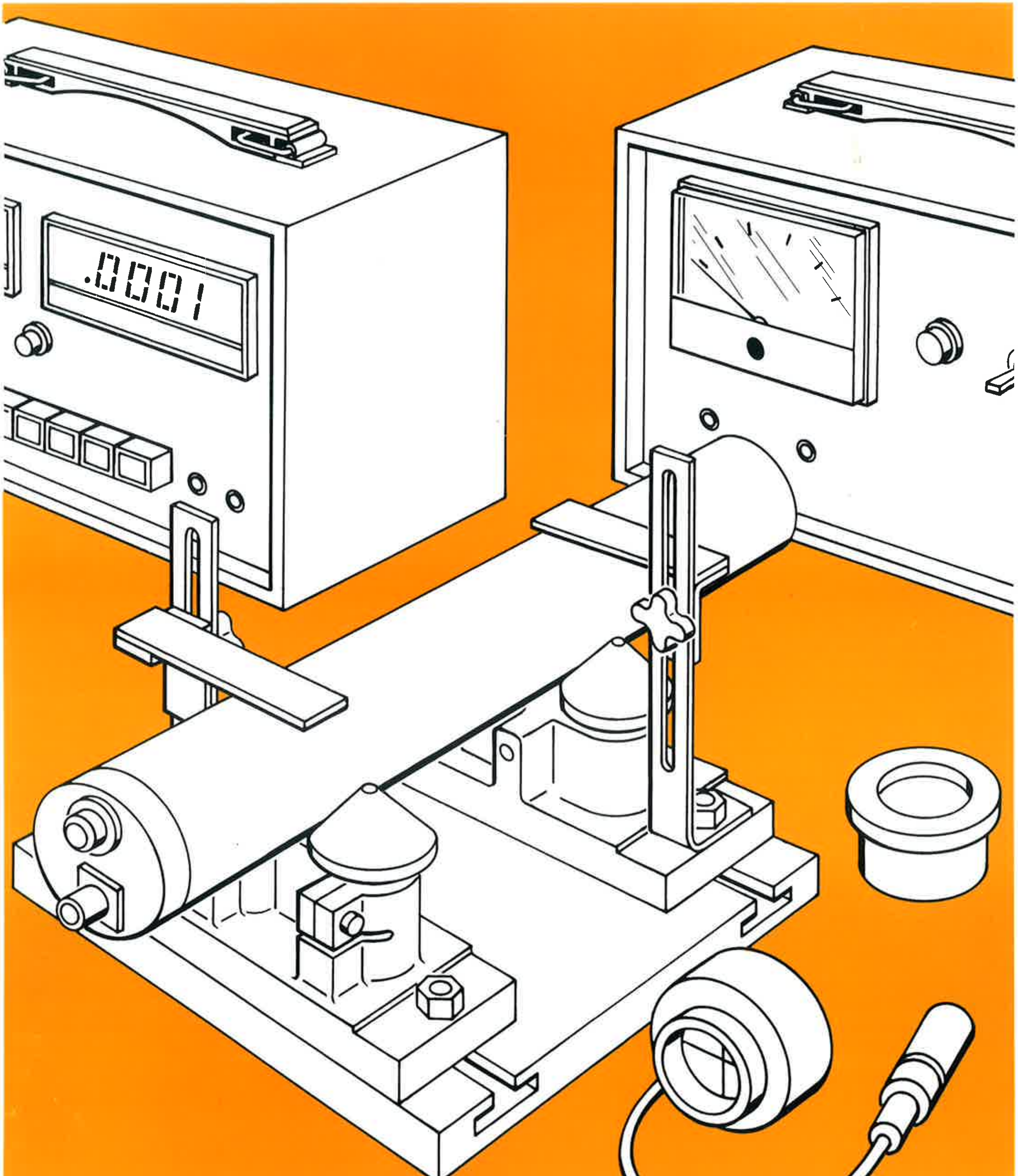
Alignment/Auto-Collimating Laser System 71 2615

Operating Manual

Manual No. 71 1001-4



CUBIC PRECISION

A member of the Cubic Corporation family of companies

K+E Electro-Optical Products

Additional manuals covering K&E Optical Alignment Equipment are available from Cubic Precision. For a complete set of manuals plus binder, contact Cubic Precision, 750 Huyler Street, Teterboro, NJ 07608.

Product Number

71 1001 Optical Alignment Equipment Operating Manuals

Set of four operating manuals with illustrations and complete instructions for the use, care and adjustment of K&E Optical Alignment Equipment. Also includes a comprehensive glossary of Optical Alignment Terms for easy and convenient referral.

The set includes the following manuals:

1. Alignment Telescope, Bright Line Alignment Telescope, Line of Sight Telescope and Alignment Collimator, Straightness of Line of Sight Collimator Operating Manual.
2. PARAGON® Tilting level, PARAGON Leveling Kit Operating Manual.
3. PARAGON® Jig Transit, PARAGON Jig Transit Telescope Square Operating Manual.
4. Alignment/Auto-Collimating Laser System Operating Manual.
5. Glossary of Optical Alignment Terms.

K&E OPTICAL ALIGNMENT EQUIPMENT

Any part of K&E Optical Alignment Instruments found by Cubic Precision to be defective in material or workmanship will be repaired, or at Cubic Precision's option, replaced, for the original purchaser within 90 days of original purchase, provided the instrument is returned*, transportation prepaid to the appropriate authorized K&E Service Center within the warranty period and the instrument is in as good a condition as when originally purchased, ordinary wear resulting from careful use only accepted, and the instrument has not been subjected to misuse, rough handling, alteration or servicing by other than an authorized service representative, negligence, fire, accident, water damage, acts of God, or other casualty.

***NOTE:** Arrangements for the return of goods should be made in advance through K&E or K&E Dealer from which the goods were purchased.

The above is in lieu of any expressed or implied warranties and **THERE ARE NO IMPLIED WARRANTIES OF MECHANTABILITY OR FITNESS FOR USE.** K&E assumes no responsibility for any inconvenience, loss, injury, or direct or consequential damage arising from the possession or use of the instrument.

The following information is provided with each Optical Alignment Instrument purchased:

1. Operating Manual
2. Warranty Registration Card

NOTE: The warranty registration card is to be filled out by the customer and returned to K&E.

BEFORE ATTEMPTING TO OPERATE ANY OPTICAL ALIGNMENT INSTRUMENT OR COMPONENT, IT IS ESSENTIAL TO READ AND FOLLOW THE PROCEDURES OUTLINED IN THE OPERATING MANUAL.

K&E WILL NOT BE RESPONSIBLE FOR DAMAGE THAT COULD OCCUR IF THESE PROCEDURES ARE NOT FOLLOWED.

Ownership of Goods in Transit—The Consignor's responsibility for delivery or damage of goods ceases when title passes to the Consignee, and therefore, Consignor's responsibility ceases as soon as the goods are delivered to the Carrier. Thereafter, responsibility for non-delivery, damage, and payment for goods resides in the Consignee. Claims against the Carrier must be made within time limits specified by the Carrier. The fact that notice has been given to the Carrier that the goods have not been delivered and that a request has been made to trace them, does not serve to extend the period within which claims for damage or loss may be made. When requested, we will furnish the necessary documents for making these claims. Shipments will be made without declaration of value unless Customer requests otherwise. Parcel Post shipments are insured for invoice price only, unless Customer requests otherwise. The Customer will be charged for the cost of any insurance. All prices are FOB shipping point unless other terms are specifically agreed upon.

TABLE OF CONTENTS

SECTION 1. INTRODUCTION

SECTION 2. OPERATION

SECTION 3. MAINTENANCE

APPENDIX-ACCESSORIES

LIST OF ILLUSTRATIONS

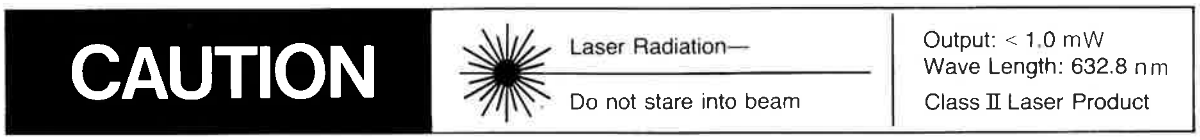
LIST OF TABLES

CAUTION
LASER RADIATION

Warning labels are affixed to the Laser Instrument in accordance with the Department of Health and Welfare Performance Standards, Vol. 40, Number 148, as follows:

1. The following warning label is affixed to the front end of the Laser Instrument and to the dust cover:

2. The following warning label is affixed around the neck of the Laser Instrument barrel:



3. The following label is affixed to the Power Supply Unit:

NOTE

The laser should be operated overnight (approximately 16 to 20 hours) once a month if it has been stored and non-operative. This will extend its shelf life.

OPERATING SAFETY NOTICE

The following precautionary measures are recommended for proper use of the equipment and to safeguard against accidental injury:

1. Do not look directly into the laser beam; it can be injurious to the eye. Looking into this laser beam will appear much the same as directly viewing an arc welder, a spotlight bulb, or the bright sun. Normal eye reflexes usually cause the eye to blink or turn away; however, to avoid accidental injury, take precautions against looking directly into the oncoming laser beam or its bright reflection. Ensure that unsuspecting persons who may be a considerable distance along the line of sight from the laser instrument are advised of this precautionary measure.

2. Ensure that personnel assigned to work with the laser equipment understand the instructions for its proper operation fully. Require them to read and understand the operating instructions supplied with the equipment.

3. Allow only authorized personnel to set up, adjust, and/or operate the equipment.

4. Identify laser operating areas with approximately worded warning signs that are posted conspicuously at entrances to these areas.

5. Ensure that rooms and other areas in which lasers are operated are well lighted to reduce the contrast of the laser beam with the background light.

6. Conform strictly with all applicable Federal, State, and local electrical and safety standards when setting up and operating the laser equipment.

7. Before turning the laser Power Supply Unit on, make sure that the coaxial power cable from the laser power supply unit is connected firmly to the rear end cap connector of the laser instrument.

8. Before disconnecting the coaxial power cable from the Laser Instrument, always make sure that the laser power supply unit is turned off.

9. Provide proper electrical grounding for all electrical line plugs. Ensure that the third grounding terminal of the plug is connected to a corresponding grounded terminal of the receptacle.

10. When the Laser Instrument is not being used, turn off the laser Power Supply Unit, disconnect the power supply line cord from the wall outlet, and install the dust cover over the end of the Laser Instrument barrel.

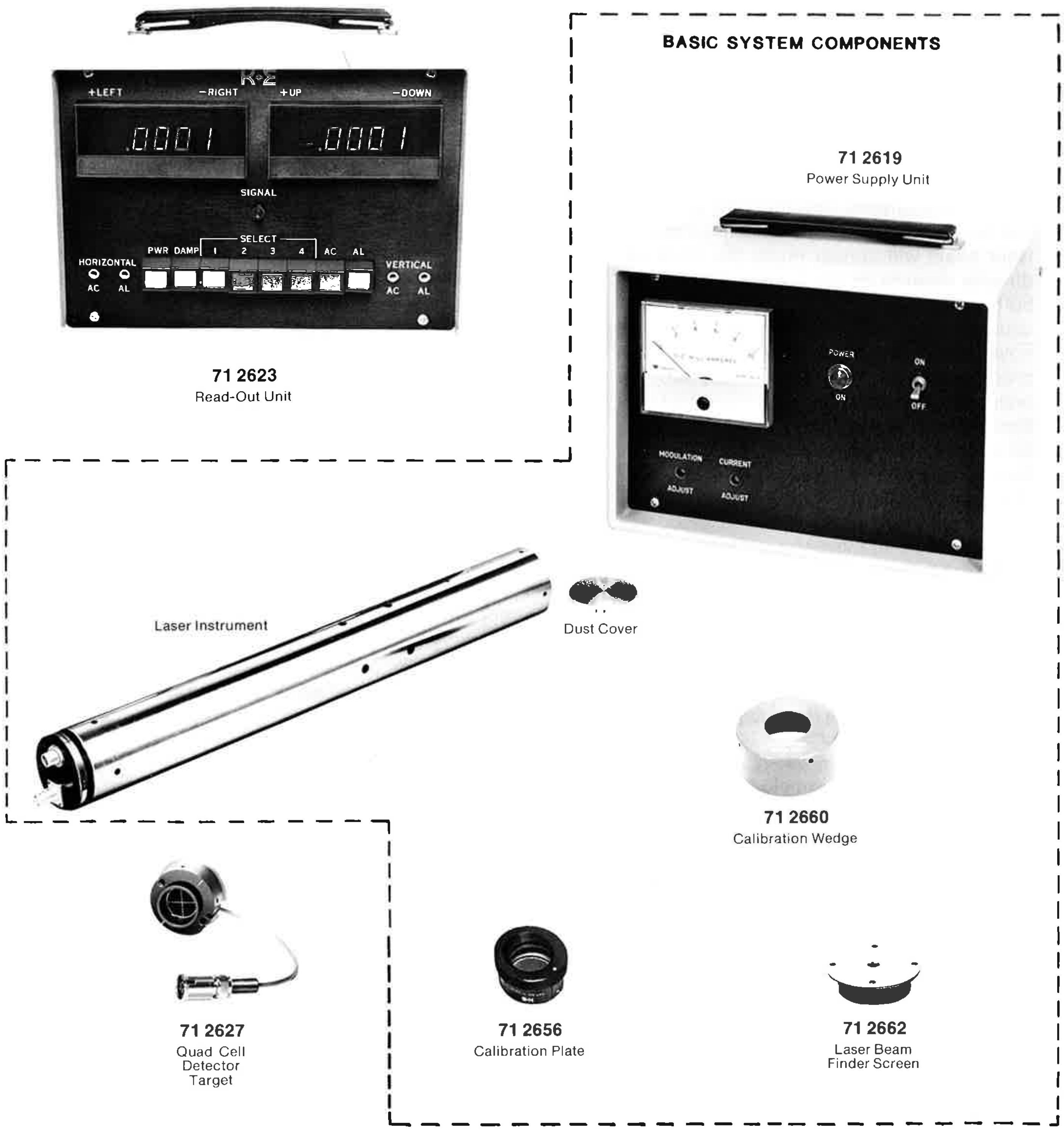


Figure 1-1. 71 2615 Alignment/Auto-Collimating Laser System

SECTION 1 — INTRODUCTION

1-1. SCOPE OF MANUAL

This manual provides descriptive data, operating instructions, theory of operation, and maintenance instructions for the 71 2615 Alignment/Auto Collimating Laser (Figure 1-1). The Laser Instrument is manufacured by Cubic Precision, Teterboro, New Jersey. Accessories for the Alignment/Auto-Collimating Laser are covered in the appendix to this manual.

1-2. PURPOSE OF EQUIPMENT

The Alignment/Auto-Collimating Laser System has been designed to meet the needs of production and laboratory engineers in the performance of precision alignment measurements. It enables direct measurement of alignment tolerances at working distances beyond the capability of conventional optical instruments, while retaining complete compatability with standard K&E optical alignment hardware and accessories. It also provides the capability for auto-collimation in null readings to within ±2 arc seconds over ar operational range of 0 to 150 feet.

1-3. The Alignment/Auto Collimating Laser System projects a low-power (under.79 milliwatt) coherent light beam along an optically straight path for operational distances up to 300 feet. Horizontal and vertical displacements of a work piece from the center of the beam can be measured to a resolution of 0.001 inch. Displacements are determined by photo-electric sensors in a detector target, and are displayed as horizontal and vertical components on direct-reading digital displays.

1-4. Conventional optical alignment techniques make use of a visible, optically straight line of sight to make precision measurements. The Alignment/Auto-Collimating Laser System provides the advantage of making this line of sight visible, thereby eliminating much of the time-consuming preliminary setup required in conventional precision optical alignment. Speed and accuracy of readings are also enhanced by the visible line of sight. The location of the laser beam on a target or work piece can be seen clearly by the operator, and the operator's hand, a piece of paper, an optical tooling scale, or a work piece can be inserted harmlessly anywhere along the laser beam path to verify its position or to measure displacement at any interim point.

1-5. DESCRIPTION

1-6. System Components. The Alignment/Auto Collimating Laser System consists of the following basic components:

1. Laser Instrument with built-in internal quad cell for auto-collimation applications.
2. 71 2619 Power Supply Unit
3. Interconnect cable to connect Laser Instrument to Power Supply Unit. (Hardwired to Power Supply Unit)
4. 71 2662 Laser Beam Finder Screen (used for acquisition of return signal.)
5. 10-foot interconnect cable to connect Laser Instrument to Read-Out Unit (71 2623) accessory.
6. 71 2656 Calibration Plate
7. 71 2660 Calibration Wedge

Complete descriptions of these components are included in this section.

1-7. System Accessories. Typical system applications require components which are not part of the basic system. Included among these are:

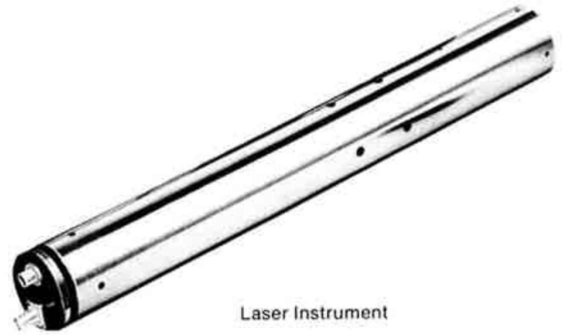
- 71 2623 Read-Out Unit with Auto-Gain Control
- 71 2627 Pig Tail Quad Cell Detector Target Assembly
- 71 1112 Optical Micrometer with Vernier Scale
- 71 2629 See-Thru Detector Target
- 71 2410 Optical Square
- 71 2412 Double Sphere Optical Square

Connecting cable of various lengths available on special order.

In addition, K&E offers an assortment of mounting accessories such as:

- 71 5150 Universal Alignment Telescope Bracket
- 71 5170 Alignment Telescope Bracket with Cup Mount and Sphere
- 71 5191 T-Slotted Base Plate plus two 71 5192 V-Block Cone Assemblies

The 71 2623 Read-Out Unit with Auto-Gain Control is essential to the basic operation of the System and will be described in this section. Complete descriptions of the other accessories are provided in the Appendix to this manual.



Laser Instrument

1-8. 71 2615 Laser System. The Laser Instrument employs a low-power, helium-neon laser plasma tube in a stable resonant cavity to produce the laser light beam. The mirrors which form the resonant cavity are firmly mounted to the steel barrel for maximum stability. The laser tube's unique design features double-wall construction and utilizes a cold cathode. Because very little heat is generated by the cold cathode, the thermal stability of the Laser Instrument is enhanced and thermal warpage is minimized. The laser tube cylinder is constructed of aluminum for uniform heat distribution.

1-9. The laser tube is housed inside the Laser Instrument barrel, and the laser beam is projected through an optical system within the barrel. The Laser Instrument barrel also houses an internal prism assembly and a pair of bi-cell sensors used for auto-collimation applications. The effective diameter of the laser beam is 7/16 inch as it emerges from the Laser Instrument; at a distance of 300 feet from the Laser Instrument, the beam diameter is 9/16 inch.

1-10. Hardened steel is used for the Laser Instrument barrel. The barrel has a nominal diameter of 2.2498 inches at a tolerance of 0.0003 inch variation per foot of length, which is compatible with an alignment accuracy of 1 arc second. No bosses or heat-dissipating perforations are required; therefore, no restrictions are imposed as to selection of the area of the barrel for mounting support during operation. Access holes are provided in the Laser Instrument barrel for calibration adjustments.

1-11. Operating power for the Laser Instrument is supplied by the Power Supply Unit. The interconnecting cable from the Power Supply Unit connects to the rear of the Laser Instrument. A second connector at the rear of the Laser Instrument is used to connect the internal bi-cell sensors to a readout unit through an interconnecting cable for auto-collimation applications.

71 2619
Power Supply Unit

1-12. 71 2619 Power Supply Unit. Electrical requirements for continuous operation of the laser plasma tube in the Laser Instrument are approximately 1200 volts DC at 5 milliamperes. This power and an ignition pulse of 10 kilovolts DC are supplied by the Power Supply Unit. The 1200 volt DC output is AC modulated at approximately 10 kHz to produce intensity modulation of the laser beam at the same rate. Modulation of the laser beam enables use of a relatively weak laser beam without danger of error from ambient light.

1-13. The Power Supply Unit is a portable instrument designed for operation from 110/115 volt 60Hz AC, single phase source or optional 220V 50Hz. All electrical connections are made at the rear of the unit. A power fuse on the rear panel protects against overload. Laser tube current is indicated on a front panel meter. The front panel also contains a power switch and access holes through which operating adjustment controls are accessible. All solid state construction is used to ensure trouble-free operation.

71 2623
Read-Out Unit

1-14. 71 2623 Read-Out Unit. The Read-Out Unit is an electronic signal conditioner that receives and processes orientation-analogous signals from a photosensitive Quad Cell Detector Target positioned in the laser beam path or, for auto-collimation applications only, from the internal bi-cell detector target in the Laser Instrument. It contains two digital displays, one indicating horizontal displacement left or right, and the other indicating vertical displacement down or up. Both displays are calibrated to indicate displacement directly in inches; resolution is 0.001 inch and range is linear to ±0.050 inch. The ratio of unbalanced electrical currents from the target causes the appropriate digital readout to indicate both the amount and the direction of displacement of the laser beam from the center of the target. When the laser beam is centered precisely on the target, both digital displays indicate zero. The direction of displacement is indicated by the presence or absence of a minus (-) sign on the digital displays. The positive directions are upward and to the left. Up to four Quad Cell Detector Targets can be connected to one Read-Out Unit. Front-panel push-switches enable selection of each of the four targets for separate readout.

1-15. The Read-Out Unit is housed in a portable steel cabinet, and operates from a 110/115 volt AC, single phase power source. All electrical connections are made at the rear of the cabinet. The rear panel also contains the power fuse. All operating controls and the digital displays are conveniently grouped on the front panel. Operating adjustment controls are accessible through access holes in the front panel. Solid-state construction is used throughout for optimal reliability.

71 2627
Quad Cell Detector Target

1-16. 71 2627 Pig Tail Quad Cell Detector Target. The Quad Cell Detector Target contains a circular photoelectric cell that is divided into four equal quadrants. Each quadrant emits an electric current that is proportional to the amount of laser light falling upon it. Movement of the laser beam from the center of the target results in unbalanced currents from the quadrants. These currents are supplied to the Read-Out Unit to produce the displacement indications on the digital displays on that unit.

1-17. The Quad Cell Detector Target is designed to fit standard K&E optical alignment hardware. It contains a 9-inch pigtail for connection to the Read-Out Unit interconnecting cable. The interconnecting cable can be positioned either to the front or to the rear to facilitate mounting.

71 2656
Calibration Plate

1-18. 71 2656 Calibration Plate. The Calibration Plate provides means for calibrating the Read-Out Unit for alignment applications. It is a circular plate that is designed for fitting to the surface of a Quad Cell Detector Target. When it is installed on the target, the Calibration Plate introduces a linear displacement of the laser beam equal to the value engraved on the plate.

71 2662
Laser Beam Finder Screen

1-19. 71 2662 Laser Beam Finder Screen. The Laser Beam Finder Screen is designed to facilitate autocollimation. It fits over the objective end of the Laser Instrument and aids the operator in guiding the reflected laser beam into the center of the Laser Instrument objective lens.

71 2660
Calibration Wedge

1-20. 71 2660 Calibration Wedge. The Calibration Wedge is used to calibrate the Read-Out Unit for autocollimation applications. When placed on the objective end of the Laser instrument, it introduces a 5 second (nominal) angular displacement of the reflected laser beam.

1-21. INSTRUMENT SPECIFICATIONS

Specifications for the main system components are shown in Table 1-1.

TABLE 1-1. ALIGNMENT/AUTO-COLLIMATING LASER SYSTEM SPECIFICATIONS

Characteristic	Specifications
LASER INSTRUMENT:	
Construction	Fully closed, tool steel, chrome plated, Rockwell C55 hardness
Operating Range	0 to 300 feet for alignment applications: 0 to 150 feet for auto-collimation applications
Laser Output Power	Uniphase output, 0.7 milliwatts maximum, TEMoo mode; stable to within 10% over 4 hour period
Modulation	Nominal 30% amplitude modulation at 10kHz
Light Source	Helium-neon laser, 632.8 nm
Laser Beam Diameter: Auto-collimation Laser	11±2 mm at 0 foot; 14±2 mm at 300 feet
Laser Beam Centering	Centered to within ±0.001 inch relative to mechanical axis of Laser Instrument
Laser Beam Direction	Laser beam axis parallel to mechanical axis of Laser Instrument within ±4 arc seconds
Spatial Filter	Internal spatial filter within Laser Instrument to enhance beam uniformity and sharpness
Laser Beam Stability	Less than ±0.0005 inch drift during 1 hour period in 2 foot enclosed air path
Warm-up Time	60 minutes from cold start, none thereafter. Instruments must be at ambient temperature for 24 hours
Auto-Collimator: Type	Auto-collimating, as opposed to autoreflecting; angular alignment readings relatively insensitive to auto-collimating distance; internal auto-collimating sensing unit wholly within Laser Instrument at focal plane of objective lens
Range	Null reading over operational range of 0 to 150 feet
Auto-Collimation Axis	Angular alignment of auto-collimation axis parallel to within ±2 seconds of mechanical axis of laser instrument
Outside Diameter	NAS standard 2.2498 inches +0.0000/-0.0003 inch per foot
Overall Length	18½ inches
Weight	9 pounds 12 ounces

TABLE 1-1. ALIGNMENT/AUTO-COLLIMATING LASER SYSTEM SPECIFICATIONS (continued)

Characteristic	Specifications
POWER SUPPLY UNIT:	
Input Power	110/115 volts AC, single phase or 220 volts 50Hz
Output to Laser Tube	Approximately 1200 volts DC, 4 to 5 milliampers, modulated 25% by 10 kHz square wave
Overall Dimensions	10 x 8 x 8 inches
Weight	12 pounds
Connection	Coaxial cable from Power Supply Unit to Laser Instrument
READ-OUT UNIT:	
Displays	Two four-digit digital displays; one displays lateral displacement, left and right, other displays vertical displacement, down and up; direct reading in inches
Range	Full Range approximately -0.1 to +0.1 inch vertical or horizontal displacement from zero null in alignment mode. Range will be linear up to ±0.050 inches.
Cross Coupling	When detector target is displaced either horizontally or vertically in relation to laser beam axis, remaining axis reading changes less than 2% of first axis
Connections	Terminals provided at rear panel for up to four Quad-Cell Detector Targets; output jacks on rear panel for connecting strip-chart recorder or servo-controlled device
Output Voltage	With 600 ohm output impedance, 30 millivolts per 0.001 inch digital display indication, relative to ground
Automatic Gain Control	Maintains display stability with power variations up to ±80%, modulation variations up to ±60%, laser beam diameter variations up to ±15%.
Dimensions	10 x 8 x 8 inches
Weight	6 pounds 4 ounces
QUAD CELL DETECTOR TARGET:	
Construction	Tool steel, chrome plated, C55 Rockwell hardness; dust cap and hood provided for mechanical protection of target
Alignment	Sensing element axis electrically concentric with outside diameter of detector target within ±0.001; center lies in plane 1.000 ±0.003 inch in front of rear indexing surface
Sensitivity	Photoelectric sensors detect displacement of laser beam to within ±0.001 inch
Outside Diameter	NAS standard 2.2498 +0.0000/-0.0005 inches

TABLE 1-1. ALIGNMENT/AUTO-COLLIMATING LASER SYSTEM SPECIFICATIONS (continued)

Characteristic	Specifications
QUAD-CELL DETECTOR TARGET:	
Overall Length	1⅛ inches
Weight	1 pound 4 ounces

1-22. PERIPHERAL EQUIPMENT

The 71 2623 Read-Out Unit has auxiliary output jacks and connectors which allow it to be utilized with a variety of recorders, printers and servo-controlled equipment.

1-23. Chart Recorders. A jack is available at the rear of the Read-Out Unit for connection of vertical and horizontal display data to a chart recorder or servo control mechanism. This data can be used to produce a permanent record of laser alignment operations or to control a servo mechanism that positions the work piece automatically. The Leeds and Northrup Speedomax Chart Recorder is typical of commercial chart recorders that may be used.

1-24. Printers and Remote Displays. Isolated, buffered data is available in unlatched-parallel BCD format for a minimum of 100 milliseconds of every conversion cycle at a BCD data output jack at the rear of the Read-Out Unit. During conversion this data is unreadable, reflecting the changing status of the internal counters. At the end of conversion, while the converter is in its auto-zero phase, counting ceases and data is stable and ready to read. Data ready is signaled by the zero state of print command PC.

1-25. Peripheral equipment, such as remote displays or printers, which require that the input data be stable for longer periods than 100 milliseconds, can hold the data as long as necessary. Several options are available to effect this:

1. **External Latch.** When the print command goes to logic zero, the negative transition of the print command can be used to initiate transfer of the BCD data to external storage registers. This is particularly useful in developing a non-blinking remote display.

2. **Hold After Print Command.** In printer applications, a logic zero busy signal can be generated by the printer and applied to the Read-Out Unit as a hold command after receipt of a print command signal. The conversion process will be halted and previous data will be held until print-out is completed and the printer busy signal is removed. The printer should generate the busy signal within 1 millisecond of receipt of a print command.

3. **Hold Before Print Command.** If a hold command is not generated automatically by the peripheral equipment, the converter hold may be switched to ground manually; however, transfer of data to the peripheral equipment must be synchronized by the print command to avoid transfer of data before conversion is complete. The hold command may be released manually after data transfer has been completed.

4. **Start/Hold and Remote/Hold.** Two independent hold lines are available, thereby making possible two alternate modes of operation. If remote/hold is connected to the busy terminal of a printer and start/hold is connected to a manual switch, the printer can be operated in either a one-shot or a free-running mode. For example: start/hold can be left at a logic one level to permit the converter to free-run. The busy signal of the printer, connected to remote /hold, will slow down and extend the duration of the auto-zero phase of the converter until printing has been completed. Conversion and printing will be continuous, but at a slow rate. Alternately, if data is not changing rapidly, printer paper can be conserved by using the start/hold signal to operate the converter in a one-shot mode. The converter and printer will both be inactive between conversions while start/hold is at logic zero. A momentary release of start/hold to a logic one level will produce one conversion and an indefinite hold. Remote/hold need not be used in this application.

A detailed description of the Read-Out Unit input and output circuitry is provided in Section 3 of this manual.

SECTION 2 — OPERATION

WARNING

To protect against accidental injury during use of the Alignment/Auto-Collimating Laser, always observe all operating precautions listed in the front of this manual.

2-1. UNPACKING AND INSPECTION

Unpack the Alignment/Auto-Collimating Laser and accessories carefully from the shipping containers. Check to make sure that all ordered components have been received. Inspect the equipment visually for any signs of damage that may have occured in shipment. Inspect especially all glass items for scratching, breakage, and dirt.

2-2. CONTROLS, INDICATORS, AND CONNECTORS

Figures 2-1 through 2-3 show the controls, indicators, and connectors used during operation of the Alignment/ Auto-Collimating Laser. The functions of the controls, indicators, and connectors are listed in Table 2-1.

"Caution — use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure."

TABLE 2-1. CONTROLS, INDICATORS, AND CONNECTORS

Fig. & Index No.	Nomenclature	Function
LASER INSTRUMENT		
2-1, 1	Power connector	Provides means for connecting Power Supply Unit output voltage to laser tube.
2-1, 2	Read-Out Unit connector	Provides means for connecting internal target output signals to Read-Out Unit for auto-collimating applications.

Figure 2-1. Laser Instrument Connectors

TABLE 2-1. CONTROLS, INDICATORS, AND CONNECTORS (continued)

Fig. & Index No.	Nomenclature	Function
POWER SUPPLY UNIT		
2-2, 1	D.C. MILLIAMPERES meter	Indicates current input to laser tube in Laser Instrument.
2-2, 2	POWER ON indicator	When lighted, indicates input of AC power to Power Supply Unit.
2-2, 3	ON/OFF switch	Used to turn Power Supply Unit on and off.
2-2, 4	CURRENT ADJUST control (recessed)	Provides means for adjustment of current supplied to laser tube in Laser Instrument; clockwise rotation increases current.
2-2, 5	MODULATION ADJUST control (recessed)	Provides means for adjustment of modulation level applied to laser tube in Laser Instrument; clockwise rotation increases modulation.
2-3, 8	Output power cord	Provides means for connecting output power of Power Supply Unit to Laser Instrument.
2-2, 7	Power fuse	Protects against electrical overload (½ ampere, 250 volt fuse).
2-2, 6	Line cord	Used to connect Power Supply Unit to 110 volt, 60 Hz AC outlet.

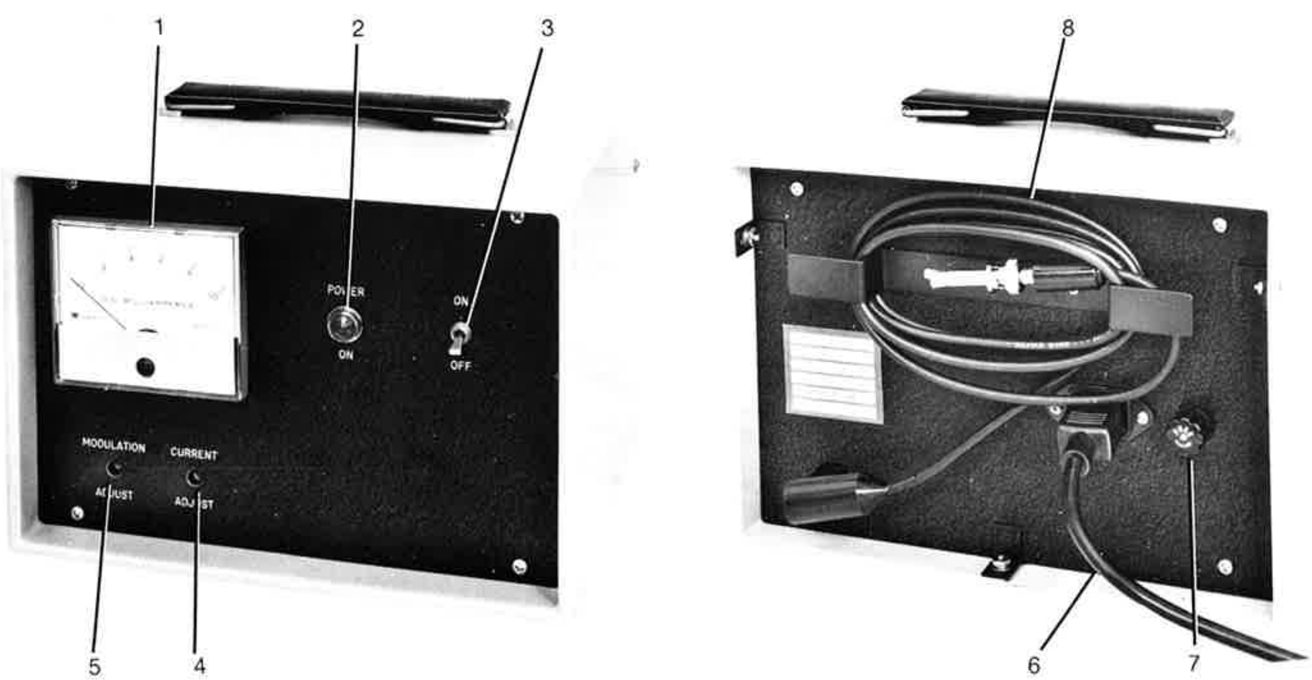


Figure 2-2. Power Supply Unit Controls, Indicators, and Connectors

TABLE 2-1. CONTROLS, INDICATORS, AND CONNECTORS (continued)

Fig. & Index No.	Nomenclature	Function
READ-OUT UNIT		
2-3, 1	+LEFT/-RIGHT display	Indicates horizontal displacement of laser beam from center of Quad Cell Detector Target. Minus (-) sign indicates displacement to right from center. Range is approximately -0.050 to +0.050 inch for alignment applications and approximately -5 to +5 arc seconds for auto-collimating applications. The range for auto-collimating applications will be displayed as -0.005 to +0.005.
2-3, 2	+UP/-DOWN display	Indicates vertical displacement of laser beam from center of Quad Cell Detector Target. Minus sign (-) indicates displacement down from center. Range is approximately -0.050 to +0.050 inch for alignment applications, and approximately -5 to +5 arc seconds for auto-collimating applications. The range for auto-collimating applications will be displayed as -0.005 to +0.005.
2-3, 3	SIGNAL indicator	When lighted, indicates that laser beam striking Quad Cell Detector Target is sufficiently modulated to produce reliable readout signals.
2-3, 4	VERTICAL AC and AL adjustment controls (recessed)	Used in auto-collimating and alignment modes, respectively, to calibrate +UP/-DOWN display with known laser beam displacement at Laser Instrument internal target or Quad Cell Detector Target.

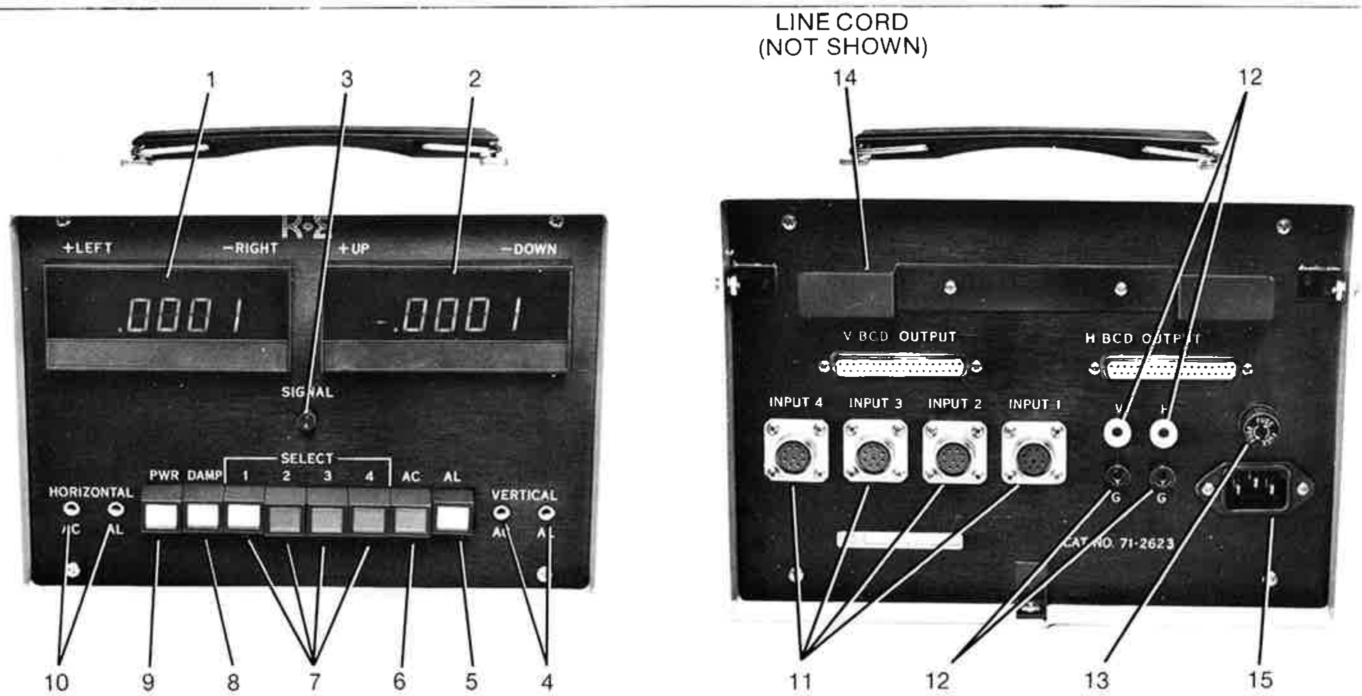


Figure 2-3. Read-Out Unit Controls, Indicators, and Connectors

TABLE 2-1. CONTROLS, INDICATORS, AND CONNECTORS (continued)

Fig. & Index No.	Nomenclature	Function
READ-OUT UNIT (continued)		
2-3, 5	AL pushbutton switch	When pressed, selects alignment mode of operation; displays indicate linear displacement of laser beam from center of Quad Cell Detector Target in inches.
2-3, 6	AC pushbutton switch	When pressed, selects auto-collimating mode of operation; displays indicate angular deflection of laser beam from center of Laser Instrument internal target in arc seconds.
2-3, 7	SELECT pushbutton switches	Enable user to select signals from any one of up to four Quad Cell Detector Targets for processing and display; numbering of switches corresponds to numbering of rear panel input connectors to which Quad Cell Detector Targets are connected.
2-3, 8	DAMP pushbutton switch	When pressed, introduces damping circuit for greater stability on long shots in unstable conditions.
2-3, 9	PWR pushbutton switch	Used to turn Read-Out Unit on and off.
2-3, 10	HORIZONTAL AC and AL adjustment controls (recessed)	Used in auto-collimating and alignment modes, respectively, to calibrate +LEFT/-RIGHT display with known laser beam displacement at Laser Instrument internal target or Quad Cell Detector Target.
2-3, 11	INPUT 1, INPUT 2, INPUT 3, and INPUT 4 connectors	Provide means for connecting up to four Quad Cell Detector Targets to Read-Out Unit.
2-3, 12	V, H, G, and G jacks	Provide means for connecting displacement signals to peripheral chart recorder or serve control mechanism; V designates vertical signal, H designates horizontal signal and G designates ground.
2-3, 13	Power fuse	For electrical overload protection. (⅛ ampere, 250 volt slow-blow fuse).
2-3, 14	Line cord	Used to connect Read-Out Unit to 110 volt, 60 Hz AC outlet.
2-3, 15	Output jack	Provide means for connection of displacement data to peripheral printer or remote display.

NOTE

The laser should be operated overnight (approximately 16 to 20 hours) once a month if it has been stored and non-operative. This will extend its shelf life.

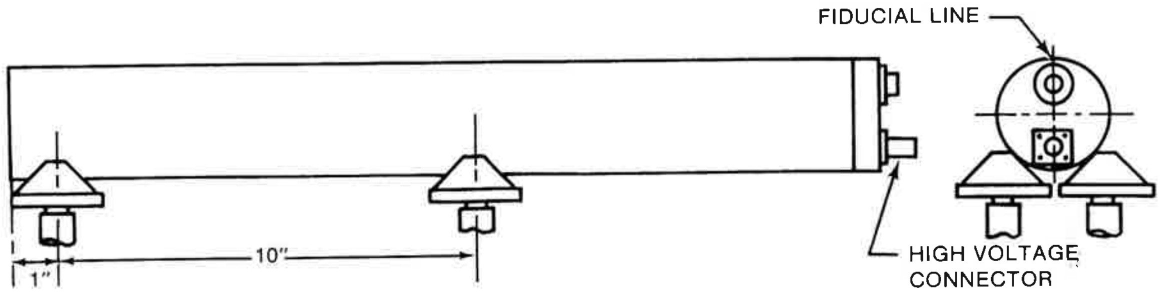


Figure 2-4. Recommended Positioning of Laser Instrument Supports

2-3. EQUIPMENT MOUNTING

2-4. Laser Instrument. Several K&E mounting brackets specifically designed for mounting of optical alignment equipment can be used to support the Laser Instrument. These include:

71 5170 Alignment Telescope Bracket with Cup Mount and Sphere

71 5191 T-Slotted Base Plate plus two 71 5192 V-Block Cone Assemblies

Set the Laser Instrument firmly onto the selected bracket. Figure 2-4 shows the recommended support positioning. Position the Laser Instrument so that it points approximately along the desired line of sight.

2-5. Quad Cell Detector Target. To mount the Quad Cell Detector Target, use the 71 5103 Spherical Adapter (without collet) with the 71 5140 Adjustable Cup Mount and 71 5142 Clamp. Clamp the spherical adapter on the adjustable cup mount using the clamp.

NOTE: The integral pig-tail cable normally exits from the rear of the Quad Cell Detector Target; however, when mounting restrictions so dictate, the cable can be brought out at the front of the target through the slot provided in the Quad Cell Detector Target housing. Proper orientation of the cable must be determined before the Quad Cell Detector Target is mounted in the spherical adapter.

2-6. Insert the Quad Cell Detector Target carefully into the Spherical Adapter. Make sure that the Quad Cell Detector Target is inserted all the way into the Spherical Adapter so that the rear shoulder plate of the Quad Cell Detector Target presses firmly against the rear surface of the Spherical Adapter. The plane of the sensing element of the Quad Cell Detector Target will then be within ±0.003 inch of the vertical plane of rotation of the Spherical Adapter.

2-7. Rotate the Quad Cell Detector Target in the Spherical Adapter so that the red registration line at the front of the Quad Cell Detector Target housing points straight up. This orientation will ensure proper registration of the four quad cell segments with respect to the horizontal and vertical axes. When the Quad Cell Detector Target is oriented properly, the scribed lines separating the four segments will be in the form of an ⊗, not a ⊕.

2-8. Read-Out and Power Supply Units. The Read-Out Unit and the Power Supply Unit are free-standing units that can be positioned as required for best operating convenience. The only positioning restrictions are those imposed by the lengths of the power cords and the interconnecting cables.

2-9. ELECTRICAL CONNECTIONS

WARNING

Before connecting or disconnecting the Power Supply Unit to Laser Instrument Interconnecting Cable, always make sure that the Power Supply Unit ON/OFF switch is set to the OFF position and/or the Power Supply Unit line cord is disconnected from the AC power outlet.

2-10. Power Supply Unit to Laser Instrument. Plug one end of the Interconnecting Cable into the twist-lock bayonet connector on the rear end cap of the Laser instrument.

2-11. Quad Cell Detector Target to Read-Out Unit (Alignment Applications Only). Connect one end of the Interconnecting Cable to the connector on the pig-tail of the Quad Cell Detector Target. Connect the other end of the Interconnecting Cable to one of the INPUT connectors at the rear of the Read-Out Unit. Note the number of the INPUT connector to which the cable is connected; the correspondingly numbered SELECTOR switch on the front panel of the Read-Out Unit must be actuated to obtain a reading from that Quad Cell Detector Target. For example: if a Quad Cell Detector Target is connected to the INPUT 2 connector, the SELECT 2 pushbutton switch must be presed in order to obtain a reading on the Read-Out Unit from that Quad Cell Detector Target.

2-12. Laser Instrument to Read-Out Unit (Auto-Collimating Applications Only.) Connect one end of the Interconnecting Cable to one of the INPUT connectors at the rear of the Read-Out Unit. Note the number of the INPUT connector to which the cable is connected; the correspondingly numbered SELECT switch on the front panel of the Read-Out Unit must be actuated to obtain a reading from the Laser Instrument target.

2-13. Read-Out Unit to Recorder (Optional). If a strip-chart recording of readings is desired, connect one input channel of the strip-chart recorder to the V and corresponding G jacks at the rear of the Read-Out Unit, and connect the second input channel of the strip-chart recorder to the H and corresponding G jacks.

2-14. Read-Out Unit to Printer (Optional). If a hard-copy printout of readings is desired, horizontal and vertical displacement data are available in BCD format at connectors J6 and J9, respectively, of the Read-Out unit for application to a peripheral printer. A description of the protocol is provided in Section 1. The exact connections to be established are dictated by the printer input characteristics. Table 2-2 lists the application of each pin of the output connectors.

2-15. AC Power Connections. Connect the line cords of the Power Supply Unit and the Read-Out Unit to 110 volt, 60 Hz AC power outlets. Wherever possible, connect the line cords to 3-terminal (grounded) AC power outlets. If only 2-terminal power outlets are available, use a 3-prong to 2-prong adapter to eliminate a potential shock hazard to the user; connect the ground wire of the adapter to a good electrical ground at the AC power outlet.

TABLE 2-2. READ-OUT UNIT BCD OUTPUT CONNECTOR STRUCTURE

Pin No.	Use
1	Digital common
2	Decimal point 2 (X.XXX)
3	Decimal point 3 (XX.XX)
4	Decimal point 4 (XXX.X)
5-9	Not used
10	+polarity
11	8000
12	4000
13	800
14	400
15	80
16	40
17	8
18	Digital common (isolated)
19	4
20	Blanking
21	Start/hold
22	Remote/hold
23-27	Not used
28	10,000
29	2000
30	1000
31	200
32	PC (print command)
33	100
34	20
35	10
36	2
37	1

2-16. STARTING PROCEDURE

After mounting the components of the Alignment/Auto-Collimating Laser and making the required electrical interconnections, proceed as follows to energize the system:

WARNING

Do not look directly into the laser beam; to do so may be injurious to the eye.

1. Select the desired mode of operation by pressing the AL (alignment mode) or AC (auto-collimating mode) pushbutton switch on the front panel of the Read-Out Unit.

2. Press the Read-Out Unit SELECT switch whose number corresponds to the number of the INPUT connector to which the Quad Cell Detector Target is connected. For example: if

it is desired to obtain a reading from a Target connected to the INPUT 3 connector at the rear of the Read-Out Unit, press the SELECT 3 push-button switch.

3. Press the PWR pushbutton switch on the Read-Out Unit.

4. Set the ON/OFF switch on the front panel of the Power Supply Unit to the ON position. Check to see that the POWER ON indicator light on the Power Supply Unit lights.

5. The laser tube in the Laser Instrument should ignite and project a red laser beam within 60 seconds. The D.C. MILLIAMPERES meter on the Power Supply Unit should indicate 4.0 to 5.0 milliamperes. If the laser tube fails to ignite within 60 seconds, adjust the Power Supply Unit MODULATION ADJUST control counterclockwise slightly with a screwdriver until a red laser beam is projected by the Laser Instrument.

6. If the system has been turned on from a cold start, allow a 60 minute stabilization period before proceeding with operation. Once the system has warmed up, no further stabilization time is required upon restarting. The system should be at ambient temperature for 24 hours prior to being turned on. Nor should the instrument be removed from the position shown in Figure 2-4.

2-17. LASER ALIGNMENT PROCEDURES

2-18. General. Alignment procedures will vary, depending upon the particular work requirements. Either the laser beam or a Quad Cell Detector Target may serve as a work reference. If the laser beam is established as a reference line, the mount or work piece containing the Quad Cell Detector Target is adjusted so that the center of the target is coincident with the center of the laser beam. If the Quad Cell Detector Target is used to establish a reference line, the laser beam is centered on the target by adjusting the position of the Laser Instrument mount. Two or more detector targets may be aligned along the same reference line. The auto-collimating capability of the system may be used to position a mirror perpendicular to the reference line. General procedures for each of these applications are provided in the following paragraphs.

2-19. To Use the Laser Beam As the Reference Line. To align a Quad Cell Detector Target to a reference line established by the laser beam, proceed as follows:

1. Turn on the system in accordance with the instructions in the "STARTING PROCEDURE" paragraph.

2. Press the AL pushbutton switch on the Read-Out Unit.

3. With the dust cover mounted over the sensing element of the Quad Cell Detector Target, prealign the Quad Cell Detector Target by visually sighting the laser beam position on the dust cover. The dust cover has an engraved ⅜ inch diameter circle which serves as a reflective visual target for prealignment.

4. When the Quad Cell Detector Target has been adjusted so that the laser beam is centered in the engraved circle on the dust cover, remove the dust cover from the Quad Cell Detector Target. The displays on the Read-Out Unit will now indicate the direction and amount of adjustment required in the Quad Cell Detector Target position.

NOTE: When properly calibrated, the Read-Out Unit displays will indicate displacement when the laser beam falls approximately 0.001 inch or more from the center of the target, but not totally outside the target. As the Quad Cell Detector Target is adjusted so that the laser beam approaches the center of the target, the indication on the appropriate Read-Out Unit display will begin to move toward zero.

5. Using a micrometer stage or equivalent, adjust the Quad Cell Detector Target in the horizontal plane as required to produce a zero reading on the +LEFT/−RIGHT display on the Read-Out Unit.

6. Using a micrometer stage or equivalent, adjust the Quad Cell Detector Target in the vertical plane as required to produce a zero reading on the +UP/−DOWN display on the Read-Out Unit.

7. When both displays on the Read-Out Unit indicate zero, the center of the laser beam is precisely coincident with the center of the Quad Cell Detector Target, and the Laser Instrument and the Quad Cell Detector Target are aligned within ±0.001 inch.

2-20. To Use the Quad Cell Detector Target As A Reference. To align the Laser Instrument with a Quad Cell Detector Target that has been established as a reference, proceed as follows:

1. Turn on the system in accordance with the instructions in the "STARTING PROCEDURE" paragraph.

2. Press the AL pushbutton switch on the sensing element of the Quad Cell Detector Target, adjust the position of the Laser Instrument as required to center the laser beam on the engraved 3/8-inch diameter circle on the dust cover.

4. When the laser beam has been centered on the Quad Cell Detector Target dust cover, remove the dust cover carefully. The displays on the Read-Out Unit will now indicate the direction and amount of displacement of the laser beam from the center of the Quad Cell Detector Target.

5. Adjust the laser instrument mount in the horizontal plane as required to produce a zero indication on the +LEFT/-RIGHT display on the Read-Out Unit.

6. Adjust the Laser Instrument mount in the vertical plane as required to produce a zero indication on the +UP/-DOWN display on the Read-Out Unit.

7. When both displays on the Read-Out Unit indicate zero, the center of the laser beam is precisely coincident with the center of the Quad Cell Detector Target, and the Laser Instrument has been aligned with the Quad Cell Detector Target within ± 0.001 inch.

2-21. To Align Multiple Quad Cell Detector Targets On the Same Laser Beam Reference Line. Up to four separate Quad Cell Detector Targets may be aligned along the same reference laser beam. The procedure is as follows:

1. Connect the first (nearest) Quad Cell Detector Target to the INPUT 1 connector on the Read-Out Unit, the second to the INPUT 2 connector, the third to the INPUT 3 connector, and the fourth (farthest) to the INPUT 4 connector.

2. Press the SELECT 1 pushbutton switch on the Read-Out Unit and align the nearest Quad Cell Detector Target in accordance with the procedure in the "To Use the Laser Beam As the Reference Line" paragraph.

3. When the first Quad Cell Detector Target has been aligned, remove it carefully from its mount so that the laser beam can project to the next Quad Cell Detector Target.

4. Press the SELECT 2 pushbutton switch on the Read-Out Unit and align the second Quad Cell Detector Target. When it has been aligned, remove it carefully from its mount.

5. Press the SELECT 3 pushbutton switch on the Read-Out Unit and align the third Quad Cell Detector Target. When the third Quad Cell Detector Target has been aligned, remove it carefully from its mount.

6. Press the SELECT 4 pushbutton switch on the Read-Out Unit and align the fourth Quad Cell Detector Target.

NOTE: In some cases, it may be more convenient to reverse the preceding procedure, installing and aligning each Quad Cell Detector Target in turn, beginning with the farthest. If this procedure is used, it is unnecessary to remove the Quad Cell Detector Targets after they are aligned.

NOTE: Alignment of multiple detector targets can be accomplished even more conveniently if accessory 71 2629 See-Through Detector Targets are used. When these targets are used, the complete alignment procedure can be completed without removing detector targets. It is easy to check back and forth between stations without removing targets, and the position of each detector target relative to a reference detector target may be monitored conveniently.

2-22. To Auto-Collimate. To set a mirror perpendicular to the laser beam, proceed as follows:

1. Mount the Laser Instrument in a suitable bracket. Rotate the Laser Instrument in its bracket so that the detent for the optical square and the register mark engraved on the rear of the Laser Instrument barrel both point directly upward. This position orients the internal target so that the displays on the Read-Out Unit will indicate horizontal and vertical angular deviations properly.

2. Install the 71 2662 Laser Beam Finder Screen on the front of the Laser Instrument

3. Place a mirror at the desired position in a mount or on the work piece.

4. Connect an Interconnecting Cable between the detector connector at the rear of the Laser Instrument and the INPUT 1 connector at the rear of the Read-Out Unit.

5. Turn on the system in accordance with the instructions in the "STARTING PROCEDURE" paragraph.

6. Press the SELECT 1 and AC pushbuttons on the Read-Out Unit.

7. Adjust the mirror and/or work piece so that the laser beam is reflected back onto the white reflective surface of the Laser Beam Finder Screen.

8. Steer the reflected laser beam visually into the center hole of the Laser Beam Finder Screen by adjusting the mirror and/or work piece. When the returned beam enters the center hole of the Laser Beam Finder Screen, displacement signals are developed by the internal target in the Laser Instrument.

9. Adjust the mirror and/or work piece in the horizontal plane as required to produce a zero reading on the +LEFT/-RIGHT display on the Read-Out Unit.

10. Adjust the mirror and/or work piece in the vertical plane as required to produce a zero reading on the +UP/-DOWN display on the Read-Out Unit.

11. When both displays on the Read-Out Unit indicate zero, the mirror surface is perpendicular to the reference line established by the laser beam.

SECTION 3 — MAINTENANCE

3-1. THEORY OF OPERATION

3-2. System Block Diagram. The Alignment/Auto-Collimating Laser System can be used for both alignment and auto-collimating applications. Figure 3-1 shows the system arrangement for each of the two applications.

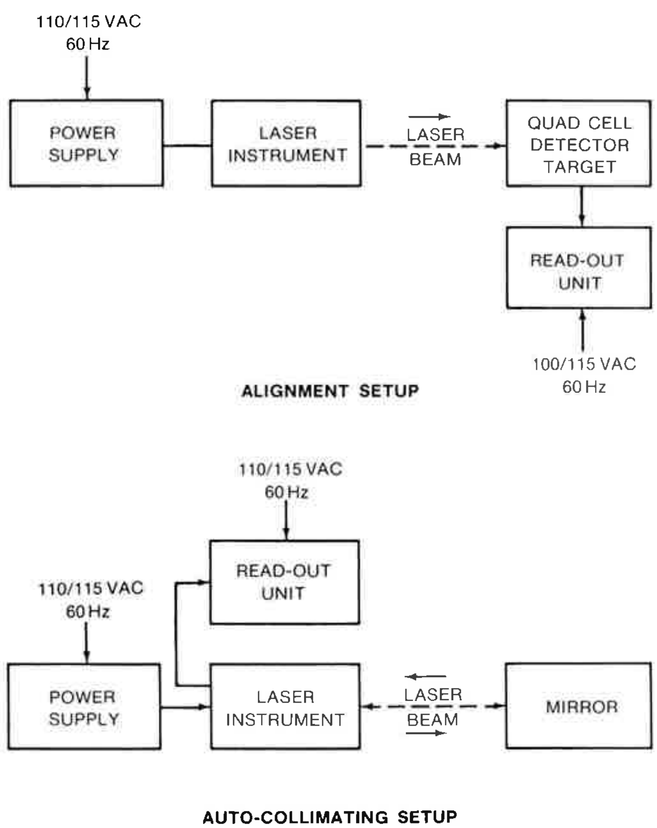


Figure 3-1. System Block Diagram

3-3. The Laser Instrument projects a low power (under .70 milliwatt) coherent light beam along an optically straight path to establish a reference line of sight. Modulation of the laser light beam at 10 kHz nullifies the effects of continuous ambient light or stray light that may strike the Quad Cell Detector Target. In alignment applications, a Quad Cell Detector Target, mounted in a suitable mount or on the work piece, is aligned with the reference line of sight. The Quad Cell Detector Target consists of four segments, each of which generate an electric current in proportion to the laser light falling upon it. The currents generated by the Quad Cell Detector Target are supplied to the Read-Out Unit, which processes the applied currents and provides direct digital readouts of the linear displacement of the center of the Quad Cell Detector Target from the center of the reference laser beam. The Read-Out Unit responds only to signals modulated at 10 kHz, thereby rejecting currents produced by ambient or stray light. Variations in displayed values due to laser power or modulation variations are eliminated by an automatic gain control feature in the Read-Out Unit. Voltages proportional to displayed horizontal and vertical displacement values are available from the Read-Out Unit for application to a peripheral strip-chart recorder, servo control device, and/or printer. Ignition and operating voltages for the Laser Instrument are provided by the Power Supply Unit.

3-4. Laser Instrument. The laser (Figure 3-2) consists of two basic sections — a resonant cavity and an active medium within that cavity. The resonant cavity consists of a pair of mirrors integral to the Laser Instrument barrel, and the active medium is a low-power plasma tube filled with helium-neon gas. The plasma tube contains two filamentary cathodes, a high-voltage anode, and a narrow capillary tube through which the electrical discharge takes place. Brewster angle windows at the ends of the plasma tube provide maximum transmission with minimum wavefront deformation. The reflectivity of the coated mirrors is very high — better than 99 percent. To couple out some light, the forward mirror is corrected to provide an output collimated to the diffraction limit, thereby permitting slightly more than one percent transmission.

3-5. The laser emits a small, coherent beam of light, approximately 1 millimeter in diameter, which is transmitted through an enlarging telescope at the front of the Laser Instrument. This enlarging telescope enlarges the beam to a diameter of approximately 1 centimeter. It has a positive rear lens that brings the laser beam, as it emerges from the plasma tube mirror, to a focus. At this focus, there is a spatial filter which suppresses scattered light and provides a very sharp symmetrical beam at the objective lens. The telescopic optics are coated with an anti-reflection coating; they reflect less than 0.25 percent of the energy at the resonant wavelength.

3-6. The Laser Instrument, in addition, contains an internal prism assembly and a pair of bi-cell sensors for monitoring the direction of the return beam reflected from a target mirror during auto-collimation. A "knife edge" reflector, not the bi-cell division, actually separates each field of view into two equal parts. Because the knife edges are at the focus of the return beam, the system is a true auto-collimating system rather than an auto-reflecting system. The true auto-collimating system eliminates the dependency of sensitivity on the working distance from the target mirror as in an auto-reflecting system, where sensitivity varies directly with the distance. A beam splitter in the return path of the laser beam decouples the bi-cell sensors so that they function independently in each of two planes to monitor centration of the return beam at focus. The auto-collimating prism assembly also contains a quarter-wave plate that prevents optical feedback into the laser cavity when the instrument is used for auto-collimation. If a substantial part of the return beam were to enter the laser cavity, the resonance of the cavity might be upset.

3-7. Read-Out Unit. The Read-Out Unit is an electronic signal conditioner that receives orientation analogous signals from a Quad Cell Detector Target positioned in the laser beam, or from the internal bi-cell detector target in the Laser Instrument, and displays displacement data in the horizontal and vertical planes on separate, direct-reading digital displays. The Read-Out Unit also develops analog output voltages for application to peripheral devices.

3-8. Figure 3-3 is a block diagram of the Read-Out Unit. A Quad Cell Detector Target is used as the signal source in the block diagram. The semiconductor material in each of the four quadrants of the Quad Cell Detector Target produces electrons under stimulus of the laser beam. The signals received from axially opposite quadrants of the Quad Cell Detector Target are processed by the Read-Out Unit to derive the signals that drive the front panel displays. The two displays indicate the deviation of the target center from the center of the laser beam directly in inches.

3-9. The output of each quadrant of the Quad Cell Detector Target is a DC current modulated at 10 kHz (the laser beam modulation frequency). The DC current and the 10 kHz component both vary directly with the strength of the laser beam striking the quadrant. Quadrants A and C of the Quad Cell Detector Target in Figure 3-3 are used to measure horizontal displacement, and quadrants B and D to measure vertical displacement. The output signals from the two quadrant pairs are applied to separate horizontal and vertical differential amplifiers; in addition, the output signals of all four quadrants are supplied to a sum amplifier. After amplification by the sum amplifier, the sum signal is rectified to develop a DC voltage that is proportional to the total strength of the laser beam on the complete Quad Cell Detector Target; the sum signal is also applied to a squarer which develops 10 kHz control signals for two in-phase rectifiers.

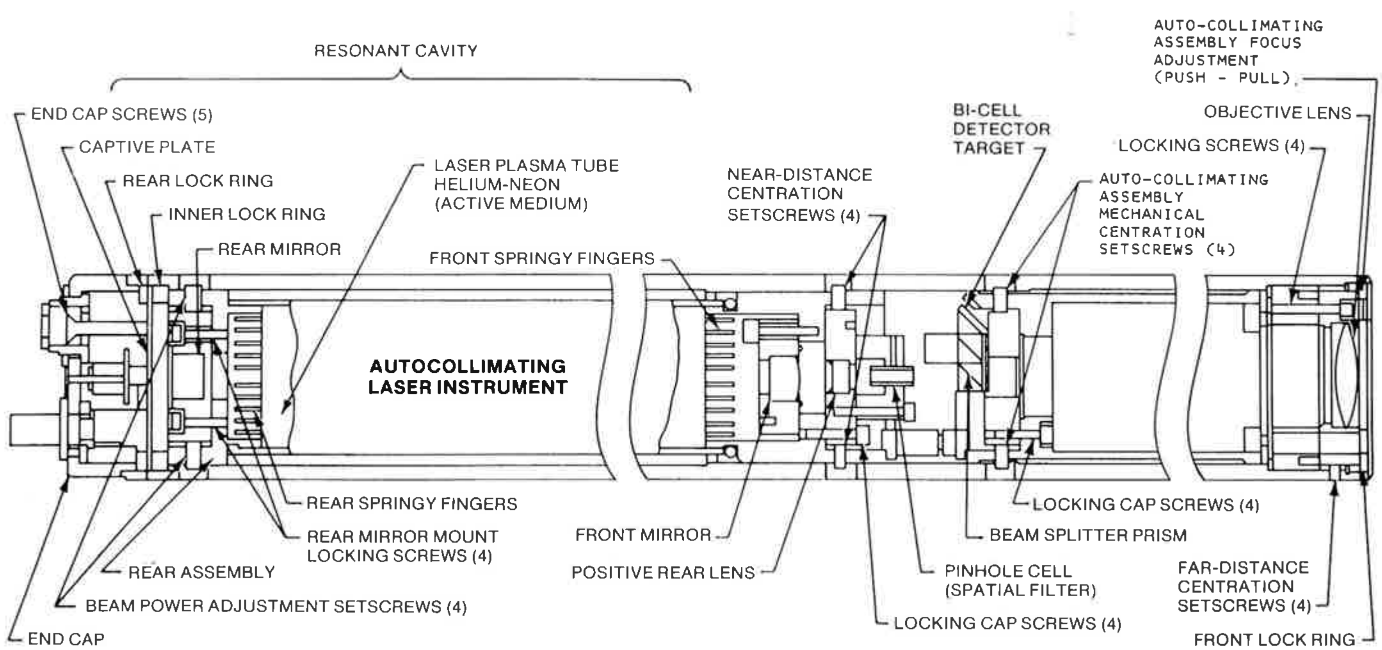


Figure 3-2. Laser Instrument, Simplified Diagram

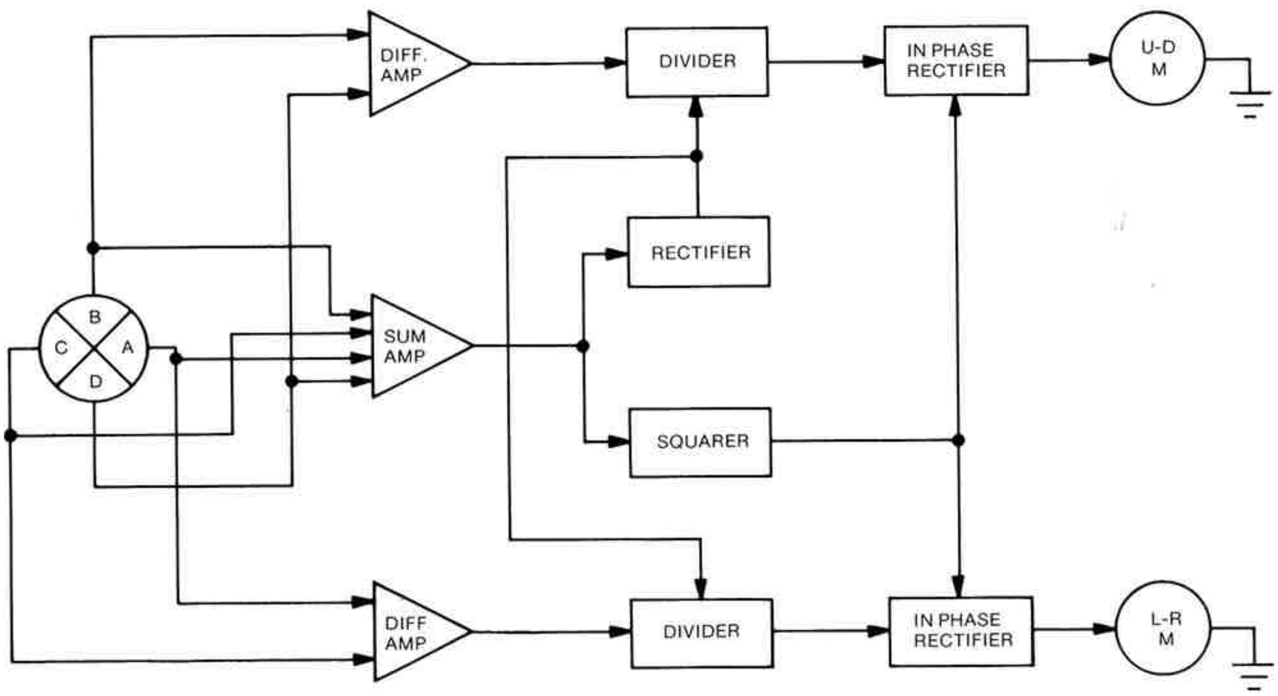


Figure 3-3. Read-Out Unit Block Diagram

3-10. The DC output of the sum rectifier is applied along with the displacement signal from the quadrant pair to a divider circuit in each channel of the Read-Out Unit. The horizontal and vertical channels are identical, and only the vertical channel is described in the following description. The divider produces an output signal with an amplitude proportional to the quotient of the two input signal levels. It is used to nullify the effects of laser beam power and modulation variations; if either of these factors changes, both the displacement signal and the sum signal change proportionally, but the quotient of the two is unaffected by the variation. The output signal of the divider, which is 10 kHz signal that is proportional to the displacement measured by the corresponding quadrant pairs, is applied to an in-phase rectifier. The in-phase rectifier operates under control of a 10 kHz square wave signal from the squarer circuit to rectify the 10 kHz displacement signal; the result is a DC voltage proportional to the displacement and with a polarity that indicates the direction of the displacement. This DC displacement voltage is applied to a self-contained display module which processes the DC input voltage to produce a direct-reading, digital display of the displacement value. The display module also contains logic circuits for interfacing and data transfer to peripheral printers.

3-11. The complete schematic diagram of the Read-Out Unit is provided by Figures 3-4 and 3-5. Figure 3-4 shows the interconnections between the major components of the Read-Out Unit, and Figure 3-5 shows the circuitry on the printed circuit board assembly. Input 110 volt, 60 Hz AC is supplied through the line cord and fuse F1 to the printed circuit board assembly. PWR switch S1 provides means for turning the AC input power on and off. Input AC is applied to power transformer T1, which has two separate primary windings that can be connected in parallel for 110 volt operation, or in series for 220 volt operation (option). Input AC power for the two display modules is derived from the 110 volt AC developed across one primary winding of transformer T1. The secondary voltages of transformer T1 are rectified by bridge rectifiers, filtered, and regulated by regulator integrated circuits to develop the + 12 volt and -12 volt regulated DC required for operation of the printed circuit board assembly circuits.

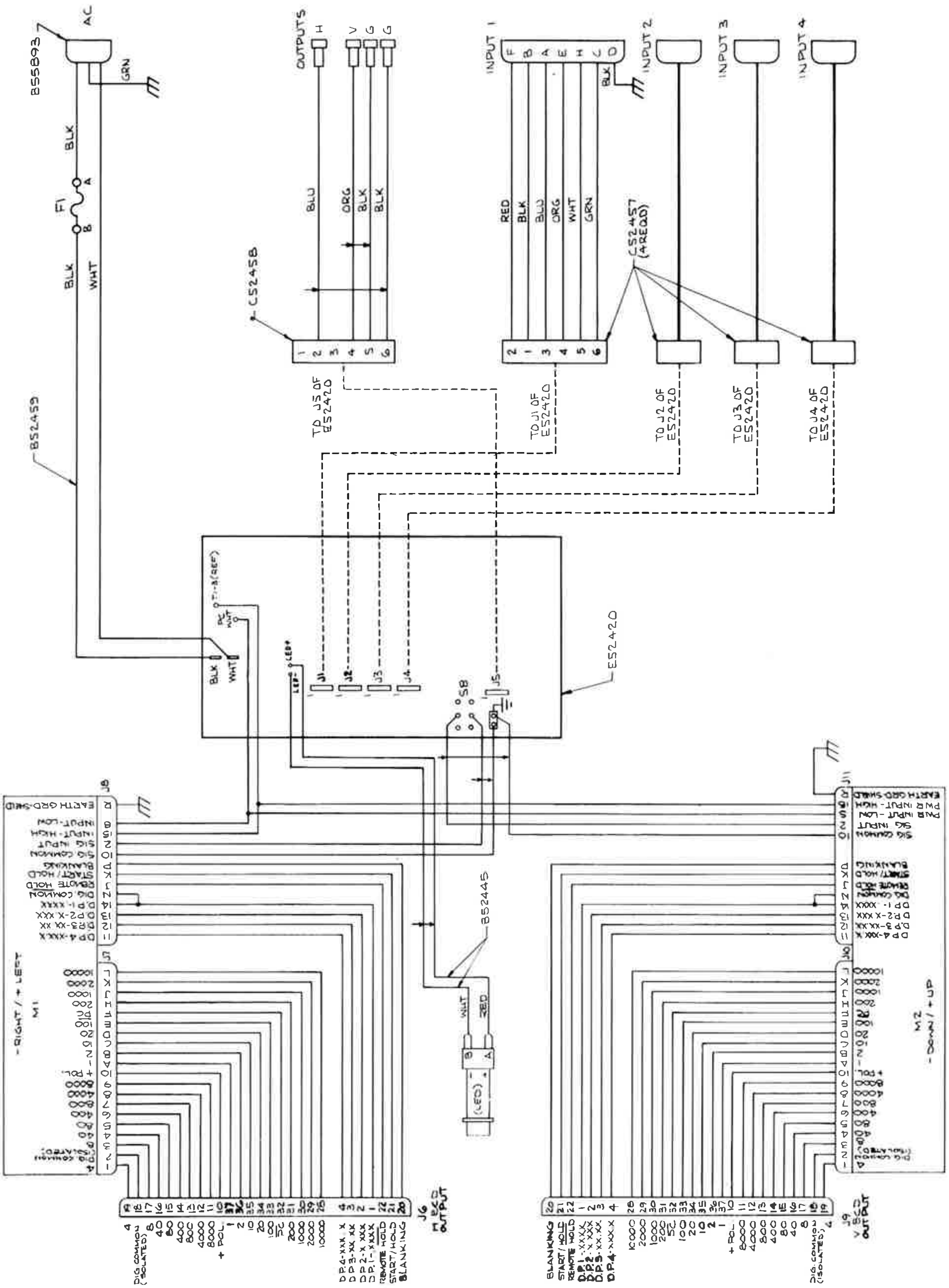


Figure 3-4. Read-Out Unit Interconnection Diagram

3-12. The Quad Cell Detector Targets connect to INPUT connectors at the rear of the Read-Out Unit. Connectors are provided for up to four Quad Cell Detector Targets. Each INPUT connector supplies input signals to one of four connectors (J1 through J4) on the printed circuit board assembly. While four Quad Cell Detector Targets may be connected, only one is selected at a time for displacement measurements. Selection of the Quad Cell Detector Target inputs is accomplished by means of SELECT 1 through SELECT 4 switches S3 through S6. The signals from the selected Quad Cell Detector Target are supplied to identical but independent vertical and horizontal channels and to a common sum channel. Because the vertical and horizontal channels are identical, only the vertical channel is described in the following paragraphs.

3-13. The 10 kHz components of the signals from the two vertical quadrants are applied through coupling capacitors to dual amplifier Q1, and the 10 kHz components of the signals from all four quadrants are applied through a summing network to differential amplifier A3-Pin-12. After amplification by amplifier Q1, the vertical signals are applied to differential amplifier A10-12, and the outputs of this differential amplifier is a 10 kHz signal with an amplitude that is proportional to the difference between the signal levels developed by the two horizontal quadrants (and, therefore, the displacement of the laser beam from the center of the detector target), and a phase dependent upon the direction of the displacement of the laser beam from the center of the detector target. Potentiometer R15 in the output circuit of amplifier A10-12 provides means for shifting the phase of the output signal slightly. The 10 kHz vertical displacement signal is applied through a 10 kHz band-pass filter to divider A11. The filter, which consists of integrated circuit A10-10 and associated circuitry, filters out any stray signals that may have been picked up by the quad cell detector target.

3-14. The 10kHz signals from all four quadrants of the Quad Cell Detector Target are summed at pin 1 of differential amplifier A3, and the summed signal is amplified and applied through a 10kHz bandpass filter, composed of integrated circuit A3-10 and associated circuitry, to rectifier A4-12 and differential amplifier A5-2. Potentiometer R40 provides means for tuning the band-pass filter. Integrated circuit A4-12 functions as a precision rectifier; its output is integrated by resistor R46 and capacitor C44 and then amplified by differential amplifier A4-10, and the resulting DC, which is proportional to the strength of the laser beam striking the entire surface of the Quad Cell Detector Target, is applied to the divider circuits in both the vertical and horizontal channels. This DC also drives Q3 if the signal strength is sufficient for reliable operation. Comparator A5-1 compares the DC level against a fixed reference level, and turns on driver Q3 only if the applied DC exceeds the reference level.

3-15. The 10 kHz sum signal developed by differential amplifier A5-2 also drives a squaring circuit that utilizes transistor Q2. The squarer circuit develops two 10 kHz square wave signals of opposite polarity, synchronized with the sum signal, for control or in-phase rectifier circuits in the vertical and horizontal channels.

3-16. Divider A11 in the vertical channel receives the 10 kHz vertical displacement signal from filter A10-10, and performs an operation that is analogous to mathematical division. If a number A is divided by a number B, a quotient C is obtained. If numbers A and B both change by the same percentage, the value of C is unaffected. This principle is used to eliminate the effects of laser beam power and modulation variations. In the divider circuit, the denominator of the division equation is the DC sum signal, and the numerator is the 10 kHz vertical displacement signal. If the laser beam strength or modulation should change for any reason, both the vertical displacement signal and the sum signal will change by the same percentage; therefore, the variation will have no effect on the output from the divider circuit. The only factor that can change the output signal amplitude is a change in the laser beam position on the Quad Cell Detector Target.

3-17. Divider A11 supplies its output signal to an in-phase rectifier, composed of integrated circuit A12-12 and analog gates A9-10 and A9-9. The output 10 kHz displacement signal of divider A11 is applied directly to gate A9-10 and through differential amplifier A12-12, which inverts the signal, to gate A9-9. Gates A9-10 and A9-9 are turned on and off alternately at a 10 kHz rate by the square wave signal from transistor Q2, effectively rectifying the applied 10 kHz displacement signal and developing a DC voltage that is proportional to the peak vertical displacement signal amplitude. The polarity of the DC is determined by the phase of the vertical displacement signal; therefore, the polarity is an indication of the direction of the displacement of the laser beam from the center of the Quad Cell Detector Target.

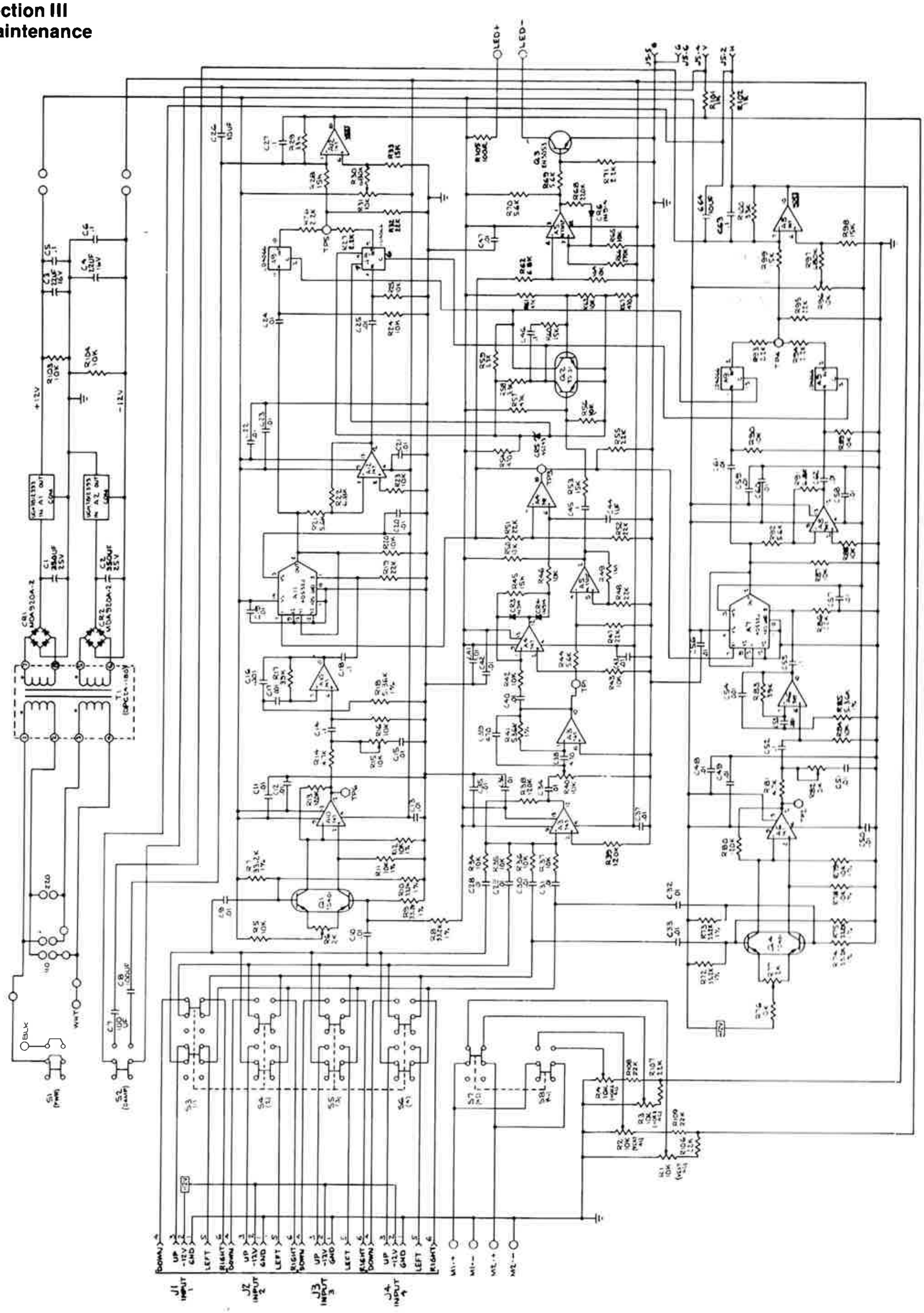


Figure 3-5. Read-Out Unit Printed Circuit Board Assembly Schematic Diagram

3-18. The DC displacement voltage is applied to differential amplifier A12-10 which integrates the signal and smooths it for operation of the digital displays and peripheral strip-chart recorders. DAMP switch S2 provides means for changing the damping constant of the differential amplifier circuit to provide greater stability on long shots in unstable operating conditions. The output of differential amplifier A12-10 is applied through connector J5 on the printed circuit board assembly to output jacks on the rear panel of the Read-Out Unit for application to a strip-chart recorder, and through scaling potentiometer R1 or R2 and AL or AC switch S9 or S7 to vertical display module M1. Potentiometers R1 and R2 and switches S8 and S7 provide means for adjusting the output vertical displacement signal for linear displacement (alignment applications) or for angular displacement (auto-collimation applications). Vertical displacement module M1 is a completely self-contained module that processes the applied DC vertical displacement voltage and provides a direct, 4-digit readout of the vertical displacement in inches (alignment applications) or arc seconds (auto-collimating applications). Module M1 also contains logic circuitry required for interfacing with a peripheral printer, thereby providing means for transfer of data analogous to vertical displacement, in BCD format, to the printer.

3-19. Power Supply Unit. The Power Supply Unit provides 8000 to 10,000 volt ignition pulses and approximately 1200 volts DC required to ignite and operate the laser plasma tube in the Laser Instrument. The 1200 volt DC is modulated at approximately 10 kHz to provide intensity modulation of the laser beam at that rate. By modulating the laser beam, the laser beam can be distinguished readily from steady ambient light or stray light that is modulated at a different frequency. Modulation coding thus enables use of a relatively weak laser beam in the presence of strong ambient light, thereby eliminating thermal warpage of close-tolerance parts and enhancing personnel safety.

3-20. Input 110 volt, 60 Hz AC is applied through the Power Supply Unit power cord, fuse F-1, and ON/OFF switch S1 to constant voltage transformer T3 and power transformer T2. (See Figure 3-6.) Transformer T3 minimizes the effect of line voltage variations on output voltage. POWER ON indicator DS1 indicates when the Power Supply Unit is turned on.

3-21. The 1200 volt DC required for steady operation of the laser plasma tube is developed by a voltage-doubling rectifier circuit composed of rectifiers CR3 through CR6 and associated circuitry, and powered by the high-voltage secondary winding of power transformer T2. The 1200 volt DC is supplied to the laser plasma tube in the Laser Instrument through resistors R3, R2, and R1. This prevents development of any high-voltage transients by limiting the charge rate of any line capacities between the Power Supply Unit and the laser tube.

3-22. The 1200 volt DC is modulated to a depth of approximately 25% by a 10 kHz modulating signal. This modulating signal is generated by integrated circuit A1-15, which operates as a multivibrator running at a 10 kHz rate. The 10 kHz signal is coupled through optical isolator A2 to transistor Q1, which is in series with the opeating DC voltage to the laser plasma tube, thereby causing modulation of the laser plasma tube DC voltage. Meter M1 measures laser tube current; because it cannot respond to 10 kHz, it indicates the average laser plasma tube current (approximately 4 milliamperes normally).

3-23. When starting up, the laser plasma tube requires application of 8000 to 10,000 volts for a few milli-seconds to cause ignition. This momentary pulse is supplied by transformer T1 and associated circuitry. When the Power Supply Unit is turned on, rectifier CR7 develops approximately 100 volts DC, and capacitor C5 charges through the primary winding of transformer T1 and resistor R27 to this level. Before ignition, there is on current drawn by the laser plasma tube; therefore, there is no voltage developed across diode CR10 as a result of current flow. The low voltage level enables integrated circuit A1-8 to operate, and it functions as a multivibrator running at a rate of approximately 0.5 Hz. The output pulses developed by the multivibrator are coupled through optical isolator A3 to SCR CR9. Each time SCR CR9 is turned on, it causes capacitor C5 to discharge rapidly through the primary winding of transformer T1, and a very high transient voltage pulse is developed in the transformer secondary. This transient pulse is applied through diode CR2 to the laser plasma tube high voltage circuit to cause ignition of the laser plasma tube. Diode CR1 blocks the ignition pulse from the 1200 volt DC power supply circuits, and diode CR2 blocks the 1200 volt DC from the ignition circuits.

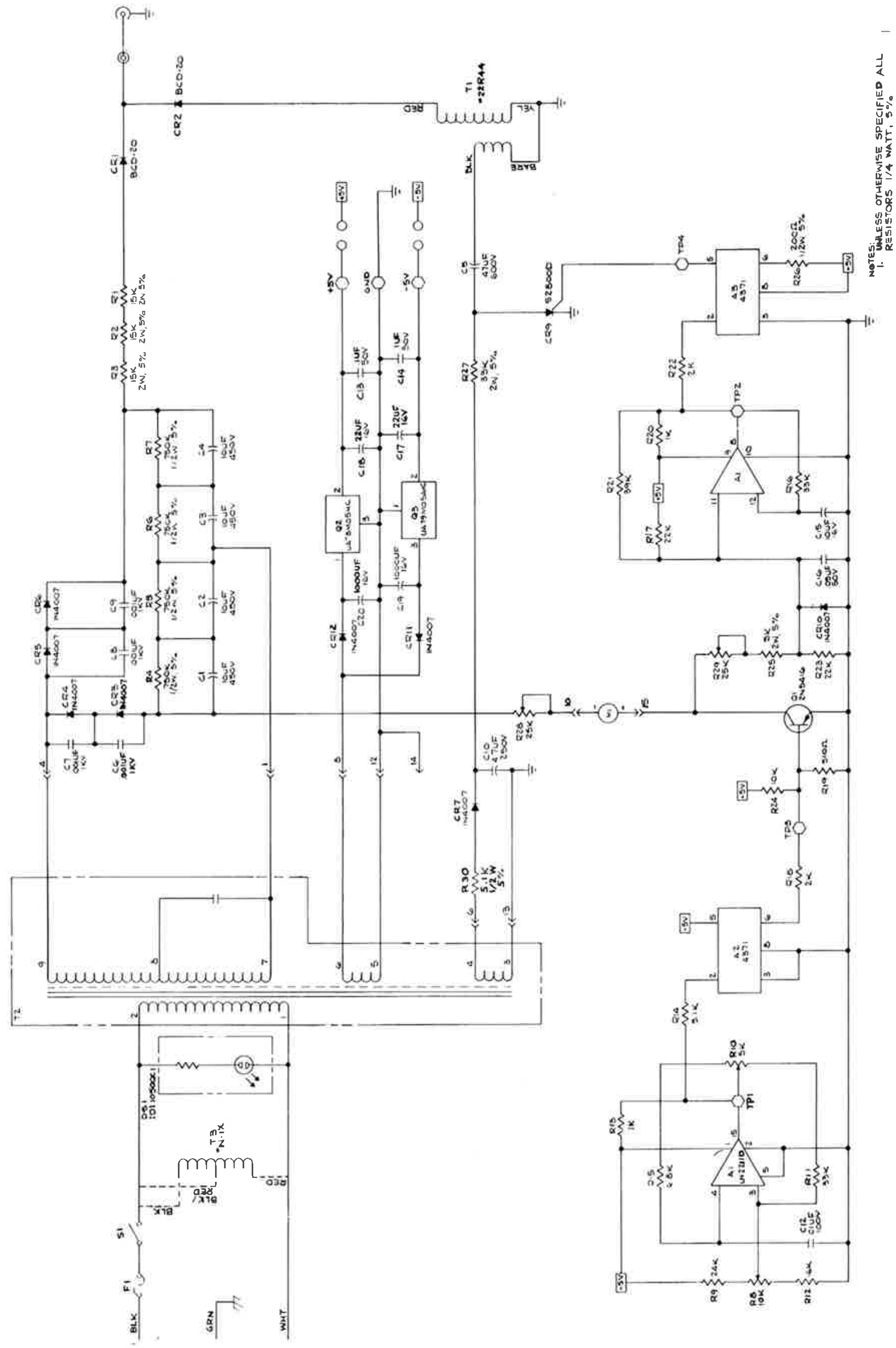


Figure 3-6. Power Supply Unit Schematic Diagram

3-24. When the laser plasma tube ignites, it draws current from the 1200 volt DC supply. This current produces a voltage drop across diode CR10, and the voltage level is sufficient to turn off multivibrator A1-8, thereby inhibiting generation of additional pulses. From this point, the laser plasma tube operates from the 1200 volt DC supply. If there is any interruption in laser plasma tube current for any reason, ignition pulses are again generated automatically to restart the laser plasma tube.

3-25. Operating voltages of +5 and -5 volts DC required by the integrated circuits in the ignition section of the Power Supply Unit are developed by rectifiers CR12 and CR11, which rectify AC voltage from a 6.3 volt secondary winding of transformer T2. Integrated circuits Q2 and Q3 are voltage regulators that regulate the output voltages automatically.

3-26. Two screwdriver-adjustable controls are provided on the Power Supply Unit for operator use. Potentiometer R28 provides a means for adjusting the laser plasma tube current; lowering the current decreases the laser plasma tube output power. Potentiometer R29 provides a means for adjusting the modulation of the laser beam.

3-27. SYSTEM TROUBLESHOOTING

Table 3-1 lists some of the most likely symptoms of malfunction of the Alignment/Auto-Collimating Laser system, together with possible causes and suggested actions.

TABLE 3-1. SYSTEM TROUBLESHOOTING

Symptom	Possible Cause	Action
Laser tube fails to light.	Defective Power Supply Unit fuse. Defective power supply line cord connection. Defective Power Supply Unit to Laser Instrument interconnecting cable. Broken high voltage or ground leads in Laser Instrument.	Return Laser Instrument to Cubic Precision for servicing.
Laser tube does not lase.	Defective laser plasma tube in Laser Instrument. Dust on Brewster angle window in Laser Instrument. Dirt on mirrors in laser instrument mirrors.	Return Laser Instrument to Cubic Precision for servicing.
	Dirt on Laser Instrument pin hole.	Clean Laser Instrument pin hole.
Laser beam blinks on and off.	CURRENT ADJUST or MODULATION ADJUST control on Power Supply Unit incorrectly adjusted.	Readjust controls on Power Supply Unit.
Read-Out Unit does not function.	Defective fuse in Read-Out Unit	Check fuse; replace if necessary.
	Defective Read-Out Unit line cord connection.	Check line cord connection to AC power source; check line cord.

TABLE 3-1. SYSTEM TROUBLESHOOTING (continued)

Symptom	Possible Cause	Action
Read-Out Unit does not function.	Defective interconnecting cable.	Check cable for continuity and shorts; replace defective cable.
	MODULATION ADJUST control incorrectly adjusted.	Readjust MODULATION ADJUST control on Power Supply Unit
	Defect in internal circuits of Read-Out Unit.	Troubleshoot Read-Out Unit; replace defective part.
	Low power from Laser Unit.	Power is below 0.18 mW. Return Laser Unit to Cubic Precision for servicing.
Quad Cell Detector Target does not function.	Defective Quad Cell Detector Target.	Check cable for continuity; repair defective cable or replace Quad Cell Detector Target.
	Cracked Quad Cell Detector Target.	Check for cracks, using 5X magnifier; replace defective Quad Cell Detector Target.

3-28. LASER INSTRUMENT MAINTENANCE INSTRUCTIONS

3-29. General. Maintenance of the Laser Instrument may require disassembly, replacement of the laser plasma tube or other internal parts, cleaning, and adjustment. Return Laser Instrument to Cubic Precision, Teterboro, New Jersey for servicing of all internal parts.

3-30. READ-OUT UNIT MAINTENANCE INSTRUCTIONS.

3-31. Checkout and Calibration.

3-32. General. The digital displays should be checked and calibrated periodically or before any major assignment to ensure that the direct-reading displacement values on the digital displays are accurate. This is a brief procedure that can be performed quickly, either in a calibration laboratory or in the field. The components of the Alignment/Auto-Collimating Laser System must be connected as for normal alignment use. The Quad Cell Detector Target should be centered approximately along the line of sight at any convenient distance; a distance of 2 to 10 feet is recommended. After setting up the equipment, the "Laser Alignment Procedure" of Section II should be performed. Then, proceed with the following checkout and alignment procedures.

3-33. Digital Display Checkout and Calibration with Alignment Laser. Proceed as follows:

a. Verify that the laser beam is precisely centered on the Quad Cell Detector Target. (Both digital displays should read zero.)

b. Place the 71 2656 Calibration Plate over the front of the Quad Cell Detector Target hood. The pigmented register mark on the calibration plate shows the direction in which the incoming laser beam will be displaced when it passes through the calibration plate. Position the calibration plate so that the register mark points up (12 o'clock position).

c. Press the AL pushbutton on the front panel.

d. Adjust the recessed VERTICAL AL control on the front panel so that the right digital display reads the value of the calibration plate.

e. Rotate the calibration plate on the Quad Cell Detector Target so that the register mark points down (6 o'clock position).

f. Adjust the front panel VERTICAL AL control so that the right digital display reads the value of the calibration plate.

g. Repeat steps b through f, making continually finer adjustments, until the right digital display reads the same absolute values with the calibration plate positioned at the 12 o'clock and 6 o'clock settings.

h. Rotate the calibration plate on the Quad Cell Detector Target so that the register mark points to the right (3 o'clock position).

i. Adjust the recessed HORIZONTAL AL control on the front panel so that the left digital display indicates the value of the calibration plate.

j. Rotate the calibration plate on the Quad Cell Detector Target so that the register mark points to the left (9 o'clock position).

k. Adjust the HORIZONTAL AL control on the front panel so that the left digital display indicates the value of the calibration plate.

l. Repeat steps h through k, making continually finer adjustments, until the left digital display reads the same absolute values with the calibration plate positioned at the 3 o'clock and 9 o'clock settings.

3-34. Digital Display Checkout and Calibration with Auto-Collimating Laser. To check and calibrate the read-out unit in the auto-collimating mode, proceed as follows:

a. Rotate the Laser Instrument so that the engraved register mark on the barrel is straight up. Do not rotate the Laser Instrument from this position when in use. When oriented this way, the left digital display on the Read-Out Unit reads horizontal angular deviation, and the right digital display reads the vertical angular deviation.

b. Place the 71 2662 Laser Beam Finder Screen over the front end of the Laser Instrument.

c. Place an adjustable mirror target at a convenient distance (5 to 10 feet) along the path of the laser beam.

d. Move the adjustable mirror target so that the incident laser beam is reflected back into the Laser Instrument. The laser beam can be steered visually onto the white reflecting surface of the Laser Beam Finder Screen, and from there it can be steered into the center hole of the laser beam finder screen by adjusting the mirror target.

e. Press the front panel AC pushbutton. Remove the Laser Beam Finder Screen, and adjust the mirror target first in the horizontal plane, then in the vertical plane, until both digital displays on the read-out unit read zero.

f. Place the 71 2660 Calibration Wedge over the front edge of the Laser Instrument. Rotate the Calibration Wedge housing so that the engraved pigmented register mark points upward (12 o'clock position).

g. Adjust the recessed VERTICAL AC control on the front panel so that the right digital display reads the value of the calibration wedge.

h. Rotate the Calibration Wedge so that the register mark points down (6 o'clock position).

i. Adjust the VERTICAL AC control on the front panel so that the right digital display reads the value of the calibration wedge.

j. Repeat steps f through i, making continually finer adjustments, until the right digital display reads the same absolute values with the Calibration Wedge positioned at the 12 o'clock and 6 o'clock settings.

k. Rotate the Calibration Wedge so that the register mark points to the right (3 o'clock position).

l. Adjust the front panel HORIZONTAL AC control so that the left digital display reads the value of the calibration wedge.

m. Rotate the Calibration Wedge so that the register mark points to the left (9 o'clock position).

n. Adjust the front panel HORIZONTAL AC control so that the left digital display reads .005.

o. Repeat steps k through n, making progressively finer adjustments, until the left digital display reads the same absolute values with the Calibration Wedge positioned at the 3 o'clock and 9 o'clock settings.

NOTE: After completing this procedure, no further adjustments should be made on the power supply and Read-Out Unit by the operator.

3-35. Troubleshooting and Maintenance.

3-36. General. If the preceding Checkout and Calibration procedures have indicated that the Read-Out Unit is malfunctioning and cannot be adjusted to meet calibration standards, the nearest K&E Sales Office may be contacted for assistance. If a skilled electronic technician is available, the following troubleshooting checkout and adjustment procedures may be performed; inability to attain the specified condition at any point in the procedure will point to a particular group of circuits as defective; reference to the Read-Out interconnection and schematic diagrams will enable the electronic technician to isolate the malfunction to a defective part through use of standard printed circuit board maintenance techniques.

WARNING

Although the operating voltage for most internal cirucits is ±12 volts DC, 115 volts, 60 Hz AC power is supplied to the Read-Out Unit power supply and care should be exercised when working on the Read-Out Unit internal circuit when power is applied.

3-37. Test Equipment Required. The troubleshooting checkout procedure requires use of the following test equipment:

a. Laser Instrument with power supply

b. V-block cone assembly

c. Spherical adapter

d. Quad Cell Detector Target

e. Single cable

f. Oscilloscope

g. Adjustable to X and Y Coordinate Stage

3-38. Troubleshooting Checkout Procedure. Perform the troubleshooting checkout procedure as follows:

a. Disconnect 115 volt, 60 Hz AC power from the Read-Out Unit.

b. Remove the Read-Out Unit from its case.

c. Reconnect 115 volt, 60 Hz AC power to the Read-Out Unit.

WARNING

Some AC power points may be exposed during the following procedures; work should be done by a competent electronic technician.

d. Connect all components of the Alignment/Auto-Collimating Laser system as for normal operation. Turn on all equipment, and align the Laser Instrument and Quad Cell Detector Target so that the laser beam strikes the Quad Cell Detector Target.

NOTE: The Quad Cell Detector Target should be checked for excessive leakage current before proceeding further.

e. Rotate the power supply MODULATION ADJUST control to the extreme counterclockwise setting (minimum modulation).

f. Rotate the power supply CURRENT ADJUST control slowly counterclockwise (reducing current) until the laser tube starts to flicker on and off. A rapid snapping sound will be heard at this point.

g. Rotate the supply CURRENT ADJUST control slowly clockwise until the laser tube just ignites and stays lighted.

h. Rotate the power supply MODULATION ADJUST control slowly clockwise until the laser tube just begins to flicker on and off again.

i. Rotate the power supply MODULATION ADJUST control slowly counterclockwise until the laser tube stays lighted. At these settings, the power supply has the combination of current and modulation for optimum laser instrument operation.

j. Press the read-out unit SELECT pushbutton that corresponds to the rear-panel connector to which the Quad Cell Detector Target is connected.

k. Press the Read-Out Unit AL pushbutton.

l. Set the vertical gain of the oscilloscope for 1 volt per division. Ground the oscilloscope to the ground test point on the printed circuit board assembly. Connect the vertical input of the oscilloscope to test point TP1. (See Figure 3-5.)

m. Adjust potentiometer R40 as required to obtain the maximum signal indication on the oscilloscope.

n. Transfer the oscilloscope vertical input probe to test point TP2. Block the laser beam with a cover or any other suitable object. Adjust potentiometer R77 as required to obtain a zero DC level at test point TP2.

o. Transfer the oscilloscope vertical input probe to test point TP6. With the laser beam still blocked, adjust potentiometer R6 as required to obtain a zero DC level at test point TP6.

p. Let the laser beam strike the Quad Cell Detector Target with the center of the laser beam offset slightly from the center of the Quad Cell Detector Target.

q. Transfer the oscilloscope vertical input probe to test point TP5. Adjust potentiometer R15 as required to obtain the best full-wave rectified signal indication on the oscilloscope.

r. Move the laser beam up and down on the Quad Cell Detector Target while observing the waveform at test point TP5. The full waveform should move from one polarity, through zero, to the opposite polarity.

s. Transfer the oscilloscope vertical input probe to test point TP4. Adjust potentiometer R82 as required to obtain the best full-wave rectified signal indication on the oscilloscope.

t. Move the laser beam left and right on the Quad Cell Detector Target. The full waveform indication at test point TP4 should move from one polarity, through zero, to the opposite polarity.

u. Block the laser beam again. Adjust potentiometer R31 as required to obtain a zero indication on the vertical digital display.

v. With the laser beam still blocked, adjust potentiometer R96 as required to obtain a zero indication on the horizontal digital display.

w. Let the laser beam again strike the Quad Cell Detector Target.

x. Move the Laser Instrument or the Quad Cell Detector Target as required to center the laser beam on the Quad Cell Detector Target and obtain a zero indication on both digital displays.

y. Using the 71 2656 Calibration Plate, displace the laser beam on the Quad Cell Detector Target the value of the calibration plate to the right. Adjust the front panel HORIZONTAL AL control as required to obtain an indication of the value of the calibration plate on the horizontal digital display.

z. Displace the laser beam on the Quad Cell Detector Target to the value of the calibration plate to the left, using the Calibration Plate. Adjust the front panel HORIZONTAL AL control as required to obtain an indication of the value of the calibration plate on the horizontal digital display.

aa. Repeat steps y and z until the same absolute reading is obtained on the horizontal digital display for both laser beam displacements.

ab. Block the laser beam and check to see that the horizontal digital display indicates zero. If it reads off zero, readjust potentiometer R96 as required to obtain a zero indication; then, repeat steps y through aa.

ac. Using the Calibration Plate, displace the laser beam on the Quad Cell Detector Target to the value of the calibration plate in the up direction. Adjust the front panel VERTICAL AL control as required to obtain an indication of the value of the calibration plate on the vertical digital display.

ad. Using the Calibration Plate, displace the laser beam on the Quad Cell Detector Target the value of the calibration plate in the down direction. Adjust the front panel VERTICAL AL control as required to obtain an indication of the value of the calibration plate on the vertical digital display.

ae. Repeat steps ac and ad until the same absolute reading is obtained on the vertical digital display for both laser beam displacements.

af. Block the laser beam and check to see that the vertical digital display indicates zero. If it reads off zero, readjust potentiometer R31 as required to obtain a zero indication; then, repeat steps ac through ae.

3-39. POWER SUPPLY MAINTENANCE INSTRUCTIONS

3-40. Checkout and Calibration. To standardize the current and modulation settings on the power supply, first perform the "Starting Procedures" and the "Laser Alignment Procedure" of Section II. Allow a warmup period of approximately 60 minutes (instrument should be at ambient temperature for 24 hours prior to turn on) before proceeding with calibration. Then proceed as follows.

1. Rotate the front panel MODULATION ADJUST control to the extreme counterclockwise position.

2. Rotate the front panel CURRENT ADJUST control slowly counterclockwise (reducing current) until the laser tube begins to flicker on and off. If flickering does not occur, leave the current adjustment at the minimum setting.

3. Rotate the front panel CURRENT ADJUST control slowly clockwise to the point where the laser tube just ignites and stays lighted. This may not be necessary if ignition occurs at minimum current. The front panel milliammeter should read approximately 4.0 to 5.0 milliamperes.

4. Rotate the front panel MODULATION ADJUST control slowly clockwise to the point where the laser tube begins to flicker on and off. If the laser tube does not flicker on and off, rotate the Modulation Adjustment to maximum, clockwise.

5. If the laser tube does flicker on and off, then rotate the front panel MODULATION ADJUST control slowly counterclockwise to the point where the laser tube stays lighted. At these settings, the power supply has the combination of minimum current and maximum modulation necessary to maintain ignition. This combination provides optimum Laser Instrument operation.

3-41. Maintenance. Because of the high voltages involved, maintenance of the power supply, other than replacement of fuses, should not be attempted by the user.

3-42. QUAD-CELL DETECTOR TARGET MAINTENANCE INSTRUCTIONS

3-43. General. The Quad Cell Detector Target has been carefully designed, manufactured, and inspected to assure reliable operation; however, normal use may require that certain servicing functions be performed to keep the system operating at peak performance. These functions are provided in the following paragraphs. More extensive procedures may require the services of a trained instrument technician. Contact your K&E sales office for assistance in such cases.

3-44. Troubleshooting. Table 3-2 provides troubleshooting information for the Quad Cell Detector Target.

TABLE 3-2. QUAD CELL DETECTOR TARGET TROUBLESHOOTING

Problem	Remedy
Quad Cell Detector sensor (blue-colored disc) covered with dirt, fingerprints, or other foreign matter.	Clean sensor with dry cotton swab or lens brush; avoid excessive rubbing or abrasion.
Quad Cell Detector Target damaged.	If it is scratched, cracked, or otherwise damaged, Quad Cell Detector Target should be replaced. Scratches near center of sensor disc are especially critical.
Quad Cell Detector Target appears sensitive to laser beam; little indication on digital displays when laser beam is moved.	Verify that Laser Instrument current and modulation are normal. Power supply milliammeter should read approximately 4.0 to 5.0 milliamperes. Power supply MODULATION ADJUST control setting should be increased with this current setting until laser tube flickers on and off, then backed off slightly. Reference Paragraphs 3.40.1 through 3.40.5. Read-Out Unit SIGNAL indicator should be illuminated. If problems persists, contact K&E sales office.
One quadrant of Quad Cell Detector Target appears more sensitive to laser beam than opposite quadrant.	Orient Quad Cell Detector target surface to be perpendicular to to laser beam. Align Quad Cell Detector Target so that both Read-Out Unit digital displays read zero. Rotate Quad Cell Detector Target slowly in its mount through 360 degrees. If system is properly calibrated, both digital displays should continue to read zero; if they do not, make same check with another Quad Cell Detector Target. If condition persists, system calibration is required; if Replacing Quad Cell Detector Target corrects problem, check mechanical alignment and electrical calibration of Quad Cell Detector Target that caused problem.

3-45. Mechanical Alignment. The Quad Cell Detector Target sensor is aligned mechanically at the factory to be within 0.0005 inch concentricity with its housing, and is then sealed. Mechanical shock to the Quad Cell Detector Target, such as dropping it on a hard surface, may necessitate rechecking of the mechanical alignment. To perform this check, proceed as follows:

1. Mount the Quad Cell Detector Target in a suitable support, such as a 71 5103 Spherical Adapter with 71 5140 Adjustable Cup Mount and 71 5142 Clamp for Cup Mount.

2. Mount a 71 2022 Alignment Telescope, or a similar instrument, in a collimating bench setup with the mounted Quad Cell Detector Target.

3. Focus the Alignment Telescope on the X pattern of the Quad Cell Detector Target sensor (blue disc).

4. Adjust the Alignment Telescope visually for coincident alignment of its reticle cross-hair pattern with the pattern on the Quad Cell Detector Target face.

5. Rotate the Quad Cell Detector Target 180 degrees in its support.

6. Check visually for coincident alignment of the patterns after rotation of the Quad Cell Detector Target. The two patterns should remain coincidentally aligned. The visual resolution of this check is accurate to within 0.0005 inch concentricity.

7. If mechanical displacement of cross-hair alignment is observed after Quad Cell Detector Target rotation, mechanical adjustment is required. Proceed as follows:

a. Note the direction of mechanical displacement of the Quad Cell Detector Target X pattern center from the reference telescope cross-hair pattern center. Mark an index of this direction on the Quad Cell Detector Target housing.

b. Remove the Quad Cell Detector Target from its support.

c. Locate four socket-hand screws around the outside of the Quad Cell Detector Target housing.

d. Using an appropriate Allen wrench, loosen the two socket-head screws that are farthest from the index marked in step a. slightly.

e. Tighten the other two socket-head screws carefully to absorb the released tension.

8. Remount the Quad Cell Detector Target in its support and repeat steps 4 through 7 until mechanical coincidence is achieved between the alignment telescope cross-hair pattern and the X pattern of the Quad Cell Detector Target, regardless of Quad Cell Detector Target rotation.

9. Lock the socket-head screws with a suitable chemical sealant.

3-46. Electrical Calibration. The Quad Cell Detector Target has been calibrated electrically at the factory for equal sensitivity in complementary quadrants. Abrasion or contamination of the sensor face may change sensor characteristics, thereby upsetting the electrical balance. If imbalance between quadrants should become apparent, check for mechanical alignment first, using the procedures in the preceding paragraph; then, proceed as follows:

CAUTION

Do not proceed with electrical calibration before checking mechanical alignment. Symptoms of incorrect mechanical alignment and incorrect electrical calibration are similar, and failure to check mechanical alignment initially may result in erroneous electrical calibration.

1. Mount the Quad Cell Detector Target in a suitable support, such as a 71 5103 Spherical Adapter with 71 5140 Adjustable Cup Mount and 71 5142 Clamp for Cup Mount.

2. Mount the Laser Instrument in a collimating bench setup with the mounted Quad Cell Detector Target.

3. Interconnect the components of the Laser System as for normal operation, and turn on all components.

4. Rotate the Quad Cell Detector Target so that its red index line is straight up.

5. Position the laser beam onto the face of the Quad Cell Detector Target. Adjust the Laser Instrument support so that both digital displays on the Read-Out Unit read zero.

6. Place a 71 2656 Calibration Plate on the front of the Quad Cell Detector Target hood with the register mark on the calibration plate pointing upward.

7. Adjust the VERTICAL AL control on the front panel of the Read-Out Unit so that the vertical digital display reads the value of the calibration plate.

8. Position the calibration plate so that its register mark points to the left (9 o'clock position).

9. Adjust the HORIZONTAL AL control on the front panel of the Read-Out Unit so that the horizontal digital display reads the value of the calibration plate.

10. Remove the calibration plate and again adjust the Laser Instrument support so that both digital displays on the Read-Out Unit read zero.

11. Rotate the Quad Cell Detector Target in its support 180 degrees so that the red index line is at the bottom of the target. Any displacement indicated on the vertical digital display on the Read-Out Unit indicates that the electrical adjustment of the vertical quadrants of the Quad Cell Detector Target is off. Record the displacement indication.

12. Rotate the Quad Cell Detector Target in its support so that the red index line points to the right (3 o'clock position).

13. Adjust the Laser Instrument support so that both digital displays on the Read-Out Unit read zero.

14. Rotate the Quad Cell Detector Target 180 degrees in its mount so that the red index line points to the left (9 o'clock position). Any displacement indicated on the horizontal digital display on the Read-Out Unit indicates that the electrical adjustment of the horizontal quadrants of the Quad Cell Detector Target is off. Record the displacement indication.

15. The electrical imbalance for each directional set of quadrants (vertical or horizontal) is equivalent to one-half of the displacement indications recorded in steps 11 through 14. For example, if vertical digital display readings of 0.000 and 0.007 were obtained with the Quad Cell Detector Target index lines pointing straight up and straight down, respectively, the electrical imbalance is equal to 0.0035 inch down from center. To correct this electrical imbalance, proceed as follows:

a. Locate four flat-head socket screws labelled U, D, L, and R at the rear of the Quad Cell Detector Target. Remove these screws to gain access to the potentiometer slotted shafts below the surface of the rear plate.

b. To restore electrical balance, the sensitivity of the quadrant opposite to the direction of imbalance must be increased in the amount equal to the computed imbalance. Adjust the Quad Cell Detector Target so that the red index mark is straight up and adjust the Laser Instrument so that the Read-Out Unit digital displays read zero. Then, rotate the Quad Cell Detector Target in its support to one of the positions that produced the unbalanced indication, and adjust the potentiometer associated with the quadrant whose sensitivity is to be increased so that the corresponding digital display reading on the Read-Out Unit is reduced to one-half of the originally displayed displacement. For example: if the displacement is 0.007 with the Quad Cell Detector Target index mark pointing down adjust the Unit potentiometer as required to reduce the displacement on the vertical digital display to 0.0035 (0.007 minus the computed electrical imbalance of 0.0035. If the Unit potentiometer has insufficient range, decrease the sensitivity of the opposite quadrant by adjusting the D potentiometer. Balance the other quadrant pair in a similar manner, using the R & L potentiometers and the horizontal digital display on the Read-Out Unit.

NOTE: Vertical and horizontal adjustments are somewhat interactive; therefore, if adjustment is required at one potentiometer of a directional set, readjustment of one potentiometer of the other directional set may also be required.

c. Rotate the Quad Cell Detector Target in its support so that its red index mark is at the top. Readjust the Laser Instrument so that both digital displays on the Read-Out Unit indicate zero.

d. Rotate the Quad Cell Detector Target in its support 180 degrees until the red index line is at the down position. No displacement should be observed on the digital displays.

e. If necessary, continue to rebalance directional sets until no further imbalance is noted. All digital display readings should remain at zero as the Quad Cell Detector Target is rotated in its mount.

f. Install the four screws removed in step a.

16. Reset the HORIZONTAL AL and VERTICAL AL controls on the Read-Out Unit by performing the Read-Out Unit "Digital Display Checkout and Calibration with Alignment Laser" procedure.

APPENDIX — ACCESSORIES

71 1112
Optical Micrometer

71 2410
Optical Square

71 2412
Double Sphere
Optical Square

71 2629
See-Through
Detector Target

Figure A-1. Accessories

A-1. 71 1112 OPTICAL MICROMETER FOR AUTO-COLLIMATING ALIGNMENT LASER

A-2. Description. The 71 1112 Optical Micrometer is used as an attachment to the Laser Instrument to enable displacement of the laser parallel to itself in two mutually independent orthogonal planes. (See Figure A-3.) Built-in horizontal and vertical optical micrometers are each direct reading to 0.001 inch over a range of ±0.100 inch to an accuracy of ±0.0002 inch over the full range. The sleeve of the Optical Micrometer has an inside diameter that is precision ground to fit over a NAS Standard barrel. The Optical Micrometer has a dustproof cover glass and a split clamp for mounting. It can be adjusted and calibrated without removal from the Laser Instrument. It weighs 1¼ pounds.

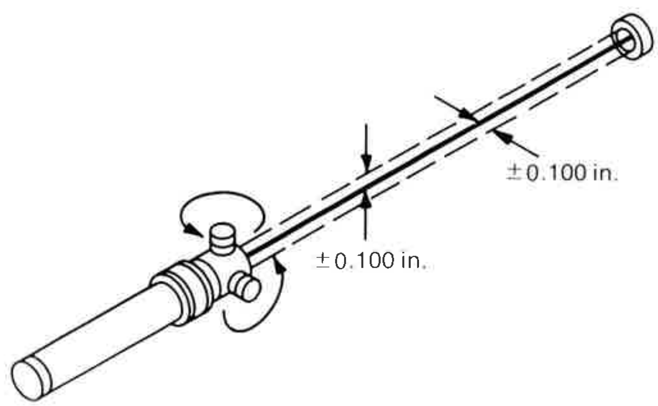


Figure A-2.
Laser Instrument with 71 1112 Optical Micrometer

A-3 Installation and Adjustment.

1. Free the split-ring clamp screw of the Optical Micrometer.
2. Slide the Optical Micrometer onto the end of the Laser Instrument barrel.
3. Rotate the Optical Micrometer until one of the two index lines is aligned with the reference line on the Laser Instrument barrel. The index line alignment can be observed through a notch-way provided by the micrometer housing next to the index mark.

NOTE: Two index lines are provided to promote ease of installation and operaion from either side of the Laser Instrument barrel.

4. Lock the split-ring clamp by tightening the knurled screw.

5. Rotate the Laser Instrument barrel so that the measuring planes of the Optical Micrometer control knobs are aligned with the planes to be measured.

6. Lock the Laser Instrument barrel to its supporting bracket in this position.

A-4. **Operation.** For the purpose of these instructions, it is assumed that the Alignment/Auto-Collimating Laser System has been placed in operation in accordance with the instructions in Section II. Operate the Optical Micrometer as follows:

1. Install and adjust the Optical Micrometer in accordance with the "Installation and Adjustment" paragraph.

2. Set both Optical Micrometer knobs to zero. If the Alignment/Auto-Collimating Laser System is operating properly, the laser beam should not be displaced from its original position; that is, if a Quad Cell Detector Target was intercepting the laser beam and was nulled against it, the readings on the digital displays of the Read-Out Unit connected to the Quad Cell Detector Target should not change.

3. Rotate the micrometer knobs to align the laser beam to a reference Quad Cell Detector Target or to set in a desired displacement in both planes. The amount of displacement can be read directly from the Optical Micrometer scales.

A-5. **Maintenance.** The Optical Micrometer has been carefully designed, manufactured, and inspected to assure reliable operation. It has been calibrated before leaving the factory. No further internal maintenance is required. Should the cover glass be damaged, it can be replaced by removing the supporting lock ring. If dirt, fingerprints, or other foreign matter are visible on the cover glass or displacement plate, clean the part carefully, using a cotton swab dipped in alcohol; avoid excessive rubbing and abrasion. If any other defect is noted contact the nearest K&E Sales Office.

A-6. 71 2410 OPTICAL SQUARE

A-7. **Description.** The 71 2410 Optical Square can be mounted on the barrel of the Laser Instrument to establish a plane perpendicular to the basic line of sight at right angles to it, with an accuracy within one second of 90 degrees. No adjustments are needed to set the right angle. The basic line of sight can be checked while the Optical Square is installed on the Laser Instrument since the Optical Square has both a front and a side aperture. The optical system is mounted in a spherical housing of 3.500 inches diameter, with the vertex of the right angle at the center of the sphere. The Optical Square weighs approximately 5 pounds.

A-8. **Installation.**

1. Remove the locating screw from the Optical Square, and clean the inside bearing rings of the Optical Square.

2. Have an assistant hold the Laser Instrument so that the front end of the barrel extends over the edge of a table or surface plate.

3. Slide the Optical Square carefully onto the barrel of the Laser Instrument, and match the locating hole in the Optical Square with the hole in the Laser Instrument barrel. Insert the locating screw of the Optical Square and tighten the locating screw.

4. Mount the Laser Instrument with the attached Optical Square in its support bracket.

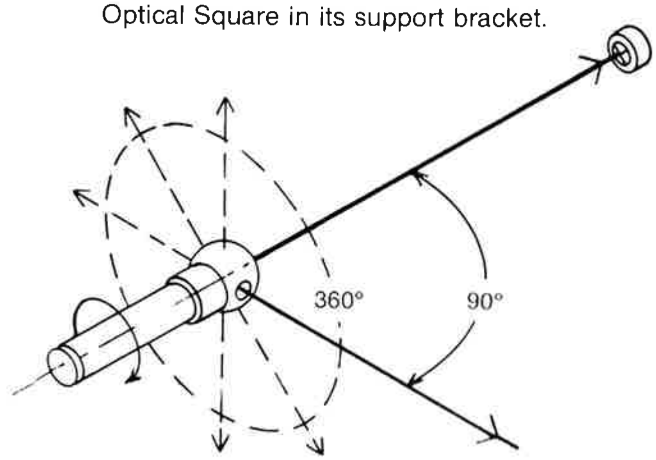


Figure A-3. Laser Instrument with Optical Square

A-9. **Operation.** The Optical Square can be used to establish a plane perpendicular to a reference line of sight as shown in Figure A-3. To establish such a plane, proceed as follows:

1. Remove the front cap from the Optical Square, and install the cap over the side opening.

2. Place the Alignment/Auto-Collimating Laser System in operation in accordance with the instructions in Section II. Establish the desired reference line by aligning the Laser Instrument with the reference Quad Cell Detector Target.

3. Remove the cap from the 90 degree opening on the Optical Square and place it on the front opening.

4. Rotate the Laser Instrument in its support bracket to aim the 90-degree laser beam where desired.

A-10. Maintenance. Clean the cover glass over the Optical Square openings as necessary, using a cotton swab moistened with alcohol; avoid excessive rubbing and abrasion. If any Optical Square defects are noted, contact the nearest K&E Sales Office.

A-11. 71 2412 DOUBLE SPHERE OPTICAL SQUARE

A-12. Description. The 71 2412 Double Sphere Optical Square is similar to the 71 2410 Optical Square, except that it has a second sphere located 2.250 inches behind the sphere that houses the prism. With the rear sphere placed in a cup mount, the instrument to which the Optical Square is attached can be rotated to provide a clear right-angle view through a full 360 degrees. The Double Sphere Optical Square weighs approximately 6 pounds.

A-13. Installation, Operation, and Maintenance. Installation, operation, and maintenance instructions are the same as for the 71 2410 Optical Square, except that the rear sphere is mounted in the cup mount.

A-14. 71 2629 SEE-THROUGH DETECTOR TARGET

A-15. Description. The 71 2629 See-Through Detector Target permits simultaneous alignment of several stations at different positions along a laser line of sight. The see-through capability permits the use of up to four units at one time. The targets connect to the Read-Out Unit.

A-16. The See-Through Detector Target contains a circular photoelectric cell that is divided into four equal quadrants. Each of these quadrants emits an electric current in proportion to the amount of laser light falling upon it. Misalignment of the laser beam off center generates an unbalanced current in favor of the segment receiving the most laser light. The axis of the quad cell is located perpendicular to the axis of the See-Through Detector Target. A small amount of the laser light entering the target is reflected through 90 degrees by a pellicle assembly to the quad cell located in the base of the target. The remainder of the laser light continues through the pellicle assembly and emerges from the See-Through Detector Target parallel with the entering laser beam. If the windows of the See-Through Detector Target are nominal to the laser beam, the exiting laser beam will be collinear with the entering beam.

A-17. The sensing element of the See-Through Detector Target is concentric within ±0.001 inch of the outside diameter of the target.

A-18. Installation. The See-Through Detector Target housing consists of a barrel and ring assembly. The stainless steel ring is 2.2498 inches in diameter, and it may be fitted into a mating hole in any work surface to be aligned. The flat interface surface of the barrel to which the ring is attached is at the virtual image plane of the quad cell target located in the base of the barrel; therefore, alignment of the quad cell takes place in exactly the same plane as that of the work surface.

A-19. For applications where the hole diameter in the work surface to be aligned is too small for the ring, or where a typical "T" pin mounting is indicated, the ring can be removed and the flat interface surface of the barrel can be fastened against the work surface. For such an installation, proceed as follows:

1. Loosen and remove the two 8-32 by one-inch long socket-head screws.

2. Withdraw the ring from the barrel carefully so that the locator pins in the barrel do not bind.

3. Fit the barrel interface surface against the work surface that has been drilled to accomodate the ring screws and locator pins.

4. Align the locator pins in the barrel with the holes drilled in the work surface, and fasten the barrel to the work surface securely with the ring screws.

A-20. Operation.

A-21. General. For the purpose of these instructions, it is assumed that the Alignment/Auto-Collimating Laser System has been placed in operation in accordance with the instructions in Section II, and that the laser is adjusted for maximum modulation with a minimum power of 0.250 milliwatts. The cover glass of the See-Through Detector Target must be clean to permit maximum transmission of the laser light. The cable connector of the See-Through Detector Target must be connected to one of the numbered INPUT connectors at the rear of the read-out unit, and the correspondingly numbered SELECT pushbutton on the front panel of the Read-Out Unit must be pressed. Figure A-5 shows a typical application of a See-Through Detector Target.

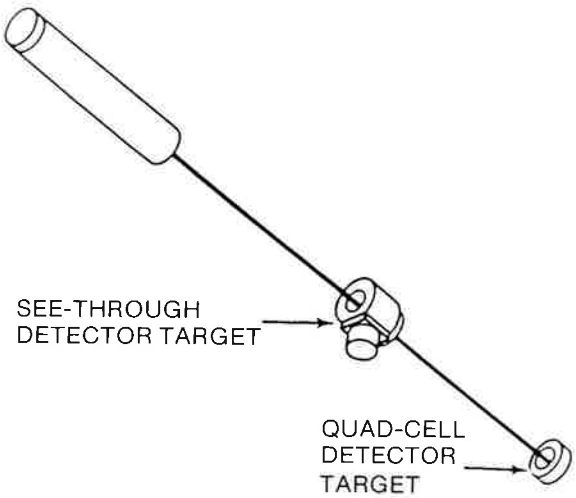


Figure A-4.
Laser Instrument with See-Through Detector Target

A-22. Prealignment. The See-Through Detector Target can be prealigned easily by observing the laser light beam as it is reflected from the cover glass of the target. Tilt the work surface (and the attached See-Through Detector Target) until this reflected beam is seen to fall back on itself. For best results, use a 71 2662 Laser Beam Finder Screen. Place the Laser Beam Finder Screen over the front end of the Laser Instrument and tilt the work surface until the incident laser light beam is reflected back onto the white reflective surface of the Laser Beam Finder Screen. Then, steer the reflected laser beam visually over the white surface of the Laser Beam Finder Screen by tilting the work surface until the reflected laser beam falls back into the center hole of the Laser Beam Finder Screen. The See-Through Detector Target is prealigned properly when the Read-Out Unit indicates sufficient signal to produce an indication other than zero on the two digital displays on the Read-Out Unit. It is not necessary at this point to seek the maximum signal position. Repeat the prealignment procedure for each successive See-Through Detector Target as it is placed in position in the laser beam path.

A-23. Using Laser Light Beam As Reference. When the laser light beam falls on any quad cell of the See-Through Detector Target, the corresponding digital display on the Read-Out Unit will indicate the laser beam deflection. As the See-Through Detector Target is adjusted so that the laser beam approaches its center, the indication on the digital display will decrease toward zero. Since the digital displays on the Read-Out Unit are direct reading in inches, the digital display indication may be used as the distance that the See-Through Detector Target must be moved to bring it into precise alignment with the laser beam center. When the laser beam is centered precisely on the See-Through Detector Target, the corresponding digital display on the Read-Out Unit will indicate zero. To perform alignment, proceed as follows:

a. Set the DAMP pushbutton on the Read-Out Unit to the off positon (out).

b. Adjust the See-Through Detector Target so that both digital displays on the Read-Out Unit read below 0.025.

c. Adjust the See-Through Detector Target in the horizontal plane as required to produce a zero reading on the horizontal digital display on the Read-Out Unit.

d. Adjust the See-Through Detector Target in the vertical plane as required to produce a zero reading on the vertical digital display on the Read-Out Unit.

e. When both digital displays on the Read-Out Unit read zero, the center of the laser beam is precisely coincident with the center of the See-Through Detector Target, and the two units are aligned.

A-24. Using See-Through Detector Target As Reference. When the See-Through Detector Target serves as the reference alignment position, the Laser Instrument should be centered on the See-Through Detector Target by adjusting the Laser Instrument mount. The Laser Instrument should be adjusted in one plane at a time until the laser beam strikes the center of the See-Through Detector Target, as indicated by a zero reading on the corresponding digital display on the Read-Out Unit. Then, the Laser Instrument should be centered in the other plane. When both digital displays read zero, the Laser Instrument is precisely centered on the See-Through Detector Target.

A-25. Using Multiple See-Through Detector Targets. Up to four separate See-Through Detector Targets may be aligned along the same laser beam. Each of the targets is connected to a separate numbererd INPUT connector on the rear panel of the Read-Out Unit. The nearest target is selected by pressing the corresponding SELECT pushbutton on the front panel of the Read-Out Unit, and this target is aligned in accordance with the preceding procedures. The remaining targets are then selected and aligned in sequence. When zero readings are obtained on both digital displays of the Read-Out Unit for all targets, the targets are aligned precisely along the laser beam.

A-26. Maintenance.

A-27. General. The See-Through Detector Target has been designed, manufactured, and inspected carefully to assure reliable operation; however, normal use may require that certain servicing functions be performed periodically to keep the system operating at peak performance. Maintenance procedures that are within the capability of the average user are provided in the following paragraphs. More extensive procedures may require the services of a trained instrument technician; contact the nearest K&E Sales Office promptly for assistance in such cases.

A-28. Troubleshooting. Table A-1 lists some problem that may be encountered, together with the procedure for correcting the problem.

TABLE A-1. SEE-THROUGH DETECTOR TARGET TROUBLESHOOTING

Problem	Remedy
Cover glass covered with dirt, fingerprints, or other foreign matter.	Clean target sensor carefully with cotton swab dipped in alcohol; avoid excessive rubbing and abrasion.
Target scratched, cracked, or otherwise damaged.	Replace See-Through Detector Target; scratches near center of sensor disc are especially critical.
See-Through Detector Target appears to be insensitive to laser beam; little displacement indication on Read-Out Unit when laser beam is moved.	Verify that Laser Instrument current and modulation are at proper levels. Power supply milliammeter should indicate 4.0 to 5.0 milliamperes; MODULATION ADJUST control on power supply should be increased with specified current until laser flickers on and off, then backed off slightly. SIGNAL indicator on Read-Out Unit should be lighted. If problem persists, contact K&E Sales Office.
One quadrant of See-Through Detector Target appears more sensitive than opposite quadrant.	Orient detector target surface visually so that it is perpendicular to laser beam. Align detector target so that digital displays on Read-Out Unit both read zero. Rotate detector target slowly in its mount; digital displays should continue to read zero. If deflection indication is obtained on either digital display, repeat this check using another detector target; if condition persists, recalibration of Alignment/Auto-Collimating Laser System is required. If replacing detector target clears problem, check mechanical alignment and electrical calibration of detector target that caused problem.

A-29. Mechanical Alignment. The See-Through Detector Target is aligned to be within 0.0005 inch concentricity with its housing at the factory, and is then sealed. Mechanical shock, such as dropping the See-Through Detector Target on a hard surface, may necessitate rechecking of the initial mechanical calibration. To perform the mechanical alignment check, proceed as follows:

a. Mount a Quad Cell Detector Target on a suitable support, such as a 71 5103 Spherical Adapter with 71 5140 Adjustable Cup Mount and 71 5142 Clamp for Cup Mount.

b. Mount a 71 2022 Alignment Telescope, or a similar instrument, in a collimating bench setup with the mounted Quad Cell Detector Target.

c. Focus the Alignment Telescope on the X pattern of the Quad Cell Detector Target (blue disc).

d. Adjust the Alignment Telescope visually for coincident registration of its reticle cross-hair pattern with the pattern on the Quad Cell Detector Target sensor face.

e. Mount the See-Through Detector Target that is to be mechanically aligned in a suitable support, such as a 71 5103 Spherical Adapter with 71 5140 Adjustable Cup Mount and 71 5142 Clamp for Cup Mount. Mount the support assembly in a two-plane micrometer stage to facilitate translation in thousandths of an inch.

f. Position the mounted See-Through Detector Target, cable up, between the Alignment Telescope and the mounted Quad Cell Detector Target, with the cover glass of the See-Through Detector Target facing the Alignment Telescope. It is not necessary to align the See-Through Detector Target precisely when placing it in this position.

g. Without changing any settings, look through the Alignment Telescope at the X pattern of the Quad Cell Detector Target. A slight shift in registration between the Alignment Telescope cross-hairs and the Quad Cell Detector Target X pattern will be observed if the line-of-sight axis of the See-Through Detector Target is not parallel to the line-of-sight between the Alignment Telescope cross-hairs and the Quad Cell Detector Target X pattern. This shift in registration is caused by refraction of the light passing through the See-Through Detector Target by the integral cover glasses.

h. Reposition the See-Through Detector Target mount until the Quad Cell Detector Target X pattern and the Alignment Telescope cross-hairs are again in coincidence. Fix the See-Through Detector Target in this position with the spherical adapter setscrew. This positioning leaves the line-of-sight axis of the See-Through Detector Target at least parallel to the line-of-sight between the Alignment Telescope cross-hairs and the Quad Cell Detector Target X pattern.

i. Cover the face of the Quad Cell Detector Target with a neutral-colored card.

j. Refocus the Alignment Telescope on the sensor X pattern reflected from the pellicle assembly in the See-Through Detector Target.

k. Using the count assembly micrometer stage, translate the See-Through Detector Target visually for coincident registration of the Alignment Telescope reticle cross-hair pattern with the X pattern in the See-Through Detector Target.

l. Loosen the setscrew in the spherical adapter, and rotate the See-Through Detector Target 180 degrees (cable down).

m. Check visually for coincident alignment of the patterns after rotation of the See-Through Detector Target. If the factory alignment has not been disturbed, the two patterns should remain coincidentally aligned. The visual resolution of this check is accurate to within 0.0005 inch concentricity.

n. If mechanical displacement of cross-hair alignment is observed after See-Through Detector Target rotation, note the direction of mechanical displacement of the See-Through Detector Target X pattern center from the center of the Alignment Telescope cross-hair pattern.

o. Note the settings of the micrometer stage in which the See-Through Detector Target is mounted.

p. Using the micrometer stage, translate the See-Through Detector Target until the X pattern of the See-Through Detector Target is coincident with the Alignment Telescope cross-hair pattern. Note the direction of mechanical displacement and the difference of the micrometer stage settings from those noted in step o.

q. If the displacement difference calculated in step p exceeds 0.025 inch, a course adjustment of the pellicle assembly is required to reduce the displacement to an amount that can be adjusted for in the following steps. This adjustment should be performed by K&E factory technicians. It is made by inserting special threaded shafts into the threaded holes at the rear face of the See-Through Detector Target housing, with the mounting ring removed, and moving the pellicle assembly as required.

r. Using the micrometer stage, translate the See-Through Detector Target in the direction opposite to that noted in step n, one-half the amount of the mechanical displacement difference calculated in step p.

s. Rotate the See-Through Detector Target 180 degrees (cable up). Observe the direction of displacement (up, down, left, right) seen through the Alignment Telescope.

t. Locate four screw access holes around the outside of the cable housing of the See-Through Detector Target. Using a socket-head wrench, adjust the See-Through Detector Target X pattern for coincidence by loosening the appropriate screw and tightening the opposite screw in accordance with the direction of displacement noted in step s and table A-2.

u. Repeat steps l through t until mechanical coincidence is achieved between the Alignment Telescope cross-hairs and the X pattern of the See-Through Detector Target regardless of rotation of the See-Through Detector Target. After mechanical alignment is achieved, lock the socket-head screws with a suitable chemical sealant, rotate the See-Through Detector Target to the normal (cable up) position, and lock it in place using the setscrew on the spherical adapter. Then, proceed directly with electrical calibration.

A-30. Electrical Calibration. The See-Through Detector Target has been calibrated electrically at the factory for equal sensitivity in complementary quadrants. Abrasion or contamination of the See-Through Detector Target face may change the electrical balance. If the See-Through Detector Target should appear to be electrically unbalanced, first check the mechanical alignment in accordance with the preceding paragraph; then, perform an electrical calibration check as follows:

CAUTION

Do not proceed with electrical calibration without first checking mechanical alignment. The symptoms for mechanical misalignment and incorrect electrical calibration are similar, and failure to check the mechanical alignment initially can result in erroneous electrical calibration.

TABLE A-2. SEE-THROUGH DETECTOR TARGET MECHANICAL ALIGNMENT

Direction of Displacement	Screw To Be Loosened	Screw To Be Tightened
Down	Farthest from Alignment Telescope	Closest to Alignment Telescope
Up	Closest to Alignment Telescope	Farthest from Alignment Telescope
Right	On left side, as viewed from cover glass end	On right side, as viewed from cover glass end
Left	On right side, as viewed from cover glass end	On left side, as viewed from cover glass end

a. Maintain the same test configuration as was used for the mechanical alignment.

b. Without changing the orientation of the mount, remove the Alignment Telescope and replace it with a Laser Instrument.

c. Connect the See-Through Detector Target to one of the INPUT Connectors on the rear panel of the Read-Out Unit. Press the Read-Out Unit AL Pushbutton and the SELECT Button whose number corresponds to that of the input connector to which the See-Through Detector Target is connected.

d. Connect the Laser Instrument to the Power Supply and turn on all equipment.

e. Rotate the Laser Instrument so that the detent for the optical square and the register mark engraved on the rear of the laser barrel point directly upward (see Figure 2-4). Install the 71 2662 Laser Beam Finder Screen on the front of the Laser Instrument. Place a mirror across the front of the See-Through Target and center the target so the return beam comes back on itself without touching the edges of the finder screen hole. When this is done, remove the mirror and finder screen.

f. Verify that both digital displays on the Read-Out Unit read zero; if necessary, adjust the position of the Laser Instrument to obtain zero indications.

g. Place a 71 1112 Optical Micrometer on the Front of the Laser Instrument. With both micrometers of the 71 1112 on zero, adjust the Laser Instrument if necessary so both digital displays read zero.

h. Move the Vertical Micrometer 0.010; the Vertical Meter should display 0.010. If not, adjust the Vertical AL Control on the Read-Out Unit until the Vertical Digital Display reads 0.010. Then move the Micrometer back to zero.

i. Rotate the Horizontal Micrometer 0.010; the Horizontal Meter should display 0.010. If not, adjust the Horizontal AL Control on the Read-Out Unit until the Horizontal Digital Display reads 0.010. Then move the Micrometer back to zero.

j. Remove the 71 1112 Optical Micrometer and verify that both Digital Displays on the Read-Out Unit still read zero. If the reading has changed, readjust the Laser Instrument.

k. Note the location of the four potentiometer screws labeled U, D, L, and R on the cable end of the See-Through Detector Target (mounted in the normal cable-down position).

l. Rotate the See-Through Detector Target 180 degrees (cable up).

m. Check the Read-Out Unit Displays; both should still read zero ±0.001. If displacement indication(s) are noted, proceed to step "n"; if not, the unit is calibrated.

n. Correct half the error by moving the Laser Instrument opposite to the direction of the imbalance. Then, correct the remainder of the error by adjusting the potentiometers. For example, if a displacement of 0.006 inches to the right was noted; translate the Laser Instrument to the left until the Horizontal Digital Display on the Read-Out Unit reads -0.003 (one half the original displacement).

o. Adjust the appropriate potentiometers on the See-Through Detector Target until the Digital Displays read approximately zero.

p. Continue to readjust until the desired tolerance is achieved.