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A FULLY AUTOMATED STAGE FOR OPTICAL WAVEGUIDE MEASUREMENTS

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1.0 INTRODUCTION

Nonlinear optical (NLO) materials are becoming increasingly important to the Air Force, and their expanding use in future systems is inevitable. Applications ranging from communications and optical computing to lasers and laser hardening will all be affected by the development of these materials. Because of this need, basic research and development of these materials are extremely important. Within the Materials Directorate of Wright Laboratory, the Electronic and Optical Materials Branch (WL/MLPO) is performing basic R&D in various areas of nonlinear optical materials. Central to this research is the measurement of the optical properties of these materials.

In order to apply these materials to device and systems, it is important to understand how they behave under the influence of various forces and conditions. These include applied voltages and currents, incident electromagnetic radiation and temperature changes. How they behave under these various conditions can be either useful or detrimental depending on the application. In the case of optical transmission, changes in material properties due to applied voltage are useful for applications where modulation is important. On the other hand, changes in characteristics due to temperature fluctuations can be detrimental when operating in harsh environments. Various methods and techniques have been developed to characterize these materials and predict their behavior in a wide variety of applications.

One important parameter of NLO materials is the attenuation of light. High loss materials can be useful for filtering applications especially when the loss is wavelength dependent. Low loss materials are very useful for transparent window applications and waveguiding. In addition, knowing the loss of a material can help determine the nature of its structure.

The losses in NLO materials can occur from many sources. For guided light structures, these include scattering due to bulk and surface defects and absorption due to resonance, losses due to substrate coupling and losses from irregularities in the interface between the guiding layer and the substrate. There are various methods that can be used to measure these losses and two of the primary methods used in WL/MLPO involve measuring the propagation loss of planar waveguides fabricated from the material being tested. This report describes the design and implementation of a fully automated waveguide stage that allows the measurement of these propagation losses.

2.0 EXPERIMENTAL BACKGROUND

Two techniques used in WL/MLPO for measuring the propagation loss in planar waveguides are the out-of-plane scattering technique[1] and the three-prism measurement technique[2]. These two techniques are similar in their measurement method and their geometrical requirements. Both employ channel or planar waveguides, and in both, the relative intensity of light is measured at points along the propagation path. In the out-of-plane technique, the relative intensity of the light scattered perpendicular to the plane of propagation is measured at many points along the guide, while in the three-prism method, guided light is coupled out from the waveguide at various points and its intensity is measured. In order to understand the design of the waveguide stage, it is useful to explore the experimental basis of these two techniques.

2.1 THE OUT-OF-PLANE TECHNIQUE

The out-of-plane scattering technique (graphically shown in Figure 1) is primarily used to measure waveguides with propagation losses higher than about 1 dB/cm. When using the visible wavelengths, these waveguides usually show a characteristic bright streak along the guide path. This is indicative of light being scattered from confined waveguide modes from scattering centers within the waveguide layer and at the interfaces. The intensity of the scattered light can be measured using a detector which is suspended above the streak and is moved parallel to the streak.

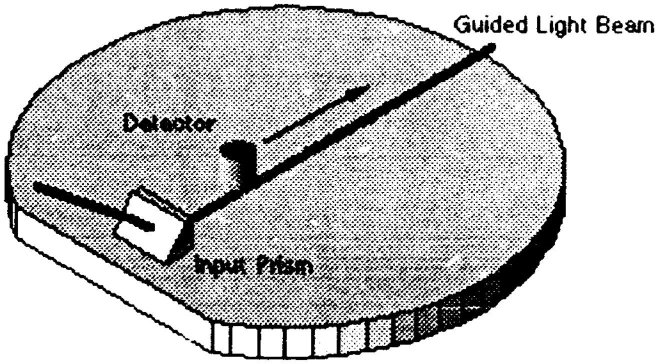


FIGURE 1 - Out-of-Plane Scattering Technique Schematic

The scattering centers are assumed to be homogeneous and evenly distributed over the length of the waveguide. This is required if a reasonable comparison is to be made of the scattered light intensity at various points along the propagation path. Inhomogeneities in the distribution of scattering centers cause substantial nonuniformities in the scattered light intensity along the direction of propagation. The result is an unreliable figure for propagation loss for the waveguide.

The actual propagation loss for this technique is calculated using Beer's Law. This is given in equation 1. The loss value is obtained by taking the slope of the log of the intensities (this is α in equation 1) between the initial intensity reading and each subsequent reading of the scattered output intensities at points along the guide path.

$$I(z) = I_o e^{-\alpha z} \tag{1}$$

$$\text{Propagation Loss in dB/cm} = 10 \log\frac{I(z)}{I_o}$$

$$= 10 \log\frac{I_o e^{-\alpha z}}{I_o} = 10 \log(e^{-\alpha z}) = -10\alpha z \log(e) = -10\alpha z \frac{\ln(e)}{\ln(10)}$$

$$= -4.343\alpha z$$

Where

I_o = relative out-scattered intensity at the first measured point
$I(z)$ = relative out-scattered intensity at point z along the path
α is the attenuation factor
z is the distance in cm (set to 1 cm)

α is determined by a least-squares curve fit or by plotting the data (i.e. $I(z)$) on a log scale and taking the slope.

A distinct advantage of this technique is the ability to measure losses in "softer" waveguide materials such as polymers and organics. Since the detector never comes in contact with the waveguide the surface is never disturbed. This is not the case with the three-prism technique.

2.2 THE THREE-PRISM TECHNIQUE

The three-prism technique, as the name implies, employs three prisms to couple light into and out of a waveguide. This is shown in Figure 2. The first prism, called the input prism, couples light energy into the waveguide. The other two prisms, called the measurement and exit prisms, respectively, are used in conjunction with the appropriate detectors to measure the intensity of the out-coupled light along the propagation path of the waveguide. This technique works well when the waveguides are sufficiently long (1-2 inches) and it is uniquely suited for measurements where the losses for the materials are relatively low (<1 dB/cm).

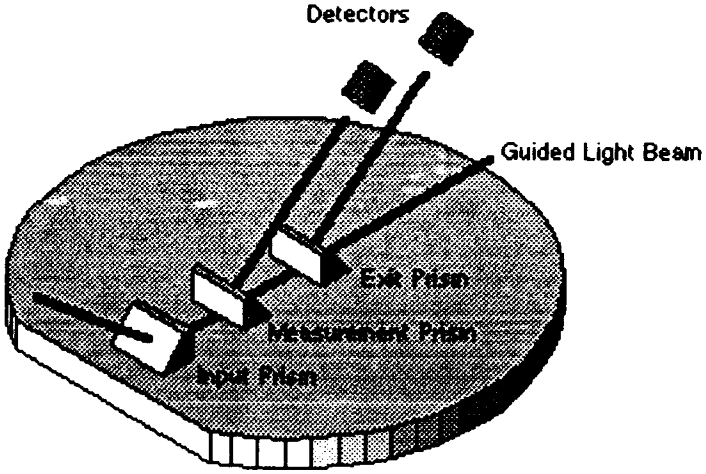


FIGURE 2 - Three-Prism Measurement Technique Schematic

The three-prism measurement is performed by using the input prism to couple light into the waveguide. The relative intensity of the light inside the guided path is then measured by using the measurement and exit prisms. First, a quiescent light intensity is measured using the exit prism with the measurement prism off of the waveguide. This value, P_{eo}, is used as the reference for all measurements taken along the points of the guide path. To make the loss measurements, the measurement prism is pressed onto the waveguide at equally spaced points along the guide path and intensity readings from both the measurement (P_m) and exit prisms (P_e) are taken. These values and P_{eo} are used to calculate the relative decrease in intensity at each point along the waveguide. The loss in dB/cm given in equation 2, is then calculated by taking the slope of these calculated values when plotted on a log scale. The advantage of using the exit prism is that it eliminates the need to know the coupling coefficient of the measurement prism.

3.0 SYSTEM REQUIREMENTS

An automated system that can be used to make out-of-plane and three-prism loss measurements for optical waveguides must meet certain requirements. For example, there are certain geometric requirements that affect the accuracy of the measurements. One of these is the need for a known reference for distance measurements. In addition, accurate light intensity measurements have certain conditions that must be met. In the case of the out-of-plane measurement, only a narrow portion of the guiding streak can be measured at each point if an accurate loss measurement is to be made. These requirements necessarily affect the design of the measurement system, and they will be explored more fully in the following sections.

3.1 SPECIFIC REQUIREMENTS

There are many geometrical, electrical, and optical requirements for a successful waveguide stage system. First, a planar surface is required to support waveguide substrates. This is needed to prevent damage to the wafers when pressure is applied from the coupling prisms. Secondly, motion along the waveguide length must be strictly controlled. The travel path must be parallel to the direction of the propagation path. The positions along the path where measurements are to be taken must be accurately known, and they must be repeatable. This is necessary if multiple measurements of the same sample are to be taken to verify operation. In addition, smooth, equal pressure must be applied to the prisms when coupling to the waveguide. This is necessary to ensure proper coupling and to prevent damage to the wafer.

Propagation Loss in dB/cm $= -4.343\alpha z$ (2)

Where

$I(z)$ = ratio of out-coupled light from the exit and measurement prisms

$$= \frac{P_m P_{eo}}{P_{eo} - P_e} = e^{-\alpha z}$$

α is the attenuation factor
z is the distance in cm (set to 1 cm)
P_m is the measurement prism intensity
P_e is the exit prism intensity
P_{eo} is the quiescent exit prism intensity (measurement prism off the waveguide)

α is determined by a least-squares curve fit of $I(z)$ or by plotting the data (i.e. $I(z)$) on a log scale and taking the slope.

The three-prism method, as in the case of the out-of-plane method, also relies on a certain level of uniformity in the waveguide. Accurate loss measurements over a distance still require a uniform distribution of loss centers. However, nonuniformities in the waveguides such as bright spots are easily detectable with this technique, and the information obtained can be useful in determining the overall physical quality of the waveguide. The main disadvantage of this technique is that it requires "harder" waveguide materials. This is due to the fact that the prisms must be pressed onto the surface of the guide in order to obtain sufficient contact to allow coupling. Softer materials may be damaged by this technique, and any data taken on a damaged surface would be useless.

Both of these techniques employ planar waveguides and make intensity measurements at points along the guide path. These commonalities lend themselves to a single test setup that could easily be changed to accommodate either method.

Interchangeability is also an issue. The system must be able to be converted from the three-prism technique to the out-of-plane scattering technique with a minimum of effort. To meet this requirement, parts of the system must be designed to allow easy disassembly and reassembly without affecting the ultimate accuracy and repeatability of the system. In addition, all parts that are not removable must be designed to allow various attachments to be added with ease. This accommodates such things as various size prisms and detectors.

The electrical and optical requirements are also numerous. For example, coupling prisms must have as much available space as possible for launching light into and out of the waveguide. This is required in order to facilitate as many coupling angles as possible for a wide variety of guiding modes. Additionally, the detectors used for measuring the out-coupled or out-scattered light must be able to capture light at any of the out-coupling angles or at any position along the waveguide. Another requirement is the need to minimize backscattered light detection. The detectors must be designed to eliminate unwanted light from input coupling and from the surroundings. This light adversely affects the measurements.

Although not necessary for the three-prism technique, it is advantageous to know the force which is being applied to the coupling prisms. This allows repeatability in coupling pressure and can also be used to prevent excessive force from being applied to sensitive waveguides. This is best accomplished through the use of force detectors such as load cells.

A final requirement for a waveguide stage system is computer control for movement and data acquisition. In the modern laboratory setting, this is essential. These measurements are tedious and time consuming. Doing these types of measurements "by hand" also greatly increases the chance for errors. Computer control of all motion and data acquisition yields vastly improved accuracy and repeatability while greatly reducing the chance for error. In addition, allowing a computer to take control frees the researcher for other more important tasks.

The waveguide stage measurement system has been designed to meet these requirements by combining commercially available equipment and custom designed parts.

4.0 EXPERIMENTAL APPARATUS

An overall schematic of the waveguide measurement system is shown in Figure 3. The heart of the system is the waveguide stage and its associated electronic and mechanical components. These are explained fully in Section 5. The remaining supporting equipment consists of the computer and electronic equipment necessary to take data from the waveguide stage.

The data acquisition portion of the waveguide measurement system is designed around a Hewlett Packard 9000 330 MMA computer using the HP BASIC 5.0 programming language. This allows easy programming for automated data acquisition. In addition, this computer is connected to a local area network which allows easy transfer of data to other systems more suitable for analysis and presentation.

The HP computer controls various external equipment necessary for supplying stimulus and acquiring response to and from the waveguide stage. In order to measure optical response from detectors on the waveguide stage as well as pressure readings from load cells, a Hewlett Packard HP3457A Digital Multimeter (DMM) is used. This DMM has an HP44492 10-channel Relay Input Card option that allows the DMM to be switched between 1-of-10 input channels. This allows a single DMM to be used to measure all signals from the waveguide stage.

In order to drive the rail table portion of the waveguide stage (rail table explained in Section 5), a Daedal MC 2000/MD 23 Linear Motion Controller/NEMA Motor Driver is employed. This combination allows accurate computer control and measurement of the out-coupling position of the measurement prism of the waveguide stage.

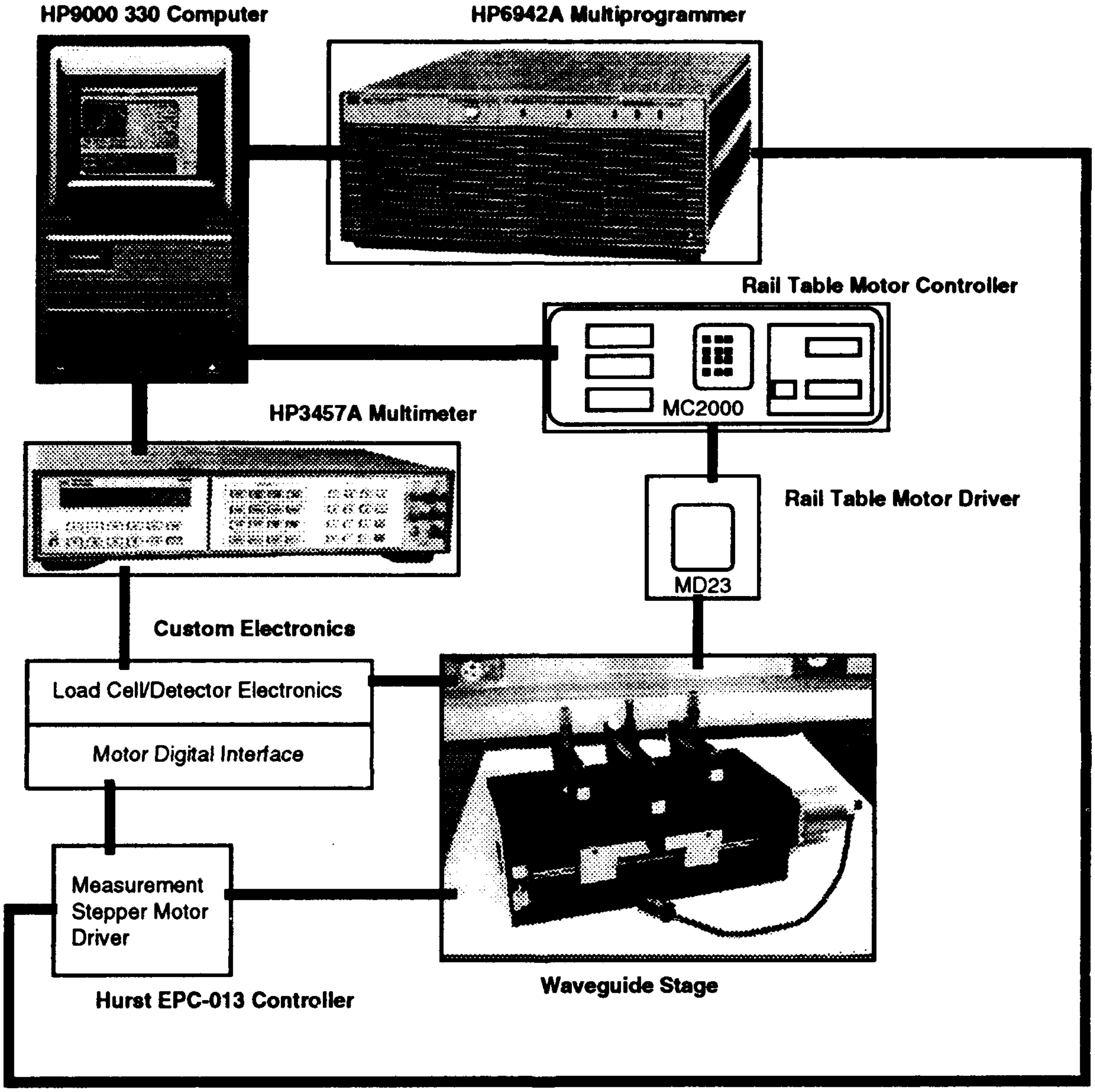


FIGURE 3 - Overall Waveguide Measurement System Schematic

Also employed in the waveguide measurement system is an HP6942A Multiprogrammer. This device is a multipurpose card cage that allows various special purpose cards such as relay cards or D/A converter cards to be accessed by a computer. As used in this system, an HP69735 Pulse Train/Stepper Motor card is used in the multiprogrammer to supply pulses to a Hurst stepper motor to control the measurement arm of the waveguide stage (see Section 5).

The rest of the system is comprised of the custom mechanics and electronics required to interface between the DMM, the Multiprogrammer and the waveguide stage. These custom components provide measurement arm drive and I/O signal condition necessary for data acquisition. Their purpose and function is explained fully in Section 5.

5.0 SYSTEM DESIGN

The system surrounding the waveguide stage (Figure 4) contains mechanical hardware, electronics and optics, and computer software. This is a mixture of commercial and custom components, and each of these will be discussed in the context of full system operation.

5.1 MECHANICAL HARDWARE

The mechanical hardware of the waveguide is comprised of a commercially available rail table to which custom-designed components have been added. The custom components are designed for specific application to three-prism or out-of-plane scattering loss measurements. The main components are the stage base plate, the input and output arms and the measurement arm. All parts are machined from aluminum, and they are black-anodized for use in laser environments.

5.1.1 THE RAIL TABLE

The rail table (Daedal Model 506041S-LH) has 4 inches of linear travel and is equipped with a five-pitch double nut ball screw mechanism to minimize backlash. The rail table is driven by a standard NEMA 23 frame stepper motor having 10,000 steps per revolution of rotational resolution. This allows the rail table to have ±0.0002-inch position repeatability and ±0.00025 in/in position accuracy. The NEMA 23 motor is driven by a Daedal single axis motion controller complete with IEEE-488 interface (Daedal Model MC 2000). This provides complete computer control of the motion of the rail table including the speed, acceleration/deceleration rate and the step resolution between measurements positions.

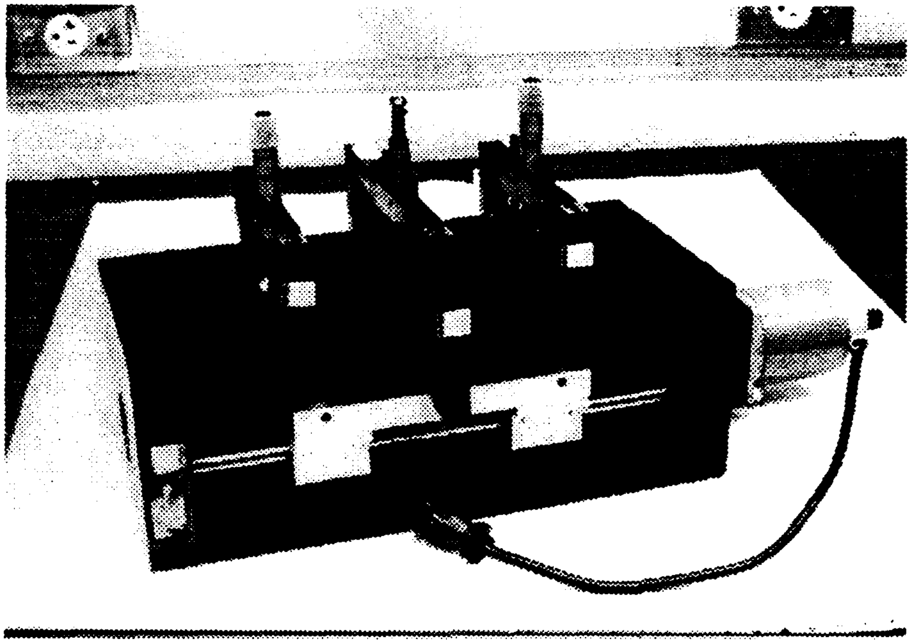


FIGURE 4 - Photograph of the Waveguide Stage

5.1.2 THE BASE PLATE

The base plate for the waveguide stage is shown in Figure 5. The base plate serves as the mounting seat for the waveguide substrates and as a mount for the input and output arms. The base plate is mounted to the rail table using $\frac{1}{4}$ - 20 NC screws. The plate has been precision machined for flatness and it is aligned to the rail table using set pins and offset mounting holes for the $\frac{1}{4}$ - 20 screws. This ensures that the base plate stays aligned parallel to the rail table and that it can only be mounted with one unique orientation in the event disassembly is required.

In order to ensure maximum flatness, the rail table was machined "true" at the time of manufacture of the base plate.

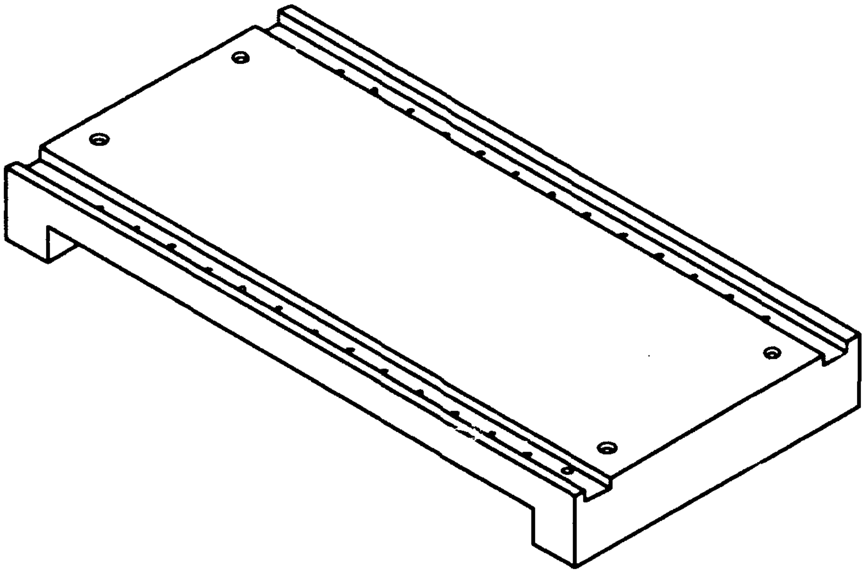


FIGURE 5 - The Waveguide Stage Base Plate

The base plate has a set of 8-32 NC mounting holes that are equally spaced along two $\frac{1}{4}$ inch troughs that run along each side of the base plate. These troughs hold the input and output arm mechanisms and allow the arms to be positioned and secured anywhere along the length of the base plate. This allows maximum flexibility while maintaining parallel positioning with respect to the sides of the base plate.

The base plate is raised up from the surface of the rail table $\frac{3}{4}$ inch to allow the measurement arm to be mounted to the rail table. This in turn allows the measurement arms to move along the length of the base plate with the accuracy of the rail table.

5.1.3 THE INPUT, OUTPUT, AND MEASUREMENT ARMS

The input and output arms, shown in Figure 6, are identical in construction. Each arm is positioned over the surface of the waveguiding substrate. The input arm is placed at the front of the waveguide, and it is used to launch light into the guide. The output arm is placed at the end of the guide, and it is used to measure the exit intensity of the light exiting from the waveguide during three-prism measurements. It is not used for out-of-plane measurements and can be removed.

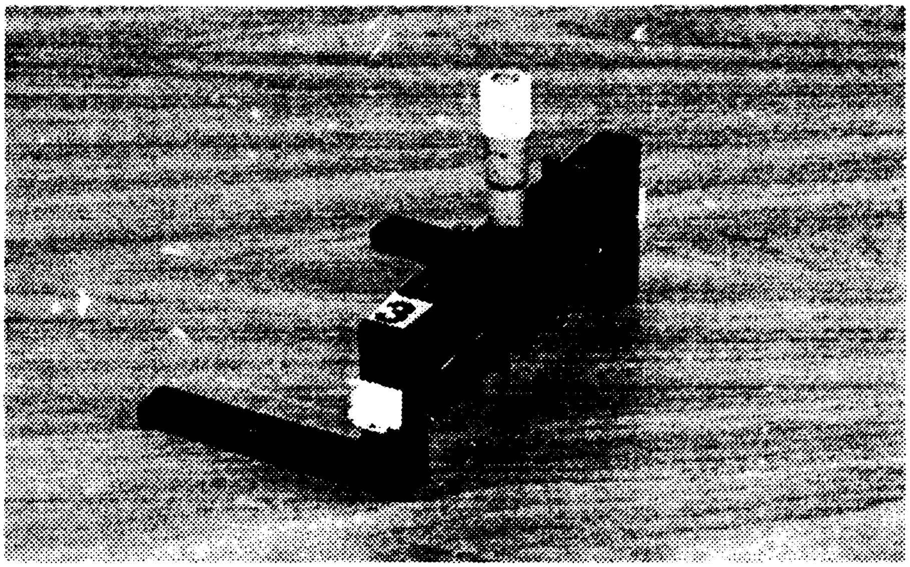


FIGURE 6 - The Input/Output Arm

The input/output arms are comprised of various moving parts that facilitate proper placement of the prisms onto the waveguide substrate. This is shown in Figure 7. Each arm is identical with the exception of a removable detector attachment for the output arm.

The operation of the input/output arm is straightforward. A set of steel rods is used to control the motion of the various moving parts of the arm. Referring to

Figure 7, the two outer steel rods are firmly press-fit into the slide bracket. This slide bracket slip-fits into the base plate and is screwed down into position over the waveguide substrate. The two inner steel rods are press-fit into the upper guide bracket and are allowed to slip freely through the slide bracket. The lower guide bracket has a prism attachment or and/or a detector attachment (depending on which measurement technique is being used), and it is also allowed to slip freely over the two inner steel rods. The whole mechanism is raised and lowered onto the waveguide substrate by a micrometer screw assembly and two springs located on the outer steel rods.

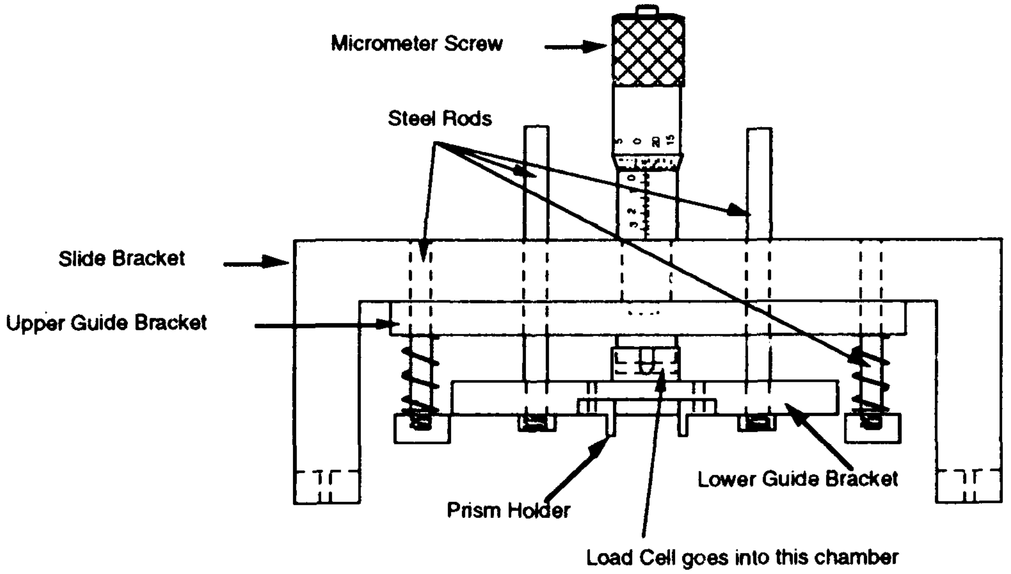


FIGURE 7 - Input/Output Arm Schematic

A unique feature of the arms is the use of compression load cells in the axis of applied force of the prisms. These load cells (Sensotec Model 13, AL322BN) are placed in all three arms of the waveguide stage, and they are located in the cup of the lower guide bracket. Due to the design of the arms, the load cell will only measure the force being applied to the prisms. This is extremely useful when the stage is being used to measure polymer and other soft material waveguides. Excessive pressure can damage these types of guides making the measured data useless. In addition, these load cells allow the coupling pressure to be maintained and duplicated between measurements on the same sample and from sample to sample.

The measurement arm is identical to the input/output arms in construction and operation with two exceptions. First, the measurement arm does not have a slide bracket but rather has a two-piece bracket that attaches to the rail table instead of the base plate. This allows the measurement arm to be moved along the waveguide path to make measurements with the positioning accuracy of the rail table. Second, the micrometer screw assembly of the measurement arm is driven by a computer-controlled stepper motor. This allows complete control of the data acquisition by software programming.

Complete drawings for the input/output and measurement arms, as well as all other custom-designed mechanical parts, can be found in the Appendices.

5.2 ELECTRONICS AND OPTICS

The electronics and optics for the waveguide stage consist of the voltage references, amplifiers, prisms, etc. that allow the actual acquisition of the data pertaining to the waveguide under test. This can be classified into three groups: (1) the prisms and detectors and their associated electronics, (2) the load cells and their electronics, and (3) the measurement stepper motor. The first two are custom implementations, and the last is a commercially available unit.

5.2.1 PRISMS AND DETECTORS

The prisms are the only strictly optical component for the stage and their operational requirements are mechanical in nature, however, their discussion with the detectors is warranted. As mentioned previously, the prisms must be applied to the waveguide with a steady and even pressure. To accomplish this, a special prism holder was developed. A representative holder is shown in Figure 8. These holders come in various sizes to accommodate various size prisms.

The prism holders are interchangeable and attach to the lower guide brackets using 2-56 NC screws. This allows all holders to fit into the lower guide bracket making it very convenient to change from one type of prism to the other.

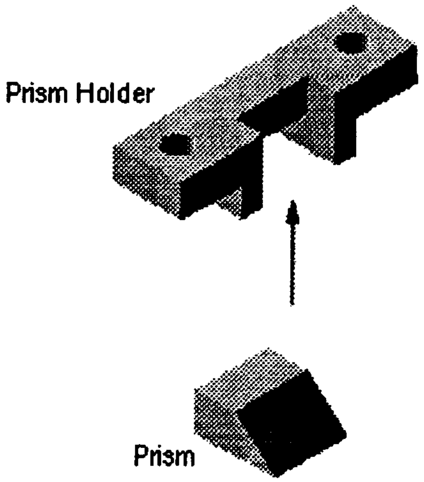


FIGURE 8 - Prism Holder and Prism

The holders were originally lined entirely on the inside with felt. This provided both a friction grip as well as protection from cracking for the prisms. However, the felt placed on the inside top produced excessive cushioning to the prism when pressure was applied. This caused a classic exponential relaxation in the pressure applied to the prism as the felt continued to compress. This made accurate pressure measurements with the load cells very difficult. To remedy this problem, the felt on the inside top was replaced with thin teflon sheeting. This allowed protection of the prism top surface while greatly reducing the compression relaxation.

The detectors associated with the three-prism and the out-of-plane techniques have both mechanical and electronic fixturing. The physical setup for the detectors is different for each technique. For the out-of-plane technique there is only one detector and it must be suspended over the waveguide on the measurement arm. For the three-prism technique, two detectors are required, one for the measurement arm and one for the output arm. These detectors must be placed as close as possible to the prisms on each arm in order to capture the exiting light regardless of the out-coupling angle. In addition, the fixturing for mounting the detectors for both techniques must allow easy interchangeability.

The configurations for detector mounting for both techniques are shown in Figures 9 and 10. For the three-prism technique, the detectors are fixed to an angled mounting bracket using silicone adhesive. The bracket is then attached to the lower guide bracket using the same 2-56 NC screws that attach the prism holder. For the out-of-plane technique, a special detector mount was fabricated that attaches to the lower guide bracket in place of the prism holder on the measurement arm. This holder is a two-piece unit and the detector fits in between the pieces. A small slit in the bottom piece that is positioned over the detector is the input for the scattered light from the waveguide.

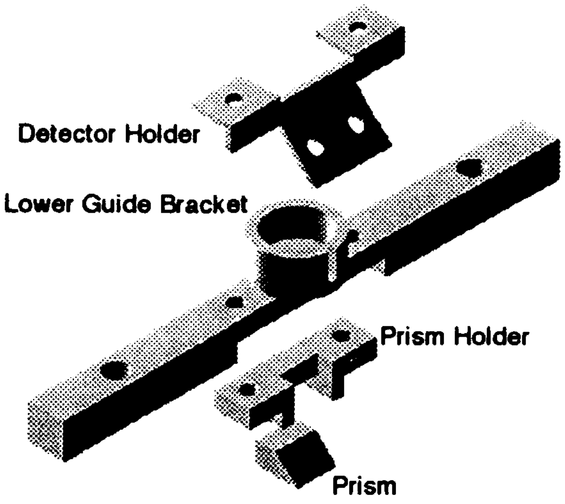


FIGURE 9 - Three-Prism Detector Holder Arrangement

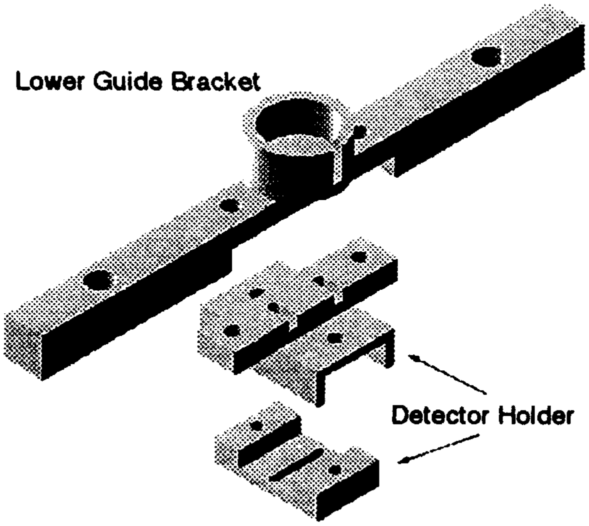


FIGURE 10 - Out-of-Plane Detector Holder Arrangement

The detectors used for both techniques are Hamamatsu model S1227-66BQ silicon photodiodes. These detectors have a thin, rectangular shape that is ideally suited for this application. The overall size of these detectors is 10 mm x 9 mm x 2 mm with an active detector area of 33 mm^2. The S1227-66BQ has a response from 190 nm to 1000 nm with a peak at 720 nm and a typical radiant sensitivity of 0.35 A/W at the peak wavelength[3].

The electronic circuitry for the detectors is shown in Figure 11. The detectors form part of a variable gain current-to-voltage converter. The gain for each amplifier is controlled by a series of resistors connected to a rotary switch. This allows gain adjustment for different light intensity levels. The current generated in the detector due to incident light is converted to a voltage at the output of the operational amplifier (op-amp) according to equation 3.

$V_O = -I_rR_f$ volts (3)
where
I_r = total photodiode current in amps
R_f = feedback resistor in ohms

The photocurrent, Ir, for the S1227-66BQ is given in equation 4[4]. The second and third terms of this equation can be ignored because the series resistance of the photodiode is small ($R_s < 10\ \Omega$) and because the shunt resistance is large ($R_{sh} > 10^7\ \Omega$)[5]. This makes the current and, thus, the output voltage from the op-amp, very nearly directly proportional to the light intensity striking the detector.

$$I_r = I_L - I_s\left(e^{\frac{qI_rR_s}{kT}} - 1\right) - \frac{I_rR_s}{R_{sh}} \tag{4}$$

where
I_r = total current pulled through the photodiode
I_L = Current due to to the incident light on the detector
I_s = photodiode reverse saturation current
R_s = photodiode series resistance
R_{sh} = photodiode shunt resistance
q = electronic charge
k = Boltzmann's constant
T = Absolute temperature of the photodiode

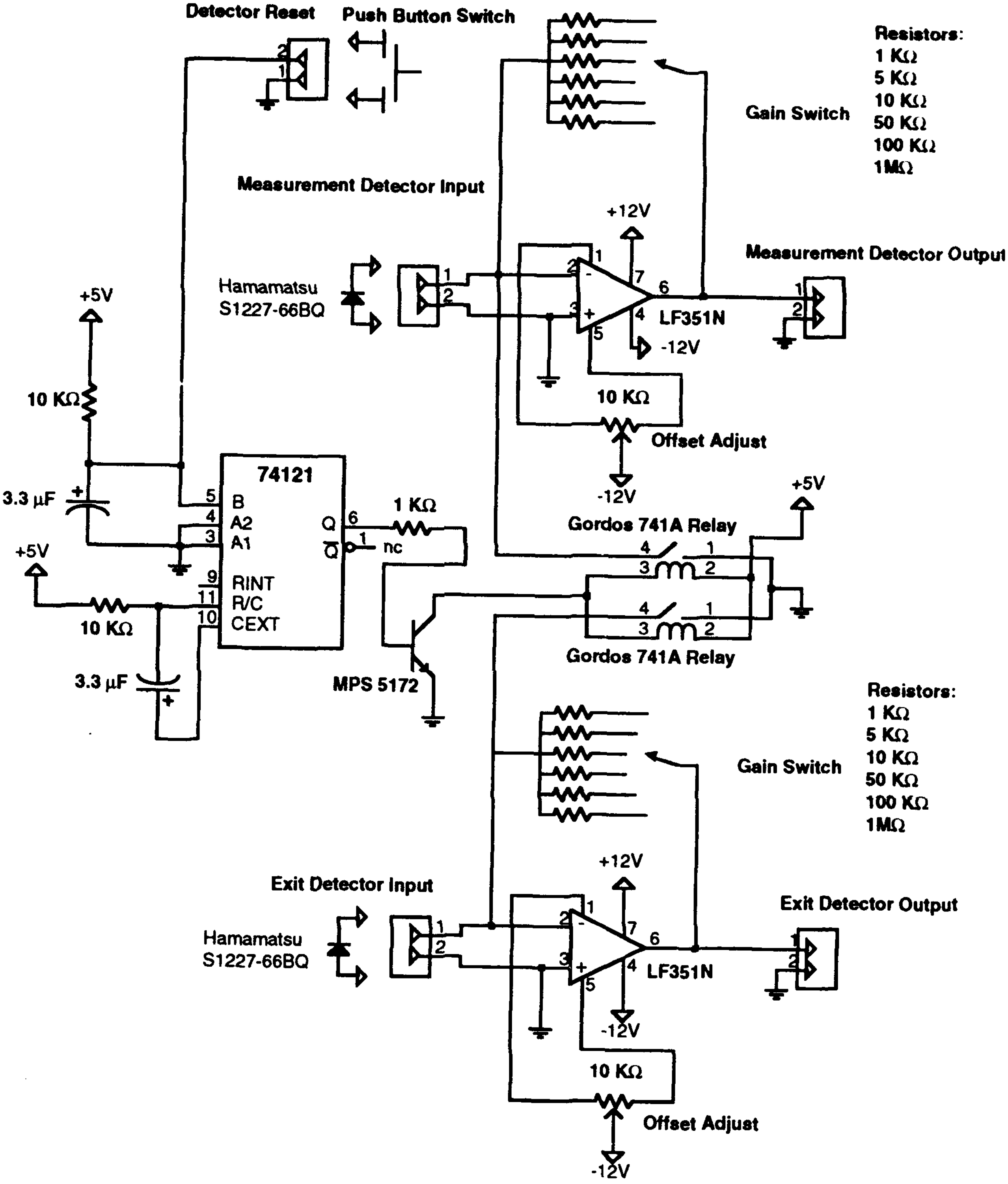


FIGURE 11 - Detector Electronics

The 74121, the relays and the transistor in the circuit of Figure 11 have been added to prevent latching of the op-amps when the power is first applied to the stage electronics. It has been experimentally determined that the high input impedance of the LF351N, coupled with the low reverse bias current of the photodiodes and the stray capacitance of the cabling connecting the photodiodes to the op-amp, causes a latched and/or oscillating condition The 74121 is a timed one-shot that shorts the inputs of the op-amps until the power supplies have settled. This allows the op-amps to have a stable reference when the inputs are released which eliminates the latching or oscillating.

5.2.2 THE LOAD CELLS

The load cell signal-conditioning electronics employed in the waveguide stage are shown in Figure 12. Each arm of the waveguide stage has a load cell that measures the pressure being applied to the prisms. These load cells operate in a standard compensated Wheatstone bridge configuration. The bridge is driven by a voltage reference, and the resistance in one of the arms changes as force is applied. This change causes a voltage differential to appear across the bridge that is related to the force that is being applied[6]. This voltage is amplified using a differential amplifier, and the output is available as a measure of the force being applied to the prisms.

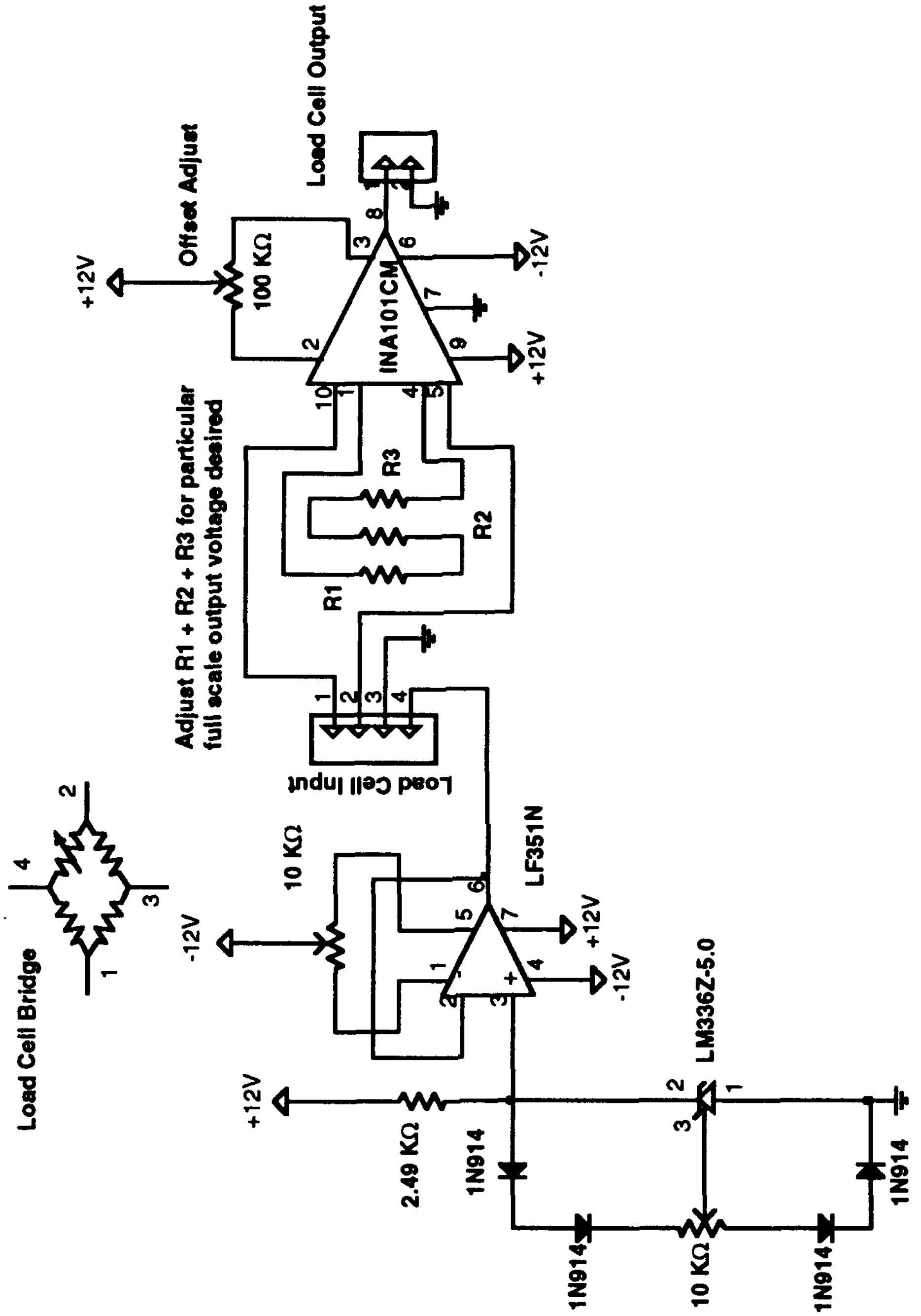


FIGURE 12 - Load Cell Electronics

In the circuit of Figure 12, the reference voltage to the load cells is produced by a temperature-compensated zener diode (LM336Z-5.0) buffered by an operational amplifier (LM351N). The zener voltage is adjusted using the potentiometer connected to pin 3. The differential voltage produced by the load cell is amplified by a Burr-Brown INA101CM Instrumentation Amplifier. The gain of this amplifier is set by resistors R1, R2 and R3. This allows precision adjustment of the full scale output of the load cell.

5.2.3 THE MEASUREMENT STEPPER MOTOR

The stepper motor assembly employed to drive the measurement arm is comprised of a commercially available stepper motor mounted on a custom-designed bracket . The motor is a Hurst SAS Series geared stepper motor with a rotation speed of 0.42 rpm providing 600:1 reduction with a typical torque of 200 oz-in. The motor is driven by a Hurst EPC-013 Stepper Motor Controller board. This board provides the drive current for the motor as well as the input/output to allow manual and digital control for the motor. The EPC-013 is interfaced to custom-designed electronics that allows switching between computer control and manual control. Ultimately, the computer control is accomplished through a Hewlett Packard HP6942A Multiprogrammer Interface Pulse Train Stepper Motor Controller card.

The EPC-013 provides inputs that allow control of various aspects of the stepper motor. This card controls the acceleration/deceleration of the motor, the rotation direction, the phase setting (3 or 4) and the run/hold status. In addition, this card has a free running pulse train to allow manual control of the motor and an input for external pulse trains to allow other circuitry to control the motor.

The custom electronics that serves as an interface between the Hewlett Packard multiprogrammer and the EPC-013 is shown in Figure 13. This circuit functions as a data router that allows the user to either control the motor manually or by the computer. The circuit has two digital data selectors (74157) that allow either pulses from the computer or a pulse train from the EPC-013 to control the motion of the stepper motor. Manual/Computer control is determined by the setting of a DPDT switch connected to the select line of one of the 74157s. Another data selector chooses from either up or down pulses being supplied from the computer. The multiprogrammer pulse train card sends pulses out on one of two lines depending on which rotation direction is desired. These pulses are distinguished by which line is active. A 74123 One Shot is triggered by the pulses and acts as a timer for the select lines to the data selector. This ensures proper pulse routing and duration to the motor driver card.

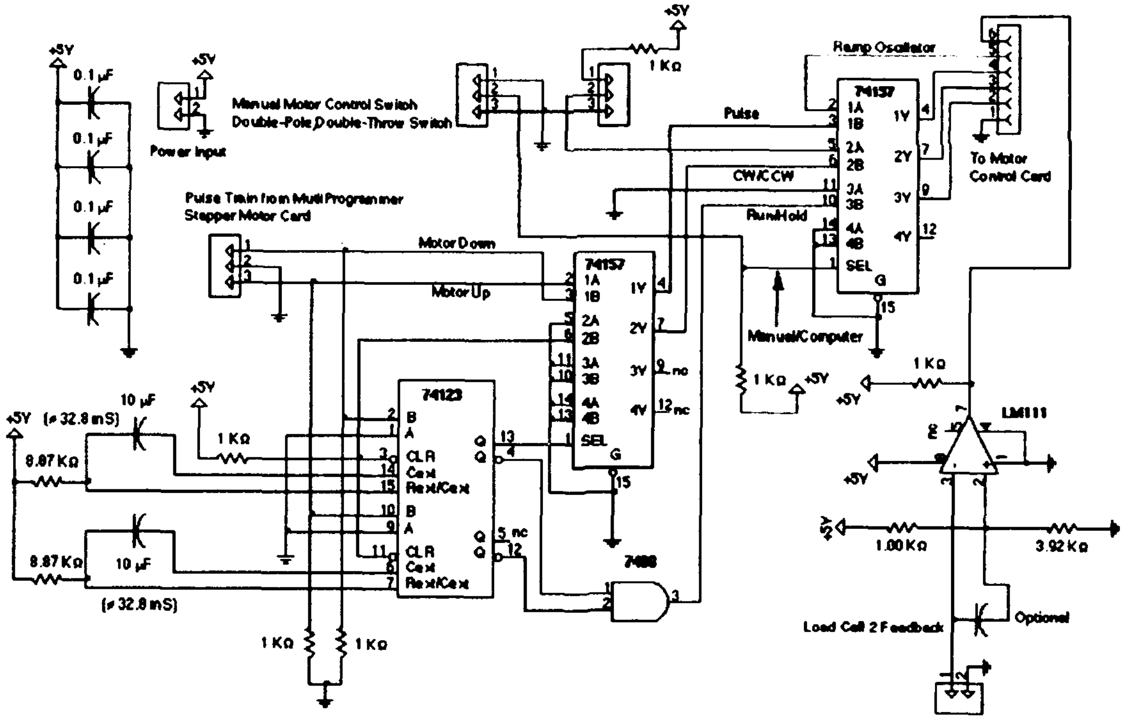


FIGURE 13 - Custom Interface Electronics

This custom interface has two special features. First, manual control automatically overrides computer control. If anything goes wrong, the motor can be controlled or shutdown manually using one of two switches. In addition, a special comparator circuit provides auto-shutdown if the load cell pressure exceeds 40 lbs of force.

6.0 EXPERIMENTAL RESULTS

The operation of the waveguide stage has been verified by the three-prism, the two-prism, and the out-of-plane scattering techniques[7]. Loss measurements using each of the techniques were taken on planar waveguides made from hexafluoro isopropylidene-polybenzoxazole (6F-PBO-1E) on oxidized Si wafers. The waveguides were fabricated by spin coating 1.0-μ-thick layers of 6F-PBO-1E on 1.4-μ-SiO_2 buffer layers on 2-and 3-inch silicon substrates. Loss measurements were taken on a 3-inch sample at a wavelength of λ = 900 nm using the out-of-plane and the three-prism and techniques for comparison. A 2-inch sample was measured using the two-prism method at a wavelength of λ = 900 nm to compare losses between samples. The resulting data for all samples were fitted to the Beer's law relationship given in equations 1 and 2. The plots of the data are shown in Figures 14 and 15. The loss for the 3-inch waveguide was found by averaging the loss for the three-prism and the out-of-plane techniques. The loss for the two-inch sample was taken from the data provided by the out-of-plane scattering technique. The average loss for the 3-inch sample was 3.93±.565 dB/cm and the measured loss for the 2-inch sample was 3.523 dB/cm.

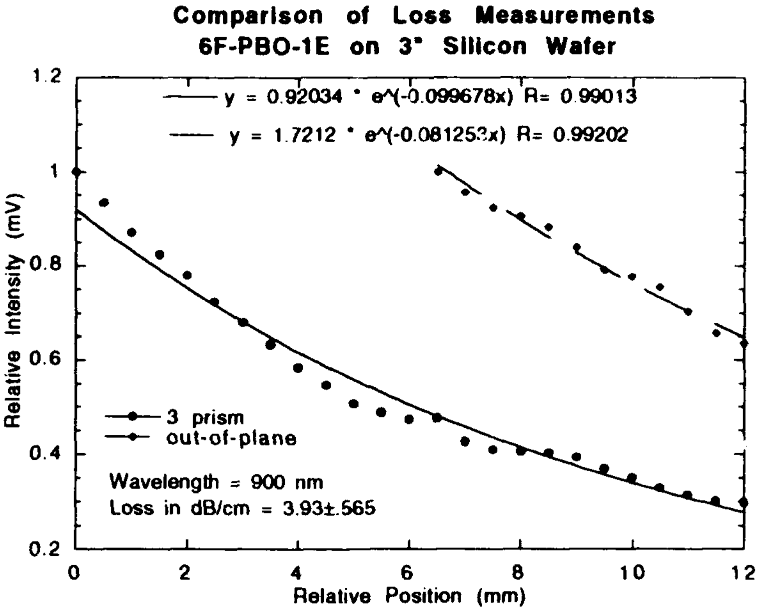


FIGURE 14 - Three-Inch Sample Measurements

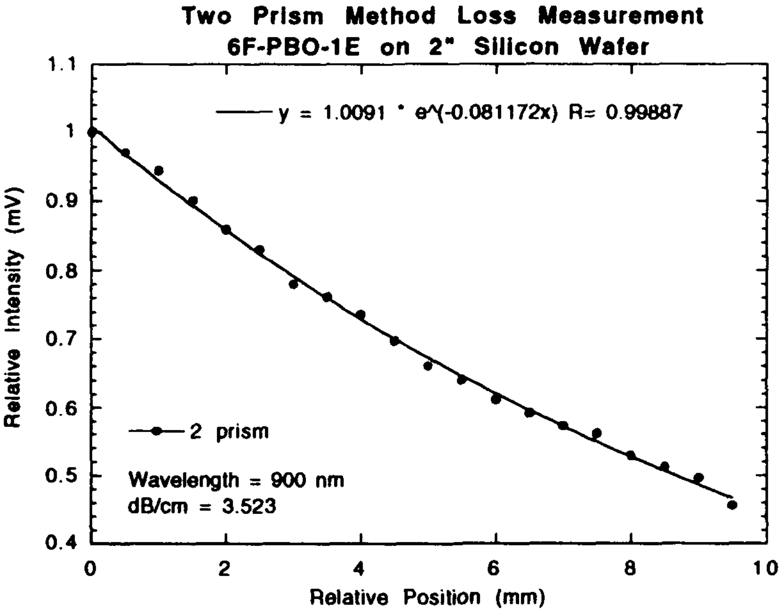


FIGURE 15 - Two-Inch Sample Measurement

7.0 REFERENCES

1. R. G. Hunsperger, Integrated Optics: Theory and Technology, Second edition, Springer-Verlag, Berlin, Heidelberg, New York, Tokyo (1984)

2. Y. H. Won, P. C. Jaussaud, and G. H. Chartier, Appl. Phys. Lett., 37, p269 (1980)

3. Hamamatsu Photodiode Product Catalog CR-3000, pp14-15, (May 1990)

4. Hamamatsu Photodiode Product Catalog CR-3000, p4, (May 1990)

5. Hamamatsu Photodiode Product Catalog CR-3000, p4, (May 1990)

6. Daniel H. Sheingold, ed., Transducer Interfacing Handbook, p16-21, Analog Devices Inc., Norwood MA, 1981

7. Angela L. McPherson, and Jeffery W. Baur, "Guided Wave Loss Measurements for End-capped 6F-Polybenzoxazole," unpublished work

APPENDIX A - ELECTRONIC SCHEMATICS

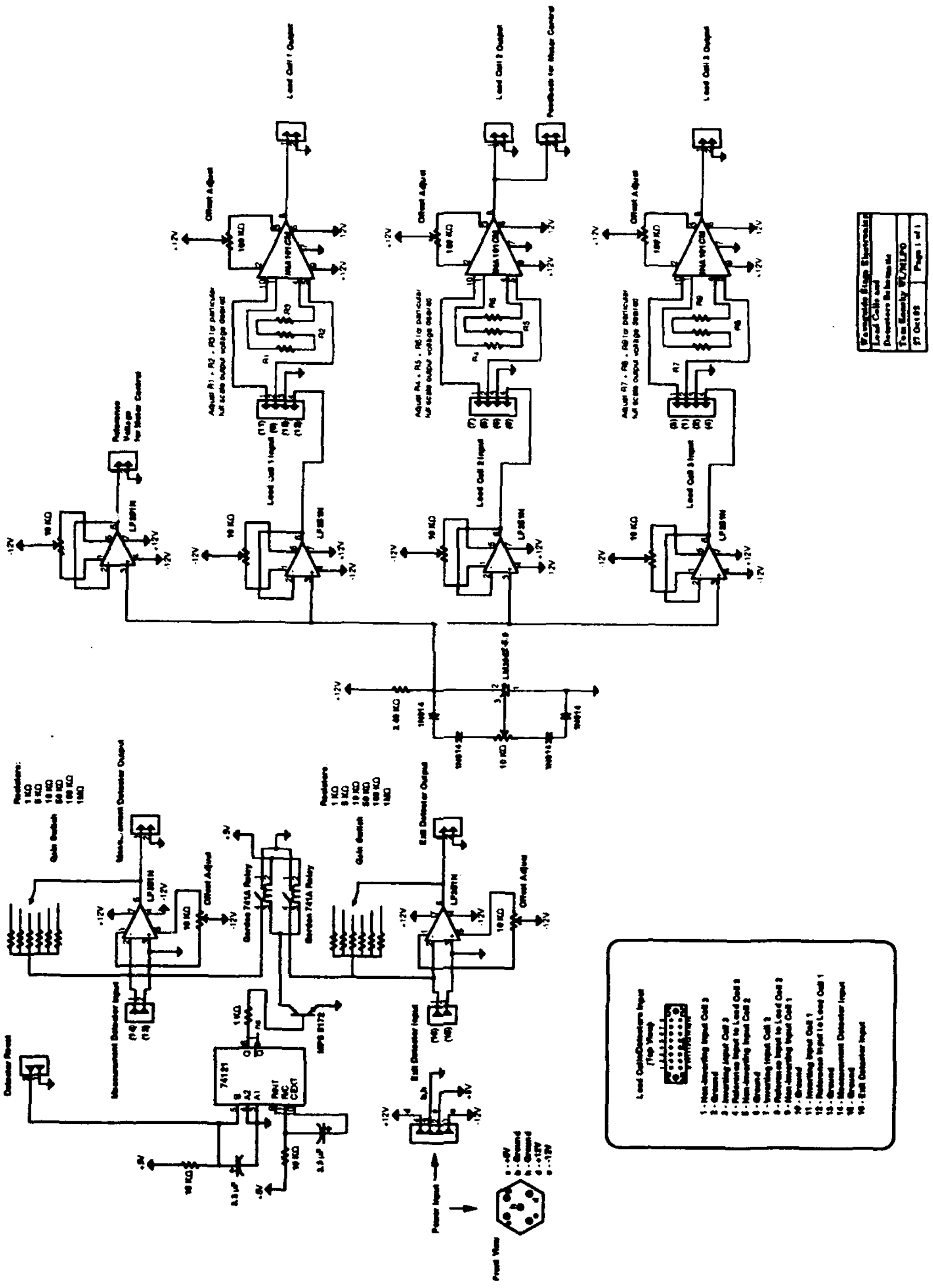


FIGURE 16 - Load Cells and Detectors Schematic

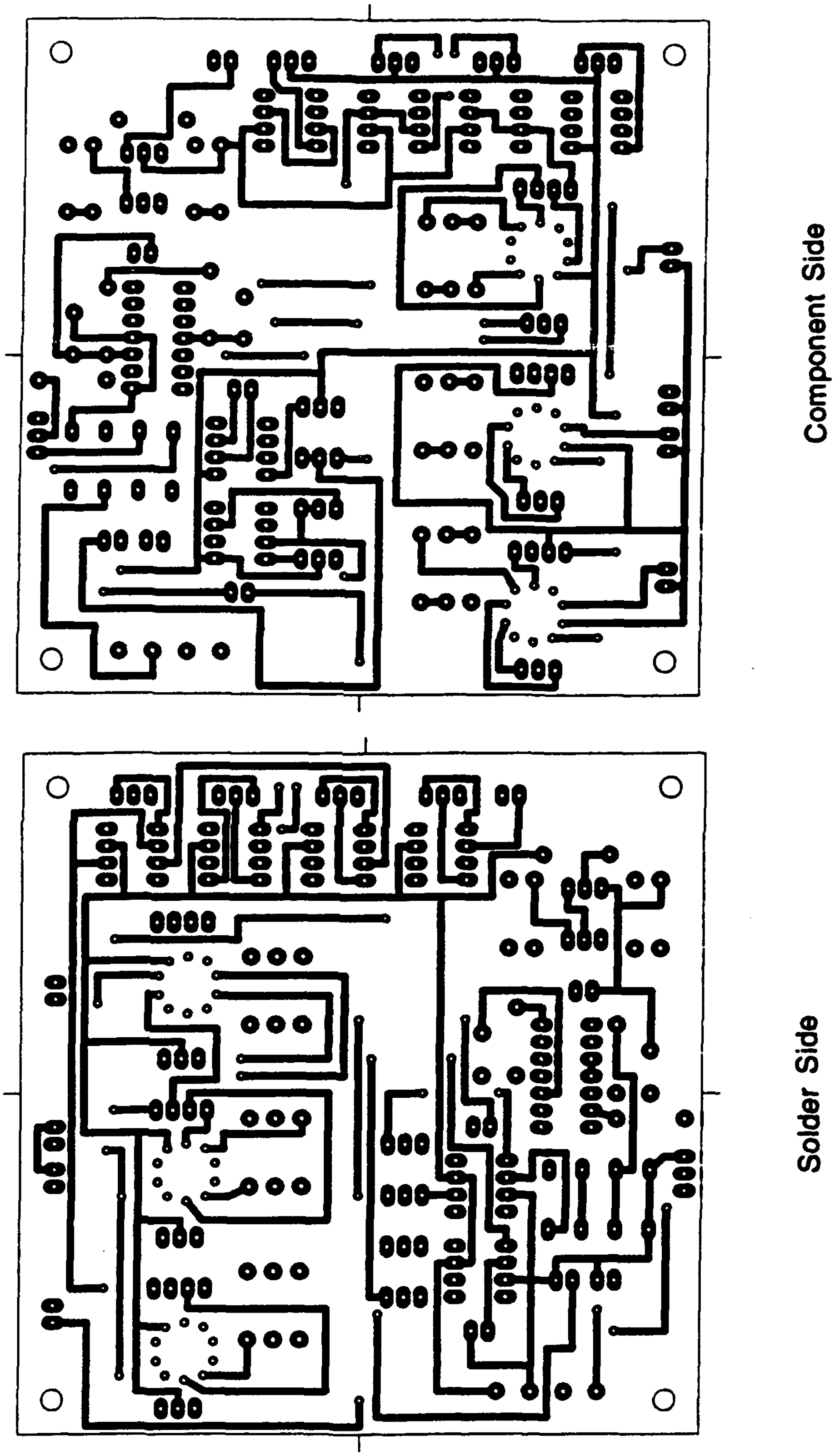


FIGURE 17 - Load Cells/Detectors Printed Circuit Board

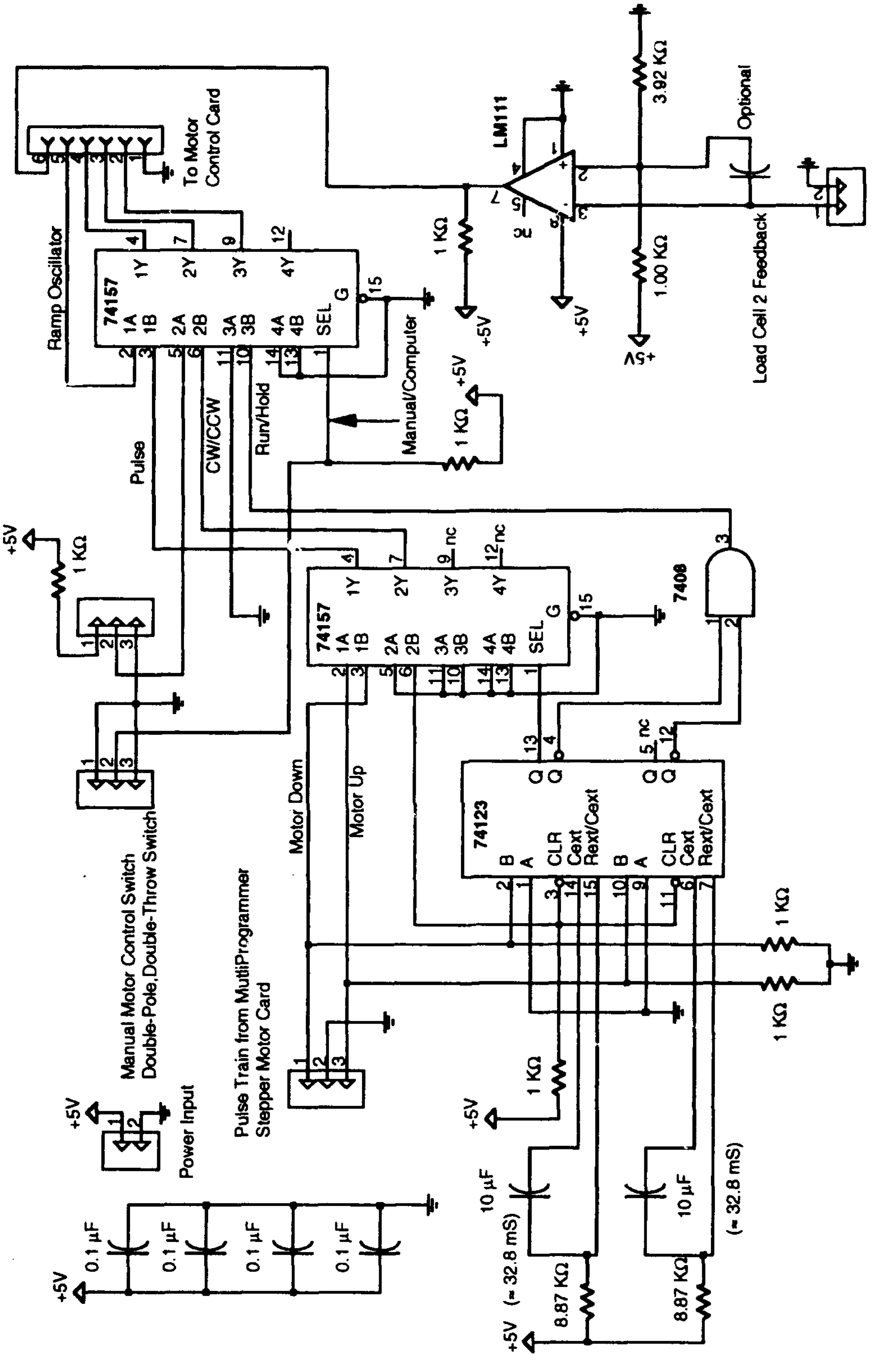
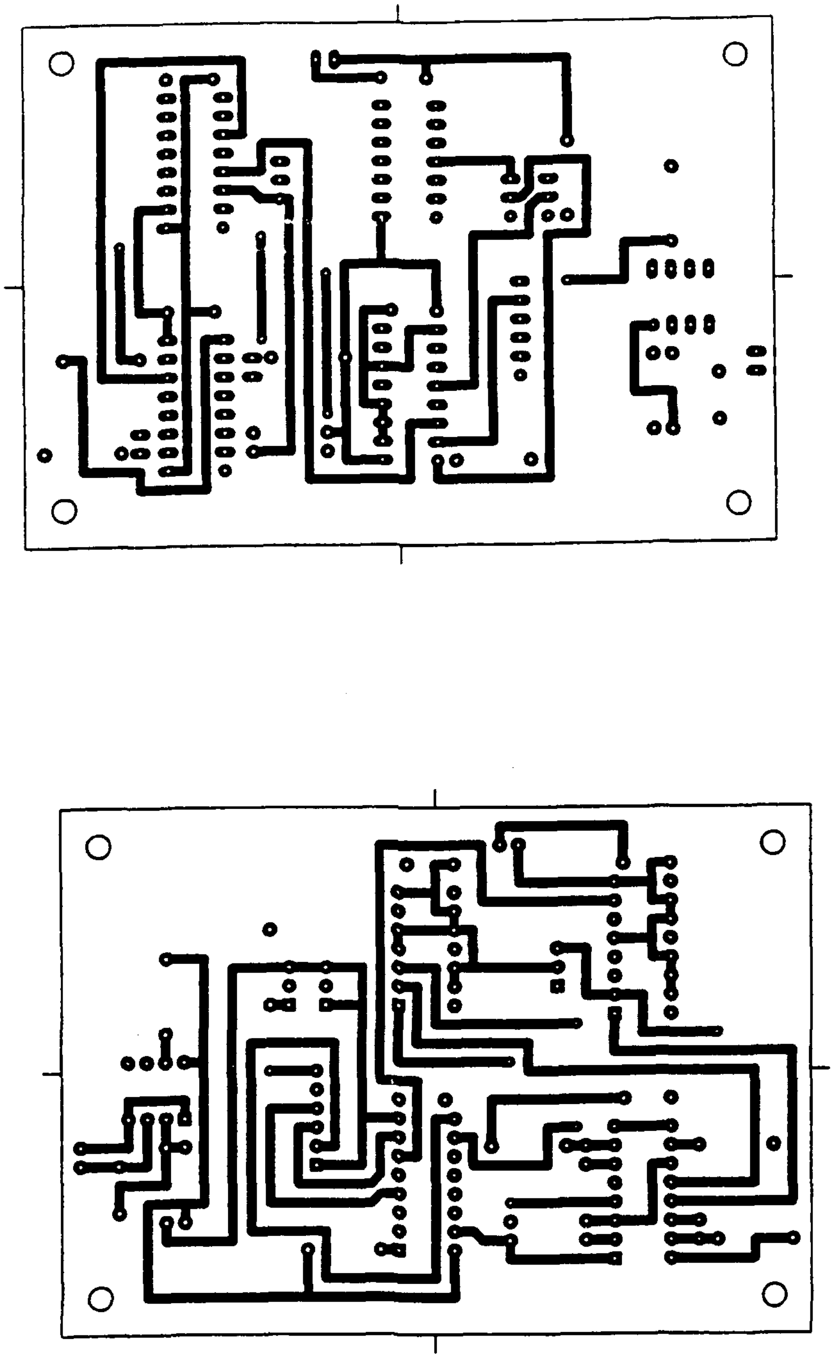


FIGURE 18 - Measurement Arm Stepper Motor Interface

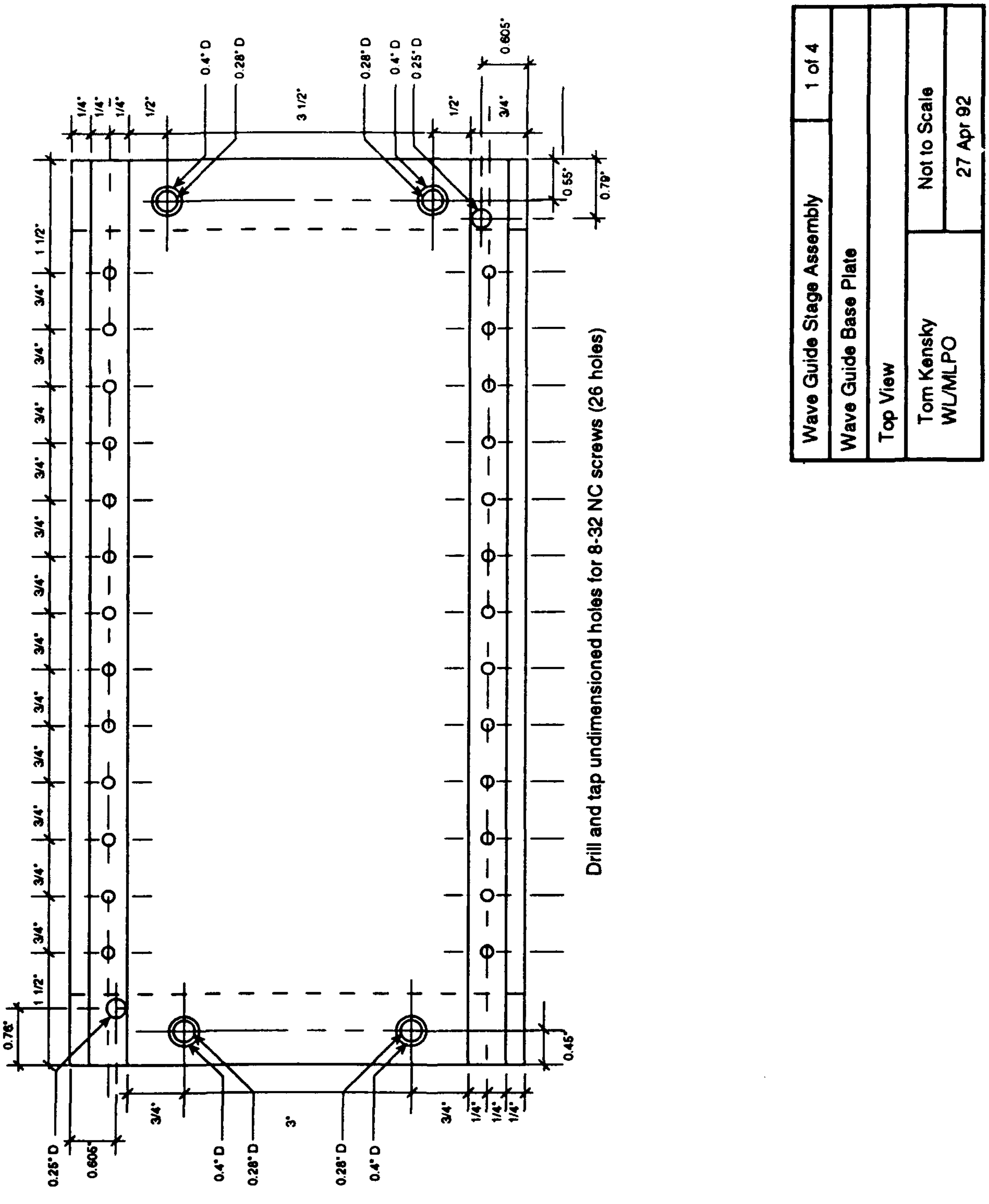


Component Side

Solder Side

FIGURE 19 - Meas. Arm Stepper Motor Printed Circuit Board

APPENDIX B - MECHANICAL DRAWINGS



Drill and tap undimensioned holes for 8-32 NC screws (26 holes)

FIGURE 20 - Base Plate Top View

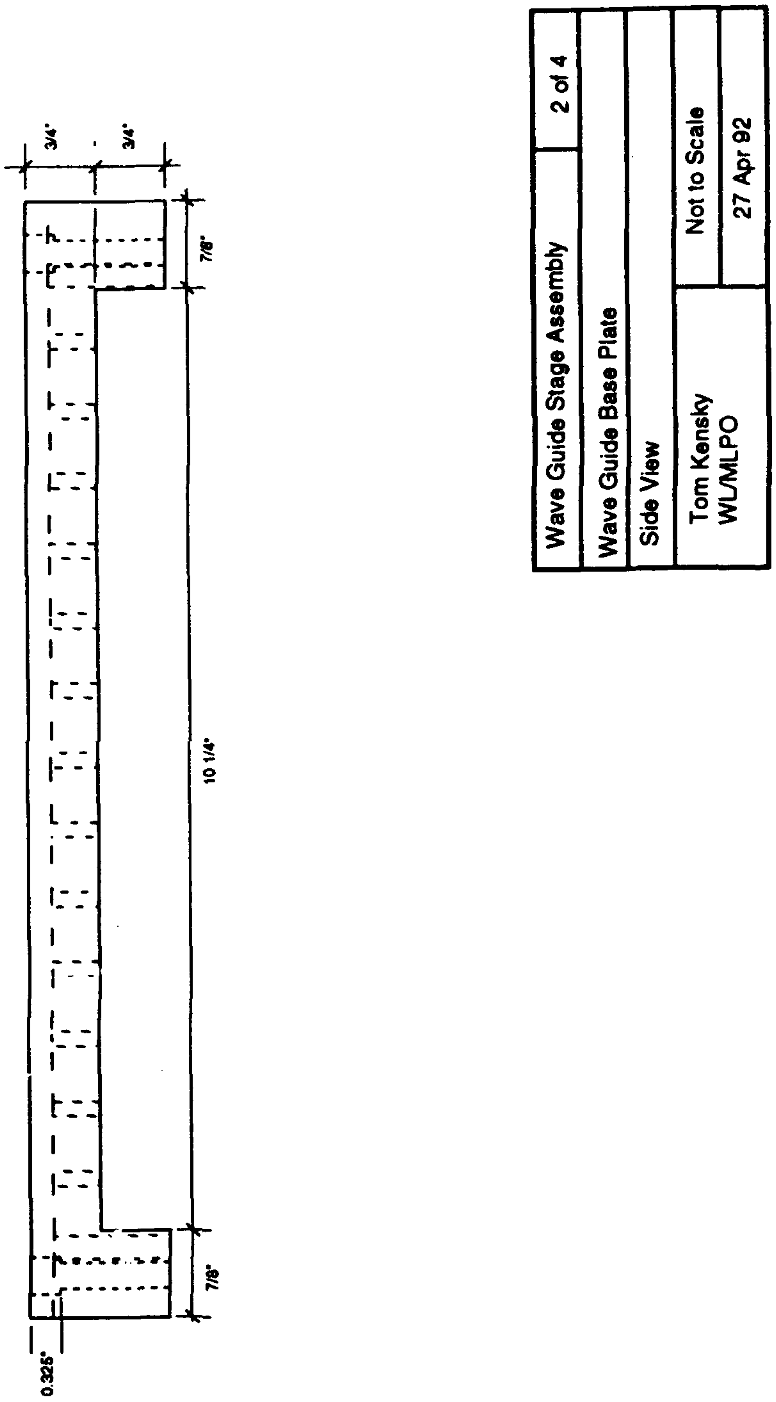
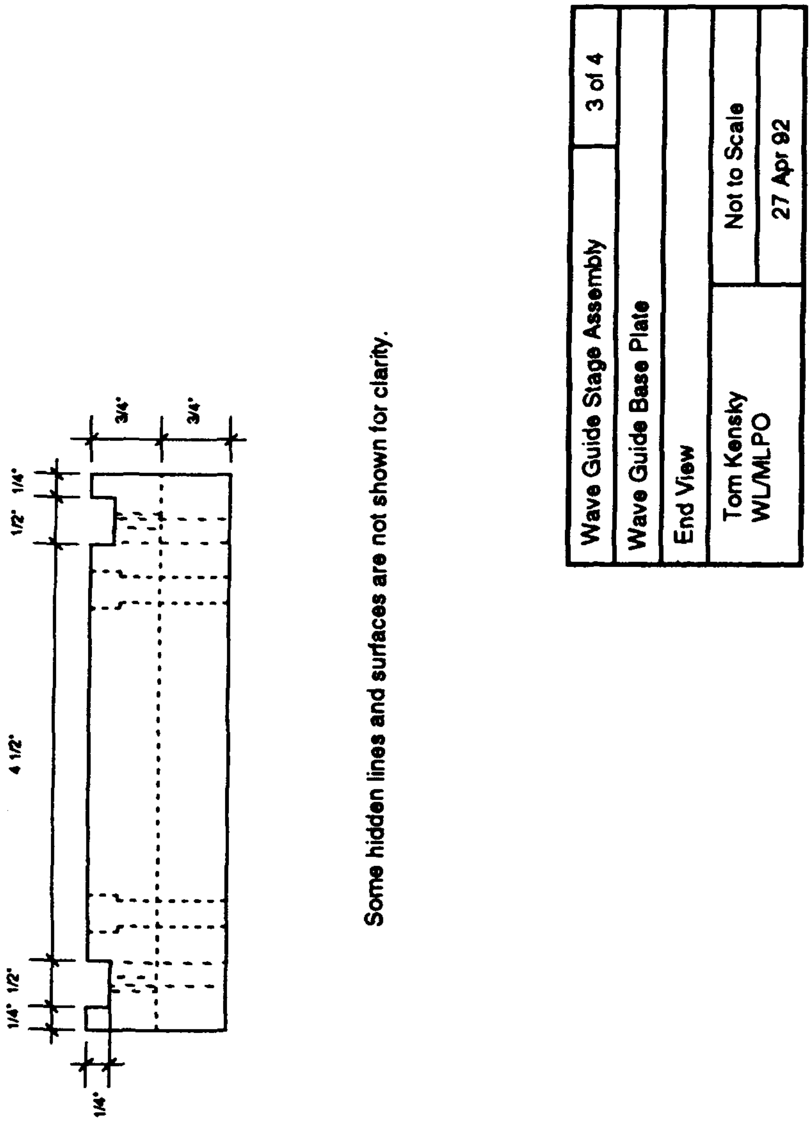


FIGURE 21 - Base Plate Side View



Some hidden lines and surfaces are not shown for clarity.

FIGURE 22 - Base Plate End View

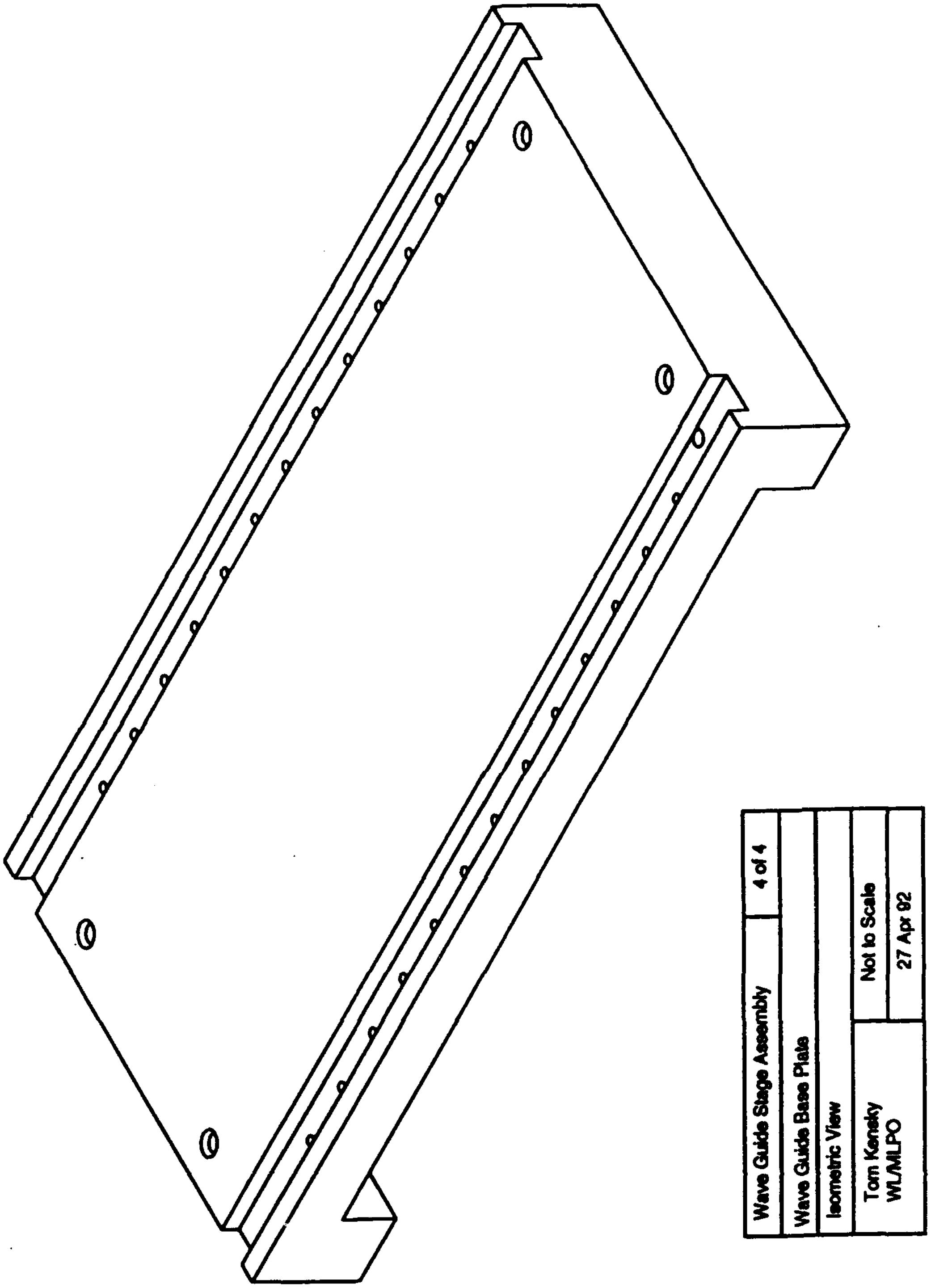


FIGURE 23 - Base Plate Isometric View

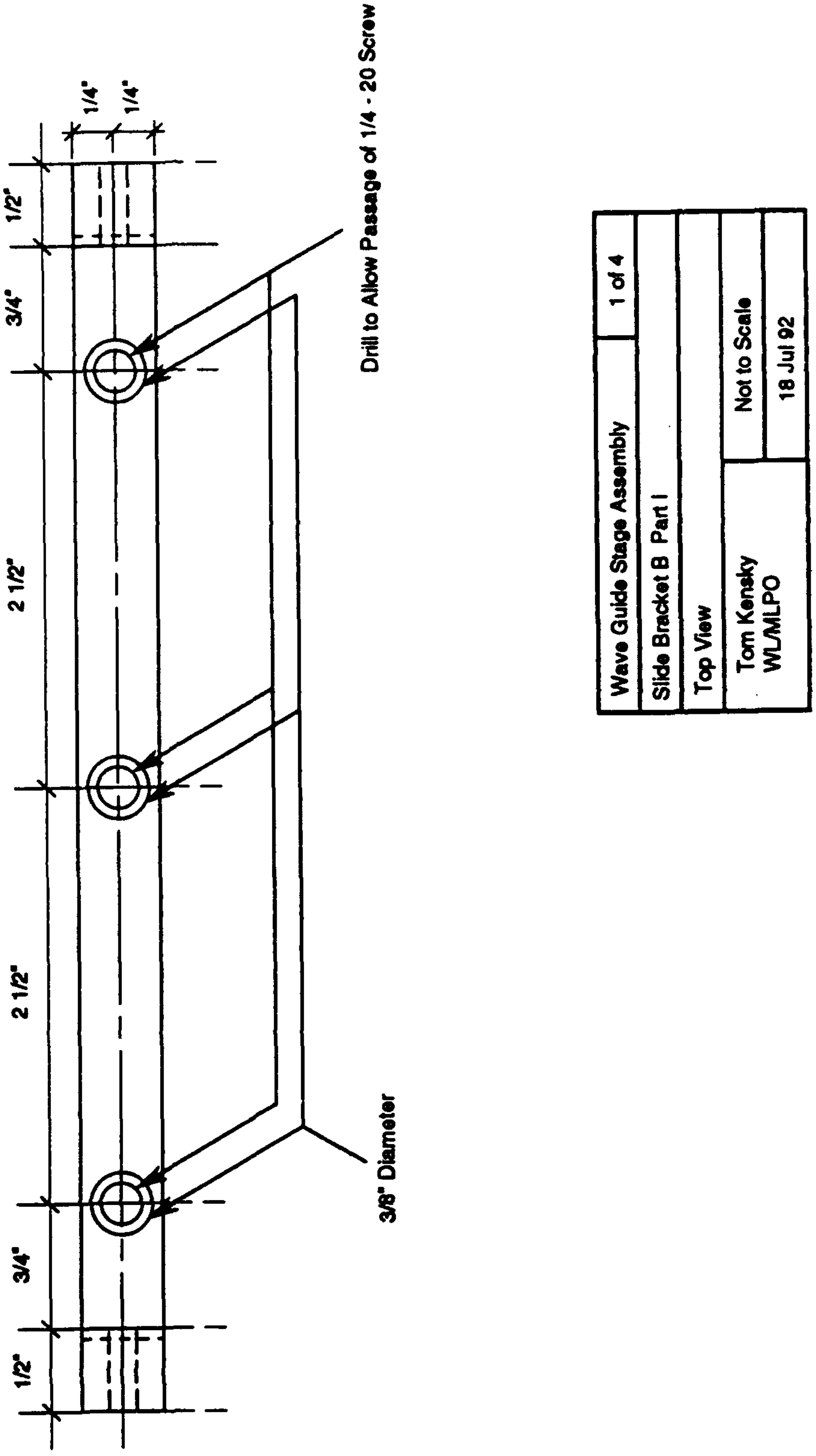
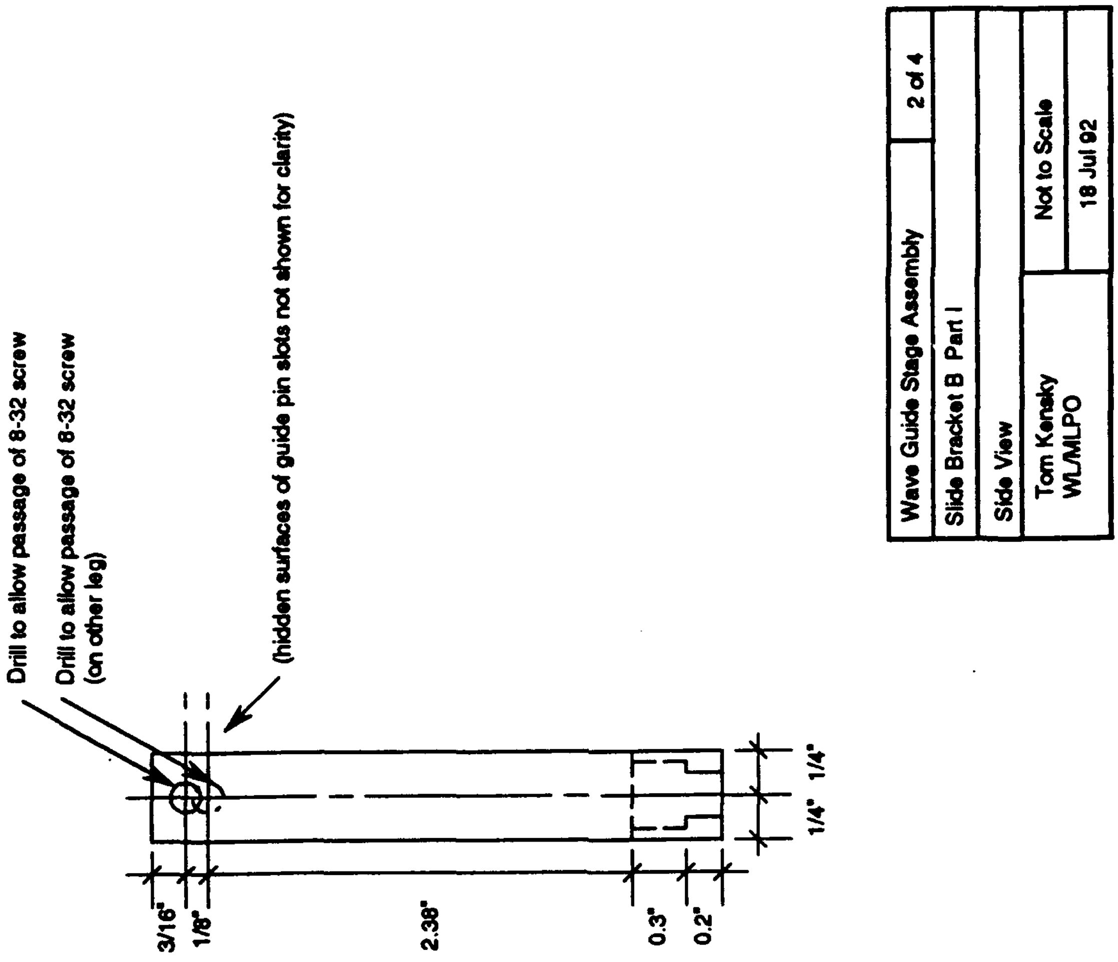


FIGURE 24 - Slide Bracket B I Top View


Drill to allow passage of 8-32 screw

Drill to allow passage of 8-32 screw (on other leg)

(hidden surfaces of guide pin slots not shown for clarity)

FIGURE 25 - Slide Bracket B I Side View

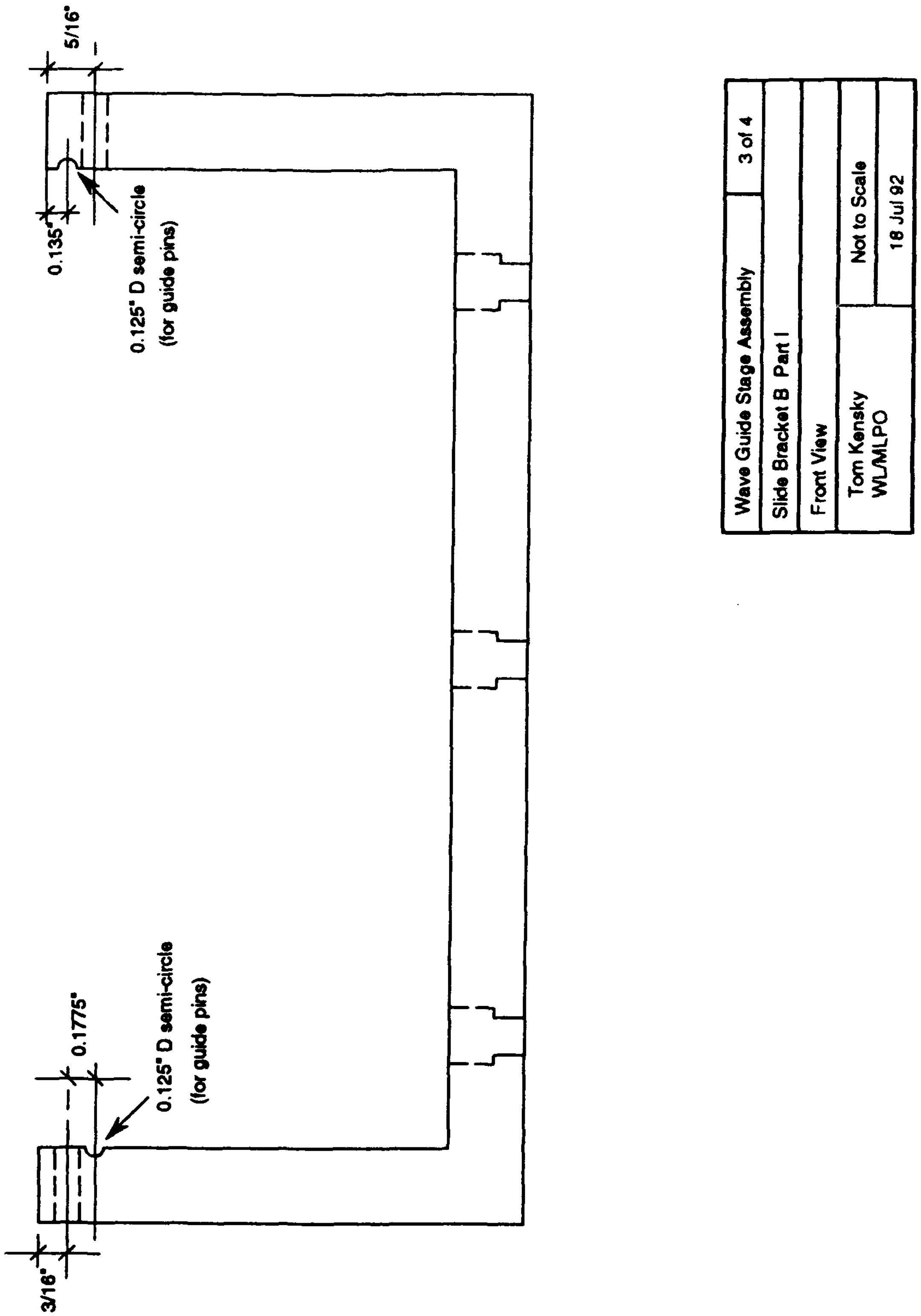


FIGURE 26 - Slide Bracket B I Front View

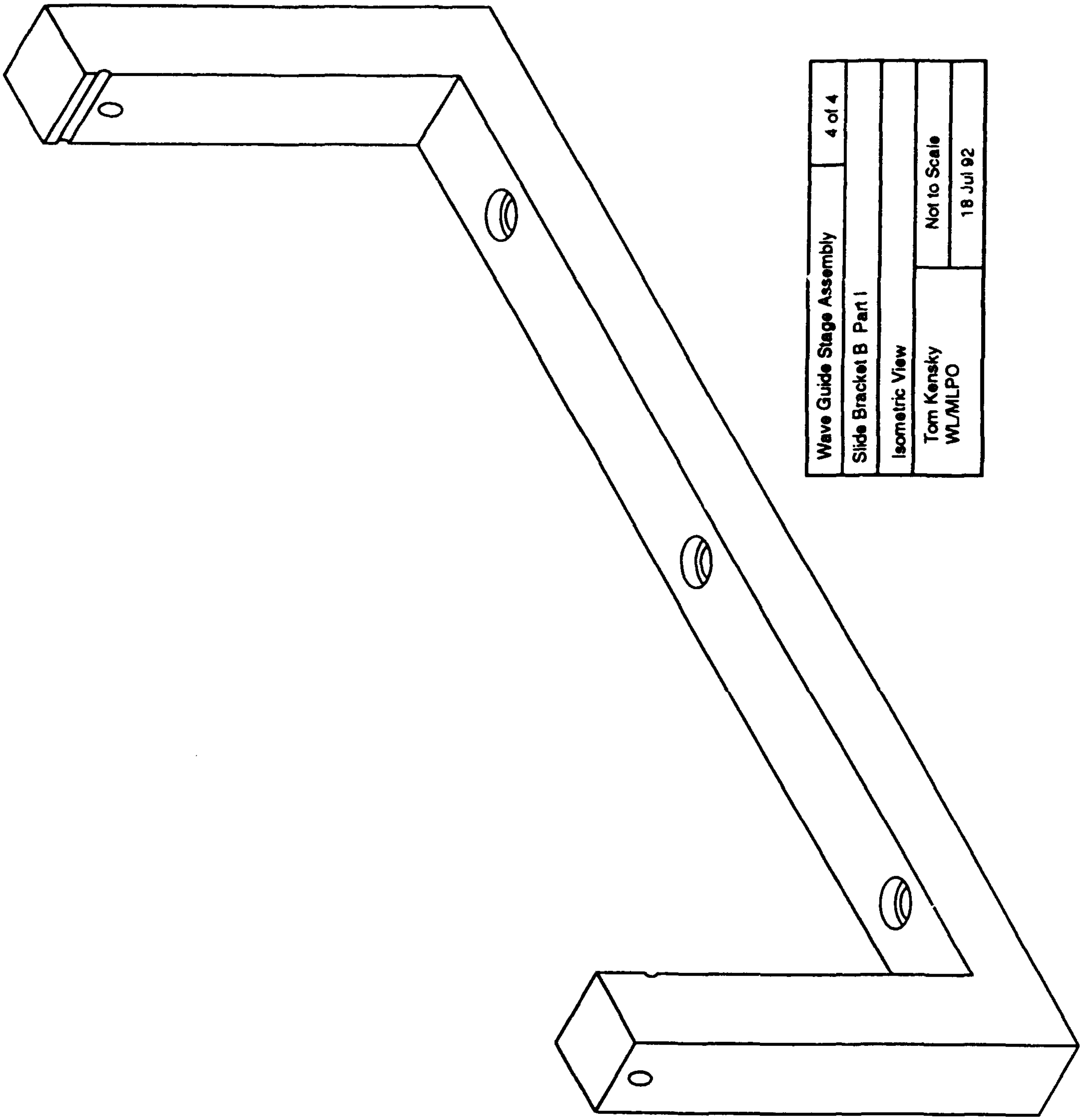
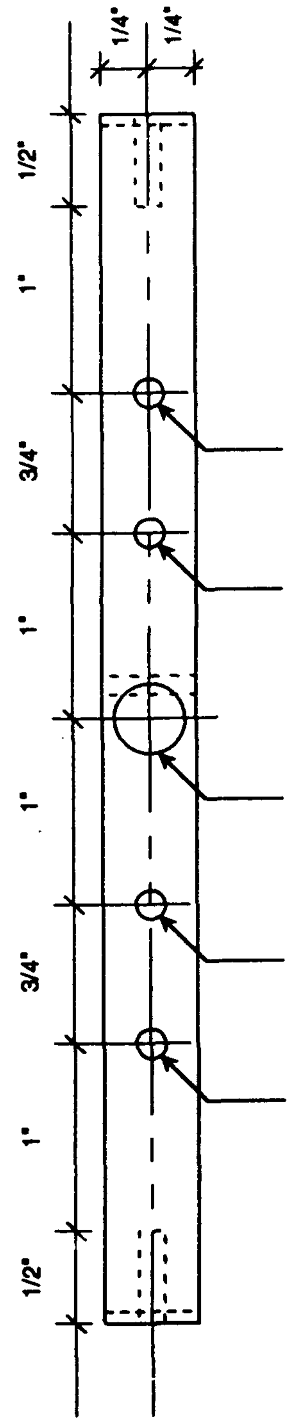


FIGURE 27 - Slide Bracket B I Isometric View



Drill to allow press fit of a 5/32" steel rod

Drill to allow slip fit of a 5/32" steel rod

Drill to allow press fit of a 3/8"
dia. micrometer screw assembly

Drill to allow slip fit of a 5/32" steel rod

Drill to allow press fit of a 5/32" steel rod

Wave Guide Stage Assembly	1 of 4
Slide Bracket B Part II	
Top View	
Tom Kensky WL/MLPO	Not to Scale 18 Jul 92

FIGURE 28 - Slide Bracket B II Top View

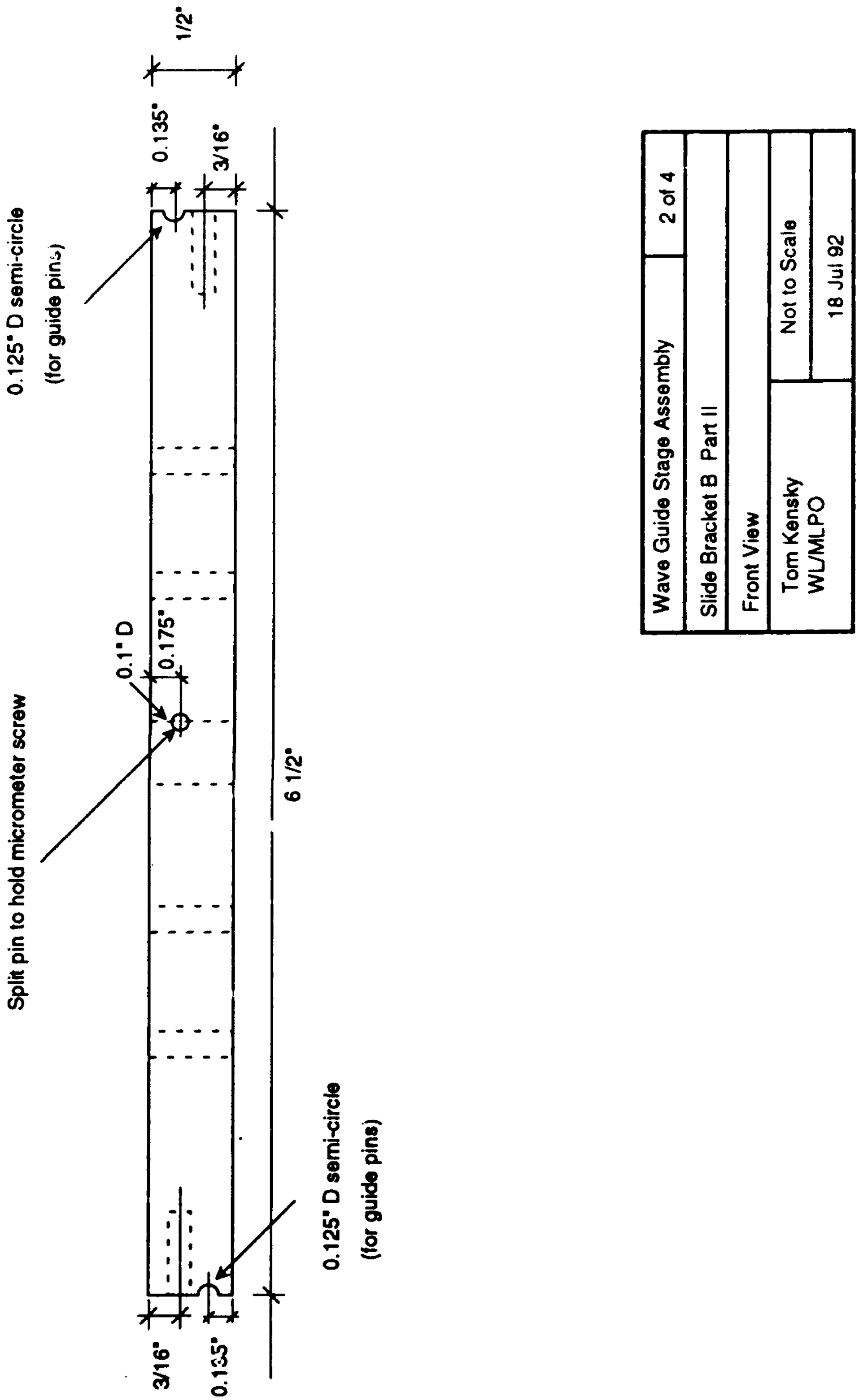


FIGURE 29 - Slide Bracket B II Front View

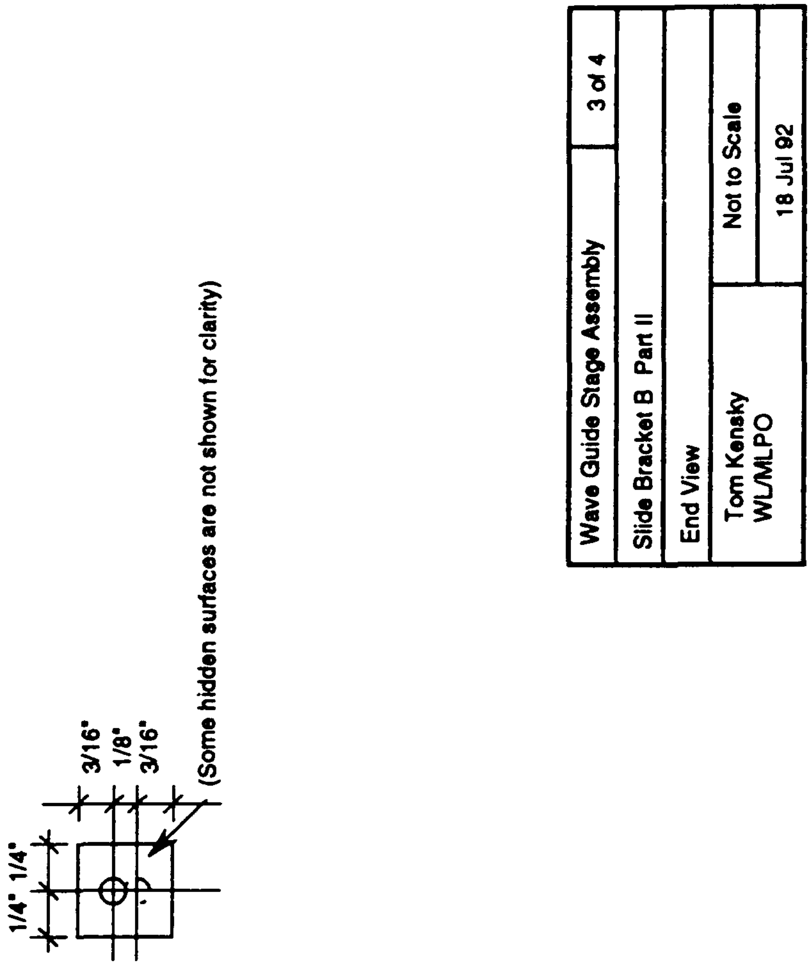
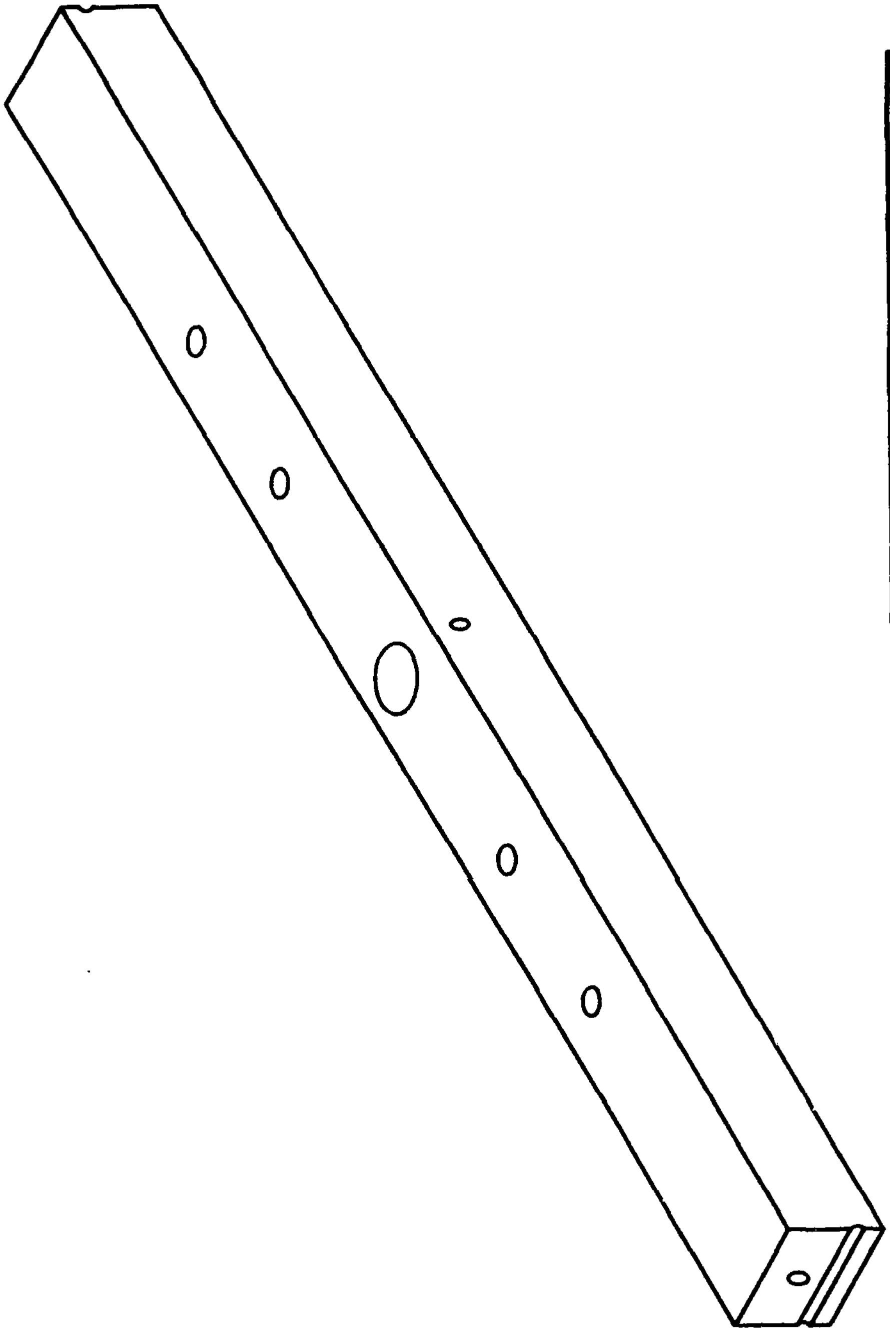
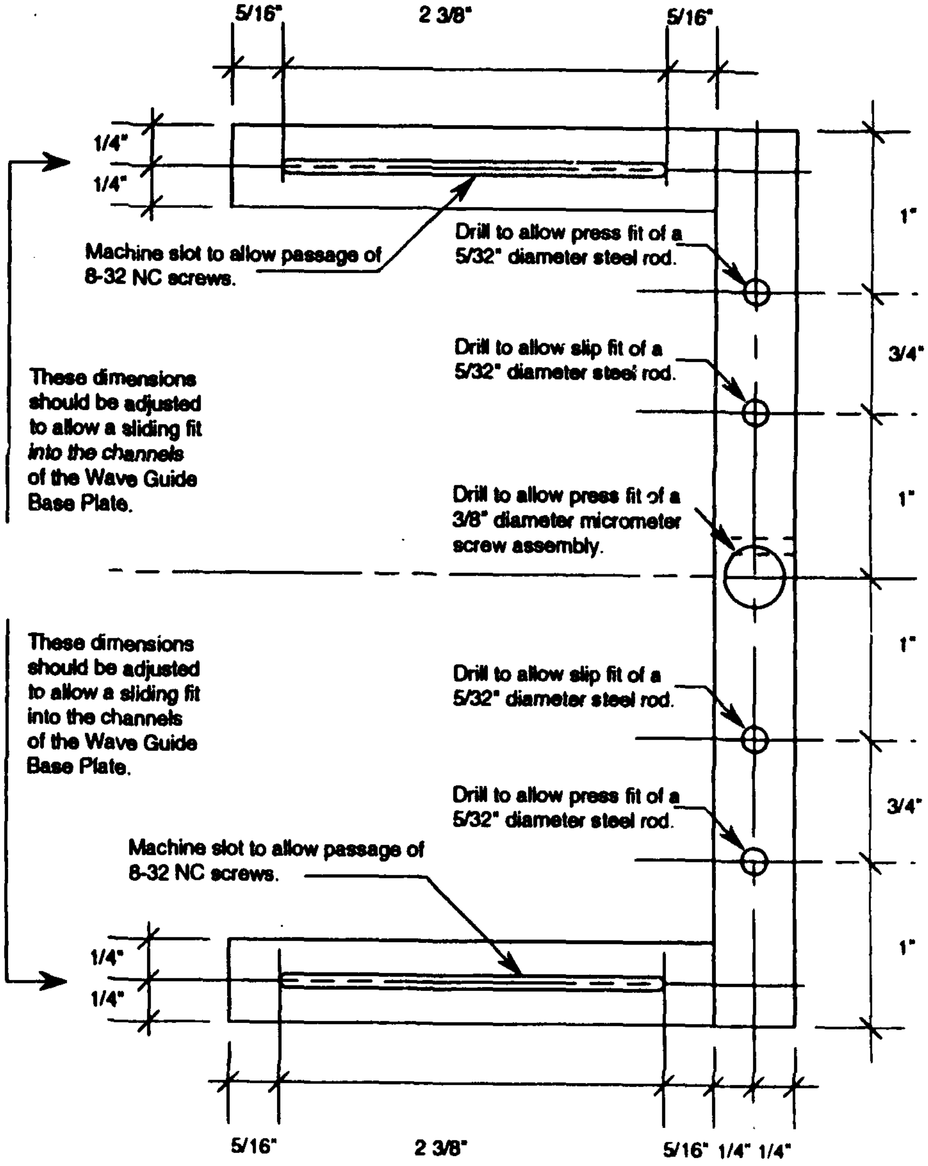


FIGURE 30 - Slide Bracket B II End View



Wave Guide Stage Assembly	4 of 4
Slide Bracket B Part II	
Isometric View	
Tom Kensky WL/MLPO	Not to Scale
	18 Jul 92

FIGURE 31 - Slide Bracket B II Isometric View



Wave Guide Stage Assembly	1 of 4
Slide Bracket A	
Top View	
Tom Kensky WL/MLPO	Not to Scale 21 Jul 92

FIGURE 32 - Slide Bracket A Top View

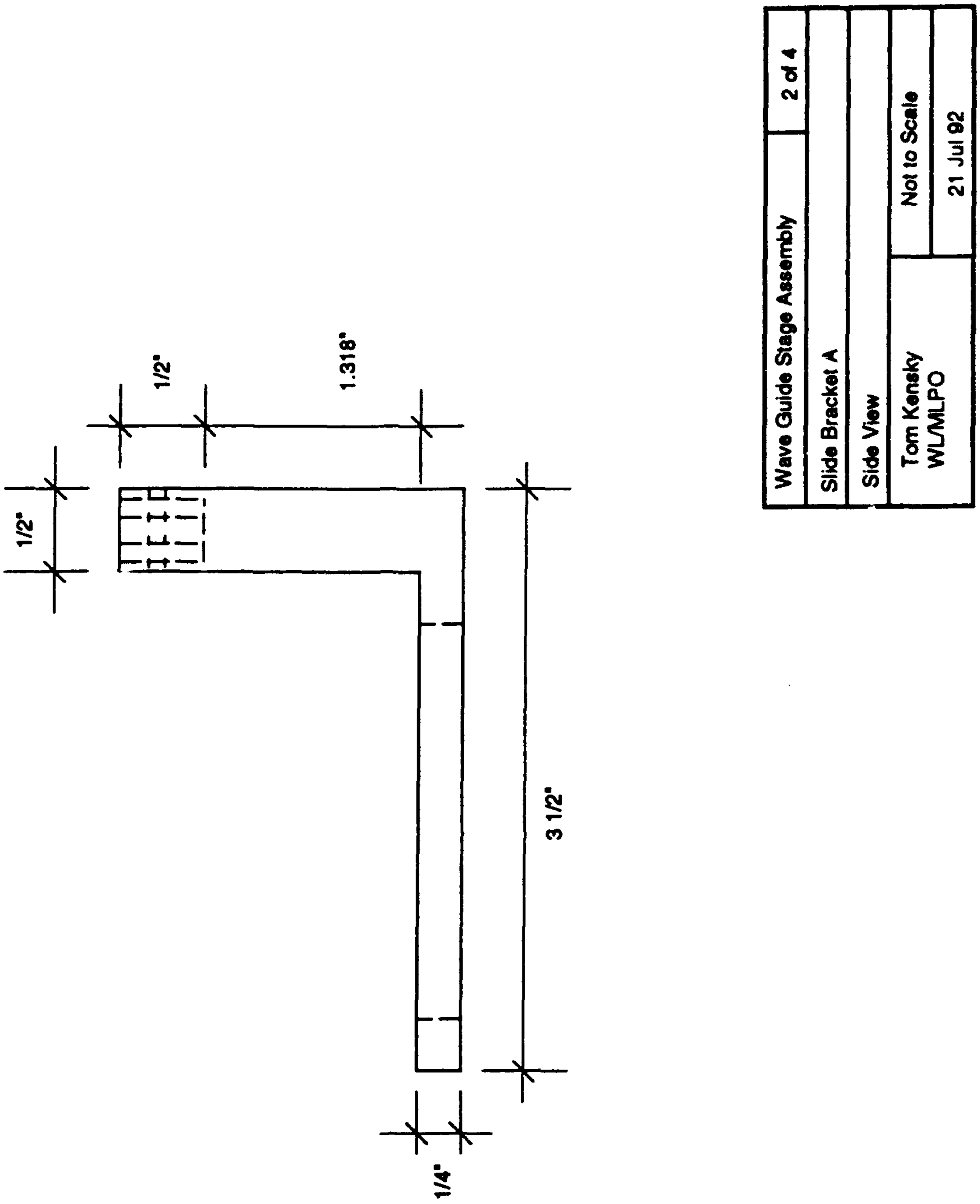


FIGURE 33 - Slide Bracket A Side View

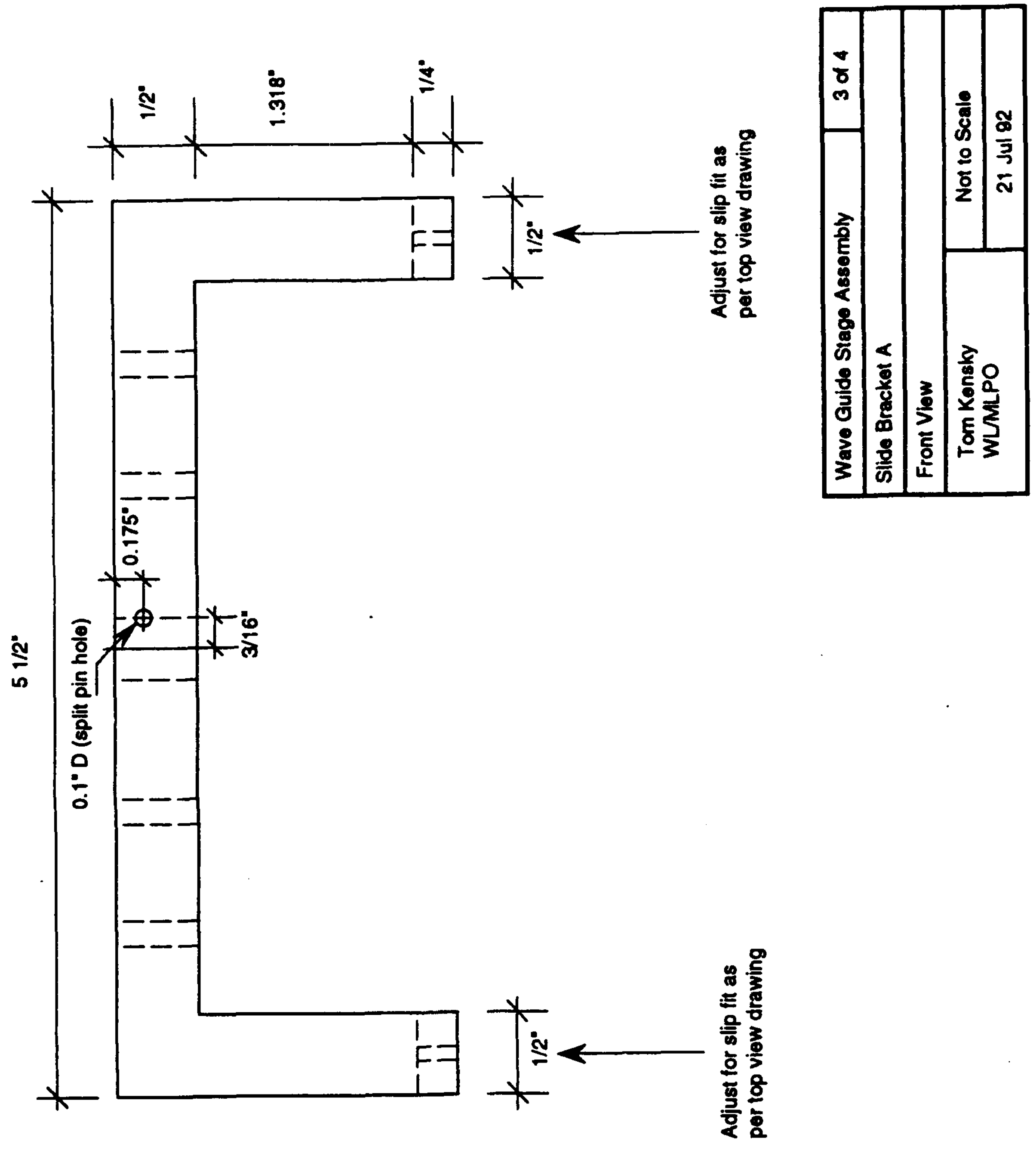


FIGURE 34 - Slide Bracket A Front View

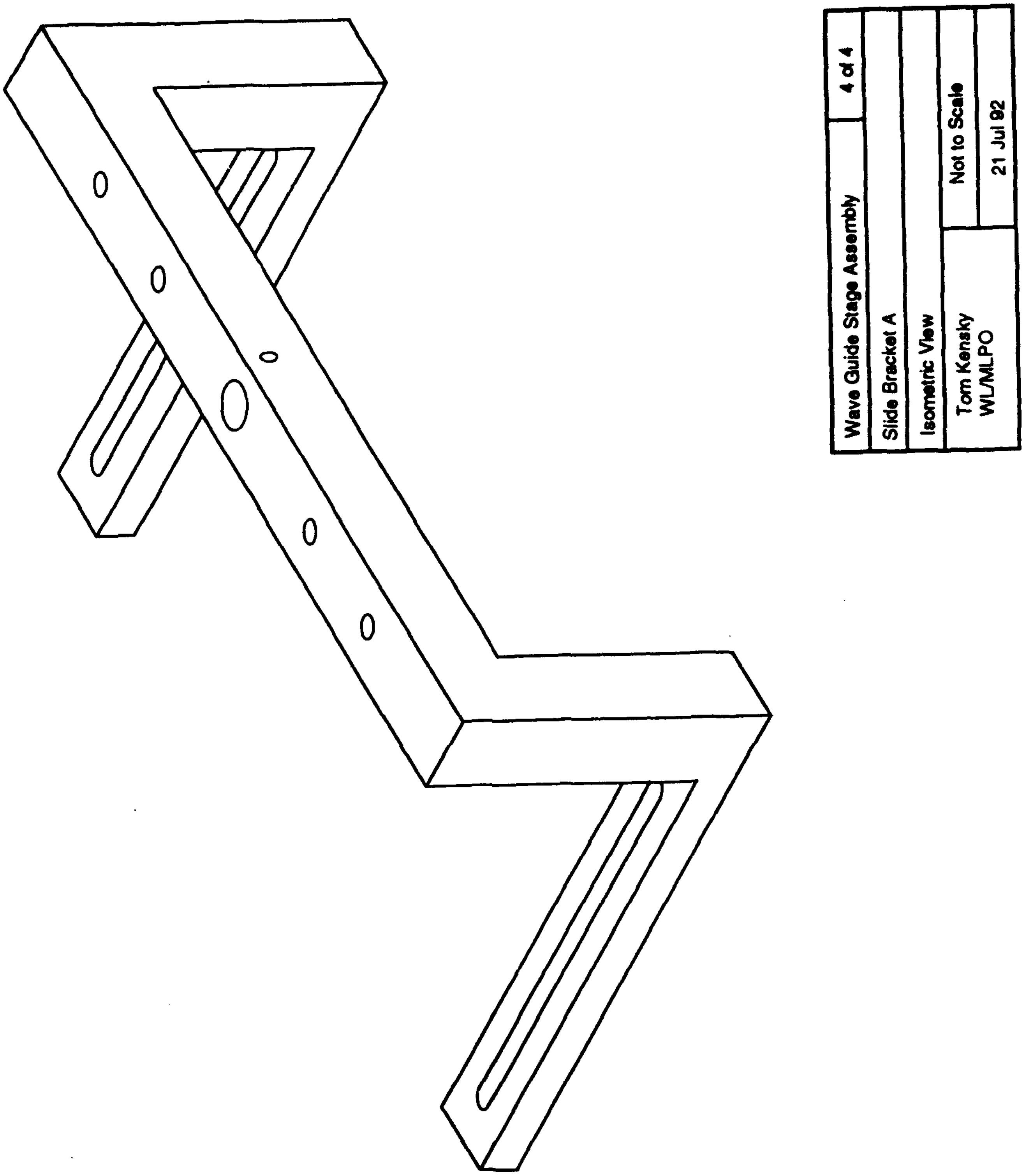
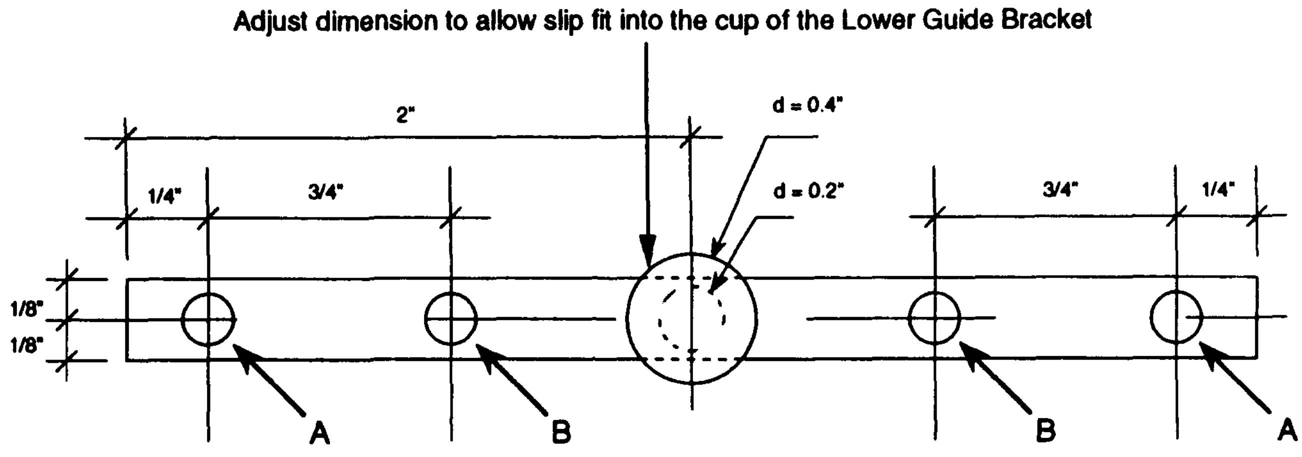


FIGURE 35 - Slide Bracket A Isometric View



A. Drill to allow sliding passage (slip fit) of 5/32" diameter steel rod.

B. Drill to allow press fit of 5/32" diameter steel rod.

Wave Guide Stage Assembly	1 of 3
Upper Guide Bracket	
Top View	
Tom Kensky WL/MLPO	Not to Scale 23 Jul 92

FIGURE 36 - Upper Guide Bracket Top View

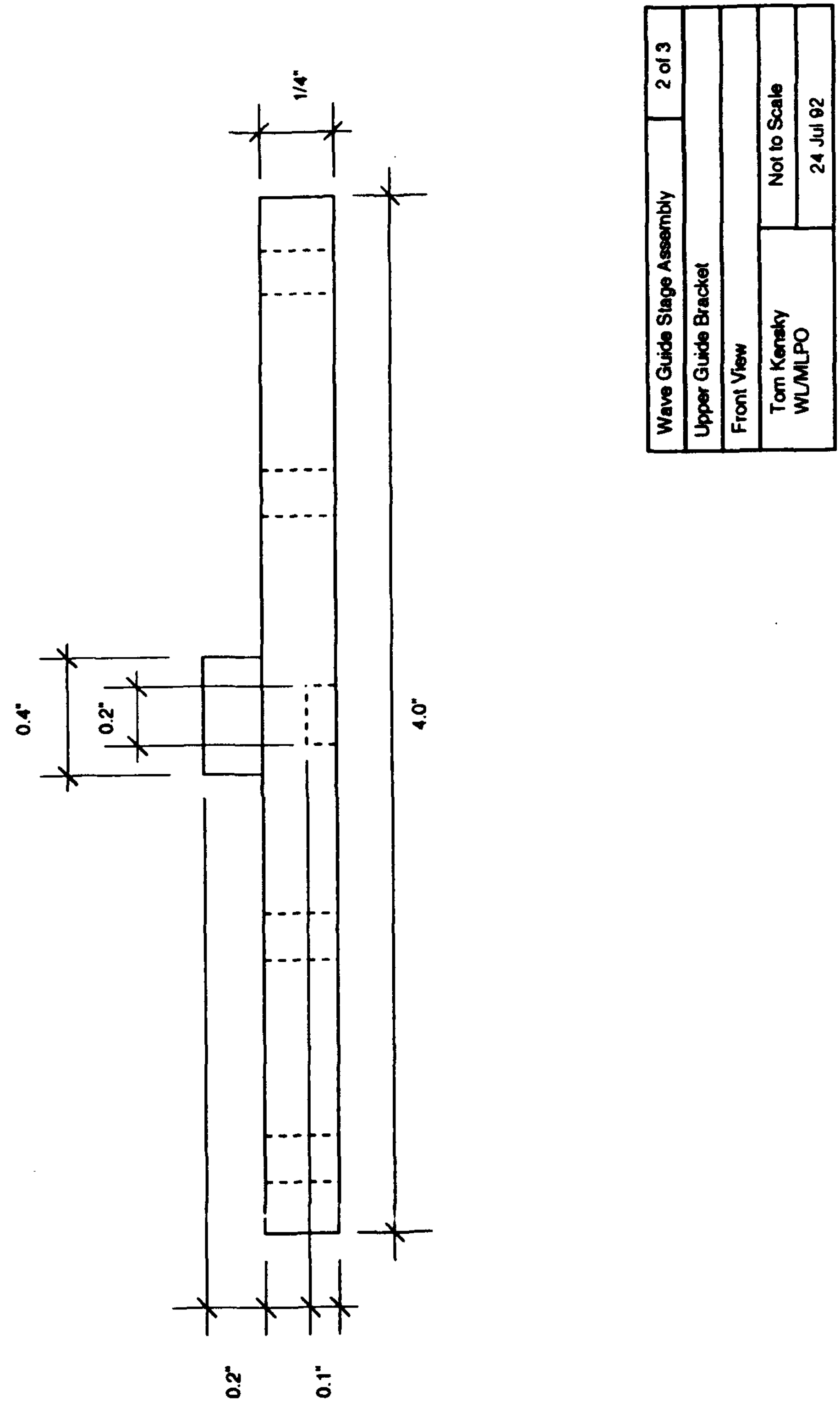


FIGURE 37 - Upper Bracket Front View

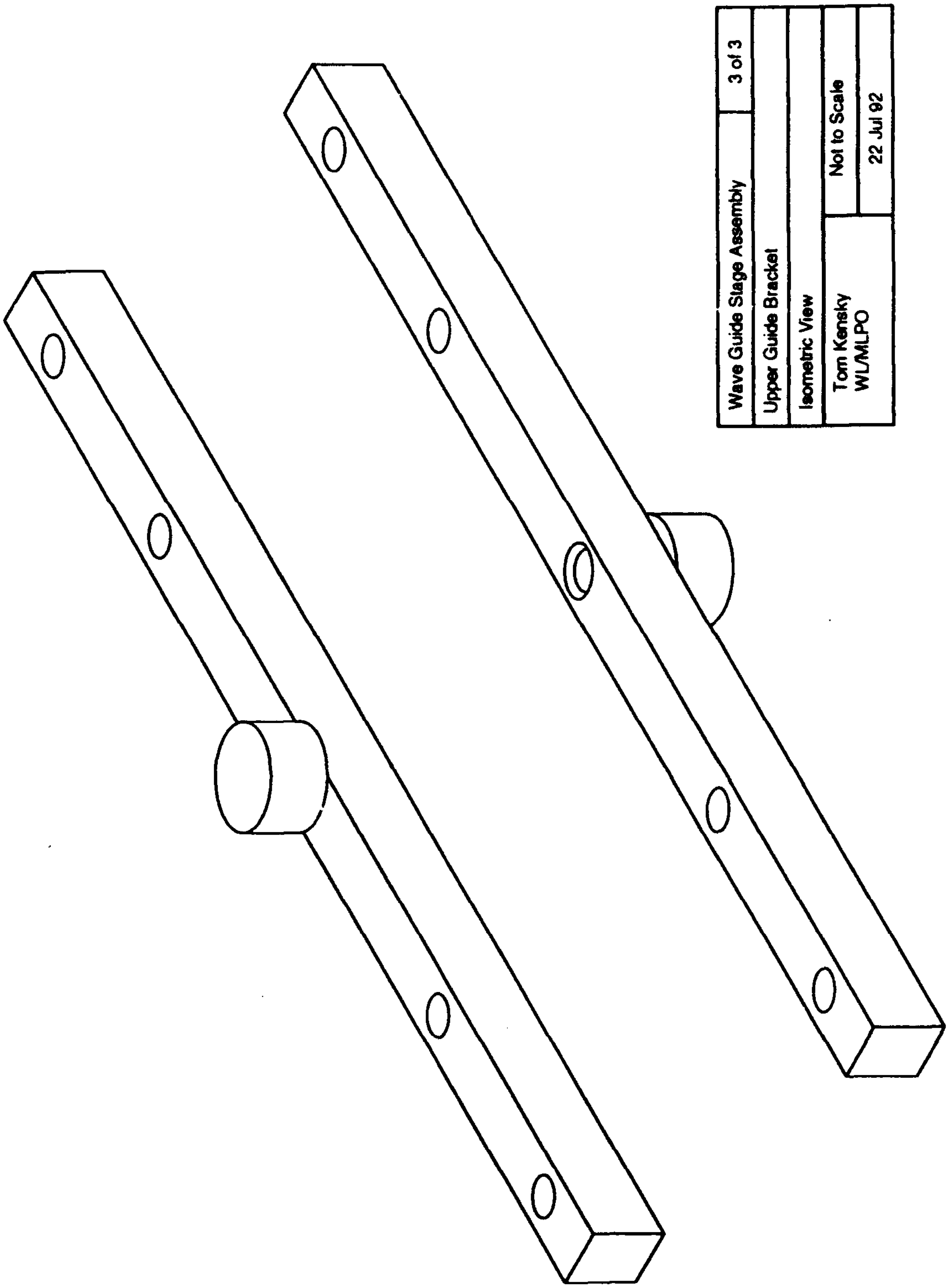
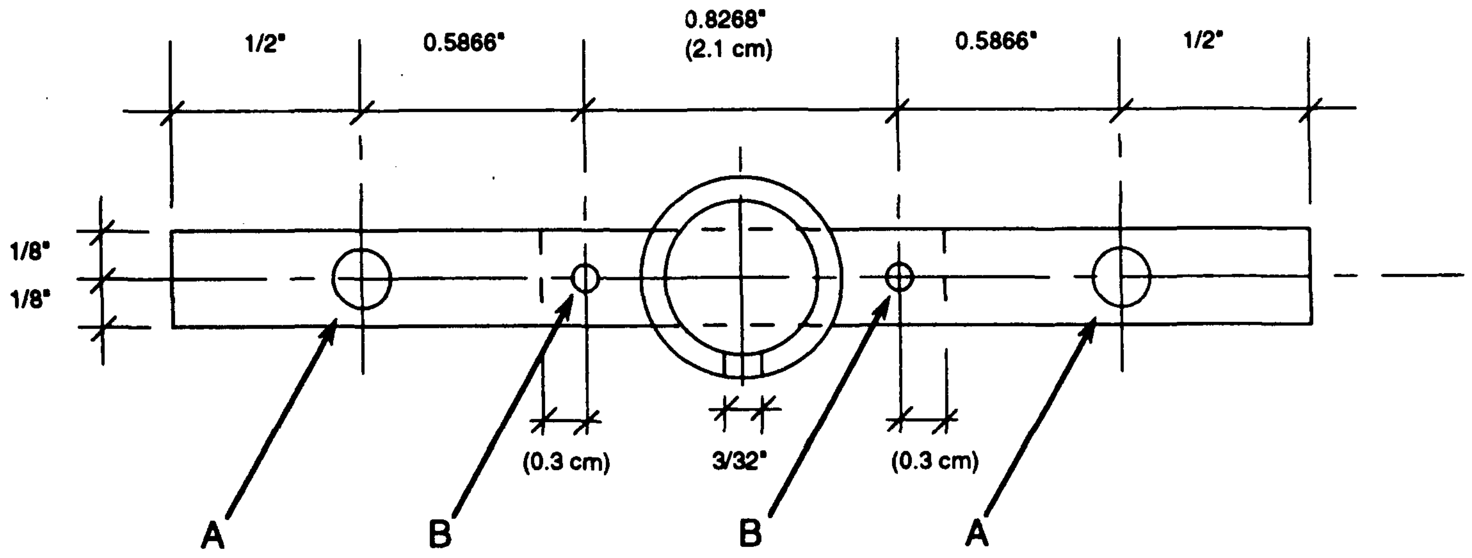


FIGURE 38 - Upper Guide Bracket Isometric View



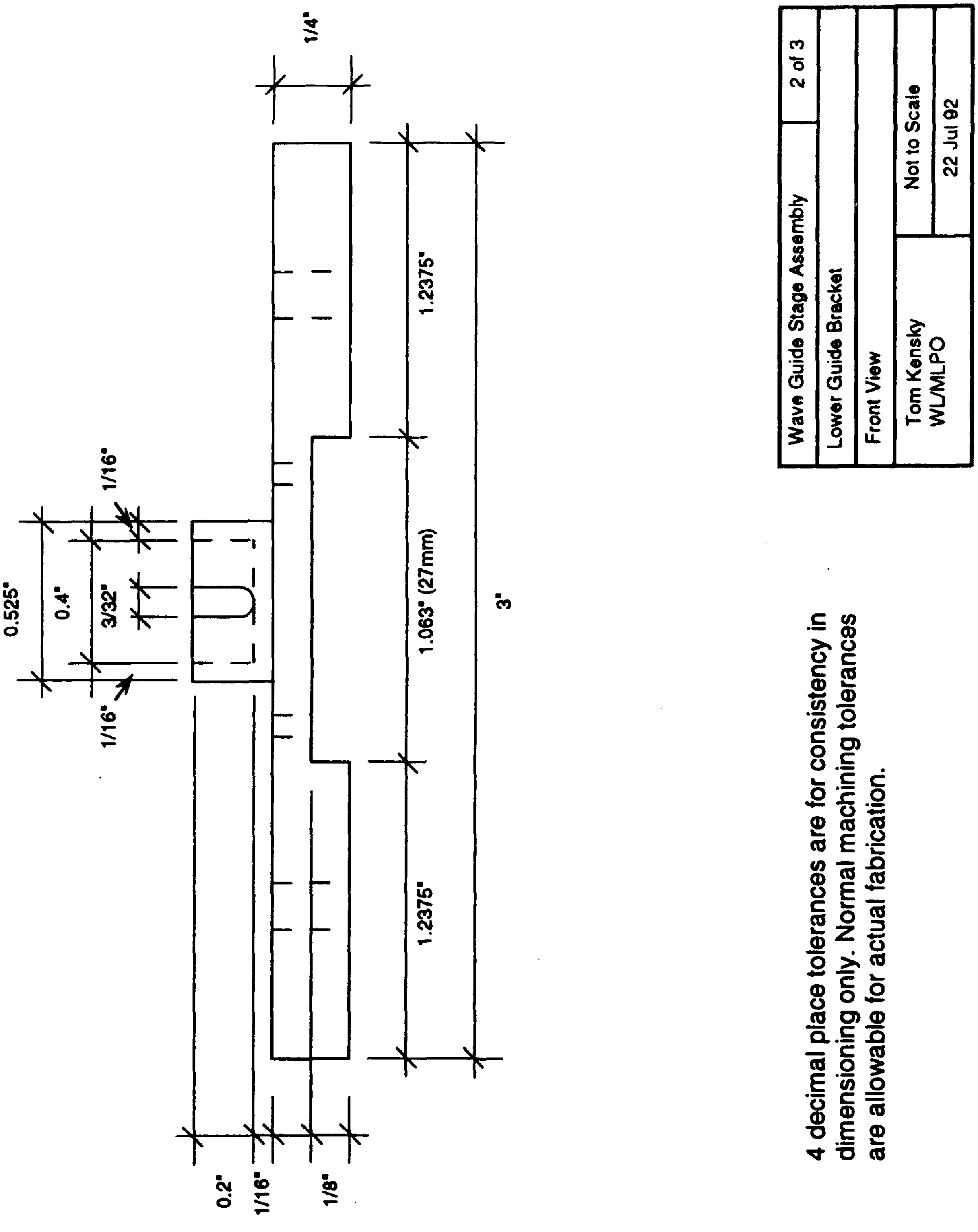
A Drill to allow slip fit of a 5/32 diameter steel rod

B Drill and tap for 2-56 NC screw.

4 decimal place tolerances are for consistency in dimensioning only. Normal machining tolerances are allowable for actual fabrication.

Wave Guide Stage Assembly	1 of 3
Lower Guide Bracket	
Top View	
Tom Kensky WL/MLPO	Not to Scale
	22 Jul 92

FIGURE 39 - Lower Guide Bracket Top View



4 decimal place tolerances are for consistency in dimensioning only. Normal machining tolerances are allowable for actual fabrication.

FIGURE 40 - Lower Guide Bracket Front View

Wave Guide Stage Assembly	3 of 3
Lower Guide Bracket	
Isometric View	
Tom Kensky WL/MLPO	Not to Scale
	22 Jul 92

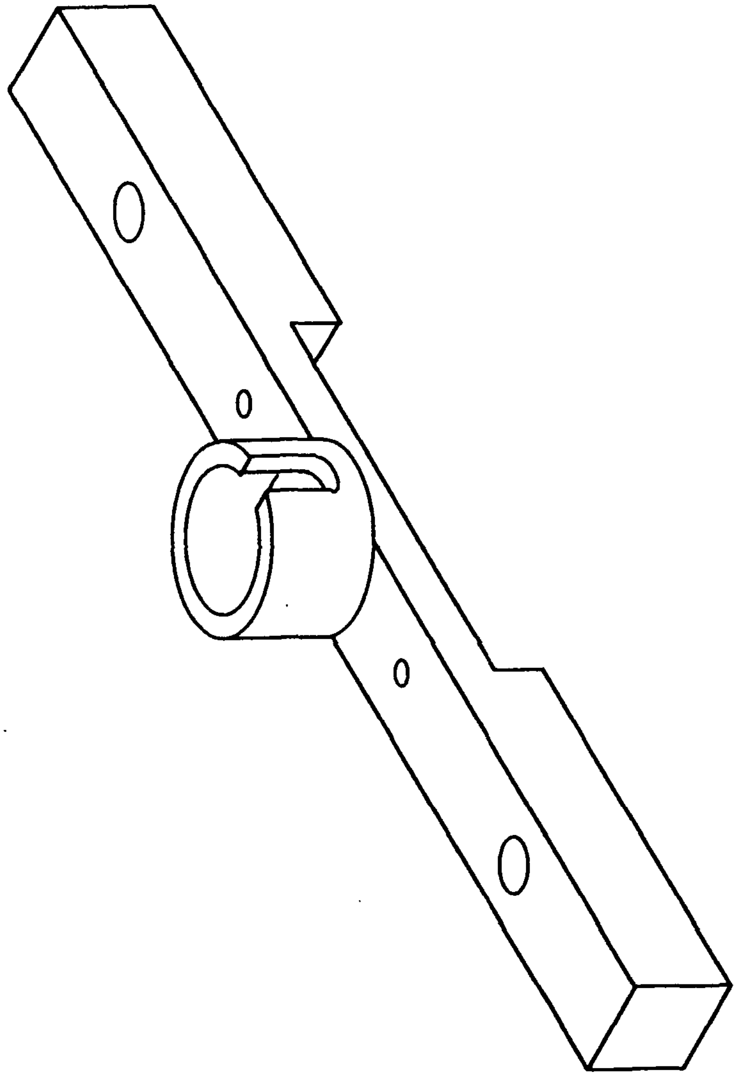
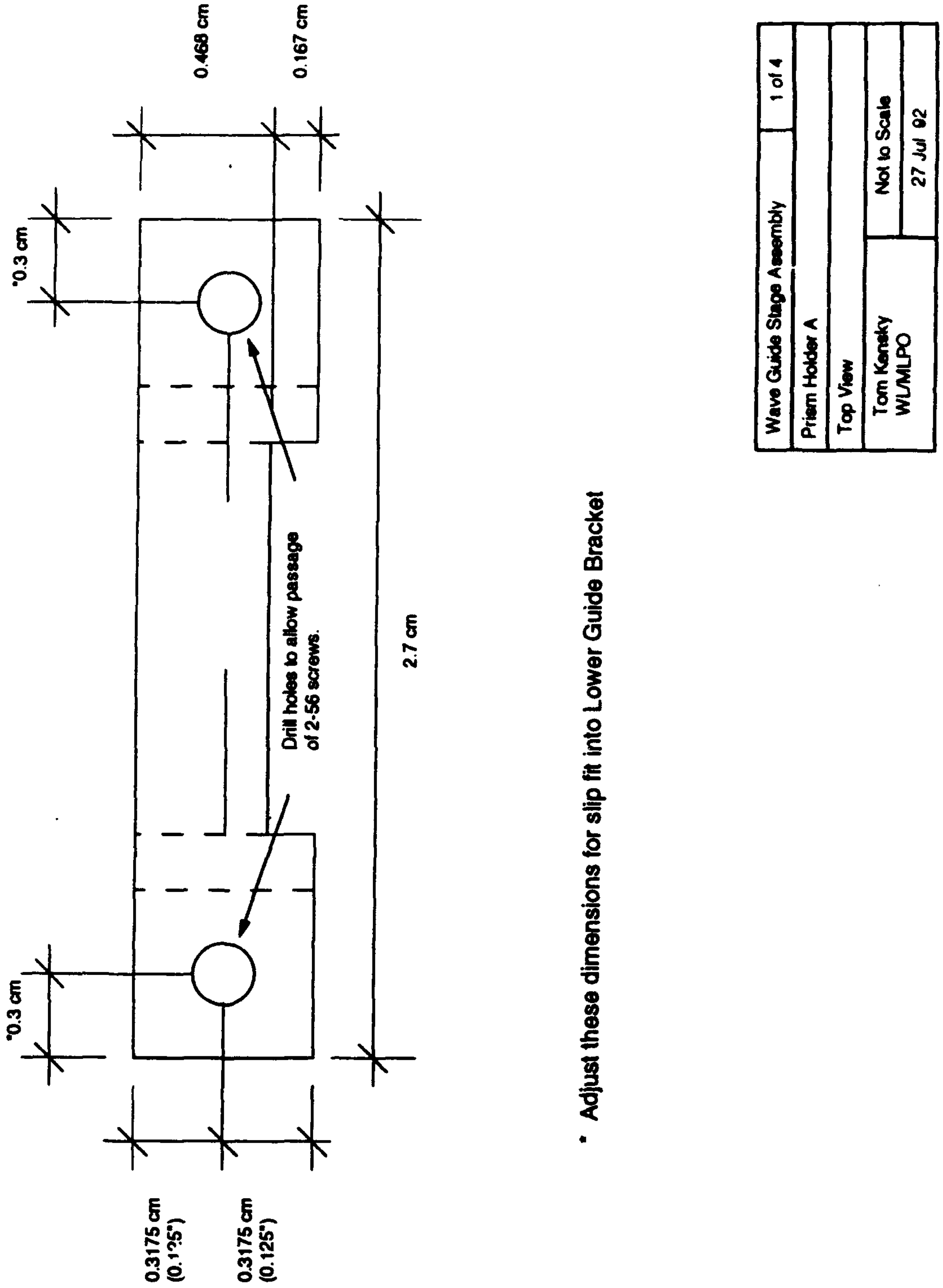


FIGURE 41 - Lower Guide Bracket Isometric View



* Adjust these dimensions for slip fit into Lower Guide Bracket

FIGURE 42 - Prism Holder A Top View

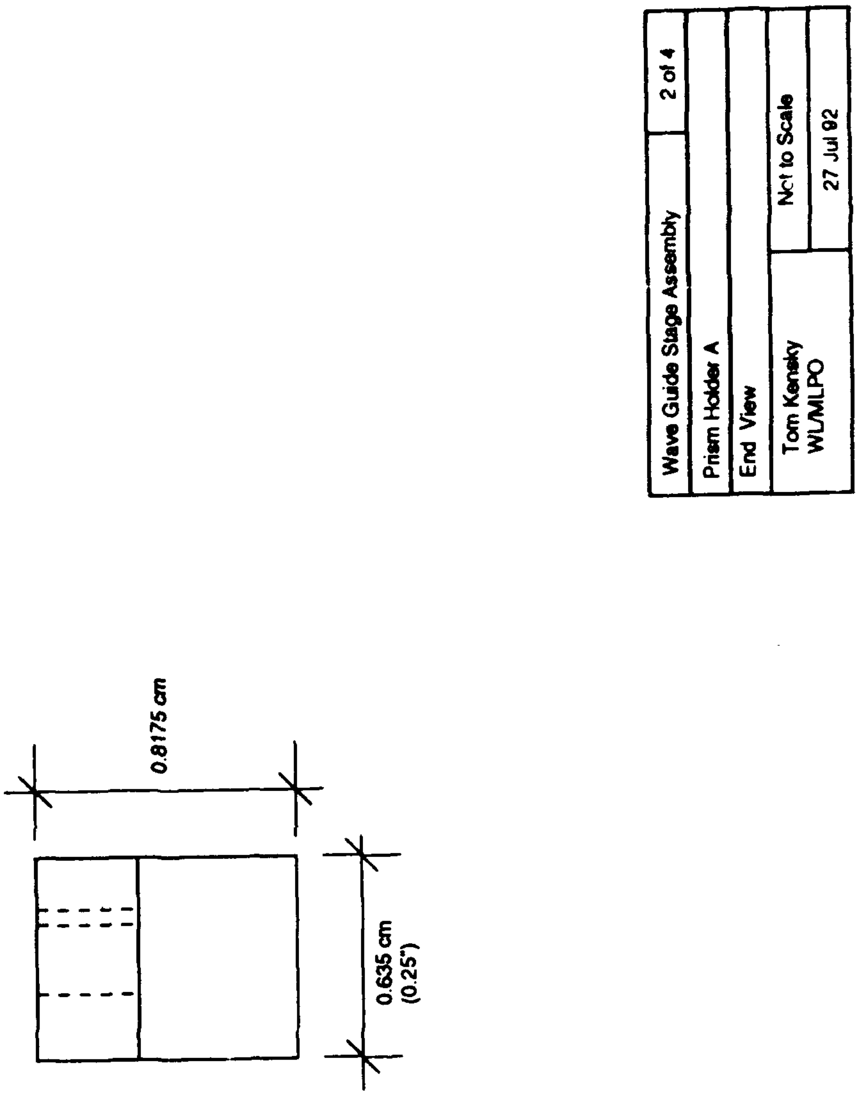


FIGURE 43 - Prism Holder A End View

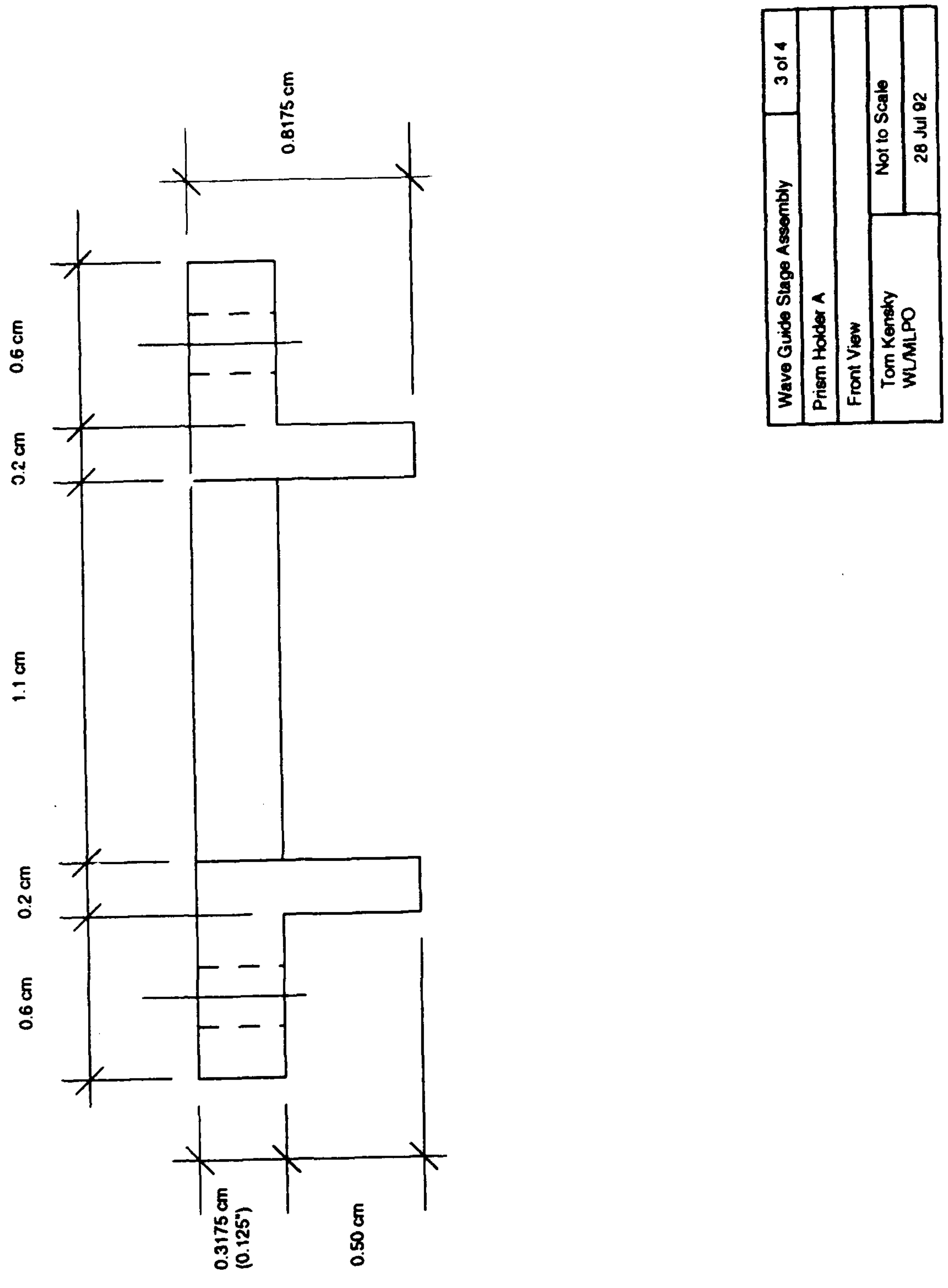


FIGURE 44 - Prism Holder A Front View

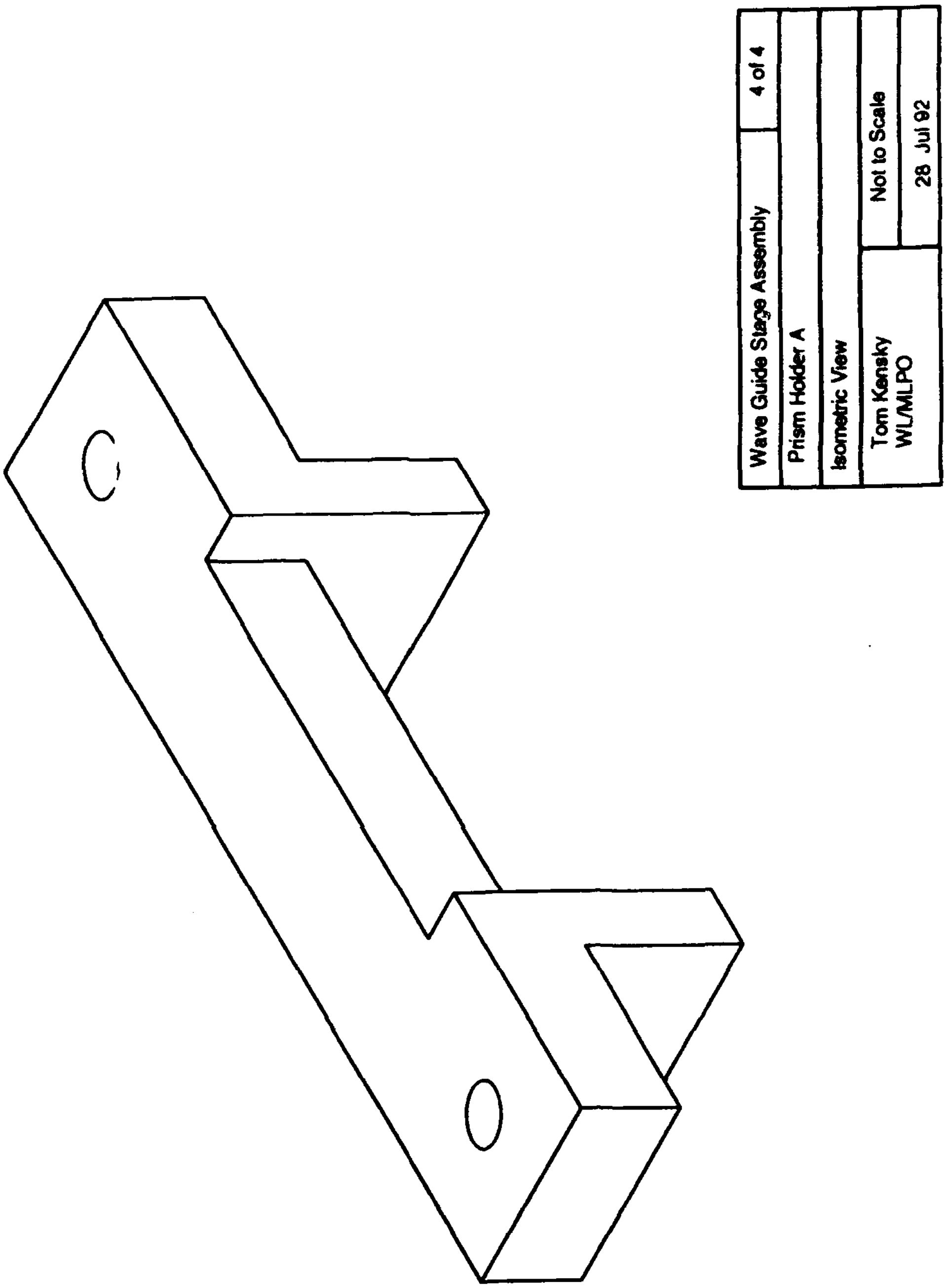
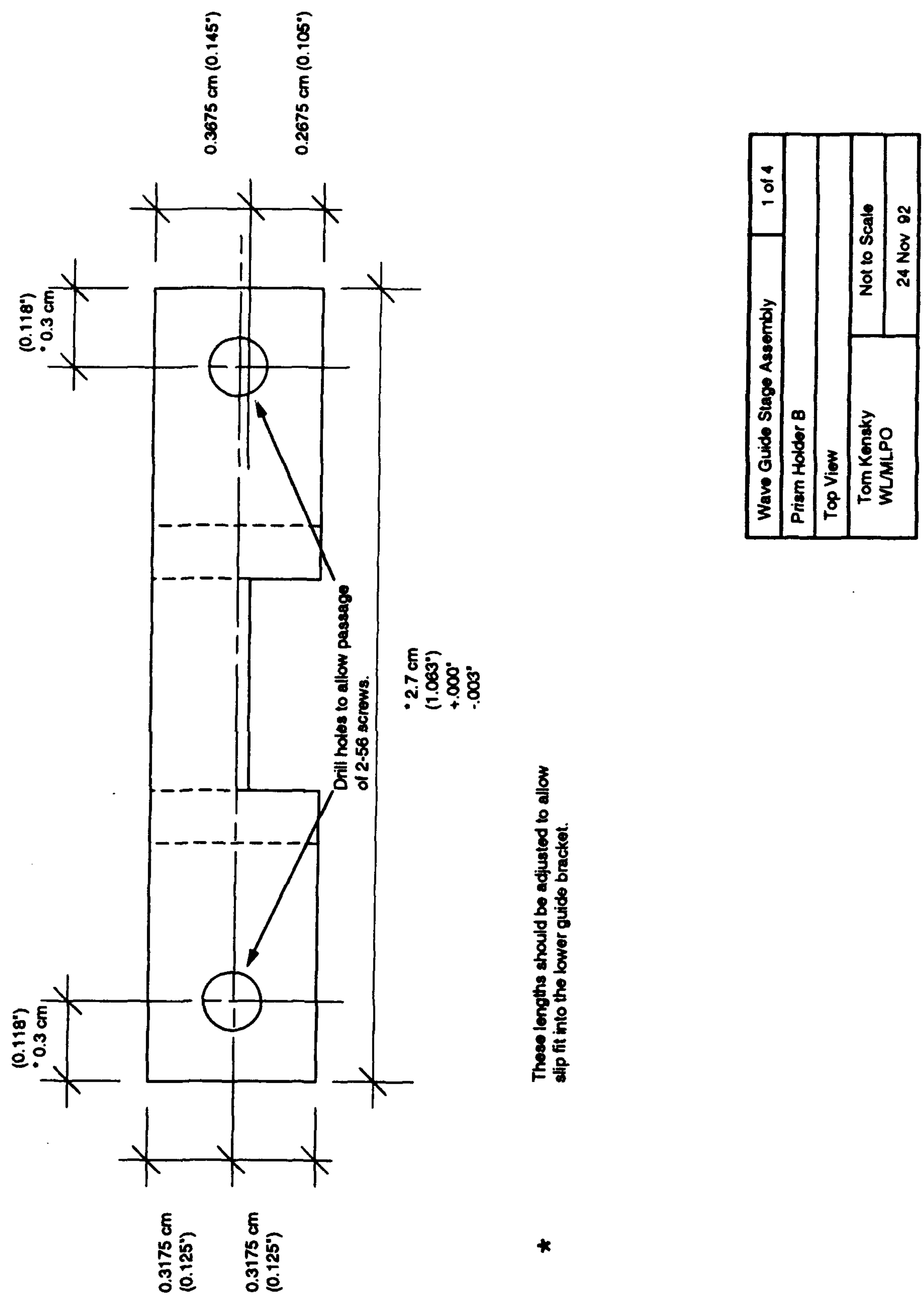


FIGURE 45 - Prism Holder A Isometric View



* These lengths should be adjusted to allow slip fit into the lower guide bracket.

FIGURE 46 - Prism Holder B Top View

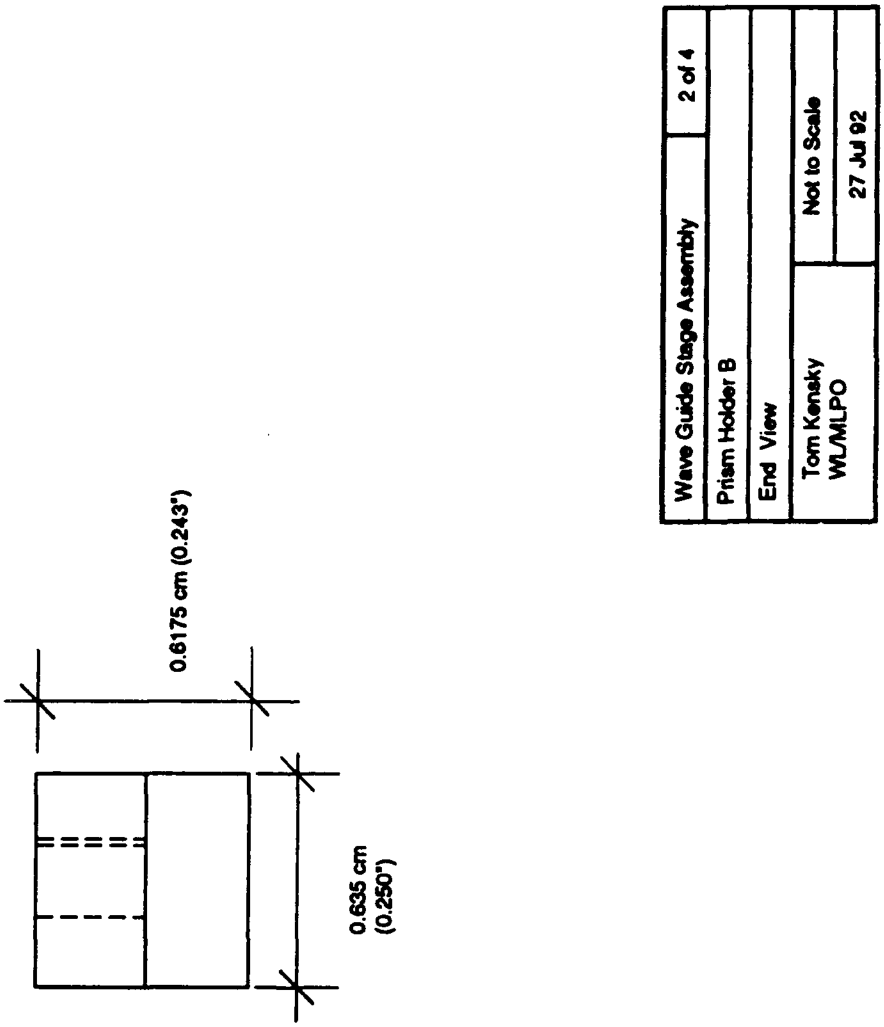


FIGURE 47 - Prism Holder B End View

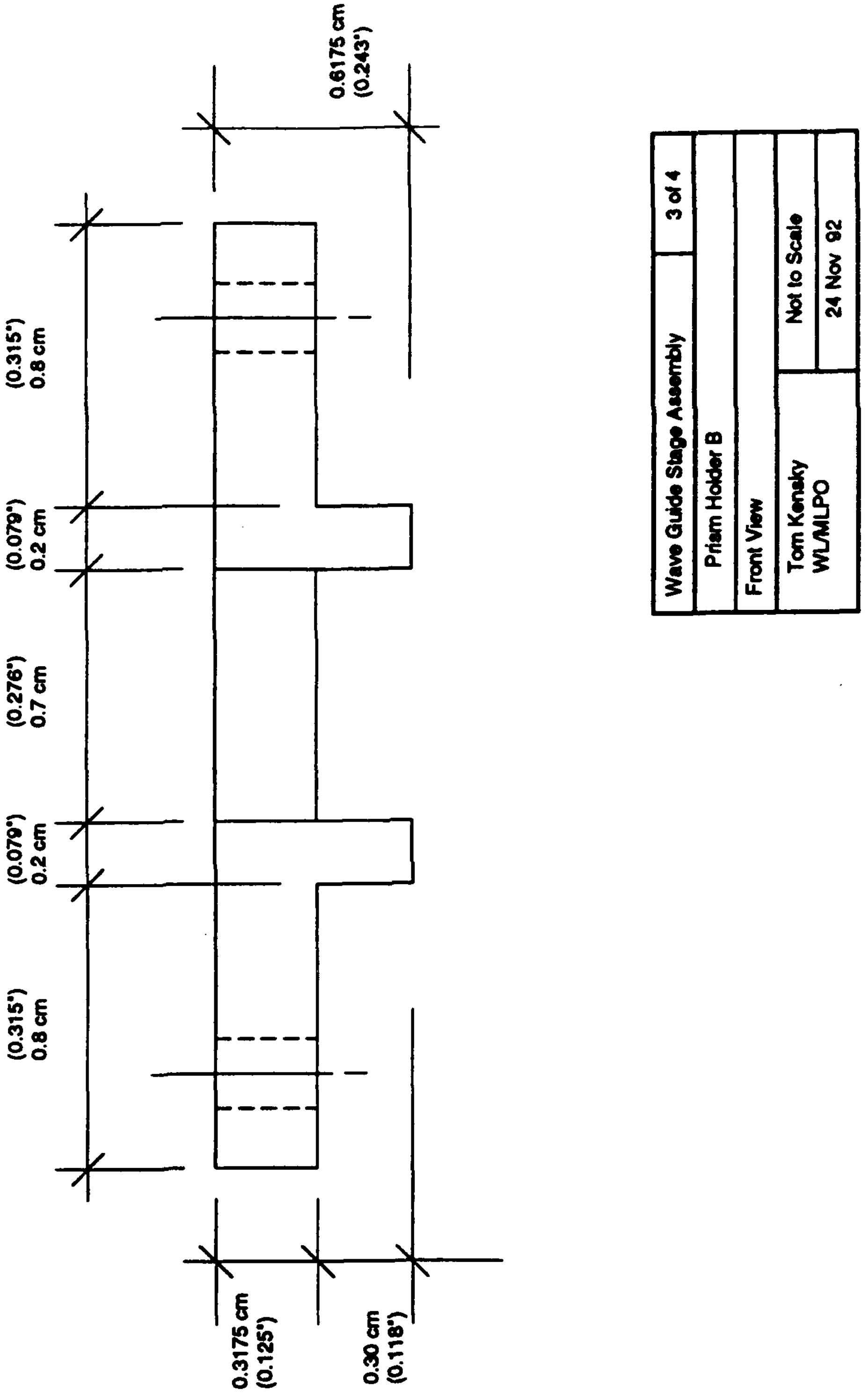


FIGURE 48 - Prism Holder B Front View

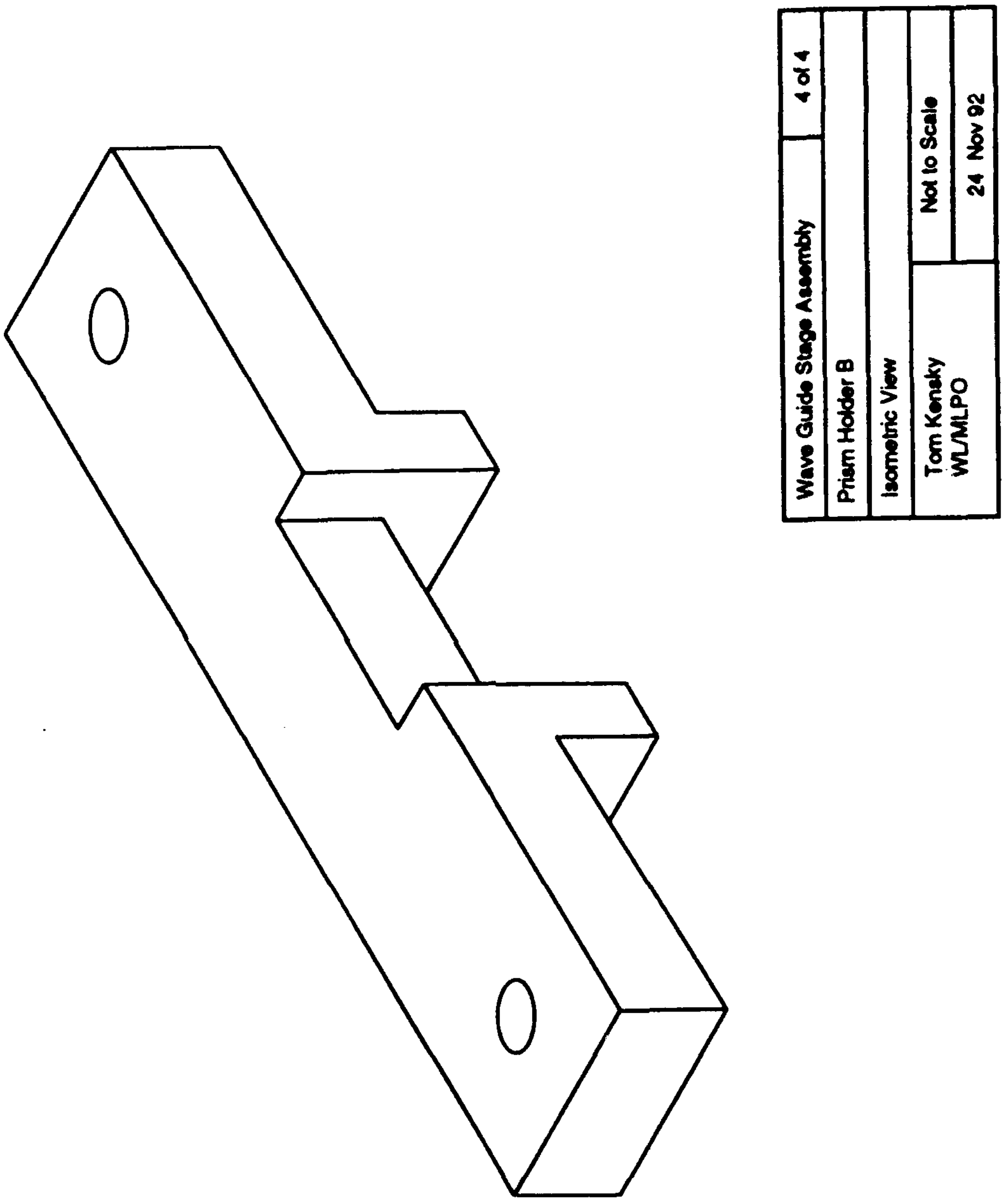
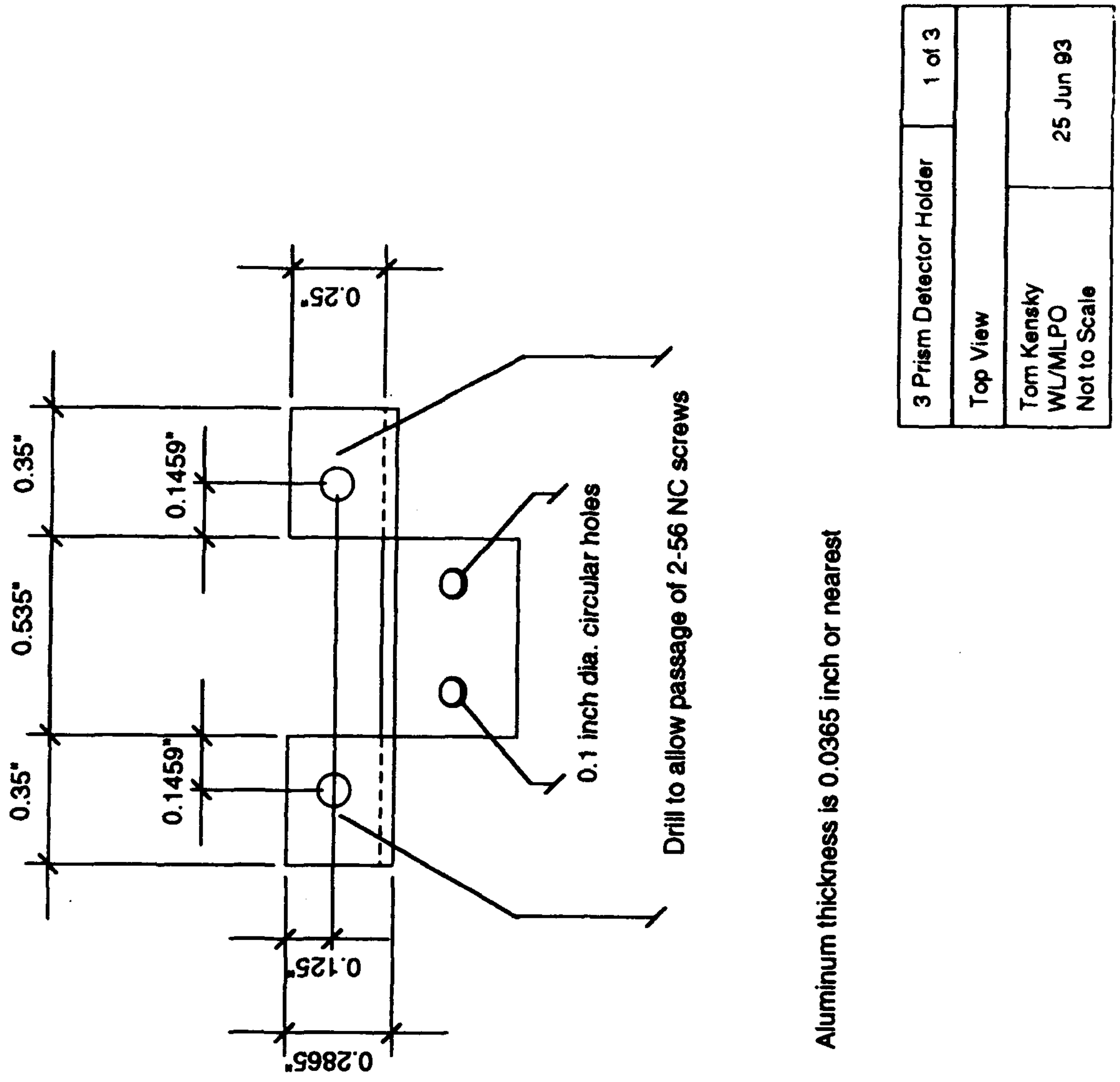


FIGURE 49 - Prism Holder B Isometric View



0.1 inch dia. circular holes

Drill to allow passage of 2-56 NC screws

Aluminum thickness is 0.0365 inch or nearest

FIGURE 50 - Detector Holder A Top View

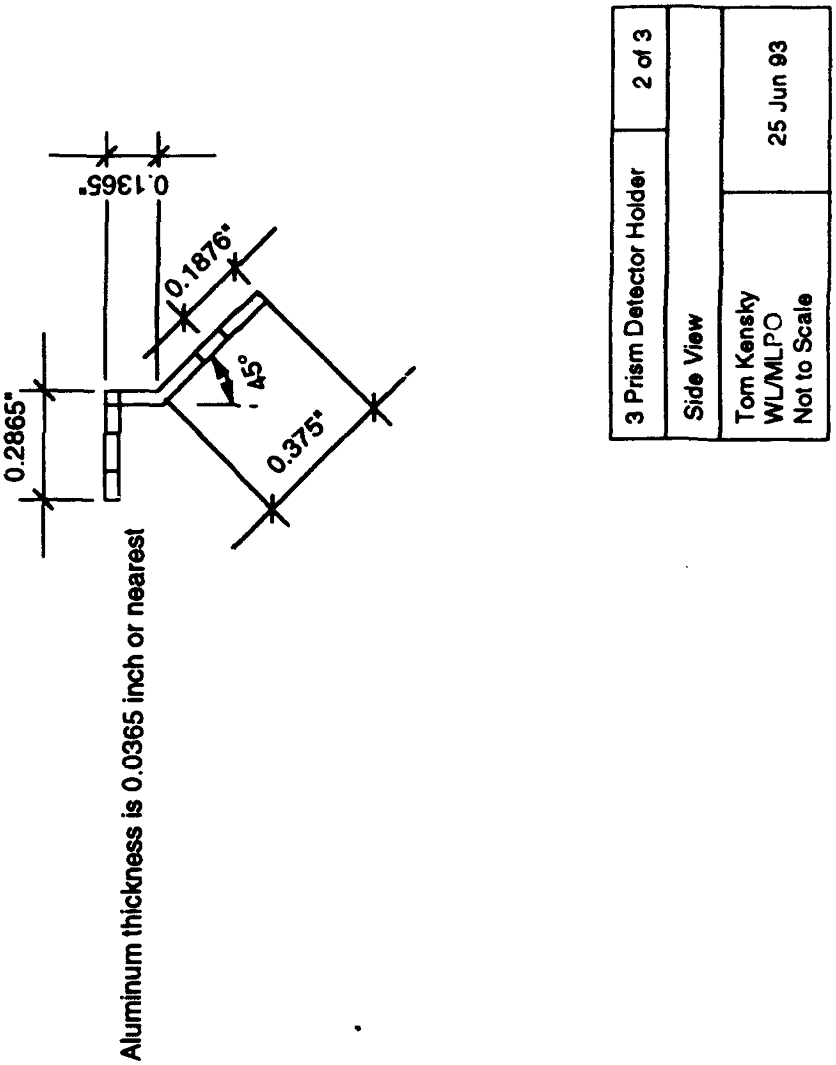


FIGURE 51 - Detector Holder A Side View

3 Prism Detector Holder	3 of 3
Isometric View	
Tom Kensky WL/MLPO Not to Scale	25 Jun 93

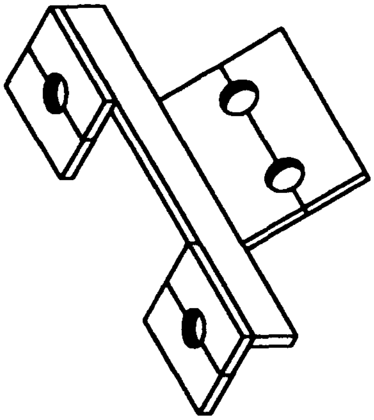


FIGURE 52 - Detector Holder A Isometric View

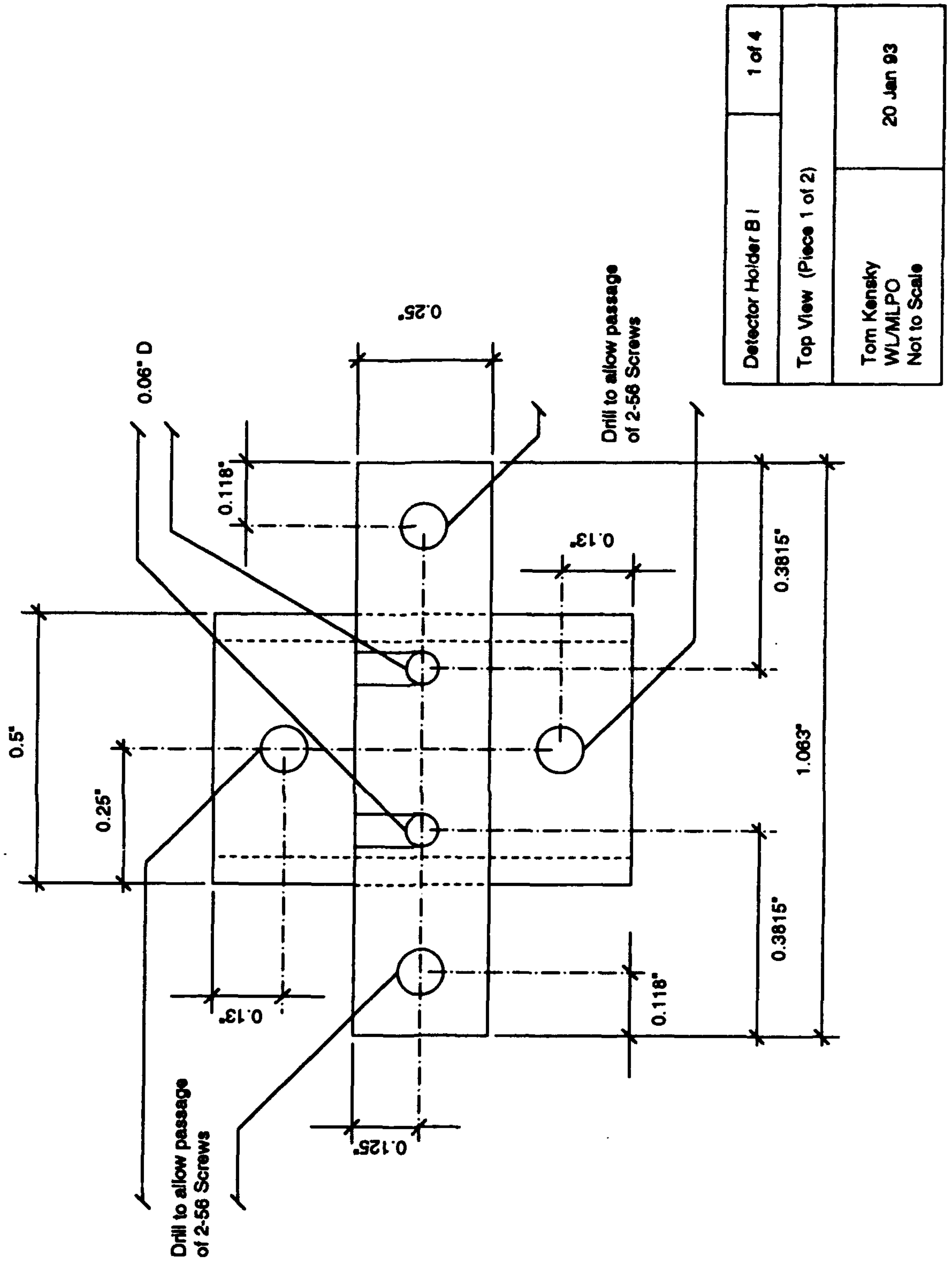


FIGURE 53 - Detector Holder B I Top View

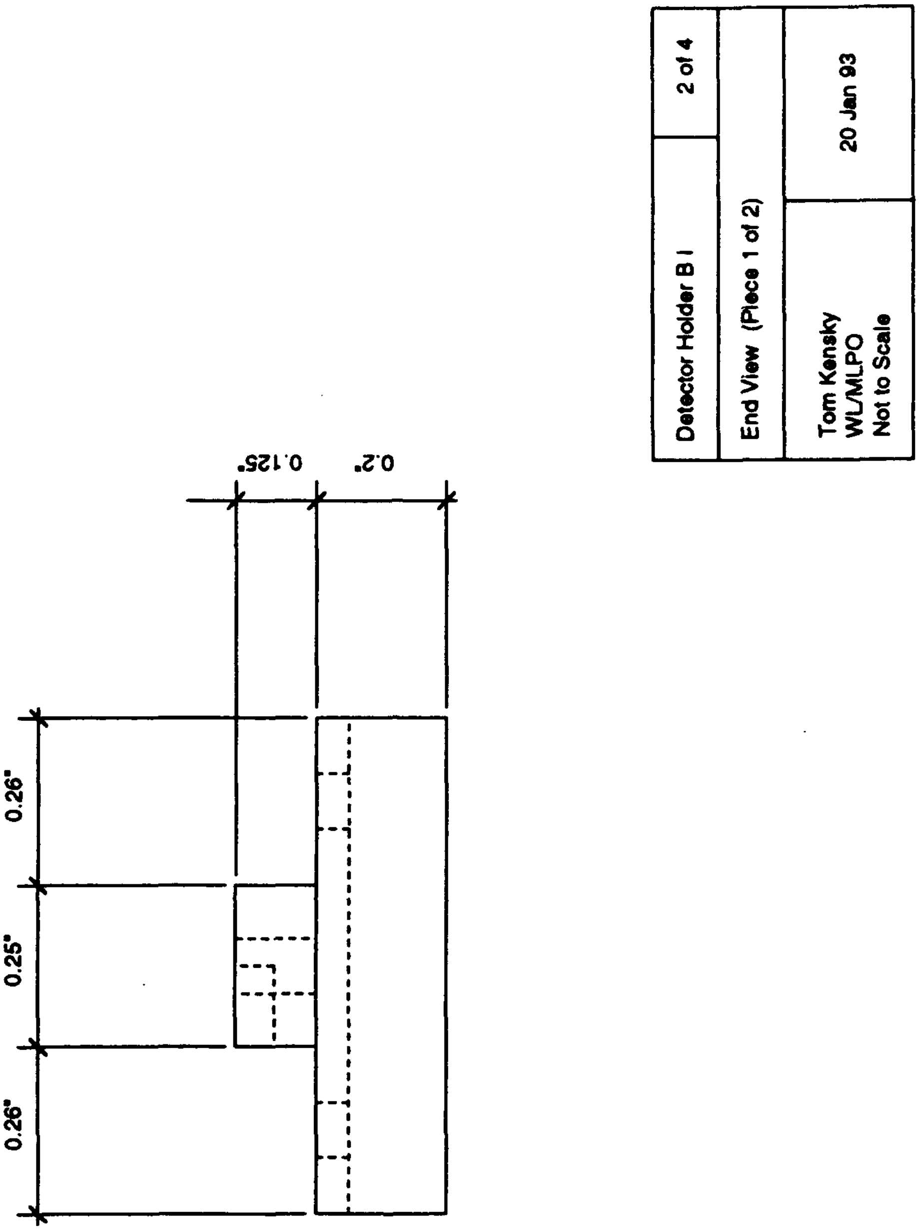


FIGURE 54 - Detector Holder B I End View

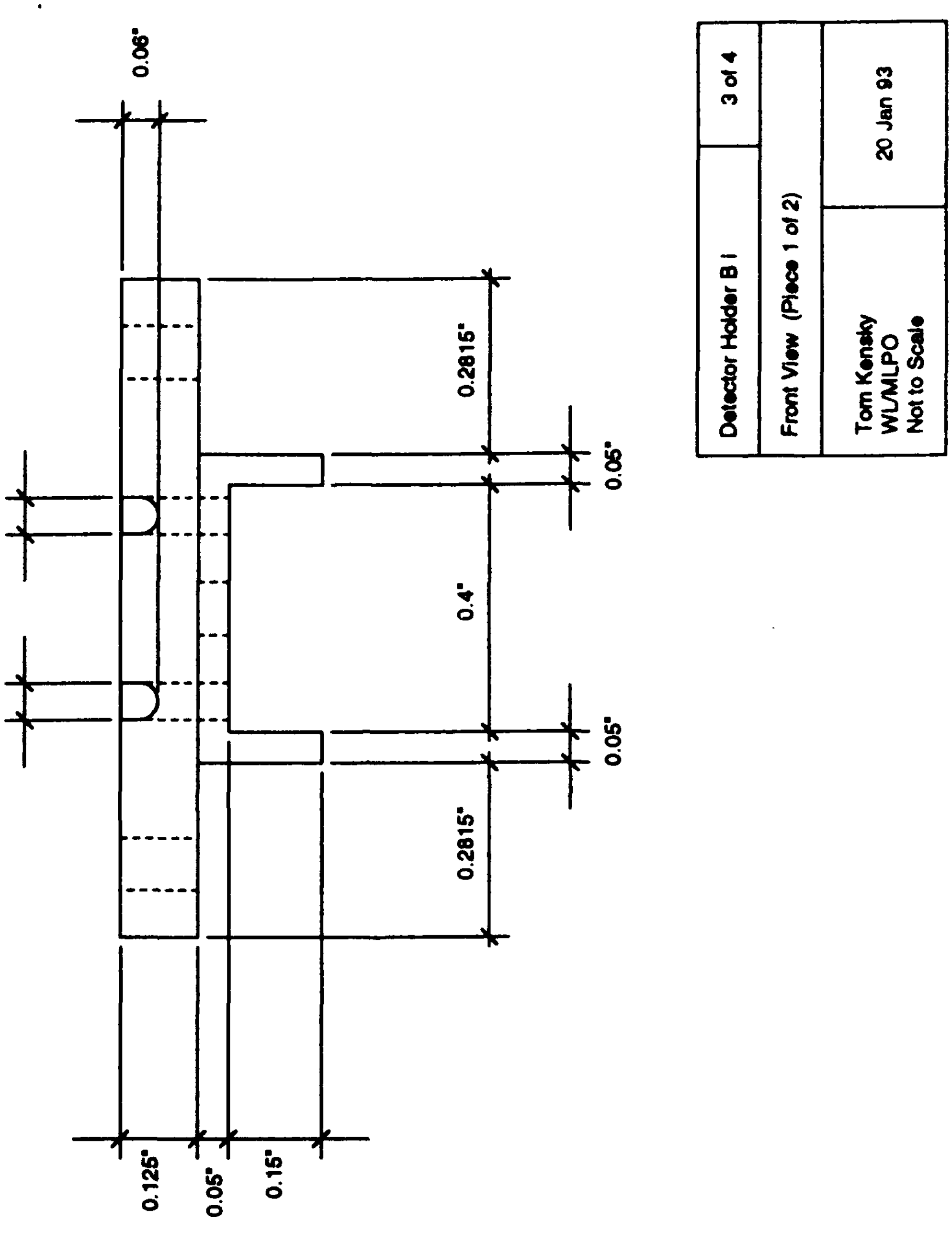


FIGURE 55 - Detector Holder B I Front View

Detector Holder B I	4 of 4
Isometric View (Piece 1 of 2)	
Tom Kensky WL/MLPO Not to Scale	20 Jan 93

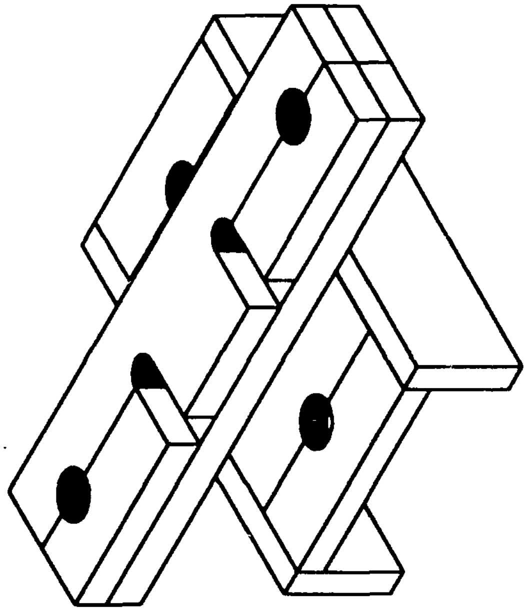


FIGURE 56 - Detector Holder B I Isometric View

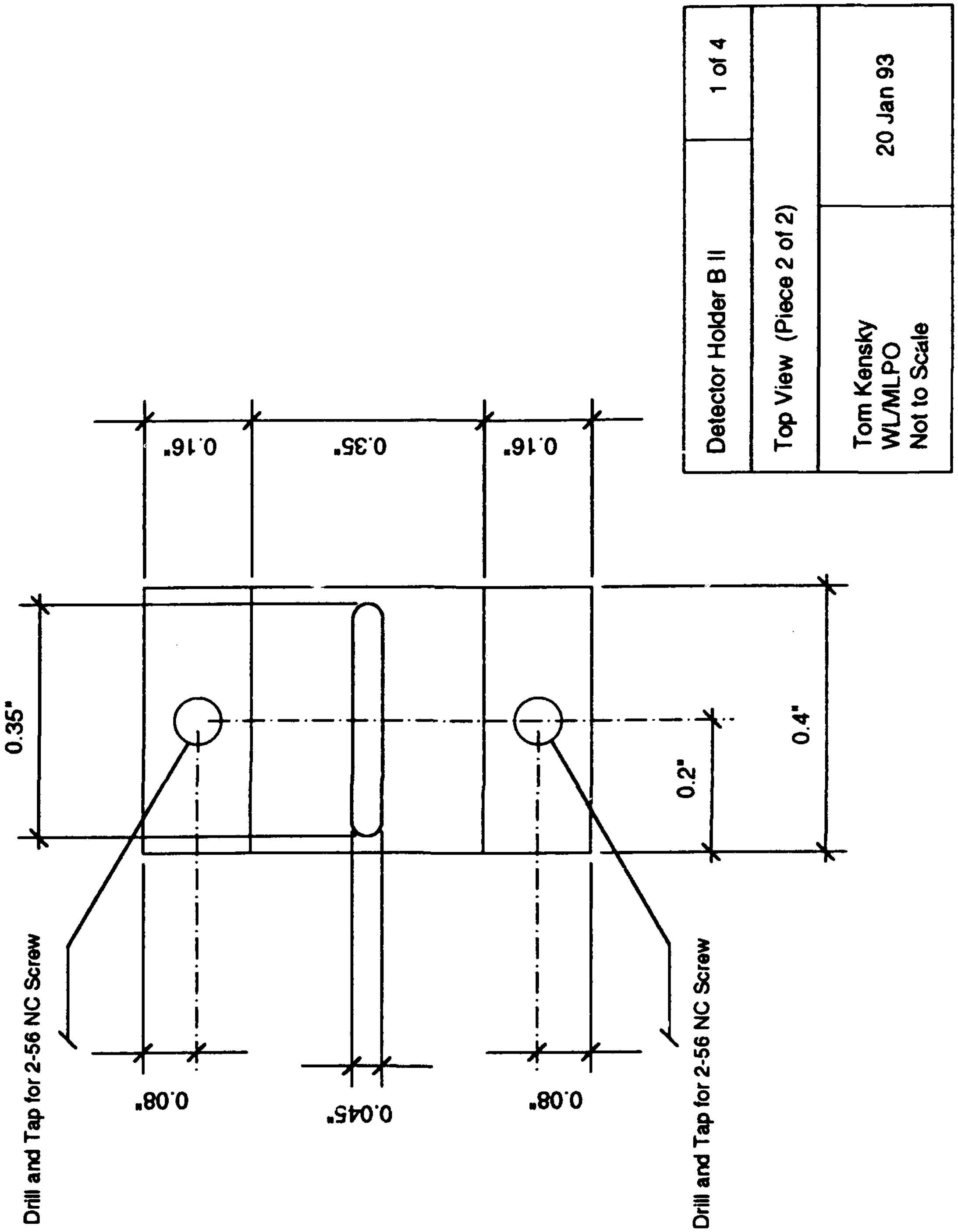


FIGURE 57 - Detector Holder B II Top View

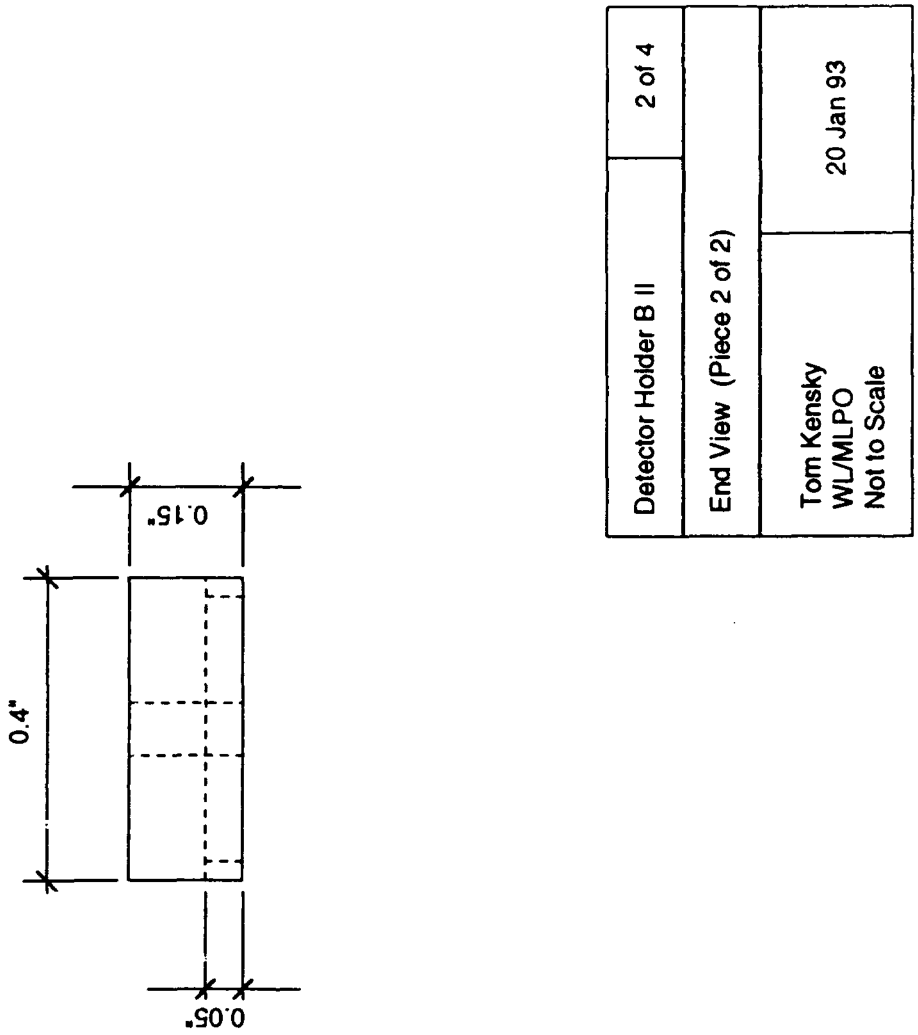


FIGURE 58 - Detector Holder B II End View

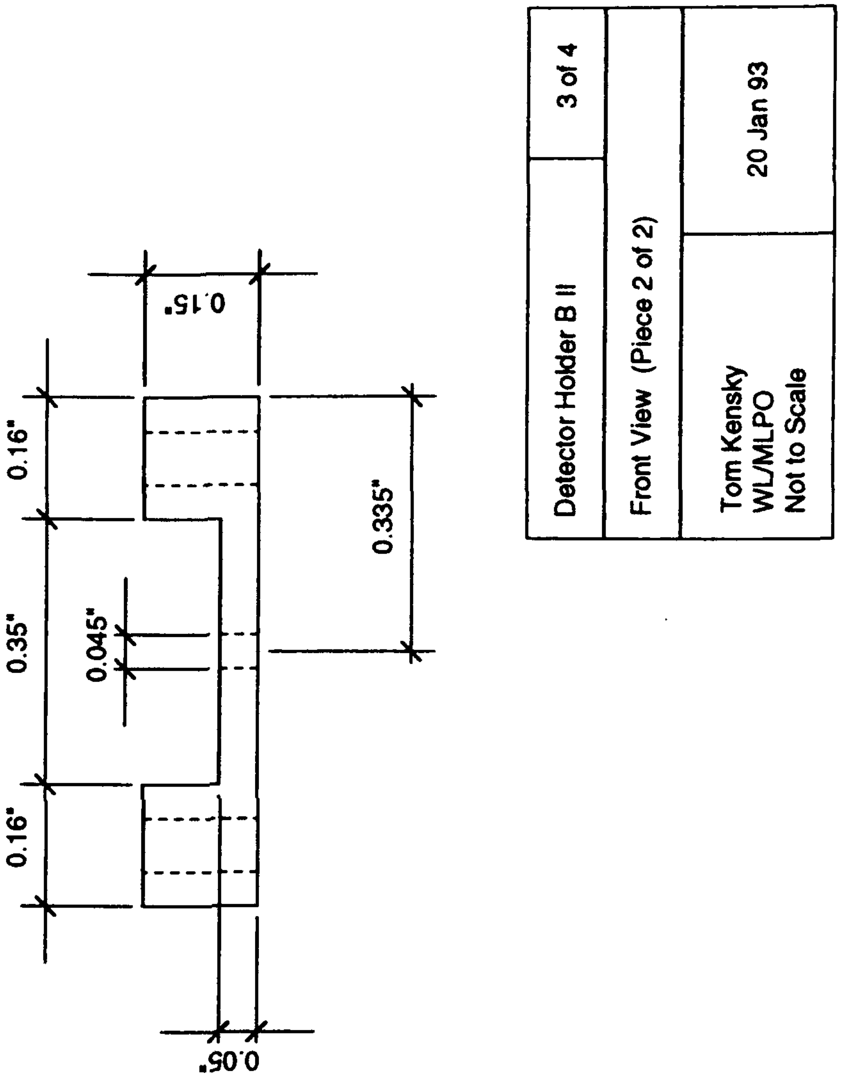


FIGURE 59 - Detector Holder B II Front View

Detector Holder B IIr	4 of 4
Perspective View (Piece 2 of 2)	
Tom Kensky WL/MLPO Not to Scale	20 Jan 93

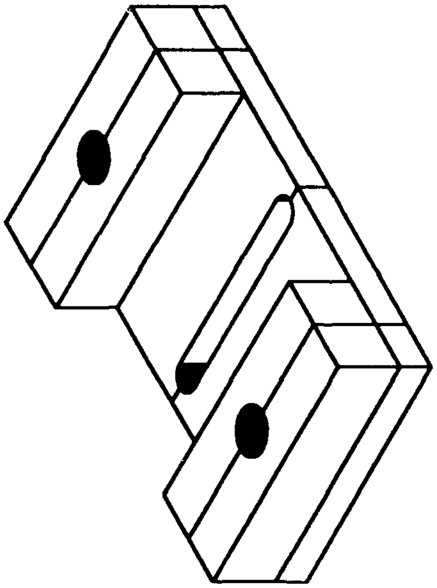


FIGURE 60 - Detector Holder B II Isometric View

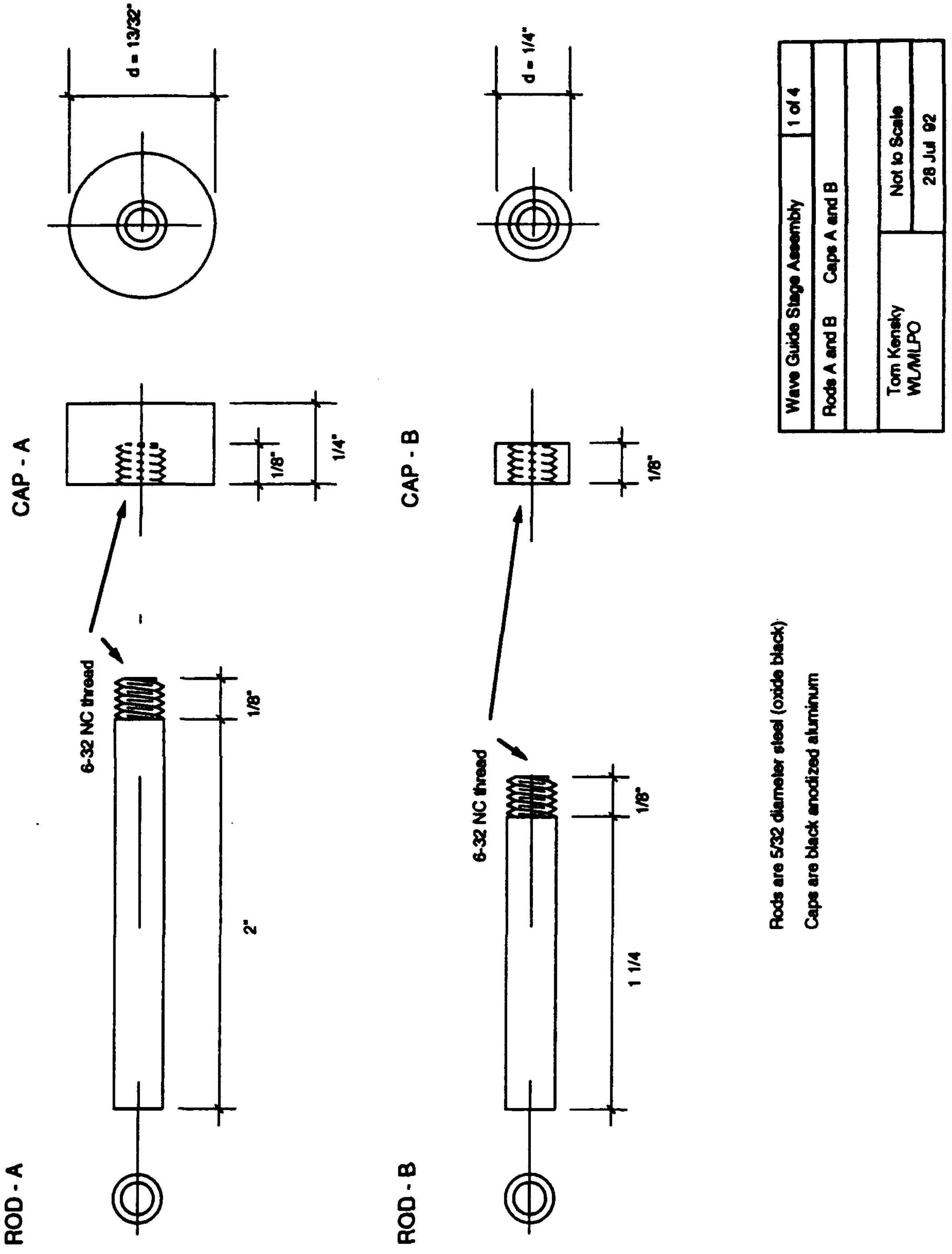


FIGURE 61 - Rods and Caps

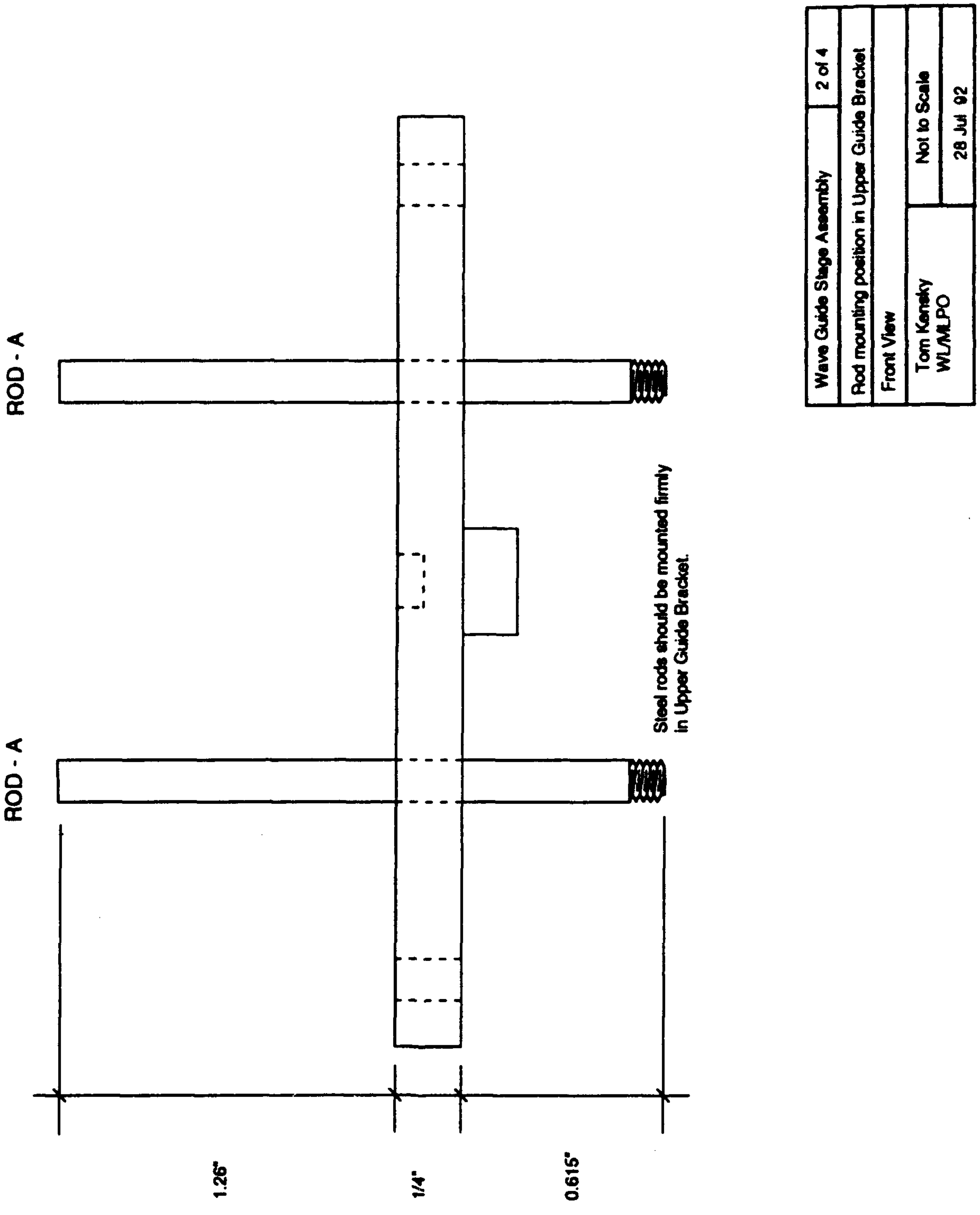
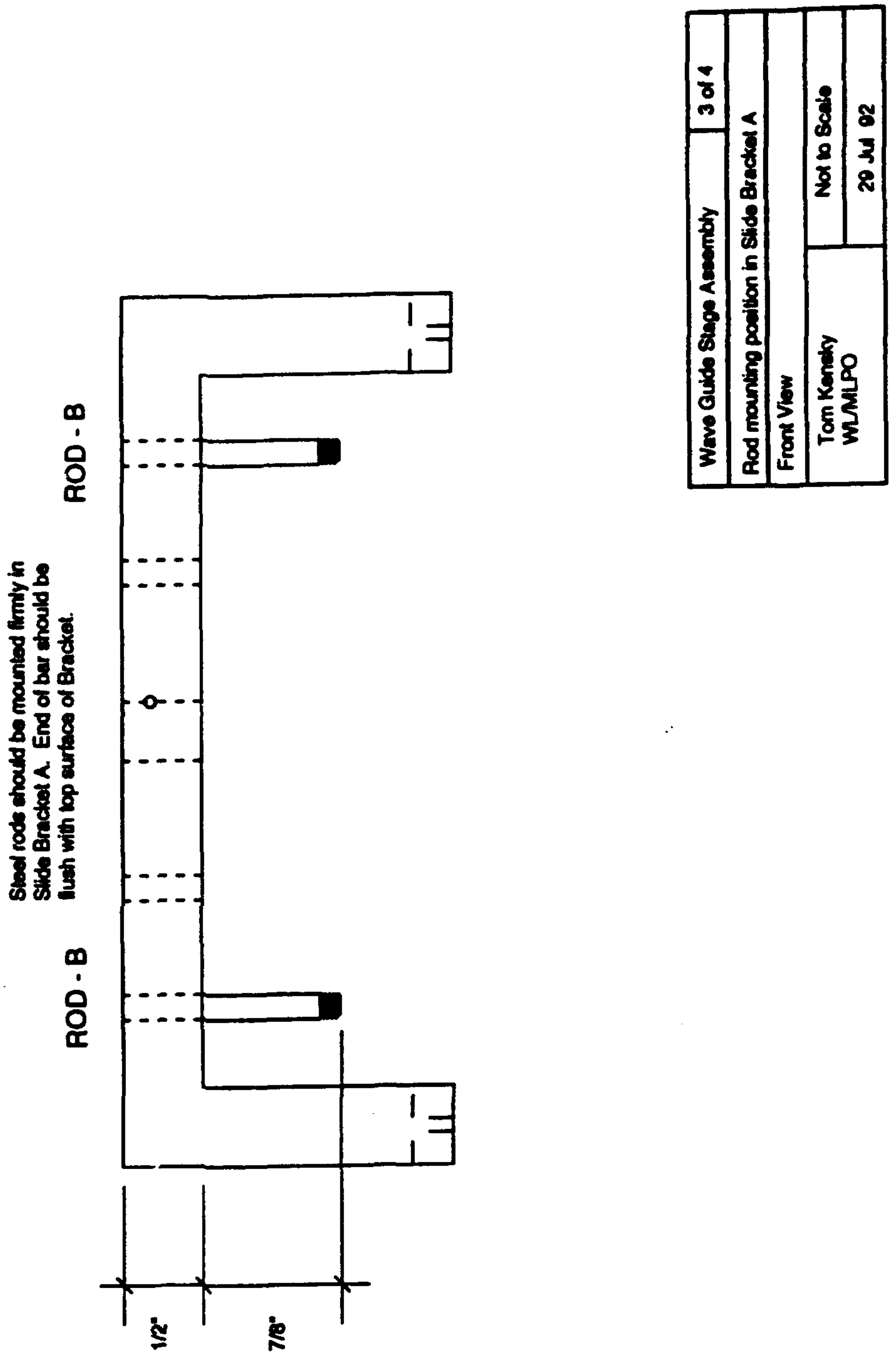
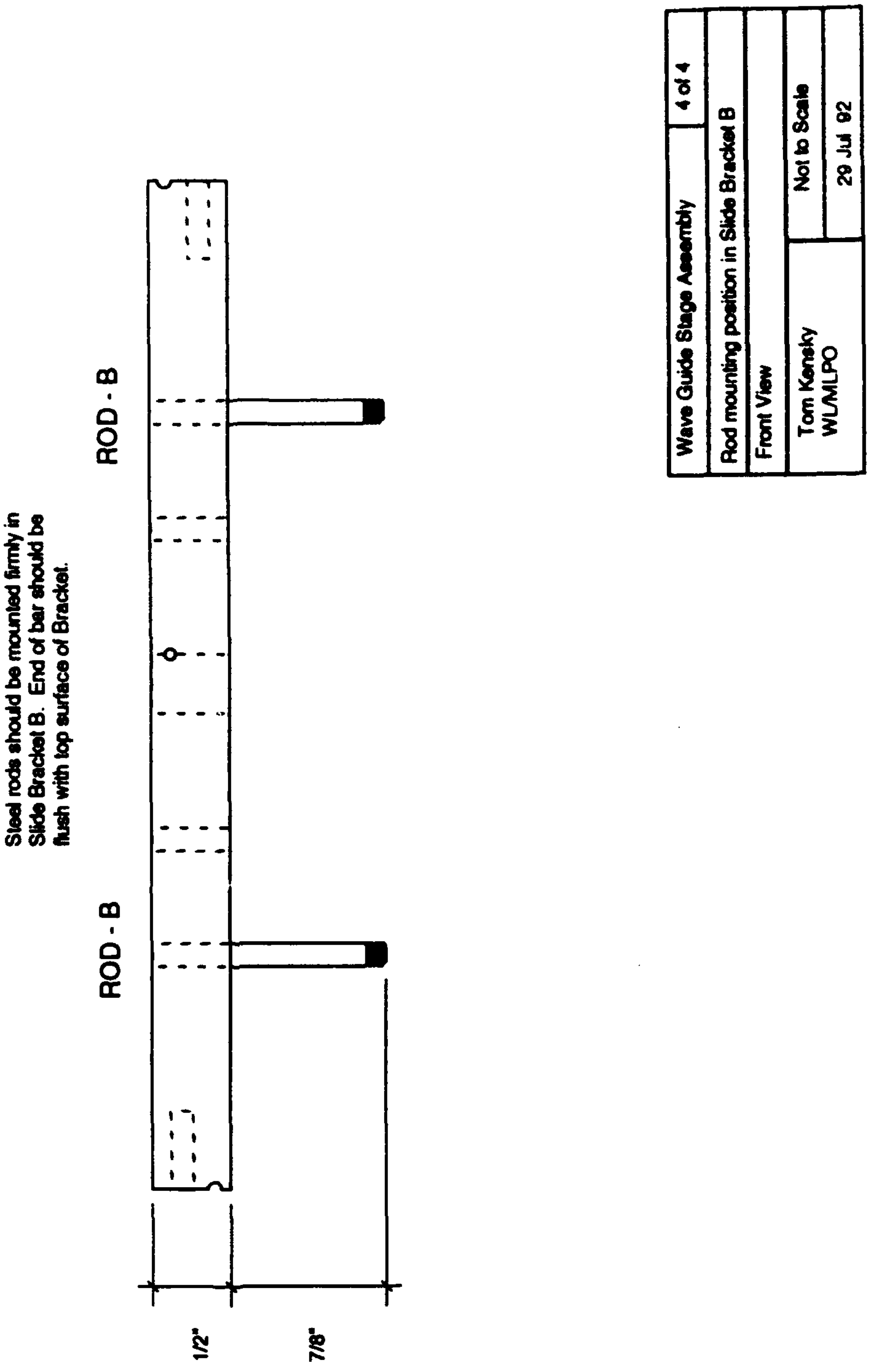


FIGURE 62 - Upper Guide Bracket Assembly



Steel rods should be mounted firmly in Slide Bracket A. End of bar should be flush with top surface of Bracket.

FIGURE 63 - Slide Bracket Assembly



Steel rods should be mounted firmly in Slide Bracket B. End of bar should be flush with top surface of Bracket.

FIGURE 64 - Slide Bracket B Assembly

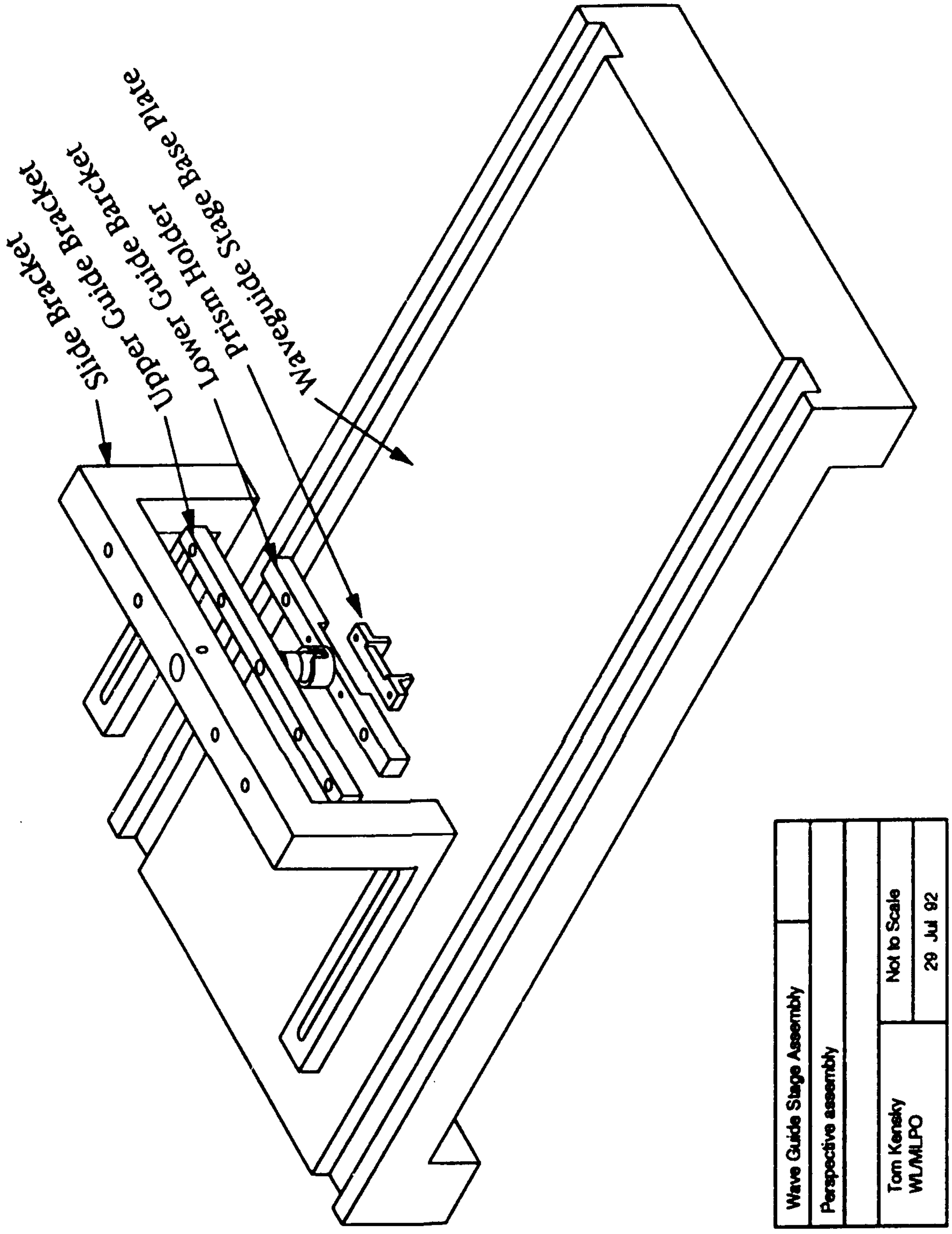


FIGURE 65 - Stage Assembly Exploded View

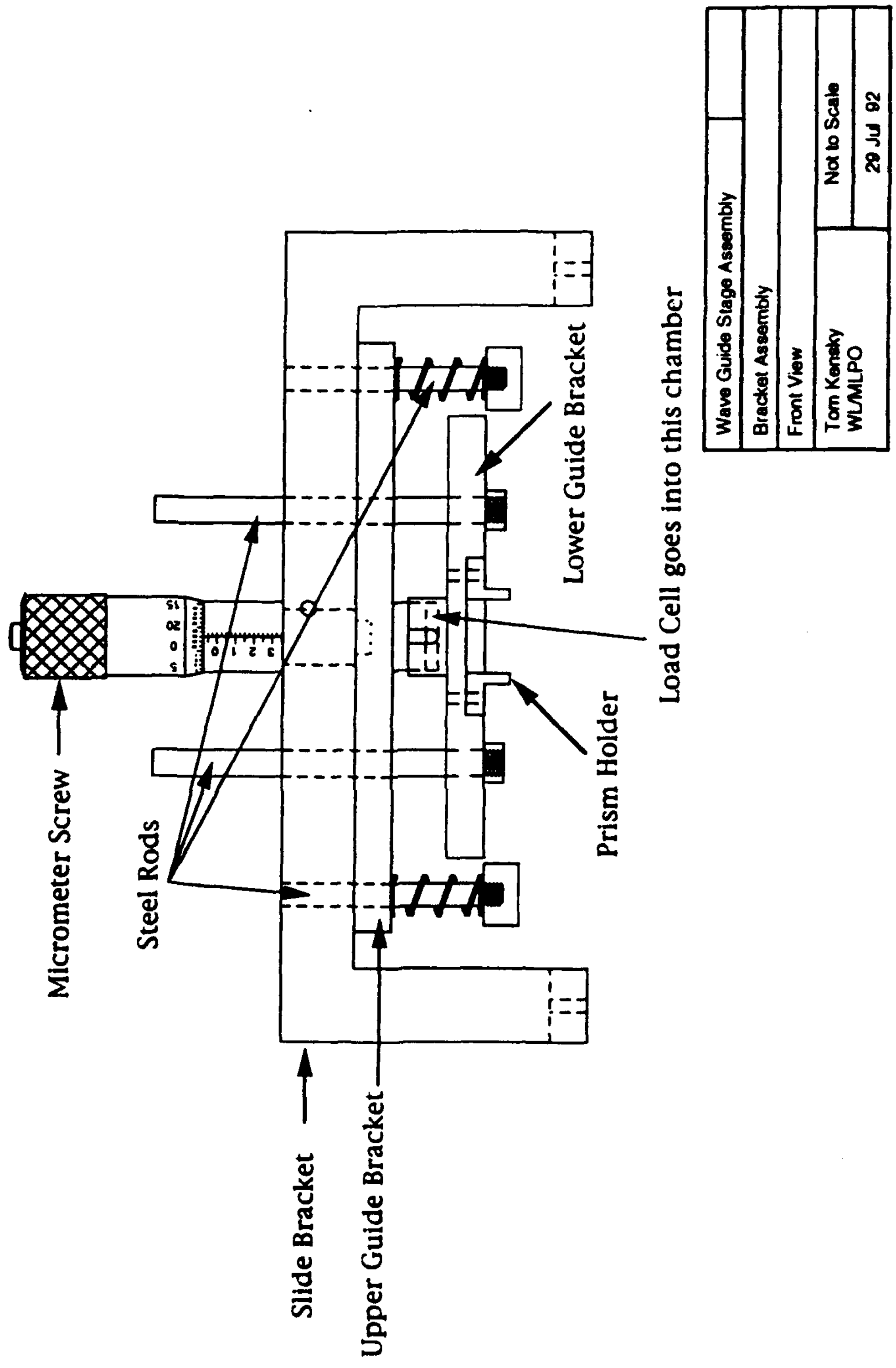


FIGURE 66 - Bracket Assembly

APPENDIX C - SOFTWARE LISTING

```
10     !************************************************
20     !** OPTICAL WAVEGUIDE LOSS MEASUREMENT PROGRAM **
30     !** TOM KENSKY                                 **
40     !** MATERIALS DIRECTORATE WL/MLPO WPAFB, OHIO  **
50     !** VERSION 6    2 SEP 93                      **
60     !************************************************
70     !
80     OPTION BASE 0
90     GINIT
100    GCLEAR
110    !
120    !***************************************
130    !** DIM ARRAYS FOR USE BY SUBROUTINES **
140    !***************************************
150    !
160    DIM Value$(10)[80]
170    DIM Choices$(10)[80]
180    DIM Distance$(10)[80]
190    DIM Constraints$(10)[80]
200    DIM Stage_pos$[30]
210    DIM Filename$[80]
220    DIM Steps$(3)[10]
230    !
240    !********************************************
250    !** SET THE ADDRESS OF THE EQUIPMENT       **
260    !** MOTION CONTROLLER ADDRESS IS 16        **
270    !** HP 3457A VOLTMETER  ADDRESS IS 22      **
280    !** HP 6942A MULTIPROGRAMMER ADDRESS IS 12 **
290    !********************************************
300    !
310    ON ERROR GOTO 330
320    CSIZE 5
330    CLEAR SCREEN
340    MOVE 15,80
350    LABEL "***********************************"
360    LABEL "*** SELECT THE BASE ADDRESS FOR ***"
370    LABEL "*** THE EQUIPMENT (i.e. which   ***"
380    LABEL "*** optical table are you on?)   ***"
390    LABEL "***********************************"
400    INPUT "ENTER THE BASE ADDRESS: (7 OR 8)",Address$
410    IF VAL(Address$)=7 THEN
420    ASSIGN @Daedal TO 716
430    ASSIGN @Voltmeter TO 722
440    ASSIGN @Multi TO 712
450    GOTO 540
460    END IF
470    IF VAL(Address$)=8 THEN
480    ASSIGN @Daedal TO 816
490    ASSIGN @Voltmeter TO 822
500    ASSIGN @Multi TO 812
510    GOTO 540
520    END IF
530    GOTO 330
540    OFF ERROR
550    !
```

```
560   !*******************************
570   !** PROMPT USER FOR CHOICE OF **
580   !** 3-PRISM OR OUT-OF-PLANE   **
590   !** TECHNIQUES                **
600   !*******************************
610   !
620   ON ERROR GOTO 630
630   CLEAR SCREEN
640   MOVE 15,80
650   LABEL "***********************************"
660   LABEL "*** ARE YOU DOING OUT OF PLANE  ***"
670   LABEL "*** MEASUREMENTS?              ***"
680   LABEL "***********************************"
690   INPUT "ENTER 'Y' OR 'N'",Out_of_plane$
700   IF Out_of_plane$="Y" OR Out_of_plane$="y" THEN
710                 Out_of_plane=1
720                                               ELSE
730                 Out_of_plane=0
740   END IF
750   CLEAR SCREEN
760   OFF ERROR
770   !
780   !*************************************
790   !** CAN'T USE THE STEPPER MOTOR FOR **
800   !** THE MEASUREMENT ARM WHEN DOING  **
810   !** OUT-OF-PLANE MEASUREMENTS       **
820   !*************************************
830   !
840   IF Out_of_plane=1 THEN
850                         Use_motor=0
860                         GOTO 1090
870   END IF
880   !
890   !*************************************
900   !** PROMPT USER FOR CHOICE OF USING **
910   !** THE STEPPER MOTOR FOR DRIVING   **
920   !** THE MEASUREMENT ARM             **
930   !*************************************
940   !
950   ON ERROR GOTO 960
960   CLEAR SCREEN
970   MOVE 15,80
980   LABEL "***********************************"
990   LABEL "*** ARE YOU USING THE STEPPER   ***"
1000  LABEL "*** MOTOR FOR THE MEASUREMENT   ***"
1010  LABEL "*** ARM?                        ***"
1020  LABEL "***********************************"
1030  INPUT "ENTER 'Y' OR 'N'",Use_motor$
1040  IF Use_motor$="Y" OR Use_motor$="y" THEN
1050                Use_motor=1
1060                                              ELSE
1070                Use_motor=0
1080  END IF
1090  CLEAR SCREEN
1100  OFF ERROR
1110  !
1120  !*****************************************************
1130  !** INITIALIZE DAEDAL MOTION CONTROLLER:            **
```

```
1140  !** ENABLE IEEE-488,NORMAL MODE,SET DISPLAY TO ZERO **
1150  !** ACCELERATION=5 REVS/SEC/SEC, VELOCITY=1 REV/SEC **
1160  !** COUNTER ZERO RESET                              **
1170  !****************************************************
1180  !
1190  OUTPUT @Daedal USING "#,K";"E MN DA A5.0 V1 X0 ",END
1200  !
1210  !*****************************************************************
1220  !** INITIALIZE HP 3457A VOLTMETER: DCV,AUTO,INTERNAL TRIGGER,   **
1230  !** 5 1/2 DIGITS,SELECT HP 44492 AS INPUT,FIX INPUT Z TO 10M    **
1240  !** FOR ALL RANGES OF DCV                                       **
1250  !*****************************************************************
1260  !
1270  OUTPUT @Voltmeter;"DCV AUTO,.01"
1280  OUTPUT @Voltmeter;"TRIG AUTO"
1290  OUTPUT @Voltmeter;"TERM REAR"
1300  OUTPUT @Voltmeter;"FIXEDZ ON"
1310  !
1320  !*******************************************
1330  !** INITIALIZE VALUES FOR SCROLL MENU    **
1340  !** MANUAL ADJUSTMENT OF STAGE POSITION **
1350  !*******************************************
1360  !
1370  Choices$(0)="10,000 STEP MOVEMENT"
1380  Choices$(1)="1,000  STEP MOVEMENT"
1390  Choices$(2)="100    STEP MOVEMENT"
1400  Choices$(3)="10     STEP MOVEMENT"
1410  Choices$(4)="1      STEP MOVEMENT"
1420  Distance$(0)="10000"
1430  Distance$(1)="1000"
1440  Distance$(2)="100"
1450  Distance$(3)="10"
1460  Distance$(4)="1"
1470  Num_of_choices=5
1480  Stage_pos$="0"
1490  !
1500  !*********************************************
1510  !** ALLOW MONITORING OF THE LOAD CELLS      **
1520  !** AND DETECTORS TO SETUP THE EXPERIMENT  **
1530  !** ALLOW ADJUSTMENT OF THE STAGE POSITION **
1540  !*********************************************
1550  !
1560  DIM Message$[50]
1570  ON KEY 7 LABEL "" GOTO 1770
1580  ON KEY 8 LABEL "" GOTO 1770
1590  ON KEY 1 LABEL "CELL 1  F1" GOTO 1780
1600  ON KEY 2 LABEL "CELL 2  F2" GOTO 1850
1610  ON KEY 3 LABEL "CELL 3  F3" GOTO 1920
1620  ON KEY 4 LABEL "EXIT P.  F4" GOTO 1990
1630  ON KEY 5 LABEL "MEAS P.  F5" GOTO 2060
1640  ON KEY 6 LABEL "STAGE   F6" GOTO 2480
1650  ON KEY 7 LABEL "PROCEED  F7" GOTO 2510
1660  CLEAR SCREEN
1670  MOVE 10,80
1680  LABEL "****************************************"
1690  LABEL "***    PRE-EXPERIMENT SETUP SECTION    ***"
1700  LABEL "***                                    ***"
1710  LABEL "*** ADJUST LOAD CELLS AND DETECTORS   ***"
```

```
1720  LABEL "***                                   ***"
1730  LABEL "*** CHOOSE AN ITEM USING THE SOFTKEYS ***"
1740  LABEL "*** OR CONTINUE WITH THE EXPERIMENT   ***"
1750  LABEL "*** BY PRESSING 'PROCEED'             ***"
1760  LABEL "*****************************************"
1770  GOTO 1770
1780  Message$="***      ADJUST PRISM 1       ***"
1790  CLEAR SCREEN
1800  CSIZE 5
1810  Multiplier=10
1820  Tail$=" lbs"
1830  OUTPUT @Voltmeter;"CHAN 0"
1840  GOTO 2120
1850  Message$="***      ADJUST PRISM 2       ***"
1860  CLEAR SCREEN
1870  CSIZE 5
1880  Multiplier=10
1890  Tail$=" lbs"
1900  OUTPUT @Voltmeter;"CHAN 1"
1910  GOTO 2120
1920  Message$="***      ADJUST PRISM 3       ***"
1930  CLEAR SCREEN
1940  CSIZE 5
1950  Multiplier=10
1960  Tail$=" lbs"
1970  OUTPUT @Voltmeter;"CHAN 2"
1980  GOTO 2120
1990  Message$="***    EXIT PRISM INTENSITY   ***"
2000  CLEAR SCREEN
2010  CSIZE 5
2020  Multiplier=1
2030  Tail$=" V"
2040  OUTPUT @Voltmeter;"CHAN 3"
2050  GOTO 2120
2060  Message$="***    MEAS PRISM INTENSITY   ***"
2070  CLEAR SCREEN
2080  CSIZE 5
2090  Multiplier=1
2100  Tail$=" V"
2110  OUTPUT @Voltmeter;"CHAN 4"
2120  MOVE 10,90
2130  LABEL "*********************************"
2140  LABEL Message$
2150  LABEL "*********************************"
2160  LABEL
2170  LABEL "  PRESS ANY KEY TO CONTINUE"
2180  LABEL "AFTER ADJUSTMENT OR MONITORING "
2190  !
2200  !***************************************************
2210  !** ON SCREEN MONITOR OF MEASURED VALUE FROM VOLTMETER **
2220  !****************************************************
2230  !
2240  ON KBD GOTO 2380
2250  MOVE 5,50
2260  LABEL "YOUR CHOSEN ITEM HAS THIS CURRENT VALUE:"
2270  CSIZE 15
2280  Old_imp_value$=Imp_value$
2290  ENTER @Voltmeter;Imp_value
```

```
2300  Imp_value$=VAL$(Imp_value*Multiplier)&Tail$
2310  MOVE 5,30
2320  PEN -1
2330  LABEL Old_imp_value$
2340  MOVE 5,30
2350  PEN 1
2360  LABEL Imp_value$
2370  GOTO 2280
2380  OFF KBD
2390  CLEAR SCREEN
2400  CSIZE 5
2410  GOTO 1660
2420  !
2430  !*******************************************************
2440  !** CALL SUBROUTINE THAT ALLOWS 'MANUAL' POSITIONING **
2450  !** OF THE WAVEGUIDE STAGE                           **
2460  !*******************************************************
2470  !
2480  CALL
Manual(Num_of_choices,Choices$(*),Distance$(*),@Daedal,Stage_pos$)
2490  !
2500  GOTO 1660
2510  OFF KBD
2520  OFF KEY
2530  CLEAR SCREEN
2540  CSIZE 5
2550  !
2560  !*******************************************************
2570  !** CALL SUBROUTINE THAT ALLOWS 'MANUAL' POSITIONING **
2580  !** OF THE WAVEGUIDE STAGE (INITIALIZE POSITION)      **
2590  !*******************************************************
2600  !
2610  CALL
Manual(Num_of_choices,Choices$(*),Distance$(*),@Daedal,Stage_pos$)
2620  !
2630  IF Use_motor=0 THEN GOTO 3160 ! SKIP WHEN NOT USING HURST
2640  !
2650  !************************************************
2660  !** CALL SUBROUTINE THAT ADJUSTS THE PRESSURE **
2670  !** ON THE MEASUREMENT ARM PRISM IF THE HURST **
2680  !** STEPPER MOTOR IS BEING USED               **
2690  !************************************************
2700  !
2710  Num_of_choices=4
2720  Choices$(0)="1000 STEPS"
2730  Choices$(1)="100  STEPS"
2740  Choices$(2)="10   STEPS"
2750  Choices$(3)="1    STEP"
2760  Steps$(0)="1000"
2770  Steps$(1)="100"
2780  Steps$(2)="10"
2790  Steps$(3)="1"
2800  Total_steps=0
2810  !
2820  CALL
Hurst(Num_of_choices,Choices$(*),Steps$(*),@Multi,@Voltmeter,Initial_steps,
Pressure2)
2830  !
```

```
2840  !*************************************************
2850  !** SET THE TARGET PRESSURE FOR THE AUTOMATED **
2860  !** MEASUREMENTS                               **
2870  !*************************************************
2880  !
2890  Target_press=Pressure2
2900  !
2910  !***********************************************
2920  !** REDUCE INITIAL NUMBER OF STEPS SLIGHTLY **
2930  !** TO PREVENT OVER PRESSURE                 **
2940  !***********************************************
2950  !
2960  IF Initial_steps<50 THEN GOTO 3160
2970  IF Initial_steps>5000 THEN
2980                             Initial_steps=Initial_steps-100
2990                        ELSE
3000                             Initial_steps=Initial_steps-50
3010  END IF
3020  !
3030  !*************************
3040  !** END OF MANUAL SETUP **
3050  !*************************
3060  !
3070  !**********************
3080  !** BEGIN EXPERIMENT **
3090  !**********************
3100  !
3110  !****************************************
3120  !** INITIALIZE VALUES FOR SCROLL MENU **
3130  !** EXPERIMENT SETUP VALUES           **
3140  !****************************************
3150  !
3160  Choices$(0)="MOVE TOWARD OR AWAY FROM MOTOR? (T/A)"
3170  Choices$(1)="TRAVEL INCREMENT IN mm (.1 - 10)"
3180  Choices$(2)="TOTAL MEAS. DIST. IN mm (1<D<100)"
3190  Choices$(3)="ENTER THE FILENAME"
3200  Choices$(4)="EXIT"
3210  Num_of_choices=5
3220  Constraints$(0)="T,0,0,T,A,!"
3230  Constraints$(1)="N,10,.1,0,0,!"
3240  Constraints$(2)="N,100,1,0,0,!"
3250  Constraints$(3)="T,0,0,,,!"
3260  !
3270  !**********************************************************
3280  !** CALL SUBROUTINE FOR INPUTING EXPERIMENT PARAMETERS **
3290  !**********************************************************
3300  !
3310  CALL Chooser(Num_of_choices,Choices$(*),Constraints$(*),Value$(*))
3320  CLEAR SCREEN
3330  Filename$=Value$(3)
3340  !
3350  !************************************************
3360  !** RESET POSITION COUNTER AND DISPLAY TO ZERO **
3370  !************************************************
3380  !
3390  OUTPUT @Daedal USING "#,K";"X0 DA ",END
3400  !
3410  !***********************************************
```

```
3420  !** CONVERSION AND PARAMETER SETUP ROUTINES **
3430  !*********************************************
3440  !
3450  !***********************************************
3460  !** SET COMMAND FOR CONTROLLER FOR FORWARD OR **
3470  !** REVERSE TRAVEL DIRECTION                  **
3480  !***********************************************
3490  !
3500  IF Value$(0)="A" THEN
3510                      Direction$=""
3520  ELSE
3530                      Direction$="-"
3540  END IF
3550  !
3560  !**************************************
3570  !** CONVERT MILLIMETERS TO INCHES    **
3580  !** GET MOTOR STEPS PER INCREMENT    **
3590  !**************************************
3600  !
3610  Increment=VAL(Value$(1))/25.4
3620  Total_dist=VAL(Value$(2))/25.4
3630  Inc_step=INT(Increment/.00002)
3640  Step_count=INT(Total_dist/Increment)
3650  !
3660  !****************************************************
3670  !** INFORM USER OF THE NUMBER OF MEASUREMENT STEPS **
3680  !****************************************************
3690  !
3700  PRINT "THE TOTAL NUMBER OF MEASUREMENT STEPS WILL BE ";Step_count
3710  WAIT 2
3720  CLEAR SCREEN
3730  !
3740  !*********************************************
3750  !** DIMENSION AN ARRAY FOR STORING THE DATA **
3760  !*********************************************
3770  !
3780  ALLOCATE Datums(Step_count-1,8)
3790  !
3800  !**********************************************
3810  !** INFORM USER THAT MEASUREMENTS WILL BEGIN **
3820  !**********************************************
3830  !
3840  MOVE 15,70
3850  LABEL "**********************************"
3860  LABEL "*** MEASUREMENT WILL NOW BEGIN ***"
3870  LABEL "**********************************"
3880  WAIT 2
3890  CLEAR SCREEN
3900  !
3910  !**************************************************
3920  !** GENERATE COMMAND STRING FOR TRAVEL DIRECTION **
3930  !** AND INCREMENTAL DISTANCE STEP.  THIS MOVE IS **
3940  !** EXECUTED IN THE UPCOMING FOR/NEXT LOOP       **
3950  !**************************************************
3960  !
3970  Command$="D"&Direction$&VAL$(Inc_step)&" "
3980  !
3990  !**********************************************
```

```
4000  !** THIS SENDS THE COMMAND TO THE CONTROLLER **
4010  !** NO ACTUAL MOVE IS DONE YET THOUGH         **
4020  !**********************************************
4030  !
4040  OUTPUT @Daedal USING "#,K";Command$,END
4050  !
4060  !************************************************
4070  !** INITIALIZE STAGE POSITION VARIABLE TO ZERO **
4080  !************************************************
4090  !
4100  Position=0
4110  !
4120  !************************************
4130  !** MOVE/MEASUREMENT FOR/NEXT LOOP **
4140  !************************************
4150  !
4160  FOR I=0 TO Step_count-1
4170  IF Out_of_plane=1 THEN GOTO 4690 ! SKIP FOR OUT OF PLANE
4180  IF Use_motor=1 THEN GOTO 4540  ! SKIP WHEN USING HURST MOTOR
4190  !
4200  MOVE 15,70
4210  LABEL "*********************************"
4220  LABEL "*** TIGHTEN MEASUREMENT PRISM ***"
4230  LABEL "*********************************"
4240  LABEL
4250  LABEL "PRESS ANY KEY TO CONTINUE AFTER"
4260  LABEL "AFTER PRISM PRESSURE STABILIZES"
4270  !
4280  !*****************************************************
4290  !** ON SCREEN MONITOR OF MEASUREMENT PRISM PRESSURE **
4300  !*****************************************************
4310  !
4320  ON KBD GOTO 4470
4330  OUTPUT @Voltmeter;"CHAN 1"
4340  CSIZE 15
4350  Old_pressure2=Pressure2
4360  Old_pressure2$=VAL$(Old_pressure2)&" lbs"
4370  ENTER @Voltmeter;Pressure2
4380  Pressure2=10*Pressure2
4390  Pressure2$=VAL$(Pressure2)&" lbs"
4400  PEN -1
4410  MOVE 5,30
4420  LABEL Old_pressure2$
4430  PEN 1
4440  MOVE 5,30
4450  LABEL Pressure2$
4460  GOTO 4350
4470  OFF KBD
4480  GOTO 4690
4490  !
4500  !*************************************
4510  !** STEPPER MOTOR ROUTINE GOES HERE **
4520  !*************************************
4530  !
4540  Total_steps=Initial_steps
4550  OUTPUT @Voltmeter;"CHAN 1"
4560  OUTPUT @Multi;"WF,8.1,0,8.2,5000T,OP,8,"&VAL$(Initial_steps)&"T"
4570  WAIT .005*Initial_steps ! WAIT UNTIL FINISHED
```

```
4580  ENTER @Voltmeter;Pressure2 !GET NEW PRESSURE
4590  !
4600  IF Pressure2>Target_press THEN
4610  GOTO 4690
4620                            ELSE
4630  OUTPUT @Multi;"WF,8.1,0,8.2,5000T,OP,8,10T"
4640  WAIT .05 ! WAIT UNTIL FINISHED
4650  Total_steps=Total_steps+10
4660  GOTO 4580
4670  END IF
4680  !
4690  CSIZE 5
4700  CLEAR SCREEN
4710  !
4720  !************************
4730  !** TAKE MEASUREMENTS **
4740  !************************
4750  !
4760  OUTPUT @Voltmeter;"CHAN 3"
4770  PRINT "Reading Exit Prism Intensity..."
4780  ENTER @Voltmeter;Exit_prism
4790  DISP "EXIT PRISM READING WAS ";Exit_prism
4800  WAIT 1
4810  OUTPUT @Voltmeter;"CHAN 4"
4820  PRINT "  Reading Measurement Prism Intensity..."
4830  ENTER @Voltmeter;Meas_prism
4840  DISP "MEASUREMENT PRISM READING WAS ";Meas_prism
4850  WAIT 1
4860  OUTPUT @Voltmeter;"CHAN 0"
4870  PRINT "    Reading Load Cell 1 Pressure..."
4880  ENTER @Voltmeter;Pressure1
4890  DISP "LOAD CELL 1 READING WAS ";Pressure1
4900  WAIT 1
4910  !
4920  IF Out_of_plane=1 THEN GOTO 4990 ! SKIP FOR OUT OF PLANE
4930  !
4940  OUTPUT @Voltmeter;"CHAN 1"
4950  PRINT "      Reading Load Cell 2 Pressure..."
4960  ENTER @Voltmeter;Pressure2
4970  DISP "LOAD CELL 2 READING WAS ";Pressure2
4980  WAIT 1
4990  OUTPUT @Voltmeter;"CHAN 2"
5000  PRINT "        Reading Load Cell 3 Pressure..."
5010  ENTER @Voltmeter;Pressure3
5020  DISP "LOAD CELL 3 READING WAS ";Pressure3
5030  WAIT 1
5040  Datums(I,0)=ABS(Position*.00002*25.4)! STAGE POSITION
5050  Datums(1,1)=Exit_prism! EXIT PRISM
5060  Datums(I,2)=Meas_prism! MEAS PRISM
5070  Datums(I,3)=10*Pressure1! LDCELL1
5080  Datums(I,4)=10*Pressure2! LDCELL2
5090  Datums(I,5)=10*Pressure3! LDCELL3
5100  CLEAR SCREEN
5110  PRINT "THE LAST MEASUREMENT POSITION WAS ";Datums(I,0);" mm"
5120  !
5130  !***************************************
5140  !** END OF TAKE MEASUREMENTS SECTION **
5150  !***************************************
```

```
5160  !
5170  IF Out_of_plane=1 THEN GOTO 5720 ! SKIP FOR OUT OF PLANE
5180  IF Use_motor=1 THEN GOTO 5690 ! SKIP WHEN USING HURST MOTOR
5190  PEN 1
5200  MOVE 15,70
5210  LABEL "*********************************"
5220  LABEL "*** LOOSEN MEASUREMENT PRISM  ***"
5230  LABEL "*********************************"
5240  LABEL
5250  LABEL "PRESS ANY KEY TO CONTINUE AFTER"
5260  LA3EL "THE PRISM IS OFF THE SAMPLE"
5270  !
5280  !*****************************************************
5290  !** ON SCREEN MONITOR OF MEASUREMENT PRISM PRESSURE **
5300  !*****************************************************
5310  !
5320  ON KBD GOTO 5530
5330  OUTPUT @Voltmeter;"CHAN 1"
5340  CSIZE 15
5350  Old_no_press=No_press
5360  Old_no_press$=VAL$(Old_no_press)&" lbs"
5370  ENTER @Voltmeter;No_press
5380  No_press=10*No_press
5390  No_press$=VAL$(No_press)&" lbs"
5400  PEN -1
5410  MOVE 5,30
5420  LABEL Old_no_press$
5430  PEN 1
5440  MOVE 5,30
5450  LABEL No_press$
5460  GOTO 5350
5470  !
5480  !**************************************
5490  !** NO MOVEMENT ALLOWED UNTIL PRISM  **
5500  !** IS OFF OF THE SAMPLE             **
5510  !**************************************
5520  !
5530  IF No_press>.08 THEN
5540       PEN -1
5550       MOVE 5,30
5560       LABEL Old_no_press$
5570       GOTO 5350
5580  END IF
5590  OFF KBD
5600  PEN -1
5610  MOVE 5,30
5620  LABEL No_press$
5630  GOTO 5720
5640  !
5650  !************************************
5660  !** RAISE HURST MOTOR ROUTINE HERE **
5670  !************************************
5680  !
5690  OUTPUT @Multi;"WF,8.1,0,8.2,5000T,OP,8,-"&VAL$(Total_steps)&"T"
5700  WAIT .005*Total_steps
5710  !
5720  PEN 1
5730  CSIZE 5
```

```
5740  CLEAR SCREEN
5750  !
5760  !******************************************
5770  !** READ EXIT PRISM QUIESCENT INTENSITY **
5780  !******************************************
5790  !
5800  OUTPUT @Voltmeter;"CHAN 3"
5810  ENTER @Voltmeter;Exit_prism
5820  Datums(I,6)=Exit_prism! EXIT PRISM QUIESCENT
5830  !
5840  !*********************************************
5850  !** CALCULATE (P3o*P2)/(P3o-P3) AND ITS LOG **
5860  !*********************************************
5870  !
5880  Datums(I,7)=((Datums(I,6)*Datums(I,2))/(Datums(I,6)-Datums(I,1)))
5890  ON ERROR GOTO 5920 !CAN'T TAKE LOG OF NEG NUMBER
5900  Datums(I,8)=LGT(Datums(I,7))
5910  GOTO 5930
5920  Datums(I,8)=0
5930  OFF ERROR
5940  !
5950  !********************************
5960  !** PREVENTS LAST MOVE COMMAND **
5970  !********************************
5980  !
5990  IF I=Step_count-1 THEN GOTO 6210
6000  OUTPUT @Daedal USING "#,K";"G ",END!** MOVE COMMAND **
6010  !
6020  !*********************************
6030  !** WAIT UNTIL MOVE IS COMPLETE **
6040  !*********************************
6050  !
6060  IF SPOLL(@Daedal)=1 THEN GOTO 6140
6070  GOTO 6060
6080  !
6090  !***************************************
6100  !** REQUEST AND RECEIVE POSITION INFO **
6110  !** FROM THE STAGE CONTROLLER         **
6120  !***************************************
6130  !
6140  OUTPUT @Daedal USING "#,K";"X1 ",END
6150  Test=SPOLL(@Daedal)
6160  IF Test>8 THEN GOTO 6180!GET FROM CONTROLLER?
6170  GOTO 6150
6180  WAIT .5
6190  ENTER @Daedal;Position$!RECEIVE POSITION
6200  Position=VAL(Position$)
6210  NEXT I
6220  !
6230  !**************************************
6240  !** END OF ACQUISITION FOR/NEXT LOOP **
6250  !**************************************
6260  !
6270  CLEAR SCREEN
6280  !
6290  !*************************************
6300  !** DISABLE IEEE-488 FOR CONTROLLER **
6310  !*************************************
```

```
6320  !
6330  OUTPUT @Daedal USING "#,K";"F ",END
6340  !
6350  !*********************************************
6360  !** CONVERT AND STORE DATA ON THE HARD DISK **
6370  !*********************************************
6380  !
6390  CALL Data_converter(Datums(*),Filename$)
6400  !
6410  !*************************
6420  !** END OF DATA STORAGE **
6430  !*************************
6440  !
6450  END
6460  !
6470  !%%%%%%%%%%%%%%%%%%%%
6480  !%% END OF PROGRAM %%
6490  !%%%%%%%%%%%%%%%%%%%%
6500  !
6510  !
6520  !%%%%%%%%%%%%%%%%%%%%%%%
6530  !%% BEGIN SUBROUTINES %%
6540  !%%%%%%%%%%%%%%%%%%%%%%%
6550  !
6560  SUB
Manual(Num_of_choices,Choices$(*),Distance$(*),@Daedal,Stage_pos$)
6570  !
6580  !*************************************************************
6590  !** THIS SUBROUTINE ALLOWS MENU-LIKE CONTROL OF THE DAEDAL **
6600  !** MOTION CONTROLLER AND THE RAIL TABLE.  IT IS USED TO   **
6610  !** 'MANUALLY' POSITION THE RAIL TABLE BEFORE BEGINNING    **
6620  !** THE EXPERIMENT                                         **
6630  !*************************************************************
6640  !
6650  !** VARIABLE DESCRIPTIONS:                                **
6660  !**                                                       **
6670  !** Num_of_choices - THIS IS THE TOTAL NUMBER OF ITEMS    **
6680  !**                  LISTED IN THE MENU ON THE SCREEN     **
6690  !
6700  !** Choices$(*) - THIS IS A SERIES OF STRINGS CONTAINING  **
6710  !**               THE TEXT ASKING FOR INPUT INFORMATION   **
6720  !**               e.g. "10,000 STEP MOVEMENT"             **
6730  !**               OPTION BASE 0 MUST BE USED e.g. WHEN    **
6740  !**               Num_of_choices=3 then Choices$(*) MUST  **
6750  !**               BE NUMBERED Choices$(0),Choices$(1),AND **
6760  !**               Choices$(2)                             **
6770  !**                                                       **
6780  !** Distance$(*) - THIS SET OF STRINGS CONTAINS THE       **
6790  !**                NUMBER OF STEPS THAT WILL BE MOVED     **
6800  !**                WHEN THE LEFT OR RIGHT ARROW KEY IS    **
6810  !**                PRESSED                                **
6820  !**                                                       **
6830  !** @DAEDAL - THIS IS THE HPIB ADDRESS OF THE MOTION      **
6840  !**           CONTROLLER.  THIS IS ASSIGNED AT THE        **
6850  !**           BEGINNING OF THE PROGRAM                    **
6860  !**                                                       **
6870  !** Stage_pos$ - THIS IS THE CURRENT POSITION OF THE      **
6880  !**              STAGE.  WHEN THIS PROGRAM IS STARTED     **
```

```
6890  !**                THE CURRENT POSITION OF THE STAGE IS      **
6900  !**                TAKEN AS ZERO.  THIS VARIABLE WILL GIVE   **
6910  !**                THE USER THE RELATIVE POSITION SINCE      **
6920  !**                BEGINNING THE PROGRAM                     **
6930  !**                                                          **
6940  !************************************************************
6950  !
6960  !*********************************************************
6970  !** THE NEXT 4 LINES CLEAR THE SCREEN,SET THE STARTING **
6980  !** POINT FOR LABELS,SET THE PEN TO WRITE AND SET THE  **
6990  !** CHARACTER SIZE                                    **
7000  !*********************************************************
7010  !
7020  CLEAR SCREEN
7030  PEN 1
7040  CSIZE 4,.5
7050  !
7060  !********************************************************
7070  !** THIS LINE MAKES THE CHOOSING CURSOR A WHITE BLOCK **
7080  !********************************************************
7090  !
7100  Cursor$=CHR$(127)
7110  !
7120  !*******************************************************
7130  !** THE FOR NEXT LOOP PUTS THE CHOICES ON THE SCREEN **
7140  !*******************************************************
7150  !
7160  FOR I=0 TO Num_of_choices-1
7170  MOVE 10,95-5*I
7180  LABEL Choices$(I)
7190  NEXT I
7200  !
7210  !*****************************************************************
7220  !** THE NEXT 3 LINES PLACES THE CURSOR BESIDE THE 1st CHOICE **
7230  !*****************************************************************
7240  !
7250  MOVE 5,95
7260  I=0
7270  LABEL Cursor$
7280  !
7290  !*******************************************************************
7300  !** THE NEXT TWO LINES PRINTS THE CURRENT POSITION OF THE STAGE **
7310  !*******************************************************************
7320  !
7330  MOVE 10,20
7340  LABEL "THE CURRENT POSITION IS ";Stage_pos$
7350  !
7360  !**********************************************************************
7370  !** THE NEXT 4 LINES PRINTS AN OPERATING INSTRUCTION ON THE SCREEN **
7380  !**********************************************************************
7390  !
7400  MOVE 10,30
7410  LABEL "PRESS RETURN WHEN MANUAL ADJUSTMENT IS COMPLETE"
7420  MOVE 10,35
7430  LABEL "USE LEFT/RIGHT ARROWS TO MOVE MOTOR"
7440  MOVE 10,40
7450  LABEL "USE UP/DOWN ARROWS TO SCROLL MENU"
7460  !
```

```
7470  !********************************************************
7480  !** WHEN A KEY IS STRUCK GO TO THE MOVE CURSOR ROUTINE **
7490  !********************************************************
7500  !
7510 Diddle_loop:  ON KBD GOTO Movement
7520         GOTO 7520
7530  !
7540  !**************************
7550  !** MOVE CURSOR ROUTINE  **
7560  !**************************
7570  !
7580  !********************************************************
7590  !** THIS ROUTINE ONLY TAKES ACTION WHEN THE UP,DOWN OR **
7600  !** RETURN KEY IS PRESSED. GO TO Up ON UP KEY, GO TO   **
7610  !** Down ON DOWN KEY, GO TO Take_data ON RETURN        **
7620  !********************************************************
7630  !
7640 Movement: !
7650           Where$=KBD$
7660           OFF KBD
7670           IF Where$=CHR$(255)&"^" THEN Up
7680           IF Where$=CHR$(255)&"V" THEN Down
7690           IF Where$=CHR$(255)&"<" THEN Move_stage_lft
7700           IF Where$=CHR$(255)&">" THEN Move_stage_rgt
7710           IF Where$=CHR$(255)&"E" THEN Finished
7720  GOTO Diddle_loop
7730  !
7740  !**********************************
7750  !**  END OF MOVE CURSOR ROUTINE  **
7760  !**********************************
7770  !
7780  !***************************
7790  !**  UP MOVEMENT ROUTINE  **
7800  !***************************
7810  !
7820  !********************************
7830  !** THIS SCROLLS THE CURSOR UP **
7840  !********************************
7850  !
7860 Up: !
7870  PEN -1
7880  MOVE 5,95-5*I
7890  LABEL Cursor$
7900  IF I=0 THEN
7910            I=Num_of_choices-1
7920         ELSE
7930            I=I-1
7940  END IF
7950  PEN 1
7960  MOVE 5,95-5*I
7970  LABEL Cursor$
7980  GOTO Diddle_loop
7990  !
8000  !**********************************
8010  !**  END OF UP MOVEMENT ROUTINE  **
8020  !**********************************
8030  !
8040  !*****************************
```

```
8050  !**  DOWN MOVEMENT ROUTINE  **
8060  !******************************
8070  !
8080  !***********************************
8090  !** THIS SCROLLS THE CURSOR DOWN **
8100  !***********************************
8110  !
8120 Down:!
8130  PEN -1
8140  MOVE 5,95-5*I
8150  LABEL Cursor$
8160  IF I=Num_of_choices-1 THEN
8170                           I=0
8180                        ELSE
8190                           I=I+1
8200  END IF
8210  PEN 1
8220  MOVE 5,95-5*I
8230  LABEL Cursor$
8240  GOTO Diddle_loop
8250  !
8260  !*************************************
8270  !**  END OF DOWN MOVEMENT ROUTINE  **
8280  !*************************************
8290  !
8300  !************************************
8310  !** BEGIN STAGE MOVEMENT ROUTINES **
8320  !************************************
8330  !
8340  !*****************************************************
8350  !** THIS SUBROUTINE MOVES THE RAIL TABLE STAGE TO   **
8360  !** THE LEFT (TOWARD THE STEPPER MOTOR) THE NUMBER **
8370  !** OF STEPS INDICATED BY Distance$(I).  THE       **
8380  !** COMPUTER THEN POLLS THE MOTION CONTROLLER TO   **
8390  !** DETERMINE WHEN THE MOVE HAS BEEN COMPLETED.    **
8400  !** AFTER THE MOVE IS COMPLETE THE                **
8410  !** COMPUTER REQUESTS THE CURRENT RELATIVE        **
8420  !** POSITION OF THE STAGE AND PRINTS IT ON THE    **
8430  !** SCREEN                                        **
8440  !*****************************************************
8450  !
8460 Move_stage_lft: !
8470  !
8480  !*******************************************************************
8490  !** THE OUTPUT STATEMENT PERFORMS THE FOLLOWING: '#,K'IN USING   **
8500  !** SUPPRESSES EOL AT THE END OF THE COMMAND AND STRIPS BLANKS   **
8510  !** FROM ANY CHARACTERS, THE CHARACTER STRING SENT IS             **
8520  !** 'D-XXXXXXX G ' WHERE XXXXXXX IS A NUMBER. THE ',END' IS      **
8530  !** USED TO SUPPRESS EOL WHEN THERE IS NO DATA SENT AND TO SEND **
8540  !** THE END-OR-IDENTIFY WHEN A COMMAND IS SENT.  SEE PAGE 450    **
8550  !** OF THE BASIC 5.0/5.1 LANGUAGE REFERENCE VOL. 2:O-Z FOR AN    **
8560  !** EQUALLY USELESS EXPLAINATION.  THIS IS ALL DUE               **
8570  !** TO DAEDAL'S PISS-POOR IMPLEMENTATION OF THE GPIB COMMAND     **
8580  !** SET                                                          **
8590  !*******************************************************************
8600  !
8610            OUTPUT @Daedal USING "#,K";"D-"&Distance$(I)&" G ",END
8620  !
```

```
8630  !***********************************************************************
8640  !** SERIAL POLL THE MOTION CONTROLLER TO DETERMINE WHEN STAGE        **
8650  !** MOVEMENT IS COMPLETE. CONTROLLER WILL RETURN A 1                 **
8660  !***********************************************************************
8670  !
8680            Move_done=SPOLL(@Daedal)
8690            IF Move_done<>1 THEN GOTO 8680
8700  !
8710  !***********************************************************************
8720  !** THIS OUTPUT STATEMENT REQUESTS THE CURRENT RELATIVE              **
8730  !** POSITION OF THE STAGE FROM THE MOTION CONTROLLER                 **
8740  !***********************************************************************
8750  !
8760            OUTPUT @Daedal USING "#,K";"X1 ",END
8770  !
8780  !***********************************************************************
8790  !** SERIAL POLL THE MOTION CONTROLLER TO DETERMINE WHEN THE          **
8800  !** CURRENT POSITION INFORMATION IS AVAILABLE                        **
8810  !***********************************************************************
8820  !
8830            Answer_back=SPOLL(@Daedal)
8840            IF Answer_back<8 THEN GOTO 8830
8850  !
8860  !***********************************************************************
8870  !** CLEAR THE OLD CURRENT POSITION FROM THE SCREEN THEN READ         **
8880  !** THE NEW CURRENT POSITION INFORMATION AND PRINT IT ON THE         **
8890  !** SCREEN                                                           **
8900  !***********************************************************************
8910  !
8920            MOVE 10,20
8930            PEN -1
8940            LABEL "THE CURRENT POSITION IS ";Stage_pos$
8950            ENTER @Daedal USING "K";Stage_pos$
8960            MOVE 10,20
8970            PEN 1
8980            LABEL "THE CURRENT POSITION IS ";Stage_pos$
8990            GOTO Diddle_loop
9000  !
9010  !*****************************************************
9020  !** THIS SUBROUTINE MOVES THE RAIL TABLE STAGE TO   **
9030  !** THE RIGHT (AWAY FROM THE STEPPER MOTOR) THE     **
9040  !** NUMBER OF STEPS INDICATED BY Distance$(I). THE **
9050  !** COMPUTER THEN POLLS THE MOTION CONTROLLER TO    **
9060  !** DETERMINE WHEN THE MOVE HAS BEEN COMPLETED.     **
9070  !** AFTER THE MOVE IS COMPLETE THE                  **
9080  !** COMPUTER REQUESTS THE CURRENT RELATIVE          **
9090  !** POSITION OF THE STAGE AND PRINTS IT ON THE      **
9100  !** SCREEN                                          **
9110  !*****************************************************
9120  !
9130 Move_stage_rgt: !
9140  !
9150  !************************************************************************
9160  !** THE OUTPUT STATEMENT PERFORMS THE FOLLOWING: '#,K'IN USING       **
9170  !** SUPPRESSES EOL AT THE END OF THE COMMAND AND STRIPS BLANKS       **
9180  !** FROM ANY CHARACTERS. THE CHARACTER STRING SENT IS                **
9190  !** 'DXXXXXXX G ' WHERE XXXXXXX IS A NUMBER. THE ',END' IS           **
9200  !** USED TO SUPPRESS EOL WHEN THERE IS NO DATA SENT AND TO SEND **
```

```
9210  !** THE END-OR-IDENTIFY WHEN A COMMAND IS SENT.  SEE PAGE 450    **
9220  !** OF THE BASIC 5.0/5.1 LANGUAGE REFERENCE VOL. 2:O-Z FOR AN     **
9230  !** EQUALLY USELESS EXPLAINATION.  THIS IS ALL DUE                **
9240  !** TO DAEDAL'S PISS-POOR IMPLEMENTATION OF THE GPIB COMMAND      **
9250  !** SET                                                           **
9260  !*****************************************************************
9270  !
9280            OUTPUT @Daedal USING "#,K";"D"&Distance$(I)&" G ",END
9290  !
9300  !****************************************************************
9310  !** SERIAL POLL THE MOTION CONTROLLER TO DETERMINE WHEN STAGE  **
9320  !** MOVEMENT IS COMPLETE. CONTROLLER WILL RETURN A 1            **
9330  !****************************************************************
9340  !
9350            Move_done=SPOLL(@Daedal)
9360            IF Move_done<>1 THEN GOTO 9350
9370  !
9380  !****************************************************************
9390  !** THIS OUTPUT STATEMENT REQUESTS THE CURRENT RELATIVE         **
9400  !** POSITION OF THE STAGE FROM THE MOTION CONTROLLER           **
9410  !****************************************************************
9420  !
9430            OUTPUT @Daedal USING "#,K";"X1 ",END
9440  !
9450  !****************************************************************
9460  !** SERIAL POLL THE MOTION CONTROLLER TO DETERMINE WHEN THE    **
9470  !** CURRENT POSITION INFORMATION IS AVAILABLE                   **
9480  !****************************************************************
9490  !
9500            Answer_back=SPOLL(@Daedal)
9510            IF Answer_back<8 THEN GOTO 9500
9520  !
9530  !****************************************************************
9540  !** CLEAR THE OLD CURRENT POSITION FROM THE SCREEN THEN READ   **
9550  !** THE NEW CURRENT POSITION INFORMATION AND PRINT IT ON THE   **
9560  !** SCREEN                                                     **
9570  !****************************************************************
9580  !
9590            MOVE 10,20
9600            PEN -1
9610            LABEL "THE CURRENT POSITION IS ";Stage_pos$
9620            ENTER @Daedal USING "K";Stage_pos$
9630            MOVE 10,20
9640            PEN 1
9650            LABEL "THE CURRENT POSITION IS ";Stage_pos$
9660            GOTO Diddle_loop
9670  !
9680  !*********************************
9690  !** END STAGE MOVEMENT ROUTINES **
9700  !*********************************
9710  !
9720  !****************************************************************
9730  !** IF THE RETURN KEY IS PRESSED THE SUBPROGRAM TERMINATES     **
9740  !****************************************************************
9750  !
9760 Finished:!
9770  SUBEND
9780  !
```

```
9790  SUB Chooser(Num_of_choices,Choices$(*),Constraints$(*),Value$(*))
9800  !***********************************************************
9810  !** THIS SUBROUTINE ALLOWS MENU-LIKE INPUT OF INFORMATION **
9820  !***********************************************************
9830  !
9840  !** VARIABLE DESCRIPTIONS:                                **
9850  !**                                                       **
9860  !** Num_of_choices - THIS IS THE TOTAL NUMBER OF ITEMS    **
9870  !**                  THAT WILL REQUIRE ENTERED VALUES     **
9880  !
9890  !** Choices$(*) - THIS IS A SERIES OF STRINGS CONTAINING  **
9900  !**               THE TEXT ASKING FOR INPUT INFORMATION   **
9910  !**               e.g. "ENTER THE PULSE WIDTH"             **
9920  !**               OPTION BASE 0 MUST BE USED e.g. WHEN    **
9930  !**               Num_of_choices=3 then Choices$(*) MUST  **
9940  !**               BE NUMBERED Choices$(0),Choices$(1),AND **
9950  !**               Choices$(2)                             **
9960  !
9970  !** Constraints$(*) - THIS IS A SERIES OF STRINGS THAT    **
9980  !**                   CONTAIN TESTING VALUES AND LIMITS   **
9990  !**                   TO BE USED WHEN DETERMINING THE     **
10000 !**                   VALIDITY OF ENTERED VALUES.  THESE  **
10010 !**                   STRINGS ARE USED TO VERIFY INPUT    **
10020 !**                   VALUES AS NUMBER OR TEXT, WITHIN    **
10030 !**                   HIGH AND LOW LIMITS IF A NUMBER     **
10040 !**                   OR A LEGAL RESPONSE IF TEXT         **
10050 !
10060 !** Value$(*) - THESE STRINGS CONTAIN THE ENTERED INFO    **
10070 !**             THAT WILL BE RETURNED TO THE MAIN PROGRAM **
10080 !***********************************************************
10090 !
10100 !*************************************************
10110 !** Erase$ IS USED WHEN CORRECTING A MISTAKE IN **
10120 !** AN ENTERED VALUE                            **
10130 !*************************************************
10140 DIM Erase$[30]
10150 Erase$=""
10160 !*******************************************************
10170 !** Temp$ IS A TEMPORARY STORAGE STRING THAT IS USED  **
10180 !** WHEN THE USER IS INPUTING INFORMATION.  WHEN      **
10190 !** Temp$ IS COMPLETED IT IS TRANSFERRED TO Value$(I) **
10200 !*******************************************************
10210 DIM Temp$[30]
10220 Temp$=""
10230 !********************************************************
10240 !** THE NEXT 4 LINES CLEAR THE SCREEN,SET THE STARTING **
10250 !** POINT FOR LABELS,SET THE PEN TO WRITE AND SET THE  **
10260 !** CHARACTER SIZE                                     **
10270 !********************************************************
10280 CLEAR SCREEN
10290 LORG 2
10300 PEN 1
10310 CSIZE 4,.5
10320 !*******************************************************
10330 !** THIS LINE MAKES THE CHOOSING CURSOR A WHITE BLOCK **
10340 !*******************************************************
10350 Cursor$=CHR$(127)
10360 !******************************************************
```

```
10370 !** THE FOR NEXT LOOP PUTS THE CHOICES ON THE SCREEN **
10380 !******************************************************
10390 FOR I=0 TO Num_of_choices-1
10400 MOVE 10,95-5*I
10410 LABEL Choices$(I)
10420 NEXT I
10430 I=0
10440 IF Value$(I)="" THEN GOTO 10520
10450 FOR I=0 TO Num_of_choices-2
10460 MOVE 85,95-5*I
10470 LABEL Value$(I)
10480 NEXT I
10490 !***************************************************************
10500 !** THE NEXT 3 LINES PLACES THE CURSOR BESIDE THE 1st CHOICE **
10510 !***************************************************************
10520 MOVE 5,95
10530 I=0
10540 LABEL Cursor$
10550 !********************************************************
10560 !** WHEN A KEY IS STRUCK GO TO THE MOVE CURSOR ROUTINE **
10570 !********************************************************
10580 Diddle_loop: ON KBD GOTO Movement
10590        GOTO 10590
10600 !**************************
10610 !** MOVE CURSOR ROUTINE  **
10620 !**************************
10630 !
10640 !********************************************************
10650 !** WHEN A KEY IS PRESSED, THIS ROUTINE DETERMINES     **
10660 !** IF THE KEYSTROKE WAS AN UP OR DOWN ARROW OR IF IT **
10670 !** WAS A CHARACTER KEY. THE ARROWS MEAN MOVE THE      **
10680 !** CURSOR UP OR DOWN THROUGH THE CHIOCES ON THE       **
10690 !** SCREEN. A CHARACTER KEY MEANS THAT INFO IS BEING   **
10700 !** ENTERED. THE "DISP Where$" PLACES THE FIRST CHAR.  **
10710 !** ON THE SCREEN BEFORE EXITING TO THE Take_data      **
10720 !** IN ORDER TO MAKE INPUT VEIWING MORE SMOOTH         **
10730 !********************************************************
10740 Movement:!
10750          Where$=KBD$
10760          OFF KBD
10770          IF Where$=CHR$(255)&"^" THEN Up
10780          IF Where$=CHR$(255)&"V" THEN Down
10790          IF LEN(Where$)=1 THEN DISP Where$
10800          IF Where$<>"" THEN
10810                             GOTO Take_data
10820          END IF
10830 GOTO Diddle_loop
10840 !**********************************
10850 !**  END OF MOVE CURSOR ROUTINE  **
10860 !**********************************
10870 !
10880 !***************************
10890 !**  UP MOVEMENT ROUTINE  **
10900 !***************************
10910 !
10920 !********************************
10930 !** THIS SCROLLS THE CURSOR UP **
10940 !********************************
```

```
10950 Up:!
10960 PEN -1
10970 MOVE 5,95-5*I
10980 LABEL Cursor$
10990 IF I=0 THEN
11000           I=Num_of_choices-1
11010        ELSE
11020           I=I-1
11030 END IF
11040 PEN 1
11050 MOVE 5,95-5*I
11060 LABEL Cursor$
11070 GOTO Diddle_loop
11080 !**********************************
11090 !**  END OF UP MOVEMENT ROUTINE  **
11100 !**********************************
11110 !
11120 !*****************************
11130 !**  DOWN MOVEMENT ROUTINE  **
11140 !*****************************
11150 !
11160 !**********************************
11170 !** THIS SCROLLS THE CURSOR DOWN **
11180 !**********************************
11190 Down:!
11200 PEN -1
11210 MOVE 5,95-5*I
11220 LABEL Cursor$
11230 IF I=Num_of_choices-1 THEN
11240                          I=0
11250                       ELSE
11260                          I=I+1
11270 END IF
11280 PEN 1
11290 MOVE 5,95-5*I
11300 LABEL Cursor$
11310 GOTO Diddle_loop
11320 !************************************
11330 !**  END OF DOWN MOVEMENT ROUTINE  **
11340 !************************************
11350 !
11360 !******************************************
11370 !**          TAKE DATA ROUTINE           **
11380 !******************************************
11390 !******************************************
11400 !** THIS LOOP TAKES YOUR ENTRY FOR A     **
11410 !** PARTICULAR PARAMETER AND DETERMINES  **
11420 !** IF IT IS VALID GIVEN THE CONSTRAINTS **
11430 !** SET FORTH IN THE CONSTRAINTS$ STRING **
11440 !******************************************
11450 !
11460 !****************************************
11470 !** CHECKS TO SEE IF "EXIT" WAS CHOSEN **
11480 !****************************************
11490 Take_data: IF I=Num_of_choices-1 THEN
11500                                     GOTO Done
11510 END IF
11520 !*********************************************
```

```
11530 !** THE FIRST CHARACTER OF THE Temp$ STRING **
11540 !** IS TAKEN FROM THE Where$ STRING SINCE   **
11550 !** THIS WAS THE FIRST CHARACTER PRESSED    **
11560 !** OTHER THAN AN UP OR DOWN ARROW KEY      **
11570 !** Where$ IS THEN CLEARED                  **
11580 !*******************************************
11590 Temp$=Where$
11600 Where$=""
11610 !****************************************************
11620 !** SET PEN TO ERASE,ERASE CURSOR,SET PEN TO WRITE, **
11630 !** MOVE TO THE LOCATION WHERE THE VALID ENTRY WILL **
11640 !** BE DISPLAYED                                   **
11650 !****************************************************
11660 PEN -1
11670 LABEL Cursor$
11680 PEN 1
11690 MOVE 85,95-5*I
11700 !****************************************************
11710 !** GO TO THE SUBROUTINE THAT STRIPS THE CONSTRAINT **
11720 !** PARAMETERS FROM THE PROPER CONSTRAINTS$ STRING  **
11730 !** FOR THE CHOSEN ENTRY ITEM                      **
11740 !****************************************************
11750 GOSUB Extract
11760 !********************************************************
11770 !** UPDATE THE ERASE STRING,GENERATE AN ATTENTION TONE  **
11780 !** AND REQUEST AN INPUT                               **
11790 !********************************************************
11800 Erase$=Value$(I)
11810 ON KBD GOTO Build_string
11820 GOTO 11820
11830 Build_string:!
11840             Char$=KBD$
11850             IF Char$=CHR$(255)&"E" THEN GOTO 12050
11860             IF Char$=CHR$(255)&"B" THEN
11870             ON ERROR GOTO 11890
11880             Temp$=Temp$[1,LEN(Temp$)-1]
11890             OFF ERROR
11900             GOTO 12030
11910             END IF
11920             IF Char$=CHR$(255)&"^" THEN
11930                                       Temp$=""
11940                                       DISP Temp$
11950                                       GOTO Up
11960             END IF
11970             IF Char$=CHR$(255)&"V" THEN
11980                                       Temp$=""
11990                                       DISP Temp$
12000                                       GOTO Down
12010             END IF
12020             Temp$=Temp$&Char$
12030             DISP Temp$
12040             GOTO 11820
12050 OFF KBD
12060 Value$(I)=Temp$
12070 Temp$=""
12080 Where$=""
12090 !********************************
12100 !** VALID ENTRY CHECK ROUTINE **
```

```
12110 !********************************
12120 !
12130 !**********************************************
12140 !** IF THE ENTRY IS SUPPOSED TO BE A NUMBER **
12150 !** CHECK TO SEE THAT IT IS AND STRIP OFF   **
12160 !** TRAILING TEXT. THEN TEST TO SEE IF THE  **
12170 !** NUMBER IS BETWEEN THE SPECIFIED HIGH    **
12180 !** AND LOW VALUES. IF ANY OF THESE         **
12190 !** CONDITIONS ARE NOT MET THEN REJECT      **
12200 !**********************************************
12210 IF N_t$="N" THEN
12220                ON ERROR GOTO 12490
12230                Number=VAL(Value$(I))
12240                OFF ERROR
12250                Value$(I)=VAL$(Number)
12260                IF Number>VAL(High$) THEN
12270                                        Value$(I)=Erase$
12280                                        GOTO 12490
12290                END IF
12300                IF Number<VAL(Low$) THEN
12310                                        Value$(I)=Erase$
12320                                        GOTO 12490
12330                END IF
12340             ELSE
12350 !****************************************************
12360 !** IF THE ENTRY IS SUPPOSED TO BE TEXT THEN CHECK **
12370 !** TO SEE THAT IT IS ONE OF THE VALID RESPONSES   **
12380 !** IF NOT THEN REJECT                             **
12390 !****************************************************
12400                IF Text1$<>"" THEN GOTO 12430
12410                IF Text2$<>"" THEN GOTO 12430
12420                GOTO 12610
12430                IF Value$(I)=Text1$ THEN GOTO 12610
12440                IF Value$(I)=Text2$ THEN GOTO 12610
12450                Value$(I)=Erase$
12460                GOTO 12490
12470 END IF
12480 GOTO 12610
12490 BEEP 83.1,.2
12500 Temp$=""
12510 DISP Temp$
12520 GOTO 11810
12530 !********************************
12540 !**  END ENTRY CHECK ROUTINE  **
12550 !********************************
12560 !
12570 !*****************************************************
12580 !** IF THE ENTRY WAS VALID THEN ERASE THE OLD VALUE **
12590 !** AND REPLACE IT WITH THE NEW VALUE               **
12600 !*****************************************************
12610 PEN -1
12620 LABEL Erase$
12630 PEN 1
12640 MOVE 85,95-5*I
12650 LABEL Value$(I)
12660 GOTO Diddle_loop
12670 !*******************************
12680 !** END OF TAKE DATA ROUTINE **
```

```
12690 !******************************
12700 !
12710 !********************************
12720 !**  EXIT ROUTINE BEGINS HERE  **
12730 !********************************
12740 Done:!
12750 !************************************************
12760 !** ERASE THE CURSOR FROM ITS PRESENT LOCATION **
12770 !************************************************
12780      MOVE 5,95-5*I
12790      PEN -1
12800      LABEL Cursor$
12810      PEN 1
12820 !**********************************************
12830 !** THIS FOR NEXT LOOP TESTS FOR ANY MISSING **
12840 !** ENTRIES.  IF ANY ARE FOUND THEN THE EXIT **
12850 !** IS IGNORED UNTIL ALL ASKED FOR VALUES    **
12860 !** ARE ENTERED                              **
12870 !**********************************************
12880 OFF KBD
12890      FOR K=0 TO Num_of_choices-2
12900      IF Value$(K)="" THEN
12910                          MOVE 5,95-5*K
12920                          LABEL Cursor$
12930                          I=K
12940                          Where$=""
12950                          GOTO 11490
12960      END IF
12970      NEXT K
12980      CLEAR SCREEN
12990 !***************************
13000 !**  END OF EXIT ROUTINE  **
13010 !***************************
13020 !**************************************************
13030 !** IF THIS POINT IS REACHED THEN THE SUBPROGRAM **
13040 !** IS EXITED                                    **
13050 !**************************************************
13060 GOTO 13620
13070 !************************************************
13080 !**       STRING EXTRACTION SUB-ROUTINE        **
13090 !************************************************
13100 !** THIS ROUTINE EXTRACTS THE INFORMATION      **
13110 !** FROM THE CONSTRAINTS$ STRING AND PLACES    **
13120 !** IT IN A SERIES OF STRINGS THAT CAN BE USED **
13130 !** TO TEST THE ENTERED VALUE$ STRING TO SEE   **
13140 !** IF IT IS VALID                             **
13150 !************************************************
13160 Extract:!
13170 N_t$=""
13180 High$=""
13190 Low$=""
13200 Text1$=""
13210 Text2$=""
13220 T$=""
13230 P=1
13240 K$=""
13250 T$=Constraints$(I)[P,P]
13260 IF T$="," THEN GOTO Next_string
```

```
13270 IF T$="!" THEN GOTO Finish
13280 K$=K$&T$
13290 P=P+1
13300 GOTO 13250
13310 Next_string:!
13320 IF N_t$="" THEN
13330              N_t$=K$
13340              P=P+1
13350              GOTO 13240
13360 END IF
13370 IF High$="" THEN
13380              High$=K$
13390              P=P+1
13400              GOTO 13240
13410 END IF
13420 IF Low$="" THEN
13430              Low$=K$
13440              P=P+1
13450              GOTO 13240
13460 END IF
13470 IF Text1$="" THEN
13480              Text1$=K$
13490              P=P+1
13500              GOTO 13240
13510 END IF
13520 IF Text2$="" THEN
13530              Text2$=K$
13540              P=P+1
13550              GOTO 13240
13560 END IF
13570 Finish:!
13580       RETURN
13590!**********************************************
13600!** END OF THE STRING EXTRACTION SUB-ROUTINE **
13610!**********************************************
13620 SUBEND
13630 !
13640 !**********************************************
13650 !** DATA ARRAY CONVERTER AND STORAGE SUBROUTINE **
13660 !**********************************************
13670 !
13680 SUB Data_converter(Datums(*),Filename$)
13690 DIM Build_string$[1000]
13700 Build_string$=""
13710 Dimen=RANK(Datums)
13720 IF Dimen<>2 THEN Finish
13730 Row_lower_bound=BASE(Datums,1)
13740 Row_upper_bound=BASE(Datums,1)+SIZE(Datums,1)-1
13750 Col_lower_bound=BASE(Datums,2)
13760 Col_upper_bound=BASE(Datums,2)+SIZE(Datums,2)-1
13770 CREATE Filename$,1
13780 ASSIGN @File_path TO Filename$;FORMAT ON
13790 !***********************************
13800 !** BUILD THE DATA COLUMN HEADINGS **
13810 !***********************************
13820 Build_string$="Stage Position"&CHR$(9)&"Exit Prism"&CHR$(9)&"Meas
Prism"&CHR$(9)&"Cell 1"&CHR$(9)&"Cell 2"&CHR$(9)&"Cell 3"&CHR$(9)
```

```
13830 Build_string$=Build_string$&"Exit
Quiescent"&CHR$(9)&"Loss"&CHR$(9)&"Log(Loss)"&CHR$(10)
13840 FOR J=Row_lower_bound TO Row_upper_bound STEP 1
13850 FOR I=Col_lower_bound TO Col_upper_bound-1 STEP 1
13860 Build_string$=Build_string$&VAL$(Datums(J,I))&CHR$(9)
13870 NEXT I
13880 Build_string$=Build_string$&VAL$(Datums(J,I))&CHR$(10)
13890 OUTPUT @File_path USING "#,K";Build_string$
13900 Build_string$=""
13910 NEXT J
13920 ASSIGN @File_path TO *
13930 GOTO 13970
13940 Finish:!
13950         BEEP 1708.98,1
13960         DISP "YOUR DATA ARRAY IS NOT TWO DIMENSIONAL"
13970 SUBEND
13980 !
13990 !**************************************
14000 !** END OF DATA CONVERTER SUBROUTINE **
14010 !**************************************
14020 SUB
Hurst(Num_of_choices,Choices$(*),Steps$(*),@Multi,@Voltmeter,Initial_steps,
Pressure2)
14030 !
14040 !**********************************************************
14050 !** THIS SUBPROGRAM ALLOWS MENU-LIKE CONTROL OF THE HURST  **
14060 !** MOTOR CONTROLLER THAT DRIVES THE MEASUREMENT ARM.      **
14070 !** THIS IS DONE TO INITIALIZE THE POSITION OF THE PRISM   **
14080 !** AND TO DETERMINE THE COUPLING PRESSURE FOR THE RUN     **
14090 !**********************************************************
14100 !
14110 !** VARIABLE DESCRIPTIONS:                                **
14120 !**                                                      **
14130 !** Num_of_choices - THIS IS THE TOTAL NUMBER OF ITEMS    **
14140 !**                  LISTED IN THE MENU ON THE SCREEN     **
14150 !
14160 !** Choices$(*)  - THIS IS A SERIES OF STRINGS CONTAINING  **
14170 !**                THE TEXT ASKING FOR INPUT INFORMATION  **
14180 !**                e.g. "1000 STEPS"                      **
14190 !**                OPTION BASE 0 MUST BE USED e.g. WHEN   **
14200 !**                Num_of_choices=3 then Choices$(*) MUST **
14210 !**                BE NUMBERED Choices$(0),Choices$(1),AND **
14220 !**                Choices$(2)                            **
14230 !**                                                      **
14240 !** Steps$(*) - THIS SET OF STRINGS CONTAINS THE          **
14250 !**             NUMBER OF STEPS THAT WILL BE MOVED        **
14260 !**             WHEN THE LEFT OR RIGHT ARROW KEY IS       **
14270 !**             PRESSED                                   **
14280 !**                                                      **
14290 !** @MULTI - THIS IS THE HPIB ADDRESS OF THE              **
14300 !**          MULTIPROGRAMMER.  THIS IS IS ASSIGNED AT THE **
14310 !**          BEGINNING OF THE PROGRAM                     **
14320 !**                                                      **
14330 !** @VOLTMETER - THIS IS THE HPIB ADDRESS OF THE HP3457A  **
14340 !**              VOLTMETER.  THIS IS ASSIGNED AT THE      **
14350 !**              BEGINNING OF THE PROGRAM                 **
14360 !**                                                      **
14370 !** Initial_steps  - THIS IS THE TOTAL NUMBER OF STEPS    **
```

```
14380 !**                THAT THE MOTOR HAS ROTATED SINCE THE   **
14390 !**                MANUAL POSITIONING OF THE PRISM BEGAN  **
14400 !**                AFTER THE FINAL PRESSURE IS DETERMINED **
14410 !**                BY THE USER THIS NUMBER IS USED AS A   **
14420 !**                BASE REFERENCE FOR THE AUTOMATED       **
14430 !**                MEASUREMENTS                           **
14440 !**                                                       **
14450 !***********************************************************
14460 !
14470 !***************************************************
14480 !** SETUP VOLTMETER TO READ THE MEASUREMENT PRISM **
14490 !***************************************************
14500 !
14510 OUTPUT @Voltmeter;"TERM REAR"
14520 OUTPUT @Voltmeter;"CHAN 1"
14530 !
14540 !********************************************************
14550 !** THE NEXT 4 LINES CLEAR THE SCREEN,SET THE STARTING **
14560 !** POINT FOR LABELS,SET THE PEN TO WRITE AND SET THE  **
14570 !** CHARACTER SIZE                                     **
14580 !********************************************************
14590 !
14600 CLEAR SCREEN
14610 PEN 1
14620 CSIZE 4,.5
14630 !
14640 !*******************************************************
14650 !** THIS LINE MAKES THE CHOOSING CURSOR A WHITE BLOCK **
14660 !*******************************************************
14670 !
14680 Cursor$=CHR$(127)
14690 !
14700 !******************************************************
14710 !** THE FOR NEXT LOOP PUTS THE CHOICES ON THE SCREEN **
14720 !******************************************************
14730 !
14740 FOR I=0 TO Num_of_choices-1
14750 MOVE 10,95-5*I
14760 LABEL Choices$(I)
14770 NEXT I
14780 !
14790 !**************************************************************
14800 !** THE NEXT 3 LINES PLACES THE CURSOR BESIDE THE 1st CHOICE **
14810 !**************************************************************
14820 !
14830 MOVE 5,95
14840 I=0
14850 LABEL Cursor$
14860 !
14870 !*****************************************************************
14880 !** THE NEXT 4 LINES PRINT THE TOTAL NUMBER OF STEPS TAKEN      **
14890 !** AND THE CURRENT PRISM PRESSURE                             **
14900 !*****************************************************************
14910 !
14920 ENTER @Voltmeter;Pressure2 !GET CURRENT PRISM PRESSURE
14930 MOVE 10,20
14940 LABEL "THE TOTAL NUMBER OF STEPS TAKEN IS ";Initial_steps
14950 LABEL "THE PRISM PRESSURE IS ";VAL$(Pressure2*10)&" Lbs"
```

```
14960 !
14970 !*******************************************************************
14980 !** THE NEXT 4 LINES PRINTS AN OPERATING INSTRUCTION ON THE SCREEN **
14990 !*******************************************************************
15000 !
15010 MOVE 10,30
15020 LABEL "PRESS RETURN WHEN MANUAL ADJUSTMENT IS COMPLETE"
15030 MOVE 10,35
15040 LABEL "USE LEFT/RIGHT ARROWS TO MOVE MOTOR (Left=Up, Right=Down)"
15050 MOVE 10,40
15060 LABEL "USE UP/DOWN ARROWS TO SCROLL MENU"
15070 !
15080 !*****************************************************
15090 !** WHEN A KEY IS STRUCK GO TO THE MOVE CURSOR ROUTINE **
15100 !*****************************************************
15110 !
15120 Diddle_loop: ON KBD GOTO Movement
15130             PEN -1
15140             MOVE 10,20
15150             LABEL
15160             LABEL "                       ";VAL$(Pressure2*10)&" Lbs"
15170             PEN 1
15180             ENTER @Voltmeter;Pressure2
15190             MOVE 10,20
15200             LABEL "                                    "
15210             LABEL "                       ";VAL$(Pressure2*10)&" Lbs"
15220             GOTO 15130
15230 !
15240 !*************************
15250 !** MOVE CURSOR ROUTINE  **
15260 !*************************
15270 !
15280 !*****************************************************
15290 !** THIS ROUTINE ONLY TAKES ACTION WHEN THE UP,DOWN OR **
15300 !** RETURN KEY IS PRESSED. GO TO Up ON UP KEY, GO TO   **
15310 !** Down ON DOWN KEY, GO TO Take_data ON RETURN        **
15320 !*****************************************************
15330 !
15340 Movement:!
15350          Where$=KBD$
15360          OFF KBD
15370          IF Where$=CHR$(255)&"^" THEN Up
15380          IF Where$=CHR$(255)&"V" THEN Down
15390          IF Where$=CHR$(255)&"<" THEN Move_arm_up
15400          IF Where$=CHR$(255)&">" THEN Move_arm_down
15410          IF Where$=CHR$(255)&"E" THEN Finished
15420 GOTO Diddle_loop
15430 !
15440 !*********************************
15450 !**  END OF MOVE CURSOR ROUTINE  **
15460 !*********************************
15470 !
15480 !**************************
15490 !**  UP MOVEMENT ROUTINE  **
15500 !**************************
15510 !
15520 !*******************************
15530 !** THIS SCROLLS THE CURSOR UP **
```

```
15540 !********************************
15550 !
15560 Up:!
15570 PEN -1
15580 MOVE 5,95-5*I
15590 LABEL Cursor$
15600 IF I=0 THEN
15610           I=Num_of_choices-1
15620        ELSE
15630           I=I-1
15640 END IF
15650 PEN 1
15660 MOVE 5,95-5*I
15670 LABEL Cursor$
15680 GOTO Diddle_loop
15690 !
15700 !**********************************
15710 !**  END OF UP MOVEMENT ROUTINE  **
15720 !**********************************
15730 !
15740 !*****************************
15750 !**  DOWN MOVEMENT ROUTINE  **
15760 !*****************************
15770 !
15780 !**********************************
15790 !** THIS SCROLLS THE CURSOR DOWN **
15800 !**********************************
15810 !
15820 Down:!
15830 PEN -1
15840 MOVE 5,95-5*I
15850 LABEL Cursor$
15860 IF I=Num_of_choices-1 THEN
15870                          I=0
15880                       ELSE
15890                          I=I+1
15900 END IF
15910 PEN 1
15920 MOVE 5,95-5*I
15930 LABEL Cursor$
15940 GOTO Diddle_loop
15950 !
15960 !************************************
15970 !**  END OF DOWN MOVEMENT ROUTINE  **
15980 !************************************
15990 !
16000 !***********************************
16010 !** BEGIN STAGE MOVEMENT ROUTINES **
16020 !***********************************
16030 !
16040 !****************************************************
16050 !** THIS SUBROUTINE MOVES THE MEASUREMENT ARM UP   **
16060 !** BY THE NUM. INDICATED BY THE CURRENT VALUE OF **
16070 !** Steps$(I).                                     **
16080 !** THE COMPUTER THEN POLLS THE VOLTMETER TO       **
16090 !** DETERMINE THE NEW PRESSURE ON THE PRISM AND    **
16100 !** PRINTS IT ON THE SCREEN                        **
16110 !****************************************************
```

```
16120 !
16130 Move_arm_up:!
16140 !
16150         IF VAL(Steps$(I))>Initial_steps THEN
16160             OUTPUT @Multi;"WF,8.1,0,8.2,5000T,OP,8,-
"&VAL$(Initial_steps)&"T"
16170             WAIT .005*Initial_steps ! WAIT UNTIL FINISHED
16180                                      ELSE
16190             OUTPUT @Multi;"WF,8.1,0,8.2,5000T,OP,8,-"&Steps$(I)&"T"
16200             WAIT .005*VAL(Steps$(I)) ! WAIT UNTIL FINISHED
16210          END IF
16220 !
16230 !**************************************************************
16240 !** CLEAR THE OLD NUMBER OF STEPS FROM THE SCREEN THEN PRINT    **
16250 !** THE NEW NUMBER OF STEPS AND CURRENT PRESSURE ON THE SCREEN **
16260 !**************************************************************
16270 !
16280           MOVE 10,20
16290           PEN -1
16300           LABEL "                                   ";Initial_steps
16310           LABEL "                       ";VAL$(Pressure2*10)&" Lbs"
16320           ENTER @Voltmeter;Pressure2 !GET NEW PRESSURE
16330 !
16340 !****************************************
16350 !** CALCULATE NEW TOTAL STEPS AFTER MOVE **
16360 !****************************************
16370 !
16380         IF VAL(Steps$(I))>Initial_steps THEN
16390                       Initial_steps=0
16400                                      ELSE
16410                       Initial_steps=Initial_steps-VAL(Steps$(I))
16420         END IF
16430 !
16440 !**********************************
16450 !** LABEL NEW VALUES ON THE SCREEN **
16460 !**********************************
16470 !
16480           MOVE 10,20
16490           PEN 1
16500           LABEL "                                   ";Initial_steps
16510           LABEL "                       ";VAL$(Pressure2*10)&" Lbs"
16520           GOTO Diddle_loop
16530 !
16540 !***************************************************
16550 !** THIS SUBROUTINE MOVES THE MEASUREMENT ARM DOWN **
16560 !** BY THE NUM. INDICATED BY THE CURRENT VALUE OF  **
16570 !** Steps$(I).                                     **
16580 !** THE COMPUTER THEN POLLS THE VOLTMETER TO        **
16590 !** DETERMINE THE NEW PRESSURE ON THE PRISM AND     **
16600 !** PRINTS IT ON THE SCREEN                         **
16610 !***************************************************
16620 !
16630 Move_arm_down:!
16640 !
16650         OUTPUT @Multi;"WF,8.1,0,8.2,5000T,OP,8,"&Steps$(I)&"T"
16660         WAIT .005*VAL(Steps$(I)) ! WAIT UNTIL FINISHED
16670 !
16680 !**************************************************************
```

```
16690 !** CLEAR THE OLD NUMBER OF STEPS FROM THE SCREEN THEN PRINT    **
16700 !** THE NEW NUMBER OF STEPS AND CURRENT PRESSURE ON THE SCREEN **
16710 !*****************************************************************
16720 !
16730            MOVE 10,20
16740            PEN -1
16750            LABEL "                                    ";Initial_steps
16760            LABEL "                       ";VAL$(Pressure2*10)&" Lbs"
16770            ENTER @Voltmeter;Pressure2 !GET NEW PRESSURE
16780            Initial_steps=Initial_steps+VAL(Steps$(I))
16790            MOVE 10,20
16800            PEN 1
16810            LABEL "                                    ";Initial_steps
16820            LABEL "                       ";VAL$(Pressure2*10)&" Lbs"
16830            GOTO Diddle_loop
16840 !
16850 !*********************************
16860 !** END ARM MOVEMENT ROUTINES   **
16870 !*********************************
16880 !
16890 !*****************************************************************
16900 !** IF THE RETURN KEY IS PRESSED THE SUBPROGRAM TERMINATES     **
16910 !** AND RETURNS THE LAST PRESSURE READING TO THE MAIN PROGRAM  **
16920 !*****************************************************************
16930 !
16940 !*************************************************
16950 !** READ PRISM PRESSURE FOR USE IN MAIN PROGRAM **
16960 !** MOVE PRISM BACK TO HOME POSITION            **
16970 !*************************************************
16980 !
16990 Finished:!
17000          ENTER @Voltmeter;Pressure2 !GET NEW PRESSURE
17010          OUTPUT @Multi;"WF,8.1,0,8.2,5000T,OP,8,-
"&VAL$(Initial_steps)&"T"
17020          WAIT .005*Initial_steps
17030          CLEAR SCREEN
17040 SUBEND
```

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