	1.329	0.438	1.014	
		1	4.52	2.36	2.11	2.10	2.13	2.35
		2	2.34	2.95	2.59	2.72	2.75	2.98
		3	2.96	2.88	2.84	2.86	2.93	2.86
		4	2.86	2.22	2.47	2.59	2.48	2.06
3941	458.0	128.7	4.553	2.617	1.332	0.426	1.019	
		1	4.53	2.42	2.13	2.13	2.18	2.41
		2	2.40	3.04	2.73	2.84	0.00	3.06
		3	3.05	2.97	2.92	2.95	3.02	2.96
		4	2.95	2.62	2.63	2.71	2.62	2.48
3943	271.3	139.9	4.332	0.606	1.268	0.252	1.108	
		1	4.32	2.44	1.86	1.91	2.08	2.43
		2	2.42	2.80	2.68	2.71	2.74	2.82
		3	2.80	2.50	2.46	2.53	2.59	2.49
		4	2.49	0.61	2.04	2.15	2.01	0.36
3944	269.4	140.9	4.340	1.196	1.270	0.250	1.116	
		1	4.32	2.40	1.84	1.89	2.05	2.40
		2	2.39	2.77	2.66	2.69	2.71	2.78
		3	2.77	2.46	2.42	2.49	2.54	2.44
		4	2.44	1.20	2.00	2.10	1.96	1.00
3945	267.7	141.3	4.332	0.941	1.268	0.249	1.119	
		1	4.32	2.39	1.83	1.87	2.03	2.38
		2	2.38	2.75	2.65	2.67	2.71	2.77
		3	2.75	2.49	2.39	2.46	2.53	2.42
		4	2.42	0.94	1.98	2.07	1.93	0.72
3946	264.3	141.8	4.332	1.623	1.268	0.246	1.123	
		1	4.31	2.37	1.82	1.86	2.01	2.35
		2	2.35	2.73	2.64	2.66	2.69	2.75
		3	2.73	2.41	2.36	2.44	2.49	2.40
		4	2.39	1.62	1.94	2.03	1.89	1.44
3947	260.8	142.7	4.324	1.996	1.265	0.242	1.130	
		1	4.31	2.34	1.80	1.83	1.99	2.33
		2	2.32	2.71	2.61	2.64	2.66	2.73
		3	2.71	2.38	2.33	2.41	2.46	2.36
		4	2.36	2.00	1.92	1.97	1.86	1.84

TABLE III. - Continued.

(d) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA		PBACK MPA	PR	GR	TR
ORIFICE	INLET		POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3948	240.7	147.5	4.318		2.258	1.264	0.224	1.168
		1	4.31	2.42	1.82	1.86	2.05	2.40
		2	2.40	2.75	2.62	2.66	2.69	2.77
		3	2.75	2.42	2.38	2.44	2.50	2.41
		4	2.40	2.26	2.11	2.07	2.06	20.31
3949	213.2	157.6	4.343		2.520	1.271	0.198	1.248
		1	4.33	2.75	2.05	2.18	2.44	2.73
		2	2.73	2.83	2.78	2.80	2.86	2.84
		3	2.83	2.63	2.51	2.61	2.65	2.56
		4	2.56	2.52	2.38	2.33	2.33	2.40
3959	383.2	132.2	4.569		0.768	1.337	0.356	1.047
		1	4.56	2.69	2.20	2.27	2.40	2.69
		2	2.68	3.14	2.94	3.01	3.01	3.17
		3	3.15	2.94	2.94	2.95	2.99	2.92
		4	2.92	0.77	2.37	2.57	2.38	0.53
3960	384.6	132.1	4.564		0.865	1.336	0.357	1.046
		1	4.55	2.69	2.20	2.27	2.40	2.69
		2	2.69	3.16	2.68	2.93	3.01	3.00
		3	3.13	2.91	3.15	2.93	2.95	2.99
		4	2.94	0.86	2.91	2.38	2.57	2.42

RUN	MASS FLOW G/S	TIN K	PIN MPA		PBACK MPA	PR	GR	TR
ORIFICE	INLET		POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3961	383.1	132.1	4.560		1.217	1.335	0.356	1.046
		1	4.55	2.69	2.20	2.27	2.40	2.69
		2	2.68	3.13	2.93	3.00	3.00	3.15
		3	3.15	2.56	2.93	2.94	2.99	2.91
		4	2.91	1.22	2.37	2.56	2.37	1.02
3962	380.6	132.2	4.556		1.486	1.333	0.354	1.047
		1	4.55	2.69	2.20	2.27	2.40	2.69
		2	2.68	3.13	2.93	3.00	3.00	3.15
		3	3.15	2.92	2.93	2.93	2.98	2.90
		4	2.90	1.49	2.36	2.55	2.36	1.30
3963	378.6	132.3	4.551		1.886	1.332	0.352	1.048
		1	4.54	2.69	2.20	2.27	2.40	2.69
		2	2.69	3.13	2.93	3.00	3.00	3.15
		3	3.14	2.91	2.92	2.93	2.96	2.89
		4	2.89	1.89	2.36	2.55	2.35	1.71
3964	375.9	132.4	4.550		2.182	1.332	0.349	1.048
		1	4.54	2.69	2.20	2.28	2.40	2.69
		2	2.69	3.13	2.93	3.00	3.00	3.15
		3	3.14	2.91	2.91	2.93	2.95	2.89
		4	2.90	2.18	2.38	2.55	2.37	2.02

TABLE III. - Continued.

(d) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA		PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3965	371.2	132.6	4.550		2.554	1.332	0.345	1.050
		1	4.55	2.71	2.23	2.30	2.42	2.71
		2	2.70	3.14	2.95	3.02	3.02	3.17
		3	3.15	2.93	2.93	2.95	3.00	2.92
		4	2.92	2.55	2.50	2.60	2.46	2.42
3966	337.0	133.4	3.666		2.196	1.073	0.313	1.056
		1	4.55	2.78	2.29	2.34	2.47	2.78
		2	2.77	3.20	3.02	3.09	3.08	3.22
		3	3.21	2.48	2.98	3.00	3.04	2.40
		4	2.86	2.20	2.12	2.17	2.09	2.09
3967	308.1	139.2	4.644		0.667	1.359	0.286	1.102
		1	4.64	2.70	2.02	2.09	2.29	2.69
		2	2.69	3.09	2.95	3.01	3.02	3.12
		3	3.11	2.86	2.81	2.87	2.93	2.84
		4	2.84	0.67	2.26	2.48	2.24	0.41
3968	305.9	139.5	4.644		0.975	1.359	0.284	1.105
		1	4.64	2.69	2.03	2.09	2.29	2.68
		2	2.67	3.08	2.95	3.00	3.00	3.10
		3	3.09	3.09	2.78	2.84	2.90	2.81
		4	2.82	0.98	2.26	2.47	2.24	0.75

RUN	MASS FLOW G/S	TIN K	PIN MPA		PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3969	431.3	123.9	4.271		0.830	1.250	0.401	0.981
		1	4.63	2.68	2.03	2.09	2.29	2.67
		2	2.66	3.06	2.94	2.98	2.99	3.09
		3	3.08	2.49	2.76	2.83	2.89	2.42
		4	2.39	0.83	1.99	1.88	2.49	1.40
3970	301.0	140.5	4.643		1.251	1.359	0.280	1.112
		1	4.64	2.65	2.02	2.07	2.25	2.64
		2	2.63	3.04	2.91	2.95	2.96	3.06
		3	3.04	2.80	2.72	2.78	2.82	2.75
		4	2.74	1.25	2.24	2.42	2.24	1.03
3971	281.1	281.1	4.602		1.561	1.347	0.261	2.226
		1	4.60	2.50	1.91	1.95	2.12	2.49
		2	2.49	2.91	2.78	2.82	2.83	2.92
		3	2.91	2.53	2.52	2.59	2.64	2.52
		4	2.52	1.56	2.03	2.11	1.97	1.36
3972	246.0	153.7	4.574		1.996	1.339	0.229	1.217
		1	4.57	2.47	1.81	1.87	2.08	2.46
		2	2.46	2.85	2.71	2.75	2.75	2.87
		3	2.86	2.53	3.11	2.49	2.53	2.44
		4	2.44	2.00	1.82	1.91	1.73	1.82

TABLE III. - Continued.

(d) Continued.

RUN	MASS FLOW G/S	TIN K	PIN MPA		PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3973	224.0	161.3	4.604		2.430	1.347	0.208	1.277
		1	4.60	2.82	2.14	2.22	2.44	2.80
		2	2.80	2.93	2.86	2.90	2.92	2.94
		3	2.93	2.60	2.53	2.64	2.69	2.58
		4	2.58	2.43	2.29	2.22	2.22	2.29
3974	207.0	174.0	4.593		2.561	1.344	0.192	1.378
		1	4.59	2.84	2.17	2.28	2.49	2.82
		2	2.82	2.95	2.89	2.91	2.95	2.96
		3	2.95	2.66	2.60	2.70	2.75	2.64
		4	2.64	2.56	2.42	2.38	2.40	2.43
3975	277.7	145.0	4.585		0.670	1.342	0.258	1.148
		1	4.58	2.45	1.81	1.87	2.07	2.44
		2	2.43	2.86	2.71	2.75	2.76	2.87
		3	2.86	2.53	2.44	2.51	2.56	2.47
		4	2.47	0.67	1.93	2.00	1.86	0.41
3976	276.8	145.0	4.577		1.230	1.339	0.257	1.148
		1	4.57	2.45	1.80	1.87	2.07	2.44
		2	2.43	2.86	2.71	2.75	2.75	2.87
		3	2.86	2.52	2.43	2.50	2.56	2.46
		4	2.46	1.23	1.91	1.98	1.85	1.01

RUN	MASS FLOW G/S	TIN K	PIN MPA		PBACK MPA	PR	GR	TR
ORIFICE INLET			POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
3977	274.9	145.8	4.574		1.603	1.339	0.255	1.154
		1	4.56	2.44	1.80	1.86	2.06	2.43
		2	2.42	2.85	2.71	2.75	2.75	2.86
		3	2.86	[a]0.00	2.42	2.49	2.56	2.46
		4	2.46	1.60	1.90	1.97	1.83	1.40
3978	272.6	146.1	4.567		1.989	1.337	0.253	1.157
		1	4.56	2.44	1.80	1.86	2.06	2.43
		2	2.42	2.85	2.71	2.75	2.75	2.86
		3	2.86	[a]0.00	2.42	2.49	2.54	2.45
		4	2.46	1.99	1.91	1.96	1.84	1.82
3979	269.9	146.5	4.565		2.258	1.336	0.251	1.160
		1	4.56	2.46	1.82	1.89	2.09	2.45
		2	2.44	2.86	2.73	2.76	2.77	2.89
		3	2.87	2.50	2.45	2.52	2.57	2.49
		4	2.49	2.26	2.10	2.06	2.01	2.11
3980	257.4	147.6	4.607		2.686	1.348	0.239	1.169
		1	4.61	2.92	2.18	2.33	2.60	2.91
		2	2.90	3.02	2.95	2.98	3.02	3.03
		3	3.02	[a]0.00	2.69	2.78	2.83	2.72
		4	2.71	2.69	2.54	2.50	2.49	2.56

[a]Data not recorded.

TABLE III. - Concluded.

(d) Concluded.

RUN	MASS FLOW G/S	TIN K	PIN MPA	PBACK MPA	PR	GR	TR
3981	226.2	156.1	4.622	2.934	1.353	0.210	1.236

ORIFICE INLET	POIN MPA	Pn	P1 MPA	P2 MPA	P3 MPA	POUT MPA
1	4.62		2.36	2.53	2.98	3.07
		3.08				
2	3.07		3.15	3.21	3.23	3.23
		3.21				
3	3.22		2.95	3.02	3.04	2.92
		[a]0.00				
4	2.91		2.80	2.75	2.77	2.82
		2.93				

[a]Data not recorded.

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16. Abstract

Choked flow rate and pressure profile data were taken and studied for configurations consisting of four axially aligned, sequential orifice inlets of 0.5 length-diameter ratio with separation distances of 0.66 and 32 diameters. A flow coefficient - reduced-temperature plot represents the flow rate data for the two cases. At a separation distance of 32 diameters the pressure profiles dropped sharply at the entrance and partially recovered within each orifice - the exception being at low temperatures, where fluid jetting through the last orifice occurred. At a separation distance of 0.66 diameter fluid jetting was prevalent at the lower inlet temperatures. These results are in qualitative agreement with data for four axially aligned, sequential Borda inlets and for tubes with single sharp-edge orifice or Borda inlets to L/D's of 105 and with a water flow visualization study reported herein and one previously reported for Borda inlets.

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