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Heat Transfer From Inflatable Structures

Christiaan Willem Snoek

The University of Western Ontario

Faculty of Graduate Studies
Stevenson-Lawson Building
London, Canada N6A 5B8

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HEAT TRANSFER FROM
INFLATABLE STRUCTURES

by

Christiaan Willem Snoek

Faculty of Engineering Science

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of the requirements for the degree of
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ABSTRACT

In recent years, considerable attention has been directed towards improved conditions in community living and working in Arctic areas of the world. It has been proposed that large areas could be covered by an inflatable structure accommodating a small town or construction site.

Due to the lack of technical data on heat transfer from internally heated inflatable structures, it was decided to investigate both the overall energy requirements of inflatable structures as well as the local convective heat transfer coefficients for several small scale models.

Interior flow visualization studies were carried out on two small models and techniques for finding an analytical solution to the problem were explored.

Actual heat transfer measurements were performed on three hemispherically shaped models.

Overall heat transfer coefficients for both natural and forced convection conditions were obtained from a solid four inch diameter model.

The variation of local conductance with respect to polar angle for natural convection conditions and with respect to polar and azimuthal angles for forced convection conditions was determined with a twenty inch diameter rigid hollow model.

A twelve foot diameter, heated, inflatable single skin model placed in a farmer's field yielded information on the

energy requirements under actual winter conditions.

Correlations and graphs are presented showing the overall and local heat conductances for the two smaller models and relating the influence of the weather conditions and the wind direction on the total heat transfer from the larger model.

The weather condition as well as the state of the surrounding terrain influence the energy requirements of the heated inflatable model. These energy requirements are shown to be least during sunny conditions and rise for cloudy and precipitation conditions. Wind at low velocities approaching the model over flat open field requires a higher energy consumption than when the wind is obstructed by buildings or trees. However, at increasing wind velocities, turbulence introduced into the air stream by buildings and trees causes the energy requirements of the model to increase at a higher rate than for wind approaching the model from the flat open field.

Whereas most designers of heating equipment for inflatable structures use the ASHRAE Handbook value for the overall heat transfer coefficient for single pane vertical flat glass of 1.13 Btu/ft^{2}hr°F, the inflatable model used in this research predicts the maximum overall heat transfer coefficient for the "design day", (when the ambient temperature is 0°F and the wind velocity is 7.5 m.p.h.) to be 0.84 Btu/ft^{2}hr°F.

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NOMENCLATURE

A	Area	ft^2
C_p	Thermal capacity	Btu/Lbm°F
D	Diameter	ft
g	Acceleration of gravity	ft/sec^2
g_c	Dimensional conversion factor, 32.2 $ft.Lbm/Lbf.sec^2$	
h	Heat transfer coefficient	$Btu/ft^2hr°F$
h_{nc}	Heat transfer coefficient by natural convection	$Btu/ft^2hr°F$
h	Height	ft
k	Thermal conductivity	Btu/ft.hr°F
k	Surface drag coefficient	-
L	Length	ft
Q	Quantity of heat	Btu
R	Radius	ft
r_c	Vortex core radius	ft
T	Temperature	°F
T	Time	sec
V	Velocity	ft/sec
V_G	Gradient wind velocity	ft/sec
x_L	Critical length	ft
Z_G	Gradient height	ft
	Pound mass	Lbm
	Pound force	Lbf

Dimensionless Groups:

Gr	Grashof number	$\frac{\rho^2 g\beta(T-T_\infty)\, R^3}{\mu^2}$
Nu	Nusselt number	$\frac{hR}{k}$
Pr	Prandtl number	$\frac{\mu C_p}{k}$
Re	Reynolds number	$\frac{\rho DV}{\mu}$

Subscripts:

D	Diameter	ft
L	Distance from leading edge	ft
R	Radius	ft
x	Distance from leading edge	ft
α	Polar angle	radians
∞	Infinity	-

Greek:

α	Power law exponent	-
α	Thermal diffusivity	ft^2/hr
β	Coefficient of expansion	1/°R
Γ	Circulation	ft^2/sec
Δp	Pressure difference	Lbf/ft^2
ΔT	Temperature difference	°F
η	Space variable	-
θ	Azimuthal Angle	radians
μ	Absolute viscosity	Lbm/ft.sec
ν	Kinematic viscosity	ft^2/sec

ξ	Space variable	-
ρ	Density	Lbm/ft^3
$\sigma(v)$	Root mean square gust velocity	ft/sec
ϕ	Polar angle	radians
ψ	Polar angle	radians

1. INTRODUCTION

1.1 General Introduction

In recent years, considerable attention has been directed towards improved conditions in community living and working in Arctic areas of the world. Frei Otto[(1)*] has proposed that large areas of up to one million square meters (about ten million square feet) could be covered by inflatable structures. These structures could accommodate a city of up to eight thousand persons. At present, the greatest problem facing the development of Arctic areas is the high cost of human habitation. Labour and construction costs are high because of the isolation, relatively poor living accommodation, high accident risk due to the difficult working conditions, and the harsh climate. Working in the Arctic means often being separated from family and friends. This separation, the isolation, the working conditions and inclement weather can lead to social maladjustments which can be avoided in part by simulating conditions existing in more habitable regions. For example, a community associated with mineral exploration in the Arctic could be housed inside an inflatable structure with the following advantages:

* Superscript numbers refer to references listed at the back of this thesis.

(1) Working and living inside the stable environment created by the inflatable structure would resemble more closely the conditions encountered in the southern part of Canada. This factor alone will probably greatly reduce the labour force turnover.

(2) The high cost of obtaining sources of energy in remote areas prompts energy conservation measures. Using an inflatable structure to cover such operations as drilling, exploring and mining will reduce energy requirements significantly.

(3) The structure could be pre-manufactured and shipped to the site.

As compared to the conventional method of constructing large structures such as geodesic domes, the air-inflated envelope could be installed and inflated at minimum cost and with a minimum amount of labour. As of 1972 the envelope material is guaranteed to have a life span of at least fifteen years[2]; relocation of the structure after a few years of service in one location is feasible.

Coulter and Bernard[3] estimated the cost of manufacturing and erection of a one thousand meter diameter enclosure near Frobisher Bay, North-West Territories, Canada, between four and five dollars per square meter covered (1972 estimate). More economical construction of inflatable structures coupled with an efficient use of energy make the cost figure per year look attractive. (Conventional structures in populated areas of Canada cost about $20 to $40 per square foot of area covered.) Furthermore, the pump energy needed to keep a structure inflated can be reduced to very acceptable levels by the efficient use of air locks and a leak-free attachment of the enclosure material to the base. See Figure 1-1.

To illustrate the importance of even unheated enclosures, wind speed measurements at Frobisher Bay, North-West Territories, during the period of 1957-1966 showed that 22 per cent of the time the wind speed was equal to or greater than 20 miles per hour[2]. Therefore, even an inflated structure that is not internally heated will still provide a very reasonable environment. The wind chill factor that influences the Arctic climate due to prevalent high winds has little effect inside the structure. Captured solar radiation may raise the ambient temperature inside the structure well above the wind temperature.

It should be noted that pressurizing the inflatable structure is not always necessary. For example, if the air inside the structure is warmer than the air outside, density differences between the air on both sides of the envelope will tend to support the enclosure. This "hot air balloon" effect decreases inflation requirements. To illustrate the effect of a temperature difference between the inside of the dome and the ambient conditions, consider a 1200 ft. diameter hemispherical envelope with a per unit area weight of 1 Lbf/ft^2. The outside ambient air temperature is assumed to be 0°F. The density of the ambient air

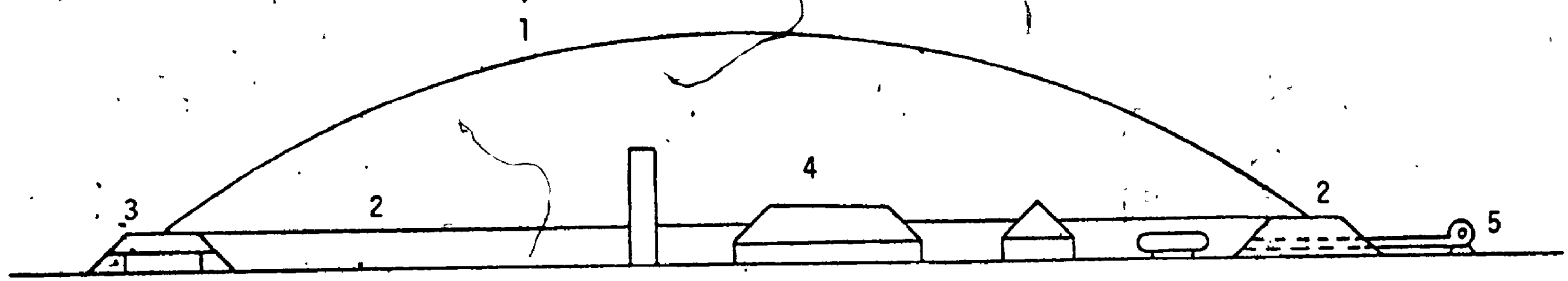


Figure 1-1: Cross-Section of Large Diameter Inflated Structure

(1) skin
(2) berm
(3) berm with air-lock
(4) interior of structure with buildings, etc.
(5) inflation and ventilation fans

$\rho_o = 0.086$ Lbm/ft^3. The weight of the envelope will be $1 \times 2\pi R^2$ Lbf and the volume of the enclosure is $2/3 \times \pi R^3 ft^3$. Equating the weight and the buoyancy force we obtain an expression for the air density (ρ_t) within the dome, so that:

$$1 \times 2\pi R^2 = (\rho_o - \rho_t) \frac{g}{g_c} 2/3 \times \pi R^3 \qquad \text{---- (1)}$$

and $\rho_t = 0.081$ Lbm/ft^3. This corresponds to a temperature of about 32°F. Therefore, a temperature difference of more than 32°F will support the envelope.

When a structure is located on permafrost, care must be taken to maintain the frozen state of this soil. Raising the temperature above the freezing point changes permafrost into marsh with associated drastic changes in the physical properties of the soil. Hence, there is little advantage of heating a covered area above permafrost to a temperature higher than the freezing point.

Another basic disadvantage associated with the use of air-inflated envelopes is the additional risk due to possible fires inside the structure. Other disadvantages are limited opportunities for expansion of operation for a given size enclosure and limited freedom of movement of personnel within the structure.

1.2 History of Inflatable Structures

The first large scale application of air-inflatable structures was at the "Distant-Early-Warning" system in the high Arctic shortly after World War Two, to protect the radar antennae from the inclement climate. These "Radomes" as they were called were designed by Walter Bird and are manufactured by Birdair Inc., Buffalo, New York, since 1950.

Soon after, the use of dome-covered swimming pools, tennis courts and warehouses gained popularity, especially in Europe, and increased in their application.

Mainly due to a few early air-supported building collapses, the application of this type of structure in Canada has slowed down considerably. Soper's Ltd. of Hamilton, Ontario, is one of Canada's air-supported structures manufacturers and donated the spherical air-inflatable dome used in this research. Also, many "tennis halls" (air-supported structures for use over tennis courts) have been imported from Sweden.

Heat transfer data for the design of heating and air-conditioning equipment for air-supported structures are not available for either the winter or summer seasons. Furthermore, the existing solutions of heat transfer design problems were done for surfaces of a different shape and are not applicable.

Designers of inflatable structures up to the present have been concerned with minimizing stresses and avoiding stress concentration. Research on envelope material so far has been carried out to improve the strength characteristics and increase the material life span by coating it with ultra violet retardent layers. Unfortunately little or no work has been done on the energy requirements of inflatable structures.

Current design practice in estimating heat transfer uses an overall heat transfer coefficient equal to 1.13 Btu/hr sq ft °F, which is the same value used for vertical, single pane glass as specified for winter conditions by the ASHRAE Handbook. This implies that heating and air-conditioning equipment must be designed as if the structure were made of glass. Obviously, structures designed this way call for large and expensive heating and air-conditioning equipment if this assumption is true.

The intent of this thesis is to question the assumption used in the design of heating loads and to establish data suitable for the design of such loads.

For large envelopes, a correct estimate of the heat transfer coefficient must be made. An overestimated U-factor will result in unnecessary investment in oversized heating and cooling equipment. For larger domes, a small per cent change in the heating load may be in the order of many megawatts[(2)].

Further information on inflatable structures pertaining to the large enclosure of a city can be found in reference 2.

Dr. Frei Otto[(1,3,4)], Director of the Institute for Lightweight Structures in Stuttgart, Germany, proposed in 1971 the construction of a one thousand meter diameter enclosed environment, with the roof suspended by pressurized air within the structure. Within the structure a complete city for a few thousand people could be built, totally controlled environmentally and protected from such inclement weather conditions as are prevalent in Arctic regions.

Price et al[5] give in "Air Structures, A Survey" a very interesting account of the history of inflatable structures and the present state of the art with many different uses for inflatables.

An article by Lutes[6] in the Canadian Building Digest describes the historical development and major applications of air-supported structures and discusses the envelope shape and design, anchorage and support systems.

In "A Proposal for the Development of a Climate Controlled Community in the Canadian Arctic", Coulter and Bernard[2] outline the feasibility of an air supported dome-covered city in great detail. In the report the total energy required to maintain an internal temperature of 25°F is calculated to be between 17 and 20 megawatts, based on an overall heat transfer coefficient estimated between 0.1 and 1.13 Btu/hr sq ft °F. The uncertainty about the overall heat transfer coefficient causes the wide range in the calculated power consumption. A better defined overall heat transfer coefficient will reduce this range.

1.3 Statement of the Problem

Due to the lack of technical data on heat transfer from internally heated or cooled inflatable structures of any shape, it was decided to investigate both the overall energy requirements of inflatable structures as well as the local convective heat transfer coefficients for several small scale models. This information on heat transfer coefficients is necessary in order to make optimal designs of air-supported structures.

The significant factors in this kind of study are the thermal conductivity of the enclosure material, the shape of the structure and the mechanics of the internal and external flow fields. From considerations of symmetry and simple configuration, a hemispherical shape was chosen for all models.

In summary, the whole thesis problem can be stated in the following chronological steps:

(1) the observation of the internal air flow for exterior natural and forced convection conditions and scaling considerations,

(2) the investigation of mathematical models which might be used to describe the flow over simple geometries for both natural and forced convection,

(3) the instrumentation of a small solid 4 inch diameter model to compare the overall heat transfer coefficients of a hemisphere with those of a sphere for natural and forced convection

conditions,

(4) the instrumentation of a hollow, thin walled 20 inch diameter model to find the variation of the heat transfer coefficient with polar and azimuth angle for both modes of heat convection, and

(5) the design and construction of a twelve foot diameter single skin inflatable model made of opaque material, placed in a farmer's field outside the city of London, Ontario.

With this latter model the influence of ambient conditions on the energy requirements of an internally heated hemispherical inflatable structure could be studied.

1.4 Literature Review

An extensive search of the literature was carried out but to the author's knowledge there is no literature directly pertaining to the topic of this thesis. In addition to a library literature search, the author used the Canadian On-Line Enquiry system at the beginning and the conclusion of the experimental work and corresponded with experts in the field of inflatable structures, but these actions did not result in establishing any directly related references.

Since hemispheres can, in the limit, be approximated by vertical and horizontal components, intuition suggests that the solid hemispherical convective heat transfer coefficients should fall between the values for a horizontal and a vertical flat plate, if one ignores the boundary layer development lengths.

Because of the similarity in shape between a sphere and a hemisphere, it is also expected that hemispherical heat transfer coefficients for both natural and forced convection will resemble those of spheres. One has to keep in mind however that the overall heat transfer coefficients of inflated structures also depend on the coupled inside and outside flow fields.

The experimental natural and forced convection heat transfer correlations for indirectly related shapes such as spheres, cylinders and flat plates are presented in Sections 1.4.1 to 1.4.7.

1.4.1 Free and Forced Convection from Spheres

According to McAdams[7], Equation (2) as is shown below can be applied to spheres when the sphere radius is used in the characteristic length in the Nusselt and Grashof numbers. See Figure 1-2.

$$\overline{Nu}_R = 0.53\ (Gr_R\ Pr)^{1/4} \qquad \text{---- (2)}$$

where $10^3 < Gr < 10^9$.

For a sphere subjected to forced convective cooling or heating, McAdams[7] recommends that the following equation be used to calculate the unit surface conductance

$$\overline{Nu}_D = 0.37\ (Re_D)^{0.6} \qquad \text{---- (3)}$$

where $25 < Re_D < 100{,}000$. In Equation (3), the diameter must

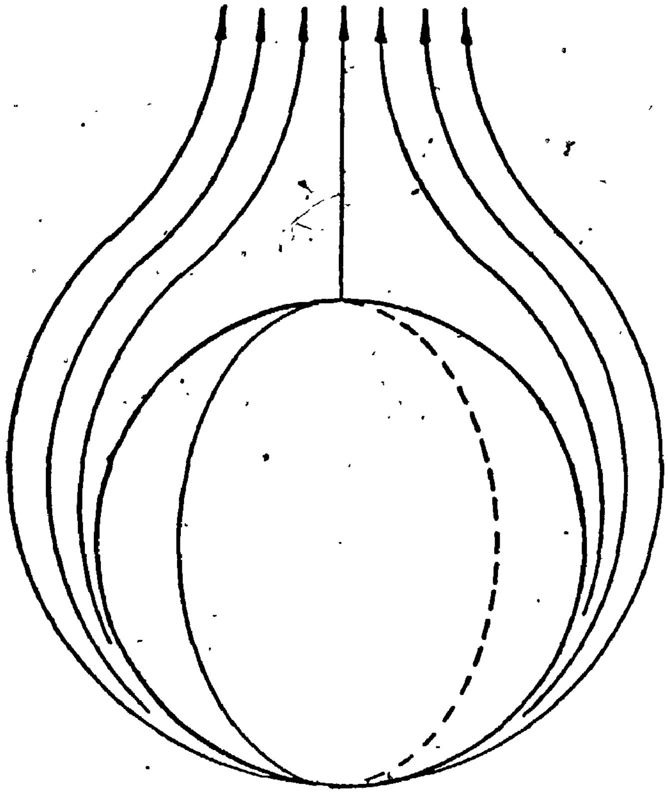


Figure 1-2: Flow Pattern for Natural Convection from a Sphere

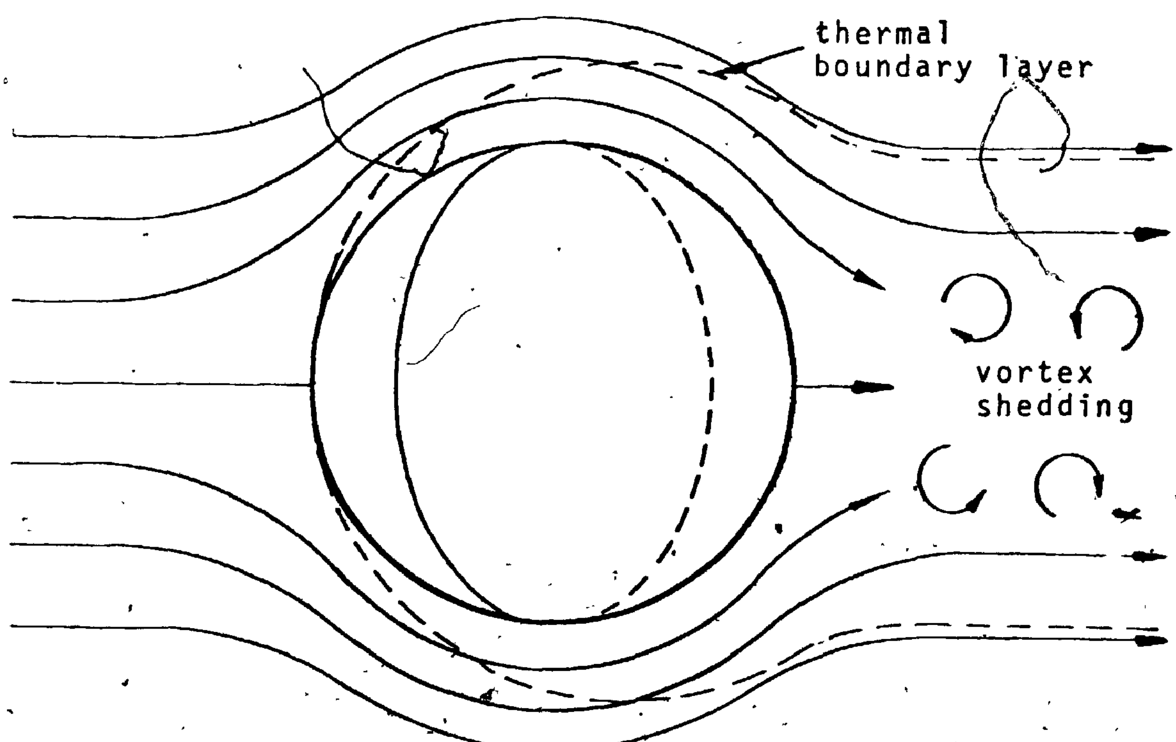


Figure 1-3: Flow Pattern for Forced Convection from a Sphere

be used as a characteristic length in both the Nusselt and Reynolds numbers. See Figure 1-3.

Shell[8] calculated in 1938 the laminar free convection from heated spheres in air and found that

$$\overline{Nu} = 0.429\ Gr^{0.25} \qquad \text{---- (4)}$$

The influence of radiation on the total heat transfer was theoretically and experimentally determined and found to be negligible. The range of Grashof numbers applying to Equation (4) was not stated in the paper, but it is reasonable to assume that the equation pertains to heat transfer by laminar flow.

For a temperature difference between the spherical surface and the ambient air temperature of more than 10°C (18°F) and $Gr<1.13\times10^6$, Acrivos[9] analyzed the laminar free convection heat transfer for non-Newtonian fluids. In his paper he presented theoretical correlations for the average and local Nusselt numbers for heat transfer to fluids with $Pr>10$.

Chiang, Ossin and Tien[10] studied laminar free convection from spheres with prescribed surface temperature, heat flux, and prescribed uniform surface temperature. Their solutions hold for angles up to 120° measured from the bottom of the sphere. For a uniform wall temperature they found

$$Nu_\alpha = \left[0.4576 - 0.03402\left(\frac{x}{R}\right)^2\right] Gr^{1/4} \qquad \text{---- (5)}$$

where x is the distance from the bottom of the sphere to α measured over the sphere surface.

Bromham and Mayhew[11] measured the natural convective heat transfer from a hollow four inch diameter sphere with a 3/8" wall thickness. With this electrically heated model they found

$$\overline{Nu}_D = 0.513\ (Gr_D\ Pr)^{1/4} \qquad \text{---- (6)}$$

which can be shown to be equal to

$$\overline{Nu}_R = 0.43\ (Gr_R\ Pr)^{1/4} \qquad \text{---- (7)}$$

Klyachko[12] did experiments for combined free and forced convection heat transfer between a gas and a spherical surface and presented calculated formulas for $500<GrPr<2\times10^7$.

For dominant free convection

$$Nu = Nu_{free}\left[1+\left(\frac{Re^2}{Gr}\right)^{1/5}\right] \qquad \text{---- (8)}$$

For dominant forced convection

$$Nu = Nu_{forced}\left[1+0.15\ \frac{Re+Re_o}{Re}\ \left(\frac{Gr}{Re}\right)^{1/4}\right] \qquad \text{---- (9)}$$

where

$$Nu_{free} = 0.54\ (GrPr)^{1/4} \qquad \text{---- (10)}$$

and

$$Nu_{forced} = 2(1+0.276\sqrt{RePr}^{1/3}) \quad \text{---- (10a)}$$

Re_0 is determined from the condition $Nu_{free} = Nu_{forced}$ depending on the value of GrPr.

1.4.2 Free and Forced Convection from Horizontal Cylinders

An equation for the average heat transfer coefficient from single horizontal wires or pipes in free convection, recommended by McAdams[7] on the basis of experimental data is

$$Nu_D = 0.53\ (Gr_D\ Pr)^{1/4} \quad \text{---- (2a)}$$

This equation is valid for Prandtl numbers larger than 0.5 and Grashof numbers ranging from 10^3 to 10^9. See Figure 1-4.

The variation of the surface conductance with angular position for natural convection conditions was theoretically calculated by Herman[13], who derived the equation

$$Nu_{D\alpha} = 0.604\ (Gr_D)^{1/4}\phi(\alpha) \quad \text{---- (11)}$$

The value of $\phi(\alpha)$ decreases from 0.76 for $\alpha = 0°$ (bottom of cylinder) to zero for $\alpha = 180°$. ($Gr<10^9$)

A number of experiments have measured mean conductances for air flow over single cylinders and spheres.

Hilpert[14] measured the average surface conductances for air flowing over cylinders of diameters ranging from

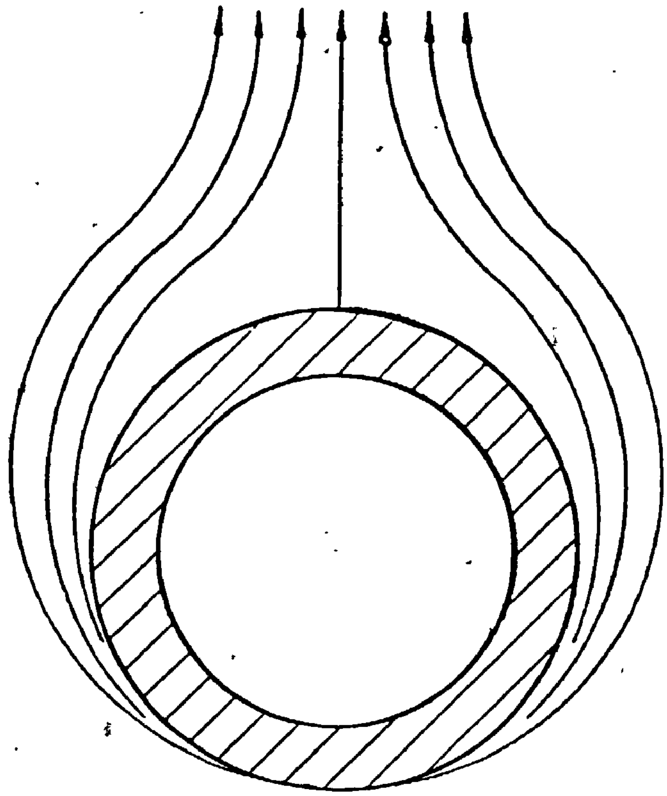


Figure 1-4: Flow Pattern for Natural Convection from a Horizontal Cylinder

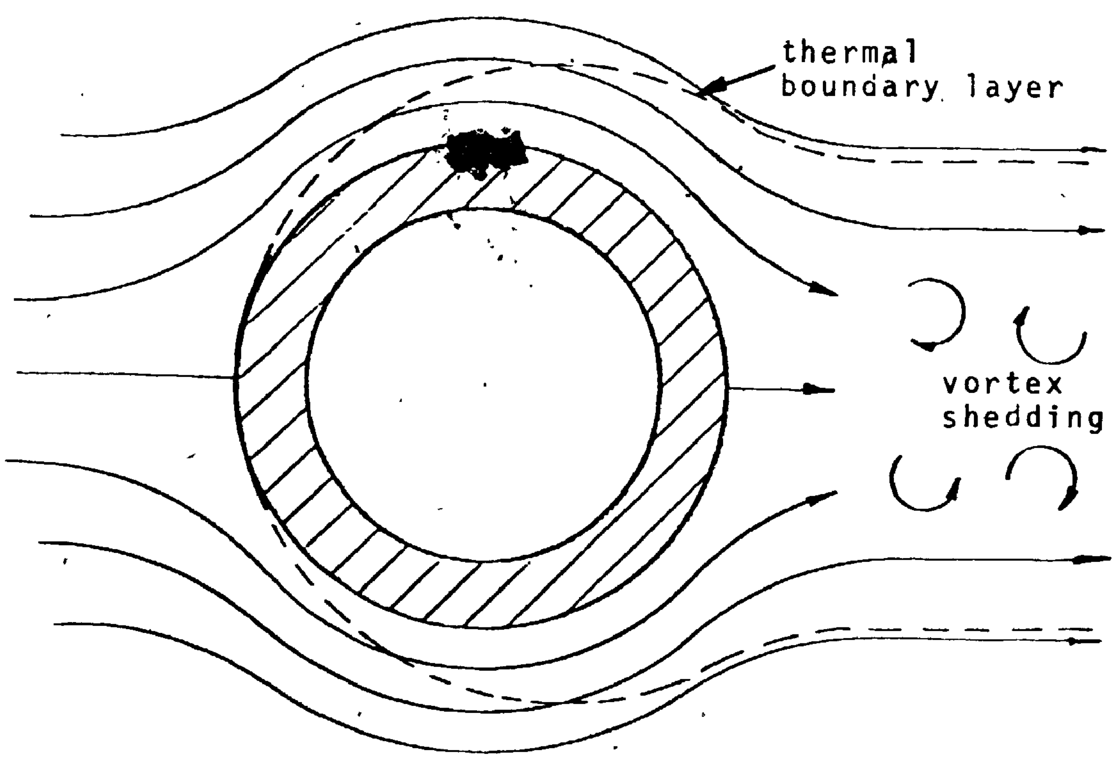


Figure 1-5: Flow Pattern for Forced Convection from a Horizontal Cylinder

0.008 to 6 inches. See Figure 1-5. For the Reynolds numbers of interest to this work, $40{,}000<Re<400{,}000$, his data can be correlated by this equation:

$$\overline{Nu}_D = 0.0239\ (Re_D)^{0.805} \qquad \text{---- (12)}$$

1.4.3 Free Convection from Vertical Flat Plates

Eckert[15] derived by integral means the equation

$$Nu_x = 0.508\ \left(\frac{Pr}{0.952+Pr}\ Gr_x\ Pr\right)^{1/4} \qquad \text{---- (13)}$$

Where x was the distance from the leading edge and $Gr_x<10^9$. See Figure 1-6.

Equation (13) can be modified to apply to inclined surfaces by using the vertical component of the body force $g\beta(T-T_\infty)\cos\alpha$.

$$Nu_x = 0.508\ \left(\frac{Pr^2}{0.952+Pr}\right)^{1/4} \left(\frac{g\beta\Delta T\cos\alpha\ x^3}{\nu^2}\right) \qquad \text{---- (14)}$$

For turbulent free convection over a vertical flat plate Eckert and Soehnghen[16] devised the equation

$$Nu_L = 0.024\ \left(\frac{Pr^{1.17}}{1+0.49Pr^{2/3}} Gr_L\right)^{2/5} \qquad \text{---- (15)}$$

where $Gr>10^{10}$.

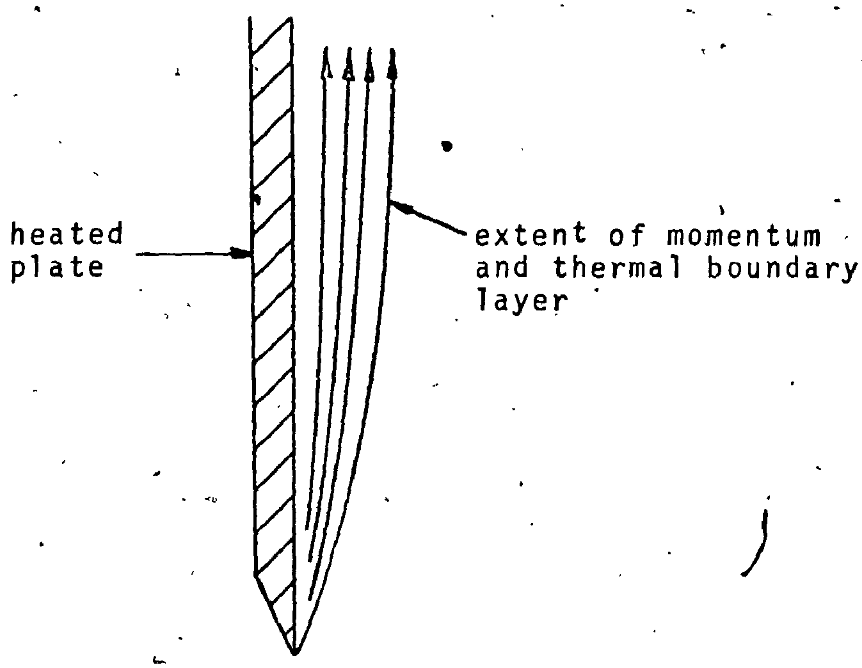


Figure 1-6: Flow Pattern for Natural Convection from a Vertical Flat Plate

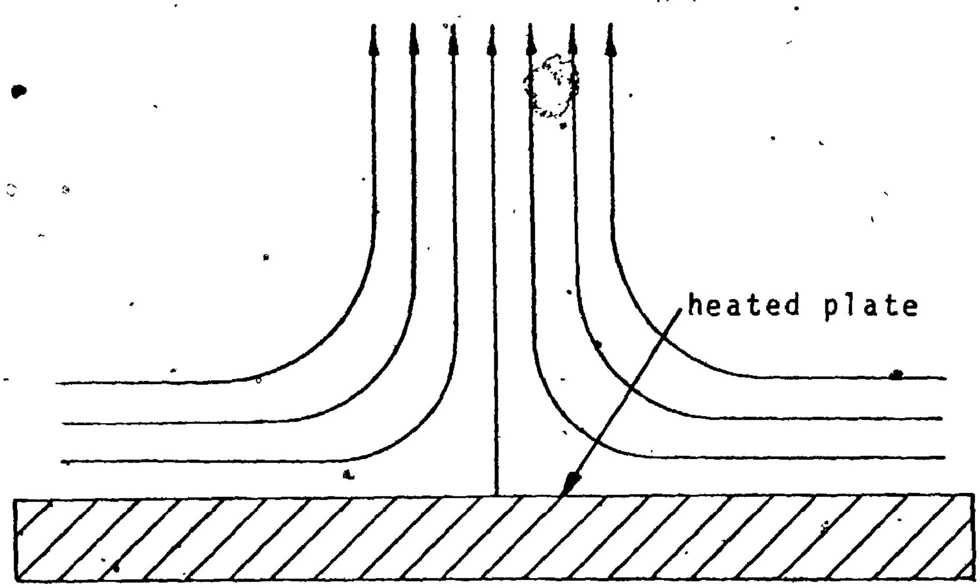


Figure 1-7: Flow Pattern for Natural Convection from a Horizontal Flat Plate

1.4.4 Free Convection from Horizontal Flat Plates

For square plates with a surface warmer than the surrounding medium facing upward or a cooler surface facing downward, McAdams[7] recommends the equation

$$Nu_L = 0.54\ (Gr_L\ Pr)^{1/4} \qquad ---- (16)$$

for laminar free convection ($Gr<10^9$) and

$$\overline{Nu}_L = 0.14\ (Gr_L\ Pr)^{1/3} \qquad ---- (17)$$

in the turbulent range, ($Gr>10^{10}$). See Figure 1-7.

Tarasuk[17] and Chan[18] have shown that for natural convection (laminar flow) three possible flows could occur on the surface resulting in a range of 0.14 to 0.54 in the coefficient or Equation (16). These flows are laminar steady, laminar unsteady or oscillating slowly and laminar rotational, depending on the temperature difference.

1.4.5 Forced Convection over Horizontal Flat Plates

Kreith[19] presents the correlation for turbulent forced convection heat transfer from a flat plate as

$$\overline{Nu}_L = 0.036\ (Pr^{1/3}\ Re_L^{0.8}) \qquad ---- (18)$$

where the influence of the laminar boundary layer is neglected. Therefore, Equation (18) is only valid when $L \gg X_c$.

1.4.6 Pressure on Domes due to Wind

Blessman[20] investigated the static wind pressures on hemispheres and spherical domes with aspect ratios ($h/_R$) of $1/_4$ and $1/_8$ with several wind profiles and wind turbulence levels. His models had a diameter of approximately 1 ft., 8 inches and had varying surface roughnesses. He concluded that the most important parameters influencing the pressure and the pressure variation over the dome surface were the intensity and scale of turbulence, the wind velocity profile and the Reynolds number.

1.4.7 Natural Convection in Enclosures

In an article entitled "Natural Convection in Enclosures", Ostrach[21] states that the main reason external natural convective heat transfer problems have received so much more attention than the interior ones is not the greater importance of the external ones but rather that internal natural convection problems are considerably more complex. The following quotation is taken from the article (p.162):

> For confined natural convection problems a boundary layer will exist near the walls but the region exterior to it will be enclosed by the boundary layer and will form a core region. Because this core is encircled by the boundary layer it cannot be considered to be independent of it. Hence, the boundary layer and core are closely coupled to each other and this coupling constitutes the main source of difficulty in obtaining analytic solutions to internal problems.

After presenting a review of existing work, Ostrach solved the natural convective heat transfer in rectangular and spherical cavities analytically.

For the rectangular case he found that

$$\overline{Nu}_d = 0.119\ (Gr_d)^{0.3}\ (d/L)^{0.1} \qquad ---- (19)$$

where d is the width and L is the height of the enclosure. Equation (19) indicates the small effect of the aspect ratio d/L on $\overline{Nu}_d$. The heat transfer coefficients calculated from this equation are reported to agree, within approximately a 20% deviation, with measurements found in the literature.

From analytical and experimental work on natural convection inside a horizontal circular cylinder Ostrach found that the flow in the core is strongly affected if not determined by the thermal boundary conditions. His cylindrical model measured eight inches long, five inches in diameter and had walls one quarter inch thick. The ends were sealed by plexiglass.

The maximum and minimum temperatures for a cosine wall temperature distribution were maintained by two heat exchangers and the cylinder could be rotated to vary the temperature boundary condition. With a light source at one end of the cylinder, and a camera at the other taking pictures of the flow at regular intervals, the motion of neutrally buoyant particles, and thereby the flow, could be visualized.

For heating at $\alpha = 45°$ (α measured from the bottom of the cylinder) and cooling at 225°, a simple vortex was generated within the cylinder. See Figure 1-8. For heating at $\alpha = 67.5°$, two vortex regions appeared which did not enclose the origin. See Figure 1-9. The flow pattern for heating at $\alpha = 90°$ is shown in Figure 1-10. This figure indicates the complex physical flow situation.

Ostrach also stated that the difficulty of analyzing natural convective heat transfer in enclosures arises from the coupling of the flows and the thermal aspects, the coupling of the boundary layer and the core, and the sensitivity of the flow configuration to the imposed thermal boundary conditions.

To the author's knowledge, experimental work dealing with natural convection heat transfer inside and from enclosures the size of inflatable structures is unavailable in the literature.

1.5 Characteristic Lengths

In the analysis of natural and forced convection heat transfer systems such as the experimental hemispherical models used in this research, the determination of the Grashof, Nusselt and Reynolds Numbers requires the choice of a length dimension, characteristic of the model.

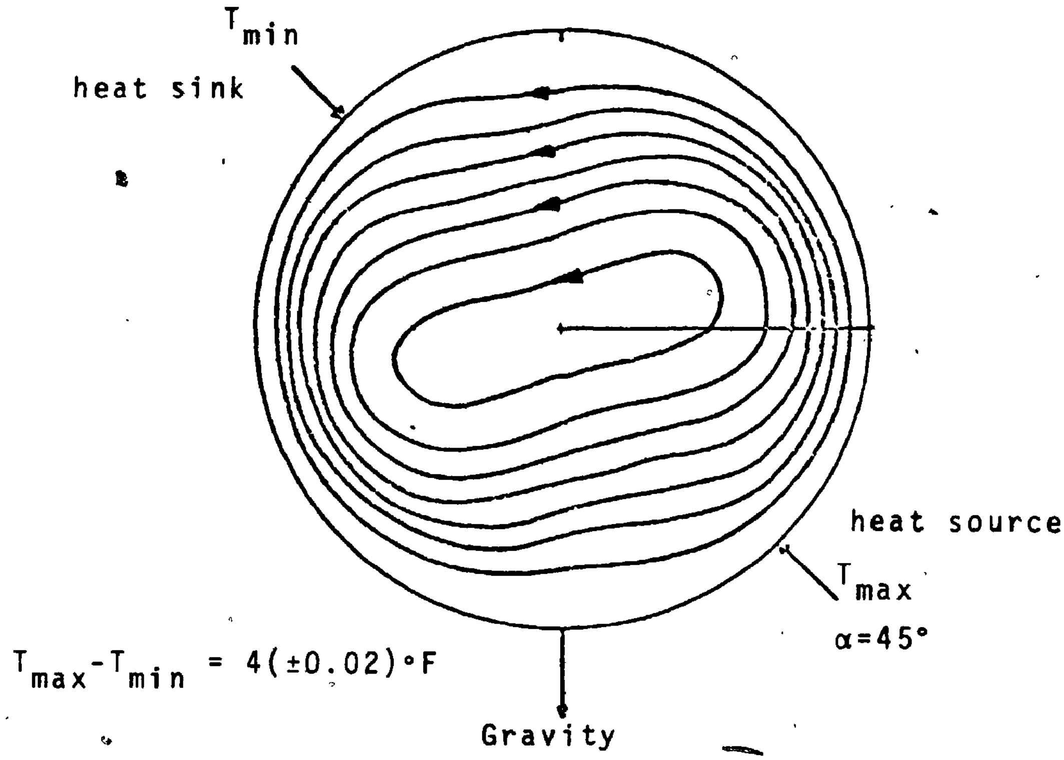


Figure 1-8: Flow Pattern Inside a Horizontal Cylinder for Heating at α = 45° (Ref 20)

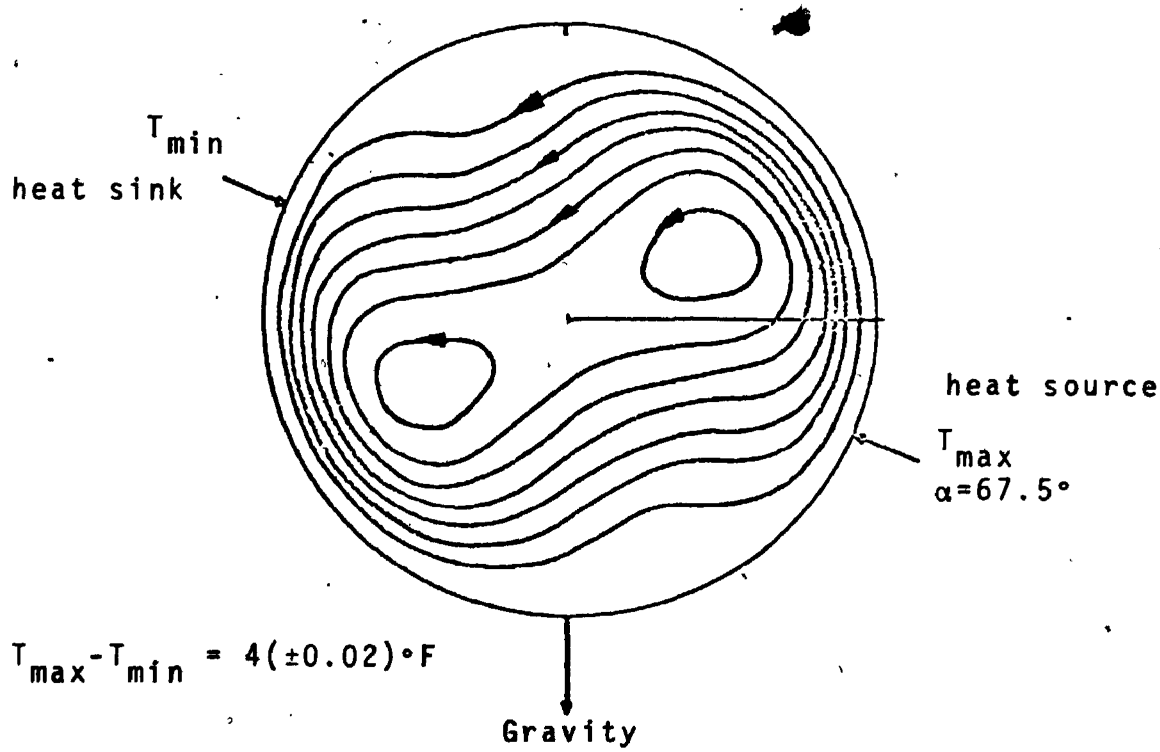


Figure 1-9: Flow Pattern Inside a Horizontal Cylinder for Heating at α = 67.5° (Ref 20)

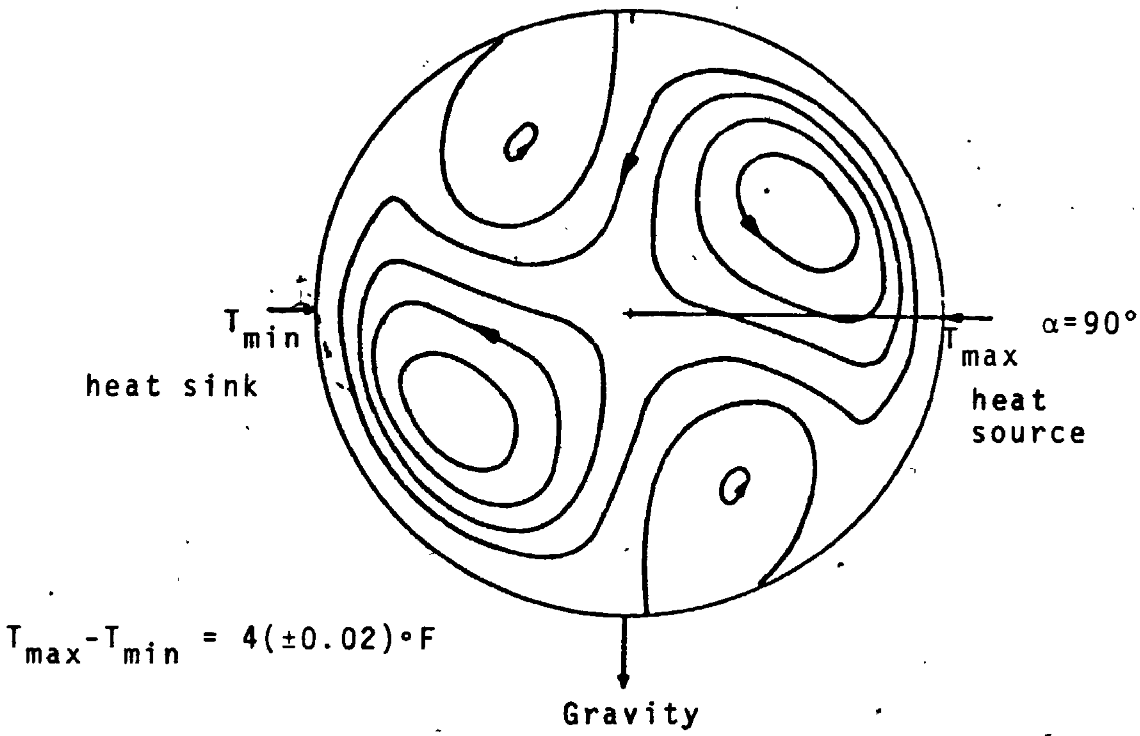


Figure 1-10: Flow Pattern Inside a Horizontal Cylinder for Heating at α = 90° (Ref 20)

1.5.1 Characteristic Length for Forced Convection

For forced convection heat transfer from cylinders and spheres, the Nusselt and Reynolds Numbers are traditionally evaluated using the diameter as characteristic length, since the approaching fluid "sees" the diameter of the model. In order to compare the forced convective heat transfer results obtained from tests with the hemispheres with those from spheres, it was decided to use the diameter of the hemispherical models to evaluate the Nusselt and Reynolds Numbers.

1.5.2 Characteristic Length for Natural Convection

It must be noted that in the case of natural convective heat transfer from cylinders and spheres there is some disagreement in the literature with respect to the choice of characteristic length. However, most authors evaluate the Nusselt and Grashof Numbers using the radius as characteristic length.[7,8,10,11,19] Since the fluid surrounding the hemisphere during natural convective heat transfer experiments "sees" only the height or radius of the model, the Nusselt and Grashof Numbers were evaluated using the radius as characteristic length.

1.6 <u>Calculated Overall Heat Transfer Coefficient Based on Previous Data</u>

One of the objects of this research was to find the overall heat transfer coefficient U for a twelve foot diameter inflatable single skin hemispherical model. This overall heat transfer coefficient was calculated for design conditions by evaluating and combining the thermal resistances due to the thermal conductivity of the skin and the interior and exterior heat transfer coefficients. The assumptions involved were that the internal and external heat transfer coefficients could be obtained by extrapolating from existing data correlations for spheres, that the effects of the boundary layer of the approaching air stream were negligible, that the internal and external heat transfer coefficients did not influence each other and that the natural convective interior air flow pattern was not disturbed by the exterior air flow pattern.

For the "design day" when the air temperature is 0°F and the wind velocity is 11 ft/sec, a Reynolds Number of 9.18×10^5 with a corresponding Nusselt Number of 1400 was found (Equation 3). The average external heat transfer coefficient for this condition was equal to 1.55 Btu/hr ft^2°F. The thermal resistance is the inverse of the heat transfer coefficient: 0.645 hr ft^2°F/Btu.

The resistance due to the conduction of heat through the skin is equal to the thickness of the skin divided by its thermal conductivity. It was assumed that the skin thickness was 3/16" and the thermal conductivity 0.1 Btu/hr ft °F. For these values the thermal resistance was equal to 0.156 hr ft^2°F/Btu.

To calculate the thermal resistance due to natural convection at the interior of the hemisphere an assumption had to be made about the temperature of the interior surface of the skin. It was assumed that the interior of the hemisphere would be maintained at 60°F and that the temperature difference across the interior boundary layer was 35°F. For these conditions the Grashof Number was equal to 2.38×10^{10}, with a corresponding Nusselt Number equal to 251 (from Figure 7-3, Ref. 19). The average internal heat transfer coefficient was then equal to 0.59 Btu/hr ft^2°F. The corresponding thermal resistance was equal to 1.71 hr ft^2°F/Btu.

The overall heat transfer coefficient U, the inverse of the sum of thermal resistances was equal to 0.40 Btu/hr ft^2°F. However, due to the questionable assumptions made, this value must be regarded with suspicion.

The results of the experimental investigation of the overall heat transfer coefficient of a twelve foot diameter inflatable hemispherical model under actual winter conditions is presented in Chapter 7.

2. APPROACH TO THE PROBLEM

2.1 Introduction

The following general discussion applies to enclosures internally heated in the winter season.

There is little understanding of the actual heat transfer mechanisms in an air-inflated structure. The convective air flow patterns inside the structure are complex and vary with outside conditions, such as the weather, the profile of the planetary boundary layer and the wind velocity, to name a few. A description of the planetary boundary layer is presented in Appendix A. For different enclosure geometries, symmetrical and non-symmetrical, different flows occur both inside and outside the structure. In most existing inflatable structures the make-up air and return air are heated before they are blown into the structure. This heated air stream causes a distortion within the enclosure's natural convection pattern.

Condensation on the enclosure walls and air leaking through the air-lock and the base complicate this pattern even more. The air within the enclosure is cooled by outside forced convection caused by wind. The area of the enclosure's skin facing the wind is cooled more than areas on the leeside. Consequently the cooling rate of the interior ambient air on the leeside is less than that of the side of the enclosure facing the wind. Since the heat flux through the skin is directly proportional to the thermal conductivity of the skin material, therefore, insulation applied to the skin or the use of a double skin where air acts as an insulator would influence the heat losses.

Deformation of the enclosure due to wind forces disrupts the boundary layer formation both on the interior and exterior wall. The boundary layer might separate from the enclosure near areas of deformation with an associated change in the heat transfer coefficient. Also, vibrations in the skin caused by wind tend to increase the heat transfer rate by making the boundary layer more turbulent.

Depending on the structure type used, the leakage rate of air at the base of the inflated structure can be as high as one cubic foot per minute per foot of base[6]. The use of air-locks for entering and leaving the enclosure also cause heated air to escape. The make-up air applied to offset this leakage, the movement of people and machinery and large scale turbulence introduced by air used for ventilating the enclosure complicate the overall energy balance.

Since values for emissivity, transmittance and absorption of commercial skin material are not available to date, heat transfer due to radiation is very difficult to estimate accurately. Radiation to and from the enclosure is a rather important factor in the overall energy balance, as is shown in Chapter 7.

The floor and the skin as well as the air inside the heated air-inflated structure have non-isothermal characteristics and this causes considerable difficulty in obtaining analytical solutions for the heat transfer through the skin. Even the analytical solution describing the heat transfer from a hemisphere with an isothermal surface presents considerable difficulties. For a first solution, simplifying assumptions such as an isothermal floor should be made to obtain manageable equations. The equations for the isothermal hemisphere are presented in Section 4.2.2.

The dome geometry used in this research was the hemisphere and it was chosen because it is ideal structurally (no stress concentrations in the skin) and has a variety of applications. The "Radome" (radar enclosures used in the Arctic) and city enclosures are such examples. Also, a city enclosure represents a sector of a hemisphere. A further practical advantage is that the internal flow in a hemisphere is less complex than that of a semi-cylinder and has the added advantage of having a maximum volume for any given surface area. A single model can easily be adapted to represent structures of different aspect ratio (h/R). This is shown in Figure 2-1.

2.2 Method used in this Study

It was decided to begin this research program by finding the local and overall heat transfer coefficients

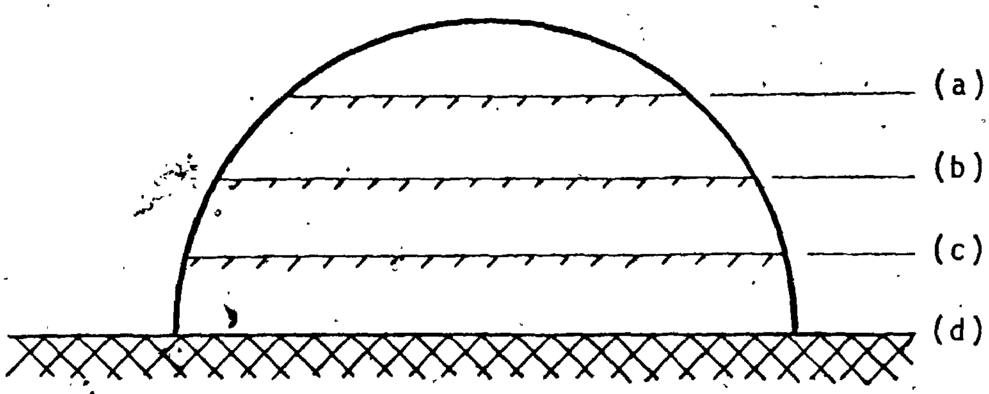


Figure 2-1 Hemispherical Enclosure Showing Several Aspect Ratios

(a) h/R = 1/4

(b) h/R = 1/2

(c) h/R = 3/4

(d) h/R = 1

for free and forced convection from hemispheres by first observing qualitatively the flow inside a hemisphere and semi-cylinder (see Chapter 3).

The next step was to construct a simple model to measure overall free and forced convection heat transfer coefficients (see Chapter 5). This was then followed by a study designed to measure local free and forced convection heat transfer coefficients. A twenty inch diameter, hollow model was instrumented and with this model the influence of the variation of the polar and azimuth angles on the heat transfer coefficient could be determined for a variety of wind velocities (see Chapter 6).

In order to study the influence of the general weather conditions on the heat transfer rates, a twelve foot diameter inflatable model was donated by Soper's Ltd. of Hamilton, Ontario. An energy balance approach was used to establish average heat transfer coefficients. With this model the influence of weather variations, such as sunny or cloudy conditions, rain or snow as well as the influence of different types of terrain (e.g. flat open country, terrain build-up by buildings, trees or bushes) on the overall heat transfer coefficient could be established (see Chapter 7).

However, a suitable location for this model was difficult to find. Several locations were considered and investigated with respect to the condition of the terrain, the surroundings, the possibility of vandalism and the availability of electric power to supply the heating systems, the fans and the instrumentation. The roof of the Engineering Science Building at the University of Western Ontario was considered but was rejected as a possible site since the earth's boundary layer wind profile and roof top end effects would render the results uncharacteristic of rural or urban dome locations.

Finally, a site on a farm near London, Ontario was chosen for the location of the dome. The site chosen was surrounded by flat open farm land on the east, farm buildings on the south and forest on the west and north.

3. FLOW VISUALIZATION STUDIES

3.1 Introduction

Since information was not available in the literature on the air flow inside a hemispherical enclosure, it was initially decided to study this flow qualitatively. It was important to know how interior air currents behave under natural and forced convection conditions in order to acquire an appreciation for the governing modes of heat transfer, stagnation points and flow directions in an enclosed hemispherical structure.

Interferometric studies on a two-dimensional model and smoke visualization experiments on a three-dimensional model were carried out.

3.2 Smoke/Injection Model

A simple model was made to visualize the air currents inside a hemisphere with a heated base. A glass hemisphere six inches in diameter was placed above a heated circular copper block. See Figure 3.1. Insulation prevented a transfer of heat from the block to the glass so that the major mode of heat transfer was primarily by convection. Five holes were drilled at locations radially outward from the centre of the block to allow smoke injection at different locations into the hemisphere. Air inside the dome acted as the smoke carrier and an amount of air equal to the volume of the smoke introduced was permitted to escape

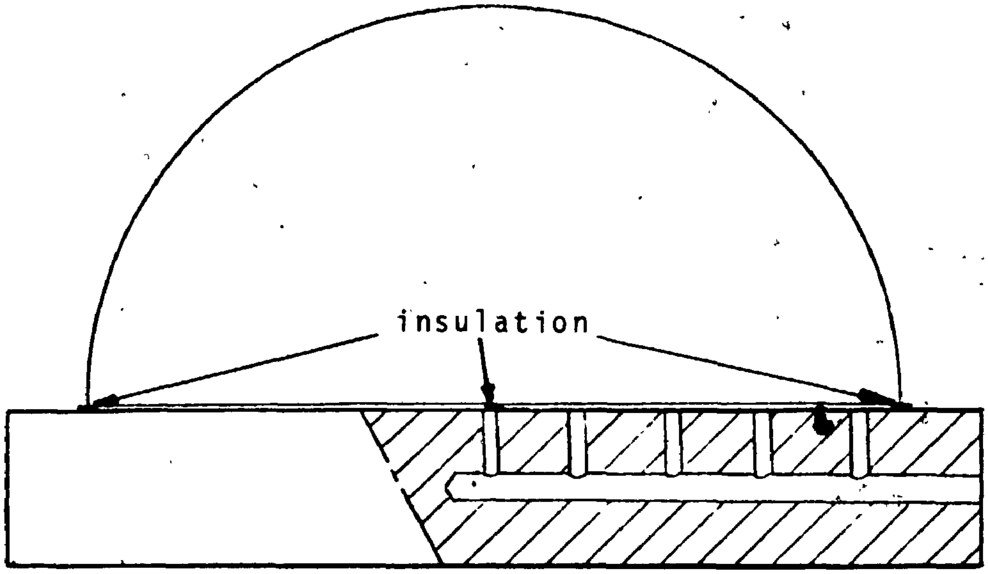


Figure 3-1: Smoke Injection Model with Glass Hemisphere

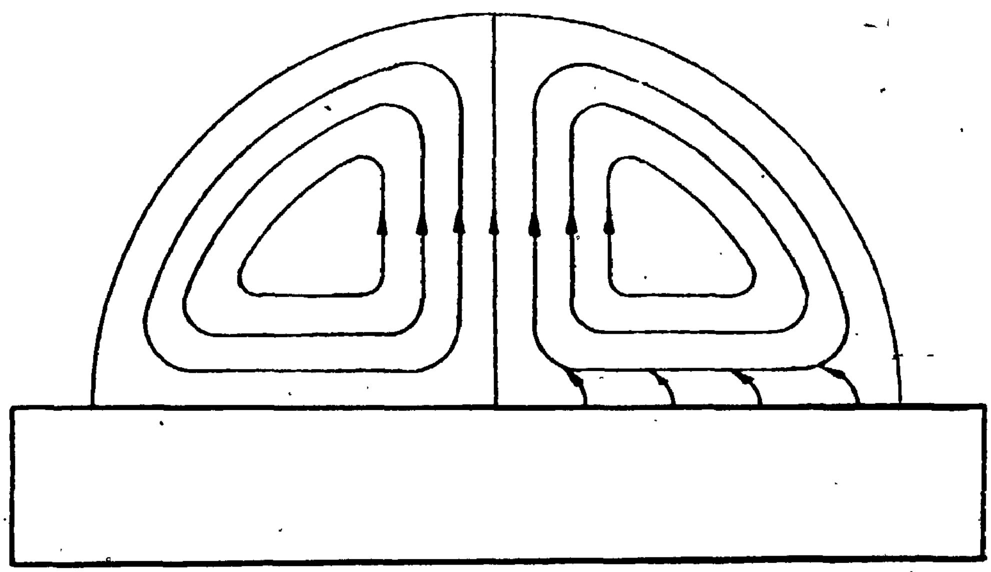


Figure 3-2: Flow Direction Pattern Inside the Smoke Injection Model

between the perimeter of the dome and the block.

When the copper block was heated and the glass hemisphere placed on top of the heated base, smoke injected through the openings in the block visualized the interior flow pattern. Under these natural convection conditions the smoke moved radially inward toward the centre of the base and then rose to the top of the hemisphere. Then the smoke travelled along the hemisphere wall toward the base. Smoke injected through any opening showed the same symmetrical toroidal flow pattern. The flow direction patterns are shown in Figure 3.2

The exterior of the glass hemisphere was also subjected to a cooling air stream during smoke injection under these conditions. The interior flow vortex strength increased greatly and became distorted depending on the direction of the cooling air stream. No attempt was made to monitor the temperatures of the copper block and the glass hemisphere.

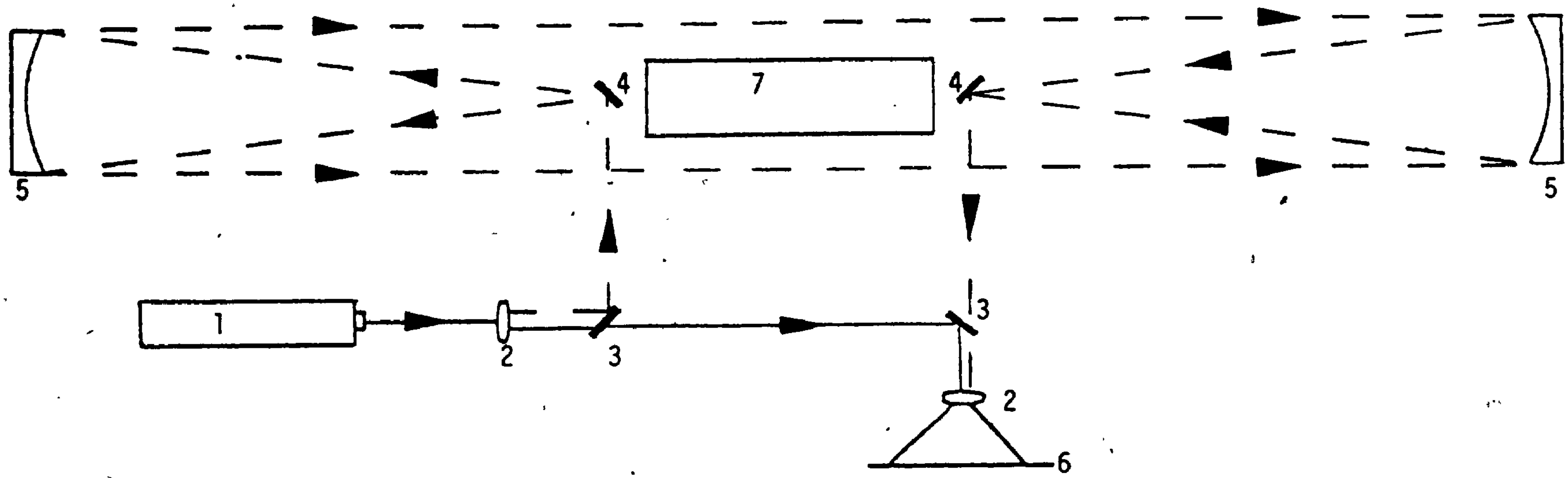
3.3 Interferometric Model

Interferometric studies were carried out on a hollow plexiglass cylinder, sixteen inches long, six inches in diameter and of one-quarter inch wall thickness. The Mach-Zehnder interferometer used for this experiment employed a Neon-Helium gas laser with an output of five milliwatts at 6328 Å. The light beam of the laser was split into two separate beams, one of which was directed past the model and recombined with the reference beam. The density differences caused by temperature gradients in the model were integrated along the path of the light beam and can be shown on a screen as interference fringes. The light beam can also be directed to a camera and the fringes can be recorded on a photographic plate. The density gradients in the model were directly proportional to the temperature gradients. Areas where the fringes are closely spaced indicate steep temperature gradients[22]. A sketch of the interferometer and the model is shown in Figure 3.3. The nature of this type of instrument dictates the use of a long, two-dimensional model with open ends.

The fringe locations representing the temperature boundary layer were examined and from their location a toroidal flow was confirmed. It was found that the highest heat transfer rates occurred near the corners and at the top centre of the semi-cylinder. It should be noted that since the interferometer requires the use of a two-dimensional model with open ends, this model only approximates a hemisphere. The resulting interferogram is shown in Figure 3.4.

3.4 Discussion and Conclusions

The qualitative experiments described in this chapter provided information on the internal flows to be expected in subsequent experiments.



1. laser
2. lens
3. beam splitter
4. mirror
5. parabolic mirror
6. screen
7. semicylindrical model

- - - - Testing Beam

——— Reference Beam

Figure 3-3: Experimental Set-Up of Semicylindrical Model and Interferometer (Not to Scale)

Figure 3-4: Interferometric Result Showing Interferometric Fringes Related to the Heat Transfer from the Semicylindrical Model

Also, from these experiments it is evident that the nature of the inside air flow is dictated by the type of air flow that occurs exterior to the model. Therefore, if the experimental heat transfer coefficient results obtained from small scale models are to be used for the prediction of heat transfer rates from large scale structures, the external flow over the experimental model must be scaled as well and it must be demonstrated that the interior flow in the model is similar to that in a full-scale structure for identical external conditions.

4. SCALING AND MATHEMATICAL MODELS

4.1 Principle of Similarity

According to the principle of similarity, the behaviour of two geometrically alike systems will be similar if the ratios of their linear dimensions, forces, velocities, etc., are the same. Under conditions of forced convection in geometrically similar systems, the velocity fields will be similar provided the ratio of inertia forces to viscous forces is the same in both fluids. Consequently it is expected that similar flow conditions in forced convection will exist for a given value of the Reynolds number.

The kinematic viscosity ($\nu = \mu/\rho$) and the thermal diffusivity ($\alpha = k/\rho c_p$) relate the temperature distribution to the velocity distribution. The Prandtl number is the ratio of these molecular transport properties. Therefore, in geometrically similar systems having the same Reynolds and Prandtl numbers, the temperature distribution will be similar.

The Nusselt number is by definition numerically equal to the ratio of the temperature gradient at a fluid to surface interface to a reference temperature gradient. It is expected therefore that in systems having similar geometries and similar temperature fields, the numerical value of the Nusselt numbers will be equal[19,23].

During the course of this research small heated hemispherical models were subjected to natural and forced convective cooling. According to the above mentioned principles, one should be able to use the results from these tests to predict heat transfer rates from larger hemispheres with identical temperature distribution subjected to similar flows having the same Reynolds and Prandtl numbers. However, it was found from the flow visualization studies that in hollow hemispheres, the interior flow was dependent on the exterior flow. Since the heat transfer rate was also dependent on the interior flow, this interior flow in the larger system must be similar to that of the experimental system.

Interferometric studies showed that similar interior flows exist for natural convection conditions in small semicylindrical models up to eight inches in diameter. For larger models, models subjected to forced convection and models with different aspect ratios, it is not clear that similar flows exist and therefore it is not valid to assume that the results obtained with the models in this research project can be scaled to models of much larger diameters.

4.2 Mathematical Models

This section deals with procedures that can be adopted for analytical natural convection heat transfer studies for spheres and hemispheres. The discussion applies only to the heat transfer from the external surface.

4.2.1 Boundary Layer Integration

To analyze the heat transfer by natural convection from hemispheres, the differential equations governing the flow in the boundary layer, namely the Navier-Stokes equation as well as the energy equation in spherical coordinates must be considered. The velocity profile in the natural convective boundary layer is quite unlike the velocity profile in a forced convection boundary layer. At the wall the velocity is zero because of the no-slip condition; it increases to some maximum value and then decreases to zero at the end of the boundary layer since the free stream is at rest in the natural convection system. Near the leading edge the boundary layer is laminar. However, at some distance downstream from the leading edge, depending on the fluid properties and the temperature difference between the wall and the environment, turbulent eddies are formed and transition to a fully turbulent boundary layer begins.

By postulating a fully laminar boundary layer (which is not realistic as is shown in Chapter 7) and assuming the velocity and temperature profiles in the boundary layer may be calculated from boundary conditions, the Navier-Stokes and energy equations may be solved simultaneously to yield the heat transfer rate.

4.2.2 Similarity Transformation

In 1937, Shell[8] presented a mathematical solution of the continuity, momentum and energy equations for natural convection heat transfer by laminar flow over a solid sphere having a uniform temperature across its surface. Without stating the similarity transformation he concluded that

$$\frac{\partial V_\psi}{r_o \partial \psi} + \frac{\partial V_r}{\partial r} = 0 \qquad \text{---- (20)}$$

$$\rho \left(V_\psi \frac{\partial V_\psi}{r_o \partial \psi} + V_r \frac{\partial V_\psi}{\partial r} \right) =$$

$$\rho \cdot \nu \frac{\partial^2 V_\psi}{r_o^2 \partial \psi^2} + g_\psi \rho \frac{T_1 - T_\infty}{T_\infty} \theta \qquad \text{---- (21)}$$

and

$$V_\psi \frac{\partial \theta}{r_o \partial \psi} + V_r \frac{\partial \theta}{\partial r} = \alpha \frac{\partial^2 \theta}{\partial r^2} \qquad \text{---- (22)}$$

had the following solution:

$$Nu = 0.429 \, Gr^{\frac{1}{4}} \qquad \text{---- (23)}$$

where

r_o = radius of sphere

T_1 = surface temperature

and $\theta = \dfrac{T - T_\infty}{T_1 - T_\infty}$

The rest of the symbols used in Equations 20-22 are shown in the nomenclature.

A solution of this kind has no practical application to heat transfer from inflatable hemispheres, since the heat transfer is also dependent on the interior flow.

4.2.3 Potential Flow Modelling

From the interferometric studies of Section 3.2 it was found that the internal flow structure within a hollow semi-cylinder, when the base was heated, consisted essentially of two finite vortices of opposite sign positioned above the base. These experimental test results can form the basis of computed vortex models.

Consider a similar array of real potential vortices as shown in Figure 4-1.

A modified Rankine vortex[24] was used for the vortex function in this eight vortex model. For the modified Rankine vortex, the azimuthal velocity component V about the centre of a vortex positioned at a point $P(\xi,\eta)$ in space is given by:

$$V = \frac{\Gamma_1 r}{(r_c^2+r^2)} \quad \text{where } r^2 = (x-\xi)^2+(y-\eta)^2 \qquad (24)$$

Γ_1 is the circulation constant and in this case its value depends on the difference in temperature between the heated base and the wall of the hollow cylinder. The vortex core radius (r_c) by definition is the radius where the vortex

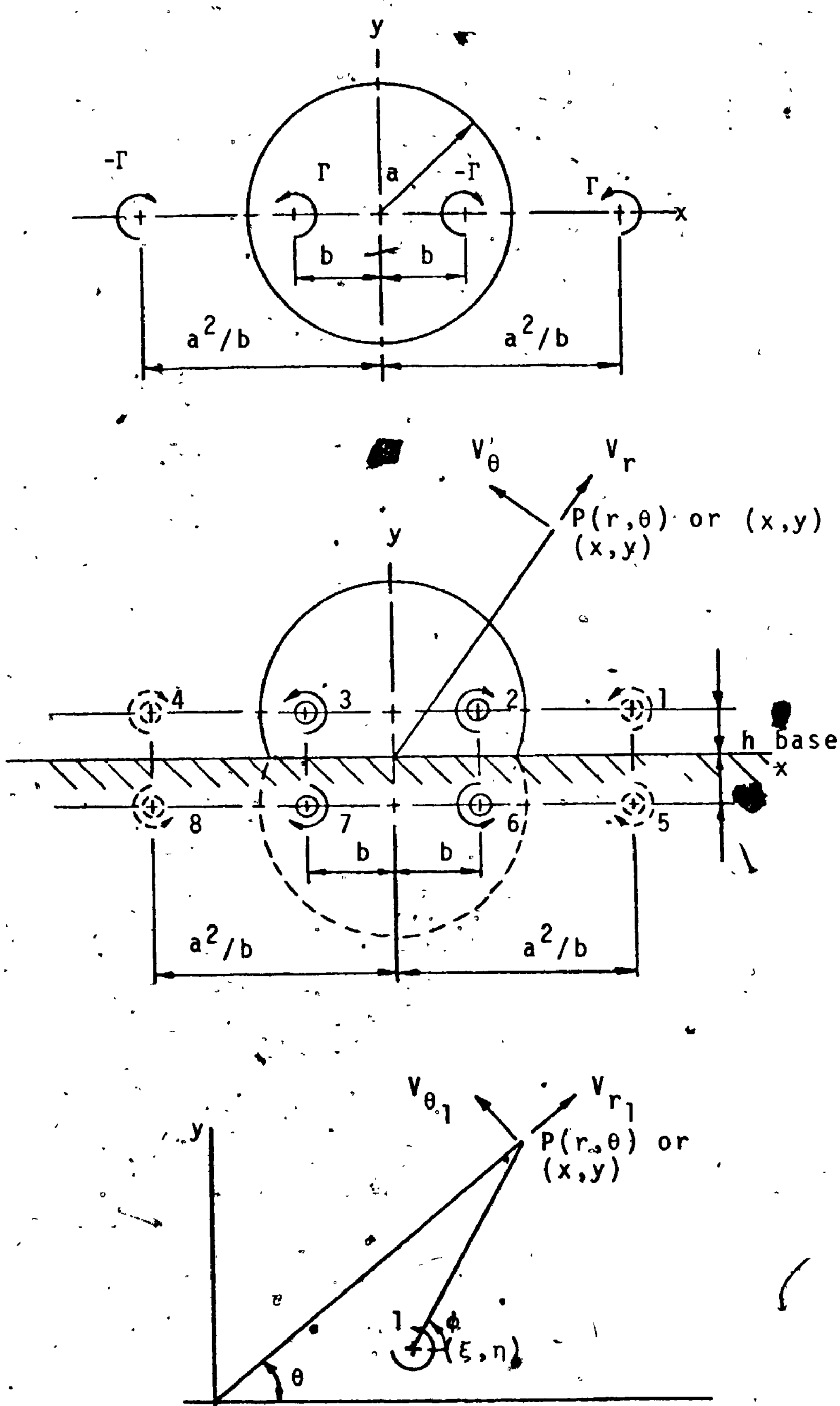


Figure 4-1: Array of Potential Vortices Representing Interior Two-Dimensional Flow in a Semicylinder

tangential velocity is a maximum. The value of the vortex core radius will also have to be determined from experimental studies.

For the complete vortex model the total velocity at any point in space is therefore given by:

$$V_\theta = \sum_{n=1}^{8} V_{\theta_n} \quad \text{---- (25)}$$

and

$$V_r = \sum_{n=1}^{8} V_{r_n} \quad \text{---- (26)}$$

Where n denotes a particular vortex, for instance,

$$V_{\theta_1} = V_1 \text{Cos}(\phi_1 - \theta) \quad \text{---- (27)}$$

and

$$V_{r_1} = V_1 \text{Sin}(\phi_1 - \theta) \quad \text{---- (28)}$$

Where

$$V_1 = \frac{\Gamma_1}{\pi} \frac{((x - a^2/b)^2 + (y-h)^2)^{\frac{1}{2}}}{(r_c^2 + (x - a^2/b)^2 + (y-h)^2)} \quad \text{---- (29)}$$

$$\text{Tan } \theta_1 = \frac{(y-h)}{(x - a^2/b)} \quad \text{and Tan } \theta = y/_x$$

Figure 4-1 shows the coordinate system used.

Similar expressions may also be written for the other seven vortices composing the complete vortex model. The shape of the dome is therefore given by solving the equation:

$$V_r = \sum_{n=1}^{8} V_{r_n} = 0 \qquad \text{---- (30)}$$

and the velocity V_θ at the edge of the boundary layer near the surface of the hollow cylinder.

The practical uses of these flow models are in the scaling up of small scale tests to full size model predictions. Since this method decouples the momentum equation from the energy equation, considerable simplifications in the computation are achieved.

4.3 Critique and Conclusions

The procedure outlined in Sections 4.2.1, 4.2.2 and 4.2.3 are premised on a correct description of the temperature distribution and the velocity profile in the boundary layer. Moreover, the procedure using the potential flow vortices presupposes an accurate description of the location of the vortex centre of rotation. However, these presuppositions have not yet been established by research and therefore solutions of this nature must be regarded with suspicion. It is also recognized that for hemispheres of different aspect ratios different solutions exist.

The author attempted an analytical solution of the natural convective heat transfer from a two dimensional semi-cylinder. By assuming laminar flow and a uniform surface temperature, the integral momentum and energy equations for the boundary layer were determined. It was also assumed that the velocity profile in the boundary layer had geometrically similar shapes at various distances along the semi-cylinder. From the boundary conditions the velocity profile and the temperature distribution in the boundary layer were found and substituted in the integral equations. However, the resulting equations were found to be extremely difficult to solve. Even if found, their solution would have very limited importance due to the unrealistic initial simplifying assumptions.

In conclusion, analytical solutions are of great value but due to the uncertainties of the interior and exterior flows during natural and forced convective conditions and the difficulties of extending the results to larger models, the author's attempts to find an analytical solution of heat transfer rates from hemispheres have been abandoned.

5. EXPERIMENTAL HEAT TRANSFER STUDIES ON A FOUR INCH DIAMETER SOLID HEMISPHERE

Initial studies were carried out on a four inch diameter solid aluminum model. It was instrumented and tested to acquire an appreciation of the significant parameters involved in correlating heat flux rates from hemispheres. This model was also used to obtain free and forced convection heat transfer data for a small hemisphere.

5.1 Description of the Four Inch Diameter Model

The four inch diameter model was made of four inch diameter aluminum alloy rod, twelve inches long, the last two inches being shaped in the form of a hemisphere as is shown in Figure 5-1. The thermal conductivity of the aluminum alloy (4% Cu, 0.5 Mg) is of the order of 105 Btu/hr ft°F at 212°F[23]. The thermal conductivity of this alloy varies with temperature[23] and this variation was taken into account in the calculations.

Absolute copper-constantan thermocouples were placed at intervals of two inches along the central axis and on the perimeter of the aluminum cylinder, as well as a thermocouple on the top of the hemisphere. The temperature difference between the points 1-2 and 1-3 were measured with differential copper-constantan thermocouples. (Please refer to Figure 5-1.)

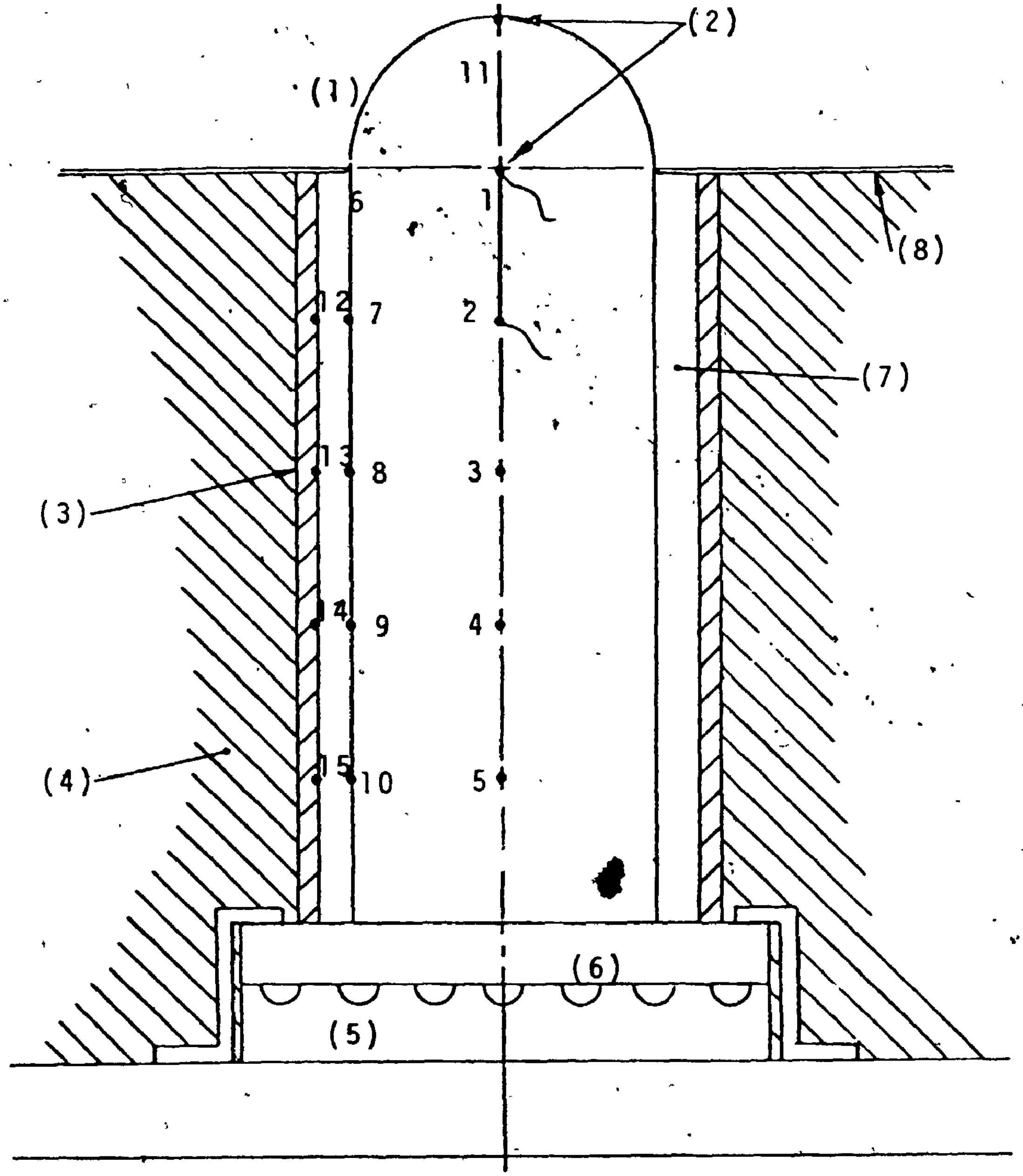


Figure 5-1: Sketch of Four Inch Diameter Hemisphere

(1) hemisphere
(2) thermocouples, differential: 1,2 and 3
absolute: 4-15
(3) adiabatic shield
(4) insulation
(5) heating element
(6) base
(7) air gap
(8) low heat conductive paper

A cylindrical adiabatic shield, made of aluminum alloy, 1/8" thick and 4½" in diameter, was placed around the solid cylinder. Absolute copper-constantan thermocouples were mounted at the interior side of the adiabatic shield at points which were directly opposite the thermocouples mounted at the surface of the solid cylinder. The temperature indications of these thermocouples on both sides of the air gap were used to calculate the radial heat transfer.

The thermocouples in the centre of the cylinder were inserted through 1/16" diameter openings, drilled from the perimeter of the cylinder. The thermocouples on the surface of the cylinder, dome and adiabatic shield were mounted in 1/16" diameter openings, 1/8" deep. All thermocouples were secured with electrically insulating, heat conductive 'Sauereisen' cement. The entire unit was placed on top of an electric heating element with a capacity of 750 watts. To reduce radial heat losses, insulation was placed around the adiabatic shield.

To avoid radial heat transfer in the cylinder just below the base of the dome, the base of the dome was extended with a thin sheet of paper. A circular opening was cut in the paper to accommodate the dome and the sheet was mounted in place level with the base of the dome and extended over the insulation, but not in contact with the dome.

Initial experiments were carried out using all thermocouples in an absolute configuration. It was found that the maximum temperature difference across the air gap was 0.5°F. The radial heat flux due to this temperature difference was calculated and found to be in the order of 0.25% of the heat flux from the dome. Therefore, radial heat transfer was not considered in the calculations and the assumption was made that the heat flux into the dome was constant over the entire cross-section of the cylinder.

It was also observed that the temperature differences between the points 1-2 and 2-3 were too small to read accurately with absolute thermocouples. Therefore, the temperature differences between points 1-2 and 1-3 were measured by means of copper-constantan differential thermocouples.

It also became evident that the temperature gradient between the points 1 and 2 was different from the gradient between the points 2 and 3. This discrepancy between temperature gradients is due to the heat transfer from the cylinder to the adiabatic shield. Rather than using a straight line temperature gradient between the points 1 and 2 or 1 and 3 as the gradient at the base of the dome, a parabolic temperature gradient was calculated from the measured temperature differences between the points 1 and 2 and between 1 and 3. With Fourier's one-dimensional conduction equation,

$$Q = kA\, dT/dx \qquad ---- (31)$$

The heat flux into the dome could then be estimated. The experimental error was estimated to be in the order of 6%, as is shown in Appendix B.

5.2 Experimental Procedure for Natural Convection Heat Transfer

To obtain natural convective heat transfer data, the experimental apparatus described in Section 5.1 was placed inside a 24"x21"x33" plexiglass box to prevent stray air currents from moving across the dome. This box influenced the experiment only to the extent that the ambient temperature inside the box was 3 - 5°F higher than room temperature. Since the box was very large compared with the size of the model, it did not change the natural convective flow configuration.

The experiment was started by switching the variac that powered the heater on to its maximum power, and the equipment was left to heat up. After the equipment had reached a steady state, (temperature variations no larger than 0.5°F/hr) the following temperature measurements were taken:

a) ambient temperature

b) dome surface temperature

c) two temperature differentials at the base of the dome, namely $\Delta T_{(t_1-t_2)}$ and $\Delta T_{(t_1-t_3)}$

The last two temperature differences served to calculate the flow of energy into the dome. Since the system remained at steady-state conditions, the energy entering the dome was equal to the energy leaving the dome by natural convection heat transfer.

The properties of the air in the boundary layer were calculated at the arithmetic mean of the temperatures of the ambient air and the metal surface. The average natural convective heat transfer coefficient h_{nc} for the dome was calculated from Newton's equation

$$Q = h_{nc} A (T_{surface} - T_{ambient}) \quad \text{---- (32)}$$

The Nusselt and Grashof numbers were determined using the radius of the dome as the characteristic length.

After the first experiment was completed the variac voltage output was lowered by about 10% for the next experiment and the equipment allowed to reach a steady state. This procedure was repeated until all tests were completed. The dome surface temperatures investigated ranged from 192.5°F to 268.0°F while the temperature difference between the dome surface and the ambient air ranged from 116.5°F to 184.0°F.

The temperature differenees between points 1 and 2 and between points 1 and 3 were interpolated from the micro-volt measurements obtained by a Honeywell Electronic 19 chart recorder and the absolute temperatures, in degrees Fahrenheit were obrained by means of a 'Multimite' temperature indicator.

5.3 Natural Convection Experimental Results

The experiments with this model were carried out to find the correlations of natural and forced convection heat transfer rates from hemispheres, also, to find out whether the significant parameters used for spheres are applicable to hemispheres. Since the initial experiments established that the model was functioning properly and that the radial heat flux was only a fraction of the axial heat flux, only those temperatures and temperature differences that were needed for the calculation of the Nusselt and Grashof Numbers were recorded in the final experiment.

The data obtained from this experiment as well as the results of calculations, a sample calculation and an error analysis can be found in Appendix B.

The results of this experiment are shown in Figure 5-2, together with the average heat transfer coefficients for heat transfer from single horizontal wires or pipes in free convection, as given by McAdams[7]

$$Nu = 0.53\ (Gr\ Pr)^{1/4} \qquad \text{---- (2b)}$$

These values for average natural convection heat transfer coefficients apply also to spheres at $Gr > 10^3$, when the sphere radius is used as characteristic length in the Nusselt and Grashof Numbers[19]. Within the range of Grashof-Prandtl products investigated, $5.36 \times 10^5 < GrPr < 6.19 \times 10^5$, the laminar convective heat transfer coefficients were found to be in very close agreement with

McAdams' correlation. On the average, the data obtained in this research agreed to within 2.4% with Equation (2b), while the largest discrepancy was 6.3%.

The influence of radiation on the heat transfer from the dome was investigated as well. The radiative heat transfer equation for the case of a convex object completely enclosed by a very large surface to which this experiment applies is

$$Q/A = F_{1-2}\,\sigma\,\varepsilon_1\,(T_1^4 - T_2^4) \qquad \text{---- (32a)}$$

where σ = Stefan-Bolzmann constant, 0.1714×10^{-8} Btu/hr ft^{2}R°^{4}

ε_1 = Emissivity of hot object

T_1 = Temperature of hot object

T_2 = Temperature of large surface

F_{1-2} = Radiation shape factor, in this case $F_{1-2} = 1.0$

The emissivity value of highly polished aluminum was taken as 0.039 (Table A-10, p. 508, Ref. 30).

Equation (32a) was applied to the experiments with the maximum and minimum dome surface temperatures and the radiative heat fluxes were compared with the natural convective heat fluxes. It was found that at the maximum dome surface temperature the ratio of the radiative and natural convective heat fluxes was equal to 0.041. At the minimum dome surface temperature this ratio was found to be equal to 0.039. One of the reasons that the calculated natural convective heat transfer coefficient increases at higher dome surface temperatures is that at higher temperatures the radiative heat flux increases. This trend can be observed in Figure 5-2.

5.4 Experimental Procedure for Forced Convection Heat Transfer

Heat transfer from a full scale inflated structure usually occurs by means of forced convection. Therefore this model was also subjected to forced convective heat transfer experiments in an 18"x18" cross-section windtunnel.

Since full scale domes extend from ground level into the atmospheric boundary layer, this model was mounted in such a way that only the dome protruded into the wind-tunnel with the base of the dome flush with the bottom wall of the rectangular cross-section wind-tunnel.

As with a full scale dome in the atmospheric boundary layer, the forced convective heat transfer rate from the model was affected by the wind-tunnel wall boundary layer. The experimental model, however, extended well above the boundary layer thickness.

The experiment was started by adjusting the wind-tunnel controls for a predetermined wind speed and the variac that powered the heater was switched on for maximum temperature in the dome.

After a steady state was reached, the various temperatures and the free stream wind velocity were recorded. See Section 5-2.

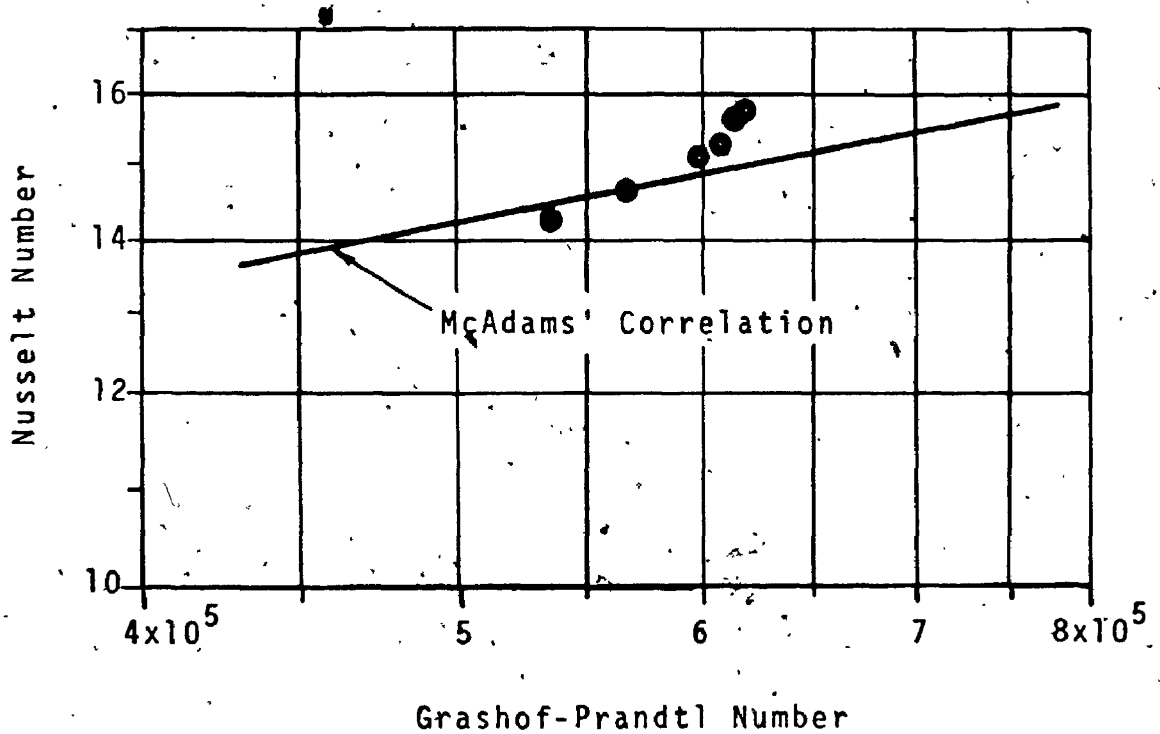


Figure 5-2: Experimental Test Results, Natural Convection, Four Inch Diameter Model

the forced convection experiments from crossing the lead wires perpendicularly and cause tripping of the air flow. In the interior of the dome the natural convective air currents moved parallel to the thermocouple and heat flux sensor lead wires.

The temperatures at both sides of the wall were considered equal in the calculations. This was justified considering Fourier's one-dimensional heat conduction equation as it applied to this case. The highest heat flux encountered during the natural and forced convection experiments was in the order of 51 Btu/hr.ft^2, the thermal conductivity of the aluminum wall in the order of 100 Btu/hr.ft°F and, by substituting these values and the value of the wall thickness in Fourier's equation, the temperature difference across the wall could be calculated and was approximately 0.003°F.

The heat flux sensors were held in place on the surface by special heat conductive tape, sticky on both sides, supplied by the manufacturer of the sensors. The thermocouples were held in place by heat conductive "Sauereisen" cement. To avoid conduction of heat through the thermocouple leads away from the junction, at least $^3/_{16}$" of the lead wires was held in contact with the wall.

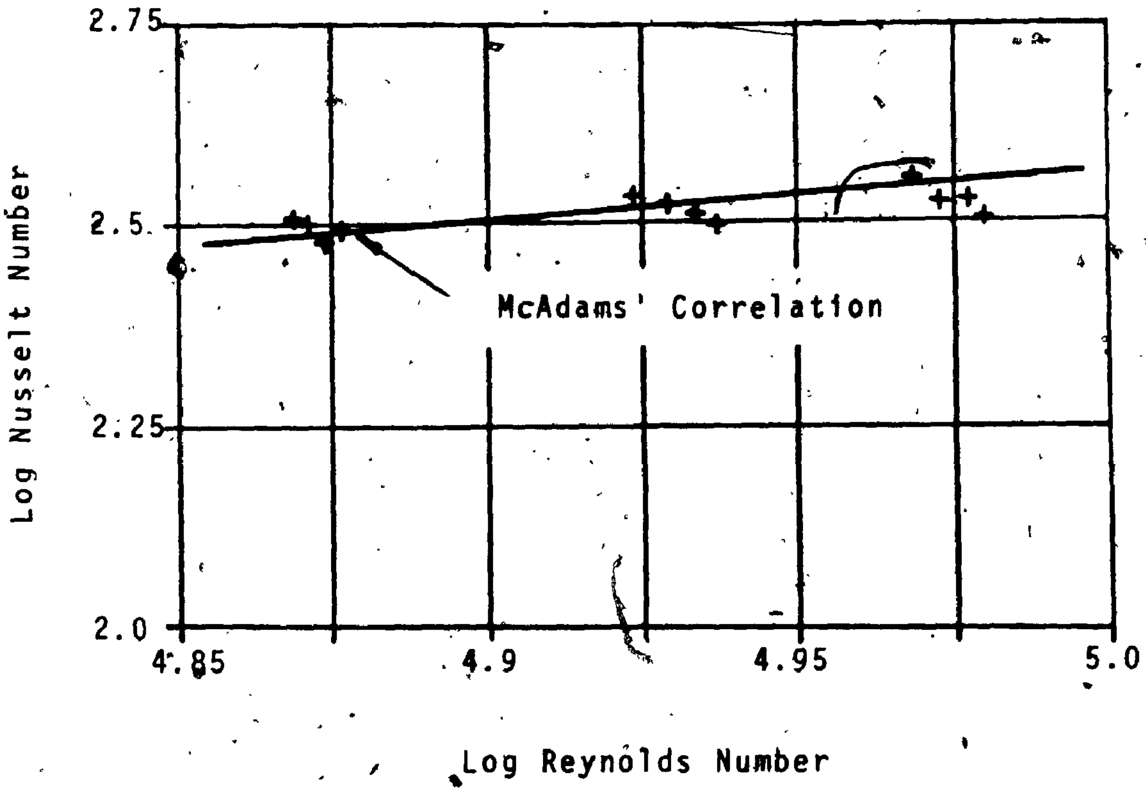


Figure 5-3: Experimental Test Results, Forced Convection, Four Inch Diameter Model

of average unit surface conductance for spheres heated or cooled by air, obtained by McAdams[7] and correlated by the equation

$$Nu = 0.37\ Re^{0.6} \qquad \text{---- (3a)}$$

The values of the heat transfer coefficients obtained from these experiments were in the range of $7.3x10^4 < Re_D < 9.6x10^4$ and were found to be in very close agreement with McAdams' heat transfer correlation for flow over a sphere.

On the average, the forced convective heat transfer data obtained in this research agreed to within 1.4% with Equation (3a), while the largest discrepancy was 9.1% below McAdams' prediction.

The influence of radiation on the heat transfer from the dome was also investigated for the forced convective situation. The application of Equation (32a) to the maximum and minimum dome surface temperatures resulted in finding the ratio of the radiative and forced convective heat flux to range between 0.032 and 0.041. At higher dome surface temperatures, increased radiative heat transfer caused the calculated forced convective heat transfer coefficient to increase as well.

It must be noted that by analysing the heat flow in the model one-dimensionnally, an additional error is introduced. Although the magnitude of the Biot Modulus is high enough (~100) to justify a one-dimensional analysis of the heat flux in the cylinder under the dome, just below the base of the dome the heat flux becomes two-dimensional due to the non-uniform temperature of the dome surface. The largest temperature gradients on the surface of the dome occurred during natural convection conditions at the highest absolute dome temperatures and during these natural convective experiments the largest errors occurred, between 10% and 50%.

During forced convective heat transfer experiments, the heat flux through the base of the dome was more uniform and the error due to ignoring the heat flow in the radial direction reduced to between 5% and 15%, depending on the absolute dome temperature. Since the prime purpose of the experiments with this model was to demonstrate that the traditional parameters could be correlated, the effects of the non-uniform heat flux through the base of the dome were disregarded in the calculations.

6. EXPERIMENTAL HEAT TRANSFER STUDIES ON A TWENTY INCH DIAMETER RIGID HEMISPHERE

This model was prepared in order to measure the variation of the heat transfer coefficient, with respect to polar angle changes under natural convection conditions, and with respect to polar and azimuthal angle changes under forced convection conditions.

The forced convection situation was simulated in a boundary layer wind-tunnel. Before the wind-tunnel air stream reached the model, it was forced to travel a length exceeding 100 feet across small rectangular blocks, spaced on the floor of the wind-tunnel, such that the boundary layer thus developed would simulate an urban boundary layer. The velocity profile and the turbulence intensity for this boundary layer is shown in Figure 6-1.

It was reported by Davenport[25,26] that the gradient height of the planetary boundary layer over a terrain uniformly covered with obstacles 30-45 feet in height, such as suburbs, small towns, and fields with bushes and trees, measures about 1400 feet. The boundary layer thickness in the wind-tunnel at the location of the model measured 1.92 feet. Therefore the external scaling factor in this experiment amounted to 1400'/1.92' = 730:1. Thus the experimental dome represented a full scale dome with a radius of 0.85 x 730 = 620 feet.

Appendix A gives a description of the planetary boundary layer over several different terrains.

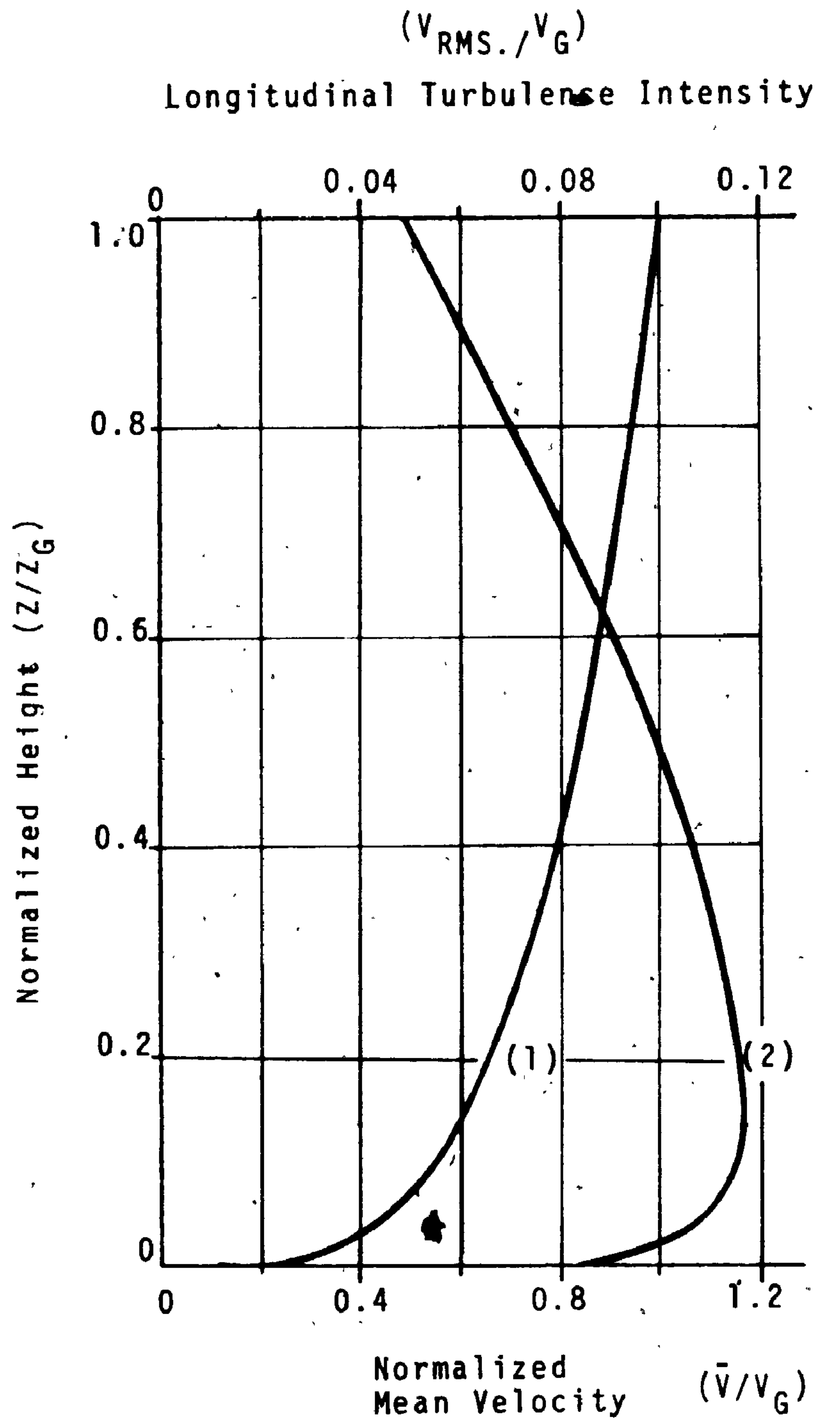


Figure 6-1: Average Profiles of Mean Velocity and Turbulence Intensity as Measured in the Wind Tunnel

(1) Normalized mean velocity
(2) Longitudinal turbulence intensity

6.1 Description of the Twenty Inch Diameter Model

The base of the twenty inch model consisted of two circular steel discs, the top disc being $^{1}/_{2}$" thick and the bottom disc being $^{3}/_{8}$" thick. In the space between the discs, heating wire was placed such that under natural convective operating conditions no radial temperature gradients larger than 0.5°F were observed at the surface of the top disc. See Figure 6-2. No attempt was made to measure radial temperature gradients in the disc during forced convective heat transfer experiments but it appears likely that gradients larger than 0.5°F existed due to the non-symmetric nature of the interior toroid vortex.

Below the bottom disc, a three inch thick layer of diatomaceous earth was installed to prevent heat losses downward. A twenty inch diameter aluminum hemisphere with a wall thickness of $^{1}/_{16}$" was bolted in place right above the top disc. Insulation prevented direct heat transfer between the disc and the hemisphere. Thermocouples (type copper-constantan) as well as heat flux sensors (Keithley Instruments, for accuracy see Section 6.3) were mounted on the interior dome wall at polar angles of 0°, 22.5°, 45°, 67.5° and 90°. One thermocouple was located in the centre of the dome five inches above the base, to measure the interior ambient temperature.

The wall temperatures and the heat fluxes were measured at the interior of the dome to prevent the air stream in

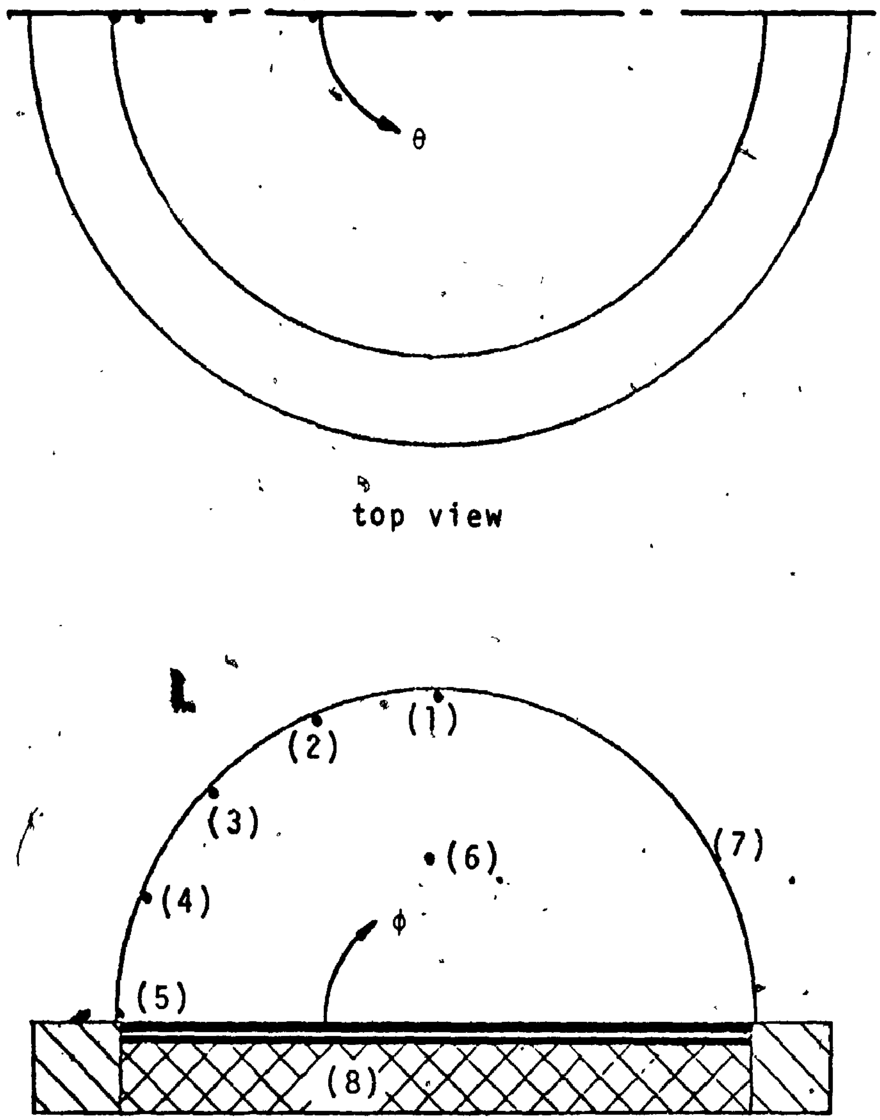


Figure 6-2 Sketch of Twenty Inch Diameter Hemisphere (not to scale)

(1)-(5), heat flux sensor and thermocouple locations

(6) thermocouple location

(7) aluminum hemisphere

(8) insulation

ϕ polar angle

θ azimuthal angle

the forced convection experiments from crossing the lead wires perpendicularly and cause tripping of the air flow. In the interior of the dome the natural convective air currents moved parallel to the thermocouple and heat flux sensor lead wires.

The temperatures at both sides of the wall were considered equal in the calculations. This was justified considering Fourier's one-dimensional heat conduction equation as it applied to this case. The highest heat flux encountered during the natural and forced convection experiments was in the order of 51 Btu/hr.ft^2, the thermal conductivity of the aluminum wall in the order of 100 Btu/hr.ft°F and, by substituting these values and the value of the wall thickness in Fourier's equation, the temperature difference across the wall could be calculated and was approximately 0.003°F.

The heat flux sensors were held in place on the surface by special heat conductive tape, sticky on both sides, supplied by the manufacturer of the sensors. The thermocouples were held in place by heat conductive "Sauereisen" cement. To avoid conduction of heat through the thermocouple leads away from the junction, at least $^3/_{16}$" of the lead wires was held in contact with the wall.

6.2 Experimental Procedure for Natural Convection Heat Transfer

Power input to the heater was provided through a variac. Initially the variac was set to deliver maximum power and the model was allowed to reach steady-state conditions at the maximum experimental temperature. To eliminate all stray air currents across the surface of the dome, the model was placed inside a box made of 4x4 foot pieces of styrofoam. Because of its large volume, this box did not affect the experiment in any other way. When the model had reached steady-state conditions, and no temperature variations greater than 0.5°F/hr. were observed, the ambient temperature in the interior, as well as the exterior of the dome, and the dome surface temperature at a polar angle of 90° was read on a 'Multimite' temperature indicator while a 20 second sample of the corresponding heat flux sensor output was recorded on a "Honeywell Electronic 19" chart recorder. This was then repeated for the thermocouples and sensors at 67.5°, 45°, 22.5°, and 0°. This completed one test. The variac was then adjusted for a lower dome temperature and as steady-state conditions were obtained, the entire procedure was repeated for this temperature.

In the natural convection case, the experiment was repeated for eleven different temperatures. The inside ambient temperatures investigated ranged from 110°F to 148°F while the ambient temperature varied between 75°F and 80°F.

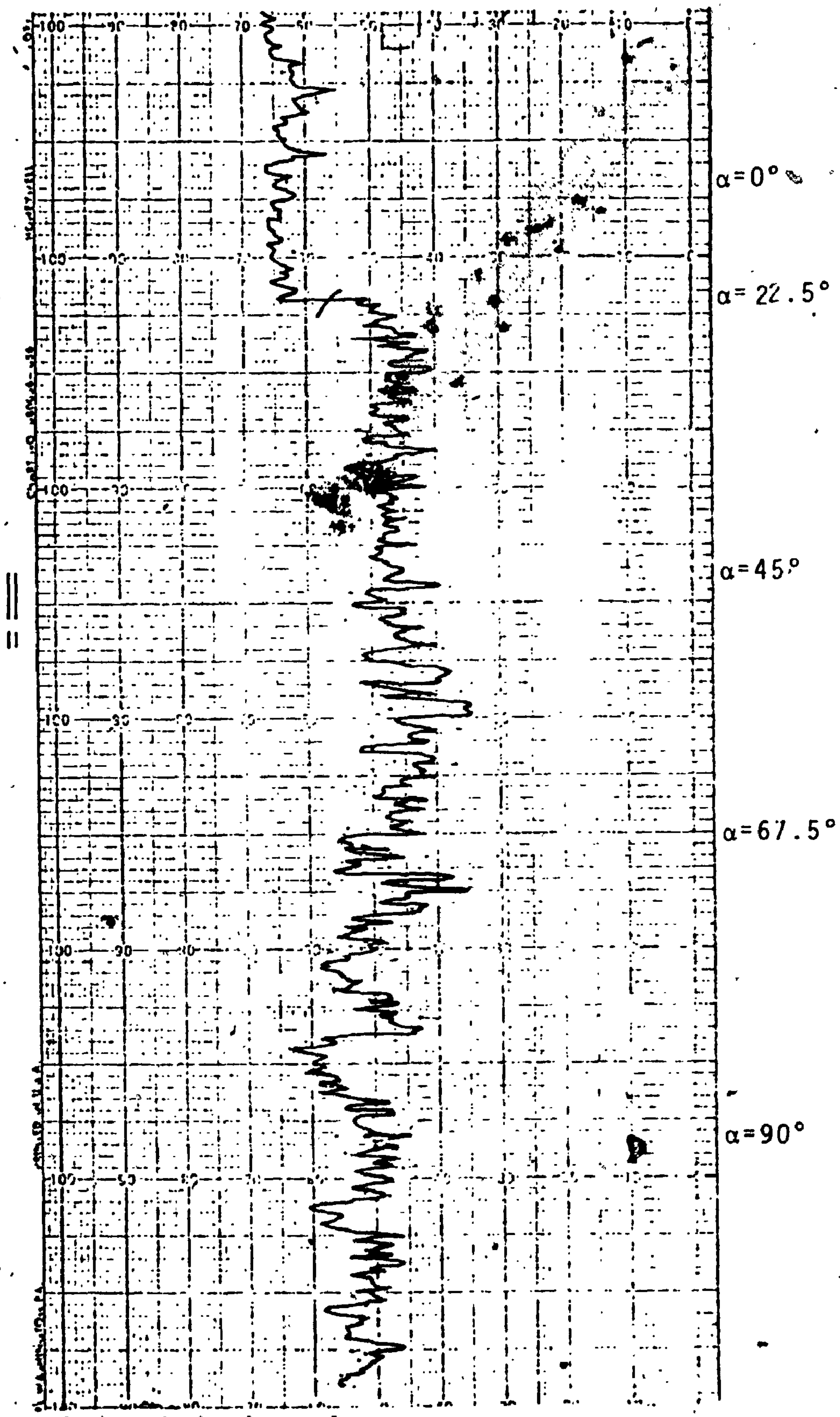
The chart recorder output indicated time dependent heat flux. See Figure 6-3. To find the average heat flux during an interval of time, the heat flux trace was integrated with a planimeter and the integrated result averaged over a twenty second interval. This time span was chosen because it was found that an increase in the span beyond twenty seconds did not affect the average value of the heat flux sensor output.

The interior and exterior heat transfer coefficients were evaluated from Newton's heat convection equation, using the temperature difference between the wall and the centre of the dome and the temperature difference between the wall and a location far from the dome respectively.

6.3 Calibration of the Heat Flux Sensors

Initially, the heat flux sensors were tested on the four inch diameter model for which heat transfer data had been obtained as described in Chapter 5. It was found that a discrepancy existed between the heat flux that the output of the sensors indicated and the heat flux as calculated from the previously obtained experimental data. Moreover, the sensor indications disagreed with each other.

For this reason a procedure had to be found by which these sensors could be calibrated. Tarasuk[17] found by means of interferometry that natural convection from vertical flat surfaces yielded reproducible results. Therefore,



Azimuth Angle: 0°
Wind Velocity: 20.1 ft/sec.

Figure 6-3: Sample of Chartrecorder Output (Forced Convection Experiment) all five sensors were mounted on a horizontal line, ten inches above the sharp leading edge of a flat, vertically suspended, aluminum plate.

To avoid stray air currents from moving across its surface, the plate was suspended inside the same plexiglass box that was used for the natural convection experiment with the four inch diameter model. After the aluminum plate was heated up and time was allowed to minimize any temperature variations, readings were then taken from all five heat flux sensors. The ambient and plate surface temperatures were also recorded as the plate slowly cooled down by natural convection.

For each sensor nine different heat fluxes were calculated using Eckert's[15] formula for a vertical plate

$$Nu_x = 0.508 \left(\frac{Pr}{0.952+Pr} Gr_x Pr_x\right)^{1/4} \qquad \text{---- (13a)}$$

The output of the sensors were compared with the calculated values and correlation factors calculated. A computer program used to find least square values through the data points along with the data and a graph of correction factors versus heat flux (in micro-volts) can be found in Appendix D. The temperature range used to calibrate the sensors was from 156.5°F to 88.0°F.

6.4 Natural Convection Experimental Results

A computer program used to process the data, the calculated results from the natural convection heat transfer experiment with the twenty inch model, as well as a sample calculation and an error analysis, can be found in Appendix E.

From the results of this experiment the ratio (Nusselt/Grashof$^{1/4}$) Number for both the interior and exterior of the hemisphere was computed. This ratio was then correlated with the polar angle as is shown in Figure 6-4.

The Nusselt and Grashof Numbers were computed using the radius of the model as characteristic length and the physical properties of the air in the boundary layer were evaluated at the arithmetic mean temperature.

By using the ratio (Nusselt/Grashof$^{1/4}$), the results of the experiment could be compared with existing data for natural convection from a cylinder as is described at the end of this Section.

As is shown in Figure 6-4, the heat transfer coefficients at the interior wall of the dome are higher than those at the exterior, since in the space between the base and the shell a vortex of high strength is generated. This vortex was assumed to rotate the interior ambient air with high velocity along the wall of the dome, as was shown in the visual studies of Chapter 3.

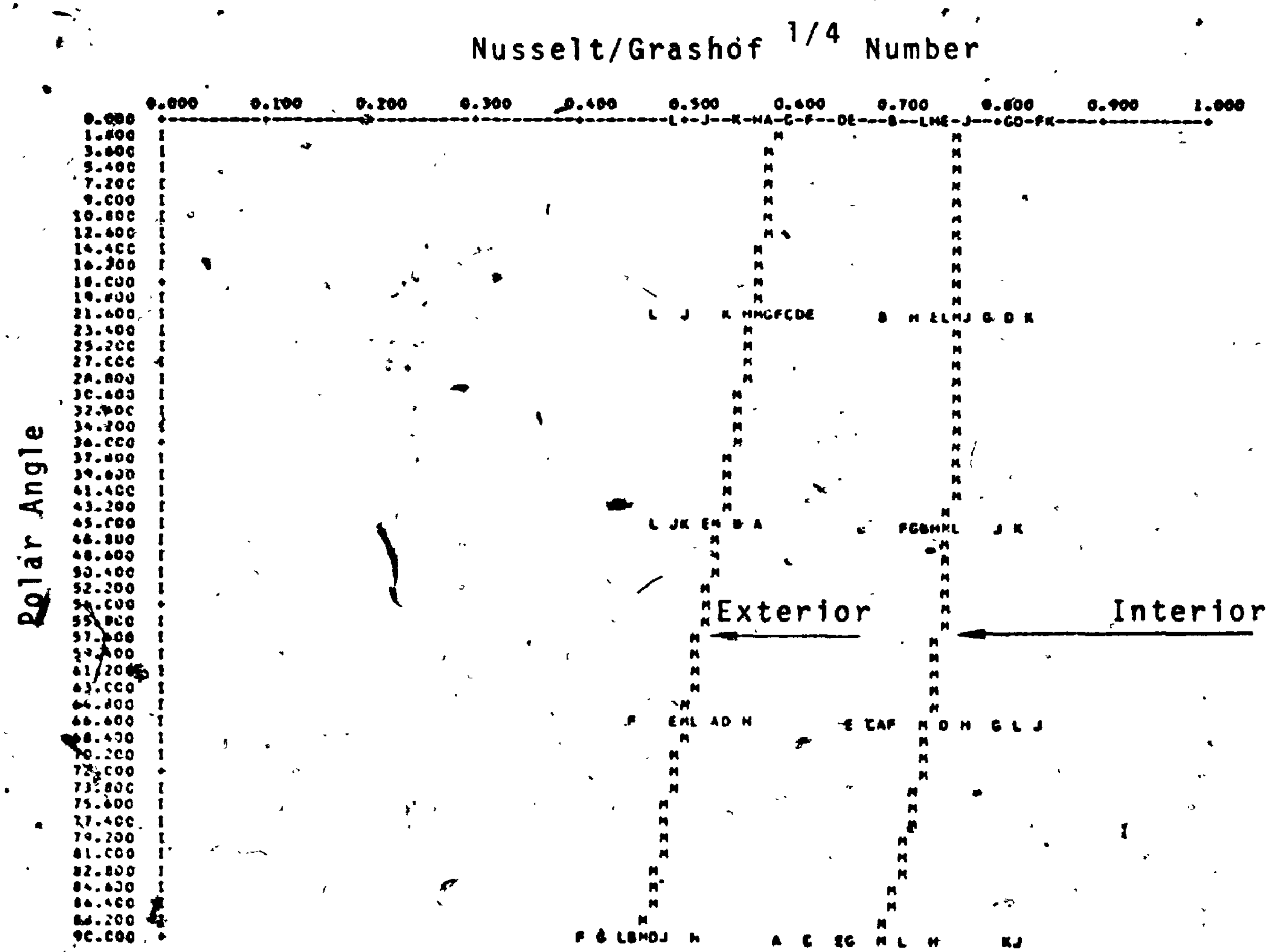


Figure 6-4: Variation of the Nusselt/Grashof$^{1/4}$ Number with Polar Angle

A-H, J-L - data points

M - best fitting curve

Q / A	DT (O)	DT (I)	HTC (O)	HTC (I)	N GR (O)	N GR (I)	N NU (O)	N NU (I)	ANGLE
0.24196E 02	0.37500E 02	0.30199E 02	0.64525E 00	0.80122E 00	0.40992E 08	0.25779E 08	0.35614E 02	0.42300E 02	90.00
0.28477E 02	0.37000E 02	0.30699E 02	0.76965E 00	0.92760E 00	0.40446E 08	0.26395E 08	0.42481E 02	0.49278E 02	67.50
0.30573E 02	0.37000E 02	0.30699E 02	0.82631E 00	0.99588E 00	0.40446E 08	0.26395E 08	0.45608E 02	0.52906E 02	45.00
0.30603E 02	0.36500E 02	0.31199E 02	0.83846E 00	0.98089E 00	0.40123E 08	0.26824E 08	0.46278E 02	0.52110E 02	22.50
0.28955E 02	0.35000E 02	0.32699E 02	0.82730E 00	0.88549E 00	0.38474E 08	0.28315E 08	0.45662E 02	0.47041E 02	-0.00
0.21474E 02	0.34000E 02	0.26500E 02	0.63160E 00	0.81035E 00	0.37584E 08	0.23597E 08	0.35089E 02	0.43321E 02	90.00
0.24185E 02	0.34000E 02	0.26500E 02	0.71132E 00	0.91264E 00	0.37584E 08	0.23597E 08	0.39518E 02	0.48789E 02	67.50
0.25915E 02	0.33500E 02	0.27000E 02	0.77361E 00	0.95985E 00	0.37031E 08	0.24042E 08	0.42978E 02	0.51312E 02	45.00
0.26285E 02	0.32000E 02	0.28500E 02	0.82141E 00	0.92229E 00	0.35570E 08	0.25553E 08	0.45634E 02	0.49304E 02	22.50
0.26717E 02	0.32000E 02	0.28500E 02	0.83492E 00	0.93745E 00	0.35570E 08	0.25553E 08	0.46384E 02	0.50115E 02	0.00
0.18287E 02	0.29000E 02	0.23299E 02	0.63059E 00	0.78486E 00	0.32769E 08	0.21892E 08	0.35033E 02	0.42223E 02	90.00
0.20289E 02	0.29000E 02	0.23299E 02	0.69963E 00	0.87079E 00	0.32769E 08	0.21892E 08	0.38868E 02	0.46846E 02	67.50
0.21064E 02	0.29000E 02	0.23299E 02	0.72637E 00	0.90407E 00	0.32769E 08	0.21892E 08	0.40354E 02	0.48636E 02	45.00
0.23129E 02	0.28500E 02	0.23799E 02	0.81154E 00	0.97180E 00	0.32234E 08	0.22362E 08	0.45085E 02	0.52280E 02	22.50
0.23353E 02	0.28000E 02	0.24299E 02	0.83405E 00	0.96105E 00	0.31639E 08	0.22832E 08	0.46336E 02	0.51702E 02	0.00
0.16669E 02	0.26500E 02	0.20500E 02	0.62902E 00	0.81312E 00	0.30107E 08	0.19891E 08	0.34945E 02	0.44022E 02	90.00
0.19047E 02	0.26500E 02	0.20500E 02	0.71877E 00	0.92915E 00	0.30107E 08	0.19891E 08	0.39932E 02	0.50304E 02	67.50
0.18686E 02	0.26500E 02	0.20500E 02	0.70514E 00	0.91152E 00	0.30107E 08	0.19891E 08	0.39174E 02	0.49350E 02	45.00
0.21205E 02	0.26000E 02	0.21000E 02	0.81559E 00	0.10097E 01	0.29539E 08	0.20376E 08	0.45310E 02	0.54670E 02	22.50
0.21928E 02	0.25500E 02	0.21500E 02	0.85994E 00	0.10199E 01	0.29127E 08	0.20861E 08	0.48088E 02	0.55219E 02	0.00
0.14100E 02	0.23000E 02	0.18200E 02	0.61305E 00	0.77474E 00	0.26554E 08	0.18330E 08	0.34282E 02	0.42213E 02	90.00
0.14513E 02	0.23000E 02	0.18200E 02	0.63101E 00	0.79743E 00	0.26554E 08	0.18330E 08	0.35287E 02	0.43450E 02	67.50
0.15054E 02	0.22500E 02	0.18700E 02	0.66909E 00	0.80506E 00	0.25977E 08	0.18833E 08	0.37416E 02	0.43865E 02	45.00
0.17343E 02	0.22000E 02	0.19200E 02	0.78831E 00	0.90328E 00	0.25400E 08	0.19337E 08	0.44083E 02	0.49217E 02	22.50
0.18022E 02	0.21500E 02	0.19700E 02	0.83826E 00	0.91486E 00	0.24954E 08	0.19962E 08	0.46876E 02	0.49848E 02	0.00
0.11572E 02	0.22500E 02	0.15199E 02	0.51431E 00	0.76134E 00	0.26530E 08	0.15775E 08	0.28761E 02	0.41751E 02	90.00
0.12664E 02	0.22000E 02	0.15699E 02	0.57565E 00	0.80664E 00	0.25940E 08	0.16294E 08	0.32191E 02	0.44235E 02	67.50
0.13434E 02	0.21500E 02	0.16200E 02	0.62484E 00	0.82926E 00	0.25351E 08	0.16813E 08	0.34941E 02	0.45475E 02	45.00
0.15499E 02	0.21000E 02	0.16700E 02	0.73807E 00	0.92812E 00	0.24761E 08	0.17435E 08	0.41274E 02	0.50897E 02	22.50
0.16460E 02	0.21000E 02	0.16700E 02	0.78383E 00	0.98566E 00	0.24761E 08	0.17435E 08	0.43832E 02	0.54052E 02	0.00
0.10489E 02	0.20000E 02	0.14000E 02	0.52448E 00	0.74927E 00	0.23950E 08	0.14874E 08	0.29524E 02	0.41088E 02	90.00
0.12726E 02	0.20000E 02	0.14000E 02	0.63631E 00	0.90901E 00	0.23950E 08	0.14874E 08	0.35818E 02	0.49847E 02	67.50
0.12437E 02	0.19000E 02	0.15000E 02	0.65461E 00	0.82917E 00	0.22753E 08	0.15936E 08	0.36849E 02	0.45470E 02	45.00
0.13629E 02	0.19000E 02	0.15000E 02	0.71734E 00	0.90864E 00	0.22753E 08	0.15936E 08	0.40380E 02	0.49828E 02	22.50
0.14025E 02	0.19000E 02	0.15000E 02	0.73819E 00	0.93505E 00	0.22753E 08	0.15936E 08	0.41554E 02	0.51277E 02	0.00
0.28221E 02	0.38000E 02	0.28799E 02	0.74267E 00	0.97992E 00	0.41539E 08	0.24761E 08	0.40991E 02	0.52058E 02	90.00
0.30262E 02	0.37500E 02	0.29299E 02	0.80700E 00	0.10328E 01	0.41223E 08	0.25191E 08	0.44542E 02	0.54870E 02	67.50
0.28994E 02	0.37500E 02	0.29299E 02	0.77319E 00	0.98958E 00	0.41223E 08	0.25191E 08	0.42676E 02	0.52571E 02	45.00
0.29268E 02	0.36500E 02	0.30299E 02	0.80186E 00	0.96594E 00	0.40123E 08	0.26237E 08	0.44258E 02	0.51315E 02	22.50
0.30187E 02	0.36500E 02	0.30299E 02	0.82705E 00	0.99629E 00	0.40123E 08	0.26237E 08	0.45649E 02	0.52928E 02	0.00
0.20797E 02	0.31500E 02	0.20699E 02	0.66024E 00	0.10047E 01	0.35401E 08	0.19322E 08	0.36680E 02	0.54051E 02	90.00
0.22051E 02	0.31000E 02	0.21199E 02	0.71134E 00	0.10401E 01	0.34839E 08	0.19789E 08	0.39519E 02	0.55959E 02	67.50
0.20917E 02	0.31000E 02	0.21199E 02	0.67476E 00	0.98668E 00	0.34839E 08	0.19789E 08	0.37486E 02	0.53081E 02	45.00
0.20903E 02	0.30500E 02	0.21699E 02	0.68535E 00	0.96328E 00	0.34464E 08	0.20389E 08	0.38075E 02	0.51822E 02	22.50
0.21604E 02	0.30000E 02	0.22199E 02	0.72015E 00	0.97317E 00	0.33899E 08	0.20859E 08	0.40008E 02	0.52354E 02	0.00
0.15900E 02	0.26000E 02	0.16700E 02	0.61153E 00	0.95209E 00	0.29699E 08	0.16511E 08	0.34197E 02	0.51546E 02	90.00
0.16814E 02	0.25500E 02	0.17200E 02	0.65939E 00	0.97758E 00	0.29127E 08	0.17006E 08	0.36873E 02	0.52926E 02	67.50
0.16719E 02	0.25500E 02	0.17200E 02	0.65566E 00	0.97206E 00	0.29127E 08	0.17006E 08	0.36665E 02	0.52627E 02	45.00
0.17534E 02	0.25000E 02	0.17700E 02	0.70138E 00	0.99065E 00	0.28556E 08	0.17500E 08	0.39222E 02	0.53634E 02	22.50
0.18067E 02	0.25000E 02	0.17700E 02	0.72270E 00	0.10207E 01	0.28556E 08	0.17500E 08	0.40414E 02	0.55264E 02	0.00
0.12649E 02	0.22500E 02	0.15500E 02	0.56220E 00	0.81610E 00	0.26530E 08	0.15087E 08	0.31439E 02	0.44754E 02	90.00
0.14637E 02	0.22500E 02	0.15500E 02	0.65055E 00	0.94435E 00	0.26530E 08	0.16087E 08	0.36379E 02	0.51787E 02	67.50
0.13641E 02	0.22500E 02	0.15500E 02	0.60630E 00	0.88011E 00	0.26530E 08	0.16087E 08	0.33905E 02	0.48254E 02	45.00
0.13449E 02	0.22500E 02	0.15500E 02	0.59773E 00	0.86767E 00	0.26530E 08	0.16087E 08	0.33425E 02	0.47582E 02	22.50
0.13625E 02	0.22000E 02	0.16000E 02	0.61933E 00	0.85158E 00	0.25940E 08	0.16605E 08	0.34633E 02	0.45699E 02	0.00

2

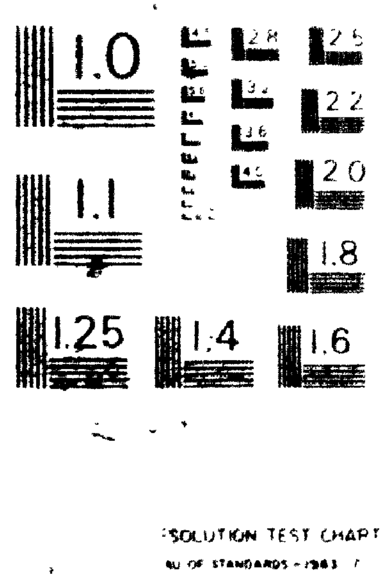


Figure 6-4 also shows that the heat transfer coefficient value reduces as the polar angle increases. This phenomenon can be accounted for as follows. Although the temperature difference between the dome wall and the outside ambient air in all cases investigated was found to be higher at a polar angle of 90° than at the base or zero polar angle, the exterior natural convection boundary layer starts forming at the base where its thickness is least. Hence a large natural convective coefficient results. This phenomenon is similar to the natural convective cooling of a flat, vertical plate. More energy is transported through the thin boundary layer at the leading edge as $\left.\frac{dT}{dy}\right|_{wall}$ has its peak value there. Therefore, the value of the heat transfer coefficient is highest at the leading edge. This observation also agrees with the values obtained from horizontal cylinders by Eckert and Soehngen[16]. They found that the local dimensionless unit surface conductance along the circumference of a horizontal cylinder in laminar free convection gradually decreased with polar angle until the minimum value at the top of the cylinder.

As in Chapter 5, the fraction of heat transfer due to radiation of the total heat transfer from this model was evaluated. The maximum average wall temperature in this experiment was 116.5°F with an ambient temperature of 79.5°F. (Experiment Number 1). The emissivity value of 0.09 was taken from reference (30). These values were substituted in Equation (32a) and the result compared with the total heat flux. It was found that the fraction of heat transfer due to radiation for this experiment was 13.9% of the total heat transfer. The radiative heat transfer during the experiment with the lowest temperature difference between the wall and the surroundings was evaluated in the same manner as described above. It was found that the fraction of heat transfer due to radiation in this case was 9.2% of the total heat transfer.

6.5 Experimental Procedure for Forced Convection Heat Transfer

The forced convection heat transfer experiments with the twenty inch diameter model were carried out in the Boundary Layer Wind-Tunnel Laboratory at the University of Western Ontario. This wind-tunnel with an eight by seven feet cross-section was set up to simulate an urban boundary layer. The model was placed in this "urban" area on top of a turntable so far from the leading edge that the boundary layer measured 1.92 feet in thickness. The experiment was started by selecting a suitable tunnel wind speed and by heating up the model. The measurements of the first test were carried out as described in Section 6-2, with the sensors and thermocouples on the dome wall facing the wind (0° azimuthal angle). The power input to the heater was set to maintain a temperature difference between the ambient dome temperature and the ambient wind-tunnel temperature of approximately 50°F. The power input was not altered during the course of an experiment with any one wind velocity.

The wind velocity was measured in the free stream with a pitot-static tube, connected to an electronic differential pressure transducer with a digital readout. A calibration curve was used to find the wind velocity in ft/sec.

After the measurements at 0° azimuthal angle were completed, the turntable was rotated 10° for the next test and the procedure repeated. In this manner, heat fluxes at 5 polar angles were measured at 19 azimuthal angles, from 0° to 180° with 10° increments.

After completing the measurements, the tunnel wind speed controller was set for a higher wind velocity and the procedure described above was repeated in its entirety. In all, heat fluxes were measured at four different tunnel wind speeds (20.1, 30.0, 40.1 and 46.5 ft/sec.).

With this experiment a total of 380 forced convective heat transfer coefficients were obtained for five polar angles, nineteen azimuthal angles and four wind velocities. After the tests with the highest wind velocity were completed, a wind-tunnel symmetry test was performed. At the same wind velocity, data was taken for two azimuthal angles between 180° and 360°. These data were then compared with the corresponding values obtained with azimuthal angles between 0° and 180°. The results of the heat transfer rates of any two corresponding azimuthal angles were reproduced to 3 percent accuracy and this confirmed that wind velocity symmetry existed for both the right and left side of the dome.

6.6 Forced Convection Experimental Results

A convenient way to correlate the results of the experiments was found by plotting the average of the logarithms of the Nusselt Numbers at 90° polar angle, where all conditions remain constant when the model is rotated, against the logarithm of the Reynolds Number for all four wind velocities.

A straight line could be drawn through these points and the tangent of the angle between this line and the x-axis was measured to be 0.334. This line could be mathematically represented by:

$$\log Nu = 0.334 \log Re + \log C \quad \text{---- (32b)}$$

where C is a constant.

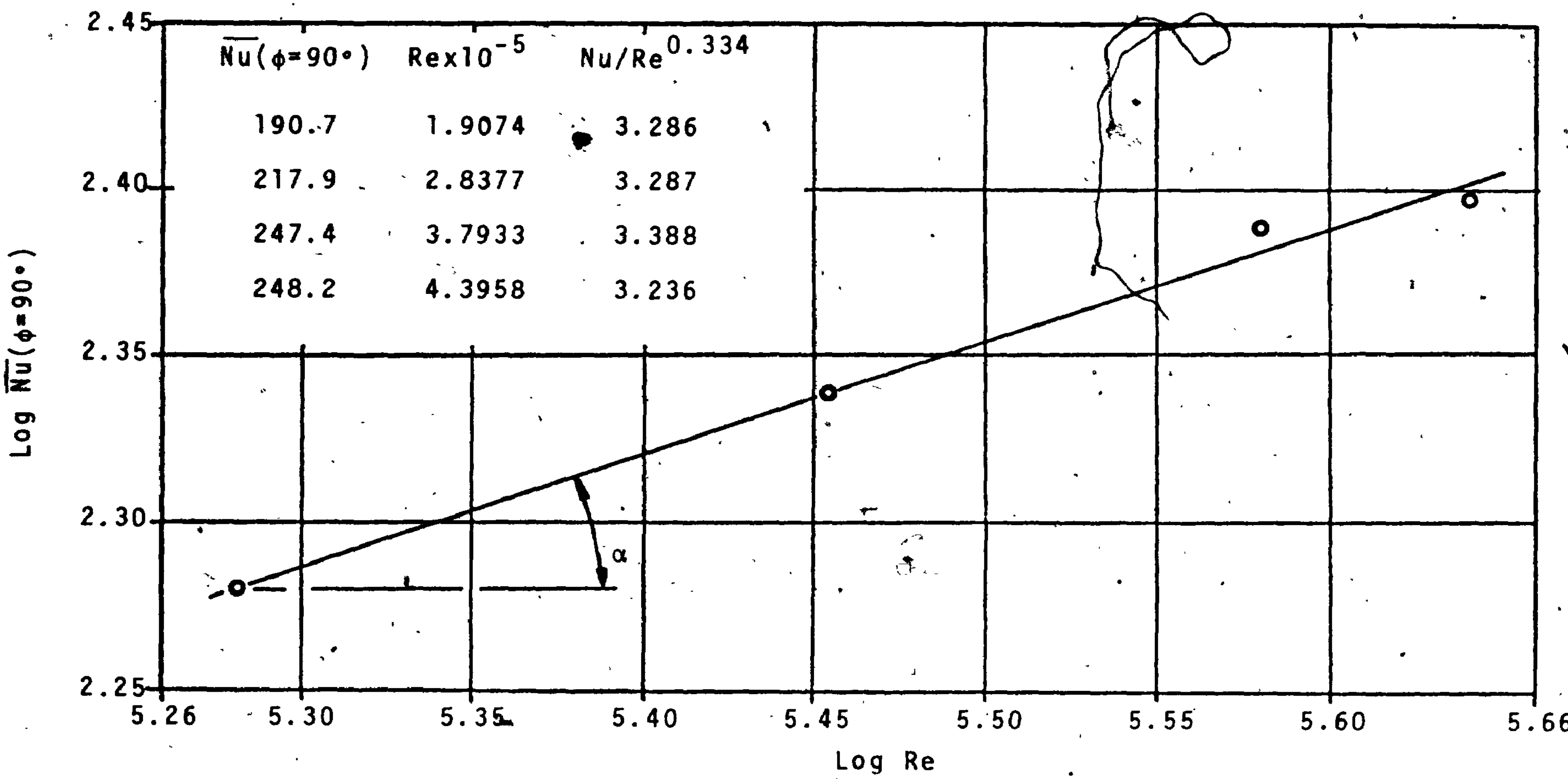
Equation (32b) could be written as:

$$Nu = C\, Re^{0.334}$$

and $Nu/Re^{0.334} = C$

By using the ratio $Nu/Re^{0.334}$, both Nusselt and Reynolds Numbers could be correlated with the azimuthal angle and this ratio remained constant for all azimuthal angles and wind velocities investigated. Please see Figure 6-5.

In Figure 6-6 the general trend of the data is shown. This Figure indicates that the variation of the azimuthal



$\overline{Nu}$(φ=90°)	Rex10^{-5}	Nu/$Re^{0.334}$
190.7	1.9074	3.286
217.9	2.8377	3.287
247.4	3.7933	3.388
248.2	4.3958	3.236

Figure 6-5: Relationship Between the Reynolds Number and the Average Nusselt Number at 90° Polar Angle

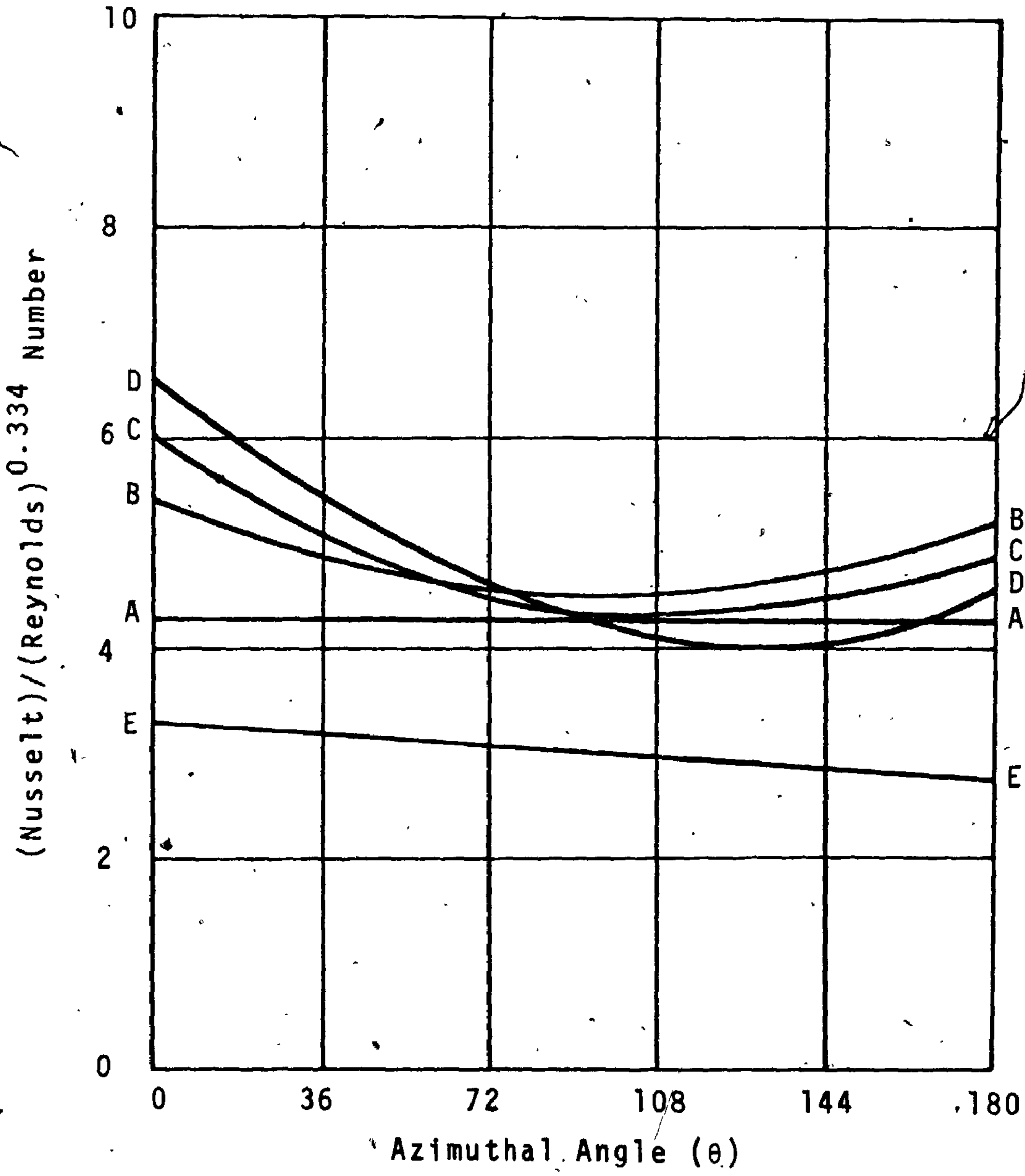


Figure 6-6: General Trend of Forced Convective Heat Transfer Data

Polar Angle: A = 90°
B = 67.5°
C = 45°
D = 22.5°
E = 0°

(The actual data are shown in the figures 6-7,8, 9 and 10) angle had no effect on the heat transfer rate at 90° polar angle, since all conditions remain constant at that point. At 0° polar angle, the forced convection heat transfer coefficient for all azimuthal angles was lower than at all other polar angles, since at the bottom of the wind-tunnel boundary layer the wind velocity approaches zero (see Figure 6-1).

The value of the heat transfer coefficient at 0° polar angle also decreased with increase in azimuthal angle. This is due to the dome boundary layer build-up from the leading edge to 180° azimuthal angle. The dome boundary layer builds up three dimensionally, with respect to both azimuthal and polar angles. Therefore, at the leading edge, it was expected that the heat transfer coefficients should increase with decreasing polar angles. This tendency was confirmed, but between 22.5° and 0° polar angle the trend reversed due to the wind tunnel boundary layer. The graphs in Figures 6-7, 6-8, 6-9 and 6-10 show this clearly, especially at the lower tunnel wind speeds. At the Teeside of the dome this trend could be expected to reverse, however, due to the complex three dimensional character of the turbulent dome boundary layer, this effect cannot be clearly demonstrated.

Since the value of the longitudinal turbulence intensity reached a maximum between 22.5° and 67.5° polar angle, as is shown in Figure 6-1, the forced convective heat transfer coefficient increased more between these polar

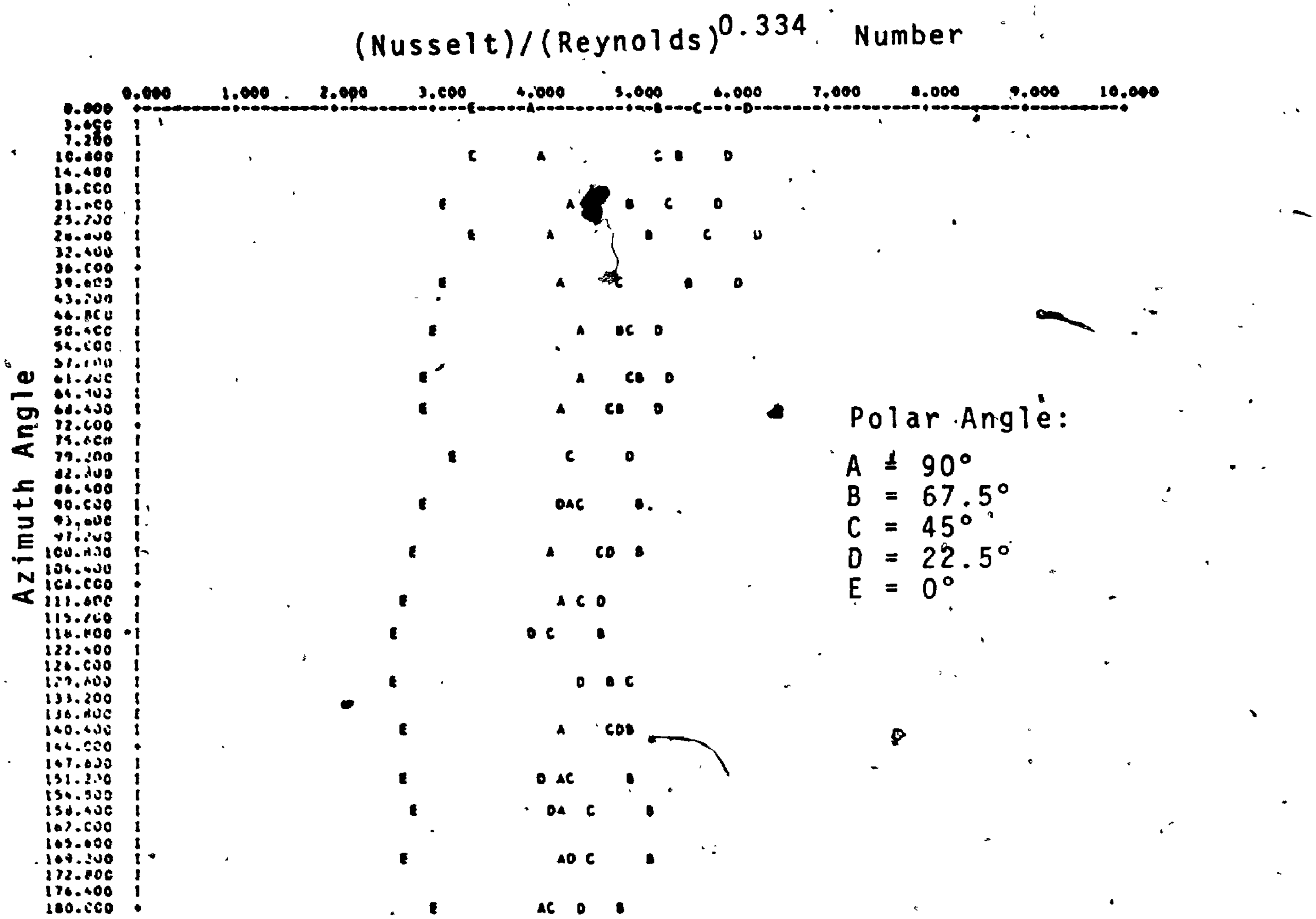


Figure 6-7: Variation of the Nusselt/Reynolds$^{0.334}$ Number with Polar and Azimuth Angle for V = 20.1 ft/sec

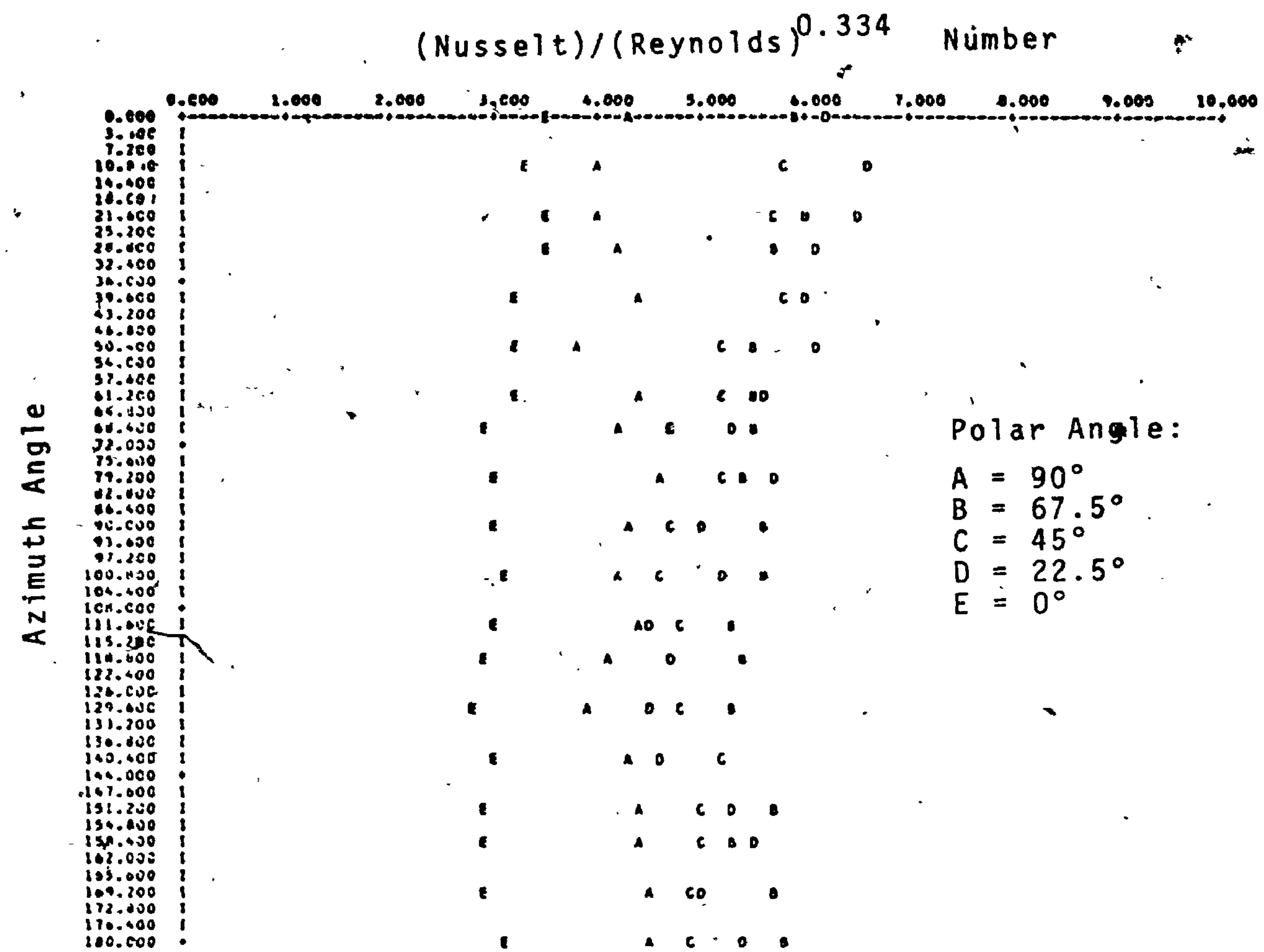


Figure 6-8: Variation of the Nusselt/Reynolds$^{0.334}$ Number with Polar and Azimuth Angle for V = 30.0 ft/sec.

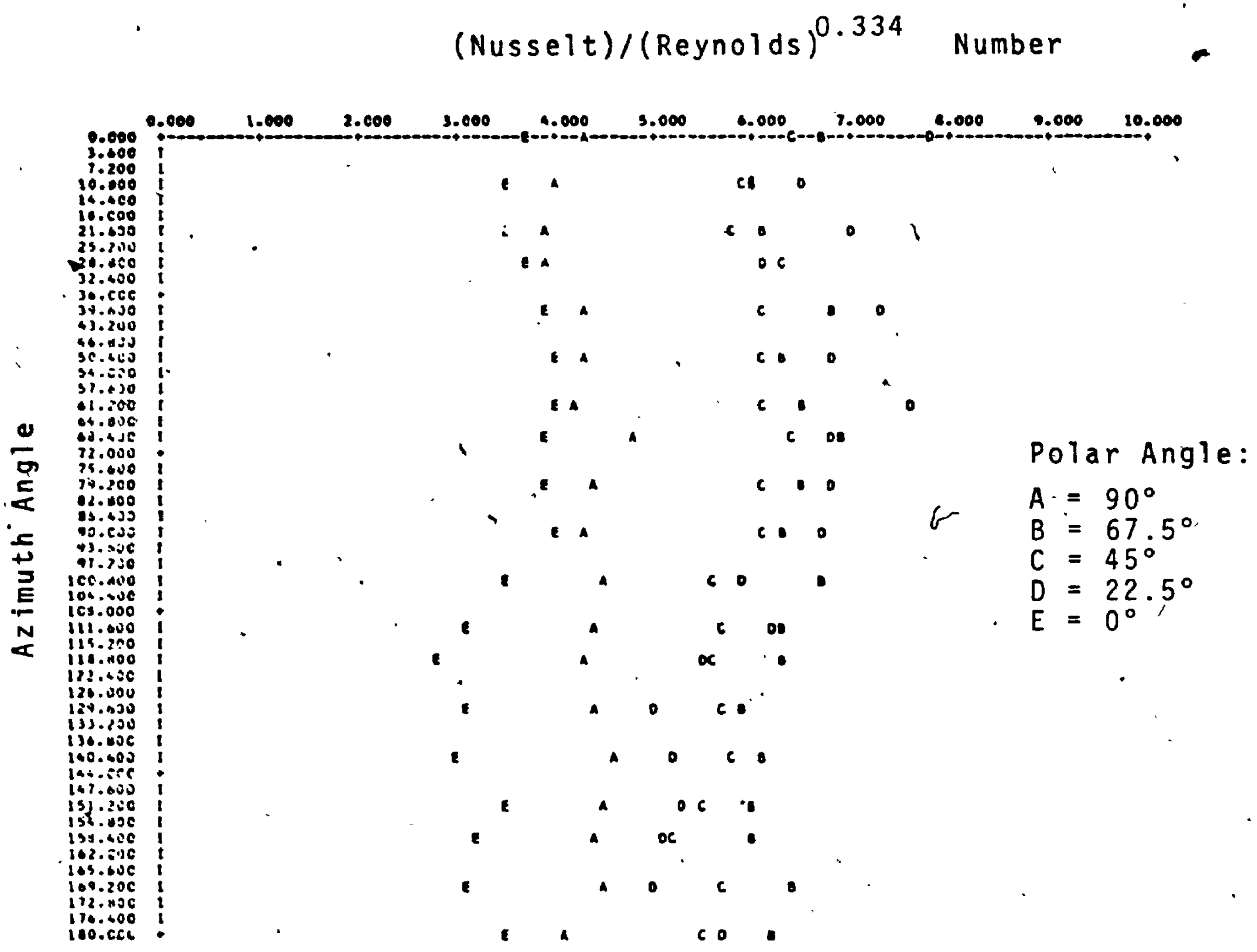


Figure 6-9. Variation of the Nusselt/Reynolds$^{0.334}$ Number with Polar and Azimuth Angle for V = 40.1 ft/sec.

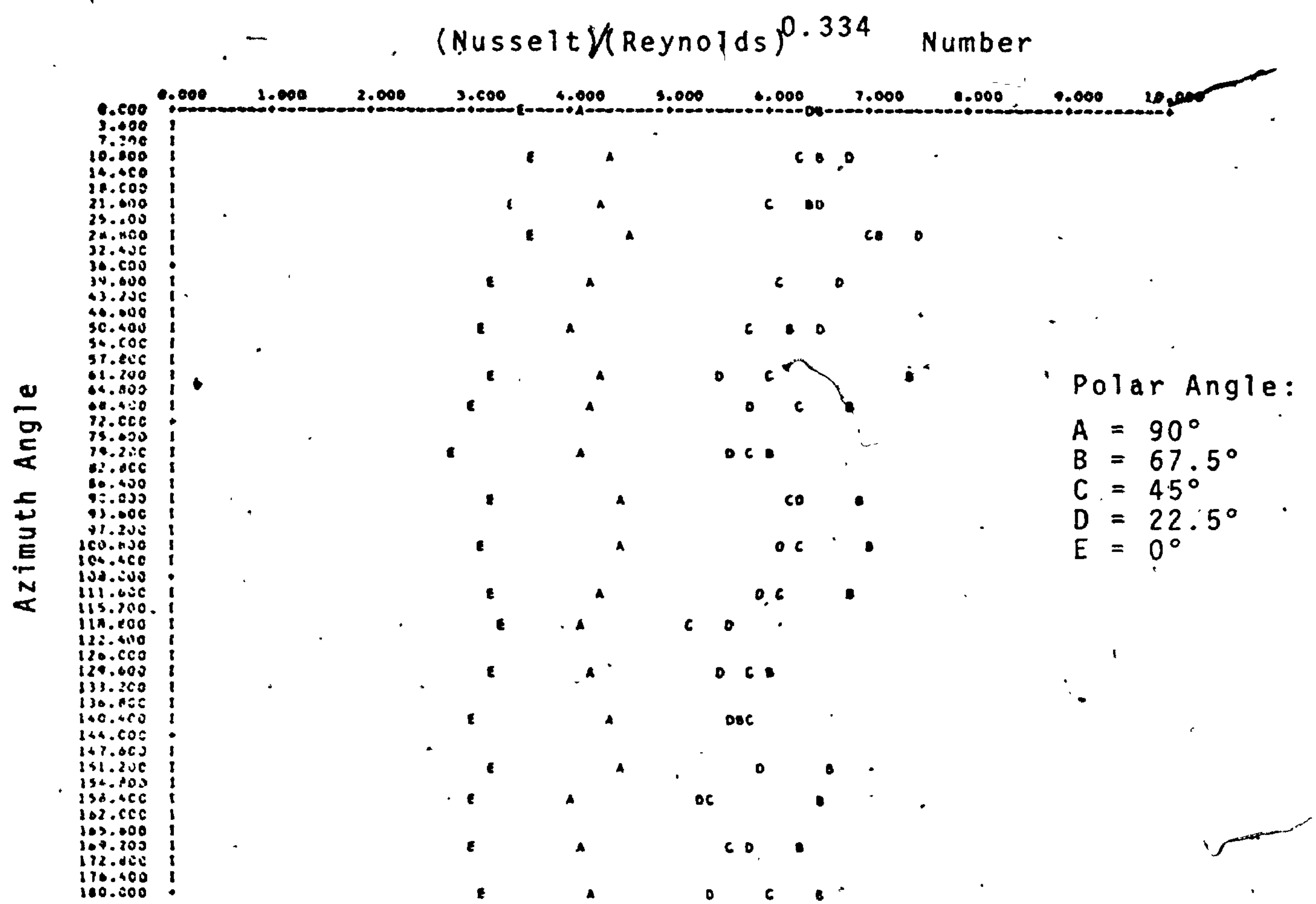


Figure 6-10: Variation of the Nusselt/Reynolds$^{0.334}$ Number with Polar and Azimuth Angle for V = 46.5 ft/sec.

angles as the wind velocity increases. This can also be observed from the graphs in Figures 6-7, 6-8, 6-9 and 6-10. Appendix F contains the data, the calculated results, a sample calculation and an error analysis of this experiment.

During these forced convection tests, continual checks were made to ensure that no leakage of air occurred at the seal between the tunnel turntable and the dome. Smoke was blown around the perimeter and towards the seal. Possible leaks would show up because the smoke would be sucked into the wind-tunnel at the location of the leak. During the test at 40.1 ft/sec wind speed, a leak was detected between 20° and 90° azimuthal angle. This leak had an effect on the readings of the heat flux sensor and thermocouple at 0° polar angle over the leaking azimuthal range. This effect can be seen in Figure 6-9. The leaking problem was overcome for the subsequent test.

The results of the inside natural convection case during the wind-tunnel studies were somewhat more difficult to interpret. The heat transfer coefficient at 0° polar angle increased with increasing azimuthal angle for wind velocities of 20.1 and 30.0 ft/sec, was about constant at 40.1 ft/sec but decreased at 46.5 ft/sec tunnel wind speed. The heat transfer coefficients were highest at 90° polar angle and gradually decreased for decreasing polar angle. There was not a great difference between the heat transfer coefficients at polar angles between 22.5° and 90°, but all tended to decrease as the azimuthal angle increased.

During forced convective heat transfer experiments, it was deduced that the interior convective air current on the windward side was stronger than the one on the leeside of the dome. This difference in toroid vortex strength implies that interior flow symmetry did not exist. Figure 6-11 shows a graphical representation of this theory.

During the forced convection heat transfer experiments with this model the heat fluxes were higher and the temperature differences between the wall and the surroundings were in the order of 20°F lower than during the natural convective tests. It was therefore expected that the influence of radiation on the total heat transfer in the forced convection situation was less than was evaluated for the natural convective experiments.

For the temperature range encountered during this experiment, it was determined that the fraction of heat transfer due to radiation ranged between 2% and 5% of the total heat transfer from the model.

The overall forced convective heat transfer coefficients of this model were evaluated as well. The sum of the products of all local heat transfer coefficients and their respective areas was evalauted for all four wind velocities individually. By dividing this sum by the entire surface area of the hemisphere the overall heat transfer coefficient was obtained. The average Nusselt Number was evalauted from the overall heat transfer coefficient.

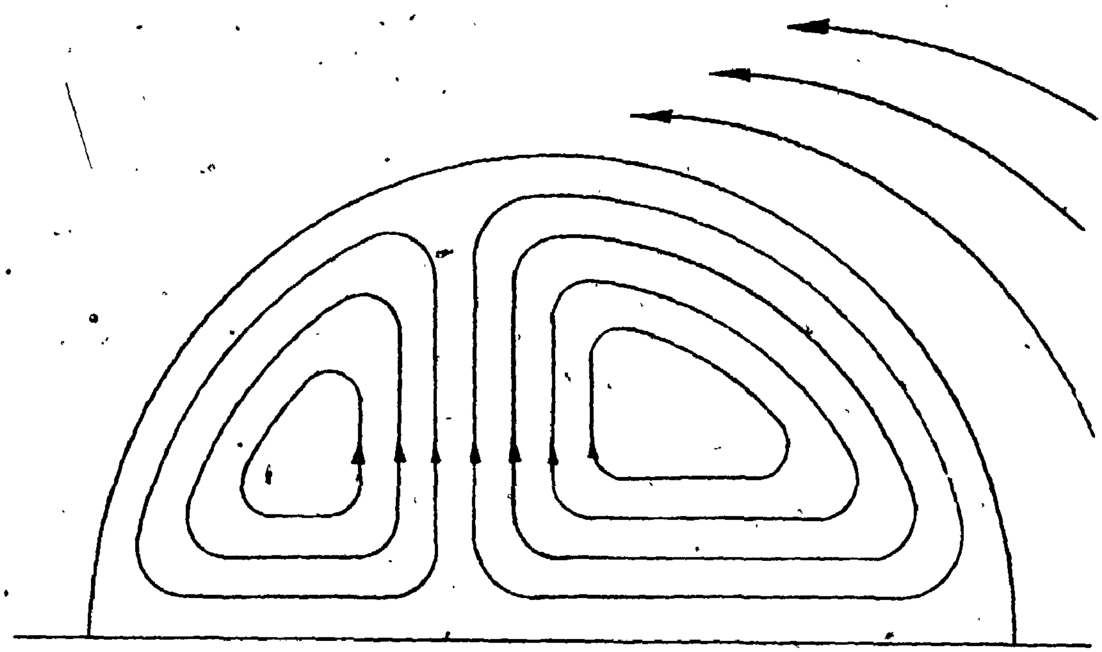


Figure 6-11: Hemispherical Air Flow Patterns During Forced Convection Conditions (Schematic representation)

The relationship between the average Nusselt Numbers and Reynolds Numbers is shown in Figure 6-12. The numerical values of the average heat transfer coefficients, Nusselt Numbers and Reynolds Numbers are shown in Table 6-1.

The Nusselt Numbers thus obtained were about 50% lower than predicted by Equation (3). This can be explained by referring to Figure 6-1. Whereas the Reynolds Numbers in this experiment were based on the free stream velocity, the velocity in the boundary layer at the level of the hemisphere was much less, e.g.: five inches above the base of the hemisphere the mean wind velocity is about 65% of the free stream velocity.

It has been observed[30] that when cylinders and spheres are subjected to a cooling air flow at Reynolds Numbers below 10^5, the local Nusselt Number decreases with polar angle until the point of separation is reached at about 80° from the stagnation point. Due to the turbulent eddy motion beyond the separation point the local Nusselt Number increases again. For flows with a Reynolds Number over 10^5, two minimum points in the local Nusselt Number are observed. The first minimum occurs at the point of transition from a laminar to a turbulent boundary layer at about 90° polar angle, while the second minimum occurs when the turbulent boundary layer separates. The Reynolds Numbers in the above cases were based on the free stream velocity. The regions of boundary layer flow and separated flow are indicated in Figure 6-13.

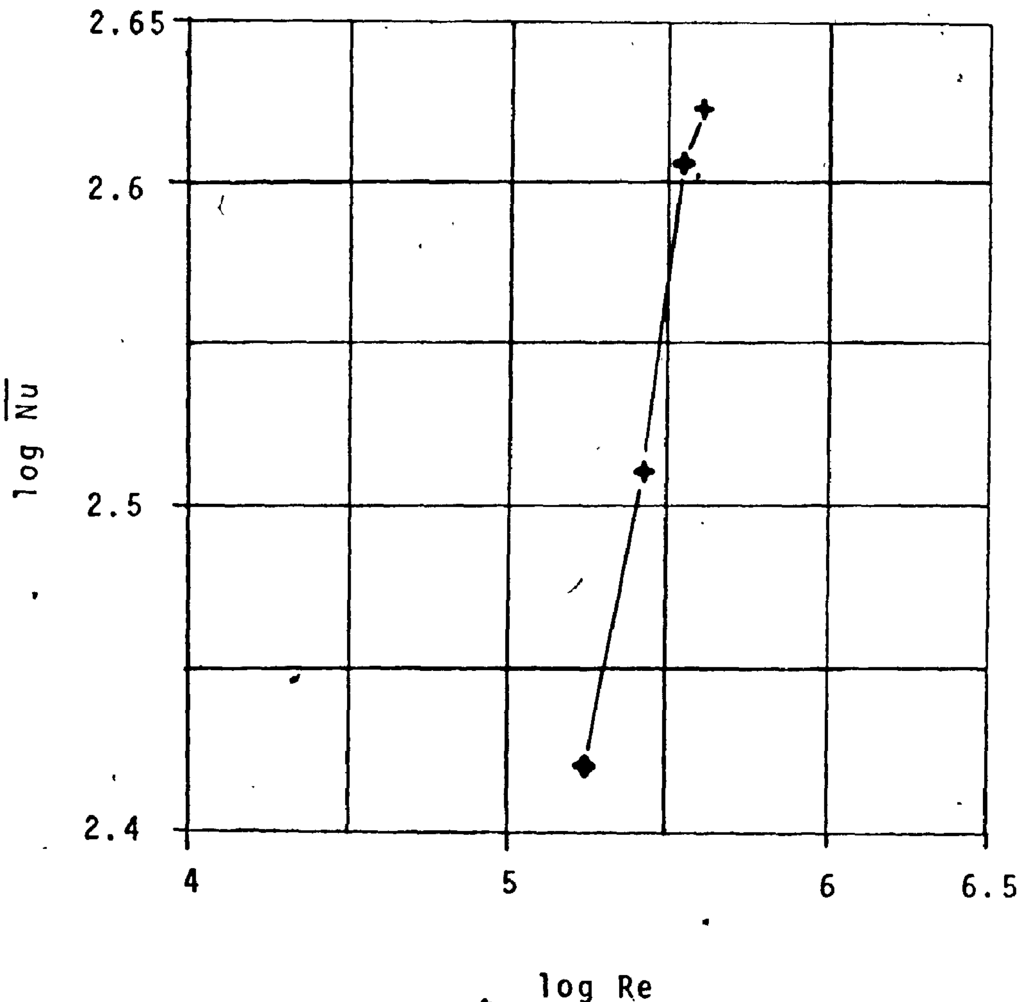
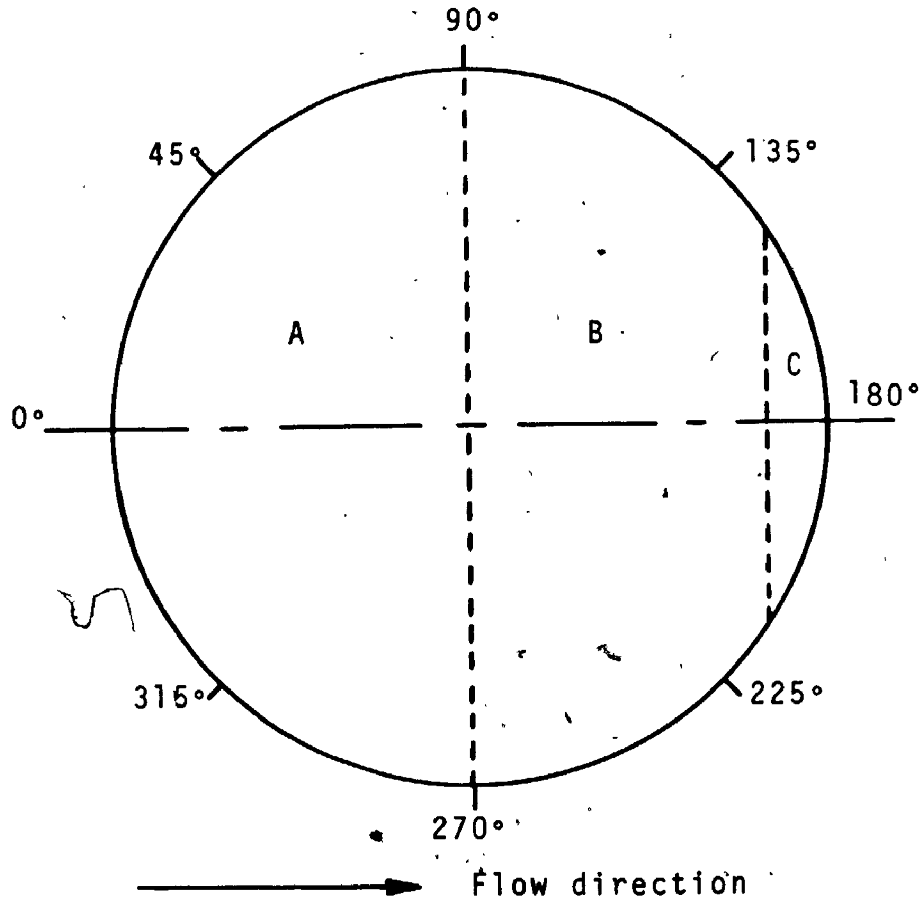


Figure 6-12: Experimental Test Results, Forced Convection, Twenty Inch Diameter Model

$\bar{h}_c$ Btu/hr.ft.^{2}°F	$\overline{Nu}$	Re
2.35	263	1.91×10^5
2.91	325	2.38×10^5
3.63	406	3.79×10^5
3.77	421	4.40×10^5

Table 6-1

Relationship between the Overall Heat Transfer Coefficient, the Nusselt and Reynolds Numbers. Forced Convection Heat Transfer, Twenty Inch Diameter Model



Region A - Laminar Flow
Region B - Turbulent Flow
Region C - Separated Flow

Figure 6-13: Schematic Representation of the Regions of Boundary Layer and Separated Flow over a Sphere at $Re > 10^5$

Although there are differences in the physical setup of the experiments with a sphere in a free stream and a hemisphere immersed in a turbulent boundary layer, the possibility of a region of boundary layer separation on the hemisphere was investigated.

For all five polar angle locations, the influence of the wind velocity and azimuthal angle on the ratio $Nu/Re^{0.334}$ was determined as is shown in the Figures 6-14, 6-15, 6-16, 6-17 and 6-18.

In Figure 6-14, at 90° polar angle, no change in the ratio $Nu/Re^{0.334}$ can be observed, since there is no variation in the location of this point when the hemisphere is rotated. However, the Nusselt Number itself increased as the wind velocity and therefore the Reynolds Number increased.

The Figures 6-15 and 6-16, for polar angles of 67.5° and 45° respectively, indicate that the ratio $Nu/Re^{0.334}$ generally increased as the Reynolds Number increased and that this ratio decreased for higher values of the azimuthal angle.

By referring to Figure 6-13 it can be observed that these locations did not enter the region of separation of the boundary layer. However, the location at 22.5° polar angle did enter the region of separation when the hemisphere was rotated as is shown in Figure 6-17. At the azimuthal angle value of approximately 145° a marked increase in the ratio $Nu/Re^{0.334}$ occurred for all wind velocities. This demonstrated that a hemisphere inside a boundary layer can experience a region of separated flow.

Although the location at the polar angle of 0° did enter this region of separation, due to the low air velocity in the wind tunnel boundary layer at that point the effects of separation cannot be clearly demonstrated as is shown in Figure 6-18.

The thermal conductivity of the heat flux sensors used in this experiment equals 333 Btu/hr. ft. ^{o}F and their thickness equals 0.004". It was calculated that the influence of the added resistance to the heat flow due to the application of the sensor is only 0.0016% of the total resistance to the radial heat flow through the aluminum dome. Therefore, this added resistance was disregarded in the calculations. However, the results of this experiment are subject to a knowledge of the sensor emissivity. The heat flow through the dome is due to the internal convection as well as the radiation from the dome floor to the dome itself. Since the surface temperature of the hemisphere is rather uniform, radiative energy exchange between different areas of the hemisphere is negligable. Therefore, if the emissivities of the sensor and the aluminum hemisphere are greatly different, different amounts of radiative energy will be absorbed by the hemisphere and the sensor.

Similar to the procedure as outlined in section 6.4, it can be shown that the maximum contribution of radiation to the total internal radial heat transfer is equal to 16%. Even if one would assume that the emissivities of the sensors were four times as high as the surrounding aluminum, the contribution of the radiactive radial heat transfer would not increase to more than 21% in the worst case. Since it is reasonable to assume that the value of the sensors' emissivities was close to that of the surrounding aluminum, the possible disrepancy ~~between~~ the radiative radial heat absorption of the aluminum hemisphere and the sensors was disregarded in the calculations.

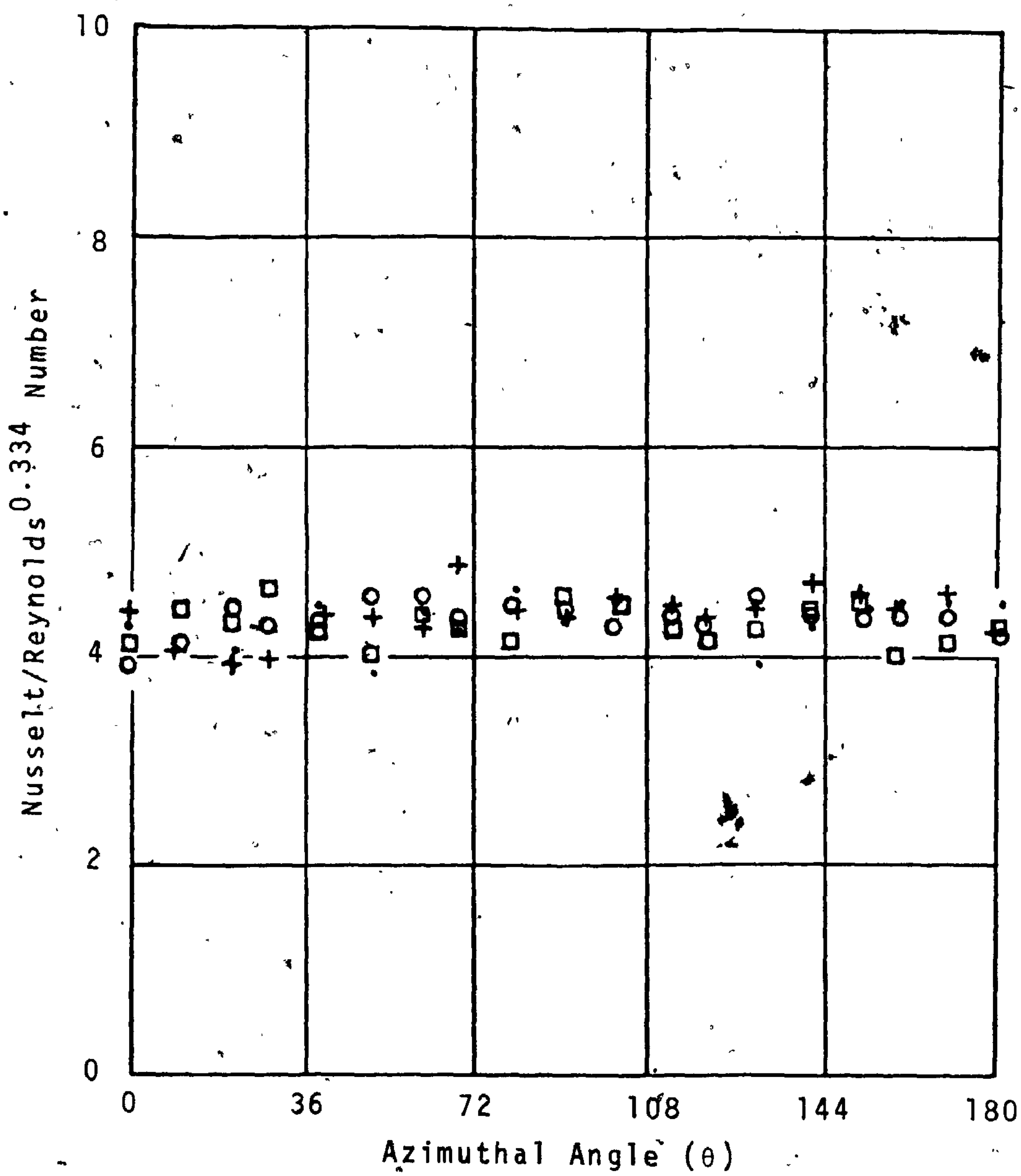


Figure 6-14: Variation of the $Nu/Re^{0.334}$ Number with Wind Velocity and Azimuthal Angle for a Polar Angle Value of 90°

- ○ - 20.1 ft/sec
- • - 30.1 ft/sec
- + - 40.1 ft/sec
- □ - 46.5 ft/sec

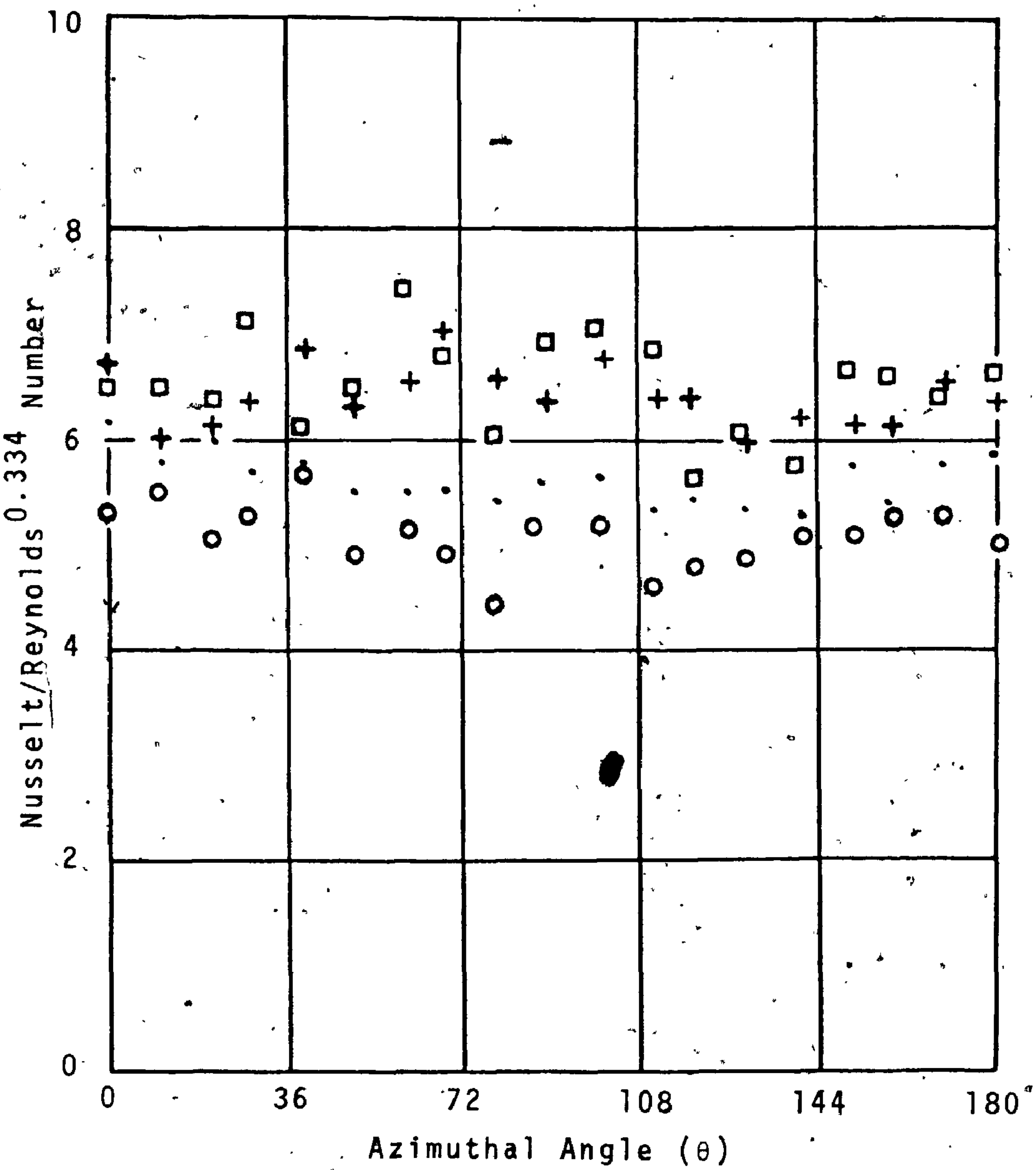


Figure 6-15: Variation of the Nu/Re$^{0.334}$ Number with Wind Velocity and Azimuthal Angle for a Polar Angle Value of 67.5°

- ○ - 20.1 ft/sec
- ● - 30.0 ft/sec
- ✚ - 40.1 ft/sec
- □ - 46.5 ft/sec

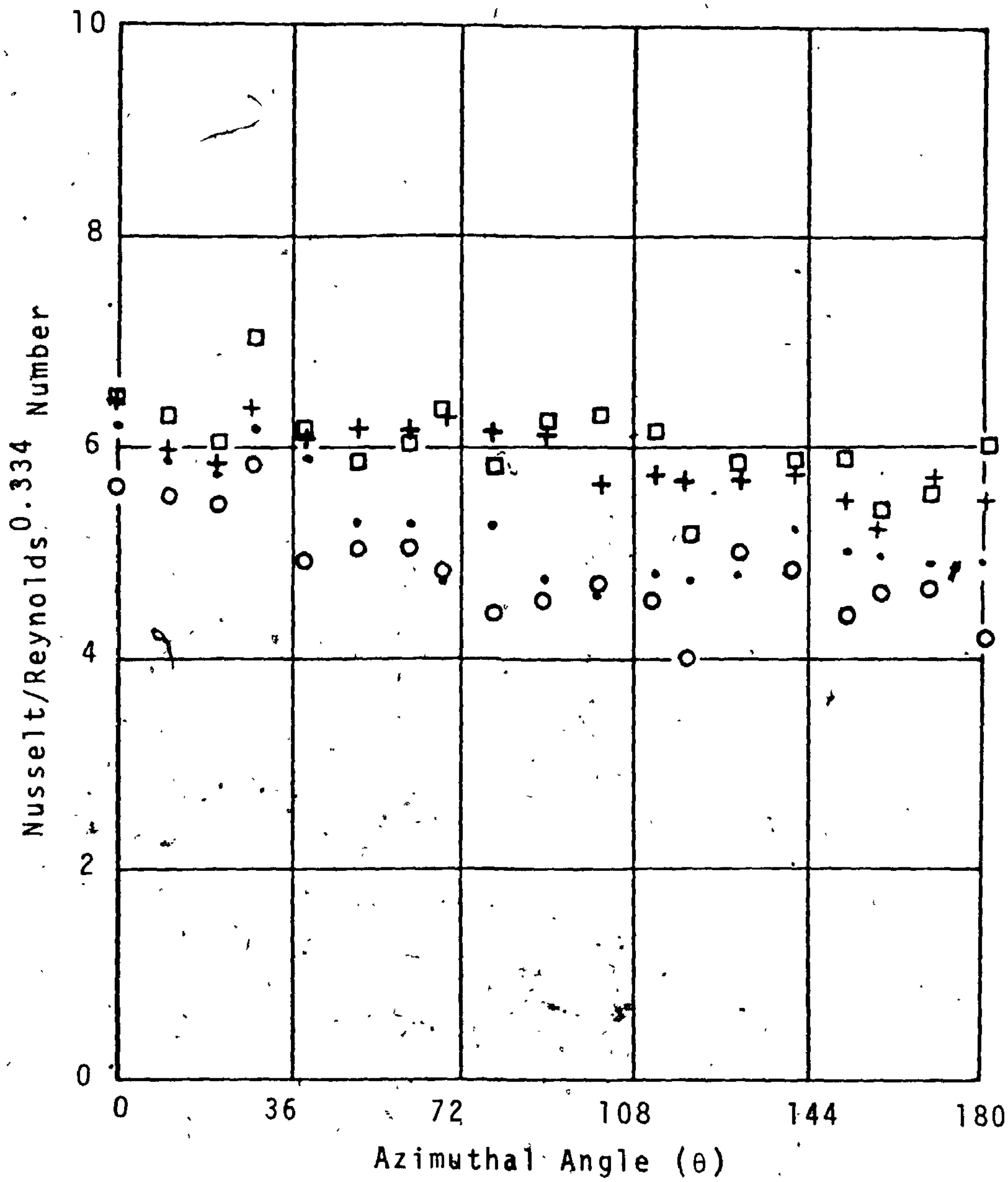


Figure 6-16: Variation of the Nu/Re$^{0.334}$ Number with Wind Velocity and Azimuthal Angle for a Polar Angle Value of 45°

- o - 20.1 ft/sec
- ● - 30.0 ft/sec
- + - 40.1 ft/sec
- □ - 46.5 ft/sec

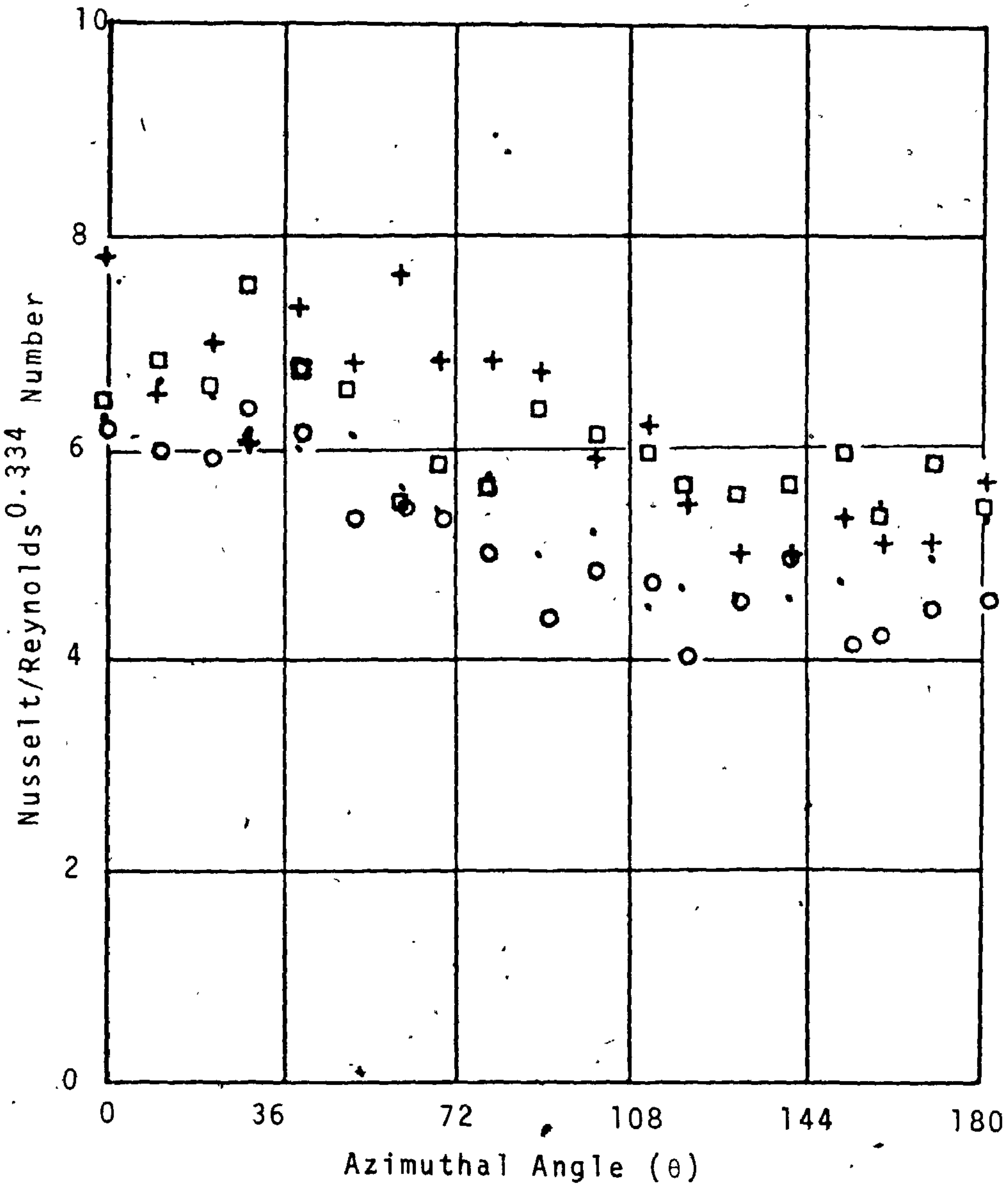


Figure 6-17: Variation of the $Nu/Re^{0.334}$ Number with Wind Velocity and Azimuthal Angle for a Polar Angle Value of 22.5°

o - 20.1 ft/sec

• - 30.0 ft/sec

+ - 40.1 ft/sec

□ - 46.5 ft/sec

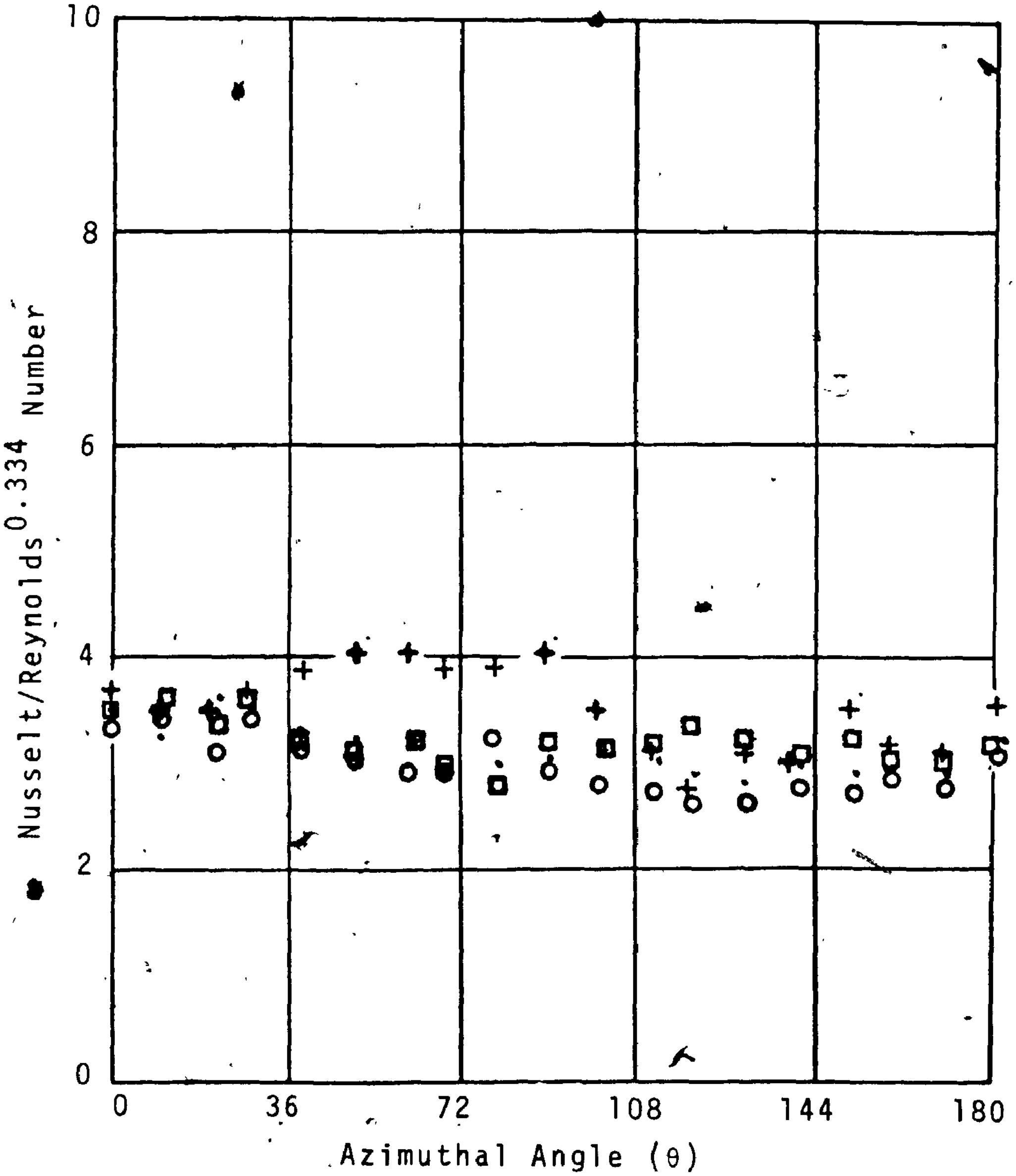


Figure 6-18: Variation of the Nu/Re$^{0.334}$ Number with Wind Velocity and Azimuthal Angle for a Polar Angle Value of 0°

○ - 20.1 ft/sec
● - 30.0 ft/sec
✚ - 40.1 ft/sec
◘ - 46.5 ft/sec

7. HEAT TRANSFER STUDIES ON AN INFLATABLE MODEL TWELVE FEET IN DIAMETER

A twelve foot diameter hemispherical inflatable model was built and instrumented for energy requirement measurements under actual field conditions. The dimensions of the dome were dictated by construction cost and energy cost limitations.

The hemispherical shape was chosen because of scaling considerations.

The influence of the weather condition and the wind direction on the overall heat transfer coefficient of this model could be determined as well. Figure 7-1 shows the location of the dome in its surroundings. In all, over 2000 data points were recorded during the winter months of 1974-1975.

It was not attempted to obtain natural convective heat transfer measurements with this model since it was realized that, with the model's experimental temperature range, all Grahsof numbers would range between 10^9 and 10^{11}, the range where the transition from fully laminar to fully turbulent natural convection occurs.

7.1 Description of Twelve Foot Diameter Model

The twelve foot diameter hemispherical inflatable structure was manufactured by Soper's of Hamilton, Ontario. The material used for the construction of the envelope was

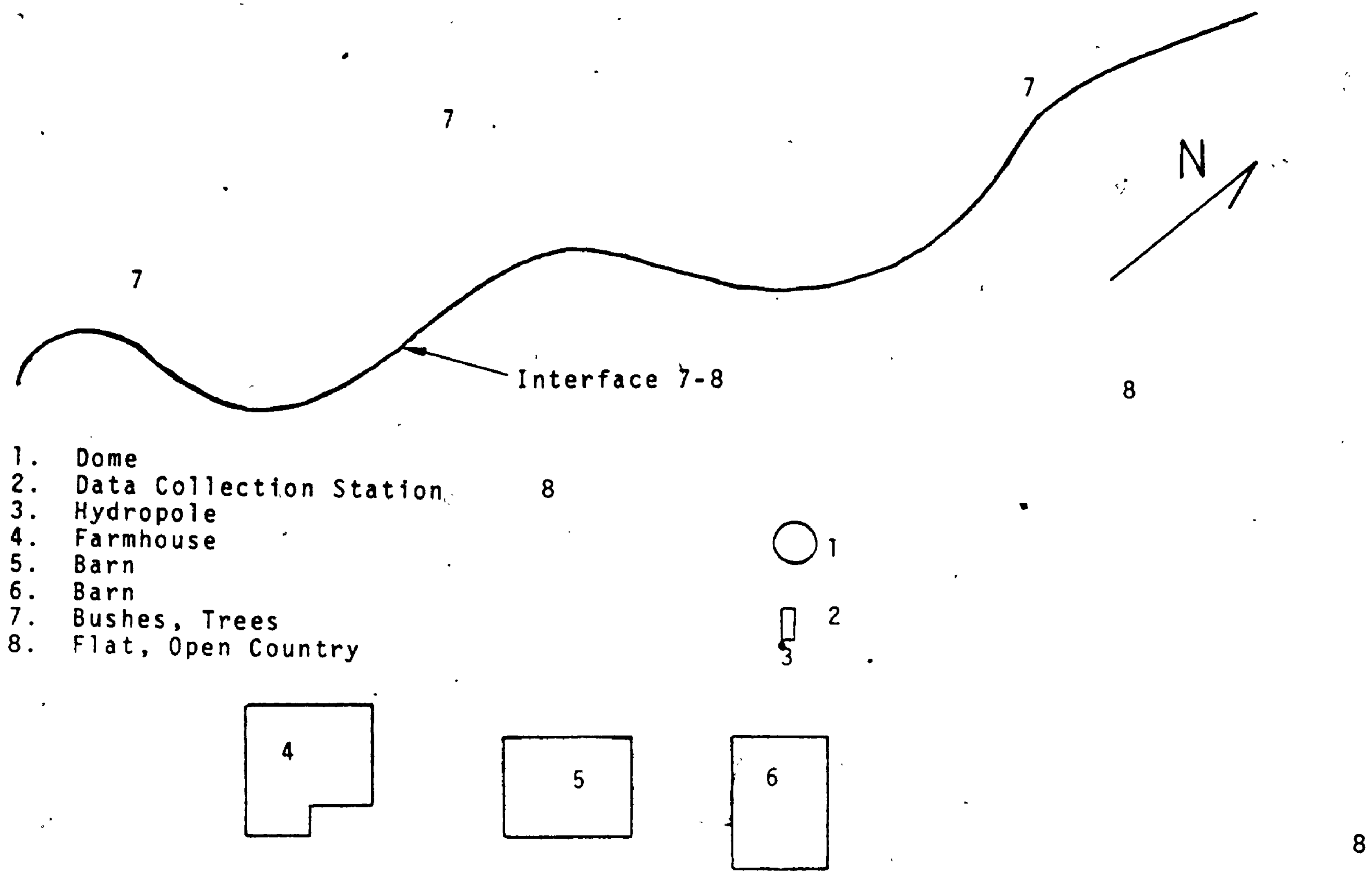


Figure 7-1: Location of Dome in its Surroundings (Not to scale)

the same that is used in the construction of full scale enclosures. It consisted of plastic coated nylon including thin layers of material designed to retard ultraviolet degradation. The base was constructed from 5/8" particle board, bolted to a frame made of two by four's as shown in Figure 7-2. Below the particle board, between the two by four's, styrofoam insulation reduced heat losses to the ground.

The thermal conductivity of the particle board and the styrofoam is 0.034 Btu/hr.ft°F[19] and 0.02 Btu/hr.ft °F[27] respectively. Openings were provided in the base to accommodate the air tube for pressurizing the dome and the tube protecting the electrical wiring for the heater, fan, thermistor and thermocouples.

Four quarter-circle electrical heating elements, seven inches high, formed the seven inch diameter heater as shown in the Figures 7-2, 7-3 and 7-4. The heater was cooled by the air stream of an upwards directed fan. This air stream was radially deflected by a six inch diameter disc, mounted horizontally about 12 inches above the top of the heater. This prevented the creation of a "hot spot" at the top of the dome. The heater current was controlled by a 208 volt, single phase "RLF - industries" temperature controller. A thermistor was used as temperature sensor. Both thermistor and all thermocouples were mounted at the inlet of the heater. See Figure 7-3.

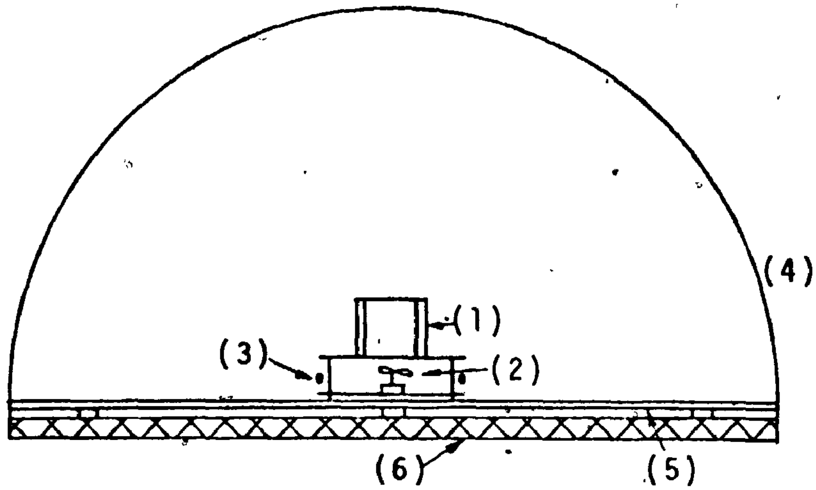
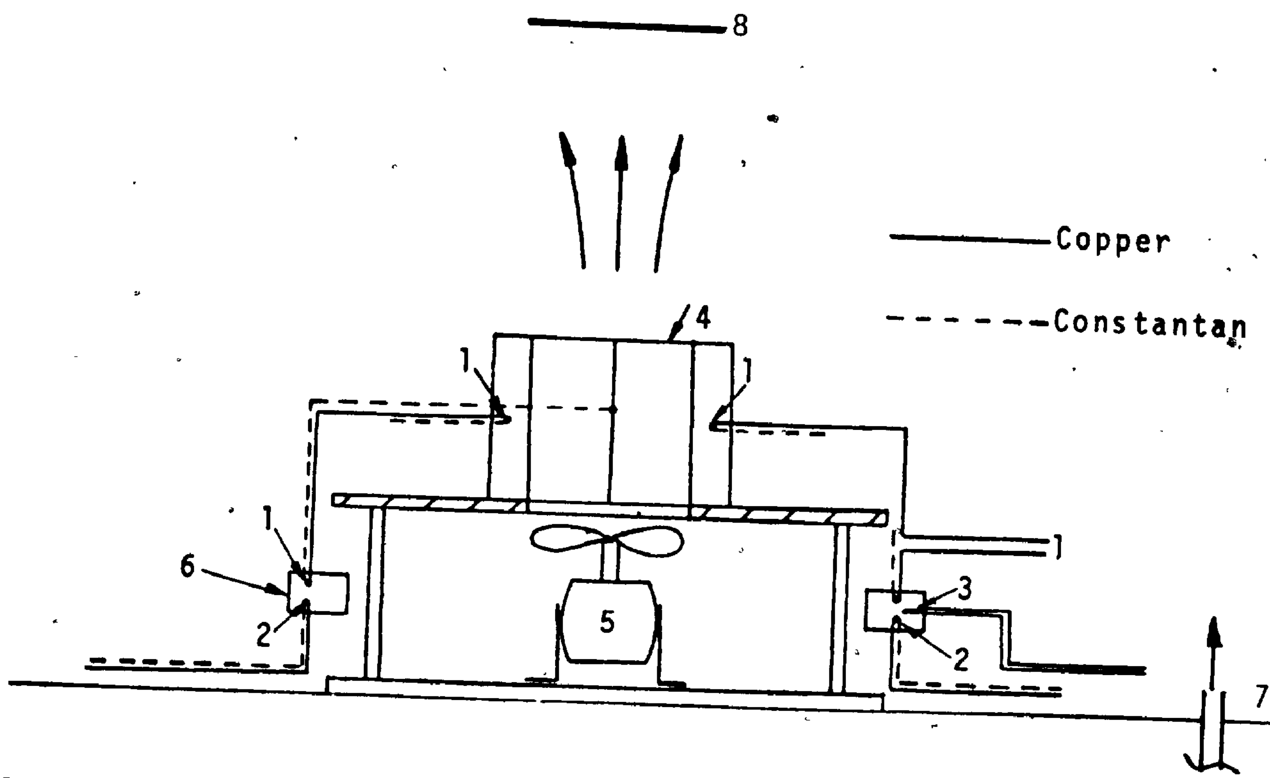


Figure 7-2: Sketch of Twelve Feet Diameter Hemisphere (Not to Scale)

(1) heater
(2) fan
(3) typical thermocouple locations
(4) hemisphere
(5) base
(6) insulation



1. Differential Thermocouples (energy consumption)
2. Differential Thermocouples (interior-exterior temperature)
3. Thermistor
4. Heater
5. Fan
6. Cylindrical Shielding
7. Make-up Air
8. Disc

Figure 7-3: Sketch of the Heater Showing Thermocouple and Thermistor Locations (not to scale)

Care was taken to eliminate all possible air leaks in the structure. All joints in the base were glued together with plastic caulking. Weather stripping and caulking were used to seal the dome material to the base. The dome was held in place with plastified steel cable kept in tension with turn-buckles.

7.2 Description of Data Station

The instrument and data collection station measured about 4x3x2 feet and was placed at a distance of 18 feet from the dome.

The data station was insulated with styrofoam and internally heated to maintain a temperature of 70°F.

It contained the following items:

(a) A variac fan arrangement to maintain the internal dome pressure between 0.5 and 1 inch of water.

(b) A motor-driven thermocouple switch, set to switch every 30 seconds.

(c) A Honeywell Electronic 19 two-channel chart recorder, recording simultaneously the power input into the heater and the four temperature differentials.

(d) A "Texas Electronics" weather station recorder, recording the wind velocity and wind direction every two seconds.

(e) A "RLF Industries" thermistor activated temperature controller controlling the interior dome temperature.

The interior of the dome was connected to the fan supplying the make-up air with a one inch diameter tygon tube. Tygon tubing was also used to shield all thermocouple and thermistor wires. The data station was placed directly beside a hydro pole and the wind vane anemometer was mounted on top of this pole, ten meters above ground level. A shielded thermocouple was also mounted on the hydro pole, ten feet above ground level, to measure the ambient temperature.

7.3 Calibration of the Heater.

For the calculation of the Nusselt Number, the amount of energy dissipated by the heater had to be known on a continuous time basis. Since line voltage fluctuations in rural areas are not uncommon, at least both voltage and current had to be measured simultaneously in order to calculate the power, but a simpler system of four differential thermocouples connected in series measuring the temperature difference between the heater and the ambient air was chosen. See Figure 7-4. The system was calibrated by connecting the heater to a high voltage D.C. supply and measuring the power absorbed with a watt meter. The output of the differential thermocouple was then recorded in millivolts.

In the laboratory, fifteen measurements were obtained using the voltage supply, and two data points were obtained by connecting the heater to the 208 volt wall outlet. These

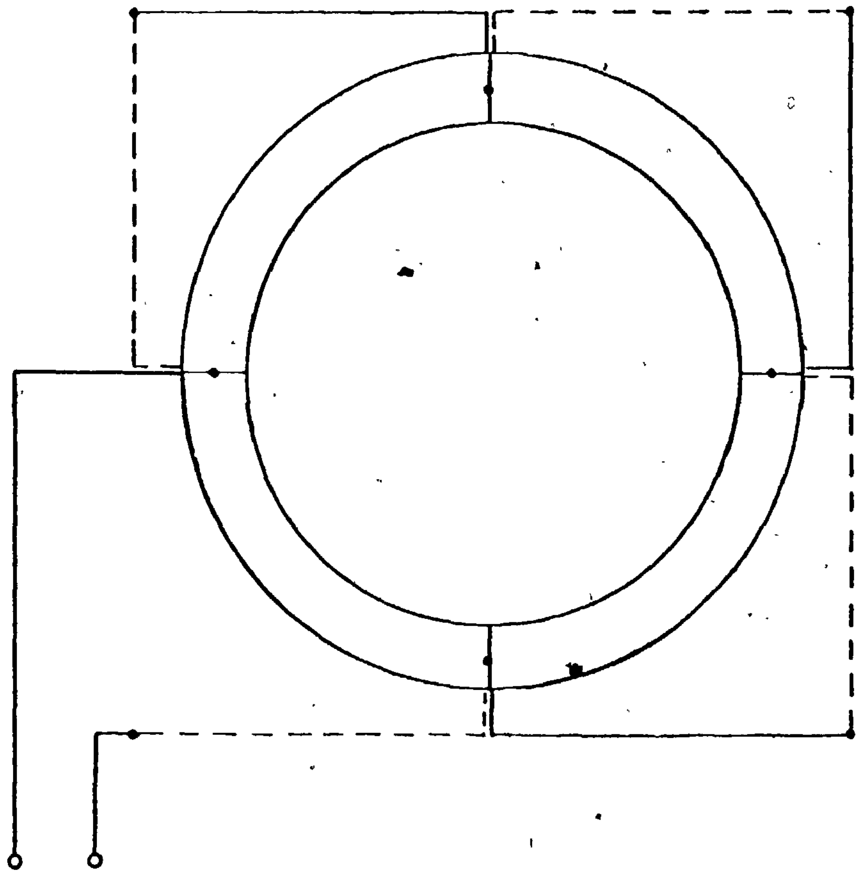


Figure 7-4: Locations of Differential Thermocouples in Heater (top view)

measurements were taken with the fan operating in an ambient temperature range of 75°F - 80°F. Two additional measurements were obtained at the field site with the heater inside the dome at 50°F with the voltage supply. The power values used were 100 and 600 watts. The temperature difference values obtained at 50°F ambient temperature were identical to those obtained in the laboratory at higher ambient temperatures and, therefore, it was assured that the calibration curve (as shown in Appendix G) is also valid at ambient temperature of 60°F, the temperature at which the interior of the dome was maintained. The calibration data as well as the computer program used to analyze this data is shown in Appendix G.

7.4 Experimental Procedure

After the dome was inflated, the temperature controller was set to maintain an interior temperature of 60°F. The recorder measuring the wind speed and wind direction was activated, as were the motor driven thermocouple switch and the recorder measuring the energy dissipated in the heater and the temperature difference between the interior and exterior of the dome. The fan used to maintain the internal pressure was manually controlled by a variac. The equipment was left to run continuously and about every three days the charts from the recorders were collected. During the execution of the experiment, the weather was observed and classified as follows:

(a) sunny

(b) cloudy

(c) partly cloudy

(d) clear (at night)

(e) precipitation (including rain, snow, sleet, and blowing snow)

The information of the charts was transferred on computer cards and the cards were grouped in 40 classes; all five weather classifications were subdivided according to the wind direction. Eight different wind directions were used: north, north-west, west, south-west, south, south-east, east and north-east. For partly cloudy conditions and easterly wind, no data was obtained. The information on the data cards was processed by an I.B.M. 1130 computer, which calculated the Nusselt and Reynolds Numbers and plotted all results on graphs. For every weather classification, all wind directions were also combined and a least square analysis was used to find the best fitting straight line through the calculated results. Also, for every wind direction, all weather classifications were combined and the best fitting straight line through the data points were found by applying a least squares analysis.

Although extreme care was taken to seal the dome airtight, at the conclusion of the experiment the leakage rate was found to be 32 cc/min. This was determined by mounting a "Brooks" air flow meter in series with make-up air supply line. While the air pressure inside the dome was held constant, the dome's leakage rate was observed by measuring the volume of air pumped into the dome. The power loss resulting from this leakage rate is 0.02 watt. The calculation is shown in Appendix H.

The heat loss through the base to the soil below was not measured, but by estimating the heat transfer coefficient between the ambient air in the dome and the particle board, as well as the thermal surface resistance between the styrofoam and the soil, a maximum heat loss rate could be calculated. The calculations are shown in Appendix H. The maximum power loss due to heat conduction into the soil was estimated to be 34 watts.

The Prandtl Number was considered to be constant in the analysis.

7.5 Discussion of Results

The data and the calculated results of this experiment, as well as a sample calculation and an experimental error analysis, can be found in Appendix H.

In Appendix J the results of the combined wind directions for all weather classifications are shown. Also shown in these graphs are the curves representing the least square data analysis.

From the graphs in Appendix H the following observation can be made: both weather classification and wind direction influence the energy requirements of the dome in this experiment. As expected, during periods of sun-shine, the energy requirements are low. The energy requirements increase for cloudy, partly cloudy, precipitation and clear (at night) conditions respectively. Generally, for all weather classifications, the energy requirements are lowest for wind from the south and south-east, where the wind is obstructed by buildings (two barns and the farm-house). From north-west to south-west, where the wind blows unobstructed toward the dome across wide open fields, the energy requirement is higher. Wind approaching the dome from the wooded areas (south-west, west, north-west) requires medium energy input. Figure 7-5 shows a graph with typical results.

To facilitate an easy overall appreciation of the influence of the weather on the energy requirements of the inflated dome, the data for all wind directions were also combined for every weather condition.

A least squares straight line was fitted through the combined data and Figure 7-6 shows the relationship of the weather classifications on the energy requirements. The following correlations were calculated:

Sunny	$Nu = 362\ Re^{0.047}$	---- (33)
Cloudy	$Nu = 380\ Re^{0.044}$	---- (34)
Partly Cloudy	$Nu = 350\ Re^{0.057}$	---- (35)
Clear	$Nu = 598\ Re^{0.017}$	---- (36)
Precipitation	$Nu = 482\ Re^{0.034}$	---- (37)

These values of the overall heat transfer coefficient (the slope of the equations) compare very well with those found with the previous analysis as shown in Figure 7-6. In addition, the value of the intercept indicates the importance of the nighttime radiative heat losses when no or few clouds are present.

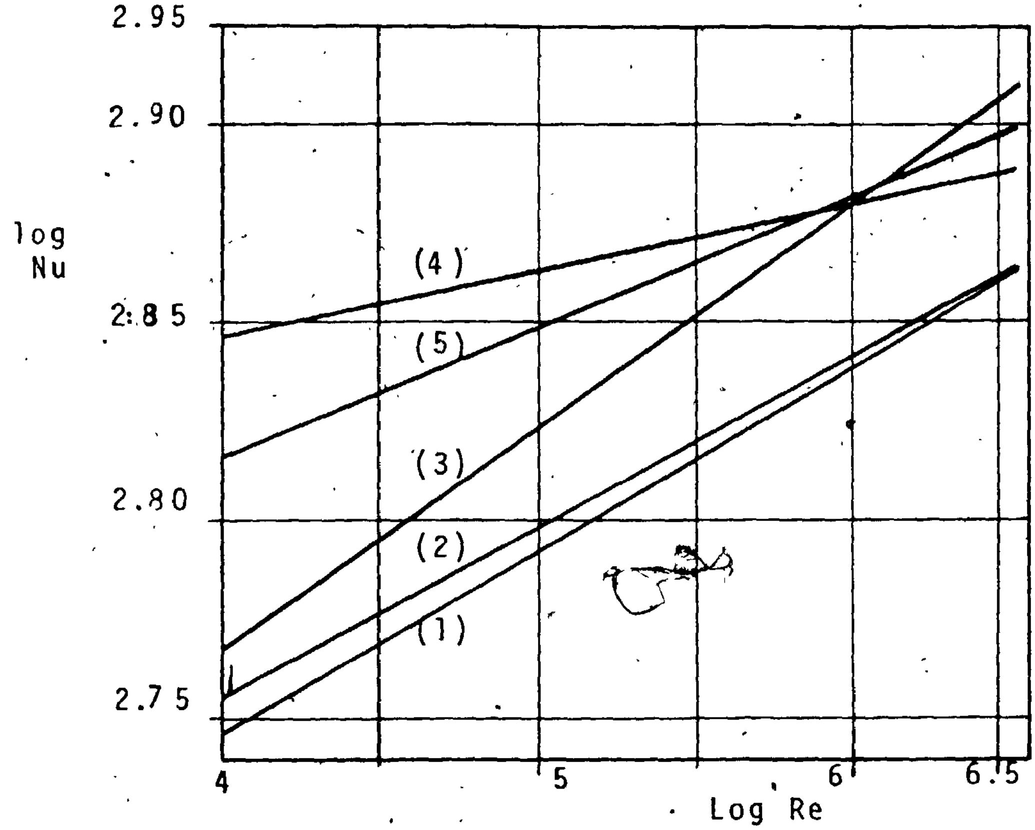


Figure 7-6: Relationship Between Weather Classification and Energy Requirements

(1) sunny . . . . $Nu = 362 \ Re^{0.047}$

(2) cloudy . . . . $Nu = 380 \ Re^{0.044}$

(3) partly cloudy . . . . $Nu = 350 \ Re^{0.057}$

(4) clear . . . . $Nu = 598 \ Re^{0.017}$

(5) precipitation . . . . $Nu = 482 \ Re^{0.034}$

As shown in Figure 7-6, under sunny conditions the energy input into the dome is least. As expected, under cloudy skies, more energy is needed to keep the interior of the dome at 60°F. At modest wind velocities, clear skies at night dictate the highest energy input.

During precipitation, energy requirements of the dome are lower than for clear skies at night, but precipitation combined with high winds causes more heat transfer from the dome than is radiated into space and convected away during periods with clear skies.

Partly cloudy conditions occurred mostly at night and this is the reason that during partly cloudy conditions the energy input is between that of cloudy and clear (at night) conditions. Figure 7-6 shows also that at higher Reynolds Numbers, the influence of the weather on the Nusselt Number decreases and at the higher Reynolds Numbers the wind speed must be considered the main influencing factor on the total energy requirements of the dome. The computer program used to analyze the energy requirements of the dome for different weather classifications and the calculated results are shown in Appendix J.

From Figure 7-6 the overall heat transfer coefficient for design conditions may be obtained. In the London (Ontario) area the design conditions are specified as a temperature of 0°F and a wind speed of 7.5 m.p.h. For these specifications, the overall heat transfer coefficient is 0.84 Btu/hr.ft^2°F.

Figure 7-7 shows the results of the combined weather classification data for all wind directions. In this figure the following correlations are shown:

For wind approaching the dome from the

North. . . . . . $Nu = 464 \ Re^{0.032}$ ---- (38)

North-East . . . $Nu = 512 \ Re^{0.026}$ ---- (39)

East . . . . . . $Nu = 288 \ Re^{0.075}$ ---- (40)

South-East . . . $Nu = 258 \ Re^{0.078}$ ---- (41)

South. . . . . . $Nu = 338 \ Re^{0.056}$ ---- (42)

South-West . . . $Nu = 380 \ Re^{0.046}$ ---- (43)

West . . . . . . $Nu = 412 \ Re^{0.042}$ ---- (44)

North-West . . . $Nu = 400 \ Re^{0.046}$ ---- (45)

From the figure, it can be concluded that when wind is approaching the dome from the south and south-east, where the flow is obstructed by the barns and the farm-house, the energy input to the dome is low. As expected, wind coming from the north-west, north and north-east dictates the highest energy input, since from these directions the air flow does not encounter any obstacles. Turbulence introduced into the air flow by the barns causes the energy requirements of the dome to increase at a higher rate than for wind approaching the dome from the flat open field. To a lesser degree, the same observation can be made for wind approaching the dome from the wooded area. Table 7-1 gives a breakdown of the number of data points collected according to weather classification and wind direction.

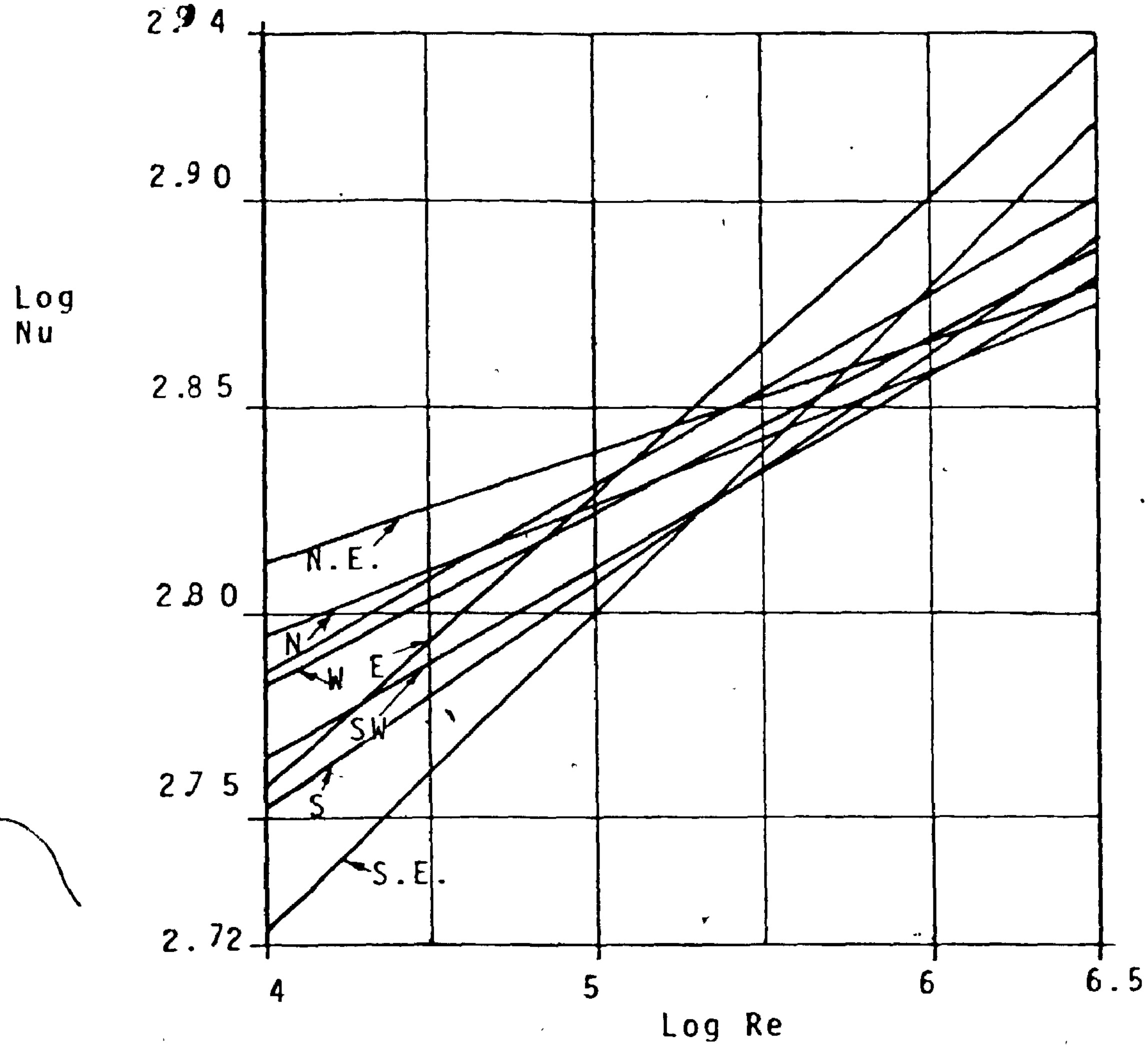


Figure 7-7: Relationship Between Wind Direction and Energy Requirements

North. . . . . . .(N) . . . $Nu = 464\ Re^{0.032}$

North-East . . .(NE). . . $Nu = 512\ Re^{0.026}$

East . . . .(E) . . . $Nu = 288\ Re^{0.075}$

South-East . . .(SE). . . $Nu = 258\ Re^{0.078}$

South. . . . . . .(S) . . . $Nu = 338\ Re^{0.056}$

South-West . . .(SW). . . $Nu = 380\ Re^{0.046}$

West . . . .(W) . . . $Nu = 412\ Re^{0.042}$

North-West . . .(NW). . . $Nu = 400\ Re^{0.046}$

	SUNNY	CLOUDY	PARTLY CLOUDY	CLEAR	PRECIPITATION	TOTAL
N	14	19	14	20	16	83
N-E	8	23	6	21	30	88
E	2	58	0	30	57	147
S-E	8	114	37	19	44	222
S	24	280	103	45	163	615
S-W	25	282	107	16	35	465
W	26	204	43	16	62	351
N-W	7	22	39	11	22	101
TOTAL	114	1002	349	178	429	2072

Table 7-1

Breakdown of the Number of Data Points

According to Weather Classification and Wind Direction

The computer program used to analyze the energy requirements of the dome for the various wind directions and the calculated results are shown in Appendix K.

In a forced convective heat transfer situation as the experiment described in this chapter, the influence of natural convective effects may be neglected if the Grashof Number is much smaller than the square of the Reynolds Number.[19] In other words, when $Gr \ll Re^2$, the buoyancy forces do not appreciably influence the velocity field.

In this experiment, the Grashof Number equals the square of the Reynolds Number when the wind velocity is 1.38 m.p.h. and natural convection effects may not be neglected for wind velocities under 4 m.p.h. For wind velocities above 4 m.p.h., the square of the Reynolds Number is an order of magnitude larger than the Grashof Number.

According to Kreith's experimental correlation for natural convection heat transfer from vertical plates and cylinders,[19]

$$\overline{Nu}_R = 0.0210\ (Gr_R Pr)^{0.4} \qquad \text{---- (45a)}$$

where $GrPr > 10^{10}$, the Nusselt Number for natural convection heat transfer from the twelve foot diameter inflatable model equals 275. (log Nu = 2.440) This is in quite good agreement with the values obtained in this experiment for low Reynolds Numbers as is shown in the graphs of Appendix J and Appendix K.

Figure 7-8 illustrates the relationship between the average Nusselt Numbers and Reynolds Numbers for the three hemispherical heat transfer models. The contribution of the natural convective heat transfer to the total heat transfer from the inflatable model at low Reynolds Numbers is shown to be significant compared with the smaller models where the effects of natural convection may be neglected. The smaller slope of the heat transfer correlations for the inflatable model compared with those for the other two models also indicates the significance of a skin with a reduced thermal conductivity.

As is shown in Appendix H-4, the maximum error due to the reading of instruments was 2% for the Nusselt Number and 26.5% for the Reynolds Number. Due to the nature of this experiment, every experimental data point has an error in the Nusselt Number and the Reynolds Number. Therefore, it can be supposed to be located in the centre of a rectangle, the sides of which represent the error in the Nusselt and Reynolds Numbers. In the Appendices J and K the limits of deviation of the Nusselt Number with respect to the best fitting straight line are indicated for three Reynolds Number ranges. These ranges are $10^{3.6}<Re<10^{4.6}$, $10^{4.6}<Re<10^{5.6}$ and $10^{5.6}<Re<10^{6.6}$

As is shown in the Appendices J and K, in the range of Reynolds Numbers between $10^{3.6}$ and $10^{4.6}$, the maximum deviation in the Nusselt Number ranged from 15% to 32% with an average of 24%. In the next range of Reynolds Numbers, the

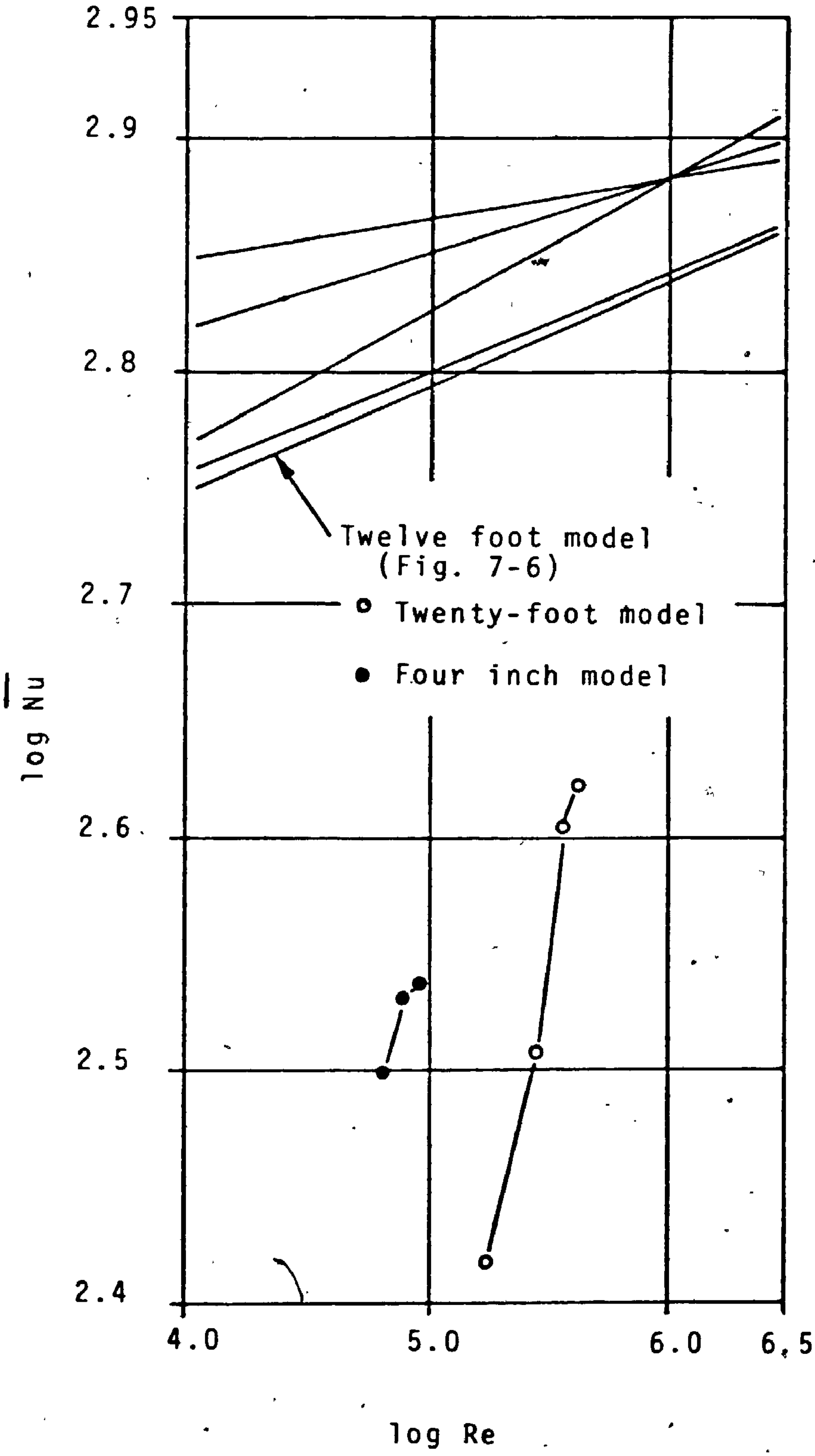


Figure 7-8: Experimental Forced Convective Heat Transfer Data Composition

same results as for the previous range were observed. However, in the range of Reynolds Numbers between $10^{5.6}$ and $10^{6.6}$, the maximum deviation in the Nusselt Number was between 19% and 32%, with an average maximum deviation of 24.2%. The graphs in the Appendices J and K also show the value of the correlation coefficient.

Since the resulting values of the Nusselt Number obtained in this experiment are very much dependent on the radiative heat transfer, also a different procedure to evaluate the overall heat transfer coefficient was employed for comparison purposes.

For all weather conditions, the influence of the difference between the interior and exterior air temperatures on the energy requirements of the inflatable structure was investigated using only the conditions where the wind velocity was between 7.0 and 8.0 m.p.h. A least squares straight line was calculated through these points of Q/A versus ΔT, the slope of this line being equal to the overall heat transfer coefficient. The results of this analysis are shown in the Equations (45b)-(45f).

Sunny . . . . $Q/A = 0.70\ \Delta T + 3.12$ . . . (45b)

Cloudy . . . . $Q/A = 0.77\ \Delta T + 1.63$ . . . (45c)

Partly Cloudy . . . $Q/A = 0.69\ \Delta T + 5.44$ . . . (45d)

Clear (at night) . . $Q/A = 0.60\ \Delta T + 8.69$ . . . (45e)

Precipitation . . . $Q/A = 0.81\ \Delta T + 1.35$ . . . (45f)

These values of the overall heat transfer coefficient (the slope of the equations) compare very well with those found with the previous analysis as shown in Figure 7-6. In addition, the value of the intercept indicates the importance of the nighttime radiative heat losses when no or few clouds are present.

8. CONCLUSIONS AND SUMMARY OF CONTRIBUTIONS

1. From the literature survey it is apparent that no theoretical or empirical solutions describing the heat transfer from inflatable structures exist. Also, it appears that mathematical solutions will be very difficult to obtain due to the non-exact description of the air flow inside the structure and the coupled interior and exterior flows.

2. The flow visualization studies indicate that a symmetrical toroidal vortex is generated within a hemisphere with a heated base for natural convective cooling. This toroid becomes distorted when the model is subjected to forced convective cooling.

3. The scaling up of test results from small scale models to full size structures is unrealistic until it is established that the interior flow geometry during natural and forced convective conditions in a small scale model is identical to that of a full size inflatable structure. Some of the reasons that have prevented an analytical solution of the energy transfer through the skin of an inflatable structure thus far are as follows:

   a) The influence of the weather condition and the turbulent intensity of the wind on the heat flux are difficult to evaluate.

b) There are great uncertainties associated with the description of the interior air flow patterns, due especially to their dependence on exterior conditions.

c) Other uncertainties are outlined in this thesis, eg.: Sections 1.4.7, 2.1, 3.4 and 4.3.

4. Natural convective heat transfer experiments on a four inch diamter solid aluminum model showed that the natural convective heat transfer coefficient agreed on the average to within 2.4% with McAdams' correlation for heat transfer by natural convection from solid spheres as expressed in Equation 2.

5. Forced convective heat transfer experiments on the model mentioned in point 4 showed that the forced convective heat transfer coefficient agreed on the average to within 1.4% with McAdams' correlation for heat transfer by forced convection from solid spheres as expressed in Equation 3.

6. Natural convective heat transfer experiments on a twenty inch diameter hollow rigid model showed that the highest heat transfer rates occurred at the interior of the wall at low values of the polar angle.

7. Forced convective heat transfer experiments on this twenty inch diameter model revealed that the value of the forced convective heat transfer coefficient at the windward side of the dome decreases with increasing polar

angle and increasing aximuthal angle except near the base of the dome where the wind velocity reduces to zero due to the wind-tunnel boundary layer. The forced convective heat transfer coefficient is most dependent on the Reynolds number at the height of the dome at which the longitudinal turbulence intensity has its largest value.

8. During forced convection conditions outside the hemisphere, the interior natural convection heat transfer coefficients decrease for decreasing polar angles and decrease for increasing azimuthal angles with the exception of 0° polar angle at low wind velocities, where the natural convective heat transfer coefficient increases for increasing azimuthal angle.

9. It was demonstrated that boundary layer separation on the twenty inch diameter model occurred at about 145° azimuthal angle.

10. The experiment with the twleve foot diameter inflatable model showed that both the weather condition and the state of the surrounding terrain influence the model's energy requirements.

11. The energy requirements of the dome are least during sunny conditions and rise for cloudy, clear (at night) and precipitation conditions in that order.

12. For modest wind velocities, wind approaching the dome over flat open field requires a higher energy input than when the wind is obstructed by buildings. However, turbulence introduced into the air stream by these buildings causes the energy requirements of the dome to increase at a higher rate than for wind approaching the dome from the flat open field. To a lesser degree, this observation can also be made for wind approaching the dome from the wooded area.

13. For the "design day", (the ambient temperature is 0°F and the wind velocity is 7.5 m.p.h.) the inflatable model predicts the maximum overall heat transfer coefficient to be 0.84 Btu/hr.ft^2°F. Most designers of inflatable structures assume ASHRAE GUIDE coefficients for glass equal to 1.13 Btu/hr.ft^2°F.

14. It is uncertain whether the results of the twelve foot diameter inflatable model can be extrapolated to domes large enough to cover a city, for the following reasons:

a) Such domes will have a smaller aspect ratio than the one used in this research.

b) The influence of different interior and exterior boundary layers on the heat transfer is unknown..

c) A larger dome in the atmospheric boundary layer will experience a different velocity distribution than the one used here, a condition dependent on surrounding terrain.

15. Due to time constraints the influence of the hemispherical aspect ratio on the heating energy requirements of the inflatable model was not investigated. However, since a reduction in the aspect ratio is proportional to the reduction of the heat transfer area, it may be assumed that for an enclosure with a given floor area a decreased aspect ratio will result in a decreased energy consumption.

16. The contribution of the natural convective heat transfer to the total heat transfer from the inflatable model at wind velocities below 4 m.p.h. is shown to be significant.

17. It is recommended that the influence of the aspect ratio on the heating energy requirements be further investigated so that the value of the average overall heat transfer coefficient can be further improved.

18. Further studies are needed in the areas of internal flow and exterior boundary layer (laminar to turbulent transition and separation of the boundary layer) to increase the accuracy of the local heat transfer coefficients.

APPENDIX A

DESCRIPTION OF THE PLANETARY BOUNDARY LAYER

A-1 Atmospheric Stability

The atmospheric static pressure at a certain level is proportional to the mass of the column of air situated above that level, and consequently atmospheric pressure decreases with height above ground level.

If a mass of air is suddenly transported upwards, it will undergo an adiabatic expansion and its temperature will decrease. In the case that the air temperature in the atmosphere decreases with increasing height above ground level at a rate equal to the decrease in temperature obtained in the adiabatic movement of a mass of air upwards, the atmosphere is said to be neutrally stable. If the temperature in the atmosphere decreases more rapidly than the adiabatic temperature change, then a vertically rising mass of air will remain warmer and therefore lighter than its surroundings and will continue to rise. Mass exchange between various heights due to these convection currents will be established. Such an atmosphere is said to be unstable. Conversely, if the temperature of the surrounding air decreases less rapidly than the adiabatic rate or increases with height, then a rising mass of air will become heavier than its new surroundings and will tend to sink back again. This type of atmosphere is called stable.

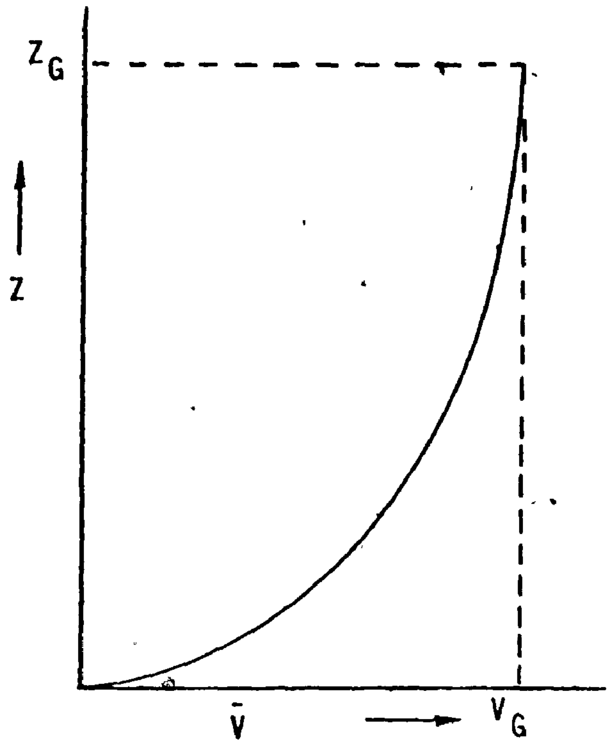


Figure A-1: Wind Velocity Gradient in the Planetary Boundary Layer

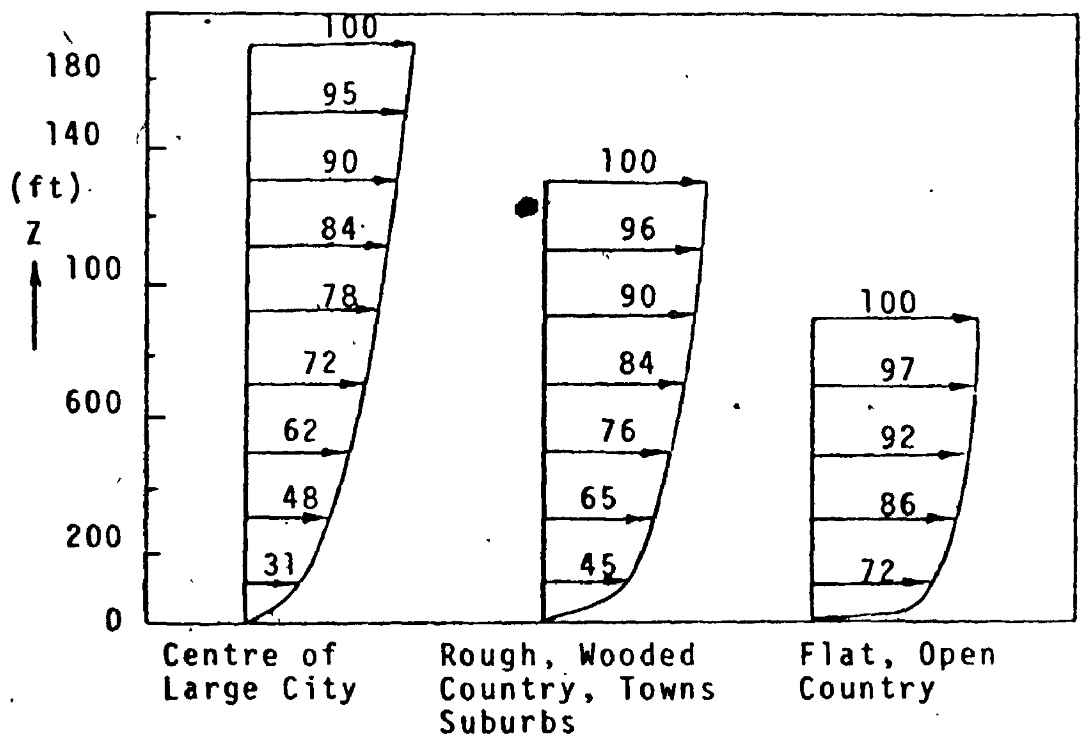


Figure A-2: Wind Velocity Versus Height Over Terrain with Three Different Surface Roughness Characteristics

$$\frac{\bar{V}_{Z1}}{\bar{V}_{Z2}} = \left(\frac{Z_1}{Z_2}\right)^{\alpha} \qquad \text{---- (46)}$$

This law relates the mean wind velocities at any pair of heights (Z_1 and Z_2). It is practical however to standardize the presentation of Equation 46 by using the gradient height or a standard height of 10 meters as a reference.

$$\frac{\bar{V}_{Z}}{\bar{V}_{G}} = \left(\frac{Z}{Z_G}\right)^{\alpha} \qquad \text{---- (47)}$$

or

$$\frac{\bar{V}_{Z}}{\bar{V}_{10}} = \left(\frac{Z}{10}\right)^{\alpha} \qquad \text{---- (48)}$$

Equation 48 is mostly used because of the difficulties in determining the gradient height (Z_G).

Davenport[25] collected mean wind profile measurements in a wide range of terrains and summarized this data by recommending values for the power law exponent α, the gradient height Z_G, and the surface drag coefficient k.

These values for various types of terrain are presented in Table A-1.

The surface drag coefficient k is usually defined from the relationship between the shear stress near the ground and the mean wind speed and is regarded as a dimensionless measure of the roughness (i.e. aerodynamic drag) of the earth's surface.

Type of Terrain	Power law exponent α	Gradient height Z_G (m)	Surface drag coefficient k
Open terrain with very few obstacles, e.g. open grass land; farm land without many trees, bushes, hedges, etc., prairie, tundra, etc.	0.16	300	0.005
Terrain uniformly covered with obstacles 10-15 meters in height: e.g. suburbs, small towns, fields with bushes, trees.	0.28	430	0.015
Terrain with large and irregular objects, e.g. centres of large cities.	0.40	560	0.050

Table A-1

Power law exponent α, Gradient height Z_G and Surface drag coefficient k for various types of terrain.

A-3 Gusts

The wind velocity at an arbitrary point (x_1, x_2, x_3) is a vector quantity, that is, it has a magnitude and a direction which both change rapidly with time, owing to the presence of gusts. This wind velocity vector is denoted by $V(x_1, x_2, x_3, t)$ and can be separated into the sum of an hourly wind speed (scalar) and a gust velocity vector:

$$V(x_1, x_2, x_3, t) = \bar{V}(x_1) + V^1(x_1, x_2, x_3, t) \quad ---- (49)$$

The gust vector can be written as

$$V^1(t) = (V_1\ (t), V_2\ (t), V_3\ (t)) \quad ---- (50)$$

and the gust speed is defined as the magnitude of the gust vector

$$\left|V^1\ (t)\right| = (V_1^2(t) + V_2^2(t) + V_3^2(t))^{1/2} \quad ---- (51)$$

The hourly mean value of $\left|V^1\ (t)\right|$ must be zero:

$$\frac{1}{T}\int_0^T \left|V^1\ (t)\right| dt = 0 \quad ---- (52)$$

where T = 1 hour.

The root mean square gust speed $\sigma(V)$ is defined by

$$\sigma^2(V) = \frac{1}{T}\int_0^T \left|V^1(t)\right|^2 dt \quad ---- (53)$$

or $$\sigma^2(V) = \frac{1}{T}\int_0^T (V_1^2(t) + V_2^2(t) + V_3^2(t))\ dt \quad ---- (54)$$

or $\sigma^2(V) = \sigma^2(V_1) + \sigma^2(V_2) + \sigma^2(V_3)$ ---- (55)

Near ground level, $\sigma(V_1) \sim 3\sigma(V_2)$ and $\sigma(V_1) >> \sigma(V_3)$, so that measurements with an anemometer provide approximations to $\sigma(V)$. Teunissen[28] showed that the root mean square gust speed decreases very slowly with height. At the gradient height the gust speed and turbulence are zero.

Figure A-2 shows the wind speed increase with height over terrain with three different roughness characteristics.

A-4 Change of Ground Roughness

When a wind flow experiences a sudden change in ground roughness over level terrain, it is reasonable to expect that a new turbulent boundary layer will begin to evolve, starting from ground level at the point where the change in roughness occurs.

Experimental data[29] shows that the slope of this interface may be between 1:100 and 1:10. This implies that the mean wind profile at 100 feet above ground level will only be established at its urban value at distances greater than 1000 feet. See Figure A-3.

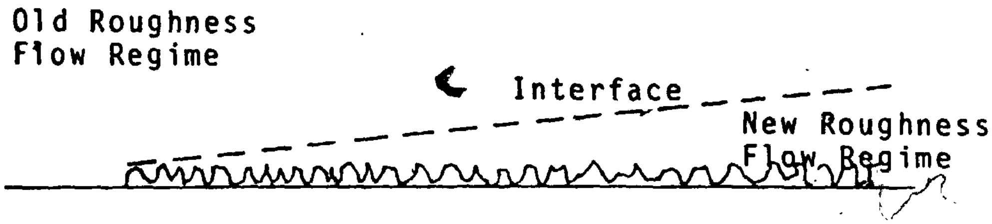


Figure A-3: Old and New Roughness Flow Regimes Showing Interface

APPENDIX B

RESULTS OF NATURAL CONVECTION HEAT TRANSFER WITH THE FOUR INCH DIAMETER MODEL

This appendix contains the experimental data, the calculated results, a sample calculation and an experimental error analysis of the natural convective heat transfer experiments that were carried out on the four inch diameter solid aluminum hemispherical model.

B-1 Data

Test No.	ΔT_{1-2} µV	ΔT_{1-3} µV	T_∞ °F	T_s °F
1	23.0	56.0	80.0	238.5
2	20.5	49.0	79.5	225.0
3	18.0	43.0	77.5	209.0
4	15.5	37.0	76.0	192.5
5	28.0	68.0	84.0	268.0
6	26.0	63.0	83.0	254.5

Table B-1

Data Obtained from Natural Convection Heat Transfer Experiments with the Four Inch Diameter Model

B-2 Calculated Results

Test No.	Nu	PrGr $\times 10^{-5}$	$\bar{h}_c$	T_s °F
1	15.04	6.08	1.498	238.5
2	15.03	5.87	1.483	225.0
3	14.58	5.85	1.426	209.0
4	14.24	5.36	1.376	192.5
5	15.86	6.19	1.608	268.0
6	15.79	6.12	1.592	254.5

Table B-2

Calculated Results of Natural Convection Heat Transfer Experiments with the Four Inch Diameter Model

B-3 Sample Calculation

Test number 1

Calculation of temperature gradient at base of dome:

$$\Delta T_{1-2} = 23\mu V$$

$$\Delta T_{1-3} = 56\mu V$$

Find a parabola $y = bx + cx^2$ through these data points.

For $x = 1$:

$$23 = b + c \quad \rightarrow \quad c = 23 - b$$

For $x = 2$:

$$56 = 2b + 4c \quad \rightarrow \quad 56 = 2b + 92 - 4b$$

The temperature gradient at the base of the dome is represented by b. ($b = 18\mu V$)

For copper-constantan thermocouples, 18μV equals (18/25)°F. From Fourier's one dimensional steady-state heat conduction equation applied to the base and Newton's convective heat transfer equation applied to the surface of the dome, $\bar{h}_c$, the average convective heat transfer coefficient, may be found from this energy balance:

Q = heat into dome = heat out by convection

$$Q = k \cdot A_{base} \cdot \frac{dT}{dx} = \bar{h}_c \cdot A_{surf} \cdot \Delta T_{s-\infty} \qquad \text{---- (56)}$$

$$\bar{h}_c = \frac{k \cdot A_{base} \cdot \frac{dT}{dx}}{A_{surf} \cdot \Delta T_{s-\infty}} \qquad \text{---- (57)}$$

Using the values

T_∞ = 80°F

T_s = 238.5°F

k (aluminum) = 106.5 (Btu/hr ft °F),

$\bar{h}_c$ = 1.498 (Btu/hr sq ft °F)

The Nusselt number (hR/k):

$$Nu = \frac{2}{12} \times \frac{1.498}{0.0166} = 15.04$$

where k_{air} at mean film temperature = 0.0166 (Btu/hr ft °F).

The Grashof-Prandtl product $\left(\frac{C_p \rho^2 g \beta (T_{s-\infty}) R^3}{\mu k}\right)$:

$$GrPr = \frac{1.15 \times 158.5}{216} \times 0.72 \times 10^6 = 6.08 \times 10^5,$$

where $Pr = C_p \mu / k = 0.72$ and the ratio $\rho^2 g \beta / \mu^2 = 1.15 \times 10^6$ (1/°F cu ft) [(19)]

In Equation (56) the assumption is made that the temperature over the dome's surface is constant. This assumption is not entirely correct. Although the dome's surface is neither adiabatic nor isothermal during the initial testing of the model, it was observed that the surface was isothermal to within 0.5°F.

B-4 Experimental Error Analysis

The total experimental error must take into account both equipment error and human error, the latter being noted especially in the reading of instruments. All equipment used in this research project was calibrated and calibration curves were used in all calculations.

One essential calibration was that of the thermocouples. All thermocouples used were taken from the same rolls of copper and constantan wire and therefore the purity of wire from both rolls was within very close tolerances. Consequently, there is a low error from this source in the differential thermocouple readings. All thermocouple junctions experience a very low temperature gradient across them and therefore by the law of intermediate metals[31] for thermo-electric phenomenon, no error due to the welds took place.

When calibrating the thermocouples in boiling distilled, deionized water, the values obtained from all thermocouples were within the reading error of 0.5°F. Therefore the conclusion must be reached that the error due to thermocouple impurities is negligible with respect to the reading error. Therefore the total error of 0.5°F is subsequently called "reading error", although at calibration, the thermocouple error was included in its value.

In all the other equipment used, the calibration was made to be more accurate than the reading error.

Therefore in this and other sections dealing with experimental errors, the error due to the reading of all instruments was considered only.

All errors in reading instruments are taken into account and accumulated for maximum possible error; i.e. when reading:

1) Temperature difference in the cylinder under the dome in μV on the Honeywell Electronic 19 chart recorder, and

2) T_∞ and T_s measured with a "Multimite" temperature indicator.

Using test number 2: (representative error)

1: Temperature difference in volts, ±0.5 μV.

$\Delta T_{1-2} = 21.0\ \mu V$

$\Delta T_{1-3} = 49.5\ \mu V$

The temperature gradient at the base of the dome can be found as follows:

$21 = b + c \rightarrow c = 21 - b$

$49.5 = 2b + 4c \rightarrow 49.5 = 2b - 4b$

$b = 17.25$ (gradient)

2: Temperature readings in °F, ±0.5°F.

$T_\infty = 80°F$

$T_{11} = 224.5°F$

With these values h is calculated to be 1.561.

The maximum error in the Nusselt number is:

$$\frac{1.561 - 1.483}{1.483} \times 100\% = 5.2\%$$

The maximum error in the Grashof-Prandtl product is:

$$\frac{145.5 - 144.5}{145.5} \times 100\% = 0.7\%$$

APPENDIX C

RESULTS OF FORCED CONVECTIVE HEAT TRANSFER EXPERIMENTS WITH THE FOUR INCH DIAMETER MODEL

This appendix contains the experimental data, the calculated results, a sample calculation and an experimental error analysis of the forced convective heat transfer experiments that were carried out on the four inch diameter solid aluminum hemispherical model.

C-2 Sample Calculation

The forced convective heat transfer coefficient and the Nusselt Number were calculated as in Appendix B-3, using the diameter of the model as characteristic length. The wind velocity was calculated using Bernoulli's equation which can be reduced to:

$$V = C_p \sqrt{\frac{2 g_c \Delta p}{\rho}} \qquad \text{---- (58)}$$

where V = air stream velocity

g_c = dimensional conversion factor

Δp = pressure difference

ρ = density of air

C_p = calibration coefficient

For a Prandtl type pitot tube as used in this research, the calibration coefficient C_p = 1.0.

For test number 1:

Since 1" of water = 5.204 lbf/ft^2, at a pitot-static tube reading of 0.35 in. of water, Δp = 0.35x5.204

$$V = \sqrt{\frac{2 \times 32.17 \times 0.35 \times 5.204}{0.0744}} = 39.69 \text{ ft/sec}$$

The Reynolds Number is:

$$Re = \frac{\rho . D . V}{\mu} = \frac{0.0744 \times 39.69 \times 4/12}{1.3350 \times 10^{-5}} = 73732$$

where ρ = 0.0744 lbm/cu ft at ambient temperature, and μ = 1.3350 x 10^{-5} lbm/ft sec at the mean film temperature.

C-3 Experimental Error Analysis

As in Appendix B-4, only the instrument reading error is considered. Similar to the procedure in Appendix B-4 we set:

$$\Delta T_{1-2} = 138.5\ \mu V$$

$$\Delta T_{1-3} = 296.5\ \mu V$$

The gradient is calculated to be 128.75.

$$T_{11} = 184.5°F$$

$$T_{\infty} = 80.0°F$$

$$\Delta T_{11-\infty} = 104.5°F$$

Accumulate these errors and the average heat transfer coefficient is:

$$\bar{h} = 15.6 \times \frac{128.75}{128} \times \frac{105.5}{104.5} = 15.84$$

and the Nusselt Number is:

$$Nu = \frac{15.84}{15.6} \times 324 = 329.0$$

The maximum possible error in the Nusselt Number is:

$$\frac{329 - 324}{324} \times 100\% = 1.54\%$$

The Dwyer flex tube manometer could be read with an accuracy of ±0.01 inches of water. The maximum possible error in the Reynolds Number caused by the reading accuracy of the manometer can be calculated as follows:

Δp = 0.36 inches of water.

$$V^2 = \frac{2 \times 0.36 \times 5.204 \times 32.17}{0.0744} = 1620$$

$$V = 40.25$$

$$Re = \frac{40.25}{39.69} \times 73732 = 74772$$

$\frac{74772 - 73732}{73732} \times 100\% = 1.4\%$, which is the maximum error in the Reynolds Number.

APPENDIX D

EXPERIMENTAL RESULTS OF THE HEAT FLUX SENSOR CALIBRATION

This appendix contains the computer program used to analyze the experimental heat flux sensor calibration for the five sensors used in the heat transfer experiment with the twenty inch diameter hollow aluminum model. The experimental data is printed on the computer output.

The experimental error analysis is shown in Section D-2.

D-1 Computer Output and Results

```
PAGE   1

// JOB    1111

LCG DRIVE   CART SPEC   CART AVAIL  PHY DRIVE
  CC00        1111        1111        0000

V2 M11   ACTUAL  8K  CCNFIG  8K

// FOR
* ICCS (CARC,1403 PRINTER)
* CNE WCRC INTEGERS
* LIST SOURCE PROGRAM
C
C     LEAST SQUARES ANALYSIS OF HEAT FLUX SENSOR
C     CALIBRATICN DATA
C
      DIMENSICN X(25),Y(25),XX(300),YY(300),MWH(10)
      WRITE (5,102)
  102 FCRMAT (1H1)
      N=0
      DC 1C NC=1,5
      REAC (2,101) J
C
C     ENTER ALL DATA
C
      REAC (2,1C0) (X(I),Y(I),I=1,J)
      WRITE(5,9C)
   90 FCRMAT(' HEAT FLUX INDICATICN  CALIBRATION FACTOR')
      WRITE(5,103) (X(I),Y(I),I=1,J)
  103 FCRMAT(5X,F1C.3,12X,F10.3)
  100 FCRMAT (F10.3,F11.4)
  101 FCRMAT (I5)
C
C     LEAST SQUARES APPROXIMATION
C
      X1 = 0.
      X2 = 0.
      X3 = 0.
      X4 = C.
      X5 = C.
      X6 = C.
      Y1 =C.
      X1Y = 0.
      X2Y = 0.
      X3Y = 0.
      CC 5 K=1,J
      X1 = X1+X(K)
      X2 = X2 + X(K)**2
      X3 = X3+X(K)**3
      X4 = X4+X(K)**4
      X5 = X5+X(K)**5
      X6 = X6+X(K)**6
      Y1 = Y1+Y(K)
      X1Y = X1Y+X(K)*Y(K)
      X2Y = X2Y+(X(K)**2)*Y(K)
    5 X3Y = X3Y+(X(K)**3)*Y(K)
      A = 3.0
      B = 0.
      C = C.
      C = C.

PAGE   2
      DC 35 K1=1,1CCC
      CC 15 K = 1,1CO
      DD = (1./X6)*(X3Y-X3*A-X4*B-X5*C)
      CC = (1./X4)*(X2Y-X2*A-X3*B-X5*DD)
      BB = (1./X2)*(X1Y-X1*A-X3*CC-X4*DD)
      AA = (1./J)*(Y1-X1*BB-X2*CC-X3*DD)
      IF (ABS(AA-A)-0.CCOC1) 1,1,25
    1 IF (ABS(BB-B)-0.CC001) 2,2,25
    2 IF (ABS(CC-C)-0.CC001) 3,3,25
    3 IF (ABS(CD-D)-C.CCOC1) 4,4,25
   25 A = AA
      B = BB
      C = CC
      D = DD
   15 CCNTINUE
   35 CCNTINUE
    4 DC 6 NA = 25,110,2
C
C     CALCULATE 43 PCINTS CN EACH CURVE FOR PLOTTING
C
      N = N + 1
      XX(N) = NA
      YY(N) = A +B*XX(N) +C*XX(N)**2 +D*XX(N)**3
    6 CCNTINUE
   10 CONTINUE
      DC 7 N = 1,5
    7 MWH(N) = N*43
      WRITE (5,102)
      WRITE (5,104)
  104 FCRMAT (30X,'HEAT FLUX VERSUS CALIBRATION FACTOR',//)
      CALL CURV9 (YY,XX,2.4,2.9,0.0,110.0,215,0,MWH,5)
      CALL EXIT
      END

FEATURES SUPPCRTEC
 CNE WORD INTEGERS
 ICCS

CORE REQUIREMENTS FOR
 CCMMCN      0  VARIABLES   1360  PROGRAM    694

END CF CCMPILATICN

// XEQ
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HEAT FLUX INDICATION	CALIBRATION FACTOR
39.500	2.815
45.500	2.789
63.500	2.749
85.500	2.753
105.000	2.649
132.000	2.679
161.000	2.664
182.000	2.669
207.500	2.660

HEAT FLUX INDICATION	CALIBRATION FACTOR
35.500	2.597
45.000	2.563
57.500	2.533
77.000	2.496
97.000	2.504
119.000	2.435
147.000	2.460
163.000	2.408
186.250	2.468

HEAT FLUX INDICATION	CALIBRATION FACTOR
36.000	2.652
45.500	2.620
60.000	2.667
81.000	2.663
100.000	2.578
123.500	2.581
152.000	2.585
168.000	2.515
190.000	2.567

HEAT FLUX INDICATION	CALIBRATION FACTOR
38.000	2.818
48.500	2.825
62.500	2.830
83.000	2.748
105.000	2.770
129.000	2.717
158.000	2.710
175.000	2.713
200.000	2.735

HEAT FLUX INDICATION	CALIBRATION FACTOR
35.500	2.669
44.000	2.587
58.500	2.666
76.500	2.564
97.000	2.621
120.000	2.575
146.000	2.522
163.000	2.547
182.500	2.527

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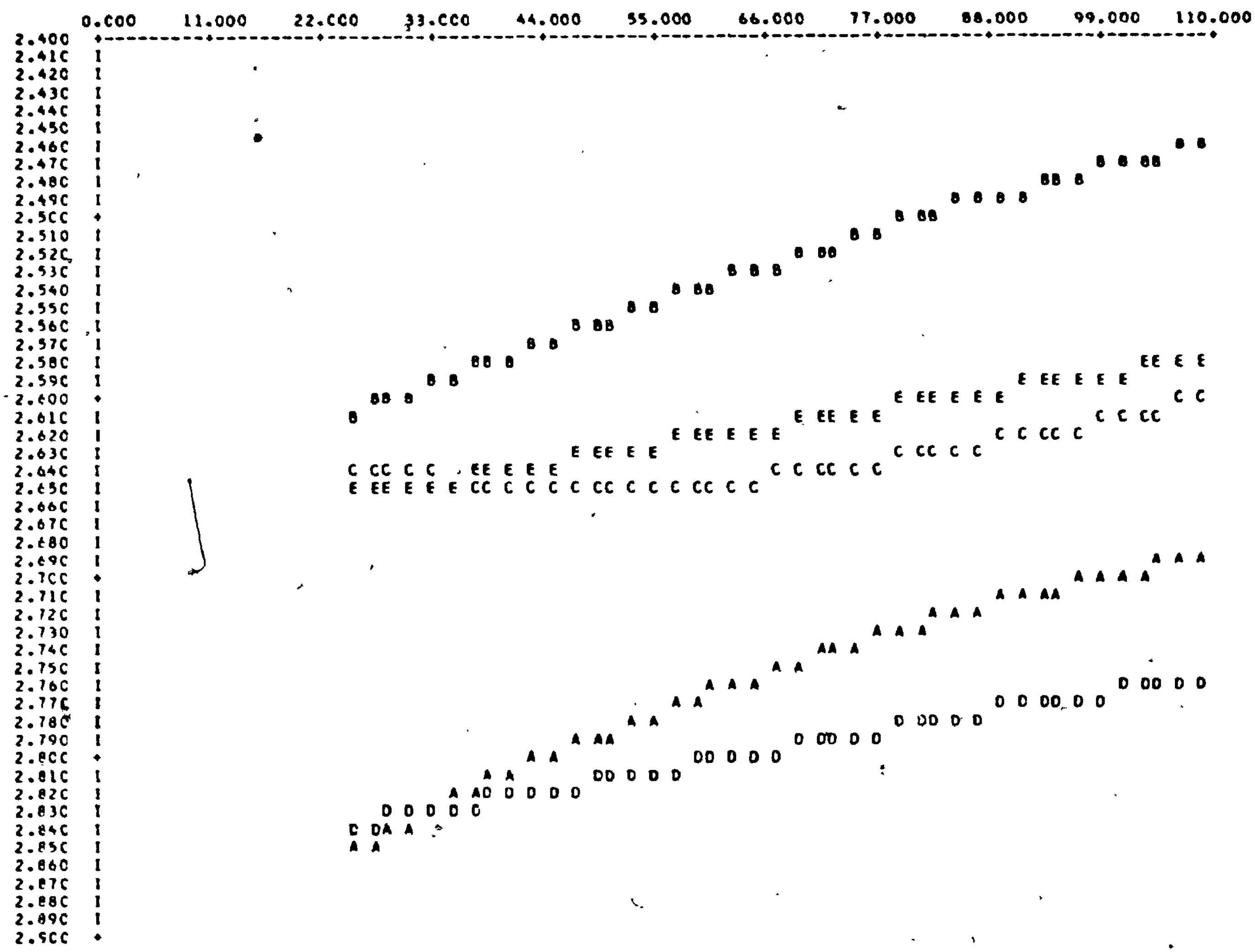
HEAT FLUX VERSUS CALIBRATION FACTOR



D-2 Experimental Error Analysis

The maximum experimental error in the heat flux sensor correction factor can be calculated as follows:

Heat flux sensor output in μV: $\pm$ 1μV.

Temperature difference in mV: $\pm$ 0.1mV.

$$h = (Q/A)/\Delta T \qquad ----(59)$$

Using the test with the lowest Q/A for maximum percent error:

$Q/A = 35.5\ \mu V$

$\Delta T = 0.455\ mV$

$(Q/A)/\Delta T$ equals 35.5/0.455 = 78.022

For maximum error:

$Q/A = 36.5\ \mu V$

$\Delta T = 0.455\ mV$

$(Q/A)/\Delta T = 36.5/0.455 = 82.022$

The maximum percent error is:

$$\frac{82.022 - 78.022}{78.022} \times 100\% = 5\%$$

APPENDIX E

RESULTS OF NATURAL CONVECTION HEAT TRANSFER EXPERIMENTS WITH THE TWENTY INCH DIAMETER MODEL

This appendix contains the computer program used to analyze the experimental data obtained from natural convective heat transfer experiments on the twenty inch diameter rigid hollow aluminum model. A sample calculation and an experimental error analysis is shown in Sections E-2 and E-3 respectively.

E-1 Computer Program and Output

Explanation of terms used for headings in data sheet:

- Q/A - heat flux, BTU/sq.ft.hr.
- D T - T wall - T ambient, °F
- H T C - heat transfer coefficient, BTU/hr.sq.ft.°F
- N GR - Grashof number, $\rho^2 \beta g \Delta T R^3 / \mu^2$
- N NU - Nusselt number, h D/k
- ANGLE - Polar angle, degrees
- (O) - Exterior
- (I) - Interior

Explanation of characters in graphs:

- A-L - Data points obtained from eleven experiments at polar angle considered.
- M - Best fitting curve obtained from least squares procedure.

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PAGE   1

// JOB    1111

LOG DRIVE   CART SPEC   CART AVAIL   PHY DRIVE
  0000        1111        1111        0000

V2 M11   ACTUAL  8K  CONFIG  8K

// FOR
* ICCS (CARD,1403 PRINTER)
* ONE WORD INTEGERS
* LIST SOURCE PROGRAM
C
C     20 INCH DIAMETER THIN WALLED ALUMINUM DOME
C
C     ANALYSIS OF NATURAL CONVECTION HEAT TRANSFER
C
      DIMENSION QOA(55),DTI(55),HO(55)
      DIMENSION XNURO(55),XNURI(55),GRRO(55),GRRI(55),XNOGO(105)
      DIMENSION DTO(55),HI(55),XNOGI(55),X(105),MWH(20)
      XY = 90.
      DO 5 N = 1,56,5
      X(N) = XY
      X(N+1) = XY-22.5
      X(N+2) = XY-45.0
      X(N+3) = XY-67.5
    5 X(N+4) = XY-90.0
      XL=.85
      WRITE(5,101)
C
C     ENTER ALL DATA AND PERFORM CALCULATIONS
C
      DO 20 N=1,55
      READ(2,100) CHART,F,TW,TIO,TII,TCO,TCI,GRO,GRI
  100 FORMAT(F6.3,F5.3,F6.2,F5.2,F6.2,2F7.5,E10.4,1X,E10.4)
  102 FORMAT(9E12.5)
      QOA(N) = CHART/F
      DTO(N) = TW-TIO
      DTI(N) = TII-TW
      HO(N)=QOA(N)/DTO(N)
      HI(N)=QOA(N)/DTI(N)
C
C     CALCULATION OF INTERIOR AND EXTERIOR NUSSELT AND
C     GRASHOF NUMBERS
C
      GRRO (N) = GRO*(XL**3)*DTO(N)
      GRRI (N) = GRI*(XL**3)*DTI(N)
      XNURO(N)=(HO(N)*XL)/TCO
      XNURI(N)=(HI(N)*XL)/TCI
C
C     CALCULATION OF INTERIOR AND EXTERIOR
C     (NUSSELT)/(GRASHOF)**0.25 NUMBERS
C
      XNOGO(N)=XNURO(N)/(GRRO(N)**0.25)
   20 XNOGI(N)=XNURI(N)/(GRRI(N)**0.25)
      WRITE (5,103)
  103 FORMAT ('     Q / A',7X,'DT (O)',6X,'DT (I)',5X,'HTC (O)',
     15X,'HTC (I)',5X,'N GR (O)',4X,'N GR (I)',4X,'N NU (O)',
     24X,'N NU (I)',3X,'ANGLE')
      WRITE (5,106) (QOA(N),DTO(N),DTI(N),HO(N),HI(N),GRRO(N),
```

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PAGE   2

      1GRRI(N),XNURO(N),XNURI(N),X(N),N=1,55)
  106 FORMAT(9E12.5,F7.2).
      DO 6 N = 1,11
    6 MWH(N) = 5*N
      WRITE(5,101)
  101 FORMAT(1H1)
      WRITE (5,104)
  104 FORMAT (20X,'(NUSSELT) / (GRASHOF)**0.25  NUMBER ',
     1'VERSUS POLAR ANGLE   (EXTERIOR)')
C
C     PLOT ALL DATA (EXTERIOR)
C
      CALL CURV9 (X,XNOGO,0.0,90.0,0.0,1.0,55,0,MWH,11)
      WRITE(5,101)
      WRITE (5,105)
  105 FORMAT (20X,'(NUSSELT) / (GRASHOF)**0.25  NUMBER ',
     1'VERSUS POLAR ANGLE   (INTERIOR)')
C
C     PLOT ALL DATA (INTERIOR)
C
      CALL CURV9 (X,XNOGI,0.0,90.0,0.0,1.0,55,0,MWH,11)
      MWH(12) = 105
      DO 9 J1=1,2
C
C     LEAST SQUARES ANALYSIS OF DATA POINTS
C
      X1=0.
      X2=0.
      X3=0.
      X4=0.
      X5=0.
      X6=0.
      Y1=0.
      X1Y=0.
      X2Y=0.
      X3Y=0.
      DO 7 K=1,55
      X1=X1 + X(K)
      X2 = X2 + X(K)**2
      X3 = X3 + X(K)**3
      X4 =X4 + X(K)**4
      X5=X5 + X(K)**5
      X6 = X6 + X(K)**6
      Y1 = Y1 + XNOGO(K)
      X1Y =X1Y + X(K)*XNOGO(K)
      X2Y = X2Y + (X(K)**2)*XNOGO(K)
    7 X3Y=X3Y + (X(K)**3)*XNOGO(K)
      A=0.
      B=0.
      C=0.
      D=0.
      DO 35 K1 =1,1000
      DO 15 K =1,100
      DD=(1./X6)*(X3Y-X3*A-X4*B-X5*C)
      CC = (1./X4)*(X2Y-X2*A-X3*B-X5*DD)
      BB=(1./X2)*(X1Y-X1*A-X3*CC-X4*DD)
      AA=(1./55.)*(Y1-X1*BB-X2*CC-X3*DD)
      IF(ABS(AA-A)-0.C0001)1,1,25
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    1 IF(ABS(BB-B)-0.00001)2,2,25
    2 IF(ABS(CC-C)-0.00001)3,3,25
    3 IF(ABS(DD-D)-0.00001)4,4,25
   25 A=AA
      B=BB
      C=CC
      D=DC
   15 CONTINUE
   35 CONTINUE
    4 DO 8 J=1,50
      X(J+55)=1.8*J
    8 XNOGO(J+55)=A+B*X(J+55)+C*X(J+55)**2+D*X(J+55)**3
      WRITE (5,101)
C
C     PLOT ALL DATA AND AVERAGE VALUES FOR EXTERIOR
C     AND FOR INTERIOR
C
      CALL CURV9 (X,XNOGO,0.0,90.0,0.0,1.0,105,0,MWH,12)
      DO 11 J=1,55
   11 XNOGO(J)=XNOGI(J)
    9 CONTINUE
      CALL EXIT
      END

UNREFERENCED STATEMENTS
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FEATURES SUPPORTED
 ONE WORD INTEGERS
 IOCS

CORE REQUIREMENTS FOR
 COMMON      0  VARIABLES   2614  PROGRAM   1056

END OF COMPILATION

// XEQ
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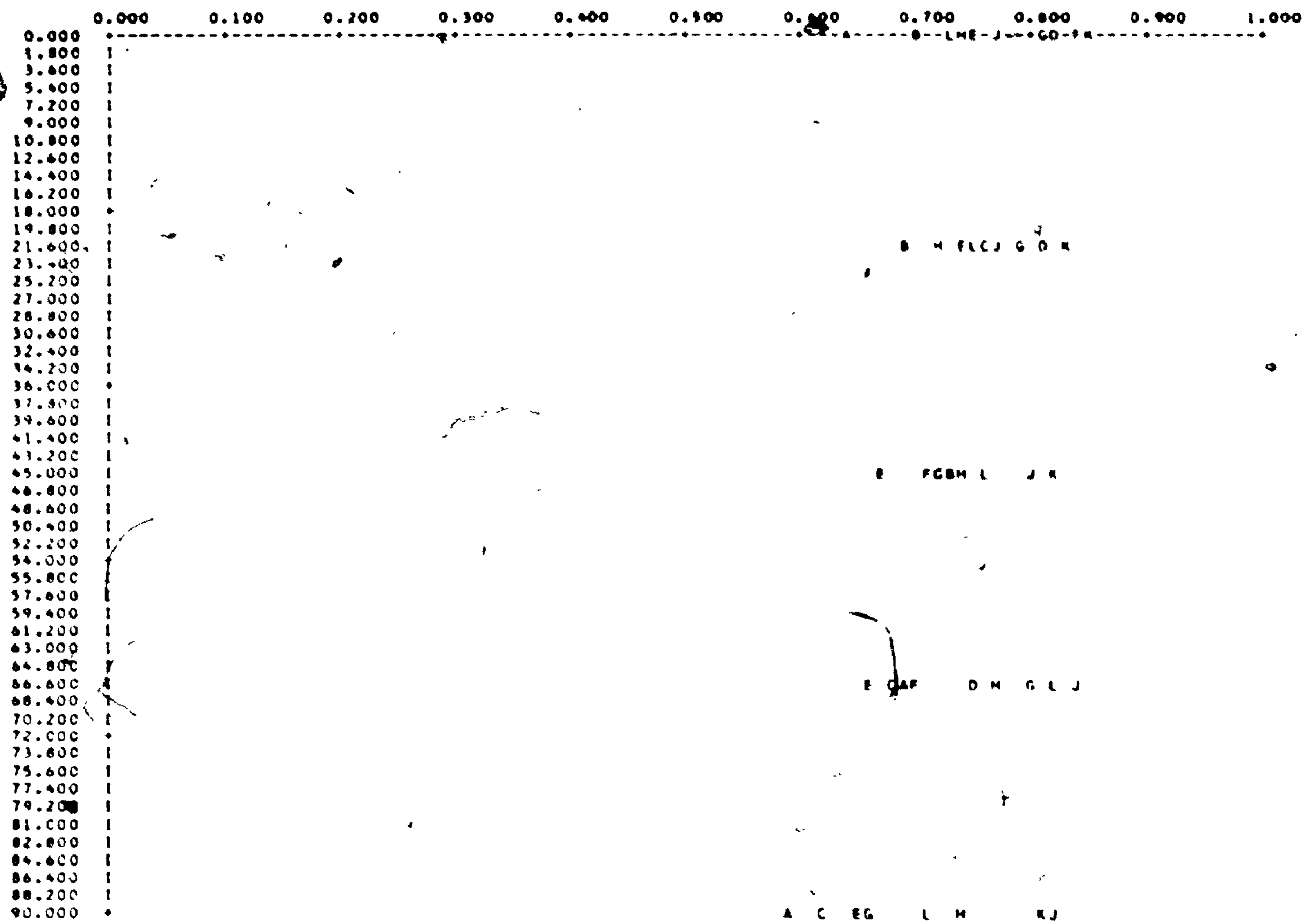
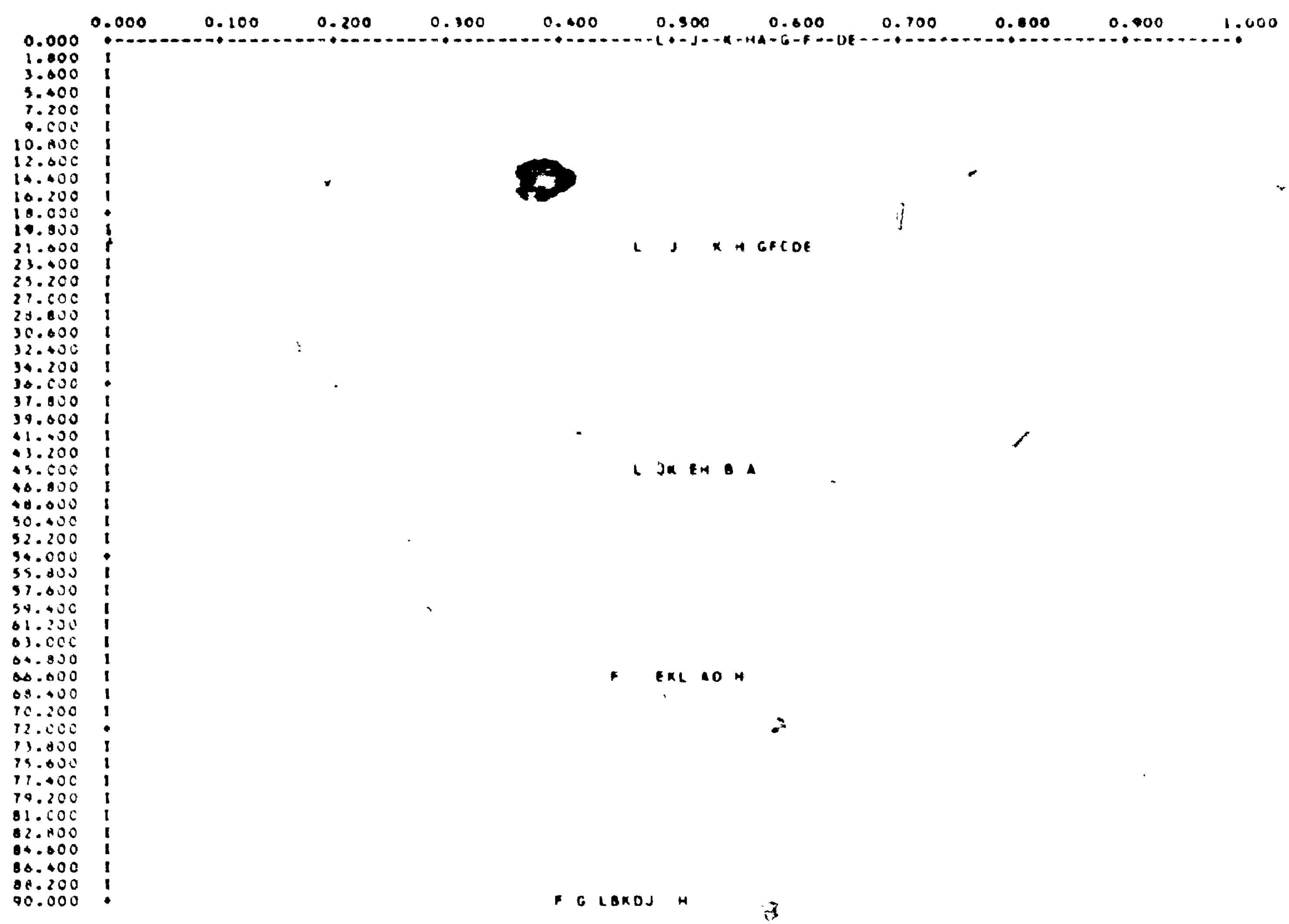
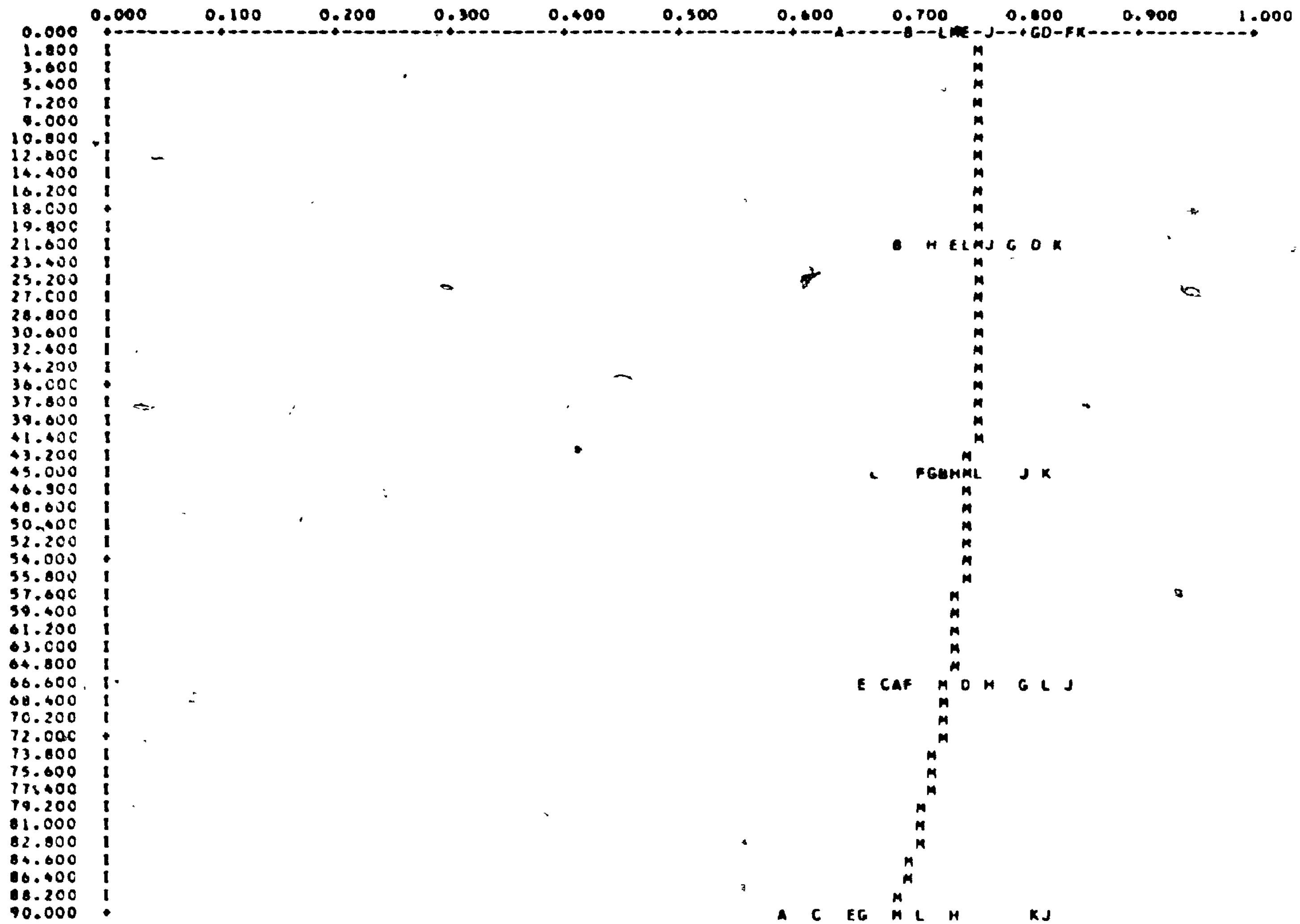
Q / A	DT (O)	DT (I)	HTC (O)	HTC (I)	N GR (O)	N GR (I)	N NU (O)	N NU (I)	ANGLE
0.24196E 02	0.37500E 02	0.30199E 02	0.64525E 00	0.80122E 00	0.40992E 08	0.25779E 08	0.35614E 02	0.42300E 02	90.00
0.28477E 02	0.37000E 02	0.30699E 02	0.76965E 00	0.92760E 00	0.40446E 08	0.26395E 08	0.42481E 02	0.49278E 02	67.50
0.30573E 02	0.37000E 02	0.30699E 02	0.82631E 00	0.99588E 00	0.40446E 08	0.26395E 08	0.45608E 02	0.52906E 02	45.00
0.30603E 02	0.36500E 02	0.31199E 02	0.83846E 00	0.98089E 00	0.40123E 08	0.28824E 08	0.46278E 02	0.52110E 02	22.50
0.28955E 02	0.35000E 02	0.32699E 02	0.82730E 00	0.88549E 00	0.38474E 08	0.28315E 08	0.45662E 02	0.47041E 02	0.00
0.21474E 02	0.34000E 02	0.26500E 02	0.63160E 00	0.81035E 00	0.37584E 08	0.23597E 08	0.35089E 02	0.43321E 02	90.00
0.24185E 02	0.34000E 02	0.26500E 02	0.71132E 00	0.91264E 00	0.37584E 08	0.23597E 08	0.39518E 02	0.48789E 02	67.50
0.25915E 02	0.33500E 02	0.27000E 02	0.77361E 00	0.95985E 00	0.37031E 08	0.24042E 08	0.42978E 02	0.51312E 02	45.00
0.26285E 02	0.32000E 02	0.28500E 02	0.82141E 00	0.92229E 00	0.35570E 08	0.25553E 08	0.456[illegible]4E 02	0.49354E 02	22.50
0.26717E 02	0.32000E 02	0.28500E 02	0.83492E 00	0.93745E 00	0.35570E 08	0.25553E 08	0.46314E 02	0.50115E 02	0.00
0.18287E 02	0.29000E 02	0.23299E 02	0.53059E 00	0.78486E 00	0.32769E 08	0.21892E 08	0.35043E 02	0.42223E 02	90.00
0.20289E 02	0.29000E 02	0.23299E 02	0.69963E 00	0.87079E 00	0.32769E 08	0.21892E 08	0.38878E 02	0.46466E 02	67.50
0.21064E 02	0.29000E 02	0.23299E 02	0.72637E 00	0.90407E 00	0.32769E 08	0.21892E 08	0.40354E 02	0.48636E 02	45.00
0.23129E 02	0.28500E 02	0.23799E 02	0.81154E 00	0.97180E 00	0.32234E 08	0.22367E 08	0.45065E 02	0.52289E 02	22.50
0.23353E 02	0.28000E 02	0.24299E 02	0.83405E 00	0.96105E 00	0.31639E 08	0.22837E 08	0.46336E 02	0.51702E 02	0.00
0.16669E 02	0.26500E 02	0.20500E 02	0.62902E 00	0.81312E 00	0.30107E 08	0.19891E 08	0.34945E 02	0.44022E 02	90.00
0.19047E 02	0.26500E 02	0.20500E 02	0.71877E 00	0.92915E 00	0.30107E 08	0.19891E 08	0.39732E 02	0.50304E 02	67.50
0.18686E 02	0.26500E 02	0.20500E 02	0.70514E 00	0.91152E 00	0.30107E 08	0.19891E 08	0.39174E 02	0.49350E 02	45.00
0.21205E 02	0.26000E 02	0.21000E 02	0.81559E 00	0.10097E 01	0.29539E 08	0.20376E 08	0.45310E 02	0.54673E 02	22.50
0.21928E 02	0.25500E 02	0.21500E 02	0.85994E 00	0.10199E 01	0.29127E 08	0.20861E 08	0.46063E 02	0.55219E 02	0.00
0.14100E 02	0.23000E 02	0.18200E 02	0.61305E 00	0.77474E 00	0.26554E 08	0.18330E 08	0.34282E 02	0.42213E 02	90.00
0.14513E 02	0.23000E 02	0.18200E 02	0.63101E 00	0.79743E 00	0.26554E 08	0.18330E 08	0.35287E 02	0.43450E 02	67.50
0.15054E 02	0.22500E 02	0.18700E 02	0.66909E 00	0.80506E 00	0.25977E 08	0.18833E 08	0.37416E 02	0.43865E 02	45.00
0.17343E 02	0.22000E 02	0.19200E 02	0.78831E 00	0.90328E 00	0.25430E 08	0.19337E 08	0.44083E 02	0.49217E 02	22.50
0.18022E 02	0.21500E 02	0.19700E 02	0.83826E 00	0.91486E 00	0.24954E 08	0.19962E 08	0.46876E 02	0.49848E 02	0.00
0.11572E 02	0.22500E 02	0.15199E 02	0.51433E 00	0.76134E 00	0.26530E 08	0.15775E 08	0.28761E 02	0.41751E 02	90.00
0.12664E 02	0.22000E 02	0.15699E 02	0.57565E 00	0.80664E 00	0.25940E 08	0.16234E 08	0.32191E 02	0.44235E 02	67.50
0.13434E 02	0.21500E 02	0.16200E 02	0.62484E 00	0.82726E 00	0.25351E 08	0.16813E 08	0.34741E 02	0.45475E 02	45.00
0.15499E 02	0.21000E 02	0.16700E 02	0.73807E 00	0.92812E 00	0.24761E 08	0.17435E 08	0.41274E 02	0.50997E 02	22.50
0.16460E 02	0.21000E 02	0.16700E 02	0.78383E 00	0.98566E 00	0.24761E 08	0.17435E 08	0.43832E 02	0.54052E 02	0.00
0.10489E 02	0.20000E 02	0.14000E 02	0.52448E 00	0.74927E 00	0.23950E 08	0.14874E 08	0.29524E 02	0.41088E 02	90.00
0.12726E 02	0.20000E 02	0.14000E 02	0.63631E 00	0.90901E 00	0.23950E 08	0.14874E 08	0.35818E 02	0.49847E 02	67.50
0.12437E 02	0.19000E 02	0.15000E 02	0.65461E 00	0.82917E 00	0.22753E 08	0.15936E 08	0.36849E 02	0.45470E 02	45.00
0.13629E 02	0.19000E 02	0.15000E 02	0.71734E 00	0.90864E 00	0.22753E 08	0.15936E 08	0.40380E 02	0.49828E 02	22.50
0.14025E 02	0.19000E 02	0.15000E 02	0.73819E 00	0.93505E 00	0.22753E 08	0.15936E 08	0.41554E 02	0.51277E 02	0.00
0.28221E 02	0.38000E 02	0.28799E 02	0.74267E 00	0.97992E 00	0.41539E 08	0.24761E 08	0.40991E 02	0.52058E 02	90.00
0.30262E 02	0.37500E 02	0.29299E 02	0.80700E 00	0.10328E 01	0.41223E 08	0.25191E 08	0.44542E 02	0.54679E 02	67.50
0.28994E 02	0.37500E 02	0.29299E 02	0.77317E 00	0.98958E 00	0.41223E 08	0.25191E 08	0.42676E 02	0.52571E 02	45.00
0.29268E 02	0.36500E 02	0.30299E 02	0.80186E 00	0.96594E 00	0.40123E 08	0.26237E 08	0.44258E 02	0.51315E 02	22.50
0.30187E 02	0.36500E 02	0.30299E 02	0.82705E 00	0.99629E 00	0.40123E 08	0.26237E 08	0.45649E 02	0.52928E 02	0.00
0.20797E 02	0.31500E 02	0.20699E 02	0.66024E 00	0.10047E 01	0.35401E 08	0.19322E 08	0.36680E 02	0.54551E 02	90.00
0.22051E 02	0.31000E 02	0.21199E 02	0.71134E 00	0.10401E 01	0.34839E 08	0.19789E 08	0.39519E 02	0.55959E 02	67.50
0.20917E 02	0.31000E 02	0.21199E 02	0.67476E 00	0.98668E 00	0.34839E 08	0.19789E 08	0.37486E 02	0.53081E 02	45.00
0.20903E 02	0.30500E 02	0.21699E 02	0.68535E 00	0.96328E 00	0.34464E 08	0.20389E 08	0.38075E 02	0.51822E 02	22.50
0.21604E 02	0.30000E 02	0.22199E 02	0.72015E 00	0.97317E 00	0.33899E 08	0.20859E 08	0.40008E 02	0.52354E 02	0.00
0.15900E 02	0.26000E 02	0.16700E 02	0.61153E 00	0.95209E 00	0.29699E 08	0.16511E 08	0.34197E 02	0.51546E 02	90.00
0.16814E 02	0.25500E 02	0.17200E 02	0.65939E 00	0.97758E 00	0.29127E 08	0.17006E 08	0.36873E 02	0.52926E 02	67.50
0.16719E 02	0.25500E 02	0.17200E 02	0.65566E 00	0.97206E 00	0.29127E 08	0.17006E 08	0.36665E 02	0.52627E 02	45.00
0.17534E 02	0.25000E 02	0.17700E 02	0.70138E 00	0.99065E 00	0.28556E 08	0.17500E 08	0.39222E 02	0.54534E 02	22.50
0.18067E 02	0.25000E 02	0.17700E 02	0.72270E 00	0.10207E 01	0.28556E 08	0.17500E 08	0.40414E 02	0.55264E 02	0.00
0.12649E 02	0.22500E 02	0.15500E 02	0.56220E 00	0.81610E 00	0.26530E 08	0.15087E 08	0.31439E 02	0.44754E 02	90.00
0.14637E 02	0.22500E 02	0.15500E 02	0.65055E 00	0.94435E 00	0.26530E 08	0.16087E 08	0.36379E 02	0.51787E 02	67.50
0.13641E 02	0.22500E 02	0.15500E 02	0.60630E 00	0.88011E 00	0.26530E 08	0.16087E 08	0.33705E 02	0.48254E 02	45.00
0.13449E 02	0.22500E 02	0.15500E 02	0.59773E 00	0.86767E 00	0.26530E 08	0.16087E 08	0.33425E 02	0.47582E 02	22.50
0.13625E 02	0.22000E 02	0.16000E 02	0.61933E 00	0.85158E 00	0.25940E 08	0.16605E 08	0.34433E 02	0.45597E 02	0.00

(NUSSELT) / (GRASHOF)**0.25 NUMBER VERSUS POLAR ANGLE (INTERIOR)

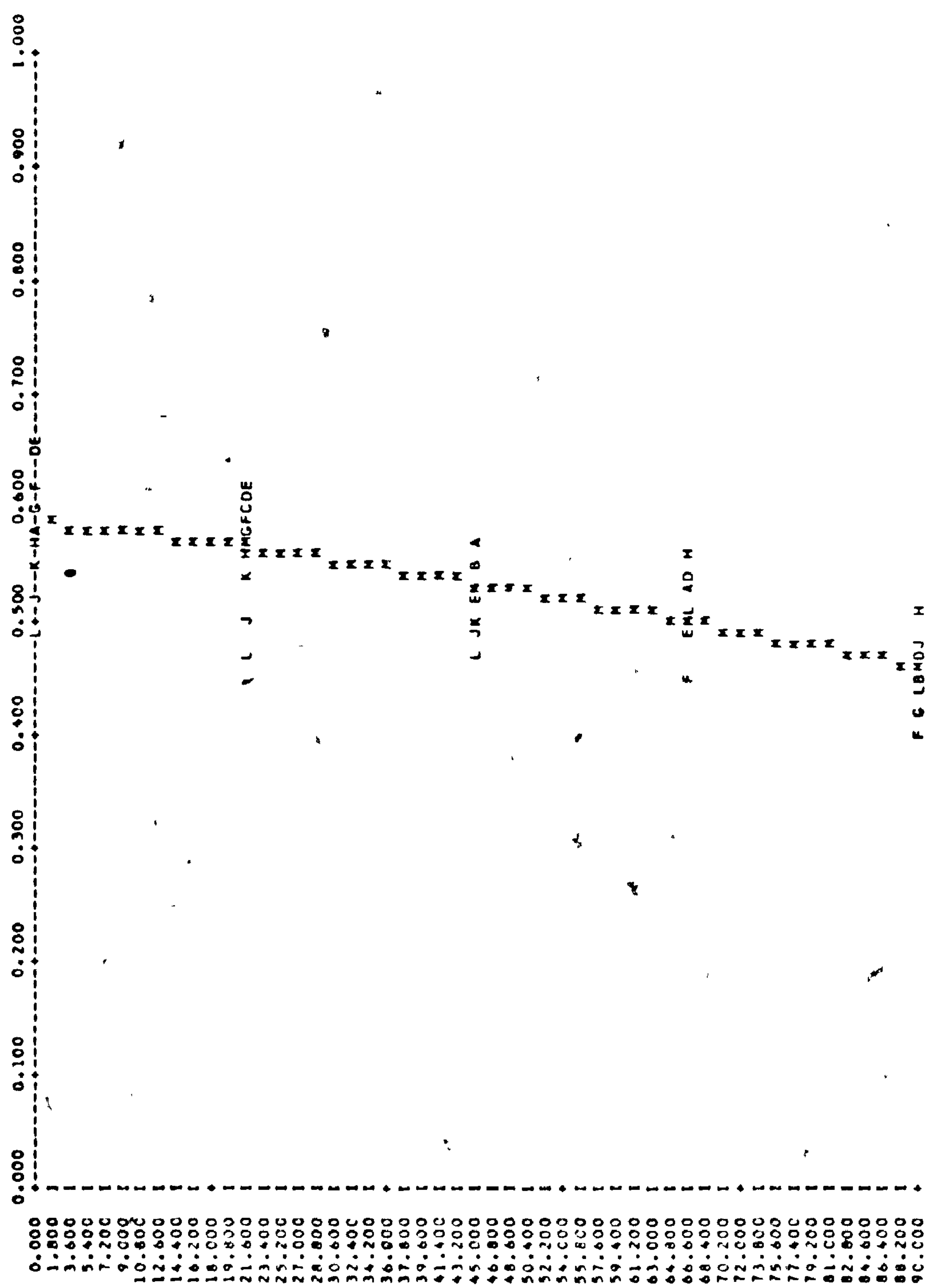


(NUSSELT) / (GRASHOF)**0.25 NUMBER VERSUS POLAR ANGLE (EXTERIOR)




0.000 0.100 0.200 0.300 0.400 0.500 0.600 0.700 0.800 0.900 1.000
0.000 1.800 3.600 5.400 7.200 9.000 10.800 12.800 14.400 16.200 18.000 19.800 21.600 23.400 25.200 27.000 28.800 30.600 32.400 34.200 36.000 37.800 39.600 41.400 43.200 45.000 46.900 48.600 50.400 52.200 54.000 55.800 57.600 59.400 61.200 63.000 64.800 66.600 68.400 70.200 72.000 73.800 75.600 77.400 79.200 81.000 82.800 84.600 86.400 88.200 90.000

113512



113511

E-2 Sample Calculation

Using test number 1 at 90° polar angle:

$Q/A = 66.59\ \mu V$

Heat flux correction factor is 2.752.

$T_\infty(I) - 147.5°F$

$T\ wall = 117.5°F$

$T_\infty(0) = 80.0°F$

The thermal conductivity of the air in the internal and the external boundary layer:

$k\ (I) = 0.0161$ BTU/hr.ft.°F

$k\ (0) = 0.0154$ BTU/hr.ft.°F

Corrected $Q/A = 66.59/2.752 = 24.197$

$$h\ (0) = (Q/A / (T\ wall - T_\infty(0))$$
$$= 24.197 / (117.5 - 80.0) = 0.645$$

$$h\ (I) = (Q/A) / (T_\infty\ (I) - T\ wall)$$
$$= 24.197 / (147.5 - 117.5) = 0.801$$

$$Nu\ (0) = h\ (0)\ R/k$$
$$= (0.645 \times (10/12)) / 0.0154 = 35.6$$

$$Nu\ (I) = h\ (I)\ R/k$$
$$= (0.801 \times (10/12) / 0.0161 = 42.3$$

$$Gr\ (0) = (\rho^2 \beta g/\mu^2) \times (T\ wall - T_\infty\ (0)) \times R^3$$
$$= 1.78 \times 10^6 \times (117.5 - 80.0) \times (10/12)^3$$
$$= 4.10 \times 10^7$$

$$Gr\ (I) = (\rho^2 \beta g/\mu^2) \times (T_\infty\ (I) - T\ wall) \times R^3$$
$$= 1.39 \times 10^6 \times (147.5 - 117.5) \times (10/12)^3$$
$$= 2.58 \times 10^7$$

$$\frac{Nu\ (0)}{Gr\ (0)^{1/4}} = 35.6\ /\ (4.10 \times 10^7)^{1/4} = 0.445$$

$$\frac{Nu\ (I)}{Gr\ (I)^{1/4}} = 42.3\ /\ (2.58 \times 10^7)^{1/4} = 0.593$$

E-3 Experimental Error Analysis

Using test number 1 at 90° polar angle.

All instrument reading errors are taken into account and accumulated for maximum possible error.

1) Heat flux sensor output in μV : ±1μV.
2) Temperature difference : 0.5° F.
3) Maximum possible error in heat flux sensor correction factor: 5%.

Maximum percent error (interior):

$Q/A = 67.59$

Heat flux sensor correction factor (2.752 x 0.95)

$T_\infty\ (I) = 147.0$

$T\ wall = 118.0$

Corrected Q/A:

$67.59\ /\ (2.752 \times 0.95) = 25.85$

$h\ (I) = (Q/A)\ /\ (T_\infty\ (I) - T\ wall)$

$= 25.85\ /\ (147.0 - 118.0) = 0.891$

The maximum error in the interior Nusselt number is:

$$\frac{0.891 - 0.801}{0.801} \times 100\% = 11\%$$

Maximum percent error (exterior):

$T\ wall = 117.0°F$

$T_\infty\ (0) = 80.5°F$

$$h(0) = (Q/A) / (T\ wall - T_\infty(0))$$

$$= 25.85 / (117.0 - 80.5) = 0.708$$

The maximum error in the exterior Nusselt number is:

$$\frac{0.708 - 0.645}{0.645} \times 100\% = 10\%$$

The maximum error in the exterior Grashof number:

$$\frac{(117.5 - 80.0) - (117.0 - 80.5)}{(117.0 - 80.5)} \times 100\% = 2.7\%$$

The maximum error in the interior Grashof number:

$$\frac{(147.5 - 117.5) - (147.0 - 118.0)}{(147.0 - 118.0)} \times 100\% = 3.4\%$$

The maximum error in the exterior NuGr number occurs when Nu is 10% high and Gr is 2.7% low:

$$\frac{1.10}{0.973^{\frac{1}{4}}} - 1 \times 100\% = 10.7\%$$

The maximum error in the interior $Nu/Gr^{\frac{1}{4}}$ number occurs when Nu is 11% high and Gr is 3.4% low:

$$\frac{1.11}{0.966^{\frac{1}{4}}} - 1 \times 100\% = 11.9\%$$

APPENDIX F

RESULTS OF FORCED CONVECTION HEAT TRANSFER EXPERIMENTS WITH THE TWENTY INCH DIAMETER MODEL

This appendix contains the computer program used to analyze the experimental data obtained from the forced convective heat transfer experiments on the twenty inch diameter rigid hollow aluminum model in the boundary layer wind tunnel. A sample calculation and an experimental error analysis is shown in Section F-2 and F-3, respectively.

F-1 Computer Program and Output

Explanation of the terms used for headings on the data sheets:

Q/A	=	Heat flux, BTU/hr.
CALIBR	=	Heat flux sensor correction factor
GRASHOF	=	$(\rho^2 \beta g/\mu^2)$ part of Grashof number
T inside	=	Interior ambient temperature, °F
T wall	=	Wall temperature, °F
T outside	=	Exterior ambient temperature, °F
AZIMUTH	=	Azimuth angle
POLAR	=	Polar angle

Explanation of Characters in graphs:

A	=	90.0° Polar angle
B	=	67.5° " "

93.4900	134.0000	100.0000	85.0000	0.1380E 07	2.6190	170	45.0
88.3500	134.0000	100.5000	85.0000	0.1380E 07	2.6240	180	45.0
93.3730	125.0000	91.5000	81.0000	0.1490E 07	2.7710	0	22.5
91.0400	126.0000	92.0000	81.5000	0.1480E 07	2.7740	10	22.5
93.7200	127.0000	93.0000	82.0000	0.1470E 07	2.7710	20	22.5
100.0300	128.0000	93.0000	82.0000	0.1460E 07	2.7620	30	22.5
96.7600	129.0000	93.5000	82.5000	0.1450E 07	2.7660	40	22.5
96.2400	130.0000	95.0000	82.5000	0.1440E 07	2.7670	50	22.5
97.2300	131.0000	95.0000	82.5000	0.1420E 07	2.7650	60	22.5
98.4000	132.0000	96.0000	81.0000	0.1410E 07	2.7640	70	22.5
96.7600	132.0000	97.0000	83.5000	0.1410E 07	2.7660	80	22.5
87.1800	132.0000	98.0000	84.0000	0.1410E 07	2.7790	90	22.5
96.2900	132.5000	98.0000	84.0000	0.1400E 07	2.7670	100	22.5
95.5900	132.5000	98.0000	84.0000	0.1400E 07	2.7680	110	22.5
87.3800	133.0000	99.0000	84.0000	0.1390E 07	2.7780	120	22.5
93.2600	133.5000	99.0000	84.5000	0.1390E 07	2.7710	130	22.5
101.9000	134.0000	99.5000	85.0000	0.1380E 07	2.7590	140	22.5
91.8500	134.0000	100.5000	85.0000	0.1380E 07	2.7730	150	22.5
93.0200	134.0000	100.5000	85.0000	0.1380E 07	2.7710	160	22.5
97.9300	134.0000	100.5000	85.0000	0.1380E 07	2.7650	170	22.5
100.2700	134.0000	100.5000	85.0000	0.1380E 07	2.7610	180	22.5
60.3000	125.0000	94.0000	81.0000	0.1490E 07	2.6270	0	0.0
59.6000	126.0000	94.5000	81.5000	0.1480E 07	2.6280	10	0.0
59.8300	127.0000	96.0000	82.0000	0.1470E 07	2.6280	20	0.0
64.2700	128.0000	96.0000	82.0000	0.1460E 07	2.6240	30	0.0
62.1700	129.0000	97.0000	82.5000	0.1450E 07	2.6250	40	0.0
63.8100	130.0000	98.0000	82.5000	0.1440E 07	2.6250	50	0.0
60.7700	131.0000	98.0000	82.5000	0.1420E 07	2.6270	60	0.0
61.6500	132.0000	99.5000	83.0000	0.1410E 07	2.6270	70	0.0
71.2900	132.0000	100.0000	83.5000	0.1410E 07	2.6190	80	0.0
63.5700	132.0000	100.0000	84.0000	0.1410E 07	2.6250	90	0.0
61.0000	132.5000	100.0000	84.0000	0.1400E 07	2.6270	100	0.0
63.5700	132.5000	101.0000	84.0000	0.1400E 07	2.6250	110	0.0
63.5700	133.0000	102.0000	84.0000	0.1390E 07	2.6250	120	0.0
63.3400	133.5000	102.0000	84.5000	0.1390E 07	2.6250	130	0.0
66.8400	134.0000	103.0000	85.0000	0.1380E 07	2.6220	140	0.0
65.4400	134.0000	103.0000	85.0000	0.1380E 07	2.6240	150	0.0
69.8800	134.0000	103.0000	85.0000	0.1380E 07	2.6200	160	0.0
65.4400	134.0000	103.0000	85.0000	0.1380E 07	2.6240	170	0.0
75.0300	134.0000	103.5000	85.0000	0.1380E 07	2.6150	180	0.0

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PAGE   1

// JOB    1111

LOG DRIVE   CART SPEC   CART AVAIL  PHY DRIVE
  0000        1111        1111        0000

V2 M11   ACTUAL  8K  CONFIG  8K

// FOR
* IOCS (CARD,1403 PRINTER)
* ONE WORD INTEGERS
* LIST SOURCE PROGRAM
C
C      20 INCH DIAMETER THIN WALLED ALUMINUM DOME
C
C      ANALYSIS OF FORCED CONVECTION HEAT TRANSFER
C
       DIMENSION FLUX(19,5),HI(19,5),HO(19,5),ANUI(19,5),MWH(10)
       DIMENSION ANUO(19,5),RE(19,5),GRRI(19,5),XNOGI(95),X(95)
       DIMENSION XNORE(95)
       RAD=0.85
       DIAM=1.70
       DO 10 II = 1,4
       WRITE (5,105)
C
C      ENTER BOUNDARY LAYER WINDTUNNEL WINDSPEED
C
       READ(2,100)WINR
  100  FORMAT(F10.5)
       VINF=29.917*SQRT(WINR)
       WRITE (5,97) VINF
   97  FORMAT('   THE TUNNEL WINDSPEED IS',F5.1,' FT/SEC.',//)
       J=0
       WRITE (5,98)
   98  FORMAT ('    Q / A    T INSIDE    T WALL    T OUTSIDE',
      1'    GRASHOF    CALIBR.   AZIMUTH    POLAR',/)
C
C      ENTER ALL DATA
C
       DO 15 N=1,5
       DO 25 M=1,19
       M1 = (M-1)*10
       X1 = 90.0-(N-1)*22.5
       READ(2,101)CHART,TII,TW,TIO,GRI,FAC
  101  FORMAT(4F10.4,E10.4,F10.4)
       WRITE (5,99)CHART,TII,TW,TIO,GRI,FAC,M1,X1
   99  FORMAT (4F10.4,2X,E10.4,F10.4,I6,F10.1)
       FLUX(M,N)=CHART/FAC
  105  FORMAT(1H1)
       RHOC=((14.358*144.)/(53.35*(460.+TIO)))
       HI(M,N)=FLUX(M,N)/(TII-TW)
       HO(M,N)=FLUX(M,N)/(TW-TIO)
       TAVI=(TII+TW)/2.
       TAVO=(TW+TIO)/2.
       TCI=(TAVI-32.)*(0.0154-0.0140)/(100.-32.)+0.0140
       TCO=(TAVO-32.)*(0.0154-0.0140)/(100.-32.)+0.0140
C
C      CALCULATION OF DIMENSIONLESS QUANTITIES
C      INTERIOR NUSSELT NUMBER
```

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```
      ANUI(M,N)=HI(M,N)*RAD/TCI
C     EXTERIOR NUSSELT NUMBER
      ANUO(M,N)=HO(M,N)*DIAM/TCO
      AMUF=1.285E-05 -(1.285E-05-1.165E-05)*(100.-TAVO)/
     1(100.-32.)
C     EXTERIOR REYNOLDS NUMBER
      RE(M,N)=RHOO*DIAM*VINF/AMUF
C     INTERIOR GRASHOF NUMBER
      GRRI (M,N) = GRI*(TII-TW)*RAD**3
      J=J+1
C     INTERIOR (NUSSELT)/(GRASHOF)**0.25 NUMBER
      XNOGI(J)=ANUI(M,N)/(GRRI(M,N)**0.25)
C     EXTERIOR (NUSSELT)/(REYNOLDS)**0.334 NUMBER
      XNORE(J) =ANUO(M,N)/(RE(M,N)**0.334)
   25 X(J)=(M-1)*10
   15 MWH(N)=J
      N=N+1
      WRITE(5,105)
C
C     PLOT (NUSSELT)/(REYNOLDS)**0.334 NUMBER VERSUS
C     AZIMUTH ANGLE
C
      WRITE (5,97) VINF
      WRITE (5,103)
  103 FORMAT (30X,'(NUSSELT)/(REYNOLDS)**0.334 NUMBER VERSUS',
     1' AZIMUTH ANGLE')
      CALL CURV9(X,XNORE,0.0,180.0,0.0,10.0,J,0,MWH,N)
      WRITE(5,105)
C
C     PLOT (NUSSELT)/(GRASHOF)**0.25 NUMBER VERSUS
C     AZIMUTH ANLE
C
      WRITE (5,97) VINF
      WRITE (5,104)
  104 FORMAT (30X,'(NUSSELT)/(GRASHOF)**0.25 NUMBER VERSUS',
     1' AZIMUTH ANGLE')
      CALL CURV9(X,XNOGI,0.0,180.0,0.0,1.0,J,0,MWH,N)
   10 CONTINUE
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
 IOCS

CORE REQUIREMENTS FOR
 COMMON       0  VARIABLES    1956  PROGRAM     660

END OF COMPILATION

// XEQ
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10333

THE TUNNEL WINDSPEED IS 20.1 FT/SEC.

Q / A	T INSIDE	T WALL	T OUTSIDE	GRASHOF	CALIBR.	AZIMUTH	POLAR
81.9200	125.0000	95.5000	81.0000	0.1490E 07	2.7250	0	90.0
85.0800	126.0000	96.0000	81.5000	0.1480E 07	2.7200	10	90.0
90.9100	127.0000	96.5000	82.0000	0.1470E 07	2.7120	20	90.0
89.9800	128.0000	97.0000	82.0000	0.1460E 07	2.7130	30	90.0
88.8100	129.0000	97.0000	82.5000	0.1450E 07	2.7150	40	90.0
97.2300	130.0000	98.0000	82.5000	0.1440E 07	2.7030	50	90.0
93.0200	131.0000	97.0000	82.5000	0.1420E 07	2.7080	60	90.0
91.6200	132.0000	98.0000	83.0000	0.1410E 07	2.7110	70	90.0
92.3200	132.0000	98.5000	83.5000	0.1410E 07	2.7090	80	90.0
90.2200	132.0000	98.5000	84.0000	0.1410E 07	2.7120	90	90.0
86.9400	132.5000	98.5000	84.0000	0.1400E 07	2.7190	100	90.0
89.0500	132.5000	98.5000	84.0000	0.1400E 07	2.7140	110	90.0
89.2800	133.0000	99.0000	84.0000	0.1390E 07	2.7140	120	90.0
91.3900	133.5000	99.0000	84.5000	0.1390E 07	2.7110	130	90.0
91.1500	134.0000	100.0000	85.0000	0.1380E 07	2.7110	140	90.0
90.4500	134.0000	100.0000	85.0000	0.1380E 07	2.7120	150	90.0
90.6800	134.0000	100.0000	85.0000	0.1380E 07	2.7120	160	90.0
93.2600	134.0000	100.5000	85.0000	0.1380E 07	2.7080	170	90.0
90.9200	134.0000	100.5000	85.0000	0.1380E 07	2.7120	180	90.0
82.8500	125.0000	93.0000	81.0000	0.1490E 07	2.5030	0	67.5
86.0100	126.0000	93.5000	81.5000	0.1480E 07	2.4970	10	67.5
81.4500	127.0000	94.5000	82.0000	0.1470E 07	2.5040	20	67.5
81.3400	128.0000	94.0000	82.0000	0.1460E 07	2.5040	30	67.5
90.6800	129.0000	95.0000	82.5000	0.1450E 07	2.4890	40	67.5
86.4800	130.0000	96.0000	82.5000	0.1440E 07	2.4960	50	67.5
89.0500	131.0000	96.0000	82.5000	0.1420E 07	2.4910	60	67.5
86.2400	132.0000	96.5000	83.0000	0.1410E 07	2.4960	70	67.5
87.8800	132.0000	97.0000	83.5000	0.1410E 07	2.4940	80	67.5
88.8100	132.0000	97.5000	84.0000	0.1410E 07	2.4920	90	67.5
89.9800	132.5000	97.5000	84.0000	0.1400E 07	2.4900	100	67.5
82.9700	132.5000	97.5000	84.0000	0.1400E 07	2.5020	110	67.5
85.0800	133.0000	98.0000	84.0000	0.1390E 07	2.4980	120	67.5
84.6100	133.5000	98.0000	84.5000	0.1390E 07	2.4990	130	67.5
86.9400	134.0000	98.5000	85.0000	0.1380E 07	2.4950	140	67.5
84.6100	134.0000	98.0000	85.0000	0.1380E 07	2.4990	150	67.5
91.6200	134.0000	98.5000	85.0000	0.1380E 07	2.4880	160	67.5
91.3900	134.0000	98.5000	85.0000	0.1380E 07	2.4870	170	67.5
88.3500	134.0000	99.0000	85.0000	0.1380E 07	2.4920	180	67.5
85.1900	125.0000	92.0000	81.0000	0.1490E 07	2.6270	0	45.0
82.7400	126.0000	93.0000	81.5000	0.1480E 07	2.6290	10	45.0
87.8800	127.0000	94.0000	82.0000	0.1470E 07	2.6240	20	45.0
95.5900	128.0000	94.0000	82.0000	0.1460E 07	2.6170	30	45.0
84.1400	129.0000	95.0000	82.5000	0.1450E 07	2.6280	40	45.0
91.6200	130.0000	96.0000	82.5000	0.1440E 07	2.6200	50	45.0
91.8500	131.0000	96.0000	82.5000	0.1420E 07	2.6200	60	45.0
89.0500	132.0000	96.5000	83.0000	0.1410E 07	2.6240	70	45.0
86.9400	132.0000	98.0000	83.5000	0.1410E 07	2.6260	80	45.0
86.2400	132.0000	98.0000	84.0000	0.1410E 07	2.6270	90	45.0
89.0500	132.5000	98.0000	84.0000	0.1400E 07	2.6230	100	45.0
86.2400	132.5000	98.0000	84.0000	0.1400E 07	2.6260	110	45.0
86.4800	133.0000	99.0000	84.0000	0.1390E 07	2.6260	120	45.0
92.3200	133.5000	98.0000	84.5000	0.1390E 07	2.6200	130	45.0
91.3900	134.0000	99.0000	85.0000	0.1380E 07	2.6210	140	45.0
88.1100	134.0000	99.5000	85.0000	0.1380E 07	2.6240	150	45.0
94.6600	134.0000	100.0000	85.0000	0.1380E 07	2.6170	160	45.0

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93.4900	134.0000	100.0000	85.0000	0.1380E 07	2.6190	170	45.0
88.3500	134.0000	100.5000	85.0000	0.1380E 07	2.6240	180	45.0
93.3700	125.0000	91.5000	81.0000	0.1490E 07	2.7710	0	22.5
91.0400	126.0000	92.0000	81.5000	0.1480E 07	2.7740	10	22.5
93.7200	127.0000	93.0000	82.0000	0.1470E 07	2.7710	20	22.5
100.0300	128.0000	93.0000	82.0000	0.1460E 07	2.7620	30	22.5
96.7600	129.0000	93.5000	82.5000	0.1450E 07	2.7660	40	22.5
96.2400	130.0000	95.0000	82.5000	0.1440E 07	2.7670	50	22.5
97.2300	131.0000	95.0000	82.5000	0.1420E 07	2.7650	60	22.5
98.4000	132.0000	96.0000	81.0000	0.1410E 07	2.7640	70	22.5
96.7600	132.0000	97.0000	83.5000	0.1410E 07	2.7660	80	22.5
87.1800	132.0000	98.0000	84.0000	0.1410E 07	2.7790	90	22.5
96.2900	132.5000	98.0000	84.0000	0.1400E 07	2.7670	100	22.5
95.5900	132.5000	98.0000	84.0000	0.1400E 07	2.7680	110	22.5
87.8800	133.0000	99.0000	84.0000	0.1390E 07	2.7780	120	22.5
93.2600	133.5000	99.0000	84.5000	0.1390E 07	2.7710	130	22.5
101.9000	134.0000	99.5000	85.0000	0.1380E 07	2.7590	140	22.5
91.8500	134.0000	100.5000	85.0000	0.1380E 07	2.7730	150	22.5
93.0200	134.0000	100.5000	85.0000	0.1380E 07	2.7710	160	22.5
97.9300	134.0000	100.5000	85.0000	0.1380E 07	2.7650	170	22.5
100.2700	134.0000	100.5000	85.0000	0.1380E 07	2.7610	180	22.5
60.3000	125.0000	94.0000	81.0000	0.1490E 07	2.6270	0	0.0
59.6000	126.0000	94.5000	81.5000	0.1480E 07	2.6280	10	0.0
59.8300	127.0000	96.0000	82.0000	0.1470E 07	2.6280	20	0.0
64.2700	128.0000	96.0000	82.0000	0.1460E 07	2.6240	30	0.0
62.1700	129.0000	97.0000	82.5000	0.1450E 07	2.6250	40	0.0
63.8100	130.0000	98.0000	82.5000	0.1440E 07	2.6250	50	0.0
60.7700	131.0000	98.0000	82.5000	0.1420E 07	2.5270	60	0.0
61.6500	132.0000	99.5000	83.0000	0.1410E 07	2.6270	70	0.0
71.2900	132.0000	100.0000	83.5000	0.1410E 07	2.6190	80	0.0
63.5700	132.0000	100.0000	84.0000	0.1410E 07	2.6250	90	0.0
61.0000	132.5000	100.0000	84.0000	0.1400E 07	2.6270	100	0.0
63.5700	132.5000	101.0000	84.0000	0.1400E 07	2.6250	110	0.0
63.5700	133.0000	102.0000	84.0000	0.1390E 07	2.6250	120	0.0
63.3400	133.5000	102.0000	84.5000	0.1390E 07	2.6250	130	0.0
66.8400	134.0000	103.0000	85.0000	0.1380E 07	2.6220	140	0.0
65.4400	134.0000	103.0000	85.0000	0.1380E 07	2.6240	150	0.0
69.8800	134.0000	103.0000	85.0000	0.1380E 07	2.6200	160	0.0
65.4400	134.0000	103.0000	85.0000	0.1360E 07	2.6240	170	0.0
75.0300	134.0000	103.5000	85.0000	0.1380E 07	2.6150	180	0.0

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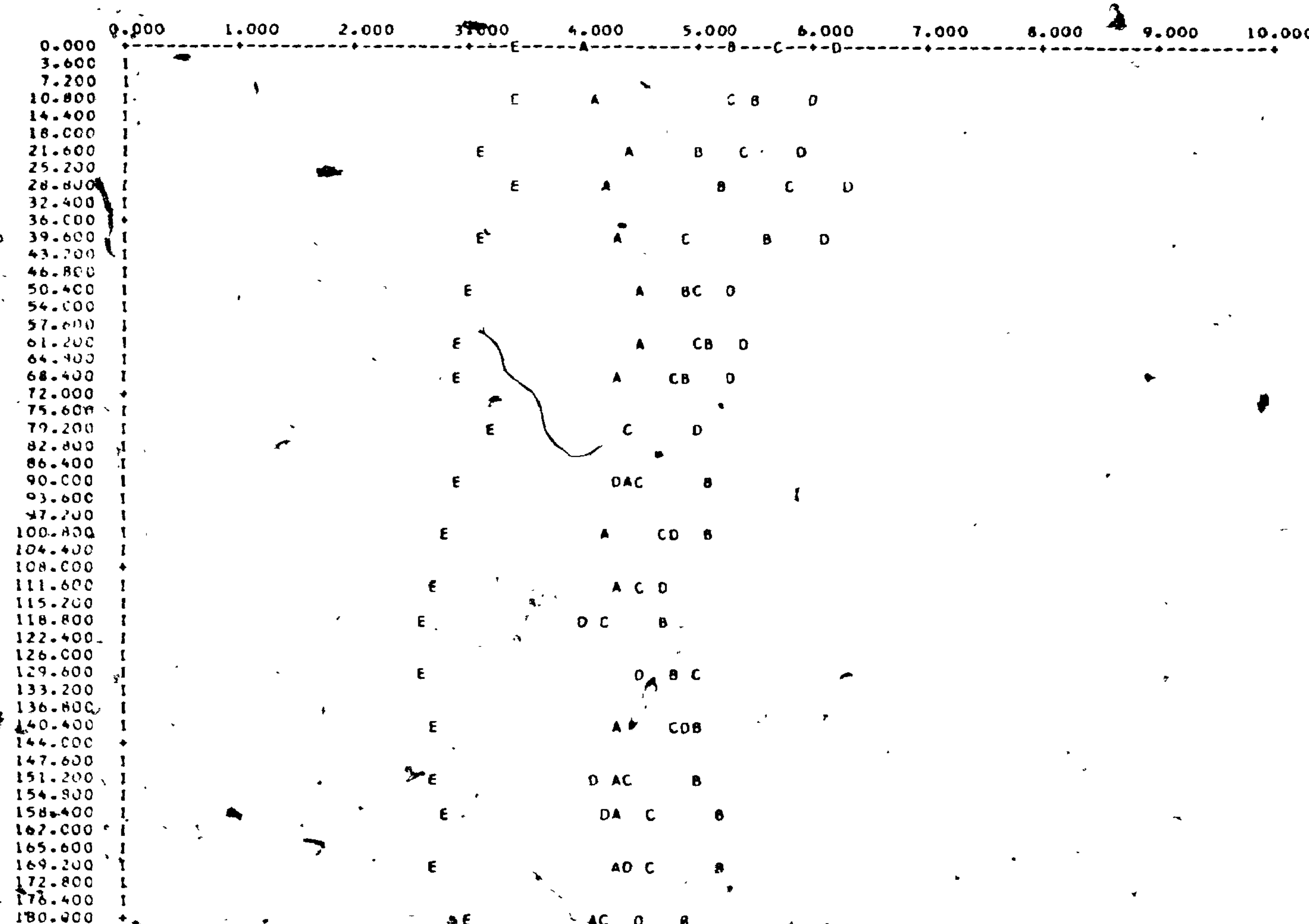
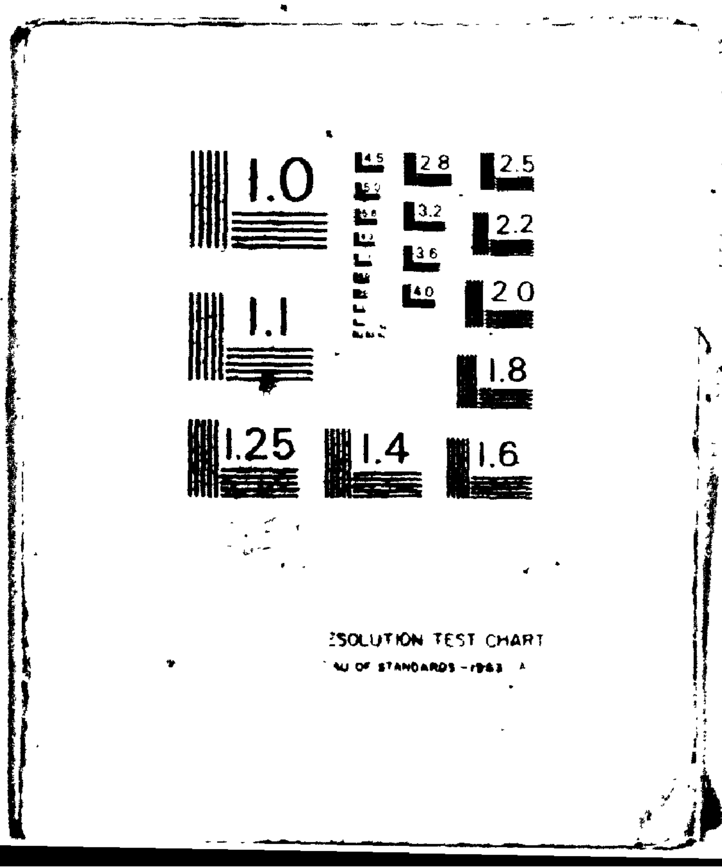
THE TUNNEL WINDSPEED IS 20.1 FT/SEC.

(NUSSELT)/(REYNOLDS)**0.334 NUMBER VERSUS AZIMUTH ANGLE

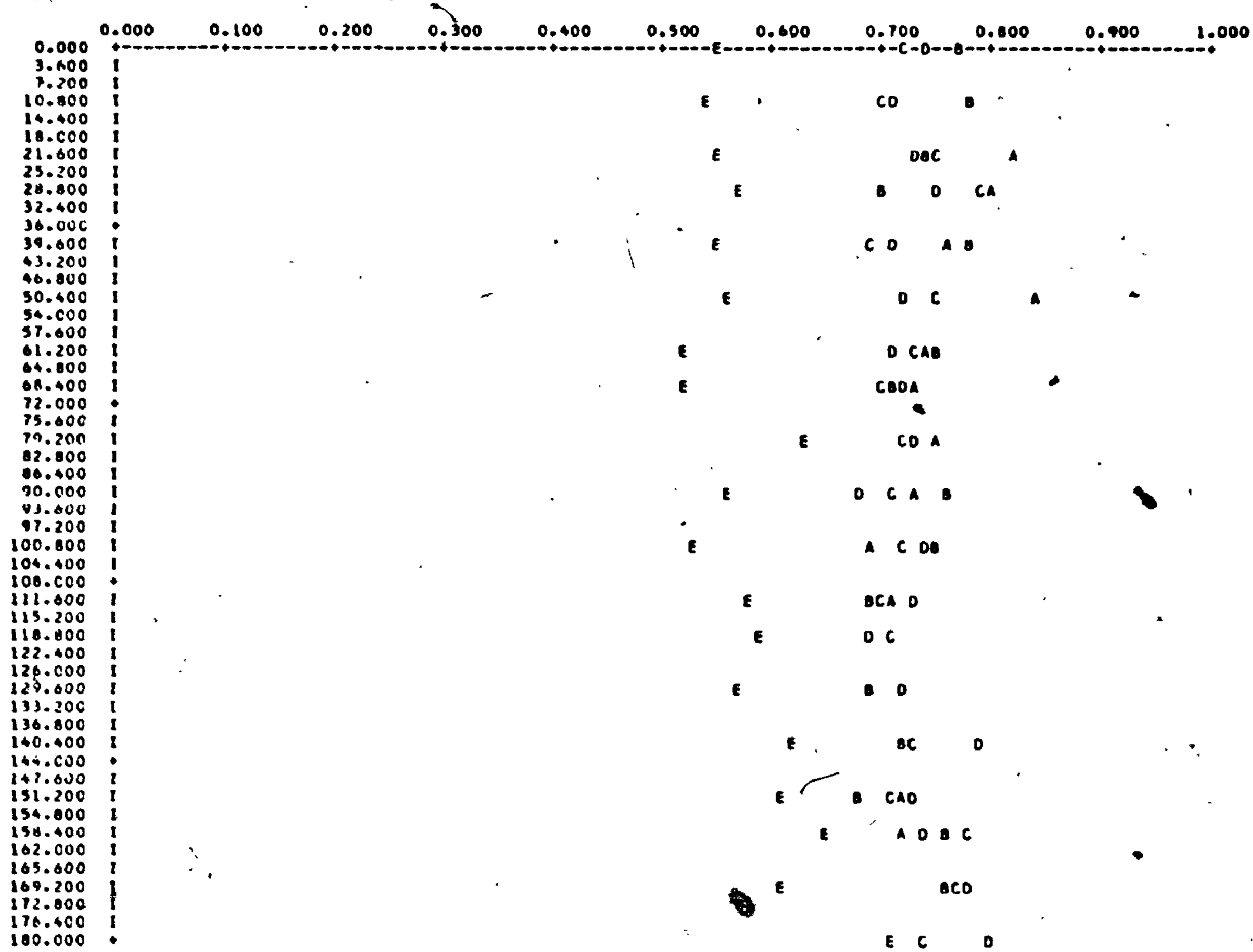


3



THE TUNNEL WINDSPEED IS 20.1 FT/SEC.

(NUSSELT)/(GRASHOF)**0.25 NUMBER VERSUS AZIMUTH ANGLE



10337

THE TUNNEL WINDSPEED IS 30.0 FT/SEC.

Q / A	T INSIDE	T WALL	T OUTSIDE	GRASHOF	CALIBR.	AZIMUTH	POLAR
126.6800	135.0000	96.5000	78.0000	0.1370E 07	2.6740	0	90.0
117.1000	135.0000	96.5000	78.0000	0.1370E 07	2.6820	10	90.0
117.5600	135.5000	97.0000	78.5000	0.1370E 07	2.6820	20	90.0
117.1000	135.5000	97.0000	79.5000	0.1370E 07	2.6820	30	90.0
123.8700	135.5000	97.0000	79.5000	0.1370E 07	2.6760	40	90.0
109.6200	135.5000	98.0000	80.0000	0.1370E 07	2.6890	50	90.0
122.2400	136.0000	97.5000	80.0000	0.1360E 07	2.6780	60	90.0
116.1600	136.5000	98.0000	80.5000	0.1360E 07	2.6830	70	90.0
121.3000	136.5000	98.0000	81.5000	0.1360E 07	2.6780	80	90.0
114.3200	136.5000	98.0000	81.5000	0.1360E 07	2.6850	90	90.0
108.1800	136.5000	98.0000	82.0000	0.1360E 07	2.6910	100	90.0
111.5900	136.5000	98.0000	82.0000	0.1360E 07	2.6870	110	90.0
102.7300	136.5000	98.0000	82.5000	0.1360E 07	2.6970	120	90.0
104.5500	136.5000	99.0000	82.5000	0.1360E 07	2.6950	130	90.0
107.2700	136.5000	98.5000	83.0000	0.1360E 07	2.6920	140	90.0
104.7700	136.5000	98.5000	83.5000	0.1360E 07	2.6940	150	90.0
110.2300	137.0000	99.0000	83.5000	0.1350E 07	2.6880	160	90.0
109.0900	137.0000	99.0000	84.0000	0.1350E 07	2.6900	170	90.0
104.7700	137.0000	98.5000	84.0000	0.1350E 07	2.6940	180	90.0
111.9500	135.0000	91.0000	78.0000	0.1370E 07	2.4510	0	67.5
114.9900	135.0000	91.5000	78.0000	0.1370E 07	2.4540	10	67.5
117.1000	135.5000	92.0000	78.5000	0.1370E 07	2.4500	20	67.5
108.9100	135.5000	92.5000	79.5000	0.1370E 07	2.4620	30	67.5
113.8200	135.5000	93.0000	79.5000	0.1370E 07	2.4550	40	67.5
104.2400	135.5000	93.0000	80.0000	0.1370E 07	2.4680	50	67.5
112.4200	136.0000	94.0000	80.0000	0.1360E 07	2.4570	60	67.5
113.3600	136.5000	94.5000	80.5000	0.1360E 07	2.4560	70	67.5
107.2800	136.5000	95.0000	81.5000	0.1360E 07	2.4640	80	67.5
109.7700	136.5000	95.0000	81.5000	0.1360E 07	2.4600	90	67.5
106.3600	136.5000	95.0000	82.0000	0.1360E 07	2.4650	100	67.5
104.7700	136.5000	95.5000	82.0000	0.1360E 07	2.4670	110	67.5
105.9100	136.5000	96.0000	82.5000	0.1360E 07	2.4660	120	67.5
105.2300	136.5000	96.0000	82.5000	0.1360E 07	2.4670	130	67.5
98.6400	136.5000	96.0000	83.0000	0.1360E 07	2.4760	140	67.5
104.0900	136.5000	96.0000	83.5000	0.1360E 07	2.4680	150	67.5
97.7300	137.0000	96.0000	83.5000	0.1350E 07	2.4780	160	67.5
103.8600	137.0000	96.5000	84.0000	0.1350E 07	2.4690	170	67.5
106.1400	137.0000	96.5000	84.0000	0.1350E 07	2.4650	180	67.5
122.9400	135.0000	91.0000	78.0000	0.1370E 07	2.5850	0	45.0
120.1300	135.0000	91.5000	78.0000	0.1370E 07	2.5880	10	45.0
119.2000	135.5000	92.0000	78.5000	0.1370E 07	2.5890	20	45.0
117.5600	135.5000	92.0000	79.5000	0.1370E 07	2.5910	30	45.0
115.9300	135.5000	92.5000	79.5000	0.1370E 07	2.5930	40	45.0
107.9800	135.5000	93.5000	80.0000	0.1370E 07	2.6020	50	45.0
112.1900	136.0000	94.0000	80.0000	0.1360E 07	2.5970	60	45.0
106.1100	136.5000	95.0000	80.5000	0.1360E 07	2.6040	70	45.0
111.9500	136.5000	95.5000	81.5000	0.1360E 07	2.5980	80	45.0
105.6800	136.5000	96.0000	81.5000	0.1360E 07	2.6050	90	45.0
100.4500	136.5000	96.0000	82.0000	0.1360E 07	2.6110	100	45.0
103.1800	136.5000	96.0000	82.0000	0.1360E 07	2.6080	110	45.0
105.6800	136.5000	97.0000	82.5000	0.1360E 07	2.6050	120	45.0
103.1800	136.5000	96.5000	82.5000	0.1360E 07	2.6080	130	45.0
103.8600	136.5000	96.0000	83.0000	0.1360E 07	2.6070	140	45.0
101.5900	136.5000	96.5000	83.5000	0.1360E 07	2.6100	150	45.0
104.5500	137.0000	97.0000	83.5000	0.1350E 07	2.6060	160	45.0

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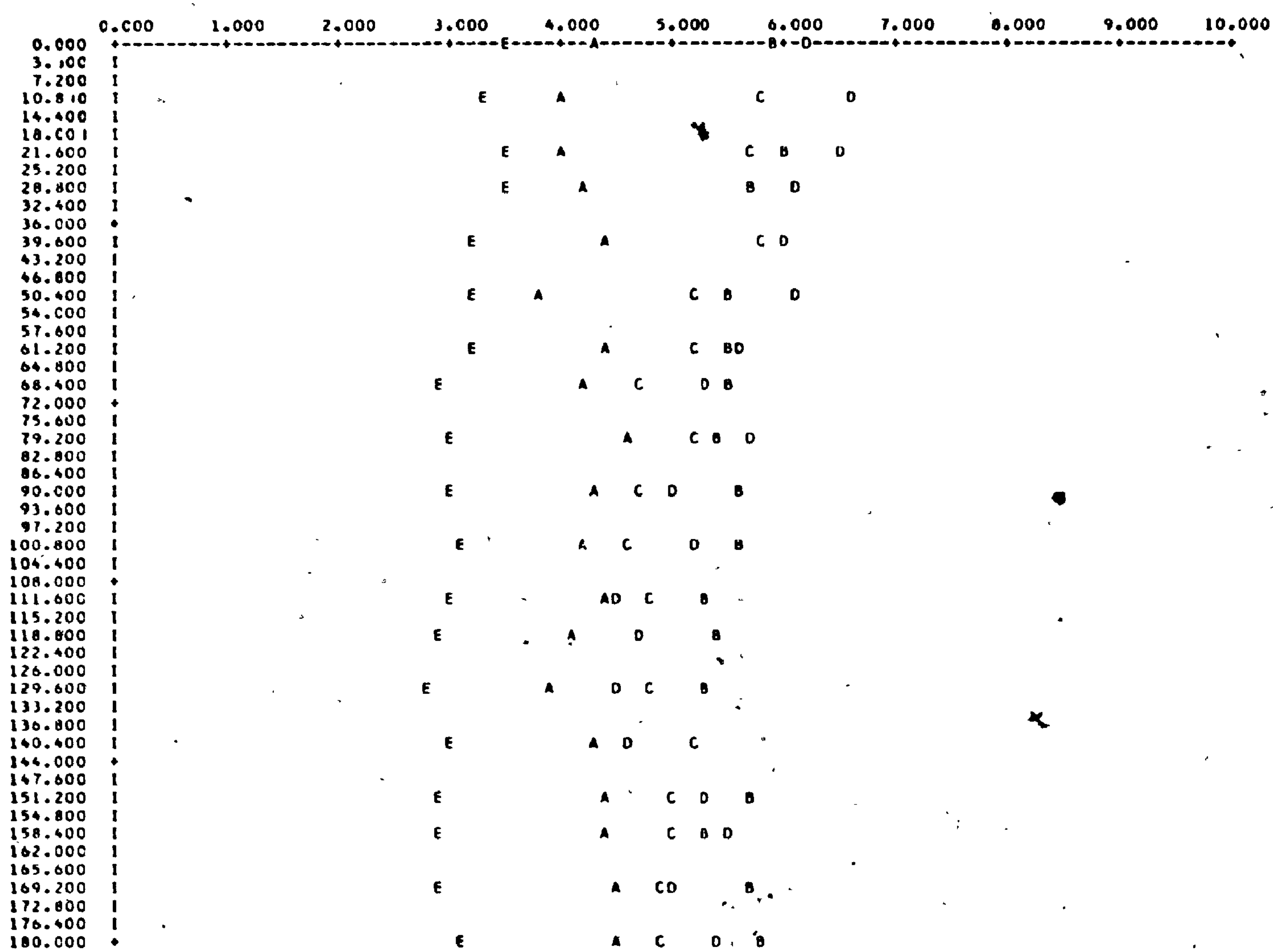
107.0500	137.0000	98.0000	84.0000	0.1350E 07	2.6030	170	45.0
105.2300	137.0000	98.0000	84.0000	0.1350E 07	2.6050	180	45.0
120.8300	135.0000	90.0000	78.0000	0.1370E 07	2.7340	0	22.5
127.3800	135.0000	90.0000	78.0000	0.1370E 07	2.7260	10	22.5
126.6800	135.5000	90.5000	78.5000	0.1370E 07	2.7270	20	22.5
119.2000	135.5000	91.5000	79.5000	0.1370E 07	2.7360	30	22.5
121.5400	135.5000	92.0000	79.5000	0.1370E 07	2.7330	40	22.5
123.1700	135.5000	92.5000	80.0000	0.1370E 07	2.7310	50	22.5
117.8000	136.0000	93.0000	80.0000	0.1360E 07	2.7380	60	22.5
115.6900	136.5000	94.0000	80.5000	0.1360E 07	2.7410	70	22.5
120.1300	136.5000	94.5000	81.5000	0.1360E 07	2.7350	80	22.5
114.3200	136.5000	95.5000	81.5000	0.1360E 07	2.7420	90	22.5
118.8600	136.5000	96.0000	82.0000	0.1360E 07	2.7360	100	22.5
117.9500	136.5000	98.0000	82.0000	0.1360E 07	2.7380	110	22.5
111.1400	136.5000	97.0000	82.5000	0.1360E 07	2.7460	120	22.5
106.8200	136.5000	97.0000	82.5000	0.1360E 07	2.7520	130	22.5
105.4500	136.5000	97.0000	83.0000	0.1360E 07	2.7540	140	22.5
117.0500	136.5000	97.0000	83.5000	0.1360E 07	2.7390	150	22.5
125.0000	137.0000	97.5000	83.5000	0.1350E 07	2.7290	160	22.5
115.0000	137.0000	98.0000	84.0000	0.1350E 07	2.7410	170	22.5
123.4100	137.0000	98.0000	84.0000	0.1350E 07	2.7310	180	22.5
80.6300	135.0000	93.0000	78.0000	0.1370E 07	2.6100	0	0.0
78.5300	135.0000	93.5000	78.0000	0.1370E 07	2.6120	10	0.0
83.6700	135.5000	94.0000	78.5000	0.1370E 07	2.6070	20	0.0
82.2700	135.5000	94.5000	79.5000	0.1370E 07	2.6080	30	0.0
78.0600	135.5000	95.0000	79.5000	0.1370E 07	2.6120	40	0.0
79.4700	135.5000	96.0000	80.0000	0.1370E 07	2.6110	50	0.0
78.7600	136.0000	96.0000	80.0000	0.1360E 07	2.6120	60	0.0
77.1300	136.5000	97.5000	80.5000	0.1360E 07	2.6130	70	0.0
77.6000	136.5000	98.0000	81.5000	0.1360E 07	2.6130	80	0.0
77.7300	136.5000	98.0000	81.5000	0.1360E 07	2.6120	90	0.0
80.2300	136.5000	98.5000	82.0000	0.1360E 07	2.6100	100	0.0
82.2700	136.5000	99.5000	82.0000	0.1360E 07	2.6080	110	0.0
81.1400	136.5000	100.5000	82.5000	0.1360E 07	2.6090	120	0.0
77.0500	136.5000	100.5000	82.5000	0.1360E 07	2.6130	130	0.0
81.1400	136.5000	100.5000	83.0000	0.1360E 07	2.6090	140	0.0
76.5900	136.5000	100.5000	83.5000	0.1360E 07	2.6140	150	0.0
78.8600	137.0000	101.0000	83.5000	0.1350E 07	2.6110	160	0.0
79.9100	137.0000	101.0000	84.0000	0.1350E 07	2.6140	170	0.0
81.8200	137.0000	101.0000	84.0000	0.1350E 07	2.6080	180	0.0

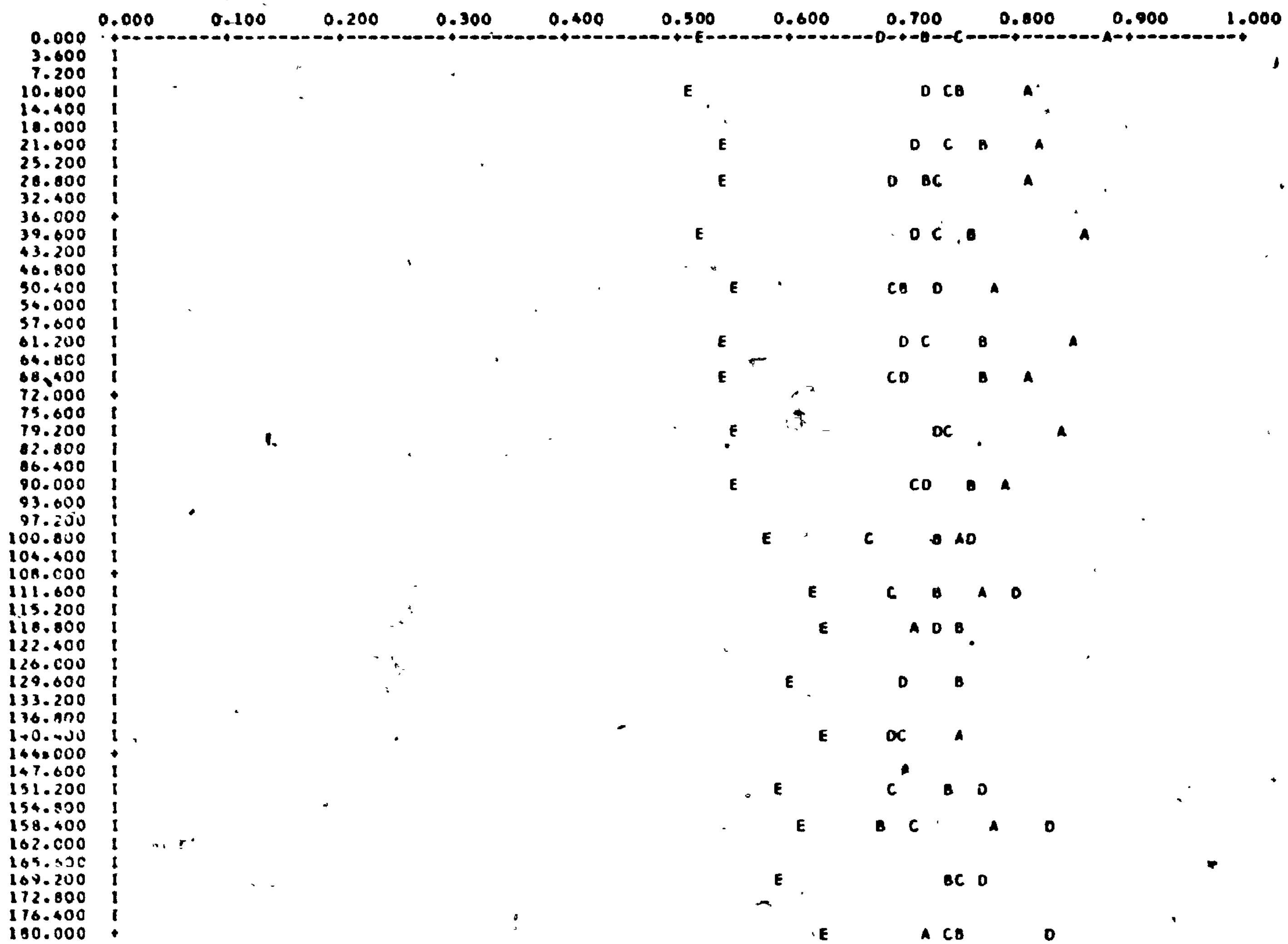
THE TUNNEL WINDSPEED IS 30.0 FT/SEC.

(NUSSELT)/(REYNOLDS)**0.334 NUMBER VERSUS AZIMUTH ANGLE



THE TUNNEL WINDSPEED IS 30.0 FT/SEC.

(NUSSELT)/(GRASHOF)**0.25 NUMBER VERSUS AZIMUTH ANGLE



THE TUNNEL WINDSPEED IS 40.1 FT/SEC.

Q / A	T INSIDE	T WALL	T OUTSIDE	GRASHOF	CALIBR.	AZIMUTH	POLAR
123.6400	137.0000	98.5000	82.0000	0.1350E 07	2.6760	0	90.0
116.5900	137.0000	98.5000	82.0000	0.1350E 07	2.6820	10	90.0
117.7300	137.0000	99.5000	82.5000	0.1350E 07	2.6810	20	90.0
114.7700	137.0000	99.5000	83.0000	0.1350E 07	2.6840	30	90.0
113.6400	137.0000	99.0000	84.0000	0.1350E 07	2.6850	40	90.0
114.3200	137.5000	99.5000	84.5000	0.1350E 07	2.6850	50	90.0
111.8200	137.5000	100.0000	85.0000	0.1350E 07	2.6870	60	90.0
121.3600	137.5000	100.0000	85.5000	0.1350E 07	2.6780	70	90.0
115.9100	137.5000	100.0000	85.0000	0.1350E 07	2.6830	80	90.0
110.9100	138.0000	100.5000	86.0000	0.1340E 07	2.6880	90	90.0
115.2300	138.0000	101.0000	86.5000	0.1340E 07	2.6840	100	90.0
113.1800	138.0000	101.0000	86.5000	0.1340E 07	2.6860	110	90.0
110.2300	138.0000	101.0000	86.5000	0.1340E 07	2.6890	120	90.0
107.9500	138.0000	101.0000	87.0000	0.1340E 07	2.6910	130	90.0
113.6400	138.0000	101.0000	87.0000	0.1340E 07	2.6850	140	90.0
107.7300	138.0000	101.0000	87.5000	0.1340E 07	2.6910	150	90.0
104.0900	138.5000	101.0000	87.5000	0.1340E 07	2.6950	160	90.0
102.6500	138.5000	101.0000	88.0000	0.1340E 07	2.6970	170	90.0
101.8200	138.5000	102.0000	88.0000	0.1340E 07	2.6980	180	90.0
118.4100	137.0000	93.0000	82.0000	0.1350E 07	2.4490	0	67.5
116.3[illegible]	137.0000	94.0000	82.0000	0.1350E 07	2.4520	10	67.5
113.4100	137.0000	94.0000	82.5000	0.1350E 07	2.4560	20	67.5
116.8200	137.0000	95.0000	83.0000	0.1350E 07	2.4520	30	67.5
115.0000	137.0000	94.5000	84.0000	0.1350E 07	2.4540	40	67.5
111.5900	137.5000	95.5000	84.5000	0.1350E 07	2.4580	50	67.5
110.6800	137.5000	95.5000	85.0000	0.1350E 07	2.4590	60	67.5
115.9100	137.5000	96.0000	85.5000	0.1350E 07	2.4530	70	67.5
109.5500	137.5000	96.0000	85.5000	0.1350E 07	2.4610	80	67.5
107.0500	138.0000	96.5000	86.0000	0.1340E 07	2.4640	90	67.5
107.7300	138.0000	96.5000	86.5000	0.1340E 07	2.4630	100	67.5
106.8200	138.0000	97.0000	86.5000	0.1340E 07	2.4640	110	67.5
107.0500	138.0000	97.0000	86.5000	0.1340E 07	2.4640	120	67.5
104.3200	138.0000	98.0000	87.0000	0.1340E 07	2.4630	130	67.5
108.1800	138.0000	98.0000	87.0000	0.1340E 07	2.4630	140	67.5
101.3600	138.0000	98.0000	87.5000	0.1340E 07	2.4720	150	67.5
102.7300	138.5000	98.0000	87.5000	0.1340E 07	2.4700	160	67.5
103.4100	138.5000	98.0000	88.0000	0.1340E 07	2.4690	170	67.5
99.7700	138.5000	98.0000	88.0000	0.1340E 07	2.4750	180	67.5
123.6400	137.0000	93.5000	82.0000	0.1350E 07	2.5840	0	45.0
120.0000	137.0000	94.0000	82.0000	0.1350E 07	2.5880	10	45.0
112.7300	137.0000	94.0000	82.5000	0.1350E 07	2.5960	20	45.0
122.0500	137.0000	94.5000	83.0000	0.1350E 07	2.5860	30	45.0
114.0900	137.0000	95.0000	84.0000	0.1350E 07	2.5950	40	45.0
113.1800	137.5000	95.5000	84.5000	0.1350E 07	2.5960	50	45.0
113.6400	137.5000	96.0000	85.0000	0.1350E 07	2.5950	60	45.0
114.3200	137.5000	96.[illegible]	85.5000	0.1350E 07	2.5950	70	45.0
109.5500	137.5000	96.0000	85.5000	0.1350E 07	2.6000	80	45.0
114.3200	138.0000	97.0000	86.0000	0.1340E 07	2.5950	90	45.0
105.6800	138.0000	97.5000	86.5000	0.1340E 07	2.6050	100	45.0
111.5900	138.0000	98.0000	86.5000	0.1340E 07	2.5980	110	45.0
109.0900	138.0000	98.0000	86.5000	0.1340E 07	2.6010	120	45.0
106.1400	138.0000	98.0000	87.0000	0.1340E 07	2.6040	130	45.0
109.3200	138.0000	98.0000	87.0000	0.1340E 07	2.6010	140	45.0
104.0900	138.0000	98.5000	87.5000	0.1340E 07	2.6060	150	45.0
102.0500	138.5000	99.0000	87.5000	0.1340E 07	2.6090	160	45.0

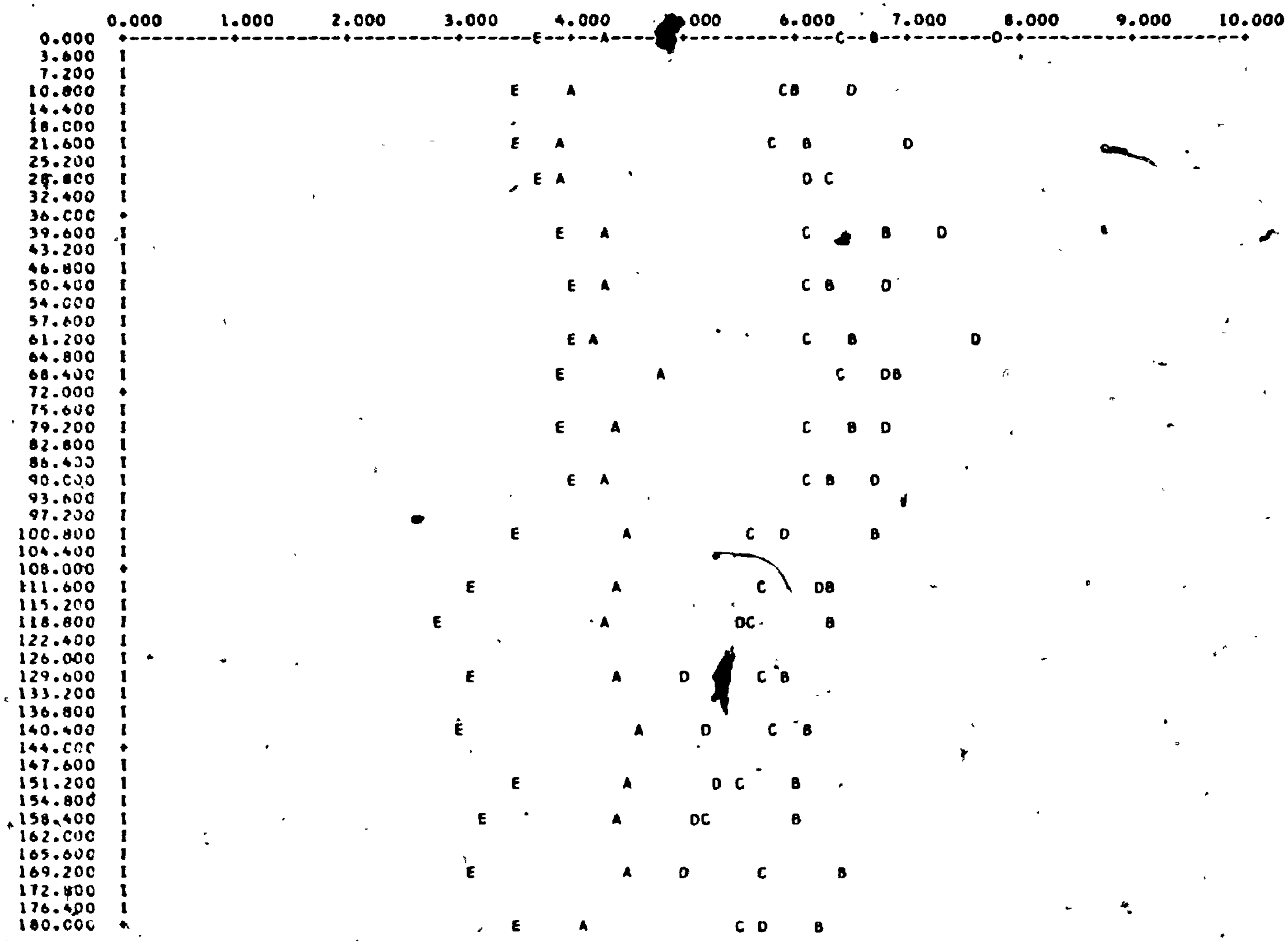
10342

107.2700	138.5000	99.0000	88.0000	0.1340E 07	2.6030	170	45.0
102.9500	138.5000	99.0000	88.0000	0.1340E 07	2.6080	180	45.0
138.8600	137.0000	92.0000	82.0000	0.1350E 07	2.7150	0	22.5
127.7300	137.0000	93.0000	82.0000	0.1350E 07	2.7260	10	22.5
130.2300	137.0000	93.0000	82.5000	0.1350E 07	2.7230	20	22.5
120.6800	137.0000	94.0000	83.0000	0.1350E 07	2.7340	30	22.5
129.5500	137.0000	94.0000	84.0000	0.1350E 07	2.7240	40	22.5
121.5900	137.5000	94.5000	84.5000	0.1350E 07	2.7330	50	22.5
121.8100	137.5000	94.0000	85.0000	0.1350E 07	2.7330	60	22.5
122.2700	137.5000	95.0000	85.0000	0.1350E 07	2.7320	70	22.5
115.9100	137.5000	95.0000	85.5000	0.1350E 07	2.7400	80	22.5
120.2300	138.0000	96.0000	86.0000	0.1340E 07	2.7350	90	22.5
112.0500	138.0000	97.0000	86.5000	0.1340E 07	2.7450	100	22.5
117.0500	138.0000	97.0000	86.5000	0.1340E 07	2.7390	110	22.5
114.3200	138.0000	98.0000	86.5000	0.1340E 07	2.7420	120	22.5
108.4100	138.0000	99.0000	87.0000	0.1340E 07	2.7500	130	22.5
108.1800	138.0000	98.5000	87.0000	0.1340E 07	2.7500	140	22.5
114.3200	138.0000	99.5000	87.5000	0.1340E 07	2.7420	150	22.5
110.4500	138.5000	99.5000	87.5000	0.1340E 07	2.7470	160	22.5
108.6400	138.5000	100.0000	88.0000	0.1340E 07	2.7500	170	22.5
112.2700	138.5000	99.0000	88.0000	0.1340E 07	2.7450	180	22.5
88.6400	137.0000	96.0000	82.0000	0.1350E 07	2.6010	0	0.0
83.1800	137.0000	96.0000	82.0000	0.1350E 07	2.6070	10	0.0
81.3600	137.0000	96.0000	82.5000	0.1350E 07	2.6090	20	0.0
86.3600	137.0000	96.5000	83.0000	0.1350E 07	2.6040	30	0.0
83.5900	137.0000	96.5000	84.0000	0.1350E 07	2.6070	40	0.0
82.4100	137.5000	96.5000	84.5000	0.1350E 07	2.6080	50	0.0
81.7300	137.5000	97.0000	85.0000	0.1350E 07	2.6090	60	0.0
80.5900	137.5000	97.5000	85.5000	0.1350E 07	2.6100	70	0.0
79.8700	137.5000	97.5000	85.5000	0.1350E 07	2.6110	80	0.0
78.1400	138.0000	97.5000	86.0000	0.1340E 07	2.6120	90	0.0
77.5000	138.0000	99.5000	86.5000	0.1340E 07	2.6130	100	0.0
72.5000	138.0000	100.0000	86.5000	0.1340E 07	2.6170	110	0.0
71.1400	138.0000	101.5000	86.5000	0.1340E 07	2.6190	120	0.0
77.0500	138.0000	101.5000	87.0000	0.1340E 07	2.6130	130	0.0
75.2300	138.0000	101.5000	87.0000	0.1340E 07	2.6150	140	0.0
82.9500	138.0000	101.5000	87.5000	0.1340E 07	2.6070	150	0.0
80.2300	138.5000	102.0000	87.5000	0.1340E 07	2.6100	160	0.0
73.6400	138.5000	102.0000	88.0000	0.1340E 07	2.6160	170	0.0
84.7700	138.5000	102.0000	88.0000	0.1340E 07	2.6050	180	0.0

10343

THE TUNNEL WINDSPEED IS 40.1 FT/SEC.

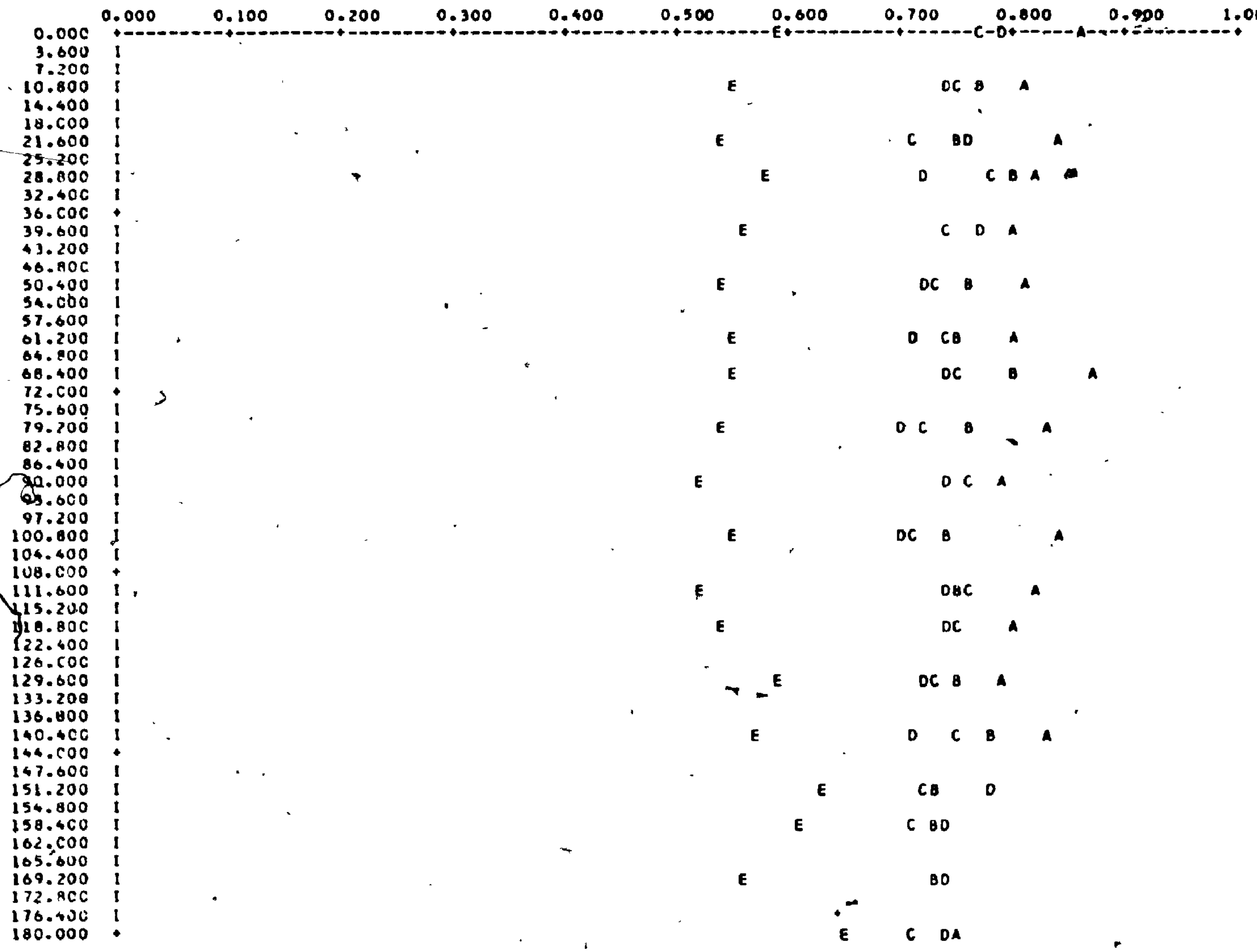
(NUSSELT)/(REYNOLDS)**0.334 NUMBER VERSUS AZIMUTH ANGLE



10344

THE TUNNEL WINDSPEED IS 40.1 FT/SEC.

(NUSSELT)/(GRASHOF)**0.25 NUMBER VERSUS AZIMUTH ANGLE



THE TUNNEL WINDSPEED IS 46.5 FT/SEC.

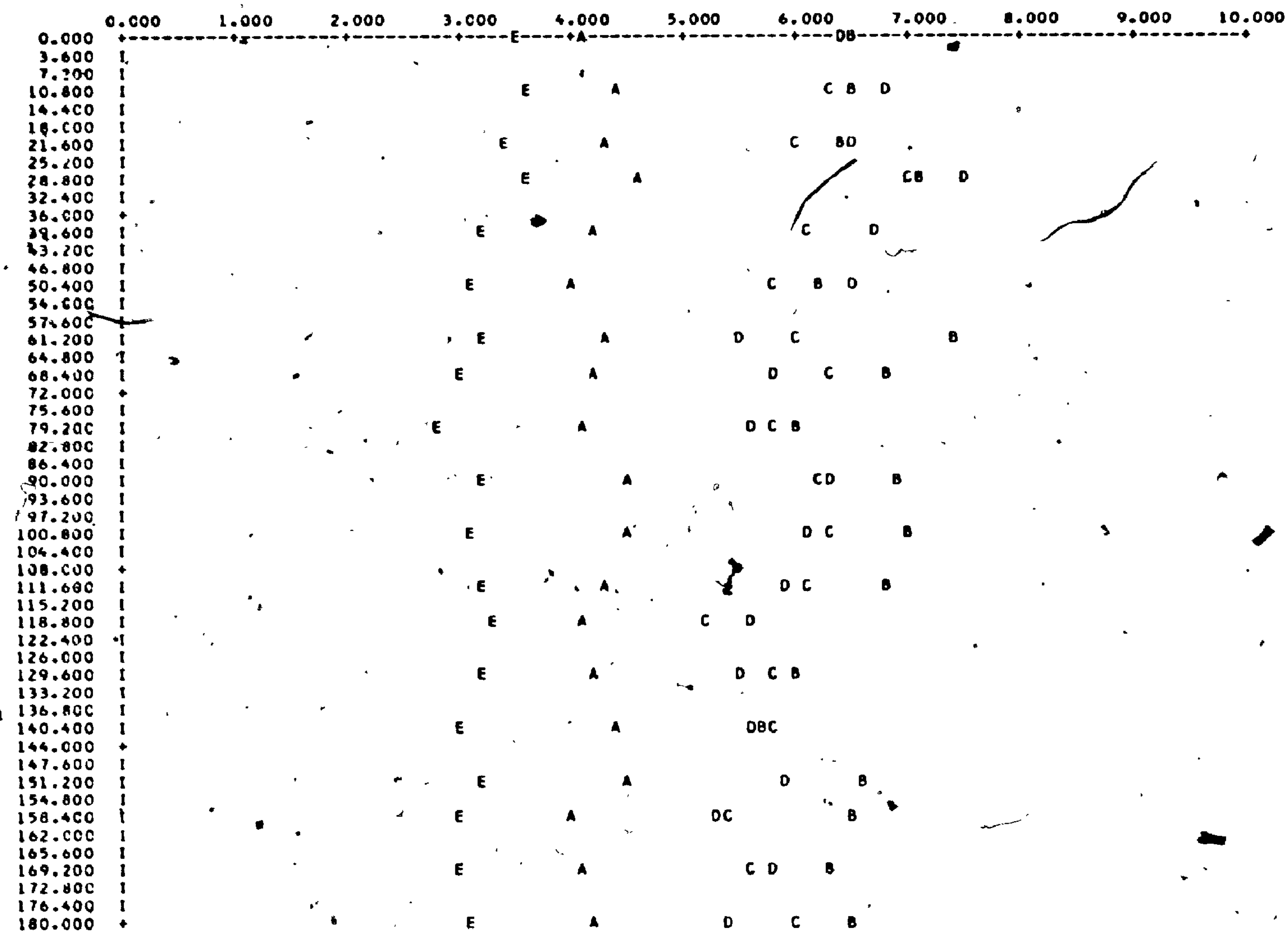
Q / A	T INSIDE	T WALL	T OUTSIDE	GRASHOF	CALIBR.	AZIMUTH	POLAR
125.2300	135.0000	95.5000	79.0000	0.1370E 07	2.6750	0	90.0
128.6400	135.0000	96.0000	80.0000	0.1370E 07	2.6730	10	90.0
127.0500	135.5000	96.5000	80.5000	0.1370E 07	2.6740	20	90.0
122.9500	135.5000	96.5000	82.0000	0.1370E 07	2.6770	30	90.0
122.7300	136.0000	98.0000	82.0000	0.1360E 07	2.6770	40	90.0
115.4500	136.0000	98.0000	82.5000	0.1360E 07	2.6830	50	90.0
118.6400	136.5000	98.0000	83.0000	0.1360E 07	2.6800	60	90.0
115.9100	136.5000	99.0000	84.0000	0.1360E 07	2.6830	70	90.0
117.9500	137.0000	99.5000	84.0000	0.1350E 07	2.6810	80	90.0
116.3600	137.0000	99.5000	85.5000	0.1350E 07	2.6830	90	90.0
115.9100	137.5000	100.0000	86.0000	0.1350E 07	2.6830	100	90.0
112.7300	137.5000	100.5000	86.5000	0.1350E 07	2.6860	110	90.0
105.4500	138.0000	100.5000	86.5000	0.1340E 07	2.6940	120	90.0
109.5400	138.0000	101.5000	87.5000	0.1340E 07	2.6890	130	90.0
109.0000	138.5000	101.5000	88.0000	0.1340E 07	2.6900	140	90.0
109.3200	138.5000	102.0000	89.0000	0.1340E 07	2.6890	150	90.0
103.6400	138.5000	103.0000	89.0000	0.1340E 07	2.6950	160	90.0
101.8200	139.0000	103.0000	89.5000	0.1330E 07	2.6980	170	90.0
101.3600	139.0000	103.0000	90.0000	0.1330E 07	2.6980	180	90.0
119.7700	135.0000	90.0000	79.0000	0.1370E 07	2.4480	0	67.5
120.6800	135.0000	91.0000	80.0000	0.1370E 07	2.4470	10	67.5
122.7300	135.5000	92.0000	80.5000	0.1370E 07	2.4450	20	67.5
120.2300	135.5000	92.0000	82.0000	0.1370E 07	2.4480	30	67.5
113.6400	136.0000	93.0000	82.0000	0.1360E 07	2.4550	40	67.5
115.4500	136.0000	93.5000	82.5000	0.1360E 07	2.4530	50	67.5
119.0900	136.5000	92.5000	83.0000	0.1360E 07	2.4490	60	67.5
114.1400	136.5000	94.0000	84.0000	0.1360E 07	2.4550	70	67.5
111.1400	137.0000	95.0000	84.0000	0.1350E 07	2.4590	80	67.5
111.1400	137.0000	95.0000	85.5000	0.1350E 07	2.4590	90	67.5
112.9500	137.5000	95.5000	86.0000	0.1350E 07	2.4560	100	67.5
109.0900	137.5000	96.0000	86.5000	0.1350E 07	2.4610	110	67.5
100.0000	138.0000	97.0000	86.5000	0.1340E 07	2.4740	120	67.5
101.3600	138.0000	97.5000	87.5000	0.1340E 07	2.4720	130	67.5
97.0500	138.5000	98.0000	88.0000	0.1340E 07	2.4790	140	67.5
101.3600	138.5000	98.0000	89.0000	0.1340E 07	2.4720	150	67.5
104.3200	138.5000	98.5000	89.0000	0.1340E 07	2.4680	160	67.5
102.5000	139.0000	99.0000	89.5000	0.1330E 07	2.4710	170	67.5
105.0000	139.0000	99.5000	90.0000	0.1330E 07	2.4670	180	67.5
125.2300	135.0000	90.0000	79.0000	0.1370E 07	2.5820	0	45.0
123.8600	135.0000	91.0000	80.0000	0.1370E 07	2.5840	10	45.0
123.4100	135.5000	92.0000	80.5000	0.1370E 07	2.5840	20	45.0
123.8600	135.5000	92.0000	82.0000	0.1370E 07	2.5840	30	45.0
119.3200	136.0000	93.0000	82.0000	0.1360E 07	2.5890	40	45.0
114.7700	136.0000	93.5000	82.5000	0.1360E 07	2.5940	50	45.0
117.0500	136.5000	94.0000	83.0000	0.1360E 07	2.5910	60	45.0
117.2700	136.5000	94.5000	84.0000	0.1360E 07	2.5910	70	45.0
114.5500	137.0000	95.0000	84.0000	0.1350E 07	2.5940	80	45.0
111.1400	137.0000	95.5000	85.5000	0.1350E 07	2.5980	90	45.0
112.7300	137.5000	96.0000	86.0000	0.1350E 07	2.5970	100	45.0
115.0000	137.5000	97.0000	86.5000	0.1350E 07	2.5940	110	45.0
107.5000	138.0000	98.0000	86.5000	0.1340E 07	2.6030	120	45.0
109.0900	138.0000	98.0000	87.5000	0.1340E 07	2.6010	130	45.0
108.4100	138.5000	98.5000	88.0000	0.1340E 07	2.6020	140	45.0
105.0000	138.5000	99.0000	89.0000	0.1340E 07	2.6060	150	45.0
106.3600	138.5000	100.0000	89.0000	0.1340E 07	2.6040	160	45.0

105.9100	139.0000	100.0000	89.5000	0.1330E 07	2.6050	170	45.0
108.4100	139.0000	100.0000	90.0000	0.1330E 07	2.6020	180	45.0
132.5000	135.0000	90.0000	79.0000	0.1370E 07	2.7210	0	22.5
133.1800	135.0000	90.5000	80.0000	0.1370E 07	2.7200	10	22.5
128.6400	135.5000	91.0000	80.5000	0.1370E 07	2.7250	20	22.5
126.5900	135.5000	91.0000	82.0000	0.1370E 07	2.7270	30	22.5
125.9100	136.0000	92.0000	82.0000	0.1360E 07	2.7280	40	22.5
121.3600	136.0000	92.5000	82.5000	0.1360E 07	2.7300	50	22.5
114.0900	136.5000	94.0000	83.0000	0.1360E 07	2.7420	60	22.5
115.6800	136.5000	94.5000	84.0000	0.1360E 07	2.7410	70	22.5
115.6800	137.0000	95.0000	84.0000	0.1350E 07	2.7410	80	22.5
117.9500	137.0000	95.5000	85.5000	0.1350E 07	2.7380	90	22.5
114.5500	137.6000	96.0000	86.0000	0.1350E 07	2.7420	100	22.5
112.2700	137.5000	96.5000	86.5000	0.1350E 07	2.7450	110	22.5
111.5900	138.0000	97.0000	86.5000	0.1340E 07	2.7460	120	22.5
108.6400	138.0000	98.0000	87.5000	0.1340E 07	2.7500	130	22.5
110.4500	138.5000	98.5000	88.0000	0.1340E 07	2.7470	140	22.5
111.3600	138.5000	99.0000	89.0000	0.1340E 07	2.7460	150	22.5
106.1400	138.5000	99.5000	89.0000	0.1340E 07	2.7530	160	22.5
109.5500	139.0000	99.5000	89.5000	0.1330E 07	2.7490	170	22.5
107.2700	139.0000	100.5000	90.0000	0.1330E 07	2.7520	180	22.5
90.4500	135.0000	93.5000	79.0000	0.1370E 07	2.5990	0	0.0
89.5500	135.0300	94.0000	80.0000	0.1370E 07	2.6010	10	0.0
89.3200	135.5000	95.0000	80.5000	0.1370E 07	2.6010	20	0.0
88.1800	135.5000	95.5000	82.0000	0.1370E 07	2.6020	30	0.0
79.3200	136.0000	96.0000	82.0000	0.1360E 07	2.6110	40	0.0
81.8200	136.0000	97.0000	82.5000	0.1360E 07	2.6080	50	0.0
80.6800	136.5000	97.0000	83.0000	0.1360E 07	2.6100	60	0.0
74.7700	136.5000	98.0000	84.0000	0.1360E 07	2.6150	70	0.0
74.0900	137.0000	98.5000	84.0000	0.1350E 07	2.6160	80	0.0
78.6400	137.0000	99.0000	85.5000	0.1350E 07	2.6110	90	0.0
75.4500	137.5000	99.5000	86.0000	0.1350E 07	2.6150	100	0.0
77.0500	137.5000	100.0000	86.5000	0.1350E 07	2.6130	110	0.0
82.5000	138.0000	100.5000	86.5000	0.1340E 07	2.6080	120	0.0
74.3200	138.0000	100.5000	87.5000	0.1340E 07	2.6160	130	0.0
76.3600	138.5000	102.0000	88.0000	0.1340E 07	2.6140	140	0.0
74.7700	138.5000	102.0000	89.0000	0.1340E 07	2.6150	150	0.0
74.5500	138.5000	103.0000	89.0000	0.1340E 07	2.6160	160	0.0
73.4100	139.0000	103.0000	89.5000	0.1330E 07	2.6170	170	0.0
72.7300	139.0000	103.0000	90.0000	0.1330E 07	2.6170	180	0.0

10347

THE TUNNEL WINDSPEED IS 46.5 FT/SEC.

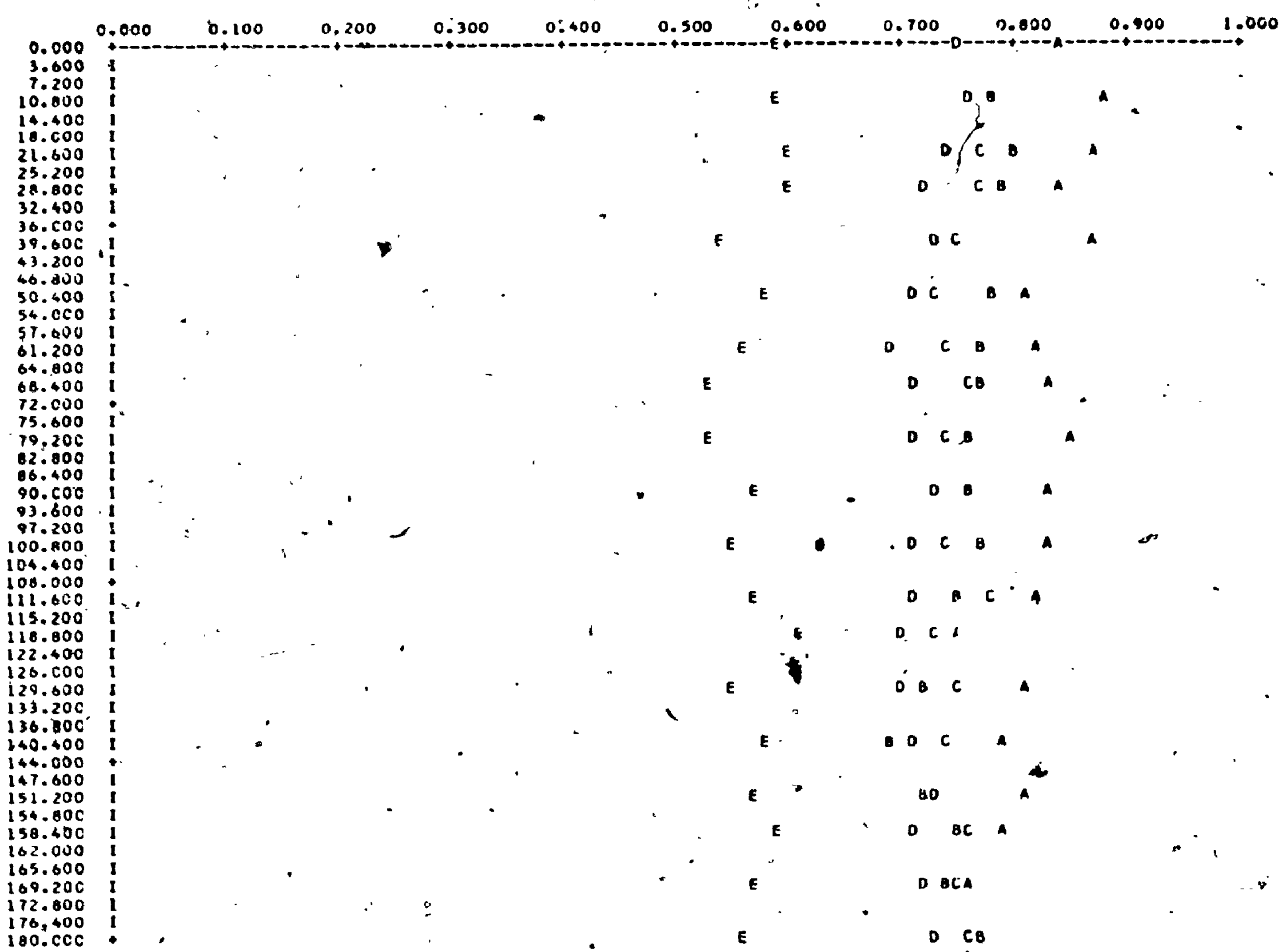
(NUSSELT)/(REYNOLDS)**0.334 NUMBER VERSUS AZIMUTH ANGLE



10348

THE TUNNEL WINDSPEED IS 46.5 FT/SEC.

(NUSSELT)/(GRASHOF)**0.25 NUMBER VERSUS AZIMUTH ANGLE



10349

F-2 Sample Calculation

Using test number 1 at 90° polar angle and 0° azimuth angle.

$Q/A = 81.92$ BTU/hr. sq.ft.

Heat flux sensor correction factor: 2.725.

$T_\infty(I) = 125.0°F$

$T\ wall = 95.5°F$

$T_\infty(0) = 81.0°F$

Corrected $Q/A = 81.92 / 2.725 = 30.06$

$h\ (0) = (Q/A) / (T\ wall - T_\infty(0))$

$= 30.06 / 14.5 = 2.07$ BTU/hr.sq.ft.°F

$h\ (I) = (Q/A) / (T_\infty(I) - T\ wall)$

$= 30.06 / 29.5 = 1.02$ BTU/hr.sq.ft.!F

Thermal conductivity, k, of air in interior and exterior boundary layers.

$T\ ave\ (I) = (125.0 + 95.5) / 2 = 110.25°F$

$T\ ave\ (0) = (95.5 + 81.0) / 2 = 88.25°F$

Interpolate:

$k\ (I) = (110.25 - 32.0) \times (0.0154 - 0.0140)$
$/ (100.0 - 32.0)$
$+ 0.0140 = 0.0156$ BTU/hr.ft.°F

$k\ (0) = (88.25 - 32.0) \times (0.0154 - 0.0140)$
$/ (100.0 - 32.0)$
$+ 0.0140 = 0.0151$ BTU/hr.ft.°F

$Nu\ (0) = h\ D/k = (2.07 \times 1.7) / 0.0151 = 233.4$

$Nu\ (I) = h\ R/k = (1.02 \times 0.85) / 0.0156 = 55.5$

$$Gr = GRASHOF \times (T_\infty(I) - T\ wall) \times R^3$$
$$= 1.490 \times 10^6 \times 29.5 \times 0.85^3 = 2.7 \times 10^7$$

Exterior air density and viscosity.

Interpolate:

$$\rho = ((81.0 - 32.0) \times 0.071 - 0.081) / (100.0 - 32.0)$$
$$+ 0.081 = 0.074 \text{ Lbm/cu.ft.}$$

$$\mu = (81.0 - 32.0) \times (1.285 \times 10^{-5} - 1.165 \times 10^{-5}) /$$
$$(100.0 - 32.0) + 1.165 \times 10^{-5} = 1.251 \times 10^{-5}$$
Lbm/ft.sec.

$$Re = \rho DV/\mu = (0.074 \times 1.7 \times 20.1) / 1.251 \times 10^{-5}$$
$$= 2.01 \times 10^5$$

$$\frac{Nu\ (0)}{Re^{0.334}} = 233.4 / (2.01)^{0.334} = 3.95$$

$$\frac{Nu\ (I)}{Gr^{1/4}} = 55.5 / (2.7 \times 10^7)^{1/4} = 0.75$$

F-3 Experimental Error Analysis

Using the same criteria as in Appendix D-3 and the same test used for the sample calculation:

$Q/A = 82.92$ BTU/hr.sq.ft.

Heat flux sensor correction factor: 2.725.

$T_\infty(I) = 124.5°F$

$T\ wall = 96.0°F$

Corrected $Q/A = 82.92 / (2.725 \times 0.95) = 32.03$

$= 1.12$ BTU/hr.sq.ft.°F

The maximum error in the interior Nusselt number is

$$\frac{1.12 - 1.02}{1.02} \times 100\% = 10.3\%$$

For maximum error (exterior):

T wall $= 95°F$

$T_\infty(0) = 81.5°F$

$h(0) = (Q/A) / (T\text{ wall} - T_\infty(0)) = 32.03/13.5$

$= 2.37$ BTU/hr.sq.ft.°F

The maximum error in the exterior Nusselt number is:

$$\frac{2.37 - 2.07}{2.07} \times 100\% = 14.4\%$$

The maximum error in the Grashof number is:

$$\frac{29.5 - (T_\infty(I) - T\text{ wall})}{29.5} \times 100\% = 3.4\%$$

The boundary layer wind-tunnel wind velocity was measured with a pitot-tube-pressure transducer arrangement. The output of the transducer was measured in volts ($\pm$ 0.001 V).

For test series 1 the maximum error in the Reynolds number can be calculated to be:

$$\frac{0.4567 - 0.4557}{0.4557} \times 100\% = 0.22\%$$

The maximum error in the Nu/Gr number is:

$$\frac{1.103}{0.966^{\frac{1}{4}}} \times 100\% = 11.3\%,$$

and the maximum error in the Nu/Re$^{0.334}$ number is:

$$\frac{1.144}{0.9978^{0.334}} - 1 \times 100\% = 14.5\%$$

APPENDIX G

EXPERIMENTAL RESULTS OF THE HEATER CALIBRATION

This appendix contains a computer program showing the data obtained from the heater calibration as well as a least square data fitting analysis.

An experimental error analysis is shown in Section G-2.

G-1 Computer Program and Output

```
PAGE   1

// JOB    1111

LOG DRIVE   CART SPEC   CART AVAIL   PHY DRIVE
  0000        1111        1111         0000

V2 M11   ACTUAL  8K  CONFIG  8K

// FOR
* IOCS (CARD,1403 PRINTER)
* ONE WORD INTEGERS
* LIST SOURCE PROGRAM
C
C     LEAST SQUARE CURVE FITTING THROUGH DATA POINTS
C
C     OBTAINED FROM HEATER CALIBRATION
C
      DIMENSION X(100),Y(100),S(25),T(25),MWM(10)
C
C     READ NUMBER OF DATA POINTS AND ALL DATA
C
      READ (2,100)N
  100 FORMAT(I3)
      READ(2,101)(X(I),Y(I),I=1,N)
  101 FORMAT(2F10.3)
      WRITE (5,105)
      WRITE (5,103)
  103 FORMAT ('     WATTS       D4 T ',//)
      WRITE (5,104) (X(I),Y(I),I=1,N)
  104 FORMAT (F10.1,F10.2)
      DO 5 NC = 1,N
      X1 = Y(NC)
      Y(NC) = X(NC)
    5 X(NC) = X1
C
C     LEAST SQUARES APPROXIMATION
C
      EX2=0.
      EX3=0.
      EX4=0.
      EXY=0.
      EX2Y=0.
      DO 10 I=1,N
      EX2=EX2 +X(I)**2
      EX3=EX3 +X(I)**3
      EX4=EX4 +X(I)**4
      EXY =EXY + X(I)*Y(I)
   10 EX2Y=EX2Y+(X(I)**2)*Y(I)
      A=0
      B=0
      DO 20 I=1,30000
      A1= (1/EX2)*(EXY-B*EX3)
      B1 = (1/EX4)*(EX2Y-A*EX3)
      IF (ABS (A-A1)-0.000001)21,22,22
   21 IF (ABS(B-B1)-0.000001)30,22,22
   22 A=A1
      B=B1
   20 CONTINUE
   30 WRITE (5,102) A,B
  102 FORMAT (/////,' THE CURVE IS OF THIS SHAPE',//,' Y=',E20.5,' X +',
```

```
PAGE   2
     1E20.5,' X**2')
      WRITE (5,105)
  105 FORMAT (1H1)
      DO 50 I = 1,20
      T(I) = I*5
   50 S(I) = A*T(I) + B*(T(I)**2)
      MWM(1) = I-1
      N = I-1
      MM = 1
      CALL CURV9 (S,T,0.0,2500.0,0.0,100.0,N,0,MWM,MM)
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
 IOCS

CORE REQUIREMENTS FOR
 COMMON      0  VARIABLES     538  PROGRAM     464

END OF COMPILATION

// XEQ
```

FACULTY OF ENGINEERING SCIENCE

WATTS	D4 T
C.0	C.00
20.0	1.13
5C.0	2.75
1CC.0	5.15
100.0	5.15
20C.0	10.10
30C.0	14.90
4CC.0	19.7C
45C.0	22.00
55C.0	26.40
6CC.C	28.3C
66C.0	28.3C
700.0	32.70
8CC.0	37.00
85C.0	38.7C
9C0.0	4C.80
950.C	42.80
1C0C.0	44.50
1598.0	85.CC
2007.0	85.50

THE CURVE IS CF THIS SHAPE

Y= 0.20237E 02 X + 0.38740E-01 X**2

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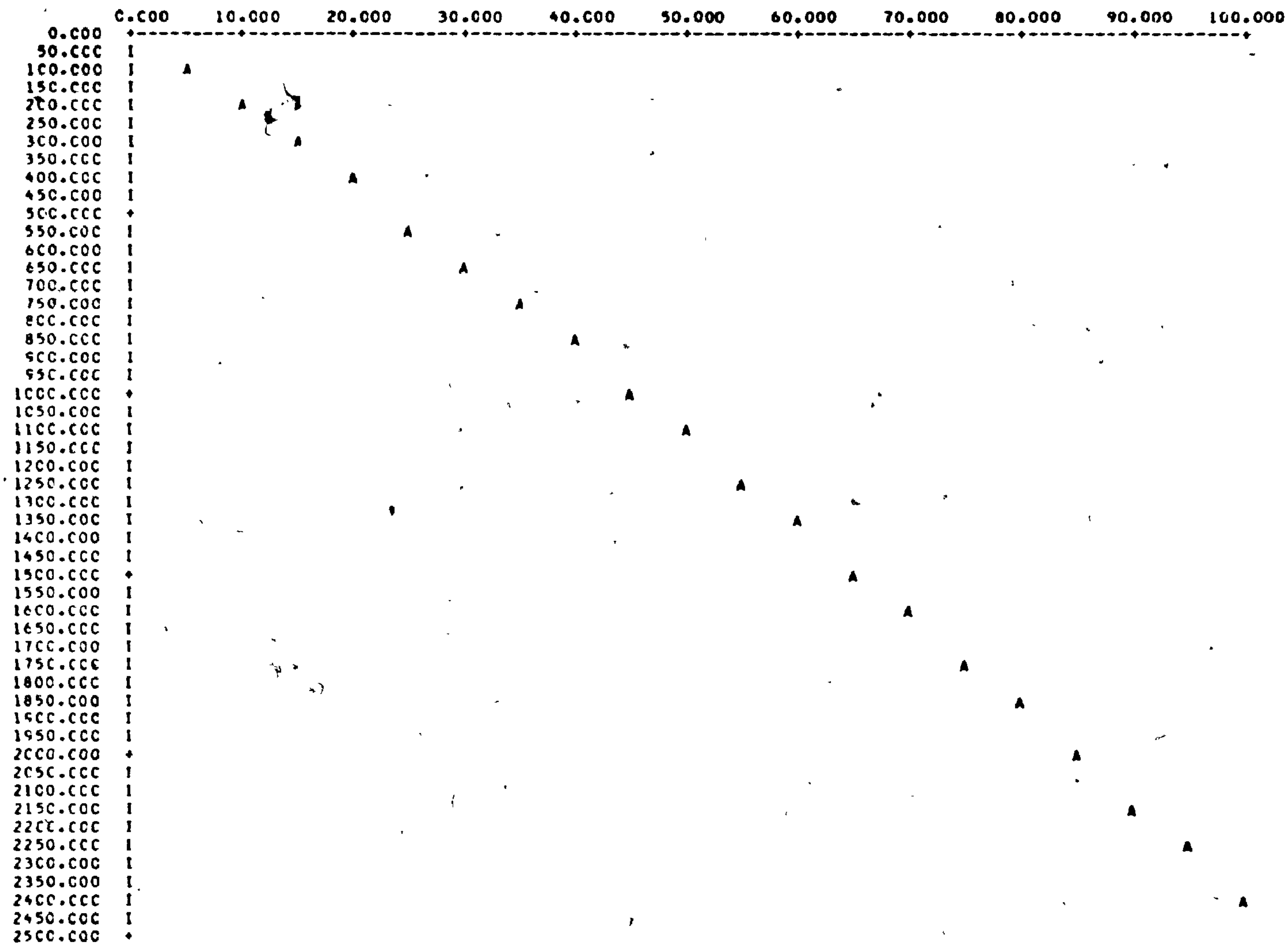

G-2 Experimental Error Analysis

The largest possible error in this experiment can be traced to the test using 206.5 volts single phase.

This error can be calculated as follows:

Voltage measurement: 206.5 V ± 0.5

Current measurement: 9.72 A ± 0.02

The percent error is:

$$\frac{207.0 \times 9.74}{206.5 \times 9.72} - 1 \times 100\% = 0.4\%,$$

which is the maximum error in the determination of the energy input into the heater.

APPENDIX H

RESULTS OF THE HEAT TRANSFER EXPERIMENTS WITH THE TWELVE FEET DIAMETER INFLATABLE MODEL

This appendix contains the computer program used to analyse the experimental data obtained from this experiment for all forty individual combinations of weather classification and wind direction. The index to this appendix is shown in section H-1. A sample calculation and an experimental error analysis are presented in Sections H-3 and H-4 respectively. The power loss due to air leakage and heat transmission through the base is determined in Sections H-5 and H-6 respectively.

H-1 Index

Code	Wind Direction	Weather classification	Page
2 5	North-East	Precipitation	213
3 1	East	Sunny	214
3 2	East	Cloudy	216
3 3	East	Partly Cloudy	-
3 4	East	Clear	218
3 5	East	Precipitation	220
4 1	South-East	Sunny	222
4 2	South-East	Cloudy	225
4 3	South-East	Partly Cloudy	227
4 4	South-East	Clear	229
4 5	South-East	Precipitation	231
5 1	South	Sunny	233
5 2	South	Cloudy	239
5 3	South	Partly Cloudy	242
5 4	South	Clear	244
5 5	South	Precipitation	248
6 1	South-West	Sunny	250
6 2	South-West	Cloudy	256
6 3	South-West	Partly Cloudy	259
6 4	South-West	Clear	261
6 5	South-West	Precipitation	264
7 1	West	Sunny	266
7 2	West	Cloudy	271
7 3	West	Partly Cloudy	273
7 4	West	Clear	275

H-2 <u>Computer Program and Output</u>

Explanation of terms used for headings in data sheet.

Q = energy input into the dome (BTU/hr.)

DTN = T ambient interior - T ambient exterior (North side)

DTW, DTS and DTE are the same temperature differences at the west, south and east side respectively.

VEL = wind velocity (m.p.h.)

D = wind direction (e.g.: 1-North, 2-North-east, etc.)

W = weather condition

1 - sunny

2 - cloudy

3 - partly cloudy

4 - clear (at night)

5 - precipitation

TIME = time of day

D = day

M = month

YEAR = year

. Explanation of characters used in graphs:

A - data points: Nu versus Re/1000 (semilogarithmic)

```
PAGE   1

// JCB    1111

LCG DRIVE    CART SPEC    CART AVAIL   PHY DRIVE
  CCOO          1111         1111         0000

V2 M11    ACTUAL -8K   CCNFIG  8K

// FCR
* ICCS (CARC,1403 FRINTER)
* CNE WCRC INTEGERS
* LIST SCLRCE PRCGRAM
      CIMENSICN XAU(350),RE(350),MWH(2)
      WRITE (5,101)
      CC 1C00 II = 1,8
      CC 1CCC JJ = 1,5
      WRITE (5,99)
   99 FCRMAT ('     C      CTN      CTW      DTS      DTE      VEL',
     1'  C W TIME  D  M   YEAR',/)
      N = C
      CIAM =12.0
      AREA =2*3.14159*(CIAM/2.)**2
    3 REAC(2,1C0) C, CTN, CTW,DTS,DTE,VEL,IDIR,IWEDR,TIME,
     1ICAY,MCNTH,IYEAR
  100 FCRMAT(F7.2,4F8.4,F7.2,2I2,F6.2,2I3,I5)
      IF ( C )2,1,1
    1 IF (CTN-0.001)6,7,7
    6 CTN = CTN
      CTS = DTN
      CTE = CTN
    7 WRITE(5,100)C,CTN,CTW,DTS,DTE,VEL,IDIR,IWEDR,TIME,
     1ICAY,MCNTH,IYEAR
C     CCNVERT MILLIVOLTS INTO WATTS
      C = 2C.237*C +C.038746*Q**2
C     CCNVERT WATTS INTO BTU/HR
      C=C*3.4129
C     CCNVERT MILLIVCLTS INTO DEGREES F
      DTN = (CTN/1.27)*60.
      CTW = (CTW/1.27)*60.
      CTS = (CTS/1.27)*60.
      CTE = (CTE/1.27)*60.
      CT =(CTN+CTE+CTS+CTW)/4
      HC = C/(AREA * CT)
      T = 6C.-CT
      TC=T*(C.0154-C.C133)/100.+0.0133
      RHO=T*(C.071-0.086)/100. +0.086
      AMU= T* (1.285E-05-1.110E-05)/100.+1.110E-05
C     CCNVERT MPH INTC FT/SEC
      VEL =VEL * 1.467
      N = N +1
      XAU(N) = (HC*CIAM)/TC
      RE(N) = (RHC*CIAM*VEL)/AMU
      RE(N) = RE(N)/1CC0.0
      GC TC 3
    2 MWH(1) = N
      MM = 1
      WRITE(5,1C1)
  101 FCRMAT(1H1)
      GC TC (21,22,23,24,25),JJ
   21 WRITE(5,121)
```

197

```
 121 FCRMAT(50X,' SUNNY')
     GC TC 4
  22 hRITE(5,122)
 122 FCRMAT(5CX,' CLCUDY')
     GC TC 4
  23 hRITE(5,123)
 123 FCRMAT(5CX,' PARTLY CLOUDY')
     GC TC 4
  24 hRITE(5,124)
 124 FCRMAT(5CX,' CLEAR')
     GC TC 4
  25 hRITE(5,125)
 125 FCRMAT(50X,' PRECIPITATION')
   4 GC TC (31,32,33,34,35,36,37,38),II
  31 hRITE(5,131)
 131 FCRMAT(5CX,' NCRTH')
     hRITE (5,139)
 139 FCRMAT (1CX,'NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3')
     GC TC 15
  32 hRITE(5,132)
 132 FCRMAT(5CX,' NCRTH-EAST')
     hRITE (5,139)
     GC TC 15
  33 hRITE(5,133)
 133 FCRMAT(50X,' EAST')
     hRITE (5,139)
     GC TC 15
  34 hRITE(5,134)
 134 FCRMAT(50X, ' SCUTH-EAST')
     hRITE (5,139)
     GC TC 15
  35 hRITE(5,135)
 135 FCRMAT(50X,' SCUTH')
     hRITE (5,139)
     GC TC 15
  36 hRITE(5,136)
 136 FCRMAT(5CX,' SCUTH-WEST')
     hRITE (5,139)
     GC TC 15
  37 hRITE(5,137)
 137 FCRMAT(50X,' WEST')
     hRITE (5,139)
     GC TC 15
  38 hRITE(5,138)
 138 FCRMAT(50X,' NCRTH-WEST')
     hRITE (5,139)
  15 CALL CURV9 (RE,XNU,5.0,5C00.0,0.0,500.0,N,1,MWH,MM)
     hRITE (5,101)
1CC0 CCNTINUE
     CALL EXIT
     END

FEATURES SUPPORTED
 CNE WORD INTEGERS
 IOCS

CORE REQUIREMENTS FCR
 CCMMCN      0 VARIABLES    1446  PROGRAM     714
```

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Q	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
75.00	0.8100	0.8000	0.8200	0.8300	2.00	1	1	9.00	14	12	1974
64.00	0.6900	0.6800	0.7000	0.7100	4.00	1	1	9.30	14	12	1974
60.00	0.5600	0.5500	0.5700	0.5800	5.00	1	1	10.00	14	12	1974
80.00	0.6700	0.6600	0.6800	0.6900	6.00	1	1	10.30	14	12	1974
60.50	0.5450	0.5400	0.5500	0.5600	4.00	1	1	11.30	14	12	1974
62.50	0.5050	0.5150	0.5200	0.4900	2.00	1	1	9.30	3	2	1975
62.00	0.5400	0.5500	0.5600	0.5300	3.50	1	1	10.00	3	2	1975
61.50	0.5400	0.5400	0.5600	0.5300	5.00	1	1	10.30	3	2	1975
60.50	0.5300	0.5700	0.5500	0.5050	4.00	1	1	11.00	3	2	1975
60.50	0.5700	0.6200	0.6100	0.5600	4.00	1	1	11.30	3	2	1975
62.20	0.5400	0.6300	0.5700	0.5100	6.00	1	1	13.00	3	2	1975
62.20	0.5500	0.6600	0.5900	0.5000	7.00	1	1	13.30	3	2	1975
63.00	0.5600	0.6600	0.6000	0.5100	5.00	1	1	14.00	3	2	1975
64.00	0.5000	0.6000	0.5800	0.5000	5.00	1	1	14.30	3	2	1975

FACULTY OF ENGINEERING SCIENCE

Q	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
59.60	0.6500	0.6400	0.6600	0.6700	0.10	1	2	11.30	13	12	1974
58.00	0.6500	0.6400	0.6600	0.6700	0.10	1	2	17.00	13	12	1974
58.80	0.6250	0.6200	0.6300	0.6400	1.00	1	2	17.30	13	12	1974
58.50	0.6050	0.6000	0.6100	0.6200	2.00	1	2	18.00	13	12	1974
60.80	0.6500	0.6400	0.6600	0.6700	0.10	1	2	21.30	13	12	1974
60.50	0.6400	0.6300	0.6500	0.6600	1.55	1	2	22.00	13	12	1974
55.00	0.4850	0.4800	0.4900	0.5000	4.00	1	2	13.30	14	12	1974
58.50	0.5200	0.5100	0.5300	0.5400	3.00	1	2	14.00	14	12	1974
59.00	0.4800	0.4700	0.4900	0.5000	5.00	1	2	15.00	14	12	1974
55.00	0.4950	0.4900	0.5000	0.5100	5.00	1	2	15.30	14	12	1974
62.00	0.6700	0.6600	0.6800	0.6900	0.40	1	2	2.30	21	12	1974
73.00	0.8250	0.8200	0.8300	0.8400	0.20	1	2	8.00	21	12	1974
63.00	0.4950	0.4950	0.4950	0.4950	14.00	1	2	0.30	2	1	1975
63.00	0.4950	0.4950	0.4950	0.4950	12.00	1	2	1.00	2	1	1975
65.00	0.4800	0.4800	0.4800	0.4800	10.00	1	2	1.30	2	1	1975
63.00	0.4650	0.4650	0.4650	0.4650	8.00	1	2	2.00	2	1	1975
71.00	0.5000	0.5000	0.5000	0.5000	7.50	1	2	2.30	2	1	1975
82.00	0.6500	0.6500	0.6500	0.6500	7.00	1	2	3.00	2	1	1975
51.00	0.7000	0.7000	0.7000	0.7000	6.50	1	2	3.30	2	1	1975

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SUNNY
NORTH
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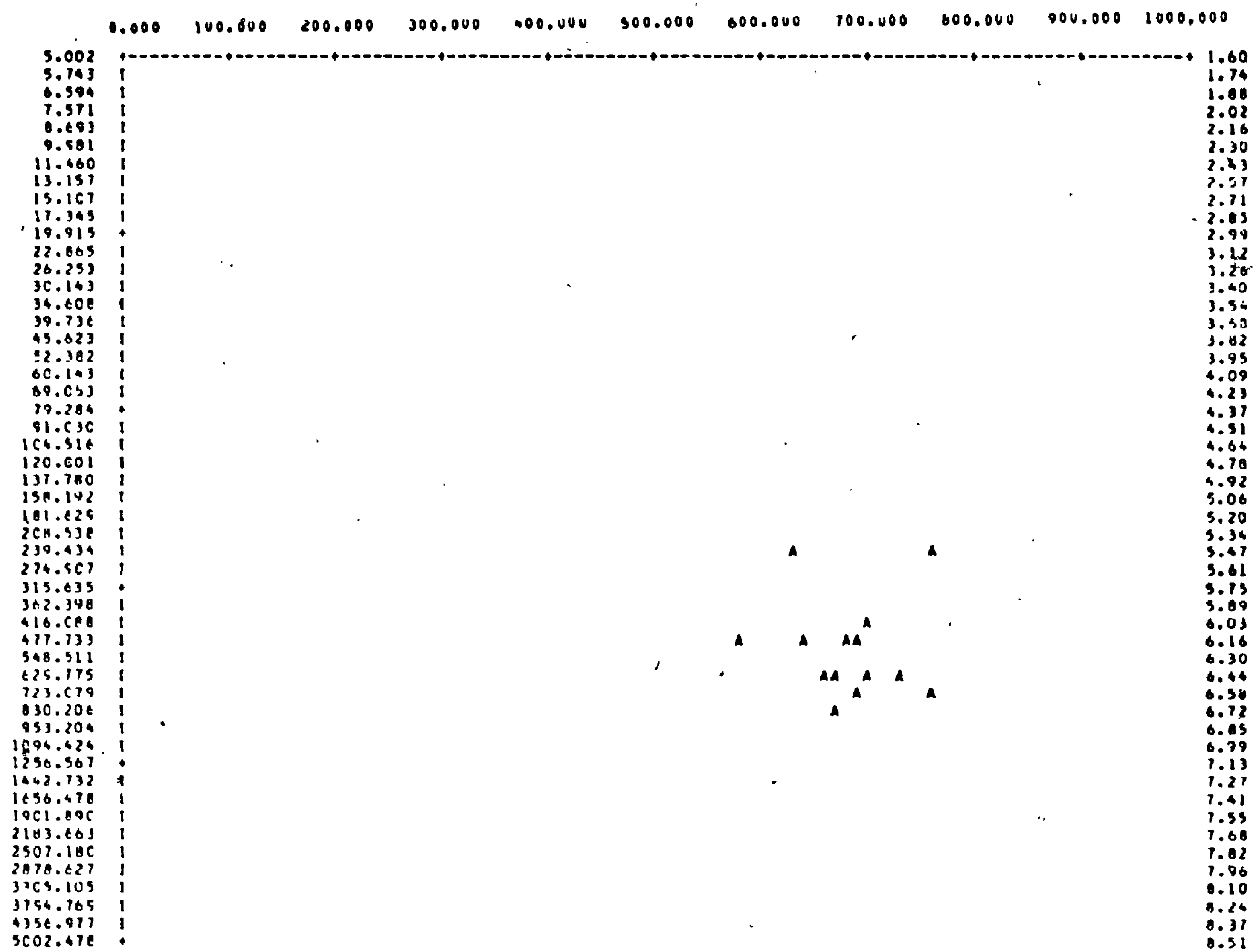

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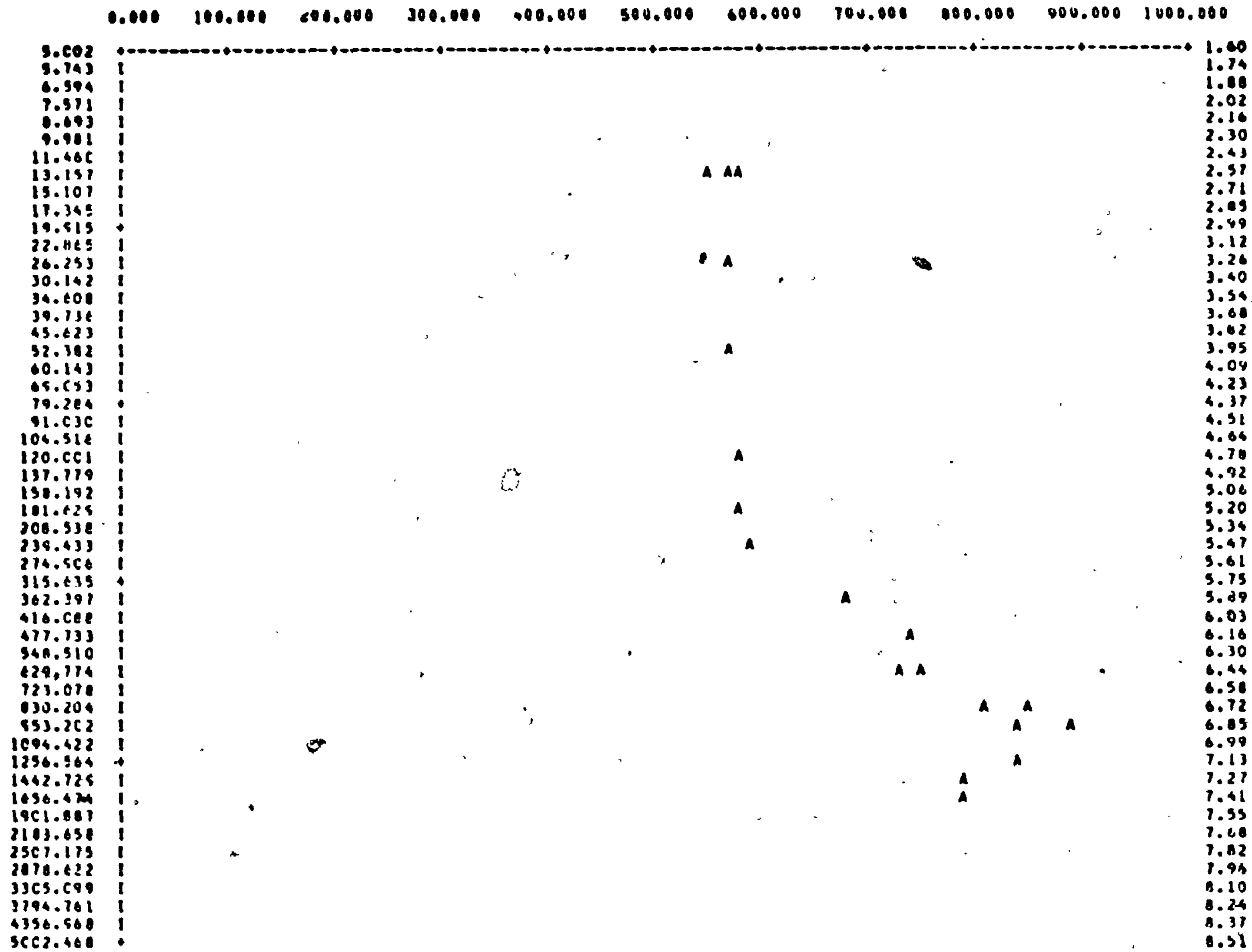


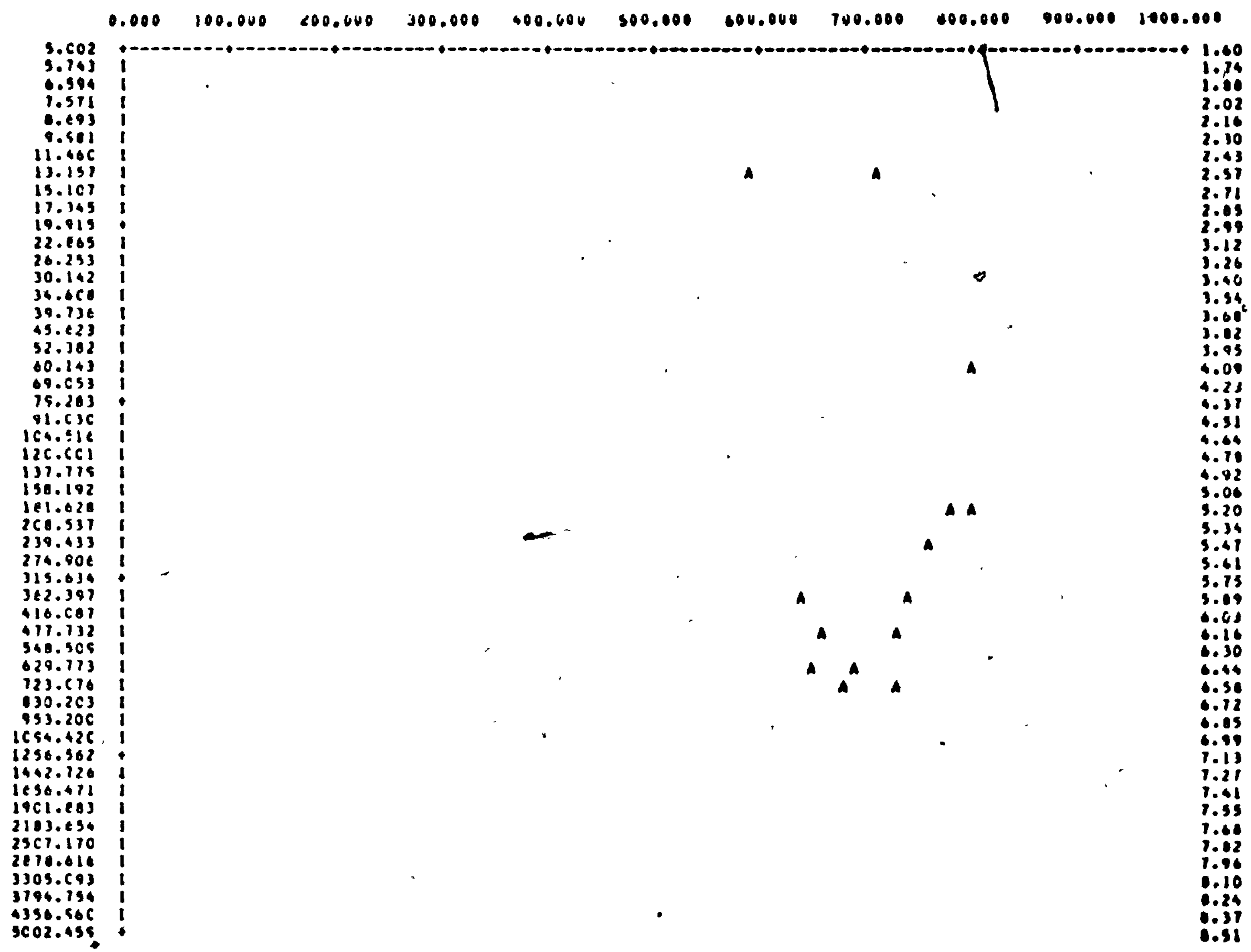
FACULTY OF ENGINEERING SCIENCE

Q	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
70.00	0.6000	0.6000	0.6000	0.6000	6.00	1	3	5.00	2	1	1975
90.00	0.7800	0.7800	0.7800	0.7800	2.00	1	3	5.30	2	1	1975
88.00	0.8200	0.8200	0.8200	0.8200	0.10	1	3	6.00	2	1	1975
70.00	0.7500	0.7500	0.7500	0.7900	0.10	1	3	6.30	2	1	1975
62.00	0.5900	0.6200	0.6350	0.5800	3.00	1	3	14.30	2	2	1975
62.80	0.5900	0.6100	0.6200	0.5800	5.00	1	3	15.00	2	2	1975
63.00	0.5900	0.5900	0.6150	0.5700	4.00	1	3	15.30	2	2	1975
63.00	0.5700	0.5800	0.5900	0.5500	6.00	1	3	16.00	2	2	1975
62.00	0.5500	0.5500	0.5700	0.5400	5.50	1	3	16.30	2	2	1975
61.00	0.5000	0.5300	0.5500	0.4900	4.00	1	3	17.00	2	2	1975
62.70	0.5100	0.5200	0.5450	0.5200	3.00	1	3	17.30	2	2	1975
62.00	0.4900	0.4500	0.5100	0.4800	1.50	1	3	18.00	2	2	1975
62.80	0.4800	0.4800	0.5000	0.4800	1.50	1	3	18.30	2	2	1975
63.00	0.4800	0.4800	0.5000	0.4800	0.50	1	3	19.00	2	2	1975

FACULTY OF ENGINEERING SCIENCE

Q	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
60.00	0.6500	0.6400	0.6600	0.6700	0.10	1	4	0.30	14	12	1974
65.50	0.7000	0.6900	0.7100	0.7200	1.00	1	4	2.00	14	12	1974
61.00	0.6700	0.6600	0.6800	0.6900	1.00	1	4	2.30	14	12	1974
60.00	0.6500	0.6400	0.6600	0.6700	1.00	1	4	3.00	14	12	1974
74.00	0.7300	0.7200	0.7400	0.7500	1.00	1	4	4.00	14	12	1974
73.00	0.7400	0.7300	0.7500	0.7600	2.00	1	4	4.30	14	12	1974
73.00	0.7400	0.7300	0.7500	0.7600	2.00	1	4	5.00	14	12	1974
75.00	0.6800	0.6700	0.6900	0.7000	1.00	1	4	6.00	14	12	1974
66.00	0.7000	0.6900	0.7100	0.7200	2.00	1	4	6.30	14	12	1974
75.00	0.7800	0.7700	0.7900	0.8000	3.00	1	4	7.30	14	12	1974
84.00	0.8000	0.7900	0.8100	0.8200	3.00	1	4	8.00	14	12	1974
81.00	0.8000	0.7900	0.8100	0.8200	3.00	1	4	8.30	14	12	1974
82.50	0.7200	0.7100	0.7300	0.7200	0.10	1	4	5.00	2	2	1975
83.00	0.7200	0.7200	0.7400	0.7250	0.10	1	4	7.00	2	2	1975
81.00	0.7200	0.7200	0.7500	0.7300	0.10	1	4	7.30	2	2	1975
66.30	0.5400	0.5500	0.5700	0.5550	4.00	1	4	6.00	3	2	1975
65.50	0.5700	0.5700	0.5900	0.5700	2.50	1	4	6.30	3	2	1975
65.00	0.5600	0.5600	0.5800	0.5500	4.00	1	4	7.00	3	2	1975
64.50	0.5550	0.5550	0.5800	0.5550	1.50	1	4	7.30	3	2	1975
64.30	0.5500	0.5600	0.5750	0.5500	3.00	1	4	8.00	3	2	1975

PARTLY CLOUDY
NORTH
NLSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



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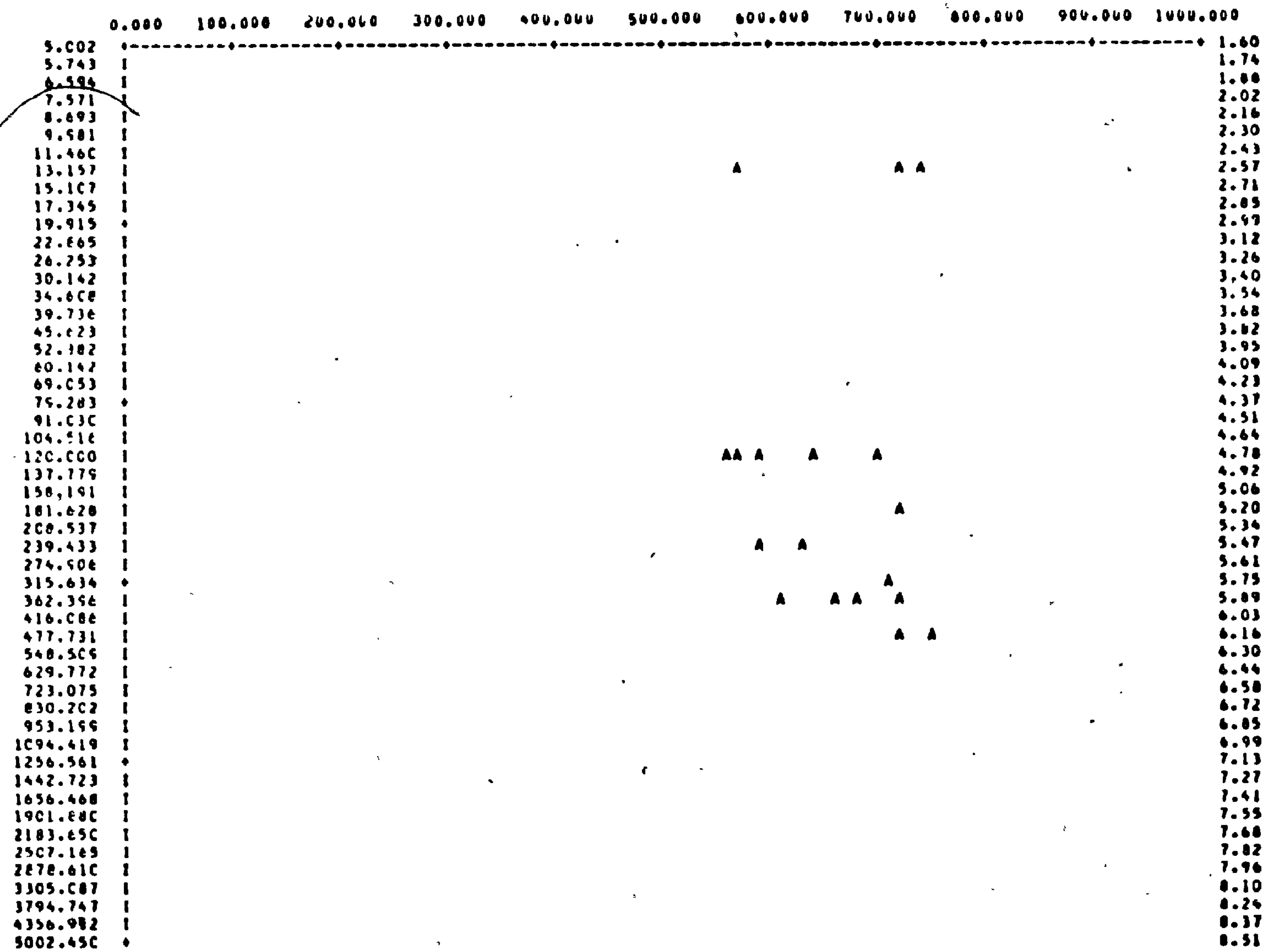

FACULTY OF ENGINEERING SCIENCE

C	CTN	CTW	DTS	CTE	VEL	D	W	TIME	D	M	YEAR
59.00	0.4800	0.4700	0.4900	0.5000	4.00	1	5	16.00	14	12	1974
62.30	0.5200	0.5100	0.5300	0.5400	0.20	1	5	17.00	14	12	1974
59.00	0.5100	0.5100	0.5100	0.5100	0.50	1	5	19.30	31	12	1974
59.50	0.5100	0.5100	0.5100	0.5100	0.50	1	5	20.00	31	12	1974
61.00	0.5200	0.5200	0.5200	0.5200	0.50	1	5	21.00	31	12	1974
61.00	0.5300	0.5300	0.5300	0.5300	1.00	1	5	21.30	31	12	1974
62.00	0.5200	0.5200	0.5200	0.5200	1.00	1	5	22.00	31	12	1974
61.00	0.5000	0.5000	0.5000	0.5000	0.50	1	5	22.30	31	12	1974
61.00	0.5300	0.5300	0.5300	0.5300	0.50	1	5	23.00	31	12	1974
73.00	0.6300	0.6400	0.6600	0.6350	8.00	1	5	12.00	19	1	1975
75.00	0.6500	0.6800	0.7100	0.6900	8.00	1	5	12.30	19	1	1975
79.00	0.7000	0.6950	0.7200	0.6900	11.00	1	5	13.00	19	1	1975
83.00	0.7300	0.7200	0.7600	0.7200	14.00	1	5	13.30	19	1	1975
83.00	0.7400	0.7300	0.7750	0.7350	11.00	1	5	14.00	19	1	1975
83.00	0.7500	0.7400	0.7800	0.7500	12.00	1	5	14.30	19	1	1975
64.80	0.5000	0.5000	0.5000	0.5000	0.50	1	5	23.30	5	2	1975

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C	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
77.00	0.6600	0.6500	0.6700	0.6800	5.00	2	1	11.00	14	12	1974
58.00	0.5000	0.4900	0.5100	0.5200	6.00	2	1	12.00	14	12	1974
63.00	0.5400	0.5500	0.5600	0.5400	2.50	2	1	8.30	3	2	1975
62.80	0.5200	0.5300	0.5400	0.5200	2.00	2	1	9.00	3	2	1975
62.00	0.5000	0.5900	0.5800	0.4800	6.00	2	1	15.00	3	2	1975
68.00	0.5600	0.6600	0.7000	0.5500	7.50	2	1	15.30	3	2	1975
65.00	0.5300	0.6100	0.6700	0.5100	7.50	2	1	16.00	3	2	1975
62.40	0.5100	0.5600	0.6500	0.5100	8.00	2	1	16.30	3	2	1975

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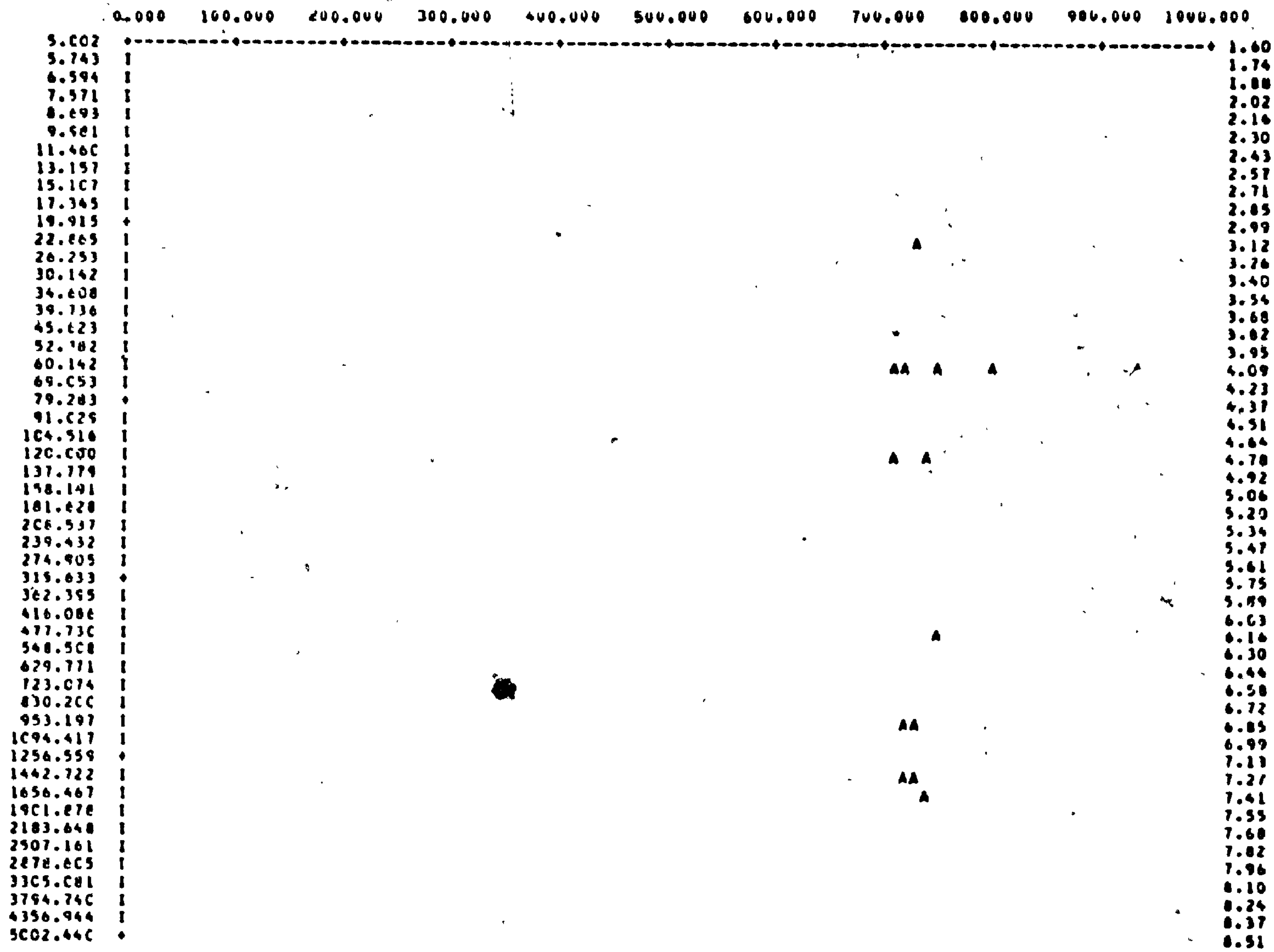
PRECIPITATION
NORTH
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



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SUNNY
NORTH-EAST
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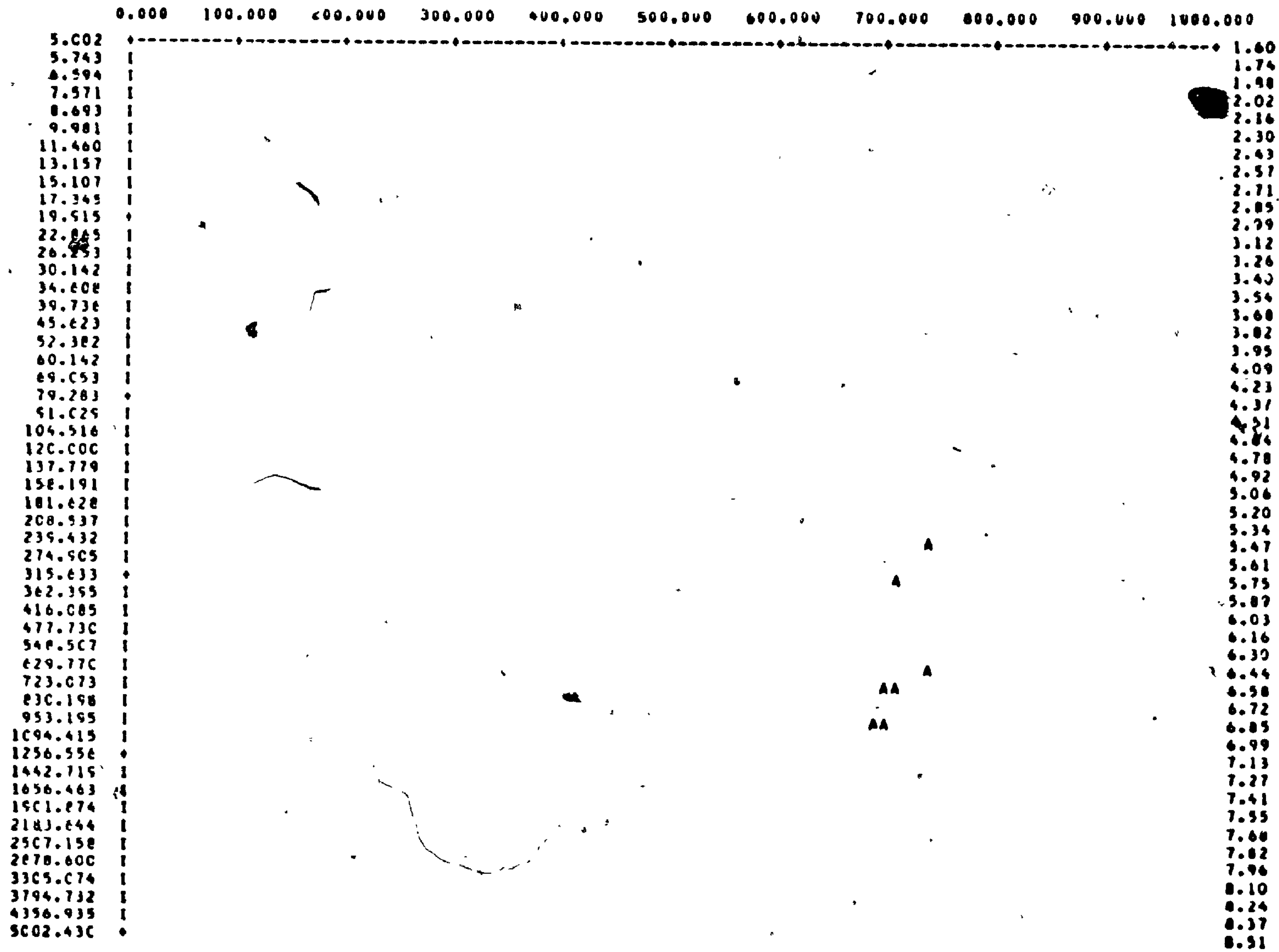

FACULTY OF ENGINEERING SCIENCE

C	CTN	CTW	DTS	CTE	VEL	D	W	TIME	D	M	YEAR
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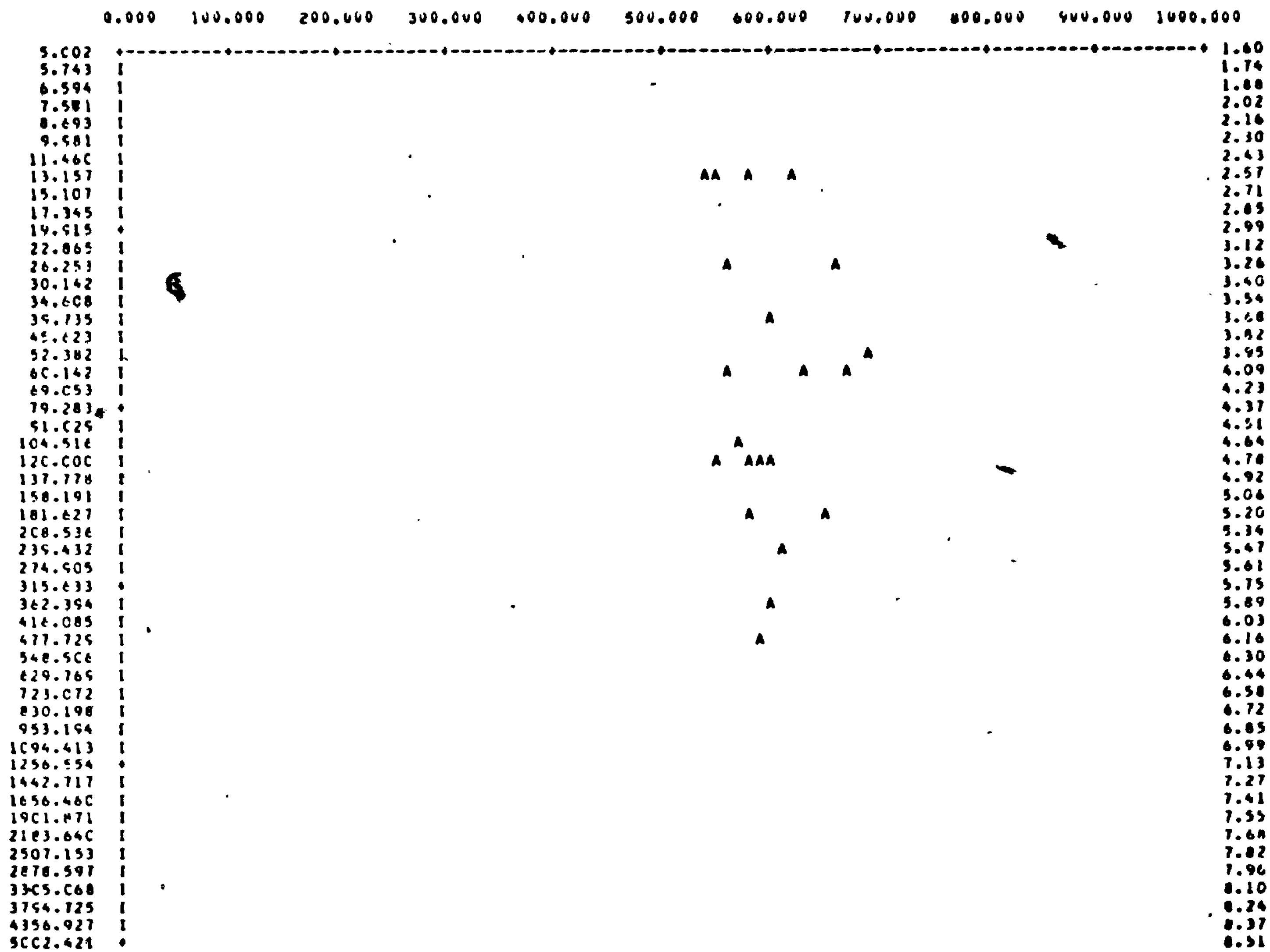
60.30	0.6800	0.6700	0.6900	0.7000	0.10	2	2	3.00	13	12	1974
60.00	0.6400	0.6300	0.6500	0.6600	0.10	2	2	12.00	13	12	1974
59.50	0.6250	0.6200	0.6300	0.6400	4.00	2	2	13.00	13	12	1974
61.00	0.6250	0.6200	0.6300	0.6400	3.00	2	2	13.30	13	12	1974
62.00	0.6300	0.6200	0.6400	0.6500	2.00	2	2	14.00	13	12	1974
60.00	0.6900	0.6800	0.7000	0.7100	0.10	2	2	16.30	13	12	1974
59.00	0.6200	0.6100	0.6300	0.6400	1.00	2	2	18.30	13	12	1974
59.50	0.6550	0.6500	0.6600	0.6700	0.50	2	2	20.00	13	12	1974
59.00	0.6600	0.6500	0.6700	0.6800	0.10	2	2	20.30	13	12	1974
60.00	0.6700	0.6600	0.6800	0.6900	1.00	2	2	21.00	13	12	1974
61.00	0.6400	0.6300	0.6500	0.6600	1.00	2	2	22.30	13	12	1974
61.00	0.6300	0.6200	0.6400	0.6500	1.00	2	2	23.00	13	12	1974
61.00	0.6350	0.6300	0.6400	0.6500	1.00	2	2	23.30	13	12	1974
61.50	0.6180	0.6100	0.6200	0.6300	0.10	2	2	18.30	14	12	1974
71.00	0.8000	0.2900	0.8100	0.8200	0.20	2	2	8.30	21	12	1974
76.80	0.8200	0.8100	0.8300	0.8400	0.30	2	2	9.00	21	12	1974
82.00	0.7700	0.7600	0.7800	0.7900	0.40	2	2	9.30	21	12	1974
77.00	0.7400	0.7300	0.7500	0.7600	0.50	2	2	10.00	21	12	1974
63.00	0.6750	0.6700	0.6800	0.6900	1.50	2	2	10.30	21	12	1974
60.00	0.6500	0.6400	0.6600	0.6700	0.80	2	2	11.00	21	12	1974
67.00	0.6200	0.6500	0.6700	0.6400	1.50	2	2	7.30	11	2	1975
65.00	0.6400	0.6100	0.6700	0.6600	[illegible]	2	2	8.00	11	2	1975

FACULTY OF ENGINEERING SCIENCE

C	CTN	CTW	DTS	CTE	VEL	D	W	TIME	D	M	YEAR
102.00	0.9150	0.9100	0.9600	0.9150	14.00	2	3	18.00	19	1	1975
103.00	0.9250	0.9100	0.9800	0.9350	17.00	2	3	18.30	19	1	1975
103.00	0.9250	0.9250	0.9900	0.9350	14.00	2	3	19.00	19	1	1975
103.00	0.9400	0.9450	1.0100	0.9550	12.00	2	3	19.30	19	1	1975
103.00	0.9500	0.9500	1.0200	0.9550	10.00	2	3	20.00	19	1	1975
103.00	0.9600	0.9600	1.0250	0.9650	8.50	2	3	20.30	19	1	1975

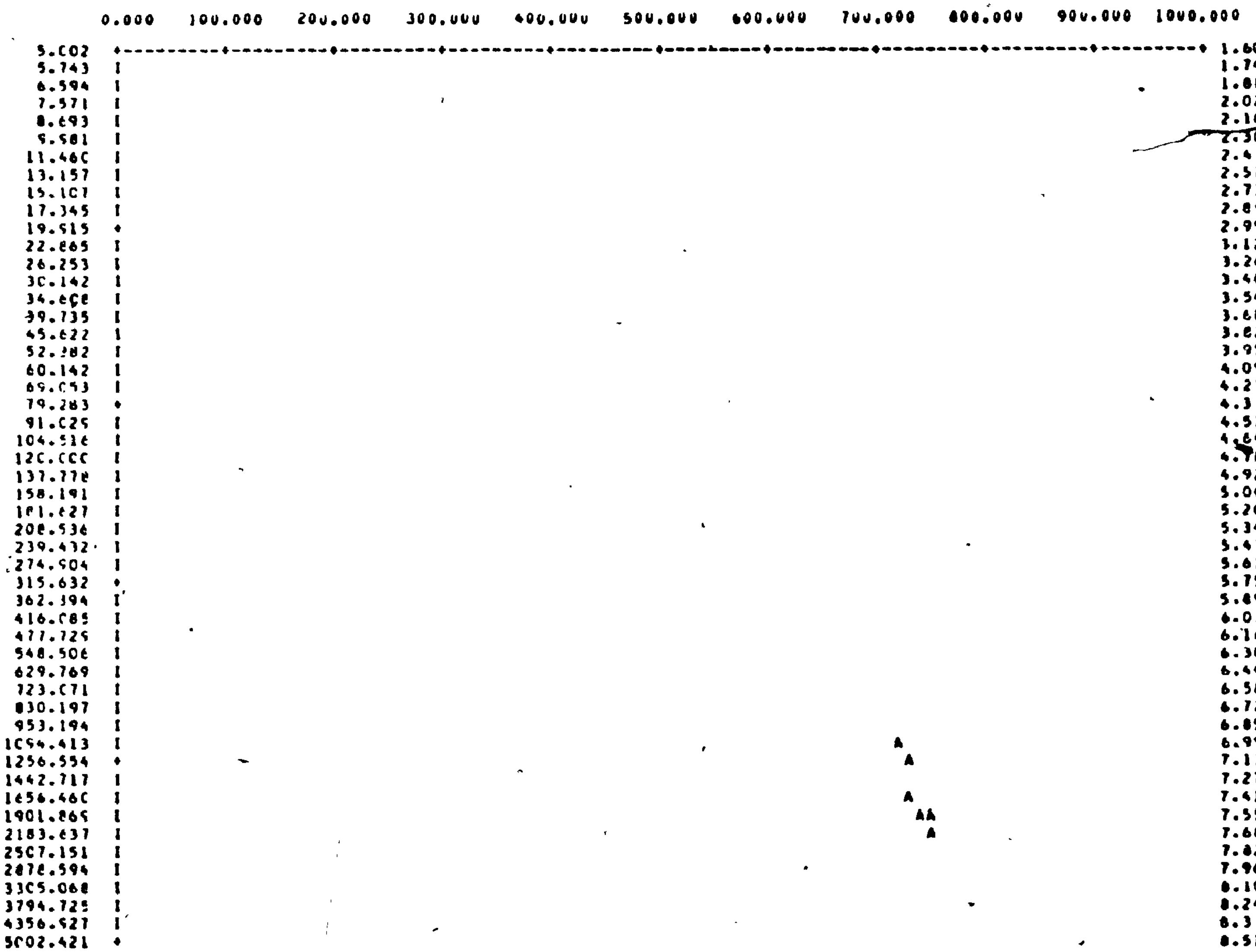
FACULTY OF ENGINEERING SCIENCE

CLOUDY
NORTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



FACULTY OF ENGINEERING SCIENCE

PARTLY CLOUDY
NORTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



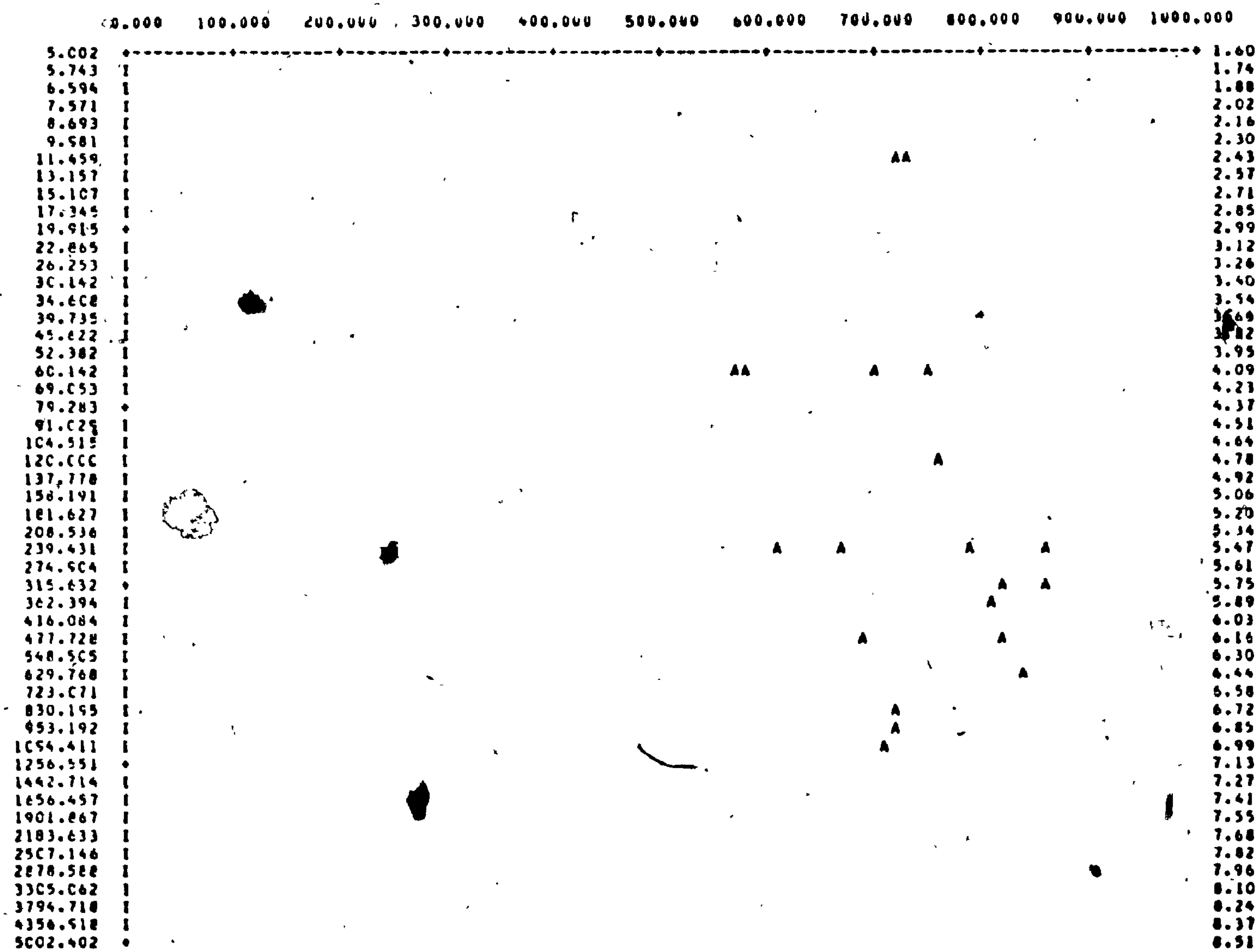
FACULTY OF ENGINEERING SCIENCE

Q	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
61.00	0.6480	0.6400	0.6500	0.6600	0.50	2	4	0.00	14	12	1974
60.00	0.6450	0.6400	0.6500	0.6600	0.50	2	4	1.00	14	12	1974
67.00	0.6950	0.6900	0.7000	0.7100	2.00	2	4	1.30	14	12	1974
81.00	0.7600	0.7500	0.7700	0.7800	4.00	2	4	7.00	14	12	1974
102.00	0.9700	0.9600	1.0250	0.9700	8.00	2	4	21.00	19	1	1975
103.00	0.9600	0.9500	1.0150	0.9600	7.50	2	4	21.30	19	1	1975
103.00	0.9550	0.9500	1.0200	0.9700	6.00	2	4	22.00	19	1	1975
69.00	0.5050	0.5050	0.5250	0.5150	5.00	2	4	20.00	1	2	1975
68.00	0.5100	0.5100	0.5300	0.5100	4.00	2	4	20.30	1	2	1975
67.00	0.5050	0.5150	0.5350	0.5100	3.00	2	4	21.00	1	2	1975
64.00	0.5200	0.5250	0.5400	0.5200	0.50	2	4	21.30	1	2	1975
64.00	0.5350	0.5350	0.5600	0.5350	0.10	2	4	22.00	1	2	1975
65.00	0.5550	0.5650	0.5800	0.5600	0.10	2	4	22.30	1	2	1975
65.00	0.5700	0.5750	0.5900	0.5700	0.50	2	4	23.00	1	2	1975
68.00	0.5850	0.5850	0.6200	0.5900	0.10	2	4	23.30	1	2	1975
71.00	0.5800	0.5800	0.6050	0.5850	1.00	2	4	0.00	2	2	1975
62.50	0.5700	0.5800	0.6000	0.5750	2.00	2	4	0.30	2	2	1975
72.00	0.5700	0.5700	0.5900	0.5650	2.00	2	4	1.00	2	2	1975
74.00	0.5600	0.5600	0.5900	0.5600	2.50	2	4	1.30	2	2	1975
77.00	0.5600	0.5700	0.5800	0.5600	2.50	2	4	2.00	2	2	1975
78.00	0.5700	0.5700	0.5950	0.5700	2.00	2	4	2.30	2	2	1975

FACULTY OF ENGINEERING SCIENCE

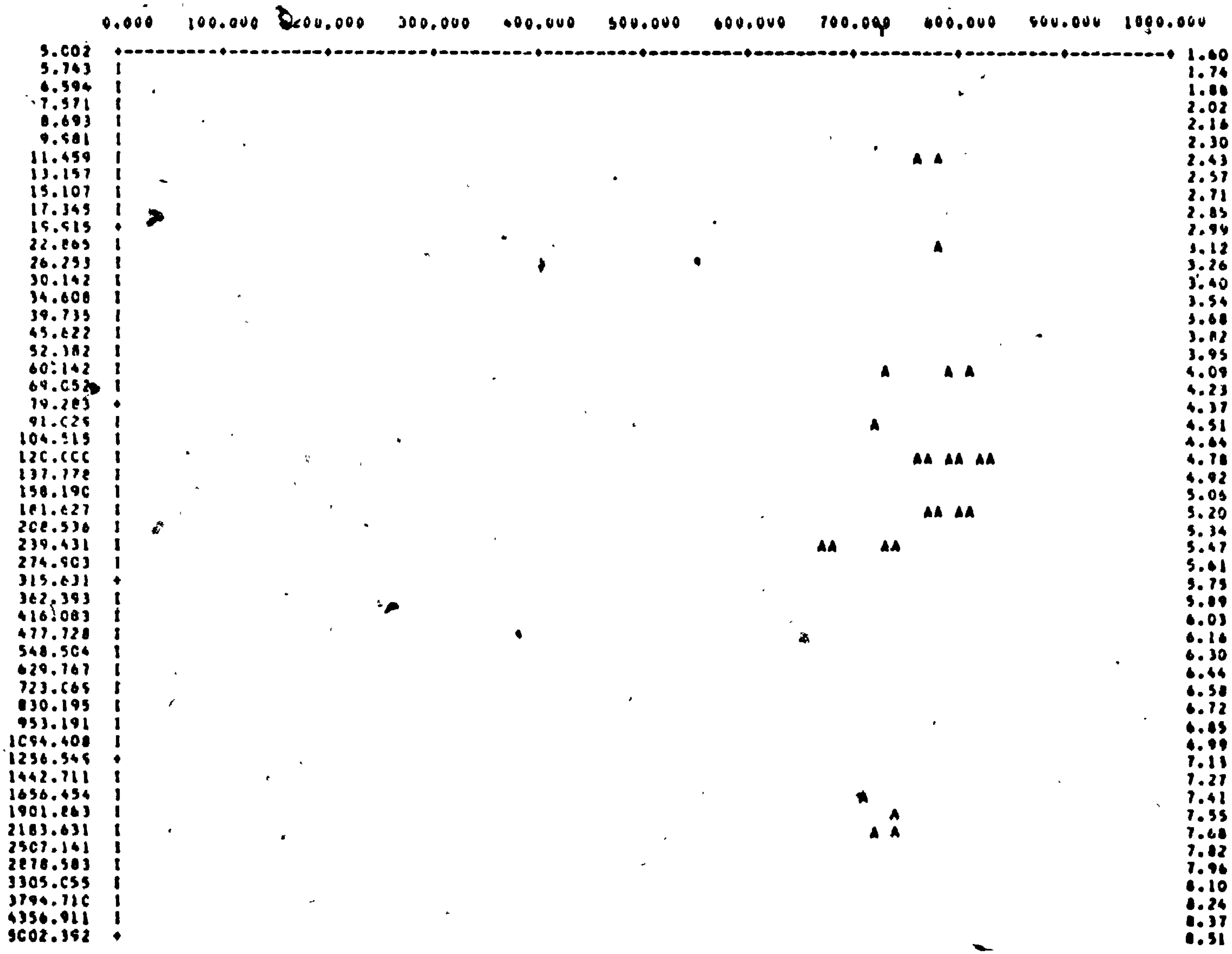
Q	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
62.00	0.5100	0.5000	0.5200	0.5300	2.00	2	5	16.30	14	12	1974
65.00	0.5300	0.5200	0.5400	0.5500	1.00	2	5	17.30	14	12	1974
58.00	0.5200	0.5100	0.5300	0.5400	2.00	2	5	16.00	21	12	1974
58.00	0.5250	0.5200	0.5300	0.5400	2.00	2	5	16.30	21	12	1974
60.00	0.5050	0.5000	0.5100	0.5200	2.00	2	5	17.00	21	12	1974
59.50	0.5000	0.4900	0.5100	0.5200	0.80	2	5	17.30	21	12	1974
57.00	0.4800	0.4800	0.4800	0.4800	0.50	2	5	20.30	31	12	1974
83.50	0.7600	0.7500	0.7900	0.7600	13.00	2	5	15.00	19	1	1975
87.50	0.7850	0.7800	0.8400	0.7900	18.00	2	5	15.30	19	1	1975
93.00	0.8200	0.8200	0.8800	0.8300	15.00	2	5	16.00	19	1	1975
95.00	0.8500	0.8400	0.9000	0.8550	18.00	2	5	16.30	19	1	1975
98.00	0.8800	0.8600	0.9400	0.8850	16.00	2	5	17.00	19	1	1975
99.50	0.8900	0.8800	0.9500	0.9000	15.00	2	5	17.30	19	1	1975
63.00	0.4900	0.4900	0.4900	0.4900	0.50	2	5	21.00	5	2	1975
64.00	0.4900	0.4900	0.4900	0.4900	0.50	2	5	21.30	5	2	1975
64.50	0.4950	0.4950	0.4950	0.4950	1.50	2	5	22.00	5	2	1975
64.30	0.4950	0.4950	0.4950	0.4950	1.50	2	5	22.30	5	2	1975
64.50	0.4950	0.4950	0.4950	0.4950	1.50	2	5	23.00	5	2	1975
66.00	0.5050	0.5050	0.5050	0.5050	0.50	2	5	0.00	6	2	1975
66.80	0.5100	0.5100	0.5100	0.5100	1.00	2	5	0.30	6	2	1975
69.00	0.5200	0.5200	0.5200	0.5200	1.00	2	5	1.00	6	2	1975
66.40	0.5200	0.5200	0.5200	0.5200	1.00	2	5	1.30	6	2	1975
64.40	0.5200	0.5200	0.5200	0.5200	1.50	2	5	2.00	6	2	1975
67.00	0.5250	0.5250	0.5250	0.5250	1.00	2	5	2.30	6	2	1975
67.50	0.5300	0.5300	0.5300	0.5300	1.00	2	5	3.00	6	2	1975
67.50	0.5400	0.5400	0.5400	0.5400	1.50	2	5	3.30	6	2	1975
67.00	0.5400	0.5400	0.5400	0.5400	1.00	2	5	4.00	6	2	1975
67.50	0.5400	0.5400	0.5400	0.5400	0.20	2	5	4.30	6	2	1975
68.00	0.5450	0.5450	0.5450	0.5450	0.10	2	5	5.00	6	2	1975
67.00	0.5500	0.5500	0.5500	0.5500	0.10	2	5	5.30	6	2	1975

CLEAR
NORTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



FACULTY OF ENGINEERING SCIENCE

PRECIPITATION
NORTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 1C**-3



FACULTY OF ENGINEERING SCIENCE

SUNNY
EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3

C	CIN	CTW	CIS	CTE	VEL	D	M	TIME	D	M	YEAR
61.20	0.4800	0.5400	0.5700	0.4900	8.00	3	1	17.00	3	2	1975
62.00	0.4400	0.4500	0.5100	0.4600	6.50	3	1	17.30	3	2	1975

Horizontal axis: 0.000 100.000 200.000 300.000 400.000 500.000 600.000 700.000 800.000 900.000 1000.000

Left axis	Right axis
5.002	1.60
5.743	1.74
6.594	1.88
7.571	2.02
8.693	2.16
9.981	2.30
11.455	2.43
13.157	2.57
15.107	2.71
17.345	2.85
19.915	2.99
22.865	3.12
26.253	3.26
30.142	3.40
34.608	3.54
39.735	3.68
45.622	3.82
52.382	3.95
60.142	4.09
69.052	4.23
79.283	4.37
91.025	4.51
104.515	4.64
120.000	4.78
137.778	4.92
158.190	5.06
181.627	5.20
208.535	5.34
239.431	5.47
274.903	5.61
315.631	5.75
362.393	5.89
416.083	6.03
477.727	6.16
548.504	6.30
629.766	6.44
723.068	6.58
830.193	6.72
953.185	6.85
1094.407	6.99
1256.548	7.13
1442.708	7.27
1656.451	7.41
1901.860	7.55
2183.627	7.68
2507.137	7.82
2878.578	7.96
3305.045	8.10
3794.704	8.24
4356.502	8.37
5002.382	8.51

Q	CTN	CTN	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
63.00	0.7250	0.7200	0.7300	0.7400	0.10	3	2	4.30	13	12	1974
64.00	0.7230	0.7200	0.7300	0.7400	0.10	3	2	5.00	13	12	1974
64.00	0.7550	0.7500	0.7600	0.7700	0.10	3	2	7.00	13	12	1974
59.00	0.7050	0.7000	0.7100	0.7200	0.10	3	2	8.00	13	12	1974
59.00	0.6780	0.6700	0.6800	0.6900	1.00	3	2	8.30	13	12	1974
58.50	0.6700	0.6600	0.6800	0.6900	1.00	3	2	9.00	13	12	1974
59.50	0.6680	0.6600	0.6700	0.6900	1.50	3	2	10.30	13	12	1974
59.80	0.6450	0.6400	0.6500	0.6600	2.00	3	2	11.00	13	12	1974
59.50	0.6400	0.6300	0.6500	0.6600	1.00	3	2	12.30	13	12	1974
64.00	0.6700	0.6600	0.6800	0.6900	2.00	3	2	14.30	13	12	1974
65.50	0.6800	0.6700	0.6900	0.7000	2.00	3	2	15.00	13	12	1974
60.50	0.6650	0.6600	0.6700	0.6800	0.10	3	2	15.30	13	12	1974
64.00	0.6500	0.6800	0.7000	0.7100	0.10	3	2	16.00	13	12	1974
[illegible]	0.6400	0.6300	0.6500	0.6600	1.00	3	2	19.00	13	12	1974
60.00	0.6600	0.6500	0.6700	0.6800	0.50	3	2	19.30	13	12	1974
70.00	0.5900	0.5800	0.6000	0.6100	4.00	3	2	19.00	14	12	1974
80.00	0.6500	0.6400	0.6600	0.6700	1.00	3	2	19.30	14	12	1974
83.00	0.7300	0.7200	0.7400	0.7500	2.00	3	2	20.00	14	12	1974
83.50	0.7600	0.7500	0.7700	0.7800	2.00	3	2	20.30	14	12	1974
61.80	0.5900	0.5800	0.6000	0.6100	4.00	3	2	2.00	15	12	1974
64.50	0.6300	0.6200	0.6400	0.6500	2.00	3	2	2.30	15	12	1974
69.00	0.6050	0.6000	0.6100	0.6200	5.00	3	2	4.00	15	12	1974
82.00	0.6950	0.6900	0.7000	0.7100	7.00	3	2	4.30	15	12	1974
71.50	0.6150	0.6100	0.6200	0.6300	7.00	3	2	5.00	15	12	1974
70.50	0.5800	0.5700	0.5900	0.6000	10.00	3	2	5.30	15	12	1974
71.00	0.5900	0.5800	0.6000	0.6100	15.00	3	2	6.00	15	12	1974
66.50	0.5500	0.5400	0.5600	0.5700	14.00	3	2	6.30	15	12	1974
61.00	0.6800	0.6700	0.6900	0.7000	0.30	3	2	3.00	21	12	1974
61.50	0.6500	0.6400	0.6600	0.6700	0.30	3	2	3.30	21	12	1974
62.80	0.6400	0.6300	0.6500	0.6600	0.20	3	2	4.00	21	12	1974
58.00	0.6300	0.6200	0.6400	0.6500	1.00	3	2	11.30	21	12	1974
58.00	0.6150	0.6100	0.6200	0.6300	1.50	3	2	12.00	21	12	1974
60.00	0.5050	0.5200	0.5300	0.5150	0.20	3	2	22.30	24	12	1974
60.00	0.4900	0.5100	0.5200	0.5050	0.20	3	2	23.00	24	12	1974
62.80	0.5900	0.5900	0.5900	0.5900	2.50	3	2	18.00	9	1	1975
63.30	0.5950	0.5950	0.5950	0.5950	0.50	3	2	18.30	9	1	1975
62.50	0.4000	0.4000	0.4000	0.4000	19.50	3	2	18.00	10	1	1975
62.00	0.4000	0.4000	0.4000	0.4000	19.00	3	2	18.30	10	1	1975
62.50	0.4850	0.4050	0.4050	0.4050	17.50	3	2	19.00	10	1	1975
63.30	0.4100	0.4100	0.4100	0.4100	18.00	3	2	19.30	10	1	1975
63.50	0.4150	0.4150	0.4150	0.4150	17.50	3	2	20.00	10	1	1975
62.00	0.4100	0.4100	0.4100	0.4100	16.00	3	2	20.30	10	1	1975
64.00	0.4200	0.4200	0.4200	0.4200	16.50	3	2	21.00	10	1	1975
64.00	0.4100	0.4100	0.4100	0.4100	19.50	3	2	21.30	10	1	1975
65.00	0.5450	0.5450	0.5450	0.5450	1.50	3	2	6.30	5	2	1975
65.00	0.5450	0.5450	0.5450	0.5450	2.50	3	2	7.00	5	2	1975
62.00	0.5550	0.5550	0.5550	0.5550	3.00	3	2	8.00	5	2	1975
63.00	0.5550	0.5550	0.5550	0.5550	2.00	3	2	8.30	5	2	1975
62.00	0.5350	0.5350	0.5350	0.5350	4.00	3	2	9.00	5	2	1975
73.00	0.6900	0.6900	0.7200	0.6900	4.00	3	2	4.00	11	2	1975
86.00	0.7400	0.7600	0.7900	0.7800	6.00	3	2	4.30	11	2	1975
78.00	0.6900	0.7000	0.7200	0.7100	5.00	3	2	5.00	11	2	1975
78.00	0.6900	0.7200	0.7400	0.7200	4.00	3	2	5.30	11	2	1975
77.00	0.6700	0.7000	0.7200	0.7000	5.00	3	2	6.00	11	2	1975
63.00	0.6200	0.6400	0.6700	0.6400	0.50	3	2	8.30	11	2	1975
63.50	0.6100	0.6500	0.6500	0.6300	2.00	3	2	9.00	11	2	1975
61.50	0.5500	0.5600	0.5800	0.5600	1.00	3	2	9.30	11	2	1975
61.50	0.5500	0.5600	0.5700	0.5500	2.00	3	2	10.00	11	2	1975

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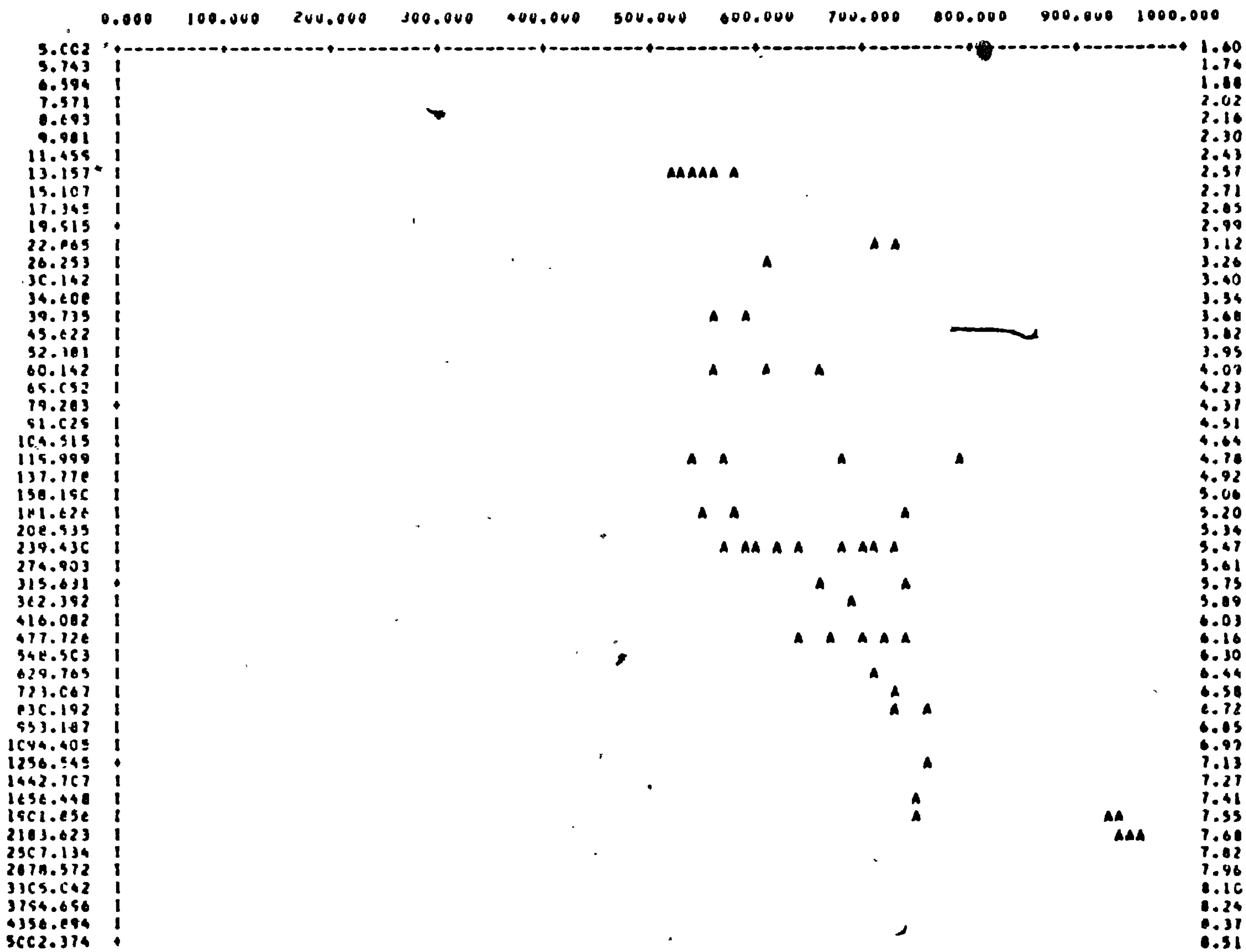
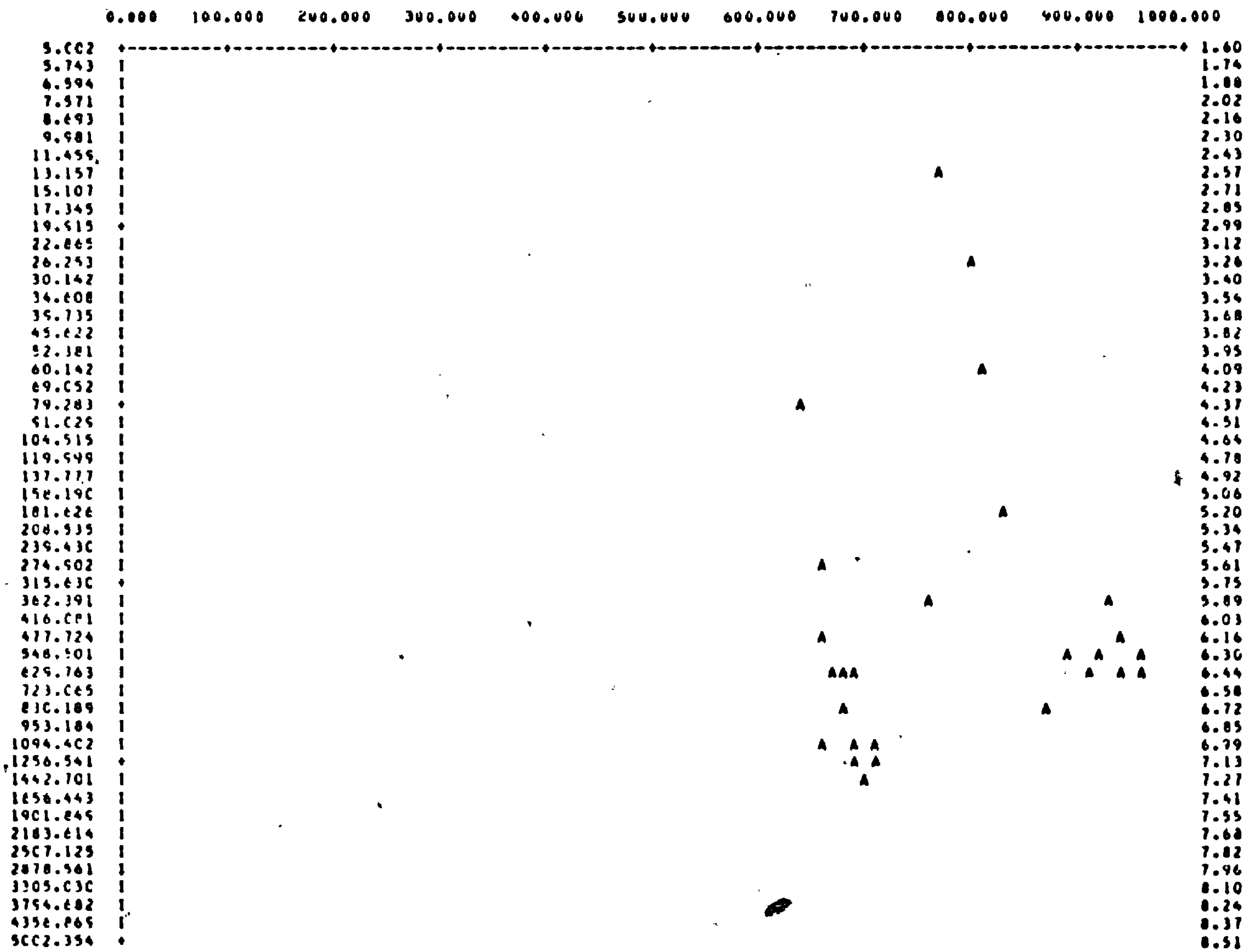
FACULTY OF ENGINEERING SCIENCE

CLOUDY
EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



Q	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
101.50	0.9650	0.9550	1.0250	0.9700	8.50	3	4	22.30	19	1	1975
103.00	0.9800	0.9800	1.0400	0.9800	9.00	3	4	23.00	19	1	1975
103.00	1.0000	1.0000	1.0500	1.0000	10.50	3	4	23.30	19	1	1975
103.00	1.0050	1.0050	1.0500	1.0200	8.00	3	4	0.00	20	1	1975
103.00	1.0150	1.0150	1.0700	1.0250	8.00	3	4	0.30	20	1	1975
102.00	1.0300	1.0300	1.0800	1.0300	5.00	3	4	1.00	20	1	1975
103.00	1.0250	1.0150	1.0600	1.0250	5.00	3	4	1.30	20	1	1975
101.50	1.0150	1.0050	1.0500	1.0050	5.00	3	4	2.00	20	1	1975
101.50	1.0200	1.0100	1.0600	1.0250	6.50	3	4	2.30	20	1	1975
101.00	1.0300	1.0300	1.0800	1.0300	3.50	3	4	3.00	20	1	1975
97.50	1.0250	1.0050	1.0700	1.0200	0.60	3	4	3.30	20	1	1975
100.50	1.0250	1.0250	1.0700	1.0200	8.00	3	4	4.00	20	1	1975
103.00	1.0050	1.0050	1.0500	1.0100	10.00	3	4	4.30	20	1	1975
101.00	1.0300	1.0300	1.0800	1.0300	2.00	3	4	5.30	20	1	1975
81.00	0.6100	0.6200	0.6500	0.6300	1.50	3	4	3.00	2	2	1975
80.50	0.6200	0.6200	0.6600	0.6400	0.50	3	4	3.30	2	2	1975
82.50	0.6500	0.6500	0.6800	0.6700	0.20	3	4	4.00	2	2	1975
82.50	0.6900	0.6900	0.7200	0.7050	3.10	3	4	4.30	2	2	1975
83.50	0.6900	0.7000	0.7200	0.7100	0.10	3	4	5.30	2	2	1975
67.00	0.4700	0.4800	0.5000	0.4700	6.50	3	4	18.00	3	2	1975
70.50	0.4700	0.4800	0.5100	0.4750	5.50	3	4	18.30	3	2	1975
74.00	0.4900	0.5000	0.5100	0.4900	5.00	3	4	19.00	3	2	1975
76.00	0.4900	0.5000	0.5200	0.4950	5.00	3	4	19.30	3	2	1975
81.00	0.5400	0.5400	0.5650	0.5500	4.00	3	4	20.00	3	2	1975
80.50	0.5300	0.5400	0.5700	0.5400	4.00	3	4	20.30	3	2	1975
80.50	0.5200	0.5300	0.5500	0.5300	4.50	3	4	21.00	3	2	1975
80.00	0.5400	0.5400	0.5700	0.5500	3.00	3	4	21.30	3	2	1975
81.00	0.5400	0.5500	0.5700	0.5500	5.00	3	4	22.00	3	2	1975
83.00	0.5700	0.5700	0.6100	0.5800	4.50	3	4	22.30	3	2	1975
81.00	0.5700	0.5700	0.6100	0.5750	4.50	3	4	23.00	3	2	1975

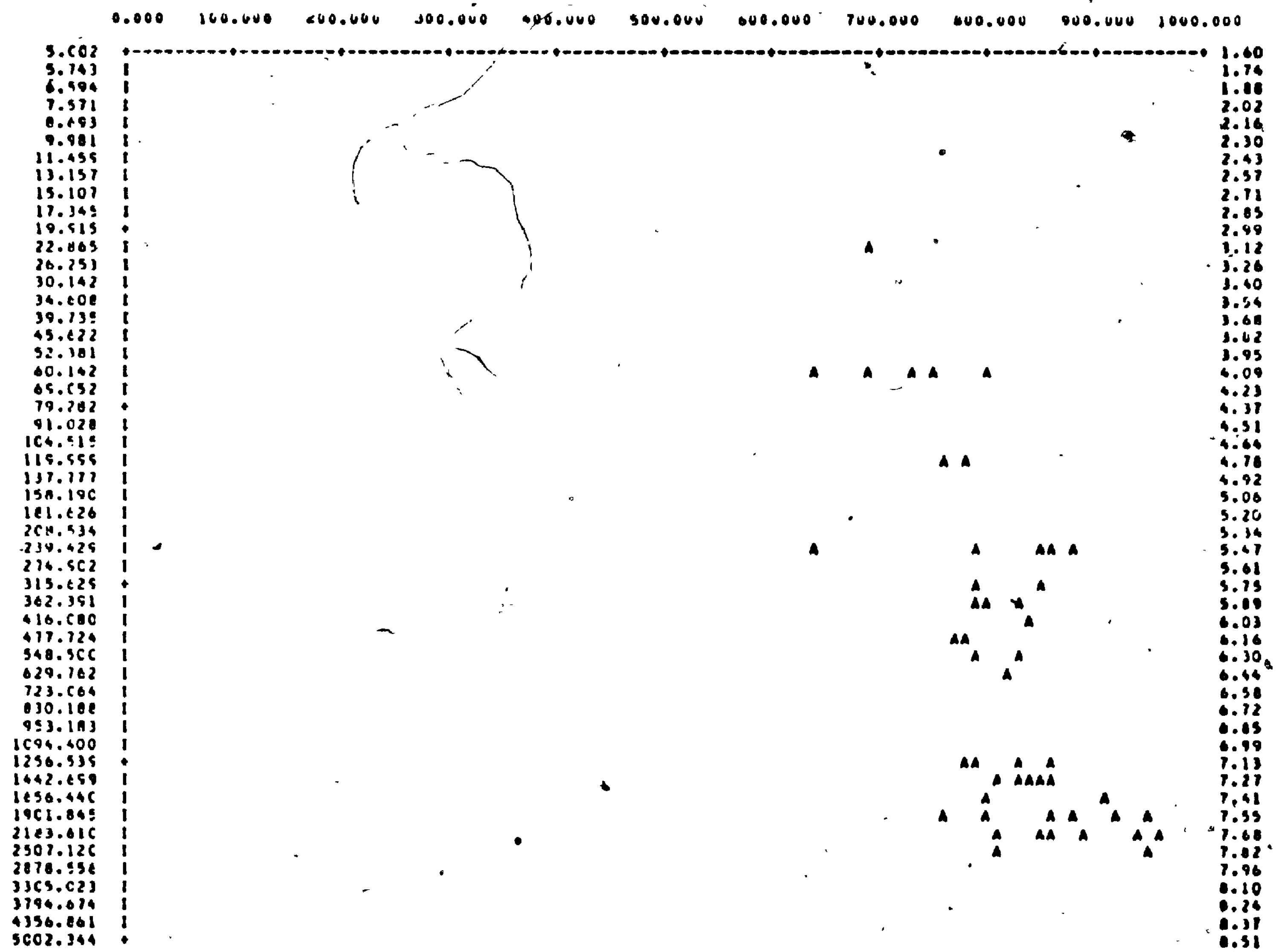
CLEAR
EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



Q	CTN	DTN	CTS	CTE	VEL	D	M	TIME	D	M	YEAR
64.00	0.5950	0.5900	0.6000	0.6100	0.50	3	5	18.00	14	12	1974
59.00	0.5600	0.5500	0.5700	0.5800	2.00	3	5	15.30	21	12	1974
60.00	0.5400	0.5400	0.5400	0.5400	0.20	3	5	14.30	31	12	1974
59.00	0.5650	0.5650	0.5650	0.5650	0.50	3	5	15.00	31	12	1974
60.00	0.5050	0.5050	0.5050	0.5050	0.50	3	5	15.30	31	12	1974
60.30	0.4950	0.4950	0.4950	0.4950	0.50	3	5	16.00	31	12	1974
60.00	0.4700	0.4700	0.4700	0.4700	1.00	3	5	16.30	31	12	1974
59.00	0.4750	0.4750	0.4750	0.4750	1.00	3	5	17.00	31	12	1974
58.50	0.4500	0.4500	0.4500	0.4500	2.00	3	5	17.30	31	12	1974
59.00	0.4800	0.4800	0.4800	0.4800	0.50	3	5	18.30	31	12	1974
60.00	0.4750	0.4750	0.4750	0.4750	1.00	3	5	19.00	31	12	1974
77.30	0.5900	0.5900	0.5900	0.5900	10.50	3	5	3.00	10	1	1975
78.50	0.5900	0.5900	0.5900	0.5900	11.50	3	5	3.30	10	1	1975
79.00	0.5900	0.5900	0.5900	0.5900	10.00	3	5	4.00	10	1	1975
72.00	0.5850	0.5850	0.5850	0.5850	10.50	3	5	4.30	10	1	1975
67.00	0.5300	0.5300	0.5300	0.5300	10.50	3	5	5.00	10	1	1975
78.50	0.5950	0.5950	0.5950	0.5950	11.50	3	5	5.30	10	1	1975
80.50	0.6000	0.6000	0.6000	0.6000	12.00	3	5	6.00	10	1	1975
77.00	0.5900	0.5900	0.5900	0.5900	12.50	3	5	6.30	10	1	1975
79.50	0.5950	0.5950	0.5950	0.5950	12.00	3	5	7.00	10	1	1975
66.50	0.5200	0.5200	0.5200	0.5200	13.00	3	5	7.30	10	1	1975
64.00	0.4950	0.4950	0.4950	0.4950	16.50	3	5	8.00	10	1	1975
63.00	0.4800	0.4800	0.4800	0.4800	17.00	3	5	8.30	10	1	1975
63.00	0.4800	0.4800	0.4800	0.4800	12.00	3	5	9.00	10	1	1975
62.00	0.4450	0.4450	0.4450	0.4450	15.00	3	5	9.30	10	1	1975
63.50	0.4600	0.4600	0.4600	0.4600	17.00	3	5	10.00	10	1	1975
72.00	0.5600	0.5600	0.5600	0.5600	19.50	3	5	10.30	10	1	1975
67.00	0.5500	0.5500	0.5500	0.5500	16.50	3	5	11.00	10	1	1975
71.00	0.5500	0.5500	0.5500	0.5500	19.00	3	5	11.30	10	1	1975
72.50	0.5100	0.5100	0.5100	0.5100	18.00	3	5	12.00	10	1	1975
65.00	0.4700	0.4700	0.4700	0.4700	18.00	3	5	12.30	10	1	1975
64.00	0.4500	0.4500	0.4500	0.4500	17.00	3	5	13.00	10	1	1975
63.50	0.4300	0.4300	0.4300	0.4300	14.50	3	5	13.30	10	1	1975
64.00	0.4300	0.4300	0.4300	0.4300	15.00	3	5	14.00	10	1	1975
63.50	0.4100	0.4100	0.4100	0.4100	16.50	3	5	14.30	10	1	1975
64.00	0.4100	0.4100	0.4100	0.4100	19.50	3	5	15.00	10	1	1975
64.00	0.4100	0.4100	0.4100	0.4100	19.50	3	5	15.30	10	1	1975
64.00	0.4100	0.4100	0.4100	0.4100	19.50	3	5	16.00	10	1	1975
63.00	0.4100	0.4100	0.4100	0.4100	19.00	3	5	16.30	10	1	1975
62.50	0.4050	0.4050	0.4050	0.4050	20.00	3	5	17.00	10	1	1975
62.00	0.4000	0.4000	0.4000	0.4000	20.50	3	5	17.30	10	1	1975
63.50	0.5000	0.5000	0.5000	0.5000	3.00	3	5	13.00	5	2	1975
62.50	0.4800	0.4800	0.4800	0.4800	3.00	3	5	13.30	5	2	1975
62.00	0.4950	0.4950	0.4950	0.4950	4.00	3	5	14.00	5	2	1975
62.80	0.4950	0.4950	0.4950	0.4950	4.00	3	5	14.30	5	2	1975
62.00	0.4850	0.4850	0.4850	0.4850	4.50	3	5	15.00	5	2	1975
63.20	0.4700	0.4700	0.4700	0.4700	4.50	3	5	16.00	5	2	1975
63.00	0.4750	0.4750	0.4750	0.4750	5.00	3	5	15.30	5	2	1975
62.70	0.4650	0.4650	0.4650	0.4650	3.00	3	5	16.30	5	2	1975
62.50	0.4600	0.4600	0.4600	0.4600	3.50	3	5	17.00	5	2	1975
63.00	0.4550	0.4550	0.4550	0.4550	2.00	3	5	17.30	5	2	1975
63.00	0.4550	0.4550	0.4550	0.4550	2.50	3	5	18.00	5	2	1975
63.70	0.4550	0.4550	0.4550	0.4550	2.00	3	5	18.30	5	2	1975
64.00	0.4500	0.4500	0.4500	0.4500	2.00	3	5	19.00	5	2	1975
63.20	0.4700	0.4700	0.4700	0.4700	3.00	3	5	19.30	5	2	1975
63.00	0.4900	0.4900	0.4900	0.4900	2.50	3	5	20.00	5	2	1975
63.50	0.4900	0.4900	0.4900	0.4900	0.50	3	5	20.30	5	2	1975

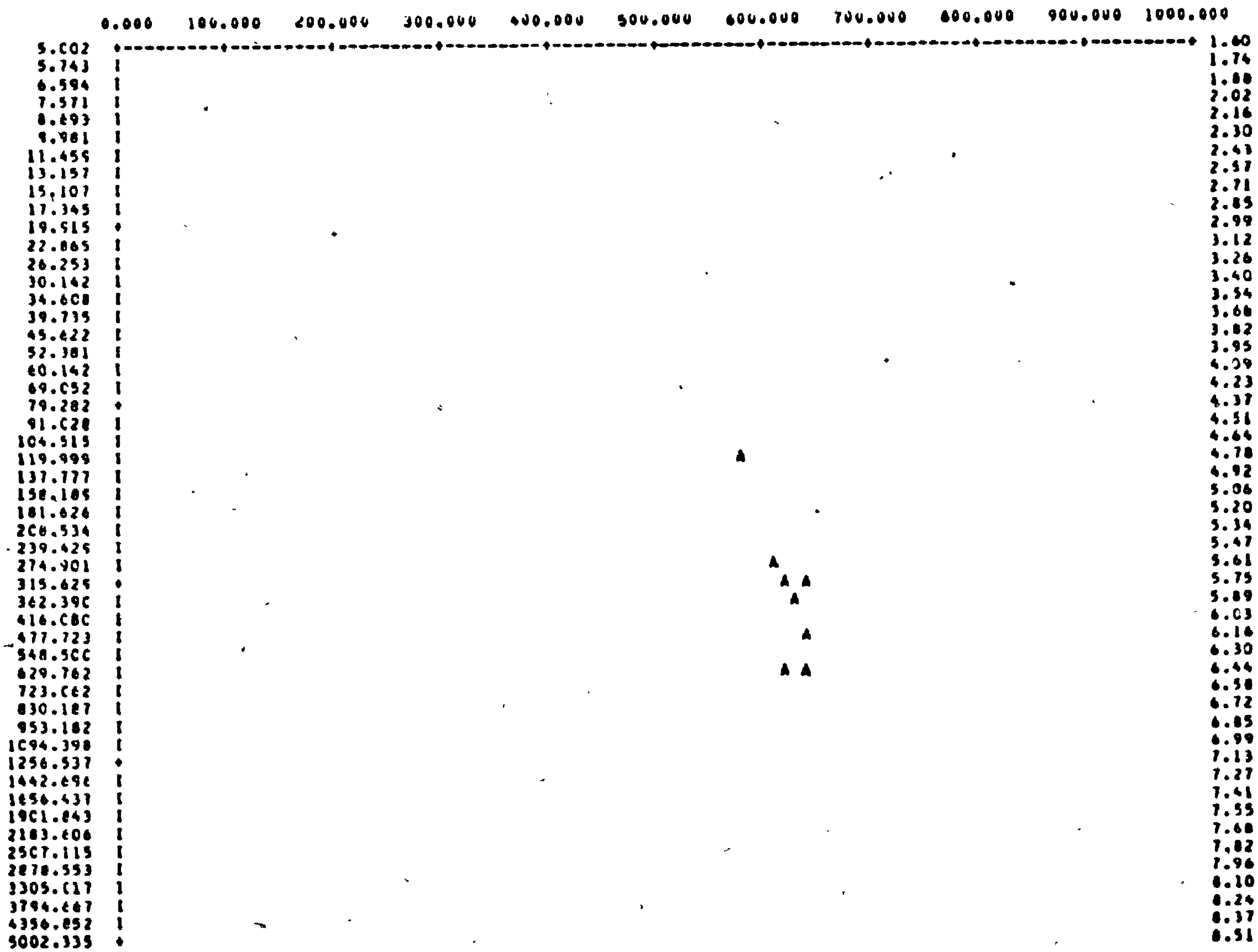
PRECIPITATION
EAST

NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



Q	CTN	DTN	CTS	DTE	VEL	D	W	TIME	D	M	YEAR
84.00	0.89C0	0.8900	0.9200	0.9C00	2.C0	4	1	9.C0	20	1	1975
85.50	0.8750	0.8550	0.9C00	0.8650	3.50	4	1	9.30	20	1	1975
83.00	0.87CC	C.8900	0.88C0	0.8200	3.C0	4	1	10.00	20	1	1975
78.00	0.81C0	0.880C	0.8300	0.7700	2.50	4	1	10.30	20	1	1975
68.CC	C.7400	0.8C00	0.75C0	0.6800	1.C0	4	1	11.00	20	1	1975
6C.C0	C.56C0	0.59C0	0.5900	0.5600	2.50	4	1	11.C0	28	1	1975
54.CC	C.5150	0.560C	C.5500	0.5C00	5.00	4	1	11.30	28	1	1975
57.CC	C.5450	0.57CC	0.5600	0.5C00	5.50	4	1	12.00	28	1	1975

SUNNY
SOUTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



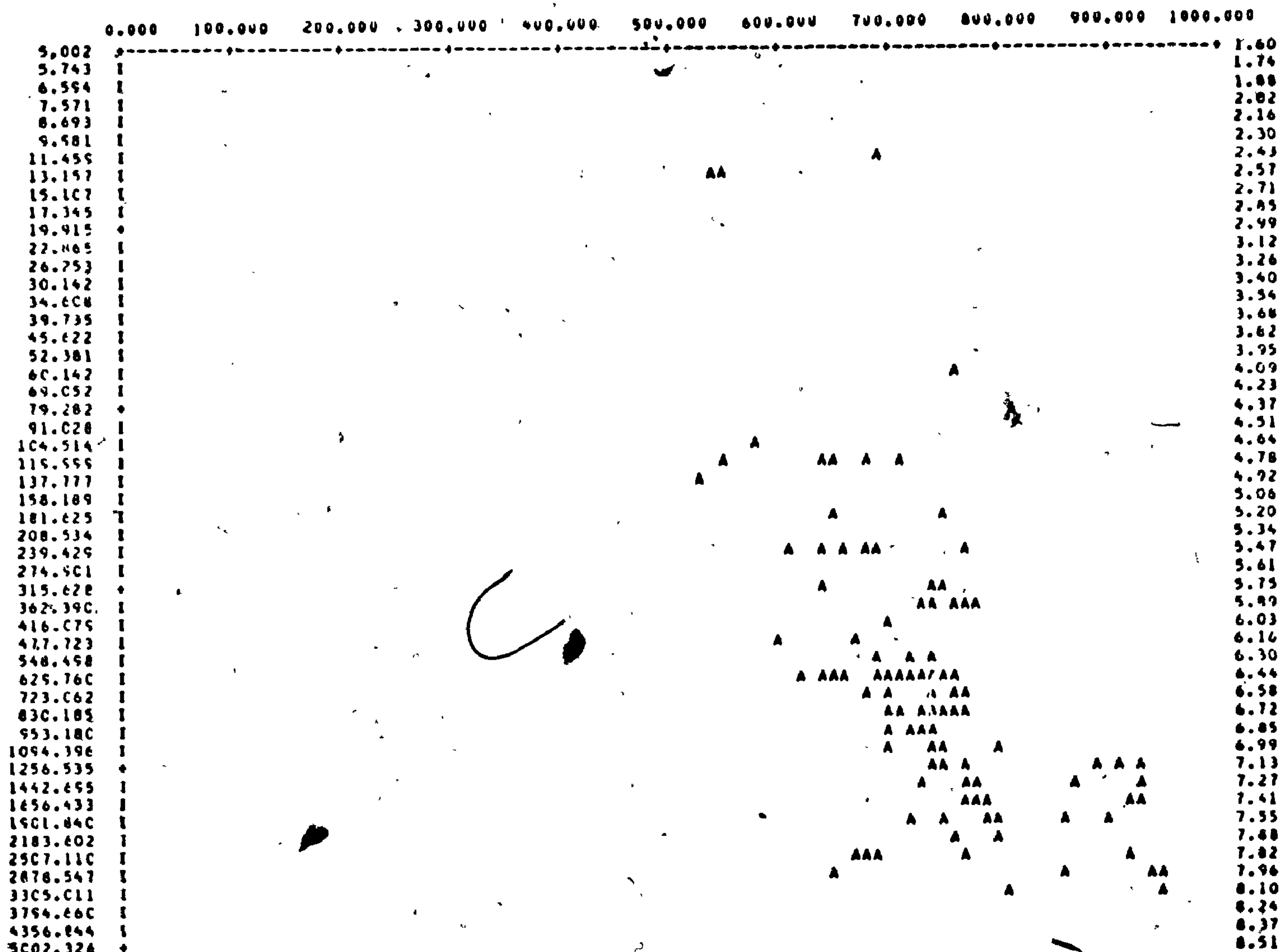
FACULTY OF ENGINEERING SCIENCE

Q	CTA	DTN	CTS	DTE	VEL	D	W	TIME	D	M	YEAR
63.30	0.7250	0.7200	0.7300	0.7400	0.10	4	2	4.00	13	12	1974
63.80	0.7250	0.7200	0.7300	0.7400	0.10	4	2	4.00	13	12	1974
62.50	0.7300	0.7200	0.7400	0.7500	1.10	4	2	7.30	13	12	1974
59.00	0.6700	0.6600	0.6800	0.6900	0.10	4	2	9.30	13	12	1974
59.00	0.6650	0.6600	0.6700	0.6800	1.00	4	2	10.00	13	12	1974
74.00	0.7400	0.7300	0.7500	0.7600	1.00	4	2	21.00	14	12	1974
83.00	0.7550	0.7500	0.7600	0.7700	1.00	4	2	21.30	14	12	1974
80.00	0.8050	0.8000	0.8100	0.8200	2.00	4	2	22.00	14	12	1974
83.50	0.7950	0.7900	0.8000	0.8100	2.00	4	2	22.30	14	12	1974
64.00	0.6450	0.6400	0.6500	0.6600	5.00	4	2	23.00	14	12	1974
60.20	0.5800	0.5700	0.5900	0.6000	5.00	4	2	23.30	14	12	1974
62.00	0.5550	0.5500	0.5600	0.5700	5.00	4	2	0.00	15	12	1974
62.80	0.5900	0.5800	0.6000	0.6100	5.00	4	2	0.30	15	12	1974
60.30	0.5800	0.5700	0.5900	0.6000	5.00	4	2	1.00	15	12	1974
60.40	0.6100	0.6000	0.6200	0.6300	2.00	4	2	1.30	15	12	1974
61.30	0.6300	0.6200	0.6400	0.6500	4.00	4	2	3.00	15	12	1974
65.80	0.6000	0.5900	0.6100	0.6200	6.00	4	2	3.30	15	12	1974
67.50	0.5400	0.5300	0.5500	0.5600	10.00	4	2	7.00	15	12	1974
83.00	0.6100	0.6000	0.6200	0.6300	12.00	4	2	7.30	15	12	1974
61.00	0.5200	0.5100	0.5300	0.5400	16.00	4	2	8.00	15	12	1974
83.00	0.6200	0.6100	0.6300	0.6400	22.00	4	2	8.30	15	12	1974
82.00	0.6800	0.6700	0.6900	0.7000	19.00	4	2	9.00	15	12	1974
61.00	0.5500	0.5400	0.5600	0.5700	20.00	4	2	9.30	15	12	1974
81.50	0.6400	0.6300	0.6500	0.6600	25.00	4	2	10.00	15	12	1974
62.50	0.5900	0.5800	0.6000	0.6100	25.00	4	2	10.30	15	12	1974
59.00	0.5350	0.5300	0.5400	0.5500	20.00	4	2	11.00	15	12	1974
58.00	0.5150	0.5100	0.5200	0.5300	20.00	4	2	11.30	15	12	1974
65.00	0.5150	0.5100	0.5200	0.5300	13.00	4	2	21.00	15	12	1974
60.80	0.5800	0.5700	0.5900	0.6000	5.00	4	2	5.00	19	12	1974
84.50	0.7800	0.7700	0.7900	0.8000	6.00	4	2	5.30	19	12	1974
61.50	0.6600	0.6500	0.6700	0.6800	0.80	4	2	4.30	21	12	1974
62.50	0.5650	0.5650	0.5650	0.5650	0.10	4	2	0.30	1	1	1975
64.00	0.6100	0.6100	0.6100	0.6100	1.50	4	2	19.00	9	1	1975
63.50	0.5700	0.5700	0.5700	0.5700	2.00	4	2	19.30	9	1	1975
64.00	0.5700	0.5700	0.5700	0.5700	3.50	4	2	20.00	9	1	1975
64.50	0.5700	0.5700	0.5700	0.5700	5.50	4	2	20.30	9	1	1975
65.00	0.5650	0.5650	0.5650	0.5650	7.50	4	2	21.00	9	1	1975
64.30	0.5400	0.5400	0.5400	0.5400	5.50	4	2	21.30	9	1	1975
64.50	0.5400	0.5400	0.5400	0.5400	6.00	4	2	22.00	9	1	1975
64.00	0.5450	0.5450	0.5450	0.5450	7.00	4	2	22.30	9	1	1975
69.00	0.5900	0.5900	0.5900	0.5900	5.50	4	2	23.00	9	1	1975
68.50	0.5750	0.5750	0.5750	0.5750	5.00	4	2	23.30	9	1	1975
64.00	0.4300	0.4300	0.4300	0.4300	20.00	4	2	22.00	10	1	1975
64.00	0.4200	0.4200	0.4200	0.4200	25.00	4	2	22.30	10	1	1975
64.50	0.4200	0.4200	0.4200	0.4200	24.00	4	2	23.00	10	1	1975
64.00	0.4150	0.4150	0.4150	0.4150	26.00	4	2	23.30	10	1	1975
63.00	0.5800	0.6000	0.6300	0.5950	1.00	4	2	17.30	28	1	1975
67.00	0.6000	0.6100	0.6400	0.6100	1.00	4	2	18.00	28	1	1975
71.00	0.6350	0.6450	0.6700	0.6400	2.00	4	2	18.30	28	1	1975
77.00	0.6600	0.6600	0.6900	0.6650	3.00	4	2	19.00	28	1	1975
69.00	0.6700	0.6800	0.7000	0.6800	2.50	4	2	19.30	28	1	1975
70.00	0.6000	0.6200	0.6500	0.6300	7.00	4	2	0.00	29	1	1975
70.50	0.6050	0.6100	0.6400	0.6200	8.00	4	2	0.30	29	1	1975
68.50	0.5900	0.6000	0.6400	0.6200	7.50	4	2	1.00	29	1	1975
68.50	0.5900	0.6000	0.6400	0.6050	7.00	4	2	1.30	29	1	1975
68.00	0.5900	0.6100	0.6450	0.6100	6.50	4	2	2.00	29	1	1975
87.50	0.6100	0.6100	0.6100	0.6100	10.00	4	2	4.00	4	2	1975
86.50	0.6000	0.6000	0.6000	0.6000	14.00	4	2	4.30	4	2	1975

85.50	0.6000	0.6000	0.6000	0.6000	13.00	4	2	5.00	4	2	1975
86.50	0.6050	0.6050	0.6050	0.6050	11.00	4	2	5.30	4	2	1975
87.00	0.6050	0.6050	0.6050	0.6050	11.00	4	2	6.00	4	2	1975
85.50	0.6050	0.6050	0.6050	0.6050	10.00	4	2	6.30	4	2	1975
73.50	0.5800	0.5800	0.5800	0.5800	9.00	4	2	7.00	4	2	1975
83.00	0.6000	0.6000	0.6000	0.6000	10.00	4	2	7.30	4	2	1975
81.50	0.6050	0.6050	0.6050	0.6050	12.50	4	2	8.00	4	2	1975
81.00	0.5750	0.5750	0.5750	0.5750	15.00	4	2	8.30	4	2	1975
74.00	0.5600	0.5600	0.5600	0.5600	16.50	4	2	9.00	4	2	1975
63.00	0.5100	0.5200	0.5300	0.5200	16.00	4	2	9.30	4	2	1975
63.50	0.4900	0.5100	0.5200	0.5100	14.00	4	2	10.00	4	2	1975
63.00	0.5000	0.5100	0.5200	0.5100	18.00	4	2	10.30	4	2	1975
62.50	0.4900	0.4900	0.4900	0.4900	15.00	4	2	11.00	4	2	1975
63.20	0.4900	0.4900	0.4900	0.4900	15.00	4	2	11.30	4	2	1975
62.00	0.4900	0.4900	0.4900	0.4900	12.00	4	2	12.00	4	2	1975
63.00	0.4900	0.4900	0.4900	0.4900	13.00	4	2	12.30	4	2	1975
63.20	0.4900	0.4900	0.4900	0.4900	17.00	4	2	13.00	4	2	1975
62.00	0.4950	0.4950	0.4950	0.4950	12.00	4	2	13.30	4	2	1975
61.80	0.5050	0.5050	0.5050	0.5050	10.00	4	2	16.30	4	2	1975
61.00	0.5150	0.5150	0.5150	0.5150	12.00	4	2	17.00	4	2	1975
61.00	0.5100	0.5100	0.5100	0.5100	10.00	4	2	17.30	4	2	1975
60.00	0.5000	0.5000	0.5000	0.5000	10.50	4	2	18.00	4	2	1975
60.50	0.5000	0.5000	0.5000	0.5000	8.00	4	2	18.30	4	2	1975
61.50	0.5100	0.5100	0.5100	0.5100	7.00	4	2	19.30	4	2	1975
61.50	0.5150	0.5150	0.5150	0.5150	7.00	4	2	20.00	4	2	1975
62.20	0.5150	0.5150	0.5150	0.5150	7.00	4	2	20.30	4	2	1975
62.30	0.5150	0.5150	0.5150	0.5150	7.00	4	2	21.00	4	2	1975
63.70	0.5100	0.5100	0.5100	0.5100	6.00	4	2	21.30	4	2	1975
64.00	0.5150	0.5150	0.5150	0.5150	7.00	4	2	22.00	4	2	1975
65.00	0.5200	0.5200	0.5200	0.5200	3.00	4	2	2.00	5	2	1975
65.00	0.5250	0.5250	0.5250	0.5250	3.00	4	2	3.30	5	2	1975
65.50	0.5300	0.5300	0.5300	0.5300	2.00	4	2	4.00	5	2	1975
65.00	0.5350	0.5350	0.5350	0.5350	0.50	4	2	4.30	5	2	1975
65.00	0.5400	0.5400	0.5400	0.5400	1.50	4	2	5.00	5	2	1975
65.50	0.5450	0.5450	0.5450	0.5450	2.50	4	2	5.30	5	2	1975
65.00	0.5450	0.5450	0.5450	0.5450	2.50	4	2	6.00	5	2	1975
63.80	0.5450	0.5450	0.5450	0.5450	3.00	4	2	7.30	5	2	1975
62.30	0.5100	0.5100	0.5100	0.5100	8.50	4	2	9.30	5	2	1975
63.00	0.5100	0.5100	0.5100	0.5100	7.00	4	2	10.00	5	2	1975
63.00	0.5100	0.5100	0.5100	0.5100	6.00	4	2	10.30	5	2	1975
63.50	0.5150	0.5150	0.5150	0.5150	7.00	4	2	11.00	5	2	1975
63.80	0.5200	0.5200	0.5200	0.5200	5.00	4	2	11.30	5	2	1975
100.00	0.8700	0.8600	0.9000	0.9100	3.00	4	2	19.30	10	2	1975
100.00	0.9100	0.8900	0.9400	0.9300	3.00	4	2	20.00	10	2	1975
100.50	0.9400	0.9100	0.9600	0.9600	4.50	4	2	20.30	10	2	1975
100.50	0.9200	0.9000	0.9600	0.9400	7.00	4	2	21.00	10	2	1975
98.00	0.9200	0.9100	0.9600	0.9500	5.00	4	2	0.00	11	2	1975
97.00	0.9200	0.9100	0.9500	0.9400	8.00	4	2	0.30	11	2	1975
100.00	0.9000	0.8900	0.9400	0.9200	4.50	4	2	1.00	11	2	1975
83.00	0.7500	0.7500	0.7700	0.7500	5.00	4	2	1.30	11	2	1975
98.80	0.8900	0.8800	0.9200	0.9200	8.00	4	2	2.00	11	2	1975
99.00	0.8800	0.8700	0.9200	0.9100	5.00	4	2	2.30	11	2	1975
84.00	0.8100	0.8100	0.8500	0.8400	4.00	4	2	3.00	11	2	1975
75.00	0.7300	0.7300	0.7500	0.7300	5.00	4	2	3.30	11	2	1975
74.00	0.6500	0.6900	0.7000	0.6800	4.50	4	2	6.30	11	2	1975
68.00	0.6100	0.6600	0.6700	0.6500	2.00	4	2	7.00	11	2	1975

FACULTY OF ENGINEERING SCIENCE

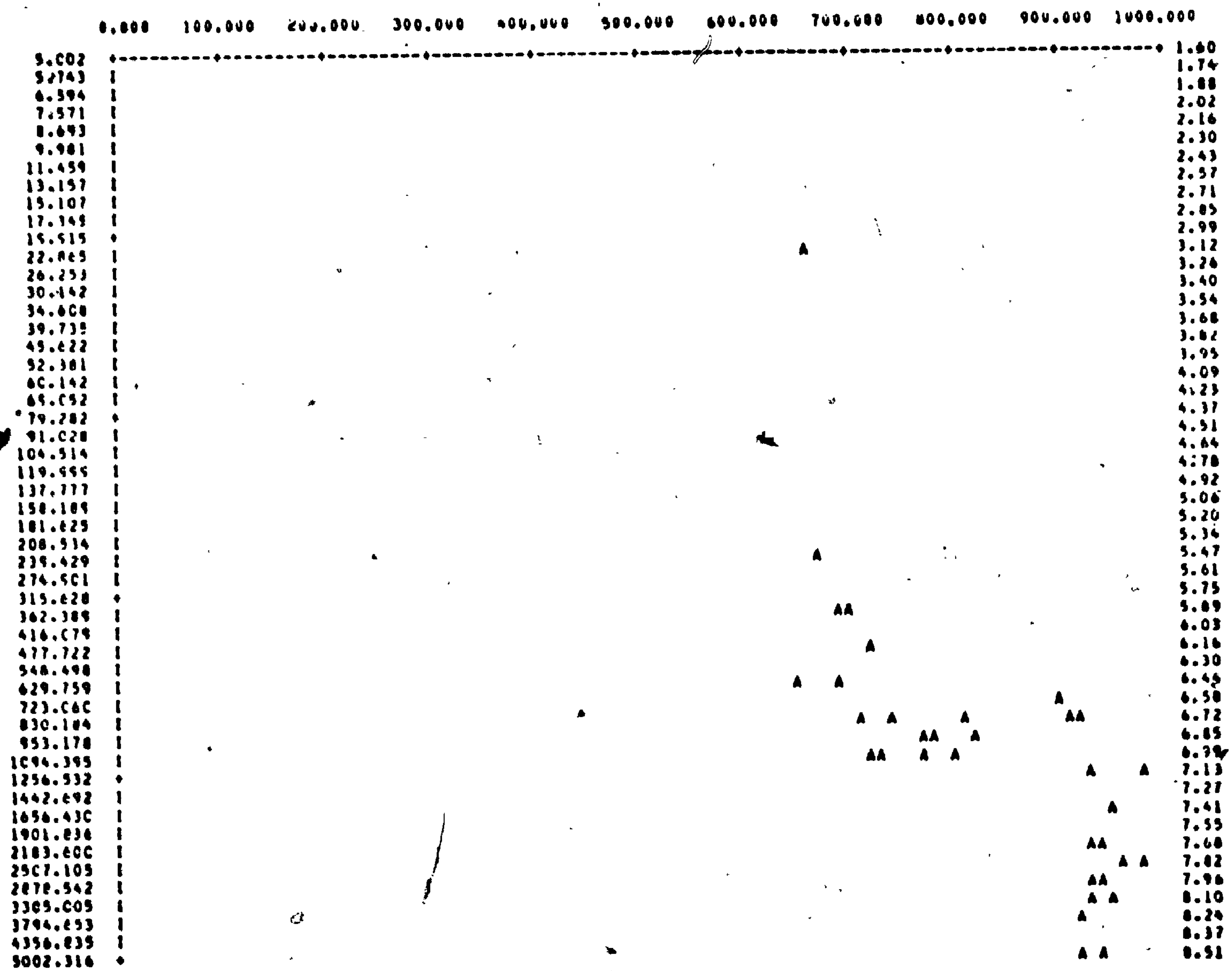
CLOUDY
SOUTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 1C**-3



C	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	N	YEAR
61.00	0.5700	0.5700	0.5700	0.5700	0.20	4	3	19.00	2	1	197[illegible]
63.CC	0.5450	0.545C	0.5450	0.5450	4.00	4	3	19.30	2	1	1975
62.50	0.55C0	0.5500	0.5500	0.5500	3.00	4	3	2C.00	2	1	1975
61.50	0.57C0	0.5700	0.5700	0.5700	2.00	4	3	20.30	2	1	1975
61.00	0.58CC	0.5800	0.5800	0.5800	5.C0	4	3	21.00	2	1	1975
66.C0	0.6CC0	0.6CC0	0.6C00	0.6C00	3.C0	4	3	17.00	7	1	1975
61.5C	C.55C0	0.55C0	0.5500	0.5500	5.00	4	3	17.30	7	1	1975
66.00	0.51C0	0.51CC	0.5100	0.5100	8.50	4	3	C.00	8	1	1975
7C.00	0.54C0	0.54C0	C.5400	0.5400	7.C0	4	3	0.30	8	1	1975
71.C0	0.56CC	0.5600	0.5600	0.5600	9.C0	4	3	1.00	8	1	1975
69.50	0.57C0	0.5700	0.5700	0.5700	8.C0	4	3	1.30	8	1	1975
69.20	0.5600	0.5600	0.5600	0.5600	7.50	4	3	2.00	8	1	1975
65.CC	0.42C0	0.42CC	0.4200	0.42C0	29.00	4	3	C.C0	11	1	1975
65.C0	0.43C0	0.43CC	0.4300	0.4300	25.C0	4	3	C.30	11	1	1975
65.00	0.43C0	0.4300	0.43C0	0.4300	25.C0	4	3	1.C0	11	1	1975
65.50	0.43CC	C.43C0	0.43C0	0.4300	24.C0	4	3	1.30	11	1	1975
57.00	0.37C0	C.3700	0.3700	0.3700	28.C0	4	3	2.00	11	1	1975
45.CC	C.29C0	0.29CC	0.2900	0.2900	33.00	4	3	2.30	11	1	1975
46.5C	C.28C0	0.28CC	0.2800	0.2800	21.00	4	3	3.00	11	1	1975
47.C0	C.29C0	0.29CC	0.2900	0.2900	21.C0	4	3	3.30	11	1	1975
46.C0	0.29C0	0.29C0	0.29C0	0.2900	2C.C0	4	3	4.C0	11	1	1975
46.50	0.295C	0.2950	0.2950	0.2950	18.C0	4	3	4.30	11	1	1975
74.C0	0.6C5C	0.6350	0.66C0	0.6350	7.C0	4	3	20.00	28	1	1975
82.00	0.63C0	0.64C0	0.6700	0.6500	8.CC	4	3	2C.30	28	1	1975
77.CC	C.6250	0.63CC	0.6700	0.6400	8.50	4	3	21.00	28	1	1975
72.CC	C.62C0	0.64CC	0.6650	0.6550	6.50	4	3	21.30	28	1	1975
72.00	C.61CC	0.63CC	0.6500	0.63C0	8.50	4	3	2[illegible].C0	28	1	1975
72.50	0.605C	0.63C0	C.6600	0.6400	8.50	4	3	23.[illegible]0	28	1	1975
72.50	0.6C5C	0.6300	0.66C0	0.6400	8.50	4	3	23.30	29	1	1975
82.00	0.57C0	0.57C0	0.6C00	0.5800	6.50	4	3	0.00	4	2	1975
81.50	0.58C0	C.5800	0.58C0	0.5800	6.C0	4	3	0.30	4	2	1975
83.C0	0.58C0	0.58CC	0.5800	0.5800	7.C0	4	3	1.00	4	2	1975
84.CC	0.58C0	0.58CC	0.5800	0.580C	10.00	4	3	1.30	4	2	1975
85.50	0.58C0	0.580C	0.5800	0.5800	13.C0	4	3	2.C0	4	2	1975
85.C0	0.58CC	0.5800	0.58C0	0.5800	11.C0	4	3	2.30	4	2	1975
84.C0	0.58CC	C.580C	0.58C0	0.5800	11.C0	4	3	3.00	4	2	1975
87.50	0.58C0	0.58C0	0.58C0	0.5800	1C.C0	4	3	3.30	4	2	1975

FACULTY OF ENGINEERING SCIENCE

PARTLY CLOUDY
SOUTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3

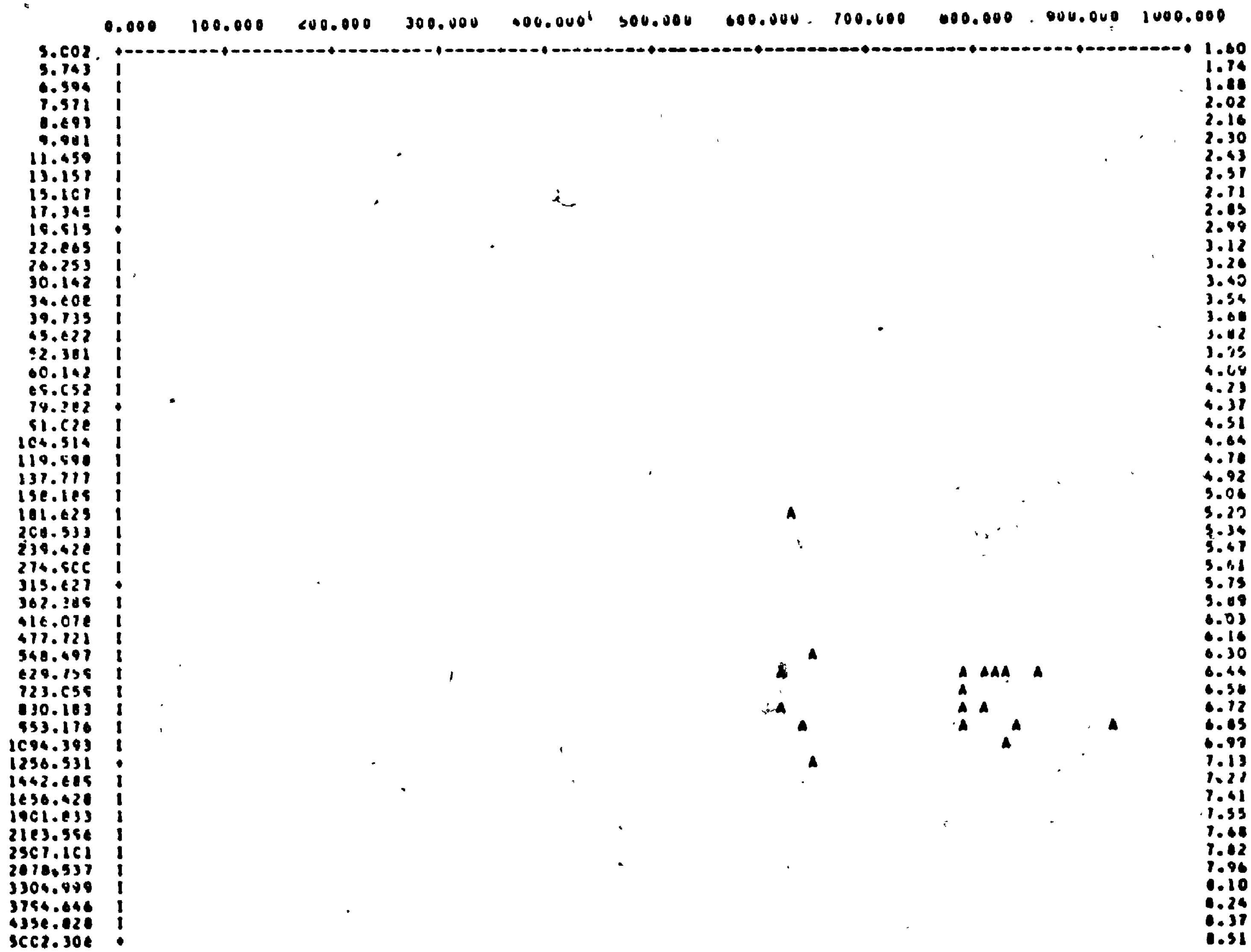


FACULTY OF ENGINEERING SCIENCE

Q	CTN	CTW	DTS	CTE	VEL	D	W	TIME	D	M	YEAR
62.80	0.4900	0.4900	0.4900	0.4900	5.00	4	4	18.00	7	1	1975
63.00	0.4900	0.4900	0.4900	0.4900	6.00	4	4	18.30	7	1	1975
63.00	0.4800	0.4800	0.4800	0.4800	7.00	4	4	19.00	7	1	1975
64.00	0.4900	0.4900	0.4900	0.4900	5.00	4	4	19.30	7	1	1975
64.50	0.4800	0.4800	0.4800	0.4800	5.00	4	4	20.00	7	1	1975
65.50	0.4700	0.4700	0.4700	0.4700	5.00	4	4	20.30	7	1	1975
64.50	0.4800	0.4800	0.4800	0.4800	8.50	4	4	21.00	7	1	1975
64.80	0.4800	0.4800	0.4800	0.4800	8.00	4	4	21.30	7	1	1975
64.80	0.5100	0.5100	0.5100	0.5100	7.50	4	4	22.00	7	1	1975
65.00	0.4900	0.4900	0.4900	0.4900	5.00	4	4	22.30	7	1	1975
65.50	0.5000	0.5000	0.5000	0.5000	7.00	4	4	23.00	7	1	1975
66.00	0.5200	0.5200	0.5200	0.5200	7.00	4	4	23.30	7	1	1975
93.50	1.0050	1.0000	1.0500	1.0000	5.00	4	4	6.00	20	1	1975
87.00	0.9200	0.9200	0.9800	0.9300	6.50	4	4	6.30	20	1	1975
88.70	0.9000	0.9100	0.9500	0.9700	7.50	4	4	7.00	20	1	1975
89.20	0.8900	0.9000	0.9400	0.9150	10.00	4	4	7.30	20	1	1975
87.00	0.8700	0.8750	0.8200	0.8900	4.00	4	4	8.00	20	1	1975
86.00	0.8850	0.8800	0.9300	0.9100	1.50	4	4	8.30	20	1	1975
83.00	0.5600	0.5600	0.5900	0.5750	8.00	4	4	23.30	3	2	1975

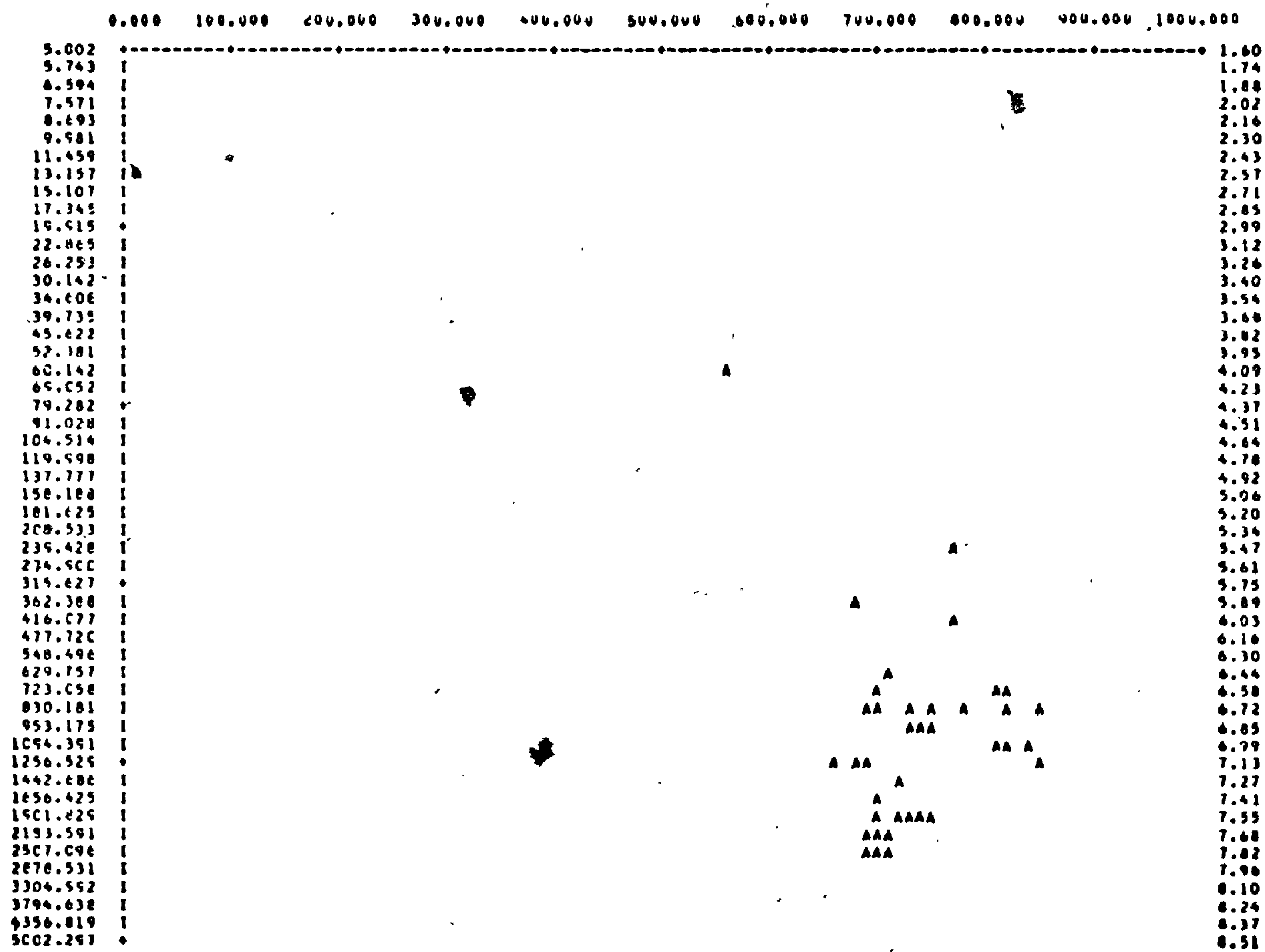
FACULTY OF ENGINEERING SCIENCE

CLEAR
SOUTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



C	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
56.00	0.4950	0.4900	0.5000	0.5100	20.00	4	5	12.00	15	12	1974
56.00	0.4900	0.4800	0.5000	0.5100	18.00	4	5	12.30	15	12	1974
56.50	0.4950	0.4900	0.5000	0.5100	20.00	4	5	13.00	15	12	1974
58.50	0.5000	0.4900	0.5100	0.5200	22.00	4	5	13.30	15	12	1974
58.50	0.5000	0.4900	0.5100	0.5200	18.00	4	5	14.00	15	12	1974
57.00	0.4950	0.4900	0.5000	0.5100	16.00	4	5	14.30	15	12	1974
58.00	0.5150	0.5100	0.5200	0.5300	17.00	4	5	15.00	15	12	1974
57.50	0.5000	0.4900	0.5100	0.5200	21.00	4	5	15.30	15	12	1974
58.00	0.5050	0.5000	0.5100	0.5200	15.00	4	5	16.00	15	12	1974
58.80	0.5100	0.5000	0.5200	0.5300	17.00	4	5	16.30	15	12	1974
60.00	0.5200	0.5100	0.5300	0.5400	14.00	4	5	17.00	15	12	1974
58.30	0.5050	0.5000	0.5100	0.5200	15.00	4	5	17.30	15	12	1974
64.00	0.5150	0.5100	0.5200	0.5600	16.00	4	5	18.30	15	12	1974
62.50	0.5150	0.5100	0.5200	0.5300	15.00	4	5	19.00	15	12	1974
60.50	0.5150	0.5100	0.5200	0.5300	12.00	4	5	19.30	15	12	1974
61.00	0.5200	0.5100	0.5300	0.5400	15.00	4	5	20.00	15	12	1974
61.00	0.5100	0.5000	0.5200	0.5300	16.00	4	5	20.30	15	12	1974
85.00	0.7950	0.7900	0.8000	0.8100	6.00	4	5	6.00	19	12	1974
76.00	0.6600	0.6500	0.6700	0.6800	7.00	4	5	8.30	19	12	1974
74.00	0.6400	0.6300	0.6500	0.6600	8.00	4	5	9.00	19	12	1974
61.50	0.5700	0.5600	0.5800	0.5900	10.00	4	5	9.30	19	12	1974
62.00	0.5550	0.5500	0.5600	0.5700	11.00	4	5	10.00	19	12	1974
73.00	0.6200	0.6100	0.6300	0.6400	8.00	4	5	10.30	19	12	1974
63.00	0.5600	0.5500	0.5700	0.5800	7.00	4	5	11.00	19	12	1974
61.50	0.5400	0.5300	0.5500	0.5600	7.00	4	5	11.30	19	12	1974
58.70	0.6400	0.6300	0.6500	0.6600	0.50	4	5	15.00	21	12	1974
59.00	0.5300	0.5300	0.5300	0.5300	3.00	4	5	18.00	31	12	1974
66.00	0.5800	0.5800	0.5800	0.5800	5.00	4	5	0.00	10	1	1975
65.50	0.5650	0.5650	0.5650	0.5650	12.00	4	5	0.30	10	1	1975
68.50	0.5700	0.5700	0.5700	0.5700	7.00	4	5	1.00	10	1	1975
69.00	0.5750	0.5750	0.5750	0.5750	7.50	4	5	1.30	10	1	1975
75.00	0.5900	0.5900	0.5900	0.5900	8.50	4	5	2.00	10	1	1975
76.00	0.5900	0.5900	0.5900	0.5900	9.00	4	5	2.30	10	1	1975
66.30	0.5950	0.6000	0.6500	0.6150	10.00	4	5	2.30	29	1	1975
76.00	0.6000	0.6000	0.6600	0.6300	6.50	4	5	3.00	29	1	1975
71.00	0.5800	0.5900	0.6400	0.6050	8.00	4	5	3.30	29	1	1975
80.00	0.5850	0.5850	0.6400	0.6100	10.50	4	5	4.00	29	1	1975
80.00	0.5900	0.6000	0.6300	0.6200	9.50	4	5	4.30	29	1	1975
79.00	0.6000	0.6000	0.6500	0.6400	5.50	4	5	5.00	29	1	1975
78.30	0.5900	0.5900	0.6500	0.6100	6.00	4	5	5.30	29	1	1975
79.50	0.5750	0.5850	0.6400	0.6000	7.00	4	5	6.00	29	1	1975
75.00	0.5600	0.5700	0.6000	0.5850	6.50	4	5	6.30	29	1	1975
63.00	0.5050	0.5050	0.5050	0.5050	3.50	4	5	12.00	5	2	1975
62.50	0.5000	0.5000	0.5000	0.5000	2.00	4	5	12.30	5	2	1975

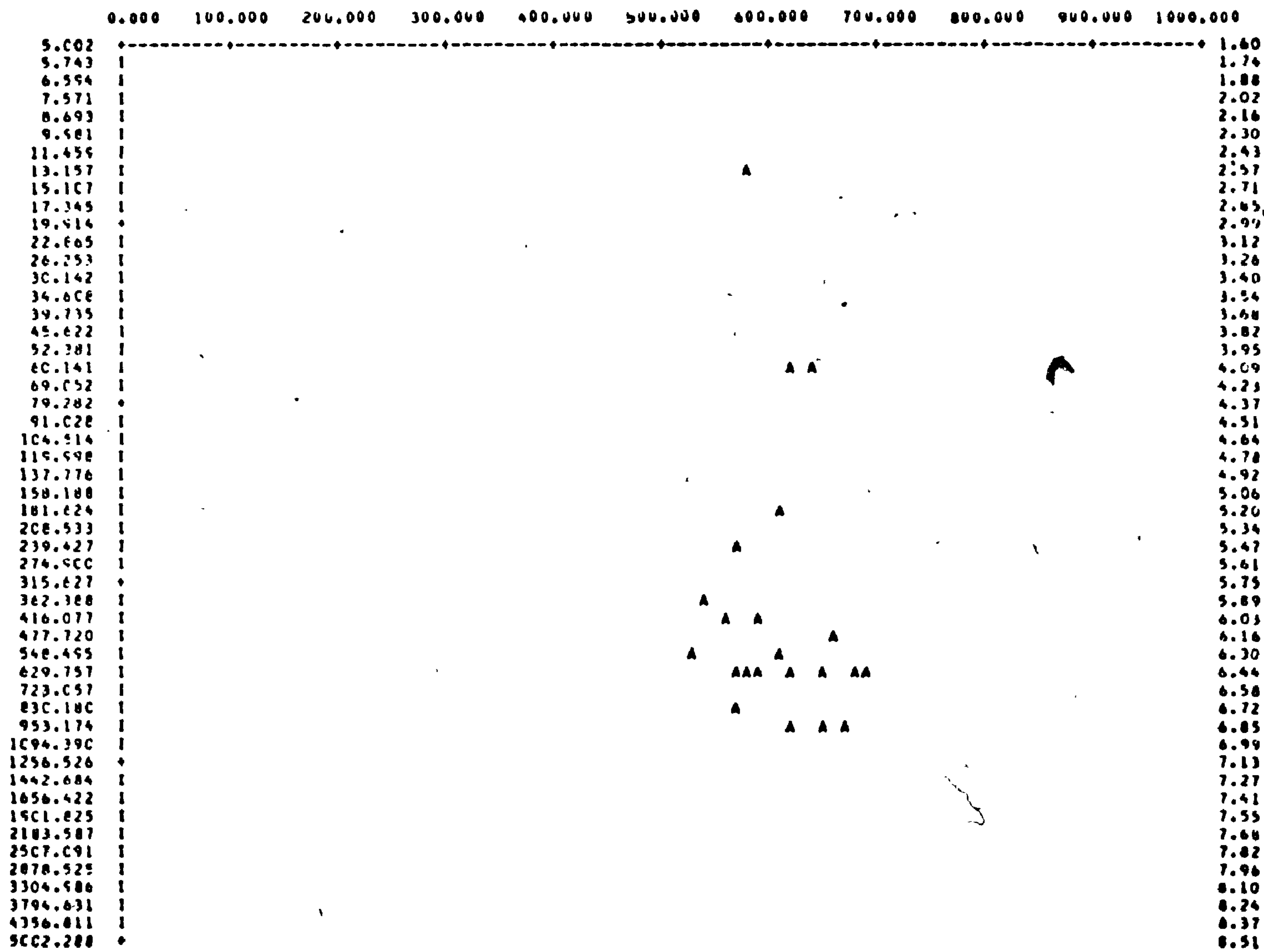
PRECIPITATION
SOUTH-EAST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



C	CTN	CTW	DTS	CTE	VEL	D	W	TIME	D	M	YEAR
63.00	0.7350	0.8000	0.7400	0.6700	3.00	5	1	11.30	20	1	1975
63.00	0.7350	0.8050	0.7700	0.7000	4.50	5	1	12.00	20	1	1975
66.00	0.7200	0.7900	0.7500	0.6800	5.00	5	1	12.30	20	1	1975
65.00	0.7000	0.7700	0.7500	0.6600	7.00	5	1	13.00	20	1	1975
88.00	0.8600	0.9450	0.9450	0.8500	5.00	5	1	13.30	20	1	1975
88.00	0.8900	0.9800	1.0000	0.8750	5.00	5	1	14.00	20	1	1975
86.50	0.8700	0.9650	0.9900	0.8650	5.00	5	1	14.30	20	1	1975
86.00	0.8600	0.9500	1.0000	0.8500	7.50	5	1	15.00	20	1	1975
90.00	0.8600	0.9450	1.0000	0.8700	7.50	5	1	15.30	20	1	1975
93.00	0.8900	0.9450	1.0200	0.8900	7.50	5	1	16.00	20	1	1975
94.00	0.8800	0.9050	0.9850	0.8850	5.00	5	1	16.30	20	1	1975
93.90	0.8900	0.9050	0.9900	0.8900	5.00	5	1	17.00	20	1	1975
65.00	0.7500	0.7500	0.7650	0.7400	0.10	5	1	8.30	28	1	1975
73.00	0.7200	0.7200	0.7400	0.7200	0.50	5	1	9.00	28	1	1975
65.00	0.6600	0.6600	0.6700	0.6500	0.50	5	1	9.30	28	1	1975
62.20	0.6150	0.6250	0.6500	0.6100	0.50	5	1	10.00	28	1	1975
63.00	0.6400	0.6400	0.6600	0.6400	1.50	5	1	10.30	28	1	1975
53.00	0.5150	0.5800	0.5800	0.5250	3.50	5	1	12.30	28	1	1975
51.00	0.5100	0.5700	0.5400	0.4800	5.00	5	1	13.00	28	1	1975
56.00	0.5500	0.6000	0.5900	0.5300	4.50	5	1	13.30	28	1	1975
51.00	0.5300	0.5900	0.5900	0.5100	3.50	5	1	14.00	28	1	1975
50.00	0.5050	0.5550	0.5650	0.4500	2.00	5	1	14.30	28	1	1975
52.00	0.5200	0.5650	0.5900	0.5200	5.00	5	1	15.00	28	1	1975
59.00	0.5300	0.5600	0.5900	0.5300	4.00	5	1	15.30	28	1	1975

FACULTY OF ENGINEERING SCIENCE

SUNNY
SOUTH
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



C	CTN	CTW	DTS	CTE	VEL	D	W	TIME	D	M	YEAR
62.00	0.5900	0.5800	0.6000	0.6100	5.00	5	2	19.00	10	12	1974
62.00	0.5900	0.5800	0.6000	0.6100	5.00	5	2	19.30	10	12	1974
59.80	0.5750	0.5700	0.5900	0.6000	6.00	5	2	20.00	10	12	1974
63.00	0.6100	0.6000	0.6200	0.6300	5.00	5	2	21.30	10	12	1974
62.00	0.6200	0.6100	0.6300	0.6400	3.00	5	2	22.00	10	12	1974
61.50	0.6150	0.6100	0.6200	0.6300	5.00	5	2	22.30	10	12	1974
61.00	0.6100	0.6000	0.6200	0.6300	3.00	5	2	23.00	10	12	1974
60.30	0.6050	0.6000	0.6200	0.6300	3.00	5	2	23.30	10	12	1974
61.00	0.6100	0.6000	0.6200	0.6300	3.00	5	2	0.00	11	12	1974
61.00	0.6250	0.6200	0.6300	0.6400	2.00	5	2	0.30	11	12	1974
82.00	0.7700	0.7600	0.7800	0.7900	0.50	5	2	1.00	11	12	1974
81.00	0.8400	0.8300	0.8500	0.8600	1.00	5	2	1.30	11	12	1974
82.50	0.8500	0.8800	0.9000	0.9100	1.00	5	2	2.00	11	12	1974
85.00	0.8700	0.8600	0.8800	0.8900	2.00	5	2	2.30	11	12	1974
85.00	0.8950	0.8900	0.9000	0.9100	0.50	5	2	3.00	11	12	1974
84.50	0.9050	0.9000	0.9100	0.9200	0.50	5	2	3.30	11	12	1974
85.50	0.9300	0.9200	0.9400	0.9500	0.50	5	2	4.00	11	12	1974
76.50	0.8150	0.8100	0.8200	0.8300	2.00	5	2	4.30	11	12	1974
80.00	0.8000	0.7900	0.8100	0.8200	5.00	5	2	5.00	11	12	1974
82.50	0.8400	0.8300	0.8500	0.8600	5.00	5	2	5.30	11	12	1974
82.00	0.8600	0.8500	0.8700	0.8800	4.00	5	2	6.00	11	12	1974
72.00	0.7450	0.7400	0.7500	0.7600	3.00	5	2	6.30	11	12	1974
81.00	0.8500	0.8400	0.8600	0.8700	1.00	5	2	7.00	11	12	1974
65.00	0.7450	0.7400	0.7500	0.7600	2.00	5	2	7.30	11	12	1974
74.00	0.7600	0.7000	0.7200	0.7300	4.00	5	2	8.00	11	12	1974
71.50	0.6800	0.6700	0.6900	0.7000	3.00	5	2	8.30	11	12	1974
68.50	0.6700	0.6600	0.6800	0.6900	4.00	5	2	9.00	11	12	1974
60.00	0.6200	0.6100	0.6300	0.6400	3.00	5	2	9.30	11	12	1974
60.00	0.6450	0.6400	0.6600	0.6700	3.00	5	2	10.00	11	12	1974
60.00	0.6600	0.6500	0.6700	0.6800	3.00	5	2	10.30	11	12	1974
59.00	0.6450	0.6400	0.6600	0.6700	1.00	5	2	11.00	11	12	1974
60.00	0.6600	0.6500	0.6700	0.6800	1.00	5	2	11.30	11	12	1974
60.00	0.6750	0.6700	0.6900	0.7000	3.00	5	2	12.00	11	12	1974
59.00	0.6450	0.6400	0.6600	0.6700	3.00	5	2	12.30	11	12	1974
58.80	0.6280	0.6200	0.6400	0.6500	3.00	5	2	13.00	11	12	1974
59.00	0.6100	0.6000	0.6200	0.6300	7.00	5	2	13.30	11	12	1974
59.00	0.5900	0.5800	0.6000	0.6100	8.00	5	2	14.00	11	12	1974
59.00	0.5650	0.5600	0.5800	0.5900	6.00	5	2	14.30	11	12	1974
55.50	0.5600	0.5500	0.5700	0.5800	5.00	5	2	15.00	11	12	1974
55.50	0.5500	0.5400	0.5600	0.5700	2.00	5	2	15.30	11	12	1974
59.00	0.5700	0.5600	0.5800	0.5900	3.00	5	2	16.00	11	12	1974
59.00	0.6250	0.6200	0.6400	0.6500	2.00	5	2	20.30	12	12	1974
60.30	0.6400	0.6300	0.6500	0.6600	0.50	5	2	21.00	12	12	1974
60.00	0.6300	0.6200	0.6400	0.6500	1.00	5	2	21.30	12	12	1974
60.30	0.6400	0.6300	0.6500	0.6600	0.50	5	2	22.00	12	12	1974
60.30	0.6550	0.6500	0.6600	0.6700	0.10	5	2	22.30	12	12	1974
61.00	0.6800	0.6700	0.6900	0.7000	0.10	5	2	23.00	12	12	1974
60.50	0.6900	0.6800	0.7000	0.7100	0.10	5	2	23.30	12	12	1974
60.00	0.6600	0.6500	0.6700	0.6800	0.10	5	2	0.00	13	12	1974
64.80	0.7200	0.7100	0.7300	0.7400	0.10	5	2	3.30	13	12	1974
63.00	0.7200	0.7100	0.7300	0.7400	0.10	5	2	5.30	13	12	1974
61.00	0.7200	0.7100	0.7300	0.7400	0.10	5	2	6.30	13	12	1974
61.50	0.5150	0.5100	0.5200	0.5300	12.00	5	2	21.30	15	12	1974
60.00	0.4850	0.4800	0.4900	0.5000	12.00	5	2	22.00	15	12	1974
83.00	0.6800	0.6700	0.6900	0.7000	12.00	5	2	22.30	15	12	1974
80.00	0.6700	0.6600	0.6800	0.6900	11.00	5	2	23.00	15	12	1974
80.00	0.6800	0.6700	0.6900	0.7000	10.00	5	2	23.30	15	12	1974
61.30	0.5500	0.5400	0.5600	0.5700	10.00	5	2	0.00	16	12	1974

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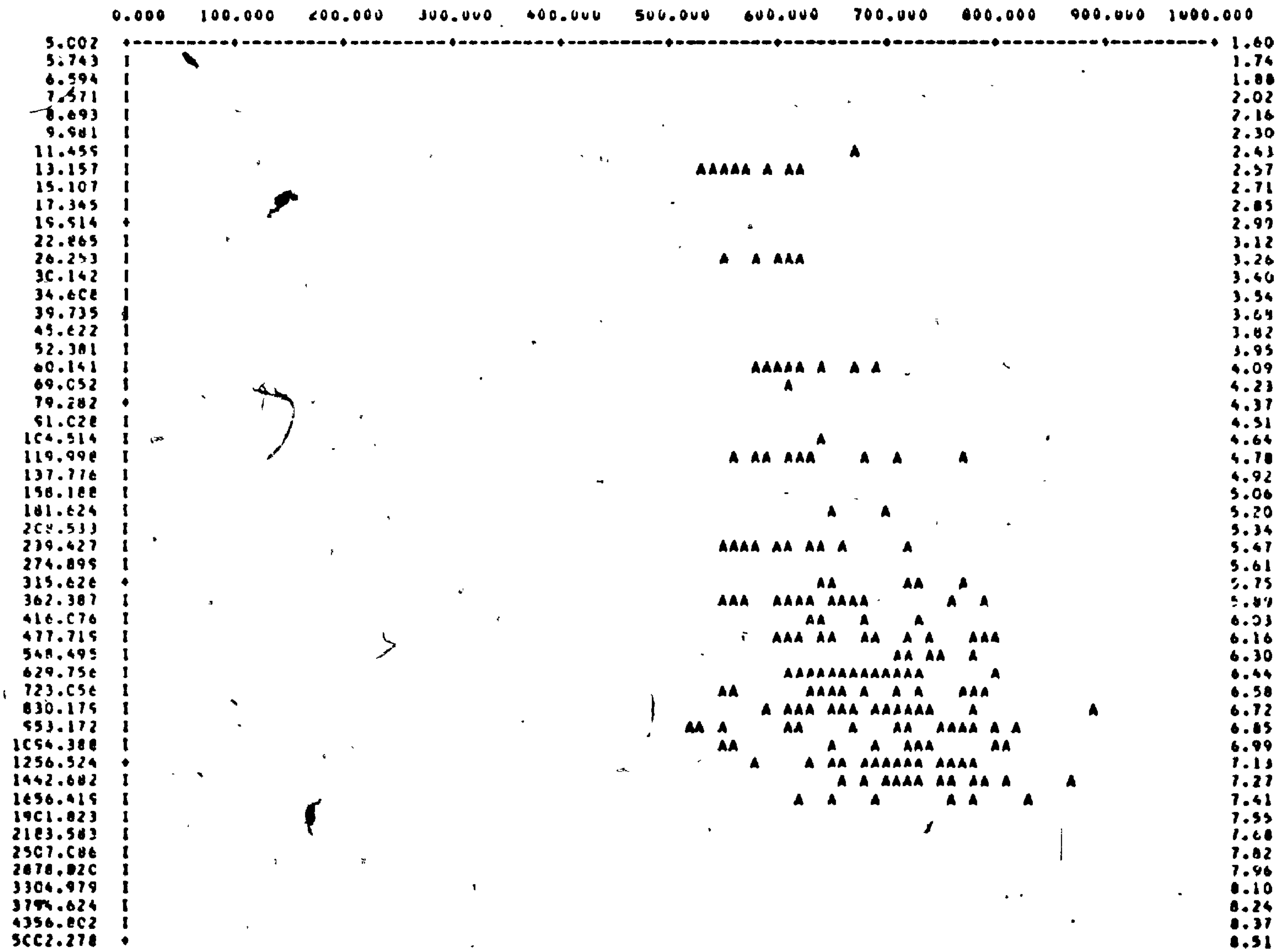
60.00	0.5100	0.5000	0.5200	0.5300	8.00	5	2	0.30	16	12	1974
60.30	0.5100	0.5000	0.5200	0.5300	8.00	5	2	1.00	16	12	1974
61.00	0.5300	0.5200	0.5400	0.5500	7.00	5	2	1.30	16	12	1974
61.00	0.5100	0.5000	0.5200	0.5300	7.00	5	2	2.00	16	12	1974
60.00	0.5000	0.4900	0.5100	0.5200	10.00	5	2	2.30	16	12	1974
60.00	0.5130	0.5100	0.5200	0.5300	7.00	5	2	3.00	16	12	1974
60.00	0.5100	0.5000	0.5200	0.5300	7.00	5	2	3.30	16	12	1974
60.00	0.5080	0.5000	0.5100	0.5200	5.00	5	2	4.00	16	12	1974
60.00	0.5300	0.5200	0.5400	0.5500	5.00	5	2	4.30	16	12	1974
60.00	0.5000	0.4900	0.5100	0.5200	5.00	5	2	5.00	16	12	1974
60.00	0.5030	0.5000	0.5100	0.5200	9.00	5	2	5.30	16	12	1974
60.00	0.5300	0.5200	0.5400	0.5500	5.00	5	2	6.00	16	12	1974
60.00	0.5450	0.5400	0.5500	0.5600	5.00	5	2	6.30	16	12	1974
70.00	0.5900	0.5800	0.6000	0.6100	4.00	5	2	7.00	16	12	1974
71.00	0.6800	0.6700	0.6900	0.7000	5.00	5	2	7.30	16	12	1974
69.00	0.7000	0.6900	0.7100	0.7200	5.00	5	2	8.00	16	12	1974
60.00	0.6100	0.6000	0.6200	0.6300	4.00	5	2	8.30	16	12	1974
58.80	0.5500	0.5400	0.5600	0.5700	5.00	5	2	9.00	16	12	1974
59.00	0.5550	0.5500	0.5600	0.5700	7.00	5	2	9.30	16	12	1974
59.00	0.5500	0.5400	0.5600	0.5700	7.00	5	2	10.00	16	12	1974
59.00	0.5400	0.5300	0.5500	0.5600	5.00	5	2	10.30	16	12	1974
58.00	0.5400	0.5300	0.5500	0.5600	5.00	5	2	11.00	16	12	1974
59.00	0.5500	0.5400	0.5600	0.5700	6.00	5	2	11.30	16	12	1974
59.00	0.5550	0.5500	0.5600	0.5700	5.00	5	2	12.00	16	12	1974
58.80	0.5750	0.5700	0.5800	0.5900	10.00	5	2	13.00	16	12	1974
59.00	0.5800	0.5700	0.5900	0.6000	8.00	5	2	13.30	16	12	1974
57.00	0.5450	0.5400	0.5500	0.5600	5.00	5	2	17.30	16	12	1974
56.30	0.5300	0.5200	0.5400	0.5500	4.00	5	2	18.00	16	12	1974
58.00	0.5400	0.5300	0.5500	0.5600	6.00	5	2	18.30	16	12	1974
59.00	0.5450	0.5400	0.5500	0.5600	5.00	5	2	19.00	16	12	1974
59.00	0.5450	0.5400	0.5500	0.5600	6.00	5	2	19.30	16	12	1974
59.00	0.5600	0.5500	0.5700	0.5800	6.00	5	2	20.00	16	12	1974
71.50	0.6700	0.6600	0.6800	0.6900	7.00	5	2	21.30	18	12	1974
70.00	0.7100	0.7000	0.7200	0.7300	7.00	5	2	22.00	18	12	1974
62.00	0.6300	0.6200	0.6400	0.6500	5.00	5	2	22.30	18	12	1974
59.50	0.6000	0.5900	0.6100	0.6200	4.00	5	2	23.00	18	12	1974
61.00	0.5980	0.5500	0.6000	0.6100	5.00	5	2	23.30	18	12	1974
63.00	0.6100	0.6000	0.6200	0.6300	4.00	5	2	0.00	19	12	1974
61.00	0.6100	0.6000	0.6200	0.6300	4.00	5	2	0.30	19	12	1974
60.00	0.6150	0.6100	0.6200	0.6300	3.00	5	2	1.00	19	12	1974
60.50	0.6200	0.6100	0.6300	0.6400	3.00	5	2	1.30	19	12	1974
60.30	0.6250	0.6200	0.6300	0.6400	3.00	5	2	2.00	19	12	1974
60.50	0.6150	0.6100	0.6200	0.6300	3.00	5	2	2.30	19	12	1974
60.50	0.6100	0.6000	0.6200	0.6300	3.00	5	2	3.00	19	12	1974
60.50	0.6100	0.6000	0.6200	0.6300	3.00	5	2	3.30	19	12	1974
61.00	0.5900	0.5800	0.6000	0.6100	6.00	5	2	4.00	19	12	1974
61.00	0.5950	0.5900	0.6000	0.6100	5.00	5	2	4.30	19	12	1974
59.50	0.6500	0.6400	0.6600	0.6700	2.00	5	2	18.30	20	12	1974
59.50	0.6150	0.6100	0.6200	0.6300	3.00	5	2	19.00	20	12	1974
58.50	0.6300	0.6200	0.6400	0.6500	2.00	5	2	19.30	20	12	1974
58.50	0.6300	0.6200	0.6400	0.6500	2.00	5	2	20.00	20	12	1974
59.50	0.6300	0.6200	0.6400	0.6500	2.00	5	2	20.30	20	12	1974
61.00	0.6500	0.6400	0.6600	0.6700	0.20	5	2	5.00	21	12	1974
79.00	0.8200	0.8100	0.8300	0.8400	0.20	5	2	5.30	21	12	1974
77.50	0.8200	0.8100	0.8300	0.8400	0.20	5	2	6.00	21	12	1974
67.00	0.7650	0.7600	0.7700	0.7800	0.20	5	2	6.30	21	12	1974
77.50	0.8250	0.8200	0.8300	0.8400	1.00	5	2	7.00	21	12	1974
75.00	0.8300	0.8200	0.8400	0.8500	1.00	5	2	7.30	21	12	1974
61.80	0.6000	0.6050	0.6200	0.6100	3.50	5	2	1.30	24	12	1974
62.00	0.5800	0.6000	0.6000	0.6000	2.50	5	2	2.00	24	12	1974
59.30	0.5900	0.6000	0.6100	0.5950	2.00	5	2	19.30	24	12	1974

59.00	0.6000	0.6100	0.6200	0.6050	0.20	5	2	20.00	24	12	1974
59.00	0.6150	0.6250	0.6400	0.6250	0.20	5	2	20.30	24	12	1974
60.00	0.5900	0.6050	0.6150	0.6000	0.20	5	2	21.00	24	12	1974
60.00	0.5100	0.5300	0.5400	0.5200	1.50	5	2	21.30	24	12	1974
60.50	0.5200	0.5200	0.5400	0.5250	1.00	5	2	22.00	24	12	1974
60.00	0.5700	0.5500	0.5750	0.5650	12.00	5	2	12.30	26	12	1974
60.00	0.5900	0.5750	0.5950	0.5850	10.00	5	2	13.00	26	12	1974
60.00	0.5950	0.5850	0.6100	0.5950	14.00	5	2	13.30	26	12	1974
60.00	0.5550	0.5800	0.5900	0.5600	14.00	5	2	14.00	26	12	1974
61.50	0.5150	0.5450	0.5500	0.5200	12.00	5	2	14.30	26	12	1974
61.50	0.5250	0.5500	0.5500	0.5400	10.00	5	2	15.00	26	12	1974
62.00	0.5550	0.5600	0.5650	0.5700	12.50	5	2	15.30	26	12	1974
61.00	0.5350	0.5500	0.5650	0.5450	13.00	5	2	16.00	26	12	1974
62.00	0.5200	0.5400	0.5550	0.5300	9.50	5	2	16.30	26	12	1974
75.00	0.6100	0.6300	0.6450	0.6300	8.00	5	2	17.00	26	12	1974
74.00	0.6300	0.6400	0.6500	0.6450	6.00	5	2	17.30	26	12	1974
73.00	0.6300	0.6200	0.6500	0.6350	10.00	5	2	18.00	26	12	1974
73.00	0.6250	0.6300	0.6400	0.6500	10.00	5	2	18.30	26	12	1974
90.00	0.6600	0.6650	0.7000	0.7000	11.00	5	2	19.00	26	12	1974
85.00	0.7000	0.6800	0.7200	0.7100	11.00	5	2	19.30	26	12	1974
82.00	0.6200	0.6300	0.6500	0.6500	13.00	5	2	20.00	26	12	1974
86.00	0.6750	0.6750	0.7050	0.7150	11.00	5	2	20.30	26	12	1974
86.00	0.6700	0.6700	0.7050	0.7000	8.00	5	2	21.00	26	12	1974
86.00	0.7000	0.6700	0.7150	0.7050	9.00	5	2	21.30	26	12	1974
86.00	0.6600	0.6600	0.7000	0.7000	8.00	5	2	22.00	26	12	1974
69.00	0.6000	0.6100	0.6150	0.6200	11.00	5	2	22.30	26	12	1974
61.00	0.5250	0.5350	0.5400	0.5400	12.00	5	2	23.00	26	12	1974
68.00	0.5800	0.5850	0.5900	0.6000	10.00	5	2	23.30	26	12	1974
90.00	0.7200	0.7000	0.7450	0.7450	9.00	5	2	0.00	27	12	1974
88.50	0.7400	0.7150	0.7500	0.7500	11.00	5	2	0.30	27	12	1974
60.00	0.5800	0.5800	0.6000	0.5900	2.00	5	2	11.00	28	12	1974
59.00	0.5900	0.5900	0.6200	0.6000	7.00	5	2	11.30	28	12	1974
59.70	0.5300	0.5200	0.5400	0.5300	7.00	5	2	15.00	28	12	1974
59.00	0.5450	0.5450	0.5600	0.5500	7.00	5	2	15.30	28	12	1974
59.00	0.5500	0.5400	0.5600	0.5500	7.00	5	2	16.00	28	12	1974
60.00	0.5450	0.5450	0.5600	0.5600	7.00	5	2	16.30	28	12	1974
55.00	0.5400	0.5400	0.5600	0.5450	8.00	5	2	17.00	28	12	1974
57.50	0.5350	0.5350	0.5500	0.5400	9.00	5	2	17.30	28	12	1974
58.50	0.5250	0.5250	0.5450	0.5350	10.00	5	2	18.00	28	12	1974
59.00	0.5250	0.5300	0.5400	0.5350	10.00	5	2	18.30	28	12	1974
59.50	0.5200	0.5350	0.5400	0.5350	10.00	5	2	19.00	28	12	1974
60.00	0.5050	0.5150	0.5250	0.5250	10.00	5	2	19.30	28	12	1974
59.80	0.5000	0.5050	0.5200	0.5150	12.00	5	2	20.00	28	12	1974
60.00	0.5000	0.5050	0.5250	0.5150	11.00	5	2	20.30	28	12	1974
60.30	0.5100	0.5150	0.5250	0.5250	10.00	5	2	21.00	28	12	1974
61.00	0.5200	0.5200	0.5400	0.5350	10.00	5	2	21.30	28	12	1974
60.50	0.5150	0.5200	0.5350	0.5250	8.00	5	2	22.00	28	12	1974
63.00	0.5700	0.5700	0.5900	0.5800	3.00	5	2	5.00	29	12	1974
71.00	0.6600	0.6500	0.6750	0.6750	5.00	5	2	7.30	29	12	1974
71.00	0.6450	0.6550	0.6650	0.6750	3.50	5	2	8.00	29	12	1974
59.00	0.5200	0.5150	0.5350	0.5250	4.00	5	2	17.30	29	12	1974
59.70	0.5350	0.5400	0.5550	0.5450	6.00	5	2	18.00	29	12	1974
60.00	0.5300	0.5300	0.5500	0.5400	5.00	5	2	18.30	29	12	1974
60.00	0.5200	0.5200	0.5400	0.5350	10.00	5	2	19.00	29	12	1974
60.00	0.5150	0.5150	0.5350	0.5250	5.00	5	2	19.30	29	12	1974
86.00	0.7800	0.7800	0.7800	0.7800	2.00	5	2	4.30	31	12	1974
80.00	0.7600	0.7600	0.7600	0.7600	3.00	5	2	5.00	31	12	1974
80.50	0.7700	0.7700	0.7700	0.7700	1.00	5	2	5.30	31	12	1974
76.50	0.8500	0.8500	0.8500	0.8500	2.00	5	2	6.00	31	12	1974
67.50	0.6900	0.6900	0.6900	0.6900	3.00	5	2	6.30	31	12	1974
75.50	0.7200	0.7200	0.7200	0.7200	3.00	5	2	7.00	31	12	1974

71.00	0.6900	0.6900	0.6900	0.6900	3.00	5	2	7.30	31	12	1974
71.00	0.6900	0.6900	0.6900	0.6900	1.50	5	2	8.00	31	12	1974
68.00	0.6700	0.6700	0.6700	0.6700	0.80	5	2	8.30	31	12	1974
65.00	0.6900	0.6900	0.6900	0.6900	0.10	5	2	9.00	31	12	1974
61.50	0.6500	0.6500	0.6500	0.6500	0.50	5	2	9.30	31	12	1974
60.00	0.6400	0.6400	0.6400	0.6400	0.50	5	2	10.00	31	12	1974
60.00	0.6200	0.6200	0.6200	0.6200	0.50	5	2	10.30	31	12	1974
61.00	0.5850	0.5850	0.5850	0.5850	4.00	5	2	11.00	31	12	1974
60.00	0.5750	0.5750	0.5750	0.5750	3.50	5	2	11.30	31	12	1974
60.00	0.5400	0.5400	0.5400	0.5400	5.00	5	2	12.00	31	12	1974
62.00	0.5700	0.5700	0.5700	0.5700	0.10	5	2	1.00	1	1	1975
[illegible]	0.6300	0.6300	0.6300	0.6300	0.10	5	2	3.00	1	1	1975
62.00	0.6350	0.6350	0.6350	0.6350	0.10	5	2	3.30	1	1	1975
62.00	0.6100	0.6100	0.6100	0.6100	1.00	5	2	4.00	1	1	1975
68.80	0.5500	0.5500	0.5500	0.5500	10.50	5	2	3.30	8	1	1975
67.50	0.5500	0.5500	0.5500	0.5500	10.00	5	2	4.00	8	1	1975
66.50	0.5400	0.5400	0.5400	0.5400	10.00	5	2	4.30	8	1	1975
67.50	0.5500	0.5500	0.5500	0.5500	8.00	5	2	5.00	8	1	1975
67.50	0.5500	0.5500	0.5500	0.5500	11.00	5	2	5.30	8	1	1975
66.50	0.5300	0.5300	0.5300	0.5300	10.00	5	2	6.00	8	1	1975
66.00	0.4600	0.4600	0.4600	0.4600	7.00	5	2	0.00	9	1	1975
90.00	0.7300	0.7150	0.7500	0.7450	8.00	5	2	18.00	17	1	1975
91.50	0.7400	0.7300	0.7750	0.7600	8.00	5	2	18.30	17	1	1975
92.00	0.7600	0.7400	0.7850	0.7750	6.00	5	2	19.00	17	1	1975
91.50	0.8000	0.7650	0.8200	0.8050	3.00	5	2	19.30	17	1	1975
80.00	0.7000	0.6800	0.7300	0.7150	3.50	5	2	20.00	17	1	1975
80.00	0.7100	0.7150	0.7450	0.7350	4.50	5	2	20.30	17	1	1975
80.00	0.6400	0.6550	0.6800	0.6900	6.00	5	2	21.00	17	1	1975
85.00	0.6950	0.7350	0.7400	0.7250	7.50	5	2	21.30	17	1	1975
84.00	0.7000	0.6800	0.7100	0.7050	10.00	5	2	22.00	17	1	1975
84.00	0.7000	0.6800	0.7100	0.7150	9.50	5	2	22.30	17	1	1975
82.50	0.7100	0.6900	0.7250	0.7200	7.50	5	2	23.00	17	1	1975
82.00	0.6900	0.6900	0.7100	0.7150	8.00	5	2	23.30	17	1	1975
57.00	0.5650	0.5650	0.5800	0.5650	6.50	5	2	13.30	24	1	1975
61.00	0.5700	0.5700	0.5900	0.5750	10.50	5	2	14.00	24	1	1975
59.80	0.5600	0.5500	0.5800	0.5650	10.00	5	2	14.30	24	1	1975
61.50	0.5700	0.5700	0.5900	0.5700	7.00	5	2	15.00	24	1	1975
61.30	0.5750	0.5700	0.5900	0.5750	7.00	5	2	15.30	24	1	1975
64.00	0.5750	0.5800	0.6000	0.5850	6.00	5	2	16.00	24	1	1975
62.50	0.5650	0.5600	0.5850	0.5700	4.00	5	2	16.30	24	1	1975
62.50	0.5550	0.5700	0.5800	0.5700	4.00	5	2	17.00	24	1	1975
63.50	0.5600	0.5600	0.5800	0.5750	5.00	5	2	17.30	24	1	1975
61.00	0.5550	0.5500	0.5650	0.5600	4.00	5	2	18.00	24	1	1975
57.00	0.5350	0.5350	0.5500	0.5400	6.00	5	2	18.30	24	1	1975
62.50	0.5300	0.5250	0.5500	0.5500	5.50	5	2	19.00	24	1	1975
57.00	0.5150	0.5150	0.5400	0.5250	5.00	5	2	19.30	24	1	1975
61.50	0.5250	0.5200	0.5500	0.5400	6.00	5	2	20.00	24	1	1975
61.30	0.5200	0.5200	0.5500	0.5300	7.00	5	2	20.30	24	1	1975
61.20	0.5250	0.5200	0.5550	0.5400	5.00	5	2	21.00	24	1	1975
61.00	0.5100	0.5100	0.5350	0.5200	6.50	5	2	21.30	24	1	1975
68.00	0.5200	0.5200	0.5550	0.5350	4.00	5	2	22.00	24	1	1975
67.00	0.5250	0.5250	0.5550	0.5400	4.50	5	2	22.30	24	1	1975
63.50	0.5150	0.5150	0.5400	0.5250	4.50	5	2	23.00	24	1	1975
62.80	0.4900	0.4900	0.5150	0.5000	7.50	5	2	23.30	24	1	1975
62.80	0.5700	0.5800	0.5900	0.5800	0.50	5	2	20.30	27	1	1975
63.50	0.6050	0.6200	0.6450	0.6200	0.50	5	2	21.00	27	1	1975
60.00	0.5600	0.5800	0.6000	0.5700	2.50	5	2	16.00	28	1	1975
60.50	0.5700	0.5800	0.6150	0.5750	3.50	5	2	16.30	28	1	1975
61.00	0.5800	0.5900	0.6300	0.5900	1.00	5	2	17.00	28	1	1975
62.20	0.4550	0.4950	0.4950	0.4950	14.00	5	2	14.00	4	2	1975
62.70	0.4950	0.4950	0.4950	0.4950	14.00	5	2	14.30	4	2	1975

62.00	0.5000	0.5000	0.5000	0.5000	13.00	5	2	15.00	4	2	1975
63.30	0.5000	0.5000	0.5000	0.5000	11.00	5	2	15.30	4	2	1975
60.00	0.5000	0.5000	0.5000	0.5000	9.00	5	2	16.00	4	2	1975
61.50	0.5000	0.5000	0.5000	0.5000	10.00	5	2	19.00	4	2	1975
64.00	0.5100	0.5100	0.5100	0.5100	8.00	5	2	22.30	4	2	1975
65.00	0.5150	0.5150	0.5150	0.5150	7.00	5	2	23.00	4	2	1975
64.20	0.5150	0.5150	0.5150	0.5150	6.00	5	2	23.30	4	2	1975
64.50	0.5150	0.5150	0.5150	0.5150	6.00	5	2	0.00	5	2	1975
65.50	0.5200	0.5200	0.5200	0.5200	7.00	5	2	0.30	5	2	1975
66.50	0.5200	0.5200	0.5200	0.5200	5.50	5	2	1.00	5	2	1975
65.50	0.5200	0.5200	0.5200	0.5200	4.00	5	2	1.30	5	2	1975
65.00	0.5250	0.5250	0.5250	0.5250	1.00	5	2	2.30	5	2	1975
63.00	0.5250	0.5250	0.5250	0.5250	2.50	5	2	3.00	5	2	1975
94.00	0.8500	0.8600	0.8750	0.8600	2.50	5	2	9.00	10	2	1975
90.00	0.8800	0.8500	0.8700	0.8600	4.00	5	2	9.30	10	2	1975
83.00	0.8300	0.7900	0.8100	0.8100	5.00	5	2	10.00	10	2	1975
79.00	0.8000	0.7900	0.7500	0.7800	4.00	5	2	10.30	10	2	1975
66.00	0.7700	0.7600	0.7500	0.7400	6.00	5	2	11.00	10	2	1975
74.00	0.7600	0.7500	0.7600	0.7300	7.00	5	2	11.30	10	2	1975
64.00	0.7400	0.7300	0.7300	0.7000	9.00	5	2	12.00	10	2	1975
63.00	0.7200	0.7300	0.7400	0.7000	8.00	5	2	12.30	10	2	1975
64.00	0.7100	0.7100	0.7300	0.7000	9.00	5	2	13.00	10	2	1975
62.00	0.7300	0.7300	0.7300	0.7200	8.00	5	2	13.30	10	2	1975
62.00	0.7200	0.7600	0.7600	0.7300	7.50	5	2	14.00	10	2	1975
63.00	0.7000	0.7100	0.7200	0.7000	6.00	5	2	14.30	10	2	1975
62.50	0.7100	0.7000	0.7200	0.7000	8.50	5	2	15.00	10	2	1975
63.00	0.6800	0.6800	0.6900	0.6800	9.50	5	2	15.30	10	2	1975
83.00	0.7400	0.7500	0.7500	0.7700	10.00	5	2	16.00	10	2	1975
101.00	0.8800	0.8600	0.8900	0.9000	9.50	5	2	16.30	10	2	1975
80.50	0.7400	0.7100	0.7400	0.7300	8.00	5	2	17.00	10	2	1975
80.00	0.6900	0.6900	0.7000	0.7000	7.00	5	2	17.30	10	2	1975
91.00	0.7400	0.7400	0.7600	0.7800	4.00	5	2	18.00	10	2	1975
90.00	0.7400	0.7300	0.7500	0.7700	3.00	5	2	18.30	10	2	1975
93.00	0.8500	0.8300	0.8600	0.8600	2.50	5	2	19.00	10	2	1975
101.50	0.9200	0.9000	0.9600	0.9500	4.00	5	2	21.30	10	2	1975
99.50	0.9300	0.9100	0.9600	0.9500	4.00	5	2	22.00	10	2	1975
99.00	0.9100	0.8500	0.9400	0.9400	5.00	5	2	22.30	10	2	1975
100.50	0.9200	0.9000	0.9500	0.9400	5.00	5	2	23.00	10	2	1975
95.00	0.9200	0.9100	0.9600	0.9500	3.50	5	2	23.30	10	2	1975

CLOUDY
SOUTH
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



Q	DTN	DTW	DTS	DTE	VEL	D	W	TIME	D	M	YEAR
84.00	0.8150	0.8100	0.8200	0.8300	5.00	5	3	7.00	20	12	1974
78.50	0.8200	0.8100	0.8300	0.8400	1.00	5	3	7.30	20	12	1974
82.50	0.8200	0.8100	0.8300	0.8400	2.00	5	3	8.00	20	12	1974
66.00	0.6800	0.6700	0.6900	0.7000	3.00	5	3	8.30	20	12	1974
63.00	0.6650	0.6600	0.6700	0.6800	2.00	5	3	9.00	20	12	1974
59.00	0.6350	0.6300	0.6400	0.6500	2.00	5	3	9.30	20	12	1974
59.00	0.6250	0.6200	0.6300	0.6400	3.00	5	3	10.00	20	12	1974
58.00	0.6250	0.6200	0.6300	0.6400	3.00	5	3	10.30	20	12	1974
57.80	0.6200	0.6100	0.6300	0.6400	3.00	5	3	11.00	20	12	1974
57.00	0.6100	0.6000	0.6200	0.6300	3.00	5	3	11.30	20	12	1974
67.00	0.7200	0.7100	0.7300	0.7400	3.00	5	3	12.00	20	12	1974
59.00	0.6400	0.6300	0.6500	0.6600	3.00	5	3	12.30	20	12	1974
57.00	0.6300	0.6200	0.6400	0.6500	5.00	5	3	13.00	20	12	1974
76.00	0.7550	0.7500	0.7600	0.7700	4.00	5	3	16.00	20	12	1974
77.50	0.8000	0.7900	0.8100	0.8200	2.00	5	3	16.30	20	12	1974
76.00	0.8200	0.8100	0.8300	0.8400	3.00	5	3	17.00	20	12	1974
73.50	0.7750	0.7700	0.7800	0.7900	2.50	5	3	17.30	20	12	1974
72.00	0.7750	0.7700	0.7800	0.7900	3.00	5	3	18.00	20	12	1974
61.00	0.5150	0.5150	0.5350	0.5350	5.00	5	3	20.00	29	12	1974
77.00	0.6850	0.6850	0.6850	0.6850	1.00	5	3	0.00	31	12	1974
88.00	0.7650	0.7650	0.7650	0.7650	1.50	5	3	0.30	31	12	1974
87.00	0.7800	0.7800	0.7800	0.7800	1.00	5	3	1.00	31	12	1974
84.00	0.7850	0.7850	0.7850	0.7850	1.00	5	3	1.30	31	12	1974
81.50	0.8000	0.8000	0.8000	0.8000	1.00	5	3	2.00	31	12	1974
85.00	0.7800	0.7800	0.7800	0.7800	2.00	5	3	2.30	31	12	1974
85.00	0.8100	0.8100	0.8100	0.8100	3.00	5	3	3.00	31	12	1974
82.30	0.7950	0.7950	0.7950	0.7950	2.00	5	3	3.30	31	12	1974
82.00	0.7750	0.7750	0.7750	0.7750	2.00	5	3	4.00	31	12	1974
78.00	0.7800	0.7800	0.7800	0.7800	0.10	5	3	7.00	2	1	1975
72.50	0.7250	0.7250	0.7250	0.7250	0.20	5	3	7.30	2	1	1975
60.00	0.5650	0.5650	0.5650	0.5650	1.00	5	3	15.00	2	1	1975
60.00	0.5500	0.5500	0.5500	0.5500	4.00	5	3	15.30	2	1	1975
60.00	0.5400	0.5400	0.5400	0.5400	2.00	5	3	16.00	2	1	1975
59.50	0.5200	0.5200	0.5200	0.5200	2.00	5	3	16.30	2	1	1975
59.50	0.5400	0.5400	0.5400	0.5400	2.00	5	3	17.00	2	1	1975
58.00	0.4950	0.4950	0.4950	0.4950	2.00	5	3	17.30	2	1	1975
59.00	0.5100	0.5100	0.5100	0.5100	2.50	5	3	18.00	2	1	1975
61.50	0.5400	0.5400	0.5400	0.5400	5.00	5	3	21.30	2	1	1975
62.00	0.5450	0.5450	0.5450	0.5450	6.00	5	3	22.00	2	1	1975
61.00	0.5200	0.5200	0.5200	0.5200	6.00	5	3	22.30	2	1	1975
61.00	0.5000	0.5000	0.5000	0.5000	6.00	5	3	23.00	2	1	1975
62.00	0.4850	0.4850	0.4850	0.4850	5.00	5	3	23.30	2	1	1975
64.00	0.5250	0.5250	0.5250	0.5250	6.00	5	3	0.00	3	1	1975
62.50	0.5250	0.5250	0.5250	0.5250	5.00	5	3	0.30	3	1	1975
62.00	0.5400	0.5400	0.5400	0.5400	6.00	5	3	1.00	3	1	1975
62.00	0.5400	0.5400	0.5400	0.5400	8.00	[illegible]	3	1.30	3	1	1975
62.00	0.5300	0.5300	0.5300	0.5300	11.00	[illegible]	3	2.00	3	1	1975
62.50	0.5500	0.5500	0.5500	0.5500	10.00	5	3	2.30	3	1	1975
62.50	0.4900	0.4900	0.4900	0.4900	12.00	5	3	3.00	3	1	1975
62.50	0.4900	0.4900	0.4900	0.4900	11.00	5	3	3.30	3	1	1975
62.50	0.5050	0.5050	0.5050	0.5050	10.00	5	3	4.00	3	1	1975
62.50	0.4900	0.4900	0.4900	0.4900	10.00	5	3	4.30	3	1	1975
90.00	0.6300	0.6300	0.6300	0.6300	7.00	5	3	5.00	3	1	1975
88.50	0.6400	0.6400	0.6400	0.6400	10.00	5	3	5.30	3	1	1975
86.00	0.6400	0.6400	0.6400	0.6400	8.00	5	3	6.00	3	1	1975
56.00	0.5800	0.5800	0.5800	0.5800	[illegible]	5	3	12.30	7	1	1975
52.00	0.5700	0.5700	0.5700	0.5700	2.00	5	3	13.00	7	1	1975

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62.00	0.6200	0.6200	0.6200	0.6200	2.00	5	3	13.30	7	1 1975
64.50	0.6400	0.6400	0.6400	0.6400	3.00	5	3	14.00	7	1 1975
64.50	0.6400	0.6400	0.6400	0.6400	2.00	5	3	14.30	7	1 1975
58.00	0.6200	0.6200	0.6200	0.6200	2.50	5	3	15.00	7	1 1975
63.80	0.6200	0.6200	0.6200	0.6200	3.00	5	3	15.30	7	1 1975
64.80	0.6000	0.6000	0.6000	0.6000	3.50	5	3	16.00	7	1 1975
64.50	0.5900	0.6000	0.6000	0.6000	3.00	5	3	16.30	7	1 1975
69.50	0.5600	0.5600	0.5600	0.5600	10.00	5	3	2.30	8	1 1975
69.00	0.5500	0.5500	0.5500	0.5500	10.50	5	3	3.00	8	1 1975
53.00	0.3400	0.3400	0.3400	0.3400	21.00	5	3	5.00	11	1 1975
52.50	0.3450	0.3450	0.3450	0.3450	18.00	5	3	5.30	11	1 1975
52.00	0.3450	0.3450	0.3450	0.3450	18.00	5	3	6.00	11	1 1975
55.00	0.3730	0.3700	0.3700	0.3700	14.00	5	3	6.30	11	1 1975
65.00	0.4300	0.4300	0.4300	0.4300	17.00	5	3	7.00	11	1 1975
60.00	0.4100	0.4100	0.4100	0.4100	23.00	5	3	7.30	11	1 1975
64.00	0.4250	0.4200	0.4200	0.4200	22.00	5	3	8.00	11	1 1975
64.00	0.4250	0.4250	[illegible]	0.4250	18.00	5	3	8.30	11	1 1975
63.00	0.4200	0.4200	0.4200	0.4200	20.00	5	3	9.00	11	1 1975
63.00	0.4200	0.4200	0.4200	0.4200	19.00	5	3	9.30	11	1 1975
63.50	0.4560	0.4500	0.4500	0.4500	25.00	5	3	10.00	11	1 1975
59.00	0.4100	0.4100	0.4100	0.4100	24.00	5	3	10.30	11	1 1975
59.00	0.4400	0.4400	0.4400	0.4400	32.00	5	3	11.00	11	1 1975
61.50	0.4300	0.4160	0.4300	0.4300	27.00	5	3	11.30	11	1 1975
88.00	0.7400	0.7650	0.7700	0.7900	5.00	5	3	0.00	21	1 1975
84.00	0.7400	0.7500	0.7700	0.7600	7.50	5	3	0.30	21	1 1975
83.00	0.7200	0.7250	0.7500	0.7400	8.50	5	3	1.00	21	1 1975
79.00	0.6900	0.6950	0.7050	0.7100	10.00	5	3	1.30	21	1 1975
72.50	0.6000	0.5950	0.6250	0.6050	10.00	5	3	2.00	21	1 1975
70.50	0.5800	0.5700	0.6000	0.5900	13.00	5	3	2.30	21	1 1975
68.50	0.5850	0.5600	0.5800	0.5750	16.00	5	3	3.00	21	1 1975
67.50	0.5600	0.5500	0.5700	0.5600	12.00	5	3	3.30	21	1 1975
67.00	0.5500	0.5400	0.5650	0.5550	11.00	5	3	4.00	21	1 1975
65.00	0.5300	0.5250	0.5400	0.5400	14.00	5	3	4.30	21	1 1975
65.00	0.5200	0.5200	0.5300	0.5250	15.00	5	3	5.00	21	1 1975
64.00	0.5250	0.5250	0.5300	0.5250	[illegible]	5	3	5.30	21	1 1975
89.00	0.9000	0.9000	0.8100	0.8100	0.10	5	3	5.00	28	1 1975
90.00	0.8000	0.8030	0.8100	0.8100	0.10	5	3	5.30	28	1 1975
87.00	0.8500	0.8500	0.9800	0.8600	0.10	5	3	6.00	28	1 1975
91.00	0.8550	0.8650	0.8800	0.8650	0.10	5	3	6.30	28	1 1975
94.00	0.9000	0.9000	0.9300	0.9050	0.10	5	3	7.00	28	1 1975
86.00	0.8830	0.8900	0.9150	0.9000	0.10	5	3	7.30	28	1 1975
83.50	0.8550	0.8550	0.8800	0.8700	0.10	5	3	8.00	28	1 1975
75.00	0.6100	0.6250	0.6600	0.6400	7.50	5	3	22.00	28	1 1975
71.50	0.6300	0.6300	0.6700	0.6450	7.00	5	3	22.30	28	1 1975
96.00	0.8900	0.8700	0.9000	0.8900	2.50	5	3	8.00	10	2 1975
95.00	0.8500	0.8400	0.8400	0.8250	4.50	5	3	8.30	10	2 1975

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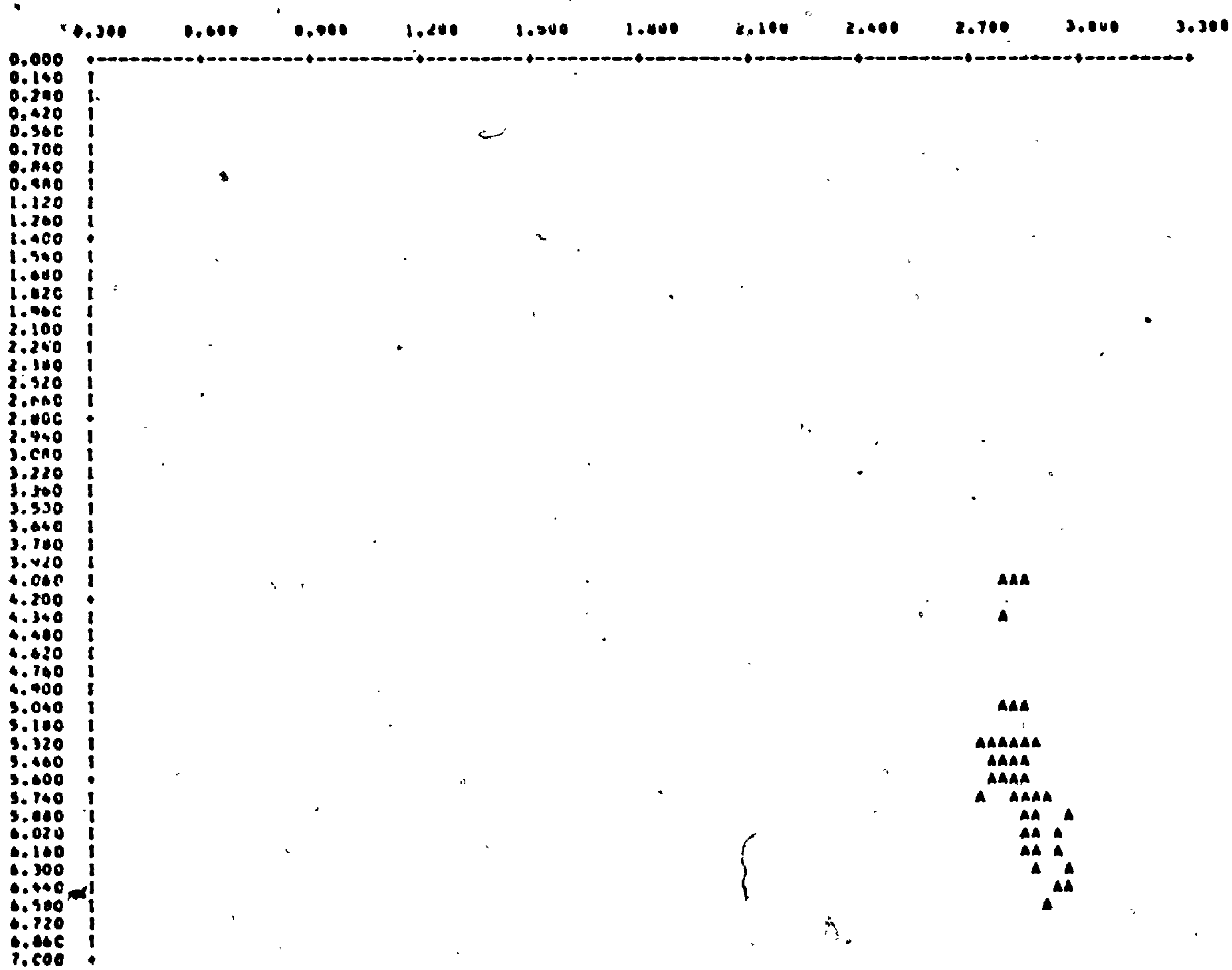
SOUTH
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



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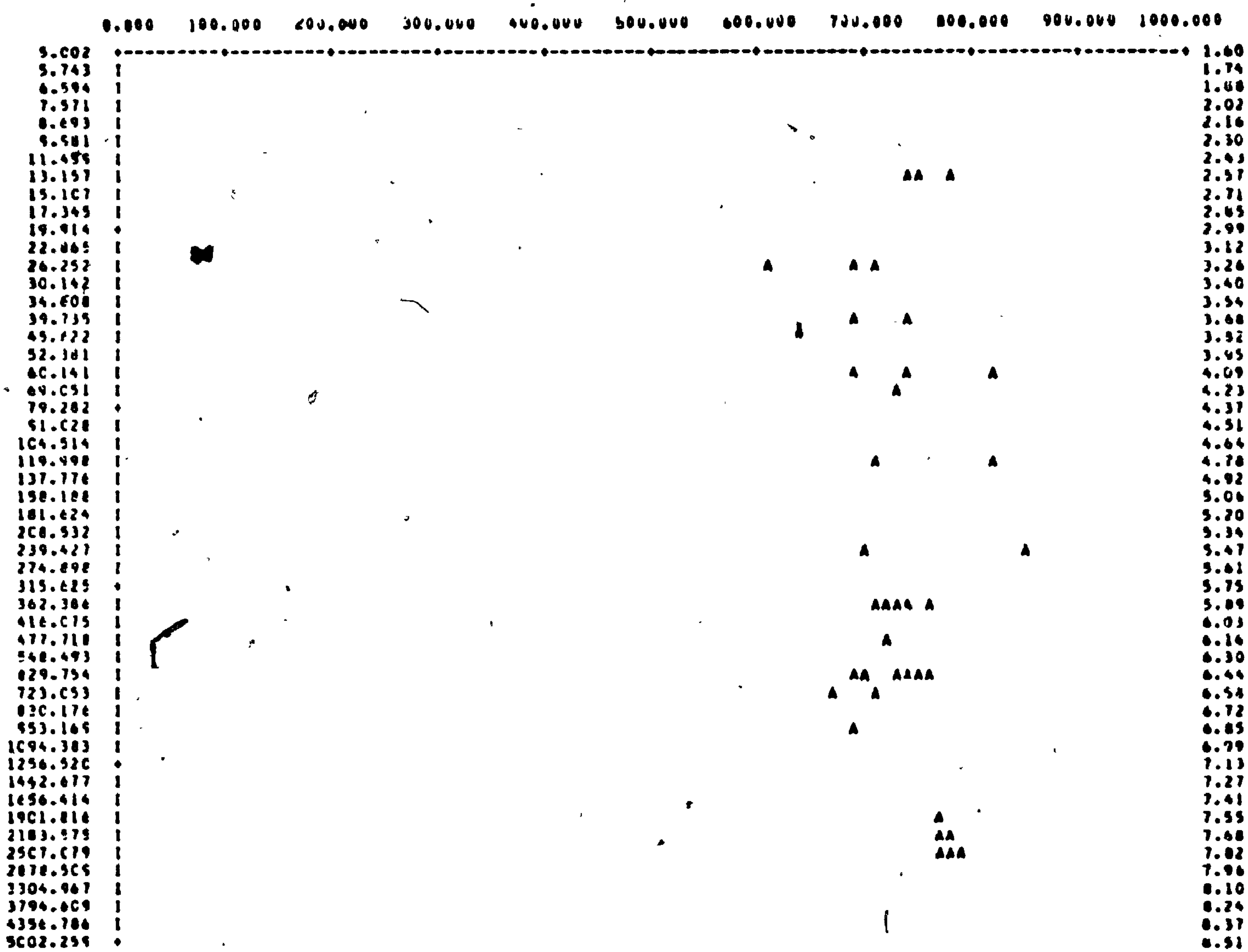
C	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
83.00	0.7250	0.7200	0.7550	0.7750	3.00	5	4	21.00	22	11	1974
82.80	0.7200	0.7050	0.7500	0.7750	3.00	5	4	21.30	22	11	1974
81.00	0.7300	0.7150	0.7600	0.7800	2.00	5	4	22.00	22	11	1974
81.20	0.7300	0.7200	0.7550	0.7800	3.00	5	4	22.30	22	11	1974
82.10	0.7200	0.7150	0.7500	0.7650	3.00	5	4	23.00	22	11	1974
83.30	0.7000	0.7000	0.7350	0.7650	5.00	5	4	23.20	22	11	1974
81.00	0.6900	0.6900	0.7250	0.7300	3.00	5	4	0.30	23	11	1974
82.00	0.6800	0.6800	0.7050	0.7350	3.00	5	4	1.00	23	11	1974
85.00	0.7800	0.7800	0.7800	0.7800	0.20	5	4	19.00	30	12	1974
70.00	0.6400	0.6400	0.6400	0.6400	0.20	5	4	19.30	30	12	1974
65.00	0.6700	0.6700	0.6700	0.6700	0.20	5	4	20.00	30	12	1974
80.00	0.7000	0.7000	0.7000	0.7000	0.30	5	4	20.30	30	12	1974
76.00	0.7100	0.7100	0.7100	0.7100	0.30	5	4	21.00	30	12	1974
74.00	0.6900	0.6900	0.6900	0.6900	1.00	5	4	21.30	30	12	1974
86.00	0.6800	0.6800	0.6800	0.6800	0.50	5	4	22.00	30	12	1974
78.00	0.7250	0.7250	0.7250	0.7250	0.50	5	4	22.30	30	12	1974
91.00	0.7300	0.7300	0.7300	0.7300	1.00	5	4	23.00	30	12	1974
91.00	0.7050	0.7050	0.7050	0.7050	2.00	5	4	23.30	30	12	1974
93.50	0.8750	0.8850	0.9400	0.8900	5.00	5	4	17.30	20	1	1975
82.00	0.7700	0.7900	0.8200	0.7900	6.00	5	4	18.00	20	1	1975
85.00	0.7400	0.7500	0.7850	0.7600	5.00	5	4	18.30	20	1	1975
86.50	0.7550	0.7550	0.8000	0.7700	5.00	5	4	19.00	20	1	1975
88.00	0.7550	0.7500	0.8000	0.7700	5.00	5	4	19.30	20	1	1975
88.00	0.7600	0.7600	0.8000	0.7900	5.00	5	4	20.00	20	1	1975
87.00	0.7500	0.7400	0.7800	0.7700	5.00	5	4	20.30	20	1	1975
87.50	0.7500	0.7550	0.7850	0.7800	5.00	5	4	21.00	20	1	1975
87.00	0.7400	0.7300	0.7800	0.7500	5.00	5	4	21.30	20	1	1975
84.00	0.7900	0.7800	0.8200	0.8100	8.00	5	4	22.00	20	1	1975
85.00	0.7500	0.7550	0.7850	0.7750	4.00	5	4	22.30	20	1	1975
82.00	0.7550	0.7600	0.7900	0.7900	5.00	5	4	23.00	20	1	1975
84.00	0.7600	0.7700	0.7900	0.7900	6.00	5	4	23.30	20	1	1975
64.50	0.5200	0.5150	0.5250	0.5250	16.00	5	4	6.00	21	1	1975
64.00	0.5050	0.5150	0.5200	0.5200	18.00	5	4	6.30	21	1	1975
64.00	0.5000	0.5050	0.5150	0.5150	18.00	5	4	7.00	21	1	1975
64.50	0.5050	0.5100	0.5150	0.5150	20.00	5	4	7.30	21	1	1975
62.00	0.4900	0.4950	0.5000	0.5000	20.00	5	4	8.00	21	1	1975
59.50	0.4700	0.4700	0.4800	0.4800	20.00	5	4	8.30	21	1	1975
59.80	0.4700	0.4600	0.4800	0.4750	20.00	5	4	9.00	21	1	1975
59.00	0.4550	0.4550	0.4650	0.4650	20.00	5	4	9.30	21	1	1975
59.00	0.4600	0.4500	0.4700	0.4500	20.00	5	4	10.00	21	1	1975
83.00	0.6800	0.6900	0.7100	0.6850	0.10	5	4	6.00	2	2	1975
83.00	0.7200	0.7200	0.7450	0.7200	0.10	5	4	6.30	2	2	1975
79.00	0.6800	0.6800	0.6900	0.6700	0.10	5	4	8.00	2	2	1975
99.20	0.5100	0.8900	0.9200	0.9050	0.50	5	4	4.00	10	2	1975
99.00	0.5300	0.9000	0.9400	0.9100	0.50	5	4	4.30	10	2	1975

FACULTY OF ENGINEERING SCIENCE

CLEAR
SOUTH
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



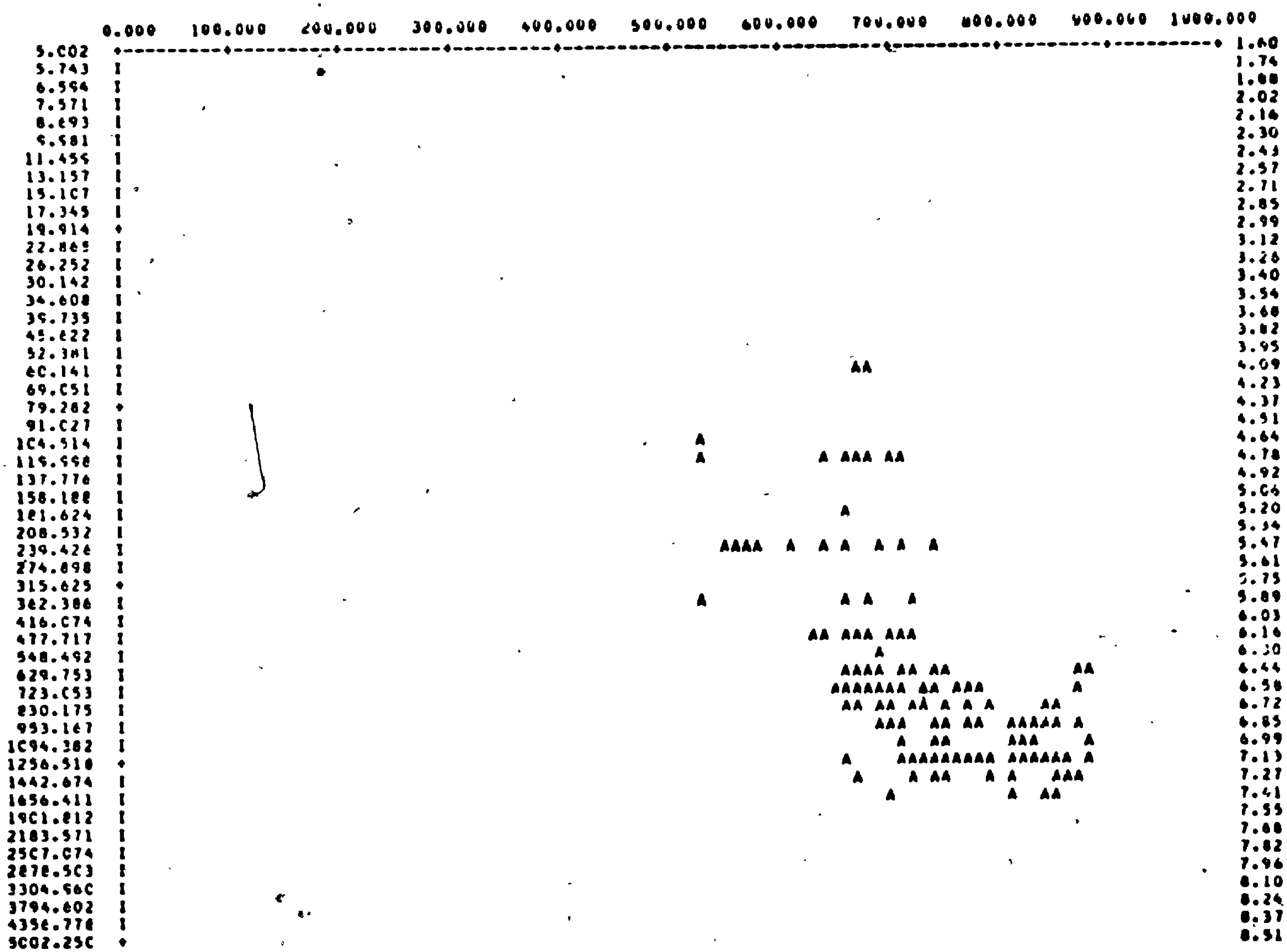
FACULTY OF ENGINEERING SCIENCE

Q	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
75.00	0.6350	0.6150	0.6400	0.6600	7.00	5	5	15.45	15	11	1974
79.00	0.6650	0.6400	0.6650	0.6750	7.00	5	5	16.10	15	11	1974
78.50	0.6750	0.6500	0.6750	0.6850	8.00	5	5	16.25	15	11	1974
76.50	0.6650	0.6400	0.6600	0.6700	9.00	5	5	16.50	15	11	1974
76.50	0.6650	0.6400	0.6650	0.6750	8.00	5	5	17.05	15	11	1974
76.70	0.6650	0.6450	0.6600	0.6850	5.00	5	5	17.20	15	11	1974
77.20	0.6750	0.6500	0.6650	0.6850	8.00	5	5	17.40	15	11	1974
77.20	0.6550	0.6500	0.6600	0.6800	9.00	5	5	18.00	15	11	1974
76.00	0.7400	0.7300	0.7400	0.7300	10.00	5	5	8.00	10	12	1974
70.00	0.6750	0.6650	0.6750	0.6650	10.00	5	5	0.00	10	12	1974
59.00	0.5550	0.5500	0.5700	0.5800	6.00	5	5	16.00	11	12	1974
58.20	0.5370	0.5300	0.5500	0.5600	6.00	5	5	17.00	11	12	1974
57.80	0.5370	0.5400	0.5500	0.5600	4.00	5	5	17.30	11	12	1974
58.00	0.5550	0.5500	0.5700	0.5800	4.00	5	5	18.00	11	12	1974
59.00	0.5250	0.5200	0.5400	0.5500	5.00	5	5	18.30	11	12	1974
60.00	0.5130	0.5100	0.5300	0.5400	4.00	5	5	19.00	11	12	1974
59.50	0.5200	0.5100	0.5300	0.5400	6.00	5	5	19.30	11	12	1974
59.50	0.5350	0.5200	0.5400	0.5500	5.00	5	5	20.00	11	12	1974
61.00	0.5230	0.5200	0.5400	0.5500	1.00	5	5	20.30	11	12	1974
60.00	0.5500	0.5400	0.5600	0.5700	4.00	5	5	21.00	11	12	1974
62.00	0.5300	0.5200	0.5400	0.5500	4.00	5	5	21.30	11	12	1974
61.50	0.5550	0.5500	0.5700	0.5800	3.00	5	5	22.00	11	12	1974
61.00	0.5250	0.5200	0.5400	0.5500	4.0[illegible]	[illegible]	5	22.30	11	12	1974
61.00	0.5300	0.5200	0.5400	0.5500	4.0[illegible]	[illegible]	5	23.00	11	12	1974
61.00	0.5250	0.5200	0.5400	0.5500	2.00	5	5	23.30	11	12	1974
61.00	0.5400	0.5300	0.5500	0.5600	2.00	5	5	0.00	12	12	1974
60.50	0.5550	0.5500	0.5700	0.5800	3.00	5	5	0.30	12	12	1974
60.00	0.5600	0.5500	0.5700	0.5800	2.00	5	5	1.00	12	12	1974
60.50	0.5550	0.5500	0.5700	0.5800	4.00	5	5	1.30	12	12	1974
61.00	0.5500	0.5400	0.5600	0.5700	4.00	5	5	2.00	12	12	1974
60.50	0.5600	0.5500	0.5700	0.5800	2.00	5	5	2.30	12	12	1974
60.00	0.5700	0.5600	0.5800	0.5900	2.00	5	5	3.00	12	12	1974
60.50	0.5800	0.5700	0.5900	0.6000	2.00	5	5	3.30	12	12	1974
61.00	0.5700	0.5600	0.5800	0.5900	1.00	5	5	4.00	12	12	1974
61.00	0.5850	0.5800	0.6000	0.6100	1.00	5	5	4.30	12	12	1974
60.50	0.5600	0.5500	0.5700	0.5800	1.00	5	5	5.30	12	12	1974
61.00	0.5600	0.5500	0.5700	0.5800	1.00	5	5	6.00	12	12	1974
61.00	0.5600	0.5500	0.5700	0.5800	0.50	5	5	6.30	12	12	1974
84.00	0.7300	0.7200	0.7400	0.7500	2.00	5	5	7.00	12	12	1974
83.00	0.7450	0.7400	0.7600	0.7700	3.00	5	5	7.30	12	12	1974
74.00	0.7100	0.7000	0.7200	0.7300	5.00	5	5	6.30	19	12	1974
85.00	0.7300	0.7200	0.7400	0.7500	8.00	5	5	7.00	19	12	1974
85.00	0.7600	0.7500	0.7700	0.7800	7.00	5	5	7.30	19	12	1974
77.00	0.6800	0.6700	0.6800	0.6900	4.00	5	5	8.00	19	12	1974
59.00	0.5200	0.5100	0.5300	0.5400	6.00	5	5	12.00	19	12	1974
58.00	0.5300	0.5200	0.5400	0.5500	6.00	5	5	12.30	19	12	1974
59.00	0.5300	0.5200	0.5400	0.5500	6.00	5	5	13.00	19	12	1974
59.00	0.6350	0.6300	0.6400	0.6500	2.00	5	5	21.00	20	12	1974
59.00	0.6450	0.6400	0.6500	0.6600	2.00	5	5	21.30	20	12	1974
58.50	0.6400	0.6300	0.6500	0.6600	2.00	5	5	22.00	20	12	1974
59.00	0.6450	0.6400	0.6500	0.6600	2.60	5	5	22.30	20	12	1974
59.00	0.6200	0.6100	0.6300	0.6400	2.00	5	5	23.00	20	12	1974
61.00	0.6200	0.6100	0.6300	0.6400	2.00	5	5	23.30	20	12	1974
59.00	0.6950	0.6900	0.7000	0.7100	1.00	5	5	12.30	21	12	1974
58.00	0.6750	0.6700	0.6800	0.6900	0.80	5	5	13.00	21	12	1974
58.00	0.6750	0.6700	0.6800	0.6900	3.00	5	5	13.30	21	12	1974
58.00	0.6500	0.6400	0.6600	0.6700	2.00	5	5	14.00	21	12	1974
59.00	0.6650	0.6600	0.6700	0.6800	2.00	5	5	14.30	21	12	1974

91.80	0.8950	0.8990	0.9200	0.9000	0.50	5	5	3.00	26	12	1974
91.50	0.9300	0.9000	0.9600	0.9400	1.50	5	5	3.30	26	12	1974
92.00	0.8700	0.8400	0.9000	0.8700	1.00	5	5	5.00	26	12	1974
59.50	0.5300	0.5300	0.5300	0.5300	5.00	5	5	12.30	31	12	1974
58.50	0.5250	0.5250	0.5250	0.5250	1.00	5	5	13.00	31	12	1974
59.50	0.5600	0.5600	0.5600	0.5600	1.00	5	5	13.30	31	12	1974
59.00	0.5500	0.5500	0.5500	0.5500	1.00	5	5	14.00	31	12	1974
85.00	0.6450	0.6450	0.6450	0.6450	7.00	5	5	6.30	3	1	1975
85.00	0.6450	0.6450	0.6450	0.6450	8.00	5	5	7.00	3	1	1975
83.00	0.6400	0.6400	0.6400	0.6400	10.00	5	5	7.30	3	1	1975
82.00	0.6400	0.6400	0.6400	0.6400	10.00	5	5	8.00	3	1	1975
69.00	0.5750	0.5750	0.5750	0.5750	11.00	5	5	8.30	3	1	1975
67.50	0.5200	0.5200	0.5200	0.5200	10.00	5	5	6.30	8	1	1975
65.50	0.5000	0.5000	0.5000	0.5000	10.00	5	5	7.00	8	1	1975
64.50	0.4900	0.4900	0.4900	0.4900	12.00	5	5	7.30	8	1	1975
64.00	0.4700	0.4700	0.4700	0.4700	13.00	5	5	8.00	8	1	1975
63.00	0.4600	0.4600	0.4600	0.4600	14.00	5	5	8.30	8	1	1975
63.00	0.4500	0.4500	0.4500	0.4500	10.00	5	5	9.00	8	1	1975
63.00	0.4500	0.4500	0.4500	0.4500	10.00	5	5	9.30	8	1	1975
65.50	0.4750	0.4750	0.4750	0.4750	11.00	5	5	10.00	8	1	1975
65.50	0.5100	0.5100	0.5100	0.5100	13.00	5	5	10.30	8	1	1975
66.50	0.5100	0.5100	0.5100	0.5100	12.00	5	5	11.00	8	1	1975
64.00	0.4600	0.4600	0.4600	0.4600	12.50	5	5	11.30	8	1	1975
66.00	0.4800	0.4800	0.4800	0.4800	12.50	5	5	12.00	8	1	1975
65.50	0.5000	0.5000	0.5000	0.5000	13.00	5	5	12.30	8	1	1975
64.00	0.5400	0.5400	0.5400	0.5400	11.00	5	5	13.00	8	1	1975
63.00	0.5200	0.5200	0.5200	0.5200	12.00	5	5	13.30	8	1	1975
63.00	0.5200	0.5200	0.5200	0.5200	10.50	5	5	14.00	8	1	1975
64.00	0.5400	0.5400	0.5400	0.5400	10.00	5	5	14.30	8	1	1975
64.00	0.5500	0.5500	0.5500	0.5500	10.50	5	5	15.00	8	1	1975
62.00	0.5400	0.5400	0.5400	0.5400	10.00	5	5	15.30	8	1	1975
64.50	0.5100	0.5100	0.5100	0.5100	10.00	5	5	16.00	8	1	1975
63.50	0.4750	0.4750	0.4750	0.4750	10.00	5	5	16.30	8	1	1975
66.00	0.5000	0.5000	0.5000	0.5000	9.50	5	5	17.00	8	1	1975
66.00	0.4900	0.4900	0.4900	0.4900	8.00	5	5	17.30	8	1	1975
62.50	0.4600	0.4600	0.4600	0.4600	7.00	5	5	18.00	8	1	1975
63.00	0.4600	0.4600	0.4600	0.4600	11.00	5	5	18.30	8	1	1975
63.00	0.4500	0.4500	0.4500	0.4500	10.50	5	5	19.00	8	1	1975
64.00	0.4500	0.4500	0.4500	0.4500	10.50	5	5	19.30	8	1	1975
64.00	0.4600	0.4600	0.4600	0.4600	11.00	5	5	20.00	8	1	1975
64.00	0.4500	0.4500	0.4500	0.4500	9.50	5	5	20.30	8	1	1975
64.00	0.4700	0.4700	0.4700	0.4700	10.00	5	5	21.00	8	1	1975
64.00	0.4750	0.4750	0.4750	0.4750	9.00	5	5	21.30	8	1	1975
64.50	0.4600	0.4600	0.4600	0.4600	8.00	5	5	22.00	8	1	1975
64.00	0.4500	0.4500	0.4500	0.4500	5.00	5	5	22.30	8	1	1975
64.50	0.4600	0.4600	0.4600	0.4600	5.00	5	5	23.00	8	1	1975
65.50	0.4650	0.4650	0.4650	0.4650	6.00	5	5	23.30	8	1	1975
81.70	0.7050	0.6850	0.7200	0.7150	7.00	5	5	0.00	18	1	1975
81.30	0.7000	0.7000	0.7200	0.7200	8.00	5	5	0.30	18	1	1975
80.20	0.6950	0.7000	0.7300	0.7200	7.00	5	5	1.00	18	1	1975
80.50	0.7150	0.7150	0.7400	0.7350	7.00	5	5	1.30	18	1	1975
80.00	0.7200	0.7050	0.7350	0.7350	8.50	5	5	2.00	18	1	1975
81.00	0.7000	0.6900	0.7250	0.7250	9.50	5	5	2.30	18	1	1975
81.30	0.7000	0.7000	0.7200	0.7200	12.00	5	5	3.00	18	1	1975
82.00	0.7200	0.7000	0.7400	0.7300	11.00	5	5	3.30	18	1	1975
83.50	0.7200	0.7050	0.7400	0.7300	10.00	5	5	4.00	18	1	1975
82.00	0.7150	0.7000	0.7300	0.7200	10.00	5	5	4.30	18	1	1975
63.40	0.5800	0.5800	0.6000	0.5800	12.00	5	5	5.00	18	1	1975
62.30	0.5450	0.5550	0.5700	0.5500	13.00	5	5	5.30	18	1	1975
62.20	0.5250	0.5250	0.5500	0.5250	12.50	5	5	6.00	18	1	1975
61.70	0.5000	0.5100	0.5300	0.5100	12.50	5	5	6.30	18	1	1975

62.C0	0.5150	0.5150	0.5350	0.5150	12.00	5	5	7.00	18	1	1975
61.50	0.51C0	0.5200	0.5300	0.5100	11.C0	5	5	7.30	18	1	1975
61.50	0.49C0	0.510C	0.5100	0.5100	12.00	5	5	8.C0	18	1	1975
6C.C0	0.48C0	0.4800	0.5C00	0.4800	11.C0	5	5	8.30	18	1	1975
59.80	0.465C	0.4750	0.49C0	0.4650	10.50	5	5	9.00	18	1	1975
59.80	0.45C0	C.47C0	0.48C0	0.4600	10.C0	5	5	9.30	18	1	1975
59.00	0.4450	0.44CC	0.4600	0.4400	9.C0	5	5	1C.00	18	1	1975
59.CC	C.44CC	0.43CC	0.4550	0.4450	10.C0	5	5	10.30	18	1	1975
62.CC	C.475C	0.475C	0.5000	0.49C0	12.00	5	5	C.C0	25	1	1975
64.50	C.47CC	0.475C	C.5CC0	0.4950	8.C0	5	5	C.30	25	1	1975
65.C0	0.485C	0.48C0	0.5C50	0.5C00	12.00	5	5	1.C0	25	1	1975
68.C0	0.51C0	0.5050	0.5350	0.5250	11.C0	5	5	1.30	25	1	1975
67.CC	0.5300	0.5300	0.55C0	0.5400	6.C0	5	5	2.00	25	1	1975
67.80	0.54CC	0.5400	0.5650	0.5600	6.C0	5	5	2.30	25	1	1975
66.00	0.55C0	0.54CC	0.57C0	0.5650	6.C0	5	5	3.00	25	1	1975
63.50	0.5650	0.57CC	0.5900	0.5800	4.50	5	5	3.30	25	1	1975
63.CC	C.57C0	0.57CC	0.6C00	0.5850	5.C0	5	5	4.00	25	1	1975
65.C0	C.56CC	0.56CC	0.5800	0.57C0	5.C0	5	5	4.30	25	1	1975
64.50	0.555C	0.5550	0.5800	0.5700	5.00	5	5	5.C0	25	1	1975
66.00	C.56CC	0.5550	0.5900	0.5700	5.C0	5	5	5.30	25	1	1975
66.20	0.57C0	0.57DC	0.6C00	0.5800	6.C0	5	5	6.00	25	1	1975
63.C0	0.555E	0.5500	0.5850	0.5750	7.C0	5	5	6.30	25	1	1975
62.80	0.54C0	0.5400	0.5700	0.5550	8.C0	5	5	7.00	25	1	1975
63.80	0.5250	0.525C	0.5550	0.5400	9.00	5	5	7.30	25	1	1975
62.C0	C.52CC	0.515C	C.5500	0.5400	7.00	5	5	8.00	25	1	1975
61.CC	C.52C0	0.52CC	0.5450	0.5350	9.00	5	5	8.30	25	1	1975
61.00	0.525C	0.525C	0.5450	0.5300	8.50	5	5	9.C0	25	1	1975
6C.00	0.52CC	0.5250	0.5500	0.5400	7.50	5	5	9.30	25	1	1975
6C.00	0.52CC	0.5200	0.54C0	0.5400	8.C0	5	5	10.00	25	1	1975
57.00	0.52C0	C.52C0	0.54C0	0.5300	6.50	5	5	10.30	25	1	1975
56.C0	0.5CC0	C.5C00	0.5250	0.5100	7.C0	5	5	11.00	25	1	1975
62.C0	0.5CC0	0.51CC	0.5300	0.5150	1C.C0	5	5	11.30	25	1	1975
63.CC	0.49C0	0.49CC	0.5200	0.5200	7.50	5	5	12.00	25	1	1975
62.5C	C.49CC	0.45CC	0.5200	0.5100	8.C0	5	5	12.30	25	1	1975
62.00	0.49C0	0.49CC	0.5150	0.5C50	6.00	5	5	13.C0	25	1	1975
59.00	0.47C0	0.4750	C.5CC0	0.49C0	5.C0	5	5	13.30	25	1	1975
59.50	0.495C	0.5C00	0.5200	0.5100	3.C0	5	5	14.00	25	1	1975
74.00	0.56C0	0.5700	0.5850	0.5700	5.50	5	5	7.C0	29	1	1975
75.C0	0.55CC	0.5600	0.5850	0.5650	1C.C0	5	5	7.30	29	1	1975
71.CC	0.525C	0.5250	0.5590	0.5400	8.C0	5	5	8.00	29	1	1975
68.C0	0.51C0	0.52CC	0.5400	0.5300	8.C0	5	5	8.30	29	1	1975
65.5C	C.515C	0.525C	0.5300	0.5250	7.50	5	5	9.00	29	1	1975
63.5C	C.5550	0.565C	0.5700	0.57C0	7.C0	5	5	9.30	29	1	1975
63.00	0.55CC	0.560C	C.5750	0.5600	7.50	5	5	1C.C0	29	1	1975

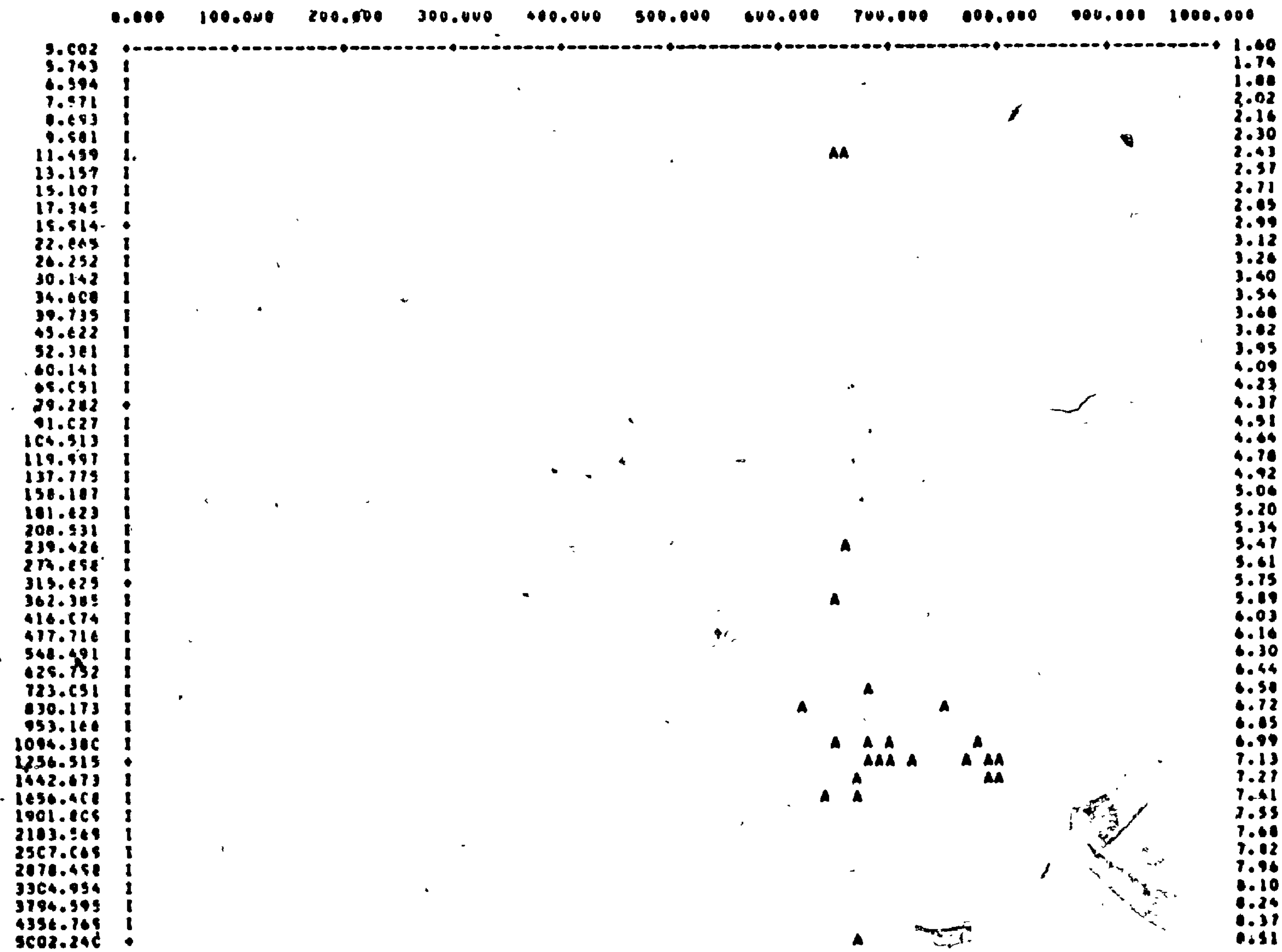
PRECIPITATION
SOUTH
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



Q	CTA	DTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
58.00	0.5000	0.5600	0.5600	0.5450	0.10	6	1	10.30	24	12	1974
58.00	0.5100	0.5600	0.5750	0.5500	0.10	6	1	11.00	24	12	1974
67.00	0.6950	0.6550	0.6850	0.6700	7.00	6	1	9.30	26	12	1974
88.00	0.7700	0.7450	0.7900	0.7700	7.00	6	1	10.00	26	12	1974
62.00	0.5750	0.5650	0.5850	0.5500	6.00	6	1	10.30	26	12	1974
66.00	0.6150	0.6350	0.6300	0.6000	11.00	6	1	11.00	26	12	1974
67.00	0.6750	0.6500	0.6700	0.6500	13.00	6	1	11.30	26	12	1974
60.00	0.5800	0.5550	0.5700	0.5600	9.00	6	1	12.00	26	12	1974
61.30	0.5700	0.5850	0.5800	0.5500	2.00	6	1	11.30	7	1	1975
57.50	0.5300	0.5700	0.5600	0.5300	3.00	6	1	12.00	7	1	1975
62.50	0.4800	0.5350	0.5250	0.4550	11.00	6	1	14.00	17	1	1975
63.00	0.4750	0.5500	0.5450	0.4650	10.00	6	1	14.30	17	1	1975
60.00	0.5000	0.5700	0.5650	0.4850	9.00	6	1	15.00	17	1	1975
60.00	0.5000	0.5600	0.5800	0.4850	10.00	6	1	15.30	17	1	1975
80.00	0.6000	0.6800	0.7100	0.6300	10.00	6	1	16.00	17	1	1975
82.00	0.6300	0.6700	0.7100	0.6500	10.50	6	1	16.30	17	1	1975
62.50	0.6500	0.6800	0.7000	0.6700	11.00	6	1	17.00	17	1	1975
62.00	0.5200	0.5900	0.6200	0.5400	10.00	6	1	14.00	7	2	1975
62.60	0.5900	0.5900	0.6000	0.5500	13.00	6	1	14.30	7	2	1975
63.00	0.5500	0.6000	0.6200	0.5500	11.00	6	1	15.00	7	2	1975
64.00	0.5300	0.5700	0.5900	0.5200	11.00	6	1	15.30	7	2	1975
66.00	0.5700	0.6400	0.6200	0.6100	9.00	6	1	16.00	7	2	1975
63.50	0.5540	0.5900	0.5800	0.5550	10.50	6	1	16.30	7	2	1975
70.00	0.5200	0.5600	0.5600	0.5500	12.50	6	1	17.00	7	2	1975
73.50	0.5700	0.6100	0.6100	0.6000	9.50	6	1	17.30	7	2	1975

FACULTY OF ENGINEERING SCIENCE

SUNNY
SOUTH-WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



FACULTY OF ENGINEERING SCIENCE

Q	CTA	DTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
78.00	0.7300	0.7200	0.7300	0.7200	8.00	6	2	1.00	10	12	1974
78.70	0.7300	0.7200	0.7300	0.7200	8.00	6	2	1.30	10	12	1974
85.50	0.7650	0.7550	0.7650	0.7550	5.00	6	2	2.00	10	12	1974
81.50	0.7800	0.7700	0.7800	0.7700	8.00	6	2	2.30	10	12	1974
80.00	0.7650	0.7550	0.7650	0.7550	6.00	6	2	3.00	10	12	1974
75.00	0.7550	0.7450	0.7550	0.7450	8.00	6	2	3.30	10	12	1974
83.00	0.7550	0.7450	0.7550	0.7450	9.00	6	2	4.00	10	12	1974
83.00	0.7650	0.7550	0.7650	0.7550	10.00	6	2	4.30	10	12	1974
82.50	0.7400	0.7300	0.7400	0.7300	12.00	6	2	5.00	10	12	1974
80.50	0.7550	0.7450	0.7550	0.7450	8.00	6	2	5.30	10	12	1974
80.50	0.7500	0.7400	0.7500	0.7400	12.00	6	2	6.00	10	12	1974
75.00	0.7100	0.7000	0.7100	0.7000	10.00	6	2	6.30	10	12	1974
67.00	0.6100	0.6000	0.6200	0.6300	13.00	6	2	12.30	10	12	1974
70.50	0.6000	0.5900	0.6100	0.6200	14.00	6	2	13.00	10	12	1974
65.00	0.5700	0.5600	0.5800	0.5900	13.00	6	2	13.30	10	12	1974
66.00	0.5900	0.5800	0.6000	0.6100	12.00	6	2	14.00	10	12	1974
64.00	0.5750	0.5700	0.5800	0.5900	11.00	6	2	14.30	10	12	1974
63.00	0.5600	0.5500	0.5700	0.5800	11.00	6	2	15.00	10	12	1974
65.00	0.5700	0.5600	0.5800	0.5900	10.00	6	2	15.30	10	12	1974
65.00	0.5850	0.5800	0.5900	0.6000	8.00	6	2	16.00	10	12	1974
61.00	0.5650	0.5600	0.5700	0.5800	6.00	6	2	16.30	10	12	1974
61.00	0.5630	0.5600	0.5700	0.5800	4.00	6	2	17.00	10	12	1974
60.50	0.5550	0.5500	0.5600	0.5700	5.00	6	2	17.30	10	12	1974
58.50	0.5600	0.5500	0.5700	0.5800	3.00	6	2	18.00	10	12	1974
61.70	0.5750	0.5700	0.5800	0.5900	5.00	6	2	18.30	10	12	1974
60.00	0.5850	0.5800	0.6000	0.6100	4.00	6	2	20.30	10	12	1974
60.50	0.5800	0.5700	0.5900	0.6000	2.00	6	2	21.00	10	12	1974
57.50	0.6050	0.6000	0.6200	0.6300	1.00	6	2	17.00	12	12	1974
57.50	0.6100	0.6000	0.6200	0.6300	2.00	6	2	17.30	12	12	1974
58.00	0.6180	0.6100	0.6300	0.6400	2.00	6	2	18.00	12	12	1974
58.00	0.6100	0.6000	0.6200	0.6300	3.00	6	2	18.30	12	12	1974
58.80	0.6000	0.5900	0.6100	0.6200	3.00	6	2	19.00	12	12	1974
59.00	0.6100	0.6000	0.6200	0.6300	2.00	6	2	19.30	12	12	1974
59.80	0.6200	0.6100	0.6300	0.6400	1.00	6	2	20.00	12	12	1974
60.00	0.6550	0.6500	0.6600	0.6700	0.20	6	2	0.30	13	12	1974
60.30	0.6780	0.6700	0.6800	0.6900	0.10	6	2	2.00	13	12	1974
59.00	0.5550	0.5500	0.5600	0.5700	7.00	6	2	12.30	16	12	1974
59.00	0.5700	0.5600	0.5800	0.5900	9.00	6	2	14.00	16	12	1974
58.50	0.5450	0.5400	0.5500	0.5600	9.00	6	2	14.30	16	12	1974
58.50	0.5600	0.5500	0.5700	0.5800	6.00	6	2	15.00	16	12	1974
58.50	0.5600	0.5500	0.5700	0.5800	5.00	6	2	15.30	16	12	1974
58.50	0.5650	0.5600	0.5700	0.5800	4.00	6	2	16.00	16	12	1974
58.00	0.5500	0.5400	0.5600	0.5700	5.00	6	2	16.30	16	12	1974
57.50	0.5500	0.5400	0.5600	0.5700	5.00	6	2	17.00	16	12	1974
59.50	0.5700	0.5600	0.5800	0.5900	6.00	6	2	20.30	16	12	1974
60.00	0.5800	0.5700	0.5900	0.6000	5.00	6	2	21.00	16	12	1974
60.00	0.5800	0.5700	0.5900	0.6000	5.00	6	2	21.30	16	12	1974
60.50	0.5700	0.5600	0.5800	0.5900	7.00	6	2	22.00	16	12	1974
61.00	0.5800	0.5700	0.5900	0.6000	6.00	6	2	22.30	16	12	1974
60.00	0.5650	0.5600	0.5700	0.5800	7.00	6	2	23.00	16	12	1974
60.50	0.5550	0.5500	0.5600	0.5700	6.00	6	2	23.30	16	12	1974
60.00	0.5500	0.5400	0.5600	0.5200	5.00	6	2	0.00	17	12	1974
60.00	0.5550	0.5500	0.5600	0.5700	5.00	6	2	0.30	17	12	1974
60.50	0.5650	0.5400	0.5500	0.5600	6.00	6	2	1.00	17	12	1974
61.00	0.5450	0.5400	0.5500	0.5600	7.00	6	2	1.30	17	12	1974
61.00	0.5500	0.5400	0.5600	0.5700	6.00	6	2	2.00	17	12	1974
72.00	0.7250	0.7200	0.7300	0.7400	7.00	6	2	2.30	17	12	1974
79.00	0.7400	0.7300	0.7500	0.7[illegible]00	7.00	6	2	3.00	17	12	1974

78.00	0.7500	0.7400	0.7600	0.7700	7.00	6	2	3.30	17	12	1974
79.00	0.7550	0.7500	0.7600	0.7700	5.00	6	2	4.00	17	12	1974
78.00	0.7600	0.7500	0.7700	0.7800	5.00	6	2	4.30	17	12	1974
77.00	0.7650	0.7600	0.7700	0.7800	6.00	6	2	5.00	17	12	1974
77.00	0.7650	0.7600	0.7700	0.7800	7.00	6	2	5.30	17	12	1974
77.00	0.7700	0.7600	0.7800	0.7900	6.00	6	2	6.00	17	12	1974
75.00	0.7600	0.7500	0.7700	0.7800	4.00	6	2	6.30	17	12	1974
61.50	0.5500	0.5400	0.5600	0.5700	11.00	6	2	15.30	18	12	1974
61.50	0.5450	0.5400	0.5500	0.5600	9.00	6	2	16.00	18	12	1974
62.50	0.5500	0.5400	0.5600	0.5700	10.00	6	2	16.30	18	12	1974
68.00	0.5600	0.5500	0.5700	0.5800	8.00	6	2	17.00	18	12	1974
63.00	0.5550	0.5500	0.5600	0.5700	13.00	6	2	17.30	18	12	1974
64.00	0.5800	0.5700	0.5900	0.6000	9.00	6	2	18.00	18	12	1974
82.00	0.7000	0.6900	0.7100	0.7200	9.00	6	2	18.30	18	12	1974
74.00	0.6700	0.6600	0.6800	0.6900	8.00	6	2	19.00	18	12	1974
81.00	0.6900	0.6800	0.7000	0.7100	8.00	6	2	19.30	18	12	1974
77.00	0.6900	0.6800	0.7000	0.7100	7.00	6	2	20.00	18	12	1974
75.00	0.6800	0.6700	0.6900	0.7000	8.00	6	2	20.30	18	12	1974
74.00	0.6650	0.6600	0.6700	0.6800	8.00	6	2	21.00	18	12	1974
60.00	0.4800	0.4700	0.4900	0.5000	15.00	6	2	18.30	19	12	1974
60.50	0.5050	0.5000	0.5100	0.5200	18.00	6	2	19.00	19	12	1974
59.00	0.4950	0.4900	0.5000	0.5100	15.00	6	2	19.30	19	12	1974
60.00	0.5000	0.4900	0.5100	0.5200	15.00	6	2	20.00	19	12	1974
60.00	0.5050	0.5000	0.5100	0.5200	18.00	6	2	20.30	19	12	1974
58.00	0.4850	0.4800	0.4900	0.5000	18.00	6	2	21.00	19	12	1974
61.00	0.4950	0.4900	0.5000	0.5100	14.00	6	2	21.30	19	12	1974
64.00	0.5700	0.5600	0.5800	0.5900	11.00	6	2	22.00	19	12	1974
61.00	0.5550	0.5500	0.5600	0.5700	10.00	6	2	23.30	19	12	1974
71.00	0.6100	0.6000	0.6200	0.6300	11.00	6	2	23.00	19	12	1974
62.50	0.5700	0.5600	0.5800	0.5900	12.00	6	2	23.30	19	12	1974
59.50	0.5600	0.5600	0.5800	0.5700	5.50	6	2	22.00	23	12	1974
61.00	0.5600	0.5600	0.5800	0.5700	4.00	6	2	22.30	23	12	1974
60.30	0.5800	0.5900	0.6000	0.5900	4.00	6	2	23.00	23	12	1974
60.00	0.5800	0.5800	0.6000	0.5900	5.00	6	2	23.30	23	12	1974
61.00	0.5700	0.5800	0.6100	0.6000	3.50	6	2	0.00	24	12	1974
62.00	0.5900	0.6100	0.6100	0.6150	1.50	6	2	0.30	24	12	1974
62.30	0.6200	0.6300	0.6350	0.6350	2.50	6	2	1.00	24	12	1974
57.50	0.6150	0.6250	0.6400	0.6200	0.80	6	2	17.30	24	12	1974
57.50	0.6000	0.6050	0.6200	0.6050	1.00	6	2	18.00	24	12	1974
58.00	0.5800	0.5900	0.6000	0.5800	3.00	6	2	18.30	24	12	1974
59.00	0.5800	0.6000	0.6100	0.5950	3.00	6	2	19.00	24	12	1974
61.00	0.5500	0.5700	0.5800	0.5750	0.20	6	2	23.30	24	12	1974
60.50	0.5450	0.5700	0.5700	0.5650	0.20	6	2	0.00	25	12	1974
63.00	0.6000	0.6200	0.6250	0.6200	0.10	6	2	1.00	25	12	1974
63.00	0.5700	0.6000	0.5950	0.5950	2.00	6	2	3.30	25	12	1974
62.50	0.5450	0.5600	0.5700	0.5550	1.00	6	2	4.00	25	12	1974
62.50	0.5550	0.5100	0.5800	0.5600	3.00	6	2	5.30	25	12	1974
92.00	0.8100	0.7850	0.8450	0.8200	2.50	6	2	1.30	26	12	1974
92.00	0.8250	0.7900	0.8500	0.8300	2.00	6	2	2.00	26	12	1974
92.00	0.8400	0.8100	0.8800	0.8500	1.00	6	2	2.30	26	12	1974
65.00	0.6100	0.6000	0.6300	0.6150	10.00	6	2	1.00	27	12	1974
64.00	0.5500	0.5600	0.5700	0.5650	11.00	6	2	1.30	27	12	1974
63.00	0.6300	0.6300	0.6450	0.6350	14.00	6	2	2.00	27	12	1974
62.00	0.6200	0.6200	0.6300	0.6250	12.00	6	2	2.30	27	12	1974
88.00	0.6800	0.6500	0.6900	0.6950	9.00	6	2	3.00	27	12	1974
87.00	0.7100	0.6800	0.7200	0.7200	8.00	6	2	3.30	27	12	1974
85.00	0.6950	0.7350	0.7300	0.7250	9.00	6	2	4.00	27	12	1974
83.00	0.7200	0.6950	0.7350	0.7350	5.00	6	2	4.30	27	12	1974
83.00	0.7200	0.7000	0.7400	0.7350	10.00	6	2	5.00	27	12	1974
83.50	0.7200	0.7000	0.7350	0.7300	10.00	6	2	5.30	27	12	1974
83.50	0.7250	0.6950	0.7350	0.7300	12.00	6	2	6.00	27	12	1974

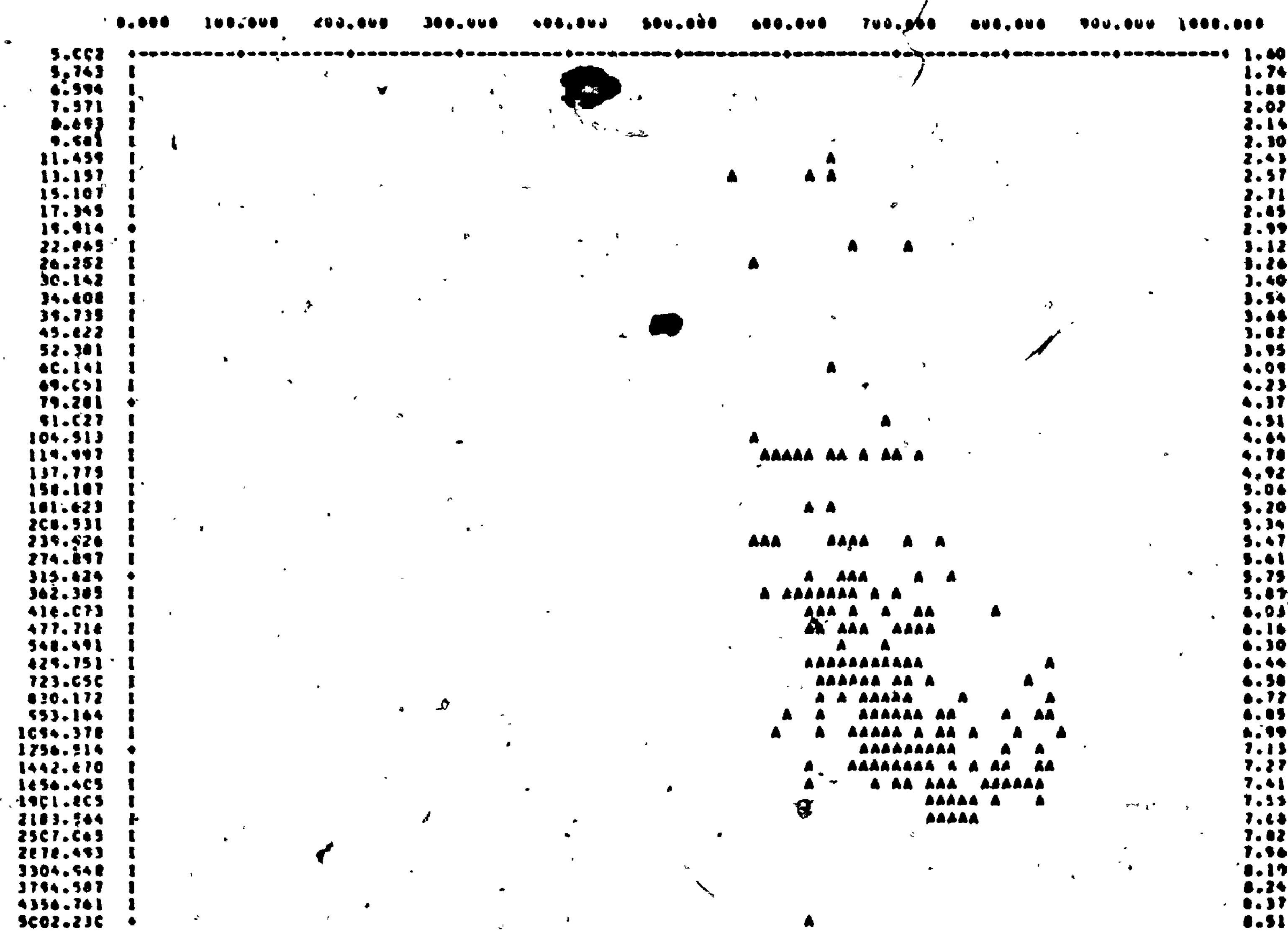
72.00	0.6700	0.6450	0.6800	0.6750	12.00	6	2	6.30	27	12	1974
65.00	0.6950	0.6750	0.7100	0.7100	11.00	6	2	7.00	27	12	1974
76.00	0.6850	0.6550	0.6900	0.6900	9.00	6	2	7.30	27	12	1974
66.00	0.6200	0.6000	0.6200	0.6150	9.00	6	2	8.00	27	12	1974
60.00	0.5500	0.5400	0.5600	0.5500	11.00	6	2	8.30	27	12	1974
60.00	0.5250	0.5100	0.5300	0.5250	14.00	6	2	9.00	27	12	1974
59.00	0.5000	0.4800	0.5100	0.5000	11.00	6	2	9.30	27	12	1974
59.00	0.5000	0.4900	0.5100	0.5100	11.00	6	2	10.00	27	12	1974
58.80	0.4900	0.4700	0.5000	0.4900	18.00	6	2	10.30	27	12	1974
59.00	0.4700	0.4650	0.4850	0.4850	16.00	6	2	11.00	27	12	1974
59.00	0.4900	0.4750	0.4950	0.4900	14.00	6	2	11.30	27	12	1974
59.00	0.4900	0.4750	0.4950	0.4900	13.00	6	2	12.00	27	12	1974
59.00	0.5100	0.5000	0.5200	0.5150	4.00	6	2	14.00	27	12	1974
60.00	0.5300	0.5200	0.5400	0.5400	5.00	6	2	14.30	27	12	1974
60.00	0.5200	0.5100	0.5350	0.5350	5.00	6	2	15.00	27	12	1974
60.00	0.5350	0.5250	0.5500	0.5400	5.00	6	2	15.30	27	12	1974
59.50	0.5200	0.5100	0.5400	0.5250	4.00	6	2	16.00	27	12	1974
59.00	0.5200	0.5050	0.5400	0.5200	4.60	6	2	16.30	27	12	1974
59.00	0.4950	0.5000	0.5100	0.4950	3.50	6	2	17.00	27	12	1974
59.00	0.5200	0.5200	0.5400	0.5200	1.00	6	2	17.30	27	12	1974
59.50	0.5150	0.5350	0.5150	0.5050	0.20	6	2	18.00	27	12	1974
62.00	0.6250	0.6200	0.6350	0.6300	4.00	6	2	19.00	27	12	1974
61.00	0.5700	0.5800	0.5850	0.5800	3.00	6	2	19.30	27	12	1974
60.00	0.5450	0.5450	0.5650	0.5550	2.50	6	2	20.00	27	12	1974
60.00	0.5550	0.5550	0.5700	0.5650	3.50	6	2	20.30	27	12	1974
59.50	0.5500	0.5400	0.5650	0.5580	2.50	6	2	21.00	27	12	1974
60.00	0.5600	0.5550	0.5800	0.5650	2.50	6	2	21.30	27	12	1974
60.00	0.5750	0.5750	0.5900	0.5800	3.50	6	2	22.00	27	12	1974
60.00	0.5800	0.5900	0.5900	0.5900	3.90	6	2	22.30	27	12	1974
60.30	0.5650	0.5650	0.5750	0.5700	3.50	6	2	23.00	27	12	1974
60.30	0.5750	0.5750	0.5950	0.5750	3.50	6	2	23.30	27	12	1974
61.00	0.5800	0.5750	0.5900	0.5850	2.00	6	2	0.00	28	12	1974
61.50	0.6050	0.6050	0.6250	0.6100	3.00	6	2	0.30	28	12	1974
61.50	0.5850	0.5850	0.6000	0.5900	2.50	6	2	1.00	28	12	1974
62.00	0.5900	0.5900	0.6100	0.6050	2.00	6	2	1.30	28	12	1974
61.50	0.5900	0.5800	0.6100	0.5950	3.00	6	2	2.00	28	12	1974
62.00	0.5800	0.5850	0.6000	0.5900	4.50	6	2	2.30	28	12	1974
63.00	0.5800	0.5800	0.6000	0.5850	2.00	6	2	3.00	28	12	1974
62.50	0.5900	0.5900	0.6100	0.6000	3.00	6	2	3.30	28	12	1974
62.00	0.5900	0.5850	0.6100	0.6050	0.50	6	2	4.00	28	12	1974
62.00	0.6100	0.6100	0.6350	0.6250	1.00	6	2	4.30	28	12	1974
61.70	0.6050	0.6050	0.6350	0.6200	3.50	6	2	5.00	28	12	1974
61.00	0.5700	0.5800	0.5950	0.5800	4.00	6	2	5.30	28	12	1974
62.00	0.5700	0.5750	0.5900	0.5800	2.50	6	2	6.30	28	12	1974
61.00	0.5750	0.5800	0.6000	0.5800	1.00	6	2	7.30	28	12	1974
61.50	0.6050	0.6300	0.6400	0.6300	1.00	6	2	8.30	28	12	1974
59.50	0.6000	0.6050	0.6350	0.6100	1.00	6	2	9.00	28	12	1974
60.00	0.6000	0.6100	0.6300	0.6100	1.00	6	2	9.30	28	12	1974
60.00	0.5800	0.5950	0.6200	0.6100	1.50	6	2	10.00	28	12	1974
60.00	0.5900	0.5850	0.6100	0.6050	3.00	6	2	10.30	28	12	1974
59.00	0.5850	0.5850	0.6050	0.5950	5.00	6	2	12.00	28	12	1974
59.00	0.5800	0.5700	0.5950	0.5850	11.00	6	2	12.30	28	12	1974
59.00	0.5500	0.5450	0.5650	0.5450	12.00	6	2	13.00	28	12	1974
60.00	0.5400	0.5300	0.5500	0.5400	10.00	6	2	13.30	28	12	1974
59.50	0.5350	0.5250	0.5500	0.5300	10.00	6	2	14.00	28	12	1974
59.50	0.5250	0.5150	0.5350	0.5250	6.00	6	2	14.30	28	12	1974
60.30	0.5000	0.5000	0.5100	0.5000	11.00	6	2	22.30	28	12	1974
61.00	0.4800	0.4800	0.5000	0.4900	15.00	6	2	23.00	28	12	1974
61.00	0.4800	0.4800	0.5000	0.4850	16.00	6	2	23.30	28	12	1974
61.30	0.4850	0.4900	0.5000	0.4950	12.00	6	2	0.00	29	12	1974
62.00	0.5050	0.5050	0.5200	0.5100	10.00	6	2	0.30	29	12	1974

62.00	0.5150	0.5150	0.5250	0.5200	8.00	6	2	1.00	29	12	1974
62.30	0.5300	0.5400	0.5500	0.5400	5.00	6	2	1.30	29	12	1974
62.70	0.5300	0.5350	0.5400	0.5350	6.00	6	2	2.00	29	12	1974
62.70	0.5450	0.5450	0.5600	0.5500	6.00	6	2	2.30	29	12	1974
62.00	0.5500	0.5505	0.5700	0.5550	5.00	6	2	3.00	29	12	1974
63.00	0.5450	0.5500	0.5650	0.5550	6.00	6	2	3.30	29	12	1974
62.70	0.5650	0.5500	0.5700	0.5650	5.00	6	2	4.00	29	12	1974
62.70	0.5650	0.5600	0.5880	0.5750	3.00	6	2	4.30	29	12	1974
63.00	0.5750	0.5650	0.5850	0.5750	6.00	6	2	5.30	29	12	1974
63.00	0.5550	0.5550	0.5700	0.5600	7.00	6	2	6.00	29	12	1974
62.00	0.5500	0.5500	0.5600	0.5550	5.00	6	2	6.30	29	12	1974
73.50	0.6500	0.6400	0.6600	0.6650	5.00	6	2	7.00	29	12	1974
69.00	0.6500	0.6550	0.6700	0.6750	3.00	6	2	8.30	29	12	1974
67.00	0.6350	0.6400	0.6550	0.6500	4.00	6	2	9.00	29	12	1974
68.50	0.6400	0.6500	0.6600	0.6700	3.00	6	2	9.30	29	12	1974
67.00	0.6400	0.6350	0.6500	0.6550	5.00	6	2	10.00	29	12	1974
60.00	0.5650	0.5550	0.5800	0.5700	6.00	6	2	10.30	29	12	1974
59.00	0.5700	0.5750	0.5900	0.5800	6.00	6	2	11.00	29	12	1974
61.50	0.5900	0.5800	0.6000	0.6000	6.00	6	2	11.30	29	12	1974
59.70	0.5700	0.5700	0.5900	0.5800	6.00	6	2	12.00	29	12	1974
59.70	0.5550	0.5400	0.5650	0.5550	7.00	6	2	12.30	29	12	1974
60.50	0.5450	0.5350	0.5600	0.5500	8.00	6	2	13.00	29	12	1974
60.50	0.5500	0.5250	0.5550	0.5500	12.00	6	2	13.30	29	12	1974
60.00	0.5300	0.5150	0.5450	0.5250	10.00	6	2	14.00	29	12	1974
60.00	0.5400	0.5350	0.5550	0.5500	8.00	6	2	14.30	29	12	1974
60.00	0.5400	0.5350	0.5600	0.5500	6.00	6	2	15.00	29	12	1974
59.30	0.5350	0.5200	0.5500	0.5350	7.00	6	2	15.30	29	12	1974
59.70	0.5350	0.5200	0.5500	0.5350	7.50	6	2	16.00	29	12	1974
59.70	0.5350	0.5250	0.5500	0.5450	7.00	6	2	16.30	29	12	1974
60.00	0.5300	0.5150	0.5400	0.5250	7.00	6	2	17.00	29	12	1974
62.00	0.6000	0.6000	0.6000	0.6000	0.10	6	2	1.30	1	1	1975
62.50	0.6100	0.6100	0.6100	0.6100	0.10	6	2	2.00	1	1	1975
62.80	0.6300	0.6300	0.6300	0.6300	0.10	6	2	2.30	1	1	1975
62.50	0.6050	0.6050	0.6050	0.6050	1.00	6	2	4.30	1	1	1975
63.00	0.6000	0.6000	0.6000	0.6000	2.00	6	2	5.00	1	1	1975
63.00	0.5800	0.5880	0.5800	0.5800	3.00	6	2	5.30	1	1	1975
62.00	0.5700	0.5700	0.5700	0.5700	5.00	6	2	6.00	1	1	1975
66.00	0.6200	0.6200	0.6200	0.6200	8.00	6	2	6.30	1	1	1975
73.50	0.6500	0.6500	0.6500	0.6500	6.50	6	2	7.00	1	1	1975
71.50	0.6450	0.6450	0.6450	0.6450	8.50	6	2	7.30	1	1	1975
72.50	0.6350	0.6350	0.6350	0.6350	5.00	6	2	8.00	1	1	1975
72.00	0.6450	0.6450	0.6450	0.6450	10.00	6	2	8.30	1	1	1975
72.00	0.6450	0.6450	0.6450	0.6450	11.00	6	2	9.00	1	1	1975
61.00	0.5550	0.5550	0.5550	0.5550	11.50	6	2	9.30	1	1	1975
60.00	0.5100	0.5100	0.5100	0.5100	12.00	6	2	10.00	1	1	1975
59.00	0.4500	0.4900	0.4500	0.4900	15.00	6	2	12.30	3	1	1975
60.00	0.4950	0.4950	0.4950	0.4950	14.00	6	2	13.00	3	1	1975
59.50	0.4900	0.4900	0.4900	0.4900	15.00	6	2	13.30	3	1	1975
55.00	0.4850	0.4850	0.4850	0.4850	15.00	6	2	14.00	3	1	1975
59.00	0.4900	0.4900	0.4900	0.4900	16.00	6	2	14.30	3	1	1975
59.00	0.4800	0.4800	0.4800	0.4800	15.00	6	2	15.00	3	1	1975
59.00	0.4750	0.4750	0.4750	0.4750	15.00	6	2	15.30	3	1	1975
58.30	0.4600	0.4600	0.4600	0.4600	18.00	6	2	16.00	3	1	1975
58.30	0.4600	0.4600	0.4600	0.4600	16.00	6	2	16.30	3	1	1975
58.30	0.4600	0.4600	0.4600	0.4600	16.00	6	2	17.00	3	1	1975
58.00	0.4500	0.4500	0.4500	0.4500	16.00	6	2	17.30	3	1	1975
57.80	0.4450	0.4450	0.4450	0.4450	12.00	6	2	18.00	3	1	1975
57.80	0.4500	0.4500	0.4500	0.4500	14.00	6	2	18.30	3	1	1975
59.00	0.4500	0.4500	0.4500	0.4500	14.00	6	2	19.00	3	1	1975
59.00	0.4550	0.4550	0.4550	0.4550	13.00	6	2	19.30	3	1	1975
55.00	0.4500	0.4500	0.4500	0.4500	13.00	6	2	20.00	3	1	1975

40.00	0.4600	0.4600	0.4600	0.4600	14.00	6	2	20.30	3	1	1975
60.00	0.4650	0.4650	0.4650	0.4650	13.00	6	2	21.00	3	1	1975
60.00	0.4650	0.4650	0.4650	0.4650	15.00	6	2	21.30	3	1	1975
66.00	0.4900	0.4900	0.4900	0.4900	[illegible].00	6	2	0.30	9	1	1975
66.50	0.4900	0.4900	0.4900	0.4900	6.50	6	2	1.00	9	1	1975
[illegible].50	0.6250	0.6300	0.6500	0.6300	9.00	6	2	12.00	24	1	1975
[illegible].00	0.6200	0.6250	0.6350	0.6200	8.00	6	2	12.30	24	1	1975
61.00	0.6000	0.5850	0.6200	0.6000	8.00	6	2	13.00	24	1	1975
61.00	0.4650	0.4750	0.4900	0.4750	3.50	6	2	18.00	27	1	1975
61.50	0.5100	0.5300	0.5400	0.5300	2.50	6	2	18.30	27	1	1975
62.00	0.5300	0.5400	0.5500	0.5400	2.00	6	2	19.00	27	1	1975
62.50	0.5500	0.5550	0.5750	0.5600	0.80	6	2	19.30	27	1	1975
62.50	0.5650	0.5800	0.5900	0.5750	1.00	6	2	20.00	27	1	1975
71.00	0.6750	0.6800	0.7100	0.7050	1.00	6	2	21.30	27	1	1975
73.50	0.6900	0.6900	0.7100	0.7000	2.00	6	2	22.00	27	1	1975
59.80	0.5400	0.5300	0.5500	0.5600	12.00	6	2	14.30	18	12	1974
61.30	0.5500	0.5400	0.5600	0.5700	10.00	6	2	15.00	18	12	1974
62.80	0.5800	0.5800	0.5800	0.5800	2.00	6	2	18.00	6	2	1975
63.80	0.5750	0.5750	0.5750	0.5750	4.50	6	2	18.30	6	2	1975
64.00	0.5750	0.5750	0.5750	0.5750	3.50	6	2	19.00	6	2	1975
64.50	0.5500	0.5500	0.5500	0.5500	4.00	6	2	19.30	6	2	1975
64.00	0.5500	0.5500	0.5500	0.5500	4.00	6	2	20.00	6	2	1975
64.00	0.5450	0.5450	0.5450	0.5450	3.50	6	2	20.30	6	2	1975
64.50	0.5350	0.5350	0.5350	0.5350	7.50	6	2	21.00	6	2	1975
86.00	0.6800	0.6600	0.6800	0.6700	10.00	6	2	21.00	7	2	1975
85.70	0.6800	0.6600	0.6700	0.6700	8.00	6	2	21.30	7	2	1975
85.70	0.6700	0.6900	0.6900	0.6700	6.00	6	2	22.00	7	2	1975
78.00	0.6650	0.6400	0.6600	0.6600	7.00	6	2	22.30	7	2	1975
81.00	0.6500	0.6300	0.6500	0.6400	9.00	6	2	23.00	7	2	1975
82.50	0.6300	0.6200	0.6400	0.6400	7.50	6	2	23.30	7	2	1975
78.00	0.6300	0.6000	0.6300	0.6200	10.00	6	2	0.00	8	2	1975
78.20	0.5900	0.5900	0.6000	0.6000	11.50	6	2	0.30	8	2	1975
76.00	0.5800	0.5700	0.5900	0.5900	13.00	6	2	1.00	8	2	1975
71.00	0.5600	0.5500	0.5700	0.5600	11.50	6	2	1.30	8	2	1975
65.50	0.5400	0.5300	0.5500	0.5400	13.00	6	2	2.00	8	2	1975
70.00	0.5300	0.5300	0.5400	0.5300	14.00	6	2	2.30	8	2	1975
69.00	0.5200	0.5200	0.5200	0.5200	14.50	6	2	3.00	8	2	1975
76.00	0.5300	0.5200	0.5300	0.5300	15.00	6	2	3.30	8	2	1975
69.00	0.5300	0.5100	0.5250	0.5200	15.00	6	2	4.00	8	2	1975
68.00	0.5200	0.5300	0.5300	0.5200	13.00	6	2	4.30	8	2	1975
69.00	0.5250	0.5200	0.5250	0.5200	12.00	6	2	5.00	8	2	1975

FACULTY OF ENGINEERING SCIENCE

CLOUDY
SOUTH-WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



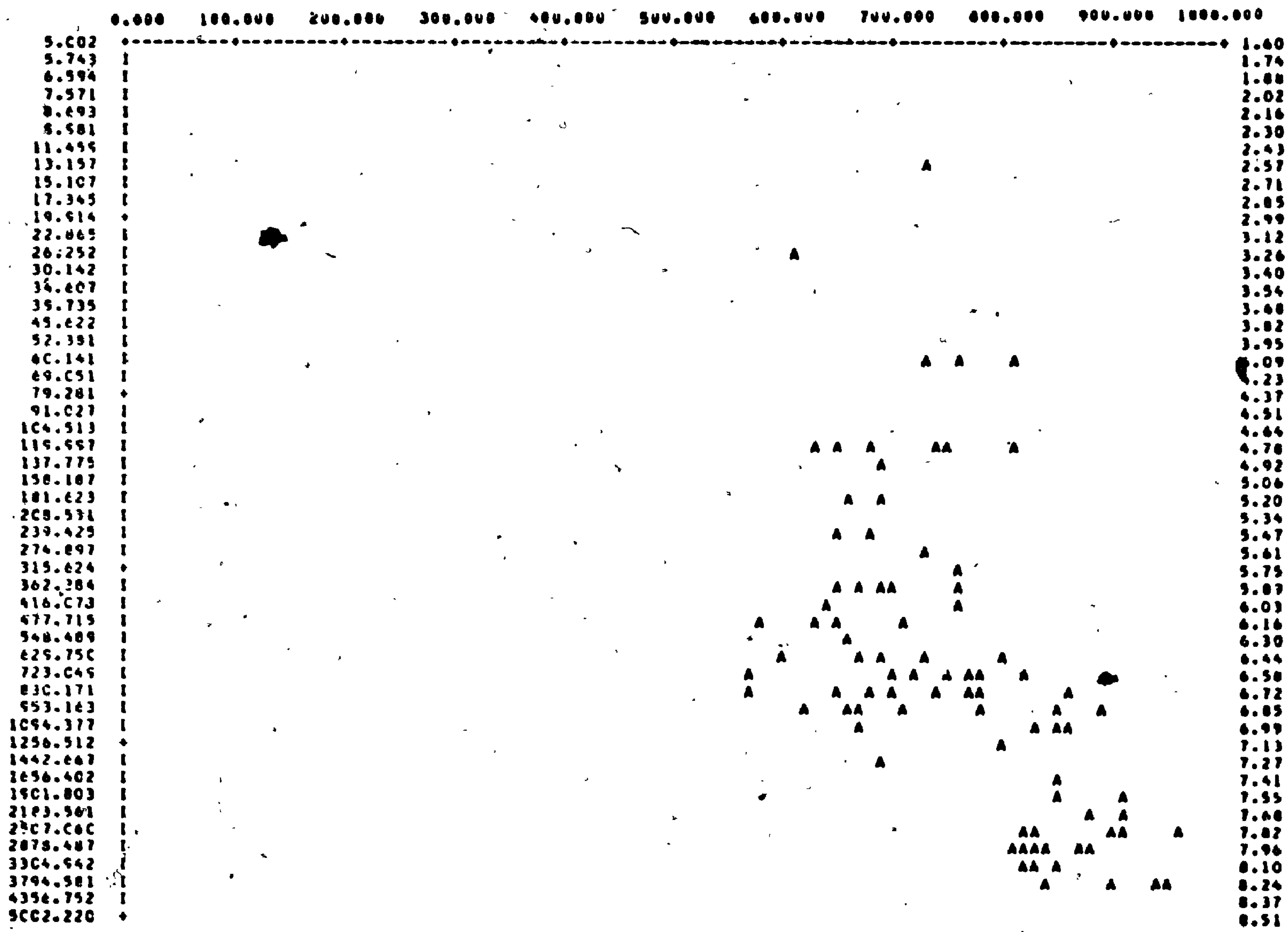
FACULTY OF ENGINEERING SCIENCE

C	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
81.00	0.7800	0.7700	0.7900	0.8000	8.00	6	3	8.30	20	12	1974
83.00	0.8000	0.7900	0.8100	0.8200	9.00	6	3	3.00	20	12	1974
83.00	0.8100	0.8000	0.8200	0.8300	9.00	6	3	3.30	20	12	1974
83.00	0.8200	0.8100	0.8300	0.8400	8.00	6	3	4.00	20	12	1974
83.50	0.8300	0.8200	0.8400	0.8500	8.00	6	3	4.30	20	12	1974
64.00	0.7050	0.7000	0.7100	0.7200	6.00	6	3	5.00	20	12	1974
61.00	0.6500	0.6400	0.6600	0.6700	4.00	6	3	5.30	20	12	1974
61.00	0.6600	0.6500	0.6700	0.6800	7.00	6	3	13.30	20	12	1974
67.00	0.6700	0.6600	0.6800	0.6000	6.50	6	3	14.00	20	12	1974
59.50	0.6100	0.6000	0.6200	0.6300	5.00	6	3	14.30	20	12	1974
58.00	0.5650	0.5600	0.5700	0.5800	4.00	6	3	15.00	20	12	1974
75.00	0.7400	0.7300	0.7500	0.7600	3.00	6	3	15.30	20	12	1974
90.00	0.8700	0.8300	0.8550	0.8650	12.00	6	3	7.00	26	12	1974
85.00	0.7900	0.7550	0.8050	0.7900	6.00	6	3	7.30	26	12	1974
90.00	0.8750	0.8450	0.8850	0.8800	3.00	6	3	8.00	26	12	1974
85.50	0.8850	0.8500	0.9050	0.8850	5.00	6	3	8.30	26	12	1974
86.00	0.8000	0.7700	0.8100	0.8050	7.50	6	3	9.00	26	12	1974
61.30	0.5250	0.5250	0.5400	0.5350	4.00	6	3	20.30	29	12	1974
62.00	0.5300	0.5350	0.5500	0.5450	4.00	6	3	21.00	29	12	1974
61.00	0.5200	0.5250	0.5350	0.5250	6.00	6	3	21.30	29	12	1974
61.00	0.5050	0.5050	0.5200	0.5100	7.00	6	3	22.00	29	12	1974
61.00	0.4850	0.4850	0.5000	0.4900	6.50	6	3	22.30	29	12	1974
62.00	0.4900	0.4900	0.5000	0.4900	8.00	6	3	23.00	29	12	1974
62.00	0.4900	0.4900	0.5000	0.4900	6.50	6	3	23.30	29	12	1974
62.00	0.4950	0.4900	0.4950	0.4950	6.00	6	3	0.00	30	12	1974
62.50	0.4950	0.4900	0.5000	0.4950	6.00	6	3	0.30	30	12	1974
70.00	0.7300	0.7300	0.7300	0.7300	0.20	6	3	8.00	2	1	1975
60.00	0.4950	0.4950	0.4950	0.4950	1.00	6	3	18.30	2	1	1975
60.50	0.4300	0.4450	0.4450	0.4500	25.00	6	3	13.40	11	1	1975
60.50	0.4350	0.4500	0.4450	0.4550	21.00	6	3	13.50	11	1	1975
60.80	0.4350	0.4550	0.4550	0.4550	26.00	6	3	14.00	11	1	1975
60.50	0.4350	0.4550	0.4550	0.4550	27.00	6	3	14.10	11	1	1975
61.00	0.4450	0.4500	0.4550	0.4550	24.00	6	3	14.20	11	1	1975
61.20	0.4400	0.4600	0.4550	0.4600	26.00	6	3	14.30	11	1	1975
61.00	0.4550	0.4600	0.4650	0.4600	24.00	6	3	14.40	11	1	1975
61.00	0.4550	0.4550	0.4650	0.4600	21.00	6	3	14.50	11	1	1975
61.10	0.4550	0.4600	0.4650	0.4600	20.00	6	3	15.00	11	1	1975
60.90	0.4400	0.4550	0.4700	0.4600	22.00	6	3	15.10	11	1	1975
60.90	0.4450	0.4550	0.4600	0.4550	24.00	6	3	15.20	11	1	1975
61.00	0.4400	0.4550	0.4550	0.4550	23.00	6	3	15.30	11	1	1975
61.00	0.4600	0.4600	0.4550	0.4600	24.00	6	3	15.40	11	1	1975
60.50	0.4400	0.4550	0.4550	0.4550	23.00	6	3	15.50	11	1	1975
60.50	0.4400	0.4500	0.4550	0.4500	22.00	6	3	16.00	11	1	1975
60.50	0.4400	0.4500	0.4500	0.4450	25.00	6	3	16.10	11	1	1975
60.50	0.4300	0.4400	0.4400	0.4400	27.00	6	3	16.20	11	1	1975
60.00	0.4250	0.4400	0.4400	0.4450	31.00	6	3	16.30	11	1	1975
60.00	0.4300	0.4500	0.4550	0.4500	25.00	6	3	16.40	11	1	1975
60.00	0.4200	0.4400	0.4450	0.4400	23.00	6	3	16.50	11	1	1975
59.80	0.4150	0.4250	0.4200	0.4200	24.00	6	3	17.00	11	1	1975
59.00	0.3900	0.4100	0.4150	0.4150	25.00	6	3	17.10	11	1	1975
59.80	0.3900	0.4150	0.4100	0.4100	21.00	6	3	17.20	11	1	1975
59.40	0.3850	0.4050	0.4050	0.4000	20.00	6	3	17.30	11	1	1975
59.00	0.3850	0.4000	0.4000	0.4000	18.00	6	3	17.40	11	1	1975
59.00	0.3800	0.4000	0.4000	0.4000	16.00	6	3	17.50	11	1	1975
59.00	0.4000	0.4150	0.4150	0.4100	18.00	6	3	18.00	11	1	1975
60.20	0.4250	0.4400	0.4400	0.4350	16.00	6	3	18.30	11	1	1975
60.50	0.3950	0.4150	0.4100	0.4150	31.00	6	3	19.00	11	1	1975
62.50	0.3950	0.4100	0.4100	0.4100	30.00	6	3	19.30	11	1	1975

63.00	0.3900	0.4100	0.4100	0.4150	34.00	6	3	20.00	11	1	1975
62.80	0.3900	0.4050	0.4050	0.4100	22.00	6	3	20.30	11	1	1975
85.00	0.6700	0.6800	0.7200	0.7100	9.50	6	3	17.30	17	1	1975
79.00	0.5800	0.5700	0.6000	0.6200	8.50	6	3	1.00	24	1	1975
84.00	0.6350	0.6100	0.6550	0.6400	8.00	6	3	1.30	24	1	1975
83.50	0.6700	0.6600	0.6900	0.6850	5.00	6	3	2.00	24	1	1975
83.50	0.7050	0.6900	0.7250	0.7200	2.50	6	3	2.30	24	1	1975
82.00	0.6900	0.6800	0.7200	0.7100	2.50	6	3	3.00	24	1	1975
82.50	0.6900	0.6800	0.7200	0.7100	3.00	6	3	3.30	24	1	1975
83.00	0.7000	0.6900	0.7200	0.7100	3.50	6	3	4.00	24	1	1975
66.00	0.6450	0.6450	0.6700	0.6400	3.50	6	3	4.30	24	1	1975
75.00	0.6900	0.6800	0.7000	0.6900	3.00	6	3	5.00	24	1	1975
65.00	0.6500	0.6400	0.6600	0.6500	4.00	6	3	5.30	24	1	1975
72.00	0.6700	0.6600	0.7000	0.7000	3.00	6	3	6.00	24	1	1975
64.00	0.6100	0.6000	0.6350	0.6100	4.00	6	3	6.30	24	1	1975
73.00	0.7000	0.6900	0.7250	0.7200	4.50	6	3	7.00	24	1	1975
63.00	0.5700	0.5600	0.5900	0.5700	7.00	6	3	7.30	24	1	1975
61.50	0.5400	0.5300	0.5600	0.5400	6.00	6	3	8.00	24	1	1975
60.50	0.5350	0.5350	0.5600	0.5400	5.00	6	3	8.30	24	1	1975
60.50	0.5100	0.5000	0.5250	0.5100	5.00	6	3	9.00	24	1	1975
61.30	0.5200	0.5200	0.5300	0.5150	5.00	6	3	9.30	24	1	1975
60.50	0.5300	0.5400	0.5400	0.5300	7.00	6	3	10.00	24	1	1975
58.00	0.5700	0.5800	0.5900	0.5650	8.00	6	3	10.30	24	1	1975
62.00	0.6050	0.5950	0.6000	0.5650	7.00	6	3	11.00	24	1	1975
61.00	0.6000	0.5900	0.6300	0.6100	8.00	6	3	11.30	24	1	1975
79.50	0.7200	0.7200	0.7450	0.7300	3.00	6	3	0.30	28	1	1975
81.00	0.7400	0.7500	0.7750	0.7600	1.50	6	3	1.00	28	1	1975
76.00	0.7450	0.7450	0.7700	0.7500	1.00	6	3	1.30	28	1	1975
74.00	0.7450	0.7550	0.7750	0.7550	1.00	6	3	2.00	28	1	1975
75.00	0.7350	0.7400	0.7600	0.7500	2.00	6	3	2.30	28	1	1975
75.50	0.7200	0.7300	0.7500	0.7300	1.50	6	3	3.00	28	1	1975
78.00	0.7200	0.7300	0.7550	0.7450	1.00	6	3	3.30	28	1	1975
[illegible]8.00	0.7300	0.7400	0.7600	0.7450	2.00	6	3	4.00	28	1	1975
83.50	0.7300	0.7400	0.7650	0.7450	0.10	6	3	4.30	28	1	1975
65.00	0.4900	0.4900	0.5100	0.4950	0.50	6	3	20.00	2	2	1975
65.00	0.4900	0.4900	0.5100	0.4900	1.00	6	3	20.30	2	2	1975
85.00	0.8000	0.7700	0.7800	0.7700	6.00	6	3	8.00	7	2	1975
88.00	0.6250	0.6400	0.6500	0.6500	8.00	6	3	18.00	7	2	1975
84.00	0.6700	0.6500	0.6700	0.6600	6.00	6	3	18.30	7	2	1975
88.00	0.6700	0.6600	0.6700	0.6600	6.50	6	3	19.00	7	2	1975
86.20	0.6500	0.6400	0.6600	0.6600	8.50	6	3	19.30	7	2	1975
87.50	0.6900	0.6700	0.6900	0.6900	9.00	6	3	20.00	7	2	1975
89.00	0.6900	0.6700	0.6500	0.6900	12.50	6	3	20.30	7	2	1975
55.00	0.5700	0.5400	0.5900	0.9700	1.00	6	3	5.00	10	2	1975
55.80	0.5300	0.5000	0.5400	0.9200	2.00	6	3	5.30	10	2	1975
55.20	0.9000	0.8600	0.9100	0.8900	1.00	6	3	6.00	10	2	1975
58.50	0.8800	0.8600	0.8900	0.8700	0.50	6	3	6.30	10	2	1975
58.00	0.9100	0.8900	0.9100	0.9000	0.50	6	3	7.00	10	2	1975
97.00	0.8900	0.8700	0.9000	0.8800	1.00	6	3	7.30	10	2	1975

FACULTY OF ENGINEERING SCIENCE

PARTLY CLOUDY
SOUTH-WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3

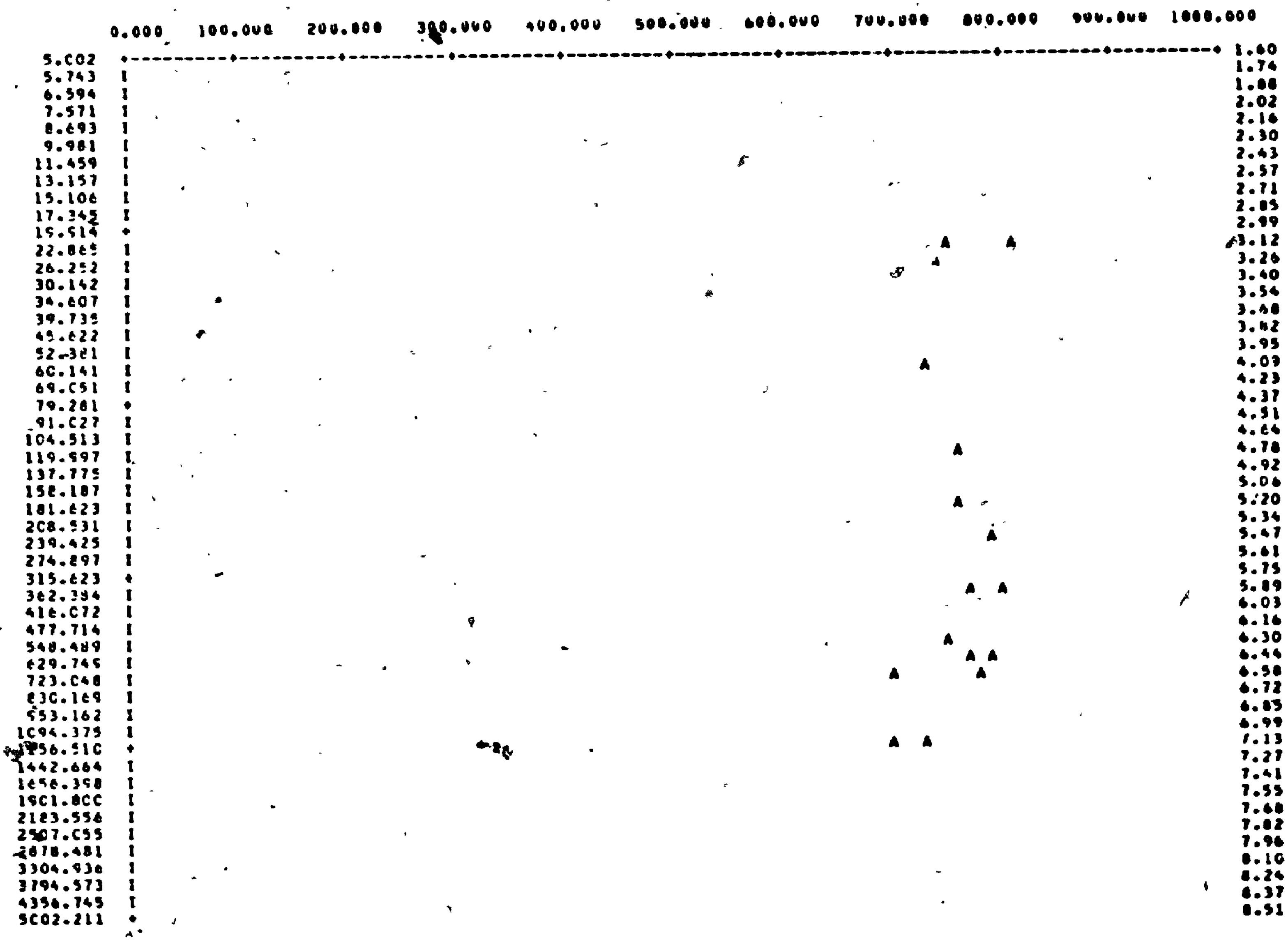


FACULTY OF ENGINEERING SCIENCE

Q	CTN	CTW	OTS	CTE	VEL	D	W	TIME	D	M	YEAR
61.50	0.4650	0.4650	0.4650	0.4650	0.20	6	4	18.00	30	12	1974
68.00	0.5700	0.5700	0.5700	0.5700	0.20	6	4	18.30	30	12	1974
104.00	1.0200	1.0100	1.0200	1.0200	9.00	6	4	20.30	9	2	1975
104.00	1.0200	1.0300	1.0300	1.0200	5.50	6	4	21.00	9	2	1975
103.50	0.9900	0.9400	0.9700	0.9600	9.50	6	4	21.30	9	2	1975
102.00	0.9100	0.8700	0.9100	0.9000	5.00	6	4	22.00	9	2	1975
100.00	0.9300	0.8900	0.9100	0.9000	4.00	6	4	22.30	9	2	1975
109.00	0.8900	0.8600	0.8700	0.8600	6.00	6	4	23.00	9	2	1975
99.00	0.8600	0.8300	0.8500	0.8400	5.00	6	4	0.00	10	2	1975
99.50	0.8900	0.8200	0.8500	0.8300	3.00	6	4	0.30	10	2	1975
99.00	0.8800	0.8500	0.8700	0.8600	3.00	6	4	1.00	10	2	1975
100.00	0.8700	0.8400	0.8700	0.8500	2.00	6	4	1.30	10	2	1975
99.50	0.8900	0.8600	0.8900	0.8800	1.50	6	4	2.00	10	2	1975
99.00	0.8800	0.8600	0.8800	0.8700	1.00	6	4	2.30	10	2	1975
98.80	0.9200	0.9000	0.9300	0.9100	0.50	6	4	3.00	10	2	1975
99.00	0.9000	0.8800	0.9300	0.9200	0.20	6	4	3.30	10	2	1975

CLEAR
SOUTH-WEST

NUSSELT ALPEER VERSUS REYNOLDS NUMBER X 10**-3



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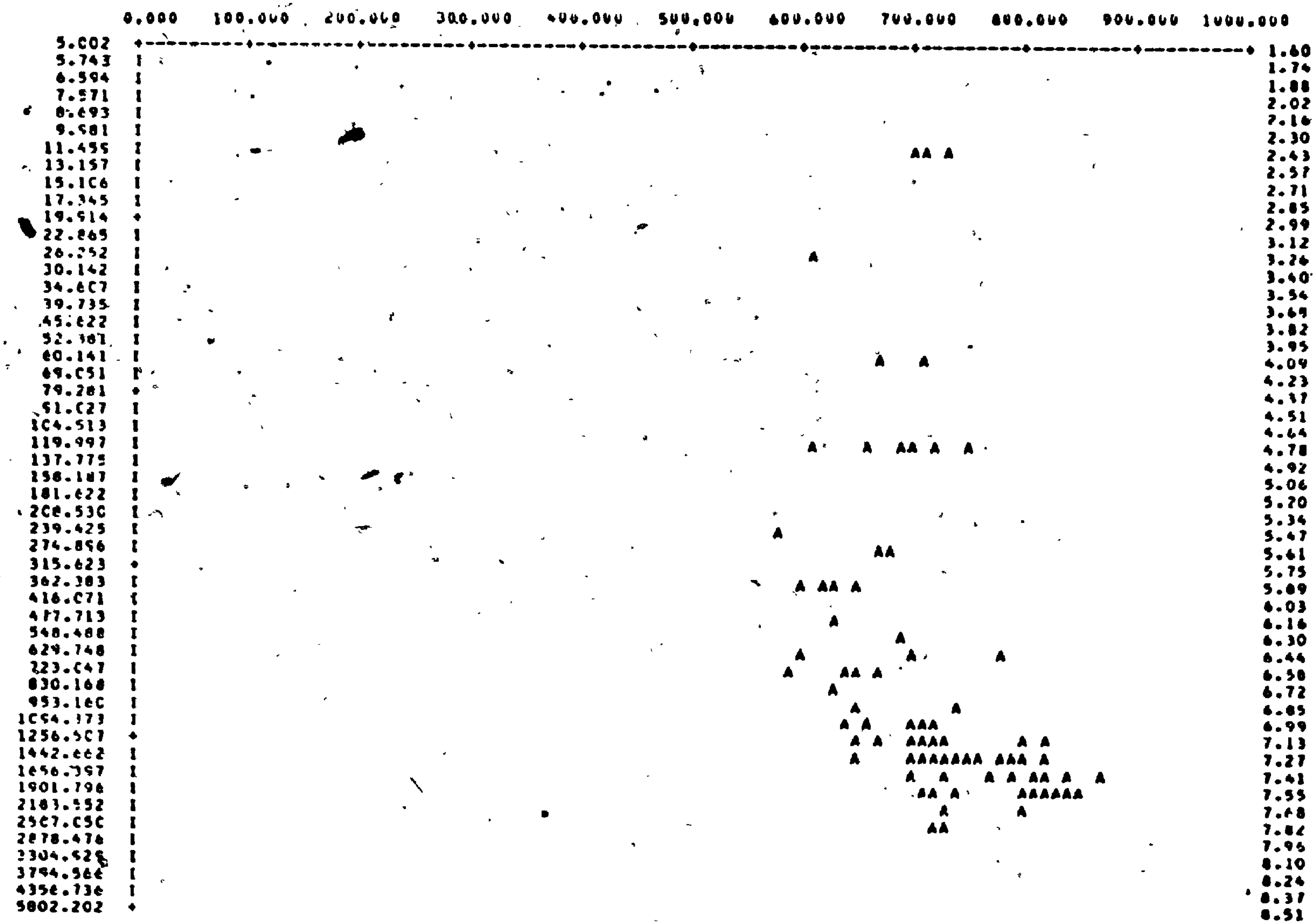
C	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
79.50	0.7400	0.7300	0.7400	0.7300	13.00	6	5	7.00	10	12	1974
80.00	0.7400	0.7300	0.7400	0.7300	14.00	6	5	7.30	10	12	1974
71.40	0.7100	0.7000	0.7100	0.7000	9.00	6	5	8.30	10	12	1974
75.30	0.6970	0.6870	0.6950	0.6870	11.00	6	5	9.00	10	12	1974
68.80	0.6780	0.6680	0.6770	0.6680	12.00	6	5	9.30	10	12	1974
70.50	0.6800	0.6700	0.6900	0.7000	10.00	6	5	10.30	10	12	1974
66.50	0.6250	0.6200	0.6300	0.6400	9.00	6	5	11.00	10	12	1974
71.50	0.6300	0.6200	0.6400	0.6500	10.00	6	5	11.30	10	12	1974
67.00	0.6200	0.6100	0.6300	0.6400	10.00	6	5	12.00	10	12	1974
60.50	0.5500	0.5400	0.5600	0.5700	0.50	6	5	5.00	12	12	1974
81.00	0.7400	0.7300	0.7500	0.7600	1.00	6	5	8.00	12	12	1974
79.50	0.7100	0.7000	0.7200	0.7300	1.00	6	5	8.30	12	12	1974
65.30	0.7000	0.6900	0.7100	0.7200	2.00	6	5	9.00	12	12	1974
60.00	0.5950	0.5900	0.6100	0.6200	3.00	6	5	9.30	12	12	1974
59.30	0.5800	0.5700	0.5900	0.6000	4.00	6	5	11.00	12	12	1974
59.30	0.5750	0.5700	0.5900	0.6000	3.60	6	5	11.30	12	12	1974
77.00	0.7300	0.7200	0.7400	0.7500	6.00	6	5	7.00	17	12	1974
68.00	0.7200	0.7100	0.7300	0.7400	6.00	6	5	7.30	17	12	1974
59.00	0.6000	0.5900	0.6100	0.6200	5.00	6	5	8.00	17	12	1974
58.70	0.5750	0.5700	0.5800	0.5900	7.00	6	5	8.30	17	12	1974
55.00	0.5650	0.5600	0.5700	0.5800	6.00	6	5	9.00	17	12	1974
55.00	0.5550	0.5500	0.5600	0.5700	6.00	6	5	9.30	17	12	1974
58.80	0.5500	0.5400	0.5600	0.5700	8.00	6	5	10.00	17	12	1974
62.00	0.5450	0.5400	0.5500	0.5600	9.00	6	5	10.30	17	12	1974
59.30	0.5000	0.4900	0.5100	0.5200	10.00	6	5	11.00	17	12	1974
60.00	0.5250	0.5200	0.5300	0.5400	10.00	6	5	11.30	17	12	1974
61.00	0.5150	0.5100	0.5200	0.5300	10.00	6	5	12.00	17	12	1974
60.60	0.5200	0.5100	0.5300	0.5400	10.00	6	5	12.30	17	12	1974
59.00	0.5050	0.5000	0.5100	0.5200	12.00	6	5	13.00	17	12	1974
55.00	0.5000	0.4900	0.5100	0.5200	12.00	6	5	13.30	17	12	1974
59.00	0.5000	0.4900	0.5100	0.5200	16.00	6	5	14.00	17	12	1974
60.20	0.5100	0.5000	0.5200	0.5300	20.00	6	5	14.30	17	12	1974
55.00	0.5100	0.5000	0.5200	0.5300	5.00	6	5	13.30	19	12	1974
61.50	0.4900	0.4800	0.5000	0.5100	13.00	6	5	14.00	19	12	1974
61.00	0.5050	0.5000	0.5100	0.5200	8.00	6	5	14.30	19	12	1974
61.30	0.5100	0.5000	0.5200	0.5300	12.00	6	5	15.00	19	12	1974
60.00	0.5150	0.5100	0.5200	0.5300	15.00	6	5	15.30	19	12	1974
59.00	0.4950	0.4900	0.5000	0.5100	13.00	6	5	16.00	19	12	1974
58.30	0.4850	0.4800	0.4900	0.5000	13.00	6	5	16.30	19	12	1974
58.00	0.4800	0.4700	0.4900	0.5000	20.00	6	5	17.00	19	12	1974
58.00	0.4800	0.4700	0.4900	0.5000	19.00	6	5	17.30	19	12	1974
58.00	0.4750	0.4700	0.4800	0.4900	15.00	6	5	18.00	19	12	1974
61.80	0.6150	0.6350	0.6400	0.6400	0.20	6	5	3.00	24	12	1974
61.00	0.5850	0.6000	0.6050	0.5450	3.00	6	5	4.00	24	12	1974
60.40	0.6000	0.6100	0.6200	0.6100	1.00	6	5	4.30	24	12	1974
60.00	0.6000	0.6300	0.6300	0.6200	3.00	6	5	5.00	24	12	1974
64.00	0.5850	0.6000	0.6150	0.6000	1.00	6	5	5.30	24	12	1974
91.50	0.5200	0.8850	0.9400	0.9000	2.00	6	5	4.00	26	12	1974
91.50	0.9000	0.8700	0.9300	0.9000	2.00	6	5	4.30	26	12	1974
91.50	0.8800	0.8350	0.8850	0.8600	0.50	6	5	5.30	26	12	1974
91.50	0.9300	0.9000	0.8600	0.8300	1.00	6	5	6.00	26	12	1974
90.00	0.8700	0.8300	0.8950	0.8550	4.50	6	5	6.30	26	12	1974
60.30	0.4900	0.4900	0.4900	0.4900	12.50	6	5	10.30	1	1	1975
60.00	0.5200	0.5200	0.5200	0.5200	9.00	6	5	9.00	3	1	1975
59.00	0.5000	0.5000	0.5000	0.5000	9.00	6	5	9.30	3	1	1975
55.00	0.4900	0.4900	0.4900	0.4900	12.00	6	5	10.00	3	1	1975
58.70	0.4800	0.4800	0.4800	0.4800	12.00	6	5	10.30	3	1	1975
59.00	0.4850	0.4850	0.4850	0.4850	12.00	6	5	11.00	3	1	1975

60.00	0.5000	0.5000	0.5000	0.5000	12.00	6	5	11.30	3	1	1975
59.00	0.5100	0.5100	0.5100	0.5100	16.00	6	5	12.00	3	1	1975
59.00	0.4400	0.4300	0.4400	0.4500	10.50	6	5	11.00	18	1	1975
59.00	0.4500	0.4400	0.4600	0.4550	10.00	6	5	11.30	18	1	1975
59.40	0.4500	0.4450	0.4550	0.4550	14.50	6	5	12.00	18	1	1975
59.70	0.4600	0.4600	0.4700	0.4700	13.00	6	5	12.30	18	1	1975
59.40	0.4600	0.4600	0.4700	0.4700	12.00	6	5	13.00	18	1	1975
72.00	0.5300	0.5300	0.5400	0.5500	14.00	6	5	13.30	18	1	1975
72.00	0.5600	0.5600	0.5700	0.5800	15.00	6	5	14.00	18	1	1975
74.00	0.5800	0.5800	0.5700	0.5900	15.00	6	5	14.30	18	1	1975
72.50	0.5750	0.5700	0.5800	0.5900	12.00	6	5	15.00	18	1	1975
73.00	0.5800	0.5650	0.5800	0.5900	15.00	6	5	15.30	18	1	1975
75.50	0.5900	0.5700	0.5800	0.6050	14.00	6	5	16.00	18	1	1975
75.50	0.5900	0.5700	0.5800	0.6000	12.00	6	5	16.30	18	1	1975
76.00	0.5800	0.5900	0.5800	0.6150	11.00	6	5	17.00	18	1	1975
76.00	0.5800	0.5850	0.5900	0.6150	11.00	6	5	17.30	18	1	1975
76.00	0.5800	0.5800	0.5900	0.6100	11.00	6	5	18.00	18	1	1975
73.00	0.5550	0.5550	0.5600	0.5800	13.00	6	5	18.30	18	1	1975
78.50	0.5800	0.5850	0.5850	0.6100	16.00	6	5	19.00	18	1	1975
76.50	0.6000	0.5800	0.5500	0.6000	15.00	6	5	19.30	18	1	1975
61.00	0.4700	0.4750	0.5000	0.4800	5.00	6	5	14.30	25	1	1975
76.50	0.6100	0.6050	0.6050	0.6050	10.00	6	5	18.30	25	1	1975
74.80	0.5950	0.5900	0.6000	0.6000	10.00	6	5	19.00	25	1	1975
74.00	0.5900	0.5800	0.5950	0.5850	11.50	6	5	19.30	25	1	1975
75.50	0.5900	0.5800	0.5900	0.5900	12.00	6	5	20.00	25	1	1975
77.50	0.5950	0.5750	0.5950	0.5950	16.00	6	5	20.30	25	1	1975
77.00	0.6000	0.5800	0.6000	0.6050	15.00	6	5	21.00	25	1	1975
79.00	0.6100	0.6000	0.6100	0.6200	15.00	6	5	21.30	25	1	1975
82.80	0.6050	0.5950	0.6200	0.6200	14.00	6	5	22.00	25	1	1975
77.50	0.6300	0.6150	0.6400	0.6300	11.00	6	5	22.30	25	1	1975
78.00	0.6200	0.6100	0.6300	0.6300	[illegible]	6	5	23.00	25	1	1975
64.00	0.5650	0.5650	0.5650	0.5650	0.10	6	5	8.00	6	2	1975
64.80	0.5700	0.5700	0.5700	0.5700	0.10	6	5	8.30	6	2	1975
63.20	0.5400	0.5400	0.5400	0.5400	0.10	6	5	9.00	6	2	1975
63.00	0.5200	0.5200	0.5200	0.5200	1.00	6	5	9.30	6	2	1975

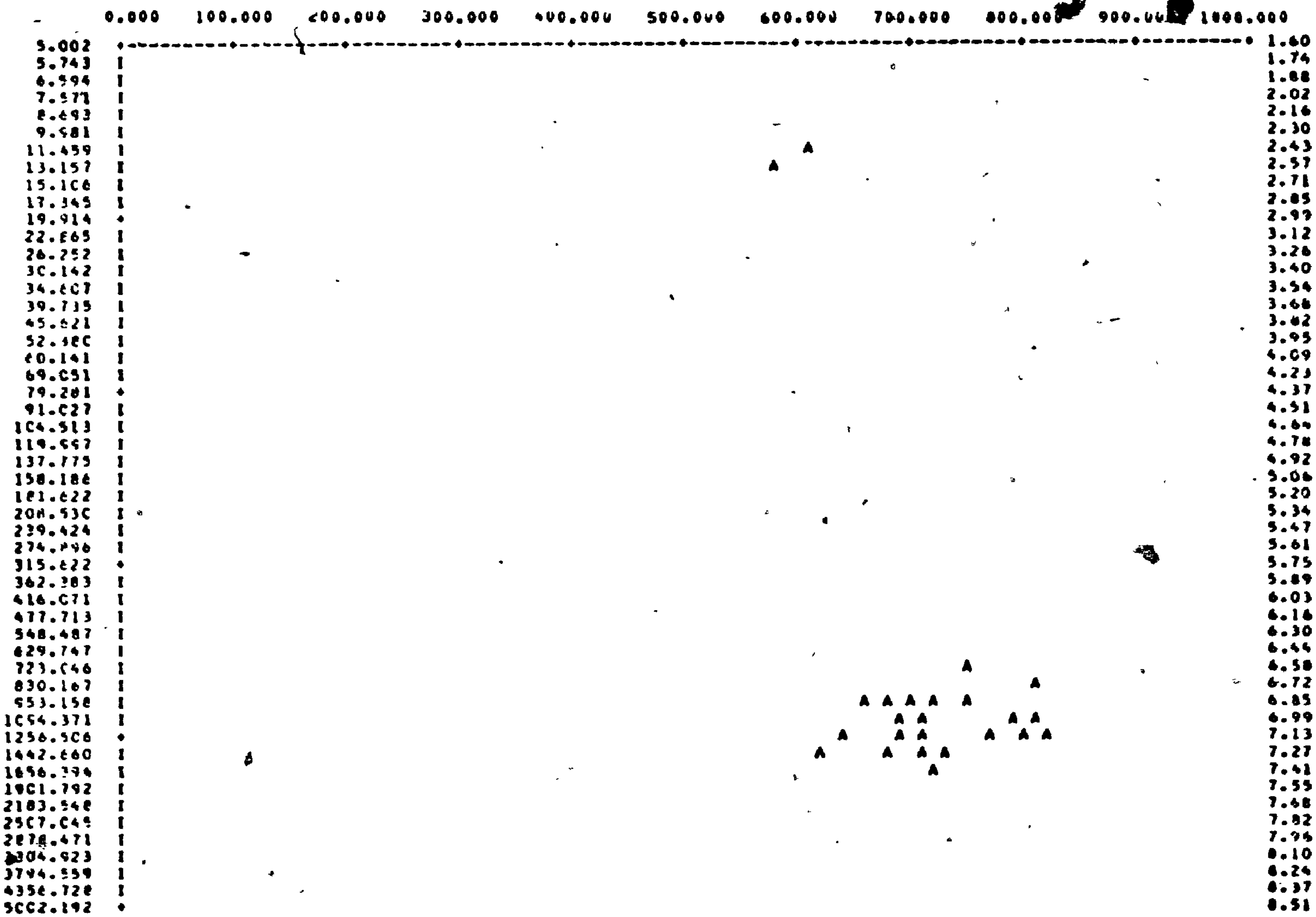
FACULTY OF ENGINEERING SCIENCE

PRECIPITATION
SOUTH-WEST
ALSSECT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



C	CTN	CTW	DTS	CTE	VEL	D	W	TIME	D	M	YEAR
57.50	0.5900	0.6050	0.6150	0.6250	0.10	7	1	9.30	24	12	1974
58.00	0.5700	0.5950	0.6050	0.5900	0.10	7	1	10.00	24	12	1974
85.00	0.7300	0.7200	0.7200	0.7100	7.00	7	1	8.30	7	2	1975
86.00	0.7600	0.7600	0.7400	0.7200	7.50	7	1	9.00	7	2	1975
76.00	0.6500	0.6900	0.6400	0.6000	6.00	7	1	9.30	7	2	1975
72.50	0.6900	0.7000	0.6500	0.6000	7.50	7	1	10.00	7	2	1975
67.00	0.5800	0.6500	0.5800	0.5500	9.50	7	1	10.30	7	2	1975
65.50	0.6000	0.6500	0.5750	0.5300	8.50	7	1	11.00	7	2	1975
64.00	0.6100	0.6600	0.5900	0.5500	7.50	7	1	11.30	7	2	1975
63.20	0.6000	0.6700	0.6400	0.5700	10.50	7	1	12.00	7	2	1975
63.00	0.6100	0.6100	0.6500	0.5900	10.00	7	1	12.30	7	2	1975
63.20	0.6500	0.6500	0.6500	0.6000	12.00	7	1	13.00	7	2	1975
62.60	0.5300	0.5700	0.5500	0.5000	8.00	7	1	13.30	7	2	1975
101.50	0.8500	0.8200	0.8400	0.8100	10.50	7	1	9.00	9	2	1975
73.00	0.6100	0.4900	0.5800	0.5300	10.00	7	1	12.00	9	2	1975
69.00	0.6500	0.6800	0.5800	0.5100	13.00	7	1	12.30	9	2	1975
61.00	0.5700	0.6000	0.5300	0.4800	10.00	7	1	13.00	9	2	1975
62.50	0.5600	0.5800	0.5400	0.4900	12.00	7	1	13.30	9	2	1975
76.00	0.7200	0.7400	0.7200	0.6700	12.00	7	1	14.00	9	2	1975
79.00	0.7000	0.7200	0.7000	0.6700	12.00	7	1	14.30	9	2	1975
75.00	0.6400	0.7100	0.7000	0.6500	9.50	7	1	15.00	9	2	1975
80.00	0.7000	0.7700	0.7600	0.6800	10.00	7	1	15.30	9	2	1975
75.00	0.6500	0.7400	0.7600	0.6600	8.00	7	1	16.00	9	2	1975
98.00	0.8000	0.8200	0.8500	0.8000	10.00	7	1	16.30	9	2	1975
101.00	0.8300	0.8300	0.8700	0.8400	9.00	7	1	17.00	9	2	1975
102.00	0.8900	0.8600	0.9000	0.8700	8.00	7	1	17.30	9	2	1975

SUNNY
WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



Q	CTA	DTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
79.50	0.6800	0.6700	0.6800	0.6700	9.00	7	2	0.00	10	12	1974
77.00	0.7100	0.7000	0.7100	0.7000	7.00	7	2	0.30	10	12	1974
59.50	0.5800	0.5700	0.5900	0.6000	2.00	7	2	12.30	12	12	1974
55.00	0.5800	0.5700	0.5900	0.6000	3.00	7	2	13.00	12	12	1974
59.00	0.5900	0.5800	0.6000	0.6100	2.00	7	2	13.30	12	12	1974
58.00	0.5800	0.5700	0.5900	0.6000	3.00	7	2	14.00	12	12	1974
58.70	0.6000	0.5900	0.6100	0.6200	1.00	7	2	15.00	12	12	1974
59.50	0.6180	0.6100	0.6300	0.6400	2.00	7	2	15.30	12	12	1974
59.00	0.6050	0.6000	0.6200	0.6300	2.00	7	2	16.00	12	12	1974
58.50	0.6000	0.5900	0.6100	0.6200	2.00	7	2	16.30	12	12	1974
60.00	0.6700	0.6600	0.6800	0.6900	0.10	7	2	1.00	13	12	1974
60.50	0.6830	0.6800	0.6900	0.7000	0.10	7	2	1.30	13	12	1974
59.30	0.5130	0.5100	0.5200	0.5300	8.00	7	2	18.30	17	12	1974
60.00	0.5200	0.5100	0.5300	0.5400	5.00	7	2	19.00	17	12	1974
59.50	0.5300	0.5200	0.5400	0.5500	5.00	7	2	19.30	17	12	1974
59.00	0.5300	0.5200	0.5400	0.5500	5.00	7	2	20.00	17	12	1974
59.00	0.5200	0.5100	0.5300	0.5400	7.00	7	2	20.30	17	12	1974
61.00	0.5250	0.5200	0.5300	0.5400	11.00	7	2	21.00	17	12	1974
62.00	0.5300	0.5200	0.5400	0.5500	10.00	7	2	21.30	17	12	1974
65.00	0.5950	0.5900	0.6000	0.6100	10.00	7	2	22.00	17	12	1974
78.00	0.6750	0.6700	0.6800	0.6900	10.00	7	2	22.30	17	12	1974
72.00	0.6600	0.6500	0.6700	0.6800	9.00	7	2	23.00	17	12	1974
82.00	0.7100	0.7000	0.7200	0.7300	10.00	7	2	23.30	17	12	1974
75.00	0.6900	0.6800	0.7000	0.7100	8.00	7	2	0.00	18	12	1974
85.00	0.7300	0.7200	0.7400	0.7500	11.00	7	2	0.30	18	12	1974
83.00	0.7200	0.7100	0.7300	0.7400	10.00	7	2	1.00	18	12	1974
86.00	0.7600	0.7500	0.7700	0.7800	8.00	7	2	1.30	18	12	1974
85.50	0.7700	0.7600	0.7800	0.7900	7.00	7	2	2.00	18	12	1974
82.00	0.7300	0.7200	0.7400	0.7500	10.00	7	2	2.30	18	12	1974
83.50	0.7400	0.7300	0.7500	0.7600	11.00	7	2	3.00	18	12	1974
83.00	0.7300	0.7200	0.7400	0.7500	10.00	7	2	3.30	18	12	1974
70.50	0.6750	0.6700	0.6800	0.6900	11.00	7	2	4.00	18	12	1974
73.00	0.6850	0.6800	0.6900	0.7000	11.00	7	2	4.30	18	12	1974
80.00	0.7100	0.7000	0.7200	0.7300	12.00	7	2	5.00	18	12	1974
80.00	0.7200	0.7100	0.7300	0.7400	10.00	7	2	5.30	18	12	1974
81.00	0.7100	0.7000	0.7200	0.7300	11.00	7	2	6.00	18	12	1974
78.00	0.7000	0.6900	0.7100	0.7200	12.00	7	2	6.30	18	12	1974
79.00	0.7100	0.7000	0.7200	0.7300	11.00	7	2	7.00	18	12	1974
84.00	0.7650	0.7600	0.7700	0.7800	12.00	7	2	7.30	18	12	1974
70.00	0.6650	0.6600	0.6700	0.6800	9.00	7	2	8.00	18	12	1974
74.00	0.6800	0.6700	0.6900	0.7000	11.00	7	2	8.30	18	12	1974
67.00	0.6300	0.6200	0.6400	0.6500	11.00	7	2	9.00	18	12	1974
65.00	0.6400	0.6300	0.6500	0.6600	9.00	7	2	9.30	18	12	1974
65.00	0.6000	0.5900	0.6100	0.6200	10.00	7	2	10.00	18	12	1974
63.00	0.5900	0.5800	0.6000	0.6100	11.00	7	2	10.30	18	12	1974
61.00	0.5600	0.5500	0.5700	0.5800	10.00	7	2	11.00	18	12	1974
60.50	0.5600	0.5500	0.5700	0.5800	10.00	7	2	11.30	18	12	1974
60.40	0.5550	0.5500	0.5600	0.5700	11.00	7	2	12.00	18	12	1974
63.00	0.5600	0.5500	0.5700	0.5800	11.00	7	2	12.30	18	12	1974
61.00	0.5550	0.5500	0.5600	0.5700	12.00	7	2	13.00	18	12	1974
61.00	0.5550	0.5500	0.5600	0.5700	12.00	7	2	13.30	18	12	1974
59.80	0.5400	0.5300	0.5500	0.5600	10.00	7	2	14.00	18	12	1974
60.00	0.6350	0.6300	0.6400	0.6500	0.50	5	2	0.00	21	12	1974
61.00	0.6450	0.6400	0.6500	0.6600	0.50	7	2	0.30	21	12	1974
62.00	0.6050	0.6250	0.6250	0.6250	1.50	7	2	2.30	24	12	1974
58.00	0.4250	0.5250	0.4550	0.3750	1.00	7	2	12.30	24	12	1974
57.20	0.6000	0.6300	0.6300	0.6050	2.00	7	2	13.30	24	12	1974
58.80	0.6150	0.6100	0.6250	0.6000	8.00	7	2	15.00	24	12	1974

59.00	0.6100	0.6150	0.6250	0.6000	3.00	7	2	15.30	24	12	1974
58.50	0.6300	0.6300	0.6500	0.6200	3.00	7	2	16.00	24	12	1974
59.00	0.6100	0.6350	0.6400	0.6250	1.00	7	2	16.30	24	12	1974
58.50	0.6300	0.6400	0.6500	0.6300	1.50	7	2	17.00	24	12	1974
62.00	0.5450	0.5700	0.5700	0.5650	1.00	7	2	0.30	25	12	1974
62.30	0.5600	0.5850	0.5900	0.5800	0.10	7	2	1.00	25	12	1974
62.30	0.5900	0.6100	0.6150	0.6100	0.30	7	2	1.30	25	12	1974
63.00	0.5900	0.6200	0.6200	0.6100	0.30	7	2	2.00	25	12	1974
62.60	0.5950	0.6200	0.6250	0.6200	0.10	7	2	2.30	25	12	1974
62.50	0.5500	0.5600	0.5700	0.5600	1.00	7	2	4.30	25	12	1974
62.80	0.5700	0.5700	0.5900	0.5750	1.50	7	2	5.00	25	12	1974
62.50	0.5500	0.5550	0.5700	0.5600	4.00	7	2	6.00	25	12	1974
62.00	0.5300	0.5400	0.5450	0.5350	6.50	7	2	6.30	25	12	1974
62.00	0.5200	0.5400	0.5400	0.5250	8.00	7	2	7.00	25	12	1974
63.00	0.5300	0.5500	0.5500	[illegible]300	7.50	7	2	7.30	25	12	1974
63.00	0.5300	0.5400	0.5500	0.5300	8.00	7	2	8.00	25	12	1974
63.00	0.5200	0.5400	0.5400	0.5200	6.00	7	2	8.30	25	12	1974
85.50	0.7200	0.7000	0.7300	0.7200	10.00	7	2	9.00	25	12	1974
85.00	0.7300	0.7050	0.7400	0.7300	12.50	7	2	9.30	25	12	1974
82.50	0.7200	0.7000	0.7300	0.7100	12.00	7	2	10.00	25	12	1974
82.00	0.7100	0.6900	0.7200	0.7100	12.00	7	2	10.30	25	12	1974
80.00	0.7100	0.6900	0.7200	0.7100	11.00	7	2	11.00	25	12	1974
61.50	0.5900	0.5800	0.6000	0.5700	14.50	7	2	11.30	25	12	1974
59.00	0.5400	0.5300	0.5450	0.5200	16.50	7	2	12.00	25	12	1974
59.00	0.5300	0.5100	0.5300	0.5100	16.00	7	2	12.30	25	12	1974
59.50	0.5150	0.5200	0.5200	0.5050	15.00	7	2	13.00	25	12	1974
59.00	0.5200	0.5050	0.5200	0.5050	18.00	7	2	13.30	25	12	1974
59.00	0.5250	0.5200	0.5300	0.5050	16.00	7	2	14.00	25	12	1974
59.00	0.5250	0.5150	0.5250	0.5100	14.00	7	2	14.30	25	12	1974
59.50	0.5150	0.5100	0.5250	0.5050	12.50	7	2	15.00	25	12	1974
60.00	0.5150	0.5050	0.5150	0.5000	12.50	7	2	15.30	25	12	1974
59.50	0.5150	0.5000	0.5150	0.5000	11.00	7	2	16.00	25	12	1974
59.50	0.5100	0.5000	0.5100	0.4950	12.00	7	2	16.30	25	12	1974
59.00	0.5000	0.4950	0.5100	0.4850	12.50	7	2	17.00	25	12	1974
59.00	0.4900	0.4800	0.4900	0.4750	13.00	7	2	17.30	25	12	1974
60.00	0.5000	0.4950	0.5000	0.4900	10.00	7	2	18.00	25	12	1974
92.00	0.6800	0.6700	0.7000	0.6950	11.00	7	2	18.30	25	12	1974
8[illegible].00	0.6900	0.6700	0.7100	0.6900	9.00	7	2	19.00	25	12	1974
91.00	0.7100	0.6900	0.7250	0.7100	7.00	7	2	19.30	25	12	1974
91.00	0.7300	0.7050	0.7500	0.7300	10.00	7	2	20.00	25	12	1974
90.80	0.7450	0.7150	0.7650	0.7450	7.00	7	2	20.30	25	12	1974
90.00	0.7450	0.7150	0.7700	0.7450	9.00	7	2	21.00	25	12	1974
90.50	0.7600	0.7350	0.7750	0.7550	8.00	7	2	21.30	2[illegible]	12	1974
91.00	0.7600	0.7300	0.7700	0.7600	6.00	7	2	22.00	[illegible]	12	1974
91.00	0.7700	0.7400	0.7900	0.7750	7.00	7	2	22.30	[illegible]5	12	1974
91.50	0.7650	0.7350	0.7850	0.7800	6.00	7	2	23.00	25	12	1974
92.00	0.7900	0.7600	0.8100	0.7900	4.00	7	2	23.30	25	12	1974
92.00	0.8300	0.7900	0.8500	0.8200	5.00	7	2	0.00	26	12	1974
91.50	0.8250	0.7950	0.8600	0.8400	5.00	7	2	0.30	26	12	1974
92.00	0.7900	0.7500	0.8050	0.7800	5.00	7	2	1.00	26	12	1974
59.00	0.4900	0.4700	0.4950	0.4900	9.00	7	2	12.30	27	12	1974
58.50	0.4900	0.4750	0.5000	0.5050	6.00	7	2	13.00	27	12	1974
59.50	0.5100	0.4950	0.5050	0.[illegible]050	7.00	7	2	13.30	27	12	1974
73.00	0.7050	0.7200	0.7200	0.7300	1.00	7	2	18.30	27	12	1974
62.50	0.5800	0.5700	0.6000	0.5850	2.00	7	2	6.00	28	12	1974
61.00	0.6000	0.6050	0.6300	0.6150	2.00	7	2	7.00	28	12	1974
60.00	0.5900	0.6000	0.6100	0.5950	1.00	7	2	8.00	28	12	1974
67.00	0.5000	0.5000	0.5000	0.5000	5.00	7	2	1.30	9	1	1975
67.00	0.4900	0.4900	0.4900	0.4900	6.50	7	2	2.00	9	1	1975
66.50	0.5000	0.5000	0.5000	0.5000	9.50	7	2	2.30	9	1	1975
67.00	0.5100	0.5100	0.5100	0.5100	11.50	7	2	3.00	9	1	1975

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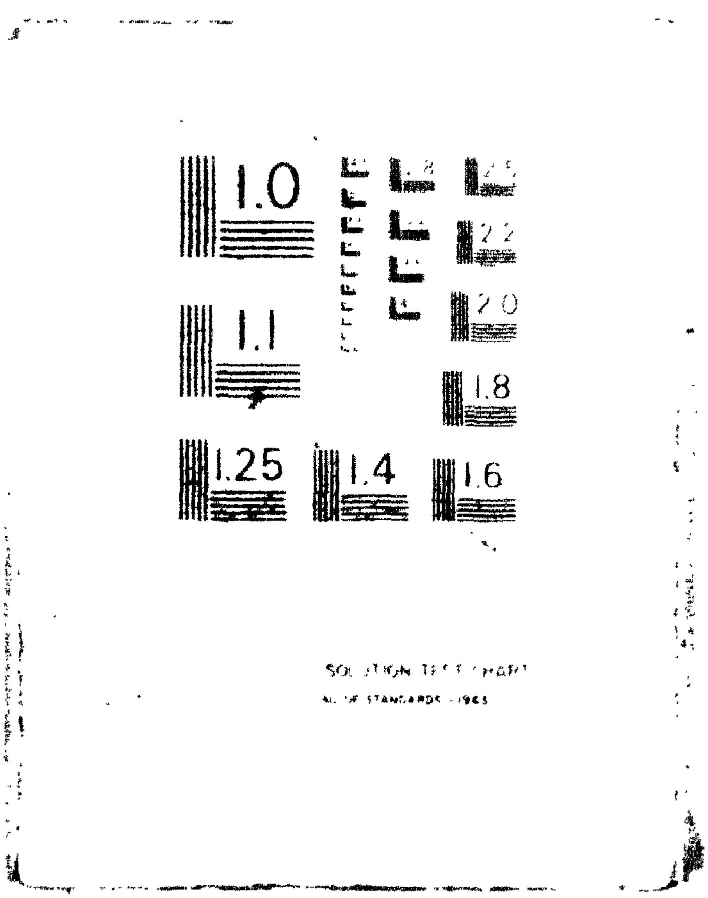
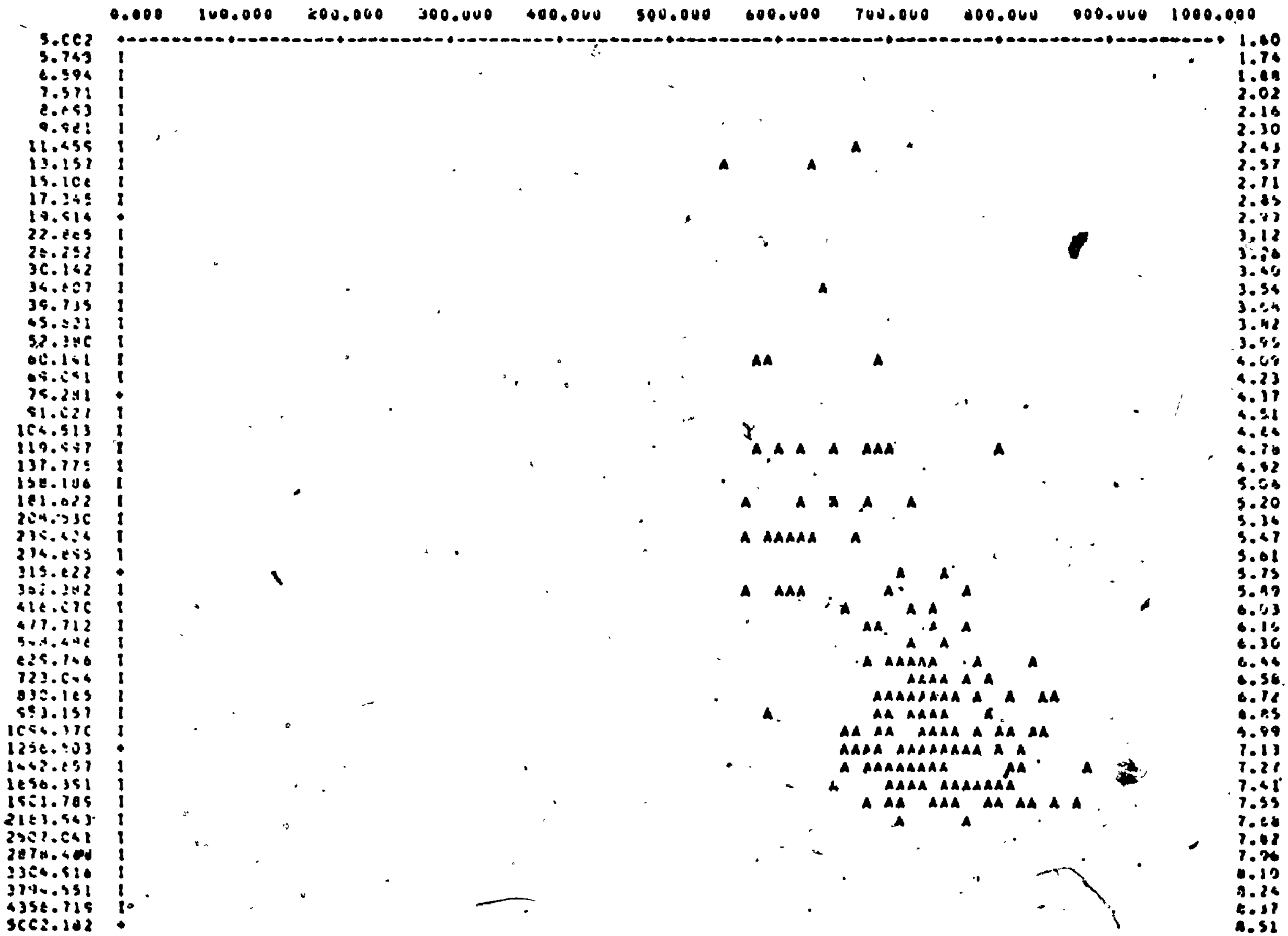


66.50	0.5200	0.5200	0.5200	0.5200	10.00	7	2	3.30	9	1	1975
66.50	0.5100	0.5100	0.5100	0.5100	9.50	7	2	4.00	9	1	1975
66.30	0.5300	0.5300	0.5100	0.5300	14.00	7	2	4.30	9	1	1975
66.30	0.5150	0.5150	0.5150	0.5150	15.00	7	2	5.00	9	1	1975
64.00	0.5100	0.5100	0.5100	0.5100	14.50	7	2	5.30	9	1	1975
65.70	0.5100	0.5100	0.5100	0.5100	10.50	7	2	6.00	9	1	1975
66.30	0.5500	0.5500	0.5500	0.5500	8.50	7	2	6.30	9	1	1975
66.00	0.5500	0.5500	0.5500	0.5500	8.00	7	2	7.00	9	1	1975
66.00	0.5450	0.5450	0.5450	0.5450	9.00	7	2	7.30	9	1	1975
64.50	0.5500	0.5500	0.5500	0.5500	8.50	7	2	8.00	9	1	1975
63.70	0.5400	0.5400	0.5400	0.5400	6.50	7	2	8.30	9	1	1975
64.00	0.5450	0.5450	0.5450	0.5450	7.50	7	2	9.00	9	1	1975
64.00	0.5400	0.5400	0.5400	0.5400	6.50	7	2	9.30	9	1	1975
64.00	0.5450	0.5450	0.5450	0.5450	7.00	7	2	10.00	9	1	1975
64.50	0.5400	0.5400	0.5400	0.5400	3.50	7	2	10.30	9	1	1975
65.00	0.5500	0.5500	0.5500	0.5500	4.00	7	2	11.00	9	1	1975
65.50	0.5600	0.5600	0.5600	0.5600	5.00	7	2	11.30	9	1	1975
65.00	0.5500	0.5500	0.5500	0.5500	6.00	7	2	12.00	9	1	1975
62.50	0.5300	0.5300	0.5300	0.5100	7.00	7	2	12.30	9	1	1975
64.00	0.5300	0.5300	0.5300	0.5300	6.00	7	2	13.00	9	1	1975
64.00	0.5300	0.5300	0.5300	0.5300	6.50	7	2	13.30	9	1	1975
66.00	0.5400	0.5400	0.5400	0.5400	9.00	7	2	14.00	9	1	1975
65.00	0.5500	0.5500	0.5500	0.5500	4.00	7	2	14.30	9	1	1975
64.50	0.5550	0.5550	0.5550	0.5550	4.50	7	2	15.00	9	1	1975
64.50	0.5700	0.5700	0.5700	0.5700	1.00	7	2	15.30	9	1	1975
62.00	0.5600	0.5600	0.5600	0.5600	0.50	7	2	17.00	9	1	1975
61.50	0.5850	0.5850	0.5850	0.5850	1.50	7	2	17.30	9	1	1975
71.50	0.5900	0.5800	0.5900	0.6300	15.00	7	2	0.00	19	1	1975
73.00	0.5900	0.5850	0.6000	0.6100	13.00	7	2	0.30	19	1	1975
72.00	0.6050	0.6000	0.6200	0.6150	10.00	7	2	1.00	19	1	1975
73.70	0.6100	0.6200	0.6300	0.6400	7.00	7	2	1.30	19	1	1975
70.50	0.6200	0.6100	0.6250	0.6300	6.00	7	2	2.00	19	1	1975
71.00	0.6100	0.6000	0.6100	0.6150	11.00	7	2	2.30	19	1	1975
75.00	0.6350	0.6100	0.6200	0.6400	10.50	7	2	3.00	19	1	1975
74.00	0.6250	0.6300	0.6300	0.6400	10.00	7	2	3.30	19	1	1975
72.00	0.6200	0.6150	0.6350	0.6350	12.00	7	2	4.00	19	1	1975
72.00	0.6250	0.6100	0.6350	0.6400	10.00	7	2	4.30	19	1	1975
74.00	0.6050	0.5900	0.6150	0.6150	18.00	7	2	5.00	19	1	1975
76.00	0.6200	0.6100	0.6400	0.6300	17.00	7	2	5.30	19	1	1975
78.00	0.7000	0.7000	0.7700	0.7050	2.50	7	2	22.30	27	1	1975
75.50	0.7000	0.7000	0.7200	0.7100	4.00	7	2	23.00	27	1	1975
77.00	0.7000	0.7000	0.7300	0.7100	3.00	7	2	23.30	27	1	1975
65.00	0.5750	0.5750	0.5750	0.5750	8.50	7	2	13.30	6	2	1975
64.00	0.5350	0.5350	0.5350	0.5350	7.50	7	2	14.00	6	2	1975
63.80	0.5450	0.5450	0.5450	0.5450	7.50	7	2	14.30	6	2	1975
64.00	0.5450	0.5450	0.5450	0.5450	6.50	7	2	15.00	6	2	1975
64.00	0.5500	0.5500	0.5500	0.5500	6.00	7	2	15.30	6	2	1975
64.00	0.5500	0.5500	0.5500	0.5500	5.00	7	2	16.00	6	2	1975
63.00	0.5500	0.5500	0.5500	0.5500	5.00	7	2	16.30	6	2	1975
64.00	0.5500	0.5500	0.5500	0.5500	3.50	7	2	17.00	6	2	1975
63.00	0.5950	0.5950	0.5950	0.5950	3.50	7	2	17.30	6	2	1975
71.00	0.5200	0.5300	0.5300	0.5200	16.50	7	2	5.30	8	2	1975
73.50	0.5300	0.5400	0.5400	0.5300	16.50	7	2	6.00	8	2	1975
69.00	0.5400	0.5300	0.5300	0.5300	14.50	7	2	6.30	8	2	1975
70.00	0.5500	0.5400	0.5500	0.5400	12.00	7	2	7.00	8	2	1975
67.50	0.5400	0.5400	0.5500	0.5300	14.00	7	2	7.30	8	2	1975
65.30	0.5200	0.5100	0.5200	0.5000	16.00	7	2	8.00	8	2	1975
68.50	0.5200	0.5100	0.5200	0.5000	15.00	7	2	8.30	8	2	1975
67.50	0.5300	0.5200	0.5100	0.5000	15.00	7	2	9.00	8	2	1975
70.00	0.5400	0.5500	0.5300	0.5100	15.00	7	2	9.30	8	2	1975
67.00	0.5400	0.5400	0.5200	0.5100	14.00	7	2	10.00	8	2	1975

C	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
56.00	0.3750	0.3700	0.3750	0.3800	20.00	7	5	17.00	20	11	1974
56.00	0.3850	0.3900	0.3950	0.4000	15.00	7	5	17.30	20	11	1974
56.60	0.4000	0.4000	0.4000	0.4000	18.00	7	5	18.00	20	11	1974
56.80	0.4100	0.4050	0.4000	0.4000	12.00	7	5	18.30	20	11	1974
60.00	0.5850	0.5800	0.6000	0.6100	2.00	7	5	10.00	12	12	1974
59.50	0.5700	0.5600	0.5800	0.5900	2.00	7	5	10.30	12	12	1974
59.00	0.5750	0.5700	0.5900	0.6000	5.00	7	5	12.00	12	12	1974
63.50	0.5300	0.5200	0.5400	0.5500	13.00	7	5	15.00	17	12	1974
62.00	0.5200	0.5100	0.5300	0.5400	14.00	7	5	15.30	17	12	1974
61.00	0.5200	0.5100	0.5300	0.5400	10.00	7	5	16.00	17	12	1974
59.80	0.5000	0.4900	0.5100	0.5200	9.00	7	5	16.30	17	12	1974
58.50	0.5000	0.4900	0.5100	0.5200	7.00	7	5	17.00	17	12	1974
59.00	0.5150	0.5100	0.5200	0.5300	7.00	7	5	17.30	17	12	1974
59.00	0.5100	0.5000	0.5200	0.5300	7.00	7	5	18.00	17	12	1974
62.00	0.5900	0.6050	0.6150	0.6100	4.00	7	5	3.30	24	12	1974
67.00	0.5800	0.6050	0.6050	0.6150	1.00	7	5	6.00	24	12	1974
65.00	0.5800	0.6100	0.6100	0.6200	1.00	7	5	6.30	24	12	1974
60.50	0.4800	0.4800	0.4800	0.4800	13.00	7	5	11.00	1	1	1975
59.70	0.4650	0.4650	0.4650	0.4650	14.50	7	5	11.30	1	1	1975
60.00	0.4750	0.4750	0.4750	0.4750	16.00	7	5	12.00	1	1	1975
59.00	0.4800	0.4800	0.4800	0.4800	17.00	7	5	12.30	1	1	1975
60.00	0.4950	0.4950	0.4950	0.4950	18.00	7	5	13.00	1	1	1975
59.50	0.4900	0.4900	0.4900	0.4900	17.50	7	5	13.30	1	1	1975
60.00	0.5000	0.5000	0.5000	0.5000	17.00	7	5	14.00	1	1	1975
60.00	0.4900	0.4900	0.4900	0.4900	17.50	7	5	14.30	1	1	1975
59.00	0.4700	0.4700	0.4700	0.4700	18.00	7	5	15.00	1	1	1975
58.80	0.4600	0.4600	0.4600	0.4600	17.50	7	5	15.30	1	1	1975
59.00	0.4500	0.4500	0.4500	0.4500	17.00	7	5	16.00	1	1	1975
60.00	0.4550	0.4550	0.4550	0.4550	18.50	7	5	16.30	1	1	1975
59.00	0.4700	0.4700	0.4700	0.4700	20.00	7	5	17.00	1	1	1975
59.00	0.4600	0.4600	0.4600	0.4600	17.50	7	5	17.30	1	1	1975
75.50	0.6000	0.5800	0.5900	0.6000	15.00	7	5	20.00	18	1	1975
74.50	0.5900	0.5800	0.5900	0.6000	14.00	7	5	20.30	18	1	1975
74.00	0.5900	0.5850	0.5900	0.6050	11.00	7	5	21.00	18	1	1975
73.50	0.5950	0.5850	0.6000	0.6100	13.00	7	5	21.30	18	1	1975
72.30	0.5900	0.5800	0.6000	0.6100	11.00	7	5	22.00	18	1	1975
70.50	0.5900	0.5800	0.6100	0.6200	9.50	7	5	22.30	18	1	1975
70.80	0.5900	0.5800	0.6000	0.6100	8.50	7	5	23.00	18	1	1975
69.00	0.5900	0.5800	0.5900	0.5900	10.50	7	5	23.30	18	1	1975
77.50	0.6200	0.6000	0.6300	0.6300	15.00	7	5	6.00	19	1	1975
77.50	0.6300	0.6100	0.6300	0.6300	13.00	7	5	6.30	19	1	1975
77.00	0.6300	0.6200	0.6400	0.6350	15.00	7	5	7.00	19	1	1975
70.00	0.6200	0.5900	0.6150	0.6000	14.00	7	5	7.30	19	1	1975
61.00	0.5400	0.5300	0.5400	0.5200	10.50	7	5	8.00	19	1	1975
59.00	0.4900	0.4900	0.5100	0.4950	4.00	7	5	15.00	25	1	1975
69.00	0.5300	0.5300	0.5500	0.5300	13.00	7	5	15.30	25	1	1975
70.80	0.5450	0.5450	0.5600	0.5600	9.00	7	5	16.00	25	1	1975
72.00	0.5490	0.5450	0.5600	0.5550	22.00	7	5	16.30	25	1	1975
77.80	0.5900	0.5900	0.5900	0.5950	19.00	7	5	17.00	25	1	1975
77.00	0.6200	0.5950	0.6100	0.6150	14.00	7	5	17.30	25	1	1975
77.00	0.6250	0.6100	0.6200	0.6200	12.50	7	5	18.00	25	1	1975
80.50	0.6500	0.6150	0.6400	0.6500	19.00	7	5	23.30	25	1	1975
82.30	0.6700	0.6700	0.6650	0.6700	22.00	7	5	0.00	26	1	1975
65.50	0.5600	0.5600	0.5600	0.5600	0.10	7	5	7.00	6	2	1975
64.80	0.5600	0.5600	0.5600	0.5600	0.10	7	5	7.30	6	2	1975
63.00	0.5100	0.5100	0.5100	0.5100	0.50	7	5	10.00	6	2	1975
63.00	0.5100	0.5100	0.5100	0.5100	0.50	7	5	10.30	6	2	1975
66.00	0.5100	0.5100	0.5200	0.5150	14.00	7	5	21.30	6	2	1975

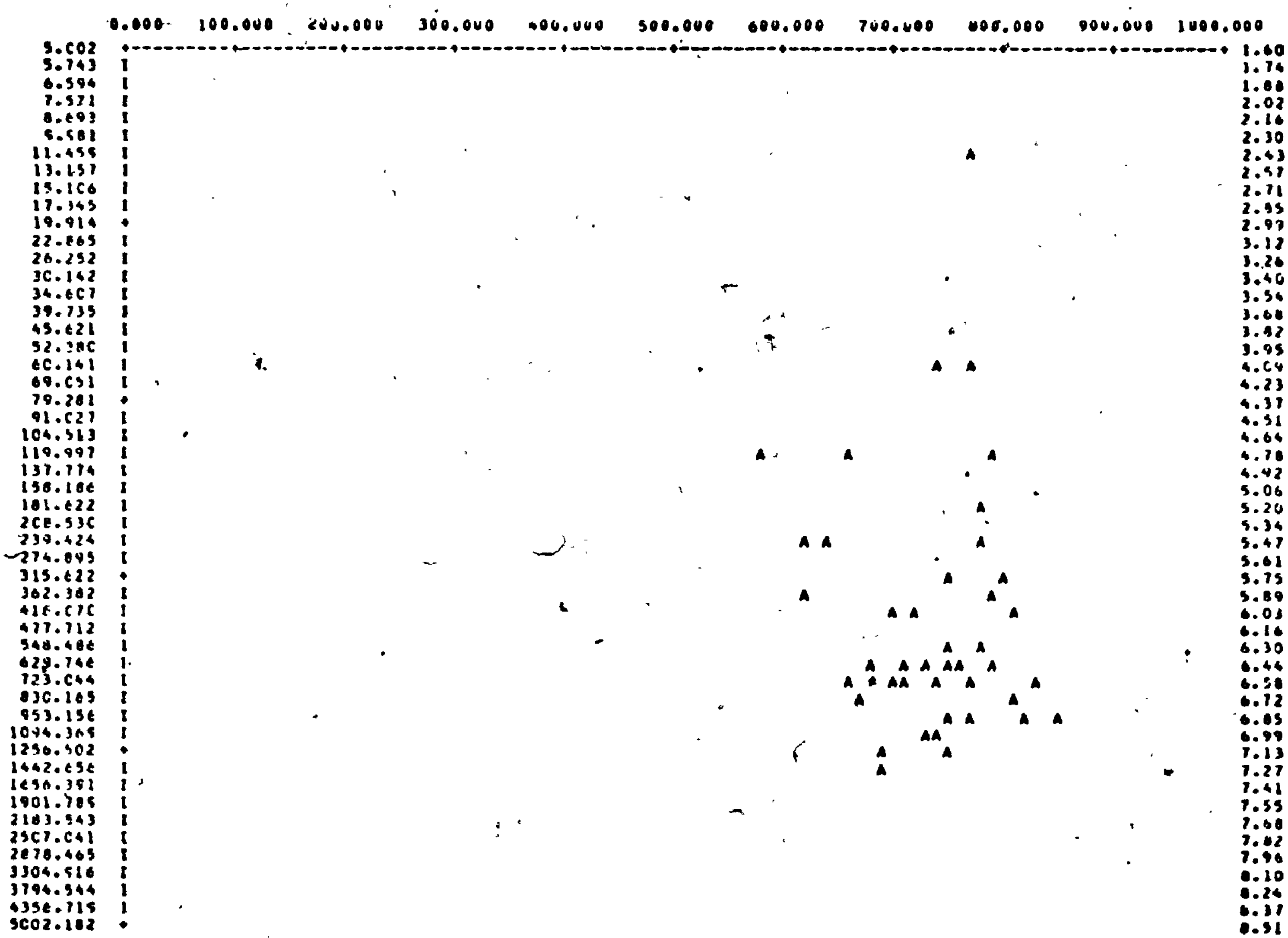
FACULTY OF ENGINEERING SCIENCE

CLOUDY
WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3.



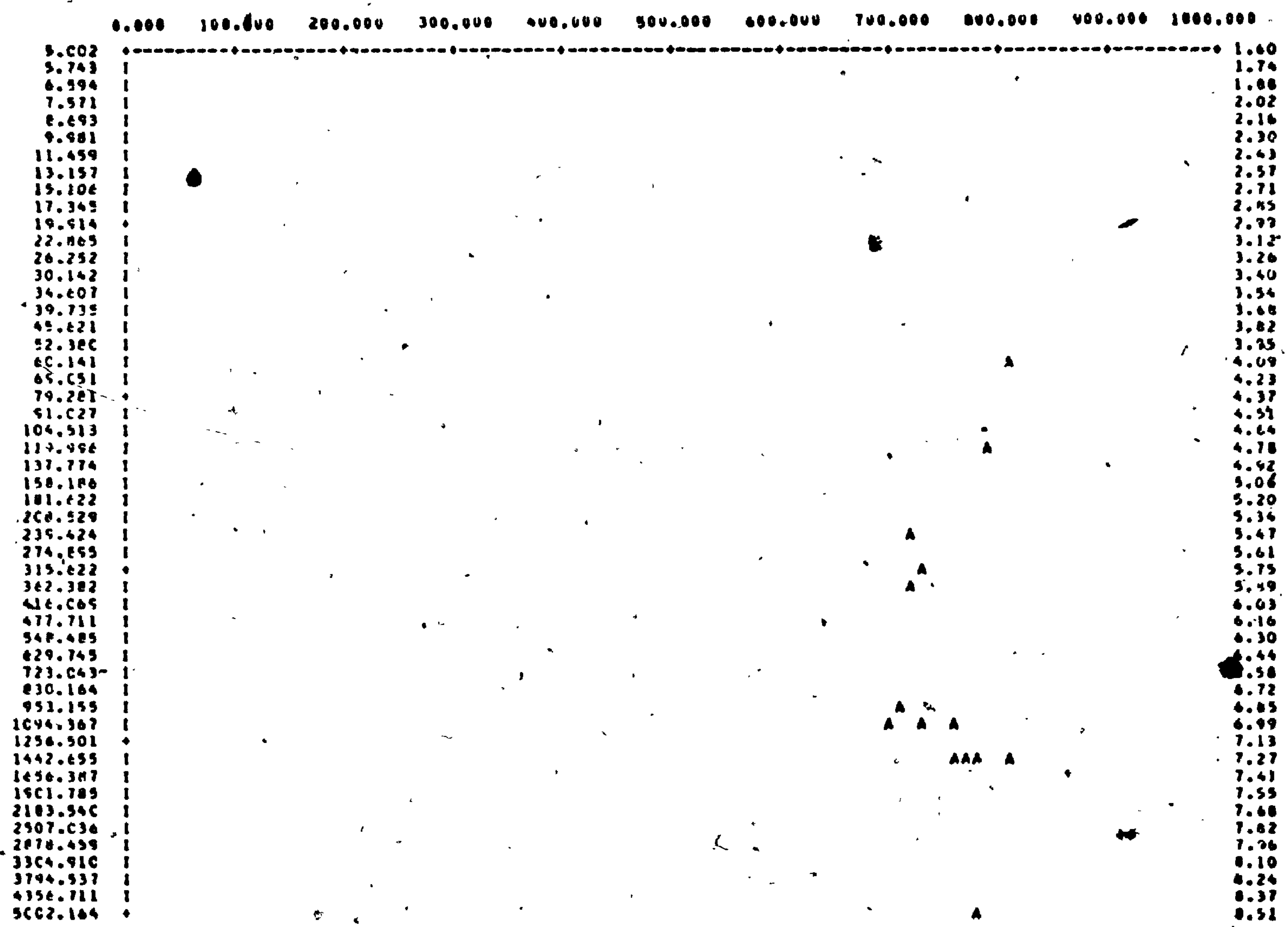
C	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
64.00	0.5750	0.5700	0.5800	0.5900	12.00	7	3	0.00	20	12	1974
61.00	0.5450	0.5400	0.5500	0.5600	10.00	7	3	0.30	20	12	1974
84.00	0.7500	0.7400	0.7600	0.7700	9.00	7	3	1.00	20	12	1974
79.00	0.7650	0.7600	0.7700	0.7800	7.00	7	3	1.30	20	12	1974
80.50	0.7700	0.7600	0.7800	0.7900	7.00	7	3	2.00	20	12	1974
84.00	0.8250	0.8200	0.8300	0.8400	6.00	7	3	6.00	20	12	1974
62.50	0.5000	0.5100	0.5000	0.4900	6.00	7	3	1.00	30	12	1974
63.00	0.5050	0.5050	0.5050	0.5050	8.00	7	3	1.30	30	12	1974
73.00	0.5600	0.5600	0.5600	0.5600	8.00	7	3	2.00	30	12	1974
73.50	0.5750	0.5750	0.5750	0.5750	7.00	7	3	2.30	30	12	1974
77.00	0.6600	0.6600	0.6600	0.6600	4.50	7	3	8.30	30	12	1974
64.00	0.5850	0.5850	0.5850	0.5850	5.00	7	3	9.00	30	12	1974
60.00	0.5300	0.5300	0.5300	0.5300	3.50	7	3	9.30	30	12	1974
59.30	0.5400	0.5400	0.5400	0.5400	5.00	7	3	10.00	30	12	1974
59.70	0.5250	0.5250	0.5250	0.5250	6.00	7	3	10.30	30	12	1974
60.00	0.5200	0.5200	0.5200	0.5200	5.00	7	3	11.00	30	12	1974
59.00	0.5100	0.5100	0.5100	0.5100	6.00	7	3	12.00	30	12	1974
59.50	0.4800	0.4800	0.4800	0.4800	5.00	7	3	12.30	30	12	1974
59.50	0.4600	0.4600	0.4600	0.4600	5.00	7	3	13.00	30	12	1974
59.50	0.5000	0.5000	0.5000	0.5000	5.00	7	3	13.30	30	12	1974
60.50	0.5150	0.5150	0.5150	0.5150	3.50	7	3	15.00	30	12	1974
59.50	0.4600	0.4600	0.4600	0.4600	3.00	7	3	16.00	30	12	1974
60.00	0.4600	0.4600	0.4600	0.4600	2.50	7	3	16.30	30	12	1974
67.00	0.7300	0.7300	0.7300	0.7300	1.00	7	3	8.30	2	1	1975
67.50	0.6900	0.6900	0.6900	0.6900	2.00	7	3	9.00	2	1	1975
63.00	0.6300	0.6300	0.6300	0.6300	3.00	7	3	9.30	2	1	1975
60.00	0.5800	0.5800	0.5800	0.5800	2.00	7	3	10.00	2	1	1975
74.00	0.7150	0.7200	0.7400	0.7150	1.00	7	3	0.00	28	1	1975
65.00	0.5200	0.5200	0.5400	0.5300	0.10	7	3	19.30	2	2	1975
65.20	0.5200	0.5200	0.5400	0.5300	0.50	7	3	21.00	2	2	1975
65.00	0.5400	0.5500	0.5600	0.5400	0.50	7	3	21.30	2	2	1975
66.00	0.5200	0.5200	0.5500	0.5300	2.00	7	3	22.00	2	2	1975
67.00	0.5500	0.5600	0.5700	0.5600	2.50	7	3	22.30	2	2	1975
69.00	0.5400	0.5500	0.5600	0.5400	1.00	7	3	23.00	2	2	1975
68.50	0.5400	0.5500	0.5650	0.5450	1.50	7	3	23.30	2	2	1975
88.20	0.6900	0.6700	0.6800	0.6800	7.50	7	3	5.30	7	2	1975
87.20	0.7000	0.6750	0.6900	0.6850	6.00	7	3	6.00	7	2	1975
85.50	0.7100	0.7000	0.7100	0.7000	5.00	7	3	6.30	7	2	1975
85.00	0.7200	0.7000	0.7150	0.7000	4.50	7	3	7.00	7	2	1975
92.00	0.7600	0.7300	0.7600	0.7400	3.50	7	3	7.30	7	2	1975
100.00	0.8900	0.9000	0.9200	0.9000	5.00	7	3	1.30	9	2	1975
100.60	0.9100	0.9000	0.9200	0.9100	6.00	7	3	2.00	9	2	1975
100.00	0.9100	0.9000	0.9100	0.9100	7.00	7	3	2.30	9	2	1975
100.00	0.9100	0.8900	0.9200	0.9100	7.00	7	3	3.00	9	2	1975
100.00	0.9100	0.8900	0.9200	0.9200	5.50	7	3	3.30	9	2	1975
101.50	0.9300	0.9100	0.9300	0.9300	7.00	7	3	4.00	9	2	1975
102.00	0.9600	0.9300	0.9500	0.9500	8.00	7	3	4.30	9	2	1975
102.50	0.9500	0.9200	0.9500	0.9400	8.50	7	3	5.00	9	2	1975
103.00	0.9500	0.9200	0.9500	0.9400	9.50	7	3	5.30	9	2	1975

PARTLY CLOUDY
WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



Q	CTN	CTW	DTS	CTE	VEL	O	W	TIME	D	M	YEAR
6C.CC	0.4650	0.465C	0.4650	0.4650	1.00	7	4	17.00	30	12	1974
60.50	0.46C0	0.4600	0.4600	0.4600	0.50	7	4	17.30	30	12	1974
67.00	C.575C	0.5850	0.5900	0.5800	2.C0	7	4	0.C0	3	2	1975
66.20	0.57C0	0.5700	0.59C0	0.5600	3.C0	7	4	0.30	3	2	1975
66.80	0.56CC	C.57C0	0.5850	0.5650	2.50	7	4	1.00	3	2	1975
1C3.C0	0.93CC	C.9C00	0.92C0	0.9200	10.50	7	4	6.00	9	2	1975
1C3.C0	0.9200	0.9CCC	0.9150	0.9100	11.C0	7	4	6.30	9	2	1975
1C3.C0	C.92C0	0.89CC	0.9100	0.91C0	11.C0	7	4	7.00	9	2	1975
1C2.5C	C.91CC	0.88CC	C.9C00	0.89CC	10.50	7	4	7.30	9	2	1975
1C2.00	C.9CCC	0.87CC	0.88C0	0.87C0	1C.50	7	4	8.C0	9	2	1975
101.50	0.87CC	0.845C	0.84C0	0.8300	11.C0	7	4	8.30	9	2	1975
1C3.C0	0.92CC	C.9CC0	C.93C0	0.9200	8.C0	7	4	18.C0	9	2	1975
1C4.C0	C.98C0	0.9500	0.99C0	0.9800	8.50	7	4	18.30	9	2	1975
1C4.CC	[illegible]CCCC	C.98C0	1.C2C0	1.0100	7.50	7	4	19.00	9	2	1975
1C4.C0	1.10CC	C.9700	1.C1C0	1.0100	8.CC	7	4	19.30	9	2	1975
1C4.C0	1.C2C0	1.C000	1.C200	1.0200	8.CC	7	4	20.00	9	2	1975

CLEAR
WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



C	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
56.00	0.3750	0.3700	0.3750	0.3800	20.00	7	5	17.00	20	11	1974
56.00	0.3850	0.3900	0.3950	0.4000	15.00	7	5	17.30	20	11	1974
56.60	0.4000	0.4000	0.4000	0.4000	18.00	7	5	18.00	20	11	1974
56.80	0.4100	0.4050	0.4000	0.4000	12.00	7	5	18.30	20	11	1974
60.00	0.5850	0.5800	0.6000	0.6100	2.00	7	5	10.00	12	12	1974
59.50	0.5700	0.5600	0.5800	0.5900	2.00	7	5	10.30	12	12	1974
59.00	0.5750	0.5700	0.5900	0.6000	5.00	7	5	12.00	12	12	1974
63.50	0.5300	0.5200	0.5400	0.5500	13.00	7	5	15.00	17	12	1974
62.00	0.5200	0.5100	0.5300	0.5400	14.00	7	5	15.30	17	12	1974
61.00	0.5200	0.5100	0.5300	0.5400	10.00	7	5	16.00	17	12	1974
59.80	0.5000	0.4900	0.5100	0.5200	9.00	7	5	16.30	17	12	1974
58.50	0.5000	0.4900	0.5100	0.5200	7.00	7	5	17.00	17	12	1974
59.00	0.5150	0.5100	0.5200	0.5300	7.00	7	5	17.30	17	12	1974
59.00	0.5100	0.5000	0.5200	0.5300	7.00	7	5	18.00	17	12	1974
62.00	0.5900	0.6050	0.6150	0.6100	4.00	7	5	3.30	24	12	1974
67.00	0.5800	0.6050	0.6050	0.6150	1.00	7	5	6.00	24	12	1974
69.00	0.5800	0.6100	0.6100	0.6200	1.00	7	5	6.30	24	12	1974
60.50	0.4800	0.4800	0.4800	0.4800	13.00	7	5	11.00	1	1	1975
59.70	0.4650	0.4650	0.4650	0.4650	14.50	7	5	11.30	1	1	1975
60.00	0.4750	0.4750	0.4750	0.4750	16.00	7	5	12.00	1	1	1975
59.00	0.4800	0.4800	0.4800	0.4800	17.00	7	5	12.30	1	1	1975
60.00	0.4950	0.4950	0.4950	0.4950	18.00	7	5	13.00	1	1	1975
59.50	0.4900	0.4900	0.4900	0.4900	17.50	7	5	13.30	1	1	1975
60.00	0.5000	0.5000	0.5000	0.5000	17.00	7	5	14.00	1	1	1975
60.00	0.4900	0.4900	0.4900	0.4900	17.50	7	5	14.30	1	1	1975
59.00	0.4700	0.4700	0.4700	0.4700	18.00	7	5	15.00	1	1	1975
58.80	0.4600	0.4600	0.4600	0.4600	17.50	7	5	15.30	1	1	1975
59.00	0.4500	0.4500	0.4500	0.4500	17.00	7	5	16.00	1	1	1975
60.00	0.4550	0.4550	0.4550	0.4550	18.50	7	5	16.30	1	1	1975
59.00	0.4700	0.4700	0.4700	0.4700	20.00	7	5	17.00	1	1	1975
59.00	0.4600	0.4600	0.4600	0.4600	17.50	7	5	17.30	1	1	1975
75.50	0.6000	0.5800	0.5900	0.6000	15.00	7	5	20.00	18	1	1975
74.50	0.5900	0.5800	0.5900	0.6000	14.00	7	5	20.30	18	1	1975
74.00	0.5900	0.5850	0.5900	0.6050	11.00	7	5	21.00	18	1	1975
73.50	0.5950	0.5850	0.6000	0.6100	13.00	7	5	21.30	18	1	1975
72.30	0.5900	0.5800	0.6000	0.6100	11.00	7	5	22.00	18	1	1975
70.50	0.5900	0.5800	0.6100	0.6200	9.50	7	5	22.30	18	1	1975
70.80	0.5900	0.5800	0.6000	0.6100	8.50	7	5	23.00	18	1	1975
69.00	0.5900	0.5800	0.5900	0.5900	10.50	7	5	23.30	18	1	1975
77.50	0.6200	0.6000	0.6300	0.6300	15.00	7	5	6.00	19	1	1975
77.50	0.6300	0.6100	0.6300	0.6300	13.00	7	5	6.30	19	1	1975
77.00	0.6300	0.6200	0.6400	0.6350	15.00	7	5	7.00	19	1	1975
70.00	0.6200	0.5900	0.6150	0.6000	14.00	7	5	7.30	19	1	1975
61.00	0.5400	0.5300	0.5400	0.5200	10.50	7	5	8.00	19	1	1975
59.00	0.4900	0.4900	0.5100	0.4950	4.00	7	5	15.00	25	1	1975
69.00	0.5300	0.5300	0.5500	0.5300	13.00	7	5	15.30	25	1	1975
70.80	0.5450	0.5450	0.5600	0.5600	9.00	7	5	16.00	25	1	1975
72.00	0.5490	0.5450	0.5600	0.5550	22.00	7	5	16.30	25	1	1975
77.80	0.5900	0.5900	0.5900	0.5950	19.00	7	5	17.00	25	1	1975
77.00	0.6200	0.5950	0.6100	0.6150	14.00	7	5	17.30	25	1	1975
77.00	0.6250	0.6100	0.6200	0.6200	12.50	7	5	18.00	25	1	1975
80.50	0.6500	0.6150	0.6400	0.6500	19.00	7	5	23.30	25	1	1975
82.30	0.6700	0.6700	0.6650	0.6700	22.00	7	5	0.00	26	1	1975
65.50	0.5600	0.5600	0.5600	0.5600	0.10	7	5	7.00	6	2	1975
64.80	0.5600	0.5600	0.5600	0.5600	0.10	7	5	7.30	6	2	1975
63.00	0.5100	0.5100	0.5100	0.5100	0.50	7	5	10.00	6	2	1975
63.00	0.5100	0.5100	0.5100	0.5100	0.50	7	5	10.30	6	2	1975
66.00	0.5100	0.5100	0.5200	0.5150	14.00	7	5	21.30	6	2	1975

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64.50	0.5000	0.5000	0.5100	0.5000	14.00	7	5	22.00	6	2	1975
65.00	0.5100	0.5200	0.5200	0.5100	12.00	7	5	22.30	6	2	1975
65.00	0.5100	0.5200	0.5200	0.5100	13.00	7	5	23.00	6	2	1975
66.00	0.5300	0.5300	0.5300	0.5300	14.50	7	5	23.30	6	2	1975

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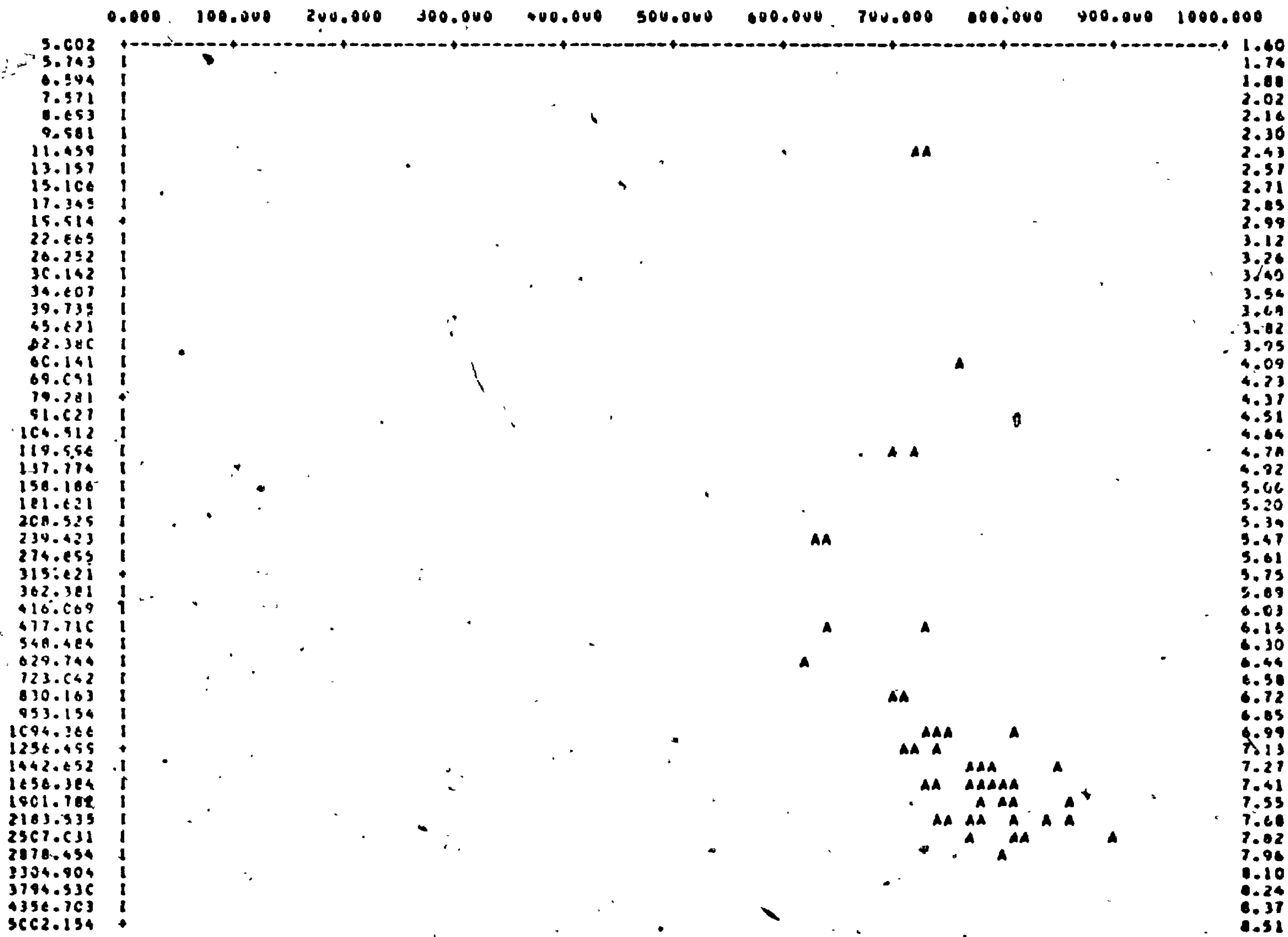
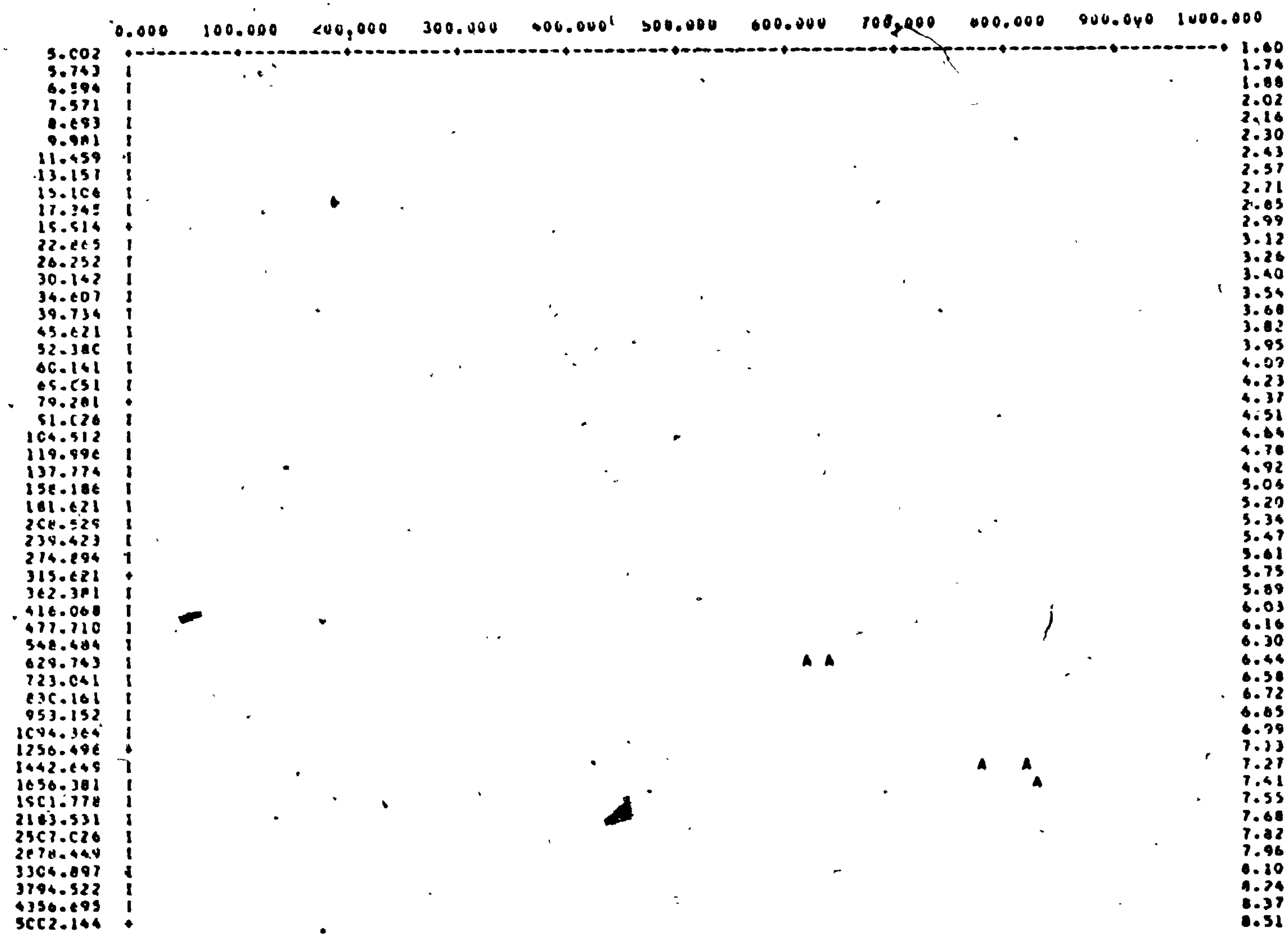
Q	CTN	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
60.80	0.5800	0.6000	0.6100	0.5650	5.00	8	1	12.00	3	2	1975
61.80	0.6200	0.6500	0.6500	0.5800	5.00	8	1	12.30	3	2	1975
100.00	0.8200	0.8500	0.8100	0.7800	12.00	8	1	9.30	9	2	1975
94.00	0.7500	0.7900	0.7400	0.7100	13.00	8	1	10.00	9	2	1975
90.00	0.7200	0.7700	0.7200	0.6700	12.00	8	1	10.30	9	2	1975
79.00	0.6800	0.7200	0.6400	0.5600	11.00	8	1	11.00	9	2	1975
77.00	0.6400	0.7000	0.6300	0.5500	12.00	8	1	11.30	9	2	1975

PRECIPITATION
WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3

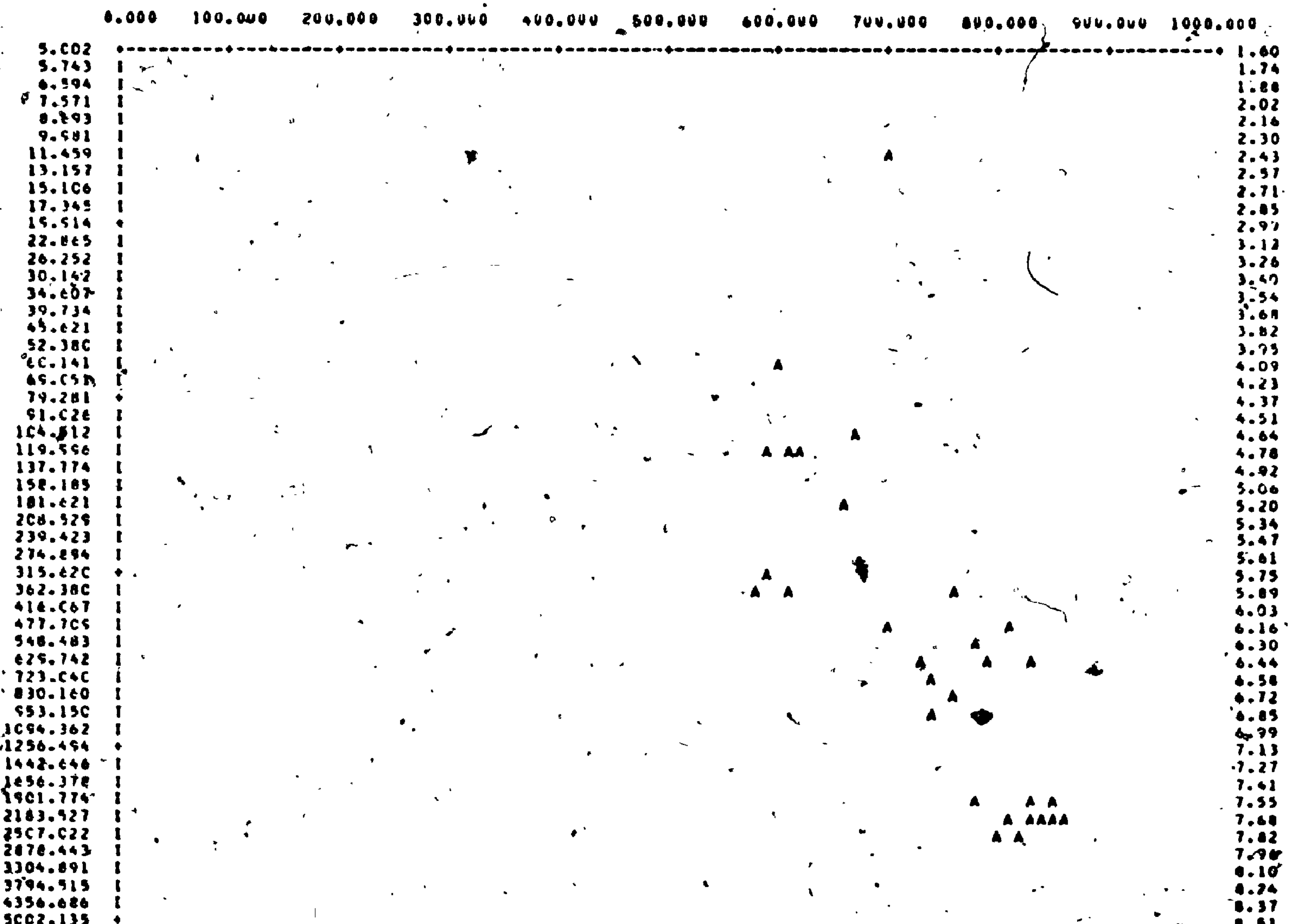


SUNNY
NORTH-WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



C	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
58.00	0.5750	0.5700	0.5900	0.6000	3.00	8	2	14.30	12	12	1974
59.00	0.4750	0.4700	0.4800	0.4900	3.00	8	2	12.30	14	12	1974
59.00	0.4500	0.4400	0.4600	0.4700	5.00	8	2	13.00	14	12	1974
59.00	0.5100	0.5000	0.5200	0.5300	4.00	8	2	14.30	14	12	1974
61.00	0.6050	0.6000	0.6100	0.6200	1.00	8	2	1.00	21	12	1974
63.00	0.6400	0.6300	0.6500	0.6600	1.00	8	2	1.30	21	12	1974
63.00	0.6500	0.6400	0.6600	0.6700	0.50	8	2	2.00	21	12	1974
58.70	0.6000	0.6400	0.6400	0.6050	3.00	8	2	13.00	24	12	1974
58.00	0.5950	0.6100	0.6150	0.6000	2.50	8	2	14.00	24	12	1974
58.70	0.6050	0.6100	0.6250	0.6100	1.00	8	2	14.30	24	12	1974
62.00	0.5450	0.5450	0.5450	0.5450	0.10	8	2	0.00	1	1	1975
58.80	0.4200	0.4200	0.4200	0.4200	15.00	8	2	18.00	1	1	1975
60.00	0.4400	0.4400	0.4400	0.4400	17.00	8	2	18.30	1	1	1975
60.30	0.4400	0.4400	0.4400	0.4400	15.00	8	2	19.00	1	1	1975
61.00	0.4400	0.4400	0.4400	0.4400	18.00	8	2	19.30	1	1	1975
61.50	0.4450	0.4450	0.4450	0.4450	17.00	8	2	20.00	1	1	1975
61.50	0.4550	0.4550	0.4550	0.4550	18.50	8	2	20.30	1	1	1975
61.00	0.4550	0.4550	0.4550	0.4550	20.00	8	2	21.00	1	1	1975
61.50	0.4500	0.4500	0.4500	0.4500	15.00	8	2	21.30	1	1	1975
63.00	0.4500	0.4500	0.4500	0.4500	18.00	8	2	22.00	1	1	1975
61.50	0.4650	0.4650	0.4650	0.4650	19.00	8	2	22.30	1	1	1975
62.00	0.4750	0.4750	0.4750	0.4750	20.00	8	2	23.00	1	1	1975
62.00	0.4700	0.4700	0.4700	0.4700	18.00	8	2	23.30	1	1	1975
62.00	0.4900	0.4900	0.4900	0.4900	16.00	8	2	0.00	2	1	1975
90.00	0.8000	0.8000	0.8000	0.8000	6.00	8	2	4.00	2	1	1975
100.00	0.9200	0.9000	0.9300	0.9300	7.00	8	2	22.30	8	2	1975
98.00	0.9200	0.8900	0.9100	0.9100	5.00	8	2	23.00	8	2	1975
90.00	0.8200	0.8000	0.8100	0.7900	6.00	8	2	23.30	8	2	1975
64.50	0.6000	0.6000	0.6000	0.6000	0.80	8	2	16.00	9	1	1975
61.00	0.5750	0.5750	0.5750	0.5750	1.50	8	2	16.30	9	1	1975
69.00	0.5200	0.5200	0.5200	0.5200	5.00	8	2	11.30	6	2	1975
69.00	0.5300	0.5300	0.5300	0.5300	4.00	8	2	12.00	6	2	1975
68.00	0.5600	0.5600	0.5600	0.5600	7.00	8	2	12.30	6	2	1975
71.00	0.5700	0.5700	0.5700	0.5700	4.50	8	2	13.00	6	2	1975

CLOUDY
NORTH-WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



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Q	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
71.00	0.8200	0.8100	0.8300	0.8400	2.00	8	3	6.30	20	12	1974
60.00	0.5800	0.6100	0.6150	0.6100	0.10	8	3	7.00	24	12	1974
76.00	0.6200	0.6400	0.6500	0.6400	0.10	8	3	7.30	24	12	1974
63.00	0.6300	0.6350	0.6500	0.6350	0.10	8	3	8.00	24	12	1974
61.00	0.6250	0.6350	0.6400	0.6350	0.10	8	3	8.30	24	12	1974
59.00	0.6050	0.6250	0.6300	0.6150	0.10	8	3	9.00	24	12	1974
70.00	0.6500	0.6500	0.6500	0.6500	6.00	8	3	3.00	30	12	1974
67.00	0.5900	0.5900	0.5900	0.5900	6.00	8	3	3.30	30	12	1974
66.00	0.5900	0.5900	0.5900	0.5900	6.00	8	3	4.00	30	12	1974
66.00	0.5900	0.5900	0.5900	0.5900	5.50	8	3	4.30	30	12	1974
63.00	0.5600	0.5600	0.5600	0.5600	6.50	8	3	5.00	30	12	1974
65.00	0.5700	0.5700	0.5700	0.5700	6.50	8	3	5.30	30	12	1974
77.00	0.5700	0.5700	0.5700	0.5700	6.50	8	3	6.00	30	12	1974
80.50	0.5900	0.5900	0.5900	0.5900	6.00	8	3	6.30	30	12	1974
81.50	0.6000	0.6000	0.6000	0.6000	6.00	8	3	7.00	30	12	1974
81.50	0.6250	0.6250	0.6250	0.6250	6.00	8	3	7.30	30	12	1974
83.50	0.6400	0.6400	0.6400	0.6400	5.00	8	3	8.00	30	12	1974
59.00	0.5200	0.5200	0.5200	0.5200	6.00	8	3	11.30	30	12	1974
60.00	0.5150	0.5150	0.5150	0.5150	3.00	8	3	14.00	30	12	1974
60.50	0.5100	0.5100	0.5100	0.5100	3.00	8	3	14.30	30	12	1974
60.50	0.4600	0.4600	0.4600	0.4600	2.00	8	3	15.30	30	12	1974
67.00	0.5900	0.5900	0.5900	0.5900	6.00	8	3	4.30	2	1	1975
62.00	0.6800	0.7000	0.7000	0.6500	2.50	8	3	13.30	2	2	1975
62.00	0.6400	0.6500	0.6600	0.6300	5.00	8	3	14.00	2	2	1975
87.00	0.7700	0.7700	0.7700	0.7600	6.00	8	3	0.00	9	2	1975
93.00	0.7900	0.7700	0.8000	0.8000	5.50	8	3	0.30	9	2	1975
99.00	0.8800	0.8700	0.8900	0.8900	5.00	8	3	1.00	9	2	1975

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Q	CTA	CTW	CTS	CTE	VEL	D	W	TIME	D	M	YEAR
60.50	0.6450	0.6400	0.6500	0.6600	2.00	8	4	3.30	14	12	1974
64.00	0.6700	0.6600	0.6800	0.6900	3.00	8	4	5.30	14	12	1974
67.00	0.5600	0.56[illegible]	0.5800	0.5700	2.50	8	4	1.30	3	2	1975
66.20	0.5500	0.5600	0.5800	0.5600	3.50	8	4	2.00	3	2	1975
67.00	0.5500	0.5500	0.5700	0.5600	4.00	8	4	2.30	3	2	1975
67.00	0.5600	0.5700	0.5800	0.5600	5.00	8	4	3.00	3	2	1975
67.00	0.5500	0.5500	0.5700	0.5500	3.50	8	4	3.30	3	2	1975
69.50	0.5400	0.5400	0.5500	0.5400	3.00	8	4	4.00	3	2	1975
67.20	0.5600	0.5700	0.5800	0.5600	2.50	8	4	4.30	3	2	1975
66.50	0.5800	0.5900	0.6100	0.5800	2.00	8	4	5.00	3	2	1975
67.00	0.5800	0.5800	0.5900	0.5700	4.00	8	4	5.30	3	2	1975

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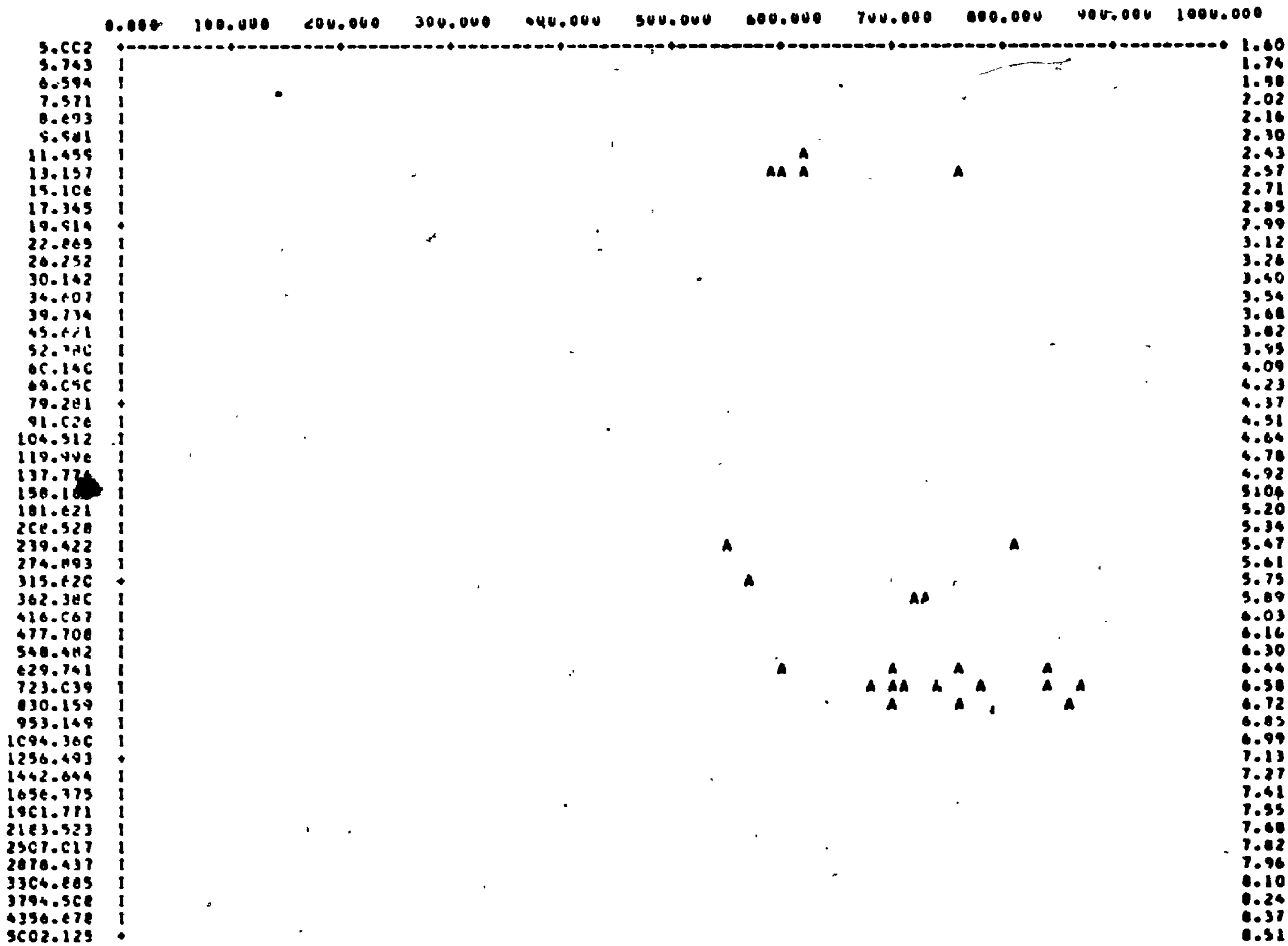
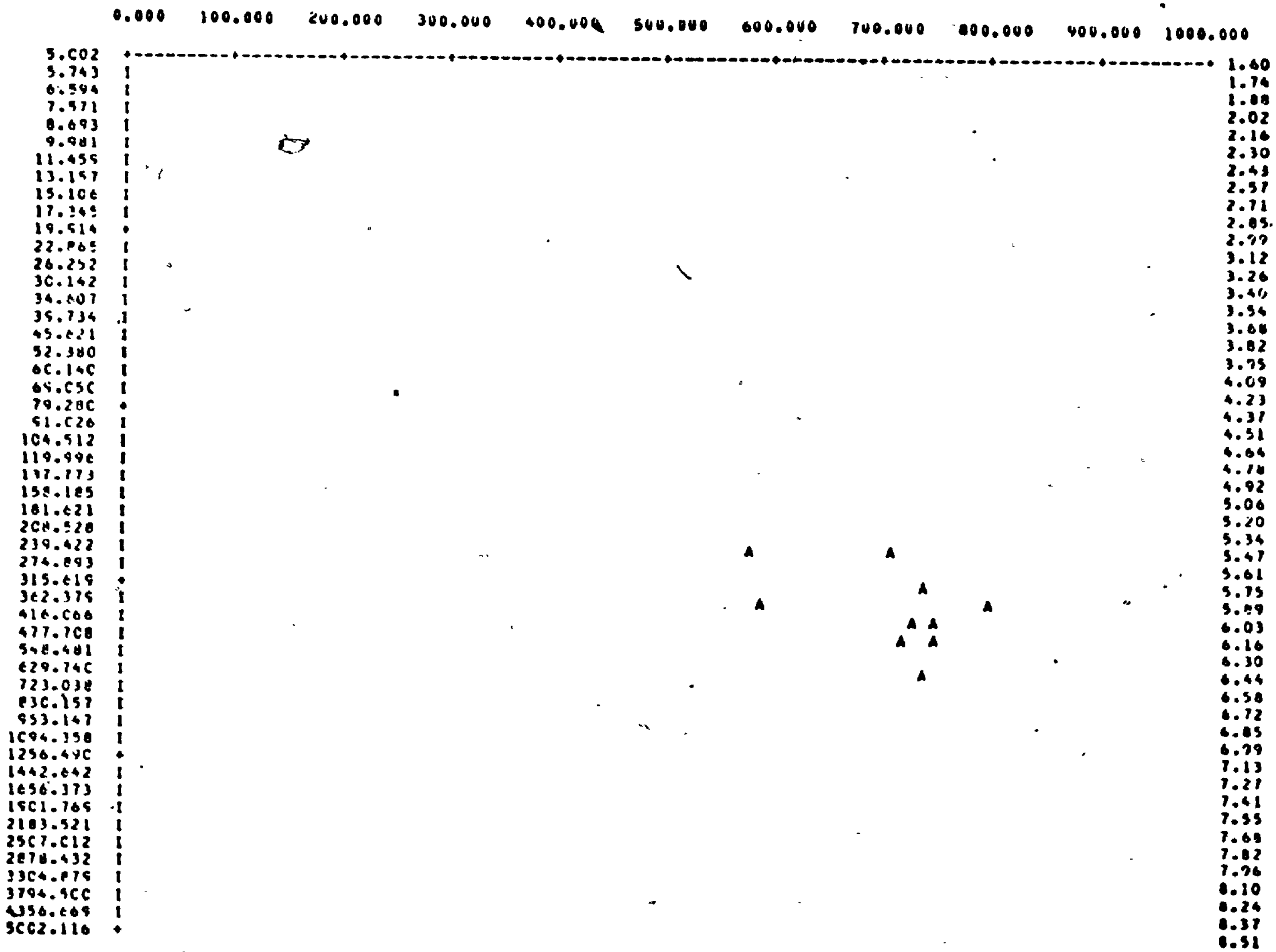
PARTLY CLOUDY
NORTH-WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



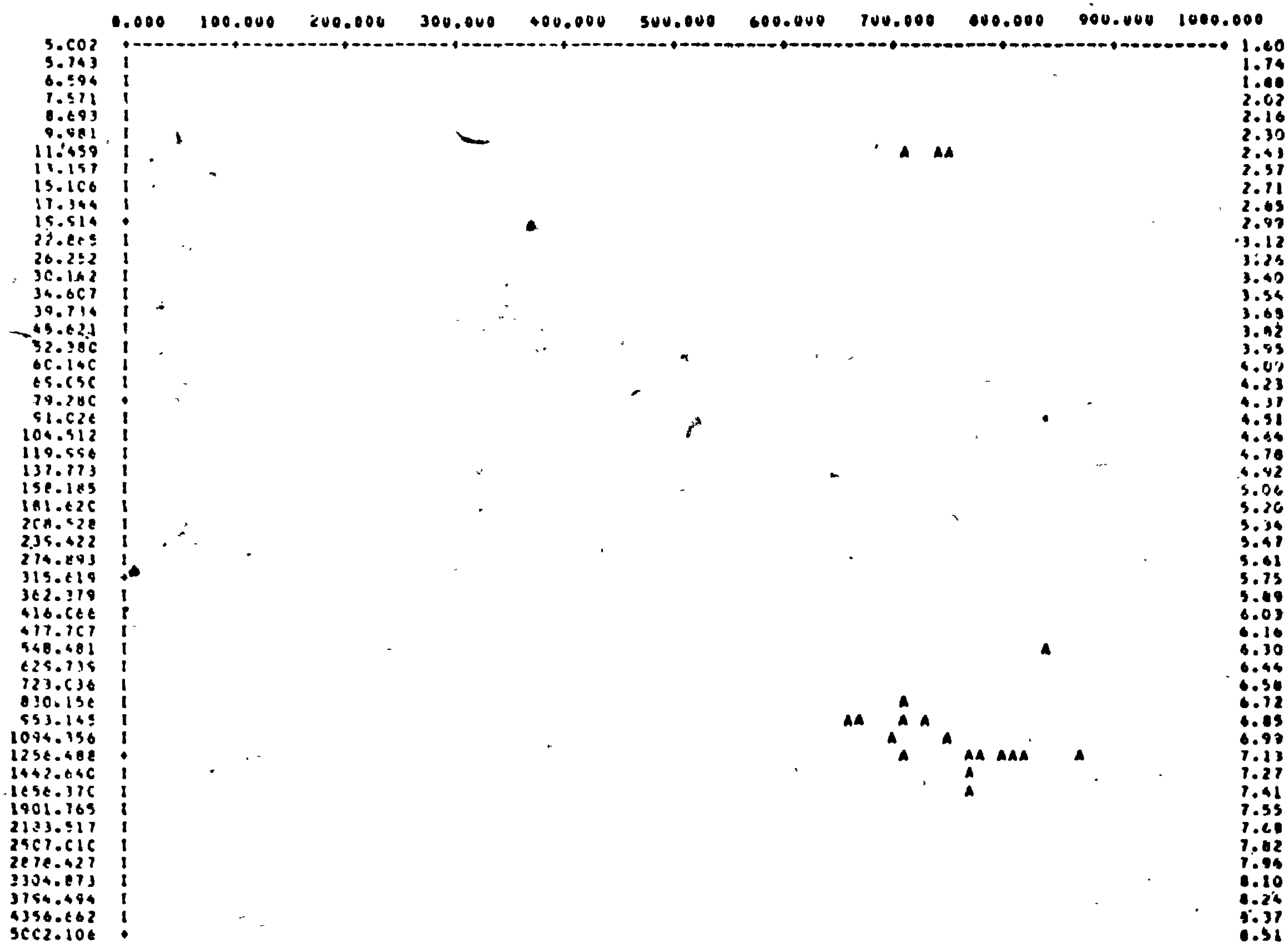
FACULTY OF ENGINEERING SCIENCE

CLEAR
NORTH-WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER x 10**-3



C	CTA	CTW	OTS	CTE	VEL	O	W	TIME	D	M	YEAR
62.00	0.5400	0.5400	0.5400	0.5400	0.10	8	5	23.30	31	12	1974
60.00	0.5200	0.5200	0.5300	0.5100	8.00	8	5	8.30	19	1	1975
60.40	0.5300	0.5250	0.5300	0.5200	11.00	8	5	9.00	19	1	1975
59.00	0.5200	0.5200	0.5200	0.5100	8.50	8	5	9.30	19	1	1975
59.00	0.5000	0.5000	0.5050	0.4900	7.50	8	5	10.00	19	1	1975
58.50	0.5050	0.5100	0.5100	0.4900	7.00	8	5	10.30	19	1	1975
59.80	0.5550	0.5650	0.5600	0.5500	7.50	8	5	11.00	19	1	1975
66.00	0.6200	0.6150	0.6300	0.6200	8.00	8	5	11.30	19	1	1975
66.50	0.5550	0.5550	0.5550	0.5550	0.10	8	5	6.00	6	2	1975
66.70	0.5600	0.5600	0.5600	0.5400	0.10	8	5	6.30	6	2	1975
69.00	0.5150	0.5150	0.5150	0.5150	4.50	8	5	11.00	6	2	1975
66.70	0.5500	0.5350	0.5450	0.5350	14.00	8	5	0.00	7	2	1975
67.00	0.5500	0.5400	0.5500	0.5300	12.00	8	5	0.30	7	2	1975
68.00	0.5600	0.5500	0.5600	0.5400	12.00	8	5	1.00	7	2	1975
72.00	0.5800	0.5600	0.5800	0.5600	11.00	8	5	1.30	7	2	1975
70.00	0.5700	0.5550	0.5700	0.5500	10.00	8	5	2.00	7	2	1975
72.50	0.5700	0.5550	0.5700	0.5550	11.00	8	5	2.30	7	2	1975
71.20	0.5900	0.5750	0.5850	0.5750	10.00	8	5	3.00	7	2	1975
68.50	0.5900	0.5700	0.5800	0.5600	9.50	8	5	3.30	7	2	1975
69.00	0.5900	0.5700	0.5800	0.5600	9.00	8	5	4.00	7	2	1975
76.00	0.6000	0.5800	0.6000	0.5750	10.00	8	5	4.30	7	2	1975
83.00	0.6300	0.6000	0.6300	0.5900	10.00	8	5	5.00	7	2	1975

PRECIPITATION
NORTH-WEST
NUSSELT NUMBER VERSUS REYNOLDS NUMBER X 10**-3



H-3 Sample Calculation

Using test number one:

Sunny conditions,

Northerly wind,

9:00 AM, December 14, 1974.

Q = 79.0 milli-volt

DTN = 0.81 "

DTW = 0.80 "

DTS = 0.82 "

DTE = 0.83 "

Wind velocity = 2.0 m.p.h.

= 2.0 x 1.467 = 2.93 ft/sec.

Dome diameter = 12 ft.

Dome surface area = $2\pi D^2/4$ = 72π

= 226.2 sq.ft.

Q = $(20.237 \times 79.0 + 0.038746 \times 79.0^2) \times 3.4129$

= 6281.6 BTU/hr.

DTN = (DTN/1.27) x 60.0 = (0.81/1.27) x 60.0

= 38.3°F

DTW = (DTW/1.27) x 60.0 = (0.80/1.27) x 60.0

= 37.8°F

DTS = (DTS/1.27) x 60.0 = (0.82/1.27) x 60.0

= 38.7°F

DTE = (DTE/1.27) x 60.0 = (0.83/1.27) x 60.0

= 39.1°F

Average temperature difference (interior-exterior):

$DT = (DTN+DTW+DTS+DTE) / 4 = 38.5^\circ F$

Overall heat transfer coefficient (forced convection):

$HO = Q / (AREA \times DT) = 6281.6 / (226.2 \times 38.5)$

$= 0.72$ BTU/hr.sq.ft.°F

Ambient air temperature (exterior):

$T = 60.0 - DT = 60.0 - 38.5 = 21.5^\circ F$

Calculation of ambient air properties:

Thermal conductivity:

$TC = T \times (0.0154 - 0.0133) / 100.0 + 0.0133$

$= 21.5 \times 0.0021 / 100.0 + 0.0133$

$= 0.0138$ BTU/hr.ft.°F

Density:

$RHO = T \times (0.071 - 0.086) / 100.0 + 0.086$

$= 21.5 \times (-0.0015) / 100.0 + 0.086$

$= 0.083$ lbm/cu.ft.

Viscosity:

$AMU = T \times (1.285 \times 10^{-5} - 1.110 \times 10^{-5}) / 100.0 + 1.110 \times 10^{-5}$

$= 21.5 \times 0.175 \times 10^{-5} / 100.0 + 1.110 \times 10^{-5}$

$= 1.1476 \times 10^{-5}$ lbm/ft.sec.

The Nusselt and Reynolds numbers are:

$XNU = HO \times DIAM / TC$

$= 0.72 \times 12 / 0.0138 = 627.2$

Log Nu = 2.797

$XRE = (RHO \times DIAM \times VEL) / AMU$

$= (0.083 \times 12 \times 2.93) / 1.1476 \times 10^{-5}$

$= 2.546 \times 10^5$

Log Re = 5.4059

H-4 Experimental Error Analysis

Using the same test as in the sample calculations, all instrument reading errors are taken into account and accumulated for maximum possible error.

Q, the energy input into the dome, measured in millivolts, ±0.5 mv. For maximum error, Q = 79.5.

The calculated energy input then is:

$$Q = (20.237 \times 79.5 + 0.008746 \times 79.5^2) \times 3.4129$$

$$= 6326.6 \text{ BTU/hr.}$$

The temperature difference between the inside and the outside of the dome was measured in millivolts, ±0.005 mv.

For maximum error, the average temperature difference is:

$$DT \times (0.815 / 0.82) =$$

$$38.5 \times (0.815 / 0.82) = 38.3^\circ F$$

This corresponds to a 0.61% error.

The wind velocity was measured in miles per hour, ±0.5 m.p.h. In this test the wind velocity was measured as 2 miles per hour and the maximum error is (2.5 - 2.0) / 2.0 x 100% = 25%.

It should be noted that at higher wind velocities the error due to this reading will reduce sharply.

With these values the heat transfer coefficient HO is:

$$HO = Q / (AREA \times DT) \quad \ldots.(60)$$

$$= 6326.6 / (226.2 \times 38.3) = 0.73$$

Therefore, the maximum error in HO is:

$$(0.73 - 0.72) / 0.72 \times 100\% = 1.4\%$$

The interpolations of the density, thermal-conductivity and viscosity are all directly proportional to the temperature and therefore the errors in these physical properties is 0.61%.

From this it follows that the maximum error in the Nusselt number is:

$$\left(\frac{1.014}{0.9939} \times 627.2\right) - 627.2 \; / \; 627.2 \times 100\% = 2.0\%$$

and the maximum error in the Reynolds number becomes:

$$\left(\frac{1.0061 \times 1.25}{0.9939}\right) \times 2.546 \times 10^5 - 2.546 \times 10^5$$

$$/ \; 2.546 \times 10^5 \times 100\% = 26.5\%$$

H-5 <u>Power Loss due to Air Leakage</u>

The rate of leakage (V) was found to be 32 cubic centimeters per minute.

For air: $C_p = 0.24$ BTU/lbm°F

$\rho = 0.081$ lbm/cu.ft.

The difference between the ambient dome temperature and the outside ambient temperature was 50°F maximum.

$$V = 32 \times 3.531 \times 10^{-5} \times 60 = 0.0678 \text{ cu.ft./hr.}$$

since 1 BTU/hr. = 0.2931 Watt and

$$Q = m \, C_p \, \Delta T: \quad \ldots.(61)$$

$$Q = 0.081 \times V \times 0.24 \times 50 \times 0.2931$$

$Q = 0.02$ Watt, which is the maximum power loss due to air leakage.

H-6 Power Loss due to Heat Transmission Through the Base

By using the analogy between heat flow and electrical flow, the one-dimensional steady-state head conduction equation may be re-written as:

$$Q/A = \Delta T / \Sigma R^{(7)} \qquad \ldots.(62)$$

Where ΣR is the sum of all effective thermal resistances in the system and ΔT the difference between the inside ambient dome temperature and the soil temperature just below the base.

R_1 is the thermal resistance between the air in the dome and the particle board.

R_1 is estimated to be 0.2[7].

R_2, the thermal resistance of the particle board is calculated as follows:

$$R_2 = L/k = \frac{5/8}{0.034 \times 12} = 1.53$$

where L is the thickness of the particle board.

For styrofoam:

$$R_3 = L/k = \frac{2}{0.02 \times 12} = 8.33$$

The contact resistance between the styrofoam and the soil is estimated to be $\frac{1}{2}R_1$.

$$R_4 = 0.1$$

$$\Sigma R = 0.2 + 1.53 + 8.33 + 0.1 = 10.16.$$

The lowest soil temperature below the dome was estimated as 45°F.

Then:

$$Q/A = (60 - 45) / 10.16 = 1.476 \text{ BTU/hr.sq.ft.}$$

and $$Q = \pi x 6^2 \times 1.476 = 167 \text{ BTU/hr.}$$

$$= 48.9 \text{ Watt.}$$

It should be noted that the circulation fan power input was 15 Watt. Therefore, the maximum power effectively lost due to heat transmission through the base and air leakage can be considered to be 48.9 + 0.02 - 15 = 33.92 Watts.

APPENDIX J

INFLUENCE OF THE WEATHER CONDITION

ON THE HEAT TRANSFER FROM THE INFLATABLE MODEL

This appendix contains the computer program used to analyse the calculated heat transfer results for all wind directions combined.

The computer output shows graphs relating the Nusselt and Reynolds Numbers by a best fitting straight line for all five weather classifications.

J-1 Computer Program and Output

Explanation of characters used in the graphs:

A - Data points. (Log Nu versus log Re)

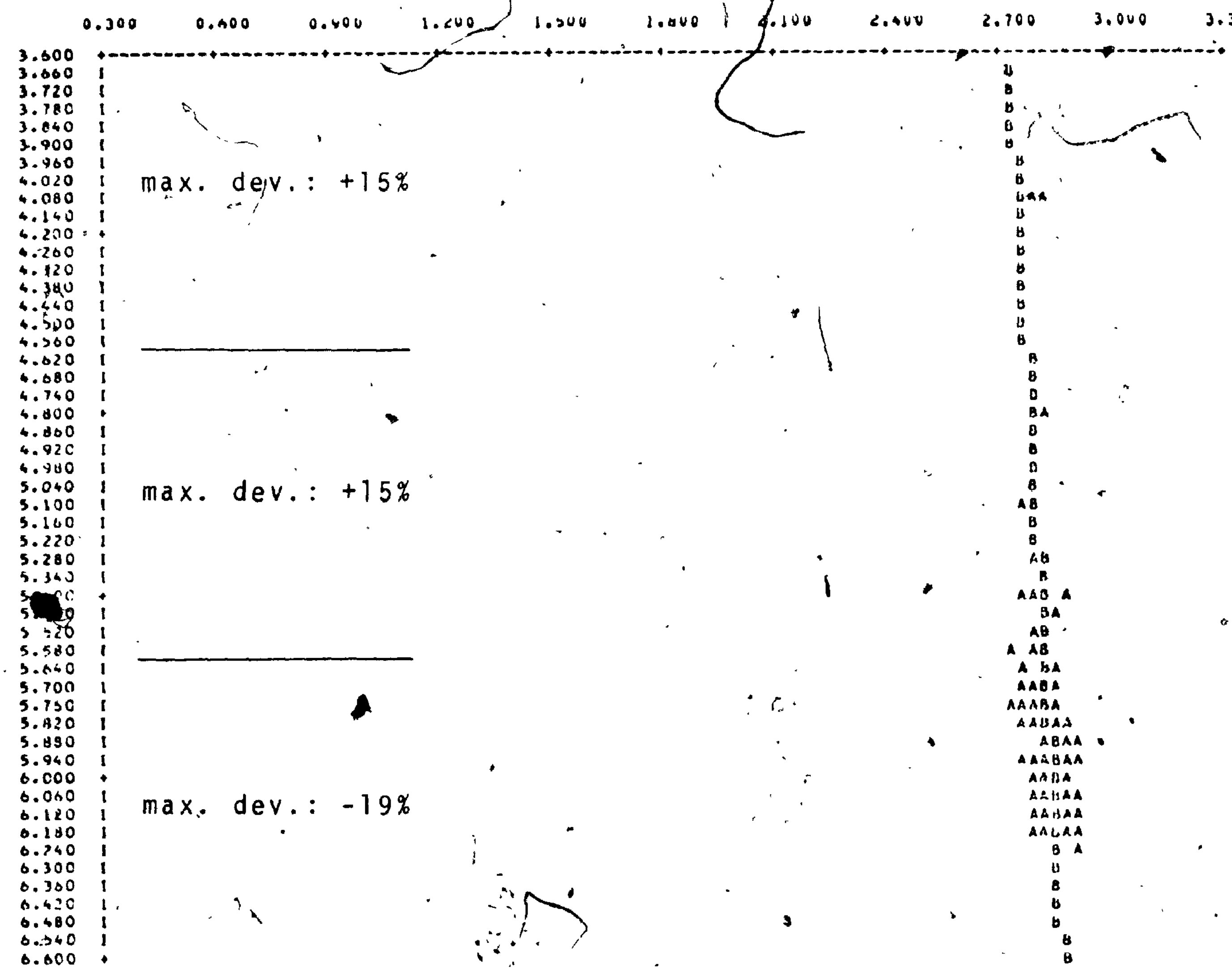
B - Best fitting straight line obtained by a least squares procedure.

The maximum deviation from the mean in the Nusselt Number for the Reynolds Number ranges of $10^{3.6}<Re<10^{4.6}$, $10^{4.6}<Re<10^{5.6}$ and $10^{5.6}<Re<10^{6.6}$ are indicated in the graphs.

```
PAGE    1

// JOB     1111

LOG DRIVE    CART SPEC    CART AVAIL   PHY DRIVE
  C000          1111         1111         0000

V2 M11    ACTUAL   8K   CONFIG   8K

// FOR
* IOCS (CARD,1403 PRINTER)
* ONE WORD INTEGERS
* LIST SOURCE PROGRAM
      DIMENSION XNU( 500),RE( 500),MWH(2)
      DO 1001 IX = 1,10
      READ (2,101)IWEOR
  101 FORMAT (I2)
      DIAM = 12.0
      AREA = 2*3.14159*(DIAM/2.)**2
      DO 1000 N = 1,500
      READ (2,100) Q,DTN,DTW,DTS,DTE,VEL
  100 FORMAT (F7.2,4F8.4,F7.2)
      IF (Q)2,1,1
    1 IF (DTW-0.001)6,7,7
    6 DTW = DTN
      DTS = DTN
      DTE = DTN
    7 Q = (20.237*Q+0.038746*Q**2)*3.4129
      DTN = (DTN/1.27)*60.
      DTW = (DTW/1.27)*60.
      DTS = (DTS/1.27)*60.
      DTE = (DTE/1.27)*60.
      DT = (DTN+DTW+DTS+DTE)/4.
      HC = Q/(AREA*DT)
      T = 60.-DT
      TC = T*(0.0154-0.0133)/100.+0.0133
      RHO = T*(0.071-0.086)/100.+0.086
      AMU = T*(1.285E-05-1.110E-05)/100.+1.110E-05
      VEL = VEL*1.467
      XNU(N) = (HC*DIAM)/TC
      XNU(N) = ALOG(XNU(N))/2.302585
      RE(N) = (RHO*DIAM*VEL)/AMU
 1000 RE(N) = ALOG(RE(N))/2.302585
    2 MWH(1) =N-1
      N = N-1
      MM = 1
      EX = 0
      EX2 = 0
      EY = 0
      EXY = 0
      DO 200 I = 1,N
      X = RE(I)
      Y = XNU(I)
      EX = EX + X
      EX2 =EX2 + X**2
      EY = EY + Y
  200 EXY = EXY + X*Y
      A = 1.0
      B = 1.0
      DO 205 J = 1,32000

PAGE    2
      AA = (EY-B*EX)/N
      BB = (EXY-AA*EX)/EX2
      IF (ABS(AA-A)-0.0001)210,210,215
  210 IF(ABS(BB-B)-0.0001)225,225,215
  215 A = AA
      B = BB
  205 CONTINUE
      WRITE (5,105)J
  105 FORMAT (I10)
  225 DO 235 I2 = 1,50
      I3 = N + I2
      Z = 3.6 +I2*3.0/50.
      XNU (I3) = A + B*Z
  235 RE(I3) = Z
      N = I3
      MWH (2) = I3
      MM = 2
      WRITE (5,102)
  102 FORMAT (1H1)
      GO TO (21,22,23,24,25),IWEOR
   21 WRITE(5,121)
  121 FORMAT(50X,' SUNNY')
      GO TO 4
   22 WRITE(5,122)
  122 FORMAT(50X,' CLOUDY')
      GO TO 4
   23 WRITE(5,123)
  123 FORMAT(50X,' PARTLY CLOUDY')
      GO TO 4
   24 WRITE(5,124)
  124 FORMAT(50X,' CLEAR')
      GO TO 4
   25 WRITE(5,125)
  125 FORMAT(50X,' PRECIPITATION')
    4 WRITE (5,103) A,B
  103 FORMAT (/,10X,'NU =',E15.5,' X RE **',E15.5)
      CALL CURVP (RE,XNU,3.6,6.6,0.0,3.0,N,0,MWH,MM)
 1001 CONTINUE
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
 IOCS

CORE REQUIREMENTS FOR
 COMMON        0  VARIABLES    2068   PROGRAM    728

END OF COMPILATION

// XEQ
```

SUNNY

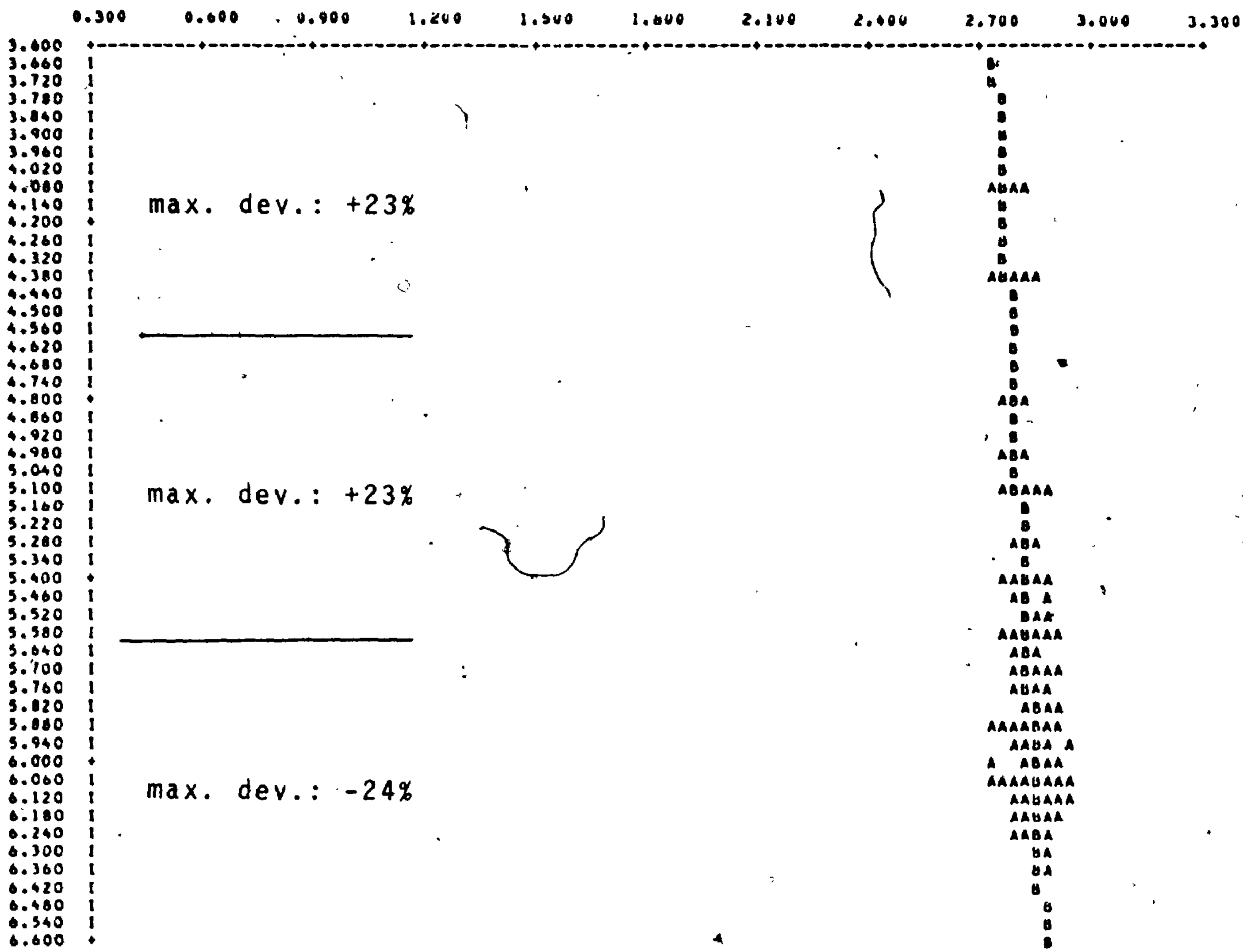
The Correlation Coefficient equals 0.46



10375

CLOUDY

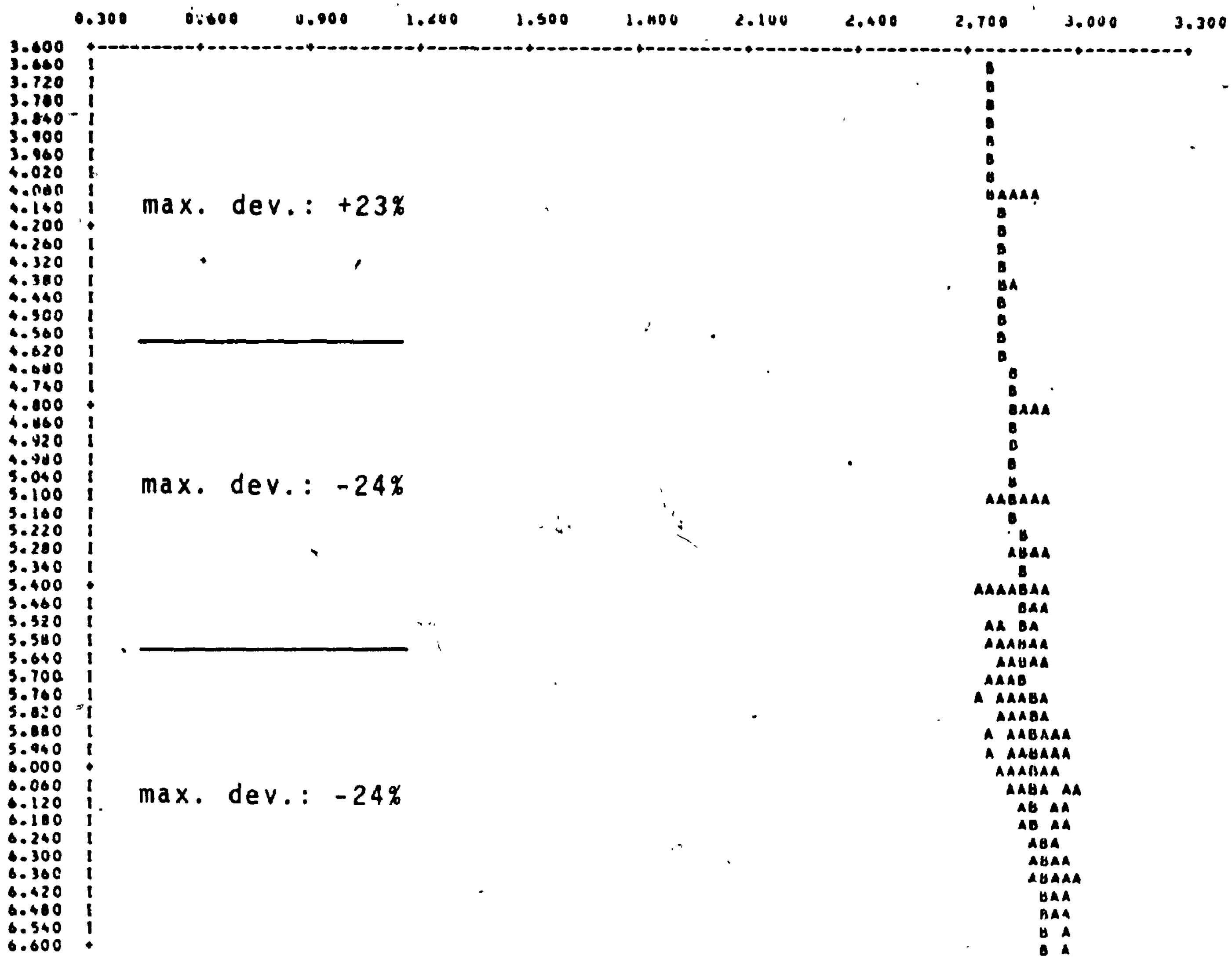
The Correlation Coefficient equals 0.62



10377

PARTLY CLOUDY

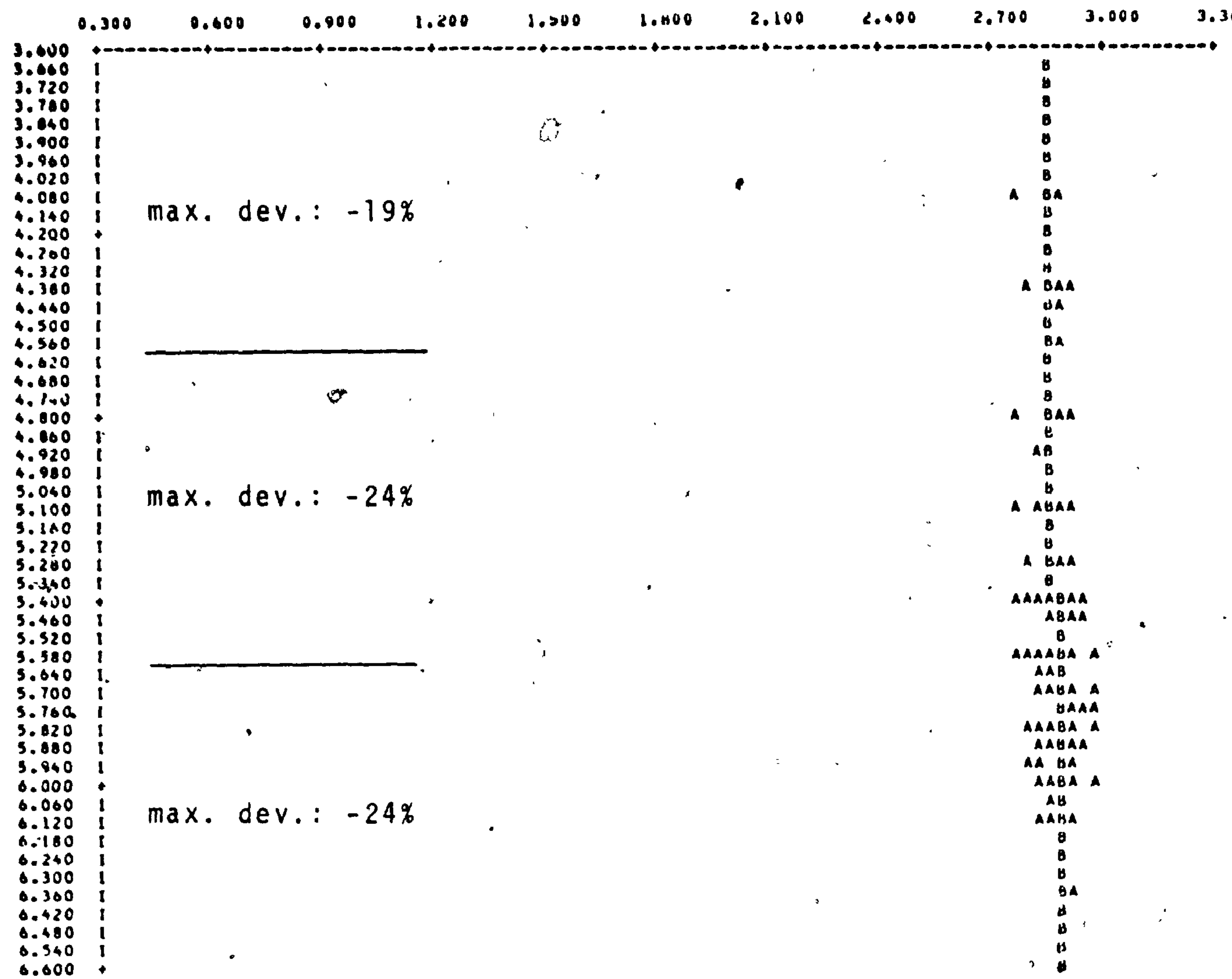
The Correlation Coefficient equals 0.53



10379

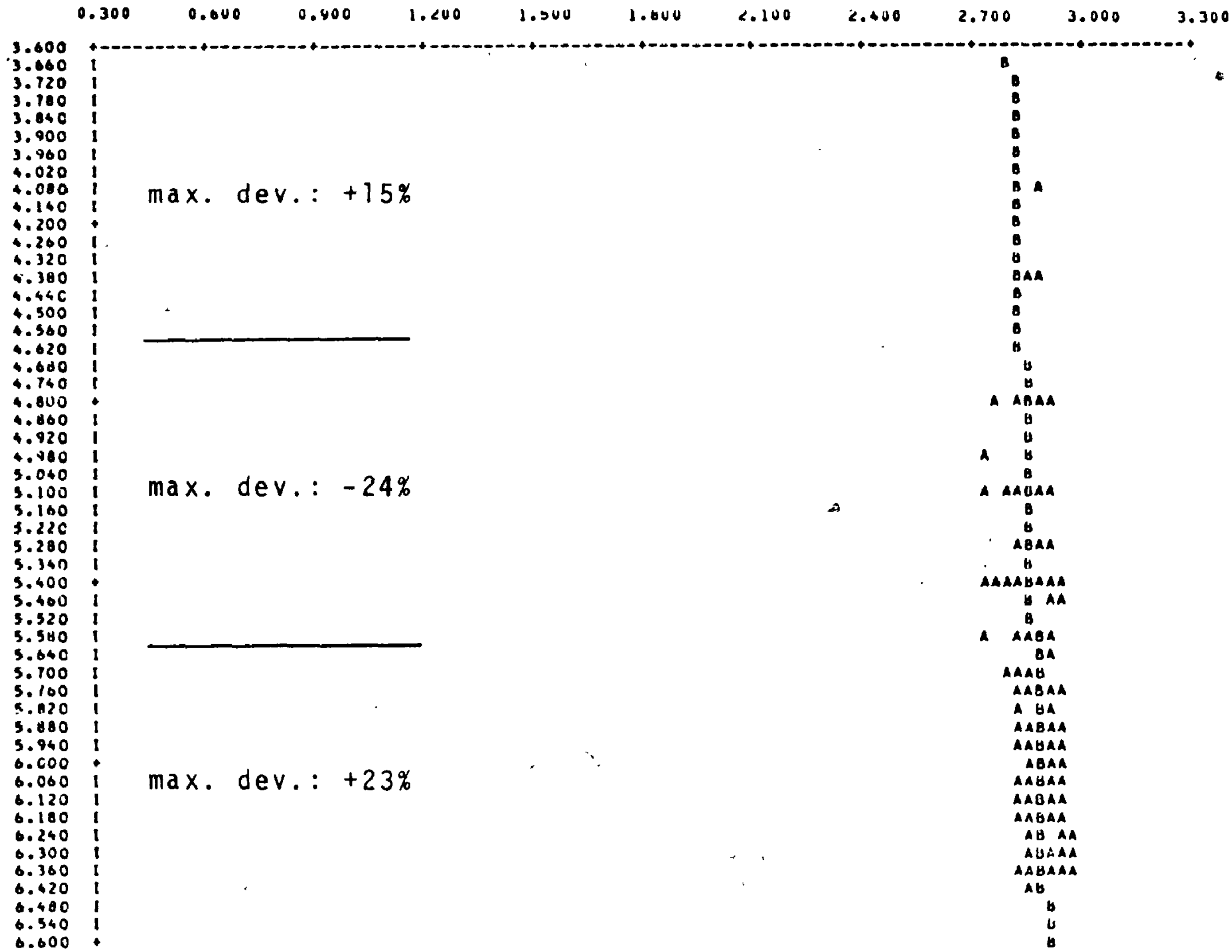
CLEAR

The Correlation Coefficient equals 0.18



PRECIPITATION

The Correlation Coefficient equals 0.33



10321

APPENDIX K

INFLUENCE OF THE WIND DIRECTION ON THE HEAT TRANSFER FROM THE INFLATABLE MODEL

This appendix contains the computer program used to analyse the calculated heat transfer results for all weather classifications combined.

The computer output shows graphs relating the Nusselt and Reynolds numbers by a best fitting straight line for all eight wind directions.

K-1 Computer Program and Output

Explanation of characters used in the graphs:

A - Data points. (Log Nu versus log Re)

B - Best fitting straight line obtained by a least squares procedure.

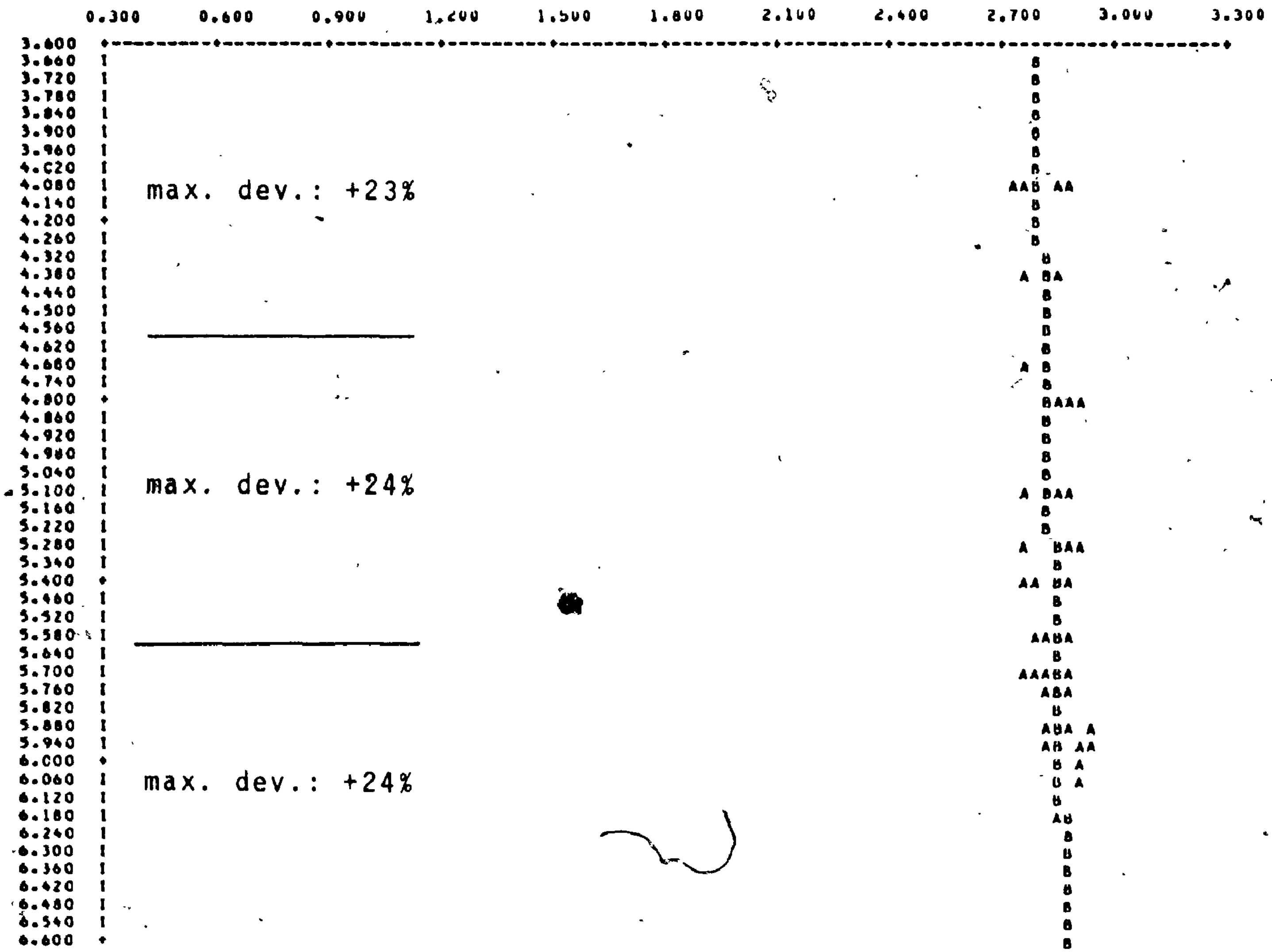
The maximum deviation from the mean in the Nusselt Number for the Reynolds Number ranges of $10^{3.6}<Re<10^{4.6}$, $10^{4.6}<Re<10^{5.6}$ and $10^{5.6}<Re<10^{6.6}$ are indicated in the graphs.

```
PAGE   1

// JOB    1111

LOG DRIVE   CART SPEC   CART AVAIL   PHY DRIVE
  0000        1111        1111         0000

V2 M11   ACTUAL  8K  CONFIG  8K

// FOR
* IOCS (CARD,1403 PRINTER)
* ONE WORD INTEGERS
* LIST SOURCE PROGRAM
      DIMENSION XNU( 500),RE( 500),MWH(2)
      DC 1001 IX = 1,10
      READ (2,101)IDIR
  101 FORMAT (I2)
      DIAM = 12.0
      AREA = *3.14159*(DIAM/2.)**2
      DO 1C00 N = 1,500
      READ (2,100) Q,DTN,DTW,DTS,DTE,VEL
  100 FORMAT (F7.2,4F8.4,F7.2)
      IF (C)2,1,1
    1 IF (DTW-0.001)6,7,7
    6 DTW = DTN
      DTS = DTN
      DTE = DTN
    7 Q = (20.237*C+0.038746*Q**2)*3.4129
      DTN = (DTN/1.27)*60.
      DTW = (DTW/1.27)*60.
      DTS = (DTS/1.27)*60.
      DTE = (DTE/1.27)*60.
      DT = (DTN+DTW+DTS+DTE)/4.
      HO = C/(AREA*DT)
      T = 60.-DT
      TC = T*(0.0154-0.0133)/100.+0.0133
      RHO = T*(0.071-0.086)/100.+0.086
      AMU = T*(1.285E-05-1.110E-05)/100.+1.110E-05
      VEL = VEL*1.467
      XNU(N) = (HO*DIAM)/TC
      XNU(N) = ALOG(XNU(N))/2.302585
      RE(N) = (RHO*DIAM*VEL)/AMU
 1000 RE(N) = ALOG(RE(N))/2.302585
    2 MWH(1) =N-1
      N = N-1
      MM = 1
      EX = 0
      EX2 = 0
      EY = 0
      EXY = 0
      DO 200 I = 1,N
      X = RE(I)
      Y = XNU(I)
      EX = EX + X
      EX2 =EX2 + X**2
      EY = EY + Y
  200 EXY = EXY + X*Y
      A = 1.0
      B = 1.0
      DO 205 J = 1,32000
      AA = (EY-B*EX)/N
```

```
      BB = (EXY-AA*EX)/EX2
      IF (ABS(AA-A)-0.0001)210,210,215
  210 IF(ABS(BB-B)-0.0001)225,225,215
  215 A = AA
      B = BB
  205 CONTINUE
      WRITE (5,105)J
  105 FORMAT (I10)
  225 DO 235 I2 = 1,50
      I3 = N + I2
      Z = 3.6 +I2*3.0/50.
      XNU (I3) = A + B*Z
  235 RE(I3) = Z
      N = I3
      MWH (2) = I3
      MM = 2
      WRITE (5,102)
  102 FORMAT (1H1)
      GO TO (21,22,23,24,25,26,27,28),IDIR
   21 WRITE(5,121)
  121 FORMAT(50X,' NORTH')
      GO TO 4
   22 WRITE(5,122)
  122 FORMAT(50X,' NORTH-EAST')
      GO TO 4
   23 WRITE(5,123)
  123 FORMAT(50X,' EAST')
      GO TO 4
   24 WRITE(5,124)
  124 FORMAT(50X,' SOUTH-EAST')
      GO TO 4
   25 WRITE(5,125)
  125 FORMAT(50X,' SOUTH')
   26 WRITE (5,126)
  126 FORMAT (50X,' SOUTH-WEST')
      GO TO 4
   27 WRITE (5,127)
  127 FORMAT (50X,' WEST')
      GO TO 4
   28 WRITE (5,128)
  128 FORMAT (50X,' NORTH-WEST')
    4 WRITE (5,103) A,B
  103 FORMAT (/,10X,'NU =',E15.5,' X RE **',E15.5)
      CALL CURV9 (RE,XNU,3.6,6.6,0.0,3.0,N,0,MWH,MM)
 1001 CONTINUE
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
 IOCS

CORE REQUIREMENTS FOR
 COMMON       0  VARIABLES   2068  PROGRAM    768

END OF COMPILATION

// XEQ
```

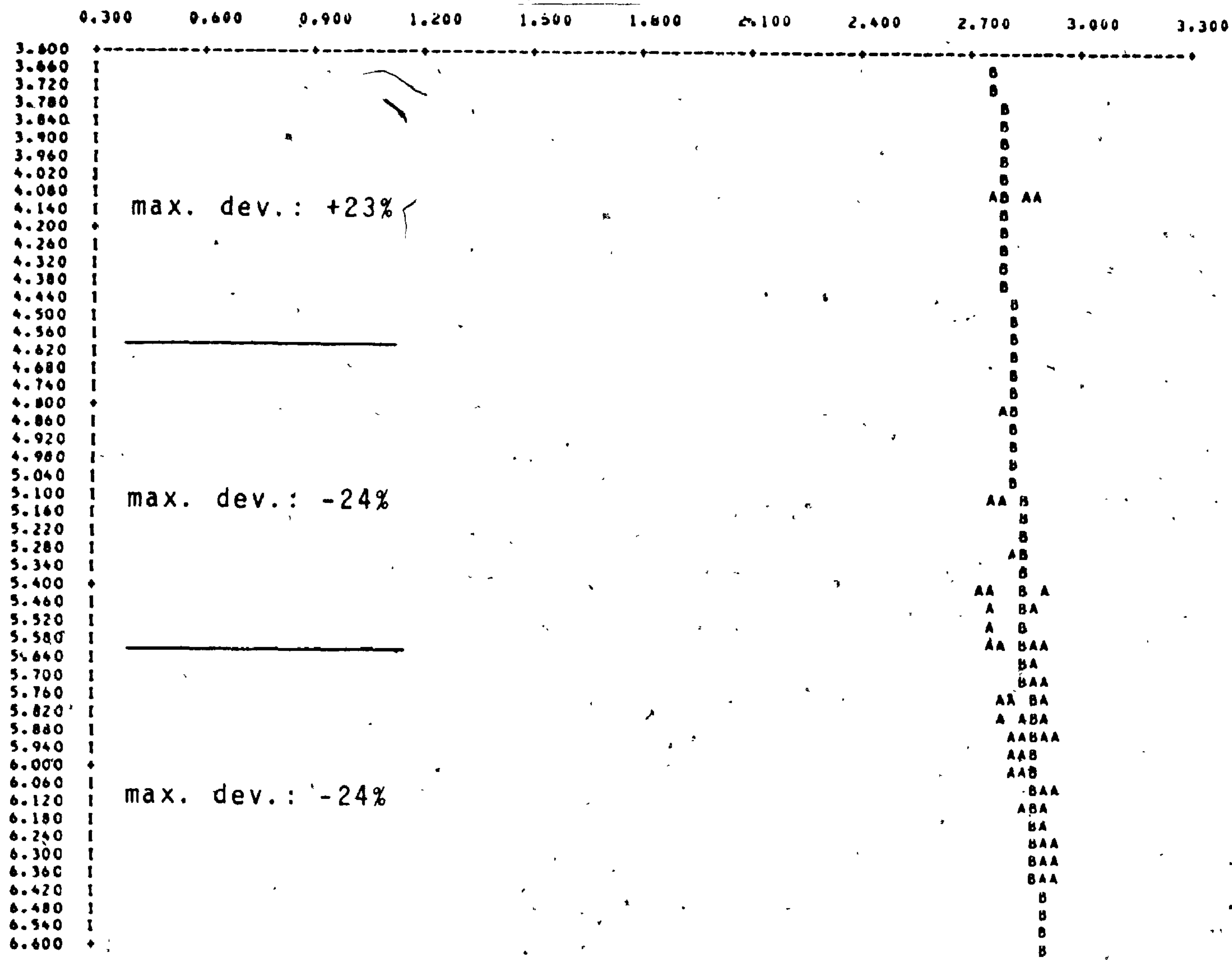
NORTH

The Correlation Coefficient equals 0.39



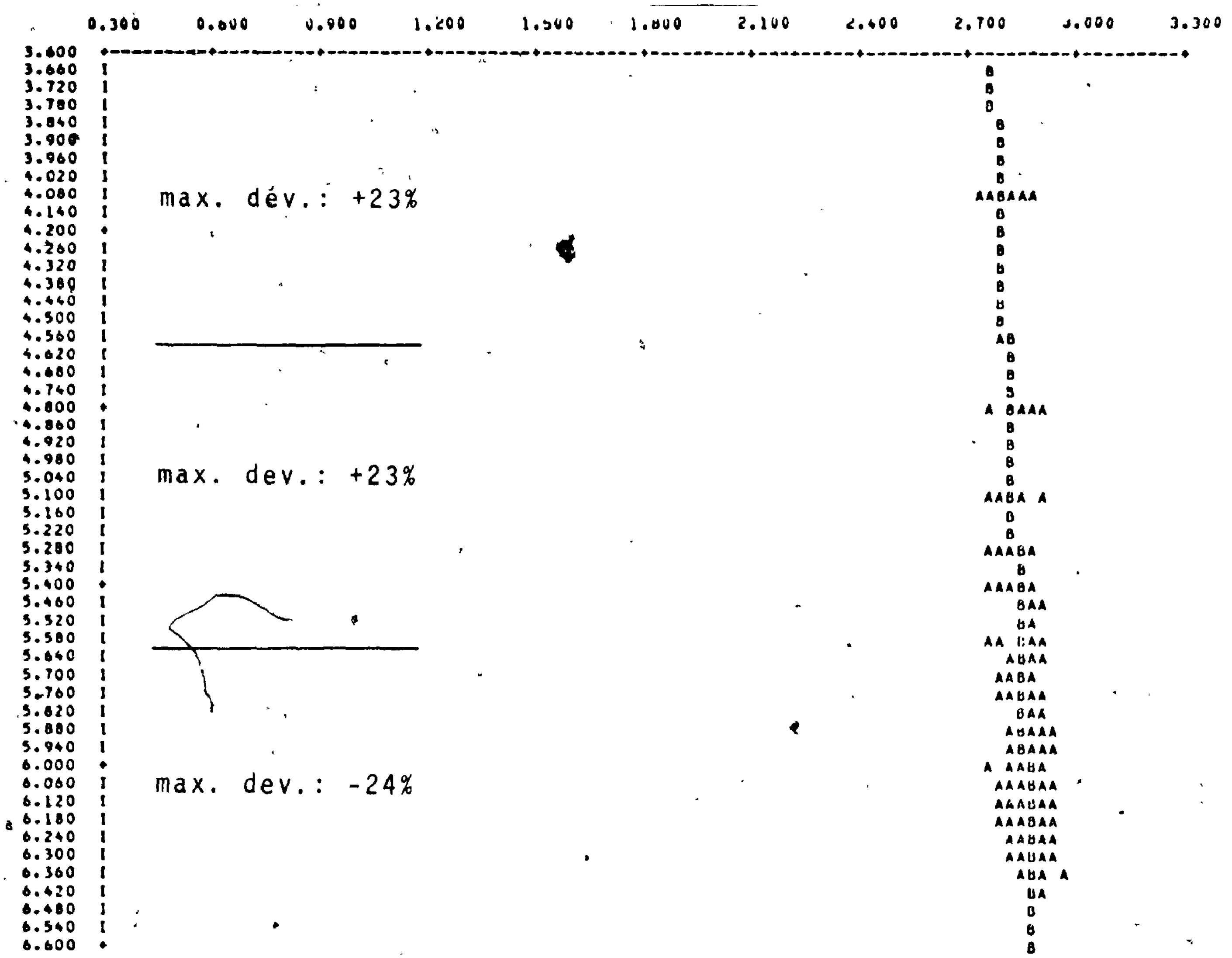
NORTH-WEST

The Correlation Coefficient equals 0.53



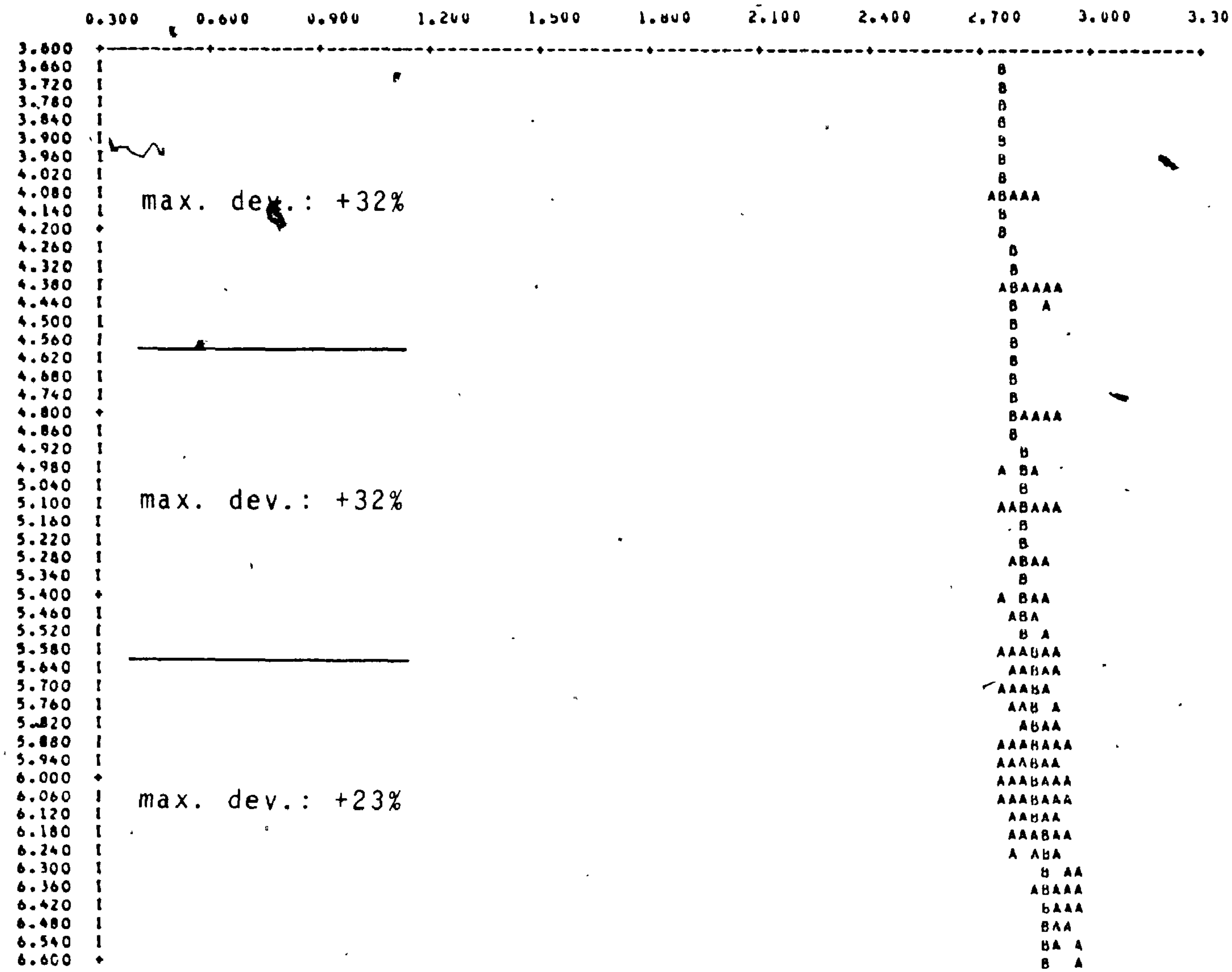
WEST

The Correlation Coefficient equals 0.46



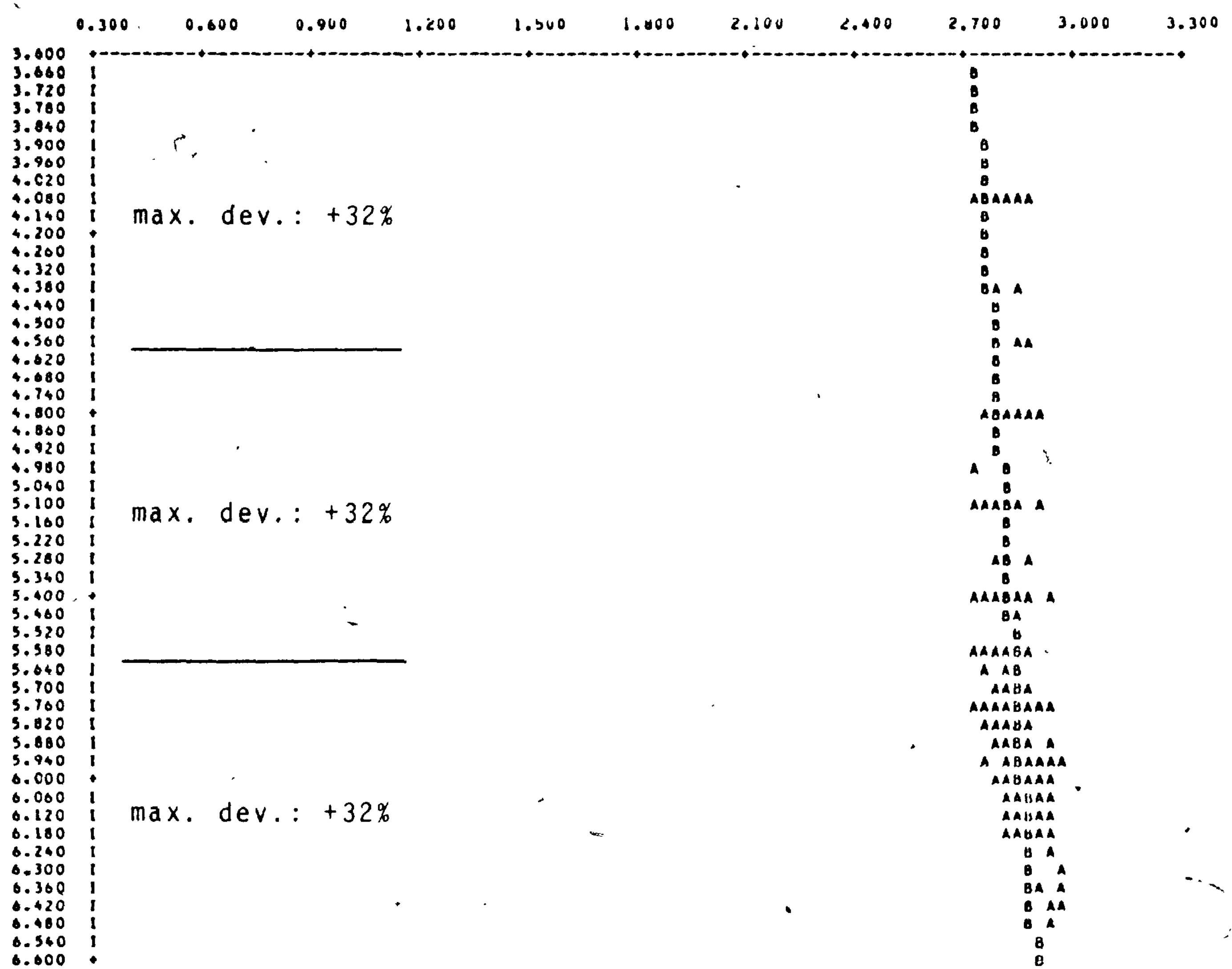
SOUTH-WEST

The Correlation Coefficient equals 0.47



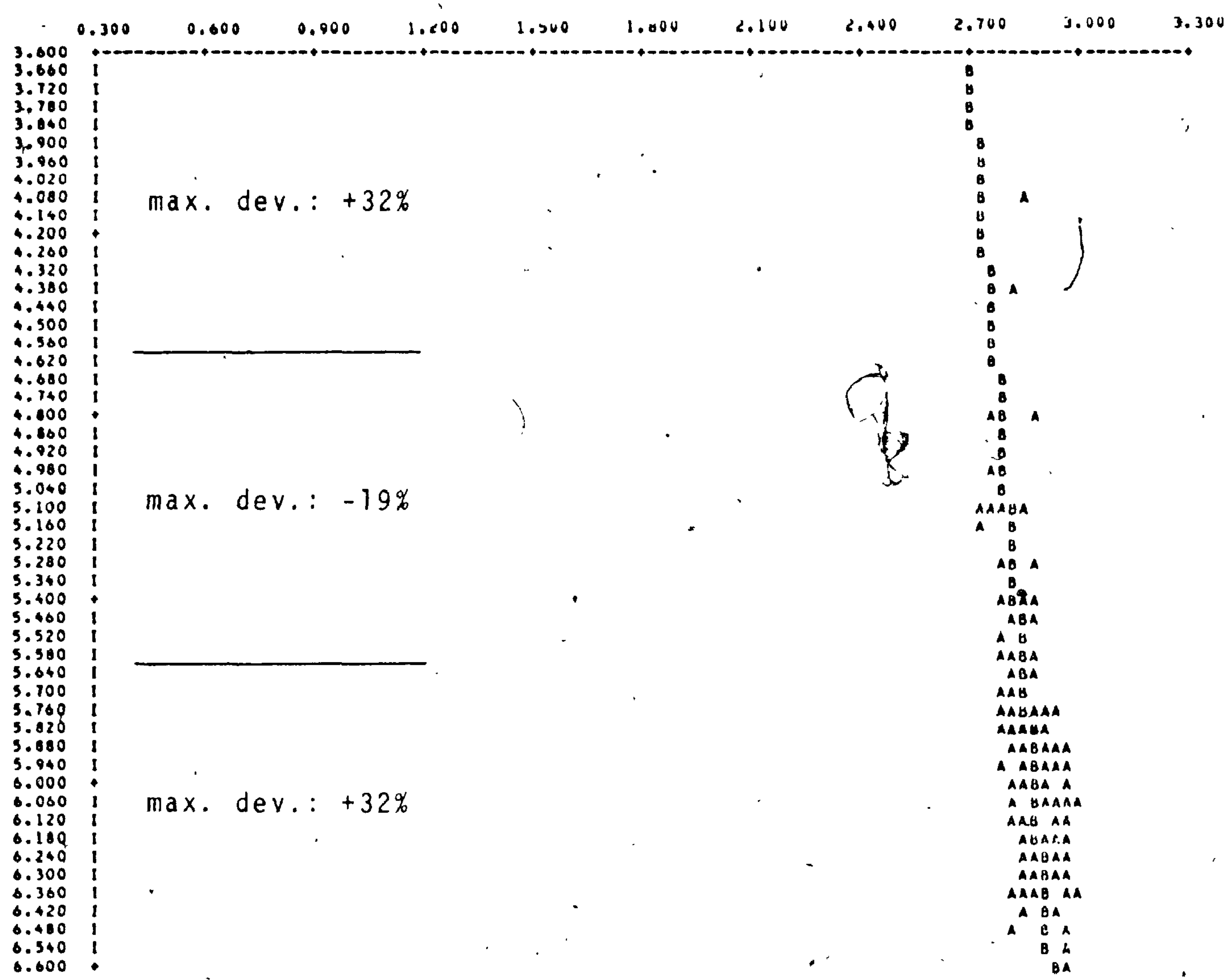
SOUTH

The Correlation Coefficient equals 0.48



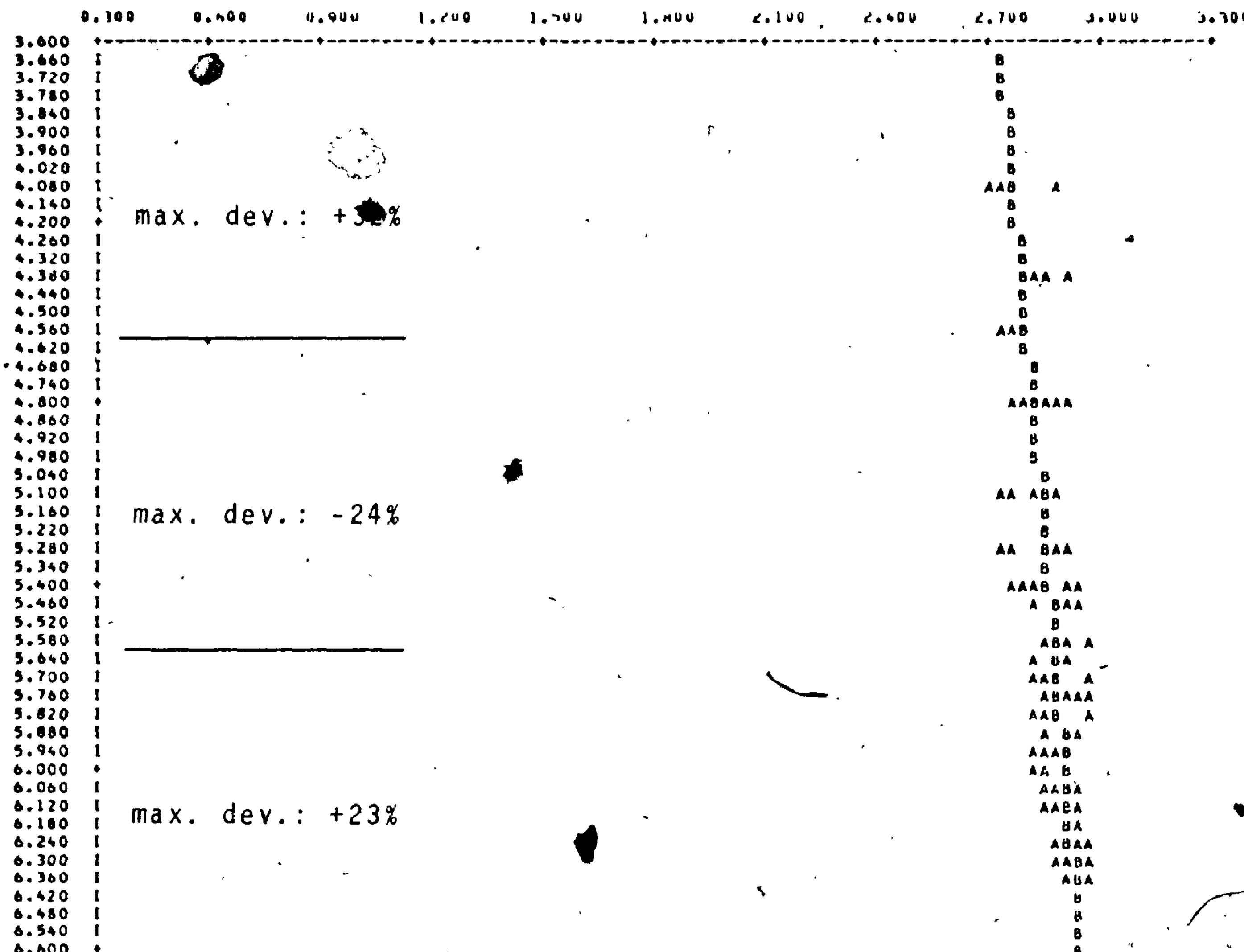
SOUTH-EAST

The Correlation Coefficient equals 0.58



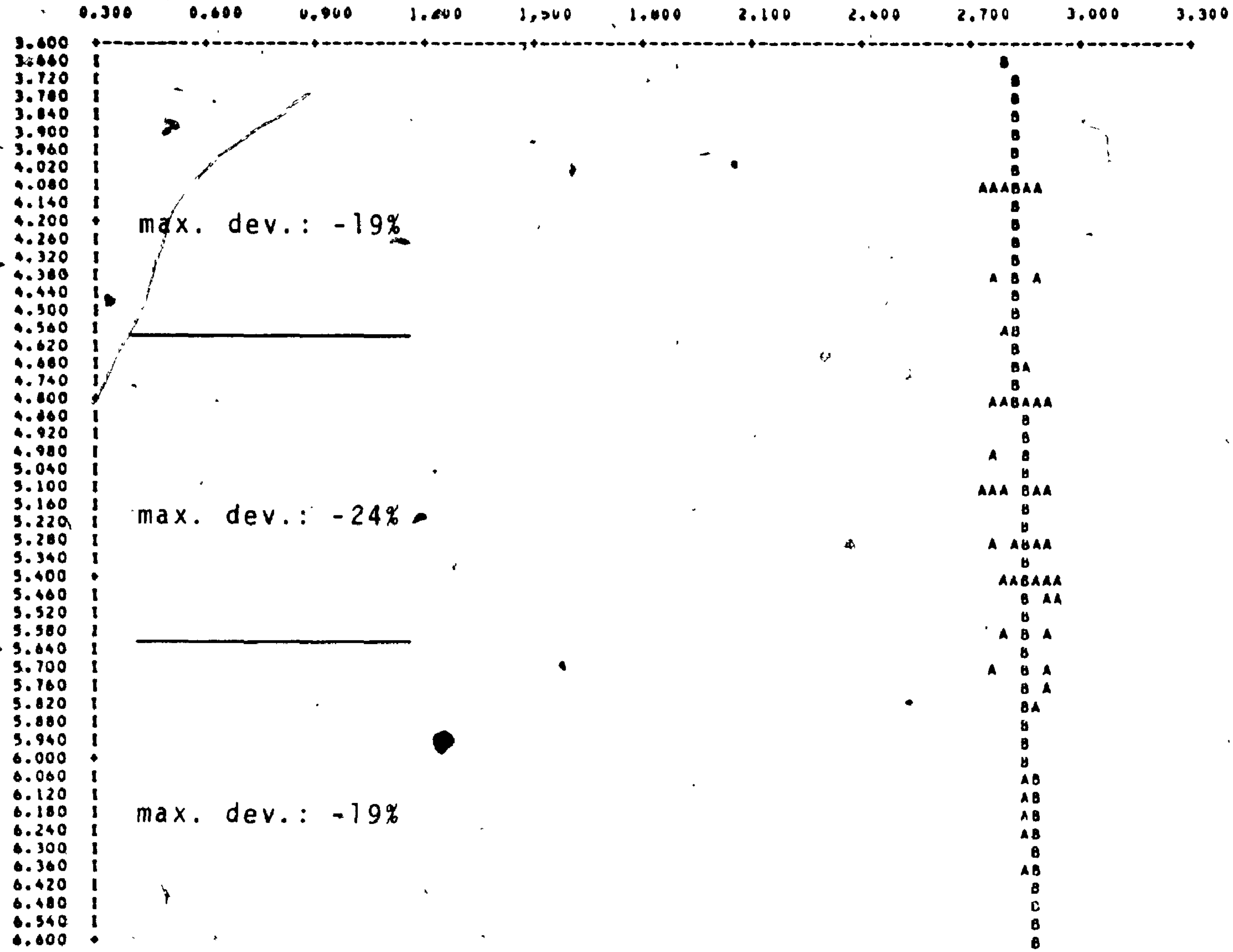
EAST

The Correlation Coefficient equals 0.64



NORTH-EAST

The Correlation Coefficient equals 0.30



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