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MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
NAVAL SUPERSONIC LABORATORY

Technical Report 303

A HIGH TEMPERATURE STREAM TUBE  
FOR A SUPERSONIC WIND TUNNEL

by

Richard H. Adams

May 1958

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
Naval Supersonic Laboratory  
Cambridge, Massachusetts

Technical Report 303

A HIGH TEMPERATURE STREAM TUBE  
FOR A SUPERSONIC WIND TUNNEL

Fifth Quarterly Progress Report  
Contract Nonr 1841(40)  
February, March, April 1958

Sixth Quarterly Progress Report  
Contract AF33(616)-3909  
February, March, April 1958

This report describes the design, construction, and calibration of a hot core circuit for the supersonic wind tunnel at the Naval Supersonic Laboratory (NSL). This work was supported out of NSL funds. However, the need for this device was clearly established in the course of work under our infrared contracts and it will be used extensively in tests for these projects. Accordingly, it seems appropriate to identify this as an Infrared Progress Report since knowledge of this facility will assist in a better understanding of tests that will be described later in this series and it may also suggest to those active in the infrared field, realistic environmental tests that might be made of their equipment.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
Naval Supersonic Laboratory  
Cambridge, Massachusetts

Technical Report 303

A HIGH TEMPERATURE STREAM TUBE  
FOR A SUPERSONIC WIND TUNNEL

May 1958

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## FOREWORD

This report was submitted in thesis form in partial fulfillment of the requirements for the degrees of Bachelor of Science and Master of Science in the Department of Aeronautical Engineering at the Massachusetts Institute of Technology, May 26, 1958. Professor John R. Markham served as Thesis Advisor.

## ABSTRACT

The increasing desirability of obtaining aerodynamic heating data at supersonic Mach numbers led to the development of a method of injecting a high temperature stream tube into a supersonic wind tunnel. A "core" of high temperature air injected slightly downstream of the throat of the Naval Supersonic Laboratory Supersonic Wind Tunnel's Mach 3.5 nozzle produces a relatively constant Mach number and temperature region in the 18 inch x 18 inch test section. This region of 900°F stagnation temperature air was approximately 7 inch x 7 inch and caused no appreciable heating of the tunnel structure. The 7 inch x 7 inch "hot" test area is approximately the blocking area of the test section. Thus by heating only one-sixth of the total mass flow of air in the test section the same aerodynamic heating models may be tested as if the entire mass flow were heated.

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## LIST OF SYMBOLS

|            |                                                        |
|------------|--------------------------------------------------------|
| $C_p$      | Specific heat at constant pressure for air             |
| $D$        | Diameter of hot core stilling section                  |
| $\bar{F}$  | Scaling factor                                         |
| $h_c$      | Half-height of hot core                                |
| $h_t$      | Half-height of test section                            |
| $\bar{h}$  | Nozzle generating function                             |
| $k$        | Thermal conductivity of air                            |
| $l$        | Distance between oblique shock and pitot shock         |
| $L$        | A characteristic length                                |
| $M$        | Mach number                                            |
| $\bar{M}$  | Mach number on nozzle axis                             |
| $p$        | Pressure                                               |
| $p_p$      | Pitot pressure                                         |
| $p_{p_s}$  | Pitot pressure behind an oblique shock                 |
| $Pr$       | Prandtl number                                         |
| $Re$       | Reynolds number                                        |
| $T$        | Temperature                                            |
| $T_1$      | Absolute temperature of the flow at velocity $U$       |
| $u, U$     | Stream velocity in x-direction                         |
| $U_0$      | $u$ of surrounding stream                              |
| $U_1$      | Largest $u$ in jet                                     |
| $U_{10}$   | $u - U_0$                                              |
| $U'$       | Resultant velocity in diverging nozzle                 |
| $v$        | Stream velocity in y - direction                       |
| $w$        | Mass flow                                              |
| $x, y, z$  | Cartesian coordinates                                  |
| $x_i, y_i$ | Coefficients in power series expansion for streamlines |
| $\alpha$   | $\sqrt{\mu_0 / \rho_0 \mu_0}$                          |
| $\gamma$   | Specific heat ratio for air                            |
| $\delta$   | Wedge angle                                            |
| $\delta'$  | Effective wedge angle (including boundary layer)       |

## LIST OF SYMBOLS (Concluded)

|            |                          |
|------------|--------------------------|
| $\epsilon$ | Emissivity               |
| $\eta$     | Streamline parameter     |
| $\mu$      | Coefficient of viscosity |
| $\xi$      | Potential line parameter |
| $\rho$     | Density                  |
| $\omega$   | Mass flow                |

### Subscripts

|   |                                       |
|---|---------------------------------------|
| o | Stagnation                            |
| c | Conditions in core                    |
| s | Conditions in stream surrounding core |

### Superscripts

|   |                            |
|---|----------------------------|
| * | Condition at nozzle throat |
|---|----------------------------|

## 1. INTRODUCTION

As the Mach numbers of aircraft and missiles increase, it is becoming more important to duplicate the aerodynamic heating which vehicles will encounter in flight through the atmosphere. It is well known that the vehicle is aerodynamically heated by high stagnation temperature air and that this heating is partially balanced by radiation to the cold surrounding medium.

The obvious tool for duplicating flight conditions is a high stagnation temperature wind tunnel. However, many difficulties arise when an attempt is made to obtain high stagnation temperatures by heating the wind tunnel air stream. Mechanical and structural difficulties arise in the wind tunnel when it is exposed to high temperatures, especially in the nozzle which distorts with thermal stresses unless an intricate cooling system is employed. Valves and other moving parts must be able to operate at the high temperatures to which they are exposed. Due to the loss of strength and the phenomenon of scaling at high temperatures it is necessary to employ stainless steel or other high temperature alloys throughout the system which are costly and difficult to machine. Large wind tunnels (100 in<sup>2</sup> test sections and up) used for testing reasonably sized models require large mass flow rates of air. The expense of heating the mass flow rates required is very high and in many cases where electric heaters would be used the power required is not available.

The Naval Supersonic Laboratory (NSL) is currently operating a hypersonic wind tunnel at a stagnation temperature of 1000°F. However, it was desirable to have heat transfer data on larger models than can be tested in this tunnel. Heating the main 18" x 18" supersonic wind tunnel air stream was undesirable due to the above mentioned problems.

A method of alleviating these problems is to heat only the central portion of the airstream to which the model is exposed. This reduces the high temperature mass flow to a fraction of the total mass flow and confines mechanical and structural difficulties due to heating to a relatively small circuit necessary to carry this small mass flow. It also provides the aerodynamically heated model with a cold surrounding medium to which it radiates, namely the cold test section walls.

The NACA Lewis Flight Propulsion Laboratory has shown through a preliminary investigation that a heated core wind tunnel is feasible (Reference 1). Upon the basis of this investigation and the increasing desirability to obtain aerodynamic heating data on large models, a heated core installation was undertaken at NSL. This installation was to make use of existing equipment at NSL to the fullest extent possible. Any additions were not to hinder the use of the supersonic wind tunnel under ordinary operation. Any equipment that could hinder the use of the supersonic wind tunnel was to be easy to install and remove.

## 2. NOTES ON THE THEORY OF MIXING BETWEEN A HIGH TEMPERATURE STREAM TUBE AND A SURROUNDING COLD STREAM

Although the method of approach to obtaining an operational heated core installation was primarily empirical it should be noted that the problem of mixing has been solved for various cases due to the interest in jet and rocket propelled aircraft. A general knowledge of what to expect of a stream tube in a wind tunnel may be obtained from these solutions.

Consider the problem of introducing a stream tube of high temperature air into a supersonic wind tunnel. The core of heated air must be introduced into the main stream via a nozzle which itself can be formed to follow the stream tube. In the absence of viscosity and by matching pressures and Mach numbers at the exit of an infinitesimally thin heated core nozzle, the heated air will follow the stream tube of the area at which it is introduced into the supersonic stream. However the exhausting nozzle must be of finite thickness, and large velocity and temperature differences may exist between the core and the surrounding stream. Thus it is reasonable to suspect that between the core and the surrounding stream there will exist a mixing region, due to slight turbulence caused by the finite size of the exhausting nozzle, viscous effects, boundary layer from the exhausting nozzle and heat transfer.

Since the exhausting nozzle may be fabricated relatively thin and tapered to zero thickness, turbulence induced by the nozzle may be considered negligible as a first approximation. As a first approximation the boundary layer will also be neglected. Consider a nozzle exhausting uniform

velocity flow into a uniform velocity stream. The temperature and velocity distribution throughout the flow may be considered governed by the solution of the problem of two dimensional laminar jet mixing of a viscous compressible fluid.

The equation of motion governing this mixing is

$$\rho u \frac{\partial u}{\partial x} + \rho v \frac{\partial u}{\partial y} = \frac{\partial}{\partial y} \left( \mu \frac{\partial u}{\partial y} \right) \quad (2.1)$$

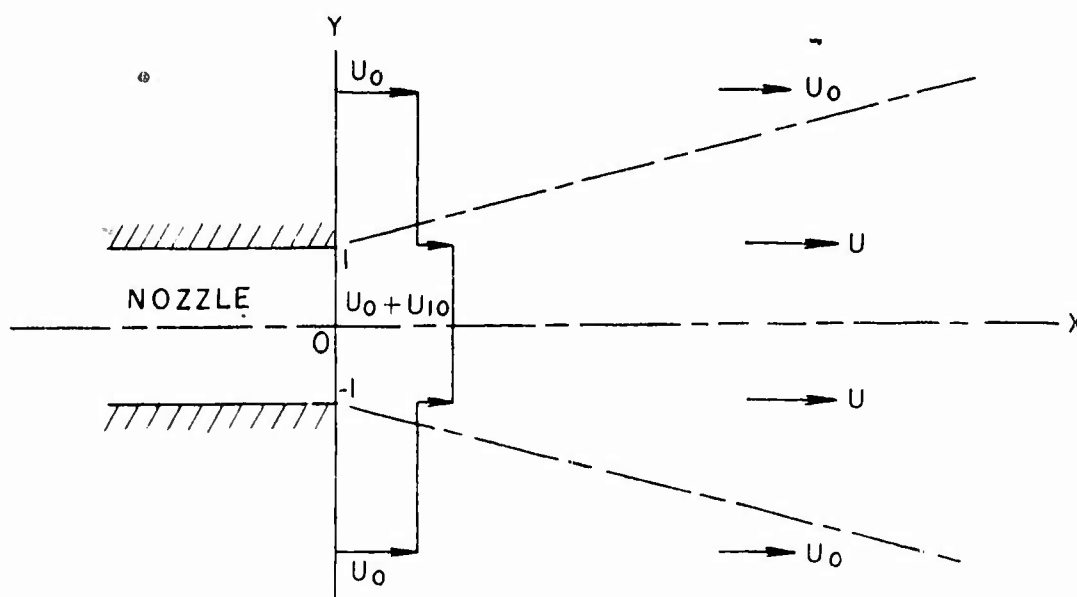
The equation of continuity is

$$\frac{\partial \rho u}{\partial x} + \frac{\partial \rho v}{\partial y} = 0 \quad (2.2)$$

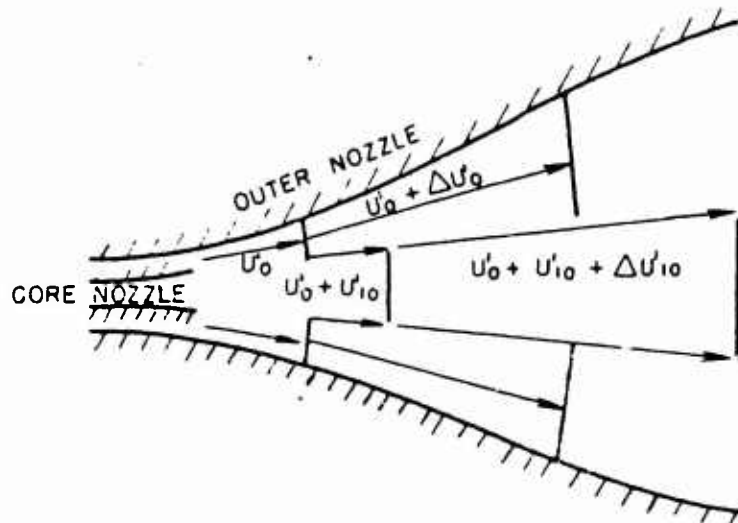
The energy equation is

$$\rho u \frac{\partial C_p T}{\partial x} + \rho v \frac{\partial C_p T}{\partial y} = \frac{\partial}{\partial y} \left( k \frac{\partial T}{\partial y} \right) + \mu \left( \frac{\partial u}{\partial y} \right)^2 \quad (2.3)$$

These equations describe two dimensional laminar jet mixing and have been solved by Pai (Reference 2) for the case of a two dimensional jet in a uniform stream of velocity  $U_0$  by the method of successive approximations.



This is the same type of problem encountered in the case of the heated core except for the fact that the heated core is an expanding stream tube, increasing in velocity in the  $x$  - direction, as illustrated below.



Without actually solving the latter case, which is complicated by the varying  $x$  - velocity, we may conclude that the shape of the temperature and velocity distribution curves in the mixing region of the former case will be similar to that of the heated core. Typical temperature and velocity distribution curves reproduced from Reference 3 are shown in Figure 1. Note that the temperature curve is slightly wider than the corresponding velocity distribution curve.

### 3. THE NACA LEWIS LABORATORY HEATED CORE SUPERSONIC WIND TUNNEL

The NACA Lewis Laboratory made a preliminary investigation into heating the central core of air in the test section of a supersonic wind tunnel (References 1 and 4).

This investigation was carried out at Mach numbers 1.9 and 3.0. The test section for each nozzle was 18 inches by 18 inches. Air for the heated core portion of the test section was heated to 500°F in a parallel arrangement of four jet-engine combustors using JP-4 fuel. The core nozzle was designed to parallel the streamlines induced by the walls of the subsonic portion of the main tunnel nozzle in order to avoid choking upstream of the throat. This nozzle which was entirely convergent in order

to create sonic flow at its exit, theoretically would create a 9 inch by 9 inch core in the test section.

The NACA did investigate partially:

1. Four axial locations of the core nozzle exit plane, i.e., 3 inches upstream, 1 inch upstream, 1 inch downstream of the tunnel throat, and at the tunnel throat.
2. A rectangular core nozzle exit.
3. Various stagnation pressure ratios of core to cold stream.
4. Temperature and Mach number profiles at several stations in the test section region.

The NACA did not investigate in detail:

1. Diffusion of the interface layer separating the hot and cold streams.
2. Effect of the area of the core nozzle exit.
3. Effect of the geometry of the core nozzle exit.
4. Positioning of the exit plane in the supersonic region.
5. Reflection strengths.
6. Possible canting or vibrations of the core inlet nozzle.
7. Mixing of the streams in and downstream of the supersonic diffuser.

The flow in the test section was surveyed with a wall to wall rake of alternately spaced temperature and pitot probes. In addition five static-pressure orifices were located on the rake within 4 1/4 inches of the tunnel wall.

A typical Mach number and temperature profile illustrating the NACA's results is reproduced in Figure 2.

The NACA concluded that the cross-sectional area of the core within 90 per cent of the stagnation temperature of the core air was about 35 per cent of theoretical for Mach number 1.9 and 25 per cent of theoretical for Mach number 3.0. The location of the core nozzle exit plane for the Mach number 3.0 tests was considerably upstream of its location for the Mach number 1.9 tests. Data indicated that the best core shapes and sizes were obtained with the core nozzle exits located at the tunnel throats or slightly downstream. The variation of the core to cold stream stagnation pressure ratio had little effect on the core size and shape.

The above summarized heated core wind tunnel was pursued no further after its preliminary investigation and at the present is inoperative.

#### 4. DESCRIPTION OF EXISTING EQUIPMENT

Since the design philosophy on the heated core installation was to use existing equipment, several definite limits were placed on the performance of the installation. A brief description of the existing equipment is presented below in two categories, the supersonic wind tunnel and the hypersonic wind tunnel circuit.

##### 4.1 Supersonic Wind Tunnel

Characteristics of the Naval Supersonic Laboratory Wind Tunnel are as follows:

|                                     |                                                                                                                                                              |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operating cycle                     | Continuous                                                                                                                                                   |
| Test section                        | 18 in X 24 in to Mach 2.5<br>18 in X 18 in to Mach 4.0                                                                                                       |
| Nozzle blocks available             | For Mach numbers 1.5, 1.7, 2.0, 2.25, 2.5, 2.75, 3.0, 3.25, 3.5 and 4.3. Also transonic blocks provide a continuous Mach-number range from $M = 0.5$ to 1.2. |
| Test-section window size            | 30-inch (24-inch diameter largest currently available)                                                                                                       |
| Optical apparatus                   | 30-inch schlieren or shadowgraph                                                                                                                             |
| Balance                             | Strain gage with automatic readout                                                                                                                           |
| Mach-number range                   | 0.5 to 4.3, approximately                                                                                                                                    |
| Reynolds-number range               | $0.05 \times 10^6$ to $10 \times 10^6 / \text{ft}$                                                                                                           |
| Stagnation-pressure range, $p_0$    | 1.5 to 42 psia                                                                                                                                               |
| Stagnation-temperature range, $T_0$ | 100 to 130° F (normal operating temperature 110 degrees)                                                                                                     |
| Drive horsepower                    | Electricity<br>10,000 hp rated<br>12,500 hp for 2 hours                                                                                                      |

|                  |                                 |
|------------------|---------------------------------|
| Main compressors | 4,000 hp 4-stage centrifugal    |
|                  | 6,000 hp 4-stage centrifugal    |
|                  | Operable in parallel or series  |
|                  | Outlet temperature limit-500° F |

#### 4.2 Hypersonic Wind Tunnel Circuit

Included in the hypersonic wind tunnel circuit and pertinent to the heated core installation are the Chicago pneumatic compressors capable of drawing 1.7 pounds of air per second from atmosphere and raising it to a pressure of 100 psia and a temperature of 100° F. Approximately one pound per second of this air after passing through driers, passes through a total pressure control and into 270.kilowatt heaters. These heaters are capable of raising a continuous mass flow of air of one pound per second to a stagnation temperature of 1000° F. This is the maximum mass flow of air available for the heated core portion of the flow in the supersonic test section, the remaining 0.7 pounds per second of air being used in the air seals of the supersonic wind tunnel compressors.

Figure 3 is a schematic diagram of the circuit used for the operation of a hot core installation. The main tunnel circuit depicted as a block in Figure 3 is broken down into components in Reference 5, but is not pertinent to the discussion at hand.

### 5. THEORETICAL PERFORMANCE CALCULATIONS

All performance calculations for the heated core were based on the performance of the apparatus discussed in the preceding section. Throughout all calculations the hot core and stream stagnation pressures were assumed identical. Also the Mach number of the core in the test section was assumed identical to the Mach number of the cold stream. These are reasonable design criteria since with isentropic, one-dimensional, non mixing flow and the above conditions the core may be dealt with as a stream tube separated from the cold stream flow. For the purpose of these performance calculations, i.e. to obtain the design criterion, the specific heat ratio  $\gamma$  can be assumed to be 1.4 without considerable loss of accuracy.

Performance characteristics based on the above assumptions are presented in Reference 6 and in Figures 4 through 10. Assuming a core mass flow of one pound per second and a core stagnation temperature of 1000°F, Figure 4 presents the theoretical heated test section area, possible, as a function of Mach number and stagnation pressure. Figure 5 gives the temperature of the completely mixed flow, downstream of the test section as a function of Mach number and stagnation pressure, assuming a cold stream stagnation temperature of 100°F. Figure 6 shows the temperature of the mixed flow as a function of the cold stream mass flow for various core stagnation temperatures. The effect of stagnation pressure and Mach number on the cold stream mass flow is indicated in Figures 7 and 8. The variation of theoretical test section area with stagnation temperature of the core for typical fixed parameters is given in Figure 9. Since the simulation of aerodynamic heating was the ultimate goal and the heating of the tunnel structure and the compressors could cause difficulties, Figure 10 is presented to indicate the heated theoretical test section area available for an allowable mixed flow temperature.

## 6. DESIGN COMPROMISES BASED ON EXISTING EQUIPMENT AT NSL

### 6.1 Design Parameters

The theoretical performance curves of the heated core installation, as is pictured schematically in Figure 3, depict the range of parameters possible using existing equipment. The only additional equipment necessary was a circuit and nozzle to inject the heated air into the supersonic test section as shown in Figures 11 through 13.

Section 4.1 indicates that the outlet temperature limit of the main compressors is 500°F. Thus knowing the efficiency of the compressors the inlet temperature limit may be obtained. As Figure 10 indicates this will set a limit on the hot core test section area obtainable for a given hot core stagnation temperature. Appendix A yields a compressor efficiency of approximately 77 per cent and a maximum intake temperature of 233°F for Mach 3.5 operation. From Figure 10 this temperature limit gives a possible test section area of 80 in<sup>2</sup> at a stagnation temperature of 800°F. It is reasonable to suspect that the actual inlet temperature will be considerably lower than the mixed flow temperature due to the heat dissipated

to the piping between the diffuser and the compressors. Thus a choice of a theoretical test section area of 80 in<sup>2</sup> will allow stagnation temperatures in the hot core of at least 800°F, and possibly 1000°F without harm to the main compressors.

It was felt that the highest Mach number conveniently possible should be chosen for the heated core installation. NSL has had considerable favorable experience with the operation of the supersonic wind tunnel with the Mach 3.5 blocks. These blocks have a throat large enough for convenient installation of an inner, hot core nozzle. A Mach number of 3.5 at a stagnation temperature of 1000°F also simulates actual flight conditions of missiles and aircraft very well.

Figure 4 indicates that under optimum theoretical conditions of  $T_{0c} = 1000^\circ\text{F}$ ,  $\dot{w}_c = 1 \text{ #/sec}$ ,  $A_c = 80 \text{ in}^2$  and  $M = 3.5$ , the stagnation pressure of the core will be about 6 psia.

The test section for Mach 3.5 is 18 in x 18 in or 324 in<sup>2</sup>. Since this test section is square the theoretical heated core test section was designed so as to be square. That is 8.94 in x 8.94 in or 80 in<sup>2</sup>.

## 6.2 Additions to the Existing NSL Piping Circuit

The additional circuitry shown schematically in Figure 11 is necessary to supply the core air from the HWT (Hypersonic Wind Tunnel) heaters to the main tunnel. Appendix B includes a detailed report of the design conditions considered and met in the construction of this additional circuit.

To transport the air heated in the HWT heaters to the wind tunnel required approximately 75 feet of pipe. Conceivably this pipe must withstand 1000°F temperatures and be insulated so as to keep heat losses to a minimum.

A  $p_0$  control located upstream of the heaters would allow use of a "cold" valve. However this would mean the use of large pipe since the heated core is operated at about 6 psia. By carrying the air at 100 psia and locating  $p_0$  control valves just upstream of the core stilling chamber, as is shown in Figure 12, it is possible to use 2 1/2 inch pipe. This 2 1/2 inch line is insulated with three inches of "Kaylo 20" on the radius. Approximate calculations show that under equilibrium conditions with one pound per second of 1000°F air a total temperature loss of 75°F is expected in the 75 foot line.

Design codes do not permit the use of steel under stresses encountered in 1000°F service. Another problem encountered at high temperatures is the phenomenon of scaling. The most practical solution to the problem of a choice of material for the pipe seems to be the use of chrome molybdenum steel. At 1000°F the pipe expands axially about one inch for every 10 feet of pipe. This expansion is taken up with flexible hose (stainless steel wire woven about stainless steel bellows). Such a hose provides practically no reaction.

The 75 foot line may be preheated by passing hot air to atmosphere through a bypass located just upstream of the entrance of the hot core line into the main tunnel (Figure B.1). This allows the core to be operated at maximum temperature shortly after supersonic flow is obtained in the test section. To allow rapid shutdown and provide for cooling of the model, provisions are made to pass cold air through the hot core stilling section and nozzle using the existing pre-drying system as a source (Figure B.1).

### 6.3 Heated Core Stilling Section

The location of the heated core stilling section immediately upstream of the heated core nozzle limits the physical size and shape of the section since it passes through the plug valve upstream of the supersonic test section (see Figure 12). Any area taken up by the heated core stilling section thus increases the velocity of the cold air through the plug valve. This cold air conceivably cools the heated core stilling section, causing a heat loss in the hot core system. It was necessary in considering the design of the heated core stilling section therefore to keep in mind the following problems in addition to the conventional problems.

1. Structural problems of the stilling section are aggravated by the high temperature requirements.
2. There are heat losses from the heated core air which may be alleviated by insulating the stilling section.
3. Size and shape of the section affect not only the flow properties of the hot air but the cold air as well.
4. The supporting structure of the stilling section should be kept aerodynamically "clean" as there is cold air flowing past the outside of the section.
5. The downstream end of the stilling section should be anchored so that thermal-expansion of the section will cause no motion of the hot core nozzle.

For structural purposes the stilling section was chosen to be fabricated from 304, 12 gauge stainless steel, rolled into a 12 inch O.D. cylinder. Such a cylinder, approximately 10 feet long, will support itself at each end and withstand pressure differences on the order of 20 psia. at 1000° F. Normally, pressure differences will be no greater than 3 or 4 psia.

A conservative estimate of the heat loss from a 10 foot cylinder with one inch of insulation under typical operating conditions, as given in section 6.1, indicates a temperature drop of 18° F. These calculations are given in Appendix C. An 18° F temperature loss might suggest a need for greater insulation. However in order to provide for large contraction ratios in the cold and hot nozzles and to keep the Reynolds Number low in the stilling chamber it was not possible to add more insulation. The fact that the 18° F loss is a conservative estimate is encouraging however.

The 12 inch stilling chamber with one inch of insulation provides Reynolds numbers of about  $5 \times 10^4$  inside of the stilling chamber and  $1.4 \times 10^5$  outside of the stilling chamber. Velocities are on the order of 100 feet per second. The insulation around the stilling section was covered with thin sheet metal to assure smooth flow over the outside of the stilling section. The contraction ratio for the hot core nozzle is 9.6 and the contraction ratio for the cold stream nozzle is 11.1. These are generally accepted ratios.

The upstream end of the stilling section is suspended from the top of the main tunnel stilling chamber by two cables. A third spring loaded cable running to the bottom of the stilling chamber anchors the upstream end of the section in the vertical and horizontal planes, but allows motion in the axial direction (Figures 12 and 13). Two sets of triangularly arranged struts anchor the downstream end of the stilling section. See Figure 12. Each set fastens at a common point on the tunnel floor and ceiling and is angulated in the vertical plane so that radial expansion of the section will not cause binding in the system. With this arrangement the nozzle end of the stilling chamber is fixed, except for minute motion in the axial direction due to radial expansion of the stilling chamber and the angular arrangement of the downstream struts. The struts are circular rods.

However, due to their location and the flow direction of the cold air they are "seen" elliptically streamlined by the flow. All cables and struts supporting the stilling chamber contain turnbuckles in order to allow proper centering of the nozzle which is fastened by stainless steel screws onto the square end of a transition section (Figure 12). In order to assure precise positioning of the core nozzle a special gauge and set of levels are used at the time of installation of the stilling section and nozzle. Photographs of the heated core stilling section and nozzle installation are shown in Figures 14 through 16.

#### 6.4. Core Nozzle Design

The ideal nozzle for the injection of a heated stream tube should follow the stream tube of the air it is replacing in the test section. Since the parameters used to design the Mach 3.5 nozzle blocks for Naval Supersonic Laboratory's supersonic wind tunnel were available, it was possible to accomplish this design condition. The design of the nozzle blocks at NSL by the Friedrichs Method and computation tables for the flow field through the nozzle are summarized in Reference 7.

In the figure below the supersonic nozzle block contour is represented by the streamline  $\eta = \eta_d$ . The contour the core nozzle should follow is determined by  $h_c$  and is represented by  $\eta = \eta_c$ . Conceivably, a scaling factor,  $\bar{F}$ , must be determined.  $\bar{F}$  is given by

$$\bar{F} = \frac{h_T}{yQ} \quad (6.4.1)$$

where

$$yQ = \frac{(M_d^2 + 5)^3}{216 M_d} \eta_d \quad (6.4.2)$$

$M_d$  is the design Mach number, and  $\eta_d$  is given in Reference 7 for  $M_d = 3.5$ .



where

$$A = \bar{M}^2 - 1$$

$$B = \gamma \bar{M}^4 - \bar{M}^2 + 2$$

$$C = \frac{(\gamma + 1) \bar{M}^4}{\bar{M}^2 - 1} - 1$$

$$D = \frac{(\gamma - 1) \bar{M}^2 + 2}{\bar{M}^2 - 1}$$

$$\delta_4 = \frac{y_1}{6} \left[ 3 y_1 (A + C + 2) - 2 C + \frac{(y_1 - 1)}{A} (2D) (C + 1) (A - 1) \right]$$

At  $\xi = 0$ , or at the nozzle throat:

$$y = \frac{h_c^*}{F} \quad (6.4.4)$$

Now if  $\eta \ll 1$ , from equation (6.4.3)

$$\begin{aligned} \eta &\cong y / y_1(0) \\ &\cong \frac{h_c^*}{F} \end{aligned}$$

as a first approximation. As a second approximation assume  $\eta = \eta_1$  and solve for  $\eta_2$  in equation (6.4.3):

$$\eta_2 = \frac{y - y_1 \eta_1^5}{y_1(0)}$$

Using this procedure until convergence, which occurred at  $\eta_2$ , a value of  $\eta$  was found. Knowing  $\eta$  and picking values of  $\xi$ , equations (6.4.3) were solved for values of  $x$  and  $y$  with the aid of the tabulated values for  $x_i$  and  $y_i$  found in Reference 12.

Since the tabulated values of  $x_i$  and  $y_i$  were given in the subsonic portion, upstream to about  $M = 0.3$ , the remainder of the nozzle was faired in according to the area ratio of the cold stream area to the hot core area, the the last point found. The core nozzle was extended downstream of the throat 10 percent of the distance to the end of the NSL Mach 3.5 nozzle blocks. This

distance was about 5 inches. The choice was based upon the fact that the NACA heated core showed increased performance with the core nozzle exit downstream of the throat. The core nozzle coordinates are listed in Appendix D.

The core nozzle was machined from four # 304 stainless steel plates bent to the proper contours and screwed together.

## 7. CALIBRATION OF THE HEATED CORE

The primary purpose of the heated core installation being the simulation of aerodynamic heating places the desirability of a total temperature survey in the test section first in importance. Conceivably a Mach number survey is of great importance also. Such properties as flow angularity were considered to be of relative unimportance at this time. The calibration of the heated core test section was further complicated over the calibration of a conventional supersonic test section due to the certainty of the existence of a turbulent mixing region, high temperatures, and varying low Reynolds numbers. The low Reynolds numbers are present due to the low  $p_0$  (6 psia) design condition. The range of Reynolds numbers existing in the test section, for a given stagnation temperature of the core, is illustrated in Figure 17.

### 7.1 Instrumentation

The primary instrumentation for the calibration of the heated core test section consists of a rake of pitot probes and a rake of total temperature probes in a "biplane" arrangement extending eight inches to either side of the test section centerline (Figures 18 and 19). In addition to these probes a sonic orifice mass flow probe, to measure local total temperature, and a wedge-pitot probe, to measure local Mach number, were mounted on the rake. By mounting this rake on a special calibration mount, which can be remotely moved in the vertical and axial direction, a Mach number and total temperature survey up to a few inches from the tunnel wall was obtained in a region extending from 16 inches upstream of the schlieren centerline to 14 inches downstream of the schlieren centerline. Stagnation pressure and stagnation temperature were measured in the stilling chamber by a pitot probe and a single shielded iron-constantan thermocouple. The shield

around the thermocouple was platinum plated to cut down radiation errors. These probes, which were mounted about the centerline of the downstream end of the stilling chamber, are shown in Figure 20. The photograph, Figure 20, was taken after the probes had been run at 900°F temperatures for about 20 hours. The discoloration noticeable is of unknown cause.

A schematic diagram of the wind tunnel instrumentation for the heated core calibration is presented in Figure 21.

#### 7.1.1 Total Temperature Probes

The total temperature probes on the rake were placed in a row, at one-half inch spacings up to five inches from the center of the rake and at one inch spacings from there on. This arrangement called for a sum of 26 total temperature probes. Thus it was necessary in picking a total temperature probe to emphasize the importance of simplicity in the design. The probe used is shown in Figure 22. It is a Pratt and Whitney type probe similar to the design found in Reference 8. The shielded probe was fabricated from thin walled stainless steel tubing with an iron-constantan thermocouple held inside by Sauerisen, an insulating cement which will withstand high temperatures. Three vent holes of total area equal to the entrance area, were placed around the circumference of the shield. Thus at Mach 3.5 operation the thermocouple junction was exposed to a Mach number of about 0.45, the Mach number behind the normal shock. This is slightly high by standards. However, since the probe was to be used at essentially one Mach number any error due to the slightly high velocity would be corrected for in the recovery factor determined at the time of the calibration tests. Radiation errors are cut down by plating the outside of the shield with platinum, which has a very low emissivity. The thermocouple junction is placed well ahead of the vent holes in the shield so that it cannot radiate to the cold walls directly through the vent holes. These probes were fabricated with relative simplicity.

#### 7.1.2 Mass Flow Probe

Due to the difficulty in calibrating temperature probes properly, a sonic orifice mass flow probe to determine temperature looked attractive.

The mass flow probe used is shown in Figure 23. It consists of an orifice and a ring opening around the orifice at which pitot pressure was measured. The mass flow is determined by connecting the probe to an evacuated tank and measuring the pressure and temperature in the tank before and after a measured period of time. The final pressure in the tank must be less than the necessary pressure to maintain sonic flow in the orifice, which when in a supersonic stream is behind a normal shock. Knowing the mass flow through the sonic orifice, the effective area of the orifice, and the stagnation pressure, the local stagnation temperature may be obtained independent of the usual thermocouple errors induced by radiation, conduction and convection. However, results are extremely sensitive to mass flow and orifice area. There was considerable difficulty in setting up the necessary leak proof mass flow probe system and in calibrating the probe for an effective orifice area (on the order of  $3 \times 10^{-4}$  in<sup>2</sup>). Due to the complication of the system and the desirability to have a check on the temperature probes a single mass flow probe was placed in the center of the rake (Figure 18). This probe was to obtain an accurate temperature reading at several points in the test section with which the thermocouple readings could be compared. Thus it was the intent to calibrate the total temperature probes near the center of the rake against the mass flow probe.

#### 7.1.3 Mach Number Measurements

A row of pitot probes at one inch spacings extending eight inches to either side of the tunnel centerline were placed on the rake one inch above the total temperature probes (Figure 18). From the ratio of pitot pressure,  $p_p$ , and stagnation pressure  $p_0$ , Mach number may be determined. However this method of measuring Mach number assumes that the stagnation pressure in the stilling chamber is identical to the stagnation pressure at every point in the test section. That is, isentropic flow must exist throughout the test section, a condition not obvious in a stream tube whose boundaries are subject to turbulence and mixing.

To calibrate a wind tunnel independent of the above assumption another local measurement is necessary in addition to the local pitot pressure. Due to the low Reynolds numbers and low pressures inherent in the heated core operation the local measurements of such parameters as

cone static or wedge static pressures will acquire great inaccuracies. These inaccuracies are induced by the displacement effect of the boundary layer on the cone or wedge and in the measurement of such low pressures. Pitot probes have acquired a reputation of accurate measurements as long as their free stream Reynolds number is greater than  $10^3$  and their hole diameter is less than one half of the tube diameter. Since pitot pressure is higher than static pressure, the pressure measurement accuracy is increased also. Pitot pressure thus seems to be the pressure which may be most accurately measured in this flow.

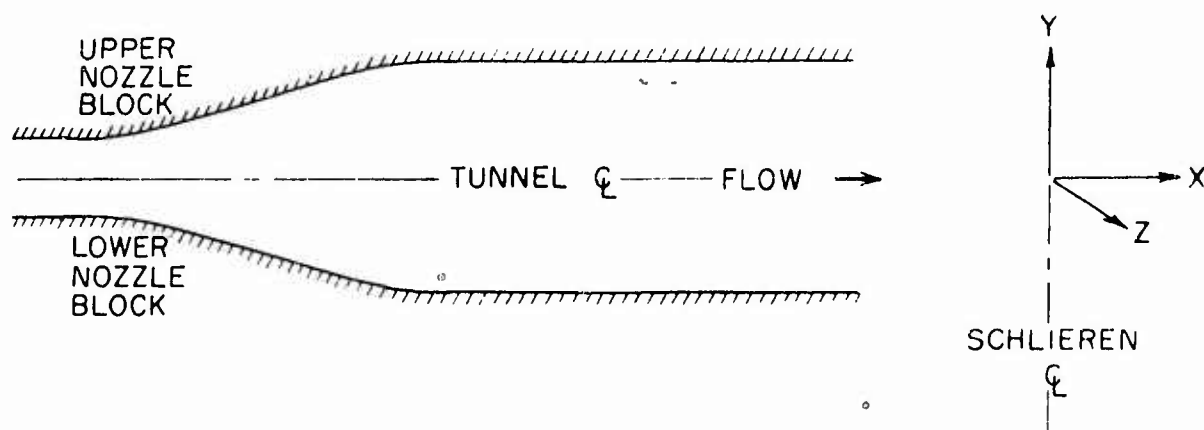
Reference 9 recommends the measurement of pitot pressure,  $p_{p_s}$ , behind a known oblique shock. This pressure is a function of the shock angle  $\theta$  (Figure 25). However, the pressure in question displays a maximum for some value of  $\theta$  close to that which gives equal values of specific entropy rise across the oblique and pitot shocks. Near this point the variation of  $p_{p_s}$  with the shock angle  $\theta$  is slight. Figure 26 shows the optimum shock angle at  $M = 3.5$  and  $\gamma = 1.36$  to be  $39.5^\circ$ . The assumption of  $\gamma = 1.36$  for Mach 3.5 flow with a stagnation temperature of  $1000^\circ\text{F}$  is in error. Reference 10 reveals that the calorically imperfect equations are more closely approximated by  $\gamma = 1.4$  for these conditions, which would yield an optimum  $\theta$  of  $38.4^\circ$ . However, Figure 27, which represents flow for  $\gamma = 1.4$ , shows that the error induced in measuring the Mach number with a one degree error in the shock angle is negligible.

A single wedge-pitot probe was mounted on the calibration rake above the central pitot probe. Thus by moving the rake, the pitot pressure,  $p_p$ , and the wedge-pitot pressure,  $p_{p_s}$ , could be found at a given point. From the ratio of  $p_{p_s}/p_p$  Mach number at that point could be determined. The wedge-pitot probe is shown in Figure 25 and Figure 28. Notice that the optimum shock angle is determined by  $\delta'$ , the effective wedge angle comprised of the physical wedge angle plus an approximation to the boundary layer angle. This boundary layer angle correction amounted to one degree. Thus the pitot tube angle in Figure 28 is one degree greater than the wedge angle. An error is induced in the wedge-pitot measurements because the oblique shock and the pitot shock are not at the same point in the flow, but are separated by a distance,  $l$ . There are expansion and compression

waves in the flow behind the oblique shock due to non-uniformity of the flow in the test section and due to disturbances from the boundary layer on the wedge. Thus the Mach number just upstream of the pitot shock is not identical to the Mach number just downstream of the oblique shock. A correction for these effects was made possible by making the pitot probe on the wedge adjustable for different values of  $l$  at which several measurements could be taken. By extrapolating data to  $l = 0$  the distance effect could be nullified.

## 7.2 Data Reduction

The primary goal in the calibration of the heated core was to obtain to the highest degree of accuracy, practically feasible, a temperature and Mach number survey in the heated core portion of the test section. The core is defined here as the region in which a constant stagnation temperature exists. Exploration of the mixing region was considered of secondary importance. Mach number and temperature surveys were taken in vertical planes with the rake described in the preceding section, at five axial,  $x$ -stations. The coordinate system used in the survey is illustrated below.



### 7.2.1 Temperature Data

The iron-constantan stilling chamber thermocouple shown in Figure 20 is shielded to cut down radiation effects, which are small since the walls of the stilling chamber are hot. Thus, the stagnation temperature measured in the stilling chamber,  $T_{0c}$ , should be accurate within one-half of one per cent. As is shown in Figure 21 the temperatures indicated by the temperature probes in the test section were read on Brown self-balancing potentiometers with bucking voltages fed in by Rubicon hand potentiometers. These temperatures were hand recorded, as were the hot core and cold stream stilling chamber temperatures. Unfortunately, the mass flow probe data has not yet been interpreted. However, work is being carried out at NSL on this data. The orifice coefficient, an efficiency index of the orifice, seems to be in error as the data yields consistent low readings for the test section total temperature.

The absence of the temperatures with expected high accuracies, determined by the mass flow probe, required that the total temperature probes be calibrated by the next best method. This was to assume that the constant total temperature core of air existing in the test section must be equal to the stagnation temperature in the stilling section. This is a good assumption since the data showed a definite constant temperature region with a distinct edge (Figure 37).

The recovery factors of the probes were not defined in the usual manner since they were used at only one Mach number and were based upon the core stagnation temperature. The recovery factor,  $r$ , was defined as the ratio of the indicated thermocouple temperature, in the core at the Schlieren centerline, to the core stagnation temperature. This ratio was  $.94 \pm .005$  for all temperature probes in the core except for the probes at  $z = \pm 1/2$ . The recovery factors for these two probes were  $.91 \pm .005$  and  $.92 \pm .005$  respectively. One would expect these two probes to have a lower recovery factor than the others. They are located near a larger heat sink than the other probes are, the large mass of the sting holding the rake. Since all probes in the core but the two central probes gave a fairly consistent recovery factor it is reasonable to assume the recovery factor of the probes outside of the core are the same, i.e.,  $.94 \pm .005$ .

Such an uncertainty in the recovery factor as  $\pm .005$  coupled with the reading accuracies in the data reduction yield an overall accuracy of the total temperature data in the core of one per cent. The data outside of the core may be slightly less accurate due to the uncertainty of the recovery factor of the probes in that region. The temperature data after the application of the above recovery factors is presented in Appendix E.

#### 7.2.2 Mach Number Data

The pitot pressures in the test section were read out on a 10 centistoke silicone manometer board and recorded by photographs. These photographs could be read to  $\pm .05$  inches of silicone or  $\pm .002$  psia. Stagnation pressures were read on the Wallace and Tiernan Gages to  $\pm .01$  psia. With the assumption that the stagnation pressure indicated in the stilling chamber exists throughout the test section these accuracies in pressures yield, by the method of Reference 11, a Mach number accuracy of  $\pm .2$  per cent.

In using the calorically perfect equations to obtain Mach number at the 900°F core temperatures however, there is another error induced. The compression of the fluid through the pitot shock is at such a high time rate, under some conditions, that there is not sufficient time to establish the distribution of energy between the various degrees of freedom corresponding to an isentropic process. In other words the degree of freedom corresponding to the intramolecular vibration has a finite "relaxation time". Also due to the variation of the static temperature as the air passes from the stilling chamber and expands through the nozzle, the specific heat ratio,  $\gamma$ , is not constant at every point throughout the process. These effects cause caloric imperfections in the process which are not completely understood. Reference 10 presents calorically imperfect equations and a method to correct for caloric imperfections in terms of the ratio of pitot pressure to stagnation pressure in supersonic flow. This correction was applied to the data obtained and amounted to dividing the pressure ratio in question by a factor of 0.98, a step in the right direction but not considered exact. It is possible that this combined with the other Mach number inaccuracies will yield a final Mach number accuracy of  $\pm 0.3$  per cent.

again based on the assumption of a constant stagnation pressure. The Mach number data reduction was carried out on the Naval Supersonic Laboratory's Bendix G-15 computer. This data is compiled in Appendix F.

On the  $x = 0, z = 0$  line, values of the wedge pitot pressure,  $p_{p_s}$ , were recorded for three positions of the wedge pitot probe at six  $y$ -stations. The corresponding pitot pressures were also found for these points and thus the ratio  $p_{p_s}/p_p$  determined. The ratios found at each point for the three values of  $l$  are plotted in Figures 29 through 34. Figures 30 and 34 show the points falling in fairly straight lines with about the same slopes, as expected. Thus extrapolations to  $l = 0$  were obtained. Figure 35 is an enlarged schlieren photograph of the wedge pitot probe set at  $l = 0.1$  inches. Notice in this figure that the oblique shock is interfering with the pitot shock and touching the pitot probe. A very likely possibility exists that this interaction interferes with the streamline entering the pitot probe causing a  $p_{p_s}$  to be read which is too low. The schlieren evidence is enough to justify eliminating the  $l = 0.1$  point in Figures 29 and 32. With the elimination of these two points the extrapolations to  $l = 0$  yields slopes in agreement with Figures 30 and 34. The  $l = 0.2$  point in Figure 31 and the  $l = 0.3$  point in Figure 33 were eliminated as bad points in light of the fact that the previous extrapolations agree well "slopeswise", and the elimination of these points would make all the extrapolations agree in this sense as expected. Based on the previously stated accuracies of pressure measurements and the accuracy of extrapolation techniques the wedge-pitot determined Mach number measurements have an accuracy of about  $\pm 0.3$  per cent.

### 7.3 Results and Discussion

The calibration of the heated core was carried out in three phases: studies of the core at Mach 3.5 with matched stagnation pressures in the core and cold streams; studies of the core under unmatched stagnation pressure conditions; and studies of the core with the NSL Mach 3.0 nozzle blocks used with the Mach 3.5 core nozzle.

Thermocouples placed on the nozzle blocks and upstream of the

" 1 compressor showed no excessive heating at these critical points.

### 7.3.1 Studies of the Core at Mach 3.5 Matched Stagnation Pressures

Figures 36 through 38 present the temperature distribution in the test section at three axial stations through the use of the parameter  $\theta$ , a total temperature difference ratio. This data repeats well over the axial distance of 22 inches. The isotherms shown in these figures reveal that the core has a cross sectional area with nearly constant stilling chamber temperature of approximately 50 square inches, or 60 per cent of the theoretical area. This is an improvement of at least 30 per cent over the similar NACA heated core data presented in Reference 1. The lower temperatures noticeable in the upper right hand corner of the figures are contributed by the disturbance in the flow caused by the stilling section temperature and pressure probes and their leadout lines installed in the corresponding location in the core stilling section (Figure 14). A decrease in the temperature slope in Figure 36,  $x = 16$ , to Figure 38,  $x = 6$ , indicates a slight broadening of the mixing region. The mixing region appears to be about three inches on the radius of the core.

A curve of the Mach number distribution in the expansion plane of the tunnel at the schlieren centerline is presented in Figure 39. This figure shows agreement of the Mach numbers as determined by pitot probes and the Mach numbers as determined by the wedge-pitot probe to be well within the accuracies of the data in the core region ( $3\frac{1}{2}$  inches to either side of the tunnel centerline). Thus it was concluded that within the core the assumption that the stilling chamber stagnation pressure exists in the test section is valid. The design of the calibration rake did not permit wedge data to be taken in the mixing region beyond  $y = -4\frac{1}{2}$ . However, the point shown at  $y = -4\frac{1}{2}$  suggests that the Mach numbers determined by the pitot probes outside of the core might not be valid. As was stated previously though the primary interest in this calibration was in the core itself. Figure 40 shows a comparison of the variation of the Mach number and the total temperature at the schlieren centerline. The values at  $z = \pm 8$  are definitely invalid, as they fall in the boundary layer region of the tunnel wall. The sharp discontinuity in the Mach number in the mixing region may be attributed to either a discontinuity in the stagnation pressure in this region or a true discontinuity in the Mach number itself. In light of Figure 39

it is felt that there is a discontinuity in the stagnation pressure in the mixing region. Comparison of Figures 41 and 42 shows the increasing Mach number variation in the streamwise direction. This is attributed to the growth of the mixing region, which evidently influences the Mach number. Mach number data shows a consistently higher Mach number than the design Mach number of 3.5. It was concluded therefore that the effect of the core nozzle in the throat had caused a change in the Mach number. The material of the core nozzle occupies about three square inches of the throat. This causes  $A/A^*$ , the ratio of test section area to throat area, to change from 6.79, corresponding to Mach 3.5, to 7.25 corresponding to Mach 3.57. Adding on an allowance in Mach number of 0.04 for the fact that the NSL 3.5 blocks yield a 3.54 test section Mach number (Reference 7), an expected Mach number of 3.61 is arrived at. This is very close to the mean Mach number which the data yields.

The Mach number data shows variations in the core as great as  $\pm 0.1$  in Mach number. These are larger variations than are generally accepted in force tests in a supersonic wind tunnel. However in aerodynamic heating tests such variations can well be tolerated. The large core of high temperature air suggests that a hemispherical model of the blocking area of the NSL wind tunnel (approximately a six inch diameter hemisphere) could be run at constant stagnation temperatures over 900°F, at Mach  $3.64 \pm 0.1$ .

### 7.3.2 Studies of the Core at Mach 3.5-Unmatched Stagnation Pressures

In an attempt to obtain a smoother Mach number distribution in the core the cold stream stagnation pressure was varied. It is seen from Figure 43 that this variation had relatively little effect on the Mach number distribution in the core, a large decrease in cold stream pressure causing a slight increase in Mach number. The Mach number distribution outside of the core is presented based on both stagnation pressure of the core,  $p_{0c}$ , and stagnation pressure of the cold stream,  $p_{0s}$ . The temperatures in the core showed little change with variation of the pressures. The above observations support the findings of the NACA (Reference 1) that the variation of the ratio  $p_{0c}/p_{0s}$  had little effect on the core, an increase in the ratio producing a slight increase in the core Mach number.

### 7.3.3 Studies of the Core Using Mach 3.0 Blocks with the Mach 3.5 Core Nozzle

During the calibration tests the Mach 3.0 nozzle blocks were inserted in place of the Mach 3.5 nozzle blocks to determine the feasibility of operating the heated core installation at Mach 3.0, an off-design condition. During this test neither the heated core nozzle nor its location was changed. Thus the throats of the core nozzle and the tunnel nozzle did not match. Two axial stations were surveyed under these conditions,  $x = -16$  and  $x = 0$ . Representative temperature and Mach number data taken at these stations is presented in Figures 44 and 45. These two figures reveal that mixing in the streamwise direction is much more prominent with these off-design conditions. The constant temperature core at the schlieren centerline,  $x = 0$ , is reduced to less than four square inches, while the Mach number shows less peaking in the core than with the Mach 3.5 blocks. The greater mixing at Mach 3.0 is further revealed by the comparison of Figure 46 with Figure 47. Figure 46 is a schlieren photograph of the calibration rake in operation at Mach 3.5, the design condition. Notice the shock waves are quite smooth and the core mixing region is not visible. Figure 47 is a schlieren photograph of the rake in operation at Mach 3.0, the off-design condition. Notice the distinct core region. The edge of this region seems to be about four inches from the centerline or as Figure 45 shows, on the outer edge of the mixing region. The bending of the shock waves suggests that beyond this region the Mach number increases, the opposite of what Figure 45 suggests. Due to the evidence in the schlieren photograph of a Mach number increase it is suspected that the stagnation pressure beyond the mixing region is higher than stilling chamber stagnation pressure. Thus, Figure 45 is in error for the region outside of the core. The additional instrument below the calibration rake in Figure 47 is a mirror placed in the stream to determine if the flow was free from foreign matter. The mirror was run in the stream for an hour and a half with no appreciable dulling occurring.

## 8. CONCLUSIONS AND RECOMMENDATIONS

From the design, construction, and calibration of the NSL heated core installation it is concluded that the injection of a high temperature stream tube into a supersonic wind tunnel is a practical way to obtain aerodynamic heating data. The Naval Supersonic Laboratory Supersonic Wind Tunnel proved to be an ideal facility for the heated core installation, considering the high temperature air source and compressing equipment available in the laboratory.

With respect to the results from the calibration of the heated core, the following is concluded:

1. The NSL Mach 3.5 heated core installation produced a 50 in<sup>2</sup> uniform temperature (900°F) core, which is about 60 per cent of the theoretical heated core area.
2. The Mach numbers at the schlieren centerline varied as much as  $\pm 2.5$  per cent about a mean Mach number of 3.64, a peak occurring at the center of the core. The Mach number distribution flattens out proceeding upstream of the schlieren centerline.
3. Stagnation pressure within the core does not vary noticeably from stilling chamber stagnation pressure.
4. Mach numbers increase slightly in the core with increases in the ratio of  $P_{0c}/P_{0s}$ .
5. Operation of the heated core installation at the off design condition of Mach 3.0 reduces the core to about 20 per cent of the theoretical area, but produces a more constant Mach number distribution in the core.
6. In light of conclusions 2.0 and 5.0 it is concluded that the percentage of the throat that the core nozzle material occupies influences the Mach number distribution unfavorably.

As an immediate improvement on the Mach 3.5 heated core installation it is recommended that the exposed stilling chamber stagnation pressure and stagnation temperature leads (Figure 14) be run under the

insulation on the stilling section. This should smooth out the flow over the stilling section considerably and thus eliminate the reduced temperature area noticeable in the upper right hand corner of Figure 37.

Further, it is recommended that a second heated core nozzle be fabricated of thinner wall thickness and that it be extended downstream from the throat ten per cent of the distance to the end of the Mach 3.5 nozzle blocks, instead of the present five per cent. By making this nozzle of one-half the cross sectional area of the existing nozzle the stagnation pressure upper limit could be increased to 12 psia, instead of the present 6 psia. This nozzle should furnish a relatively constant 900° F test section of 25 in<sup>2</sup> cross sectional area, with less variation in Mach number across the core and a greater stagnation pressure range.

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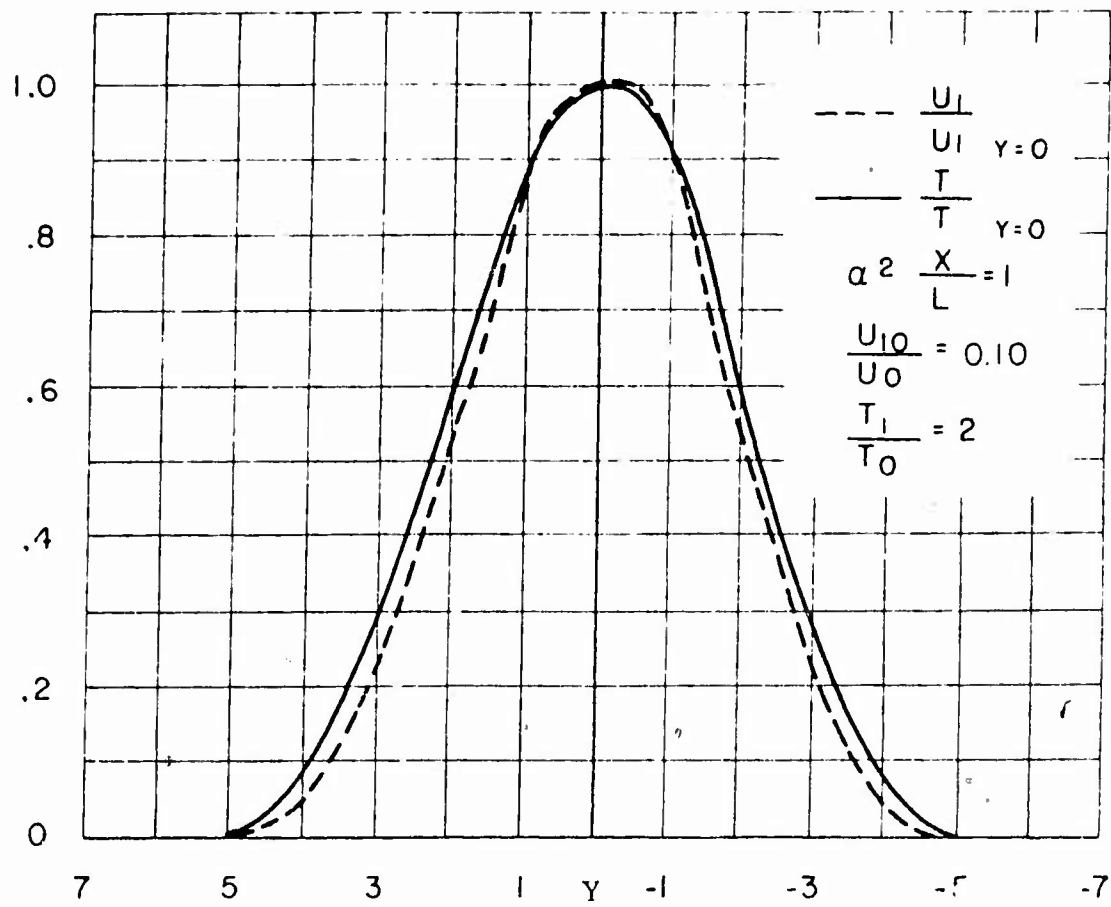


Figure 1. Temperature distribution in the jet of flow from a two-dimensional nozzle.

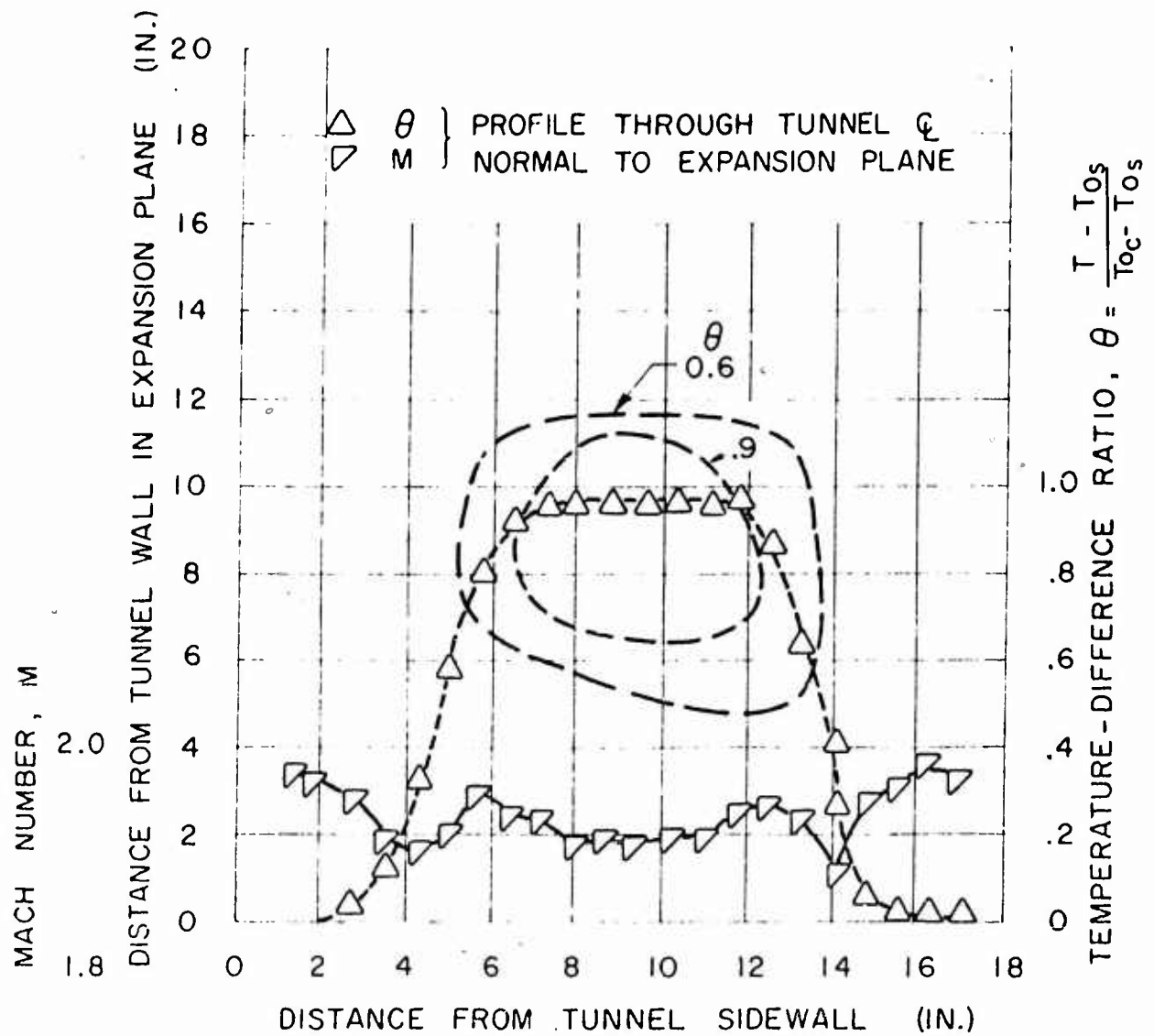


Figure 2. Temperature and Mach number distribution in the NACA Mach 1.9 heated core tunnel.

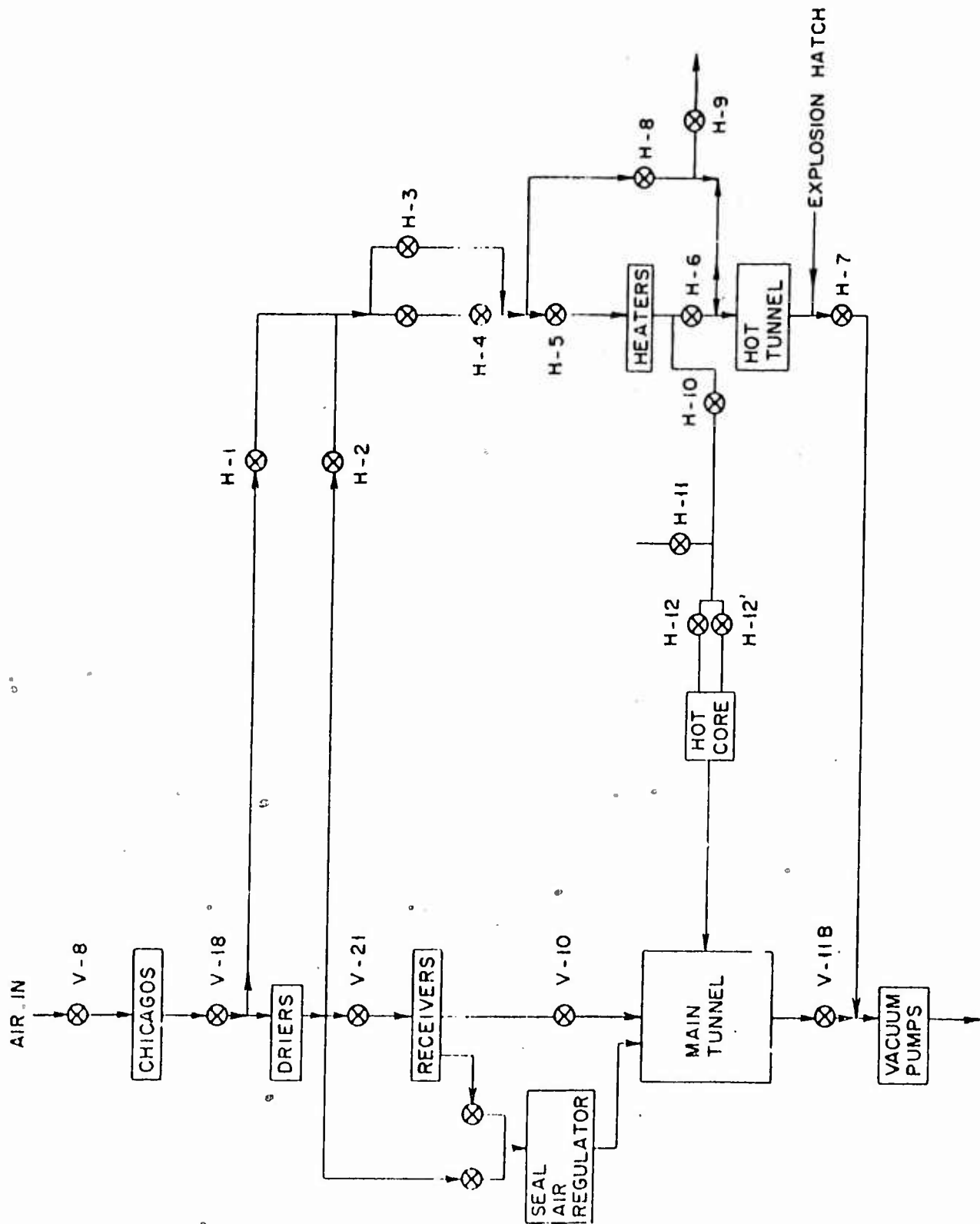


Figure 3. NSL heated core circuit - schematic diagram.

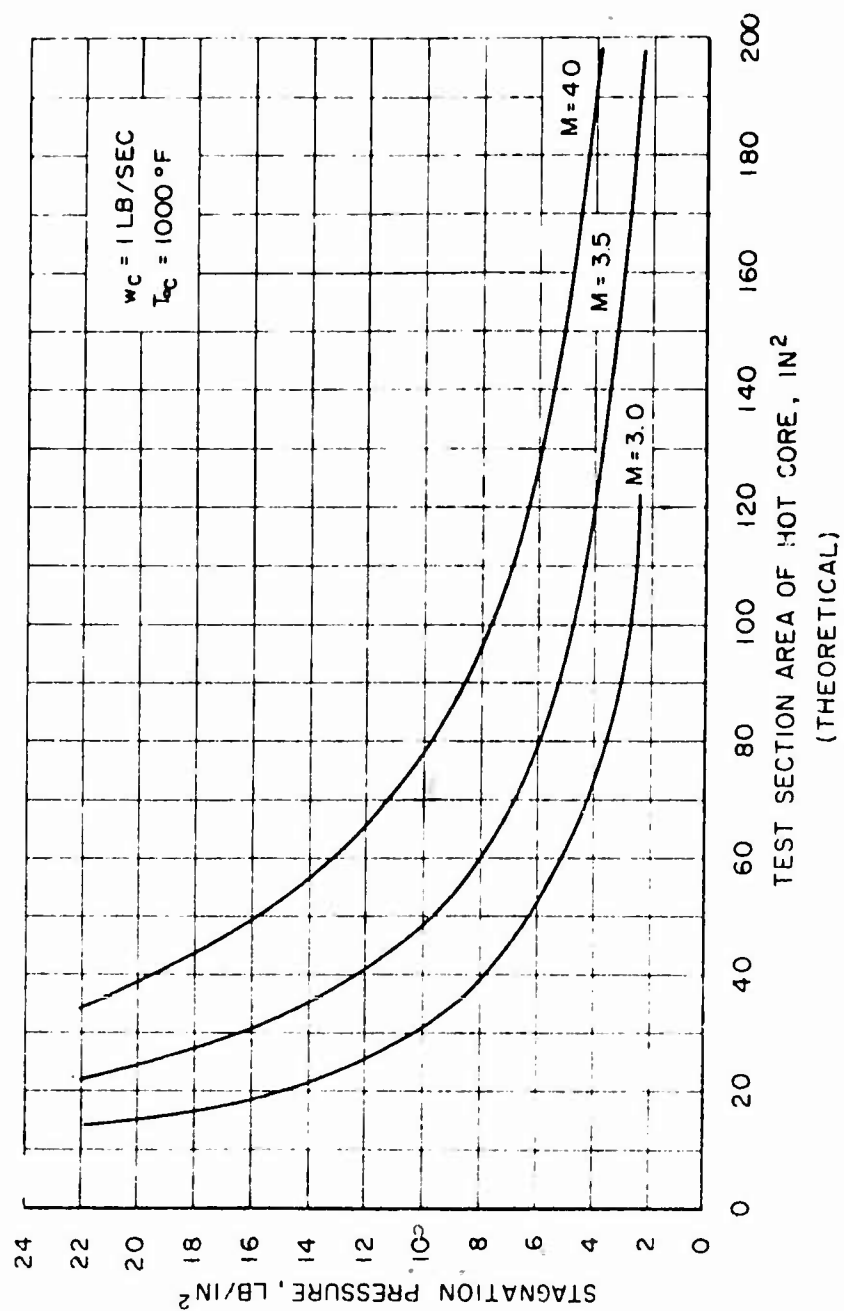


Figure 4. Theoretical test section area of hot core versus stagnation pressure.

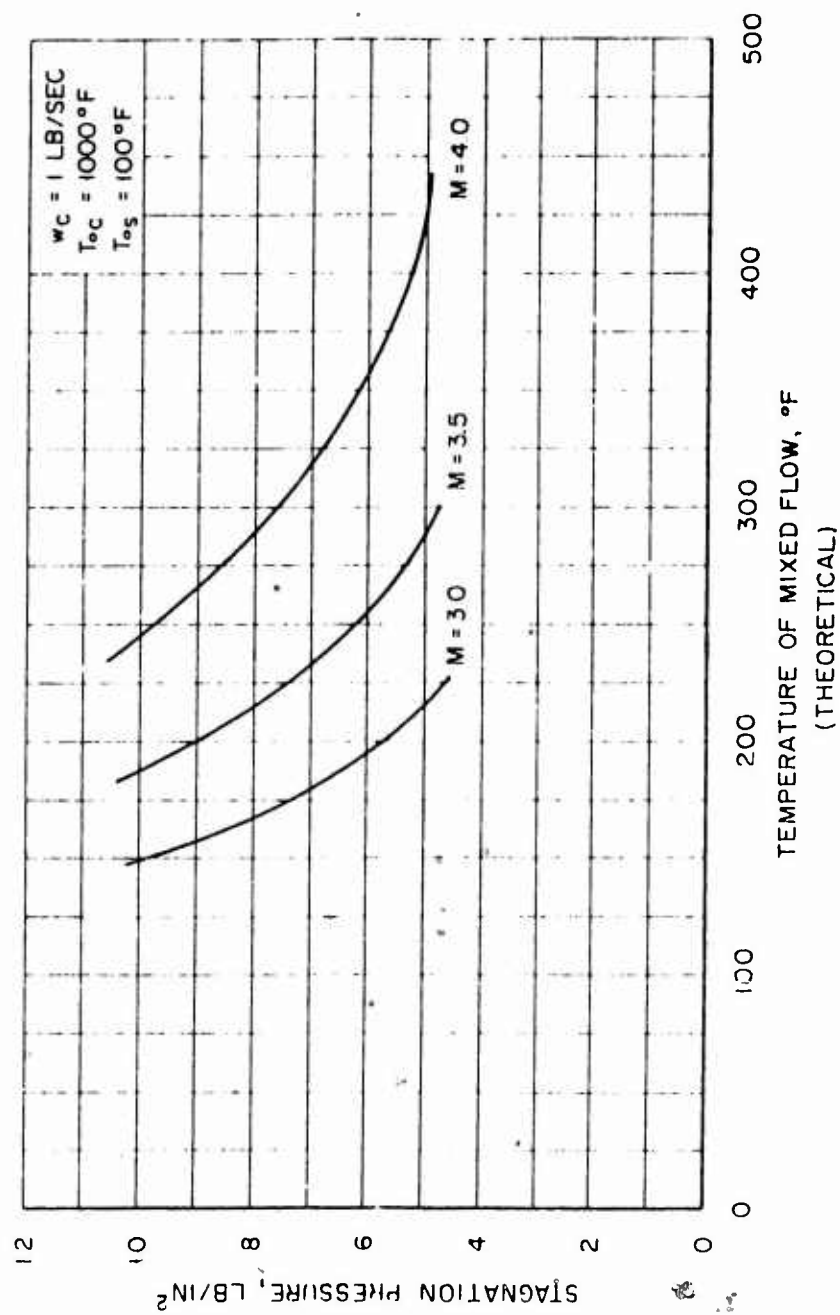


Figure 5. Theoretical temperature of mixed flow versus stagnation pressure.

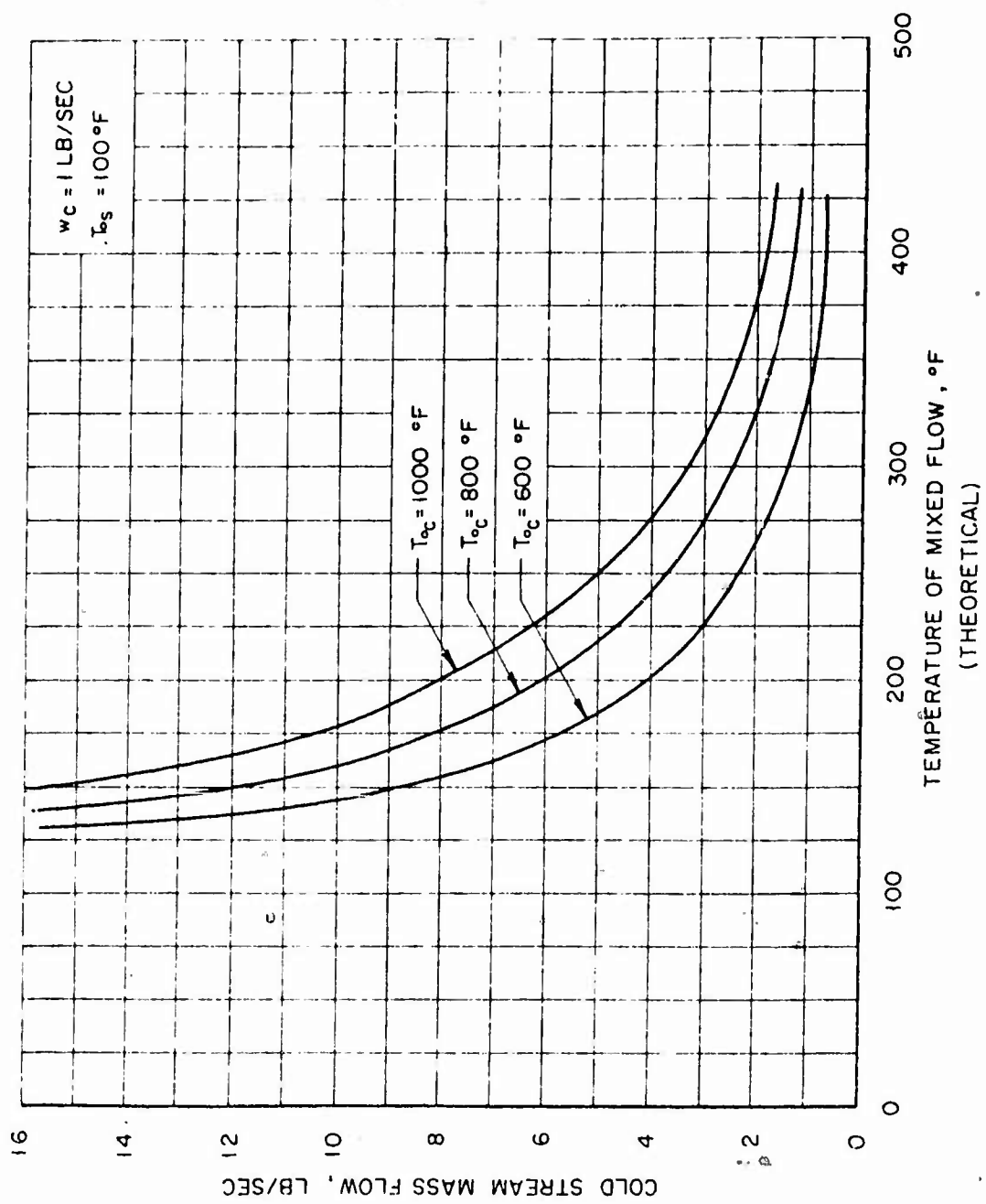


Figure 6. Theoretical temperature of mixed flow versus cold stream mass flow.

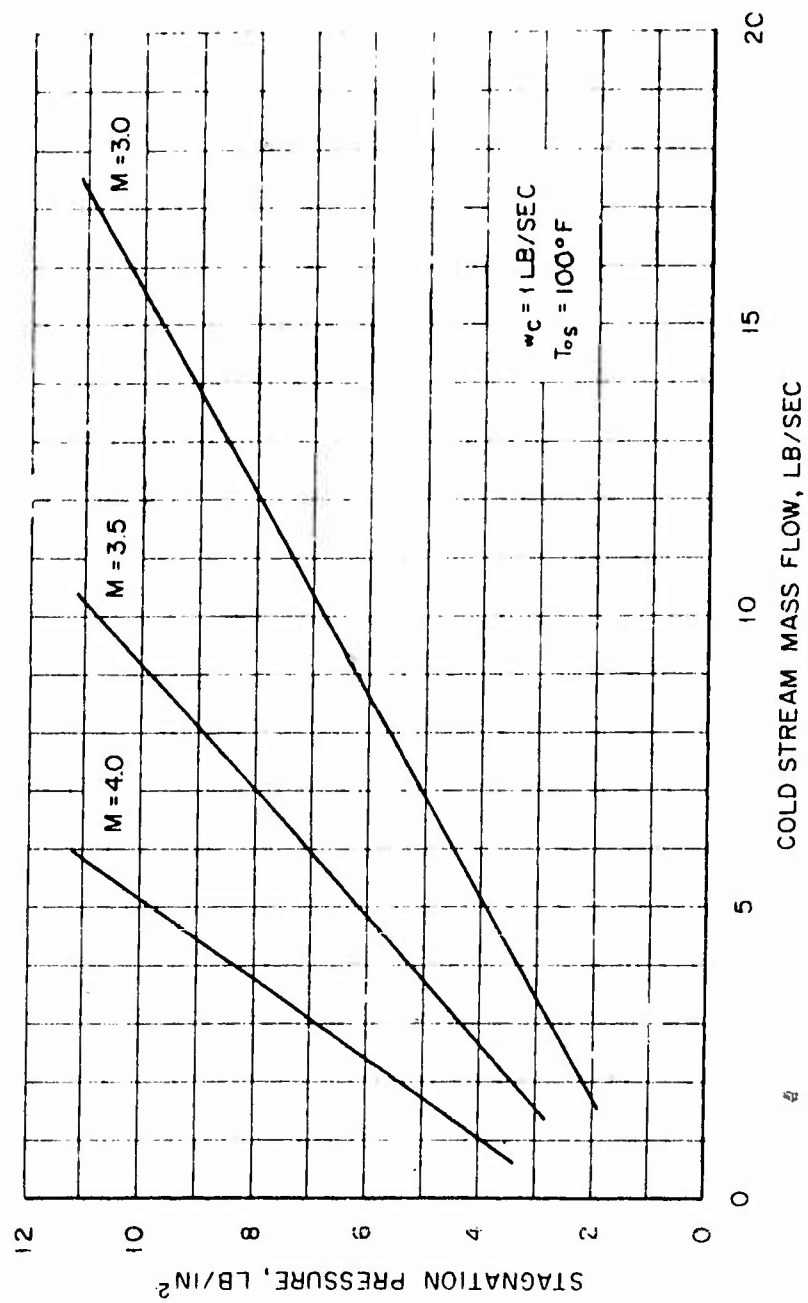


Figure 7. Cold stream mass flow versus stagnation pressure.

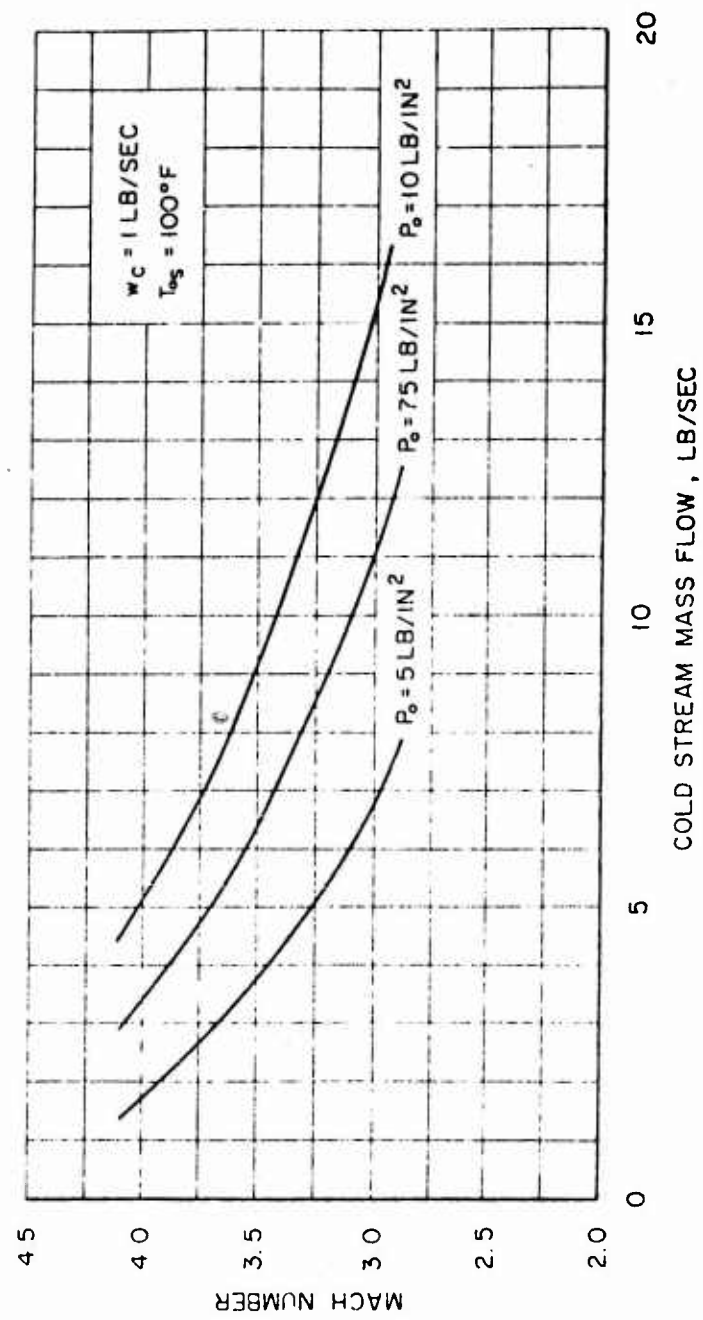


Figure 8. Cold stream mass flow versus Mach number.

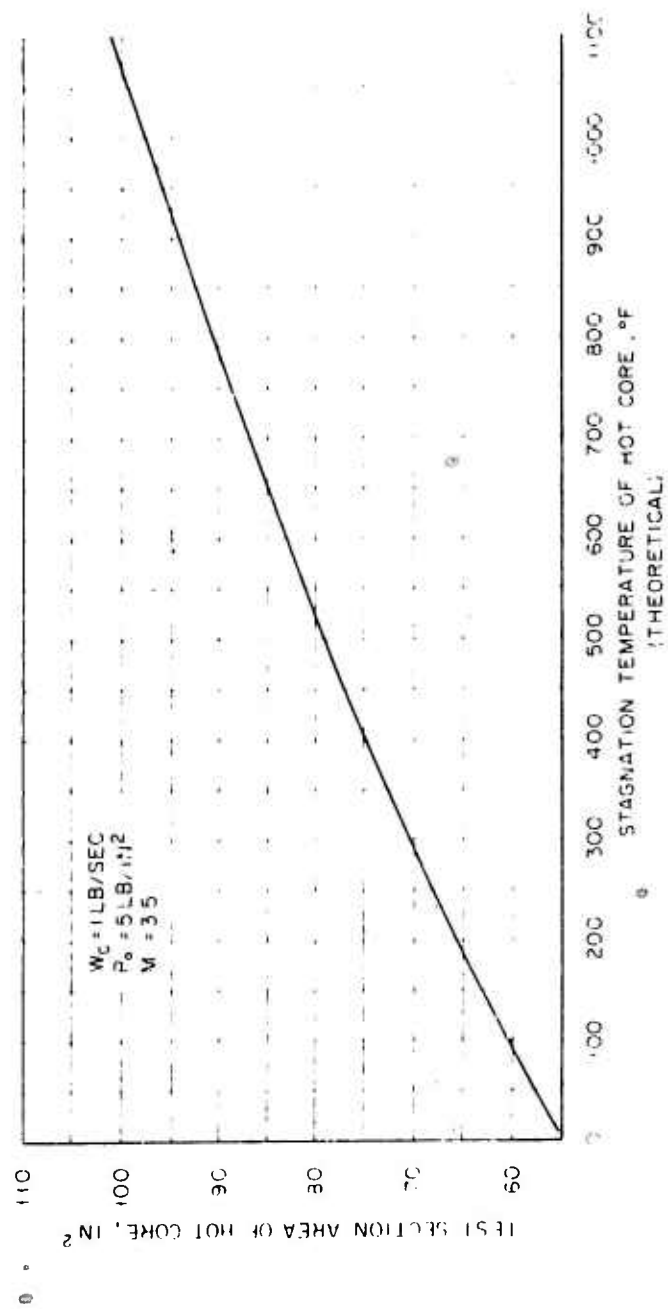


Figure 9. Theoretical test section area of hot core versus stagnation temperature

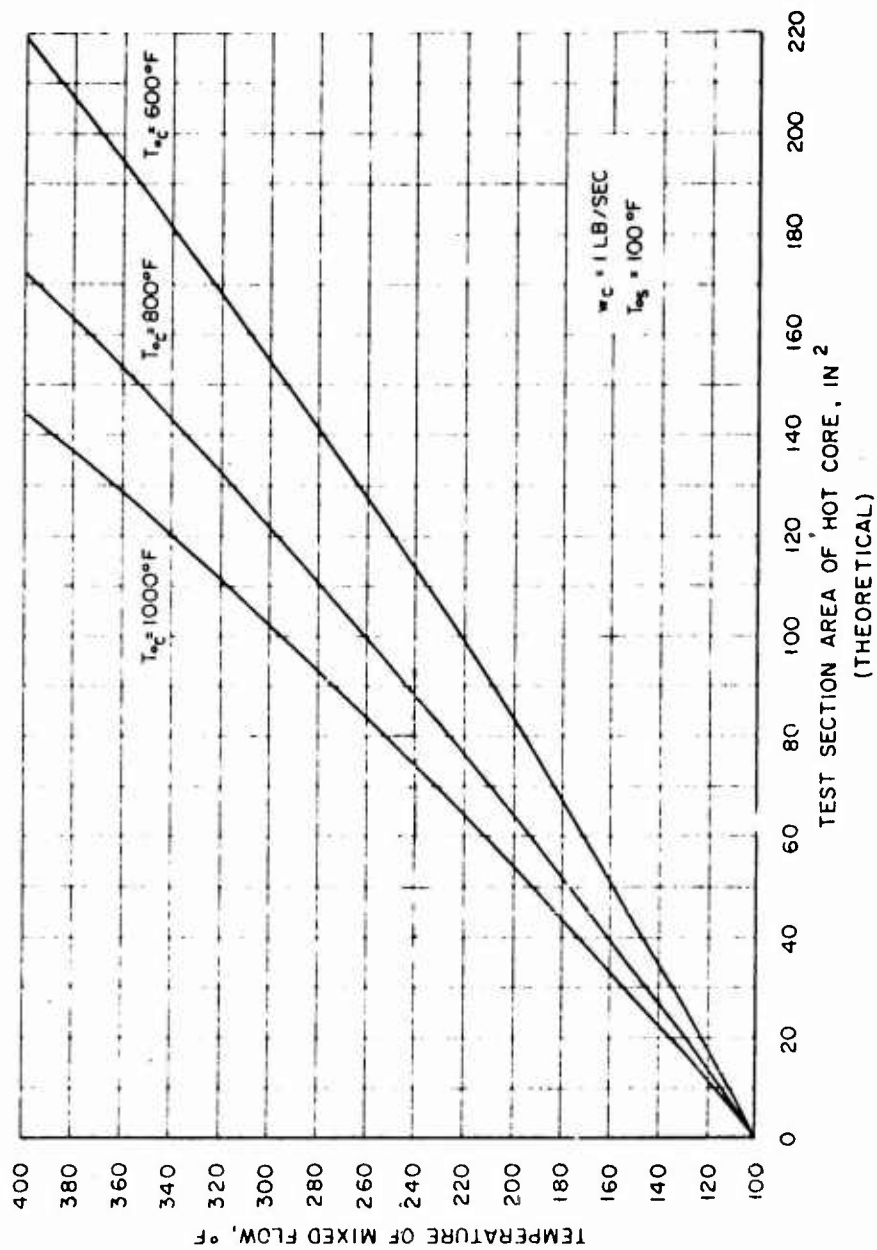


Figure 10. Theoretical test section area of hot core versus temperature of mixed flow.

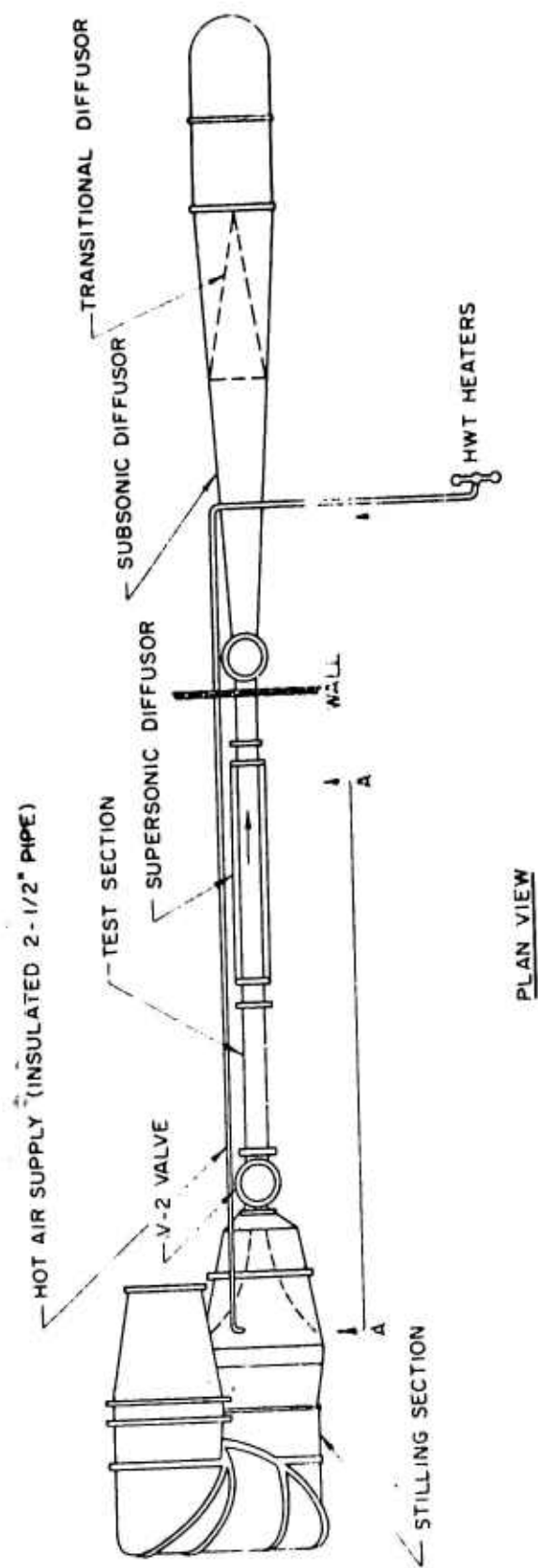


Figure 11. The NSL Mach 3.5 heated core installation - schematic diagram.

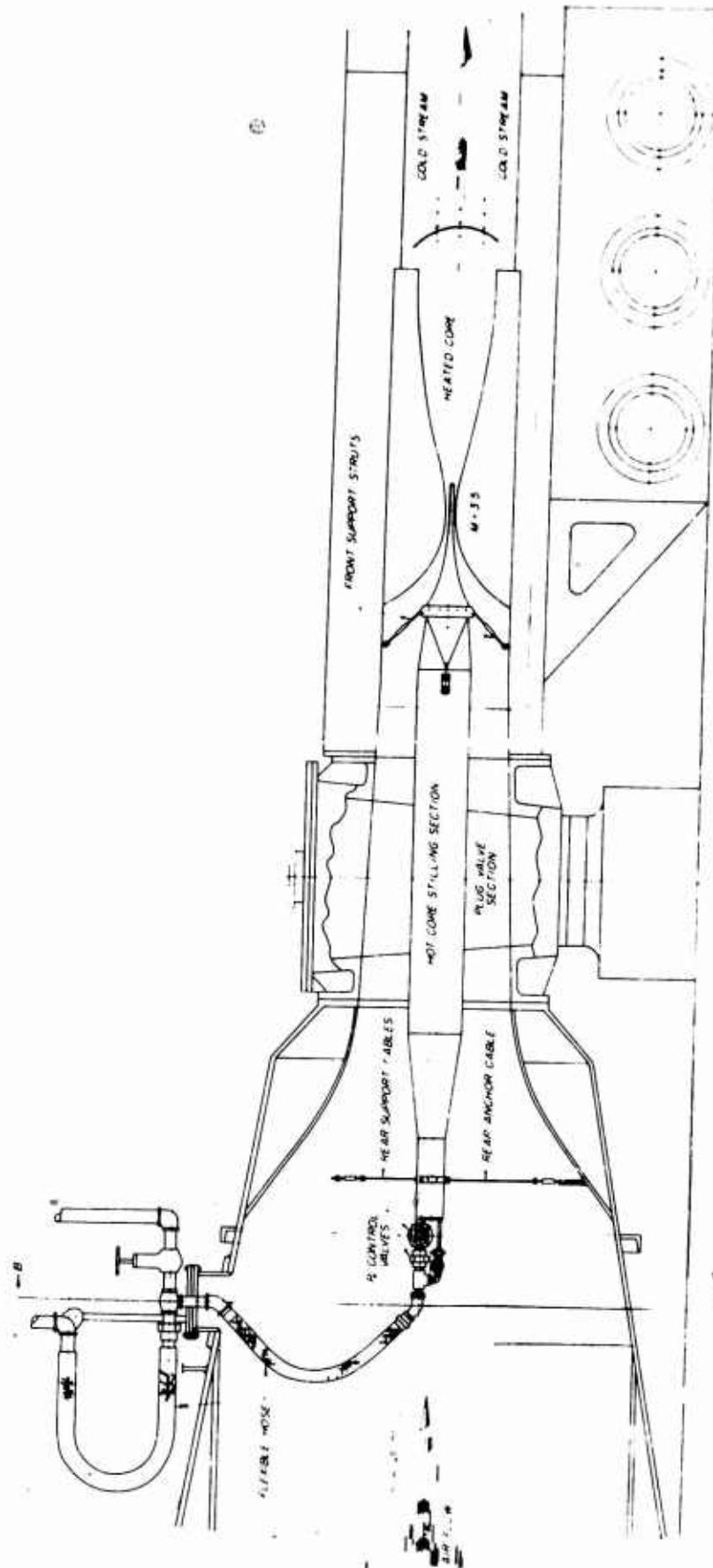


Figure 12. The NSL Mach 3.5 heated core installation - enlarged section A-A.

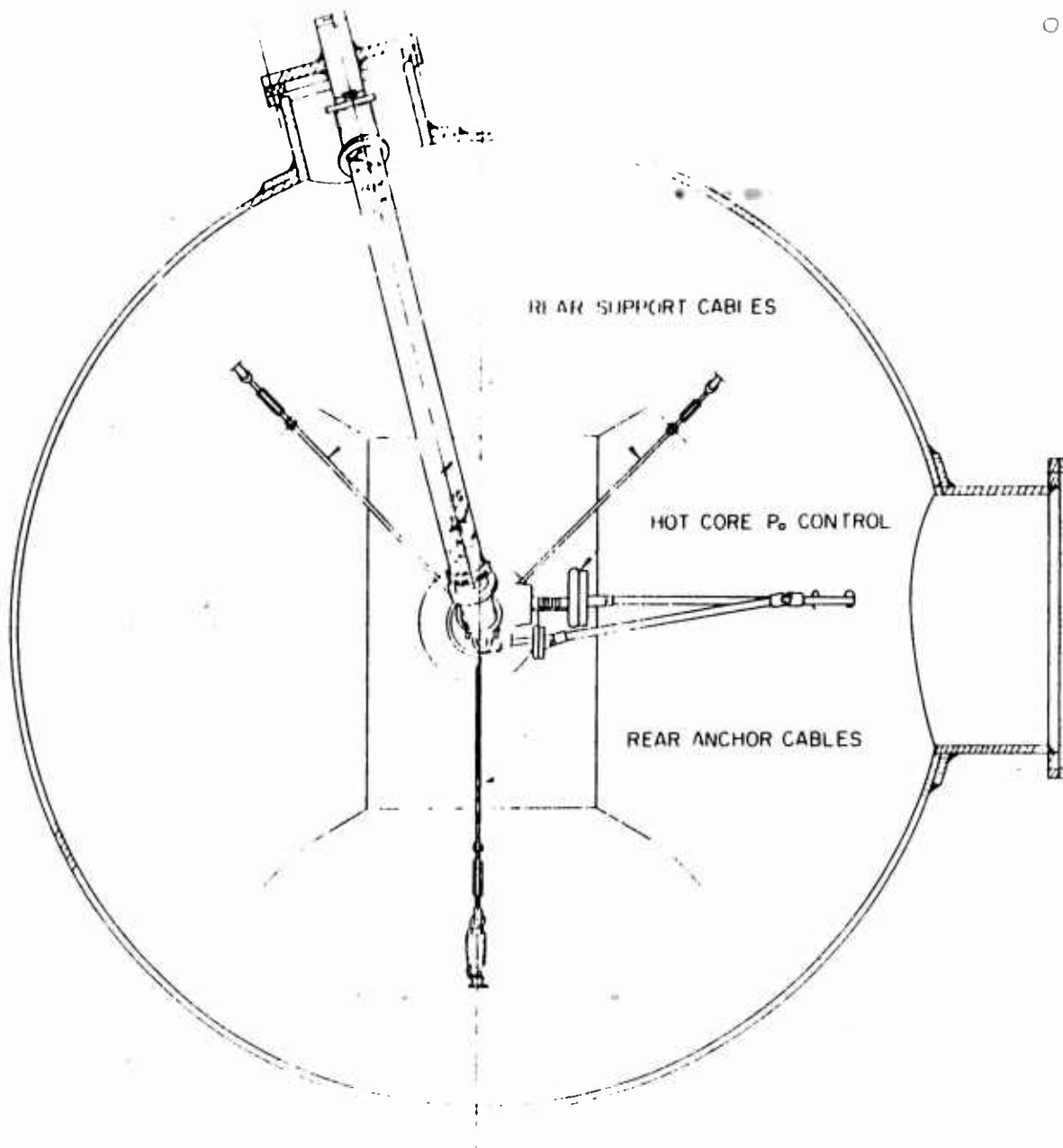


Figure 13. The NSL Mach 3.5 heated core installation  
- enlarged section B-B.

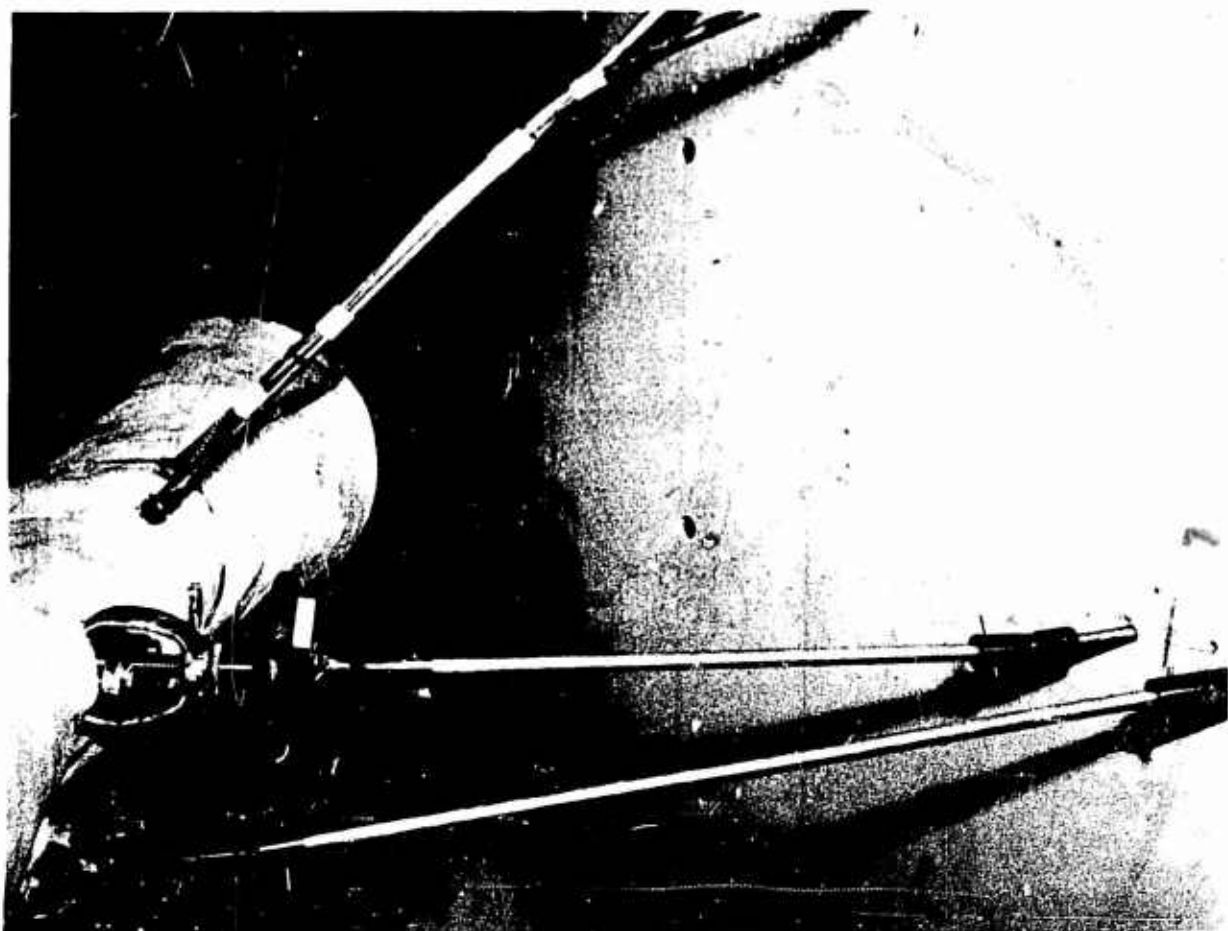


Figure 14. Installation of insulated heated core stilling section - looking downstream.

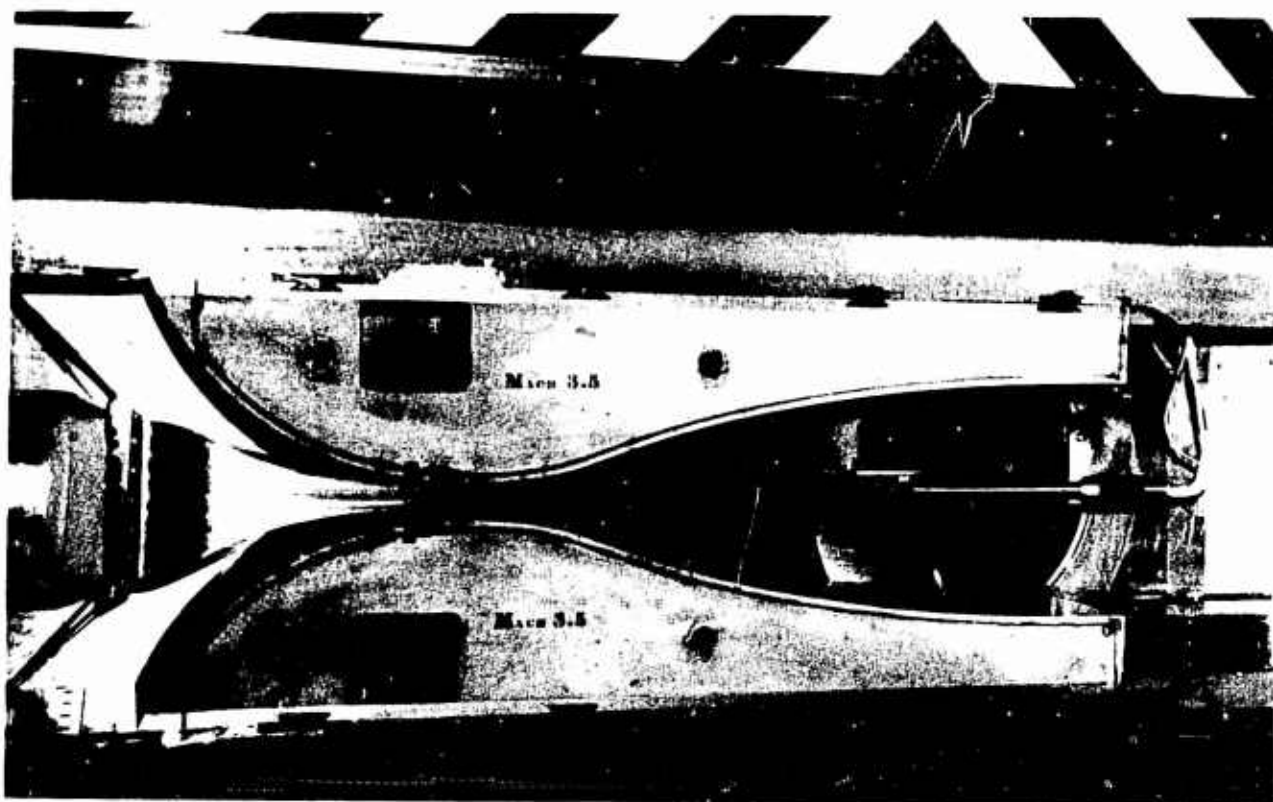


Figure 15. NSL heated core nozzle installation and calibration rake - side view.

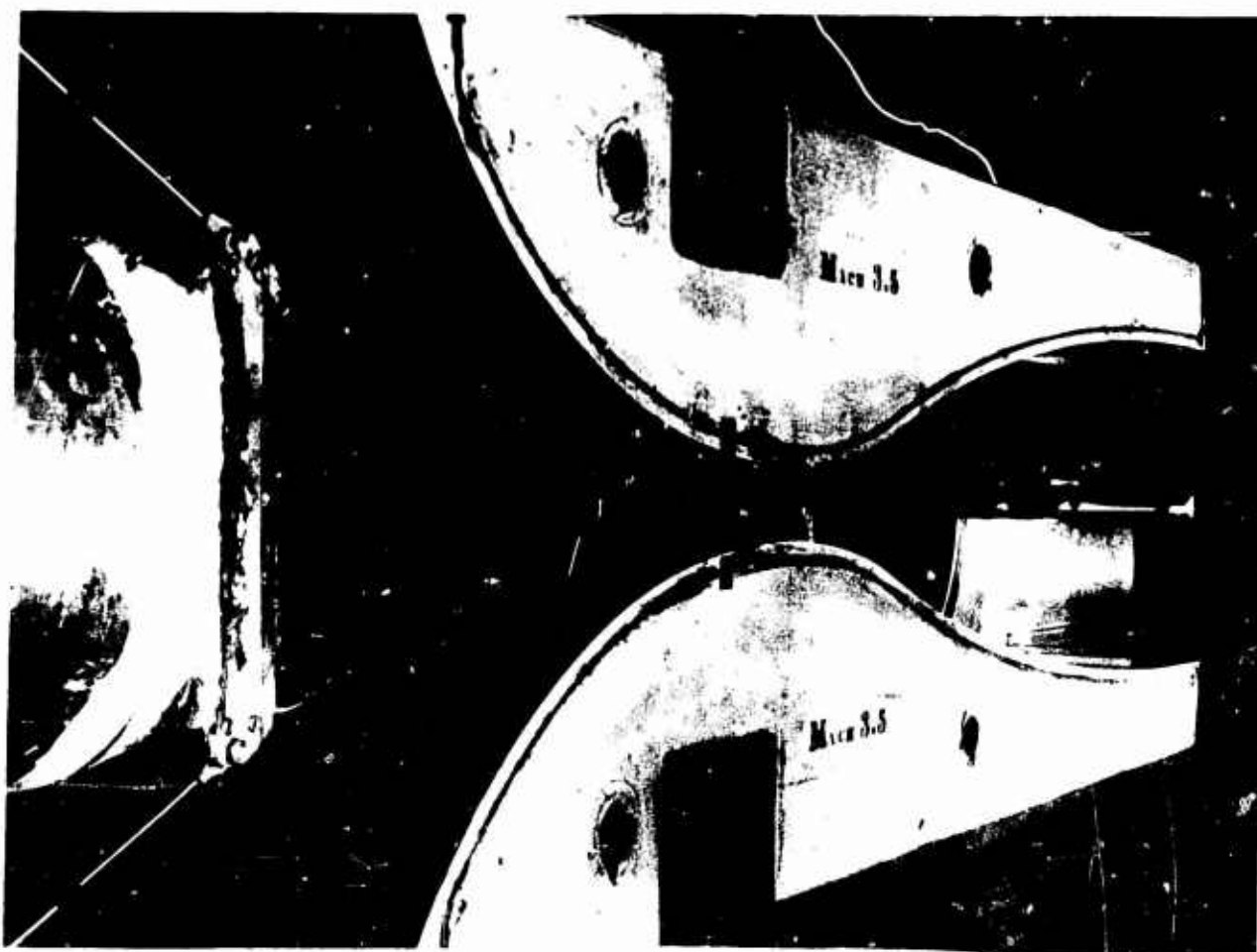


Figure 16. NSL heated core nozzle installation - looking downstream at calibration rake.

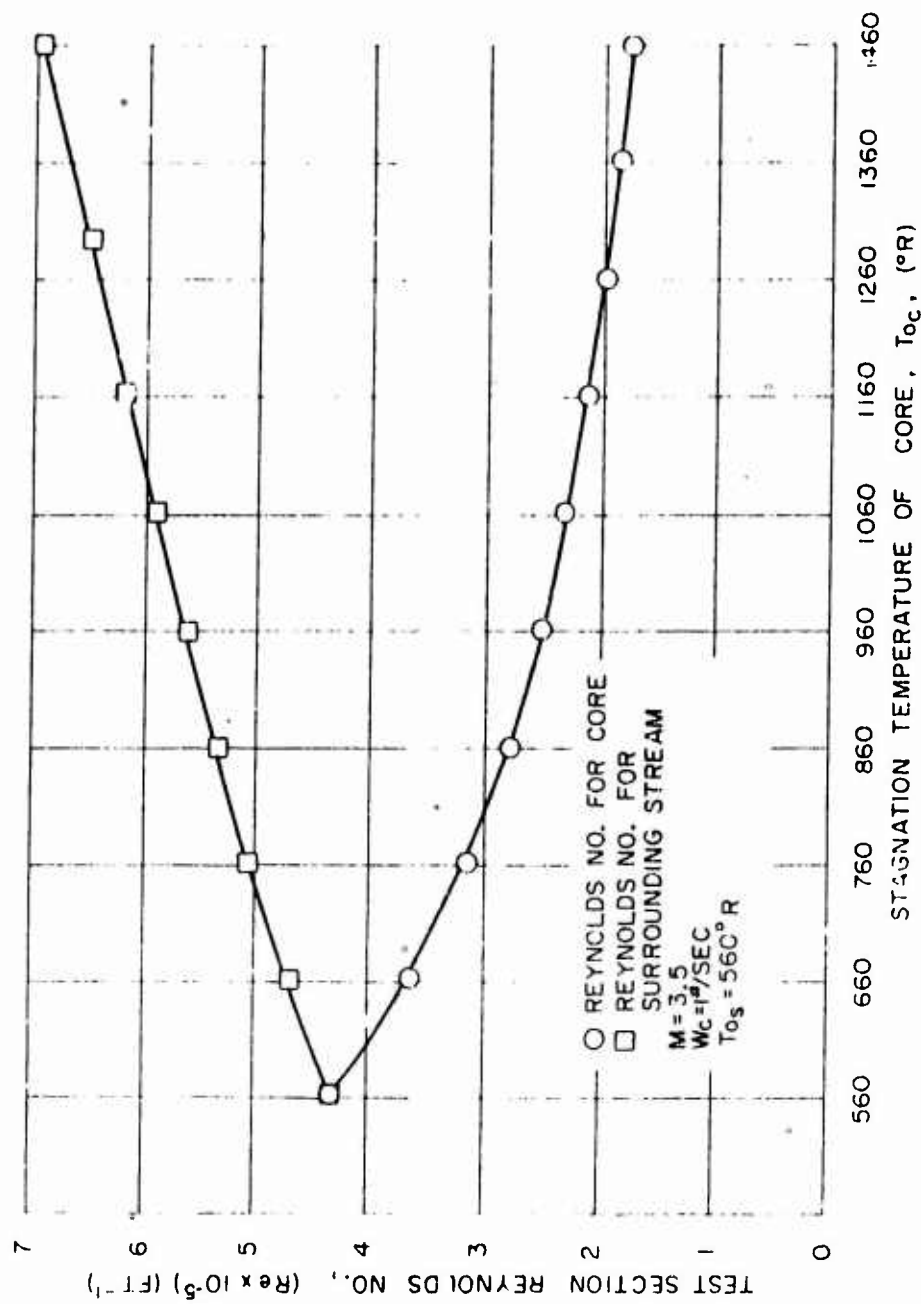


Figure 17. Reynolds numbers encountered during operation of the NSL heated core installation.

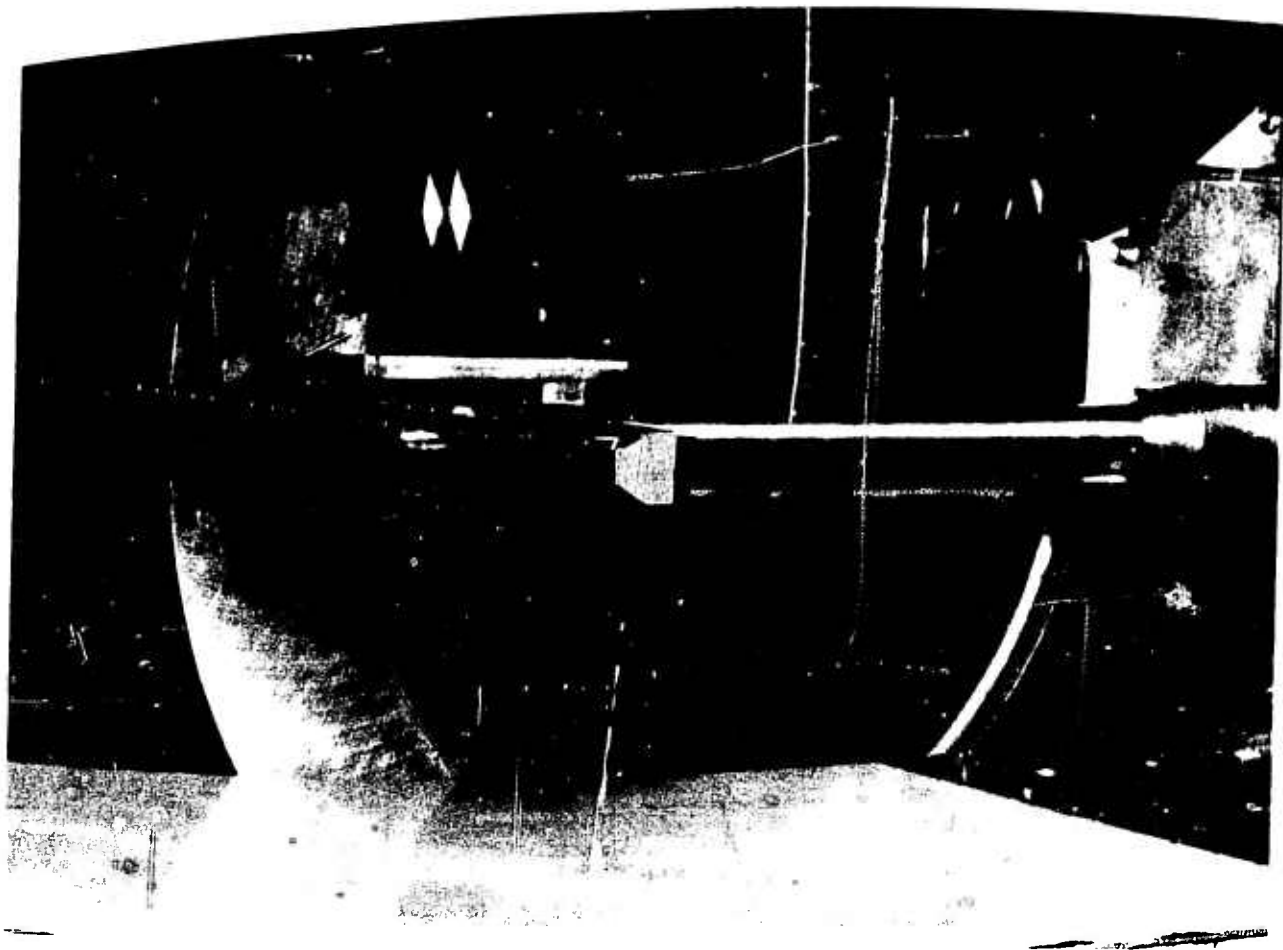


Figure 18. Calibration rake installed in the NSL Mach 3.5 test section.

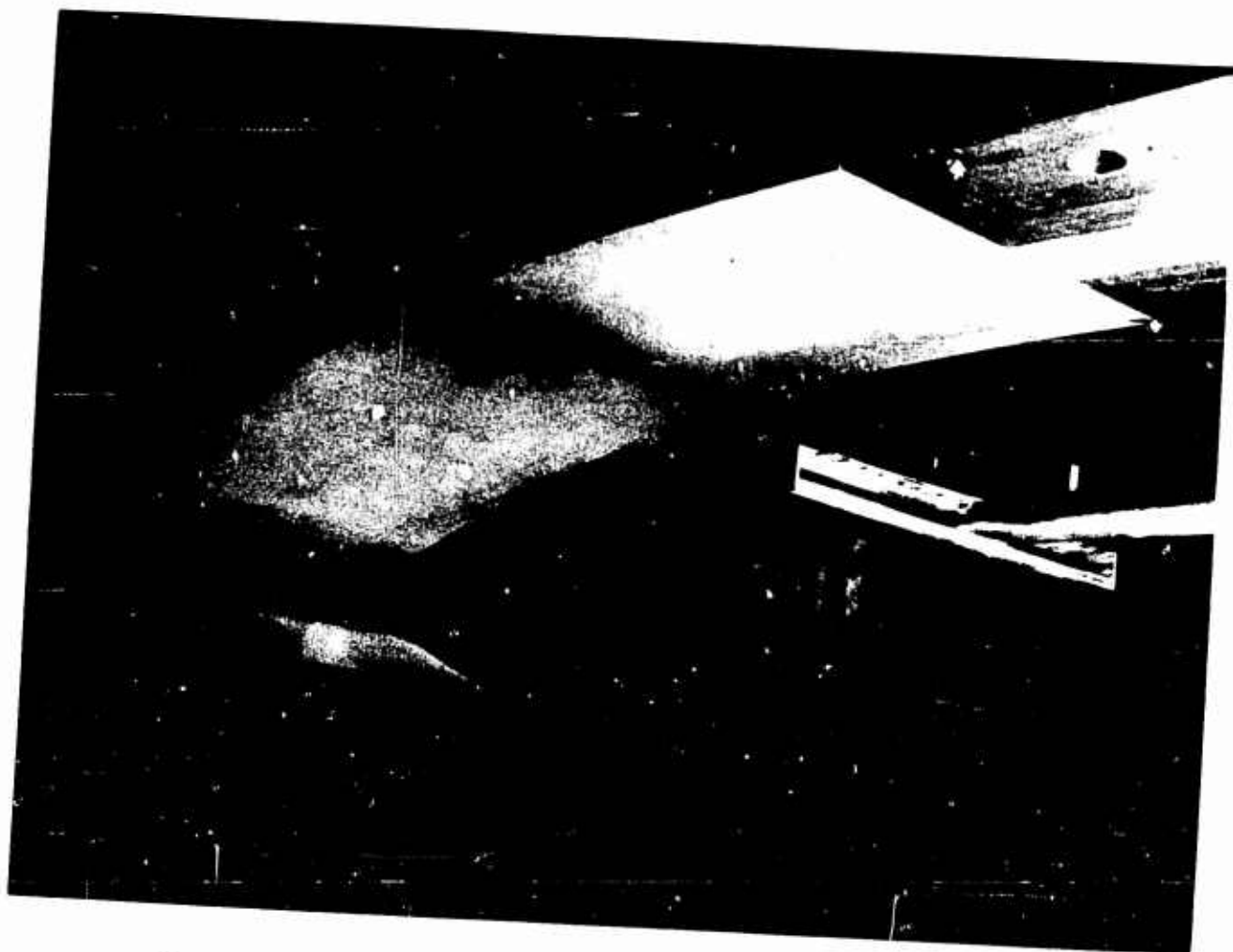


Figure 19. NSL heated core calibration rake - looking upstream at the core nozzle.

0-2

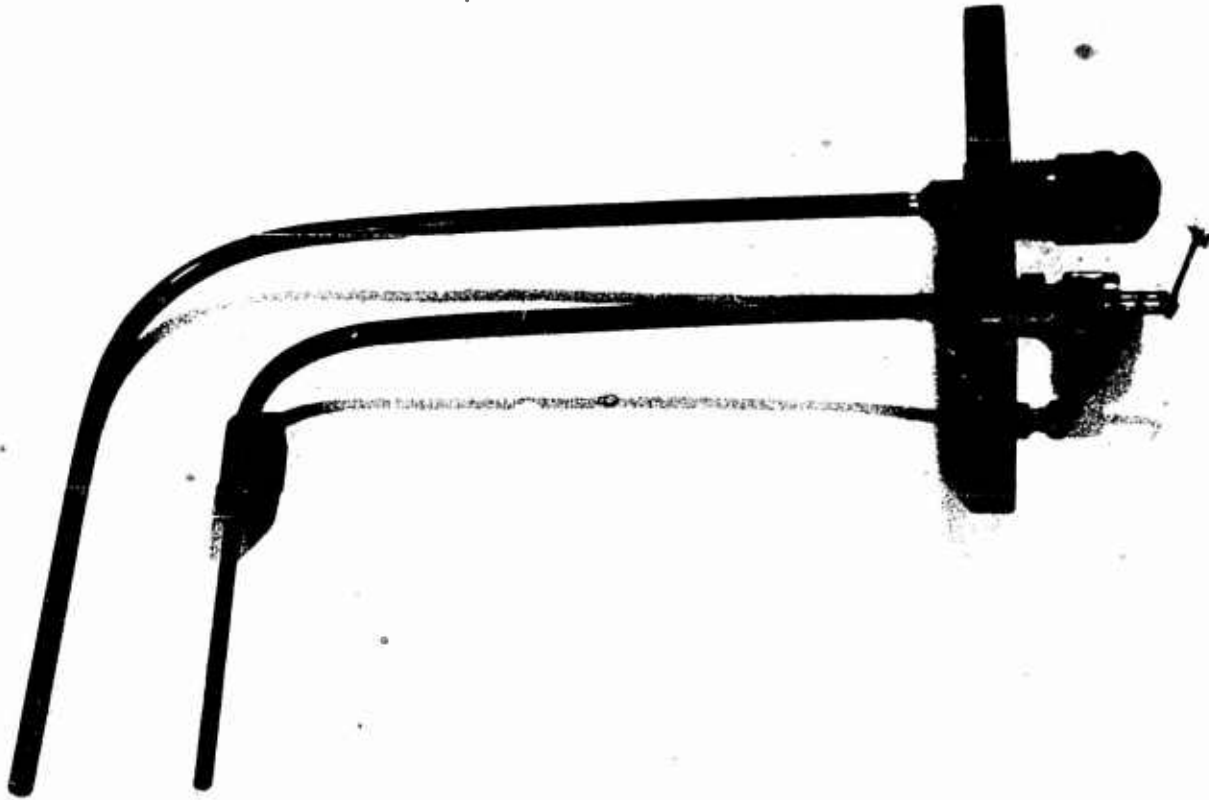


Figure 20. Heated core stilling chamber stagnation pressure and stagnation temperature probes.

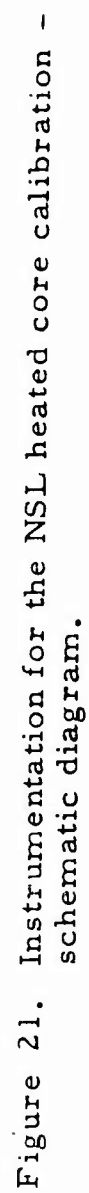


Figure 21. Instrumentation for the NSL heated core calibration - schematic diagram.

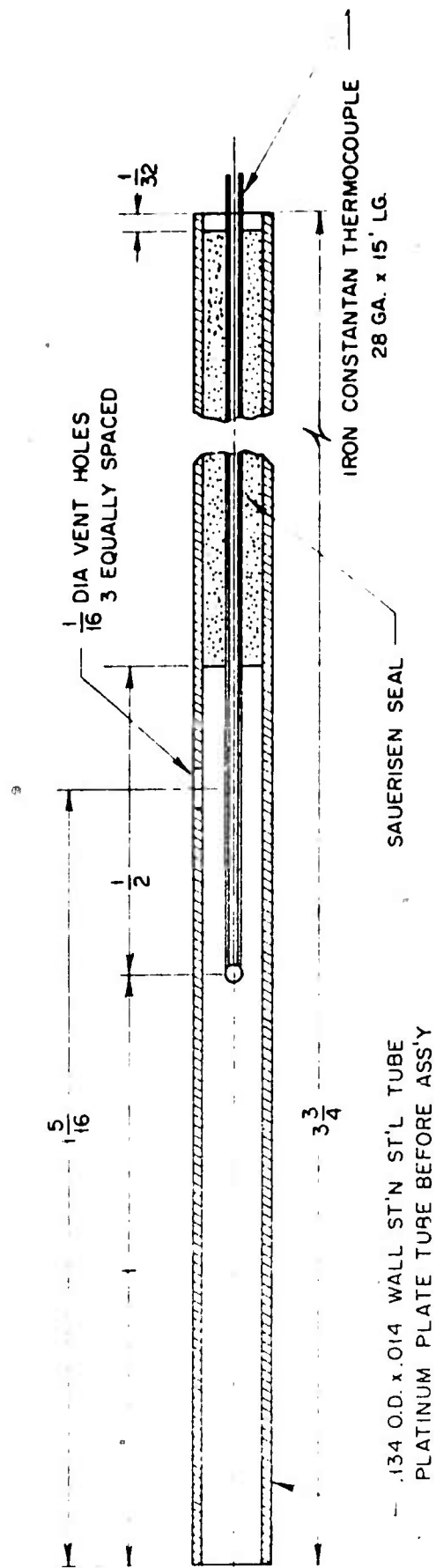


Figure 22. Detailed diagram of heated core calibration total temperature probe.

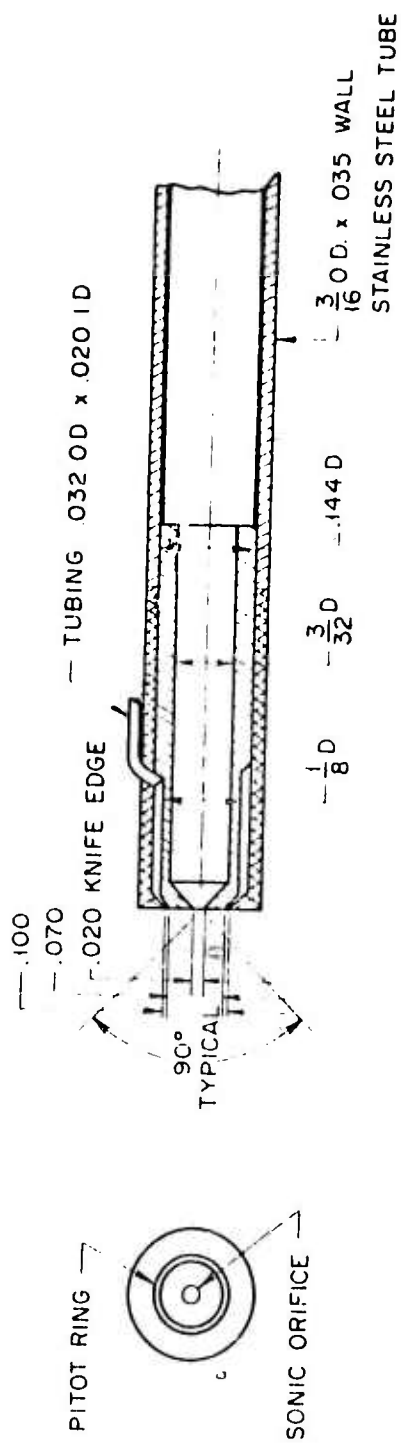


Figure 23. Detailed diagram of heated core calibration mass flow probe.

.125 O.D. x .055 I.D. STAINLESS STEEL TUBING



Figure 24. Detailed diagram of heated core calibration pitot probe.

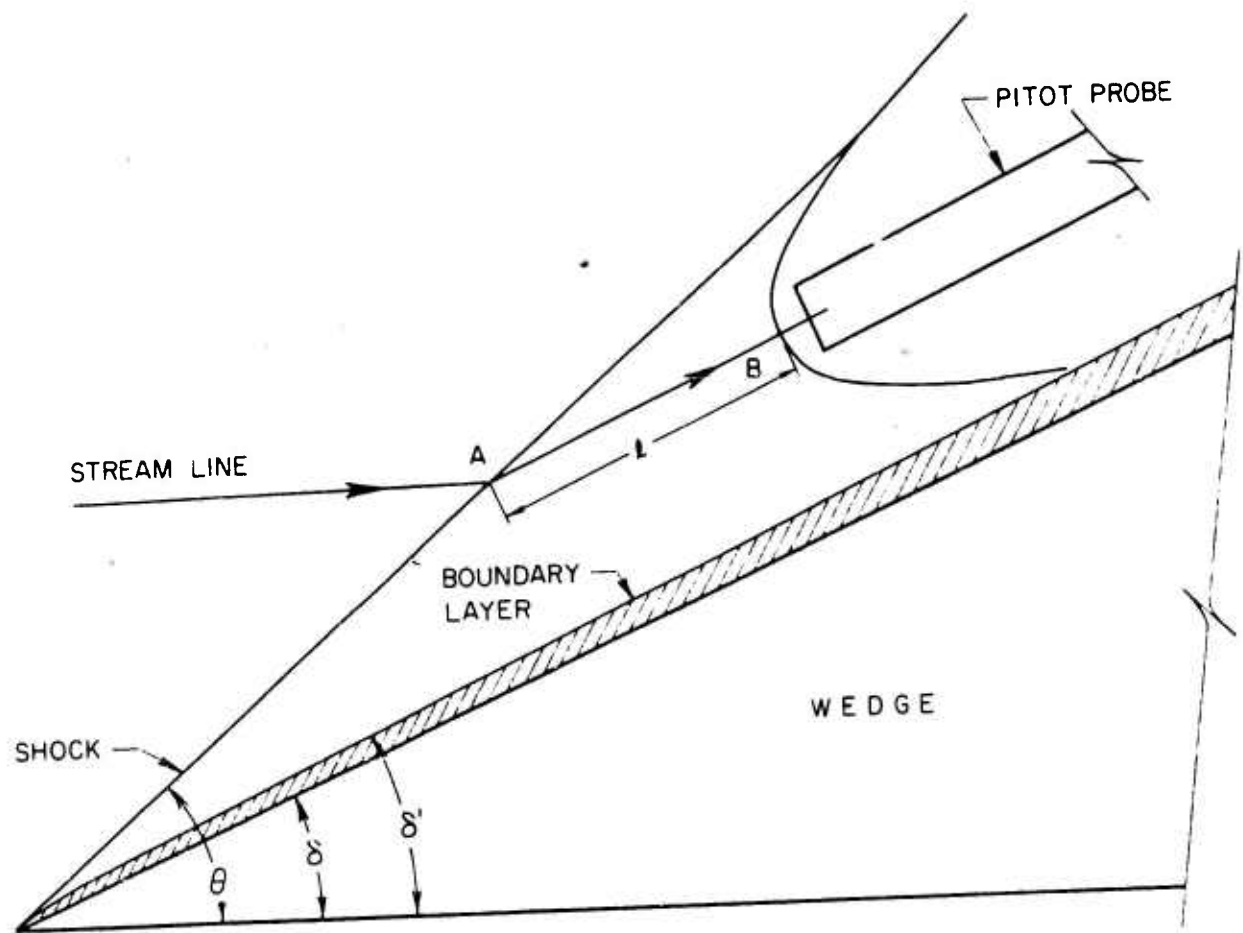


Figure 25. Sketch of wedge-pitot probe corrected for boundary layer.

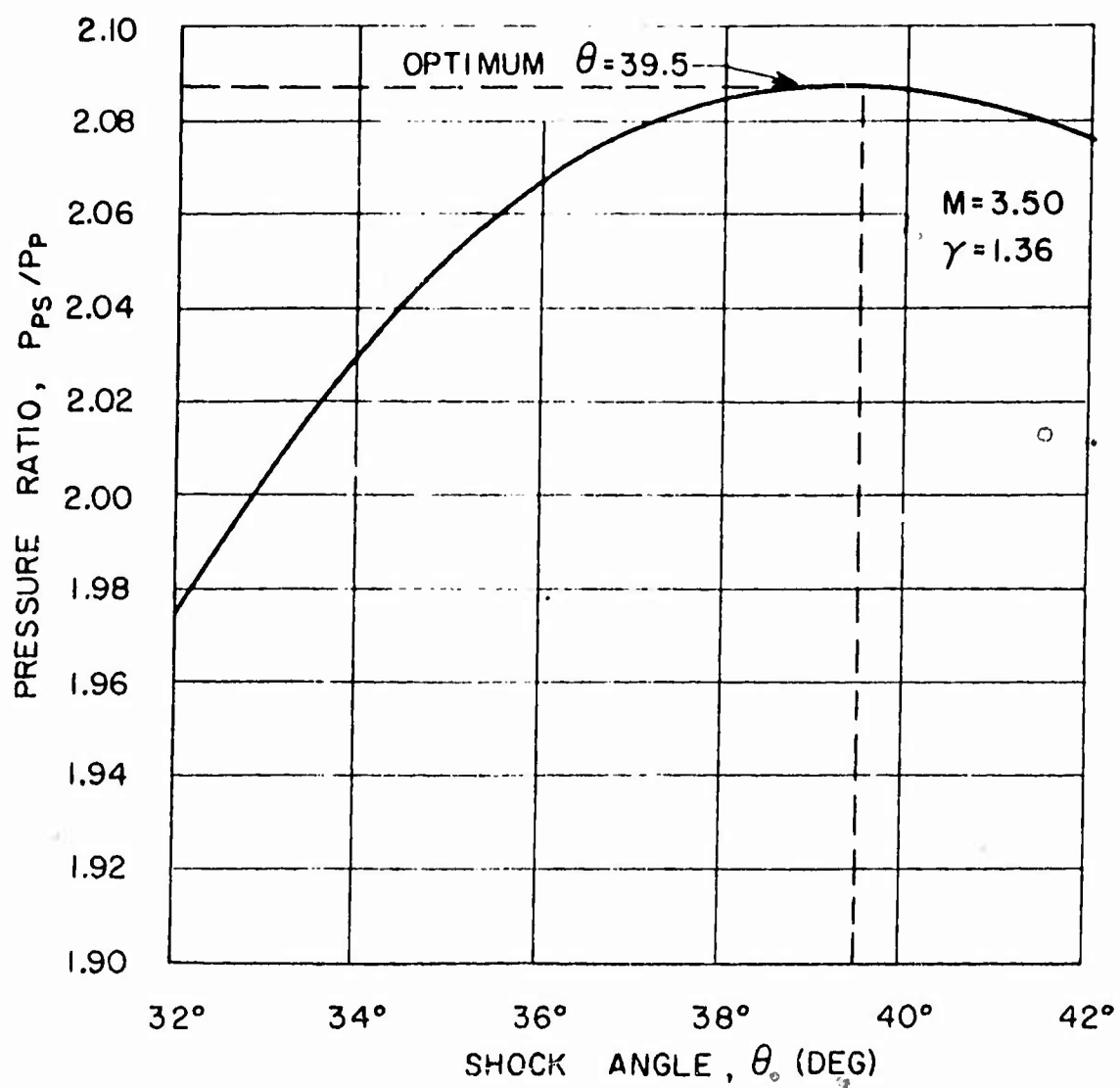


Figure 26. Optimum shock angle for wedge-pitot probe.

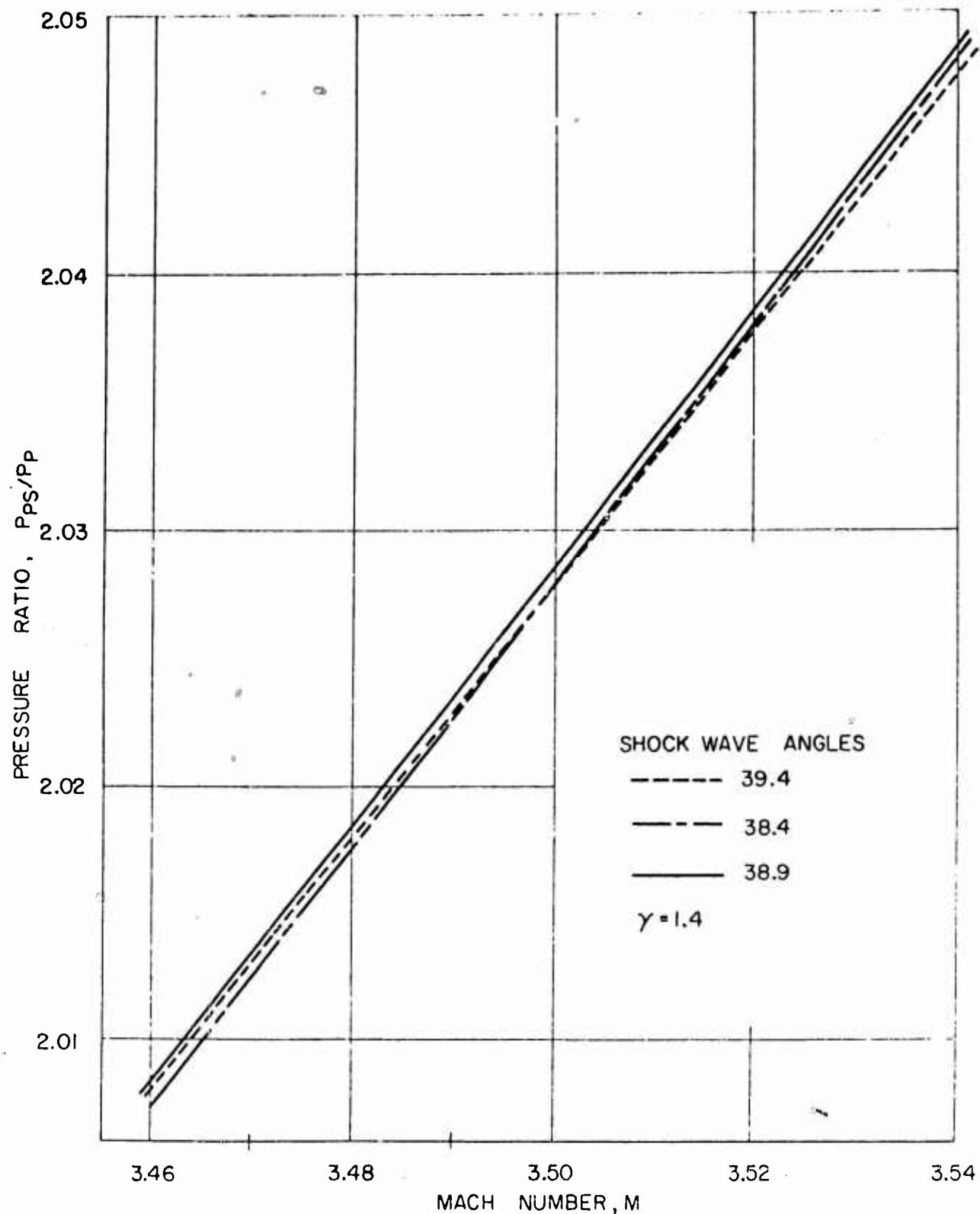


Figure 27. Pitot pressure behind and oblique shock over pitot pressure,  $p_{ps}/p_p$  versus Mach number, for shock angles near the optimum.

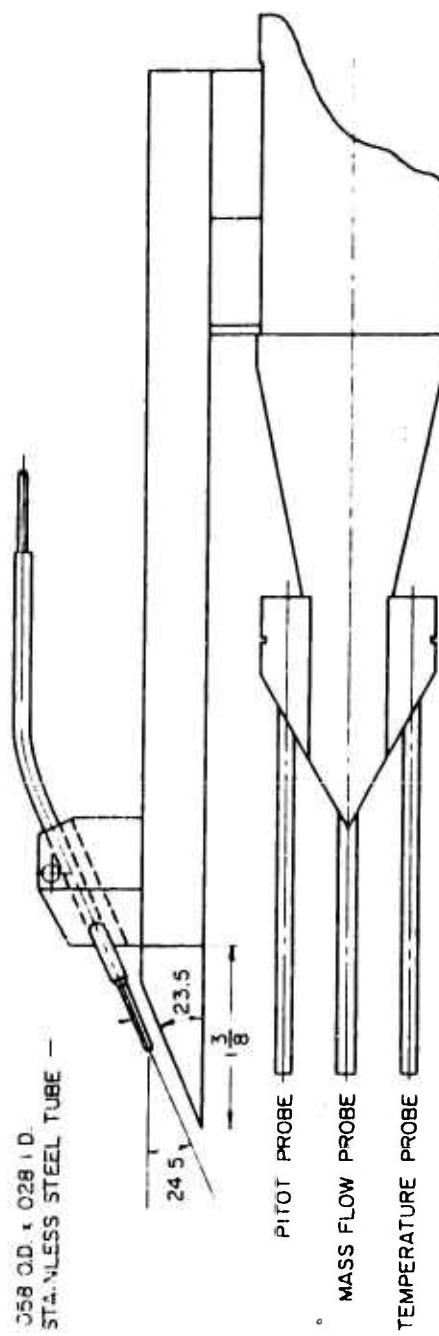
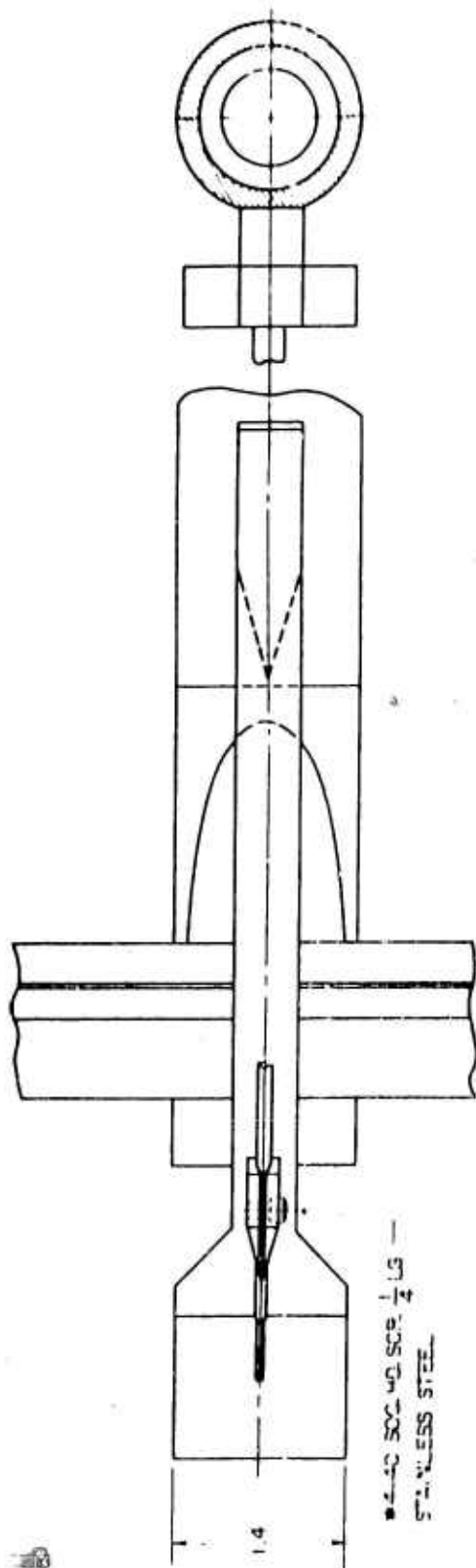


Figure 28. Wedge pitot probe assembly mounted on the calibration rake.

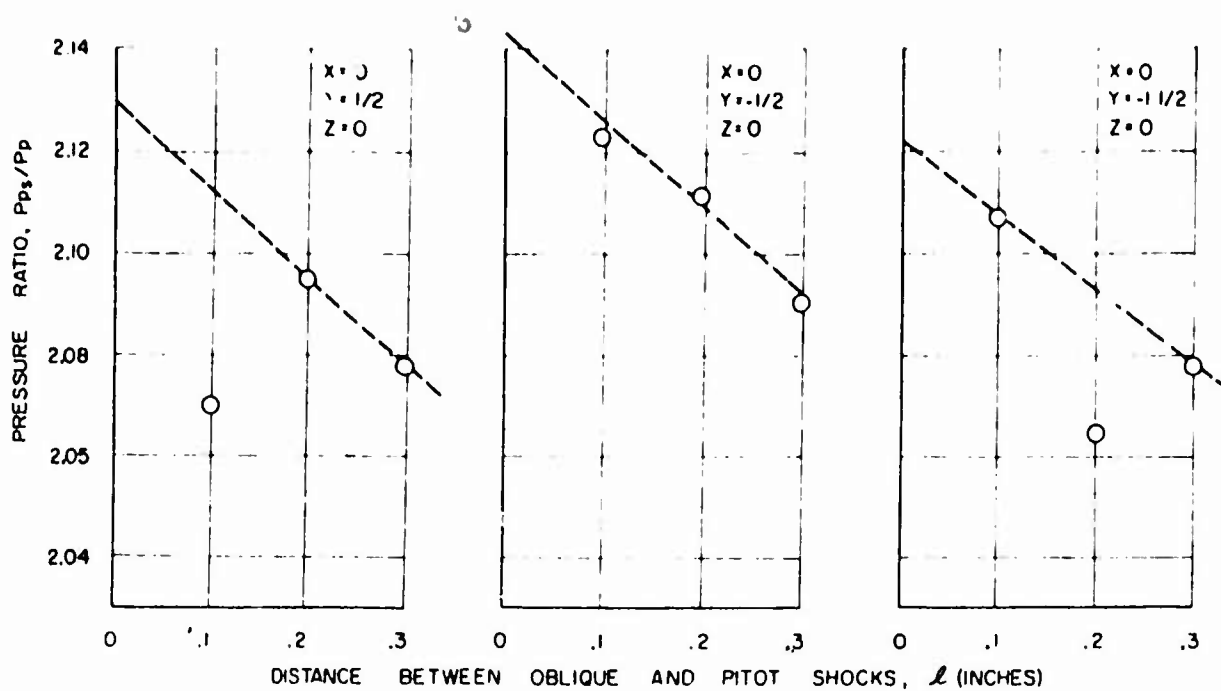


Figure 29.

Figure 30.

Figure 31.

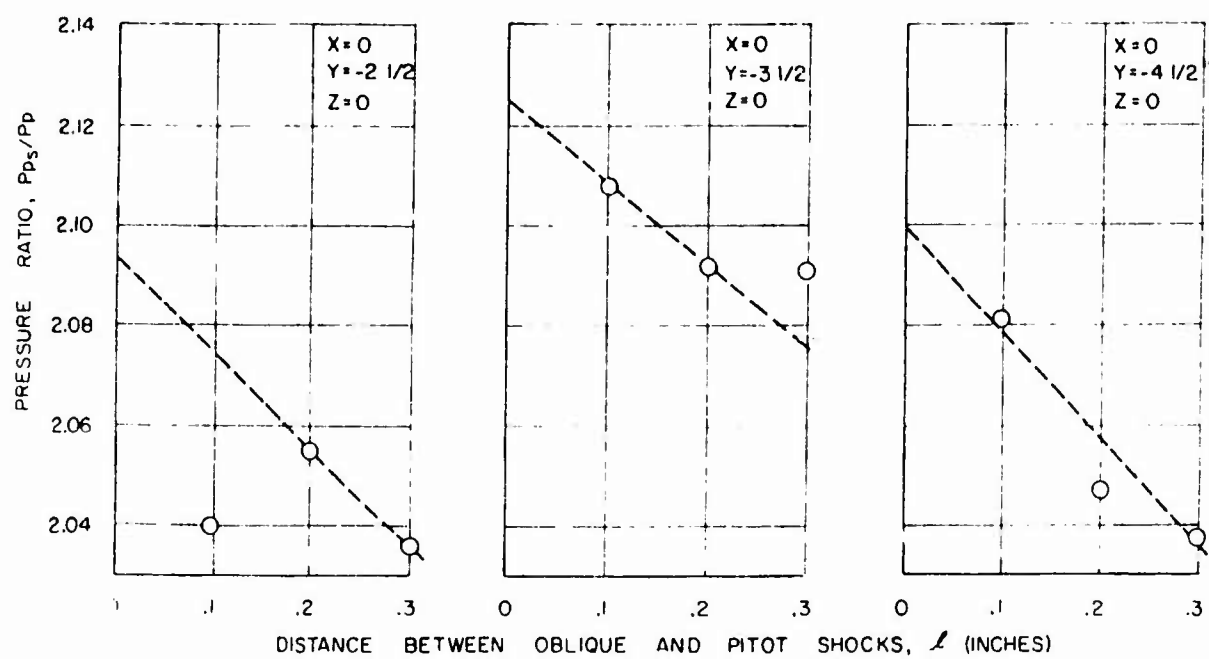


Figure 32.

Figure 33.

Figure 34.

Figures 29 - 34. Extrapolations to zero separation of oblique and pitot shocks for wedge-pitot probe data.

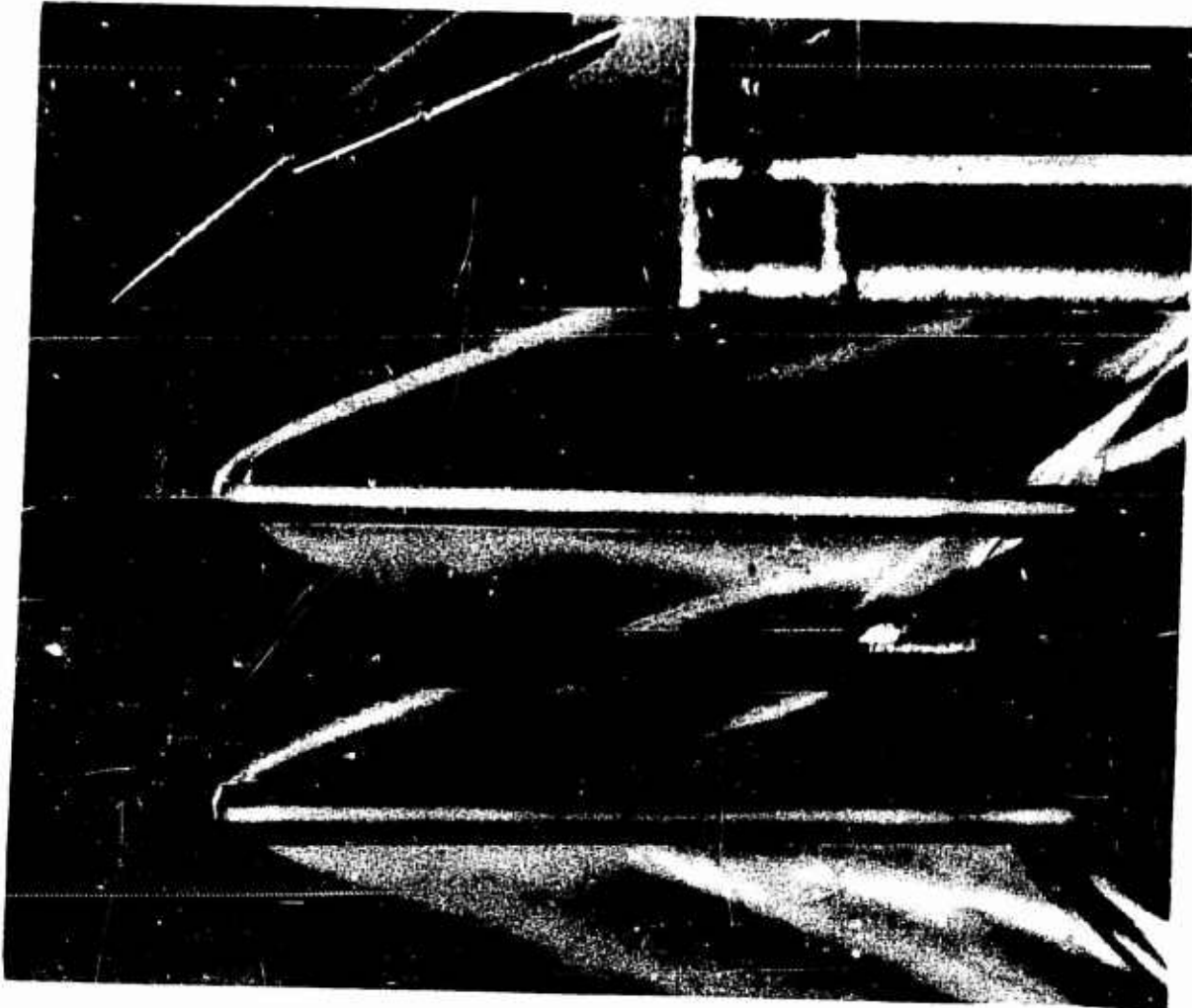


Figure 35. Enlarged schlieren photograph of calibration rake probes in Mach 3.5 flow.

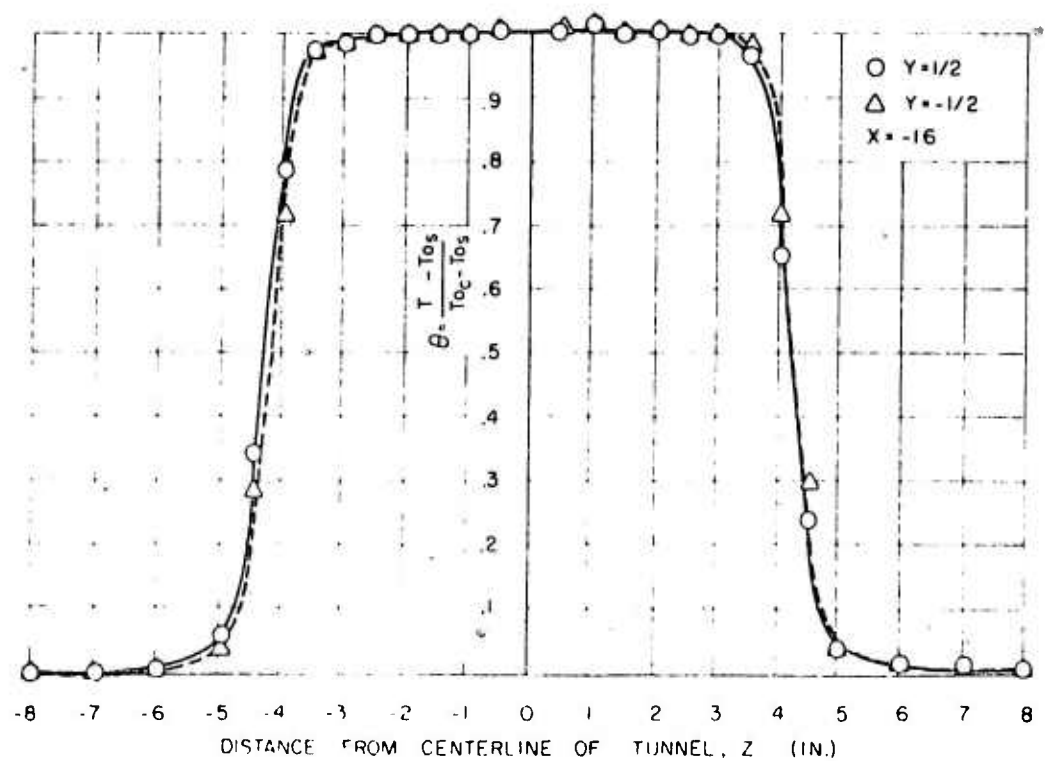
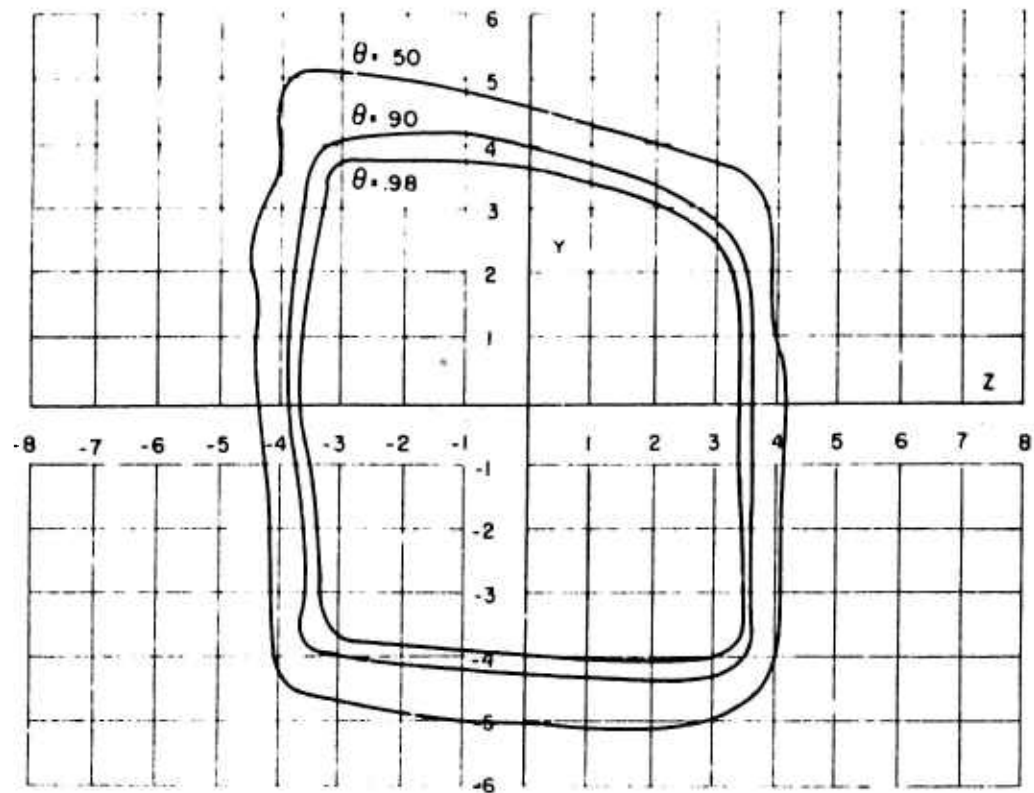


Figure 36. Isotherms and temperature distribution across the Mach 3.5 test section, sixteen inches upstream of the schlieren centerline.

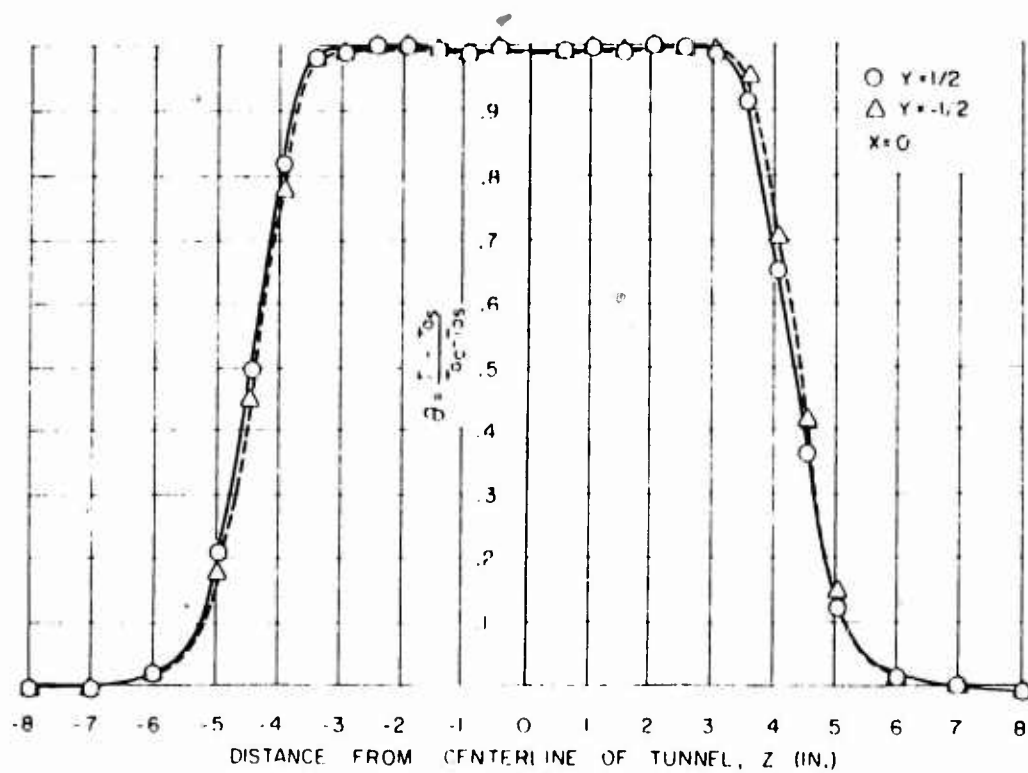
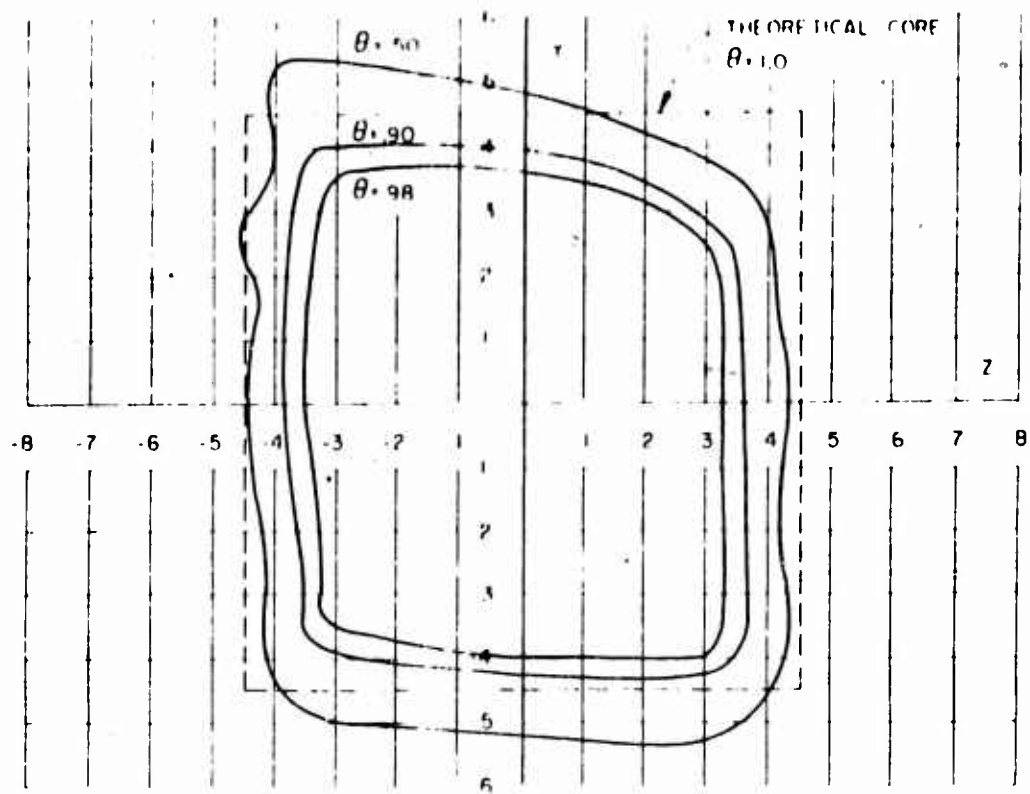


Figure 37. Isotherms and temperature distribution across the Mach 3.5 test section, at the schlieren centerline.

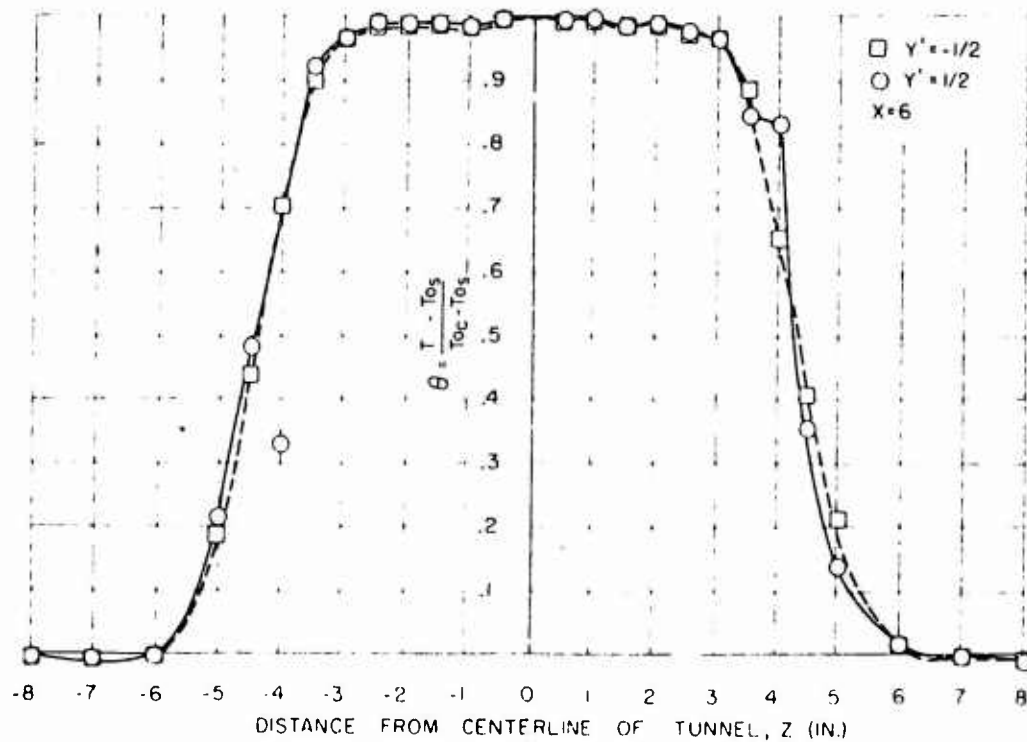
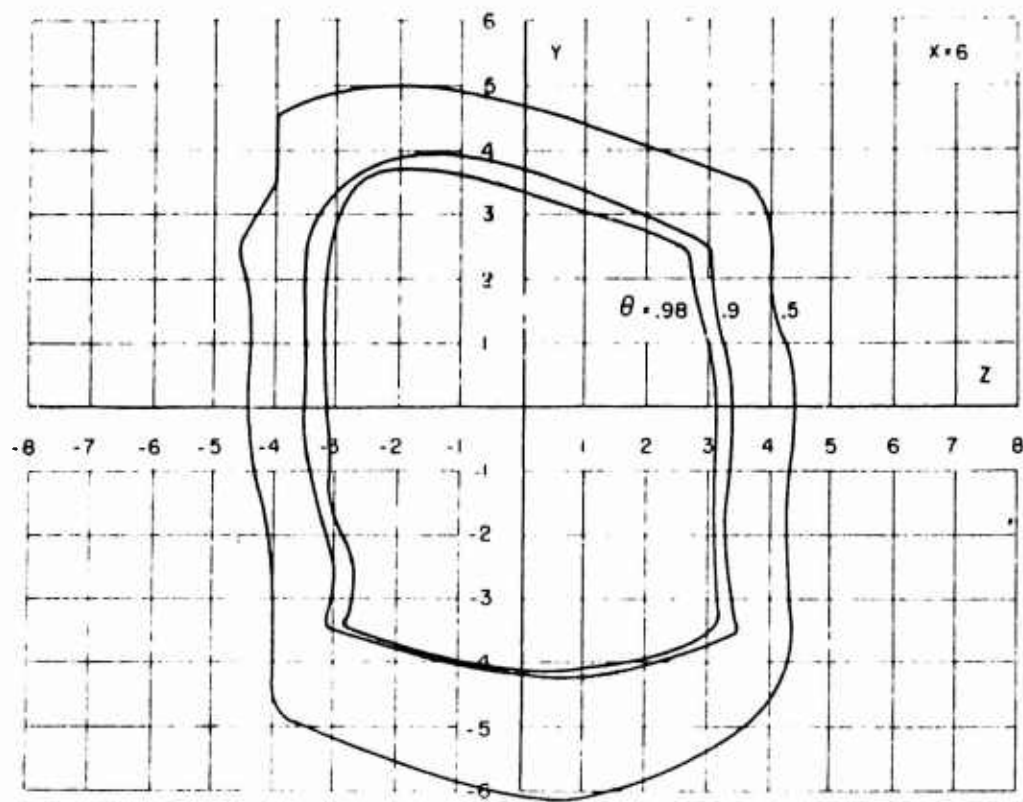


Figure 38. Isotherms and temperature distribution across the Mach 3.5 test section, six inches downstream of the schlieren centerline.

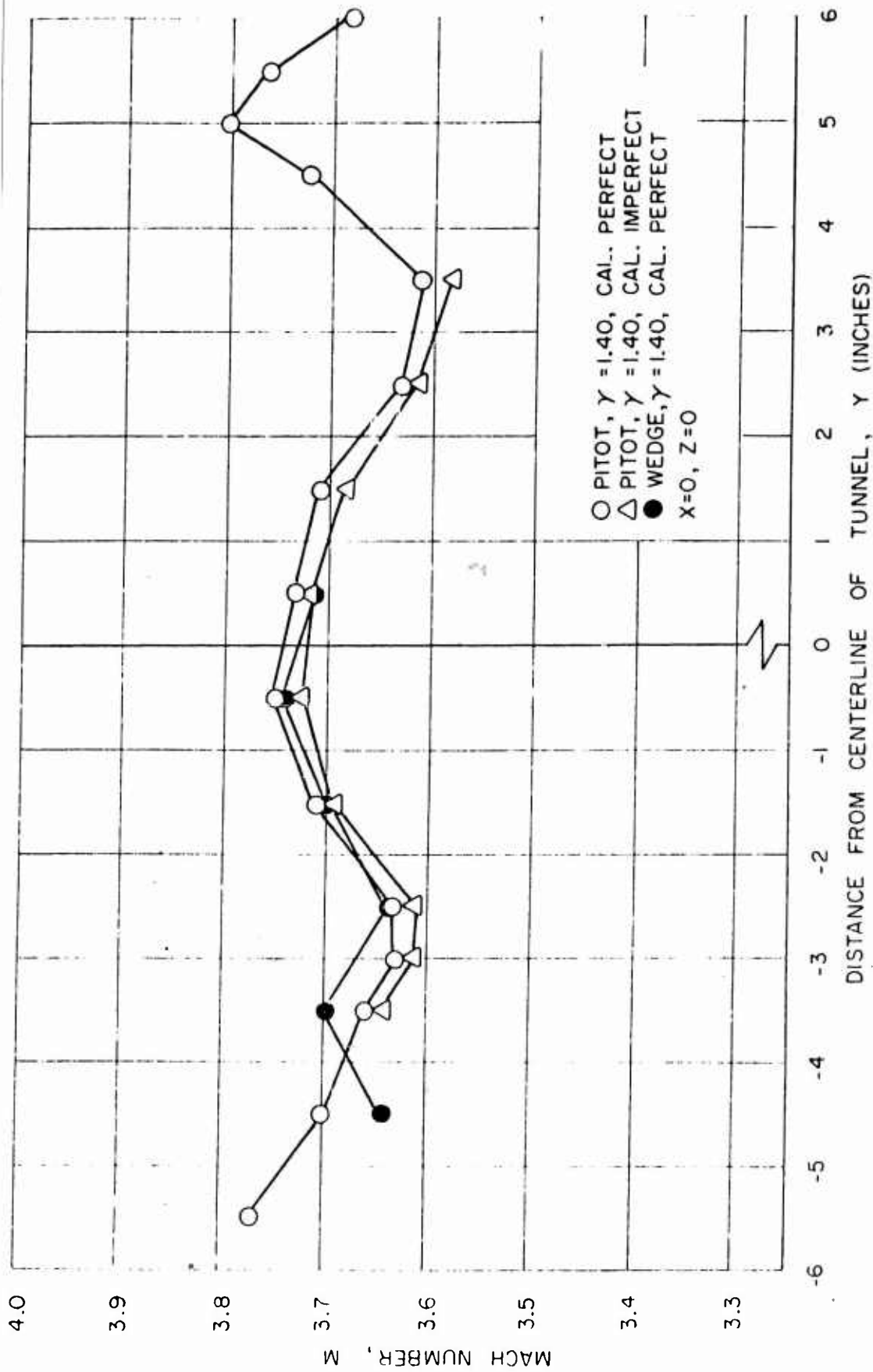


Figure 39. Comparison of pitot determined Mach numbers with wedge-pitot determined Mach numbers.

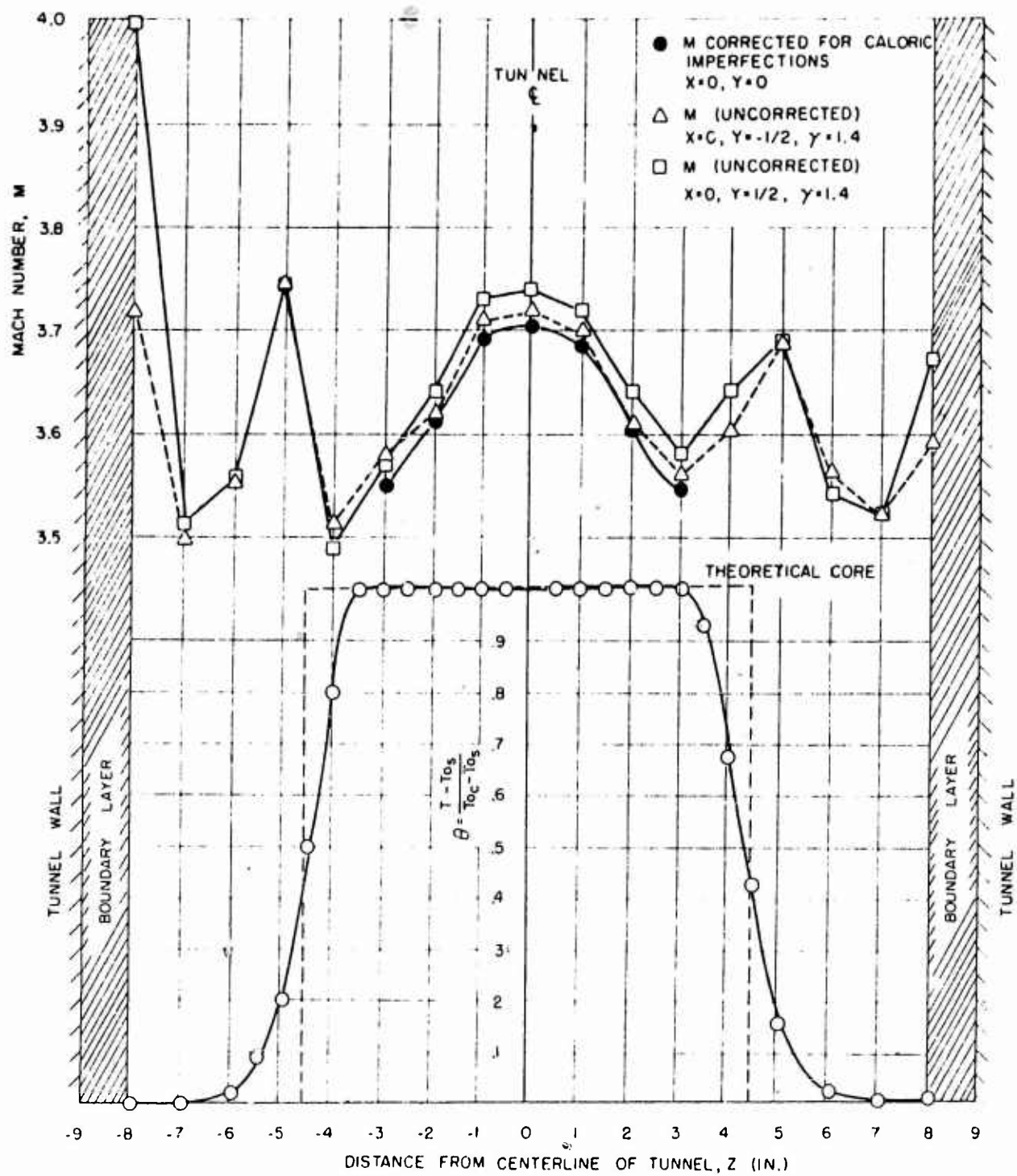


Figure 40. Mach number and temperature distribution in Mach 3.5 test section.

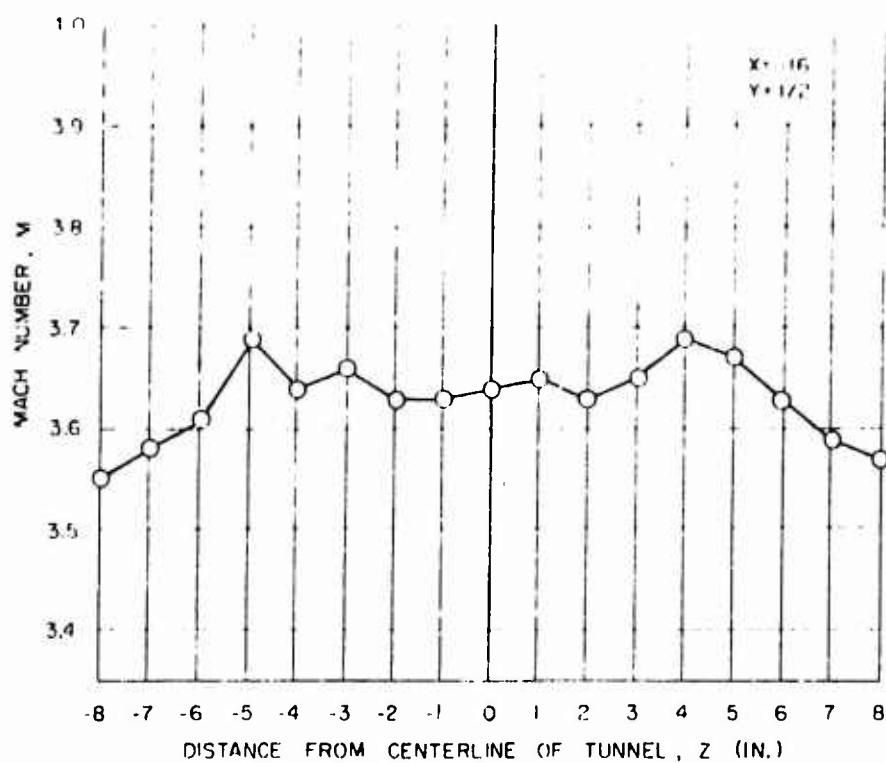


Figure 41. Mach number distribution in Mach 3.5 test section, sixteen inches in front of schlieren centerline.

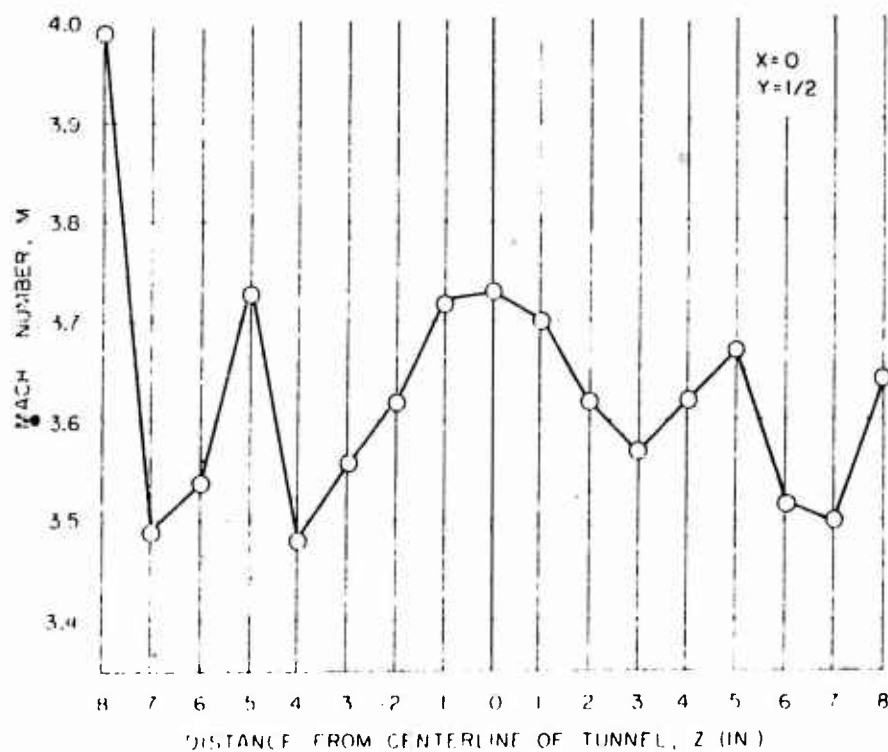


Figure 42. Mach number distribution in Mach 3.5 test section, at schlieren centerline.

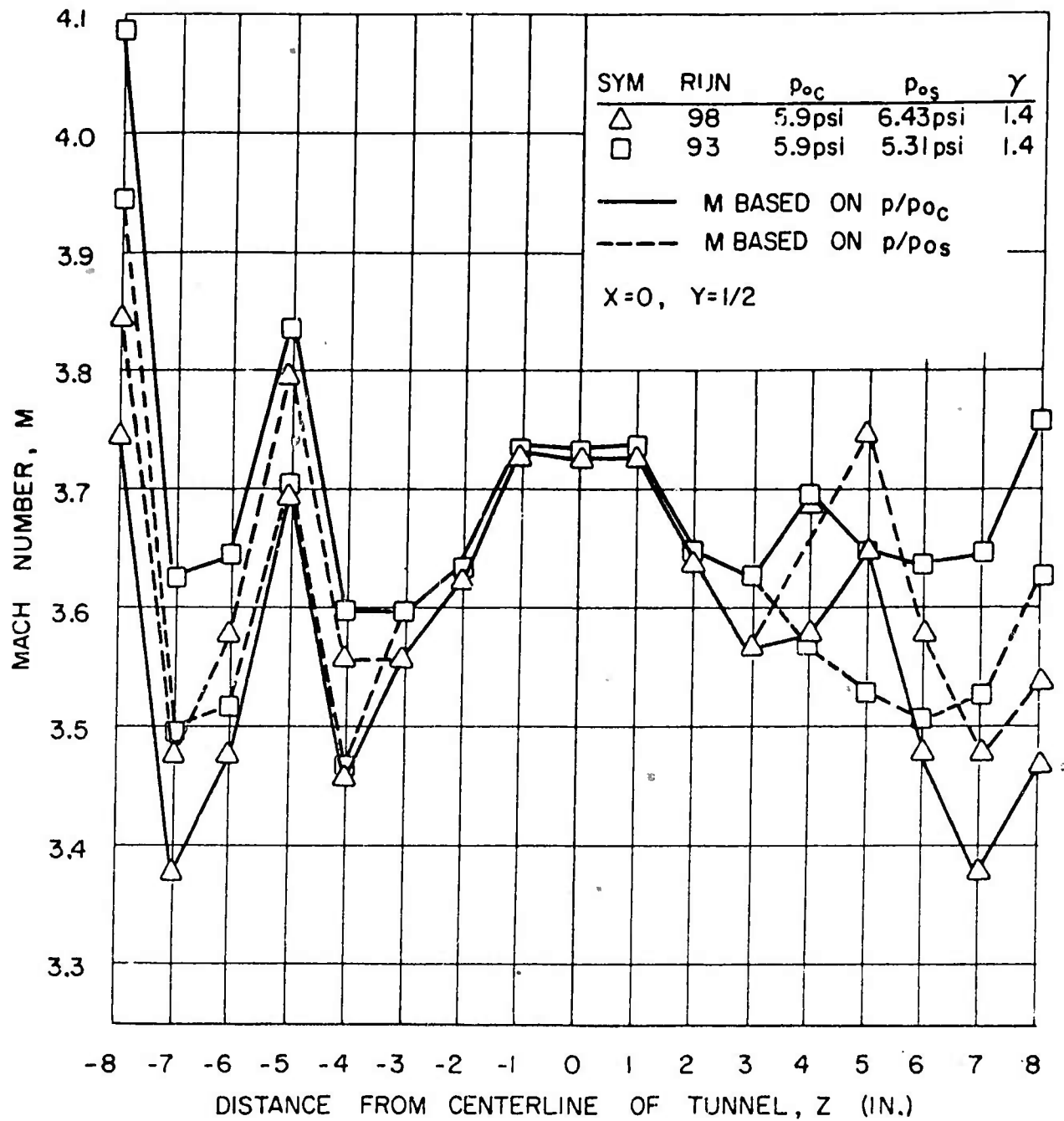


Figure 43. Effect of the variation of the ratio of core pressure to stream pressure on the Mach number distribution.

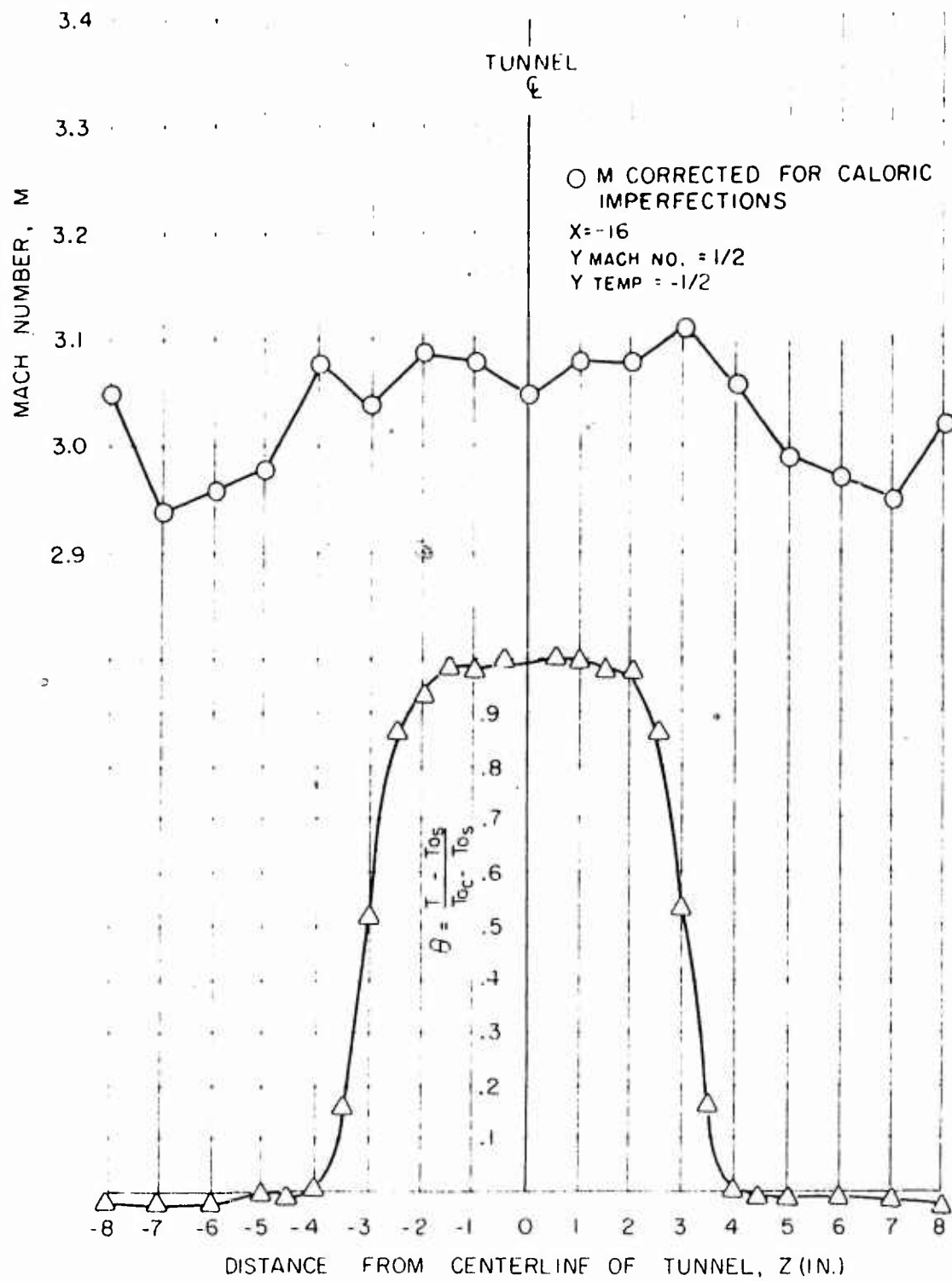


Figure 44. Mach number and temperature distributions sixteen inches in front of the schlieren centerline for the Mach 3.0 test section.

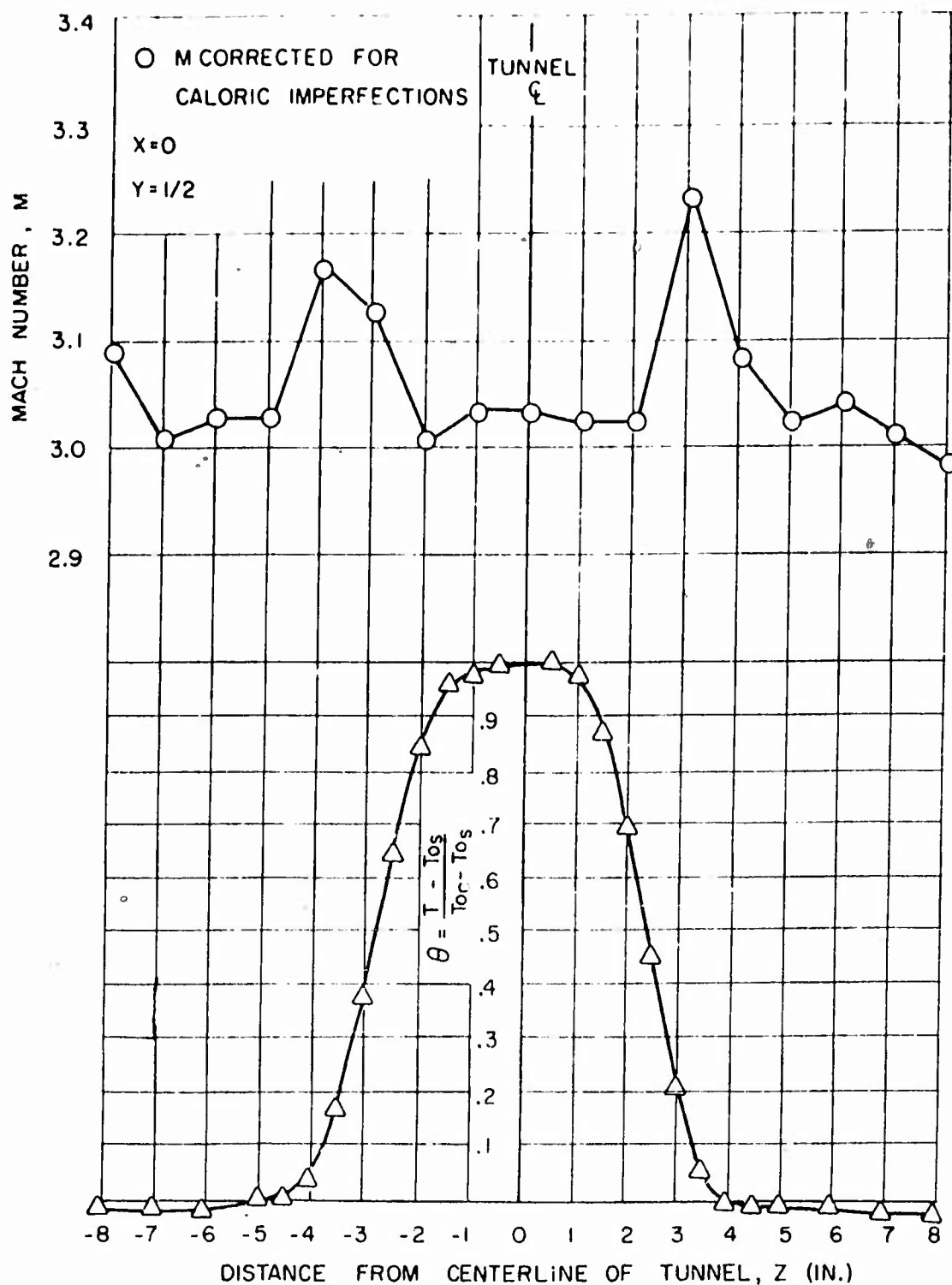


Figure 45. Mach number and temperature distributions at the schlieren centerline for the Mach 3.0 test section.

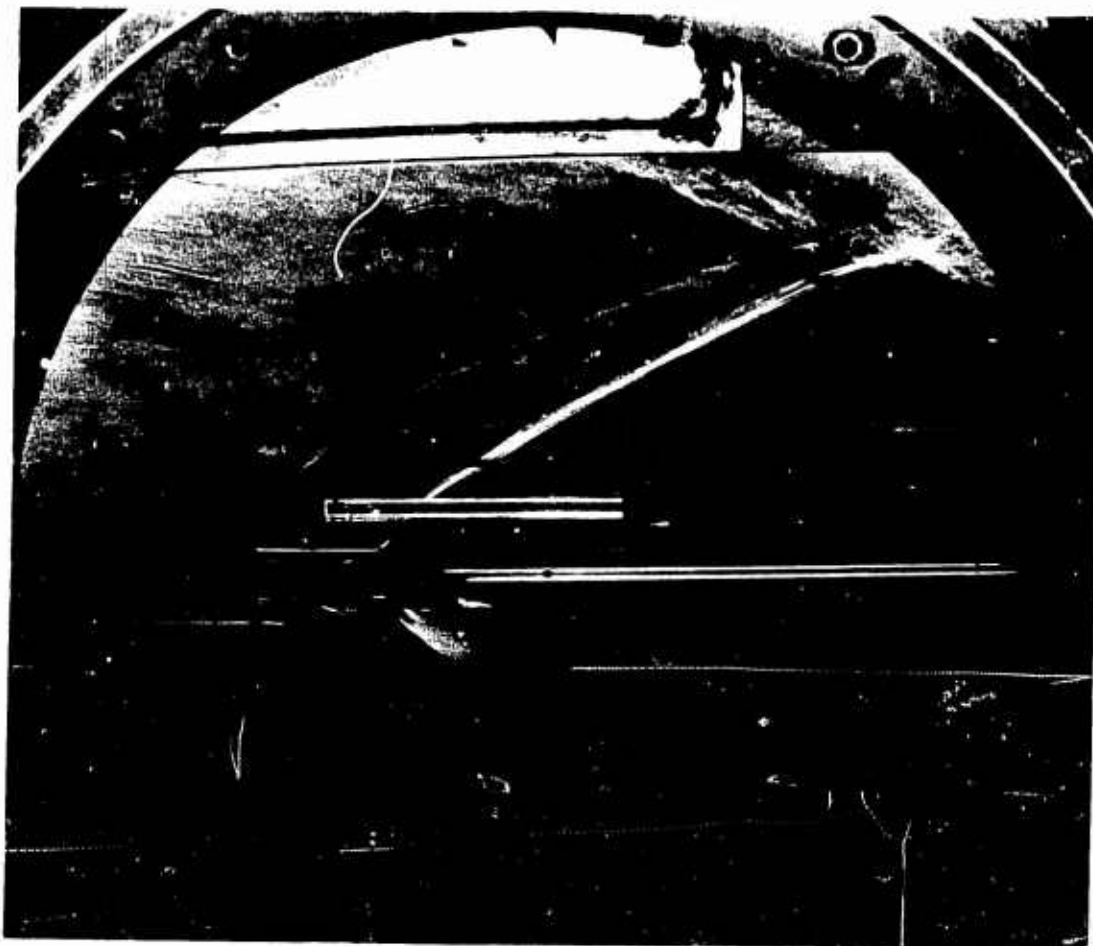


Figure 46. Schlieren photograph of calibration rake  
operating in Mach 3.5 test section.

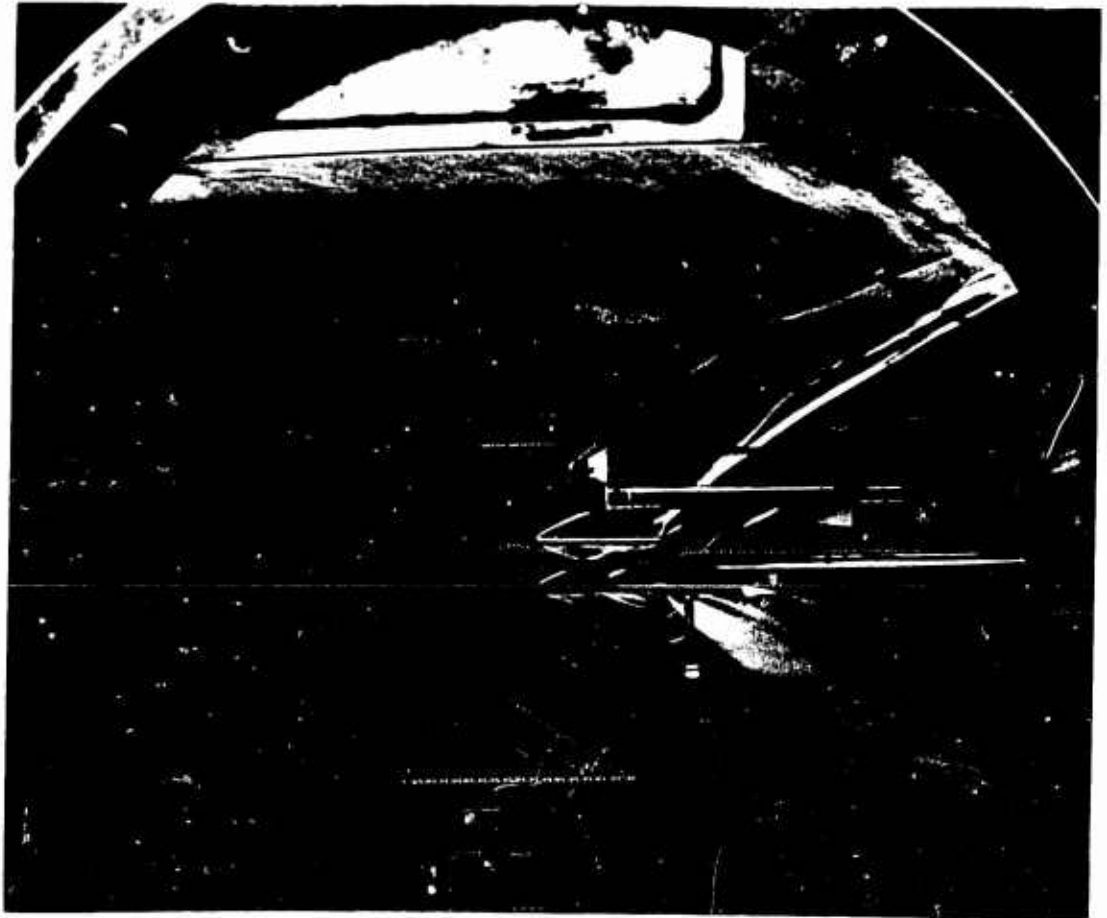


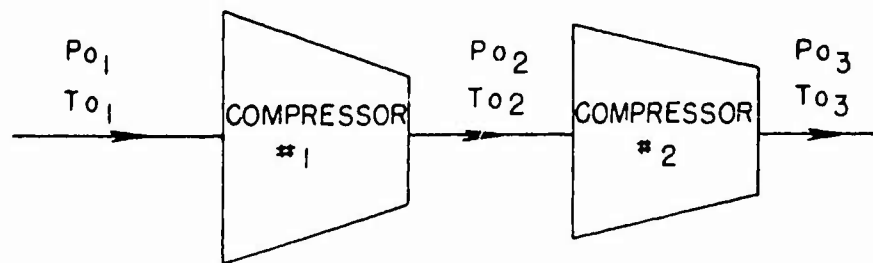
Figure 47. Schlieren photograph of calibration rake operating in Mach 3.0 test section.

## APPENDIX A

### ALLOWABLE COMPRESSOR INTAKE TEMPERATURE ESTIMATE

Due to the outlet temperature limit on the main compressors it was felt that the compressor efficiency should be found so as to be able to predict outlet temperatures for a given inlet temperature.

At  $M = 3.5$  the compressors operate in series. Thus the critical compressor is the #1 compressor. A schematic diagram of series operation of the compressors is shown below.



In order to obtain an indication of the efficiency, a thermocouple was installed at the outlet of the #1 compressor to obtain  $T_{02}$ .  $T_{01}$  was taken as  $T_0$  of the tunnel under operation. Measurements indicated that at  $M = 3.5$  and  $T_{01} = 110^\circ\text{F}$  a maximum  $T_{02}$  of  $333^\circ\text{F}$  would be obtained. From Reference 13 at  $M = 3.5$ ,  $p_{03}/p_{01} = 6.2$ . In series operation

$$p_{02}/p_{01} = \sqrt{p_{03}/p_{01}} = 2.49 \quad (\text{A.1})$$

Compressor efficiency is given by:

$$\eta_c = \frac{\left[ \left( \frac{p_{02}}{p_{01}} \right)^{\frac{\gamma-1}{\gamma}} - 1 \right]}{T_{02}/T_{01} - 1} \quad (\text{A.2})$$

and for  $T_{02}/T_{01} = 793/570$  and  $p_{02}/p_{01} = 2.49$

$$\therefore \eta_c \cong 77\%$$

Now, allowing  $T_{02}$  to be the limit of the compressor of  $500^\circ\text{F}$  and assuming  $\eta_c = 0.77$  the maximum  $T_{01}$  from equation (A.2) was found to be  $233^\circ\text{F}$ .

It should be pointed out that the above investigation is not entirely conclusive and a more thorough investigation is now underway at NSL to determine the compressor efficiencies more accurately. However the above results are felt to be a good and sufficient approximation applicable to the hot core design problem at hand.

## APPENDIX B

### MECHANICAL DESIGN OF THE "HOT CORE" CIRCUIT

The following NSL report of the above title includes the work done on the revision of the NSL wind tunnel circuit in conjunction with obtaining an operational high temperature test section at NSL. Information included in this report upon the mechanical design of a high temperature wind tunnel circuit is apt to be of considerable value to one interested in the design and construction of a similar installation. For this reason the following report from Reference 12 is presented in whole:

Included are the design conditions considered and met in the construction of the addition to the S.W.T. known as the "Hot Core". References to specific parts can be followed on the attached sketch.

1) Proposed: to increase the range of wind tunnel operation in terms of stagnation temperature. Since the tunnel cannot withstand temperatures much greater than 200°F as it is now constructed, and to change its construction would be practically impossible, it was proposed to supply heated air to a section around the centerline of the tunnel. The tunnel walls would be insulated from this high temperature by the cooler air flowing around it.

2) Solution: supply air at a high temperature and at a controllable pressure to an auxiliary nozzle situated on the centerline of the existing S.W.T. nozzle.

3) Procedure: The H.W.T. heaters are able to supply air at 1000°F at a maximum flow of 1 #/sec. and 100 psia. Since this hot air source is available, it was decided to tap its outlet line--this point can be considered as the start of the "Hot Core". For this purpose two valves are supplied: one each to connect or disconnect the H.W.T. or the hot core to the H.W.T. heaters. (H-6 and H-10)

From the valve mentioned above (H-10), it is possible to pass

air at a pressure needed for testing in the tunnel. Accordingly, it would be possible to locate the  $p_0$  control valve at this point. Three valid arguments are used against this proposal. The test facility is to operate at 5 psia; for air to be transported at such a low pressure using 1 #/sec. as design conditions shows extremely large velocity in even a 6-inch diameter pipe. Insulation would make the diameter of the unit much too large to handle. Finally, an expensive remote control valve would have to be purchased. Accordingly, a 2-1/2-inch line was chosen, giving a velocity of 160 ft/sec. at the design condition of 1000°F, 100 psia, and 1 #/sec. flow.  $p_0$  control is attained by means of two hand-operated Globe valves (H-12 and H-12') located just before the hot core stilling section inside the main tunnel stilling section. They are reached by means of shafts through holes in the tunnel wall. Choice of the size of these valves was determined by use of Fisher Company Valve Sizing and Capacity Charts Bulletin AL-4 for design conditions of 1 #/sec. at 1000°F and a reduction of 100 psia to 5 psia.

Other valves (H-6, H-10, H-11) used are of the gate type specially constructed with a hinge in the gate so that it falls away from its seat when the stem is retracted. Also, gate and seat are of two different types of stainless steel. These two features prevent "galling" or seizing characteristics of stainless steel.

At 1000°F service, it is not permitted by any design codes to use steel under any stress. For this reason, and for its reputed resistance to scaling; chrome molybdenum steel was chosen as piping material (1-1/4 CR-1/2 Mo). Chrome-Mo fittings are practically impossible to obtain, so stainless-steel screwed fittings with litharge to prevent leaks have been used.

To further reduce complications, it is necessary to run the pipe from its origin to the point of use with as few bends as possible. This is to reduce the number of expansion joints used as they are expensive and involve long delivery time. Two pipe lengths were selected, one 40-feet long, the other 25-feet long; at 1-inch expansion for every

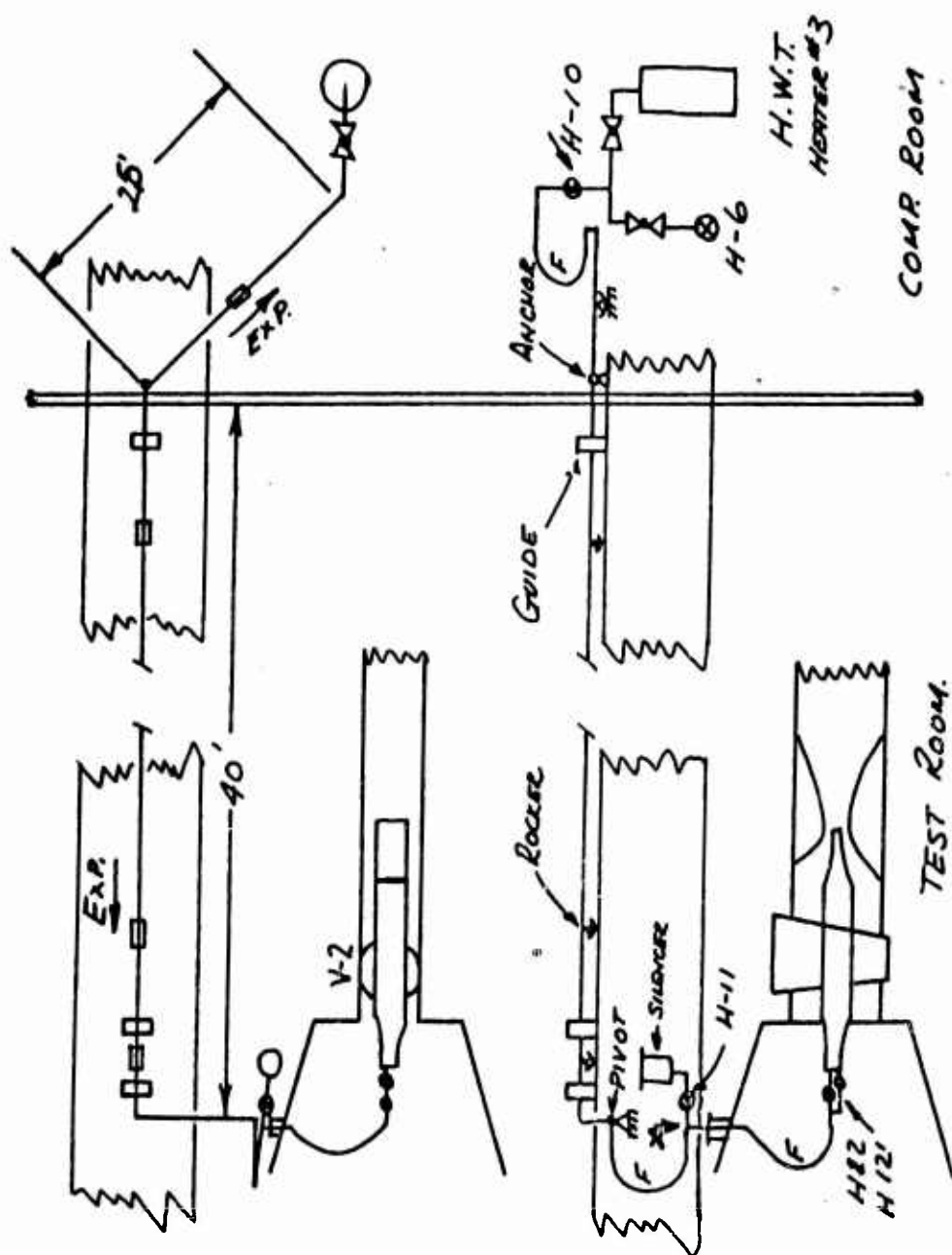
10-feet of pipe at 1000° F, 4 inches and 2.5 inches of expansion must be allowed. Therefore rockers and flexible joints have been provided. The rockers can be considered as point supports; a rough calculation which assumes the pipe to be equally supported on each rocker, with no end moments, shows that supports 5 feet apart give stresses of about 3200 psi. 7800 psi is allowed at 1000° F. Further factor of safety is provided by more redundant supports. The long lengths of small diameter tubing suggest buckling if any appreciable end loads are applied. Eulers buckling formula gives a critical end load of 2450 lbs at 1000° F for the 40-foot length. Loads of this size are not expected, but guides are supplied which restrict the motion of the pipe to that along the axis. (Flexible hoses provide expansion joints with practically no reaction).

Expansion in the 90-degree bend near the main tunnel stilling section is taken up by bending in the pipe itself, and in the pivot located there.

Heating of the lines without running the main tunnel is accomplished by passing the hot air into the test room through a bypass (H-11). Provision has also been made to pass cool air through the stilling section and nozzle using the pre-drying system as a source; thus allowing rapid shutdown of the system.

Insulation was designed and installed by the New England Insulation Company. It consists of 3 inches of "Kaylo 20" on the radius of the pipe. Flexible hoses and the stilling section are covered with a wool-like substance known as T.W.F. The wool is held in place by an asbestos jacket. The stilling section is covered on the outside by a skin of sheet metal to present a smooth surface to air flow by it.

Major alterations to the main tunnel consist of two openings cut in the stilling section between V-2 and the screen. The largest is an access hatch cut on the console side. The smaller on the top is to allow for the entrance of the 2-1/2-inch pipe carrying the hot air. In both cases, the piece cut out of the tunnel wall was replaced as nearly as possible to its original position to present a smooth surface to the flow of air past it.



F INDICATES FLEXIBLE HOSE  
EXP. " DIR. OF EXPANSION

Figure B.1

## APPENDIX C

### TEMPERATURE LOSS IN THE STILLING SECTION

Assume that the stilling section is a 10 foot insulated pipe with fully developed turbulent flow on both the outside and the inside.

The heat transfer rate from a fluid to the surface of a solid was defined by Newton as

$$q = hA (T_f - T_p) \quad (C.1)$$

where  $q$  is the heat transfer rate,  $h$  the coefficient of heat transfer between a fluid and a solid surface,  $A$  the area normal to the direction of heat flow,  $T_f$  the temperature of the fluid, and  $T_p$  the temperature of the pipe.

W.H. McAdams, in Reference 13, has suggested the following empirical relation for the film coefficient  $h$  which has met with much success

$$\frac{hD}{k} = 0.023 (Re)^{0.8} (Pr)^{0.4} \quad (C.2)$$

where  $k$  is the thermal conductivity of the fluid.

First consider the flow inside of the pipe. For the problem at hand, i. e. operation of the hot core at a stagnation temperature of 1000 °F,  $M = 3.5$ ,  $\omega_c = 1 \text{ #/sec}$  and  $p_0 = 6 \text{ #/in}^2$ :

$$D = 1 \text{ ft.}$$

$$k = .0395 \text{ Btu/(hr.) (ft.}^2\text{) }^\circ\text{F/ft}$$

$$Re = 5.14 \times 10^4$$

$$Pr = 0.665$$

Using equation (C.2)

$$h_i = 4.1 \text{ Btu/(hr.) (ft.}^2\text{) }^\circ\text{F}$$

Secondly consider the flow outside of the pipe. As an approximation, consider this flow as being inside of the pipe and again use equation (C.2) in order to determine  $h$ . Such an approximation is conservative since the boundary layer for the fully developed pipe flow will not be as thick as for the fully developed turbulent flow on the outside of the pipe. Based on the

following flow properties outside of the pipe

$$\begin{array}{ll} T_f &= 100^\circ \text{F} \\ p_0 &= 6 \text{ #/in}^2 \\ D &= 1 \text{ ft.} \end{array} \qquad \begin{array}{ll} k &= .016 \text{ Btu}/(\text{hr.}) (\text{ft.}^2) ^\circ \text{F}/\text{ft} \\ \text{Re} &= 1.375 \times 10^5 \\ \text{Pr} &= 0.696 \end{array}$$

and using equation (C.2)

$$h_2 = 4.1 \text{ Btu}/(\text{hr.}) (\text{ft.}^2) (^\circ \text{F})$$

Equation (C.1) written so as to include the two heat transfer processes is

$$q = UA \Delta T_m \tag{C.3}$$

Where  $\Delta T_m$  is the difference between the mean temperature of the fluid inside of the pipe and of the pipe itself, and the temperature of the fluid outside of the pipe and the pipe itself.  $U$  is the overall heat transfer coefficient which, allowing for insulation of thermal conductivity  $k$ , on the pipe is approximated by

$$1/U \cong 1/h_1 + 1/h_2 + 1/k_i \tag{C.4}$$

A reasonable value for the thermal conductivity of insulation is  $k_i = .6 \text{ Btu}/(\text{hr.}) (\text{ft.}^2) (^\circ \text{F}/\text{ft.})$ . Therefore  $U \cong .465 \text{ Btu}/(\text{hr.}) (\text{ft.}^2) (^\circ \text{F}/\text{ft.})$ . Using equation (C.3)

$$q_c \cong 13,150 \text{ Btu/hr.}$$

Now in order to find the heat loss due to radiation to the walls of the tunnel the temperature of the surface of the insulation must be known. Assume this temperature to be  $170^\circ \text{F}$ . The radiation equation is

$$q_r = A \sigma (T_1^4 - T_2^4) \frac{1}{1/\epsilon_1 + 1/\epsilon_2 - 1} \tag{C.5}$$

Assume the emissivity of the insulation is  $\epsilon_1 = 1$  to be conservative. The emissivity of steel (the tunnel wall) is about 0.6.  $T_1$  is the temperature of the insulation and  $T_2$  is the temperature of the tunnel wall,  $100^\circ \text{F}$ .

$\sigma$  is the Stefan-Boltzmann constant. Thus we find

$$q_r = 2000 \text{ Btu/hr.}$$

and if the above assumptions are valid the total heat loss is

$$q_T = q_c + q_r = 15,500 \text{ Btu/hr.}$$

A check may be made to see if the assumed insulation temperature of  $170^\circ\text{F}$  was correct. Since the total heat loss must pass through the one inch of insulation  $\delta$  and the conductivity  $k_i$  is known for the insulation we may solve for  $\Delta T$  and thus find the temperature of the insulation if we assume  $T_p = 1000^\circ\text{F}$ . The conductivity equation is

$$q_T = k A \Delta T / \delta \quad (\text{C.6})$$

thus we find

$$\Delta T = 825^\circ\text{F}$$

or the temperature of the insulation is  $175^\circ\text{F}$ . This is in very close agreement with the original assumption so the conclusion is that  $q_T = 15,000 \text{ Btu/hr.}$  is the heat lost from the heated air in the stilling section. The heat loss is given by

$$q_T = \omega C_p \Delta T$$

Thus  $\Delta T$ , the temperature drop is

$$\begin{aligned} \Delta T &= \frac{15,500 \text{ Btu/hr.}}{3000 \text{ \# / hr.} \times .24 \frac{\text{Btu}}{\text{\#} \cdot ^\circ\text{F}}} \\ &= 18^\circ\text{F} \end{aligned}$$

Such a temperature drop can be tolerated.

APPENDIX D  
HEATED CORE NOZZLE COORDINATES

| <u>ξ</u> | <u>x</u> | <u>y</u> | <u>z</u> |
|----------|----------|----------|----------|
| .5350    | 5.426    | .849     | 4.472    |
| .5300    | 5.375    | .845     |          |
| .5250    | 5.324    | .842     |          |
| .5200    | 5.274    | .838     |          |
| .5150    | 5.233    | .835     |          |
| .5100    | 5.173    | .832     |          |
| .5050    | 5.122    | .828     |          |
| .5000    | 5.071    | .825     |          |
| .4950    | 5.021    | .822     |          |
| .4900    | 4.970    | .818     |          |
| .4850    | 4.920    | .815     |          |
| .4800    | 4.869    | .812     |          |
| .4750    | 4.818    | .809     |          |
| .4700    | 4.768    | .805     |          |
| .4650    | 4.717    | .802     |          |
| .4600    | 4.666    | .799     |          |
| .4550    | 4.616    | .796     |          |
| .4500    | 4.565    | .793     |          |
| .4450    | 4.575    | .790     |          |
| .4400    | 4.464    | .787     |          |
| .4350    | 4.413    | .784     |          |
| .4300    | 4.363    | .782     |          |
| .4250    | 4.312    | .779     |          |
| .4200    | 4.261    | .776     |          |
| .4150    | 4.211    | .773     |          |
| .4100    | 4.160    | .770     |          |
| .4050    | 4.109    | .768     |          |
| .4000    | 4.059    | .765     |          |
| .3950    | 4.008    | .762     |          |
| .3900    | 3.957    | .760     |          |
| .3850    | 3.907    | .757     |          |

# HEATED CORE NOZZLE COORDINATES (Continued)

| <u>ξ</u> | <u>x</u> | <u>y</u> | <u>z</u> |
|----------|----------|----------|----------|
| .3800    | 3.856    | .755     | 4.472    |
| .3750    | 3.805    | .752     |          |
| .3700    | 3.755    | .750     |          |
| .3650    | 3.704    | .747     |          |
| .3600    | 3.653    | .745     |          |
| .3550    | 3.603    | .742     |          |
| .3500    | 3.552    | .740     |          |
| .3450    | 3.501    | .738     |          |
| .3400    | 3.451    | .735     |          |
| .3350    | 3.400    | .733     |          |
| .3300    | 3.349    | .731     |          |
| .3250    | 3.298    | .729     |          |
| .3200    | 3.248    | .727     |          |
| .3150    | 3.197    | .725     |          |
| .3100    | 3.146    | .723     |          |
| .3050    | 3.096    | .721     |          |
| .3000    | 3.045    | .718     |          |
| .2950    | 2.994    | .717     |          |
| .2900    | 2.944    | .715     |          |
| .2850    | 2.893    | .713     |          |
| .2800    | 2.842    | .711     |          |
| .2750    | 2.791    | .709     |          |
| .2700    | 2.741    | .707     |          |
| .2650    | 2.690    | .705     |          |
| .2600    | 2.639    | .704     |          |
| .2550    | 2.588    | .702     |          |
| .2500    | 2.538    | .700     |          |
| .2450    | 2.487    | .699     |          |
| .2400    | 2.436    | .697     |          |
| .2350    | 2.386    | .695     |          |
| .2300    | 2.335    | .694     |          |
| .2250    | 2.284    | .692     |          |

# HEATED CORE NOZZLE COORDINATES (Continued)

| <u>ξ</u> | <u>x</u> | <u>y</u> | <u>z</u> |
|----------|----------|----------|----------|
| .2200    | 2.233    | .691     | 4.472    |
| .2150    | 2.103    | .689     |          |
| .2100    | 2.132    | .688     |          |
| .2050    | 2.081    | .687     |          |
| .2000    | 2.030    | .695     |          |
| .1950    | 1.900    | .684     |          |
| .1900    | 1.929    | .683     |          |
| .1850    | 1.878    | .681     |          |
| .1800    | 1.827    | .680     |          |
| .1750    | 1.777    | .679     |          |
| .1700    | 1.726    | .678     |          |
| .1650    | 1.675    | .677     |          |
| .1600    | 1.624    | .676     |          |
| .1550    | 1.574    | .675     |          |
| .1500    | 1.523    | .674     |          |
| .1450    | 1.472    | .673     |          |
| .1400    | 1.421    | .672     |          |
| .1350    | 1.371    | .671     |          |
| .1300    | 1.320    | .670     |          |
| .1250    | 1.269    | .669     |          |
| .1200    | 1.218    | .668     |          |
| .1150    | 1.168    | .667     |          |
| .1100    | 1.117    | .667     |          |
| .1050    | 1.066    | .666     |          |
| .1000    | 1.015    | .665     |          |
| .0950    | .965     | .665     |          |
| .0900    | .914     | .664     |          |
| .0850    | .863     | .663     |          |
| .0800    | .812     | .663     |          |
| .0750    | .761     | .662     |          |
| .0700    | .711     | .862     |          |
| .0650    | .660     | .661     |          |

# HEATED CORE NOZZLE COORDINATES (Continued)

| <u>ξ</u> | <u>x</u> | <u>y</u> | <u>z</u> |
|----------|----------|----------|----------|
| .0600    | .609     | .661     | 4.472    |
| .0550    | .558     | .661     |          |
| .0500    | .508     | .660     |          |
| .0450    | .457     | .660     |          |
| .0400    | .406     | .660     |          |
| .0350    | .355     | .659     |          |
| .0300    | .305     | .659     |          |
| .0250    | .254     | .659     |          |
| .0200    | .203     | .659     |          |
| .0150    | .152     | .659     |          |
| .0125    | .127     | .659     |          |
| -.015    | -.152    | .659     |          |
| -.02     | -.203    | .659     |          |
| -.04     | -.406    | .659     |          |
| -.06     | -.609    | .661     |          |
| -.03     | -.812    | .663     |          |
| -.12     | -1.218   | .668     |          |
| -.16     | -1.624   | .675     |          |
| -.20     | -2.031   | .684     |          |
| -.30     | -3.045   | .717     |          |
| -.40     | -4.059   | .763     |          |
| -.50     | -5.072   | .822     |          |
| -.60     | -6.083   | .893     |          |
| -.70     | -7.093   | .978     |          |
| -.80     | -8.102   | 1.076    |          |
| -.90     | -9.108   | 1.107    |          |
| -1.00    | -10.112  | 1.310    |          |
|          | -11.0    | 1.469    |          |
|          | -12.0    | 1.665    |          |
|          | -13.0    | 1.890    |          |
|          | -14.0    | 2.157    |          |

# HEATED CORE NOZZLE COORDINATES (Concluded)

| <u>ξ</u> | <u>x</u> | <u>y</u> | <u>z</u> |
|----------|----------|----------|----------|
|          | -15.0    | 2.444    | 4.472    |
|          | -16.0    | 2.777    | 4.472    |
|          | -17.0    | 3.147    | 4.472    |
|          | -18.0    | 3.571    | 4.472    |
|          | -19.0    | 4.025    | 4.525    |
|          | -19.5    |          | 4.560    |
|          | -20.0    | 4.448    | 4.625    |
|          | -20.5    |          | 4.700    |
|          | -21.0    | 4.860    | 4.810    |
| 90       | -21.5    |          | 4.950    |
|          | -22.0    | 5.150    | 5.110    |
|          | -22.5    |          | 5.240    |
|          | -23.0    | 5.320    | 5.310    |
|          | -23.5    |          | 5.350    |
|          | -24.0    | 5.35     | 5.350    |
|          | -25.0    | 5.35     | 5.350    |
|          | -26.0    | 5.35     | 5.350    |

## APPENDIX E

### TEMPERATURE DATA

The temperature data from the heated core calibration tests is presented in tabulated form for future reference. The run numbers shown are the wind tunnel run numbers used in the tests. The temperatures,  $T$ , are the temperatures obtained after the application of the recovery factors explained in section 7.1.2. All temperatures are given in degrees Fahrenheit.

# TEMPERATURE DATA

## RUN 1

$T_{0_s} = 100, T_{0_c} = 906, x = 0, y = -1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 93       | 8        | 91       |
| -7       | 97       | 7        | 104      |
| -6       | 122      | 6        | 119      |
| -5       | 243      | 5        | 229      |
| -4 1/2   | 463      | 4 1/2    | 455      |
| -4       | 732      | 4        | 688      |
| -3 1/2   | 887      | 3 1/2    | 880      |
| -3       | 905      | 3        | 916      |
| -2 1/2   | 907      | 2 1/2    | 916      |
| -2       | 915      | 2        | 916      |
| -1 1/2   | 905      | 1 1/2    | 915      |
| -1       | 902      | 1        | 918      |
| -1/2     | 915      | 1/2      | 916      |

## RUN 4

$T_{0_s} = 100, T_{0_c} = 906, x = 0, y = -3 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 88       | 8        | 90       |
| -7       | 94       | 7        | 99       |
| -6       | 98       | 6        | 106      |
| -5       | 163      | 5        | 248      |
| -4 1/2   | 382      | 4 1/2    | 495      |
| -4       | 650      | 4        | 727      |
| -3 1/2   | 855      | 3 1/2    | 888      |
| -3       | 904      | 3        | 918      |
| -2 1/2   | 906      | 2 1/2    | 918      |
| -2       | 914      | 2        | 920      |
| -1 1/2   | 907      | 1 1/2    | 919      |
| -1       | 908      | 1        | 926      |
| -1/2     | 924      | 1/2      | 930      |

## RUN 2

$T_{0_s} = 100, T_{0_c} = 906, x = 0, y = -1 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 88       | 8        | 88       |
| -7       | 96       | 7        | 99       |
| -6       | 107      | 6        | 112      |
| -5       | 200      | 5        | 236      |
| -4 1/2   | 412      | 4 1/2    | 462      |
| -4       | 677      | 4        | 706      |
| -3 1/2   | 871      | 3 1/2    | 891      |
| -3       | 913      | 3        | 922      |
| -2 1/2   | 915      | 2 1/2    | 919      |
| -2       | 921      | 2        | 921      |
| -1 1/2   | 918      | 1 1/2    | 919      |
| -1       | 913      | 1        | 924      |
| -1/2     | 924      | 1/2      | 926      |

## RUN 5

$T_{0_s} = 73, T_{0_c} = 917, x = 0, y = -1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 69.5     | 8        | 68.1     |
| -7       | 69.2     | 7        | 76.7     |
| -6       | 88.3     | 6        | 89.0     |
| -5       | 222      | 5        | 204      |
| -4 1/2   | 452      | 4 1/2    | 428      |
| -4       | 726      | 4        | 670      |
| -3 1/2   | 899      | 3 1/2    | 880      |
| -3       | 914      | 3        | 919      |
| -2 1/2   | 923      | 2 1/2    | 921      |
| -2       | 922      | 2        | 922      |
| -1 1/2   | 920      | 1 1/2    | 919      |
| -1       | 910      | 1        | 922      |
| -1/2     | 918      | 1/2      | 905      |

## RUN 3

$T_{0_s} = 100, T_{0_c} = 906, x = 0, y = -2 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 87       | 8        | 85       |
| -7       | 90       | 7        | 95       |
| -6       | 95       | 6        | 101      |
| -5       | 163      | 5        | 223      |
| -4 1/2   | 361      | 4 1/2    | 470      |
| -4       | 610      | 4        | 732      |
| -3 1/2   | 835      | 3 1/2    | 901      |
| -3       | 908      | 3        | 922      |
| -2 1/2   | 913      | 2 1/2    | 921      |
| -2       | 907      | 2        | 924      |
| -1 1/2   | 913      | 1 1/2    | 921      |
| -1       | 915      | 1        | 931      |
| -1/2     | 927      | 1/2      | 932      |

## RUN 6

$T_{0_s} = 73, T_{0_c} = 910, x = 0, y = -4 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 66       | 8        | 66       |
| -7       | 67       | 7        | 68       |
| -6       | 70       | 6        | 74       |
| -5       | 113      | 5        | 124      |
| -4 1/2   | 291      | 4 1/2    | 301      |
| -4       | 540      | 4        | 534      |
| -3 1/2   | 668      | 3 1/2    | 708      |
| -3       | 637      | 3        | 719      |
| -2 1/2   | 620      | 2 1/2    | 729      |
| -2       | 623      | 2        | 742      |
| -1 1/2   | 622      | 1 1/2    | 758      |
| -1       | 662      | 1        | 779      |
| -1/2     | 715      | 1/2      | 766      |

# RUN 7

$T_{0s} = 73.5$ ,  $T_{0c} = 907$ ,  $x = 0$ ,  $y = -5 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 67  | 8     | 65  |
| -7     | 67  | 7     | 68  |
| -6     | 74  | 6     | 72  |
| -5     | 96  | 5     | 166 |
| -4 1/2 | 217 | 4 1/2 | 300 |
| -4     | 329 | 4     | 414 |
| -3 1/2 | 316 | 3 1/2 | 407 |
| -3     | 250 | 3     | 347 |
| -2 1/2 | 211 | 2 1/2 | 356 |
| -2     | 256 | 2     | 368 |
| -1 1/2 | 266 | 1 1/2 | 384 |
| -1     | 303 | 1     | 399 |
| -1/2   | 343 | 1/2   | 388 |

# RUN 10

$T_{0s} = 74$ ,  $T_{0c} = 912$ ,  $x = 0$ ,  $y = 1 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 79.8 | 8     | 72.3 |
| -7     | 714  | 7     | 76.6 |
| -6     | 90.5 | 6     | 85.2 |
| -5     | 204  | 5     | 138  |
| -4 1/2 | 444  | 4 1/2 | 308  |
| -4     | 744  | 4     | 533  |
| -3 1/2 | 894  | 3 1/2 | 790  |
| -3     | 908  | 3     | 902  |
| -2 1/2 | 912  | 2 1/2 | 910  |
| -2     | 918  | 2     | 910  |
| -1 1/2 | 906  | 1 1/2 | 907  |
| -1     | 907  | 1     | 916  |
| -1/2   | 914  | 1/2   | 910  |

# RUN 8

$T_{0s} = 73.5$ ,  $T_{0c} = 909$ ,  $x = 0$ ,  $y = -6 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 67  | 8     | 67  |
| -7     | 68  | 7     | 69  |
| -6     | 74  | 6     | 71  |
| -5     | 96  | 5     | 131 |
| -4 1/2 | 120 | 4 1/2 | 181 |
| -4     | 117 | 4     | 197 |
| -3 1/2 | 104 | 3 1/2 | 157 |
| -3     | 86  | 3     | 124 |
| -2 1/2 | 89  | 2 1/2 | 124 |
| -2     | 88  | 2     | 123 |
| -1 1/2 | 97  | 1 1/2 | 123 |
| -1     | 91  | 1     | 125 |
| -1/2   | 97  | 1/2   | 111 |

# RUN 11

$T_{0s} = 74.0$ ,  $T_{0c} = 913$ ,  $x = 0$ ,  $y = 2 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 79.7 | 8     | 72.3 |
| -7     | 72.4 | 7     | 80.0 |
| -6     | 86.2 | 6     | 80.9 |
| -5     | 314  | 5     | 150  |
| -4 1/2 | 573  | 4 1/2 | 332  |
| -4     | 779  | 4     | 533  |
| -3 1/2 | 883  | 3 1/2 | 742  |
| -3     | 907  | 3     | 880  |
| -2 1/2 | 911  | 2 1/2 | 907  |
| -2     | 917  | 2     | 912  |
| -1 1/2 | 907  | 1 1/2 | 907  |
| -1     | 909  | 1     | 915  |
| -1/2   | 919  | 1/2   | 912  |

# RUN 9

$T_{0s} = 74$ ,  $T_{0c} = 911$ ,  $x = 0$ ,  $y = 1 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 67.1 | 8     | 69.1 |
| -7     | 70.2 | 7     | 76.6 |
| -6     | 90.5 | 6     | 88.5 |
| -5     | 250  | 5     | 178  |
| -4 1/2 | 491  | 4 1/2 | 381  |
| -4     | 760  | 4     | 621  |
| -3 1/2 | 898  | 3 1/2 | 845  |
| -3     | 910  | 3     | 908  |
| -2 1/2 | 913  | 2 1/2 | 914  |
| -2     | 920  | 2     | 914  |
| -1 1/2 | 907  | 1 1/2 | 906  |
| -1     | 907  | 1     | 916  |
| -1/2   | 912  | 1/2   | 910  |

# RUN 12

$T_{0s} = 74.0$ ,  $T_{0c} = 914$ ,  $x = 0$ ,  $y = 3 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 73.4 | 8     | 71.3 |
| -7     | 70.3 | 7     | 81.0 |
| -6     | 79.7 | 6     | 72.4 |
| -5     | 147  | 5     | 90.5 |
| -4 1/2 | 285  | 4 1/2 | 16.2 |
| -4     | 505  | 4     | 330  |
| -3 1/2 | 765  | 3 1/2 | 573  |
| -3     | 892  | 3     | 774  |
| -2 1/2 | 905  | 2 1/2 | 818  |
| -2     | 907  | 2     | 824  |
| -1 1/2 | 904  | 1 1/2 | 837  |
| -1     | 905  | 1     | 867  |
| -1/2   | 910  | 1/2   | 889  |

# RUN 13

$T_{0s} = 74.5$ ,  $T_{0c} = 914$ ,  $x = 0$ ,  $y = 4$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 72.4 | 8     | 72.4 |
| -7     | 70.3 | 7     | 79.7 |
| -6     | 72.4 | 6     | 74.5 |
| -5     | 110  | 5     | 95.7 |
| -4 1/2 | 259  | 4 1/2 | 202  |
| -4     | 511  | 4     | 375  |
| -3 1/2 | 761  | 3 1/2 | 219  |
| -3     | 844  | 3     | 640  |
| -2 1/2 | 838  | 2 1/2 | 613  |
| -2     | 831  | 2     | 625  |
| -1 1/2 | 833  | 1 1/2 | 656  |
| -1     | 830  | 1     | 712  |
| 1/2    | 815  | 1/2   | 771  |

# RUN 16

$T_{0s} = 76$ ,  $T_{0c} = 900$ ,  $x = 0$ ,  $y = 1/2$

| $z$   | $T$  | $z$   | $T$  |
|-------|------|-------|------|
| 8     | 73.4 | 8     | 72.3 |
| 7     | 72.3 | 7     | 79.8 |
| 6     | 85.1 | 6     | 87.2 |
| 5     | 226  | 5     | 262  |
| 4 1/2 | 452  | 4 1/2 | 417  |
| 4     | 832  | 4     | 659  |
| 3 1/2 | 880  | 3 1/2 | 862  |
| 3     | 899  | 3     | 903  |
| 2 1/2 | 906  | 2 1/2 | 903  |
| 2     | 906  | 2     | 906  |
| 1 1/2 | 900  | 1 1/2 | 900  |
| 1     | 940  | 1     | 905  |
| 1/2   | 903  | 1/2   | 904  |

# RUN 14

$T_{0s} = 74.5$ ,  $T_{0c} = 916$ ,  $x = 0$ ,  $y = 4 1/2$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 72.3 | 8     | 70.2 |
| -7     | 70.2 | 7     | 78.7 |
| -6     | 74.5 | 6     | 78.7 |
| -5     | 150  | 5     | 117  |
| -4 1/2 | 348  | 4 1/2 | 269  |
| -4     | 573  | 4     | 404  |
| -3 1/2 | 694  | 3 1/2 | 454  |
| -3     | 703  | 3     | 428  |
| -2 1/2 | 682  | 2 1/2 | 394  |
| -2     | 668  | 2     | 417  |
| -1 1/2 | 676  | 1 1/2 | 465  |
| -1     | 666  | 1     | 533  |
| -1/2   | 642  | 1/2   | 587  |

# RUN 17

$T_{0s} = 76$ ,  $T_{0c} = 904$ ,  $x = 0$ ,  $y = -1 1/2$

| $z$   | $T$  | $z$   | $T$  |
|-------|------|-------|------|
| 8     | 70.2 | 8     | 71.3 |
| 7     | 71.3 | 7     | 77.6 |
| 6     | 81.9 | 6     | 85.1 |
| 5     | 176  | 5     | 195  |
| 4 1/2 | 394  | 4 1/2 | 417  |
| 4     | 658  | 4     | 660  |
| 3 1/2 | 855  | 3 1/2 | 866  |
| 3     | 899  | 3     | 905  |
| 2 1/2 | 904  | 2 1/2 | 903  |
| 2     | 904  | 2     | 908  |
| 1 1/2 | 901  | 1 1/2 | 900  |
| 1     | 898  | 1     | 908  |
| 1/2   | 905  | 1/2   | 906  |

# RUN 15

$T_{0s} = 74.5$ ,  $T_{0c} = 917$ ,  $x = 0$ ,  $y = 5$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 72.3 | 8     | 70.2 |
| -7     | 70.2 | 7     | 74.5 |
| -6     | 78.7 | 6     | 78.7 |
| -5     | 213  | 5     | 123  |
| -4 1/2 | 432  | 4 1/2 | 265  |
| -4     | 557  | 4     | 349  |
| -3 1/2 | 544  | 3 1/2 | 313  |
| -3     | 537  | 3     | 264  |
| -2 1/2 | 521  | 2 1/2 | 249  |
| -2     | 510  | 2     | 274  |
| -1 1/2 | 520  | 1 1/2 | 317  |
| -1     | 511  | 1     | 376  |
| -1/2   | 485  | 1/2   | 423  |

# RUN 18

$T_{0s} = 76.0$ ,  $T_{0c} = 905$ ,  $x = 0$ ,  $y = -2 1/2$

| $z$   | $T$  | $z$   | $T$  |
|-------|------|-------|------|
| 8     | 69.1 | 8     | 70.2 |
| 7     | 70.2 | 7     | 74.5 |
| 6     | 72.3 | 6     | 79.8 |
| 5     | 134  | 5     | 191  |
| 4 1/2 | 329  | 4 1/2 | 426  |
| 4     | 574  | 4     | 685  |
| 3 1/2 | 815  | 3 1/2 | 878  |
| 3     | 894  | 3     | 904  |
| 2 1/2 | 905  | 2 1/2 | 903  |
| 2     | 905  | 2     | 904  |
| 1 1/2 | 899  | 1 1/2 | 900  |
| 1     | 898  | 1     | 910  |
| 1/2   | 906  | 1/2   | 911  |

# RUN 19

$$T_{0_H} = 76.5, T_{0_C} = 905, x = 0, y = -3 \frac{1}{2}$$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 69.1 | 8     | 70.2 |
| -7     | 69.1 | 7     | 71.3 |
| -6     | 71.3 | 6     | 77.6 |
| -5     | 139  | 5     | 205  |
| -4 1/2 | 348  | 4 1/2 | 437  |
| -4     | 611  | 4     | 678  |
| -3 1/2 | 830  | 3 1/2 | 865  |
| -3     | 890  | 3     | 901  |
| -2 1/2 | 900  | 2 1/2 | 899  |
| -2     | 900  | 2     | 903  |
| -1 1/2 | 895  | 1 1/2 | 898  |
| -1     | 895  | 1     | 907  |
| -1/2   | 905  | 1/2   | 909  |

# RUN 22

$$T_{0_H} = 76.5, T_{0_C} = 906, x = 0, y = -5 \frac{1}{2}$$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 70.2 | 8     | 70.2 |
| -7     | 71.3 | 7     | 74.5 |
| -6     | 80.8 | 6     | 77.6 |
| -5     | 104  | 5     | 169  |
| -4 1/2 | 224  | 4 1/2 | 299  |
| -4     | 326  | 4     | 403  |
| -3 1/2 | 310  | 3 1/2 | 401  |
| -3     | 246  | 3     | 340  |
| -2 1/2 | 241  | 2 1/2 | 349  |
| -2     | 255  | 2     | 362  |
| -1 1/2 | 264  | 1 1/2 | 378  |
| -1     | 301  | 1     | 398  |
| -1/2   | 338  | 1/2   | 388  |

# RUN 20

$$T_{0_H} = 76.5, T_{0_C} = 905, x = 0, y = -4$$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 69.2 | 8     | 70.2 |
| -7     | 69.2 | 7     | 73.4 |
| -6     | 73.4 | 6     | 79.8 |
| -5     | 142  | 5     | 168  |
| -4 1/2 | 350  | 4 1/2 | 367  |
| -4     | 614  | 4     | 610  |
| -3 1/2 | 806  | 3 1/2 | 815  |
| -3     | 836  | 3     | 866  |
| -2 1/2 | 832  | 2 1/2 | 872  |
| -2     | 832  | 2     | 882  |
| -1 1/2 | 819  | 1 1/2 | 882  |
| -1     | 835  | 1     | 897  |
| -1/2   | 872  | 1/2   | 894  |

# RUN 23

$$T_{0_H} = 76.5, T_{0_C} = 907, x = 0, y = -6 \frac{1}{2}$$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 70.2 | 8     | 70.2 |
| -7     | 72.3 | 7     | 74.5 |
| -6     | 79.8 | 6     | 75.5 |
| -5     | 98.9 | 5     | 128  |
| -4 1/2 | 117  | 4 1/2 | 164  |
| -4     | 115  | 4     | 181  |
| -3 1/2 | 98.9 | 3 1/2 | 150  |
| -3     | 90.4 | 3     | 117  |
| -2 1/2 | 91.5 | 2 1/2 | 122  |
| -2     | 91.5 | 2     | 123  |
| -1 1/2 | 91.5 | 1 1/2 | 121  |
| -1     | 91.5 | 1     | 126  |
| -1/2   | 100  | 1/2   | 114  |

# RUN 21

$$T_{0_H} = 76.5, T_{0_C} = 905, x = 0, y = -4 \frac{1}{2}$$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 69.2 | 8     | 69.2 |
| -7     | 70.2 | 7     | 73.4 |
| -6     | 75.5 | 6     | 80.9 |
| -5     | 123  | 5     | 131  |
| -4 1/2 | 305  | 4 1/2 | 306  |
| -4     | 545  | 4     | 533  |
| -3 1/2 | 669  | 3 1/2 | 705  |
| -3     | 640  | 3     | 721  |
| -2 1/2 | 624  | 2 1/2 | 731  |
| -2     | 628  | 2     | 744  |
| -1 1/2 | 628  | 1 1/2 | 759  |
| -1     | 666  | 1     | 780  |
| -1/2   | 718  | 1/2   | 770  |

# RUN 24

$$T_{0_H} = 76.5, T_{0_C} = 907, x = 0, y = 4$$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 78  | 8     | 79  |
| -7     | 72  | 7     | 85  |
| -6     | 78  | 6     | 80  |
| -5     | 113 | 5     | 97  |
| -4 1/2 | 260 | 4 1/2 | 196 |
| -4     | 510 | 4     | 369 |
| -3 1/2 | 752 | 3 1/2 | 565 |
| -3     | 839 | 3     | 658 |
| -2 1/2 | 838 | 2 1/2 | 633 |
| -2     | 828 | 2     | 641 |
| -1 1/2 | 834 | 1 1/2 | 668 |
| -1     | 828 | 1     | 727 |
| -1/2   | 822 | 1/2   | 781 |

# RUN 32

$T_{0A} = 75$ ,  $T_{0C} = 900$ ,  $x = 0$ ,  $y = 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 70  | 8     | 70  |
| -7     | 70  | 7     | 79  |
| -6     | 87  | 6     | 89  |
| -5     | 230 | 5     | 194 |
| -4 1/2 | 460 | 4 1/2 | 512 |
| -4     | 729 | 4     | 644 |
| -3 1/2 | 886 | 3 1/2 | 856 |
| -3     | 902 | 3     | 905 |
| -2 1/2 | 912 | 2 1/2 | 906 |
| -2     | 907 | 2     | 910 |
| -1 1/2 | 905 | 1 1/2 | 904 |
| -1     | 897 | 1     | 907 |
| -1/2   | 904 | 1/2   | 906 |

# RUN 35

$T_{0A} = 75.5$ ,  $T_{0C} = 913$ ,  $x = -2$ ,  $y = 1 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 72  | 8     | 79  |
| -7     | 723 | 7     | 86  |
| -6     | 90  | 6     | 95  |
| -5     | 206 | 5     | 145 |
| -4 1/2 | 461 | 4 1/2 | 314 |
| -4     | 754 | 4     | 548 |
| -3 1/2 | 903 | 3 1/2 | 808 |
| -3     | 922 | 3     | 911 |
| -2 1/2 | 920 | 2 1/2 | 916 |
| -2     | 918 | 2     | 920 |
| -1 1/2 | 915 | 1 1/2 | 914 |
| -1     | 911 | 1     | 920 |
| -1/2   | 917 | 1/2   | 920 |

# RUN 33

$T_{0A} = 75$ ,  $T_{0C} = 903$ ,  $x = -2$ ,  $y = -1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 69  | 8     | 70  |
| -7     | 70  | 7     | 80  |
| -6     | 88  | 6     | 89  |
| -5     | 218 | 5     | 186 |
| -4 1/2 | 469 | 4 1/2 | 402 |
| -4     | 750 | 4     | 657 |
| -3 1/2 | 894 | 3 1/2 | 869 |
| -3     | 905 | 3     | 908 |
| -2 1/2 | 913 | 2 1/2 | 907 |
| -2     | 908 | 2     | 912 |
| -1 1/2 | 906 | 1 1/2 | 905 |
| -1     | 899 | 1     | 910 |
| -1/2   | 906 | 1/2   | 909 |

# RUN 36

$T_{0A} = 75.5$ ,  $T_{0C} = 915$ ,  $x = -2$ ,  $y = 2 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 77  | 8     | 78  |
| -7     | 73  | 7     | 83  |
| -6     | 87  | 6     | 86  |
| -5     | 313 | 5     | 156 |
| -4 1/2 | 578 | 4 1/2 | 348 |
| -4     | 773 | 4     | 206 |
| -3 1/2 | 887 | 3 1/2 | 760 |
| -3     | 910 | 3     | 891 |
| -2 1/2 | 920 | 2 1/2 | 915 |
| -2     | 917 | 2     | 921 |
| -1 1/2 | 916 | 1 1/2 | 915 |
| -1     | 912 | 1     | 923 |
| -1/2   | 920 | 1/2   | 924 |

# RUN 34

$T_{0A} = 75$ ,  $T_{0C} = 908$ ,  $x = -2$ ,  $y = 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 64  | 8     | 73  |
| -7     | 72  | 7     | 85  |
| -6     | 91  | 6     | 94  |
| -5     | 233 | 5     | 174 |
| -4 1/2 | 500 | 4 1/2 | 372 |
| -4     | 770 | 4     | 623 |
| -3 1/2 | 900 | 3 1/2 | 855 |
| -3     | 907 | 3     | 913 |
| -2 1/2 | 917 | 2 1/2 | 913 |
| -2     | 915 | 2     | 918 |
| -1 1/2 | 911 | 1 1/2 | 908 |
| -1     | 903 | 1     | 917 |
| -1/2   | 912 | 1/2   | 916 |

# RUN 37

$T_{0A} = 75.5$ ,  $T_{0C} = 917$ ,  $x = -2$ ,  $y = 3$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 79  | 8     | 78  |
| -7     | 81  | 7     | 87  |
| -6     | 83  | 6     | 83  |
| -5     | 259 | 5     | 121 |
| -4 1/2 | 439 | 4 1/2 | 238 |
| -4     | 614 | 4     | 406 |
| -3 1/2 | 823 | 3 1/2 | 650 |
| -3     | 905 | 3     | 851 |
| -2 1/2 | 919 | 2 1/2 | 908 |
| -2     | 918 | 2     | 917 |
| -1 1/2 | 917 | 1 1/2 | 911 |
| -1     | 912 | 1     | 920 |
| -1/2   | 922 | 1/2   | 925 |

# RUN 38

$T_{0_H} = 75.5$ ,  $T_{0_C} = 918$ ,  $x = -2$ ,  $y = 3 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 77  | 8     | 80  |
| -7     | 73  | 7     | 91  |
| -6     | 81  | 6     | 83  |
| -5     | 157 | 5     | 98  |
| -4 1/2 | 284 | 4 1/2 | 161 |
| -4     | 517 | 4     | 338 |
| -3 1/2 | 789 | 3 1/2 | 597 |
| -3     | 894 | 3     | 784 |
| -2 1/2 | 908 | 2 1/2 | 805 |
| -2     | 904 | 2     | 805 |
| -1 1/2 | 904 | 1 1/2 | 819 |
| -1     | 899 | 1     | 856 |
| -1/2   | 903 | 1/2   | 884 |

# RUN 41

$T_{0_H} = 75.5$ ,  $T_{0_C} = 920$ ,  $x = -2$ ,  $y = 4 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 78  | 8     | 77  |
| -7     | 78  | 7     | 81  |
| -6     | 80  | 6     | 80  |
| -5     | 142 | 5     | 114 |
| -4 1/2 | 345 | 4 1/2 | 262 |
| -4     | 574 | 4     | 412 |
| -3 1/2 | 695 | 3 1/2 | 467 |
| -3     | 700 | 3     | 440 |
| -2 1/2 | 687 | 2 1/2 | 405 |
| -2     | 666 | 2     | 430 |
| -1 1/2 | 682 | 1 1/2 | 480 |
| -1     | 670 | 1     | 550 |
| -1/2   | 660 | 1/2   | 609 |

# RUN 39

$T_{0_H} = 75.5$ ,  $T_{0_C} = 919$ ,  $x = -2$ ,  $y = 3 \frac{3}{4}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 78  | 8     | 80  |
| -7     | 723 | 7     | 85  |
| -6     | 80  | 6     | 81  |
| -5     | 113 | 5     | 94  |
| -4 1/2 | 249 | 4 1/2 | 166 |
| -4     | 511 | 4     | 349 |
| -3 1/2 | 783 | 3 1/2 | 587 |
| -3     | 877 | 3     | 729 |
| -2 1/2 | 881 | 2 1/2 | 710 |
| -2     | 870 | 2     | 713 |
| -1 1/2 | 871 | 1 1/2 | 736 |
| -1     | 865 | 1     | 783 |
| -1/2   | 863 | 1/2   | 830 |

# RUN 42

$T_{0_H} = 76$ ,  $T_{0_C} = 923$ ,  $x = -2$ ,  $y = 5$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 73  | 8     | 83  |
| 7     | 84  | 7     | 87  |
| 6     | 85  | 6     | 86  |
| 5     | 206 | 5     | 125 |
| 4 1/2 | 437 | 4 1/2 | 289 |
| 4     | 550 | 4     | 354 |
| 3 1/2 | 520 | 3 1/2 | 307 |
| 3     | 502 | 3     | 260 |
| 2 1/2 | 501 | 2 1/2 | 242 |
| 2     | 470 | 2     | 265 |
| 1 1/2 | 483 | 1 1/2 | 306 |
| 1     | 478 | 1     | 362 |
| 1/2   | 461 | 1/2   | 407 |

# RUN 40

$T_{0_H} = 75.5$ ,  $T_{0_C} = 920$ ,  $x = -2$ ,  $y = 4$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 77  | 8     | 80  |
| -7     | 77  | 7     | 87  |
| -6     | 79  | 6     | 85  |
| -5     | 114 | 5     | 102 |
| -4 1/2 | 263 | 4 1/2 | 204 |
| -4     | 520 | 4     | 388 |
| -3 1/2 | 767 | 3 1/2 | 558 |
| -3     | 834 | 3     | 647 |
| -2 1/2 | 830 | 2 1/2 | 607 |
| -2     | 812 | 2     | 615 |
| -1 1/2 | 820 | 1 1/2 | 647 |
| -1     | 808 | 1     | 713 |
| -1/2   | 802 | 1/2   | 766 |

# RUN 43

$T_{0_H} = 76.5$ ,  $T_{0_C} = 930$ ,  $x = -2$ ,  $y = 1 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 72  | 8     | 75  |
| -7     | 77  | 7     | 83  |
| -6     | 84  | 6     | 86  |
| -5     | 171 | 5     | 542 |
| -4 1/2 | 410 | 4 1/2 | 434 |
| -4     | 689 | 4     | 693 |
| -3 1/2 | 885 | 3 1/2 | 897 |
| -3     | 923 | 3     | 931 |
| -2 1/2 | 934 | 2 1/2 | 930 |
| -2     | 930 | 2     | 936 |
| -1 1/2 | 928 | 1 1/2 | 925 |
| -1     | 922 | 1     | 936 |
| -1/2   | 925 | 1/2   | 930 |

# RUN 44

$T_{0_B} = 76.5$ ,  $T_{0_C} = 915$ ,  $x = -2$ ,  $y = -2 \frac{1}{2}$

| $\underline{z}$ | $\underline{T}$ | $\underline{z}$ | $\underline{T}$ |
|-----------------|-----------------|-----------------|-----------------|
| -8              | 72              | 8               | 75              |
| -7              | 74              | 7               | 80              |
| -6              | 78              | 6               | 81              |
| -5              | 136             | 5               | 191             |
| -4 1/2          | 328             | 4 1/2           | 432             |
| -4              | 579             | 4               | 713             |
| -3 1/2          | 826             | 3 1/2           | 890             |
| -3              | 905             | 3               | 913             |
| -2 1/2          | 920             | 2 1/2           | 910             |
| -2              | 918             | 2               | 917             |
| -1 1/2          | 916             | 1 1/2           | 910             |
| -1              | 913             | 1               | 922             |
| -1/2            | 923             | 1/2             | 918             |

# RUN 47

$T_{0_B} = 76.5$ ,  $T_{0_C} = 906$ ,  $x = -2$ ,  $y = -4 \frac{1}{4}$

| $\underline{z}$ | $\underline{T}$ | $\underline{z}$ | $\underline{T}$ |
|-----------------|-----------------|-----------------|-----------------|
| -8              | 72              | 8               | 74              |
| -7              | 74              | 7               | 76              |
| -6              | 77              | 6               | 82              |
| -5              | 130             | 5               | 206             |
| -4 1/2          | 346             | 4 1/2           | 424             |
| -4              | 627             | 4               | 670             |
| -3 1/2          | 840             | 3 1/2           | 856             |
| -3              | 894             | 3               | 896             |
| -2 1/2          | 894             | 2 1/2           | 896             |
| -2              | 890             | 2               | 903             |
| -1 1/2          | 886             | 1 1/2           | 897             |
| -1              | 894             | 1               | 905             |
| -1/2            | 899             | 1/2             | 907             |

# RUN 45

$T_{0_B} = 76.5$ ,  $T_{0_C} = 906$ ,  $x = -2$ ,  $y = -3 \frac{1}{2}$

| $\underline{z}$ | $\underline{T}$ | $\underline{z}$ | $\underline{T}$ |
|-----------------|-----------------|-----------------|-----------------|
| -8              | 72              | 8               | 76              |
| -7              | 75              | 7               | 78              |
| -6              | 76              | 6               | 82              |
| -5              | 129             | 5               | 213             |
| -4 1/2          | 335             | 4 1/2           | 464             |
| -4              | 609             | 4               | 716             |
| -3 1/2          | 833             | 3 1/2           | 883             |
| -3              | 892             | 3               | 906             |
| -2 1/2          | 905             | 2 1/2           | 903             |
| -2              | 903             | 2               | 911             |
| -1 1/2          | 900             | 1 1/2           | 903             |
| -1              | 898             | 1               | 913             |
| -1/2            | 906             | 1/2             | 913             |

# RUN 48

$T_{0_B} = 76.5$ ,  $T_{0_C} = 906$ ,  $x = -2$ ,  $y = -4$

| $\underline{z}$ | $\underline{T}$ | $\underline{z}$ | $\underline{T}$ |
|-----------------|-----------------|-----------------|-----------------|
| -8              | 72              | 8               | 74              |
| -7              | 74              | 7               | 77              |
| -6              | 78              | 6               | 85              |
| -5              | 137             | 5               | 173             |
| -4 1/2          | 349             | 4 1/2           | 381             |
| -4              | 632             | 4               | 621             |
| -3 1/2          | 832             | 3 1/2           | 840             |
| -3              | 861             | 3               | 871             |
| -2 1/2          | 864             | 2 1/2           | 881             |
| -2              | 862             | 2               | 891             |
| -1 1/2          | 856             | 1 1/2           | 889             |
| -1              | 864             | 1               | 900             |
| -1/2            | 887             | 1/2             | 901             |

# RUN 46

$T_{0_B} = 76.5$ ,  $T_{0_C} = 905$ ,  $x = -2$ ,  $y = -4 \frac{1}{2}$

| $\underline{z}$ | $\underline{T}$ | $\underline{z}$ | $\underline{T}$ |
|-----------------|-----------------|-----------------|-----------------|
| -8              | 72              | 8               | 75              |
| -7              | 75              | 7               | 78              |
| -6              | 78              | 6               | 85              |
| -5              | 122             | 5               | 136             |
| -4 1/2          | 315             | 4 1/2           | 308             |
| -4              | 567             | 4               | 542             |
| -3 1/2          | 709             | 3 1/2           | 727             |
| -3              | 681             | 3               | 745             |
| -2 1/2          | 675             | 2 1/2           | 762             |
| -2              | 685             | 2               | 779             |
| -1 1/2          | 682             | 1 1/2           | 790             |
| -1              | 720             | 1               | 819             |
| -1/2            | 770             | 1/2             | 815             |

# RUN 49

$T_{0_B} = 76.5$ ,  $T_{0_C} = 908$ ,  $x = -2$ ,  $y = 5$

| $\underline{z}$ | $\underline{T}$ | $\underline{z}$ | $\underline{T}$ |
|-----------------|-----------------|-----------------|-----------------|
| -8              | 74              | 8               | 74              |
| -7              | 76              | 7               | 78              |
| -6              | 80              | 6               | 84              |
| -5              | 109             | 5               | 139             |
| -4 1/2          | 272             | 4 1/2           | 282             |
| -4              | 458             | 4               | 464             |
| -3 1/2          | 496             | 3 1/2           | 568             |
| -3              | 438             | 3               | 534             |
| -2 1/2          | 438             | 2 1/2           | 548             |
| -2              | 458             | 2               | 569             |
| -1 1/2          | 472             | 1 1/2           | 597             |
| -1              | 514             | 1               | 626             |
| -1/2            | 567             | 1/2             | 623             |

# RUN 50

$T_{0a} = 70.5$ ,  $T_{0c} = 910$ ,  $x = 2$ ,  $y = -5 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| 8      | 75  | 8     | 74  |
| 7      | 76  | 7     | 78  |
| 6      | 84  | 6     | 80  |
| 5      | 109 | 5     | 157 |
| -4 1/2 | 335 | 4 1/2 | 281 |
| -4     | 335 | 4     | 396 |
| -3 1/2 | 315 | 3 1/2 | 396 |
| -3     | 256 | 3     | 333 |
| -2 1/2 | 260 | 2 1/2 | 348 |
| -2     | 277 | 2     | 369 |
| -1 1/2 | 287 | 1 1/2 | 389 |
| -1     | 327 | 1     | 417 |
| -1/2   | 368 | 1/2   | 414 |

# RUN 53

$T_{0a} = 77$ ,  $T_{0c} = 910$ ,  $x = 6$ ,  $y = 6 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| 8      | 70  | 8     | 723 |
| 7      | 73  | 7     | 734 |
| 6      | 81  | 6     | 79  |
| 5      | 915 | 5     | 107 |
| -4 1/2 | 112 | 4 1/2 | 128 |
| -4     | 103 | 4     | 159 |
| -3 1/2 | 947 | 3 1/2 | 128 |
| -3     | 89  | 3     | 104 |
| -2 1/2 | 90  | 2 1/2 | 113 |
| -2     | 90  | 2     | 115 |
| -1 1/2 | 91  | 1 1/2 | 115 |
| -1     | 98  | 1     | 121 |
| -1/2   | 100 | 1/2   | 107 |

# RUN 51

$T_{0a} = 77$ ,  $T_{0c} = 910$ ,  $x = -2$ ,  $y = -6$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 74  | 8     | 76  |
| -7     | 77  | 7     | 79  |
| -6     | 84  | 6     | 80  |
| -5     | 109 | 5     | 153 |
| -4 1/2 | 162 | 4 1/2 | 230 |
| -4     | 199 | 4     | 273 |
| -3 1/2 | 178 | 3 1/2 | 238 |
| -3     | 136 | 3     | 187 |
| -2 1/2 | 140 | 2 1/2 | 198 |
| -2     | 146 | 2     | 206 |
| -1 1/2 | 151 | 1 1/2 | 216 |
| -1     | 170 | 1     | 223 |
| -1/2   | 190 | 1/2   | 221 |

# RUN 54

$T_{0a} = 77$ ,  $T_{0c} = 910$ ,  $x = -6$ ,  $y = -5 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 70  | 8     | 72  |
| -7     | 73  | 7     | 74  |
| -6     | 80  | 6     | 82  |
| -5     | 95  | 5     | 133 |
| -4 1/2 | 204 | 4 1/2 | 256 |
| -4     | 343 | 4     | 400 |
| -3 1/2 | 344 | 3 1/2 | 430 |
| -3     | 282 | 3     | 361 |
| -2 1/2 | 285 | 2 1/2 | 381 |
| -2     | 300 | 2     | 399 |
| -1 1/2 | 315 | 1 1/2 | 421 |
| -1     | 358 | 1     | 455 |
| -1/2   | 391 | 1/2   | 436 |

# RUN 52

$T_{0a} = 77$ ,  $T_{0c} = 910$ ,  $x = -2$ ,  $y = -6 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 74  | 8     | 74  |
| -7     | 77  | 7     | 78  |
| -6     | 82  | 6     | 79  |
| -5     | 101 | 5     | 128 |
| -4 1/2 | 112 | 4 1/2 | 134 |
| -4     | 109 | 4     | 153 |
| -3 1/2 | 98  | 3 1/2 | 131 |
| -3     | 90  | 3     | 109 |
| -2 1/2 | 94  | 2 1/2 | 114 |
| -2     | 85  | 2     | 115 |
| -1 1/2 | 94  | 1 1/2 | 115 |
| -1     | 98  | 1     | 121 |
| -1/2   | 103 | 1/2   | 113 |

# RUN 55

$T_{0a} = 77$ ,  $T_{0c} = 912$ ,  $x = -6$ ,  $y = -4 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 70  | 8     | 76  |
| -7     | 72  | 7     | 77  |
| -6     | 76  | 6     | 83  |
| -5     | 103 | 5     | 110 |
| -4 1/2 | 281 | 4 1/2 | 256 |
| -4     | 553 | 4     | 500 |
| -3 1/2 | 724 | 3 1/2 | 723 |
| -3     | 711 | 3     | 748 |
| -2 1/2 | 700 | 2 1/2 | 765 |
| -2     | 705 | 2     | 776 |
| -1 1/2 | 706 | 1 1/2 | 805 |
| -1     | 741 | 1     | 834 |
| -1/2   | 774 | 1/2   | 807 |

RUN 56

$T_{0g} = 78, T_{0c} = 900, x = -6, y = -1 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 67       | 8        | 73       |
| -7       | 69       | 7        | 76       |
| -6       | 71       | 6        | 77       |
| -5       | 111      | 5        | 166      |
| -4 1/2   | 315      | 4 1/2    | 420      |
| -4       | 603      | 4        | 705      |
| -3 1/2   | 843      | 3 1/2    | 885      |
| -3       | 893      | 3        | 905      |
| -2 1/2   | 903      | 2 1/2    | 904      |
| -2       | 904      | 2        | 911      |
| -1 1/2   | 903      | 1 1/2    | 904      |
| -1       | 896      | 1        | 906      |
| -1/2     | 902      | 1/2      | 905      |

RUN 59

$T_{0g} = 78, T_{0c} = 897, x = -6, y = -1 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| 8        | 68       | 8        | 72       |
| 7        | 71       | 7        | 81       |
| 6        | 88       | 6        | 86       |
| 5        | 195      | 5        | 172      |
| 4 1/2    | 456      | 4 1/2    | 404      |
| 4        | 751      | 4        | 687      |
| 3 1/2    | 888      | 3 1/2    | 900      |
| 3        | 894      | 3        | 902      |
| 2 1/2    | 902      | 2 1/2    | 899      |
| 2        | 902      | 2        | 905      |
| 1 1/2    | 899      | 1 1/2    | 900      |
| 1        | 895      | 1        | 905      |
| 1/2      | 902      | 1/2      | 905      |

RUN 57

$T_{0g} = 78, T_{0c} = 899, x = -6, y = -2 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 67       | 8        | 73       |
| -7       | 70       | 7        | 81       |
| -6       | 73       | 6        | 82       |
| -5       | 117      | 5        | 152      |
| -4 1/2   | 315      | 4 1/2    | 395      |
| -4       | 590      | 4        | 597      |
| -3 1/2   | 834      | 3 1/2    | 880      |
| -3       | 891      | 3        | 902      |
| -2 1/2   | 903      | 2 1/2    | 901      |
| -2       | 905      | 2        | 910      |
| -1 1/2   | 899      | 1 1/2    | 898      |
| -1       | 893      | 1        | 904      |
| -1/2     | 901      | 1/2      | 903      |

RUN 60

$T_{0g} = 78, T_{0c} = 895, x = -6, y = -1 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| 8        | 71       | 8        | 74       |
| 7        | 72       | 7        | 81       |
| 6        | 88       | 6        | 90       |
| 5        | 220      | 5        | 148      |
| 4 1/2    | 500      | 4 1/2    | 359      |
| 4        | 767      | 4        | 632      |
| 3 1/2    | 891      | 3 1/2    | 863      |
| 3        | 927      | 3        | 899      |
| 2 1/2    | 901      | 2 1/2    | 897      |
| 2        | 900      | 2        | 903      |
| 1 1/2    | 889      | 1 1/2    | 898      |
| 1        | 891      | 1        | 903      |
| 1/2      | 900      | 1/2      | 903      |

RUN 58

$T_{0g} = 78, T_{0c} = 898, x = -6, y = -1 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 67       | 8        | 71       |
| -7       | 71       | 7        | 83       |
| -6       | 79       | 6        | 84       |
| -5       | 119      | 5        | 139      |
| -4 1/2   | 395      | 4 1/2    | 383      |
| -4       | 685      | 4        | 690      |
| -3 1/2   | 870      | 3 1/2    | 880      |
| -3       | 891      | 3        | 900      |
| -2 1/2   | 901      | 2 1/2    | 899      |
| -2       | 882      | 2        | 905      |
| -1 1/2   | 898      | 1 1/2    | 898      |
| -1       | 894      | 1        | 904      |
| -1/2     | 922      | 1/2      | 904      |

RUN 61

$T_{0g} = 78, T_{0c} = 895, x = -6, y = -1 1/2$

| <u>z</u> | <u>T</u> | <u>z</u> | <u>T</u> |
|----------|----------|----------|----------|
| -8       | 72       | 8        | 77       |
| -7       | 73       | 7        | 82       |
| -6       | 87       | 6        | 88       |
| -5       | 184      | 5        | 189      |
| -4 1/2   | 447      | 4 1/2    | 284      |
| -4       | 748      | 4        | 516      |
| -3 1/2   | 747      | 3 1/2    | 817      |
| -3       | 893      | 3        | 897      |
| -2 1/2   | 902      | 2 1/2    | 912      |
| -2       | 902      | 2        | 905      |
| -1 1/2   | 897      | 1 1/2    | 899      |
| -1       | 888      | 1        | 904      |
| -1/2     | 866      | 1/2      | 904      |

# RUN 62

$T_{0_s} = 78$ ,  $T_{0_c} = 895$ ,  $x = -6$ ,  $y = 2 \frac{1}{2}$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 71  | 8     | 74  |
| 7     | 73  | 7     | 82  |
| 6     | 79  | 6     | 82  |
| 5     | 273 | 5     | 130 |
| 4 1/2 | 551 | 4 1/2 | 323 |
| 4     | 897 | 4     | 543 |
| 3 1/2 | 869 | 3 1/2 | 762 |
| 3     | 890 | 3     | 880 |
| 2 1/2 | 901 | 2 1/2 | 896 |
| 2     | 902 | 2     | 905 |
| 1 1/2 | 898 | 1 1/2 | 899 |
| 1     | 890 | 1     | 903 |
| 1/2   | 900 | 1/2   | 904 |

# RUN 65

$T_{0_s} = 77.5$ ,  $T_{0_c} = 904$ ,  $x = -16$ ,  $y = 4 \frac{1}{2}$

| $z$   | $T$  | $z$   | $T$  |
|-------|------|-------|------|
| 8     | 71.3 | 8     | 78.7 |
| 7     | 71.3 | 7     | 81.9 |
| 6     | 75.5 | 6     | 80.8 |
| 5     | 86.2 | 5     | 89.4 |
| 4 1/2 | 192  | 4 1/2 | 157  |
| 4     | 510  | 4     | 394  |
| 3 1/2 | 613  | 3 1/2 | 396  |
| 3     | 554  | 3     | 323  |
| 2 1/2 | 555  | 2 1/2 | 297  |
| 2     | 522  | 2     | 323  |
| 1 1/2 | 541  | 1 1/2 | 356  |
| 1     | 538  | 1     | 419  |
| 1/2   | 524  | 1/2   | 471  |

# RUN 63

$T_{0_s} = 78$ ,  $T_{0_c} = 896$ ,  $x = -6$ ,  $y = 3 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 76  | 8     | 79  |
| -7     | 72  | 7     | 85  |
| -6     | 76  | 6     | 81  |
| -5     | 112 | 5     | 91  |
| -4 1/2 | 221 | 4 1/2 | 133 |
| -4     | 455 | 4     | 306 |
| -3 1/2 | 757 | 3 1/2 | 593 |
| -3     | 877 | 3     | 796 |
| -2 1/2 | 843 | 2 1/2 | 815 |
| -2     | 890 | 2     | 810 |
| -1 1/2 | 888 | 1 1/2 | 820 |
| -1     | 875 | 1     | 850 |
| -1/2   | 879 | 1/2   | 870 |

# RUN 66

$T_{0_s} = 77$ ,  $T_{0_c} = 904$ ,  $x = -16$ ,  $y = 3 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 71.3 | 8     | 74.5 |
| -7     | 71.3 | 7     | 84.0 |
| -6     | 75.5 | 6     | 76.6 |
| -5     | 85.1 | 5     | 84.0 |
| -4 1/2 | 131  | 4 1/2 | 88.3 |
| -4     | 322  | 4     | 237  |
| -3 1/2 | 708  | 3 1/2 | 571  |
| -3     | 888  | 3     | 822  |
| -2 1/2 | 903  | 2 1/2 | 812  |
| -2     | 898  | 2     | 812  |
| -1 1/2 | 901  | 1 1/2 | 819  |
| -1     | 896  | 1     | 860  |
| -1/2   | 900  | 1/2   | 890  |

# RUN 64

$T_{0_s} = 78$ ,  $T_{0_c} = 901$ ,  $x = -6$ ,  $y = 4 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 74  | 8     | 78  |
| -7     | 73  | 7     | 84  |
| -6     | 79  | 6     | 82  |
| -5     | 114 | 5     | 103 |
| -4 1/2 | 307 | 4 1/2 | 249 |
| -4     | 558 | 4     | 417 |
| -3 1/2 | 685 | 3 1/2 | 467 |
| -3     | 681 | 3     | 421 |
| -2 1/2 | 667 | 2 1/2 | 390 |
| -2     | 642 | 2     | 417 |
| -1 1/2 | 658 | 1 1/2 | 473 |
| -1     | 648 | 1     | 541 |
| -1/2   | 632 | 1/2   | 588 |

# RUN 67

$T_{0_s} = 77$ ,  $T_{0_c} = 904$ ,  $x = -16$ ,  $y = 2 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 73.4 | 8     | 75.5 |
| -7     | 73.4 | 7     | 85.1 |
| -6     | 80.8 | 6     | 80.8 |
| -5     | 131  | 5     | 90.4 |
| -4 1/2 | 429  | 4 1/2 | 211  |
| -4     | 721  | 4     | 503  |
| -3 1/2 | 870  | 3 1/2 | 776  |
| -3     | 899  | 3     | 894  |
| -2 1/2 | 910  | 2 1/2 | 906  |
| -2     | 913  | 2     | 916  |
| -1 1/2 | 913  | 1 1/2 | 912  |
| -1     | 907  | 1     | 920  |
| -1/2   | 918  | 1/2   | 922  |

RUN 68

$T_{0_H} = 77, T_{0_C} = 904, x = -16, y = -1 1/2$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 73.4 | 8     | 74.5 |
| -7     | 73.4 | 7     | 83.0 |
| -6     | 87.2 | 6     | 85.1 |
| -5     | 122  | 5     | 96.8 |
| -4 1/2 | 333  | 4 1/2 | 197  |
| -4     | 704  | 4     | 499  |
| -3 1/2 | 889  | 3 1/2 | 898  |
| -3     | 896  | 3     | 902  |
| -2 1/2 | 910  | 2 1/2 | 903  |
| -2     | 911  | 2     | 915  |
| -1 1/2 | 910  | 1 1/2 | 911  |
| -1     | 906  | 1     | 921  |
| -1/2   | 915  | 1/2   | 919  |

RUN 71

$T_{0_H} = 77, T_{0_C} = 904, x = -16, y = -1 1/2$

| $z$   | $T$  | $z$   | $T$  |
|-------|------|-------|------|
| 8     | 64.9 | 8     | 68.1 |
| 7     | 72.3 | 7     | 75.5 |
| 6     | 73.4 | 6     | 79.8 |
| 5     | 91.5 | 5     | 72.3 |
| 4 1/2 | 239  | 4 1/2 | 319  |
| 4     | 589  | 4     | 674  |
| 3 1/2 | 863  | 3 1/2 | 895  |
| 3     | 900  | 3     | 911  |
| 2 1/2 | 912  | 2 1/2 | 911  |
| 2     | 913  | 2     | 919  |
| 1 1/2 | 913  | 1 1/2 | 916  |
| 1     | 911  | 1     | 923  |
| 1/2   | 922  | 1/2   | 924  |

RUN 69

$T_{0_H} = 77, T_{0_C} = 904, x = -16, y = 1/2$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 69.1 | 8     | 72.3 |
| -7     | 73.4 | 7     | 81.9 |
| -6     | 86.2 | 6     | 87.2 |
| -5     | 126  | 5     | 104  |
| -4 1/2 | 365  | 4 1/2 | 272  |
| -4     | 733  | 4     | 615  |
| -3 1/2 | 888  | 3 1/2 | 879  |
| -3     | 894  | 3     | 902  |
| -2 1/2 | 905  | 2 1/2 | 902  |
| -2     | 906  | 2     | 912  |
| -1 1/2 | 904  | 1 1/2 | 906  |
| -1     | 905  | 1     | 914  |
| -1/2   | 910  | 1/2   | 913  |

RUN 72

$T_{0_H} = 77, T_{0_C} = 905, x = -16, y = -2 1/2$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 66.0 | 8     | 69.1 |
| -7     | 70.2 | 7     | 71.3 |
| -6     | 69.1 | 6     | 73.4 |
| -5     | 79.8 | 5     | 93.6 |
| -4 1/2 | 168  | 4 1/2 | 290  |
| -4     | 473  | 4     | 662  |
| -3 1/2 | 802  | 3 1/2 | 900  |
| -3     | 902  | 3     | 912  |
| -2 1/2 | 912  | 2 1/2 | 913  |
| -2     | 915  | 2     | 921  |
| -1 1/2 | 915  | 1 1/2 | 918  |
| -1     | 912  | 1     | 926  |
| -1/2   | 922  | 1/2   | 926  |

RUN 70

$T_{0_H} = 77, T_{0_C} = 904, x = -16, y = 1/2$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 66.0 | 8     | 69.1 |
| -7     | 74.5 | 7     | 79.8 |
| -6     | 83.0 | 6     | 85.1 |
| -5     | 112  | 5     | 110  |
| -4 1/2 | 313  | 4 1/2 | 318  |
| -4     | 676  | 4     | 670  |
| -3 1/2 | 885  | 3 1/2 | 891  |
| -3     | 894  | 3     | 904  |
| -2 1/2 | 908  | 2 1/2 | 904  |
| -2     | 910  | 2     | 915  |
| -1 1/2 | 910  | 1 1/2 | 912  |
| -1     | 907  | 1     | 919  |
| -1/2   | 917  | 1/2   | 919  |

RUN 73

$T_{0_H} = 77, T_{0_C} = 907, x = -16, y = -3 1/2$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 66.0 | 8     | 68.1 |
| -7     | 68.1 | 7     | 69.2 |
| -6     | 68.1 | 6     | 73.4 |
| -5     | 111  | 5     | 90.4 |
| -4 1/2 | 136  | 4 1/2 | 308  |
| -4     | 472  | 4     | 655  |
| -3 1/2 | 817  | 3 1/2 | 917  |
| -3     | 902  | 3     | 914  |
| -2 1/2 | 916  | 2 1/2 | 916  |
| -2     | 917  | 2     | 924  |
| -1 1/2 | 917  | 1 1/2 | 920  |
| -1     | 914  | 1     | 928  |
| -1/2   | 924  | 1/2   | 928  |

# RUN 74

$T_{0_H} = 77$ ,  $T_{0_C} = 907$ ,  $x = -16$ ,  $y = -4 \frac{1}{2}$

| $z$   | $T$  | $z$   | $T$  |
|-------|------|-------|------|
| 8     | 66.0 | 8     | 66.0 |
| 7     | 69.2 | 7     | 69.2 |
| 6     | 70.2 | 6     | 79.8 |
| 5     | 75.5 | 5     | 88.3 |
| 4 1/2 | 114  | 4 1/2 | 158  |
| 4     | 352  | 4     | 390  |
| 3 1/2 | 649  | 3 1/2 | 729  |
| 3     | 679  | 3     | 716  |
| 2 1/2 | 664  | 2 1/2 | 724  |
| 2     | 665  | 2     | 734  |
| 1 1/2 | 650  | 1 1/2 | 756  |
| 1     | 679  | 1     | 786  |
| 1/2   | 735  | 1/2   | 784  |

# RUN 77

$T_{0_H} = 76.5$ ,  $T_{0_C} = 906$ ,  $x = -16$ ,  $y = -1/2$

| $z$   | $T$  | $z$   | $T$  |
|-------|------|-------|------|
| 8     | 68.1 | 8     | 68.1 |
| 7     | 69.2 | 7     | 76.6 |
| 6     | 76.6 | 6     | 79.8 |
| 5     | 101  | 5     | 99.0 |
| 4 1/2 | 246  | 4 1/2 | 240  |
| 4     | 584  | 4     | 583  |
| 3 1/2 | 864  | 3 1/2 | 871  |
| 3     | 896  | 3     | 908  |
| 2 1/2 | 911  | 2 1/2 | 911  |
| 2     | 912  | 2     | 916  |
| 1 1/2 | 911  | 1 1/2 | 914  |
| 1     | 909  | 1     | 921  |
| 1/2   | 920  | 1/2   | 921  |

# RUN 75

$T_{0_H} = 77$ ,  $T_{0_C} = 908$ ,  $x = -16$ ,  $y = -5 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 67.0 | 8     | 68.1 |
| -7     | 71.3 | 7     | 71.3 |
| -6     | 74.5 | 6     | 78.7 |
| -5     | 75.5 | 5     | 107  |
| -4 1/2 | 117  | 4 1/2 | 190  |
| -4     | 211  | 4     | 347  |
| -3 1/2 | 267  | 3 1/2 | 337  |
| -3     | 184  | 3     | 242  |
| -2 1/2 | 188  | 2 1/2 | 248  |
| -2     | 196  | 2     | 253  |
| -1 1/2 | 188  | 1 1/2 | 269  |
| -1     | 217  | 1     | 285  |
| -1/2   | 249  | 1/2   | 285  |

# RUN 78

$T_{0_H} = 78$ ,  $T_{0_C} = 104$ ,  $x = 0$ ,  $y = -1/2$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 65   | 8     | 66   |
| -7     | 67   | 7     | 62   |
| -6     | 62   | 6     | 64   |
| -5     | 66   | 5     | 66   |
| -4 1/2 | 71   | 4 1/2 | 57.5 |
| -4     | 58.5 | 4     | 56   |
| -3 1/2 | 57.5 | 3 1/2 | 58.5 |
| -3     | 59.5 | 3     | 59.5 |
| -2 1/2 | 59.5 | 2 1/2 | 59.5 |
| -2     | 58.5 | 2     | 58.5 |
| -1 1/2 | 59.5 | 1 1/2 | 56   |
| -1     | 59.5 | 1     | 64   |
| -1/2   | 58   | 1/2   | 57   |

# RUN 76

$T_{0_H} = 76.5$ ,  $T_{0_C} = 910$ ,  $x = -16$ ,  $y = -6 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 67.0 | 8     | 67.0 |
| -7     | 72.4 | 7     | 71.3 |
| -6     | 75.5 | 6     | 75.5 |
| -5     | 74.5 | 5     | 83.0 |
| -4 1/2 | 86.2 | 4 1/2 | 74.5 |
| -4     | 74.5 | 4     | 75.5 |
| -3 1/2 | 72.4 | 3 1/2 | 74.5 |
| -3     | 76.6 | 3     | 76.6 |
| -2 1/2 | 79.8 | 2 1/2 | 76.6 |
| -2     | 75.5 | 2     | 76.6 |
| -1 1/2 | 76.6 | 1 1/2 | 76.6 |
| -1     | 75.5 | 1     | 77.7 |
| -1/2   | 75.0 | 1/2   | 75.8 |

# RUN 79

$T_{0_H} = 77$ ,  $T_{0_C} = 800$ ,  $x = 0$ ,  $y = -1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 69  | 8     | 69  |
| -7     | 68  | 7     | 73  |
| -6     | 78  | 6     | 81  |
| -5     | 170 | 5     | 187 |
| -4 1/2 | 361 | 4 1/2 | 385 |
| -4     | 605 | 4     | 606 |
| -3 1/2 | 760 | 3 1/2 | 764 |
| -3     | 782 | 3     | 790 |
| -2 1/2 | 790 | 2 1/2 | 788 |
| -2     | 787 | 2     | 793 |
| -1 1/2 | 786 | 1 1/2 | 787 |
| -1     | 782 | 1     | 793 |
| -1/2   | 788 | 1/2   | 790 |

# RUN 80

$T_{0_s} = 77$ ,  $T_{0_c} = 906$ ,  $x = 0$ ,  $y = 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 68  | 8     | 71  |
| -7     | 67  | 7     | 78  |
| -6     | 80  | 6     | 85  |
| -5     | 196 | 5     | 211 |
| -4 1/2 | 415 | 4 1/2 | 435 |
| -4     | 675 | 4     | 670 |
| -3 1/2 | 858 | 3 1/2 | 859 |
| -3     | 884 | 3     | 892 |
| -2 1/2 | 897 | 2 1/2 | 899 |
| -2     | 892 | 2     | 897 |
| -1 1/2 | 891 | 1 1/2 | 888 |
| -1     | 883 | 1     | 896 |
| -1/2   | 890 | 1/2   | 891 |

# RUN 83

$T_{0_s} = 77$ ,  $T_{0_c} = 918$ ,  $x = 6$ ,  $y = 1 1/2$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 70  | 8     | 70  |
| 7     | 69  | 7     | 76  |
| 6     | 81  | 6     | 91  |
| 5     | 234 | 5     | 161 |
| 4 1/2 | 457 | 4 1/2 | 297 |
| 4     | 691 | 4     | 500 |
| 3 1/2 | 849 | 3 1/2 | 724 |
| 3     | 886 | 3     | 865 |
| 2 1/2 | 904 | 2 1/2 | 893 |
| 2     | 904 | 2     | 901 |
| 1 1/2 | 905 | 1 1/2 | 900 |
| 1     | 898 | 1     | 911 |
| 1/2   | 907 | 1/2   | 911 |

# RUN 81

$T_{0_s} = 77$ ,  $T_{0_c} = 913$ ,  $x = 6$ ,  $y = 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 67  | 8     | 67  |
| -7     | 68  | 7     | 77  |
| -6     | 80  | 6     | 84  |
| -5     | 232 | 5     | 256 |
| -4 1/2 | 440 | 4 1/2 | 417 |
| -4     | 662 | 4     | 622 |
| -3 1/2 | 827 | 3 1/2 | 816 |
| -3     | 878 | 3     | 886 |
| -2 1/2 | 898 | 2 1/2 | 888 |
| -2     | 897 | 2     | 900 |
| -1 1/2 | 900 | 1 1/2 | 896 |
| -1     | 894 | 1     | 904 |
| -1/2   | 907 | 1/2   | 905 |

# RUN 84

$T_{0_s} = 76.5$ ,  $T_{0_c} = 919$ ,  $x = 6$ ,  $y = 2 1/2$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 71  | 8     | 73  |
| 7     | 69  | 7     | 81  |
| 6     | 80  | 6     | 85  |
| 5     | 331 | 5     | 174 |
| 4 1/2 | 552 | 4 1/2 | 335 |
| 4     | 728 | 4     | 499 |
| 3 1/2 | 844 | 3 1/2 | 682 |
| 3     | 886 | 3     | 830 |
| 2 1/2 | 906 | 2 1/2 | 885 |
| 2     | 905 | 2     | 903 |
| 1 1/2 | 905 | 1 1/2 | 903 |
| 1     | 898 | 1     | 912 |
| 1/2   | 907 | 1/2   | 910 |

# RUN 82

$T_{0_s} = 77$ ,  $T_{0_c} = 915$ ,  $x = 6$ ,  $y = 1/2$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 70  | 8     | 64  |
| -7     | 68  | 7     | 74  |
| -6     | 85  | 6     | 90  |
| -5     | 255 | 5     | 193 |
| -4 1/2 | 479 | 4 1/2 | 373 |
| -4     | 351 | 4     | 574 |
| -3 1/2 | 849 | 3 1/2 | 784 |
| -3     | 884 | 3     | 883 |
| -2 1/2 | 904 | 2 1/2 | 896 |
| -2     | 904 | 2     | 904 |
| -1 1/2 | 904 | 1 1/2 | 900 |
| -1     | 901 | 1     | 911 |
| -1/2   | 909 | 1/2   | 912 |

# RUN 85

$T_{0_s} = 76.5$ ,  $T_{0_c} = 921$ ,  $x = 6$ ,  $y = 3 1/2$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 70  | 8     | 74  |
| 7     | 66  | 7     | 86  |
| 6     | 71  | 6     | 80  |
| 5     | 167 | 5     | 101 |
| 4 1/2 | 301 | 4 1/2 | 187 |
| 4     | 478 | 4     | 331 |
| 3 1/2 | 700 | 3 1/2 | 538 |
| 3     | 855 | 3     | 719 |
| 2 1/2 | 897 | 2 1/2 | 776 |
| 2     | 887 | 2     | 783 |
| 1 1/2 | 889 | 1 1/2 | 784 |
| 1     | 879 | 1     | 815 |
| 1/2   | 876 | 1/2   | 847 |

# RUN 86

$T_{0_B} = 76.5$ ,  $T_{0_C} = 924$ ,  $x = 6$ ,  $y = 4 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| 8      | 68  | 8     | 76  |
| 7      | 67  | 7     | 84  |
| 6      | 69  | 6     | 77  |
| 5      | 135 | 5     | 135 |
| -4 1/2 | 327 | 4 1/2 | 263 |
| -4     | 510 | 4     | 368 |
| -3 1/2 | 636 | 3 1/2 | 417 |
| -3     | 653 | 3     | 401 |
| -2 1/2 | 632 | 2 1/2 | 359 |
| -2     | 598 | 2     | 372 |
| -1 1/2 | 613 | 1 1/2 | 413 |
| -1     | 596 | 1     | 473 |
| -1/2   | 578 | 1/2   | 525 |

# RUN 89

$T_{0_B} = 77$ ,  $T_{0_C} = 928$ ,  $x = 6$ ,  $y = 3 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| 8      | 59  | 8     | 68  |
| 7      | 64  | 7     | 67  |
| 6      | 62  | 6     | 74  |
| 5      | 128 | 5     | 234 |
| -4 1/2 | 301 | 4 1/2 | 451 |
| -4     | 511 | 4     | 679 |
| -3 1/2 | 739 | 3 1/2 | 854 |
| -3     | 858 | 3     | 903 |
| -2 1/2 | 909 | 2 1/2 | 905 |
| -2     | 906 | 2     | 915 |
| -1 1/2 | 908 | 1 1/2 | 906 |
| -1     | 904 | 1     | 919 |
| -1/2   | 918 | 1/2   | 916 |

# RUN 87

$T_{0_B} = 76.5$ ,  $T_{0_C} = 925$ ,  $x = 6$ ,  $y = -1 \frac{1}{2}$

| $z$    | $T$  | $z$   | $T$  |
|--------|------|-------|------|
| -8     | 60.6 | 8     | 63.9 |
| -7     | 65   | 7     | 79.7 |
| -6     | 71.3 | 6     | 79.7 |
| -5     | 188  | 5     | 213  |
| -4 1/2 | 353  | 4 1/2 | 413  |
| -4     | 604  | 4     | 626  |
| -3 1/2 | 798  | 3 1/2 | 820  |
| -3     | 897  | 3     | 898  |
| -2 1/2 | 908  | 2 1/2 | 898  |
| -2     | 908  | 2     | 909  |
| -1 1/2 | 908  | 1 1/2 | 903  |
| -1     | 903  | 1     | 918  |
| -1/2   | 918  | 1/2   | 914  |

# RUN 90

$T_{0_B} = 77$ ,  $T_{0_C} = 929$ ,  $x = 6$ ,  $y = -4 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 62  | 8     | 66  |
| -7     | 63  | 7     | 63  |
| -6     | 63  | 6     | 75  |
| -5     | 117 | 5     | 159 |
| -4 1/2 | 287 | 4 1/2 | 344 |
| -4     | 517 | 4     | 531 |
| -3 1/2 | 691 | 3 1/2 | 691 |
| -3     | 686 | 3     | 725 |
| -2 1/2 | 658 | 2 1/2 | 732 |
| -2     | 646 | 2     | 745 |
| -1 1/2 | 676 | 1 1/2 | 758 |
| -1     | 666 | 1     | 772 |
| -1/2   | 722 | 1/2   | 773 |

# RUN 88

$T_{0_B} = 77$ ,  $T_{0_C} = 926$ ,  $x = 6$ ,  $y = -2 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 62  | 8     | 69  |
| -7     | 64  | 7     | 76  |
| -6     | 64  | 6     | 74  |
| -5     | 132 | 5     | 196 |
| -4 1/2 | 303 | 4 1/2 | 405 |
| -4     | 504 | 4     | 634 |
| -3 1/2 | 721 | 3 1/2 | 817 |
| -3     | 862 | 3     | 902 |
| -2 1/2 | 908 | 2 1/2 | 902 |
| -2     | 906 | 2     | 915 |
| -1 1/2 | 910 | 1 1/2 | 905 |
| -1     | 906 | 1     | 920 |
| -1/2   | 918 | 1/2   | 915 |

# RUN 91

$T_{0_B} = 77$ ,  $T_{0_C} = 924$ ,  $x = 6$ ,  $y = 5 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 63  | 8     | 67  |
| -7     | 64  | 7     | 65  |
| -6     | 68  | 6     | 73  |
| -5     | 97  | 5     | 157 |
| -4 1/2 | 223 | 4 1/2 | 279 |
| -4     | 349 | 4     | 388 |
| -3 1/2 | 353 | 3 1/2 | 419 |
| -3     | 283 | 3     | 372 |
| -2 1/2 | 264 | 2 1/2 | 368 |
| -2     | 271 | 2     | 384 |
| -1 1/2 | 284 | 1 1/2 | 400 |
| -1     | 316 | 1     | 421 |
| -1/2   | 362 | 1/2   | 411 |

# RUN 92

| $T_{0_s} = 77, T_{0_c} = 924, x = 0, y = -1/2$ |     |       |     |
|------------------------------------------------|-----|-------|-----|
| $z$                                            | $T$ | $z$   | $T$ |
| -8                                             | 76  | 8     | 66  |
| -7                                             | 94  | 7     | 65  |
| -6                                             | 104 | 6     | 74  |
| -5                                             | 170 | 5     | 135 |
| -4 1/2                                         | 264 | 4 1/2 | 176 |
| -4                                             | 295 | 4     | 195 |
| -3 1/2                                         | 257 | 3 1/2 | 139 |
| -3                                             | 175 | 3     | 133 |
| -2 1/2                                         | 171 | 2 1/2 | 128 |
| -2                                             | 172 | 2     | 126 |
| -1 1/2                                         | 170 | 1 1/2 | 126 |
| -1                                             | 191 | 1     | 131 |
| -1/2                                           | 107 | 1/2   | 119 |

# RUN 95

| $T_{0_s} = 77, T_{0_c} = 925, x = 0, y = -1/2$ |     |       |     |
|------------------------------------------------|-----|-------|-----|
| $z$                                            | $T$ | $z$   | $T$ |
| -8                                             | 66  | 8     | 85  |
| -7                                             | 66  | 7     | 74  |
| -6                                             | 80  | 6     | 87  |
| -5                                             | 206 | 5     | 209 |
| -4 1/2                                         | 426 | 4 1/2 | 438 |
| -4                                             | 692 | 4     | 676 |
| -3 1/2                                         | 871 | 3 1/2 | 869 |
| -3                                             | 897 | 3     | 904 |
| -2 1/2                                         | 907 | 2 1/2 | 903 |
| -2                                             | 906 | 2     | 909 |
| -1 1/2                                         | 903 | 1 1/2 | 902 |
| -1                                             | 896 | 1     | 908 |
| -1/2                                           | 901 | 1/2   | 904 |

# RUN 93

| $T_{0_s} = 77, T_{0_c} = 924, x = 0, y = -1/2$ |      |       |      |
|------------------------------------------------|------|-------|------|
| $z$                                            | $T$  | $z$   | $T$  |
| -8                                             | 65.9 | 8     | 63.8 |
| -7                                             | 64.9 | 7     | 72.3 |
| -6                                             | 77.6 | 6     | 85.1 |
| -5                                             | 209  | 5     | 265  |
| -4 1/2                                         | 422  | 4 1/2 | 452  |
| -4                                             | 686  | 4     | 686  |
| -3 1/2                                         | 869  | 3 1/2 | 869  |
| -3                                             | 894  | 3     | 903  |
| -2 1/2                                         | 905  | 2 1/2 | 903  |
| -2                                             | 903  | 2     | 908  |
| -1 1/2                                         | 902  | 1 1/2 | 901  |
| -1                                             | 896  | 1     | 907  |
| -1/2                                           | 902  | 1/2   | 905  |

# RUN 96

| $T_{0_s} = 77, T_{0_c} = 928, x = 0, y = -1/2$ |     |       |     |
|------------------------------------------------|-----|-------|-----|
| $z$                                            | $T$ | $z$   | $T$ |
| -8                                             | 66  | 8     | 67  |
| -7                                             | 67  | 7     | 74  |
| -6                                             | 80  | 6     | 87  |
| -5                                             | 206 | 5     | 211 |
| -4 1/2                                         | 425 | 4 1/2 | 436 |
| -4                                             | 696 | 4     | 675 |
| -3 1/2                                         | 873 | 3 1/2 | 871 |
| -3                                             | 899 | 3     | 906 |
| -2 1/2                                         | 909 | 2 1/2 | 905 |
| -2                                             | 907 | 2     | 912 |
| -1 1/2                                         | 905 | 1 1/2 | 903 |
| -1                                             | 898 | 1     | 911 |
| -1/2                                           | 903 | 1/2   | 906 |

# RUN 94

| $T_{0_s} = 77, T_{0_c} = 925, x = 0, y = -1/2$ |     |       |     |
|------------------------------------------------|-----|-------|-----|
| $z$                                            | $T$ | $z$   | $T$ |
| -8                                             | 66  | 8     | 67  |
| -7                                             | 67  | 7     | 74  |
| -6                                             | 80  | 6     | 86  |
| -5                                             | 208 | 5     | 213 |
| -4 1/2                                         | 426 | 4 1/2 | 439 |
| -4                                             | 690 | 4     | 676 |
| -3 1/2                                         | 869 | 3 1/2 | 863 |
| -3                                             | 895 | 3     | 903 |
| -2 1/2                                         | 906 | 2 1/2 | 902 |
| -2                                             | 903 | 2     | 908 |
| -1 1/2                                         | 902 | 1 1/2 | 900 |
| -1                                             | 895 | 1     | 907 |
| -1/2                                           | 900 | 1/2   | 902 |

# RUN 97

| $T_{0_s} = 77, T_{0_c} = 925, x = 0, y = -1/2$ |     |       |     |
|------------------------------------------------|-----|-------|-----|
| $z$                                            | $T$ | $z$   | $T$ |
| -8                                             | 66  | 8     | 66  |
| -7                                             | 67  | 7     | 78  |
| -6                                             | 79  | 6     | 87  |
| -5                                             | 206 | 5     | 211 |
| -4 1/2                                         | 423 | 4 1/2 | 437 |
| -4                                             | 693 | 4     | 676 |
| -3 1/2                                         | 870 | 3 1/2 | 868 |
| -3                                             | 896 | 3     | 904 |
| -2 1/2                                         | 907 | 2 1/2 | 902 |
| -2                                             | 904 | 2     | 907 |
| -1 1/2                                         | 902 | 1 1/2 | 900 |
| -1                                             | 895 | 1     | 907 |
| -1/2                                           | 900 | 1/2   | 903 |

RUN 98

$T_{0a} = 77.5, T_{0c} = 908, x = 0, y = -1/2$

| $z$    | $T$ | $z$    | $T$ |
|--------|-----|--------|-----|
| 8      | 67  | 8      | 65  |
| 7      | 67  | 7      | 71  |
| 6      | 80  | 6      | 85  |
| -5     | 207 | 5      | 211 |
| -4 1/2 | 423 | -4 1/2 | 431 |
| -4     | 688 | -4     | 666 |
| -3 1/2 | 856 | -3 1/2 | 851 |
| -3     | 880 | -3     | 887 |
| -2 1/2 | 890 | -2 1/2 | 886 |
| -2     | 887 | -2     | 889 |
| -1 1/2 | 886 | -1 1/2 | 883 |
| -1     | 878 | -1     | 889 |
| -1/2   | 886 | -1/2   | 887 |

RUN 101

$T_{0a} = 76.5, T_{0c} = 917, x = 13.9, y = -1/2$

| $z$                                               | $T$ | $z$ | $T$ |
|---------------------------------------------------|-----|-----|-----|
| Unable to obtain data due to unsteady conditions. |     |     |     |
| -1 1/2                                            | 902 |     |     |
| -1                                                | 919 |     |     |
| -1/2                                              | 934 | 1/2 | 936 |

RUN 99

$T_{0a} = 76.5, T_{0c} = 914, x = 13.9, y = -1/2$

| $z$                                               | $T$ | $z$   | $T$ |
|---------------------------------------------------|-----|-------|-----|
| Unable to obtain data due to unsteady conditions. |     |       |     |
| -2                                                | 807 | 2     | 528 |
| -1 1/2                                            | 905 | 1 1/2 | 682 |
| -1                                                | 918 | 1     | 829 |
| -1/2                                              | 937 | 1/2   | 915 |

RUN 102

$T_{0a} = 76.5, T_{0c} = 917, x = 8, y = -1/2$

| $z$    | $T$ | $z$    | $T$ |
|--------|-----|--------|-----|
| -8     | 61  | 8      | 63  |
| -7     | 59  | 7      | 55  |
| -6     | 61  | 6      | 78  |
| -5     | 171 | 5      | 167 |
| -4 1/2 | 384 | -4 1/2 | 383 |
| -4     | 626 | -4     | 594 |
| -3 1/2 | 811 | -3 1/2 | 796 |
| -3     | 870 | -3     | 879 |
| -2 1/2 | 888 | -2 1/2 | 886 |
| -2     | 893 | -2     | 898 |
| -1 1/2 | 901 | -1 1/2 | 896 |
| -1     | 895 | -1     | 907 |
| -1/2   | 902 | -1/2   | 905 |

RUN 100

$T_{0a} = 76.5, T_{0c} = 914, x = 13.9, y = -2 1/2$

| $z$                                               | $T$ | $z$   | $T$ |
|---------------------------------------------------|-----|-------|-----|
| Unable to obtain data due to unsteady conditions. |     |       |     |
| -2                                                | 888 | 2     | 909 |
| -1 1/2                                            | 901 | 1 1/2 | 909 |
| -1                                                | 917 | 1     | 924 |
| -1/2                                              | 931 | 1/2   | 937 |

RUN 103

$T_{0a} = 77.5, T_{0c} = 805, x = 0, y = -1/2$

| $z$    | $T$ | $z$    | $T$ |
|--------|-----|--------|-----|
| -8     | 62  | 8      | 62  |
| -7     | 67  | 7      | 70  |
| -6     | 72  | 6      | 74  |
| -5     | 185 | 5      | 181 |
| -4 1/2 | 394 | -4 1/2 | 386 |
| -4     | 638 | -4     | 594 |
| -3 1/2 | 764 | -3 1/2 | 758 |
| -3     | 773 | -3     | 785 |
| -2 1/2 | 783 | -2 1/2 | 783 |
| -2     | 779 | -2     | 784 |
| -1 1/2 | 779 | -1 1/2 | 782 |
| -1     | 771 | -1     | 784 |
| -1/2   | 777 | -1/2   | 786 |

RUN 104

$T_{0_s} = 77.5, T_{0_c} = 810, x = 0, y = 2 1/2$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 67  | 8     | 70  |
| 7     | 71  | 7     | 70  |
| 6     | 75  | 6     | 75  |
| 5     | 205 | 5     | 138 |
| 4 1/2 | 492 | 4 1/2 | 302 |
| 4     | 662 | 4     | 465 |
| 3 1/2 | 759 | 3 1/2 | 643 |
| 3     | 781 | 3     | 757 |
| 2 1/2 | 769 | 2 1/2 | 773 |
| 2     | 787 | 2     | 780 |
| 1 1/2 | 787 | 1 1/2 | 774 |
| 1     | 783 | 1     | 781 |
| 1/2   | 790 | 1/2   | 790 |

RUN 107

$T_{0_s} = 74, T_{0_c} = 707, x = 0, y = 1 1/2$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 57  | 8     | 57  |
| 7     | 57  | 7     | 61  |
| 6     | 50  | 6     | 67  |
| 5     | 71  | 5     | 69  |
| 4 1/2 | 67  | 4 1/2 | 67  |
| 4     | 84  | 4     | 80  |
| 3 1/2 | 166 | 3 1/2 | 151 |
| 3     | 317 | 3     | 301 |
| 2 1/2 | 498 | 2 1/2 | 472 |
| 2     | 656 | 2     | 638 |
| 1 1/2 | 764 | 1 1/2 | 744 |
| 1     | 786 | 1     | 813 |
| 1/2   | 800 | 1/2   | 780 |

RUN 105

$T_{0_s} = 77.5, T_{0_c} = 800, x = 0, y = 3 1/2$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 57  | 8     | 61  |
| 7     | 62  | 7     | 56  |
| 6     | 59  | 6     | 66  |
| 5     | 113 | 5     | 197 |
| 4 1/2 | 292 | 4 1/2 | 80  |
| 4     | 519 | 4     | 635 |
| 3 1/2 | 704 | 3 1/2 | 755 |
| 3     | 756 | 3     | 768 |
| 2 1/2 | 768 | 2 1/2 | 765 |
| 2     | 766 | 2     | 771 |
| 1 1/2 | 767 | 1 1/2 | 765 |
| 1     | 764 | 1     | 774 |
| 1/2   | 771 | 1/2   | 777 |

RUN 108

$T_{0_s} = 73, T_{0_c} = 804, x = 0, y = 1/2$

| $z$   | $T$  | $z$   | $T$  |
|-------|------|-------|------|
| 8     | 61.1 | 8     | 60   |
| 7     | 60   | 7     | 62.2 |
| 6     | 58.9 | 6     | 69   |
| 5     | 74.7 | 5     | 71.3 |
| 4 1/2 | 75.8 | 4 1/2 | 69   |
| 4     | 101  | 4     | 736  |
| 3 1/2 | 197  | 3 1/2 | 117  |
| 3     | 352  | 3     | 234  |
| 2 1/2 | 547  | 2 1/2 | 411  |
| 2     | 695  | 2     | 584  |
| 1 1/2 | 783  | 1 1/2 | 715  |
| 1     | 795  | 1     | 793  |
| 1/2   | 808  | 1/2   | 813  |

RUN 106

$T_{0_s} = 77.5, T_{0_c} = 802, x = -16, y = -1/2$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 56  | 8     | 59  |
| 7     | 61  | 7     | 65  |
| 6     | 65  | 6     | 70  |
| 5     | 98  | 5     | 101 |
| 4 1/2 | 280 | 4 1/2 | 396 |
| 4     | 603 | 4     | 608 |
| 3 1/2 | 757 | 3 1/2 | 764 |
| 3     | 763 | 3     | 772 |
| 2 1/2 | 773 | 2 1/2 | 771 |
| 2     | 774 | 2     | 781 |
| 1 1/2 | 779 | 1 1/2 | 774 |
| 1     | 773 | 1     | 787 |
| 1/2   | 782 | 1/2   | 786 |

RUN 109

$T_{0_s} = 73.5, T_{0_c} = 806, x = 0, y = 1 1/2$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 61  | 8     | 62  |
| 7     | 58  | 7     | 62  |
| 6     | 58  | 6     | 69  |
| 5     | 80  | 5     | 87  |
| 4 1/2 | 107 | 4 1/2 | 137 |
| 4     | 153 | 4     | 175 |
| 3 1/2 | 257 | 3 1/2 | 212 |
| 3     | 404 | 3     | 294 |
| 2 1/2 | 594 | 2 1/2 | 447 |
| 2     | 729 | 2     | 598 |
| 1 1/2 | 756 | 1 1/2 | 724 |
| 1     | 795 | 1     | 793 |
| 1/2   | 806 | 1/2   | 812 |

# RUN 110

$T_{0_H} = 73.5$ ,  $T_{0_C} = 808$ ,  $x = 0$ ,  $y = 2 \frac{1}{2}$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 8     | 59  | 8     | 61  |
| 7     | 57  | 7     | 66  |
| 6     | 58  | 6     | 69  |
| 5     | 171 | 5     | 153 |
| 4 1/2 | 268 | 4 1/2 | 272 |
| 4     | 356 | 4     | 350 |
| 3 1/2 | 462 | 3 1/2 | 419 |
| 3     | 586 | 3     | 500 |
| 2 1/2 | 707 | 2 1/2 | 608 |
| 2     | 756 | 2     | 348 |
| 1 1/2 | 776 | 1 1/2 | 723 |
| 1     | 770 | 1     | 731 |
| 1/2   | 771 | 1/2   | 744 |

# RUN 113

$T_{0_H} = 73.5$ ,  $T_{0_C} = 812$ ,  $x = -16$ ,  $y = 2 \frac{1}{2}$

| $z$   | $T$ | $z$   | $T$ |
|-------|-----|-------|-----|
| 3     | 664 | 3     | 611 |
| 2 1/2 | 751 | 2 1/2 | 716 |
| 2     | 735 | 2     | 714 |
| 1 1/2 | 740 | 1 1/2 | 673 |
| 1     | 741 | 1     | 676 |
| 1/2   | 746 | 1/2   | 711 |

# RUN 111

$T_{0_H} = 73.5$ ,  $T_{0_C} = 809$ ,  $x = 0$ ,  $y = 3 \frac{1}{2}$

| $z$    | $T$ | $z$   | $T$ |
|--------|-----|-------|-----|
| -8     | 58  | 8     | 59  |
| -7     | 57  | 7     | 66  |
| -6     | 58  | 6     | 64  |
| -5     | 201 | 5     | 120 |
| -4 1/2 | 340 | 4 1/2 | 214 |
| -4     | 446 | 4     | 299 |
| -3 1/2 | 508 | 3 1/2 | 371 |
| -3     | 529 | 3     | 417 |
| -2 1/2 | 519 | 2 1/2 | 401 |
| -2     | 491 | 2     | 381 |
| -1 1/2 | 507 | 1 1/2 | 364 |
| -1     | 508 | 1     | 376 |
| -1/2   | 504 | 1/2   | 430 |

# RUN 112

$T_{0_H} = 73.5$ ,  $T_{0_C} = 810$ ,  $x = -16$ ,  $y = -1/2$

| $z$    | $T$   | $z$   | $T$  |
|--------|-------|-------|------|
| -8     | 55.5  | 8     | 56.6 |
| -7     | 56.6  | 7     | 65.6 |
| -6     | 56.6  | 6     | 69   |
| -5     | 70.2  | 5     | 69   |
| -4 1/2 | 66.8  | 4 1/2 | 69   |
| -4     | 80.4  | 4     | 80.4 |
| -3 1/2 | 192.5 | 3 1/2 | 198  |
| -3     | 458   | 3     | 470  |
| -2 1/2 | 713   | 2 1/2 | 713  |
| -2     | 766   | 2     | 799  |
| -1 1/2 | 805   | 1 1/2 | 798  |
| -1     | 798   | 1     | 810  |
| -1/2   | 810   | 1/2   | 818  |

# APPENDIX F

## PRESSURE AND MACH NUMBER DATA

A complete table of pitot pressure to core stagnation pressure ratios,  $P_p/p_{0c}$ , and Mach numbers computed on the Bendix G-15 computer from pressure data taken in the calibration tests of the NSL Heated Core Installation is presented in this appendix. The Mach number was computed from the ratio  $P_p/p_{0c}$  divided by 0.98, the correction factor for this ratio which accounts for caloric imperfections at  $T_{0c} = 900^\circ\text{F}$  and  $M = 3.5$  (Reference 10). All runs were conducted with the Mach 3.5 nozzle blocks, with the exception of runs 107-113 which were conducted with the Mach 3.0 nozzle blocks.

The following summary of core stagnation pressures and ratios of cold stream stagnation pressure to core stagnation pressure,  $P_{0s}/p_{0c}$ , for each wind tunnel run is presented for use in conjunction with the table.

| Run     | $p_{0c}$ | $P_{0s}/p_{0c}$ |
|---------|----------|-----------------|
| 1-4     | 5.90     | 1.00            |
| 5-31    | 5.95     | 1.00            |
| 32-42   | 5.90     | 1.00            |
| 43-45   | 5.95     | 1.00            |
| 46-76   | 5.90     | 1.00            |
| 77      | 5.60     | 1.05            |
| 78      | 5.20     | 1.00            |
| 79      | 5.65     | 1.00            |
| 80-92   | 5.90     | 1.00            |
| 93      | 5.90     | 0.90            |
| 94      | 5.90     | 0.96            |
| 95      | 5.90     | 0.98            |
| 96      | 5.90     | 1.02            |
| 97      | 5.90     | 1.04            |
| 98      | 5.90     | 1.06            |
| 99-102  | 5.90     | 1.00            |
| 103-113 | 5.65     | 1.00            |

The following table employs the "floating decimal" system, based upon the prefix 50 representing the decimal point as it stands (i.e. a prefix 51 indicates the decimal point should be shifted one place to the right, etc.) Based upon the accuracies stated in section 7.2.2 the data should be considered valid to three significant figures only.

# PRESSURE AND MACH NUMBER DATA

| Run | x | y      | z  | P <sub>p</sub> , P <sub>0</sub> | M        | Run | x | y      | z  | P <sub>p</sub> , P <sub>0</sub> | M        |
|-----|---|--------|----|---------------------------------|----------|-----|---|--------|----|---------------------------------|----------|
| 1   | 0 | 1/2    | 8  | 50.18152                        | 51.36615 | 5   | 0 | 1/2    | 8  | 50.18453                        | 51.36424 |
|     |   |        | 7  | 50.21473                        | 51.36670 |     |   |        | 7  | 50.20810                        | 51.35032 |
|     |   |        | 6  | 50.20328                        | 51.35304 |     |   |        | 6  | 50.20441                        | 51.35239 |
|     |   |        | 5  | 50.17865                        | 51.36796 |     |   |        | 5  | 50.20157                        | 51.35401 |
|     |   |        | 4  | 50.18896                        | 51.36144 |     |   |        | 4  | 50.18709                        | 51.36262 |
|     |   |        | 3  | 50.19583                        | 51.35708 |     |   |        | 3  | 50.19646                        | 51.35698 |
|     |   |        | 2  | 50.18782                        | 51.36216 |     |   |        | 2  | 50.18823                        | 51.36190 |
|     |   |        | 1  | 50.17407                        | 51.37086 |     |   |        | 1  | 50.17375                        | 51.37107 |
|     |   |        | 0  | 50.17064                        | 51.37304 |     |   |        | 0  | 50.17091                        | 51.37287 |
|     |   |        | -1 | 50.17293                        | 51.37159 |     |   |        | -1 | 50.17261                        | 51.37179 |
|     |   |        | -2 | 50.18782                        | 51.36216 |     |   |        | -2 | 50.18794                        | 51.36208 |
|     |   |        | -3 | 50.19870                        | 51.35567 |     |   |        | -3 | 50.19873                        | 51.35565 |
|     |   |        | -4 | 50.21301                        | 51.34762 |     |   |        | -4 | 50.21179                        | 51.34829 |
|     |   |        | -5 | 50.17121                        | 51.37268 |     |   |        | -5 | 50.17034                        | 51.37323 |
|     |   |        | -6 | 50.20041                        | 51.35468 |     |   |        | -6 | 50.20157                        | 51.35401 |
|     |   |        | -7 | 50.21358                        | 51.34732 |     |   |        | -7 | 50.21009                        | 51.34923 |
|     |   |        | -8 | 50.15747                        | 51.38272 |     |   |        | -8 | 50.13627                        | 51.39964 |
| 2   | 0 | -1/2   | 8  | 49.86166                        | 51.46408 | 6   | 0 | -3 1/2 | 8  | 50.211                          | 51.349   |
|     |   |        | 7  | 50.27485                        | 51.31825 |     |   |        | 7  | 50.209                          | 51.350   |
|     |   |        | 6  | 50.27371                        | 51.31878 |     |   |        | 6  | 50.1985                         | 51.356   |
|     |   |        | 5  | 50.18953                        | 51.36107 |     |   |        | 5  | 50.174                          | 51.371   |
|     |   |        | 4  | 50.19297                        | 51.35890 |     |   |        | 4  | 50.1824                         | 51.364   |
|     |   |        | 3  | 50.19812                        | 51.35601 |     |   |        | 3  | 50.1805                         | 51.367   |
|     |   |        | 2  | 50.18839                        | 51.36180 |     |   |        | 2  | 50.1715                         | 51.373   |
|     |   |        | 1  | 50.17465                        | 51.37050 |     |   |        | 1  | 50.1685                         | 51.375   |
|     |   |        | 0  | 50.17293                        | 51.37159 |     |   |        | 0  | 50.1865                         | 51.363   |
|     |   |        | -1 | 50.17407                        | 51.37086 |     |   |        | -1 | 50.1715                         | 51.373   |
|     |   |        | -2 | 50.19068                        | 51.36033 |     |   |        | -2 | 50.1775                         | 51.369   |
|     |   |        | -3 | 50.19812                        | 51.35601 |     |   |        | -3 | 50.1875                         | 51.362   |
|     |   |        | -4 | 50.21072                        | 51.34887 |     |   |        | -4 | 50.1835                         | 51.365   |
|     |   |        | -5 | 50.17865                        | 51.36796 |     |   |        | -5 | 50.1835                         | 51.365   |
|     |   |        | -6 | 50.26054                        | 51.32441 |     |   |        | -6 | 50.205                          | 51.352   |
|     |   |        | -7 | 50.27027                        | 51.32019 |     |   |        | -7 | 50.2075                         | 51.3505  |
|     |   |        | -8 | 49.86746                        | 51.45720 |     |   |        | -8 | 50.2085                         | 51.350   |
| 3   | 0 | -1 1/2 | 8  | 49.58406                        | 51.50373 | 7   | 0 | 4 1/2  | 8  | 50.21576                        | 51.34614 |
|     |   |        | 7  | 50.25710                        | 51.32595 |     |   |        | 7  | 50.21463                        | 51.34675 |
|     |   |        | 6  | 50.31494                        | 51.30249 |     |   |        | 6  | 50.20498                        | 51.35207 |
|     |   |        | 5  | 50.21416                        | 51.34701 |     |   |        | 5  | 50.13230                        | 51.40310 |
|     |   |        | 4  | 50.19812                        | 51.35601 |     |   |        | 4  | 50.18056                        | 51.36676 |
|     |   |        | 3  | 50.19755                        | 51.35634 |     |   |        | 3  | 50.17602                        | 51.36963 |
|     |   |        | 2  | 50.18667                        | 51.36289 |     |   |        | 2  | 50.17204                        | 51.37215 |
|     |   |        | 1  | 50.17522                        | 51.37014 |     |   |        | 1  | 50.18056                        | 51.36676 |
|     |   |        | 0  | 50.17808                        | 51.36833 |     |   |        | 0  | 50.17886                        | 51.36783 |
|     |   |        | -1 | 50.17579                        | 51.36978 |     |   |        | -1 | 50.16466                        | 51.37750 |
|     |   |        | -2 | 50.18782                        | 51.36216 |     |   |        | -2 | 50.16239                        | 51.37912 |
|     |   |        | -3 | 50.20999                        | 51.35435 |     |   |        | -3 | 50.17318                        | 51.37143 |
|     |   |        | -4 | 50.20958                        | 51.34951 |     |   |        | -4 | 50.18170                        | 51.36604 |
|     |   |        | -5 | 50.21015                        | 51.34919 |     |   |        | -5 | 50.18794                        | 51.36708 |
|     |   |        | -6 | 50.30577                        | 51.30592 |     |   |        | -6 | 50.21065                        | 51.34891 |
|     |   |        | -7 | 50.25481                        | 51.32676 |     |   |        | -7 | 50.22258                        | 51.34254 |
|     |   |        | -8 | 49.52108                        | 51.51948 |     |   |        | -8 | 50.21917                        | 51.34433 |
| 4   | 0 | -2 1/2 | 8  | 49.66995                        | 51.48649 | 8   | 0 | 5 1/2  | 8  | 50.22258                        | 51.34254 |
|     |   |        | 7  | 50.27600                        | 51.31777 |     |   |        | 7  | 50.22087                        | 51.34343 |
|     |   |        | 6  | 50.31265                        | 51.30334 |     |   |        | 6  | 50.20952                        | 51.34954 |
|     |   |        | 5  | 50.21473                        | 51.34670 |     |   |        | 5  | 50.19021                        | 51.36064 |
|     |   |        | 4  | 50.19755                        | 51.35634 |     |   |        | 4  | 50.17829                        | 51.36819 |
|     |   |        | 3  | 50.19068                        | 51.36035 |     |   |        | 3  | 50.16296                        | 51.37872 |
|     |   |        | 2  | 50.18209                        | 51.36579 |     |   |        | 2  | 50.16012                        | 51.38077 |
|     |   |        | 1  | 50.17694                        | 51.36905 |     |   |        | 1  | 50.16864                        | 51.37472 |
|     |   |        | 0  | 50.19182                        | 51.35962 |     |   |        | 0  | 50.16637                        | 51.37630 |
|     |   |        | -1 | 50.17636                        | 51.36941 |     |   |        | -1 | 50.16523                        | 51.37710 |
|     |   |        | -2 | 50.18782                        | 51.36216 |     |   |        | -2 | 50.15955                        | 51.38118 |
|     |   |        | -3 | 50.19641                        | 51.35702 |     |   |        | -3 | 50.16296                        | 51.37872 |
|     |   |        | -4 | 50.19125                        | 51.35999 |     |   |        | -4 | 50.17886                        | 51.36783 |
|     |   |        | -5 | 50.22332                        | 51.34215 |     |   |        | -5 | 50.19532                        | 51.35741 |
|     |   |        | -6 | 50.30749                        | 51.30527 |     |   |        | -6 | 50.21236                        | 51.34798 |
|     |   |        | -7 | 50.26054                        | 51.32441 |     |   |        | -7 | 50.22258                        | 51.34254 |
|     |   |        | -8 | 49.56116                        | 51.50877 |     |   |        | -8 | 50.22428                        | 51.34166 |

| Run | x | y     | z  | $P_p/P_{p0}$ | M        | Run | x | y     | z  | $P_p/P_{p0}$ | M        |
|-----|---|-------|----|--------------|----------|-----|---|-------|----|--------------|----------|
| 9   | 0 | 1 1/2 | 8  | 50.19816     | 51.35598 | 13  | 0 |       | 8  | 50.21633     | 51.34584 |
|     |   |       | 7  | 50.21406     | 51.34706 |     |   |       | 7  | 50.21463     | 51.34675 |
|     |   |       | 6  | 50.20469     | 51.35223 |     |   |       | 6  | 50.20327     | 51.35304 |
|     |   |       | 5  | 50.18397     | 51.36460 |     |   |       | 5  | 50.18567     | 51.36352 |
|     |   |       | 4  | 50.18170     | 51.36604 |     |   |       | 4  | 50.17375     | 51.37107 |
|     |   |       | 3  | 50.19759     | 51.35632 |     |   |       | 3  | 50.16523     | 51.37710 |
|     |   |       | 2  | 50.18084     | 51.36658 |     |   |       | 2  | 50.15955     | 51.38118 |
|     |   |       | 1  | 50.17431     | 51.37071 |     |   |       | 1  | 50.16466     | 51.37750 |
|     |   |       | 0  | 50.17829     | 51.36819 |     |   |       | 0  | 50.16409     | 51.37791 |
|     |   |       | -1 | 50.17431     | 51.37071 |     |   |       | -1 | 50.16637     | 51.37630 |
|     |   |       | -2 | 50.18567     | 51.36352 |     |   |       | -2 | 50.15671     | 51.38328 |
|     |   |       | -3 | 50.19759     | 51.35632 |     |   |       | -3 | 50.16353     | 51.37831 |
|     |   |       | -4 | 50.21207     | 51.34813 |     |   |       | -4 | 50.17772     | 51.36855 |
|     |   |       | -5 | 50.17545     | 51.36999 |     |   |       | -5 | 50.18453     | 51.36424 |
|     |   |       | -6 | 50.19986     | 51.35499 |     |   |       | -6 | 50.20214     | 51.35368 |
|     |   |       | -7 | 50.21349     | 51.34776 |     |   |       | -7 | 50.21917     | 51.34433 |
|     |   |       | -8 | 50.18964     | 51.36100 |     |   |       | -8 | 50.21917     | 51.34433 |
| 10  | 0 | 2 1/2 | 8  | 50.21179     | 51.34829 | 14  | 0 | 5 1/2 | 8  | 50.22087     | 51.34343 |
|     |   |       | 7  | 50.21463     | 51.34675 |     |   |       | 7  | 50.21974     | 51.34403 |
|     |   |       | 6  | 50.20498     | 51.35207 |     |   |       | 6  | 50.20498     | 51.35207 |
|     |   |       | 5  | 50.18425     | 51.36442 |     |   |       | 5  | 50.19532     | 51.35741 |
|     |   |       | 4  | 50.18397     | 51.36460 |     |   |       | 4  | 50.17999     | 51.36712 |
|     |   |       | 3  | 50.19305     | 51.35885 |     |   |       | 3  | 50.18056     | 51.36676 |
|     |   |       | 2  | 50.18737     | 51.36244 |     |   |       | 2  | 50.17204     | 51.37215 |
|     |   |       | 1  | 50.17375     | 51.37107 |     |   |       | 1  | 50.17375     | 51.37107 |
|     |   |       | 0  | 50.19021     | 51.36064 |     |   |       | 0  | 50.17034     | 51.37323 |
|     |   |       | -1 | 50.17545     | 51.36999 |     |   |       | -1 | 50.17204     | 51.37215 |
|     |   |       | -2 | 50.18453     | 51.36424 |     |   |       | -2 | 50.16069     | 51.38036 |
|     |   |       | -3 | 50.19305     | 51.35885 |     |   |       | -3 | 50.16523     | 51.37710 |
|     |   |       | -4 | 50.19674     | 51.35682 |     |   |       | -4 | 50.17659     | 51.36927 |
|     |   |       | -5 | 50.19021     | 51.36064 |     |   |       | -5 | 50.19248     | 51.35920 |
|     |   |       | -6 | 50.19561     | 51.35723 |     |   |       | -6 | 50.20668     | 51.35112 |
|     |   |       | -7 | 50.21463     | 51.34675 |     |   |       | -7 | 50.22258     | 51.34254 |
|     |   |       | -8 | 50.20923     | 51.34969 |     |   |       | -8 | 50.22428     | 51.34166 |
| 11  | 0 | 3 1/2 | 8  | 50.26800     | 51.32116 | 15  | 0 | 6     | 8  | 50.22201     | 51.34283 |
|     |   |       | 7  | 50.21179     | 51.34829 |     |   |       | 7  | 50.224       | 51.342   |
|     |   |       | 6  | 50.20412     | 51.35256 |     |   |       | 6  | 50.21        | 51.349   |
|     |   |       | 5  | 50.19362     | 51.35843 |     |   |       | 5  | 50.201       | 51.354   |
|     |   |       | 4  | 50.17318     | 51.37143 |     |   |       | 4  | 50.188       | 51.362   |
|     |   |       | 3  | 50.18964     | 51.36100 |     |   |       | 3  | 50.188       | 51.362   |
|     |   |       | 2  | 50.18198     | 51.36586 |     |   |       | 2  | 50.1815      | 51.366   |
|     |   |       | 1  | 50.17744     | 51.36873 |     |   |       | 1  | 50.187       | 51.363   |
|     |   |       | 0  | 50.19419     | 51.35813 |     |   |       | 0  | 50.1815      | 51.366   |
|     |   |       | -1 | 50.18113     | 51.36640 |     |   |       | -1 | 50.181       | 51.366   |
|     |   |       | -2 | 50.18397     | 51.36460 |     |   |       | -2 | 50.1685      | 51.375   |
|     |   |       | -3 | 50.19362     | 51.35849 |     |   |       | -3 | 50.173       | 51.372   |
|     |   |       | -4 | 50.17602     | 51.36963 |     |   |       | -4 | 50.1775      | 51.369   |
|     |   |       | -5 | 50.19447     | 51.35795 |     |   |       | -5 | 50.1925      | 51.359   |
|     |   |       | -6 | 50.20384     | 51.35272 |     |   |       | -6 | 50.211       | 51.349   |
|     |   |       | -7 | 50.20753     | 51.35064 |     |   |       | -7 | 50.224       | 51.341   |
|     |   |       | -8 | 50.21122     | 51.34860 |     |   |       | -8 | 50.226       | 51.341   |
| 12  | 0 | 4 1/2 | 8  | 50.21747     | 51.34523 | 16  | 0 | 1 1/2 | 8  | 50.18453     | 51.36424 |
|     |   |       | 7  | 50.21236     | 51.34798 |     |   |       | 7  | 50.20838     | 51.35017 |
|     |   |       | 6  | 50.20668     | 51.35112 |     |   |       | 6  | 50.20534     | 51.35175 |
|     |   |       | 5  | 50.18737     | 51.36264 |     |   |       | 5  | 50.18113     | 51.36640 |
|     |   |       | 4  | 50.17829     | 51.36819 |     |   |       | 4  | 50.18908     | 51.36136 |
|     |   |       | 3  | 50.16466     | 51.37750 |     |   |       | 3  | 50.19816     | 51.35598 |
|     |   |       | 2  | 50.16012     | 51.38077 |     |   |       | 2  | 50.19021     | 51.36064 |
|     |   |       | 1  | 50.17148     | 51.37251 |     |   |       | 1  | 50.17545     | 51.36999 |
|     |   |       | 0  | 50.17659     | 51.36927 |     |   |       | 0  | 50.17261     | 51.37179 |
|     |   |       | -1 | 50.17545     | 51.36999 |     |   |       | -1 | 50.17431     | 51.37071 |
|     |   |       | -2 | 50.16750     | 51.37551 |     |   |       | -2 | 50.19021     | 51.36064 |
|     |   |       | -3 | 50.17602     | 51.36963 |     |   |       | -3 | 50.20043     | 51.35467 |
|     |   |       | -4 | 50.18113     | 51.36640 |     |   |       | -4 | 50.21406     | 51.34706 |
|     |   |       | -5 | 50.16340     | 51.36500 |     |   |       | -5 | 50.172       | 51.372   |
|     |   |       | -6 | 50.21009     | 51.34923 |     |   |       | -6 | 50.2025      | 51.353   |
|     |   |       | -7 | 50.218       | 51.345   |     |   |       | -7 | 50.2105      | 51.349   |
|     |   |       | -8 | 50.1933      | 51.343   |     |   |       | -8 | 50.2105      | 51.349   |

| Run | x | y      | z  | P <sub>p</sub> | P <sub>o</sub> | M | Run | x | y      | z  | P <sub>p</sub> | P <sub>o</sub> | M |
|-----|---|--------|----|----------------|----------------|---|-----|---|--------|----|----------------|----------------|---|
| 17  | 0 | 1/2    | 8  | 50.19419       | 51.35813       |   | 21  | 0 | 1/2    | 8  | 50.21236       | 51.34798       |   |
|     |   |        | 7  | 50.20668       | 51.35112       |   |     |   |        | 7  | 50.21065       | 51.34891       |   |
|     |   |        | 6  | 50.19930       | 51.35532       |   |     |   |        | 6  | 50.20100       | 51.35434       |   |
|     |   |        | 5  | 50.17772       | 51.36855       |   |     |   |        | 5  | 50.17602       | 51.36963       |   |
|     |   |        | 4  | 50.19192       | 51.35956       |   |     |   |        | 4  | 50.18397       | 51.36460       |   |
|     |   |        | 3  | 50.19816       | 51.35598       |   |     |   |        | 3  | 50.18170       | 51.36606       |   |
|     |   |        | 2  | 50.18908       | 51.36136       |   |     |   |        | 2  | 50.17318       | 51.37143       |   |
|     |   |        | 1  | 50.17431       | 51.37071       |   |     |   |        | 1  | 50.17034       | 51.37323       |   |
|     |   |        | 0  | 50.17261       | 51.37179       |   |     |   |        | 0  | 50.18681       | 51.36280       |   |
|     |   |        | -1 | 50.17375       | 51.37107       |   |     |   |        | 1  | 50.17318       | 51.37143       |   |
|     |   |        | -2 | 50.19078       | 51.36028       |   |     |   |        | -2 | 50.17886       | 51.36783       |   |
|     |   |        | -3 | 50.19930       | 51.35532       |   |     |   |        | -3 | 50.18908       | 51.36136       |   |
|     |   |        | -4 | 50.21122       | 51.34860       |   |     |   |        | -4 | 50.18567       | 51.36352       |   |
|     |   |        | -5 | 50.17148       | 51.37251       |   |     |   |        | -5 | 50.18397       | 51.36460       |   |
|     |   |        | -6 | 50.20214       | 51.35368       |   |     |   |        | -6 | 50.20725       | 51.35080       |   |
|     |   |        | -7 | 50.21292       | 51.34767       |   |     |   |        | -7 | 50.20895       | 51.34985       |   |
|     |   |        | -8 | 50.17602       | 51.36963       |   |     |   |        | -8 | 50.21009       | 51.34921       |   |
| 18  | 0 | -1 1/2 | 6  | 50.207         | 51.351         |   | 22  | 0 | -4 1/2 | 8  | 50.21747       | 51.34523       |   |
|     |   |        | 7  | 50.209         | 51.35          |   |     |   |        | 7  | 50.21520       | 51.34645       |   |
|     |   |        | 6  | 50.201         | 51.354         |   |     |   |        | 6  | 50.20611       | 51.35143       |   |
|     |   |        | 5  | 50.1765        | 51.369         |   |     |   |        | 5  | 50.18510       | 51.36388       |   |
|     |   |        | 4  | 50.19362       | 51.35849       |   |     |   |        | 4  | 50.18226       | 51.36568       |   |
|     |   |        | 3  | 50.19703       | 51.35665       |   |     |   |        | 3  | 50.17659       | 51.36927       |   |
|     |   |        | 2  | 50.18624       | 51.36316       |   |     |   |        | 2  | 50.17261       | 51.37179       |   |
|     |   |        | 1  | 50.17431       | 51.37071       |   |     |   |        | 1  | 50.18056       | 51.36676       |   |
|     |   |        | 0  | 50.17659       | 51.36927       |   |     |   |        | 0  | 50.17886       | 51.36783       |   |
|     |   |        | -1 | 50.17545       | 51.36999       |   |     |   |        | -1 | 50.16580       | 51.37670       |   |
|     |   |        | -2 | 50.18737       | 51.36244       |   |     |   |        | -2 | 50.16353       | 51.37831       |   |
|     |   |        | -3 | 50.20          | 51.355         |   |     |   |        | -3 | 50.17375       | 51.37107       |   |
|     |   |        | -4 | 50.207         | 51.351         |   |     |   |        | -4 | 50.18283       | 51.36532       |   |
|     |   |        | -5 | 50.177         | 51.360         |   |     |   |        | -5 | 50.18908       | 51.36136       |   |
|     |   |        | -6 | 50.190         | 51.356         |   |     |   |        | -6 | 50.212         | 51.348         |   |
|     |   |        | -7 | 50.21          | 51.349         |   |     |   |        | -7 | 50.2235        | 51.342         |   |
|     |   |        | -8 | 50.193         | 51.359         |   |     |   |        | -8 | 50.22          | 51.344         |   |
| 19  | 0 | -2 1/2 | 8  | 50.20952       | 51.34954       |   | 23  | 0 | -5 1/2 | 8  | 50.22428       | 51.34166       |   |
|     |   |        | 7  | 50.21179       | 51.34829       |   |     |   |        | 7  | 50.22258       | 51.34254       |   |
|     |   |        | 6  | 50.20157       | 51.35401       |   |     |   |        | 6  | 50.21179       | 51.34829       |   |
|     |   |        | 5  | 50.17715       | 51.36891       |   |     |   |        | 5  | 50.19192       | 51.35956       |   |
|     |   |        | 4  | 50.19535       | 51.35885       |   |     |   |        | 4  | 50.17942       | 51.36747       |   |
|     |   |        | 3  | 50.19078       | 51.36028       |   |     |   |        | 3  | 50.16409       | 51.37791       |   |
|     |   |        | 2  | 50.18170       | 51.36604       |   |     |   |        | 2  | 50.16182       | 51.37953       |   |
|     |   |        | 1  | 50.17715       | 51.36891       |   |     |   |        | 1  | 50.16977       | 51.37394       |   |
|     |   |        | 0  | 50.18964       | 51.36100       |   |     |   |        | 0  | 50.16864       | 51.37472       |   |
|     |   |        | -1 | 50.17602       | 51.36963       |   |     |   |        | -1 | 50.16750       | 51.37551       |   |
|     |   |        | -2 | 50.18737       | 51.36244       |   |     |   |        | -2 | 50.16182       | 51.37953       |   |
|     |   |        | -3 | 50.19703       | 51.35665       |   |     |   |        | -3 | 50.16637       | 51.37630       |   |
|     |   |        | -4 | 50.18908       | 51.36136       |   |     |   |        | -4 | 50.18113       | 51.36640       |   |
|     |   |        | -5 | 50.19248       | 51.35920       |   |     |   |        | -5 | 50.19759       | 51.35632       |   |
|     |   |        | -6 | 50.19135       | 51.35992       |   |     |   |        | -6 | 50.21406       | 51.34706       |   |
|     |   |        | -7 | 50.21179       | 51.34829       |   |     |   |        | -7 | 50.22428       | 51.34166       |   |
|     |   |        | -8 | 50.20554       | 51.35175       |   |     |   |        | -8 | 50.22598       | 51.34078       |   |
| 20  | 0 | -3     | 8  | 50.21065       | 51.34891       |   | 24  | 0 | 5      | 8  | 50.21917       | 51.34433       |   |
|     |   |        | 7  | 50.21020       | 51.34916       |   |     |   |        | 7  | 50.21633       | 51.34584       |   |
|     |   |        | 6  | 50.20100       | 51.35434       |   |     |   |        | 6  | 50.2106        | 51.352         |   |
|     |   |        | 5  | 50.17488       | 51.37035       |   |     |   |        | 5  | 50.1885        | 51.362         |   |
|     |   |        | 4  | 50.18851       | 51.36172       |   |     |   |        | 4  | 50.1865        | 51.369         |   |
|     |   |        | 3  | 50.18567       | 51.36352       |   |     |   |        | 3  | 50.167         | 51.376         |   |
|     |   |        | 2  | 50.17886       | 51.36783       |   |     |   |        | 2  | 50.162         | 51.38          |   |
|     |   |        | 1  | 50.17488       | 51.37035       |   |     |   |        | 1  | 50.1675        | 51.375         |   |
|     |   |        | 0  | 50.19021       | 51.36064       |   |     |   |        | 0  | 50.167         | 51.376         |   |
|     |   |        | -1 | 50.17488       | 51.37035       |   |     |   |        | 1  | 50.1675        | 51.375         |   |
|     |   |        | -2 | 50.18397       | 51.36460       |   |     |   |        | 2  | 50.16          | 51.381         |   |
|     |   |        | -3 | 50.19248       | 51.35920       |   |     |   |        | 3  | 50.165         | 51.376         |   |
|     |   |        | -4 | 50.18453       | 51.36424       |   |     |   |        | 4  | 50.1865        | 51.367         |   |
|     |   |        | -5 | 50.20100       | 51.35434       |   |     |   |        | 5  | 50.187         | 51.363         |   |
|     |   |        | -6 | 50.19703       | 51.35665       |   |     |   |        | 6  | 50.205         | 51.352         |   |
|     |   |        | -7 | 50.21009       | 51.34923       |   |     |   |        | 7  | 50.222         | 51.343         |   |
|     |   |        | -8 | 50.20838       | 51.35017       |   |     |   |        | 8  | 50.222         | 51.343         |   |

| Run | x | y      | z  | $\rho_p / \rho_0$ | M        | Run | x  | y      | z  | $\rho_p / \rho_0$ | M        |
|-----|---|--------|----|-------------------|----------|-----|----|--------|----|-------------------|----------|
| 25  | 0 | 1/2    | 8  | 50.18453          | 51.36524 | 29  | 0  | 1 1/2  | 8  | 50.21065          | 51.34891 |
|     |   |        | 7  | 50.20781          | 51.35048 |     |    |        | 7  | 50.20895          | 51.34985 |
|     |   |        | 6  | 50.20611          | 51.35143 |     |    |        | 6  | 50.19872          | 51.35565 |
|     |   |        | 5  | 50.18113          | 51.36640 |     |    |        | 5  | 50.17488          | 51.37035 |
|     |   |        | 4  | 50.19021          | 51.36064 |     |    |        | 4  | 50.18170          | 51.36604 |
|     |   |        | 3  | 50.19930          | 51.35532 |     |    |        | 3  | 50.18113          | 51.36640 |
|     |   |        | 2  | 50.22031          | 51.34373 |     |    |        | 2  | 50.17204          | 51.37215 |
|     |   |        | 1  | 50.17659          | 51.36927 |     |    |        | 1  | 50.16920          | 51.37433 |
|     |   |        | 0  | 50.17375          | 51.37107 |     |    |        | 0  | 50.18453          | 51.36424 |
|     |   |        | -1 | 50.17602          | 51.36963 |     |    |        | -1 | 50.17091          | 51.37287 |
|     |   |        | -2 | 50.19192          | 51.35956 |     |    |        | -2 | 50.17772          | 51.36855 |
|     |   |        | -3 | 50.20157          | 51.35401 |     |    |        | -3 | 50.18737          | 51.36244 |
|     |   |        | -4 | 50.21576          | 51.34614 |     |    |        | -4 | 50.18397          | 51.36460 |
|     |   |        | -5 | 50.17261          | 51.37179 |     |    |        | -5 | 50.18170          | 51.36604 |
|     |   |        | -6 | 50.20327          | 51.35304 |     |    |        | -6 | 50.20611          | 51.35143 |
|     |   |        | -7 | 50.21065          | 51.34891 |     |    |        | -7 | 50.20725          | 51.35080 |
|     |   |        | -8 | 50.14025          | 51.39628 |     |    |        | -8 | 50.20895          | 51.34985 |
| 26  | 0 | -1/2   | 8  | 50.19986          | 51.35499 | 30  | 0  | -4 1/2 | 8  | 50.21747          | 51.34523 |
|     |   |        | 7  | 50.21292          | 51.34767 |     |    |        | 7  | 50.21576          | 51.34614 |
|     |   |        | 6  | 50.20554          | 51.35175 |     |    |        | 6  | 50.20668          | 51.35112 |
|     |   |        | 5  | 50.18453          | 51.36424 |     |    |        | 5  | 50.18510          | 51.36388 |
|     |   |        | 4  | 50.19873          | 51.35565 |     |    |        | 4  | 50.18113          | 51.36640 |
|     |   |        | 3  | 50.20554          | 51.35175 |     |    |        | 3  | 50.17602          | 51.36963 |
|     |   |        | 2  | 50.19646          | 51.35698 |     |    |        | 2  | 50.17204          | 51.37215 |
|     |   |        | 1  | 50.18170          | 51.36604 |     |    |        | 1  | 50.18056          | 51.36676 |
|     |   |        | 0  | 50.17999          | 51.36712 |     |    |        | 0  | 50.17942          | 51.36747 |
|     |   |        | -1 | 50.18113          | 51.36640 |     |    |        | -1 | 50.16750          | 51.37551 |
|     |   |        | -2 | 50.19192          | 51.35956 |     |    |        | -2 | 50.16796          | 51.37872 |
|     |   |        | -3 | 50.19930          | 51.35532 |     |    |        | -3 | 50.17261          | 51.37179 |
|     |   |        | -4 | 50.21236          | 51.34798 |     |    |        | -4 | 50.18283          | 51.36532 |
|     |   |        | -5 | 50.17204          | 51.37215 |     |    |        | -5 | 50.18794          | 51.36208 |
|     |   |        | -6 | 50.20214          | 51.35368 |     |    |        | -6 | 50.23166          | 51.33790 |
|     |   |        | -7 | 50.21236          | 51.34798 |     |    |        | -7 | 50.22371          | 51.34195 |
|     |   |        | -8 | 50.17659          | 51.36927 |     |    |        | -8 | 50.22087          | 51.34343 |
| 27  | 0 | -1 1/2 | 8  | 50.20668          | 51.35112 | 31  | 0  | -5 1/2 | 8  | 50.22371          | 51.34195 |
|     |   |        | 7  | 50.20838          | 51.35017 |     |    |        | 7  | 50.22258          | 51.34254 |
|     |   |        | 6  | 50.20100          | 51.35434 |     |    |        | 6  | 50.21122          | 51.34860 |
|     |   |        | 5  | 50.17829          | 51.36819 |     |    |        | 5  | 50.19135          | 51.35992 |
|     |   |        | 4  | 50.19362          | 51.35849 |     |    |        | 4  | 50.17886          | 51.36783 |
|     |   |        | 3  | 50.19816          | 51.35598 |     |    |        | 3  | 50.16409          | 51.37791 |
|     |   |        | 2  | 50.18794          | 51.36208 |     |    |        | 2  | 50.16182          | 51.37953 |
|     |   |        | 1  | 50.17545          | 51.36999 |     |    |        | 1  | 50.17091          | 51.37287 |
|     |   |        | 0  | 50.17829          | 51.36819 |     |    |        | 0  | 50.16920          | 51.37433 |
|     |   |        | -1 | 50.17659          | 51.36927 |     |    |        | -1 | 50.16750          | 51.37551 |
|     |   |        | -2 | 50.18794          | 51.36208 |     |    |        | -2 | 50.16182          | 51.37953 |
|     |   |        | -3 | 50.20100          | 51.35434 |     |    |        | -3 | 50.16523          | 51.37710 |
|     |   |        | -4 | 50.20838          | 51.35017 |     |    |        | -4 | 50.18113          | 51.36640 |
|     |   |        | -5 | 50.17829          | 51.36819 |     |    |        | -5 | 50.19703          | 51.35665 |
|     |   |        | -6 | 50.19986          | 51.35499 |     |    |        | -6 | 50.21292          | 51.34767 |
|     |   |        | -7 | 50.21122          | 51.34860 |     |    |        | -7 | 50.22371          | 51.34195 |
|     |   |        | -8 | 50.17476          | 51.35777 |     |    |        | -8 | 50.22542          | 51.34107 |
| 28  | 0 | -2 1/2 | 8  | 50.20952          | 51.34954 | 33  | -2 | 1/2    | 8  | 50.19240          | 51.35926 |
|     |   |        | 7  | 50.21179          | 51.34829 |     |    |        | 7  | 50.20041          | 51.35468 |
|     |   |        | 6  | 50.20157          | 51.35401 |     |    |        | 6  | 50.19812          | 51.35601 |
|     |   |        | 5  | 50.17886          | 51.36783 |     |    |        | 5  | 50.17980          | 51.36724 |
|     |   |        | 4  | 50.19192          | 51.35956 |     |    |        | 4  | 50.18896          | 51.36144 |
|     |   |        | 3  | 50.19192          | 51.35956 |     |    |        | 3  | 50.19812          | 51.35601 |
|     |   |        | 2  | 50.18283          | 51.36532 |     |    |        | 2  | 50.18782          | 51.36216 |
|     |   |        | 1  | 50.17715          | 51.36891 |     |    |        | 1  | 50.17350          | 51.37123 |
|     |   |        | 0  | 50.19078          | 51.36028 |     |    |        | 0  | 50.15919          | 51.38145 |
|     |   |        | -1 | 50.17715          | 51.36891 |     |    |        | -1 | 50.17121          | 51.37268 |
|     |   |        | -2 | 50.18851          | 51.36172 |     |    |        | -2 | 50.18553          | 51.36361 |
|     |   |        | -3 | 50.19759          | 51.35632 |     |    |        | -3 | 50.20041          | 51.35468 |
|     |   |        | -4 | 50.19021          | 51.36064 |     |    |        | -4 | 50.19641          | 51.35702 |
|     |   |        | -5 | 50.19192          | 51.35956 |     |    |        | -5 | 50.18553          | 51.36361 |
|     |   |        | -6 | 50.19078          | 51.36028 |     |    |        | -6 | 50.19126          | 51.35745 |
|     |   |        | -7 | 50.21122          | 51.34860 |     |    |        | -7 | 50.20213          | 51.35369 |
|     |   |        | -8 | 50.20554          | 51.35175 |     |    |        | -8 | 50.13972          | 51.39672 |

| Run | x  | y     | z  | $P_p - P_{p_0}$ | M        | Run | x  | y     | z  | $P_p - P_{p_0}$ | M        |
|-----|----|-------|----|-----------------|----------|-----|----|-------|----|-----------------|----------|
| 34  | -2 | 1/2   | 8  | 50.21015        | 51.34919 | 38  | 2  | 4 1/2 | 8  | 50.21759        | 51.34516 |
|     |    |       | 7  | 50.20499        | 51.35206 |     |    |       | 7  | 50.20557        | 51.35174 |
|     |    |       | 6  | 50.20385        | 51.35271 |     |    |       | 6  | 50.20041        | 51.35468 |
|     |    |       | 5  | 50.18724        | 51.36252 |     |    |       | 5  | 50.18667        | 51.36289 |
|     |    |       | 4  | 50.18667        | 51.36289 |     |    |       | 4  | 50.17923        | 51.36760 |
|     |    |       | 3  | 50.19870        | 51.35567 |     |    |       | 3  | 50.16606        | 51.37652 |
|     |    |       | 2  | 50.19182        | 51.35962 |     |    |       | 2  | 50.16205        | 51.37937 |
|     |    |       | 1  | 50.18157        | 51.36611 |     |    |       | 1  | 50.16205        | 51.37937 |
|     |    |       | 0  | 50.16377        | 51.37814 |     |    |       | 0  | 50.17536        | 51.36941 |
|     |    |       | -1 | 50.18095        | 51.36651 |     |    |       | -1 | 50.16663        | 51.37612 |
|     |    |       | -2 | 50.18953        | 51.36107 |     |    |       | -2 | 50.17637        | 51.37374 |
|     |    |       | -3 | 50.20213        | 51.35369 |     |    |       | -3 | 50.17577        | 51.36978 |
|     |    |       | -4 | 50.20041        | 51.35468 |     |    |       | -4 | 50.18724        | 51.36500 |
|     |    |       | -5 | 50.19411        | 51.35817 |     |    |       | -5 | 50.18438        | 51.36434 |
|     |    |       | -6 | 50.25825        | 51.32543 |     |    |       | -6 | 50.20385        | 51.35271 |
|     |    |       | -7 | 50.20671        | 51.35110 |     |    |       | -7 | 50.21587        | 51.34608 |
|     |    |       | -8 | 50.20671        | 51.35110 |     |    |       | -8 | 50.22103        | 51.34335 |
| 35  | -2 | 2 1/2 | 8  | 50.21702        | 51.34547 | 39  | -2 | 5     | 8  | 50.21645        | 51.34577 |
|     |    |       | 7  | 50.20786        | 51.35046 |     |    |       | 7  | 50.21015        | 51.34919 |
|     |    |       | 6  | 50.20499        | 51.35206 |     |    |       | 6  | 50.20270        | 51.35336 |
|     |    |       | 5  | 50.18610        | 51.36325 |     |    |       | 5  | 50.18667        | 51.36289 |
|     |    |       | 4  | 50.18724        | 51.36252 |     |    |       | 4  | 50.17636        | 51.36941 |
|     |    |       | 3  | 50.17007        | 51.37374 |     |    |       | 3  | 50.16606        | 51.37652 |
|     |    |       | 2  | 50.18953        | 51.36107 |     |    |       | 2  | 50.16319        | 51.37855 |
|     |    |       | 1  | 50.18381        | 51.36500 |     |    |       | 1  | 50.16090        | 51.38020 |
|     |    |       | 0  | 50.17178        | 51.37231 |     |    |       | 0  | 50.17350        | 51.37123 |
|     |    |       | -1 | 50.18495        | 51.36397 |     |    |       | -1 | 50.16377        | 51.37814 |
|     |    |       | -2 | 50.18782        | 51.36216 |     |    |       | -2 | 50.16720        | 51.37572 |
|     |    |       | -3 | 50.19984        | 51.35501 |     |    |       | -3 | 50.17121        | 51.37268 |
|     |    |       | -4 | 50.19984        | 51.35501 |     |    |       | -4 | 50.18209        | 51.36579 |
|     |    |       | -5 | 50.19125        | 51.35999 |     |    |       | -5 | 50.18381        | 51.36500 |
|     |    |       | -6 | 50.20270        | 51.35336 |     |    |       | -6 | 50.20499        | 51.35206 |
|     |    |       | -7 | 50.20385        | 51.35271 |     |    |       | -7 | 50.21301        | 51.34762 |
|     |    |       | -8 | 50.21129        | 51.34856 |     |    |       | -8 | 50.21988        | 51.34395 |
| 36  | -2 | 3 1/2 | 8  | 50.21645        | 51.34577 | 40  | -2 | 4 3/4 | 8  | 50.21931        | 51.34425 |
|     |    |       | 7  | 50.20614        | 51.35142 |     |    |       | 7  | 50.20958        | 51.34951 |
|     |    |       | 6  | 50.20156        | 51.35402 |     |    |       | 6  | 50.20499        | 51.35206 |
|     |    |       | 5  | 50.19068        | 51.36335 |     |    |       | 5  | 50.18839        | 51.36180 |
|     |    |       | 4  | 50.16606        | 51.37652 |     |    |       | 4  | 50.17694        | 51.36905 |
|     |    |       | 3  | 50.18896        | 51.36144 |     |    |       | 3  | 50.17121        | 51.37268 |
|     |    |       | 2  | 50.17980        | 51.36724 |     |    |       | 2  | 50.16720        | 51.37572 |
|     |    |       | 1  | 50.17923        | 51.36760 |     |    |       | 1  | 50.16319        | 51.37855 |
|     |    |       | 0  | 50.18953        | 51.36107 |     |    |       | 0  | 50.17350        | 51.37123 |
|     |    |       | -1 | 50.18324        | 51.36500 |     |    |       | -1 | 50.16319        | 51.37855 |
|     |    |       | -2 | 50.18667        | 51.36289 |     |    |       | -2 | 50.16663        | 51.37612 |
|     |    |       | -3 | 50.19297        | 51.35890 |     |    |       | -3 | 50.17007        | 51.37074 |
|     |    |       | -4 | 50.17407        | 51.37086 |     |    |       | -4 | 50.18037        | 51.36687 |
|     |    |       | -5 | 50.18209        | 51.36579 |     |    |       | -5 | 50.18610        | 51.36325 |
|     |    |       | -6 | 50.22446        | 51.34156 |     |    |       | -6 | 50.20900        | 51.34982 |
|     |    |       | -7 | 50.20843        | 51.35014 |     |    |       | -7 | 50.21187        | 51.34825 |
|     |    |       | -8 | 50.21301        | 51.34762 |     |    |       | -8 | 50.22275        | 51.34245 |
| 37  | -2 | 4     | 8  | 50.21587        | 51.34608 | 41  | -2 | 5 1/2 | 8  | 50.22275        | 51.34245 |
|     |    |       | 7  | 50.20728        | 51.35078 |     |    |       | 7  | 50.21244        | 51.34794 |
|     |    |       | 6  | 50.20270        | 51.35336 |     |    |       | 6  | 50.21187        | 51.34825 |
|     |    |       | 5  | 50.18896        | 51.36144 |     |    |       | 5  | 50.19526        | 51.35745 |
|     |    |       | 4  | 50.17636        | 51.36941 |     |    |       | 4  | 50.18095        | 51.36651 |
|     |    |       | 3  | 50.17350        | 51.37123 |     |    |       | 3  | 50.18553        | 51.36361 |
|     |    |       | 2  | 50.15976        | 51.38103 |     |    |       | 2  | 50.17808        | 51.36833 |
|     |    |       | 1  | 50.16033        | 51.38061 |     |    |       | 1  | 50.17064        | 51.37304 |
|     |    |       | 0  | 50.17980        | 51.36724 |     |    |       | 0  | 50.17694        | 51.36905 |
|     |    |       | -1 | 50.17007        | 51.37374 |     |    |       | -1 | 50.16606        | 51.37652 |
|     |    |       | -2 | 50.17522        | 51.37014 |     |    |       | -2 | 50.16777        | 51.37532 |
|     |    |       | -3 | 50.18381        | 51.36500 |     |    |       | -3 | 50.17064        | 51.37304 |
|     |    |       | -4 | 50.17751        | 51.36869 |     |    |       | -4 | 50.17808        | 51.36833 |
|     |    |       | -5 | 50.18553        | 51.36361 |     |    |       | -5 | 50.19125        | 51.35999 |
|     |    |       | -6 | 50.20213        | 51.35369 |     |    |       | -6 | 50.21187        | 51.34825 |
|     |    |       | -7 | 50.22046        | 51.34365 |     |    |       | -7 | 50.21702        | 51.34547 |
|     |    |       | -8 | 50.22103        | 51.34335 |     |    |       | -8 | 50.22504        | 51.34127 |

| Run | x  | y      | z  | $P_p/P_{0c}$ | M        | Run | x  | y      | z  | $P_p/P_{0c}$ | M        |
|-----|----|--------|----|--------------|----------|-----|----|--------|----|--------------|----------|
| 42  | -2 | 6      | 8  | 50.22618     | 51.34068 | 46  | 2  | -3 1/2 | 8  | 50.21587     | 51.34608 |
|     |    |        | 7  | 50.21759     | 51.34516 |     |    |        | 7  | 50.20786     | 51.35046 |
|     |    |        | 6  | 50.21015     | 51.34919 |     |    |        | 6  | 50.20385     | 51.35271 |
|     |    |        | 5  | 50.20328     | 51.35304 |     |    |        | 5  | 50.17636     | 51.36941 |
|     |    |        | 4  | 50.19240     | 51.35926 |     |    |        | 4  | 50.18553     | 51.36361 |
|     |    |        | 3  | 50.19469     | 51.35781 |     |    |        | 3  | 50.18381     | 51.36500 |
|     |    |        | 2  | 50.19011     | 51.36071 |     |    |        | 2  | 50.17751     | 51.36869 |
|     |    |        | 1  | 50.18610     | 51.36325 |     |    |        | 1  | 50.17121     | 51.37268 |
|     |    |        | 0  | 50.19125     | 51.35999 |     |    |        | 0  | 50.16548     | 51.37692 |
|     |    |        | -1 | 50.17751     | 51.36869 |     |    |        | -1 | 50.17064     | 51.37304 |
|     |    |        | -2 | 50.17923     | 51.36760 |     |    |        | -2 | 50.17751     | 51.36869 |
|     |    |        | -3 | 50.18266     | 51.36542 |     |    |        | -3 | 50.18782     | 51.36216 |
|     |    |        | -4 | 50.18209     | 51.36579 |     |    |        | -4 | 50.18381     | 51.36500 |
|     |    |        | -5 | 50.19927     | 51.35534 |     |    |        | -5 | 50.18209     | 51.36579 |
|     |    |        | -6 | 50.21072     | 51.34887 |     |    |        | -6 | 50.20614     | 51.35142 |
|     |    |        | -7 | 50.21988     | 51.34395 |     |    |        | -7 | 50.21358     | 51.34732 |
|     |    |        | -8 | 50.22847     | 51.33951 |     |    |        | -8 | 50.21473     | 51.34670 |
| 43  | -2 | -1/2   | 8  | 50.20441     | 51.35239 | 47  | -2 | -2 3/4 | 8  | 50.21187     | 51.34825 |
|     |    |        | 7  | 50.20100     | 51.35434 |     |    |        | 7  | 50.20328     | 51.35304 |
|     |    |        | 6  | 50.19986     | 51.35499 |     |    |        | 6  | 50.19812     | 51.35601 |
|     |    |        | 5  | 50.17602     | 51.36963 |     |    |        | 5  | 50.17293     | 51.37159 |
|     |    |        | 4  | 50.19419     | 51.35813 |     |    |        | 4  | 50.18667     | 51.36289 |
|     |    |        | 3  | 50.20043     | 51.35467 |     |    |        | 3  | 50.18553     | 51.36361 |
|     |    |        | 2  | 50.18908     | 51.36136 |     |    |        | 2  | 50.17579     | 51.36978 |
|     |    |        | 1  | 50.17488     | 51.37035 |     |    |        | 1  | 50.17465     | 51.37050 |
|     |    |        | 0  | 50.16239     | 51.37912 |     |    |        | 0  | 50.15690     | 51.38315 |
|     |    |        | -1 | 50.17602     | 51.36963 |     |    |        | -1 | 50.17407     | 51.37086 |
|     |    |        | -2 | 50.19192     | 51.35956 |     |    |        | -2 | 50.17808     | 51.36833 |
|     |    |        | -3 | 50.20498     | 51.35207 |     |    |        | -3 | 50.18782     | 51.36216 |
|     |    |        | -4 | 50.19373     | 51.35565 |     |    |        | -4 | 50.17923     | 51.36760 |
|     |    |        | -5 | 50.18737     | 51.36244 |     |    |        | -5 | 50.17865     | 51.36796 |
|     |    |        | -6 | 50.19930     | 51.35532 |     |    |        | -6 | 50.20786     | 51.35046 |
|     |    |        | -7 | 50.20327     | 51.35304 |     |    |        | -7 | 50.19469     | 51.35781 |
|     |    |        | -8 | 50.19192     | 51.35956 |     |    |        | -8 | 50.20843     | 51.35014 |
| 44  | -2 | -1 1/2 | 8  | 50.21009     | 51.34923 | 48  | -2 | -3     | 8  | 50.21358     | 51.34732 |
|     |    |        | 7  | 50.20214     | 51.35368 |     |    |        | 7  | 50.20499     | 51.35206 |
|     |    |        | 6  | 50.20117     | 51.35401 |     |    |        | 6  | 50.20099     | 51.35435 |
|     |    |        | 5  | 50.18056     | 51.36676 |     |    |        | 5  | 50.17522     | 51.37014 |
|     |    |        | 4  | 50.19873     | 51.35565 |     |    |        | 4  | 50.18839     | 51.36180 |
|     |    |        | 3  | 50.20100     | 51.35434 |     |    |        | 3  | 50.18495     | 51.36397 |
|     |    |        | 2  | 50.19021     | 51.36064 |     |    |        | 2  | 50.18209     | 51.36579 |
|     |    |        | 1  | 50.18453     | 51.36424 |     |    |        | 1  | 50.17236     | 51.37195 |
|     |    |        | 0  | 50.16466     | 51.37750 |     |    |        | 0  | 50.15804     | 51.38230 |
|     |    |        | -1 | 50.18397     | 51.36460 |     |    |        | -1 | 50.17178     | 51.37231 |
|     |    |        | -2 | 50.19305     | 51.35885 |     |    |        | -2 | 50.17751     | 51.36869 |
|     |    |        | -3 | 50.20270     | 51.35336 |     |    |        | -3 | 50.18839     | 51.36180 |
|     |    |        | -4 | 50.19816     | 51.35598 |     |    |        | -4 | 50.18095     | 51.36651 |
|     |    |        | -5 | 50.19759     | 51.35632 |     |    |        | -5 | 50.18037     | 51.36687 |
|     |    |        | -6 | 50.18908     | 51.36136 |     |    |        | -6 | 50.21530     | 51.34639 |
|     |    |        | -7 | 50.20157     | 51.35401 |     |    |        | -7 | 50.19984     | 51.35501 |
|     |    |        | -8 | 50.20461     | 51.35239 |     |    |        | -8 | 50.21015     | 51.34919 |
| 45  | -2 | -2 1/2 | 8  | 50.21453     | 51.34675 | 49  | -2 | -4     | 8  | 50.21702     | 51.34547 |
|     |    |        | 7  | 50.20498     | 51.35207 |     |    |        | 7  | 50.20614     | 51.35142 |
|     |    |        | 6  | 50.20043     | 51.35467 |     |    |        | 6  | 50.20499     | 51.35206 |
|     |    |        | 5  | 50.17565     | 51.36999 |     |    |        | 5  | 50.17808     | 51.36833 |
|     |    |        | 4  | 50.18851     | 51.36172 |     |    |        | 4  | 50.18266     | 51.36542 |
|     |    |        | 3  | 50.18964     | 51.36100 |     |    |        | 3  | 50.18381     | 51.36500 |
|     |    |        | 2  | 50.18283     | 51.36532 |     |    |        | 2  | 50.17923     | 51.36760 |
|     |    |        | 1  | 50.18170     | 51.36604 |     |    |        | 1  | 50.17579     | 51.36978 |
|     |    |        | 0  | 50.16482     | 51.37953 |     |    |        | 0  | 50.17865     | 51.36796 |
|     |    |        | -1 | 50.18170     | 51.36604 |     |    |        | -1 | 50.17522     | 51.37014 |
|     |    |        | -2 | 50.18453     | 51.36424 |     |    |        | -2 | 50.18037     | 51.36687 |
|     |    |        | -3 | 50.19305     | 51.35885 |     |    |        | -3 | 50.18896     | 51.36144 |
|     |    |        | -4 | 50.18397     | 51.36460 |     |    |        | -4 | 50.18839     | 51.36180 |
|     |    |        | -5 | 50.17829     | 51.36819 |     |    |        | -5 | 50.18495     | 51.36397 |
|     |    |        | -6 | 50.20456     | 51.35207 |     |    |        | -6 | 50.20557     | 51.35174 |
|     |    |        | -7 | 50.19816     | 51.35598 |     |    |        | -7 | 50.21931     | 51.34425 |
|     |    |        | -8 | 50.21009     | 51.34923 |     |    |        | -8 | 50.21988     | 51.34395 |

| P <sub>1</sub> | K  | V      | P <sub>2</sub> | P <sub>1</sub> | K        | V  | P <sub>2</sub> | P <sub>1</sub> | K | V        | P <sub>2</sub> |
|----------------|----|--------|----------------|----------------|----------|----|----------------|----------------|---|----------|----------------|
| 50             | -2 | 4 1/2  | 8              | 50.21601       | 51.34009 | 50 | -2             | 4 1/2          | 8 | 50.20213 | 51.34009       |
|                |    |        | 7              | 50.21726       | 51.34094 |    |                |                | 7 | 50.20159 | 51.34002       |
|                |    |        | 6              | 50.21849       | 51.34199 |    |                |                | 6 | 50.20051 | 51.34008       |
|                |    |        | 5              | 50.19325       | 51.34000 |    |                |                | 5 | 50.19853 | 51.34001       |
|                |    |        | 4              | 50.18017       | 51.34008 |    |                |                | 4 | 50.19583 | 51.34008       |
|                |    |        | 3              | 50.17980       | 51.34072 |    |                |                | 3 | 50.19583 | 51.34008       |
|                |    |        | 2              | 50.17980       | 51.34072 |    |                |                | 2 | 50.18896 | 51.34064       |
|                |    |        | 1              | 50.17980       | 51.34072 |    |                |                | 1 | 50.18897 | 51.34067       |
|                |    |        | 0              | 50.18010       | 51.34072 |    |                |                | 0 | 50.18895 | 51.34061       |
|                |    |        | 1              | 50.17907       | 51.34076 |    |                |                | 1 | 50.17980 | 51.34072       |
|                |    |        | 2              | 50.17906       | 51.34006 |    |                |                | 2 | 50.18951 | 51.34007       |
|                |    |        | 3              | 50.17751       | 51.34009 |    |                |                | 3 | 50.19541 | 51.34002       |
|                |    |        | 4              | 50.18067       | 51.34009 |    |                |                | 4 | 50.20085 | 51.34071       |
|                |    |        | 5              | 50.18896       | 51.34064 |    |                |                | 5 | 50.19438 | 51.34034       |
|                |    |        | 6              | 50.20063       | 51.34016 |    |                |                | 6 | 50.22790 | 51.34080       |
|                |    |        | 7              | 50.22103       | 51.34037 |    |                |                | 7 | 50.19011 | 51.34071       |
|                |    |        | 8              | 50.22103       | 51.34037 |    |                |                | 8 | 50.17178 | 51.34231       |
| 51             | -2 | -5     | 8              | 50.21988       | 51.34095 | 51 | -2             | -5             | 8 | 50.21244 | 51.34094       |
|                |    |        | 7              | 50.21587       | 51.34008 |    |                |                | 7 | 50.20328 | 51.34004       |
|                |    |        | 6              | 50.20786       | 51.34006 |    |                |                | 6 | 50.20156 | 51.34002       |
|                |    |        | 5              | 50.19068       | 51.34035 |    |                |                | 5 | 50.19041 | 51.34002       |
|                |    |        | 4              | 50.18095       | 51.34061 |    |                |                | 4 | 50.17293 | 51.34059       |
|                |    |        | 3              | 50.17064       | 51.34004 |    |                |                | 3 | 50.19011 | 51.34071       |
|                |    |        | 2              | 50.16949       | 51.34013 |    |                |                | 2 | 50.18381 | 51.34000       |
|                |    |        | 1              | 50.16949       | 51.34013 |    |                |                | 1 | 50.17808 | 51.34033       |
|                |    |        | 0              | 50.17522       | 51.34014 |    |                |                | 0 | 50.17007 | 51.34074       |
|                |    |        | 1              | 50.16319       | 51.34055 |    |                |                | 1 | 50.17178 | 51.34231       |
|                |    |        | 2              | 50.16319       | 51.34055 |    |                |                | 2 | 50.19182 | 51.34062       |
|                |    |        | 3              | 50.16663       | 51.34012 |    |                |                | 3 | 50.19469 | 51.34081       |
|                |    |        | 4              | 50.18095       | 51.34061 |    |                |                | 4 | 50.17579 | 51.34078       |
|                |    |        | 5              | 50.19297       | 51.34090 |    |                |                | 5 | 50.19011 | 51.34071       |
|                |    |        | 6              | 50.21072       | 51.34087 |    |                |                | 6 | 50.20499 | 51.34206       |
|                |    |        | 7              | 50.22046       | 51.34065 |    |                |                | 7 | 50.20000 | 51.34082       |
|                |    |        | 8              | 50.22275       | 51.34245 |    |                |                | 8 | 50.21645 | 51.34077       |
| 52             | -2 | 5 1/2  | 8              | 50.22389       | 51.34186 | 52 | -2             | 5 1/2          | 8 | 50.21473 | 51.34070       |
|                |    |        | 7              | 50.22046       | 51.34065 |    |                |                | 7 | 50.21816 | 51.34086       |
|                |    |        | 6              | 50.21244       | 51.34094 |    |                |                | 6 | 50.23191 | 51.34078       |
|                |    |        | 5              | 50.19297       | 51.34090 |    |                |                | 5 | 50.23878 | 51.34037       |
|                |    |        | 4              | 50.18266       | 51.34054 |    |                |                | 4 | 50.23763 | 51.34094       |
|                |    |        | 3              | 50.16777       | 51.34032 |    |                |                | 3 | 50.23882 | 51.34018       |
|                |    |        | 2              | 50.16663       | 51.34012 |    |                |                | 2 | 50.23992 | 51.34082       |
|                |    |        | 1              | 50.16663       | 51.34012 |    |                |                | 1 | 50.24676 | 51.34052       |
|                |    |        | 0              | 50.17121       | 51.34268 |    |                |                | 0 | 50.24622 | 51.34079       |
|                |    |        | 1              | 50.16319       | 51.34055 |    |                |                | 1 | 50.23821 | 51.34066       |
|                |    |        | 2              | 50.16548       | 51.34092 |    |                |                | 2 | 50.23019 | 51.34064       |
|                |    |        | 3              | 50.16892       | 51.34053 |    |                |                | 3 | 50.21988 | 51.34095       |
|                |    |        | 4              | 50.17980       | 51.34072 |    |                |                | 4 | 50.22389 | 51.34086       |
|                |    |        | 5              | 50.19870       | 51.34067 |    |                |                | 5 | 50.24279 | 51.34243       |
|                |    |        | 6              | 50.21358       | 51.34032 |    |                |                | 6 | 50.23363 | 51.34092       |
|                |    |        | 7              | 50.22504       | 51.34127 |    |                |                | 7 | 50.22160 | 51.34035       |
|                |    |        | 8              | 50.22504       | 51.34127 |    |                |                | 8 | 50.21874 | 51.34055       |
| 56             | -6 | -2 1/2 | 8              | 50.20786       | 51.34066 | 56 | -6             | -2 1/2         | 8 | 50.19411 | 51.34017       |
|                |    |        | 7              | 50.20385       | 51.34071 |    |                |                | 7 | 50.19755 | 51.34034       |
|                |    |        | 6              | 50.19927       | 51.34054 |    |                |                | 6 | 50.19755 | 51.34034       |
|                |    |        | 5              | 50.17751       | 51.34069 |    |                |                | 5 | 50.21358 | 51.34032       |
|                |    |        | 4              | 50.19011       | 51.34071 |    |                |                | 4 | 50.18667 | 51.34089       |
|                |    |        | 3              | 50.19125       | 51.34099 |    |                |                | 3 | 50.20728 | 51.34078       |
|                |    |        | 2              | 50.19240       | 51.34092 |    |                |                | 2 | 50.21129 | 51.34056       |
|                |    |        | 1              | 50.17121       | 51.34268 |    |                |                | 1 | 50.22160 | 51.34035       |
|                |    |        | 0              | 50.17121       | 51.34268 |    |                |                | 0 | 50.22561 | 51.34097       |
|                |    |        | 1              | 50.17064       | 51.34004 |    |                |                | 1 | 50.22561 | 51.34097       |
|                |    |        | 2              | 50.19068       | 51.34035 |    |                |                | 2 | 50.22160 | 51.34035       |
|                |    |        | 3              | 50.18896       | 51.34064 |    |                |                | 3 | 50.19469 | 51.34081       |
|                |    |        | 4              | 50.18381       | 51.34000 |    |                |                | 4 | 50.19354 | 51.34053       |
|                |    |        | 5              | 50.18595       | 51.34097 |    |                |                | 5 | 50.21416 | 51.34070       |
|                |    |        | 6              | 50.20270       | 51.34036 |    |                |                | 6 | 50.20557 | 51.34074       |
|                |    |        | 7              | 50.21577       | 51.34035 |    |                |                | 7 | 50.20213 | 51.34069       |
|                |    |        | 8              | 50.22000       | 51.34082 |    |                |                | 8 | 50.19812 | 51.34061       |

| Run | x   | y     | z  | $P_p/P_0$ | M        | Run | x   | y      | z  | $P_p/P_0$ | M        |
|-----|-----|-------|----|-----------|----------|-----|-----|--------|----|-----------|----------|
| 67  | 16  | 3 1/2 | 8  | 50.19469  | 51.35781 | 71  | -16 | 1 2    | 8  | 50.19812  | 51.35601 |
|     |     |       | 7  | 50.19698  | 51.35668 |     |     |        | 7  | 50.19411  | 51.35817 |
|     |     |       | 6  | 50.19812  | 51.35601 |     |     |        | 6  | 50.18896  | 51.36144 |
|     |     |       | 5  | 50.20385  | 51.35271 |     |     |        | 5  | 50.18209  | 51.36579 |
|     |     |       | 4  | 50.18610  | 51.36325 |     |     |        | 4  | 50.18209  | 51.36579 |
|     |     |       | 3  | 50.20328  | 51.35304 |     |     |        | 3  | 50.18839  | 51.36180 |
|     |     |       | 2  | 50.21129  | 51.34856 |     |     |        | 2  | 50.19984  | 51.35501 |
|     |     |       | 1  | 50.22046  | 51.34365 |     |     |        | 1  | 50.20328  | 51.35304 |
|     |     |       | 0  | 50.21816  | 51.34486 |     |     |        | 0  | 50.20385  | 51.35271 |
|     |     |       | -1 | 50.21931  | 51.34425 |     |     |        | -1 | 50.20328  | 51.35304 |
|     |     |       | -2 | 50.21473  | 51.34670 |     |     |        | -2 | 50.19641  | 51.35702 |
|     |     |       | -3 | 50.20614  | 51.35142 |     |     |        | -3 | 50.18495  | 51.36397 |
|     |     |       | -4 | 50.21759  | 51.34516 |     |     |        | -4 | 50.18782  | 51.36216 |
|     |     |       | -5 | 50.19297  | 51.35890 |     |     |        | -5 | 50.17923  | 51.36760 |
|     |     |       | -6 | 50.20328  | 51.35304 |     |     |        | -6 | 50.19011  | 51.36071 |
|     |     |       | -7 | 50.21702  | 51.34547 |     |     |        | -7 | 50.19641  | 51.35702 |
|     |     |       | -8 | 50.19870  | 51.35567 |     |     |        | -8 | 50.20156  | 51.35402 |
| 68  | -16 | 2 1/2 | 8  | 50.193    | 51.359   | 72  | -16 | -1 1/2 | 8  | 50.20156  | 51.35402 |
|     |     |       | 7  | 50.1945   | 51.358   |     |     |        | 7  | 50.20270  | 51.35336 |
|     |     |       | 6  | 50.196    | 51.357   |     |     |        | 6  | 50.19297  | 51.35890 |
|     |     |       | 5  | 50.203    | 51.353   |     |     |        | 5  | 50.19297  | 51.35890 |
|     |     |       | 4  | 50.1845   | 51.364   |     |     |        | 4  | 50.18953  | 51.36107 |
|     |     |       | 3  | 50.2015   | 51.354   |     |     |        | 3  | 50.20099  | 51.35435 |
|     |     |       | 2  | 50.209    | 51.350   |     |     |        | 2  | 50.21072  | 51.34887 |
|     |     |       | 1  | 50.218    | 51.345   |     |     |        | 1  | 50.21416  | 51.34701 |
|     |     |       | 0  | 50.216    | 51.346   |     |     |        | 0  | 50.21301  | 51.34762 |
|     |     |       | -1 | 50.217    | 51.346   |     |     |        | -1 | 50.21530  | 51.34639 |
|     |     |       | -2 | 50.212    | 51.348   |     |     |        | -2 | 50.20671  | 51.35110 |
|     |     |       | -3 | 50.204    | 51.353   |     |     |        | -3 | 50.19870  | 51.35567 |
|     |     |       | -4 | 50.1925   | 51.359   |     |     |        | -4 | 50.19182  | 51.35962 |
|     |     |       | -5 | 50.1915   | 51.360   |     |     |        | -5 | 50.19411  | 51.35817 |
|     |     |       | -6 | 50.2015   | 51.354   |     |     |        | -6 | 50.18953  | 51.36107 |
|     |     |       | -7 | 50.198    | 51.356   |     |     |        | -7 | 50.20213  | 51.35369 |
|     |     |       | -8 | 50.1965   | 51.357   |     |     |        | -8 | 50.20499  | 51.35206 |
| 69  | -16 | 1 1/2 | 8  | 50.19927  | 51.35534 | 73  | -16 | -2 1/2 | 8  | 50.19755  | 51.35634 |
|     |     |       | 7  | 50.19927  | 51.35534 |     |     |        | 7  | 50.20614  | 51.35142 |
|     |     |       | 6  | 50.18495  | 51.36397 |     |     |        | 6  | 50.20900  | 51.34982 |
|     |     |       | 5  | 50.19469  | 51.35781 |     |     |        | 5  | 50.20385  | 51.5271  |
|     |     |       | 4  | 50.18037  | 51.36687 |     |     |        | 4  | 50.19354  | 51.3585  |
|     |     |       | 3  | 50.18953  | 51.36107 |     |     |        | 3  | 50.20786  | 51.3504  |
|     |     |       | 2  | 50.20213  | 51.3569  |     |     |        | 2  | 50.21759  | 51.34516 |
|     |     |       | 1  | 50.20728  | 51.35078 |     |     |        | 1  | 50.22103  | 51.4335  |
|     |     |       | 0  | 50.20499  | 51.35206 |     |     |        | 0  | 50.21988  | 51.34395 |
|     |     |       | -1 | 50.20557  | 51.35174 |     |     |        | -1 | 50.22046  | 51.465   |
|     |     |       | -2 | 50.20156  | 51.35402 |     |     |        | -2 | 50.2150   | 51.4639  |
|     |     |       | -3 | 50.18953  | 51.36107 |     |     |        | -3 | 50.20385  | 51.35271 |
|     |     |       | -4 | 50.18724  | 51.36252 |     |     |        | -4 | 50.19125  | 51.35999 |
|     |     |       | -5 | 50.18724  | 51.36252 |     |     |        | -5 | 50.20900  | 51.34982 |
|     |     |       | -6 | 50.19011  | 51.36071 |     |     |        | -6 | 50.20156  | 51.35402 |
|     |     |       | -7 | 50.20156  | 51.35402 |     |     |        | -7 | 50.20385  | 51.35271 |
|     |     |       | -8 | 50.20099  | 51.35435 |     |     |        | -8 | 50.20270  | 51.35336 |
| 70  | -16 | 1/2   | 8  | 50.19698  | 51.35668 | 74  | 16  | 3 1/2  | 8  | 50.19870  | 51.35567 |
|     |     |       | 7  | 50.19354  | 51.35853 |     |     |        | 7  | 50.20213  | 51.35369 |
|     |     |       | 6  | 50.18610  | 51.36325 |     |     |        | 6  | 50.21129  | 51.34856 |
|     |     |       | 5  | 50.18037  | 51.36687 |     |     |        | 5  | 50.21072  | 51.34887 |
|     |     |       | 4  | 50.17694  | 51.36905 |     |     |        | 4  | 50.19641  | 51.35702 |
|     |     |       | 3  | 50.18266  | 51.36542 |     |     |        | 3  | 50.21358  | 51.34732 |
|     |     |       | 2  | 50.18724  | 51.36252 |     |     |        | 2  | 50.22160  | 51.34305 |
|     |     |       | 1  | 50.18381  | 51.36500 |     |     |        | 1  | 50.22733  | 51.34009 |
|     |     |       | 0  | 50.18495  | 51.36397 |     |     |        | 0  | 50.22618  | 51.34068 |
|     |     |       | -1 | 50.18667  | 51.36289 |     |     |        | -1 | 50.22561  | 51.34097 |
|     |     |       | -2 | 50.18610  | 51.36325 |     |     |        | -2 | 50.21988  | 51.34395 |
|     |     |       | -3 | 50.18152  | 51.36615 |     |     |        | -3 | 50.20900  | 51.34982 |
|     |     |       | -4 | 50.18495  | 51.36397 |     |     |        | -4 | 50.20270  | 51.35336 |
|     |     |       | -5 | 50.17636  | 51.36941 |     |     |        | -5 | 50.22046  | 51.34365 |
|     |     |       | -6 | 50.19011  | 51.36071 |     |     |        | -6 | 50.20270  | 51.35336 |
|     |     |       | -7 | 50.19469  | 51.35781 |     |     |        | -7 | 50.20270  | 51.35336 |
|     |     |       | -8 | 50.20041  | 51.35668 |     |     |        | -8 | 50.19927  | 51.35534 |

| Run | x   | y     | z  | P <sub>p</sub> - P <sub>0</sub> | M        | Run | x | y     | z  | P <sub>p</sub> - P <sub>0</sub> | M        |
|-----|-----|-------|----|---------------------------------|----------|-----|---|-------|----|---------------------------------|----------|
| 75  | 16  | 4 1/2 | 8  | 50.21072                        | 51.34887 | 79  | 0 | 1 1/2 | 8  | 50.21115                        | 51.34854 |
|     |     |       | 7  | 50.21301                        | 51.34762 |     |   |       | 7  | 50.21115                        | 51.34864 |
|     |     |       | 6  | 50.22561                        | 51.34097 |     |   |       | 6  | 50.20934                        | 51.34963 |
|     |     |       | 5  | 50.22217                        | 51.34275 |     |   |       | 5  | 50.18225                        | 51.36568 |
|     |     |       | 4  | 50.20442                        | 51.35239 |     |   |       | 4  | 50.19486                        | 51.35770 |
|     |     |       | 3  | 50.20499                        | 51.35206 |     |   |       | 3  | 50.19848                        | 51.35580 |
|     |     |       | 2  | 50.21645                        | 51.34577 |     |   |       | 2  | 50.19004                        | 51.36076 |
|     |     |       | 1  | 50.22618                        | 51.34068 |     |   |       | 1  | 50.17616                        | 51.36954 |
|     |     |       | 0  | 50.22561                        | 51.34097 |     |   |       | 0  | 50.16952                        | 51.37411 |
|     |     |       | -1 | 50.21759                        | 51.34516 |     |   |       | -1 | 50.17616                        | 51.36954 |
|     |     |       | -2 | 50.20900                        | 51.34982 |     |   |       | -2 | 50.19185                        | 51.35961 |
|     |     |       | -3 | 50.20213                        | 51.35369 |     |   |       | -3 | 50.20089                        | 51.35440 |
|     |     |       | -4 | 50.21072                        | 51.34887 |     |   |       | -4 | 50.21417                        | 51.34700 |
|     |     |       | -5 | 50.22618                        | 51.34068 |     |   |       | -5 | 50.17918                        | 51.36763 |
|     |     |       | -6 | 50.21587                        | 51.34608 |     |   |       | -6 | 50.20451                        | 51.35233 |
|     |     |       | -7 | 50.21244                        | 51.34794 |     |   |       | -7 | 50.21417                        | 51.34700 |
|     |     |       | -8 | 50.20900                        | 51.34982 |     |   |       | -8 | 50.15022                        | 51.38824 |
| 76  | -16 | 5 1/2 | 8  | 50.21988                        | 51.34395 | 80  | 0 | 1 1/2 | 8  | 50.25767                        | 51.32569 |
|     |     |       | 7  | 50.22160                        | 51.34305 |     |   |       | 7  | 50.21129                        | 51.34856 |
|     |     |       | 6  | 50.23935                        | 51.33410 |     |   |       | 6  | 50.20557                        | 51.35174 |
|     |     |       | 5  | 50.23534                        | 51.33606 |     |   |       | 5  | 50.17980                        | 51.36724 |
|     |     |       | 4  | 50.22446                        | 51.34156 |     |   |       | 4  | 50.19125                        | 51.35999 |
|     |     |       | 3  | 50.19755                        | 51.35634 |     |   |       | 3  | 50.19812                        | 51.35601 |
|     |     |       | 2  | 50.21072                        | 51.34887 |     |   |       | 2  | 50.18953                        | 51.36107 |
|     |     |       | 1  | 50.21702                        | 51.34547 |     |   |       | 1  | 50.17522                        | 51.37014 |
|     |     |       | 0  | 50.21874                        | 51.34455 |     |   |       | 0  | 50.17407                        | 51.37086 |
|     |     |       | -1 | 50.21587                        | 51.34608 |     |   |       | -1 | 50.17522                        | 51.37014 |
|     |     |       | -2 | 50.20958                        | 51.34951 |     |   |       | -2 | 50.19125                        | 51.35999 |
|     |     |       | -3 | 50.19870                        | 51.35567 |     |   |       | -3 | 50.20041                        | 51.35468 |
|     |     |       | -4 | 50.21645                        | 51.34577 |     |   |       | -4 | 50.21015                        | 51.34919 |
|     |     |       | -5 | 50.23534                        | 51.33606 |     |   |       | -5 | 50.17121                        | 51.37268 |
|     |     |       | -6 | 50.23763                        | 51.33494 |     |   |       | -6 | 50.20442                        | 51.35239 |
|     |     |       | -7 | 50.22046                        | 51.34365 |     |   |       | -7 | 50.21416                        | 51.34701 |
|     |     |       | -8 | 50.21816                        | 51.34486 |     |   |       | -8 | 50.15002                        | 51.38838 |
| 77  | -16 | 1/2   | 8  | 50.20391                        | 51.35268 | 81  | 6 | 1/2   | 8  | 50.14602                        | 51.39156 |
|     |     |       | 7  | 50.19788                        | 51.35615 |     |   |       | 7  | 50.21645                        | 51.34577 |
|     |     |       | 6  | 50.19245                        | 51.35923 |     |   |       | 6  | 50.21587                        | 51.34608 |
|     |     |       | 5  | 50.19426                        | 51.35808 |     |   |       | 5  | 50.18266                        | 51.36542 |
|     |     |       | 4  | 50.17978                        | 51.36725 |     |   |       | 4  | 50.18266                        | 51.36542 |
|     |     |       | 3  | 50.19667                        | 51.35686 |     |   |       | 3  | 50.18782                        | 51.36216 |
|     |     |       | 2  | 50.19969                        | 51.35510 |     |   |       | 2  | 50.18495                        | 51.36397 |
|     |     |       | 1  | 50.20150                        | 51.35405 |     |   |       | 1  | 50.17865                        | 51.36796 |
|     |     |       | 0  | 50.20331                        | 51.35302 |     |   |       | 0  | 50.19068                        | 51.36035 |
|     |     |       | -1 | 50.20210                        | 51.35371 |     |   |       | -1 | 50.19182                        | 51.35962 |
|     |     |       | -2 | 50.19788                        | 51.35615 |     |   |       | -2 | 50.19354                        | 51.35853 |
|     |     |       | -3 | 50.19064                        | 51.36037 |     |   |       | -3 | 50.19526                        | 51.35745 |
|     |     |       | -4 | 50.18581                        | 51.36343 |     |   |       | -4 | 50.18152                        | 51.36615 |
|     |     |       | -5 | 50.18943                        | 51.36114 |     |   |       | -5 | 50.18610                        | 51.36325 |
|     |     |       | -6 | 50.20150                        | 51.35405 |     |   |       | -6 | 50.18324                        | 51.36500 |
|     |     |       | -7 | 50.20089                        | 51.35440 |     |   |       | -7 | 50.21416                        | 51.34701 |
|     |     |       |    |                                 |          |     |   |       | -8 | 50.14029                        | 51.39624 |
| 78  | 0   | 1/2   | 8  | 50.172                          | 51.372   | 82  | 6 | 1 1/2 | 8  | 50.17007                        | 51.37374 |
|     |     |       | 7  | 50.1885                         | 51.362   |     |   |       | 7  | 50.21358                        | 51.34732 |
|     |     |       | 6  | 50.1752                         | 51.370   |     |   |       | 6  | 50.21244                        | 51.34794 |
|     |     |       | 5  | 50.1663                         | 51.376   |     |   |       | 5  | 50.18438                        | 51.36434 |
|     |     |       | 4  | 50.1645                         | 51.378   |     |   |       | 4  | 50.17751                        | 51.36869 |
|     |     |       | 3  | 50.164                          | 51.379   |     |   |       | 3  | 50.18495                        | 51.36397 |
|     |     |       | 2  | 50.155                          | 51.385   |     |   |       | 2  | 50.17751                        | 51.36869 |
|     |     |       | 1  | 50.1445                         | 51.393   |     |   |       | 1  | 50.19011                        | 51.36071 |
|     |     |       | 0  | 50.144                          | 51.393   |     |   |       | 0  | 50.19011                        | 51.36071 |
|     |     |       | -1 | 50.1452                         | 51.392   |     |   |       | -1 | 50.19068                        | 51.36035 |
|     |     |       | -2 | 50.158                          | 51.382   |     |   |       | -2 | 50.20156                        | 51.35402 |
|     |     |       | -3 | 50.167                          | 51.376   |     |   |       | -3 | 50.18495                        | 51.36397 |
|     |     |       | -4 | 50.1835                         | 51.365   |     |   |       | -4 | 50.18324                        | 51.36500 |
|     |     |       | -5 | 50.1605                         | 51.380   |     |   |       | -5 | 50.18152                        | 51.36615 |
|     |     |       | -6 | 50.176                          | 51.369   |     |   |       | -6 | 50.21072                        | 51.34887 |
|     |     |       | -7 | 50.191                          | 51.360   |     |   |       | -7 | 50.21473                        | 51.34670 |
|     |     |       | -8 | 50.176                          | 51.370   |     |   |       | -8 | 50.17548                        | 51.37692 |

| Run | x | y     | z | P <sub>p</sub> , P <sub>0</sub> | M'       | Run | x | y     | z | P <sub>p</sub> , P <sub>0</sub> | M'       |
|-----|---|-------|---|---------------------------------|----------|-----|---|-------|---|---------------------------------|----------|
| 83  | 6 | 2 1/2 | 8 | 50.19755                        | 51.36635 | 87  | 6 | 1 1/2 | 8 | 50.18491                        | 51.37733 |
|     |   |       | 7 | 50.21616                        | 51.36701 |     |   |       | 7 | 50.21874                        | 51.36455 |
|     |   |       | 6 | 50.20557                        | 51.36174 |     |   |       | 6 | 50.21416                        | 51.36701 |
|     |   |       | 5 | 50.18553                        | 51.36361 |     |   |       | 5 | 50.18037                        | 51.36687 |
|     |   |       | 4 | 50.17751                        | 51.36869 |     |   |       | 4 | 50.18381                        | 51.36500 |
|     |   |       | 3 | 50.18266                        | 51.36542 |     |   |       | 3 | 50.18266                        | 51.36542 |
|     |   |       | 2 | 50.19011                        | 51.36971 |     |   |       | 2 | 50.17865                        | 51.36796 |
|     |   |       | 1 | 50.19526                        | 51.37555 |     |   |       | 1 | 50.19125                        | 51.35999 |
|     |   |       | 0 | 50.19297                        | 51.36890 |     |   |       | 0 | 50.19870                        | 51.35567 |
|     |   |       | 1 | 50.19297                        | 51.36890 |     |   |       | 1 | 50.22153                        | 51.36335 |
|     |   |       | 2 | 50.20270                        | 51.37336 |     |   |       | 2 | 50.21988                        | 51.36395 |
|     |   |       | 3 | 50.19240                        | 51.37926 |     |   |       | 3 | 50.19698                        | 51.35668 |
|     |   |       | 4 | 50.18209                        | 51.36579 |     |   |       | 4 | 50.18495                        | 51.36397 |
|     |   |       | 5 | 50.18839                        | 51.36180 |     |   |       | 5 | 50.18438                        | 51.36434 |
|     |   |       | 6 | 50.20786                        | 51.37046 |     |   |       | 6 | 50.21187                        | 51.34825 |
|     |   |       | 7 | 50.21473                        | 51.36770 |     |   |       | 7 | 50.21645                        | 51.36577 |
|     |   |       | 8 | 50.18896                        | 51.36144 |     |   |       | 8 | 50.18487                        | 51.39248 |
| 84  | 6 | 3 1/2 | 8 | 50.21587                        | 51.36608 | 88  | 6 | 1 1/2 | 8 | 50.19755                        | 51.35634 |
|     |   |       | 7 | 50.21587                        | 51.36608 |     |   |       | 7 | 50.21816                        | 51.36486 |
|     |   |       | 6 | 50.21416                        | 51.36701 |     |   |       | 6 | 50.21129                        | 51.36856 |
|     |   |       | 5 | 50.19411                        | 51.35817 |     |   |       | 5 | 50.18266                        | 51.36542 |
|     |   |       | 4 | 50.18610                        | 51.36325 |     |   |       | 4 | 50.18495                        | 51.36397 |
|     |   |       | 3 | 50.19125                        | 51.35999 |     |   |       | 3 | 50.18610                        | 51.36325 |
|     |   |       | 2 | 50.19698                        | 51.35668 |     |   |       | 2 | 50.18495                        | 51.36397 |
|     |   |       | 1 | 50.20156                        | 51.35402 |     |   |       | 1 | 50.19354                        | 51.35853 |
|     |   |       | 0 | 50.17007                        | 51.37374 |     |   |       | 0 | 50.19583                        | 51.35708 |
|     |   |       | 1 | 50.18553                        | 51.36351 |     |   |       | 1 | 50.19641                        | 51.35702 |
|     |   |       | 2 | 50.21129                        | 51.34856 |     |   |       | 2 | 50.19583                        | 51.35708 |
|     |   |       | 3 | 50.21759                        | 51.34516 |     |   |       | 3 | 50.18610                        | 51.36325 |
|     |   |       | 4 | 50.20900                        | 51.34982 |     |   |       | 4 | 50.18324                        | 51.36500 |
|     |   |       |   |                                 |          |     |   |       | 5 | 50.18839                        | 51.36180 |
|     |   |       |   |                                 |          |     |   |       | 6 | 50.21244                        | 51.34794 |
|     |   |       |   |                                 |          |     |   |       | 7 | 50.21816                        | 51.36486 |
|     |   |       |   |                                 |          |     |   |       |   |                                 |          |
|     |   |       |   |                                 |          |     |   |       |   |                                 |          |
| 85  | 6 | 4 1/2 | 8 | 50.21816                        | 51.34486 | 89  | 6 | 2 1/2 | 8 | 50.22561                        | 51.34097 |
|     |   |       | 7 | 50.21874                        | 51.34455 |     |   |       | 7 | 50.24794                        | 51.32997 |
|     |   |       | 6 | 50.21931                        | 51.34425 |     |   |       | 6 | 50.20786                        | 51.35046 |
|     |   |       | 5 | 50.19583                        | 51.35708 |     |   |       | 5 | 50.18381                        | 51.36500 |
|     |   |       | 4 | 50.17980                        | 51.36724 |     |   |       | 4 | 50.18667                        | 51.36289 |
|     |   |       | 3 | 50.17236                        | 51.37195 |     |   |       | 3 | 50.18896                        | 51.36144 |
|     |   |       | 2 | 50.17064                        | 51.37304 |     |   |       | 2 | 50.20270                        | 51.35336 |
|     |   |       | 1 | 50.17121                        | 51.37268 |     |   |       | 1 | 50.25252                        | 51.37782 |
|     |   |       | 0 | 50.16949                        | 51.37413 |     |   |       | 0 | 50.19469                        | 51.35781 |
|     |   |       | 1 | 50.17579                        | 51.36978 |     |   |       | 1 | 50.20099                        | 51.35435 |
|     |   |       | 2 | 50.17980                        | 51.36724 |     |   |       | 2 | 50.19240                        | 51.35926 |
|     |   |       | 3 | 50.18896                        | 51.36144 |     |   |       | 3 | 50.19011                        | 51.36071 |
|     |   |       | 4 | 50.18324                        | 51.36500 |     |   |       | 4 | 50.17636                        | 51.36941 |
|     |   |       | 5 | 50.18953                        | 51.36107 |     |   |       | 5 | 50.19068                        | 51.36035 |
|     |   |       | 6 | 50.21473                        | 51.34670 |     |   |       | 6 | 50.21530                        | 51.36639 |
|     |   |       | 7 | 50.22103                        | 51.34335 |     |   |       | 7 | 50.25767                        | 51.32569 |
|     |   |       | 8 | 50.21759                        | 51.34516 |     |   |       | 8 | 50.17522                        | 51.37014 |
|     |   |       |   |                                 |          |     |   |       |   |                                 |          |
| 86  | 6 | 5 1/2 | 8 | 50.22217                        | 51.34275 | 90  | 6 | 3 1/2 | 8 | 50.21816                        | 51.34486 |
|     |   |       | 7 | 50.21759                        | 51.34516 |     |   |       | 7 | 50.27886                        | 51.31657 |
|     |   |       | 6 | 50.21187                        | 51.34825 |     |   |       | 6 | 50.21129                        | 51.36856 |
|     |   |       | 5 | 50.20385                        | 51.35271 |     |   |       | 5 | 50.18553                        | 51.36361 |
|     |   |       | 4 | 50.18324                        | 51.36500 |     |   |       | 4 | 50.19125                        | 51.35999 |
|     |   |       | 3 | 50.19698                        | 51.35668 |     |   |       | 3 | 50.19240                        | 51.35926 |
|     |   |       | 2 | 50.19125                        | 51.35999 |     |   |       | 2 | 50.19927                        | 51.35534 |
|     |   |       | 1 | 50.18552                        | 51.36615 |     |   |       | 1 | 50.19469                        | 51.35781 |
|     |   |       | 0 | 50.17522                        | 51.37014 |     |   |       | 0 | 50.19125                        | 51.35999 |
|     |   |       | 1 | 50.17579                        | 51.36978 |     |   |       | 1 | 50.19812                        | 51.35601 |
|     |   |       | 2 | 50.18037                        | 51.36687 |     |   |       | 2 | 50.20328                        | 51.35304 |
|     |   |       | 3 | 50.17808                        | 51.36833 |     |   |       | 3 | 50.20156                        | 51.35402 |
|     |   |       | 4 | 50.18667                        | 51.36289 |     |   |       | 4 | 50.17636                        | 51.36941 |
|     |   |       | 5 | 50.20156                        | 51.35402 |     |   |       | 5 | 50.19125                        | 51.35999 |
|     |   |       | 6 | 50.21187                        | 51.34825 |     |   |       | 6 | 50.21759                        | 51.34516 |
|     |   |       | 7 | 50.21416                        | 51.36701 |     |   |       | 7 | 50.29031                        | 51.31192 |
|     |   |       | 8 | 50.22046                        | 51.36365 |     |   |       | 8 | 50.19076                        | 51.38103 |
|     |   |       |   |                                 |          |     |   |       |   |                                 |          |
|     |   |       |   |                                 |          |     |   |       |   |                                 |          |

| Run | x | y     | z  | $P_p/P_{p0}$ | M        | Run | x | y     | z  | $P_p/P_{p0}$ | M        |
|-----|---|-------|----|--------------|----------|-----|---|-------|----|--------------|----------|
| 91  | 0 | 4 1/2 | 8  | 50.27085     | 51.31994 | 95  | 0 | 1 1/2 | 8  | 50.19297     | 51.35890 |
|     |   |       | 7  | 50.25939     | 51.32492 |     |   |       | 7  | 50.20557     | 51.35174 |
|     |   |       | 6  | 50.20958     | 51.34951 |     |   |       | 6  | 50.20156     | 51.35402 |
|     |   |       | 5  | 50.18567     | 51.36289 |     |   |       | 5  | 50.17751     | 51.36869 |
|     |   |       | 4  | 50.17980     | 51.36724 |     |   |       | 4  | 50.18839     | 51.36180 |
|     |   |       | 3  | 50.18782     | 51.36216 |     |   |       | 3  | 50.19641     | 51.35702 |
|     |   |       | 2  | 50.18610     | 51.36325 |     |   |       | 2  | 50.18839     | 51.36180 |
|     |   |       | 1  | 50.18553     | 51.36361 |     |   |       | 1  | 50.17407     | 51.37086 |
|     |   |       | 0  | 50.18324     | 51.36500 |     |   |       | 0  | 50.17236     | 51.37195 |
|     |   |       | -1 | 50.18266     | 51.36542 |     |   |       | -1 | 50.17407     | 51.37086 |
|     |   |       | -2 | 50.18324     | 51.36500 |     |   |       | -2 | 50.19011     | 51.36071 |
|     |   |       | -3 | 50.19068     | 51.36035 |     |   |       | -3 | 50.19870     | 51.35567 |
|     |   |       | -4 | 50.18896     | 51.36144 |     |   |       | -4 | 50.20671     | 51.35110 |
|     |   |       | -5 | 50.18839     | 51.36180 |     |   |       | -5 | 50.16835     | 51.37492 |
|     |   |       | -6 | 50.21301     | 51.34762 |     |   |       | -6 | 49.12597     | 51.72835 |
|     |   |       | -7 | 50.28516     | 51.31399 |     |   |       | -7 | 50.43089     | 51.26543 |
|     |   |       | -8 | 50.18782     | 51.36216 |     |   |       |    |              |          |
| 92  | 0 | 5 1/2 | 8  | 50.25939     | 51.32492 | 96  | 0 | 1 1/2 | 8  | 50.20099     | 51.35435 |
|     |   |       | 7  | 50.21931     | 51.34425 |     |   |       | 7  | 50.21530     | 51.34639 |
|     |   |       | 6  | 50.20728     | 51.35078 |     |   |       | 6  | 50.20728     | 51.35078 |
|     |   |       | 5  | 50.19297     | 51.35890 |     |   |       | 5  | 50.18152     | 51.36615 |
|     |   |       | 4  | 50.17579     | 51.36978 |     |   |       | 4  | 50.19182     | 51.35962 |
|     |   |       | 3  | 50.16835     | 51.37492 |     |   |       | 3  | 50.19670     | 51.35567 |
|     |   |       | 2  | 50.16777     | 51.37532 |     |   |       | 2  | 50.18953     | 51.36107 |
|     |   |       | 1  | 50.16606     | 51.37652 |     |   |       | 1  | 50.17522     | 51.37014 |
|     |   |       | 0  | 50.16491     | 51.37733 |     |   |       | 0  | 50.17407     | 51.37086 |
|     |   |       | -1 | 50.16606     | 51.37652 |     |   |       | -1 | 50.17522     | 51.37014 |
|     |   |       | -2 | 50.16949     | 51.37413 |     |   |       | -2 | 50.19125     | 51.35999 |
|     |   |       | -3 | 50.17064     | 51.37304 |     |   |       | -3 | 50.20099     | 51.35435 |
|     |   |       | -4 | 50.18782     | 51.36216 |     |   |       | -4 | 50.21244     | 51.34794 |
|     |   |       | -5 | 50.20099     | 51.35435 |     |   |       | -5 | 50.17293     | 51.37159 |
|     |   |       | -6 | 50.21301     | 51.34762 |     |   |       | -6 | 50.20614     | 51.35142 |
|     |   |       | -7 | 50.23248     | 51.33749 |     |   |       | -7 | 50.21187     | 51.34825 |
|     |   |       | -8 | 50.26626     | 51.32191 |     |   |       | -8 | 50.15690     | 51.38315 |
| 93  | 0 | 1 1/2 | 8  | 50.17064     | 51.37304 | 97  | 0 | 1 1/2 | 8  | 50.32009     | 51.30060 |
|     |   |       | 7  | 50.18610     | 51.36325 |     |   |       | 7  | 50.22275     | 51.34245 |
|     |   |       | 6  | 50.18839     | 51.36180 |     |   |       | 6  | 50.21072     | 51.34887 |
|     |   |       | 5  | 50.16835     | 51.37492 |     |   |       | 5  | 50.18438     | 51.36434 |
|     |   |       | 4  | 50.18037     | 51.36687 |     |   |       | 4  | 50.19411     | 51.35817 |
|     |   |       | 3  | 50.19011     | 51.36071 |     |   |       | 3  | 50.20041     | 51.35468 |
|     |   |       | 2  | 50.18553     | 51.36361 |     |   |       | 2  | 50.19068     | 51.36035 |
|     |   |       | 1  | 50.17236     | 51.37195 |     |   |       | 1  | 50.17579     | 51.36978 |
|     |   |       | 0  | 50.17293     | 51.37159 |     |   |       | 0  | 50.17465     | 51.37050 |
|     |   |       | -1 | 50.17293     | 51.37159 |     |   |       | -1 | 50.17579     | 51.36978 |
|     |   |       | -2 | 50.18724     | 51.36252 |     |   |       | -2 | 50.19125     | 51.35999 |
|     |   |       | -3 | 50.19411     | 51.35817 |     |   |       | -3 | 50.20213     | 51.35369 |
|     |   |       | -4 | 50.19583     | 51.35708 |     |   |       | -4 | 50.21530     | 51.34639 |
|     |   |       | -5 | 50.15861     | 51.38187 |     |   |       | -5 | 50.17522     | 51.37014 |
|     |   |       | -6 | 50.18610     | 51.36325 |     |   |       | -6 | 50.21015     | 51.34919 |
|     |   |       | -7 | 50.19068     | 51.36035 |     |   |       | -7 | 50.22389     | 51.34186 |
|     |   |       | -8 | 50.12597     | 51.40881 |     |   |       | -8 | 50.16262     | 51.37896 |
| 94  | 0 | 1 1/2 | 8  | 50.18610     | 51.36325 | 98  | 0 | 1 1/2 | 8  | 50.21816     | 51.34486 |
|     |   |       | 7  | 50.19927     | 51.35534 |     |   |       | 7  | 50.23534     | 51.33606 |
|     |   |       | 6  | 50.19812     | 51.35601 |     |   |       | 6  | 50.21530     | 51.34639 |
|     |   |       | 5  | 50.17522     | 51.37014 |     |   |       | 5  | 50.18724     | 51.36252 |
|     |   |       | 4  | 50.18610     | 51.36325 |     |   |       | 4  | 50.19755     | 51.35634 |
|     |   |       | 3  | 50.18896     | 51.36144 |     |   |       | 3  | 50.19984     | 51.35501 |
|     |   |       | 2  | 50.18782     | 51.36216 |     |   |       | 2  | 50.18896     | 51.36144 |
|     |   |       | 1  | 50.17350     | 51.37123 |     |   |       | 1  | 50.17350     | 51.37123 |
|     |   |       | 0  | 50.17178     | 51.37231 |     |   |       | 0  | 50.17465     | 51.37050 |
|     |   |       | -1 | 50.17350     | 51.37123 |     |   |       | -1 | 50.17293     | 51.37159 |
|     |   |       | -2 | 50.18953     | 51.36107 |     |   |       | -2 | 50.18953     | 51.36107 |
|     |   |       | -3 | 50.19698     | 51.35668 |     |   |       | -3 | 50.20099     | 51.35435 |
|     |   |       | -4 | 50.20328     | 51.35304 |     |   |       | -4 | 50.22046     | 51.34365 |
|     |   |       | -5 | 50.16548     | 51.37692 |     |   |       | -5 | 50.17923     | 51.36760 |
|     |   |       | -6 | 50.19583     | 51.35708 |     |   |       | -6 | 50.21702     | 51.34547 |
|     |   |       | -7 | 50.20328     | 51.35304 |     |   |       | -7 | 50.24221     | 51.33271 |
|     |   |       | -8 | 50.14029     | 51.39124 |     |   |       | -8 | 50.11968     | 51.41478 |

| Run | x   | y      |    | $P_p/P_{p,c}$ | M        | Run | x | y     |    | $P_p/P_{p,c}$ | M        |
|-----|-----|--------|----|---------------|----------|-----|---|-------|----|---------------|----------|
| 103 | 0   | 1/2    | 8  | 50.17539      | 51.34939 | 107 | 0 | 1/2   | 8  | 50.32409      | 51.29617 |
|     |     |        | 7  | 50.20009      | 51.35167 |     |   |       | 7  | 50.31572      | 51.30219 |
|     |     |        | 6  | 50.20091      | 51.35439 |     |   |       | 6  | 50.30914      | 51.30657 |
|     |     |        | 5  | 50.17938      | 51.36750 |     |   |       | 5  | 50.31213      | 51.30349 |
|     |     |        | 4  | 50.19015      | 51.36068 |     |   |       | 4  | 50.29897      | 51.30853 |
|     |     |        | 3  | 50.19473      | 51.35756 |     |   |       | 3  | 50.26130      | 51.32406 |
|     |     |        | 2  | 50.18536      | 51.36371 |     |   |       | 2  | 50.31213      | 51.30349 |
|     |     |        | 1  | 50.17161      | 51.37242 |     |   |       | 1  | 50.31332      | 51.30306 |
|     |     |        | 0  | 50.16563      | 51.37682 |     |   |       | 0  | 50.31093      | 51.30392 |
|     |     |        | -1 | 50.16922      | 51.37432 |     |   |       | -1 | 50.30975      | 51.30635 |
|     |     |        | -2 | 50.18536      | 51.36371 |     |   |       | -2 | 50.31930      | 51.30090 |
|     |     |        | -3 | 50.19613      | 51.35690 |     |   |       | -3 | 50.28701      | 51.31325 |
|     |     |        | -4 | 50.21287      | 51.34770 |     |   |       | -4 | 50.27745      | 51.31716 |
|     |     |        | -5 | 50.17061      | 51.37318 |     |   |       | -5 | 50.31273      | 51.30327 |
|     |     |        | -6 | 50.19792      | 51.35413 |     |   |       | -6 | 50.31452      | 51.30262 |
|     |     |        | -7 | 50.20009      | 51.35167 |     |   |       | -7 | 50.31871      | 51.30111 |
|     |     |        | -8 | 50.12318      | 51.41143 |     |   |       | -8 | 50.29897      | 51.30853 |
| 104 | 0   | 3 1/2  | 8  | 50.21466      | 51.34673 | 108 | 0 | 1 1/2 | 8  | 50.32528      | 51.29874 |
|     |     |        | 7  | 50.20510      | 51.35201 |     |   |       | 7  | 50.32289      | 51.29960 |
|     |     |        | 6  | 50.20211      | 51.35370 |     |   |       | 6  | 50.31572      | 51.30219 |
|     |     |        | 5  | 50.19453      | 51.35803 |     |   |       | 5  | 50.30316      | 51.30692 |
|     |     |        | 4  | 50.17759      | 51.36864 |     |   |       | 4  | 50.29120      | 51.31157 |
|     |     |        | 3  | 50.19194      | 51.35935 |     |   |       | 3  | 50.26130      | 51.32406 |
|     |     |        | 2  | 50.18357      | 51.36400 |     |   |       | 2  | 50.28941      | 51.31229 |
|     |     |        | 1  | 50.18058      | 51.36674 |     |   |       | 1  | 50.30196      | 51.30737 |
|     |     |        | 0  | 50.20091      | 51.35439 |     |   |       | 0  | 50.30077      | 51.30783 |
|     |     |        | -1 | 50.18536      | 51.36371 |     |   |       | -1 | 50.30017      | 51.30806 |
|     |     |        | -2 | 50.18776      | 51.36220 |     |   |       | -2 | 50.30316      | 51.30692 |
|     |     |        | -3 | 50.19672      | 51.35683 |     |   |       | -3 | 50.28522      | 51.31397 |
|     |     |        | -4 | 50.17998      | 51.36712 |     |   |       | -4 | 50.27386      | 51.31866 |
|     |     |        | -5 | 50.20031      | 51.35474 |     |   |       | -5 | 50.30555      | 51.30586 |
|     |     |        | -6 | 50.20091      | 51.35439 |     |   |       | -6 | 50.31751      | 51.30154 |
|     |     |        | -7 | 50.20510      | 51.35201 |     |   |       | -7 | 50.32469      | 51.29895 |
|     |     |        | -8 | 50.20689      | 51.35100 |     |   |       | -8 | 50.32708      | 51.29809 |
| 105 | 0   | -2 1/2 | 8  | 50.20390      | 51.35268 | 109 | 0 | 2 1/2 | 8  | 50.32050      | 51.30046 |
|     |     |        | 7  | 50.20450      | 51.35234 |     |   |       | 7  | 50.32887      | 51.29744 |
|     |     |        | 6  | 50.25532      | 51.32674 |     |   |       | 6  | 50.32349      | 51.29938 |
|     |     |        | 5  | 50.17061      | 51.37318 |     |   |       | 5  | 50.30017      | 51.30806 |
|     |     |        | 4  | 50.18417      | 51.36447 |     |   |       | 4  | 50.29180      | 51.31134 |
|     |     |        | 3  | 50.18118      | 51.36636 |     |   |       | 3  | 50.29419      | 51.31039 |
|     |     |        | 2  | 50.17460      | 51.37053 |     |   |       | 2  | 50.29180      | 51.31134 |
|     |     |        | 1  | 50.16922      | 51.37432 |     |   |       | 1  | 50.29539      | 51.30992 |
|     |     |        | 0  | 50.17699      | 51.36902 |     |   |       | 0  | 50.29598      | 51.30969 |
|     |     |        | -1 | 50.17520      | 51.37015 |     |   |       | -1 | 50.29718      | 51.30922 |
|     |     |        | -2 | 50.17998      | 51.36712 |     |   |       | -2 | 50.29539      | 51.30992 |
|     |     |        | -3 | 50.18656      | 51.36296 |     |   |       | -3 | 50.30495      | 51.30608 |
|     |     |        | -4 | 50.18118      | 51.36636 |     |   |       | -4 | 50.30017      | 51.30806 |
|     |     |        | -5 | 50.18477      | 51.36409 |     |   |       | -5 | 50.28522      | 51.31397 |
|     |     |        | -6 | 50.18357      | 51.36500 |     |   |       | -6 | 50.31871      | 51.30111 |
|     |     |        | -7 | 50.20211      | 51.35370 |     |   |       | -7 | 50.33126      | 51.29658 |
|     |     |        | -8 | 50.19852      | 51.35578 |     |   |       | -8 | 50.31930      | 51.30090 |
| 106 | -16 | 1/2    | 8  | 50.19314      | 51.35879 | 110 | 0 | 3 1/2 | 8  | 50.32588      | 51.29852 |
|     |     |        | 7  | 50.18716      | 51.36258 |     |   |       | 7  | 50.32170      | 51.30000 |
|     |     |        | 6  | 50.18237      | 51.36561 |     |   |       | 6  | 50.32409      | 51.29917 |
|     |     |        | 5  | 50.17938      | 51.36750 |     |   |       | 5  | 50.31572      | 51.30219 |
|     |     |        | 4  | 50.17879      | 51.36783 |     |   |       | 4  | 50.29180      | 51.31134 |
|     |     |        | 3  | 50.17819      | 51.36826 |     |   |       | 3  | 50.28522      | 51.31397 |
|     |     |        | 2  | 50.18237      | 51.36561 |     |   |       | 2  | 50.25831      | 51.32538 |
|     |     |        | 1  | 50.18118      | 51.36636 |     |   |       | 1  | 50.26967      | 51.32043 |
|     |     |        | 0  | 50.18118      | 51.36636 |     |   |       | 0  | 50.27685      | 51.31741 |
|     |     |        | -1 | 50.24217      | 51.33273 |     |   |       | -1 | 50.27805      | 51.31691 |
|     |     |        | -2 | 50.24217      | 51.33273 |     |   |       | -2 | 50.27386      | 51.31866 |
|     |     |        | -3 | 50.17819      | 51.36826 |     |   |       | -3 | 50.29539      | 51.30992 |
|     |     |        | -4 | 50.17998      | 51.36712 |     |   |       | -4 | 50.30256      | 51.30714 |
|     |     |        | -5 | 50.16264      | 51.37894 |     |   |       | -5 | 50.31093      | 51.30392 |
|     |     |        | -6 | 50.18536      | 51.36371 |     |   |       | -6 | 50.32170      | 51.30000 |
|     |     |        | -7 | 50.19015      | 51.36068 |     |   |       | -7 | 50.32110      | 51.30025 |
|     |     |        | -8 | 50.19433      | 51.35803 |     |   |       | -8 | 50.32708      | 51.29809 |

| Run | x   | y   |    | $\rho_p - \rho_s$ | K1       |
|-----|-----|-----|----|-------------------|----------|
| 111 | 0   | 1/2 | 8  | 50.33185          | 51.29636 |
|     |     |     | 7  | 50.32887          | 51.29744 |
|     |     |     | 6  | 50.33306          | 51.29593 |
|     |     |     | 5  | 50.33664          | 51.29463 |
|     |     |     | 4  | 50.30256          | 51.30716 |
|     |     |     | 3  | 50.29679          | 51.31016 |
|     |     |     | 2  | 50.28701          | 51.31325 |
|     |     |     | 1  | 50.28213          | 51.31494 |
|     |     |     | 0  | 50.27555          | 51.31516 |
|     |     |     | -1 | 50.27556          | 51.31866 |
|     |     |     | -2 | 50.28104          | 51.31568 |
|     |     |     | -3 | 50.28343          | 51.31470 |
|     |     |     | -4 | 50.29359          | 51.31063 |
|     |     |     | -5 | 50.33485          | 51.29528 |
|     |     |     | -6 | 50.33605          | 51.29485 |
|     |     |     | -7 | 50.32648          | 51.29830 |
|     |     |     | -8 | 50.33007          | 51.29701 |
| 112 | -16 | 1/2 | 8  | 50.31631          | 51.30198 |
|     |     |     | 7  | 50.33485          | 51.29528 |
|     |     |     | 6  | 50.33126          | 51.29658 |
|     |     |     | 5  | 50.32588          | 51.29852 |
|     |     |     | 4  | 50.30615          | 51.30505 |
|     |     |     | 3  | 50.29180          | 51.31134 |
|     |     |     | 2  | 50.30077          | 51.30783 |
|     |     |     | 1  | 50.30137          | 51.30760 |
|     |     |     | 0  | 50.30734          | 51.30522 |
|     |     |     | -1 | 50.30077          | 51.30783 |
|     |     |     | -2 | 50.29838          | 51.30876 |
|     |     |     | -3 | 50.31153          | 51.30370 |
|     |     |     | -4 | 50.30137          | 51.30760 |
|     |     |     | -5 | 50.32648          | 51.29830 |
|     |     |     | -6 | 50.33246          | 51.29614 |
|     |     |     | -7 | 50.33844          | 51.29398 |
|     |     |     | -8 | 50.30854          | 51.30478 |
| 113 | -16 | 3/2 | 8  | 50.32229          | 51.29982 |
|     |     |     | 7  | 50.33545          | 51.29506 |
|     |     |     | 6  | 50.33605          | 51.29485 |
|     |     |     | 5  | 50.32588          | 51.29852 |
|     |     |     | 4  | 50.30974          | 51.30435 |
|     |     |     | 3  | 50.30017          | 51.30806 |
|     |     |     | 2  | 50.29000          | 51.31205 |
|     |     |     | 1  | 50.27924          | 51.31641 |
|     |     |     | 0  | 50.28343          | 51.31470 |
|     |     |     | -1 | 50.28104          | 51.31568 |
|     |     |     | -2 | 50.29299          | 51.31086 |
|     |     |     | -3 | 50.30555          | 51.30586 |
|     |     |     | -4 | 50.31572          | 51.30219 |
|     |     |     | -5 | 50.32170          | 51.30000 |
|     |     |     | -6 | 50.33724          | 51.29441 |
|     |     |     | -7 | 50.33724          | 51.29441 |
|     |     |     | -8 | 50.33066          | 51.29679 |