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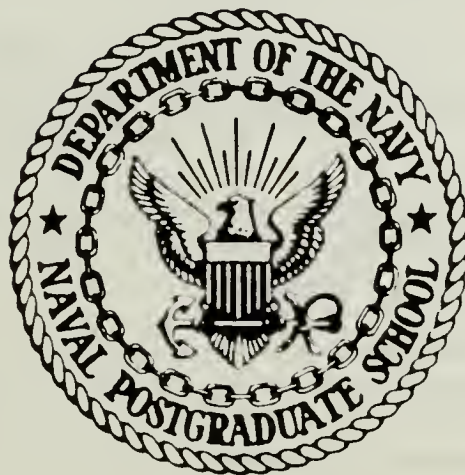
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# NAVAL POSTGRADUATE SCHOOL

Monterey, California



## THESIS

HEAT TRANSFER FROM AN ARRAY OF HEATED  
RECTANGULAR  
ELEMENTS ON AN ADIABATIC CHANNEL WALL

by

David W. Mears

December 1986

Thesis Advisor

Allan D. Kraus

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Heat Transfer From An Array of Heated Rectangular  
Elements On An Adiabatic Channel Wall

by

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Submitted in partial fulfillment of the  
requirements for the degrees of

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and  
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## ABSTRACT

This thesis describes an experimental study to determine the heat transfer characteristics of rectangular elements mounted on an adiabatic wall in a laminar air flow. The study involves forced convection and the determination of the heat transfer coefficients as influenced by the unheated elements. The study is timely in that major concern is the understanding of removal of the generated heat from electrical equipment and electronic devices which utilize microelectronic chips.

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## TABLE OF SYMBOLS AND ABBREVIATIONS

A	Constant in the smooth law of the wall.
B	Characteristic dimension of cubical blocks.
C	Constant in roughness function.
$C_f'^2$	Local skin friction coefficient.
d	Pipe diameter, or distance between channel walls.
e	Some arbitrary characteristic height of roughness.
$e^+$	Roughness Reynolds number based on e.
$g^+$	Heat-transfer similarity function, Eq. (1.4).
H	Distance between channel walls.
hb	Designation for heated block.
h	Local convective heat transfer coefficient.
$\bar{h}$	Area average convective heat transfer coefficient.
k	Conductivity of the fluid.
k	Roughness height.
L	Test section channel length.
N	Row position number in the array.
Nu	Nusselt number.
P or p	Pitch of repeated roughness geometries.
Pr	Prandtl number.
q	Power input from electrical resistance heating.
$R^+$	Friction-similarity or roughness function.
Re	Reynolds number.
$R^+(\infty)$	Roughness function constant for a fully rough flow.
$Re^+(k)$	Roughness Reynolds number based on equivalent height, k.
S	Spanwise and streamwise characteristic dimension of regular array.
St	Stanton Number.
$T_{hb}$	Temperature of the heated block.
$T_\infty$	Freestream temperature.
$T_{element}$	Final temperature achieved by an element in the array.
u	Downstream direction velocity.
$u_b$	Bulk mean velocity.

$u_\tau$	Frictional velocity.
$\underline{V}$	Velocity vector.
$u^+$	Dimensionless velocity, $u/u_\tau$ .
$\Delta u/u_\tau$	Roughness function = $R^+$ , defines shift of the rough-wall log region from the smooth wall behavior.
$\alpha$	Thermal diffusivity.
$\delta$	99% thickness of the momentum boundary layer.
$\kappa$	Von-Karman constant.
$\rho$	Fluid density.
$\theta$	Dimensionless adiabatic element temperature (temperature of passive elements in wake of a single element being heated in the array).
$\theta(R1)$	Dimensionless temperature of the element directly behind the heated block.
$\tau_o$	Shear stress at the wall.
$\nu$	Kinematic viscosity.
$\nu_e$	Equivalent kinematic viscosity.

## I. INTRODUCTION

### A. DESCRIPTION OF THE PROBLEM

Over the past decade, recent advances in electronic systems have given rise to the challenging problems in applications of advanced heat transfer techniques to electronic equipment cooling. This study models forced convection cooling of electronic components on vertically oriented circuit boards where adjacent boards form channels, with one surface being relatively smooth, and the other populated by an array of large, heat dissipating elements. This research is of immediate practical interest to the electronics industry because cooling of electronic components has become increasingly important as power dissipation and component densities continue to increase in each new generation of electronic devices.

One method of electronics cooling is for a small cooling fan with a small capacity to blow or induce a flow of cooling air over a high density array of micro-electronic components mounted on a bakelite or epoxy board. This type of cooling offers low cost, high thermal reliability and an absence of noise. There is a desire in this study to understand the relation of rough walled heat transfer and the structure of flow in the near-wall region, it's conditions and it's relation to the separated flow heat transfer around bluff bodies.

This research, with it's practical relationship to the technical problems in the electronics industry, derives from the work in heat transfer from cubical elements done at Stanford University. This study extends the data base from cubical elements to rectangular low-height elements.

Printed circuit boards exhibit great variabilities in size and shape of components, and the way in which the components are arranged, as shown in Figure 1.1. Most geometries resemble plane surfaces with varying degrees of roughness which may be random in size and shape. The present study attempts to relate the heat transfer behavior of large rectangular heated elements in an array mounted on one wall of an adiabatic channel to the concepts of sub-layer Stanton numbers found in the literature for small scale rough wall theory.

There are many distinct methods available for mounting and inter-connecting electronic components and one of the most popular is the printed circuit board (PCB).

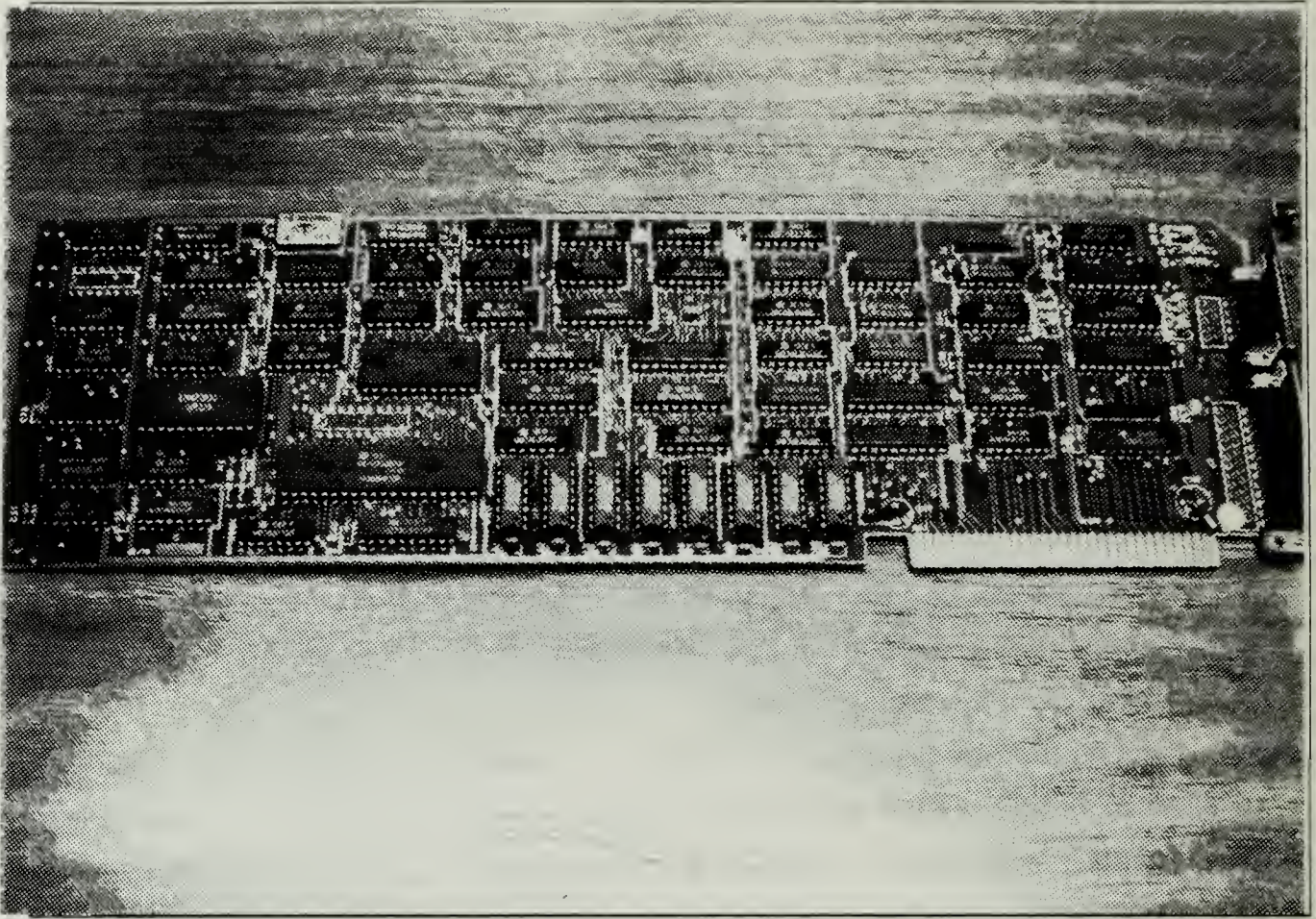


Figure 1.1 Photograph of a Printed Circuit Board for a Personal Computer.

This is a representative sub-system upon which arrays of heat dissipating electronic components are mounted. Components may be semi-regular in geometry as for example VLSI chip carriers, Dual-In-Line Packages (DIPS), and Single-In-Line Packages (SIPS), or they may be irregular shaped components on a board such as resistors and capacitors.

The distribution of components on a circuit board is application dependent, but frequently components are mounted "in-line" in the direction of the coolant flow. Space considerations often dictate PCB's to be mounted vertically in system racks and if multiple PCB's are utilized, they may be back to back in horizontal racks. Figure 1.2 shows a typical card stack in which many printed circuit boards, each with an array of hot components deployed on one side, are arranged to form long semi-continuous vertical channels, open at top and bottom for natural or forced ventilation.

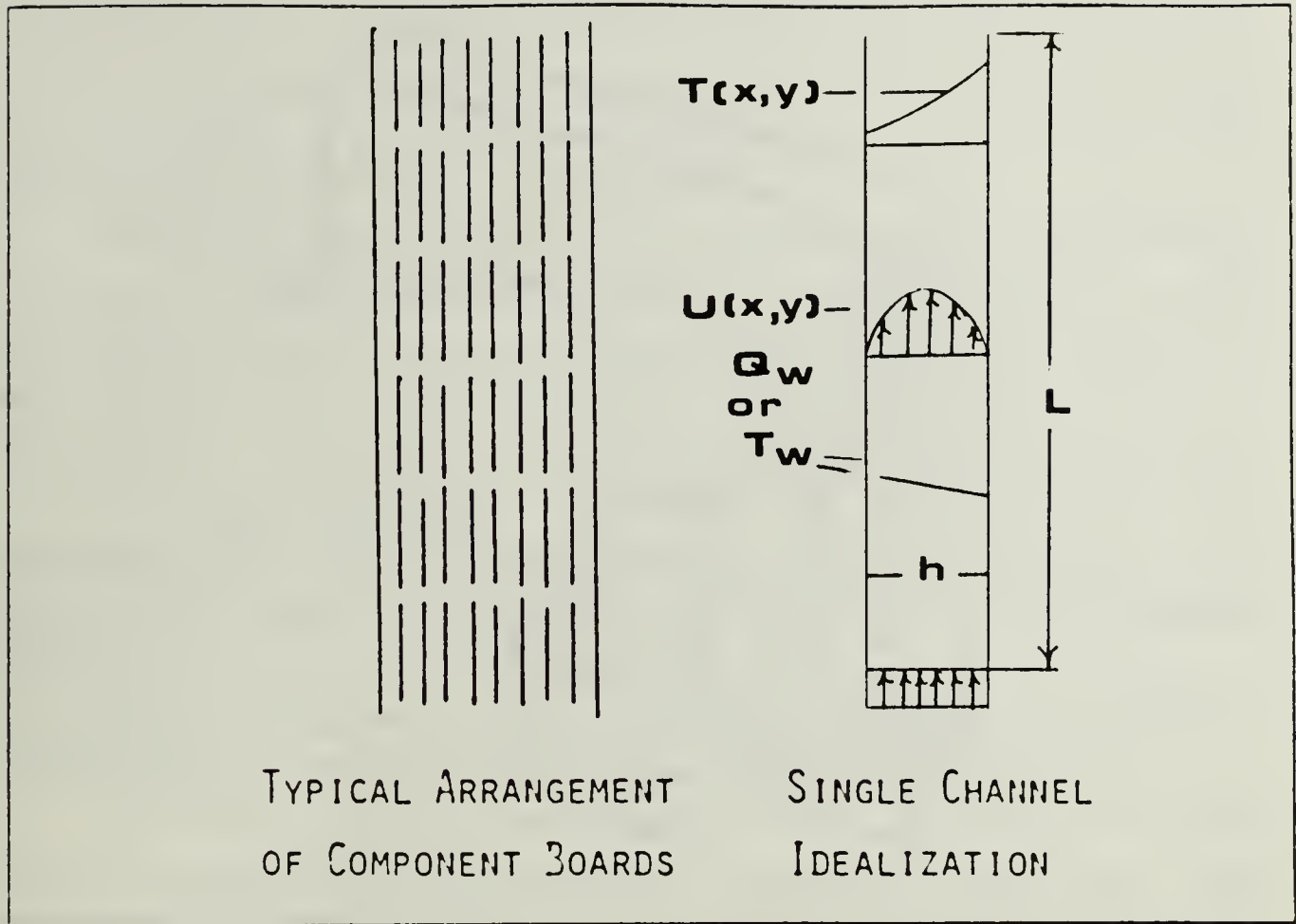


Figure 1.2 Typical configuration of printed circuit boards in rack and cabinet.

The present study is concerned with this type of configuration. The flow is induced through the arrays by a fan and ejected at the top. The heat-transfer surface has two characteristics: 1) heat dissipation is mainly from discrete sources on a plane surface, and 2) the sources are three-dimensional protrusions.

In order to study the problem, idealizations, as shown in Figure 1.3, have been developed. Array geometry is described by element shape and spacing,  $S$ , the wall to wall spacing,  $H$ , and the channel length,  $L$ . In order to remove geometric variabilities, rectangular elements were chosen to model Dual-In-Line Packages (DIPS). If  $B$  is the minor rectangular length scale, the geometry can be completely specified in terms of  $S/B$ ,  $H/B$  and  $L/H$ .

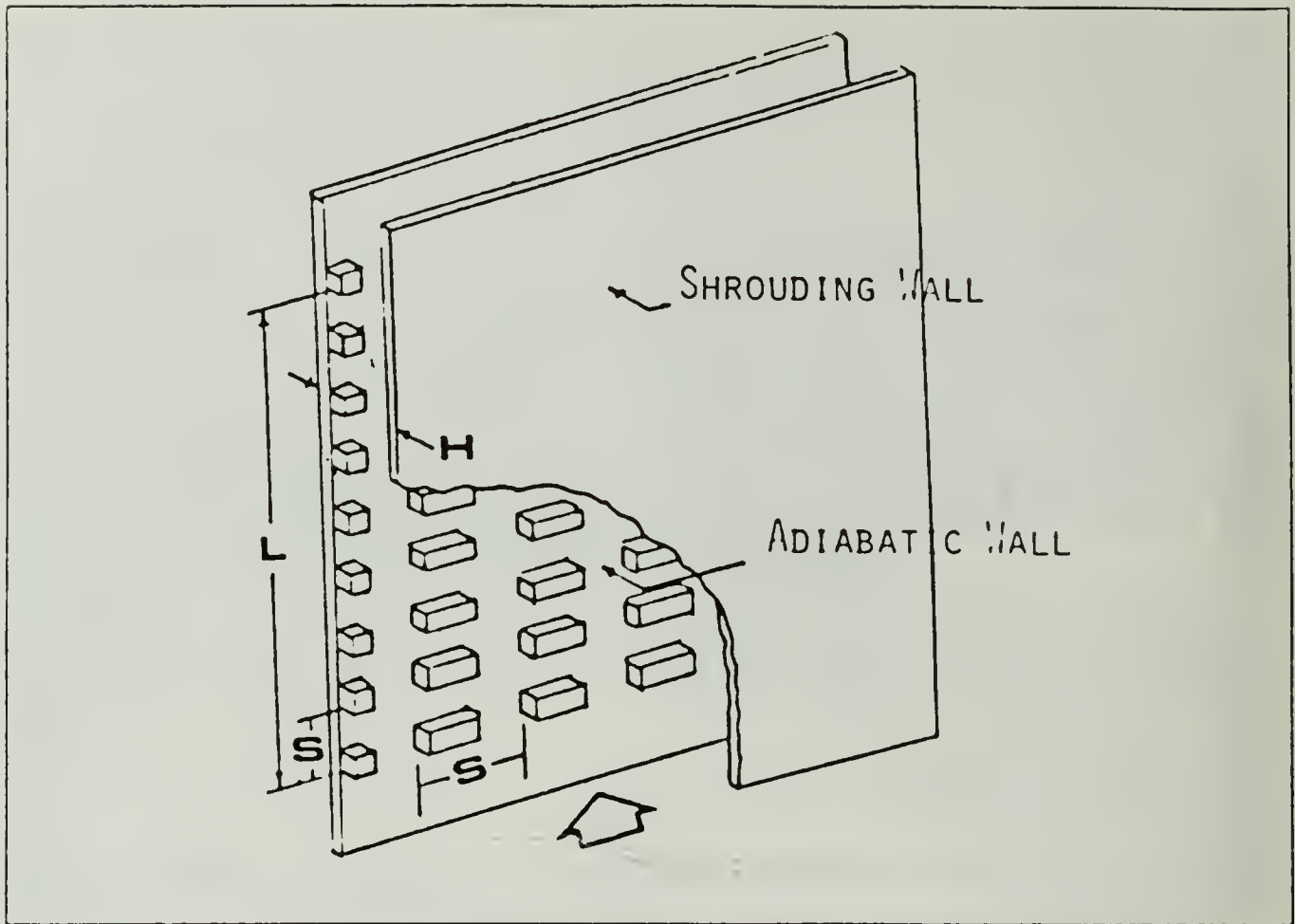


Figure 1.3 Test channel for present study, 1/2 inch x 1 inch low profile rectangular elements spaced at  $S/B = 1.0$  with 5 full columns, 2 half columns and 9 rows..

## B. PREVIOUS RELATED WORK

### 1. Electronics Cooling by Forced Convection

Several factors are taken into account when analysing a heat-removal system. Among these are the operating characteristics of the components themselves, the requirements of the electronic system designer with respect to component layout, and the operating environment of the system. Even if this information could be assimilated in guidelines, the packaging designer would still need a technique which would allow him to predict the thermal performance of the components. For the cooling of such geometries, there have been many attempts at the development of techniques, but success has been restricted to specific geometries. Trial and error is usually the basis for the successful development of the electronic modules.

There are two predominant areas of modeling. The first is the case of modeling small portions of the problem by finite elements. Heat transfer from an

element in an array on a PCB is a complex process. Heat is conducted from the component to its carrier circuit board, convected to the cooling air flow, and radiated to its surroundings. The opposing board delivers heat, by conduction, into the flow channel from elements located on its other surface.

By the use of finite element representation, elegant codes have been developed to compute the conduction and radiation interaction. The majority of these codes have been developed in the private sector, but some have been in the public domain. The book by Kraus and Bar-Cohen [Ref. 1] includes sample codes of this type where the convective heat transfer ultimately is handled by specifying the convective conductance, or the heat transfer coefficient, from the surface nodes to the cooling fluid. The specification of this surface conductance usually entails some experimental data from the prototype in question, along with standard correlations for highly simplified geometries with well known boundary conditions.

The major problem lies with the capabilities of the modern computer to handle enough of the problems to give the packaging designers practical input.

The second and most common category is the case where the physical situation has been reduced to an analytically or numerically tractable model. Many times the model no longer reflects all of the features of the actual situation, and subsequently piecewise improvements must be made. Most of the current modeling efforts are beginning to resemble the physical situations. There are still large strides to be taken before a true representation of the typical configuration can be made. Note that in both natural and forced convection the same details of flow behavior must be studied. It is possible to develop simplified models of forced convection but natural convection is much more difficult. With these observations it is not surprising to find that the literature typically presents empirical or semi-empirical approaches. Care must be taken in assessing the generality of most techniques since they quite frequently apply only within specific data base.

One summary concerning this topic was presented in the concluding remarks of the Directions of Heat Transfer in Electronics Equipment Research Workshop by A. D. Kraus [Ref. 2]. It is partially repeated here:

The problem of heat transfer in electronic equipment is readily admitted to be very complex and worthy of attention. The complexity is a result of many factors. Perhaps the most important of these is that the rapidly changing and highly competitive technology results in a vast multiplicity of complex physical configurations. Another general aspect of complexity is the first-order coupling of several physical phenomena. For example, it is usually not possible to

separately consider conduction, convection or radiation as separate modes of energy transport in electronic equipment. These modes are often inextricably tied together, along with additional complexities. Even an accurate formulation is often not possible. Simplifications lead to more tractable formulations, but, of course, do so at the expense of reduced accuracy. One faces here, the age-old problem of casting the results of the investigation of complex phenomena into easy-to-use form. It may be true that the development of simple design techniques for sufficiently complex phenomena is just not possible, although highly desirable. In any event, however, the attainment of such a goal would lead to great efficiency in design and operation of electronic equipment.

The attainment of this goal is made difficult by the fact that many of the most fundamental aspects of heat transfer in electronic equipment are not well defined. For example, it is often not clear whether the flow of air in card arrays is laminar, turbulent or a flow undergoing transition. Indeed, it may be a "meandering" laminar flow. Another example is the difficulty of making an accurate assessment of mixed convection effects. It is necessary to define such factors as a first step, if increased accuracy is to follow from increased understanding.

Heat transfer groups in both the electronics industry and at universities are concerned with thermal aspects of electronic equipment but each has different missions and constraints. Industry is certainly bound much more by practical constraints such as time deadlines and cost limitations. An overriding mission is to "get it to work," whether or not all of the fundamental details are understood. On the other hand, great improvement and efficiency in design and operation could perhaps be realized if the fundamentals were better understood. In university research, however, problems are often defined so as to make them "doable" rather than what really needs to be done and in the process, reality tends to be obscured. When real-world constraints are imposed, the results are often inapplicable because important complexities are ignored.

## C. BACKGROUND OF ACKNOWLEDGED DIFFERENCES DUE TO SURFACE ROUGHNESS GEOMETRIES

### 1. With Regard to Friction Behavior (k vs. d type)

Surface roughness has been classified into two general categories, two dimensional or three dimensional. (See Figure 1.4 for representation of two dimensional and three dimensional, rectangular type roughness.) These categories have further been divided into "artificial roughness" vs. "commercial roughness." As Schlichting [Ref. 3] points out, these surface subclasses often behave differently. To amplify the definitions, sand-grain roughness is of the three dimensional type, normally closely packed and spherical in shape and may be of the artificial or commercial subclass. Ribbed roughness is a representation of the two dimensional artificial type. Rib shape and pitch ratio further classify ribbed roughness.

The d - or - k type roughness classification is in use by researchers as a scheme for surface roughness description. The next few paragraphs summarize the classification scheme for k - and - d type roughness in the literature.

The framework of rough-walled flow analysis was established by Nikuradse [Ref. 4] who experimented with flow in sand roughened pipes. His experimentation led

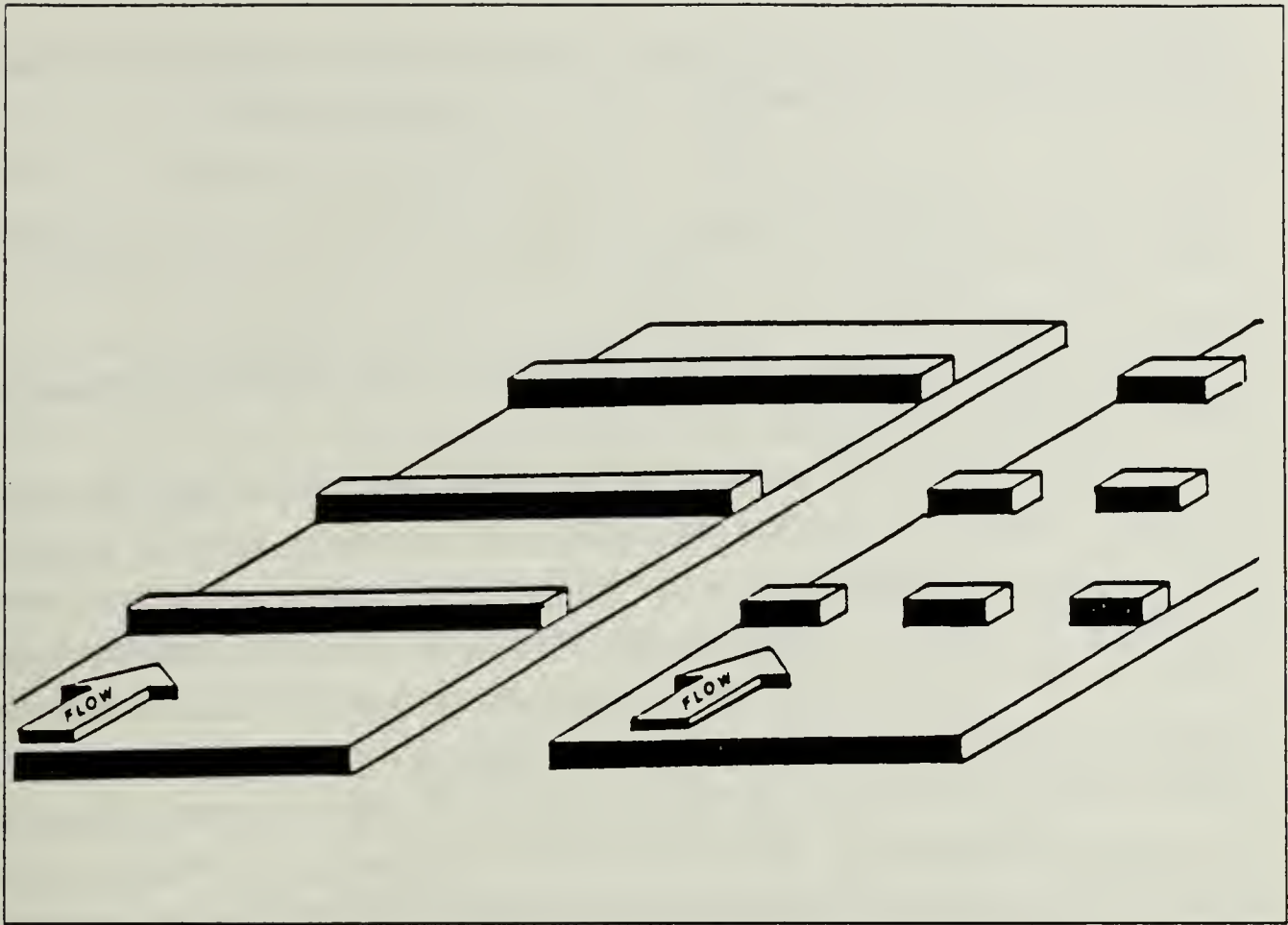


Figure 1.4 Rectangular roughness geometry,  
two dimensional vs. three dimensional..

to relationships between the flow behavior and the relative roughness scale  $k/d$  ( $k$  is the roughness scale and  $d$  is the pipe diameter) as well as the Reynolds number. Nikuradse's work led Clauser [Ref. 5] to form the logarithmic velocity distribution for flow over rough walls.

$$\frac{u}{u_{\tau}} = \frac{1}{\kappa} \ln \left( \frac{yu_{\tau}}{\nu} \right) + A - \frac{\Delta u}{u_{\tau}} \quad (\text{eqn 1.1})$$

In this equation  $u_{\tau} = \sqrt{\tau_o/\rho}$ , with  $\tau_o$  = the wall shear stress and,  $\rho$  = fluid density. The roughness function  $R^+ = (\Delta u/u_{\tau})$ , which is zero for smooth walls.  $\kappa$  and  $A$  are universal constants. Equation 1.1 can be written for smooth walls as:

$$\frac{u}{u_{\tau_o}} = \frac{1}{\kappa} \ln \left( \frac{yu_{\tau}}{\nu_e} \right) + A \quad (\text{eqn 1.2})$$

Hama [Ref. 6] showed from results of an extensive experimental program that equation 1.1 and the Clauser form of roughness function for fully rough flow,

$$\frac{\Delta u}{u_{\tau}} = \frac{1}{\kappa} \ln \left( \frac{\kappa u_{\tau}}{\nu} \right) + \text{constant} \quad (\text{eqn 1.3})$$

are both universal for a given roughness geometry in a pipe, channel and zero pressure gradient boundary-layer flow.

Arvizu [Ref. 7: p. 7], summarized Perry's [Ref. 8] test to determine the relative roughness function. To illustrate the method, first consider a graph of  $C_f$  plotted against  $\ln \text{Re}$  for a smooth pipe in turbulent flow. Here both  $C_f$  and  $\text{Re}$  are based on the bulk mean velocity  $u_b$ . Now, from equation 1.2, note that the rough-wall velocity profiles can be collapsed onto the smooth-wall results by replacing  $\nu$  by some equivalent viscosity,  $\nu_e$ . It follows, therefore, that a rough-wall friction factor versus Reynolds number curve for constant  $\nu_e$  is identical to the smooth-wall curve with  $\nu$  replaced by  $\nu_e$  in the Reynolds number. Hence the curves of constant  $\nu_e/\nu$  in the  $C_f$  vs.  $\ln \text{Re}$  graph are simply the smooth-wall friction factor graph shifted sideways by a factor  $\ln(\nu_e/\nu)$ . Equation 1.2 also shows that these curves are also contours of  $\Delta u/u_{\tau}$ . By plotting experimental data on this graph, it is possible to read off the appropriate value of  $\Delta u/u_{\tau}$  and to calculate the product  $\text{Re} \sqrt{C_f/2} \times (k/d)$ , or simply  $\text{Re}^+(k)$ . Note that  $C_f$  can be determined by force or pressure measurements. One then plots  $\Delta u/u_{\tau}$  vs.  $\text{Re}^+(k)$ . If a correlation is found to exist, then it is stated that the roughness function depends on the height  $k$  and this roughness geometry is called  $k$ -type roughness. If instead it correlates on  $\text{Re} \sqrt{C_f/2} = du_{\tau}/\nu$ , then it is classified as  $d$ -type roughness, referring to its dependence on the equivalent pipe diameter. For the equilibrium boundary layer in zero pressure gradient, the correlation height has been shown by Perry [Ref. 8: p. 390], to be the boundary-layer thickness,  $\delta$ .

Sand grain geometry has been verified to be of  $k$ -type and further correlated by Clauser's roughness function form [Ref. 7: p. 8]. Studies of ribbed two dimensional roughness geometries have also made it apparent that the roughness parameter can also be correlated with  $k$ , the roughness height. Closely spaced ribbed roughness, i.e.  $P/K \leq 2$  however is one of  $d$ -type roughness.

Arvizu [Ref. 7: p. 9], summarized the data concerning the roughness function  $R^+$ . With ribbed roughness pitch ratio the roughness ratio reaches a constant value,

i.e.  $R^+(\infty)$ , for high values of  $Re^+(k)$ . Sand grain and several other roughnesses have been experimentally observed. A curve of  $R^+(\infty)$  vs.  $P/k$  ratio for ribbed roughness is constructed as shown in Figure 1.5 [Ref. 7: p. 21]. This curve shows a marked difference in the  $Re^+(\infty)$  behavior for the two distinct pitch-ratio ranges given by values above and below a nominal value of  $P/k \sim 8$ . This suggests that pitch ratios in the range of seven (7) to ten (10) fall in the transition region between two different roughness function behaviors. Further, a surface has the highest  $St$  and  $C_f$  when  $P/k$  ratio is seven (7) to (8). Studies of the pressure distribution around rectangular finned surfaces for various pitches have divided the loss into two components, friction and form drag. It is concluded that friction losses are at a minimum at  $P/k$  of about ten (10). At  $P/k \sim 8$  to 10 flow reattachment to the bottom of the wall downstream of the separated shear layer over a rib occurs. This flow behavior represents an independent event and is significant in determining  $k$  or  $d$  type behavior.

Only a handful of researchers use the terminology of  $k$  and  $d$  type roughness. The general concensus is not apparent, but many allude to the characteristics of these classifications. This thesis is not concerned with the small grained roughness, but rather with large roughness compared with scale of the measurement probe. In this experiment the boundary layer is disturbed to the point of turbulence within the array.

## 2. With Regard to Heat Transfer

The development of the equivalent heat-transfer roughness parameter,  $g^+$  is an extension of the friction-factor roughness parameter,  $R^+$  development. There are several assumptions needed. The interpretation of  $g^+$  is commonly referred to as the inverse of a sublayer Stanton number

$$g^+ = 1/St_{\text{sublayer}} = C_1(e^+)^p(Pr)^q \quad (\text{eqn 1.4})$$

The constants  $p$  and  $q$  fall into two categories:

1. Assumption of similarity of the profiles near the wall results in  $p = .2$ ,  $q = .44$ .
2. Assumption of breakdown close in to the wall leads to the neglect of the roughness subsequently  $p = .45$  and  $q = .57$ .

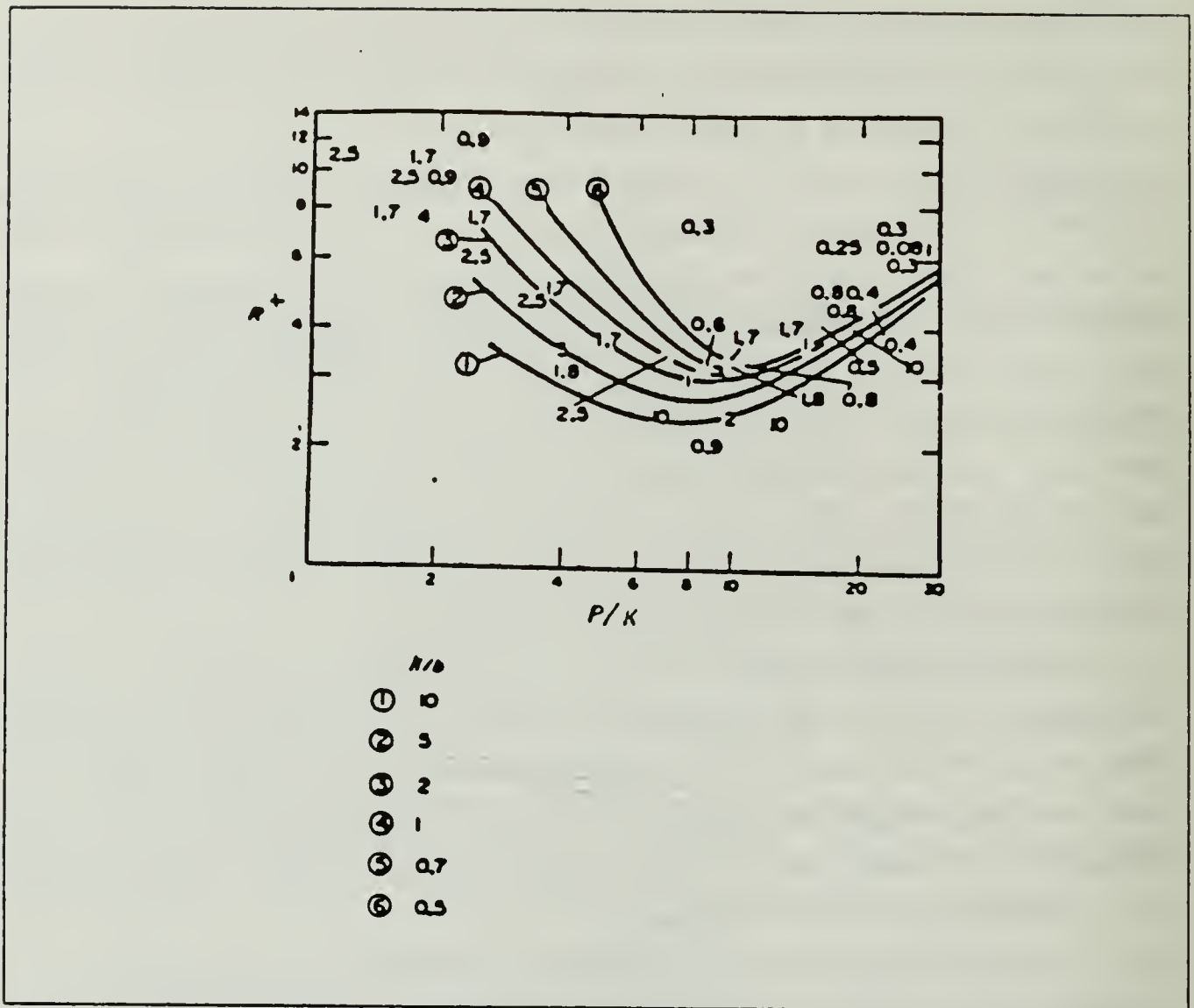


Figure 1.5 Roughness function vs. pitch ratio for rectangular ribbed roughness.

#### D. THE RESEARCH PROBLEM

##### 1. Objective

The discussion of the previous sections showed the two areas of concern in this study. The first was the more practical nature of determining heat transfer coefficients to sophisticated techniques in determining the temperature distribution by modern computer codes. The second area was to look at the surface roughness area.

This research was more concerned with the practical applications by studying the convective aspects of the circuit pack problem, utilizing an adiabatic wall (similar to epoxy-glass circuit boards commonly used). The necessary radiation and conduction corrections were made to the model. A specific geometry was selected in order to

model present technological trends. Isolating a particular geometry for study, i.e., the regular rectangular element, allows the program to fit nicely into the study of classical small scale roughness theory, since geometry length can be easily described. With these intentions, the following objectives have been defined.

1. To develop a model of a circuit board and forced convection apparatus using regular rectangular elements as the geometry.
2. To develop methods for calculating the temperature distribution in a regular array of arbitrarily heated rectangular elements on an adiabatic wall in a channel.
3. To compare the heat transfer behavior to previous work in this area by Arvizu, Ortega and Piatt. [Refs. 7,9,10]

## 2. Approach

The approach taken was to conduct an experimental study paralleling the study of forced convection in cubical arrays by Arvizu [Ref. 7: p. 17-19]. The model geometry is as shown in Figure 1.3. It consists of an array of rectangular elements mounted on a nearly adiabatic wall. There will always be an opposing smooth wall. The opposing wall and channel sides are thus impermeable.

The geometry chosen for study, were  $1/2'' \times 1/2'' \times 1''$  rectangular elements in a relatively sparse in-line array. This geometry and arrangement was intended to resemble the flat geometry and configuration presently used in electronic equipment. This geometry does retain two important features which cannot be ignored: The heating takes place on discrete locations of the surface of the array and these locations are three dimensional protuberances of a particular geometry.

For this study, use was made use of the superposition principle used by Arvizu [Ref. 7: p. 18]. Arvizu considered a regular array of passive elements with the exception of a single heated element. This element causes energy to be convected to the elements within the wake of the downstream airflow causing their temperatures to rise. These temperatures represent the adiabatic temperatures of passive elements.

For this study, only elements in the same column as the heated block were considered. In this way, the assumption was that the governing equations were linear. The adiabatic temperatures were calculated by simply adding the contributions from each of the two elements. Thus, adiabatic temperatures could be determined by adding or superposing the contributions from each of the upstream heated elements. The contributions from an element five rows upstream would be different from that of one located one row away. Therefore, it was necessary to determine the entire thermal wake profiles of the column elements. Furthermore, it was expected that the thermal

wake profiles would be functions of the previously mentioned parameters, i.e. H B, S B, position in the array, and mass flow rate.

Once the adiabatic temperature of an element has been determined, its temperature rise above adiabatic temperature could be calculated from a knowledge of the heat transfer coefficient and its heat dissipation. It was also expected that the heat-transfer coefficient also would be a function of all the parameters of interest.

The approach taken was similar to the one taken by Arvizu [Ref. 7: pp. 17-19]. Heat-transfer coefficients for each position in the column were determined experimentally (by heating each element individually and measuring the temperature rise) as a function of channel-height ratio, and mass flow rate. As each element was being tested, the column wake profile was also determined by measuring the temperature of the downstream elements. Then, all heat transfer parameters and constants were calculated and analysed for trends.

## II. APPARATUS AND INSTRUMENTATION

### A. INTRODUCTION

The experimental apparatus was designed to measure the heat transfer rates from each element in an array of rectangular elements mounted on a vertical surface with an opposing vertical surface in a forced flow. The objective to obtain was an extension of heat-transfer data of Arvizu [Ref. 7: pp. 35-40], to a different shape than his cubical elements. All equipment was manufactured by the Engineering Department of the Naval Postgraduate School, Monterey, California. Most aspects of the design and instrumentation reflect the space and budget allocations for this experiment.

### B. WIND TUNNEL

The measurements for the experiment were taken in a draw through open-loop wind tunnel with a vertical test section Figure 2.1. The tunnel intake bell with an eighteen (18) inch radius of curvature has an orifice cross-section of forty (40) inches by twelve (12) inches. Adjustable legs are attached at each corner to serve as supports, provide an eighteen (18) inch clearance off the floor and level the tunnel. The intake section was constructed of one-eighth ( $1/8$ ) inch plexiglass. One inch reinforcement plexiglass was attached to the exterior to provide additional support to the test section.

The test section, Figure 2.2, was constructed of one-eighth ( $1/8$ ) inch plexiglass with the exception of access and mount plates made of one-quarter ( $1/4$ ) inch plexiglass. The test section channel has a four (4) inch by twelve (12) inch cross-section with a height of eighteen (18) inches. A pitot-static tube was mounted on the access plate opposite the test surface to measure the free stream velocity over the test plate.

The top of the wind tunnel was reduced to a section of two (2) inch PVC ducting which was connected to a 550 scfm turbo-fan compressor, Figure 2.3. Air flow through the tunnel was controlled by a series of valves connected in line with the flow.

The access plate opposing the test surface has a splitter plate mounting to offset any boundary layer formed between the bell inlet and the test section. The distance was predetermined by use of computer software [Ref. 11] and is displayed in Figure 2.4.

To eliminate the effects of incident radiation, a wooden frame box (4'x4'x8') was constructed around the wind tunnel. The box also served to reduce any transient air currents created by movements in the room (i.e., doors opening and closing).

The primary test section, Figure 2.5, was modified to accept the test plate mounted on four screws. The screw mountings offered the means by which the test channel height could be varied within the test section. It was not an objective of this investigation to study effects of inlet conditions such as boundary-layer thickness and free stream turbulence. It was desired only to maintain a uniform free-stream core velocity. In order to maintain clean parallel flow (i.e. no separation) at the leading edges of the splitter plate and test surface, it was necessary to match the flow resistance in each of the three separate flow channels. Each time the test plate was adjusted, this flow matching had to be performed. Matching was checked by means of a wool thread inserted into the flow path. The thread indications were subjective, but found to be a dependable method to determine if leading edge separation had occurred. The flow resistance matching was accomplished by a four (4) inch plexiglass flap mounted on the downstream edge of the test surface see Figure 2.2. A hot wire anemometer was mounted upstream of the test surface. The hot wire anemometer was used to probe the channel checking for uniform air flow entering the test section.

### C. TEST SURFACE

The design of the test surface was inspired by the test surfaces used by Arvizu [Ref. 7 pp. 33-40], and Ortega [Ref. 9: pp. 25-30]. The test surfaces were constructed of a 12"x18"x3/8" sheet of balsa wood (adiabatic surface) cemented to a 12"x18"x1/8" sheet of plexiglass. The leading edge of the balsa wood-plexiglass test surface was cut at a thirty-five (35) degree angle to form a sharp leading edge, reducing the effects of leading edge separation. The balsa wood surface was sanded and painted with one coat of aluminum heat resistant paint and five coats of white enamel paint. The white enamel paint was sanded between each application to ensure a smooth test surface. Small (1/16" diameter) holes were drilled to permit the access of thermocouples and resistor leads into the rectangular elements mounted on the face of the test surface. Three mounting screws were attached to the plexiglass plate and to the access plate which were utilized in the positioning of the test surface.

#### 1. Elements

The array, Figure 2.6, consists of nine rows of five complete elements and two half elements mounted at the ends of each row. Rows were spaced at one half (1/2) inch intervals with the columns having a one inch spacing. The first row of elements was located four (4) inches from the leading edge. The elements used in this study

were aluminum rectangular prism nominally 1/2"x1/2"x1". Each element in the array could be heated separately and had one embedded thermocouple for temperature measurement. The heater consisted of a one ohm, one watt resistor. In order to minimize thermal conduction through the power leads, the normal resistor leads were trimmed almost flush to the resistor body and replaced with fine AWG-20 gauge wire leads soldered to the remaining stubs. The resistors were potted in a 3/16" diameter hole in the element with Thermal Epoxy so that only the fine leads protruded from the base of the element. Element temperature was monitored with 20 AWG Type T thermocouples potted in a 3/8" deep well with a 1/32" diameter using a general purpose glue (super glue).

The 3/8" well depth was selected to insure thermocouple wires were embedded to a minimum of fifty (50) wire diameters to produce negligible conduction error in the thermocouple signal. After assembly, the elements were cemented to the test surface with the same glue used to pot the thermocouples. The heater leads and thermocouples were fed through the board holes drilled in the pattern of the heater and thermocouple leads. The heater and thermocouple leads were further fed through single access holes located in the access plate for eventual hookup to the heat input control patch board and the temperature instrumentation.

## **D. INSTRUMENTATION**

### **1. Temperature Measurements**

Type T copper constantine thermocouples were routed through an access plate in the wind tunnel test section through the test plate and potted in each element. The thermocouples were connected to six scanner boards in an Autodata Nine. The Autodata Nine is a self contained, 100-channel data recording device, Figure 2.7. Channels were on ten (10) wafer style boards so the master unit could be used to measure voltages or temperatures with the appropriate value taken directly as output. For this equipment, fifty-eight (58) channels were configured for direct read out in Fahrenheit. All fifty-eight (58) thermocouples and the Autodata Nine were calibrated as a system to an accuracy of  $\pm 0.2^\circ$  Fahrenheit. (Appendix A)

### **2. Hotwire Anemometer**

The Hotwire Anemometer and associative equipment consisted of five major items:

1. Hotwire probe, Figure 2.2
2. Resistance Bridge, Figure 2.7

3. Amplifier Filter Display Unit, Figure 2.7
4. Oscilloscope, Figure 2.7
5. Micro-manometer, Figure 2.9

A TSI (Model 1050 1050AA) hot wire anemometer was used to determine the velocity profile prior to entry into the test section. The hot wire anemometer was calibrated with the micro-manometer and used only to ensure that the approach velocity was uniform.

### 3. Velocity Measurements

Measurements of the flow rate through the test section were obtained by a micro-manometer and a pitot-static tube. The difference between the dynamic and static pressure was measured by the micro-manometer. The pitot static tube was mounted on the access plate opposite the test surface (see Figure 2.5). Accuracy of the micro-manometer was determined to be  $\pm 0.0005$  inches of water which translates to an error of  $\pm 0.2$  ft./sec. or 7 cm/s.

### 4. Power Supply and Power Measurement

A LAMBDA (60 volt, 10 amp) regulated power supply (Model LK 3454 FM), Figure 2.7, was utilized to supply power to the heaters.

A switch board was constructed to distribute power to the individual heaters or combinations of heaters, whichever was required. A Hewlett Packard digital multimeter (3466 A) was utilized to measure voltage and a Westinghouse ammeter measured current, Figure 2.7. The total power was computed as the product of the measured current and voltage drop. For the test, the power supply was set manually to obtain the desired heater voltage.

## E. DATA REDUCTION

The primary data-reduction program "JITTER", was written to facilitate taking inputs from manual readings and reducing them to usable parameters for analysis. The program required input concerning Audodata Nine readout, atmospheric pressure, voltage, current input to the heaters, micromanometer reading and test plate setting. The program automatically calibrated thermocouples and calculated Reynolds and Nusselt numbers, convective heat transfer coefficients and freestream velocities. (Appendix B)

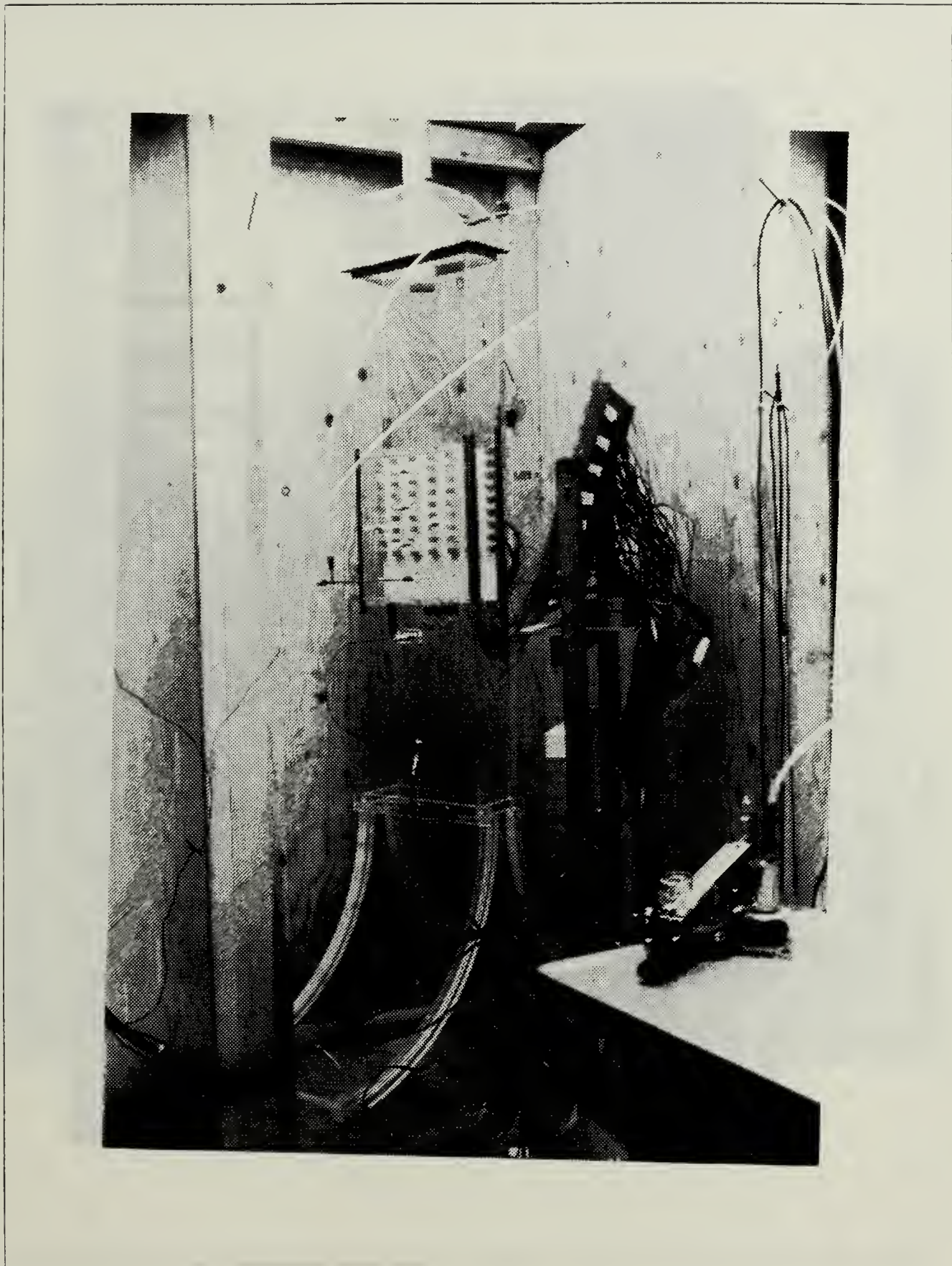


Figure 2.1 Photograph of Wind Tunnel System..

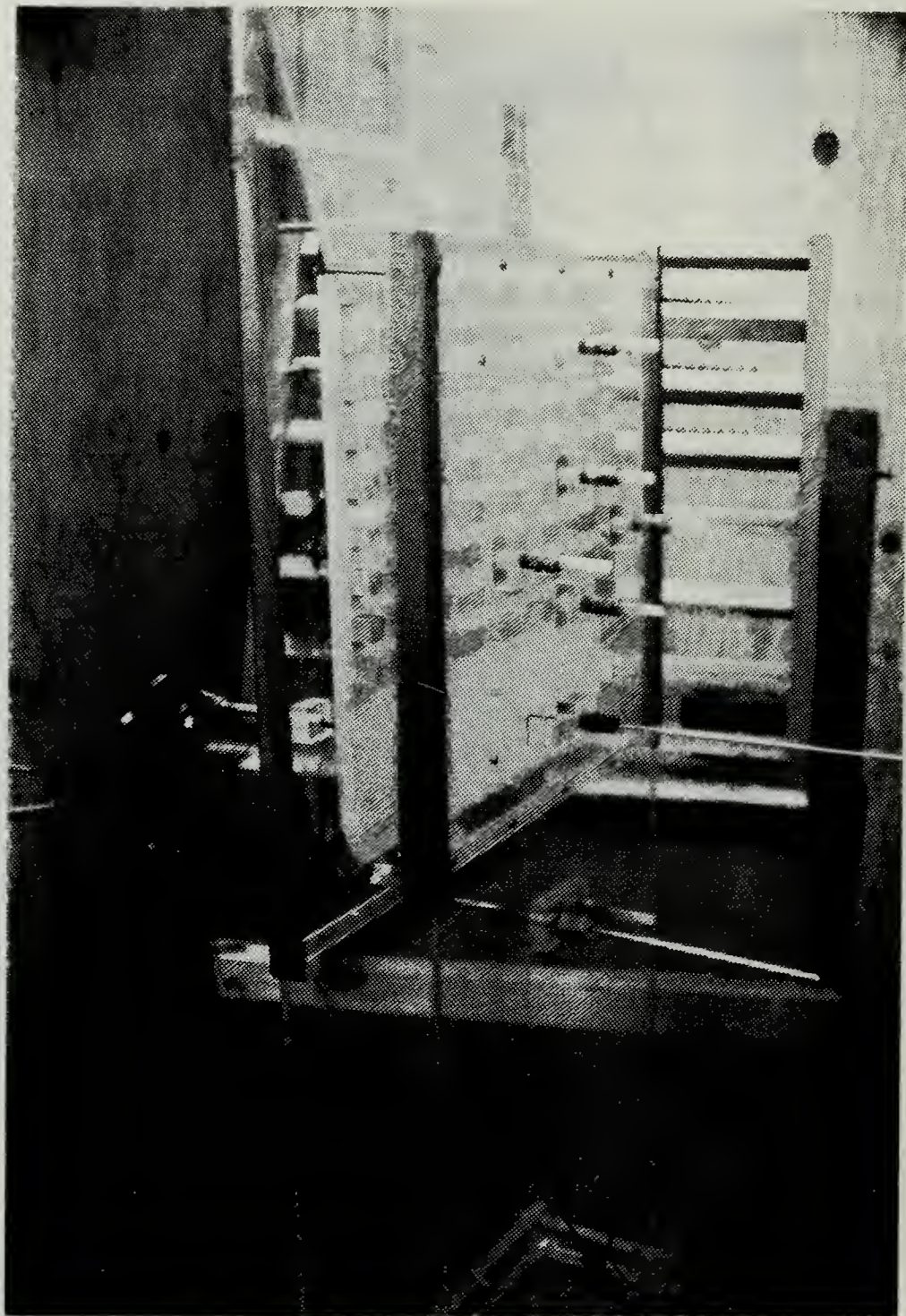


Figure 2.2 Wind Tunnel Test Section.

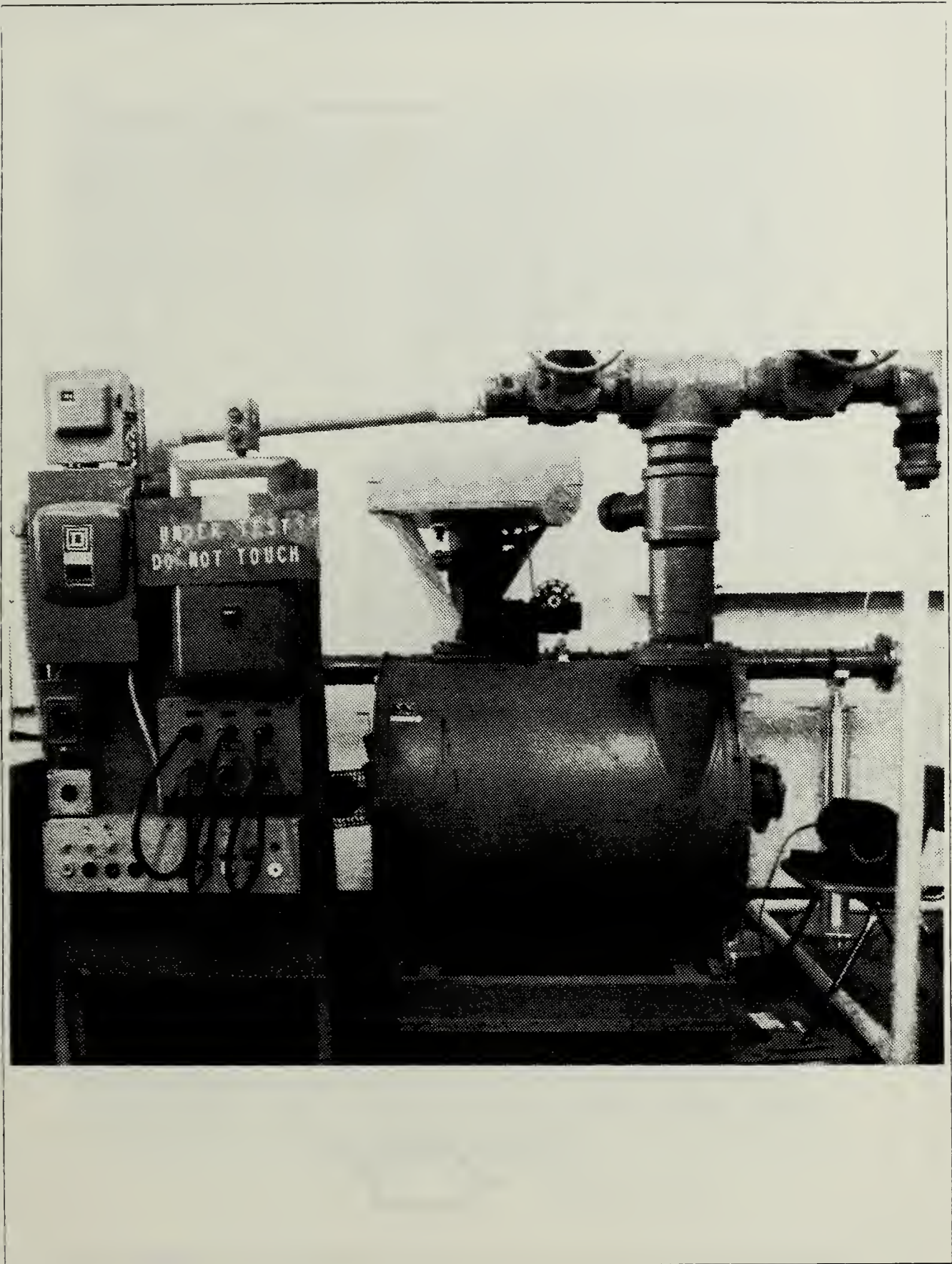


Figure 2.3 Photograph of the Wind Tunnel Air Compressor.

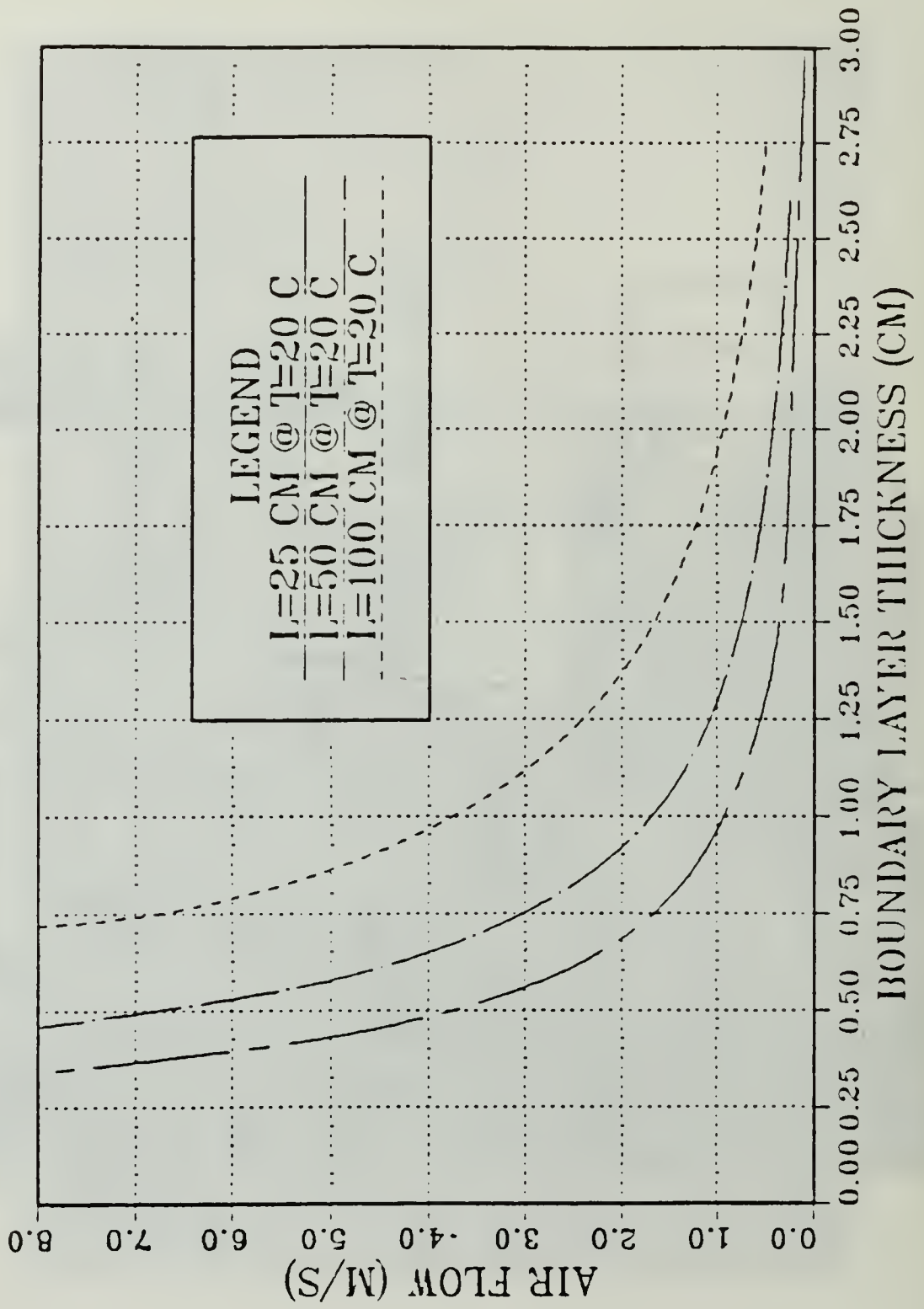


Figure 2.4 Approach Velocity vs. Boundary Layer Thickness for Various Channel Lengths.

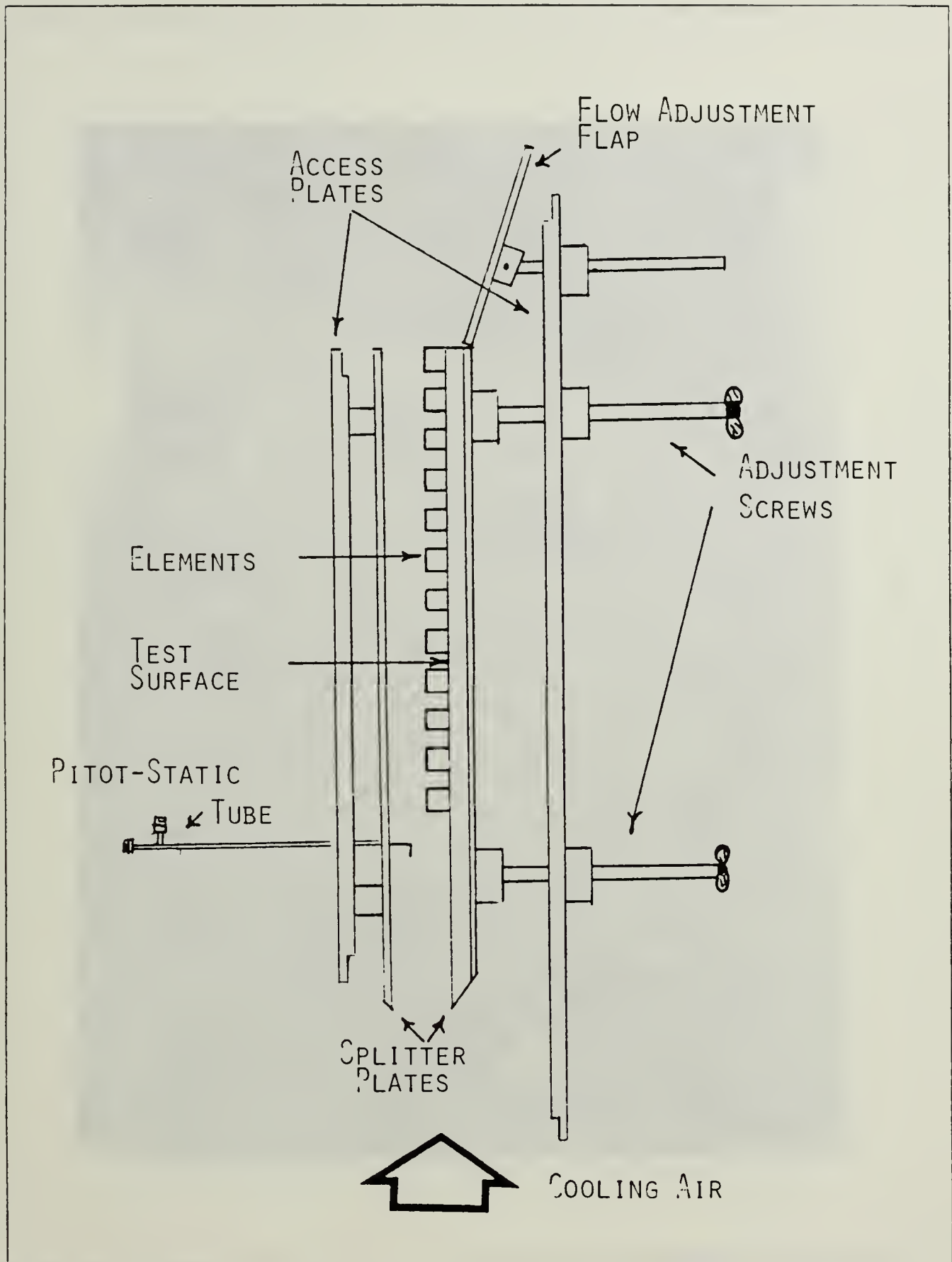


Figure 2.5 Sketch of Test Surface Configuration.

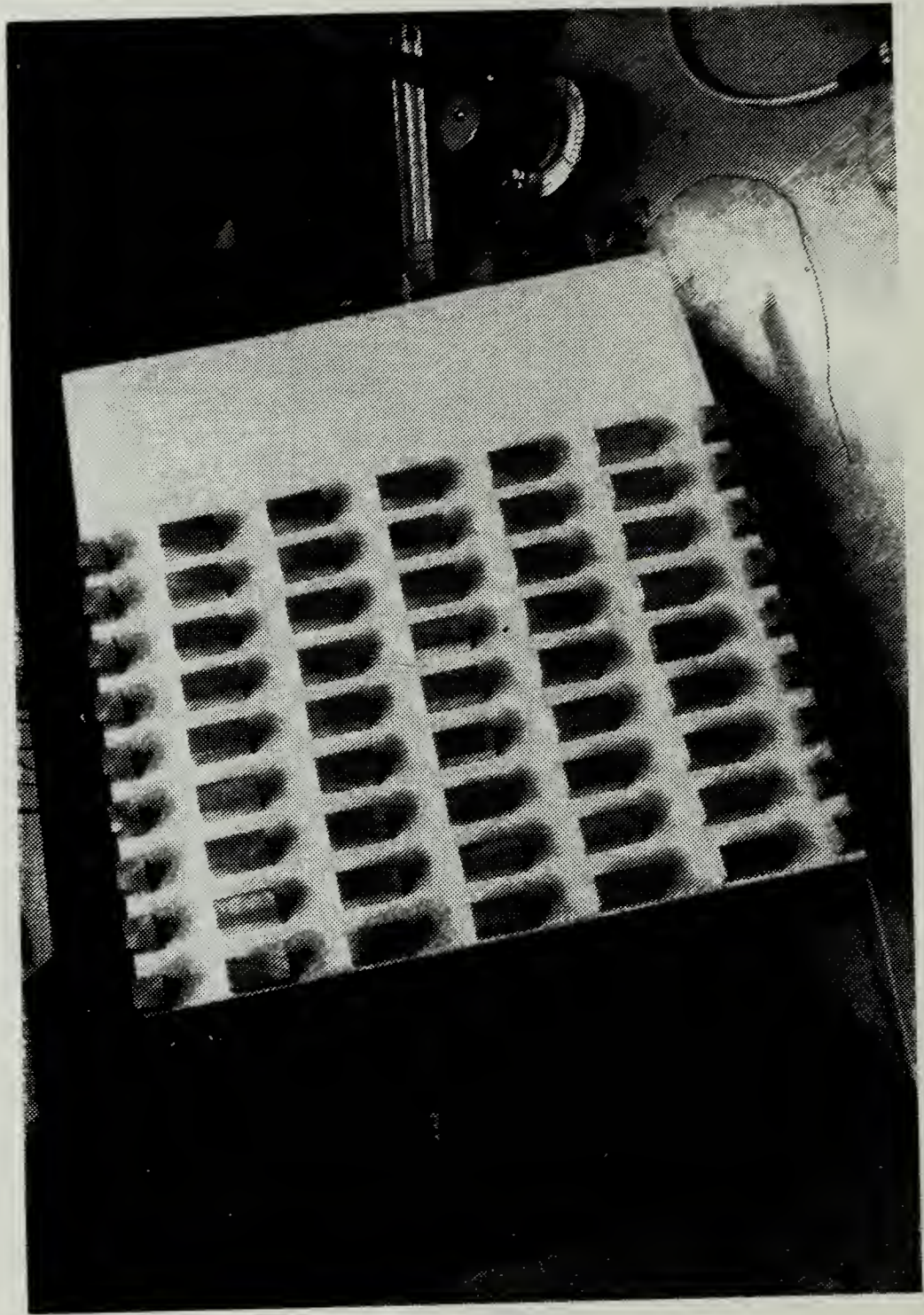


Figure 2.6 Photograph of the Test Plate used in the Experiment.

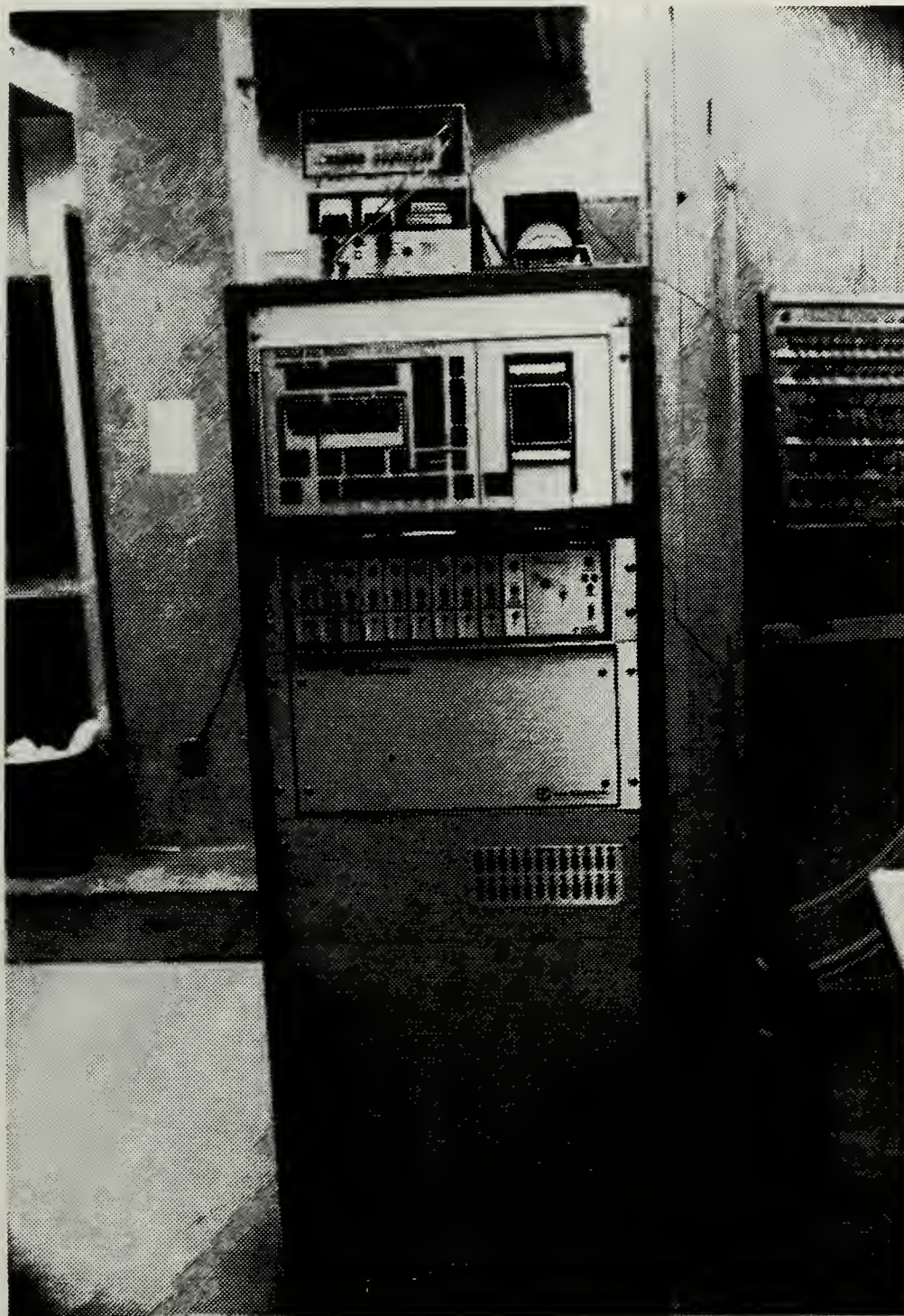


Figure 2.7 Photograph of the Auto-Data Nine.

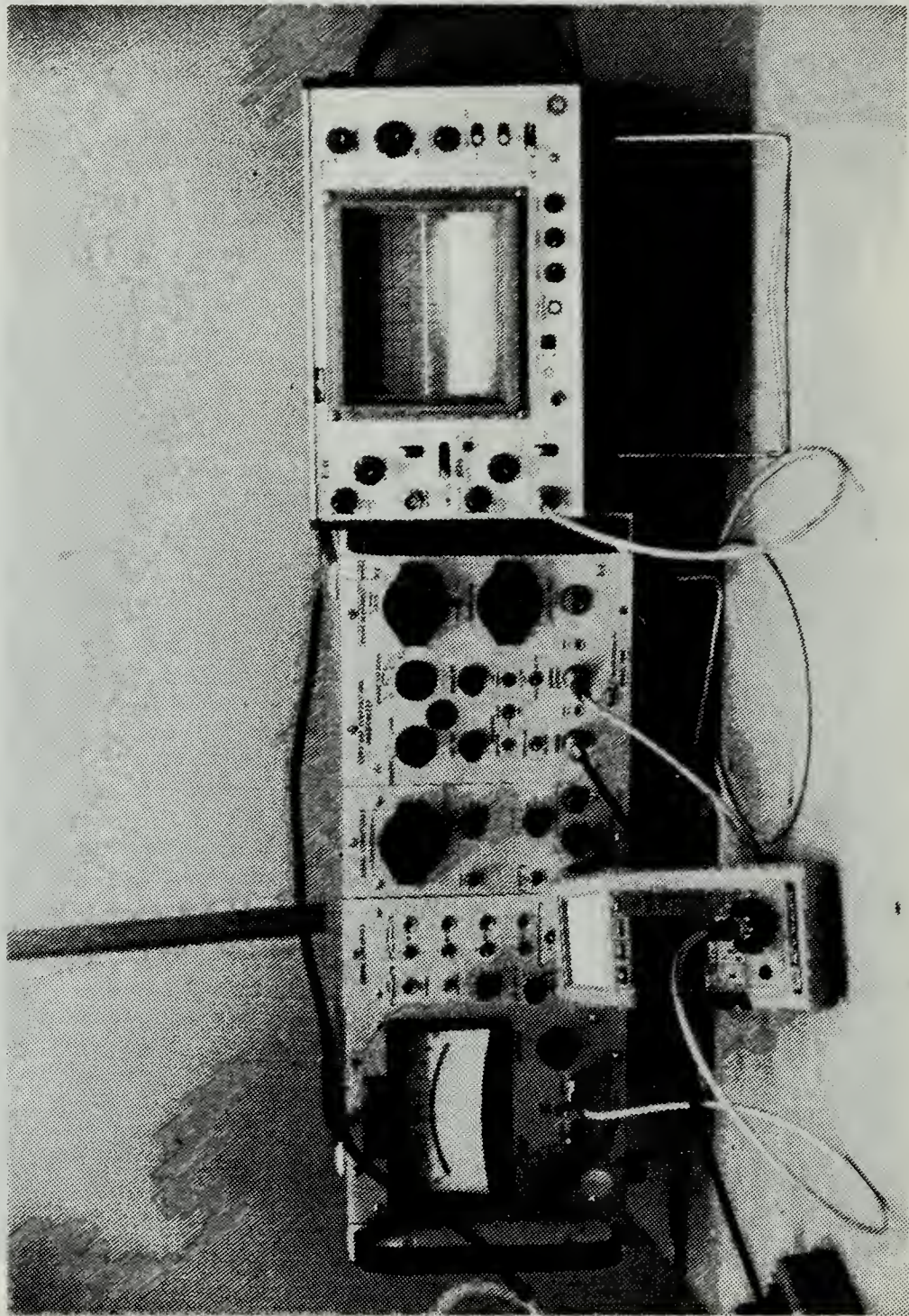


Figure 2.8 Photograph of the Hotwire Instrumentation.

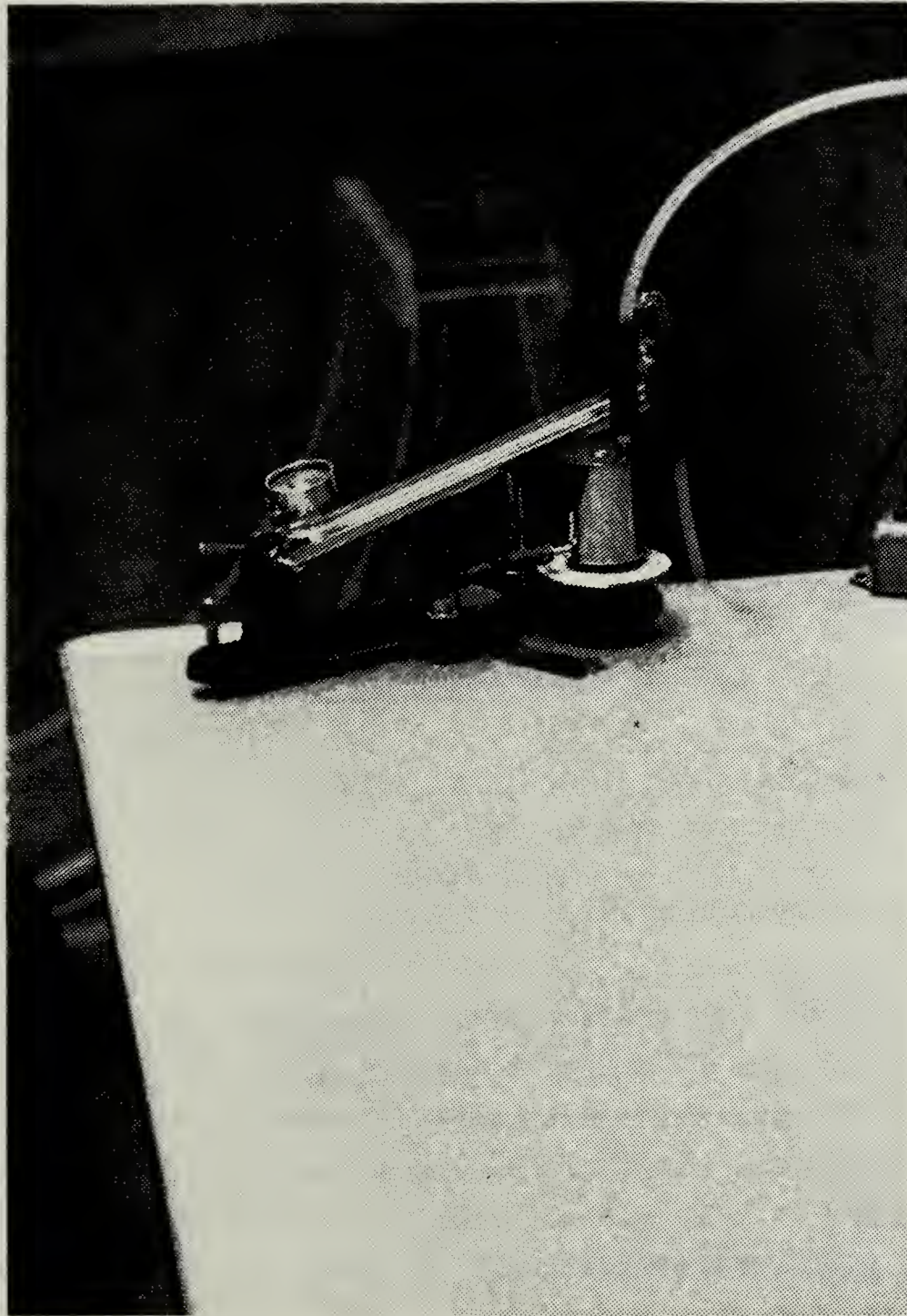


Figure 2.9 Photograph of the Micro-manometer.

### III. EXPERIMENTAL RESULTS

#### A. INTRODUCTION

As discussed in Chapter one, the heat transfer behavior is a function of spacing, channel height and flow velocity. The measurements may be considered as divided into two categories:

1. Heat Transfer Coefficient
2. Thermal Wake Function

Table 1 summarizes all parameters. All data is included in Appendix B. Table 2 is provided for the understanding of the graphical curves found in the legends.

TABLE 1  
RANGE OF EXPERIMENTAL PARAMETERS TESTED

Thermal Wake			
H/B	1.0	2.3	4.6
Data Row No.	1-6	1-6	1-6
$u_{ref}$ m/s	1.5, 3.0, 4.5	1.5, 3.0, 4.5	1.5, 3.0, 4.5
Heat Transfer Coefficient			
H/B	1.0	2.3	4.6
H. B. Row No.	1-6	1-6	1-6
$u_{ref}$ m/s	1.5, 3.0, 4.5	1.5, 3.0, 4.5	1.5, 3.0, 4.5

#### B. THE RESEARCH ITSELF

The test surface was initially positioned with the top of the cubes touching the opposing wall. The free-stream air velocity was allowed to stabilize at the required velocity and the individual cubes were heated and allowed to warm-up for approximately 90 minutes. Temperature readings for the entire array were taken and the initial cube heater was turned off and another cube heater was allowed to heat and

TABLE 2  
LEGEND SYMBOLS

$H_{x,x}R_xV_{x,x}$	
$H_{x,x}$	Channel Height, Cylinder Height Ratio $x,x$
$R_x$	Row That the Heated Cylinder is in $x$
$V_{x,x}$	Approach Velocity $x,x$

stabilize. All temperature readings and air flow velocities were taken at the selected channel height. The channel height was adjusted and the data acquisition was repeated. Through this adjustment, of channel height and flow velocities, all cube temperatures were measured.

### C. HEAT TRANSFER COEFFICIENT

The heat transfer coefficient in this study is given by

$$h = \frac{q/A}{T_e - T_{ref}} \quad (\text{eqn 3.1})$$

The power input to the element is  $q$  and  $A$  is the total area of the block exposed to the air (five sides if  $H/B > 1$ ; four sides if  $H/B = 1$ ).

In Figure 3.1, the average heat-transfer-coefficient data,  $h$ , for single blocks heated in the first row of an array were plotted against  $H/B$  ratio, for three different velocities. At  $H/B = 1.0$  (channel height = block height) the value of  $h$  is highest for any given approach velocity. The blockage ratio was largest in this geometry and the rectangular cubes are exposed to the highest "local" velocities for a given approach velocity. As  $H/B$  is increased,  $h$  drops off. The flow appears to take the path of least resistance: over the array instead of through it.

Figure 3.2 shows  $h$  for a block heated in the sixth row of the array, plotted against  $H/B$  for the same conditions as Figure 3.1. The trends in Figure 3.2 are the same, but here, in the interior of the array, the effects are more pronounced. At  $H/B = 1.0$ ,  $h$  in row six is predominantly higher than the values in row one, while for  $H/B = 4.6$ ,  $h$  in row six is predominantly lower than in row one.

Figure 3.3 is a cross-plot of  $h$  vs. position for  $H/B = 1.0$ , parametric on velocity. The value of  $h$  for velocities of 3.0 and 4.5 m/s increase with distance into the array and at 1.5 m/s  $h$  stays fairly constant. The increase in  $h$  can be attributed to the increased turbulence level with downstream distance.

Figure 3.4 is also a crossplot of  $h$  vs. position in the array, for  $H/B = 4.6$ , parametric on velocity. For this channel height, the value of  $h$  decreases with distance into the array for velocities of 3.0 and 4.5 m/s. At the velocity of 1.5 m/s the  $h$  stays fairly constant. The behaviors can be attributed to the velocities at 3.0 and 4.5 where there was a reduction in the local mass flow rate below the crests of the elements. There was a slight increase in  $h$  during the first two rows before it began to decrease.

The mass flow rate below the crests of the elements and the level of turbulent kinetic energy per unit mass of flow were the influencing factors on the heat transfer. This behavior is shown in Figures 3.1 - 3.4.

Figures 3.5 and 3.6 present the heat transfer data in terms of Nusselt number  $\times H/B$  vs. Reynolds numbers for two different locations within the array (rows 1 and 6).

#### D. THERMAL WAKE PROFILE

The thermal wake behind a single block in an array was influenced by the  $H/B$  ratio, position in the array and the mass flow rate. Present methods for calculating the distribution of temperature in the array uses the superposition of the wake functions of individual heated blocks. The  $\theta$  dimensionless temperature parameter is used to analyse the thermal wake.

$$\theta = \frac{T_{\text{measured}} - T_{\text{amb}}}{T_{\text{hb}} - T_{\text{amb}}} \quad (\text{eqn 3.2})$$

Figures 3.7 - 3.9 relate the temperatures of the blocks downstream of the heated block, in the same streamwise column, to the value of  $\theta(R1)$ . The data was plotted as measured dimensionless temperature  $\theta$ , normalized on  $\theta(R1)$  vs. the row number downstream of the heated block. A simple  $1/N$  type dependence was observed. Arvizu [Ref. 7: p. 53], found that, with cubes, this relation is  $1/N$  vice a  $1/x$  relationship. He also relates this behavior to the dispersion behavior of the pollution behind a single source. The concentrations decayed with distance to the 0.6 and 0.7 power.

## E. INTERPRETATION OF RESULTS

In general, it has been shown that:

$$\text{Nu} = C_1 \text{Pr}^m \text{Re}^n \quad (\text{eqn 3.3})$$

Because Pr for this experiment can be considered a constant, it is combined with  $C_1$  and the equation becomes  $\text{Nu} = C_1 \text{Re}^n$ . The definition of Reynolds number uses the characteristic velocity related to the array velocity. In this experiment,  $n$ , the exponent value, varies between .55 to .60. Arvizu [Ref. 7: p. 82], found that the coefficient  $n$  is directly related this to the array density, with  $n$  equal to .8 for a smooth wall and  $n$  equal to .5 for cubical arrays with a  $S/B$  equal to 1.5.

### 1. The Array Velocity

Recall Figure 3.4, which shows that the value of the convective heat transfer coefficient,  $h$ , decreases in the flow direction for  $H/B > 1.0$ . The value of  $h$  is a direct reflection of the local air flow around the cube. This suggested that the flow immediately around the cube was decreasing, even though the total flow was constant. Arvizu states [Ref. 7: pp. 85-86], that for cubical arrays, the local flow within the array is the same whenever that axial pressure drop is the same. He also found that there would be the same flow within the array whenever there was the same pressure gradient, regardless of the value of  $H/B$ . This assumes that the roughness elements are responsible for most of the pressure drop in the channel: i.e., that the wall shear and bottom wall shear are negligible.

It is possible from the above paragraph to assume that the array velocity and block height are to be used to form the Nusselt number and  $H/B$  can be removed as a parameter for this study.

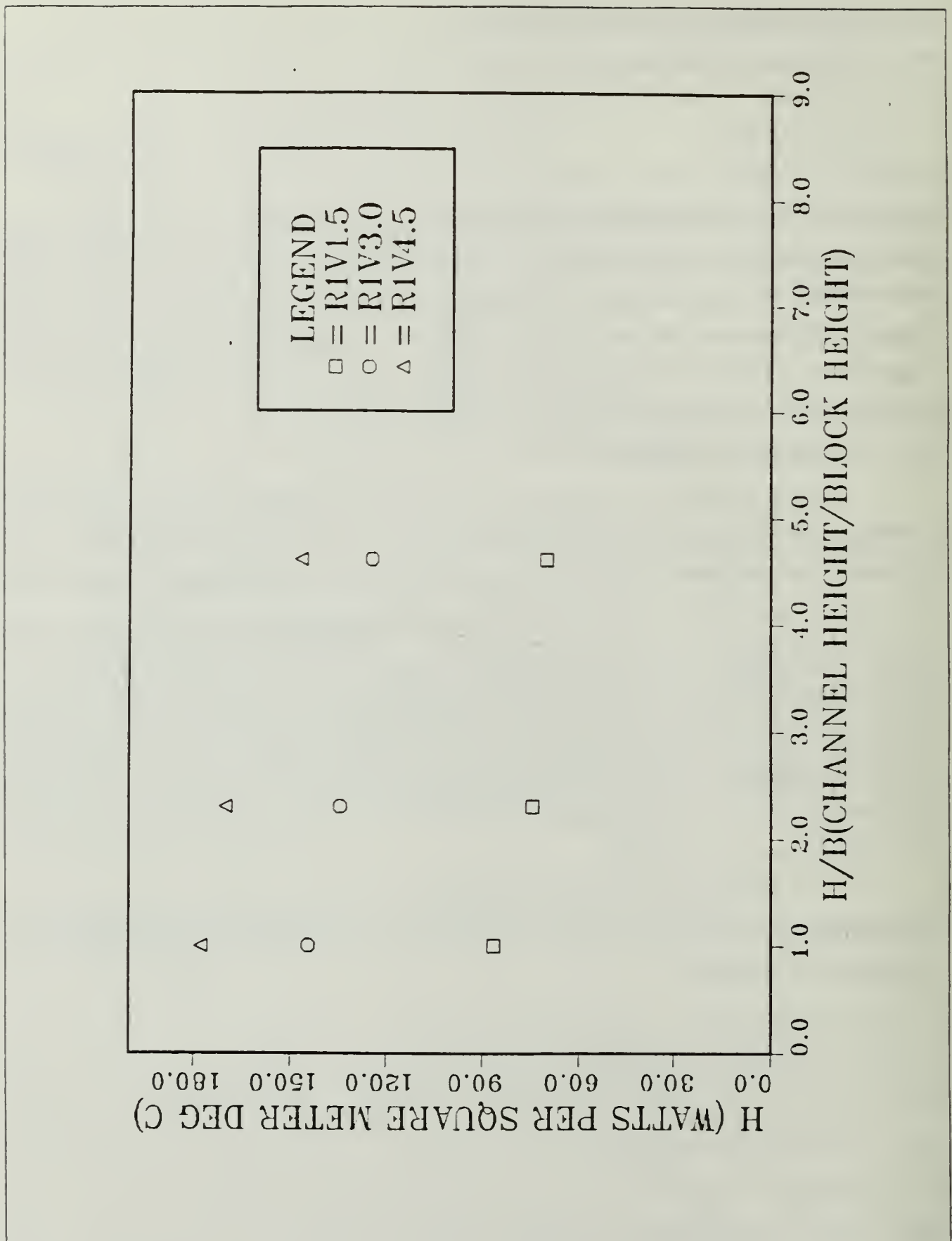


Figure 3.1 Heat Transfer Coefficient vs. channel height ratio for a heated element in the first row..

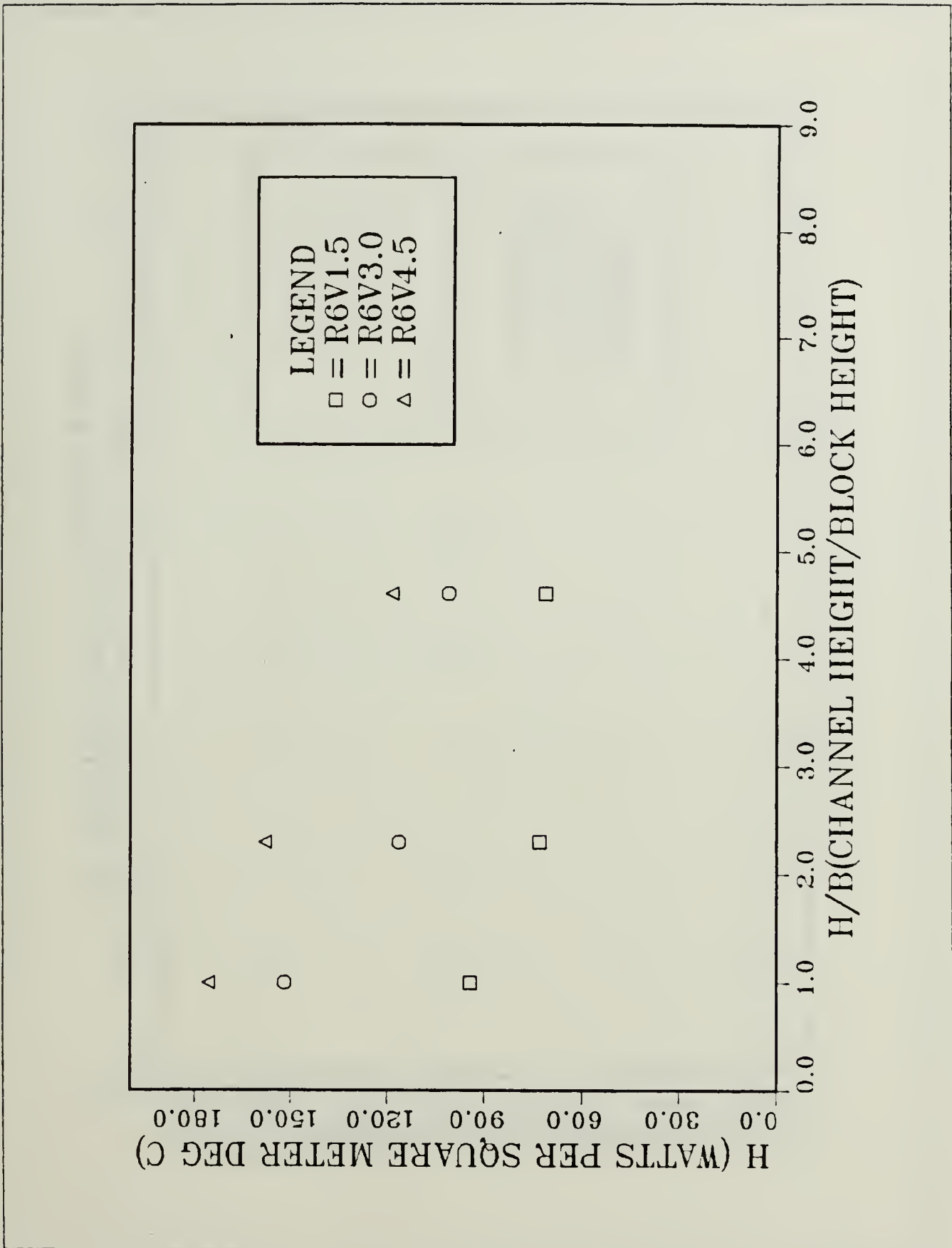


Figure 3.2 Heat Transfer Coefficient vs. Channel Height ratio for a heated element in the sixth row..

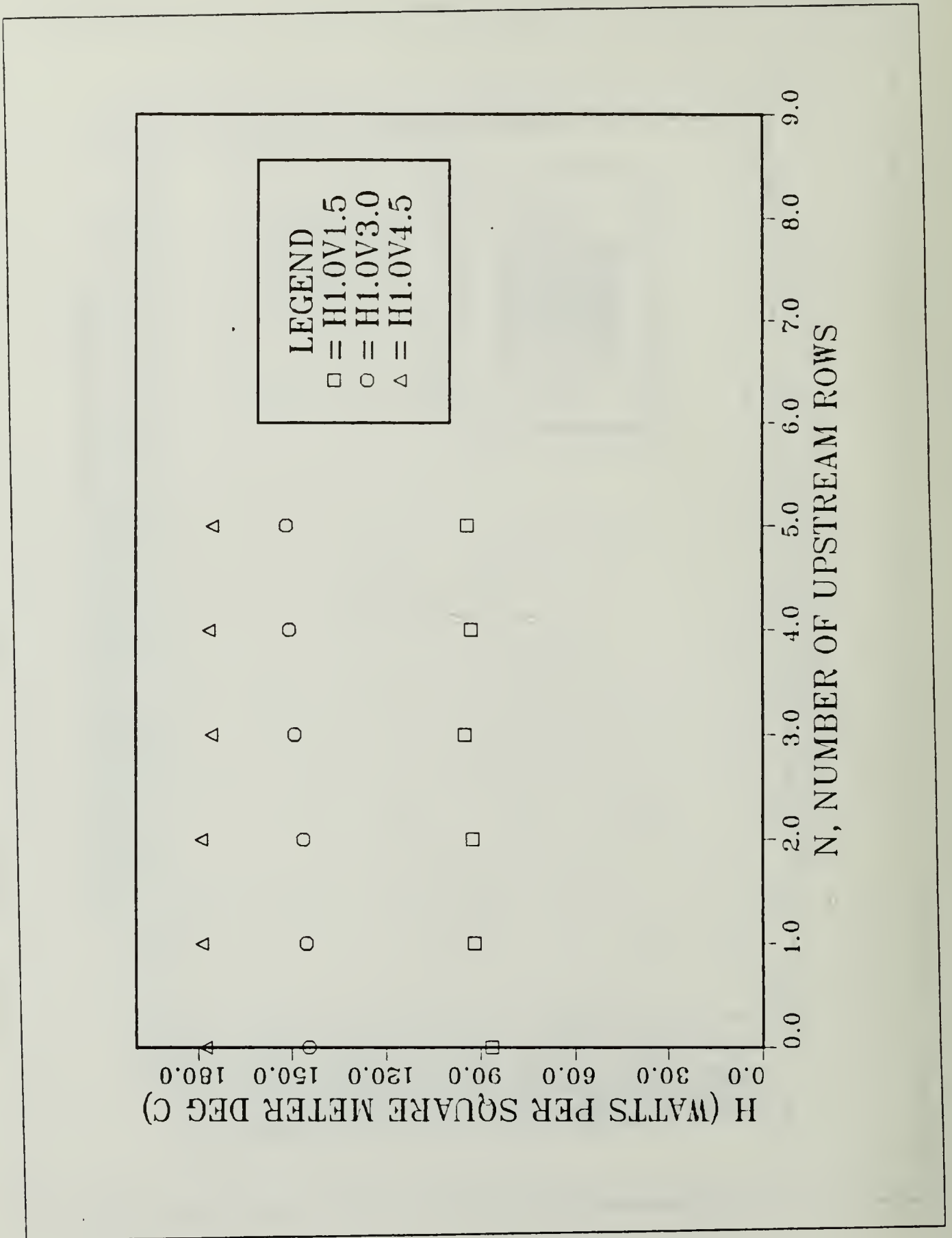


Figure 3.3 Heat Transfer coefficient vs. row position for  $H/B = 1.0$ .

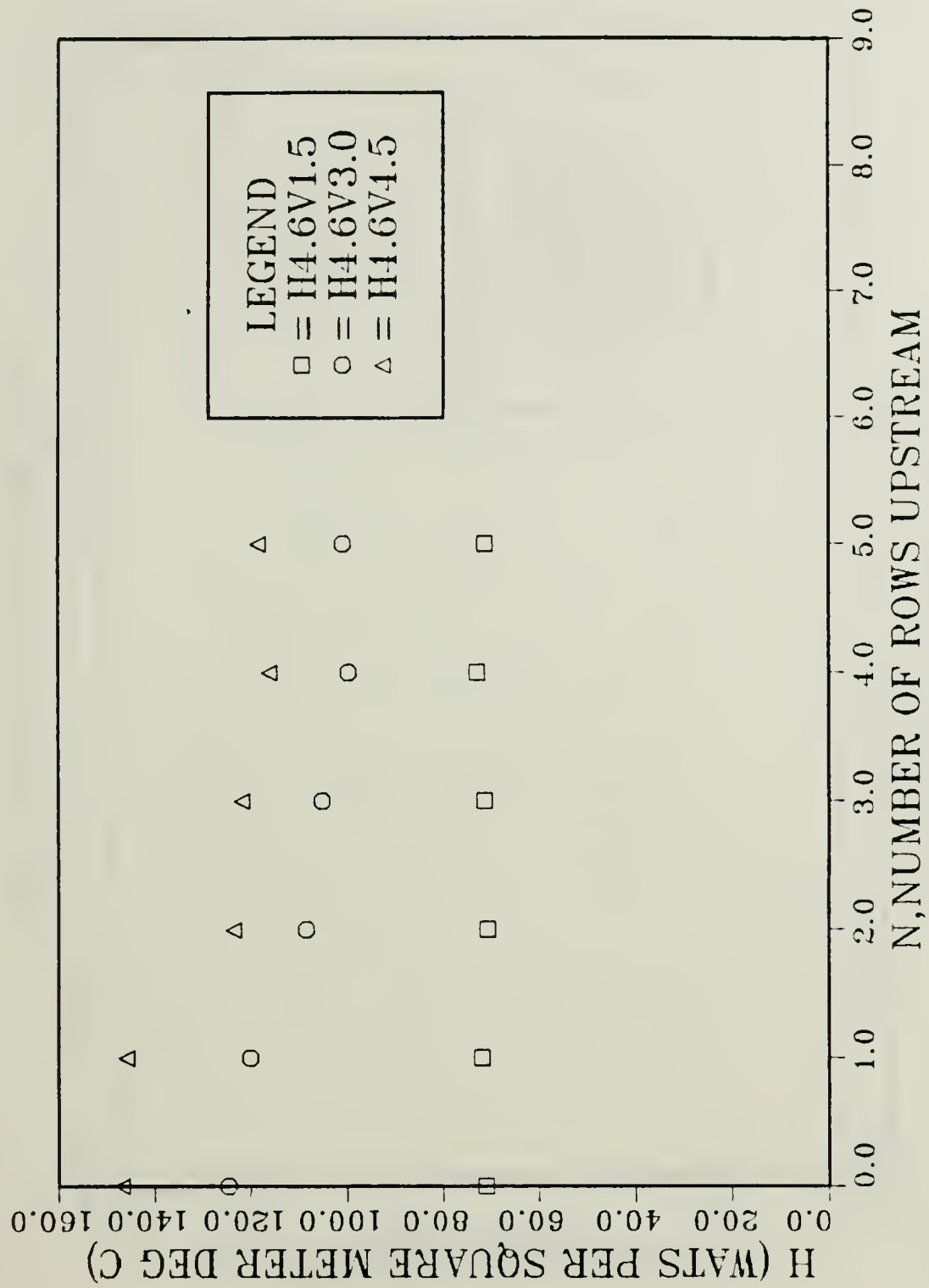


Figure 3.4 HeatTransfer coefficient vs. row position for H/B = 4.6.

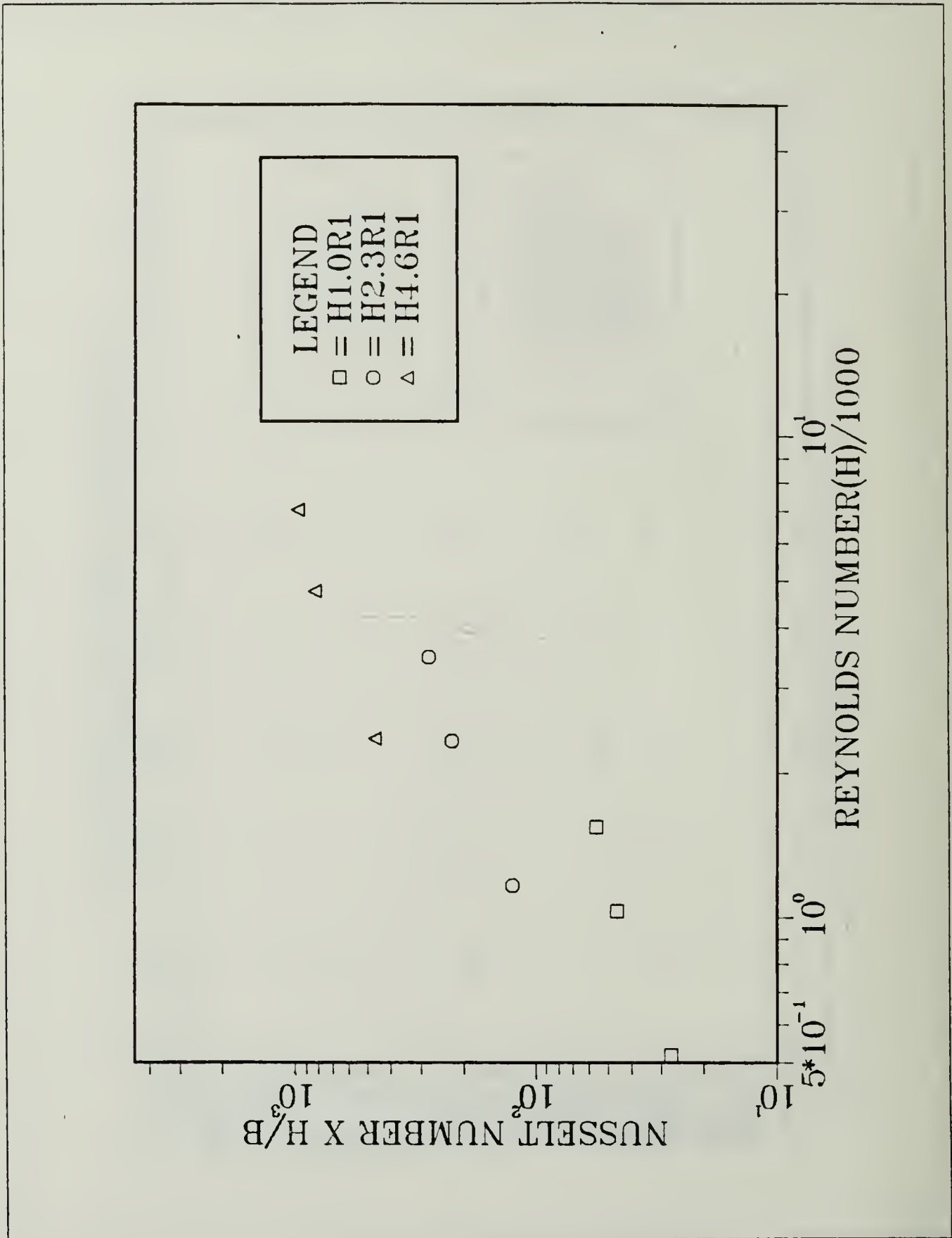


Figure 3.5 Modified Nusselt number vs. duct Reynolds number for heated element in the first row.

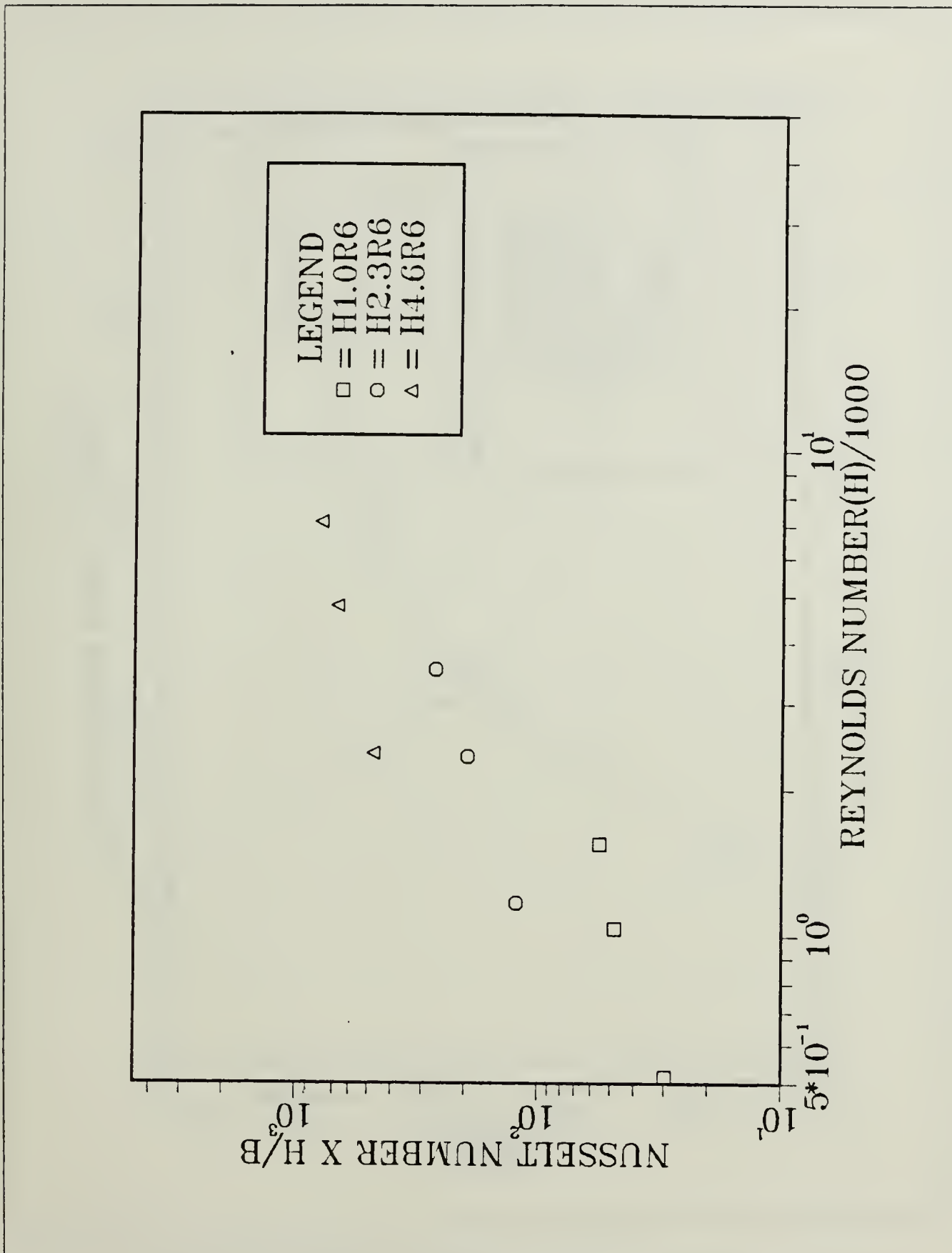


Figure 3.6 Modified Nusselt number vs. duct Reynolds number for heated element in an interior array position.

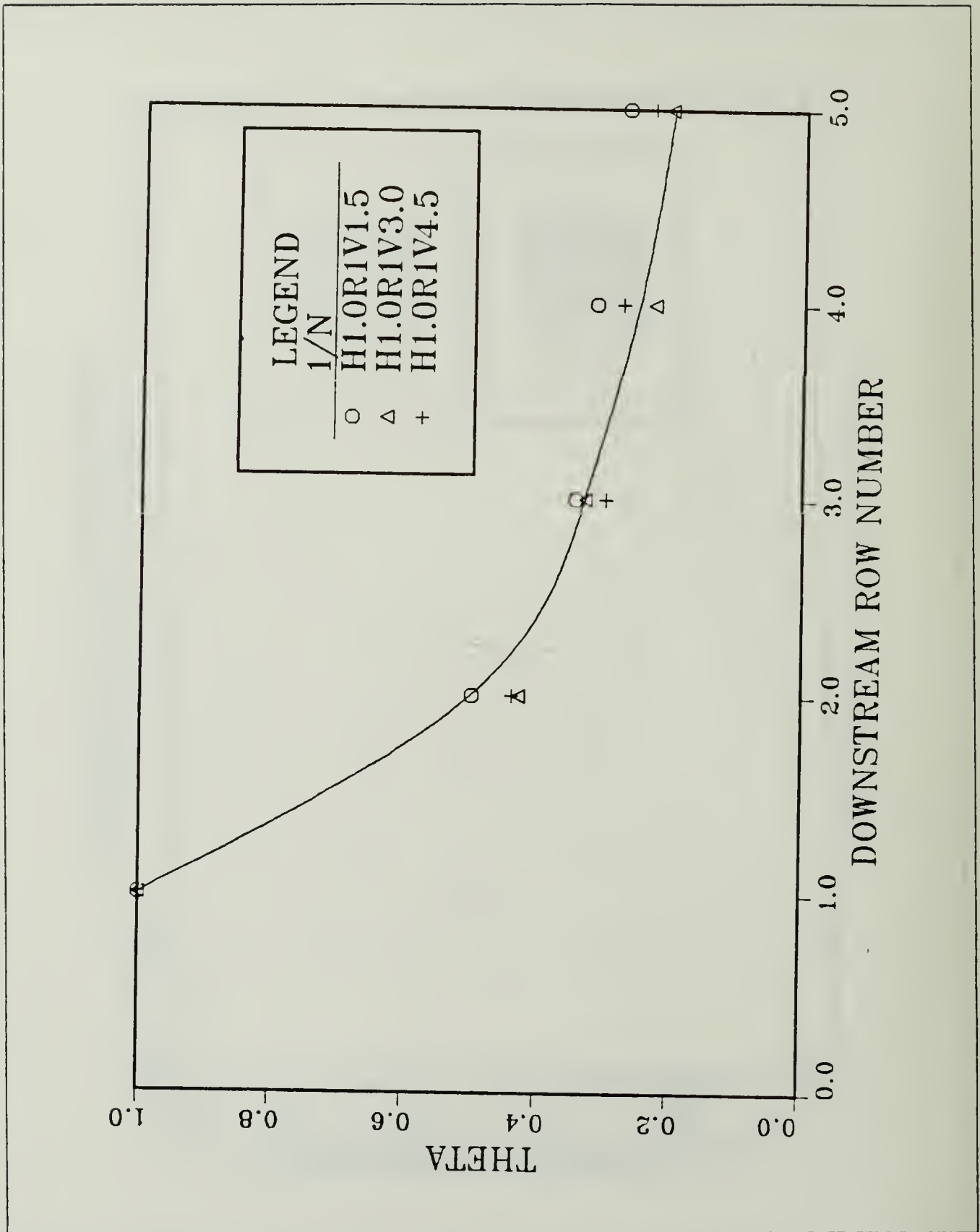


Figure 3.7. Normalized Dimensionless Temperature vs. Row Position for a Channel height Cylinder height ratio of 1.0 with the heated element in the first row..

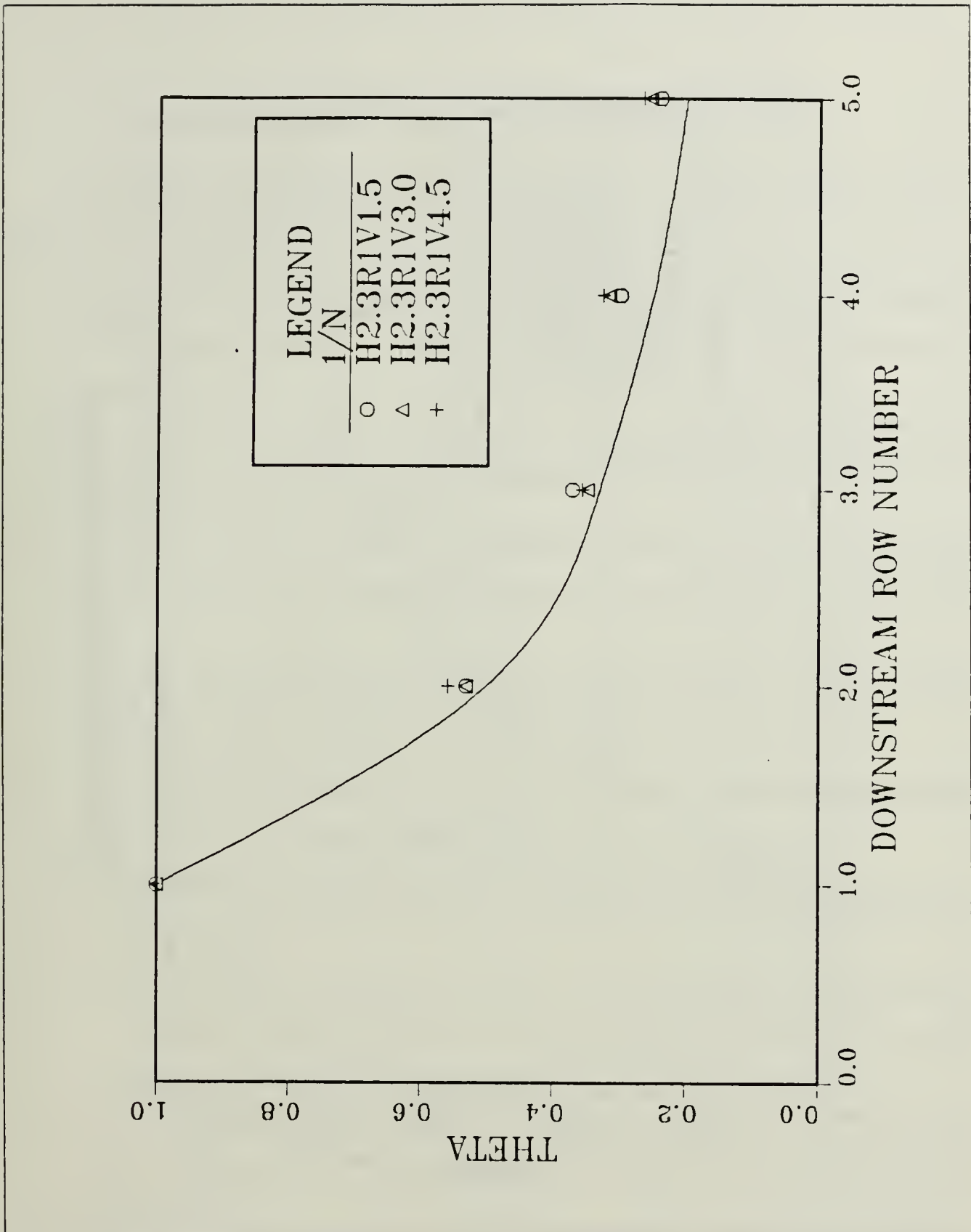


Figure 3.8 Normalized Dimensionless Temperature vs. Row Position for a Channel height/Cylinder height ratio of 2.3 with the heated element in the first row.

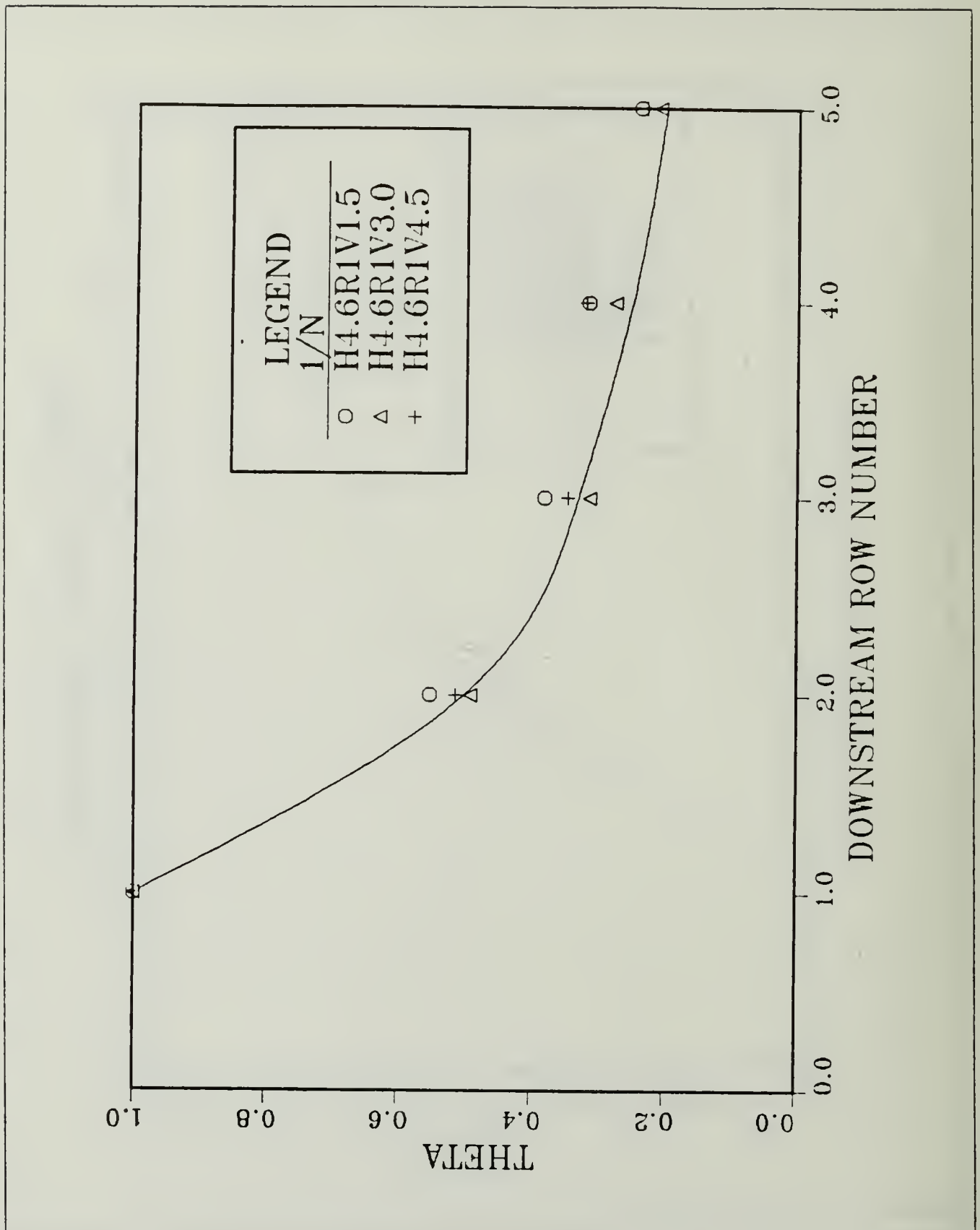


Figure 3.9 Normalized dimensionless Temperature vs. Row Position for a Channel height, Cylinder height ratio of 4.6 with the heated element in the first row..

#### IV. CONCLUSIONS AND RECOMMENDATIONS

The results and conclusions of this research are for rectangular heated elements on an adiabatic channel wall. They can be summarized as follows:

1. The temperatures of each element in a column of a regular array on an adiabatic wall can be predicted by use of the  $1/N$  characteristic curve produced by the thermal wake of a heated element for a range of channel spacings and mass flow rates.
2. The influence of channel spacings and air-flow rates can be neglected as a controlling parameter for the characteristic curve produced by the thermal wake of a heated element in the array.
3. The heat transfer in the array is primarily influenced by the flow rate of air below the crests of the elements and less by the turbulent kinetic energy in that flow.
4. The convective heat transfer coefficient,  $h$ , over the range of channel spacings and mass flow rates tested shows a definite dependence on the form  $Nu = C_1 Re^n$ , where  $n = 0.55$ .
5. There is an asymptotic limit that the convective heat transfer coefficient approaches as the channel height increases.

For continued work in this field, the following are recommended:

1. Use hot wire anemometry to determine, within the array, wake distributions and velocity profiles.
2. Include a pressure measurement system over the axial length of the test section to determine pressure drops for calculation and correlation of pressure coefficients to the convective heat transfer.
3. Develop a larger test area, expand the number of columns and rows available in order to observe the sideways thermal wakes with minimal interference from the side walls.
4. Manufacture additional test plates to investigate the effects of array density on the convective heat transfer problem.
5. Use Arvizu's program "COOLIT" [Ref. 7: pp. 135-141], and compare the results of this research to the empirical results that the program would produce.



THERMOCOUPLE 16	M=	1.0031261	B=	-1.1981716
THERMOCOUPLE 17	M=	1.0021448	B=	-0.7098911
THERMOCOUPLE 18	M=	1.0052872	B=	-1.2181568
THERMOCOUPLE 19	M=	1.0256109	B=	-4.9308729
THERMOCOUPLE 20	M=	1.0178928	B=	-4.4353018
THERMOCOUPLE 21	M=	1.0171432	B=	-4.5746365
THERMOCOUPLE 22	M=	1.0136099	B=	-4.0994339
THERMOCOUPLE 23	M=	1.0167179	B=	-4.4907570
THERMOCOUPLE 24	M=	1.0167246	B=	-4.5790310
THERMOCOUPLE 25	M=	1.0123777	B=	-3.9271755
THERMOCOUPLE 26	M=	1.0121641	B=	-3.7766800
THERMOCOUPLE 27	M=	1.0101500	B=	-3.4335232
THERMOCOUPLE 28	M=	1.0116796	B=	-3.8131971
THERMOCOUPLE 29	M=	1.0055132	B=	-1.2403736
THERMOCOUPLE 30	M=	1.0005398	B=	-0.0643136
THERMOCOUPLE 31	M=	1.0032072	B=	-0.6667480
THERMOCOUPLE 32	M=	0.9998126	B=	0.0388184
THERMOCOUPLE 33	M=	1.0024481	B=	-0.6872907
THERMOCOUPLE 34	M=	1.0025978	B=	-0.8118024
THERMOCOUPLE 35	M=	1.0013151	B=	0.0251465
THERMOCOUPLE 36	M=	1.0037594	B=	-0.9280482
THERMOCOUPLE 37	M=	1.0049391	B=	-1.0613489
THERMOCOUPLE 38	M=	1.0051708	B=	-1.6157923
THERMOCOUPLE 39	M=	1.0021906	B=	-0.6456822
THERMOCOUPLE 40	M=	1.0026150	B=	-1.2585440
THERMOCOUPLE 41	M=	1.0012007	B=	-0.5714285
THERMOCOUPLE 42	M=	1.0197983	B=	10.8571415
THERMOCOUPLE 43	M=	1.0007734	B=	-0.5309012
THERMOCOUPLE 44	M=	1.0036097	B=	-1.2622766
THERMOCOUPLE 45	M=	1.0048122	B=	-0.9260951
THERMOCOUPLE 46	M=	1.0015764	B=	1.1849537
THERMOCOUPLE 47	M=	1.0073318	B=	-1.4914198
THERMOCOUPLE 48	M=	1.0028048	B=	-0.8452497
THERMOCOUPLE 49	M=	1.0031147	B=	-0.6231514
THERMOCOUPLE 50	M=	1.0086575	B=	-1.7490225
THERMOCOUPLE 51	M=	1.0019674	B=	-0.5809500
THERMOCOUPLE 52	M=	1.0040884	B=	-1.2538013
THERMOCOUPLE 53	M=	1.0013723	B=	-0.5133928
THERMOCOUPLE 54	M=	1.0043945	B=	-1.2029505
THERMOCOUPLE 55	M=	0.9999830	B=	-0.2315499
THERMOCOUPLE 56	M=	1.0062981	B=	-1.7986183
THERMOCOUPLE 57	M=	1.0061407	B=	-1.3419361
THERMOCOUPLE 58	M=	1.0090332	B=	-0.7863420

## APPENDIX B

### DATA REDUCTION PROGRAM AND REDUCED DATA

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C*****PROGRAM JITTER*****
C   THIS PROGRAM WRITTEN BY LCDR D. W. MEARS CALCULATES
C   THE COOLING CHARACTERISTICS OF A RECTANGULAR CUBED
C   FINNED ARRAY WHICH SIMULATES A PRINTED CIRCUIT BOARD
C
C       THETA - DIMENSIONLESS TEMPERATURE RATIO
C
C       H - CONVECTIVE HEAT TRANSFER COEFFICIENT
C
C       REH - REYNOLDS NUMBER
C
C       NUH - NUSSELT NUMBER
C
C   THE FOLLOWING DATAIS REQUIREDTOBE ENTERED INTO A
C   INPUT FILE NAMED HEAT.INP
C
C       N - ROW IN WHICH THE HEATED CUBE IS IN
C
C       CHANHT - CHANNEL HEIGHT DIVIDED BY THE CUBE HEIGHT
C
C       PATM - ATMOSPHERIC IN INCHES OF Hg
C
C       DELP - PITOT STATIC TUBE DELTA P (IN WATER)
C
C       VOLTS - VOLTAGE TOTHE HEATED CUBE
C
C       AMPS - CURRENT TO THE HEATED CUBE
C
C       T(I,J) - TEMPERATURES OF THE CUBES IN THE ARRAY
C
C       T(K) - AMBIENT TEMPERATURE THERMOCOUPLES
C
C   THE INPUT FILE IS TO BE IN THIS FORMAT
C
C   N   PATM   DELP   VOLT AMP CHANHT
C   T(1,1) . . . .   T(1,5)
C   :
C   :
C
C       T(9,1) . . . .   T(9,5)
C   T(1) . . . T(3)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
IMPLICIT REAL(A-H,Q-Z)
DIMENSION CAL(9,5,2),CALI(3,2),T(9,5),TINF(3),THETA(10)
M=9
N=5
P=3
OPEN(1,FILE='HEAT.INP')
OPEN(2,FILE='CAL.DAT')
OPEN(3,FILE='HEAT.RES')
DO 20 I=1,M
DO 10 J=1,N
READ(2,*)CAL(I,J,1),CAL(I,J,2)
10 CONTINUE
20 CONTINUE
DO 25 I=1,3
READ(2,*)CALI(I,1),CALI(I,2)
25 CONTINUE
READ(1,*)NU,ATM,DELP,VOLT,AMP,CHANHT

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DO 30 I=1,M
  READ(1,*)T(I,1),T(I,2),T(I,3),T(I,4),T(I,5)
30 CONTINUE
  WRITE(3,31)NU
31 FORMAT(2X,'THE HEATED CUBE IS IN COLUMN 3 AND ROW ',I2)
  WRITE(3,32)ATM
32 FORMAT(2X,'BAROMETRIC PRESSURE ',F7.3,' INCHES OF Hg')
  WRITE(3,33)DELP
33 FORMAT(2X,'PITOT-STATIC TUBE DELTA ',F6.5,' INCHES WATER')
  WRITE(3,34)VOLT,AMP
34 FORMAT(2X,'VOLTS ',F7.4,5X,'AMPS ',F7.4)
  WRITE(3,35)CHANHT
35 FORMAT(2X,'CHANNEL HEIGHT RATIO ',F3.1)
  WRITE(3,36)
36 FORMAT(/,2X,'THE INPUT TEMPERATURE ARRAY IN DEGREES F')
  DO 38 I=1,M
  WRITE(3,37)T(I,1),T(I,2),T(I,3),T(I,4),T(I,5)
37 FORMAT(2X,F4.1,5X,F4.1,5X,F5.1,5X,F4.1,5X,F4.1)
38 CONTINUE
  DO 50 I=1,M
  DO 40 J=1,N
  T(I,J)=CAL(I,J,1)*T(I,J)+CAL(I,J,2)
40 CONTINUE
50 CONTINUE
  READ(1,*)TINF(1),TINF(2),TINF(3)
  DO 60 I=1,3
  TINF(I)=CALI(I,1)*TINF(I)+CALI(I,2)
60 CONTINUE
  WRITE(3,62)
62 FORMAT(/,2X,'CALIBRATED TEMPERATURES IN DEGREES F')
  DO 65 I=1,9
  WRITE(3,63)T(I,1),T(I,2),T(I,3),T(I,4),T(I,5)
63 FORMAT(2X,F4.1,5X,F4.1,5X,F5.1,5X,F4.1,5X,F4.1)
65 CONTINUE
  WRITE(3,66)
66 FORMAT(/,2X,'AMBIENT TEMPERATURE CALIBRATED IN FAHR.')
  WRITE(3,67)TINF(1),TINF(2),TINF(3)
67 FORMAT(2X,F7.3,3X,F7.3,3X,F7.3)
  TAMB=(TINF(1)+TINF(2)+TINF(3))/3
  K=9-NU
  DO 70 I=1,K
  THETA(I)=(T(NU+I,3)-TAMB)/(T(NU+1,3)-TAMB)
70 CONTINUE
  DO 90 I=1,M
  DO 80 J=1,N
  T(I,J)=(T(I,J)-32.0)*.55556
80 CONTINUE
90 CONTINUE
  TAMB=(TAMB-32.0)*.55556
  RHO=ATM*3386.5/(287*(TAMB+273.0))
  DELPPA=DELP*248.84
  VELMS=SQRT(2.0*DELPPA/RHO)
  VELFS=3.2808*VELMS
  QINPUT=VOLT*AMP
  QLOSS=.62927E-3+.5059E-2*(T(NU,3)-TAMB)-.023695E-5*(T(NU,3)-TAMB)
  **2
  IF(CHANHT.EQ.1)GO TO 100
  A=1.29E-3
  GO TO 110
100 CONTINUE
  A=.9677E-3
110 CONTINUE
  TEMP=T(NU,3)
  H=(QINPUT-QLOSS)/(A*(TEMP-TAMB))
  VISK=38.02E-6-109.8E-9*(27.0-TAMB)
  X=CHANHT*.0127
  COND=.0407-76.8E-6*(27.0-TAMB)
  DUH=X*H/COND
  REH=X*VELMS/VISK

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DO 130 I=1,K
WRITE(3,120)I,THETA(I)
120 FORMAT(2X,'THETA',I1,'=',2X,F14.7)
130 CONTINUE
WRITE(3,140)H,REH
140 FORMAT(/,2X,'H=',2X,F7.3,' W/m2C',15X,'ReH=',F14.7)
WRITE(3,150)DUH
150 FORMAT(2X,'NUSSELT#=',F7.3)
WRITE(3,160)VELMS,VELFS
160 FORMAT(2X,'FREESTREAM VELOCITY =',F7.3,' m/s=',F7.3,' ft/s')
WRITE(3,170)QINPUT,QLOSS,COND
170 FORMAT(2X,'Qin=',F7.3,' Watts',3X,'Qloss=',F7.3,' Watts',5X,
.' CONDUCTIVITY=',F7.3,' W/mC')
WRITE(3,180)TAMB,VISK
180 FORMAT(2X,'TAMB=',F7.3,' C',10X,'VISCOSITY=',F10.8,' m2/s')
WRITE(3,190)
190 FORMAT(/,2X,'SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE')
DO 210 I=1,M
WRITE(3,200)T(I,1),T(I,2),T(I,3),T(I,4),T(I,5)
200 FORMAT(2X,F8.1,5X,F8.1,5X,F10.1,5X,F8.1,5X,F8.1)
210 CONTINUE
END

```

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1  
BAROMETRIC PRESSURE 30.286 INCHES OF Hg  
PITOT-STATIC TUBE DELTA .00560 INCHES WATER  
VOLTS 2.9270 AMPS 1.4000  
CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.4	65.4	152.9	65.7	65.5
65.4	65.4	73.1	65.1	65.9
65.8	65.9	69.8	68.8	65.6
65.5	65.5	68.3	69.5	69.2
69.3	69.3	71.6	69.2	69.1
69.1	68.9	71.1	65.3	65.3
65.1	65.3	67.2	65.5	65.2
65.3	65.3	67.0	65.7	65.5
65.6	65.6	66.9	65.9	65.6

CALIBRATED TEMPERATURES IN DEGREES F

63.6	63.6	151.4	63.9	63.8
63.7	63.8	71.6	63.5	63.5
63.4	63.5	67.4	66.6	63.3
63.3	63.4	66.1	63.5	63.3
63.4	63.5	65.9	63.5	63.4
63.5	63.4	65.5	63.4	63.4
63.3	63.4	65.4	63.6	63.4
63.4	63.4	64.9	63.6	63.4
63.4	63.5	64.6	63.7	63.3

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.400	63.302	63.200
THETA1=	1.0000000	
THETA2=	.4966078	
THETA3=	.3439455	
THETA4=	.3154521	
THETA5=	.2683605	
THETA6=	.2571974	
THETA7=	.1973163	
THETA8=	.1598605	

H= 86.495 W/m2C ReH= 517.0348000  
NUSSELT#= 27.488  
FREESTREAM VELOCITY = 1.505 m/s = 4.937 ft/s  
Qin= 4.098 Watts Qloss= .248 Watts CONDUCTIVITY= .040 W/mC  
TAMB= 17.389 C VISCOSITY= .00003696 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.6	17.6	66.3	17.7	17.7
17.6	17.7	22.0	17.5	17.5
17.4	17.5	19.7	19.2	17.4
17.4	17.5	19.0	17.5	17.4
17.5	17.5	18.8	17.5	17.5
17.5	17.4	18.6	17.5	17.4
17.4	17.5	18.6	17.5	17.4
17.5	17.4	18.3	17.6	17.5
17.4	17.5	18.1	17.6	17.4

THE HEATED CUBE IS IN COLUMN 3 AND ROW 2  
 BAROMETRIC PRESSURE 30.286 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00560 INCHES WATER  
 VOLTS 2.9410 AMPS 1.4000  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.9	65.9	67.4	66.2	65.9
65.7	65.9	148.0	65.5	66.4
66.2	66.4	75.6	66.3	66.0
65.9	66.0	69.9	70.1	69.9
70.0	69.9	72.8	69.8	69.7
69.6	69.5	71.9	65.7	65.7
65.5	65.7	67.9	65.9	65.7
65.8	65.7	67.4	66.1	66.0
66.0	66.0	67.5	66.4	66.1

CALIBRATED TEMPERATURES IN DEGREES F

64.1	64.1	65.6	64.4	64.2
64.0	64.3	147.1	63.9	64.0
63.8	64.0	73.2	64.1	63.7
63.7	63.9	67.8	64.2	64.0
64.1	64.2	67.1	64.1	64.0
64.0	64.0	66.3	63.8	63.8
63.7	63.8	66.1	64.0	63.9
63.9	63.8	65.3	64.0	63.9
63.8	63.9	65.2	64.2	63.8

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.801	63.805	63.702
THETA1=	1.0000000	
THETA2=	.4200136	
THETA3=	.3542062	
THETA4=	.2698356	
THETA5=	.2485592	
THETA6=	.1649532	
THETA7=	.1532385	

H= 91.925 W/m<sup>2</sup>C

ReH= 516.8669000

NUSSELT#= 29.199

FREESTREAM VELOCITY = 1.506 m/s= 4.939 ft/s

Q<sub>in</sub>= 4.117 Watts Q<sub>loss</sub>= .234 Watts CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 17.650 C VISCOSITY= .00003699 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.8	17.9	18.7	18.0	17.9
17.8	18.0	63.9	17.7	17.8
17.7	17.8	22.9	17.8	17.6
17.6	17.7	19.9	17.9	17.8
17.8	17.9	19.5	17.8	17.8
17.8	17.8	19.1	17.7	17.6
17.6	17.7	19.0	17.8	17.7
17.7	17.6	18.5	17.8	17.7
17.7	17.7	18.5	17.9	17.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 2  
 BAROMETRIC PRESSURE 30.286 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00560 INCHES WATER  
 VOLTS 2.9410 AMPS 1.4000

CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.9	65.9	67.4	66.2	65.9
65.7	65.9	148.0	65.5	66.4
66.2	66.4	75.6	66.3	66.0
65.9	66.0	69.9	70.1	69.9
70.0	69.9	72.8	69.8	69.7
69.6	69.5	71.9	65.7	65.7
65.5	65.7	67.9	65.9	65.7
65.8	65.7	67.4	66.1	66.0
66.0	66.0	67.5	66.4	66.1

CALIBRATED TEMPERATURES IN DEGREES F

64.1	64.1	65.6	64.4	64.2
64.0	64.3	147.1	63.9	64.0
63.8	64.0	73.2	64.1	63.7
63.7	63.9	67.8	64.2	64.0
64.1	64.2	67.1	64.1	64.0
64.0	64.0	66.3	63.8	63.8
63.7	63.8	66.1	64.0	63.9
63.9	63.8	65.3	64.0	63.9
63.8	63.9	65.2	64.2	63.8

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.801	63.805	63.702
THETA1=	1.0000000	
THETA2=	.4200136	
THETA3=	.3542062	
THETA4=	.2698356	
THETA5=	.2485592	
THETA6=	.1649532	
THETA7=	.1532385	

H= 91.925 W/m<sup>2</sup>C

ReH= 516.8669000

NUSSELT#= 29.199

FREESTREAM VELOCITY = 1.506 m/s= 4.939 ft/s

Q<sub>in</sub>= 4.117 Watts Q<sub>loss</sub>= .234 Watts CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 17.650 C VISCOSITY= .00003699 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.8	17.9	18.7	18.0	17.9
17.8	18.0	63.9	17.7	17.8
17.7	17.8	22.9	17.8	17.6
17.6	17.7	19.9	17.9	17.8
17.8	17.9	19.5	17.8	17.8
17.8	17.8	19.1	17.7	17.6
17.6	17.7	19.0	17.8	17.7
17.7	17.6	18.5	17.8	17.7
17.7	17.7	18.5	17.9	17.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 3

BAROMETRIC PRESSURE 30.286 INCHES OF Hg

PITOT-STATIC TUBE DELTA .00560 INCHES WATER

VOLTS 2.7500 AMPS 1.4000

CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.9	65.9	65.8	66.1	65.9
65.7	65.9	67.3	65.5	66.6
66.4	66.8	143.3	66.5	66.1
66.0	66.2	77.6	70.4	70.0
70.2	70.1	75.3	70.0	69.8
69.7	69.7	73.1	65.9	65.9
65.7	65.9	68.7	66.0	65.9
66.0	65.9	67.9	66.2	66.1
66.2	66.2	67.9	66.5	66.3

CALIBRATED TEMPERATURES IN DEGREES F

64.1	64.1	64.0	64.3	64.2
64.0	64.3	65.7	63.9	64.2
64.0	64.4	141.5	64.3	63.8
63.8	64.1	75.5	64.5	64.1
64.3	64.4	69.7	64.3	64.1
64.1	64.2	67.5	64.0	64.0
63.9	64.0	66.9	64.1	64.1
64.1	64.0	65.8	64.1	64.0
64.0	64.1	65.6	64.3	64.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

64.001      64.007      63.802  
 THETA1=      1.0000000  
 THETA2=      .4960722  
 THETA3=      .3119469  
 THETA4=      .2586492  
 THETA5=      .1643351  
 THETA6=      .1458730

H= 92.358 W/m2C

ReH=516.807

NUSSELT#= 29.332

FREESTREAM VELOCITY = 1.506 m/s= 4.940 ft/s

Qin= 3.850 Watts

Qloss= .218 Watts

CONDUCTIVITY= .040 W/mC

TAMB= 17.743 C

VISCOSITY= .00003700 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.8	17.9	17.8	18.0	17.9
17.8	18.0	18.7	17.7	17.9
17.8	18.0	60.8	17.9	17.6
17.7	17.9	24.2	18.0	17.8
18.0	18.0	20.9	17.9	17.9
17.8	17.9	19.7	17.8	17.8
17.7	17.8	19.4	17.8	17.8
17.8	17.8	18.8	17.8	17.8
17.8	17.8	18.7	17.9	17.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 4

BAROMETRIC PRESSURE 30.286 INCHES OF Hg

PITOT-STATIC TUBE DELTA .00560 INCHES WATER

VOLTS 2.9470 AMPS 1.4000

CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.9	65.9	65.8	66.0	65.9
65.7	65.8	65.5	65.5	66.6
66.4	66.8	68.7	66.5	66.1
66.0	66.2	146.7	70.4	70.1
70.4	70.1	84.6	70.0	70.0
69.8	69.8	75.8	65.8	65.9
65.7	65.9	70.0	65.9	65.8
66.0	65.9	68.6	66.1	66.2
66.2	66.3	68.4	66.4	66.3

CALIBRATED TEMPERATURES IN DEGREES F

64.1	64.1	64.0	64.2	64.2
64.0	64.2	63.9	63.9	64.2
64.0	64.4	66.3	64.3	63.8
63.8	64.1	145.0	64.5	64.2
64.5	64.4	79.1	64.3	64.3
64.2	64.3	70.3	63.9	64.0
63.9	64.0	68.2	64.0	64.0
64.1	64.0	66.5	64.0	64.1
64.0	64.2	66.1	64.2	64.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

64.001      64.007      63.802  
 THETA1=      1.0000000  
 THETA2=      .4171876

THETA3= .2823656  
THETA4= .1713571  
THETA5= .1439298

H= 94.720 W/m<sup>2</sup>C ReH=516.807  
NUSSELT#= 30.082  
FREESTREAM VELOCITY = 1.506 m/s= 4.940 ft/s  
Q<sub>in</sub>= 4.126 Watts Q<sub>loss</sub>= .228 Watts CONDUCTIVITY= .040 W/mC  
T<sub>AMB</sub>= 17.743 C VISCOSITY= .00003700 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.8	17.9	17.8	17.9	17.9
17.8	17.9	17.7	17.7	17.9
17.8	18.0	19.1	17.9	17.6
17.7	17.9	62.8	18.0	17.9
18.1	18.0	26.2	17.9	18.0
17.9	17.9	21.3	17.7	17.8
17.7	17.8	20.1	17.8	17.8
17.8	17.8	19.2	17.8	17.8
17.8	17.9	19.0	17.9	17.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
BAROMETRIC PRESSURE 30.286 INCHES OF Hg  
PITOT-STATIC TUBE DELTA .00560 INCHES WATER  
VOLTS 2.6970 AMPS 1.4000  
CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.9	65.9	65.9	66.1	66.0
65.9	65.9	65.7	65.6	66.6
66.5	66.6	66.4	66.4	66.1
66.1	66.1	69.4	70.7	70.4
70.8	70.4	143.9	70.2	70.2
69.9	69.9	83.1	65.9	66.0
65.8	66.0	72.3	66.1	65.9
66.1	66.0	69.7	66.1	66.2
66.2	66.3	68.9	66.5	66.4

CALIBRATED TEMPERATURES IN DEGREES F

64.1	64.1	64.1	64.3	64.3
64.2	64.3	64.1	64.0	64.2
64.1	64.2	64.0	64.2	63.8
63.9	64.0	67.2	64.8	64.5
64.9	64.7	139.4	64.5	64.5
64.3	64.4	77.7	64.0	64.1
64.0	64.1	70.5	64.2	64.1
64.2	64.1	67.6	64.0	64.1
64.0	64.2	66.6	64.3	64.1

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

64.101 64.007 63.802  
THETA1= 1.0000000  
THETA2= .4788637  
THETA3= .2684694  
THETA4= .1938155

H= 93.091 W/m<sup>2</sup>C ReH= 516.7949000  
NUSSELT#= 29.563  
FREESTREAM VELOCITY = 1.506 m/s= 4.940 ft/s  
Q<sub>in</sub>= 3.776 Watts Q<sub>loss</sub>= .212 Watts CONDUCTIVITY= .040 W/mC  
T<sub>AMB</sub>= 17.761 C VISCOSITY= .00003701 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.8	17.9	17.9	18.0	17.9
17.9	18.0	17.8	17.8	17.9
17.8	17.9	17.8	17.9	17.6
17.7	17.8	19.6	18.2	18.1
18.3	18.1	59.7	18.1	18.1
17.9	18.0	25.4	17.8	17.8

17.8	17.9	21.4	17.9	17.8
17.9	17.8	19.8	17.8	17.8
17.8	17.9	19.2	17.9	17.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 6  
 BAROMETRIC PRESSURE 30.286 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00560 INCHES WATER  
 VOLTS 2.4840 AMPS 1.9000  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

66.3	66.3	66.3	66.4	66.3
66.2	66.2	66.0	66.0	67.0
66.8	66.9	66.6	66.7	66.6
66.4	66.5	66.5	71.0	70.8
71.0	70.5	72.8	70.4	70.5
70.2	70.1	162.0	66.1	66.3
66.0	66.3	77.2	66.3	66.2
66.3	66.2	71.6	66.4	66.6
66.5	66.6	69.6	66.7	66.7

CALIBRATED TEMPERATURES IN DEGREES F

64.5	64.5	64.5	64.6	64.6
64.5	64.6	64.4	64.4	64.6
64.4	64.5	64.2	64.5	64.3
64.2	64.4	64.3	65.1	64.9
65.1	64.8	67.1	64.7	64.8
64.6	64.6	157.5	64.2	64.4
64.2	64.4	75.4	64.4	64.4
64.4	64.3	69.6	64.3	64.5
64.3	64.5	67.3	64.5	64.4

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

64.402	64.410	64.203
THETA1=	1.0000000	
THETA2=	.4705607	
THETA3=	.2692943	

H=	94.253 W/m <sup>2</sup> C	ReH=	516.6631000
NUSSELT#	= 29.921		
FREESTREAM VELOCITY	= 1.506 m/s = 4.942 ft/s		
Q <sub>in</sub>	= 4.720 Watts	Q <sub>loss</sub>	= .262 Watts
TAMB	= 17.966 C	CONDUCTIVITY	= .040 W/mC
		VISCOSITY	= .00003703 m <sup>2</sup> /s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.1	18.1	18.1	18.1	18.1
18.1	18.1	18.0	18.0	18.1
18.0	18.0	17.9	18.0	17.9
17.9	18.0	18.0	18.4	18.3
18.4	18.2	19.5	18.2	18.2
18.1	18.1	69.7	17.9	18.0
17.9	18.0	24.1	18.0	18.0
18.0	17.9	20.9	17.9	18.1
17.9	18.0	19.6	18.0	18.0

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1  
 BAROMETRIC PRESSURE 29.865 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 3.9610 AMPS 1.9000  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

68.5	68.5	164.6	68.7	68.5
68.4	68.4	76.8	68.2	69.1
69.0	68.9	72.7	68.9	68.7
68.6	68.4	71.6	72.8	72.6
72.5	72.5	74.5	72.5	72.3
72.2	72.1	74.1	68.5	68.4

68.1	68.3	70.3	68.7	68.3
68.4	68.3	69.9	69.0	68.6
68.7	68.5	70.0	69.3	68.7

CALIBRATED TEMPERATURES IN DEGREES F

67.0	67.0	163.5	67.2	67.0
66.9	67.1	75.5	66.8	66.7
66.6	66.7	70.4	66.8	66.4
66.5	66.4	69.6	66.6	66.5
66.4	66.5	68.7	66.6	66.5
66.4	66.4	68.5	66.8	66.6
66.4	66.5	68.6	66.9	66.6
66.6	66.5	67.8	66.9	66.5
66.5	66.4	67.8	67.1	66.5

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

66.705      66.625      66.609

THETA1=            1.0000000  
 THETA2=            .4272328  
 THETA3=            .3293090  
 THETA4=            .2270755  
 THETA5=            .2041866  
 THETA6=            .2236516  
 THETA7=            .1355750  
 THETA8=            .1330826

H= 144.593 W/m2C

ReH= 1029.6060000

NUSSELT#= 45.789

FREESTREAM VELOCITY = 3.013 m/s= 9.886 ft/s

Qin= 7.526 Watts      Qloss= .272 Watts      CONDUCTIVITY= .040 W/mC

TAMB= 19.248 C

VISCOSITY= .00003717 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

19.4	19.4	73.0	19.6	19.4
19.4	19.5	24.2	19.3	19.3
19.2	19.3	21.3	19.3	19.1
19.2	19.1	20.9	19.2	19.1
19.1	19.2	20.4	19.2	19.1
19.1	19.1	20.3	19.4	19.2
19.1	19.1	20.3	19.4	19.2
19.2	19.2	19.9	19.4	19.2
19.2	19.1	19.9	19.5	19.2

THE HEATED CUBE IS IN COLUMN 3 AND ROW 2  
 BAROMETRIC PRESSURE 29.865 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 4.1940      AMPS 1.9000  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

68.7	68.7	70.0	69.1	68.9
68.7	68.7	169.5	68.5	69.4
69.2	69.4	79.0	69.2	69.1
68.8	68.8	73.4	73.2	72.9
72.9	72.8	75.5	72.8	72.7
72.6	72.5	74.8	68.8	68.7
68.4	68.6	70.9	69.1	68.7
68.7	68.6	70.3	69.3	69.0
69.0	69.0	70.5	69.6	69.2

CALIBRATED TEMPERATURES IN DEGREES F

67.2	67.2	68.6	67.6	67.4
67.2	67.4	169.0	67.1	67.0
66.8	67.2	76.8	67.1	66.8
66.7	66.8	71.4	67.0	66.8
66.8	66.8	69.7	66.9	66.9
66.8	66.8	69.2	67.1	66.9
66.7	66.8	69.2	67.3	67.0

66.9 66.8 68.2 67.2 66.9  
66.8 66.9 68.3 67.4 67.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

67.106 67.028 67.010

THETA1= 1.0000000  
THETA2= .4442505  
THETA3= .2697625  
THETA4= .2172257  
THETA5= .2237964  
THETA6= .1233546  
THETA7= .1311951

H= 145.438 W/m<sup>2</sup>C

ReH= 1029.3210000

NUSSELT#= 46.037

FREESTREAM VELOCITY = 3.014 m/s= 9.890 ft/s

Q<sub>in</sub>= 7.969 Watts Q<sub>loss</sub>= .286 Watts CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 19.471 C

VISCOSITY= .00003719 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

19.6	19.5	20.3	19.8	19.7
19.6	19.6	76.1	19.5	19.4
19.3	19.5	24.9	19.5	19.3
19.3	19.4	21.9	19.5	19.3
19.3	19.3	20.9	19.4	19.4
19.3	19.3	20.6	19.5	19.4
19.3	19.3	20.7	19.6	19.4
19.4	19.3	20.1	19.6	19.4
19.3	19.4	20.2	19.7	19.4

THE HEATED CUBE IS IN COLUMN 3 AND ROW 3  
BAROMETRIC PRESSURE 29.888 INCHES OF Hg  
PITOT-STATIC TUBE DELTA .02220 INCHES WATER  
VOLTS 2.8416 AMPS 1.4950  
CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.5	65.5	65.5	65.9	65.8
65.4	65.6	65.9	65.3	66.5
66.1	66.4	119.6	66.3	66.0
65.7	65.9	71.8	70.4	70.1
70.3	69.9	72.6	69.8	70.0
69.6	69.6	71.1	65.5	65.8
65.4	65.6	67.0	65.7	65.6
65.7	65.5	66.7	65.8	65.9
65.9	65.9	66.9	66.1	66.2

CALIBRATED TEMPERATURES IN DEGREES F

63.7	63.7	63.7	64.1	64.1
63.7	64.0	64.3	63.7	64.1
63.7	64.0	117.6	64.1	63.7
63.5	63.8	69.7	64.5	64.2
64.4	64.2	66.9	64.1	64.3
64.0	64.1	65.5	63.6	63.9
63.6	63.7	65.2	63.8	63.8
63.8	63.6	64.6	63.7	63.8
63.7	63.8	64.6	63.9	63.9

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.701 63.705 63.401

THETA1= 1.0000000  
THETA2= .5482168  
THETA3= .3161946  
THETA4= .2679693  
THETA5= .1695479  
THETA6= .1682471

H= 146.363 W/m<sup>2</sup>C

ReH= 1036.0670000

NUSSELT#= 46.500

FREESTREAM VELOCITY = 3.017 m/s= 9.898 ft/s  
 Qin= 4.248 Watts Qloss= .152 Watts CONDUCTIVITY= .040 W/mC  
 Tamb= 17.557 C VISCOSITY= .00003698 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.6	17.6	17.6	17.8	17.8
17.6	17.8	17.9	17.6	17.8
17.6	17.8	47.6	17.8	17.6
17.5	17.7	20.9	18.0	17.9
18.0	17.9	19.4	17.8	18.0
17.8	17.8	18.6	17.6	17.7
17.5	17.6	18.5	17.7	17.6
17.7	17.5	18.1	17.6	17.7
17.6	17.6	18.1	17.7	17.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 4  
 BAROMETRIC PRESSURE 29.888 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02220 INCHES WATER  
 VOLTS 2.9320 AMPS 1.4950  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.6	65.6	65.5	65.9	65.9
65.5	65.6	65.3	65.3	66.5
66.2	66.4	67.1	66.2	66.1
65.9	65.8	120.2	70.4	70.2
70.4	69.9	77.0	69.8	70.0
69.6	69.6	72.3	65.5	65.8
65.5	65.6	67.5	65.7	65.7
65.8	65.6	67.1	65.8	66.1
65.9	65.8	67.1	66.1	66.2

CALIBRATED TEMPERATURES IN DEGREES F

63.8	63.8	63.7	64.1	64.2
63.8	64.0	63.7	63.7	64.1
63.8	64.0	64.7	64.0	63.8
63.7	63.7	118.3	64.5	64.3
64.5	64.2	71.4	64.1	64.3
64.0	64.1	66.7	63.6	63.9
63.7	63.7	65.7	63.8	63.9
63.9	63.7	65.0	63.7	64.0
63.7	63.7	64.8	63.9	63.9

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.701 63.705 63.401  
 THETA1= 1.0000000  
 THETA2= .4015054  
 THETA3= .2724119  
 THETA4= .1833620  
 THETA5= .1564473

H= 149.014 W/m2C ReH= 1036.0670000  
 NUSSELT#= 47.342  
 FREESTREAM VELOCITY = 3.017 m/s= 9.898 ft/s  
 Qin= 4.383 Watts Qloss= .154 Watts CONDUCTIVITY= .040 W/mC  
 Tamb= 17.557 C VISCOSITY= .00003698 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.7	17.7	17.6	17.8	17.9
17.7	17.8	17.6	17.6	17.8
17.7	17.8	18.2	17.8	17.6
17.6	17.6	48.0	18.0	18.0
18.1	17.9	21.9	17.8	18.0
17.8	17.8	19.3	17.6	17.7
17.6	17.6	18.7	17.7	17.7
17.7	17.6	18.4	17.6	17.8
17.6	17.6	18.2	17.7	17.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
 BAROMETRIC PRESSURE 29.888 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02220 INCHES WATER  
 VOLTS 2.8400 AMPS 1.5000  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.7	65.7	65.6	65.9	65.9
65.6	65.7	65.5	65.4	66.6
66.2	66.4	66.1	66.3	66.0
65.8	65.9	65.4	70.6	70.3
70.6	70.1	121.1	70.0	70.1
69.6	69.6	76.3	65.7	65.9
65.5	65.7	68.8	65.8	65.8
65.9	65.7	67.7	65.9	66.1
66.0	65.9	67.5	66.2	66.3

CALIBRATED TEMPERATURES IN DEGREES F

63.9	63.9	63.8	64.1	64.2
63.9	64.1	63.9	63.8	64.2
63.8	64.0	63.7	64.1	63.7
63.6	63.8	63.2	64.7	64.4
64.7	64.4	116.2	64.3	64.4
64.0	64.1	70.8	63.8	64.0
63.7	63.8	67.0	63.9	64.0
64.0	63.8	65.6	63.8	64.0
63.8	63.8	65.2	64.0	64.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.  
 63.801 63.805 63.601  
 THETA1= 1.0000000  
 THETA2= .4670710  
 THETA3= .2695867  
 THETA4= .2110019

H= 150.936 W/m<sup>2</sup> ReH= 1035.9700000  
 NUSSELT#= 47.946  
 FREESTREAM VELOCITY = 3.017 m/s = 9.900 ft/s  
 Qin= 4.260 Watts Qloss= .148 Watts CONDUCTIVITY= .040 W/mC  
 TAMB= 17.631 C VISCOSITY= .00003699 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.7	17.7	17.7	17.8	17.9
17.7	17.9	17.7	17.7	17.9
17.7	17.8	17.6	17.8	17.6
17.6	17.7	17.3	18.2	18.0
18.2	18.0	46.8	17.9	18.0
17.8	17.8	21.5	17.7	17.8
17.6	17.7	19.5	17.7	17.8
17.8	17.6	18.7	17.7	17.8
17.7	17.6	18.5	17.8	17.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 6  
 BAROMETRIC PRESSURE 29.888 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02220 INCHES WATER  
 VOLTS 2.8100 AMPS 2.0400  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.9	66.2	66.1	65.8	66.1
65.7	65.8	65.6	65.6	66.7
66.3	66.5	66.2	66.4	66.2
66.0	66.1	66.0	70.8	70.5
70.7	70.2	71.5	70.1	70.2
69.8	69.7	139.0	65.8	66.1
65.6	65.9	72.4	65.9	65.9
66.0	65.8	69.2	66.0	66.3
66.1	66.1	68.1	66.3	66.4

CALIBRATED TEMPERATURES IN DEGREES F

64.1	64.4	64.3	64.0	64.4
64.0	64.2	64.0	64.0	64.3
63.9	64.1	63.8	64.2	63.9
63.8	64.0	63.8	64.9	64.6
64.8	64.5	65.8	64.4	64.5
64.2	64.2	134.2	63.9	64.2
63.8	64.0	70.6	64.0	64.1
64.1	63.9	67.1	63.9	64.2
63.9	64.0	65.8	64.1	64.1

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

64.001      64.007      63.802  
 THETA1=      1.0000000  
 THETA2=      .4793034  
 THETA3=      .2819515

H= 151.730 W/m<sup>2</sup>C      ReH= 1035.8260000  
 NUSSELT#= 48.187  
 FREESTREAM VELOCITY = 3.018 m/s= 9.902 ft/s  
 Qin= 5.732 Watts      Qloss= .198 Watts      CONDUCTIVITY= .040 W/mC  
 TAMB= 17.743 C      VISCOSITY= .00003700 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.8	18.0	18.0	17.8	18.0
17.8	17.9	17.8	17.8	17.9
17.7	17.8	17.7	17.9	17.7
17.7	17.8	17.7	18.3	18.1
18.2	18.0	18.8	18.0	18.1
17.9	17.9	56.8	17.7	17.9
17.7	17.8	21.5	17.8	17.8
17.8	17.7	19.5	17.7	17.9
17.7	17.8	18.8	17.8	17.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1  
 BAROMETRIC PRESSURE 30.024 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
 VOLTS 4.0650      AMPS 2.0000  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

72.2	72.2	157.3	72.5	72.3
72.1	72.1	79.0	71.8	72.7
72.6	72.7	75.7	72.5	72.3
72.2	72.3	74.6	76.7	76.4
76.7	76.4	78.2	76.3	76.1
76.1	76.1	77.7	72.0	72.0
71.9	72.0	73.4	72.3	71.9
72.2	72.0	73.3	72.4	72.3
72.4	72.4	73.4	72.6	72.4

CALIBRATED TEMPERATURES IN DEGREES F

70.6	70.6	155.9	70.9	70.8
70.6	70.8	77.8	70.5	70.7
70.6	70.8	73.8	70.8	70.4
70.5	70.8	72.9	70.9	70.6
71.0	70.7	72.7	70.7	70.6
70.6	70.7	72.4	70.8	70.6
70.7	70.6	72.0	70.9	70.6
70.7	70.6	71.8	70.8	70.5
70.7	70.8	71.5	70.8	70.6

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.811      70.803      70.719  
 THETA1=      1.0000000  
 THETA2=      .4366989  
 THETA3=      .2982576



19.8	19.8	20.2	20.1	20.0
19.9	19.9	65.9	19.7	19.7
19.7	19.8	23.2	19.8	19.5
19.6	19.6	21.1	19.7	19.7
19.7	19.6	20.6	19.7	19.7
19.6	19.7	20.4	19.7	19.6
19.6	19.6	20.4	19.8	19.6
19.7	19.6	20.0	19.7	19.7
19.6	19.7	20.1	19.8	19.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 3  
 BAROMETRIC PRESSURE 29.687 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
 VOLTS 3.3510 AMPS 1.7500  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

64.8	64.8	64.7	65.3	65.2
64.6	64.9	65.2	64.6	65.9
65.3	65.7	125.9	65.6	65.3
64.9	65.1	71.8	69.8	69.5
69.6	69.2	72.2	69.2	69.3
68.9	68.9	70.8	64.9	65.1
64.7	64.8	66.5	65.1	65.0
65.1	64.8	66.2	65.1	65.3
65.1	65.1	66.3	65.4	65.5

CALIBRATED TEMPERATURES IN DEGREES F

63.0	63.0	62.9	63.5	63.5
62.9	63.3	63.6	63.0	63.5
62.9	63.3	123.9	63.4	63.0
62.7	63.0	69.7	63.9	63.6
63.7	63.4	66.5	63.5	63.6
63.3	63.4	65.2	63.0	63.2
62.9	62.9	64.7	63.2	63.2
63.2	62.9	64.1	63.0	63.2
62.9	62.9	64.0	63.2	63.2

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.000	63.000	62.799
THETA1=	1.0000000	
THETA2=	.5327140	
THETA3=	.3391106	
THETA4=	.2664897	
THETA5=	.1774625	
THETA6=	.1617433	

H= 178.799 W/m<sup>2</sup>C

ReH= 1545.1700000

NUSSELT#= 56.845

FREESTREAM VELOCITY = 4.495 m/s = 14.746 ft/s

Q<sub>in</sub>= 5.864 Watts    Q<sub>loss</sub>= .172 Watts    CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 17.185 C    VISCOSITY= .00003694 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.2	17.2	17.2	17.5	17.5
17.2	17.4	17.6	17.2	17.5
17.2	17.4	51.1	17.4	17.2
17.1	17.2	20.9	17.7	17.6
17.6	17.5	19.2	17.5	17.6
17.4	17.4	18.5	17.2	17.3
17.2	17.2	18.2	17.3	17.3
17.3	17.1	17.8	17.2	17.3
17.2	17.2	17.8	17.3	17.3

THE HEATED CUBE IS IN COLUMN 3 AND ROW 4  
 BAROMETRIC PRESSURE 29.687 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER

VOLTS 3.6040 AMPS 1.7500  
CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

64.8	64.8	64.7	65.2	65.1
64.6	64.8	64.5	64.6	65.8
65.3	65.7	66.4	65.5	65.2
64.9	65.1	131.5	69.7	69.5
69.5	69.2	77.3	69.1	69.3
68.9	68.8	72.0	64.8	65.1
64.6	64.8	67.1	65.0	64.9
65.0	64.7	66.6	65.0	65.3
65.1	65.1	66.6	65.3	65.5

CALIBRATED TEMPERATURES IN DEGREES F

63.0	63.0	62.9	63.4	63.4
62.9	63.2	62.9	63.0	63.4
62.9	63.3	64.0	63.3	62.9
62.7	63.0	129.7	63.8	63.6
63.6	63.4	71.7	63.4	63.6
63.3	63.3	66.4	62.9	63.2
62.8	62.9	65.3	63.1	63.1
63.1	62.8	64.5	62.9	63.2
62.9	62.9	64.3	63.1	63.2

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.000 62.899 62.699  
THETA1= 1.0000000  
THETA2= .4031697  
THETA3= .2783767  
THETA4= .1882048  
THETA5= .1647105

H= 175.591 W/m<sup>2</sup>C ReH= 1545.2420000  
NUSSELI# = 55.829  
FREESTREAM VELOCITY = 4.494 m/s = 14.745 ft/s  
Q<sub>in</sub> = 6.307 Watts Q<sub>loss</sub> = .188 Watts CONDUCTIVITY = .040 W/mC  
T<sub>AMB</sub> = 17.148 C VISCOSITY = .00003694 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.2	17.2	17.2	17.5	17.4
17.2	17.4	17.2	17.2	17.4
17.2	17.4	17.8	17.4	17.1
17.1	17.2	54.3	17.6	17.6
17.6	17.5	22.1	17.4	17.6
17.4	17.4	19.1	17.2	17.3
17.1	17.2	18.5	17.3	17.3
17.3	17.1	18.1	17.2	17.3
17.2	17.2	18.0	17.3	17.3

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
BAROMETRIC PRESSURE 29.687 INCHES OF Hg  
PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
VOLTS 3.4120 AMPS 1.7500  
CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.0	65.0	64.9	65.3	65.3
64.8	65.0	64.6	64.8	65.9
65.4	65.6	65.3	65.6	65.4
65.1	65.2	66.8	65.9	65.6
69.9	69.3	130.6	69.2	69.5
69.0	68.9	76.5	64.9	65.2
65.8	65.9	68.5	65.1	65.0
65.1	64.9	67.3	65.1	65.3
65.2	66.9	65.4	65.4	65.5

CALIBRATED TEMPERATURES IN DEGREES F

63.2	63.2	63.1	63.5	63.6
------	------	------	------	------

63.1	63.4	63.0	63.2	63.5
63.0	63.2	62.9	63.4	63.1
62.9	63.1	64.6	59.9	59.6
64.0	63.5	125.9	63.5	63.8
63.4	63.4	71.0	63.0	63.3
64.0	64.0	66.7	63.2	63.2
63.2	63.0	65.2	63.0	63.2
63.0	64.8	63.1	63.2	63.2

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.100      63.100      62.899  
 THETA1=      1.0000000  
 THETA2=      .4645612  
 THETA3=      .2767180  
 THETA4=      .0109622

H= 176.686 W/m2C      ReH= 1545.0620000  
 NUSSELT#= 56.167  
 FREESTREAM VELOCITY = 4.495 m/s= 14.747 ft/s  
 Qin= 5.971 Watts      Qloss= .177 Watts      CONDUCTIVITY= .040 W/mC  
 TAMB= 17.241 C      VISCOSITY= .00003695 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.3	17.4	17.3	17.5	17.6
17.3	17.5	17.2	17.4	17.5
17.2	17.3	17.1	17.4	17.3
17.2	17.3	18.1	15.5	15.4
17.8	17.5	52.2	17.5	17.7
17.4	17.4	21.7	17.2	17.4
17.8	17.8	19.3	17.3	17.3
17.3	17.2	18.5	17.2	17.3
17.2	18.2	17.3	17.3	17.3

THE HEATED CUBE IS IN COLUMN 3 AND ROW 6  
 BAROMETRIC PRESSURE 29.687 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
 VOLTS 2.5850      AMPS 1.9500  
 CHANNEL HEIGHT RATIO 1.0

THE INPUT TEMPERATURE ARRAY IN DEGREES F

64.9	64.9	64.8	65.2	65.2
64.7	64.8	64.6	64.7	65.8
65.4	65.5	65.2	65.5	65.2
65.0	65.1	65.1	69.8	69.6
69.8	69.2	70.0	69.2	69.3
69.0	68.8	121.4	64.8	65.1
64.7	64.8	69.0	64.9	65.0
65.1	64.8	67.0	65.0	65.3
65.1	65.1	66.5	65.3	65.5

CALIBRATED TEMPERATURES IN DEGREES F

63.1	63.1	63.0	63.4	63.5
63.0	63.2	63.0	63.1	63.4
63.0	63.1	62.8	63.3	62.9
62.8	63.0	62.9	63.9	63.7
63.9	63.4	64.3	63.5	63.6
63.4	63.3	116.4	62.9	63.2
62.9	62.9	67.2	63.0	63.2
63.2	62.9	64.9	62.9	63.2
62.9	62.9	64.2	63.1	63.2

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.000      63.000      62.799  
 THETA1=      1.0000000  
 THETA2=      .4654886  
 THETA3=      .3001426

H= 175.346 W/m2C      ReH= 1545.1700000  
 NUSSELT#= 55.747

FREESTREAM VELOCITY = 4.495 m/s = 14.746 ft/s  
 Qin = 5.041 Watts    Qloss = .151 Watts    CONDUCTIVITY = .040 W/mC  
 Tamb = 17.185 C    VISCOSITY = .00003694 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.3	17.3	17.2	17.5	17.5
17.2	17.4	17.2	17.3	17.4
17.2	17.3	17.1	17.4	17.1
17.1	17.2	17.2	17.7	17.6
17.7	17.5	17.9	17.5	17.6
17.4	17.4	46.9	17.2	17.3
17.2	17.2	19.6	17.2	17.3
17.3	17.1	18.3	17.2	17.3
17.2	17.2	17.9	17.3	17.3

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1  
 BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00550 INCHES WATER  
 VOLTS 3.9340    AMPS 1.8000  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

70.8	70.8	203.3	71.2	71.0
70.7	70.9	84.0	70.6	71.4
71.2	71.4	78.6	71.5	71.0
70.8	70.9	76.5	75.7	75.1
75.3	75.0	79.4	75.2	75.0
74.7	74.9	78.5	71.1	70.8
70.4	70.8	73.9	71.3	70.7
70.8	70.7	73.7	71.4	71.2
71.0	71.1	73.9	71.6	71.3

CALIBRATED TEMPERATURES IN DEGREES F

69.3	69.3	202.2	69.7	69.5
69.1	69.5	82.8	69.3	69.2
68.9	69.3	76.6	69.5	68.9
68.8	69.1	74.5	69.6	69.0
69.2	69.0	73.5	69.3	69.2
68.7	69.3	72.8	69.5	69.0
68.7	69.1	72.2	69.6	69.0
68.9	68.9	71.6	69.3	69.0
68.8	68.8	71.5	69.3	69.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

69.609    69.695    69.516  
 THETA1 = 1.0000000  
 THETA2 = .5298308  
 THETA3 = .3711366  
 THETA4 = .2989878  
 THETA5 = .2432286  
 THETA6 = .1991213  
 THETA7 = .1490015  
 THETA8 = .1460584

H = 74.527 W/m<sup>2</sup>C

ReH = 1166.2510000

NUSSELT# = 54.111

FREESTREAM VELOCITY = 1.491 m/s = 4.892 ft/s  
 Qin = 7.081 Watts    Qloss = .372 Watts    CONDUCTIVITY = .040 W/mC  
 Tamb = 20.893 C    VISCOSITY = .00003735 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

20.7	20.7	94.5	21.0	20.8
20.6	20.8	28.2	20.7	20.7
20.5	20.7	24.8	20.8	20.5
20.5	20.6	23.6	20.9	20.6
20.7	20.6	23.1	20.7	20.7
20.4	20.7	22.7	20.8	20.5
20.4	20.6	22.3	20.9	20.5

20.5	20.5	22.0	20.7	20.6
20.5	20.4	22.0	20.7	20.6

THE HEATED CUBE IS IN COLUMN 3 AND ROW 2  
 BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00550 INCHES WATER  
 VOLTS 4.2430 AMPS 1.9300  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

70.8	70.8	74.7	71.2	71.0
70.8	70.8	217.9	70.6	71.4
71.3	71.4	88.1	71.3	71.2
71.0	70.9	80.3	75.6	75.2
75.2	75.2	81.4	75.3	75.0
74.8	74.7	79.9	71.1	70.8
70.6	70.8	75.1	71.3	70.8
70.8	70.7	74.5	71.6	71.2
71.0	71.1	74.4	71.7	71.3

CALIBRATED TEMPERATURES IN DEGREES F

69.3	69.3	73.2	69.7	69.5
69.2	69.4	217.8	69.3	69.2
69.0	69.3	86.1	69.3	69.1
69.0	69.1	78.3	69.5	69.1
69.1	69.2	75.6	69.4	69.2
68.8	69.1	74.2	69.5	69.0
68.9	69.1	73.4	69.6	69.1
68.9	68.9	72.4	69.5	69.0
68.8	68.8	72.0	69.4	69.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

69.609	69.695	69.717
THETA1=	1.0000000	
THETA2=	.5240500	
THETA3=	.3580016	
THETA4=	.2760395	
THETA5=	.2276916	
THETA6=	.1636733	
THETA7=	.1428837	

H=	77.159 W/m <sup>2</sup> C	ReH=	1166.1970000
NUSSELT#=#	56.018		
FREESTREAM VELOCITY =	1.491 m/s = 4.893 ft/s		
Qin=	8.189 Watts	Qloss=	.415 Watts
TAMB=	20.930 C	CONDUCTIVITY=	.040 W/mC
		VISCOSITY=	.00003735 m <sup>2</sup> /s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

20.7	20.7	22.9	21.0	20.8
20.7	20.8	103.2	20.7	20.7
20.6	20.7	30.1	20.7	20.6
20.6	20.6	25.7	20.8	20.6
20.6	20.7	24.2	20.8	20.7
20.5	20.6	23.5	20.8	20.5
20.5	20.6	23.0	20.9	20.6
20.5	20.5	22.4	20.8	20.6
20.5	20.4	22.2	20.8	20.6

THE HEATED CUBE IS IN COLUMN 3 AND ROW 3  
 BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00550 INCHES WATER  
 VOLTS 3.8320 AMPS 1.9300  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

70.9	70.9	70.9	71.1	71.1
70.8	70.9	75.5	70.6	71.7

71.4	71.8	204.6	71.6	71.3
71.1	71.2	97.3	75.7	75.4
75.4	75.3	88.5	75.3	75.2
74.9	74.9	83.6	71.2	71.0
71.7	71.1	77.5	71.5	70.9
71.0	70.9	76.3	71.6	71.3
71.2	71.3	75.7	71.8	71.5

CALIBRATED TEMPERATURES IN DEGREES F

69.4	69.4	69.4	69.6	69.6
69.2	69.5	74.2	69.3	69.5
69.1	69.7	203.6	69.6	69.2
69.1	69.4	95.4	69.6	69.3
69.3	69.3	82.8	69.4	69.4
68.9	69.3	78.0	69.6	69.2
70.0	69.4	75.8	69.8	69.2
69.1	69.1	74.2	69.5	69.1
69.0	69.0	73.3	69.5	69.2

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

69.709      69.896      69.717

THETA1= 1.0000000  
 THETA2= .5079736  
 THETA3= .3196352  
 THETA4= .2361114  
 THETA5= .1719169  
 THETA6= .1387121

H= 77.140 W/m2C

ReH= 1166.1170000

NUSSELT#= 55.998

FREESTREAM VELOCITY = 1.491 m/s= 4.893 ft/s

Qin= 7.396 Watts      Qloss= .375 Watts      CONDUCTIVITY= .040 W/mC

TAMB= 20.986 C

VISCOSITY= .00003736 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

20.8	20.8	20.8	20.9	20.9
20.7	20.8	23.4	20.7	20.8
20.6	20.9	95.3	20.9	20.7
20.6	20.8	35.2	20.9	20.7
20.7	20.7	28.2	20.8	20.8
20.5	20.7	25.5	20.9	20.7
21.1	20.8	24.3	21.0	20.6
20.6	20.6	23.4	20.8	20.6
20.6	20.5	23.0	20.8	20.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 4  
 BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00550 INCHES WATER  
 VOLTS 3.9630      AMPS 1.8000  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

70.7	70.7	70.6	71.0	70.8
70.6	70.7	70.7	70.5	71.6
71.2	71.6	77.4	71.4	71.1
70.8	70.8	203.0	75.4	75.2
75.2	75.1	98.7	75.0	75.0
74.7	74.9	85.9	70.9	70.9
70.5	70.8	78.3	71.1	70.7
70.8	70.7	76.4	71.2	71.1
71.0	71.0	75.7	71.5	71.3

CALIBRATED TEMPERATURES IN DEGREES F

69.2	69.2	69.1	69.5	69.3
69.0	69.3	69.3	69.2	69.4
68.9	69.5	75.4	69.4	69.0
68.8	69.0	201.7	69.3	69.1
69.1	69.1	93.2	69.1	69.2
68.7	69.3	80.3	69.3	69.1

68.8	69.1	76.6	69.4	69.0
68.9	68.9	74.3	69.1	68.9
68.8	68.7	73.3	69.2	69.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

69.609      69.695      69.516  
 THETA1=      1.0000000  
 THETA2=      .4536088  
 THETA3=      .2979166  
 THETA4=      .1983913  
 THETA5=      .1580028

H= 75.377 W/m2C      ReH= 1166.2510000  
 NUSSELT#= 54.728  
 FREESTREAM VELOCITY = 1.491 m/s= 4.892 ft/s  
 Qin= 7.133 Watts      Qloss= .370 Watts      CONDUCTIVITY= .040 W/mC  
 TAMB= 20.893 C      VISCOSITY= .00003735 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

20.7	20.6	20.6	20.9	20.7
20.6	20.7	20.7	20.6	20.8
20.5	20.8	24.1	20.8	20.5
20.5	20.6	94.3	20.7	20.6
20.6	20.6	34.0	20.6	20.7
20.4	20.7	26.8	20.7	20.6
20.4	20.6	24.8	20.8	20.5
20.5	20.5	23.5	20.6	20.5
20.5	20.4	23.0	20.7	20.6

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
 BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00550 INCHES WATER  
 VOLTS 3.7900      AMPS 1.8000  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

70.7	70.7	70.6	70.9	70.8
70.5	70.6	70.4	70.4	71.5
71.2	71.5	71.3	71.2	71.0
70.8	70.9	75.9	75.3	75.1
75.1	74.9	202.6	74.9	74.9
74.7	74.9	97.5	70.7	70.8
70.4	70.7	81.8	70.9	70.7
70.8	70.7	78.0	71.1	71.0
70.9	71.0	76.7	71.4	71.3

CALIBRATED TEMPERATURES IN DEGREES F

69.2	69.2	69.1	69.4	69.3
68.9	69.2	69.0	69.1	69.3
68.9	69.4	69.2	69.2	68.9
68.8	69.1	73.9	69.2	69.0
69.0	68.9	198.8	69.0	69.1
68.7	69.3	92.0	69.0	69.0
68.7	69.0	80.1	69.2	69.0
68.9	68.9	75.9	69.0	68.8
68.7	68.7	74.3	69.1	69.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

69.609      69.594      69.416  
 THETA1=      1.0000000  
 THETA2=      .4706517  
 THETA3=      .2823049  
 THETA4=      .2129837

H= 73.644 W/m2C      ReH= 1166.3050000  
 NUSSELT#= 53.474  
 FREESTREAM VELOCITY = 1.491 m/s= 4.892 ft/s  
 Qin= 6.822 Watts      Qloss= .363 Watts      CONDUCTIVITY= .040 W/mC

TAMB= 20.856 C

VISCOSITY= .00003735 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

20.7	20.6	20.6	20.8	20.7
20.5	20.7	20.6	20.6	20.7
20.5	20.8	20.7	20.7	20.5
20.5	20.6	23.3	20.7	20.6
20.6	20.5	92.7	20.5	20.6
20.4	20.7	33.3	20.6	20.5
20.4	20.5	26.7	20.7	20.5
20.5	20.5	24.4	20.6	20.5
20.4	20.4	23.5	20.6	20.6

THE HEATED CUBE IS IN COLUMN 3 AND ROW 6  
 BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00550 INCHES WATER  
 VOLTS 2.7930 AMPS 1.8000  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

70.7	70.7	70.6	70.9	70.8
70.5	70.6	70.3	70.4	71.5
71.2	71.5	71.1	71.2	71.0
70.8	70.8	70.9	75.3	75.2
75.2	74.9	77.0	74.8	74.6
74.6	74.8	170.5	70.6	70.8
70.4	70.7	81.3	70.8	70.7
70.8	70.6	76.2	70.8	71.1
70.9	71.0	74.5	71.1	71.3

CALIBRATED TEMPERATURES IN DEGREES F

69.2	69.2	69.1	69.4	69.3
68.9	69.2	68.9	69.1	69.3
68.9	69.4	69.0	69.2	68.9
68.8	69.0	68.9	69.2	69.1
69.1	68.9	71.1	68.9	68.8
68.6	69.2	165.9	68.9	69.0
68.7	69.0	79.6	69.1	69.0
68.9	68.8	74.1	68.7	68.9
68.7	68.7	72.1	68.8	69.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

69.609 69.594 69.416  
 THETA1= 1.0000000  
 THETA2= .4501186  
 THETA3= .2566145

H= 72.815 W/m2C

ReH= 1166.3050000

NUSSELT#= 52.872

FREESTREAM VELOCITY = 1.491 m/s= 4.892 ft/s

Qin= 5.027 Watts Qloss= .271 Watts CONDUCTIVITY= .040 W/mC

TAMB= 20.856 C

VISCOSITY= .00003735 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

20.7	20.6	20.6	20.8	20.7
20.5	20.7	20.5	20.6	20.7
20.5	20.8	20.6	20.7	20.5
20.5	20.6	20.5	20.7	20.6
20.6	20.5	21.7	20.5	20.4
20.4	20.7	74.4	20.5	20.5
20.4	20.5	26.5	20.6	20.5
20.5	20.4	23.4	20.4	20.5
20.4	20.4	22.3	20.4	20.6

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1  
 BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER

VOLTS 3.8850 AMPS 1.8000  
CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F  
71.3 71.3 143.8 71.6 71.5  
71.2 71.3 76.5 71.0 71.9  
71.7 71.8 74.8 71.7 71.4  
71.2 71.4 73.8 75.8 75.6  
75.7 75.4 77.5 75.4 75.3  
75.2 75.3 77.0 71.2 71.2  
71.0 71.2 72.5 71.4 71.1  
71.3 71.2 72.7 71.5 71.5  
71.3 71.5 72.8 71.7 71.7

CALIBRATED TEMPERATURES IN DEGREES F  
69.8 69.8 142.5 70.1 70.0  
69.6 69.9 75.2 69.7 69.7  
69.4 69.7 72.7 69.7 69.3  
69.2 69.6 71.8 69.7 69.5  
69.6 69.4 71.6 69.5 69.5  
69.2 69.7 71.3 69.6 69.4  
69.3 69.5 70.8 69.7 69.4  
69.4 69.4 70.6 69.4 69.3  
69.1 69.2 70.4 69.4 69.4

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.010 69.896 69.917  
THETA1= 1.0000000  
THETA2= .5336266  
THETA3= .3486588  
THETA4= .3170511  
THETA5= .2563253  
THETA6= .1683013  
THETA7= .1179530  
THETA8= .0923567

H= 134.490 W/m<sup>2</sup>C ReH= 2331.9650000  
NUSSELT#= 97.613  
FREESTREAM VELOCITY = 2.983 m/s= 9.788 ft/s  
Q<sub>in</sub>= 6.993 Watts Q<sub>loss</sub>= .204 Watts CONDUCTIVITY= .040 W/mC  
T<sub>AMB</sub>= 21.079 C VISCOSITY= .00003737 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE  
21.0 21.0 61.4 21.2 21.1  
20.9 21.0 24.0 20.9 20.9  
20.8 20.9 22.6 20.9 20.7  
20.7 20.9 22.1 21.0 20.8  
20.9 20.8 22.0 20.8 20.8  
20.7 21.0 21.8 20.9 20.8  
20.7 20.8 21.6 20.9 20.8  
20.8 20.8 21.4 20.8 20.7  
20.6 20.7 21.3 20.8 20.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 2  
BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
VOLTS 4.1390 AMPS 1.9000  
CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F  
71.4 71.4 73.2 71.7 71.5  
71.2 71.4 155.8 71.1 72.0  
71.7 71.9 79.8 71.8 71.5  
71.4 71.4 75.7 75.9 75.6  
75.7 75.4 78.6 75.6 75.4  
75.2 75.4 77.7 71.4 71.3  
70.9 71.2 73.1 71.6 71.2  
71.3 71.2 73.0 71.6 71.6

71.4      71.5      73.1      71.9      71.7

CALIBRATED TEMPERATURES IN DEGREES F

69.9	69.9	71.7	70.2	70.0
69.6	70.0	155.1	69.8	69.8
69.4	69.8	77.8	69.8	69.4
69.4	69.6	73.7	69.8	69.5
69.6	69.4	72.7	69.7	69.6
69.2	69.8	72.0	69.8	69.5
69.2	69.5	71.4	69.9	69.5
69.4	69.4	70.9	69.5	69.4
69.2	69.2	70.7	69.6	69.4

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.010	69.997	69.917
THETA1=	1.0000000	
THETA2=	.4748241	
THETA3=	.3521572	
THETA4=	.2587749	
THETA5=	.1857150	
THETA6=	.1136423	
THETA7=	.0962606	

H= 128.833 W/m<sup>2</sup>C

ReH= 2331.9110000

NUSSELT#= 93.503

FREESTREAM VELOCITY = 2.983 m/s= 9.788 ft/s

Q<sub>in</sub>= 7.864 Watts      Q<sub>loss</sub>= .239 Watts      CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 21.097 C      VISCOSITY= .00003737 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

21.1	21.0	22.0	21.2	21.1
20.9	21.1	68.4	21.0	21.0
20.8	21.0	25.4	21.0	20.8
20.8	20.9	23.2	21.0	20.8
20.9	20.8	22.6	20.9	20.9
20.7	21.0	22.2	21.0	20.8
20.7	20.8	21.9	21.0	20.8
20.8	20.8	21.6	20.8	20.8
20.7	20.7	21.5	20.9	20.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 3

BAROMETRIC PRESSURE 30.658 INCHES OF Hg

PITOT-STATIC TUBE DELTA .02200 INCHES WATER

VOLTS 3.7590      AMPS 1.9200

CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

71.2	71.2	71.2	71.5	71.4
71.1	71.3	73.0	71.0	72.0
71.7	72.1	155.8	71.8	71.6
71.4	71.5	82.1	75.9	75.6
75.7	75.5	80.8	75.5	75.5
75.3	75.4	78.6	71.4	71.4
71.0	71.3	73.6	71.6	71.2
71.4	71.2	73.4	71.6	71.6
71.5	71.6	73.3	72.0	71.8

CALIBRATED TEMPERATURES IN DEGREES F

69.7	69.7	69.7	70.0	69.9
69.5	69.9	71.7	69.7	69.8
69.4	70.0	154.4	69.8	69.5
69.4	69.7	80.1	69.8	69.5
69.6	69.5	75.0	69.6	69.7
69.3	69.8	72.9	69.8	69.6
69.3	69.6	71.9	69.9	69.5
69.5	69.4	71.3	69.5	69.4
69.3	69.3	70.9	69.7	69.5

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.010 70.098 69.917  
 THETA1= 1.0000000  
 THETA2= .4899860  
 THETA3= .2866377  
 THETA4= .1895818  
 THETA5= .1242340  
 THETA6= .0908313

H= 119.371 W/m<sup>2</sup>C ReH= 2331.8570000  
 NUSSELT#= 86.633  
 FREESTREAM VELOCITY = 2.984 m/s= 9.789 ft/s  
 Qin= 7.217 Watts Qloss= .237 Watts CONDUCTIVITY= .040 W/mC  
 TAMB= 21.116 C VISCOSITY= .00003737 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

21.0	20.9	20.9	21.1	21.1
20.9	21.0	22.0	20.9	21.0
20.8	21.1	68.0	21.0	20.8
20.8	21.0	26.7	21.0	20.8
20.9	20.8	23.9	20.9	20.9
20.7	21.0	22.7	21.0	20.9
20.7	20.9	22.2	21.0	20.8
20.9	20.8	21.8	20.8	20.8
20.7	20.7	21.6	20.9	20.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 4  
 BAROMETRIC PRESSURE 30.007 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 3.8570 AMPS 1.9000  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

67.7	67.7	67.6	67.9	67.8
67.5	67.6	67.4	67.3	68.5
68.1	68.5	70.9	68.3	67.9
67.7	67.9	155.1	72.5	72.0
72.2	71.9	82.3	72.0	71.9
71.6	71.7	75.7	67.9	67.7
67.4	67.6	70.2	68.2	67.5
67.8	67.5	69.7	68.3	67.9
67.9	67.9	69.6	68.7	68.2

CALIBRATED TEMPERATURES IN DEGREES F

65.9	65.9	65.8	65.9	66.1
65.8	65.9	65.8	65.8	66.3
65.9	66.4	68.8	66.2	65.8
65.7	66.1	153.7	66.2	65.9
66.2	66.0	76.6	66.1	66.1
65.8	66.1	70.1	66.3	66.0
65.8	65.8	68.5	66.5	65.8
66.0	65.7	67.7	66.3	65.8
65.7	65.8	67.3	66.5	65.9

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

66.304 66.420 66.607  
 THETA1= 1.0000000  
 THETA2= .3577057  
 THETA3= .2052243  
 THETA4= .1282964  
 THETA5= .0867538

H= 117.186 W/m<sup>2</sup>C ReH= 2362.7990000  
 NUSSELT#= 85.370  
 FREESTREAM VELOCITY = 3.006 m/s= 9.861 ft/s  
 Qin= 7.328 Watts Qloss= .245 Watts CONDUCTIVITY= .040 W/mC  
 TAMB= 19.135 C VISCOSITY= .00003716 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.8	18.8	18.8	18.8	18.9
18.8	18.9	18.8	18.8	19.0
18.8	19.1	20.5	19.0	18.8
18.7	19.0	67.6	19.0	18.8
19.0	18.9	24.8	19.0	18.9
18.8	18.9	21.2	19.1	18.9
18.8	18.8	20.3	19.2	18.8
18.9	18.7	19.9	19.1	18.8
18.7	18.8	19.6	19.2	18.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
 BAROMETRIC PRESSURE 29.291 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 3.8250 AMPS 1.4900  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

66.5	66.5	66.4	66.8	66.7
66.3	66.4	66.2	66.3	67.4
67.0	67.3	67.0	67.1	66.9
66.6	66.7	68.3	71.2	71.0
71.0	70.8	137.3	70.8	70.8
70.4	70.4	75.1	66.7	66.6
66.2	66.4	68.5	66.9	66.5
66.5	66.4	67.8	67.1	66.8
66.7	66.7	67.8	67.4	66.9

CALIBRATED TEMPERATURES IN DEGREES F

64.7	64.7	64.7	65.0	65.0
64.6	64.8	64.6	64.7	65.2
64.9	65.2	65.0	65.1	64.9
64.7	64.9	66.4	65.2	65.0
65.0	65.0	132.5	64.9	65.0
64.7	64.8	69.5	65.1	64.8
64.8	64.8	67.0	65.3	64.9
64.9	64.8	65.9	65.3	64.9
64.9	65.0	65.9	65.5	64.9

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

64.802 64.911 64.803  
 THETA1= 1.0000000  
 THETA2= .4727159  
 THETA3= .2370119  
 THETA4= .2342279

H= 117.524 W/m<sup>2</sup> ReH= 2394.1960000  
 NUSSELT#= 85.763  
 FREESTREAM VELOCITY = 3.038 m/s= 9.965 ft/s  
 Qin= 5.699 Watts Qloss= .190 Watts CONDUCTIVITY= .040 W/mC  
 TAMB= 18.244 C VISCOSITY= .00003706 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.2	18.2	18.2	18.3	18.3
18.1	18.2	18.1	18.2	18.4
18.3	18.4	18.3	18.4	18.3
18.2	18.3	19.1	18.4	18.4
18.4	18.3	55.8	18.3	18.4
18.2	18.2	20.8	18.4	18.2
18.2	18.2	19.5	18.5	18.3
18.3	18.2	18.9	18.5	18.3
18.3	18.3	18.8	18.6	18.3

THE HEATED CUBE IS IN COLUMN 3 AND ROW 6  
 BAROMETRIC PRESSURE 30.658 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 3.4000 AMPS 2.2000

CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

71.3	71.3	71.2	71.7	71.5
71.2	71.4	71.0	71.2	72.2
71.9	72.2	71.9	72.0	71.6
71.5	71.6	71.5	76.0	75.8
75.8	75.6	77.0	75.5	75.6
75.3	75.4	164.5	71.3	71.5
71.2	71.4	78.3	71.5	71.3
71.5	71.4	74.6	71.5	71.7
71.6	71.7	73.7	71.9	71.9

CALIBRATED TEMPERATURES IN DEGREES F

69.8	69.8	69.7	70.2	70.0
69.6	70.0	69.6	69.9	70.0
69.6	70.1	69.8	70.0	69.5
69.5	69.8	69.5	69.9	69.7
69.7	69.6	71.1	69.6	69.8
69.3	69.8	159.8	69.7	69.7
69.5	69.7	76.6	69.8	69.6
69.6	69.6	72.5	69.4	69.5
69.4	69.4	71.3	69.6	69.6

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.110      70.098      70.118  
THETA1=      1.0000000  
THETA2=      .3624850  
THETA3=      .1869672

H= 116.356 W/m<sup>2</sup>C

ReH= 2331.6970000

NUSSELT#= 84.436

FREESTREAM VELOCITY = 2.984 m/s= 9.789 ft/s

Q<sub>in</sub>= 7.480 Watts      Q<sub>loss</sub>= .252 Watts      CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 21.172 C      VISCOSITY= .00003738 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

21.0	21.0	20.9	21.2	21.1
20.9	21.1	20.9	21.0	21.1
20.9	21.2	21.0	21.1	20.8
20.8	21.0	20.8	21.1	21.0
21.0	20.9	21.7	20.9	21.0
20.7	21.0	71.0	20.9	20.9
20.8	20.9	24.8	21.0	20.9
20.9	20.9	22.5	20.8	20.8
20.8	20.8	21.8	20.9	20.9

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1

BAROMETRIC PRESSURE 30.658 INCHES OF Hg

PITOT-STATIC TUBE DELTA .04900 INCHES WATER

VOLTS 4.2400      AMPS 1.8700

CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

71.7	71.7	136.6	72.0	71.8
71.6	71.7	76.9	71.3	72.2
72.1	72.3	75.3	72.0	71.8
71.7	71.9	74.2	76.1	75.8
76.1	75.9	77.9	75.7	75.7
75.7	75.7	77.4	71.6	71.6
71.4	71.6	73.0	71.7	71.4
71.8	71.6	73.2	71.8	71.9
71.9	71.9	73.2	72.0	72.0

CALIBRATED TEMPERATURES IN DEGREES F

70.2	70.2	135.3	70.5	70.3
70.0	70.3	75.6	70.0	70.0
69.8	70.2	73.2	70.0	69.7



THETA4= .3208491  
THETA5= .2396767  
THETA6= .2155451  
THETA7= .1672953

H= 165.408 W/m<sup>2</sup> ReH= 3518.4090000  
NUSSELT#=120.138  
FREESTREAM VELOCITY = 4.496 m/s= 14.752 ft/s  
Q<sub>in</sub>= 7.885 Watts Q<sub>loss</sub>= .187 Watts CONDUCTIVITY= .040 W/mC  
T<sub>AMB</sub>= 20.707 C VISCOSITY= .00003733 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

20.7	20.6	21.5	20.8	20.7
20.8	20.8	57.7	20.6	20.7
20.8	20.8	24.5	20.8	20.5
20.7	20.7	22.7	20.7	20.6
20.8	20.7	22.2	20.7	20.6
20.7	20.7	21.9	20.7	20.6
20.7	20.7	21.6	20.7	20.6
20.7	20.7	21.5	20.7	20.6
20.7	20.8	21.3	20.7	20.6

THE HEATED CUBE IS IN COLUMN 3 AND ROW 3  
BAROMETRIC PRESSURE 30.024 INCHES OF Hg  
PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
VOLTS 3.6500 AMPS 1.8700  
CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

71.5	71.5	71.4	71.6	71.5
71.5	71.5	72.3	71.2	72.2
72.2	72.3	131.7	71.9	71.8
71.8	71.6	77.2	75.9	75.7
76.0	75.8	78.4	75.6	75.5
75.6	75.5	77.2	71.4	71.5
71.3	71.5	72.7	71.6	71.3
71.6	71.5	72.8	71.6	71.7
71.8	71.8	72.8	71.9	71.8

CALIBRATED TEMPERATURES IN DEGREES F

69.9	69.9	69.8	70.0	70.0
70.0	70.2	71.1	69.9	70.2
70.2	70.4	130.3	70.2	69.9
70.1	70.1	75.5	70.1	69.9
70.3	70.1	72.9	70.0	70.0
70.1	70.1	71.9	70.2	70.1
70.1	70.1	71.3	70.2	70.0
70.1	70.1	71.3	70.0	69.9
70.1	70.2	70.9	70.1	70.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.110 70.199 70.118  
THETA1= 1.0000000  
THETA2= .5195871  
THETA3= .3266883  
THETA4= .2211323  
THETA5= .2092143  
THETA6= .1465864

H= 158.356 W/m<sup>2</sup> ReH= 3516.3030000  
NUSSELT#=114.910  
FREESTREAM VELOCITY = 4.500 m/s= 14.764 ft/s  
Q<sub>in</sub>= 6.826 Watts Q<sub>loss</sub>= .169 Watts CONDUCTIVITY= .040 W/mC  
T<sub>AMB</sub>= 21.190 C VISCOSITY= .00003733 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

21.1	21.0	21.0	21.1	21.1
21.1	21.2	21.7	21.0	21.2

21.2	21.3	54.6	21.2	21.0
21.2	21.2	24.2	21.2	21.1
21.3	21.2	22.7	21.1	21.1
21.2	21.2	22.2	21.2	21.2
21.2	21.1	21.8	21.2	21.1
21.2	21.2	21.8	21.1	21.1
21.2	21.2	21.6	21.2	21.1

THE HEATED CUBE IS IN COLUMN 3 AND ROW 4  
 BAROMETRIC PRESSURE 30.024 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
 VOLTS 3.8600 AMPS 1.8700  
 CHANNEL HEIGHT RATIO 2.3

THE INPUT TEMPERATURE ARRAY IN DEGREES F

71.6	71.6	71.4	71.7	71.5
71.5	71.5	71.2	71.2	72.2
71.1	71.3	73.3	72.0	71.8
71.8	71.7	134.9	76.0	75.8
76.1	75.8	81.6	75.7	75.6
75.5	75.5	78.0	71.4	71.5
71.4	71.6	73.1	71.5	71.4
71.6	71.5	73.1	71.6	71.8
71.9	71.9	73.0	71.9	71.8

CALIBRATED TEMPERATURES IN DEGREES F

70.0	70.0	69.8	70.1	70.0
70.0	70.2	69.9	69.9	70.2
69.1	69.4	71.4	70.3	69.9
70.1	70.2	133.5	70.2	70.0
70.4	70.1	76.2	70.1	70.1
70.0	70.1	72.7	70.2	70.1
70.2	70.2	71.7	70.1	70.1
70.1	70.1	71.6	70.0	70.0
70.2	70.3	71.1	70.1	70.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.210	70.199	70.118
THETA1=	1.0000000	
THETA2=	.4205808	
THETA3=	.2582320	
THETA4=	.2312055	
THETA5=	.1584733	

H=	159.064 W/m <sup>2</sup> C	ReH=	3516.2230000
NUSSELT#	=115.420		
FREESTREAM VELOCITY	= 4.500 m/s = 14.764 ft/s		
Q <sub>in</sub>	= 7.218 Watts	Q <sub>loss</sub>	= .178 Watts
T <sub>AMB</sub>	= 21.209 C	CONDUCTIVITY	= .040 W/mC
		VISCOSITY	= .00003738 m <sup>2</sup> /s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

21.1	21.1	21.0	21.2	21.1
21.1	21.2	21.1	21.0	21.2
20.6	20.8	21.9	21.3	21.0
21.2	21.2	56.4	21.2	21.1
21.4	21.2	24.5	21.2	21.2
21.1	21.2	22.6	21.2	21.2
21.2	21.2	22.1	21.2	21.1
21.2	21.2	22.0	21.1	21.1
21.2	21.3	21.7	21.2	21.1

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
 BAROMETRIC PRESSURE 30.024 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
 VOLTS 3.8510 AMPS 1.8700  
 CHANNEL HEIGHT RATIO 2.3



70.6	70.2	71.4	70.1	70.2
70.1	70.2	145.1	70.2	70.1
70.2	70.2	74.7	70.1	70.1
70.2	70.1	72.5	70.0	70.1
70.2	70.3	71.5	70.1	70.1

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.310      70.299      70.218

THETA1=      1.0000000

THETA2=      .4926057

THETA3=      .2811364

H= 157.971 W/m<sup>2</sup>C

ReH= 3515.9800000

NUSSELT#=114.615

FREESTREAM VELOCITY = 4.501 m/s= 14.766 ft/s

Qin= 8.475 Watts      Qloss= .211 Watts      CONDUCTIVITY= .040 W/mC

TAMB= 21.265 C      VISCOSITY= .00003739 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

21.1	21.1	21.0	21.2	21.2
21.2	21.3	21.1	21.1	21.2
20.7	21.2	21.1	21.3	21.0
21.2	21.2	21.1	21.3	21.1
21.5	21.2	21.9	21.2	21.2
21.2	21.2	62.9	21.2	21.2
21.2	21.2	23.7	21.2	21.1
21.2	21.2	22.5	21.1	21.2
21.2	21.3	22.0	21.2	21.2

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1  
 BAROMETRIC PRESSURE 30.024 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00550 INCHES WATER  
 VOLTS 3.4650      AMPS 1.8000  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

71.5	71.5	195.7	72.0	71.7
71.3	71.6	86.1	71.5	72.2
71.8	72.2	80.2	72.5	71.6
71.4	71.7	77.6	77.0	75.9
75.9	75.9	80.4	76.4	75.7
75.4	75.7	79.1	72.3	71.6
71.2	71.8	74.5	71.6	71.4
71.6	71.7	72.8	72.8	71.8
71.7	72.0	74.2	73.0	72.0

CALIBRATED TEMPERATURES IN DEGREES F

69.9	69.9	194.5	70.4	70.2
69.8	70.3	85.0	70.2	70.2
69.8	70.3	78.4	70.8	69.7
69.7	70.2	75.9	71.2	70.1
70.2	70.2	75.0	70.8	70.2
69.9	70.3	73.8	71.1	70.2
70.0	70.4	73.1	70.2	70.1
70.1	70.3	71.3	71.2	70.0
70.0	70.4	72.3	71.2	70.2

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.310      70.400      70.218

THETA1=      1.0000000

THETA2=      .5507835

THETA3=      .3807500

THETA4=      .3167980

THETA5=      .2388533

THETA6=      .1919971

THETA7=      .0648929

THETA8=      .1376179





67.9	68.1	71.0	67.9	67.8
67.5	67.4	144.4	71.9	71.6
71.6	71.9	82.0	71.6	71.4
71.3	71.3	75.8	67.5	67.3
67.0	67.3	70.0	67.7	67.2
67.3	67.2	69.5	67.9	67.6
67.5	67.6	69.4	68.2	67.7

CALIBRATED TEMPERATURES IN DEGREES F

65.8	65.8	65.8	66.0	65.8
65.7	65.6	65.7	65.5	65.8
65.7	66.0	68.9	65.9	65.7
65.7	65.6	142.8	65.8	65.6
65.6	66.0	76.3	65.8	65.6
65.6	65.8	70.3	65.9	65.6
65.4	65.5	68.3	65.9	65.6
65.5	65.5	67.5	66.0	65.6
65.5	65.6	67.2	66.1	65.6

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

66.003      66.016      66.006  
 THETA1=      1.0000000  
 THETA2=      .4151201  
 THETA3=      .2255199  
 THETA4=      .1494618  
 THETA5=      .1182665

H= 71.146 W/m<sup>2</sup>C

ReH= 2377.0710000

NUSSELT#=103.708

FREESTREAM VELOCITY = 1.511 m/s = 4.957 ft/s

Q<sub>in</sub>= 3.918 Watts      Q<sub>loss</sub>= .216 Watts      CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 18.894 C

VISCOSITY= .00003713 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.8	18.8	18.8	18.9	18.8
18.7	18.7	18.7	18.6	18.8
18.7	18.9	20.5	18.8	18.7
18.7	18.7	61.6	18.8	18.7
18.6	18.9	24.6	18.8	18.6
18.7	18.8	21.3	18.9	18.6
18.5	18.6	20.2	18.8	18.6
18.6	18.6	19.7	18.9	18.7
18.6	18.7	19.6	18.9	18.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
 BAROMETRIC PRESSURE 29.996 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .00550 INCHES WATER  
 VOLTS 2.8750      AMPS 1.4100  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.8	65.8	65.6	66.0	65.9
65.6	65.7	65.5	65.4	66.5
66.3	66.6	66.5	66.3	66.1
65.9	66.0	70.6	70.4	70.2
70.3	70.1	146.7	69.9	70.0
69.8	70.0	85.7	65.7	65.7
65.6	66.0	73.0	65.9	65.7
65.9	66.1	71.0	65.9	66.0
66.1	66.4	70.0	66.2	66.2

CALIBRATED TEMPERATURES IN DEGREES F

64.0	64.0	63.9	64.2	64.2
63.9	64.1	63.9	63.8	64.3
64.2	64.5	64.5	64.3	64.1
64.0	64.2	68.8	64.4	64.2
64.3	64.3	142.1	64.0	64.2
64.1	64.4	80.2	64.1	63.9



TAMB= 18.002 C

VISCOSITY= .00003703 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.9	17.9	17.9	17.9	17.8
17.8	18.0	17.8	18.0	18.0
18.0	18.1	17.9	18.0	17.9
17.9	18.0	18.0	18.1	18.0
18.0	18.0	19.2	17.9	18.0
17.9	18.0	50.2	18.0	17.9
17.9	18.0	21.3	17.9	17.9
18.0	18.0	19.7	17.9	18.0
17.9	18.1	19.1	17.9	18.0

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1  
 BAROMETRIC PRESSURE 29.666 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 3.8970 AMPS 1.8900  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

66.6	66.6	149.1	67.1	66.8
66.5	66.7	72.8	66.4	67.3
67.1	67.2	70.5	67.2	66.7
66.6	66.9	69.3	71.4	71.0
71.0	70.9	73.0	70.9	70.8
70.5	70.8	72.3	66.8	66.6
66.3	66.7	67.9	67.0	66.5
66.7	66.7	68.0	67.1	66.8
66.7	67.0	68.2	67.3	67.1

CALIBRATED TEMPERATURES IN DEGREES F

65.1	65.0	147.9	65.6	65.3
65.0	65.2	71.5	64.8	65.1
64.9	65.1	68.4	65.2	64.6
64.8	65.1	67.3	65.3	65.0
64.9	65.0	67.1	65.1	64.9
64.8	65.3	66.7	65.2	64.9
64.7	64.9	66.2	65.2	64.9
64.9	65.0	66.0	65.2	64.8
64.7	65.0	66.0	65.2	65.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

65.603 65.513 65.304  
 THETA1= 1.0000000  
 THETA2= .4903917  
 THETA3= .3131048  
 THETA4= .2768086  
 THETA5= .2102556  
 THETA6= .1256749  
 THETA7= .0940354  
 THETA8= .0917619

H= 124.665 W/m2C

ReH= 4755.9020000

NUSSELT#=181.825

FREESTREAM VELOCITY = 3.020 m/s= 9.908 ft/s

Qin= 7.365 Watts Qloss= .232 Watts CONDUCTIVITY= .040 W/mC

TAMB= 18.596 C

VISCOSITY= .00003710 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.4	18.4	64.4	18.7	18.5
18.3	18.5	21.9	18.2	18.4
18.3	18.4	20.2	18.4	18.1
18.2	18.4	19.6	18.5	18.4
18.3	18.3	19.5	18.4	18.3
18.2	18.5	19.3	18.5	18.3
18.2	18.3	19.0	18.4	18.3
18.3	18.3	18.9	18.4	18.2
18.2	18.3	18.9	18.4	18.3

THE HEATED CUBE IS IN COLUMN 3 AND ROW 2  
 BAROMETRIC PRESSURE 29.666 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 3.8430 AMPS 1.8900  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

66.7	66.7	68.4	67.1	66.9
66.4	66.8	150.4	66.4	67.3
67.0	67.2	74.2	67.3	66.7
66.7	66.8	70.5	71.6	70.9
71.0	70.9	73.4	71.1	70.8
70.6	70.7	72.5	67.0	66.6
66.3	66.7	68.0	67.2	66.5
66.7	66.6	67.9	67.4	66.9
66.7	66.9	68.1	67.5	67.1

CALIBRATED TEMPERATURES IN DEGREES F

65.2	65.1	67.0	65.6	65.4
64.9	65.3	149.7	64.8	65.1
64.8	65.1	72.1	65.3	64.6
64.9	65.0	68.6	65.5	64.9
64.9	65.0	67.5	65.3	64.9
64.9	65.2	66.9	65.4	64.9
64.7	64.9	66.3	65.4	64.9
64.9	64.9	65.9	65.5	64.9
64.7	64.9	65.9	65.4	65.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

65.302 65.311 65.103  
 THETA1= 1.0000000  
 THETA2= .4805199  
 THETA3= .3331070  
 THETA4= .2457309  
 THETA5= .1574955  
 THETA6= .1009766  
 THETA7= .0990667

H= 119.988 W/m<sup>2</sup>C ReH= 4756.6720000  
 NUSSELT#=175.048  
 FREESTREAM VELOCITY = 3.019 m/s= 9.906 ft/s  
 Qin= 7.263 Watts Qloss= .238 Watts CONDUCTIVITY= .040 W/mC  
 TAMB= 18.466 C VISCOSITY= .00003708 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.4	18.4	19.4	18.7	18.6
18.3	18.5	65.4	18.2	18.4
18.2	18.4	22.3	18.5	18.1
18.3	18.4	20.3	18.6	18.3
18.3	18.3	19.7	18.5	18.3
18.3	18.4	19.4	18.6	18.3
18.2	18.3	19.1	18.5	18.3
18.3	18.3	18.9	18.6	18.3
18.2	18.3	18.8	18.5	18.3

THE HEATED CUBE IS IN COLUMN 3 AND ROW 3  
 BAROMETRIC PRESSURE 29.884 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 3.5720 AMPS 1.8000  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.4	65.4	65.4	65.6	65.6
65.3	65.4	67.5	65.2	66.2
65.9	66.0	147.8	66.0	65.8
65.6	65.6	74.8	70.4	69.9

70.1	65.7	74.3	69.8	69.7
69.3	69.4	72.3	65.6	65.5
65.2	65.5	67.6	65.8	65.3
65.5	65.4	67.4	65.9	65.7
65.6	65.8	67.4	66.2	65.9

CALIBRATED TEMPERATURES IN DEGREES F

63.6	63.6	63.7	63.9	63.9
63.5	63.8	66.0	63.7	64.0
63.7	63.9	146.3	64.0	63.8
63.6	63.7	72.9	64.4	63.9
64.1	59.8	68.6	64.0	64.0
63.5	63.8	66.6	64.1	63.9
63.6	63.8	65.6	64.1	63.7
63.7	63.7	65.1	64.0	63.8
63.5	63.8	65.2	64.3	63.9

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.600      63.703      63.600

THETA1= 1.0000000  
 THETA2= .5320663  
 THETA3= .3243040  
 THETA4= .2154206  
 THETA5= .1621243  
 THETA6= .1717415

H= 108.515 W/m2C

ReH= 4744.5610000

NUSSELT#=158.581

FREESTREAM VELOCITY = 3.004 m/s= 9.855 ft/s

Qin= 6.430 Watts      Qloss= .232 Watts      CONDUCTIVITY= .040 W/mC

TAMB= 17.575 C      VISCOSITY= .00003699 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.6	17.6	17.6	17.7	17.7
17.5	17.7	18.9	17.6	17.8
17.6	17.7	63.5	17.8	17.6
17.6	17.6	22.7	18.0	17.7
17.8	15.4	20.3	17.8	17.8
17.5	17.7	19.2	17.8	17.7
17.5	17.7	18.7	17.8	17.6
17.6	17.6	18.4	17.8	17.7
17.5	17.6	18.5	17.9	17.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 4  
 BAROMETRIC PRESSURE 29.666 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 3.6360      AMPS 1.8900  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

66.7	66.7	66.7	67.1	67.0
66.6	66.8	66.6	66.5	67.5
67.3	67.5	70.3	67.4	67.1
66.9	67.0	158.2	71.5	71.2
71.3	71.1	81.9	71.1	71.0
70.7	70.9	75.2	67.0	66.8
66.5	66.9	69.5	67.3	66.7
66.9	66.8	69.0	67.4	67.1
67.0	67.1	68.9	67.7	67.2

CALIBRATED TEMPERATURES IN DEGREES F

65.2	65.1	65.2	65.6	65.5
65.1	65.3	65.2	64.9	65.3
65.1	65.4	68.2	65.4	65.0
65.1	65.2	156.7	65.4	65.2
65.2	65.2	76.2	65.3	65.2
65.0	65.4	69.7	65.4	65.1
64.9	65.1	67.8	65.5	65.1

65.1 65.1 67.0 65.5 65.1  
65.0 65.1 66.7 65.6 65.1

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

65.502 65.513 65.404  
THETA1= 1.0000000  
THETA2= .3916121  
THETA3= .2196969  
THETA4= .1464698  
THETA5= .1167443

H= 105.089 W/m<sup>2</sup>C ReH= 4755.9020000  
NUSSELT#=153.273  
FREESTREAM VELOCITY = 3.020 m/s= 9.908 ft/s  
Q<sub>in</sub>= 6.872 Watts Q<sub>loss</sub>= .256 Watts CONDUCTIVITY= .040 W/mC  
T<sub>AMB</sub>= 18.596 C VISCOSITY= .00003710 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.4	18.4	18.5	18.7	18.6
18.4	18.5	18.4	18.3	18.5
18.4	18.5	20.1	18.5	18.3
18.4	18.5	69.3	18.6	18.5
18.5	18.4	24.5	18.5	18.4
18.3	18.5	20.9	18.6	18.4
18.3	18.4	19.9	18.6	18.4
18.4	18.4	19.5	18.6	18.4
18.3	18.4	19.3	18.7	18.4

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
BAROMETRIC PRESSURE 29.884 INCHES OF Hg  
PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
VOLTS 3.5980 AMPS 1.8000  
CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.5	65.5	65.4	65.6	65.5
65.4	65.4	65.2	65.2	66.2
65.9	66.0	65.9	66.0	65.7
65.6	65.6	68.9	70.2	69.9
70.2	69.8	158.7	69.6	69.7
69.3	69.4	79.7	65.4	65.5
65.2	65.5	69.9	65.6	65.4
65.5	65.5	68.6	65.8	65.8
65.7	65.8	68.2	66.1	65.9

CALIBRATED TEMPERATURES IN DEGREES F

63.7	63.7	63.7	63.9	63.8
63.6	63.8	63.7	63.7	64.0
63.7	63.9	63.8	64.0	63.7
63.6	63.7	66.9	64.2	63.9
64.2	64.0	154.4	63.8	64.0
63.5	63.8	74.1	63.9	63.9
63.6	63.8	67.9	63.9	63.8
63.7	63.8	66.3	63.9	63.9
63.6	63.8	66.0	64.2	63.9

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.700 63.703 63.700  
THETA1= 1.0000000  
THETA2= .4054705  
THETA3= .2532205  
THETA4= .2228174

H= 99.676 W/m<sup>2</sup>C ReH= 4744.3410000  
NUSSELT#=145.654  
FREESTREAM VELOCITY = 3.004 m/s= 9.855 ft/s  
Q<sub>in</sub>= 6.476 Watts Q<sub>loss</sub>= .255 Watts CONDUCTIVITY= .040 W/mC  
T<sub>AMB</sub>= 17.612 C VISCOSITY= .00003699 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.6	17.6	17.6	17.7	17.7
17.6	17.7	17.6	17.6	17.8
17.6	17.7	17.7	17.8	17.6
17.6	17.6	19.4	17.9	17.7
17.9	17.8	68.0	17.7	17.8
17.5	17.7	23.4	17.7	17.7
17.5	17.7	20.0	17.7	17.6
17.6	17.6	19.1	17.7	17.7
17.6	17.6	18.9	17.9	17.7

THE HEATED CUBE IS IN COLUMN 3 AND ROW 6  
 BAROMETRIC PRESSURE 29.666 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .02200 INCHES WATER  
 VOLTS 2.9110 AMPS 2.1000  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

66.8	66.8	66.7	66.9	66.8
66.6	66.7	66.5	66.4	67.4
67.2	67.3	67.1	67.2	66.9
66.9	66.9	66.9	71.4	71.1
71.5	71.0	72.6	70.8	70.8
70.7	70.8	154.8	66.6	66.7
66.4	66.7	73.5	66.9	66.6
66.8	66.7	68.8	67.1	67.0
66.9	67.1	69.0	67.4	67.1

CALIBRATED TEMPERATURES IN DEGREES F

65.3	65.2	65.2	65.4	65.3
65.1	65.2	65.1	64.8	65.2
65.0	65.2	65.0	65.2	64.8
65.1	65.1	64.9	65.3	65.1
65.5	65.1	66.7	65.0	64.9
65.0	65.3	150.2	65.0	65.0
64.8	64.9	71.8	65.1	65.0
65.0	65.0	66.8	65.2	65.0
64.9	65.1	66.8	65.3	65.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

65.502 65.311 66.106  
 THETA1= 1.0000000  
 THETA2= .1940702  
 THETA3= .1912994

H= 100.879 W/m<sup>2</sup>C

ReH= 4755.3540000

NUSSELT#=147.107

FREESTREAM VELOCITY = 3.021 m/s = 9.910 ft/s

Q<sub>in</sub>= 6.113 Watts Q<sub>loss</sub>= .238 Watts CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 18.689 C VISCOSITY= .00003711 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.5	18.5	18.5	18.6	18.5
18.4	18.5	18.4	18.2	18.4
18.3	18.4	18.3	18.4	18.2
18.4	18.4	18.3	18.5	18.4
18.6	18.4	19.3	18.3	18.3
18.3	18.5	65.7	18.3	18.3
18.2	18.3	22.1	18.4	18.3
18.3	18.3	19.4	18.4	18.3
18.3	18.4	19.3	18.5	18.3

THE HEATED CUBE IS IN COLUMN 3 AND ROW 1  
 BAROMETRIC PRESSURE 30.024 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
 VOLTS 4.1140 AMPS 2.0000

CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

72.3	72.3	150.4	72.7	72.4
72.3	72.3	77.9	72.0	72.9
72.7	72.8	75.7	72.9	72.4
72.4	72.4	74.6	77.2	76.6
76.7	76.5	78.2	76.7	76.3
76.2	76.3	77.5	72.5	72.2
72.0	72.3	73.2	72.7	72.1
72.3	72.2	73.3	72.8	72.5
72.4	72.6	73.4	72.9	72.6

CALIBRATED TEMPERATURES IN DEGREES F

70.7	70.7	149.0	71.1	70.9
70.8	71.0	76.7	70.7	70.9
70.7	70.9	73.8	71.2	70.5
70.7	70.9	72.9	71.4	70.8
71.0	70.8	72.7	71.1	70.8
70.7	70.9	72.2	71.3	70.8
70.8	70.9	71.8	71.3	70.8
70.8	70.8	71.8	71.2	70.7
70.7	71.0	71.5	71.1	70.8

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

70.811 70.904 70.820

THETA1= 1.0000000  
THETA2= .5129483  
THETA3= .3467078  
THETA4= .3196545  
THETA5= .2300852  
THETA6= .1672513  
THETA7= .1568281  
THETA8= .1163621

H= 146.870 W/m<sup>2</sup>C

ReH= 7029.2110000

NUSSELT#=212.992

FREESTREAM VELOCITY = 4.503 m/s= 14.774 ft/s

Q<sub>in</sub>= 8.228 Watts Q<sub>loss</sub>= .220 Watts CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 21.581 C VISCOSITY= .00003742 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

21.5	21.5	65.0	21.7	21.6
21.6	21.7	24.8	21.5	21.6
21.5	21.6	23.2	21.8	21.4
21.5	21.6	22.7	21.9	21.6
21.7	21.6	22.6	21.7	21.6
21.5	21.6	22.3	21.8	21.5
21.5	21.6	22.1	21.8	21.5
21.6	21.6	22.1	21.8	21.5
21.5	21.7	22.0	21.7	21.6

THE HEATED CUBE IS IN COLUMN 3 AND ROW 2

BAROMETRIC PRESSURE 29.666 INCHES OF Hg

PITOT-STATIC TUBE DELTA .05000 INCHES WATER

VOLTS 3.8380 AMPS 1.8700

CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

67.1	67.1	68.4	67.5	67.3
67.0	67.3	135.3	66.9	67.7
67.6	67.8	72.8	67.6	67.2
67.2	67.3	69.9	71.8	71.3
71.6	71.4	73.2	71.4	71.2
71.1	71.2	72.5	67.2	67.1
66.9	67.1	68.1	67.4	66.9
67.2	67.1	68.2	67.5	67.4
67.4	67.5	68.4	67.7	67.5

CALIBRATED TEMPERATURES IN DEGREES F

65.6	65.5	67.0	66.0	65.8
65.5	65.8	134.5	65.3	65.5
65.4	65.7	70.7	65.6	65.1
65.4	65.5	68.0	65.7	65.3
65.6	65.5	67.3	65.6	65.4
65.4	65.7	66.9	65.6	65.4
65.3	65.3	66.4	65.6	65.3
65.4	65.4	66.2	65.6	65.4
65.4	65.5	66.2	65.6	65.4

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

65.803	65.815	65.705
THETA1=	1.0000000	
THETA2=	.4394598	
THETA3=	.3148502	
THETA4=	.2341962	
THETA5=	.1314742	
THETA6=	.0934434	
THETA7=	.0905195	

H= 145.763 W/m2C

ReH= 7168.2990000

NUSSELT#=212.528

FREESTREAM VELOCITY = 4.554 m/s= 14.941 ft/s

Qin= 7.177 Watts

Qloss= .193 Watts

CONDUCTIVITY=

.040 W/mC

TAMB= 18.764 C

VISCOSITY= .00003712 m2/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

18.7	18.6	19.4	18.9	18.8
18.6	18.8	56.9	18.5	18.6
18.6	18.7	21.5	18.7	18.4
18.6	18.6	20.0	18.7	18.5
18.6	18.6	19.6	18.7	18.5
18.5	18.7	19.4	18.7	18.5
18.5	18.5	19.1	18.7	18.5
18.6	18.5	19.0	18.7	18.6
18.6	18.6	19.0	18.7	18.6

THE HEATED CUBE IS IN COLUMN 3 AND ROW 3  
 BAROMETRIC PRESSURE 29.884 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04950 INCHES WATER  
 VOLTS 3.4230 AMPS 1.8000  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.8	65.8	65.8	66.1	65.9
65.7	65.7	67.1	65.5	66.6
66.4	66.7	135.3	66.4	66.2
65.9	66.0	72.5	70.6	70.2
70.2	70.1	73.3	70.1	70.0
69.7	69.7	71.8	65.9	65.8
65.5	65.8	67.3	66.0	65.8
65.8	65.8	67.2	66.2	66.1
66.0	66.2	67.3	66.4	66.2

CALIBRATED TEMPERATURES IN DEGREES F

64.0	64.0	64.1	64.4	64.2
63.9	64.1	65.6	64.0	64.4
64.2	64.6	133.7	64.4	64.2
63.9	64.1	70.6	64.6	64.2
64.2	64.3	67.5	64.3	64.3
63.9	64.1	66.1	64.4	64.2
63.9	64.1	65.3	64.3	64.2
64.0	64.1	64.9	64.3	64.2
63.9	64.2	65.1	64.5	64.2

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

64.101      64.005      64.102  
 THETA1=      1.0000000  
 THETA2=      .5336164  
 THETA3=      .3166398  
 THETA4=      .1934063  
 THETA5=      .1327974  
 THETA6=      .1620259

H= 123.447 W/m<sup>2</sup>C      ReH= 7114.6970000  
 NUSSELT#=180.318  
 FREESTREAM VELOCITY = 4.507 m/s= 14.788 ft/s  
 Qin= 6.161 Watts      Qloss= .196 Watts      CONDUCTIVITY= .040 W/mC  
 TAMB= 17.816 C      VISCOSITY= .00003701 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.8	17.8	17.9	18.0	17.9
17.7	17.9	18.7	17.8	18.0
17.9	18.1	56.5	18.0	17.9
17.7	17.9	21.4	18.1	17.9
17.9	17.9	19.7	17.9	18.0
17.7	17.8	19.0	18.0	17.9
17.7	17.9	18.5	17.9	17.9
17.8	17.8	18.3	17.9	17.9
17.7	17.9	18.4	18.0	17.9

THE HEATED CUBE IS IN COLUMN 3 AND ROW 4  
 BAROMETRIC PRESSURE 29.884 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04950 INCHES WATER  
 VOLTS 3.9510      AMPS 1.8000  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.7	65.7	65.7	65.9	65.8
65.5	65.5	65.5	65.5	66.4
66.3	66.4	68.3	66.3	66.2
65.9	65.8	146.9	70.2	70.0
70.0	69.9	78.2	69.9	69.9
69.6	69.5	73.0	65.6	65.7
65.4	65.6	67.9	65.9	65.6
65.7	65.6	67.6	66.1	65.9
65.8	65.9	67.5	66.3	66.1

CALIBRATED TEMPERATURES IN DEGREES F

63.9	63.9	64.0	64.2	64.1
63.7	63.9	64.0	64.0	64.2
64.1	64.3	66.2	64.3	64.2
63.9	63.9	145.4	64.2	64.0
64.0	64.1	72.5	64.1	64.2
63.8	63.9	67.3	64.1	64.1
63.8	63.9	65.9	64.2	64.0
63.9	63.9	65.3	64.2	64.0
63.7	63.9	65.3	64.4	64.1

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.901      63.804      63.901  
 THETA1=      1.0000000  
 THETA2=      .4013845  
 THETA3=      .2378280  
 THETA4=      .1694369  
 THETA5=      .1680405

H= 121.774 W/m<sup>2</sup>C      ReH= 7115.6870000  
 NUSSELT#=177.913  
 FREESTREAM VELOCITY = 4.507 m/s= 14.785 ft/s  
 Qin= 7.112 Watts      Qloss= .229 Watts      CONDUCTIVITY= .040 W/mC  
 TAMB= 17.705 C      VISCOSITY= .00003700 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.7	17.7	17.8	17.9	17.8
17.6	17.7	17.8	17.8	17.9
17.8	17.9	19.0	17.9	17.9
17.7	17.7	63.0	17.9	17.8
17.8	17.8	22.5	17.8	17.9
17.6	17.7	19.6	17.8	17.8
17.7	17.7	18.8	17.9	17.8
17.7	17.7	18.5	17.9	17.8
17.6	17.7	18.5	18.0	17.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 5  
 BAROMETRIC PRESSURE 29.884 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
 VOLTS 3.5260 AMPS 1.8400  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.5	65.5	65.6	65.7	65.6
65.6	65.5	65.5	65.4	66.3
66.1	66.1	66.2	66.0	66.1
65.9	65.7	68.3	70.2	70.1
70.2	69.9	146.0	69.9	69.8
69.6	69.4	77.4	65.5	65.6
65.3	65.6	68.9	65.7	65.6
65.5	65.5	68.0	65.9	65.9
65.8	65.9	65.9	66.1	66.0

CALIBRATED TEMPERATURES IN DEGREES F

63.7	63.7	63.9	64.0	63.9
63.8	63.9	64.0	63.9	64.1
63.9	64.0	64.1	64.0	64.1
63.9	63.8	66.3	64.2	64.1
64.2	64.1	141.5	64.1	64.1
63.8	63.8	71.8	64.0	64.0
63.7	63.9	66.9	64.0	64.0
63.7	63.8	65.7	64.0	64.0
63.7	63.9	63.7	64.2	64.0

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.901	63.703	62.898
THETA1=	1.0000000	
THETA2=	.4130622	
THETA3=	.2696180	
THETA4=	.0265265	

H= 116.136 W/m <sup>2</sup> C	ReH= 7081.4630000	
NUSSELT#=169.742		
FREESTREAM VELOCITY = 4.482 m/s= 14.705 ft/s		
Q <sub>in</sub> = 6.488 Watts	Q <sub>loss</sub> = .219 Watts	CONDUCTIVITY= .040 W/mC
T <sub>AMB</sub> = 17.501 C	VISCOSITY= .00003698 m <sup>2</sup> /s	

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.6	17.6	17.7	17.8	17.7
17.7	17.7	17.8	17.7	17.8
17.7	17.8	17.8	17.8	17.8
17.7	17.7	19.1	17.9	17.8
17.9	17.8	60.8	17.8	17.9
17.6	17.7	22.1	17.8	17.8
17.6	17.7	19.4	17.8	17.8
17.6	17.6	18.7	17.8	17.8
17.6	17.7	17.6	17.9	17.8

THE HEATED CUBE IS IN COLUMN 3 AND ROW 6  
 BAROMETRIC PRESSURE 29.884 INCHES OF Hg  
 PITOT-STATIC TUBE DELTA .04900 INCHES WATER  
 VOLTS 2.7780 AMPS 2.0500  
 CHANNEL HEIGHT RATIO 4.6

THE INPUT TEMPERATURE ARRAY IN DEGREES F

65.4	65.4	65.5	65.5	65.4
65.4	65.2	65.3	65.3	66.1
65.9	65.9	65.9	65.9	65.9
65.7	65.6	65.7	69.9	69.8
69.9	69.7	70.9	69.6	69.6
69.4	69.2	135.7	65.3	65.5
65.2	65.3	69.9	65.4	65.4
65.4	65.3	67.7	65.7	65.7
65.6	65.8	67.2	65.8	65.8

CALIBRATED TEMPERATURES IN DEGREES F

63.6	63.6	63.8	63.8	63.7
63.6	63.6	63.8	63.8	63.9
63.7	63.8	63.8	63.9	63.9
63.7	63.7	63.7	63.9	63.8
63.9	63.8	65.1	63.8	63.9
63.6	63.6	130.8	63.8	63.9
63.6	63.6	67.9	63.7	63.8
63.6	63.6	65.4	63.8	63.8
63.5	63.8	65.0	63.9	63.8

AMBIENT TEMPERATURE CALIBRATED IN FAHR.

63.700      63.602      63.700  
 THETA1=      1.0000000  
 THETA2=      .4149780  
 THETA3=      .3180087

H= 118.417 W/m<sup>2</sup>C

ReH= 7080.6430000

NUSSELT#=173.046

FREESTREAM VELOCITY = 4.483 m/s= 14.708 ft/s

Q<sub>in</sub>= 5.695 Watts      Q<sub>loss</sub>= .189 Watts      CONDUCTIVITY= .040 W/mC

T<sub>AMB</sub>= 17.593 C      VISCOSITY= .00003699 m<sup>2</sup>/s

SMOOTH TEMPERATURE ARRAY IN DEGREES CENTIGRADE

17.6	17.6	17.7	17.7	17.6
17.6	17.6	17.7	17.7	17.7
17.6	17.6	17.7	17.7	17.7
17.6	17.6	17.6	17.7	17.7
17.7	17.7	18.4	17.7	17.7
17.5	17.5	54.9	17.7	17.7
17.5	17.6	20.0	17.6	17.6
17.6	17.5	18.6	17.7	17.7
17.5	17.6	18.3	17.7	17.7

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