MODEL L-711

LASER ALIGNMENT SYSTEM

INSTRUCTION MANUAL

HAMAR LASER

HAMAR LASER INSTRUMENTS, INC.
5 Ye Olde Road
Danbury, CT 06810
Phone: (203) 730-4600 Fax: (203) 730-4611

MODEL 711 LASER ALIGNMENT SYSTEM

You have just received the Model 711 Laser Alignment System, which is the most advanced and accurate such system available today. This precision instrument is quite rugged and will give excellent service with reasonable care and handling. This Instruction Manual covers the basics of system use and contains a trouble-shooting section. If you have any questions, please feel free to call us at 203/544-9321. We will be glad to help you get the most out of your new 711 Laser Alignment System.

CHAPTER I

DESCRIPTION OF THE 711 SYSTEM

Laser

The compact Model 711 laser unit contains a laser, power supply, expanding optics, sweep optics, two precision levels, and the necessary mechanical adjustments. The basic frame of the laser can be leveled in two directions by turning the coarse leveling screws, located on the top of the instrument. (See Figure 1.) Fine leveling micrometers (.001" on micrometer, equivalent to a .001" tilt of the beam at 10 feet) are located directly under each coarse leveling screw on the under side of the main body of the laser. The sweep turret is turned by hand to point the beam in approximately the right direction, and the coarse thumb screw and fine micrometer azimuth adjustments are located on the swivel head itself. The unit is mounted on magnetic bases.

Target and Target Stand

The Model T212 dual axis target and the Model T230 target stand are used together for most machine tool work. The target contains two pairs of silicon solar cells, whose output indicate throught the readout the relative position of the target center to the laser beam. The target cells are centered within .001" of the 1.500" diameter housing of the target. The Model T230 target stand has two square micrometer slides with a range of $\pm \frac{1}{4}$" and mounts on a magnetic base. This T230 is used as a target support fixture and for calibration of the readout.

Readout

The target readout is a two-channel digital readout system that displays the relative alignment of the target center and laser beam center directly in inches. The front face of the readout unit has two digital meters: one for the vertical channel, and one for the horizontal channel. (See Figure 3.) Separate calibration knobs for each channel are also located on the front panel. In addition, there is a three-position selector switch, providing On/Off power switching with a third position labeled "Slow Response." When the switch is in this third position, electronic damping has been switched into the circuit to help average out atmospherically caused fluctuations. The connector for the target is located in the rear of the unit.

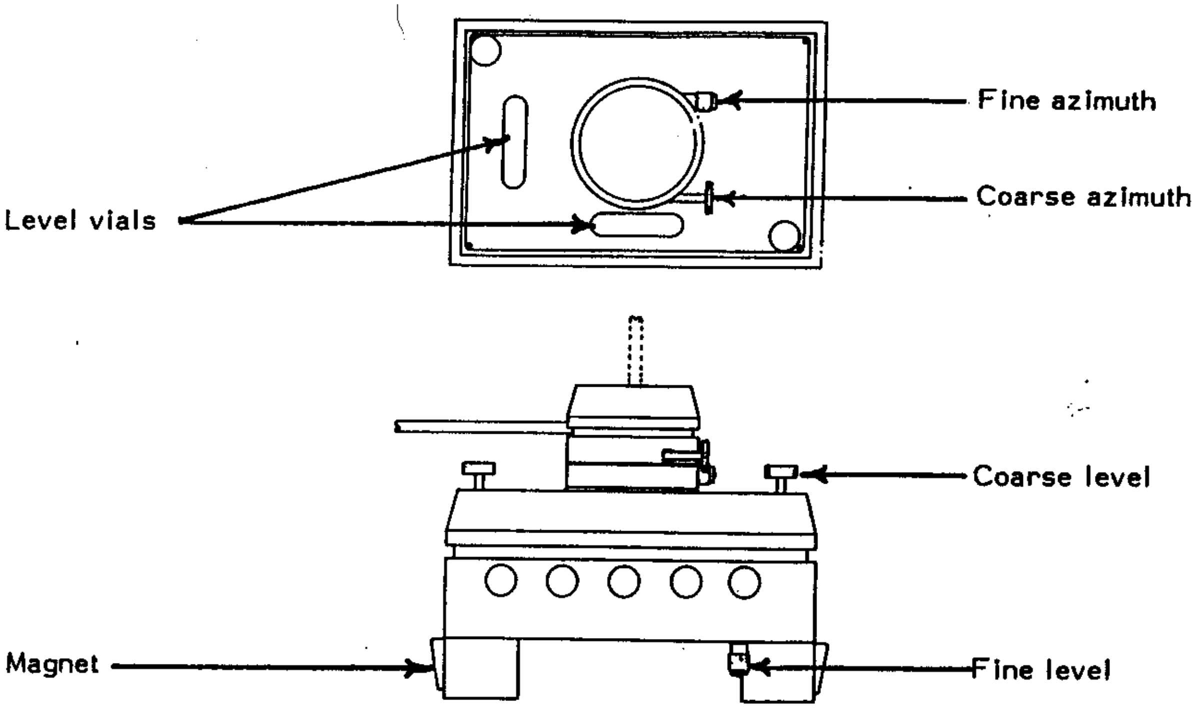


Figure 1

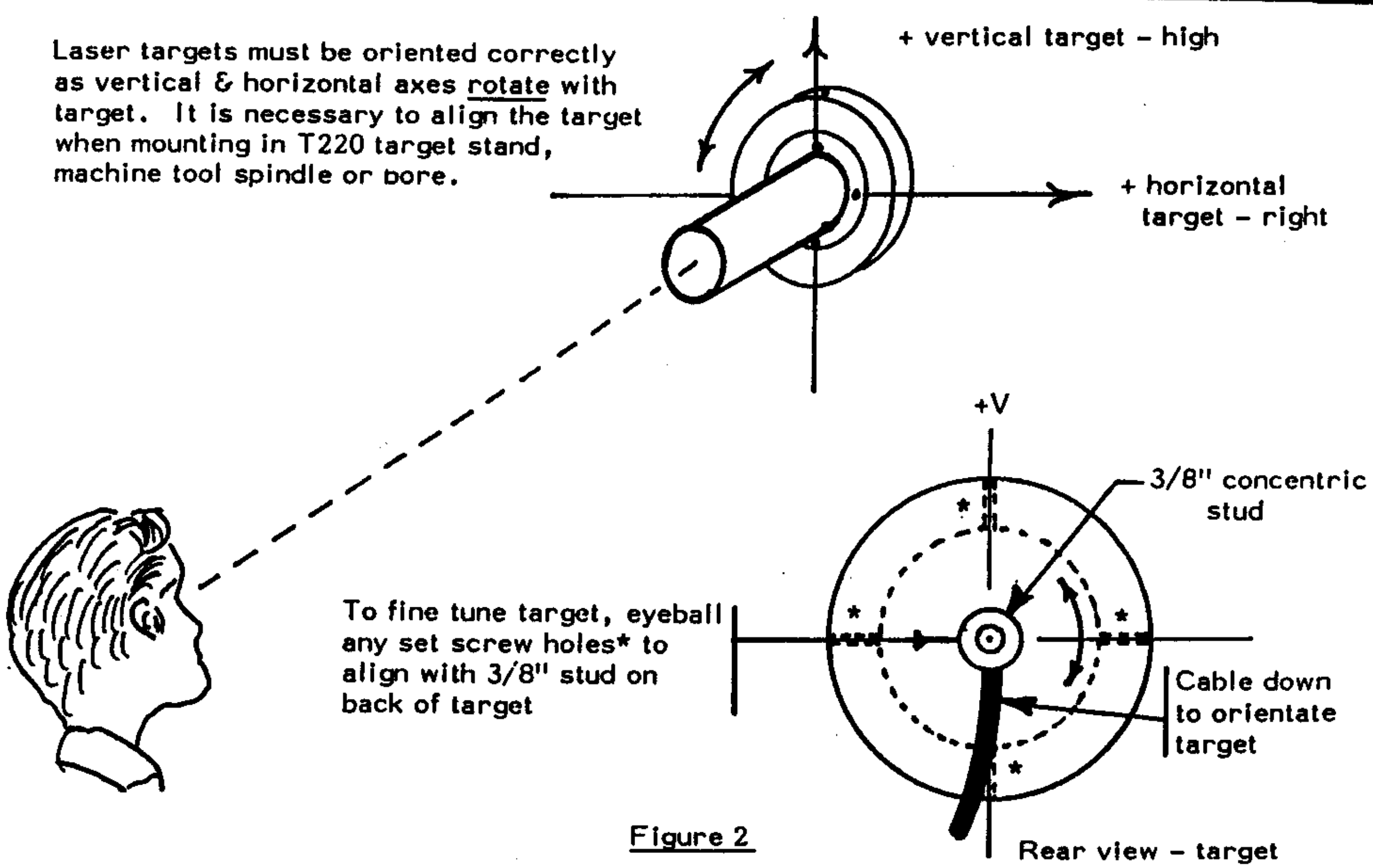
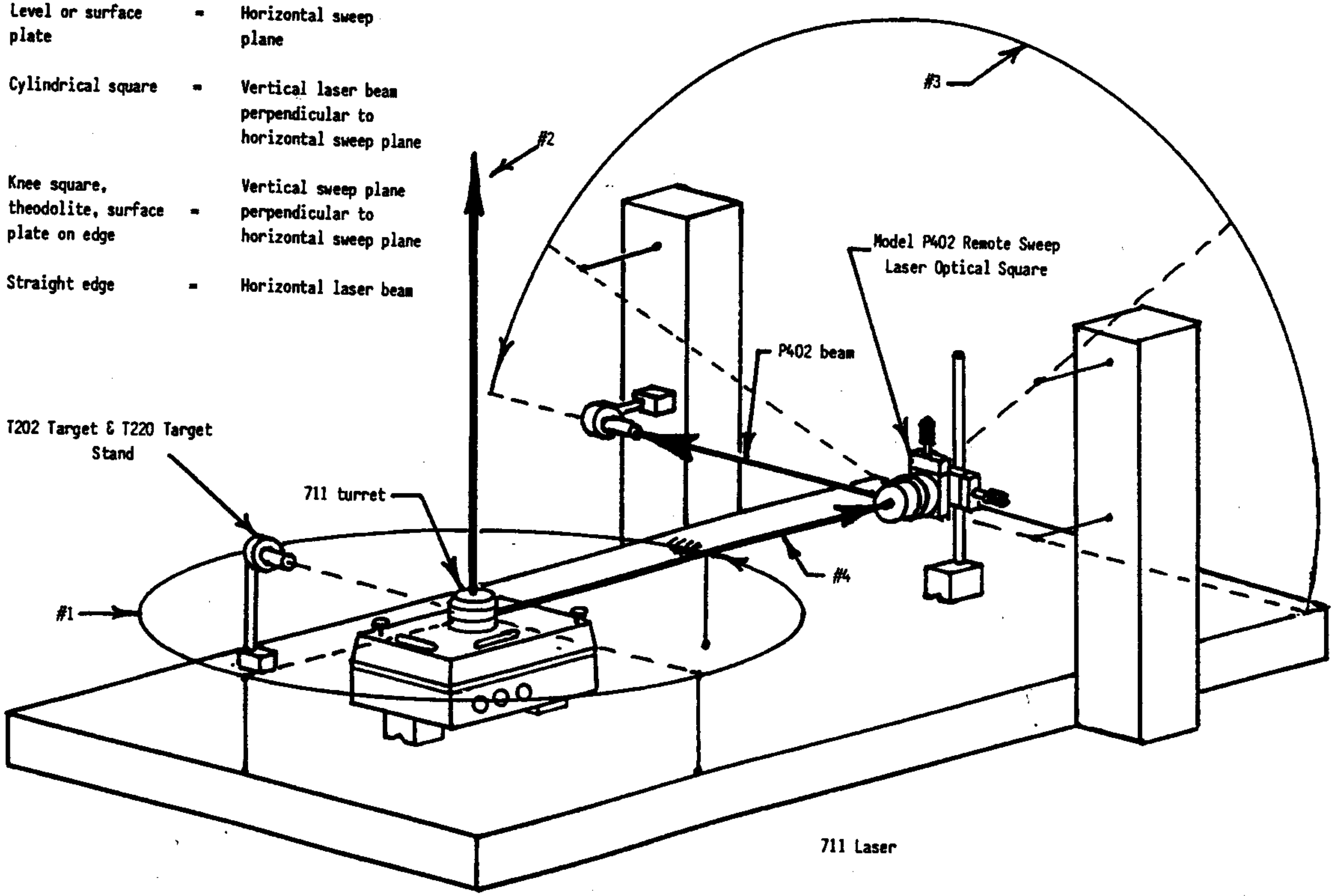


Figure 2

MODEL 711 MACHINE TOOL PACKAGE

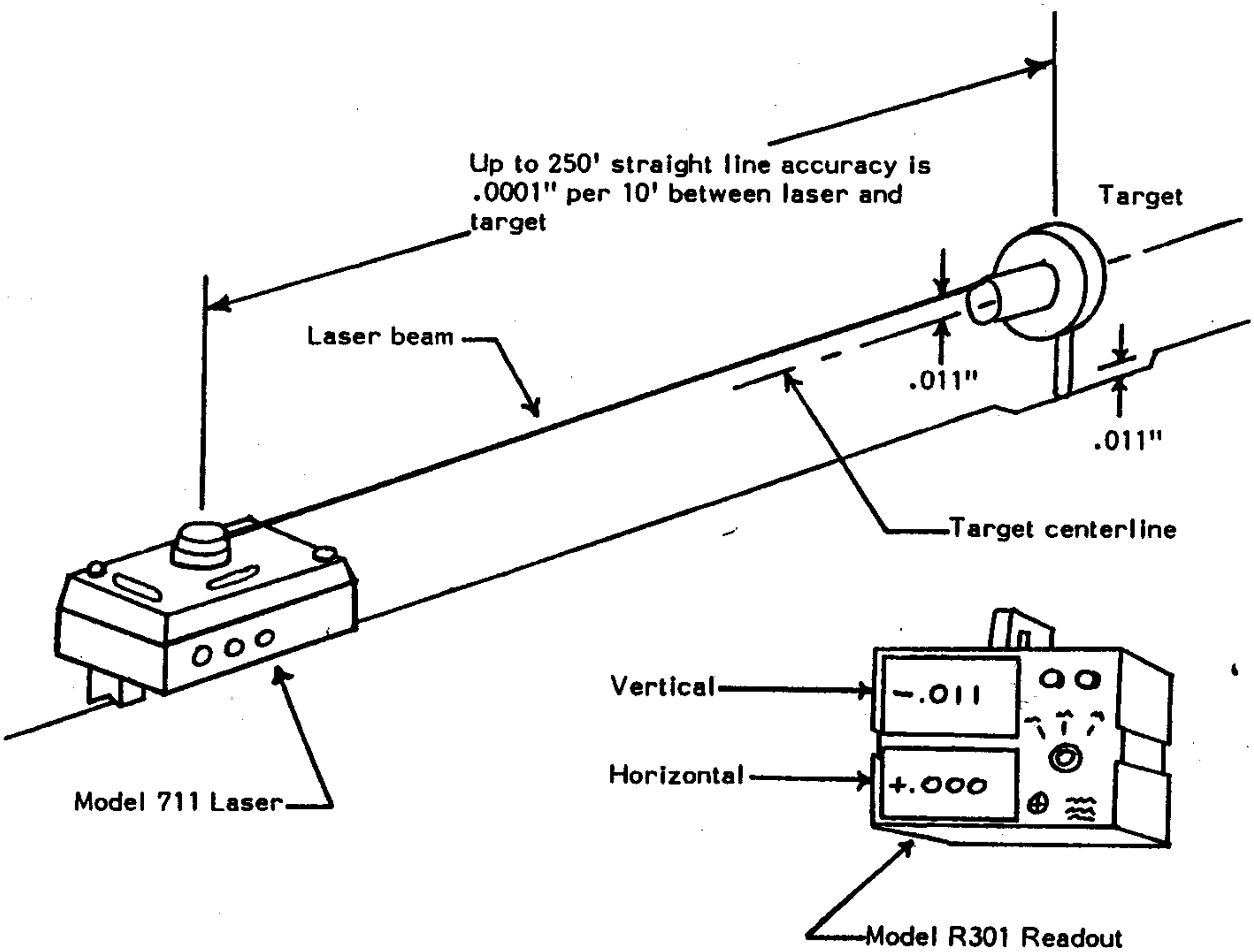
Basic Capabilities

Mechanical Device		Laser Equivalent
1. Level or surface plate	=	Horizontal sweep plane
2. Cylindrical square	=	Vertical laser beam perpendicular to horizontal sweep plane
3. Knee square, theodolite, surface plate on edge	=	Vertical sweep plane perpendicular to horizontal sweep plane
4. Straight edge	=	Horizontal laser beam



LASER ALIGNMENT - BASIC CONCEPT

The laser produces an intense beam of light whose center of energy is an absolutely straight line. The beam is approximately 3/8" in diameter, which spreads not at all in the first 100' of travel and very little thereafter. A two-axis quad cell target is used to find the center of energy of the laser beam, and the readout unit displays any offset vertically or horizontally between the center of the target and the center of the laser beam. It is important to note that the laser system measures this displacement directly; thus to measure a way profile, the target can be moved along the way in any intervals desired. In the illustration below the target is sitting in a low spot in a way that is .011" deep.



SAFETY INFORMATION

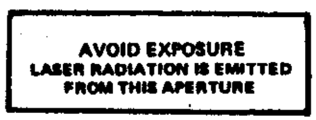
This Instruction Manual contains information regarding the operation and use of the Model 711 Laser Alignment System. The safety information contained on this page should be reviewed and understood prior to the reading of the rest of this Manual or prior to the setup and operation of the system.

If the unit is operated according to these instructions, this laser will not emit radiation in excess of the power level shown below on the "Caution and Certification" label and is within the limits of a Class II device. The user is specifically warned against the disassembly of the 711 laser and that such disassembly may result in hazardous laser readiation output. The warranty will be void if any such disassembly has occurred. The laser unit must be returned to Hamar Laser Instruments, Inc., for repair. No specific maintenance is required to keep the unit power output within the limits of a Class II device.

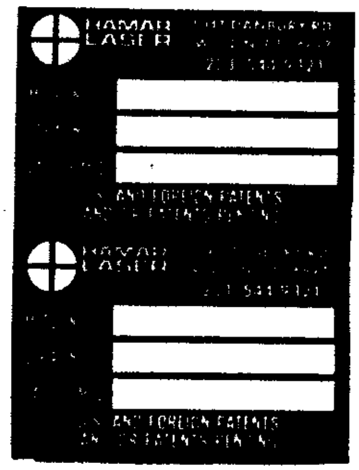
> "CAUTION – USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE."

Affixed to this unit are warning and aperture labels of the type shown below with their positions indicated on the instrument. The power level shown in the "Caution and Certification" label below is the maximum actual power for this particular laser, the Serial Number of which is ____________.

1. Caution and Certification Label



2. Aperture Label

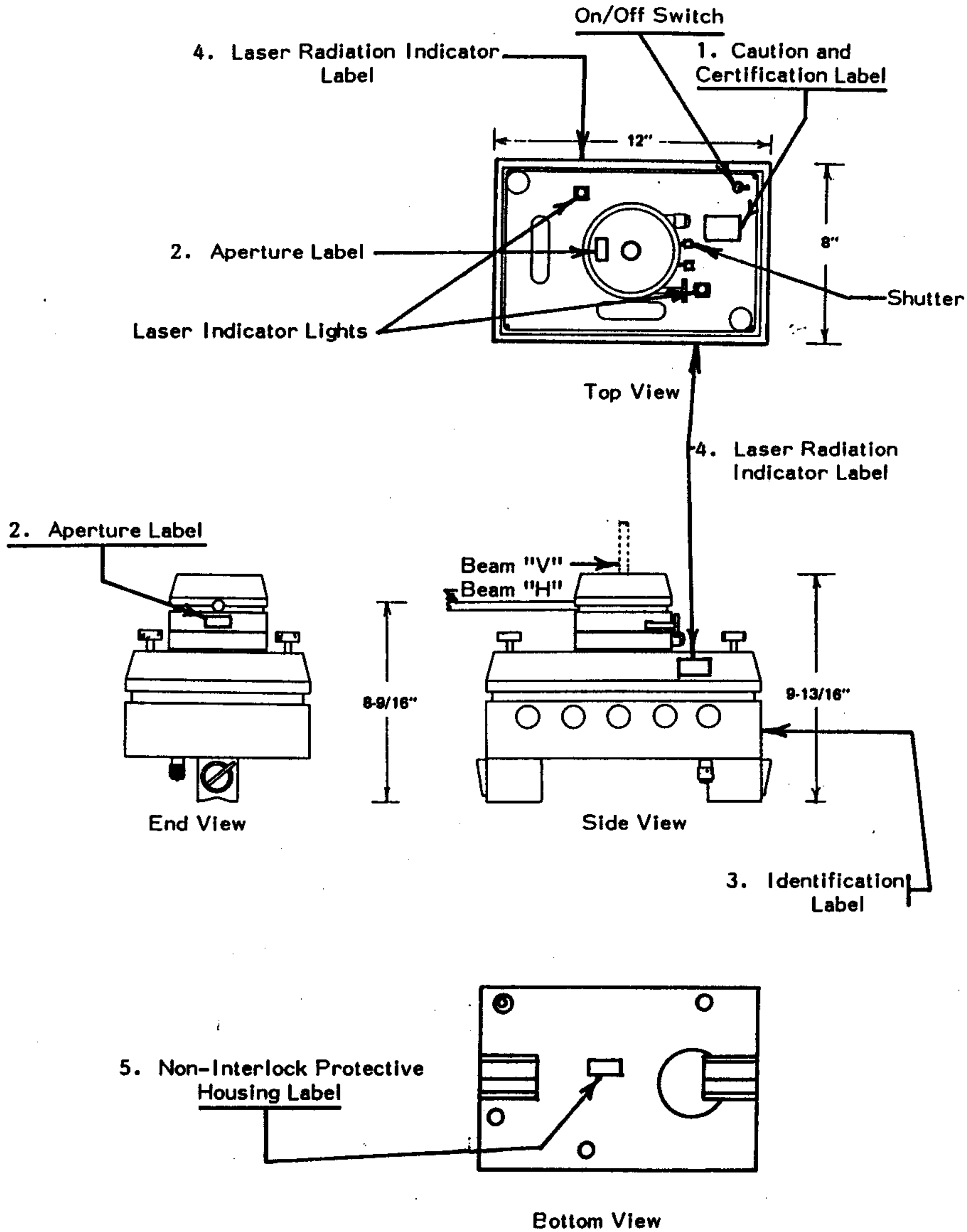


3. Identification Label

4. Laser Radiation Indicator Label

5. Non-Interlock Protective Housing Label

Note: See Figure A for label location.



On/Off Switch
4. Laser Radiation Indicator Label
1. Caution and Certification Label
12"
8"
2. Aperture Label
Shutter
Laser Indicator Lights
Top View
4. Laser Radiation Indicator Label
2. Aperture Label
Beam "V"
Beam "H"
8-9/16"
9-13/16"
End View
Side View
3. Identification Label
5. Non-Interlock Protective Housing Label
Bottom View

FIGURE A

WARRANTY

HAMAR LASER INSTRUMENTS, INC., warrants each instrument and other articles of equipment manufactured by it to be free from defects in material and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any instrument or other article of equipment which shall within one year after shipment of each instrument or other article of equipment to the original purchaser be returned intact to it with transportation prepaid, and which its examination shall disclose to its satisfaction to have been thus defective; this warranty express or implied and of all other obligations and liabilities on its part, and HAMAR LASER INSTRUMENTS, INC., neither assumes or authorizes any other persons to assume for it any other liability in connection with the sale of its products.

This warranty shall not apply to any instrument or other article of equipment which shall have been repaired or altered outside the HAMAR LASER INSTRUMENTS, INC., factory or authorized service station, nor which has been subject to misuse, negligence or accident, incorrect wiring by others, or installation or use not in accord with instructions furnished by the manufacturer.

BASIC SETUP PROCEDURES

Setting up to measure or level

The first thing to do is plan the job, so you know where to put the laser and what measurements are to be made. It is also desirable to reset the levels (see chapter III) before starting the job. The levels will stay set for one to two weeks with normal handling.

As a general rule, it is best to set up the laser and never move it; that is, to make all measurements with the laser in one posistion. The laser can be moved (see "Instrument Transfer Procedure"), but it is better to do as much as possible from a single location.

The laser is generally mounted on the machine tool itself if measurements of the machine tool are to be made. However, if the machine tool is to be leveled, the laser should be mounted off the machine tool on a Model L-104 Instrument Stand, or equivalent, but on the foundation of the machine.

Setting up each morning

In the morning setup the following procedures are performed in order and generally by the time these are finished the laser is sufficiently warmed up to begin the job.

1. Check laser beam centering in L-711 turret.

2. Level the laser or buck-in to machine tool.

TO CENTER BEAM IN 711 TURRET

(NOTE: FOR THE MOST ACCURATE SWEEP WORK, IT IS NECESSARY THAT THE BEAM BE EXACTLY CENTERED ON THE TURRET AXIS. ANY ERROR IN CENTERING WILL PRODUCE TWICE THAT ERROR IN THE FLATNESS OF THE PLANE.)

Place the laser as shown in Figure 4A, with the long axis level toward you and the short axis level to your left. Turn the turret so that the azimuth, coarse and fine, adjustments on the turret are pointing at approximately 10 o'clock. A small index screw, located on the side of the turret, will then be pointing toward you and should be lined up at 6 o'clock directly over the middle of the long axis level. (This orients the flip target so that + vertical is at 12 o'clock.) Flip the prism out of the way and flip the target element into position, making sure it is seated properly. Connect the special cable supplied to the connector on the top of the turret and to the readout unit. The target element has been centered at the factory, so any error read on the meter is the amount the beam is de-centered. (Note: Any reading from the turret flip target should be divided by 2, if the readout has been calibrated in the normal manner.) If any error is noted, then proceed as follows to re-center the beam on the turret axis. Again, referring to Figure 4A, there are two holes located on the left side of the instrument. Inside each hole is a socket head adjustment set screw. Using a 3/32 Allen wrench, adjust first the horizontal and then the vertical adjustments (see Figure 4A for location) until the readout reads "0" in each axis. The beam is now re-centered on the turret axis.

<u>To Check That Flip Target Is Properly Centered:</u> After the adjustments have been made as described above, it may be desired to check that the flip target is perfectly centered. To do this, rotate the turret 180° so that the index screw that was located at 6 o'clock is now located at 12 o'clock. If any error exists in the centering of the flip target cells, it will show up here as a reading on the meter. <u>To remove this error without adjusting the target cells,</u> proceed as follows: Leaving the the index screw at 12 o'clock, and using the horizontal and vertical adjustments on the side of the instrument, readjust the centering so that half the error observed on each axis is removed. For instance, in the 12 o'clock position assume that the error readings are as follows: Vertical +.002, Horizontal -.002. You would then adjust the vertical to read +.001 and the horizontal to read -.001. If this has been carefully done, when the turret is rotated back to the 6 o'clock position, the meter will continue to read Vertical +.001, Horizontal -.001. If this is not exactly so, then continue to adjust so that the <u>error reading</u> at the <u>6 o'clock</u> position and the <u>12 o'clock</u> position have the <u>same sign</u> and the <u>same magnitude.</u> When this has been done, the beam will be perfectly centered on the turret axis, even though the flip target may be slightly off center.

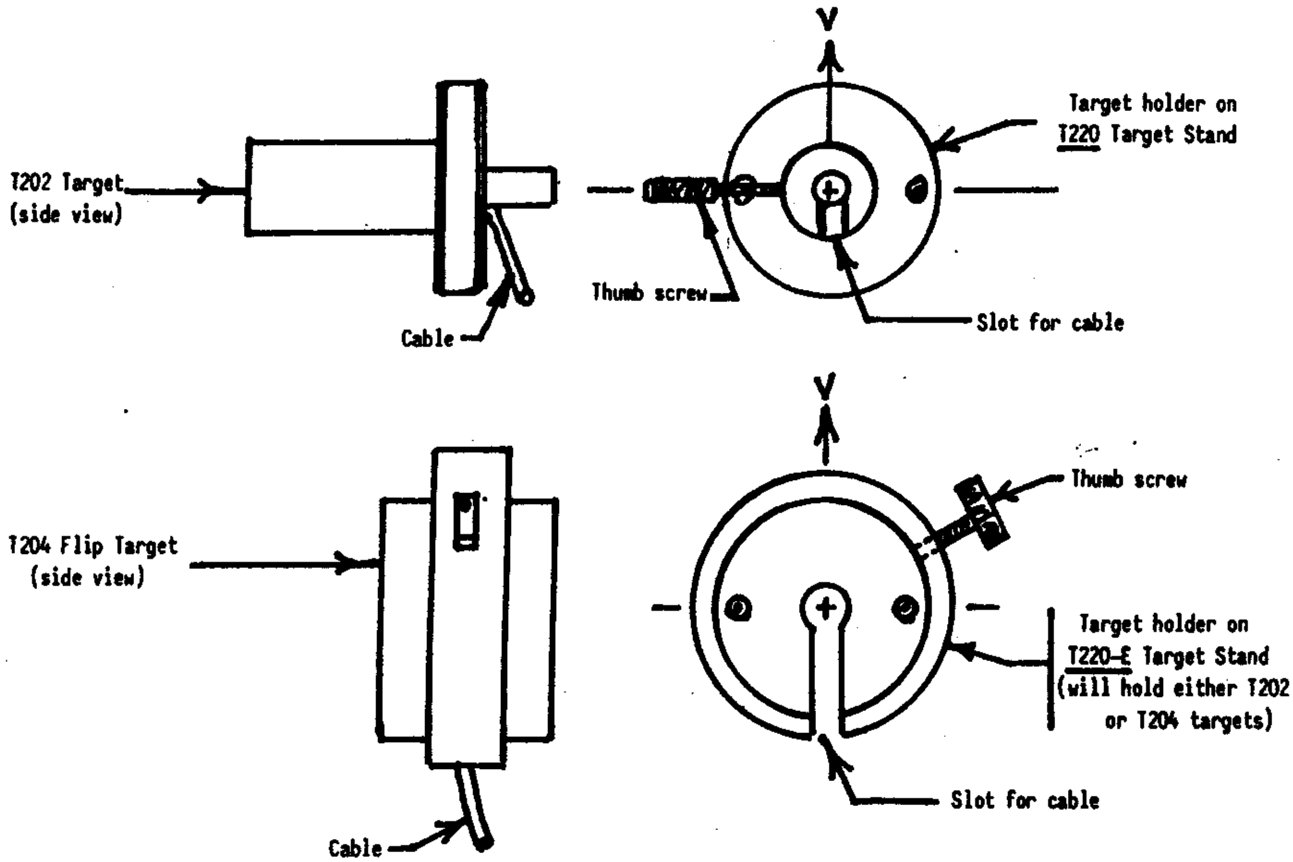


Figure 3

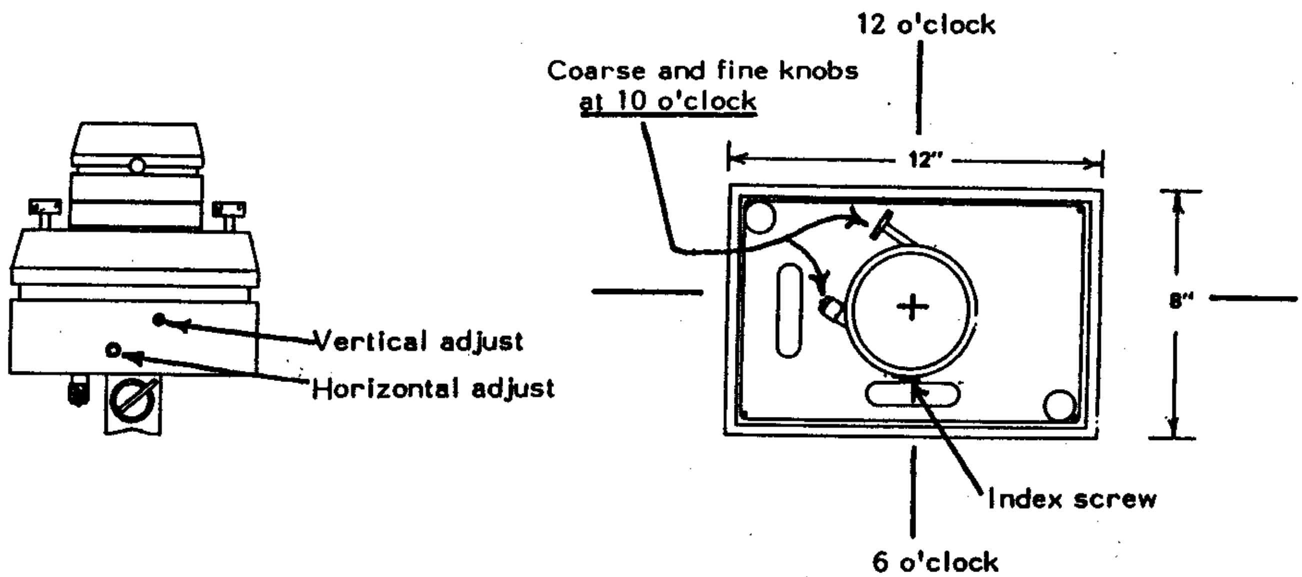


Figure 4A

TO SET UP AND LEVEL LASER

Place the laser instrument on any steel surface of suitable stability, such as the bed of a mchine to separate instrument stand. Twist both magnet levers to the "On" position. This locks the instrument down to the surface. Next, plug in instrument and turn on, using switch located on the top cover. In turn, grasp each of the coarse leveling screws, located on the top of the instrument, and adjust the tilt of the instrument as needed to roughly level the respective vials. (Note: Look at bubble, ignoring split image prism until fine leveling.) (See Figure 4.) Next, grasp each fine-adjust leveling micrometer, located under each respective coarse tilting screw, and adjust each micrometer as needed, so that the split image as viewed in the small prism looking directly down is aligned. A small flashlight may be used to illuminate level vials, if held at least one foot away and for short periods of time. When this has been accomplished for both axes, the instrument has been leveled.

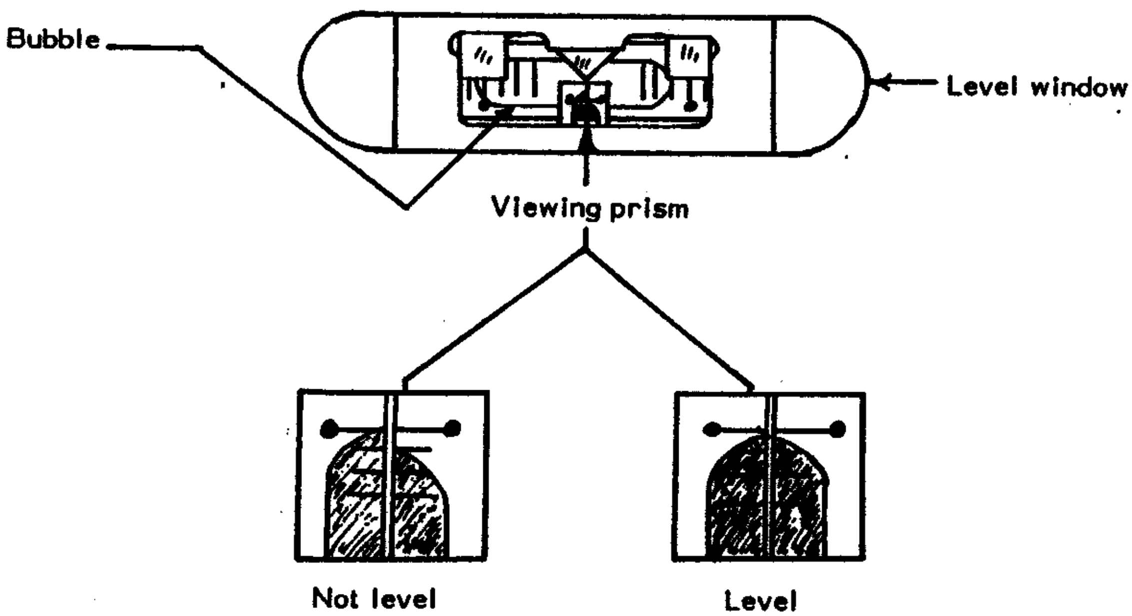


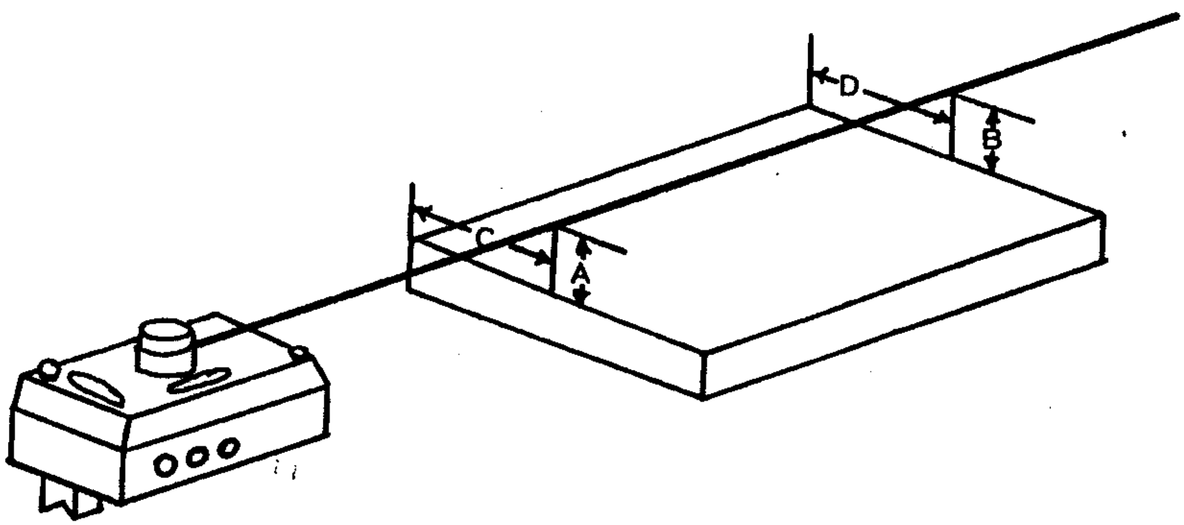
Figure 4

"BUCKING IN" PROCEDURE

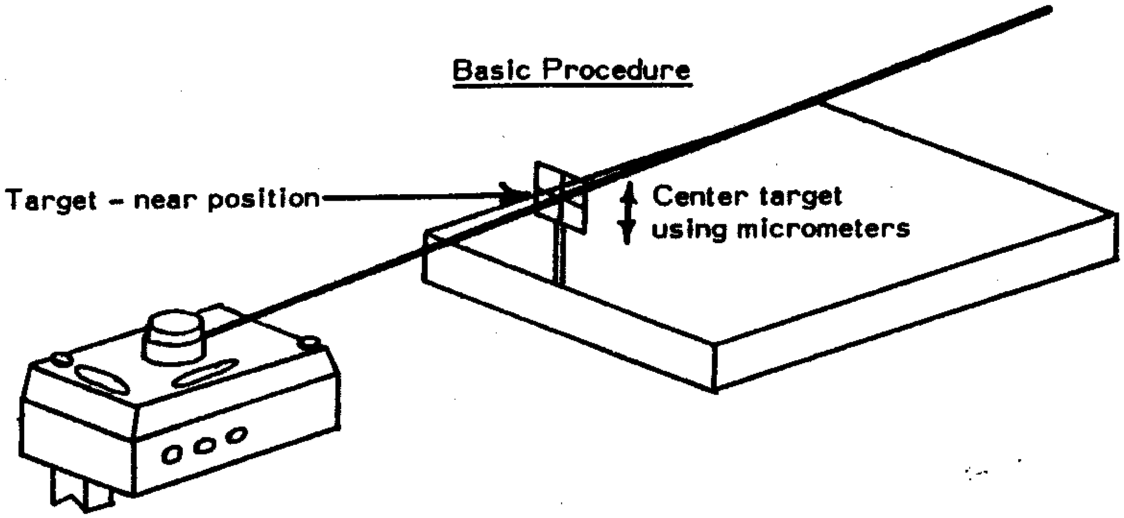
The laser produces a straight line (beam) that can be tilted up and down or side to side. The beam must be adjusted to make it parallel to a surface, edge, centerline, etc., and from this parallel line measurements are made. This procedure is called "bucking in."

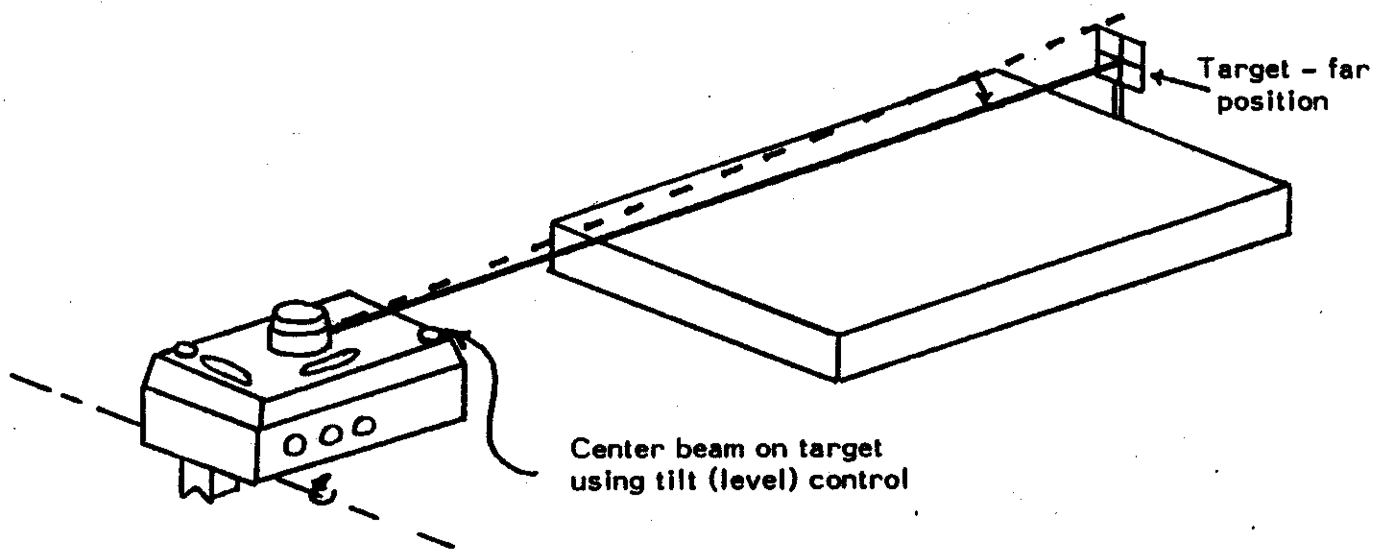
Basic Principle

If the beam is adjusted so the Vertical Height A and Vertical Height B are the same, then the laser beam is parallel to the table top. If the beam is adjusted so that Offset C is equal to Offset D, then the beam is also parallel to the edge of the table. Thus the laser beam can be "bucked in" horizontally, or vertically, or both at the same time.



Basic Procedure





BASIC RULE
Target Near Position – Adjust Target (or Beam)
Target Far Position – Adjust Laser Tilt (Level) Control

The laser can be "bucked in" to several references: machine way or table top and edge; line of motion or a slide, table (plane), quill, or axis of rotation; a centerline through two bores; and gravity. The detailed "buck in" procedure is given below. There are two procedures: one to be used when the target can be moved for centering, and the other to be used when the target cannot be moved. The procedures are basically the same, but vary in detail.

A. Procedure to be used when the target can be moved to center on the laser beam (examples are when "bucking in" to a surface, edge or line of motion.)

1. Put target and fixture in position as close to laser as possible, and center target on beam by using X-Y micrometers, so readout reads 0-0.

2. Place target and fixture in far position, and adjust laser tilt controls (i.e. vertical tilt and azimuth) until spot hits target center and readout reads 0-0.

3. Place target and fixture in near position and re-center target, using micrometer until readout reads 0-0.

4. Repeat Steps 2 and 3 as needed, until target can be placed in far position and readout reads 0-0 without further adjustment of tilt controls (the beam is now at the same elevation and offset at both the near and far positions; therefore, is parallel to ways.)

B. Procedure to be used when the target cannot be centered on laser beam (examples are target is mounted on spindle or in the middle of a bore, etc. Note: When the target cannot be centered on the beam, the beam must be centered on the target. The beam can be shifted laterally parallel to itself through the use of a beam translator. See appropriate section of Manual.)

1. With target in near position, center beam on target using beam translator so readout reads 0-0.

2. Move target to far position (or read far target in bore) and tilt laser to center beam on far target, using laser tilt control, until readout reads 0-0.

3. Move target to near position (or look at target in near bore) and re-center beam, using beam translator, until readout reads 0-0.

4. Repeat Steps 2 and 3 as needed, until target in near position and the target in far position both read 0-0 without further adjustment. The beam is now "bucked in" to a centerline defined by the centers of the two targets. It is now both parallel and coincident with that centerline.

C. Procedure to be used for "bucking in" to a table top. This procedure would be followed if it is desirable to adjust the sweep plane of the laser to be parallel to the surface, such as a table top.

1. Rotate the turret until the beam is approximately parallel to one edge of the table.

2. Proceed as described in Section A above.

3. Rotate head 90° and repeat procedure as described in Section. A above using the original near target position and the new far position.

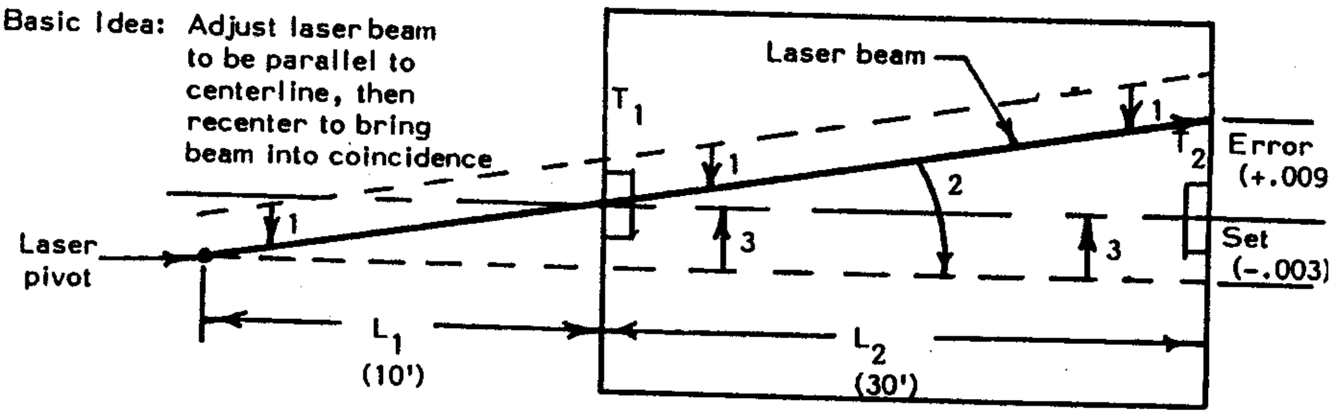
4. Rotate head back to original position. Repeat Procedure A as necessary.

5. Repeat Steps 2 through 4 as necessary, until target reading at any of the 3 positions is the same. The laser plane is now parallel to the surface.

D. Procedure to be used for "bucking in" to gravity. The instrument can be "bucked in" to gravity; that is, made level. The procedure for doing this is covered elsewhere in the Manual.

E. Procedure to be used when target in the near position is some distance from the laser. Use this procedure when L_1 is 10% to 200% of L_2. Use standard buckin procedure when L_1 is 10% or less of L_2. The standard buckin procedure will always work, but in this case may require 10 to 30 cycles. This "short cut" procedure requires only 1 to 3 cycles, and will save much time.

Basic Idea: Adjust laser beam to be parallel to centerline, then recenter to bring beam into coincidence



1. Center beam on T_1 using Model L102 Beam Translator.

2. Tilt laser beam through 0 to set point. (See below.)

3. Recenter beam on T_1 using Model L102 Beam Translator.

4. Repeat Steps 1 and 2 as needed to bring beam into coincidence (1 to 3 cycles is usually enough).

$$\text{Set Point} = -\left[\frac{L_1}{L_2} \times \text{error at } T_2\right]$$

Example: L_1=10', L_2=30', error=+.009"

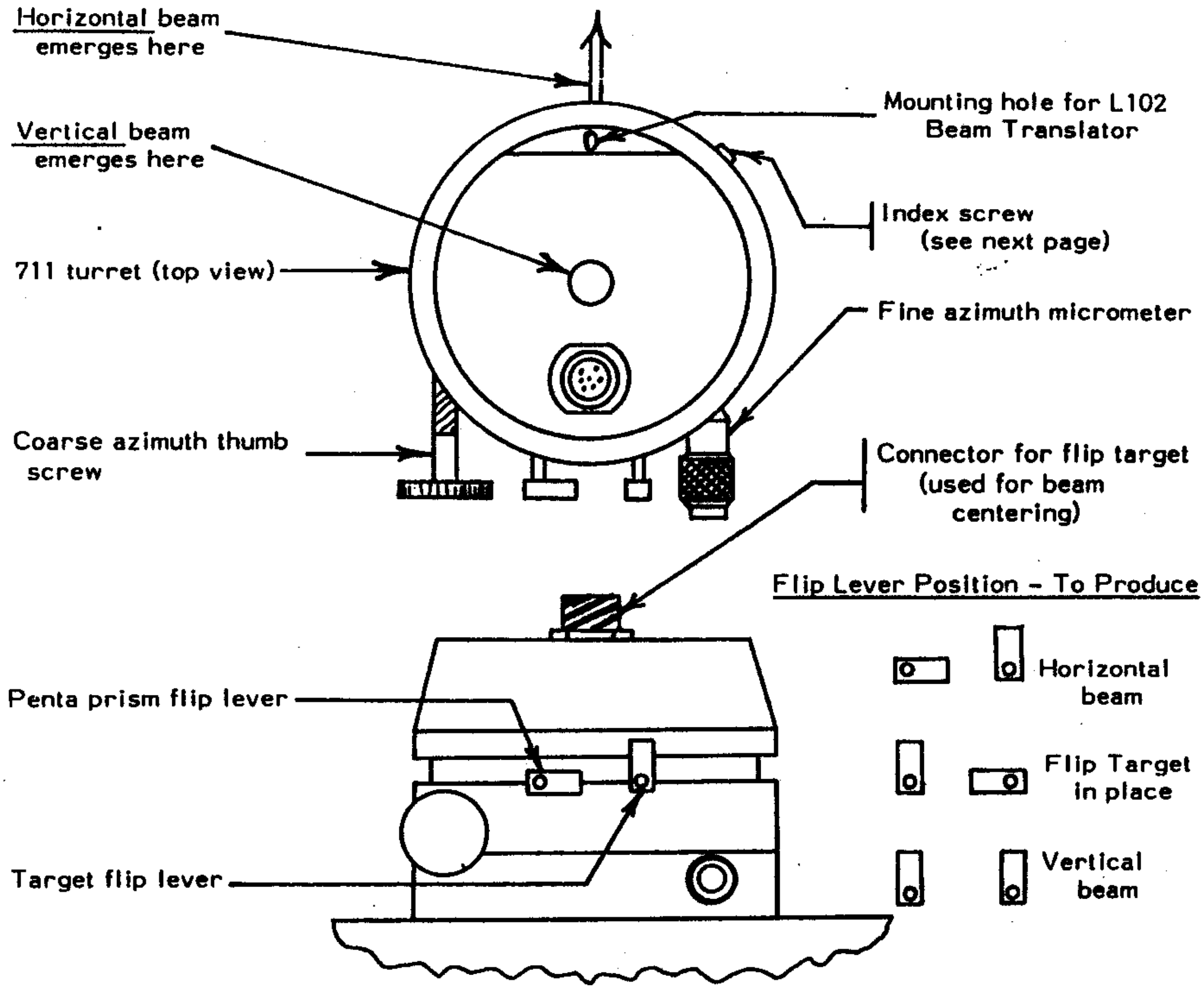
$$= -\frac{10}{30} \times .009$$

Set Point = −.003

*Note: This same procedure can be used equally well in machine tool work where the beam translator is not used. Simply center target at T_1, using T220.

TO SWEEP A FLAT PLANE

711 Turret Details



DETAILS TO CHECK BEFORE USING SWEEP:

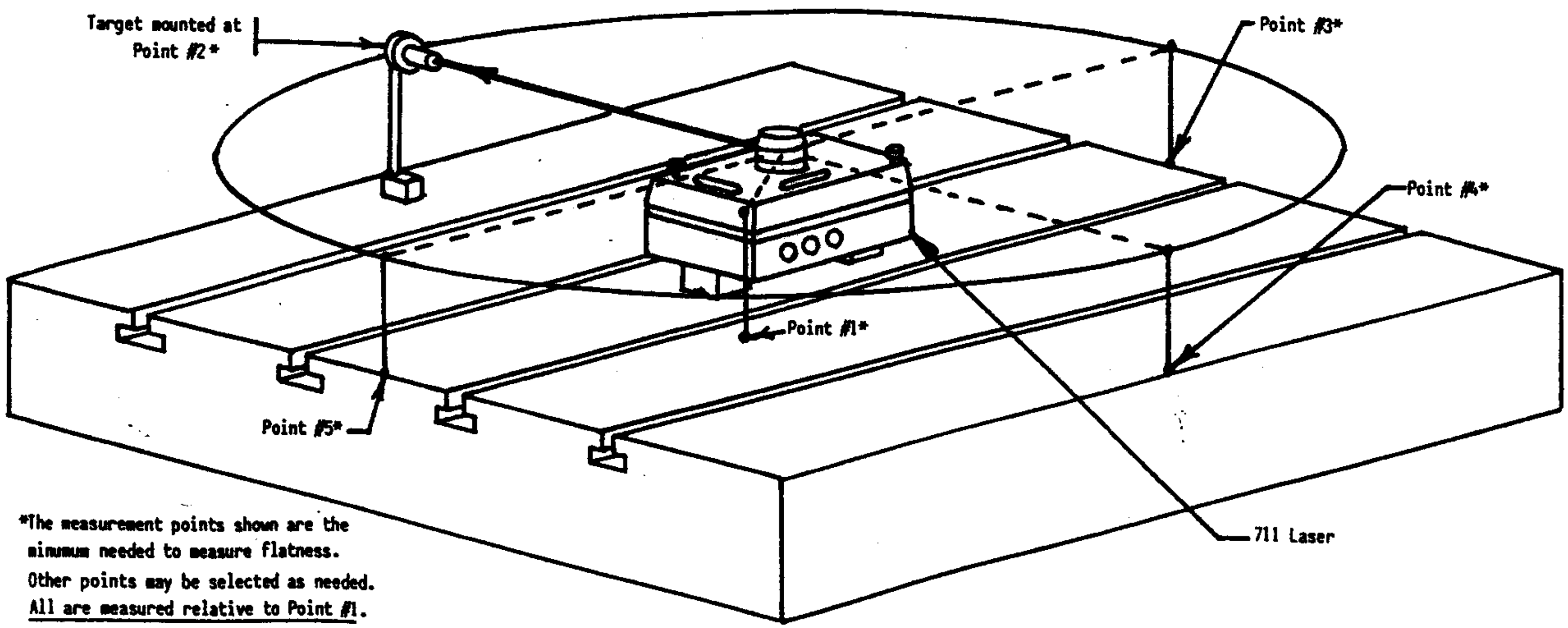
1. Make sure vertical laser beam is centered on turret axis of rotation. (See procedure on next page.)
2. Be sure penta prism is fully rotated against its stop.

TO SWEEP A FLAT PLANE:

1. Turn turret by hand to point beam approximately in desired direction and release. (Clutch will hold turret in place.)
2. Use coarse azimuth thumb screw to align beam more closely to desired direction.
3. Use fine azimuth micrometer to bring beam to exact desired direction. (CAUTION: When using fine micrometer, DO NOT push down on micrometer while turning.)

FLATNESS MEASUREMENT

Making the measurement. To measure another point, move target and A-517Target Stand, being careful not to disturb the micrometers, and place on the table top. Swivel entire A517.unit, so that the light shield of the target is pointed back toward the 711 Laser. Lock magnet in place. Now rotate the 711 turret so that the beam falls approximately centered in the light shield of the target. (If laser spot hits anywhere on the target, this is close enough for roughing in.) Release 711 turret (clutch is automatically engaged). Continue to adjust laser beam, using the turret micrometer until laser beam is centered on the target, as shown by the horizontal meter reading. When performing this step, be sure to adjust the beam so that you go through "0" on the horizontal meter by .005" to .010". Then reverse the tangent micrometer to center the beam ± .001" horizontally. The vertical meter will now read the elevation at this point relative to Point #1.



*The measurement points shown are the minimum needed to measure flatness.
Other points may be selected as needed.
All are measured relative to Point #1.

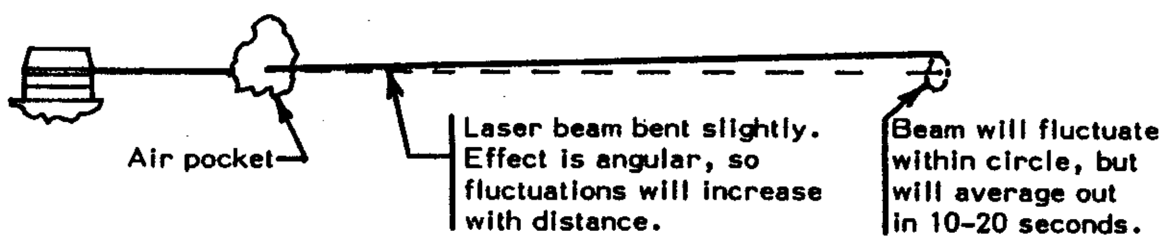
COPING WITH AIR TURBULENCE

A. Introduction

The performance of the laser system is limited by the turbulence in the atmosphere. The usable accuracy of the system, as a rule of thumb, is .0001" per 10 ft. between the laser and the target for typical machine shop conditions. The accuracy can be worse by a factor of 2 in the winter, when the air is cold and dense, and can be better by a factor of 2 in the summer, when the air is hot and humid and not very dense.

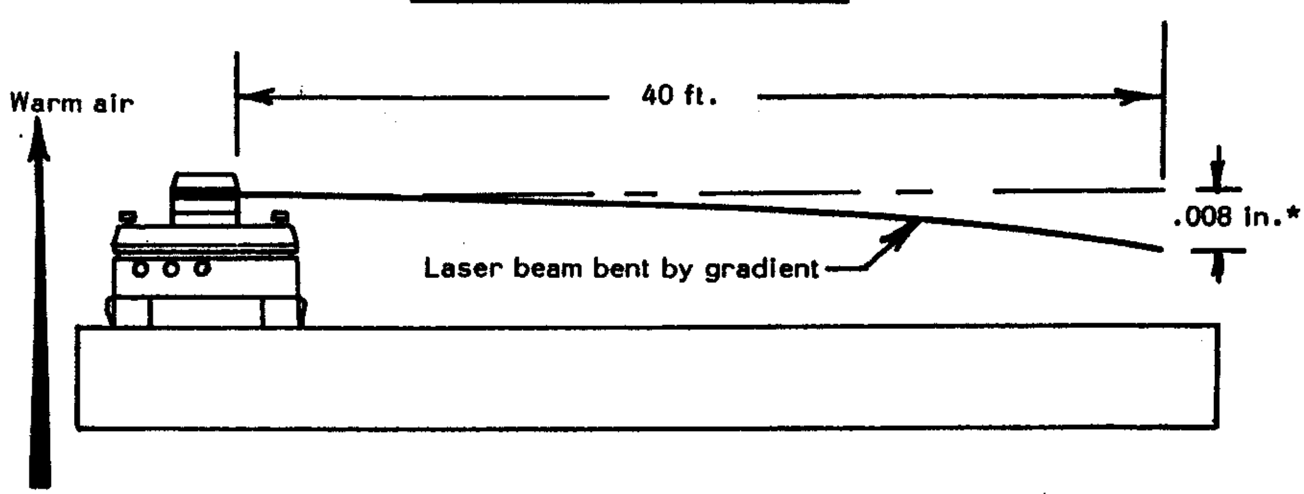
There are two atmospheric effects that influence the system accuracy. The first is turbulence, caused by pockets of air at a slightly higher or lower temperature which act like weak lenses when passing through the laser beam, causing it to fluctuate slightly. This is an angular effect, so that the farther away the target, the greater the effect. This is similar to the shimmer seen over a hot tar road in the summer. The same effect is present in the shop, but is not visible to the naked eye.

Turbulence



The other effect is vertical temperature gradient, or refraction. In still air the temperature is warmer nearer the ceiling than it is at floor level. This condition has the effect of bending the line of sight downward. It can amount to as much as .008" in 40 ft. at a 50°F. shop temperature. This same phenomenon occurs with optical tooling or theodolytes. This effect only occurs when the air in the shop is very still and can be recognized by a sudden shift in the apparent vertical reading of the target when someone opens a door and creates a faint breeze. Usually when vertical gradient errors are present, turbulence will be very light.

Vertical Temperature Gradient



*50°F. shop temperature

TURBULENCE WILL AVERAGE OUT OVER A PERIOD OF 10 TO 20 SECONDS, AND ACCURATE READINGS CAN BE TAKEN IN ITS PRESENCE BY SIMPLY NOTING THE HIGH LIMIT AND LOW LIMIT OF THE FLUCTUATIONS IN THE READOUT AND SPLITTING THE DIFFERENCE.

B. Reducing Atmospheric Effects

1. Use of Fans

The most practical way of eliminating vertical temperature gradient and substantially reducing the fluctuations of turbulence is to use a fan placed behind the target, blowing toward the laser. This fan literally "homogenizes" the air, breaking up the vertical temperature gradient and the pockets of air that cause the turbulence effect. When the fans are used in conjunction with the "slow response" position of the readout switch, the effects of turbulence can be reduced up to a factor of 10, and vertical temperature gradient virtually eliminated.

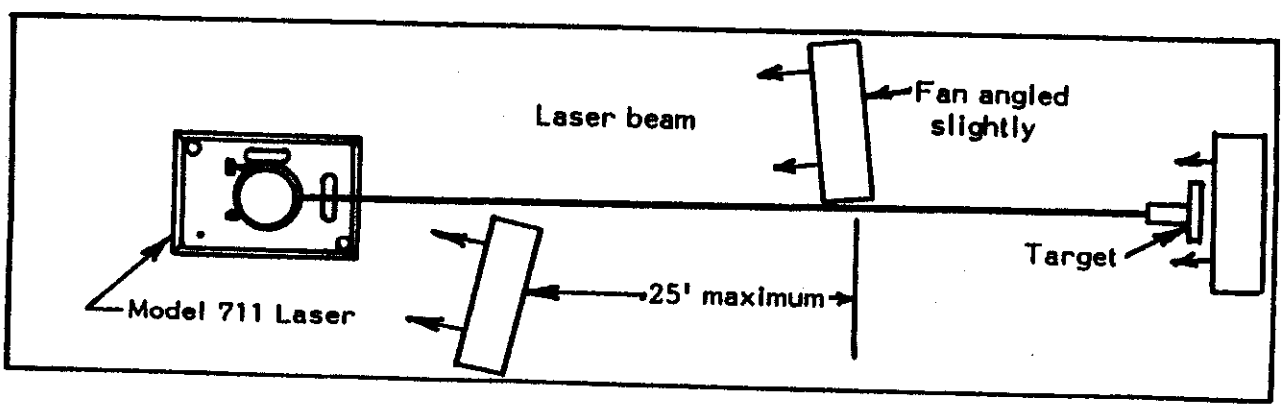
IT IS EXTREMELY IMPORTANT TO USE BOTH THE FANS AND ELECTRONIC DAMPING, WHEN THE MAXIMUM SYSTEM ACCURACY IS REQUIRED.

In the summer, when working to an accuracy of .001" in 20 ft., then the use of fans and damping would not be needed. If, on the other hand, .0001" level accuracy is required, then they would be used. In the winter fans will most probably be necessary at all times.

2. Types of Fans to Use

We recommend one of two types of fans. The first type, which is the least expensive, is an ordinary box window fan, available in most hardware or department stores. Usually the least expensive fan is the best, as it will blow a cylinder of air, rather than a cone of air, produced by the more expensive models. What is needed is maximum mixing of the air, and the cheaper type usually provides this. (These can be tested readily by the use of a cigarette held in the hand; 10 to 20 feet from the fan the smoke should still be blown outward at an appreciable angle.) A single fan of this type can be used to a distance of about 25 feet. If distances greater than 25 feet are involved, then several fans must be used and postioned as shown in the figure below.

The use of fans will always improve the accuracy of the readings, except when the wrong type or too few of them are used. If it is found that turbulence is worse with the fan than without - USE MORE FANS.



The second type of fan that is particularly good, if available, is the large propeller type shop fan. These fans are much bigger and usually good to 50 feet or more. They are not, however, as portable as the window fans. Oscillating fans with almost round blades and office fans do not work well.

3. Electronic Damping

Electronic damping involves the selector switch on the front of the readout unit. Normally all adjustments are performed with this switch set at "fast response". When switched to "slow response", additional damping, or electronic averaging, is switched in and will substantially reduce the magnitude of the fluctuations from air turbulence. When initially switched to "slow response", the meter readings most likely will jump to some completely different numbers. This is perfectly normal. The readings will settle down to their original values in 10 to 20 seconds. (Note: Do not take readings until after this period of time has passed, as the readings would be misleading.) This jump occurs because of residual charge existing in the capacitors, which are switched into the circuit. Fluctuations will still occur, though greatly reduced in magnitude, and the readings should be taken by observing the limits and splitting the difference, as described above. This procedure works well for turbulence, but has no effect on vertical temperature gradient.

C. Outdoor Use - Fixed Centerline

Occasionally on very long shots involving the alignment of a centerline of rotary equipment where the laser beam represents a fixed centerline around which the machinery is to be built and aligned, such as in the alignment of large steam turbines, paper mills, etc., the effects of air turbulence and gradient may be several times worse than those quoted for the machine shop. If such is the case, as it inevitably will be in outside or semi-protected work zones, then the laser beam may be enclosed in 6 in. diameter plastic sewer pipe. This method is extremely effective in such circumstances in reducing the atmospheric effects; however, a vertical gradient immediately sets itself up inside the pipe, and blowers must be used to break up this gradient. These blowers are usually mounted in elbows or T's and can be obtained from Hamar Laser Instruments, Inc., if desired. This situation is a specialized one, and if it applies, we recommend you contact the Company for further details.

LASER PROCEDURE – INSTRUMENT TRANSFER

The Model 711 laser is provided with very accurate and repeatable levels to allow the transfer of the instrument from one location to another for the sake of convenience. The laser should be initially leveled, as in Position 1 below, and measurements made as needed. In the example below, the table is to be measured for flatness, then moved in its X and Y travel directions to determine that the table top always remained in a level plane. The instrument was then moved to Position 2 and releveled. (Note: The laser was kept in the same orientation when placed in Position 2.) The plane generated in Position 2 and the plumb beam are parallel with those in Position 1 within 60 uin/ft or better. In this case the plumb beam was used in Position 2 to measure column squareness to the table top.

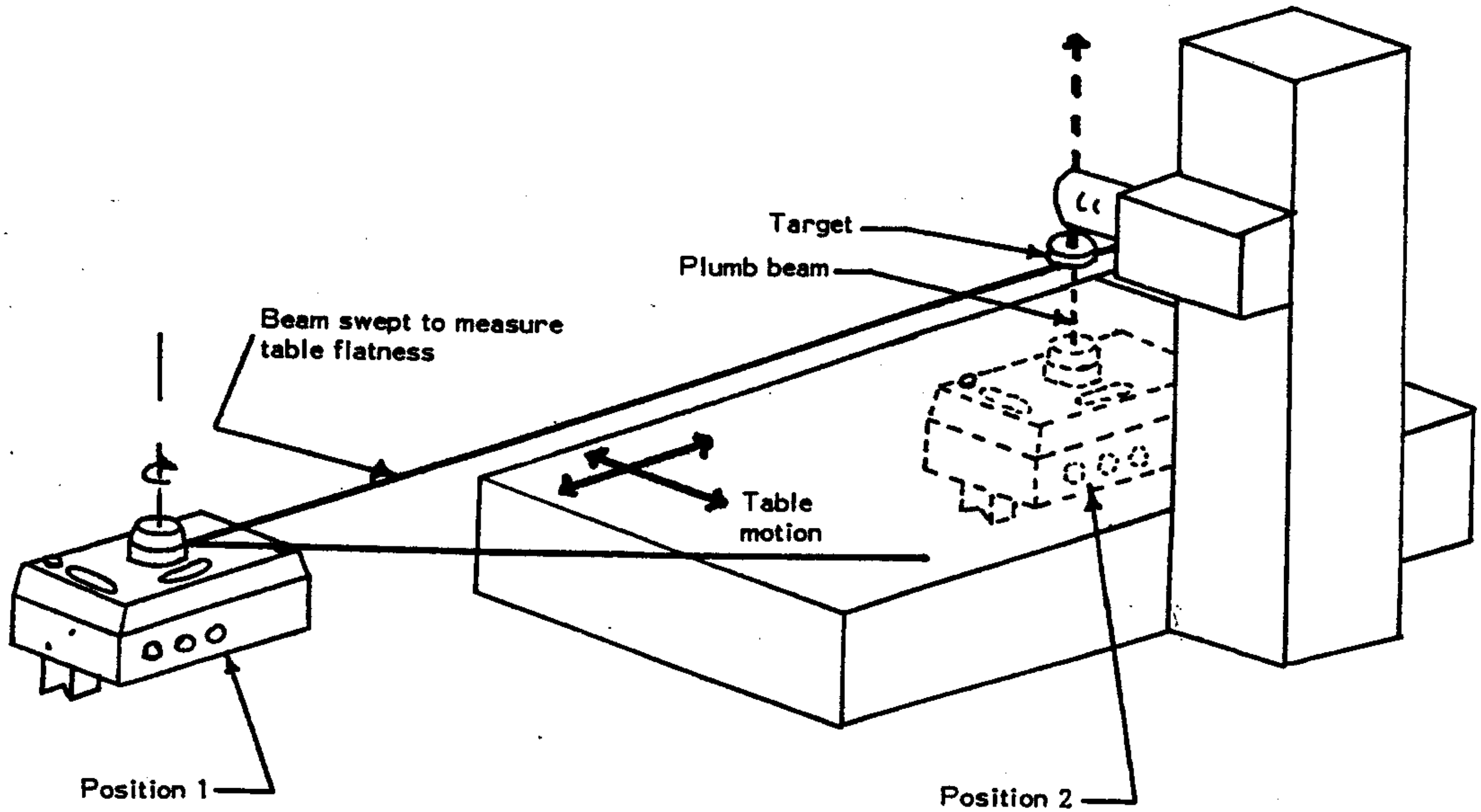
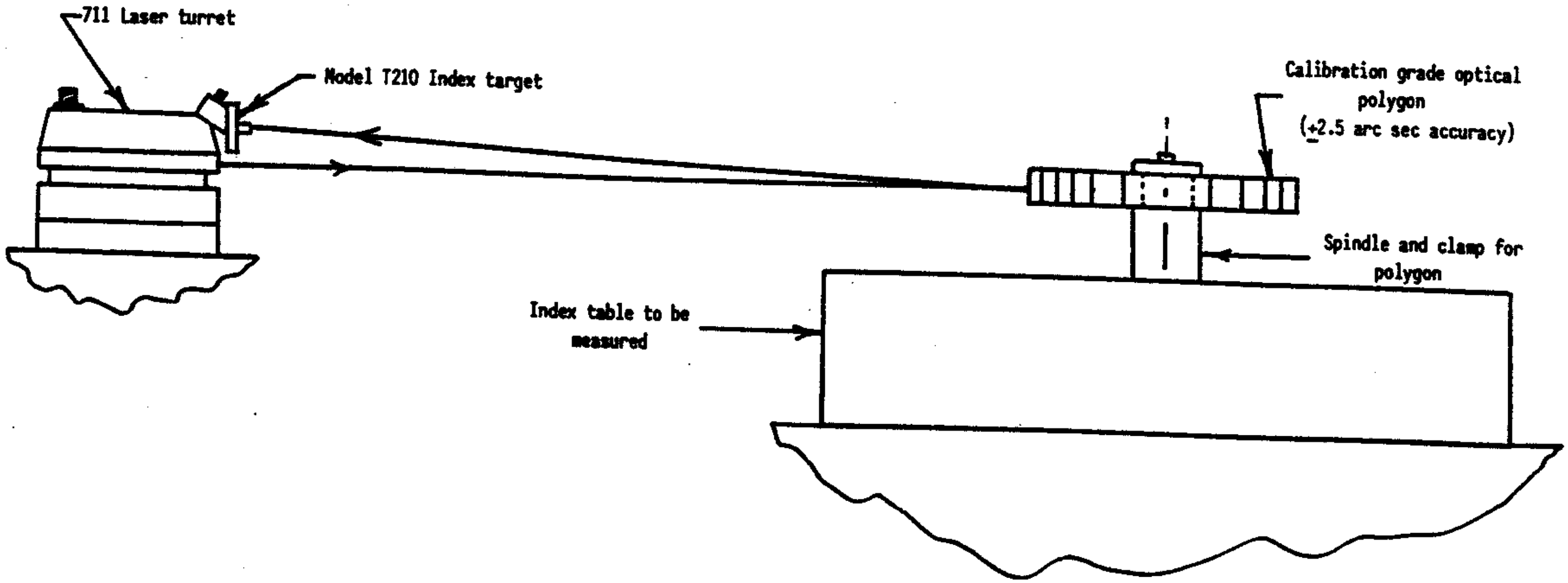


TABLE INDEX ERROR MEASUREMENT



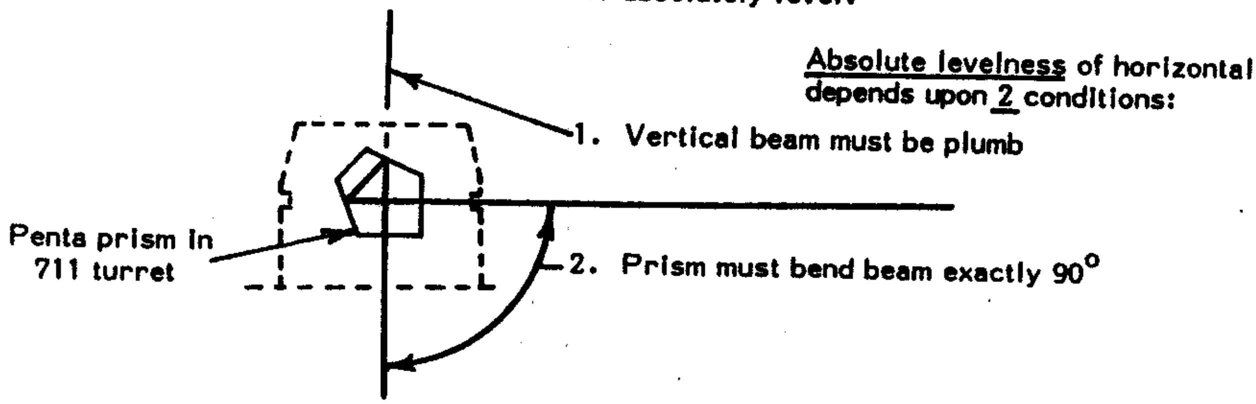
BASIC PRINCIPLE

The beam from the laser is adjusted to hit the face of the polygon and is reflected back into the Model T210 Index Target. Adjustment of the laser head and/or polygon is made to center the return beam on the T210 Target. The table is then indexed to the next position (example: 30°). The next face of the polygon has been rotated into position with the table, and the return beam from this next face should be centered (left or right) on the T210 Target. If an error exists in the index, the horizontal meter of the Readout will display the error in index. This error can readily be divided by the radius from the target to the polygon to obtain an angular error reading, if desired. It is very important to choose a polygon with the correct number of faces and the required angular accuracy (2.5 arc seconds equals an index error .0003" per foot). The use of the polygon is limited to checking index errors that are integral multiples of the angle between the faces (example: a 12-sided polygon could check index every 30°). For smaller angles or odd angles, an index table would be needed in place of the polygon, and a slightly different method of operation would be used.

TO VERIFY LEVEL AND PRISM ACCURACY

I. Introduction

The absolute levelness of the horizontal output beam of the Model 711 Laser depends upon two conditions being met. The vertical beam coming up through the hollow turret axis must be truly plumb, and the penta prism (90° prism) in the turret must bend the laser beam through an exact 90° angle. If both of these conditions are met, then the horizontal output beam will be precisely level. In order to check both of these conditions, the two procedures shown below must be followed, and in the order shown. The first procedure deals with the setting of the levels and, in effect, makes the vertical beam plumb. Once this has been accomplished or checked, then the second procedure may be performed to verify that the penta prism is bending the beam through exactly 90° and that the horizontal beam is absolutely level.



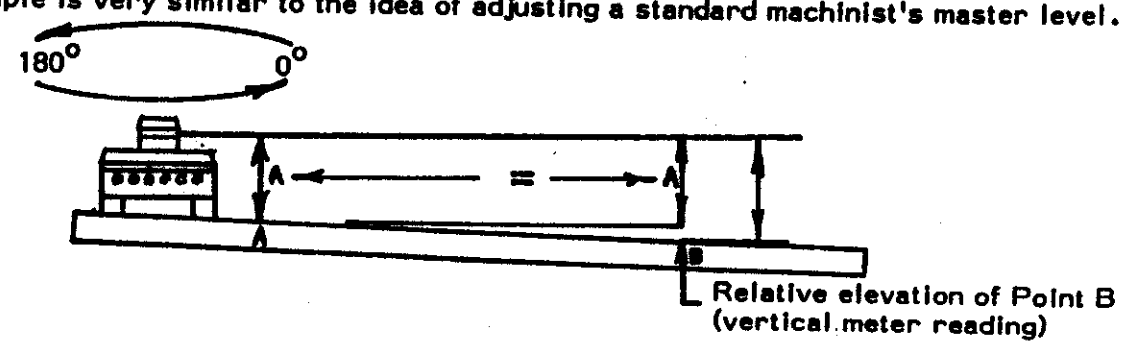
II. To Check or Set Levels

A. Introduction

This procedure must be performed first, and while the horizontal beam is used in this procedure, the vertical or plumb beam is in reality being set plumb. In this procedure, first the long axis level is checked or set, and then the short axis level will be set or checked. When the short axis is checked, if an error greater than .005" is discovered, then the long axis level should be rechecked after the short axis level has been reset.

Basic Principle

A correctly leveled laser will show the same elevation of Point B relative to Point A, whether the laser is set in one position or is turned 180° from that position. This principle is very similar to the idea of adjusting a standard machinist's master level.



Basic Procedure

The basic procedure is to set the laser beam level and then adjust the level vials to show "level". This is accomplished by following the steps listed below.

1. Measurements are made to determine absolute level.
2. The laser beam is set to absolute level, using a set point obtained from these measurements.
3. The level vial is then adjusted so that it shows "level".

B. The Setup

In order to perform this procedure, a flat and level steel or cast iron surface is needed. This surface should be level to .002" per foot or better in both directions. Examples could be machine tool way, layout table, floor plates, machine tool table, or any similar type of surface. The place where the laser is to be set (see Figure below) should be wide enough so that the laser can be set with either the long axis or the short axis parallel to the table edge. In addition to the basic laser equipment, it would be useful to have some means of marking the positions (footprints) of the magnetic bases of the laser and the Model A517 Target Stand.

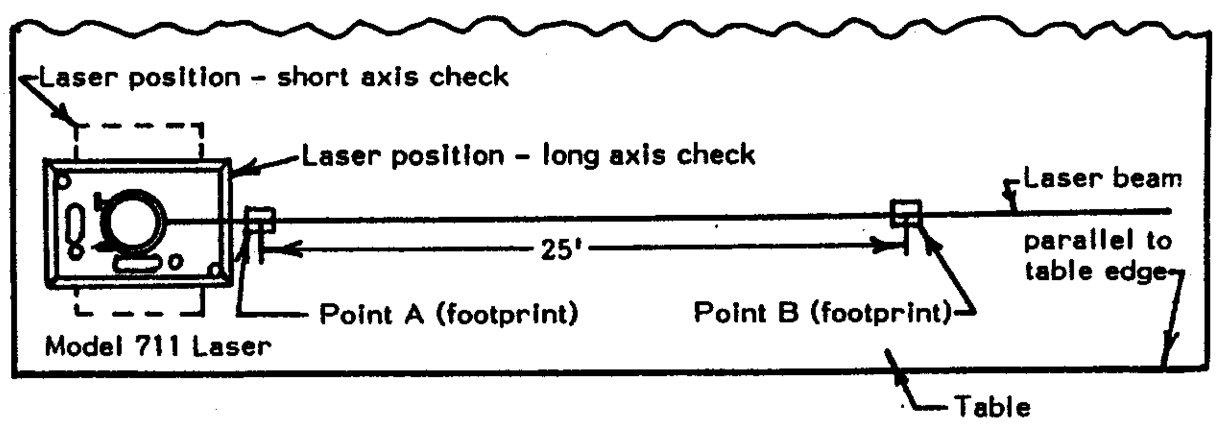
1. Place laser at one end (see Figure below) with the long side of the laser parallel to the edge and the long axis level toward the edge. Level laser carefully both ways.

2. Turn turret so laser beam is approximately parallel to edge.

3. Place target at Point A, center vertically with micrometer and horizontally by sliding the entire Model A517Target and Target Stand assembly side to side. Check calibration and recalibrate, if necessary. (Vertical is important, horizontal is not as important.)

4. At this point mark position of target magnet and laser magnets (footprints) on surface, using pencil or magic marker.

5. Move target to Position B and center horizontally by sliding entire target and magnet side to side. Mark this position, as in Step 4 above.



C. The Measurement

1. Return target to Position A, recenter horizontally and center vertically, using micrometer if necessary. Meter should read:

Vertical	.000
Horizontal	.000

2. Move target to Position B and recenter horizontally. Meter should read:

Vertical	Actual reading
Horizontal	.000

3. Record the vertical reading. Example:

Vertical	+.004
Horizontal	.000

4. Leave target at Position B. Pick up laser, turn 180°, set it down on its footprints, turn magnets on and relevel carefully.

5. Turn turret 180° and adjust turret in azimuth (horizontally) until beam is centered horizontally on target at Point B.

6. Move target to Point A, center horizontally as usual and reset vertical axis, using micrometer, so readout reads:

Vertical	.000
Horizontal	.000

7. Move target to Position B and center target horizontally, as before.

8. Observe vertical reading. If levels are set correctly, you should have the same vertical reading at Step 8 as you did in Step 3, within a tolerance of .001" at 20 feet.

   Note: If the vertical readings in Steps 3 and 8 are the same, then skip the rest of this section and proceed to Section II.F below for the short axis level check. The set point referred to in Section F would be the vertical reading obtained in Steps 3 and 8 above. If the readings differ by more than the amounts shown above, then continue with the balance of this Section.

9. Record vertical reading. Example:

Vertical	-.008
Horizontal	.000

D. To Set the Laser Beam Level

1. If the two vertical readings at Point B (0° & 180°) are not the same within the tolerances permitted in Section C.8 above, proceed as follows. Example:

Point B	Vertical reading	0° laser	+.004	(recorded in Step C.3)
Point B	Vertical reading	180° laser	-.008	(recorded in Step C.9)
		Total Difference	.012	

Total spread is .012". Divide by 2 to yield level error of .006" over distance A-B.

Set point is found by adding level error to the lowest reading.

i.e.
-.008 negative reading
+.006 level error
-.002 set point

2. Tilt long axis beam by using fine adjust micrometer on laser (long axis) until the vertical axis of the target still at Point B reads the set point value. Example: -.002. Now recheck that laser beam is set correctly.

3. Place target at Point A and center horizontally. Make sure vertical reads 0. If not, reset vertical to 0, and move target to Point B and center horizontal.

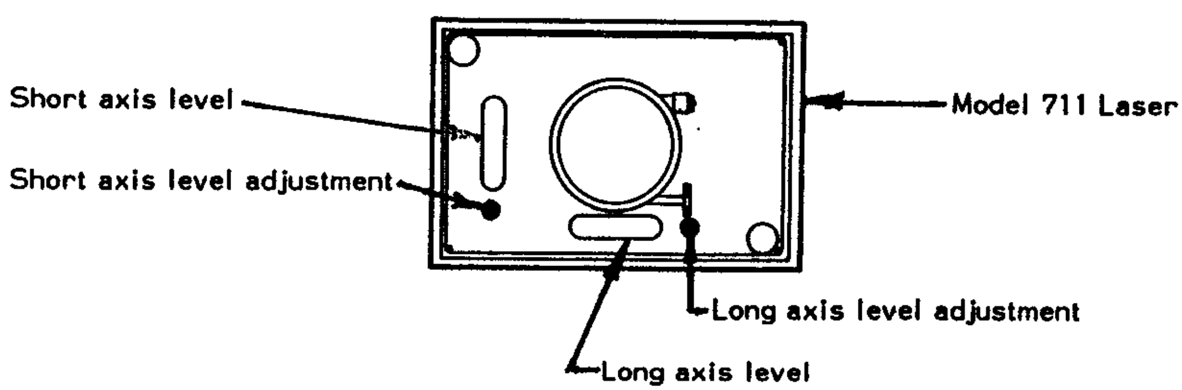
4. Vertical meter should read set point value (-.002). If necessary, retilt beam to set point. Laser beam is now level. (Note: At this point we are still working with long axis level only. Do not reset short axis until later.)

E. Resetting Long Axis Level

1. Pry off cover button (black) to gain access to level vial screw adjustment (single screw for each level) which is accessible through cover (see below). For long axis adjust level vial so it shows level. (Note: This adjustment is very sensistive. Turn screw with screwdriver as little as possible.) Note result.

2. Remove screwdriver and wait 10-20 seconds; then recheck that level vial is showing level. Continue to adjust as needed until level stays level after the 10-20 second period.

3. Laser beam is now level, and level reads level; so the long axis is now set correctly. Put plug back in hole of cover.



F. Resetting Short Axis Level

At this point the short axis level is to be checked. As the true level set point (relative elevation of Point B to Point A relative to a level line) is known from Step II.D.1, we can shortcut the procedure.

1. Turn laser 90° and relevel with target still at Point B.

2. Turn turret 90° and adjust in azimuth (horizontally) until <u>horizontal</u> meter at Point B reads 0; i.e. beam is centered.

3. Place target at Point A, center horizontal, and using micrometer, set vertical to read 0.

4. Place target at Point B, center <u>horizontal</u>.

5. Adjust beam vertically using <u>fine</u> level adjustment for <u>short</u> axis until vertical meter reads the set point (example: -.002). Laser beam is now level, as before.

6. Pry up button for short axis level adjustment and proceed as in Steps II.E.1-3.

7. Levels are now set correctly.

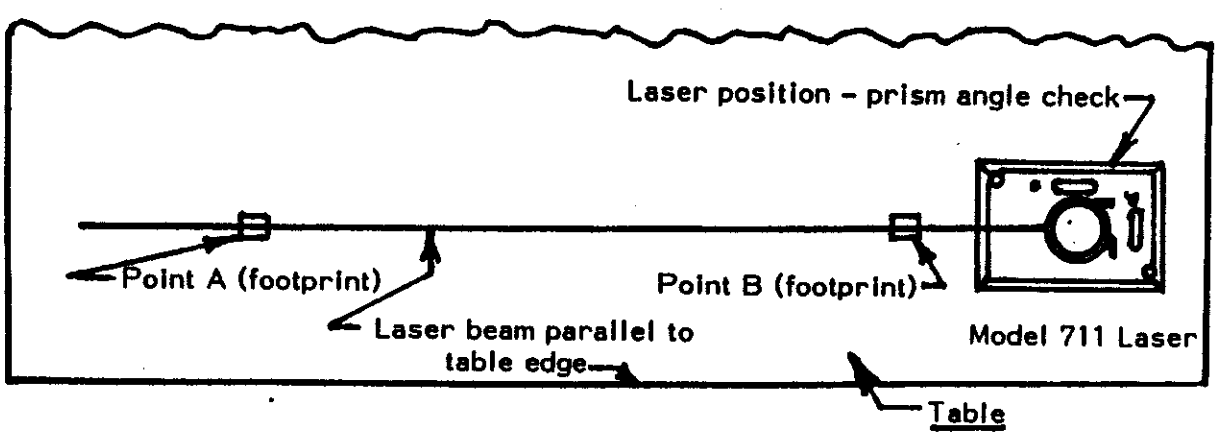
III. To Verify Penta Prism Accuracy

A. Introduction

Once the level setting has been verified, this procedure can then be used to verify that the horizontal laser beam is absolutely level. If the measured error exceeds the limits shown in the table in this section, the cause will be an error in the 90° deflection in the penta prism.

B. The Setup

The exact same setup used in Section II above would be used here; the only difference would be that only one axis need be checked, and the laser is placed at the opposite end of the range.



C. The Measurement

1. Place laser on opposite end of range, as shown in the Figure above and swivel turret and slide laser side to side as necessary, so that the horizontal beam passes approximately over the middle of the target footprints at Points A and B.

2. Level laser carefully. (Caution: Be sure that penta prism is firmly against its stop.) Place target in target stand in Footprint B. Center target horizontally, using micrometers, to read 0. Set the vertical axis using micrometers, so that the vertical axis reads the value of the set point. (Example: -.002, as in Section II.D.1 above.)

3. Place target in footprint at Point A and center beam horizontally on target, using turret controls.

4. The vertical axis at this point should read .000. It most probably will not read exactly 0, but the values should not exceed those listed in the table below. If they are within these values, then the prism is set correctly, and the horizontal beam is level within specifications.

<u>Error Table</u>

Prism 90° angle is within specification if Point A reading does not exceed $\pm.003$

Actual error in 90° angle (seconds of arc)

$$= \frac{\text{Point A reading}}{.006}$$

SCHEMATICS AND TROUBLE-SHOOTING CHART

This section includes a trouble-shooting chart and three electrical schematics, covering the 711 system. It should be noted that the trouble-shooting chart covers operating problems, as well as technical problems. If questions arise that are not included in the chart, please contact Hamar Laser Instruments, Inc. (203/544-9321) for further information.

LASER

Trouble	Corrective Action
1. Laser tube will not turn on	Check fuse located on underside of unit near power cord.
2. Fuse blows repeatedly	Power supply blown – return to manufacturer.
3. When laser is turned on, tube will not light, but arcing is heard or seen	Unit is wet inside (condensation), as may occur if instrument is very cold and is brought into a warm room. Let unit sit for a few minutes; try again.
4. Tube is lit, but no laser beam visible	First, check that sweep prism cap is correctly orientated. It could have been put on backwards. If still no beam, look through cooling holes at side and observe color. If not salmon-red or orange-red, but purple or blue-red, tube is bad and must be replaced at factory.
5. Level vials will not stay aligned	Check what laser is mounted on. If solid, illuminating light may have been held too closely to level vials. If so, let vials settle out for several minutes and then re-level. If problem persists, tighten largest single screw (pivot) under laser.
6. Fine leveling micrometer does not work	Micrometer may be at end of its travel. Reset to .250". Re-adjust coarse leveling screw and proceed as normal.
7. Coarse leveling cannot be done	Structure on which unit is placed is too far out of level, causing laser unit to exceed coarse adjusting range ($\pm 2^{\circ}$). Re-level structure, or use shims under laser magnet. (Note: Be careful with shims. Laser may not be satisfactorily held down.

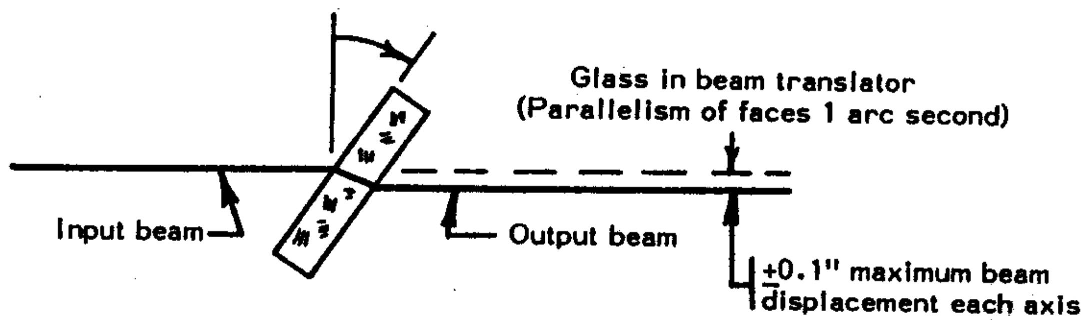
MODEL L102 BEAM TRANSLATOR

A. Introduction

The Model L102 Beam Translator is an optical device wheich will shift a laser beam, or line of sight, parallel to itself without tilting. It is to be used when it is desired to center the laser beam on a target, when the target cannot be moved, such as in centerline alignment of a turbine, pump or engine block.

B. Principle of Operation

A parallel sided piece of glass, when tilted at an angle to an incoming laser beam, will displace that beam by an amount proportional to the thickness of the glass and the angle at which it is tilted relative to the beam. The output beam will be exactly parallel to the input beam, if the sides of the glass are parallel. The Model L102 Beam Translator incorporates a 1½" diameter by ½" thick optical window with parallel sides. With 2 coarse/fine adjusting knobs, the unit will displace the laser beam ±0.1", either horizontally or vertically or both. The unit mounts on the Model 711 Laser turret.

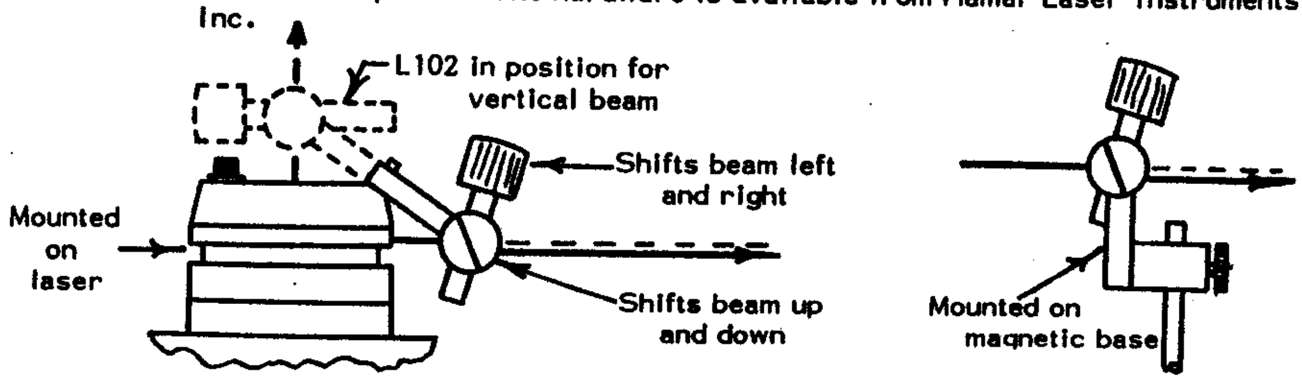


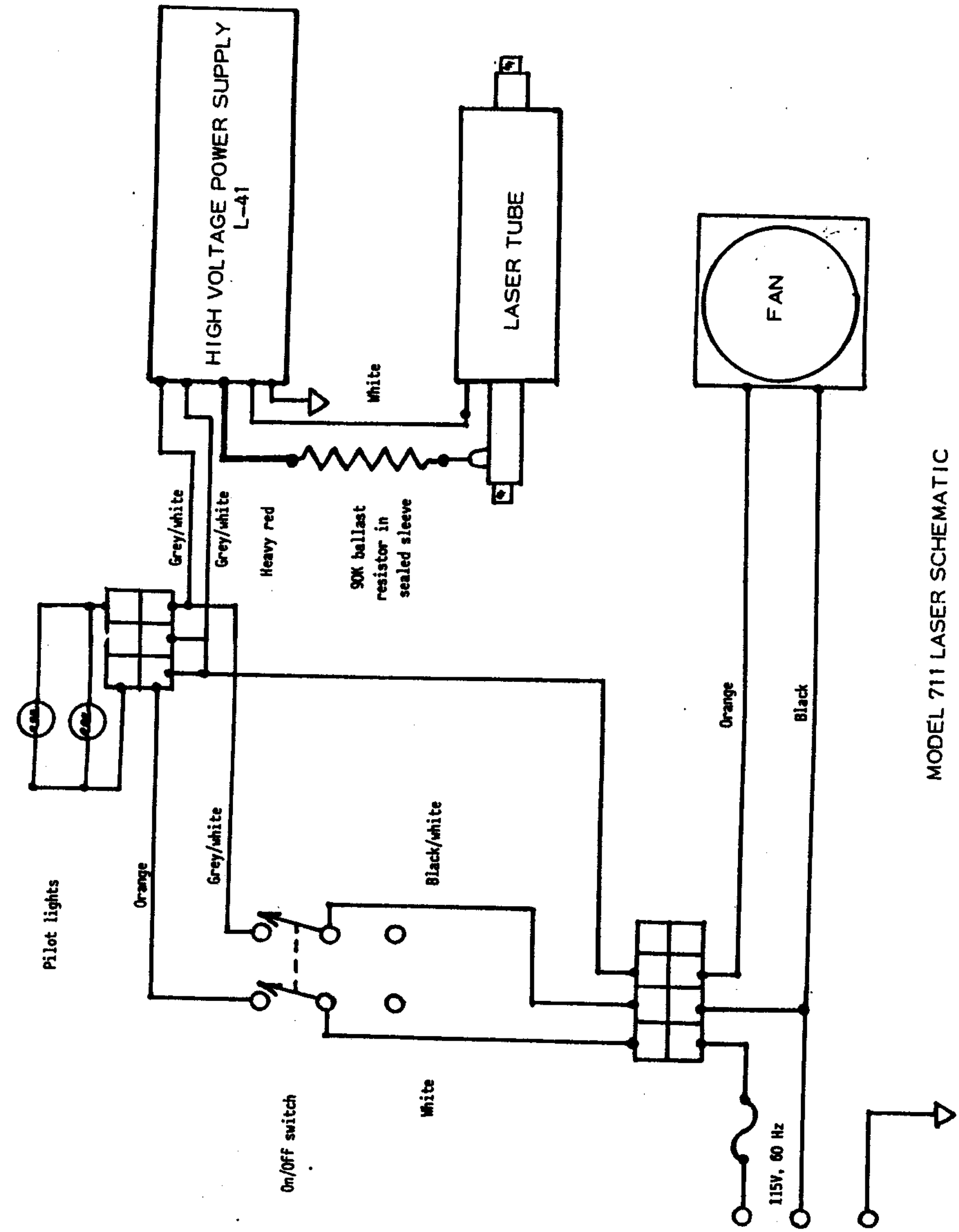
C. Instructions for Use

1. Mount unit on turret as shown below, using the captive screw. Orient as needed for either vertical or horizontal beam and tighten screw. Make sure beam is centered in glass and that glass is approximately square to beam.

2. Center beam on near target, using the 2 knobs as required. (Note: Turning knob gives a 40:1 reduction. Pressing knob in engages a spline and will give a 1:1 ratio for coarse adjustment.)

3. It is recommended that the Model L102 Beam Translator be mounted on a separate magnetic base as shown below, if adjustments near the .0001" level are required. The hardware is available from Hamar Laser Instruments, Inc.





MODEL 711 LASER SCHEMATIC