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PAPI

(PRECISION APPROACH PATH INDICATOR)

INSTRUCTION BOOK

Made Per

US DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AC-150/5345-28

TYPE L-880
TYPE L-881
STYLES A & B

Manufactured By:

OCEM Acquisition, Corp. d.b.a.

MULTI ELECTRIC MFG.

4223-43 West Lake Street
Chicago, Illinois 60624
sales@multielectric.com

GUARANTEE

(A) The Contractor guarantees each item against defects in material or workmanship. This Guarantee extends for a period of one year, unless otherwise specified, from the date of installation or use, provided that this period shall not exceed two years from the date of delivery.

(B) Upon notice in writing, the Contractor shall promptly repair or replace all defective or damaged items f.o.b. any point designated by the Government within the 48 contiguous States and the District of Columbia, at no expense to the Government. The Contractor may elect to have any replaced item returned to his plant at his request.

(C) This Guarantee shall exclude lamps and material normally consumed in operation unless excluded item fails as a result of improper application by the Contractor, in which case, the Guarantee shall be equally applicable to these items; provided that the Contractor shall guarantee excluded items to the extent of the guarantee received by the Contractor from his supplier.

(D) If 20 percent or more of the total quantity for any part or component to which this Guarantee applies, but not less than two of any such part, or component furnished under the contract, fail in normal service, the fact shall be conclusive evidence that the particular part or component or the item or part design, is unsuitable for the purpose intended. The Contractor, upon written notice of this fact, shall replace or correct the design of all quantities of the item or part in a manner satisfactory to the Government, unless the use of such part, component or design was specifically required by the Government.

(E) The guarantee period shall exclude any period of time the unit or part fails to perform satisfactorily due to defects.

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1 GENERAL DESCRIPTION

1.1 Scope

This Instruction Manual covers the Precision Approach Path Indicator system, a visual landing aid developed in accordance with FAA AC-150/5345-28. The advantages found for this system are that it provides:

(a) Better guidance below 200 feet elevation;
(b) Sharper transition between red and white than previous systems;
(c) Information as to the degree of divergence from the nominal glide path;
(d) A single wing bar indicating the touchdown aiming point.

1.2 Classification

The PAPI System can be classified by type and style.

1.2.1 Type

(1) L-880 system consisting of 4 light units.
(2) L-881 system consisting of 2 light units.

1.2.2 Style

(1) Style A - Voltage powered (multiple circuit) systems.
(2) Style B - Current powered (series circuit) systems.

1.3 Class

All Multi Electric PAPI systems are Class I and Class II, which operate to -55^{O}C.

1.4 Number of Lights Per Unit

Each Lamp Housing Assembly contains three 105-watt lamps per unit for a total of 315 watts per Lamp Housing Assembly.

2 DESCRIPTION OF SYSTEM

The PAPI System has either two or four Lamp Housing Assemblies (LHAs) in a single wing bar usually located on the left side of the runway. Larger military and international airports may have the same array of PAPI LHAs on each side of the runway. Each LHA projects a split beam of light precisely divided horizontally into a white upper sector and a red lower sector. The transition from red to white or vice versa occurs over a vertical angle of less than 3 minutes of arc.

2.1 Light Pattern

The light pattern projected to the approaching pilot in a Type L-880 System provides signals indicating 5 vertical locations about the nominal or ideal glide path. Figure 2.1 shows these five signal representations and the information they convey. The Type L-881 system provides signals indicating 3 vertical locations about the ideal glide path. These signal representations are shown in Figure 2.2. These vertical locations are set by the elevation angle of each LHA. The type of aircraft and location determines the nominal glide slope and the offset angle of each LHA. The LHA closest to the runway is set at the highest angle. The set angle is decreased for each LHA. The nominal glide path angle is the angle half way between the two center box set angles for the L-880 and half way between the two box set angles for the L-881.

Figure 2.1 *Light Pattern: Type L-880 System*

○ ○ ○ ○	4-White 0 - Red	Too High
○ ○ ○ ●	3-White 1 Red	Slightly High
○ ○ ● ●	2-White 2-Red	On Glide Path
○ ● ● ●	1-White 3-Red	Slightly Low
● ● ● ●	0-White 4-Red	Too Low

Figure 2.2 *Light Pattern: Type L-881 System*

○ ○	2-White 0-Red	Too High
○ ●	1-White 1-Red	On Glide Path
● ●	0-White 2-Red	Too Low

3 THEORY OF OPERATION

3.1 PAPI Lamp Housing Assembly

The PAPI Light Housing Assembly consists of a base t-frame with three optical projector modules mounted to an optical bench. Each module contains a pre focused integral reflector lamp to produce a plane of light beams parallel to the optical base. Half of these beams pass through a glass red filter. The lens positioned at the front of the module is located so that the beams cross over at a position approximately 5-1/4 inches in front of the unit. The result is that, although the red filters are positioned on top in the unit, the emerging beam, as seen from the pilot's eye, is flipped with white on top and red on the bottom.

3.2 Power and Control Unit (Style A System)

The Style A System is designed to operate from a Power and Control Unit (PCU), Multi P/N 5920-101, with a 120/240 VAC, 3-wire input. The PCU is the same for both the L-880 and the L-881 systems. A circuit breaker is included to de-energize the input power for field maintenance. The PCU incorporates a Photo Cell, Multi P/N 5910-10, which is used to provide automatic switching between day and night intensity levels. During day conditions (full intensity), the Photo Cell sends a logic "high" signal to the Master Control PCB assembly, Multi P/N 5920-185, which, in turn, energizes contactor K2. This allows the full 240V to be applied across the primary of the transformer, producing 16V for the two lamp loops on the secondary. During night conditions (low intensity), the Photo Cell sends a logic "low" signal to the Master Control, which, in turn, de-energizes contactor K2. In this case, 120V is applied to the primary of the transformer, producing either 6.7V (optional ultra-low night intensity) or 10.0V (low intensity) for the two lamps loops on the secondary. Wiring diagrams for the Style A systems are shown in Figures 10.2 and 10.3.

3.3 Night Sentinel Option (Style A System Only)

At night, it may be desired that the PAPI system be on only when the runway lights are on. This is accomplished with the inclusion of the Night Sentinel option. For further information regarding this option, please refer to Multi Instructional Bulletin IB 5900-100-03-NS.

3.4 Power Supply (Style B System)

The Style B system is designed to operate from a 6.6 amp series circuit. The series circuit regulator controls the PAPI system exclusively and can be controlled from the tower or from the regulator vault location. Typically 3 steps of intensity (6.6, 5.5, and 4.8 amperes) are provided but 5 steps can be furnished if desired. The regulator can be furnished for 50 or 60 Hertz operation. Isolation transformers are used to provide power to each LHA in the system to prevent total system failure in the event of an LHA failure. Furthermore, the Tilt Sensor and Lamp Control, Multi P/N 5903-185, provides power to each lamp individually in any given LHA. Therefore, if any lamps fail in an LHA, the remaining lamps will continue to burn. Wiring diagrams for the Style B systems are shown in Figures 10.5 and 10.6. A detailed wiring diagram for an individual Style B LHA is show in Figure 10.7.

3.5 Tilt Switch

The Tilt Switch Assembly, Multi P/N 5900-77, is a mechanical tilt switch designed to shut off the power to all LHAs if one or more LHA is displaced from its set angle of elevation by 15 to 30 minutes of arc in a downward direction, or by 30 to 60 minutes of arc in an upward direction. There is approximately a 10 second delay before the shut down occurs.

In a Style A system, the Tilt Driver PCB assembly, Multi P/N 5900-186, checks for tilts detected by the Tilt Switch Assembly. If a unit is displaced, the Tilt Driver will send a signal to the Master Control PCB assembly on the PCU. After 10 seconds of a continuous tilt condition, the Master Control de-energizes contactor K1, thus removing power from the primary of the transformer. All of the lamps in the system remain off until 10 seconds of a continuous NO-tilt condition occurs. At this point, the PCB re-energizes K1, which then restores power to all of the lamps. Wiring diagrams for the Style A PAPIs are shown in Figures 10.2 and 10.3.

In a Style B system, the Tilt Sensor and Lamp Controls in each LHA are used to check the Tilt Switch Assemblies for tilts. If a tilt occurs in any LHA in a system, the Tilt Sensor and Lamp Control in the LHA where the tilt is occurring will open the tilt signal circuit loop. The other Tilt Sensor and Lamp Controls will sense this open circuit, and after 10 seconds of a continuous tilt condition, power is removed from all of the lamps. Once the tilt is resolved, the tilt signal circuit loop is made continuous again. After 10 consecutive seconds of a NO-tilt condition, power is restored to all of the lamps. Wiring diagrams for the Style B PAPIs are shown in Figures 10.5 through 10.7.

4 OPERATION AND STANDARDS

4.1 Operation - Style A

Operation of a Style A PAPI system is completely automatic; the intensities are selected by the Photo Cell controlling the power supply. However, the Style A PAPI system may be remotely controlled by use of the Night Sentinel option.

4.2 Operation - Style A Reduced Night Intensity

The Style A system can operate with a reduced night intensity where ambient lighting is subdued, and the standard low intensity may be too bright and uncomfortable for an approaching pilot. The reduced night setting is manually configured by changing the tap on Transformer T1. To change the tap, shut the power off, and remove the wire connected to T1-H3 and connect it to T1-H2.

4.3 Operation - Style B

The tower normally controls operation of a Style B PAPI system. The Constant Current Regulator, however, allows for local control at the regulator location. In a Style B PAPI system, regulator step 1 provides the dimmest intensity and step 3 (or 5 if a 5 step regulator is being used) is the brightest.

4.4 Standards and Tolerances

The following are the standards and tolerances for the PAPI System.

Table 4 Standards and Tolerances.

System	Id	Description of Parameter	Measured AT	Nominal Value	Tolerance	Ref
Style A		**Power and Control Unit**				
	A)	**Input Voltage**				
		240VAC	L1 - L2	240Vrms	±10%	
		120VAC	L1 - N N - L2	120 Vrms 120 Vrms	±10%	
	B)	**Lamp Loop Voltage (Day Setting)**				
		Loop 1	T1-X1 to T1-X2	16 Vrms	± 3%	
		Loop 2	T1-X3 to T1-X2	16 Vrms	± 3%	
	C)	**Lamp Loop Voltage (Night Setting--Standard)**				
		Loop 1	T1-X1 to T1-X2	10 Vrms	± 3%	
		Loop 2	T1-X3 to T1-X2	10 Vrms	± 3%	
	D)	**Lamp Loop Voltage (Night Setting--Optional)**				
		Loop 1	T1-X1 to T1-X2	6.7 Vrms	± 3%	
		Loop 2	T1-X3 to T1-X2	6.7 Vrms	± 3%	

System	Id	Description of Parameter	Measured AT	Nominal Value	Tolerance	Ref
	E)	**Photo Cell**				
		Input Voltage	TB1-12V to TB1-0V	12 V	±10%	
		Output Voltage (Day Setting)	TB1-SGL to TB1-0V	0 V	±1 Vrms	
		Output Voltage (Night Setting)	TB1-SGL to TB1-0V	12 V	±10%	
	F)	**Tilt Switch**				
		Tilt	TB1-*+ to TB1-*-	5 Vrms	±10%	
		No Tilt	TB1-*+ to TB1-*- (* = 1, 2, 3, or 4)	7 Vrms	±10%	
Style A		**Lamp Housing Assembly**				
	A)	**Lamp Loop Voltage (Day Setting)**	Terminal Block Assy Input	16 Vrms	± 3%	
	B)	**Lamp Loop Voltage (Night Setting--Standard)**	Terminal Block Assy Input	10 Vrms	± 3%	
	C)	**Lamp Loop Voltage (Night Setting--Optional)**	Terminal Block Assy Input	6.7 Vrms	± 3%	
	D)	**Tilt Switch**				
		Tilt	PCU+ to PCU-	5 Vrms	±10%	
		No Tilt	PCU+ to PCU-	7 Vrms	±10%	

System	Id	Description of Parameter	Measured AT	Nominal Value	Tolerance	Ref
Style B		**Lamp Housing Assembly**				
	A)	**Lamp Loop Current (B-100)**	Lamp Leads	6.6 A	± 3%	
	B)	**Lamp Loop Voltage (B-30)**	Lamp Leads	5.5 A	± 3%	
	C)	**Lamp Loop Voltage (B-10)**	Lamp Leads	4.8 A	± 3%	
	D)	**Tilt Switch Option**				
		Tilt (L-880 only)	Tilt Signal In to Tilt Signal Out	6 Vrms	± 10%	
		Tilt (L-881 only)	Tilt Signal In to Tilt Signal Out	3 Vrms	± 10%	
		No-Tilt (L-880 or L-881)	Tilt Signal In to Tilt Signal Out	0 Vrms	± 1 Vrms	

5 PERIODIC MAINTENANCE

5.1 Maintenance Of Lamp Housing Assembly

Periodic and corrective maintenance of the LHA is critical to maintaining optimum system performance. A maintenance program should be established to prevent catastrophic failures of the system and to schedule performance during hours with the least impact on the facility. The PAPI system has been designed for easy maintenance. Most operations are performed with a screwdriver or no tools at all.

5.1.1 Removal and Replacement of the LHA Hood

To remove the hood, loosen the two thumbscrews at the lower rear of the LHA. Slide the hood forward and lift it away for the base assembly. To replace the LHA hood, reverse this procedure.

5.1.2 Lamp Replacement

The replacement of burned out lamps is an important aspect of maintenance. To remove the lamp from the socket, start by shutting off the power to the system. Detach the male leads of the lamp from the corresponding female crimp connectors. Next, remove the lamp by moving the lever on the side of the lamp holder to the rear. Withdraw the lamp from the spring retainer and move the extractor lever to the front. Install a new lamp by sliding it into the lamp holder with the extractor lever all the way forward. Reconnect the lamp leads to the crimp connectors. There is no requirement to adjust the focus of the optical assembly after re-lamping. All optical system focusing must be performed at the Multi Electric plant or a designated repair facility. A reasonable supply of replacement lamps should be kept on hand at all times. Only direct replacement lamps should be used in the system. Contact Multi Electric’s Airfield Lighting Specialists for information on replacement lamps and maintenance programs.

5.1.3 Aiming

Aiming of the light boxes to the correct elevation level is another important aspect of the maintenance of a PAPI system. All boxes should be regularly checked to ensure that they are at the proper setting. Refer to the site data to determine the proper angle for each LHA. To check or adjust the aiming angle, follow these steps:

1. Remove the hood for the LHA.
2. Set the aiming instrument CAM for zero degrees on the side of the aiming instrument.
3. Place the aiming instrument across the front of the lens holder casting.
4. If not zero, adjust the front leg jackscrews on the leg cap assembly until the aiming instrument reads zero.
5. Adjust the angle on the aiming instrument CAM for the desired aiming angle for the particular LHA.
6. The angle measurement is taken from the side of the LHA with the lenses on the right and the rear to the left. In most U.S. installations, you would be facing the runway.

7. Place the aiming instrument so that it is straddled across the lens casting and filter bracket. The aiming device should be seated in the notch in the lens casting and should not be touching the lamp mounting bracket.
8. Adjust the jackscrews on the rear leg cap assembly if required.
9. Recheck the level in front if any adjustments were made to the unit.
10. Ensure that the green LED is lit inside of the LHA.
11. If required, loosen the locking screws on the side of the Tilt Switch Assembly, and set it using the green LED.
12. Clean and inspect the unit as required.
13. Replace the hood assembly.

5.1.4 Cleaning and Inspection

Periodically wipe the inside surfaces of the LHA clean with a clean, slightly moistened rag to remove dirt and grime from the interior. Use a mild detergent or window cleaner to wash and polish the red filter and lens surfaces to maintain high light transmissibility. Inspect the units for wear and tear and replace components as required.

5.1.5 Front Lens Replacement

Replacement of the front lens must be accomplished at the factory.

5.1.6 Red Filter Replacement

Refer to Figure 10.15 for replacement of the red glass filter in the LHA.

1. Remove the filter-retaining bracket by removing the screws from the front of the filter bracket.
2. Remove and replace the red filter from the holder.
3. Reattach the filter retainer bracket
4. Remove any dirt or fingerprints from the filter

5.2 Maintenance of the PCU

For a Style A system, the 240V power supply to the Power and Control Unit (PCU) must be maintained. Basic maintenance checkpoints for operating standards are outlined in Section 4.

6 TROUBLESHOOTING

The following troubleshooting chart is included for your assistance in restoring the system after a failure.

Table 6 Troubleshooting

Problem	Check	Corrective Action
All Lamps Out (Style A ONLY)	1. Check for proper power to the PCU from the utility.	1. Restore power from source.
	2. Check if the circuit breaker on the PCU is ON.	2. Reset circuit breaker.
	3. Check to see if relay K1 is energized.	3. Check all LHAs for tilts. If no tilts are present, replace the relay. If this does not resolve the problem, check the wiring on the PCU.
	4. Check all LHAs for tilts.	4. Check the wiring in the LHA and on the PCU.
	5. Check for a failed Tilt Driver PCB assembly.	5. Replace Tilt Driver PCB assembly.
All Lamps Out (Style B ONLY)	1. Check for proper power to the LHA from the series circuit.	1. Restore power from source.
	2. Check for a failed Tilt Sensor and Lamp Module and/or Tilt Switch Buffer (on systems with Tilt Switch Option ONLY).	2. Replace Tilt Sensor and Lamp Module and/or Tilt Switch Buffer.
All Lamps Out (Styles A and B)	1. Check the tilts switches for proper adjustment.	1. Adjust Tilt Switch Assembly.
	2. Check if all lamps in the LHA are burned out.	2. Replace all the lamps in the LHA.

Some Lamps Out--Premature Failure (Style A ONLY)	1. Check voltages at LHA per Table 4.	1. Change taps on the power transformer per Table 9.2 if required.
Some Lamps Out—Premature Failure (Style B ONLY)	1. Check currents at LHA.	1. Check all wiring. Check for faults/alarms at power source.
Some Lamps Out—Premature Failure (Style A and B)	1. Check for burned out lamps. 2. Check for frayed or severed lamp wiring.	1. Replace lamps that are burned out. 2. Replace frayed or severed wires, or lamps if necessary.

7 RENEWAL PARTS

Renewal Parts may be ordered directly from the factory or sales representatives. To contact your sales representative log on to www.multielectric.com or phone (773) 722-1900.

Table 7 Renewal Parts

Ref.	Part Number	Description
Units 1 - 4	5903-100A	PAPI Assy, 3 light unit, Style A
	5903-100B	PAPI Assy, 3 light unit, Style B
	5556-19	Flange, Floor
	5900-158	Leg Cap Assy, PAPI
	5900-77	Tilt Switch Assy
	5560-73	Mounting Bracket, Tilt Switch
	5903-159	Filter Retainer Assy, PAPI, 3 light unit
	5903-104	Filter Retainer
	5903-107	Lamp Bracket, PAPI, 3 light unit
	5900-105	Filter, PAPI
	779-02	Extension Spring
	9637-05	Lamp, Quartz-halogen, 105W, 6.6A, MR16
	5903-157	Hood Assy, PAPI, 3 light unit
	961-ATP	Coupling Assy, Frangible, 2 in EMT
	964-P	Coupling Assy, Frangible, 1 in Liquid Tight
	2-140	Terminal Block, 2 position
	5900-186	Tilt Driver PCB assembly (Style A only)
	5903-196	Tilt Switch Buffer (Style B only)
	5903-185	Tilt Sensor and Lamp Control (Style B only)
	5900-500-02	Terminal Block Assy (Style A only)
	5903-135	Back Cover (Style A only)
	5903-202	Back Cover Weldment (Style B only)
Unit 5	5920-101	Power And Control Unit (Style A)
	5900-150	Transformer
	1118	Terminal Block, 18 position
	5910-06	Circuit Breaker
	5910-04	Contactor
	5910-07	Socket, Relay
	5910-10	Photo Cell Assy
	5920-185	Master Control PCB assembly
	5920-200	Night Sentinel option PCB assembly
Unit 6	5900-166	Aiming Instrument with Carrying Case
	5900-09	Aiming Instrument

8 SITING THE PAPI

8.1 Siting Considerations.

Siting a PAPI requires consideration of the following: if there is or will be an ILS glide slope, the established glide path (aiming angle, typically 3 degrees), the threshold crossing height (TCH) for the selected aircraft height group, the runway gradient (longitudinal slope) from the threshold to the PAPI location, along with other factors.

8.2 Siting With An ILS Glide Slope

With an ILS glide slope, the PAPI is located at a distance from the runway threshold so that the elevation of the lens center of the light units intercepts the runway at the same location as the virtual source of the ILS glide slope, within a tolerance of ±10 meters (±30 feet), and is aimed at the same angle as the ILS glide slope. The virtual source is the Runway Point of Intercept (RPI), where the glide path intercepts the ground elevation along the runway centerline. PAPI location considers the light beam, where the elevation of the lens center of the PAPI light units should intercept the ground elevation along the runway centerline (within the tolerance).

8.3 Siting Without An ILS Glide Slope

If there is no ILS glide slope, the PAPI is sited as shown in Figure 8.1. First determine the following:

8.3.1 Glide Path

Typically this is 3 degrees, but may vary at some locations.

8.3.2 Threshold Crossing Height (TCH)

The TCH is based on the aircraft using the runway. See Table 8.1 for guidance.

8.3.3 Runway Gradient

The Runway Gradient may be available from record drawings, or determined by field survey. Usually the grade is given as a percent representing the vertical elevation difference over a longitudinal distance (threshold through approximate PAPI location). For example, a 1% grade represents a 0.3 meter (12 inch) height difference over a 30 meter (100 feet) length. This is converted to an angle in degrees, α, using the relationship:

$$\tan \alpha = (\%\ \text{grade})/100$$

With this relationship, a grade of 1% represents a runway slope of 0.573 degrees (from the horizontal).

8.3.4 Runway Reference Point

Determine the Runway Reference Point (RRP) based on runway gradient, as shown in Figure 7.1, establishing the RRP where the elevation of the lens center of the light units coincides with the elevation of the runway centerline. The method provides a direct solution, based on two equations and two unknowns, when the grade of the runway is relatively uniform. The RRP is based on the PAPI light beam, where the elevation of the lens center of the PAPI light units intercept the ground elevation along the runway centerline (within tolerance). Case 4 in Figure 8.1 provides an iteration method for locating the RRP when the runway grade varies significantly through approximately the first 450 meters (1,500 feet).

8.3.4.1 Cross Slope Adjustment

Adjust the location of the PAPI for cross slope or other factors, as required. Several examples of how the location of the RRP or location of the PAPI might be adjusted are presented below. Stay within allowable tolerances and other dimensional requirements of paragraph 8.2. See Figure 8.1 for guidance on tolerances and adjustments if the PAPI cannot be located at the RRP.

8.3.4.2 Rapid Terrain Drop-Off

In the case where the terrain drops off rapidly near the approach threshold and severe turbulence is typically experienced, it would be beneficial to locate the RRP and PAPI farther from the threshold if sufficient runway length is available. In this case consider using the maximum TCH allowed by tolerance in determining the RRP.

8.3.4.3 Shorter Runways

On shorter runways, the RRP and PAPI may be located nearer to the threshold to provide the maximum amount of runway for braking after landing. In this case consider using a lower TCH as allowed by tolerance in determining the RRP.

8.3.4.4 Snowy Areas

At locations where snow is likely to obscure the light beams, the light units may be installed so the top of the unit is a maximum of 2 meters (6 feet) above ground level. This may require locating the light units farther from the runway edge to ensure adequate clearance for the most critical aircraft. If the light beams are higher than the allowable tolerance with respect to the elevation of the runway centerline (raising the TCH for the visual glide path), the PAPI may be relocated closer to the threshold to maintain the RRP and TCH.

8.3.4.5 Sitting Too High or Too Low

The cross slope at the preliminary RRP location may result in the light units sitting too high or too low with respect to the runway centerline elevation. In such cases, the PAPI may be relocated closer to or farther from the threshold in order to maintain the RRP and TCH and remain within tolerance.

8.3.5 Other Dimensions and Tolerances

8.3.5.1 Distance From Runway Edge

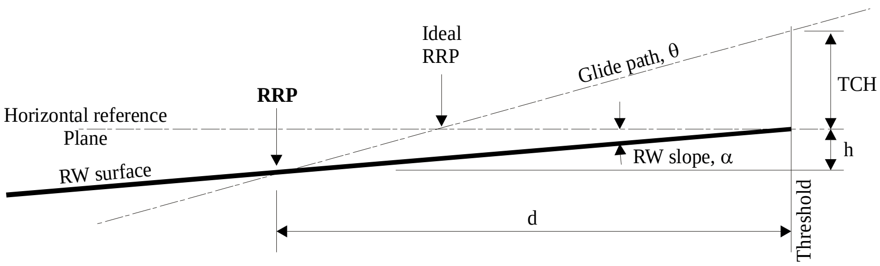
Install the inboard PAPI light unit no closer than 15 meters, +3 meters –0 meters (50 feet, +10 feet –0 feet) from the runway edge, or from the edge of other runways or taxiways.

Table 8.1 Visual threshold crossing heights.

Representative Aircraft Type	Approximate Cockpit-to-Wheel Height	Visual Threshold Crossing Height	Remarks
<u>Height Group 1</u> General Aviation Small Commuters Corporate Turbo-Jets	10 Feet or Less	40 Feet + 5, -20 10 Meters + 2, -6	Many runways less than 6,000 feet long with reduced widths and/or restricted weight bearing which normally prohibits landing by larger aircraft
<u>Height Group 2</u> F-28, CV-340/440/580 A737, DC-9, DC-8	15 Feet	45 Feet + 5, -20 12 Meters + 2, -6	Regional Airport with Limited Air Carrier Service
<u>Height Group 3</u> B-727/707/720/757	20 Feet	50 Feet + 5, -15 15 Meters + 2, -6	Primary runways not normally used by aircraft with ILS glide path-to-wheel height exceeding 20 feet.
<u>Height Group 4</u> B-747/767/777, L-1011 DC-10, MD11, A-300	Over 25 feet	75 Feet + 5, -15 22 Meters + 2, -6	Most Primary runways at major airports.

Figure 8.1 *Siting PAPI without an ILS Glide Slope (1 of 2).*

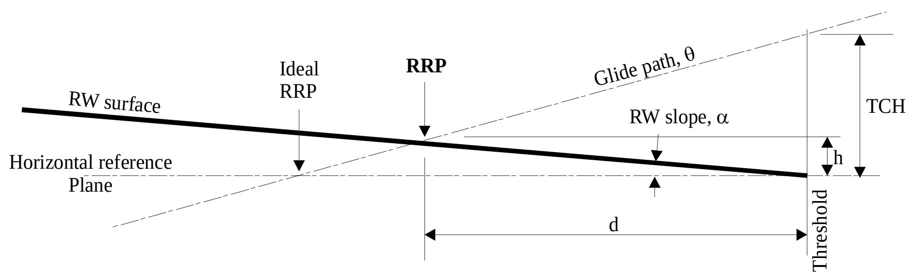
a. Case 1 - Runway with downward grade.



Two relationships can be defined which have two unknowns (d, h): $\tan\theta = \frac{TCH + h}{d}$, and $\tan\alpha = \frac{h}{d}$

Substituting and solving the above, d is determined directly by: $\mathbf{d} = \frac{\mathbf{TCH}}{(\tan\theta - \tan\alpha)}$

b. Case 2 - Runway with upward grade.



From the above relationships, d is determined directly by: $\mathbf{d} = \frac{\mathbf{TCH}}{(\tan\theta + \tan\alpha)}$

EXAMPLES (Assume the following: TCH = 15 meters (50 feet), θ = 3 degrees)

Case 1 (RW with 1% downward grade, α = 0.573 degrees) => d = 50/[tan 3 degrees - tan 0.573 degrees] = 360 meters (1,179 feet)

Case 2 (RW with 1% upward grade,(α = 0.573 degrees) => d = 50/[tan 3 degrees + tan 0.573 degrees] = 244 meters (801 feet)

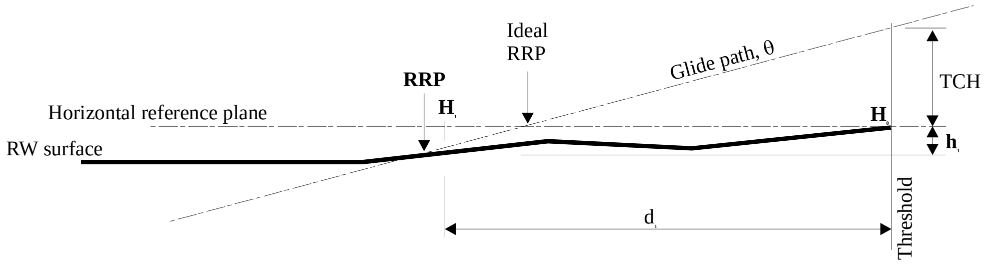
Case 3 (RW is level - 0% grade, α and tan α are both 0) => d = 50/[tan 3 degrees] = 290 meters (954 feet)
[*not illustrated*]

While the slope should be constant through the first part of a runway, if the existing slope varies too much to directly apply Case 1, 2 or 3, then a trial method illustrated by Case 4 can be used. In all cases, the location of the glide path intercept with the actual runway surface (RRP) must be determined.

Case 4 - Runway grade varies too much to apply above methods => [*See sheet 2 of 2*]

Figure 8.1 *Siting PAPI without an ILS Glide Slope (2 of 2).*

c. Case 4 - Runway with varying grade.



Use this method if longitudinal runway grade changes within 671 meters (2200 feet) from the runway threshold. Consider that a 0.1% change in runway grade at about 150M (500') from threshold translates to a 15cm (6") change in elevation at 300M (1,000'), and about a 3M (10') error in calculating the RRP, using the runway grade beginning at the threshold. The trial method requires elevation data along the runway centerline in proximity of the PAPI site.

(1) Select a trial value for d ("d_1"). [*Case 1 or Case 2 can be used to select initial trial value*].

(2) At distance d_1, determine elevation difference from threshold (**H_0 - H_1 = h_1**)

(3) Test d_1 and h_1 in following equation: $$\frac{TCH + h_1}{d_1} =? \tan\theta$$

[*NOTE: tan θ = 0.0524 for glide path angle of 3°.*]

(4) If value in (3) is larger than tan θ , then increase d, determine new h, and test equation in (3). If value is smaller than tan θ , then decrease d, determine new h, and test equation in (3). Continue until within about ± .0001 of tan θ [*this yields a value for "d" within about ± 2' of where RRP should be located.*

EXAMPLE Case 4 (Assume the following: TCH = 50', θ = 3°).

At d_1 = 950', h_1 = 4.2', and (TCH+h)/d = 0.0571 (too large)

At d_2 = 1,000', h_2 = 4.6', and (TCH+h)/d = 0.0546 (closer)

At d_3 = 1,050', h_3 = 5.0', and (TCH+h)/d = 0.0524 (matches tan θ - OK)

[*NOTE: Suggested longitudinal tolerance for locating PAPI is + or - 10 '.*]

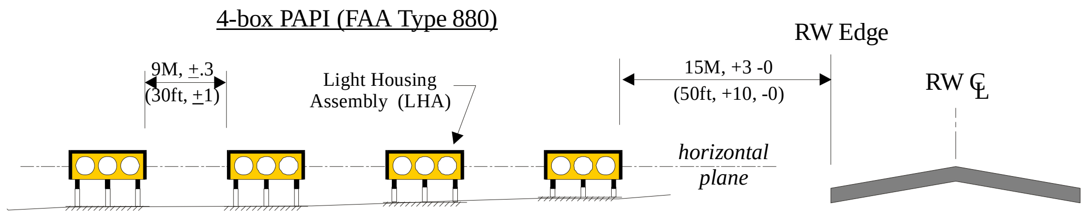
Example data from field survey

Point	Station	d	H	h
Thld, 0	0+00	0	110.4'	-
1	9+50	950'	114.6'	4.2'
2	10+00	1,00'	115.0'	4.6'
3	10+50	1,050'	115.4'	5.0'

DEFINITIONS:

RRP =	RW reference point, where PAPI is located based on adjustment for runway grade.
Ideal RRP =	RW reference point if runway has 0% grade (no slope).
RW =	Runway
TCH =	Threshold crossing height
d =	Distance PAPI is located from runway threshold, based on adjustment for runway grade.
θ =	Glide path angle, degrees (from horizontal).
α =	Runway slope, degrees (use positive value in above equations).
h =	Elevation (height) difference between RW threshold and RRP, measured on RW centerline surface.
H =	Elevation at a point along runway centerline.

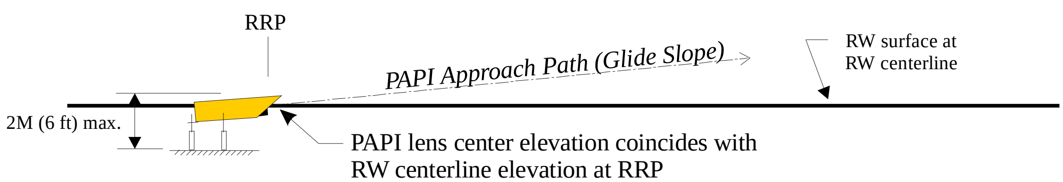
Figure 8.2 *PAPI Positioning Guidance.*



PAPI is located so that <u>center of lenses are level with RW centerline</u> at RRP (Runway Reference Point), within following tolerances:

± 0.3M (1 ft) of RW elevation (lens or beam intercept plane with RW centerline at RRP
± 25 mm (1 in) between LHAs (lens centers of one LHA with lens centers of another)

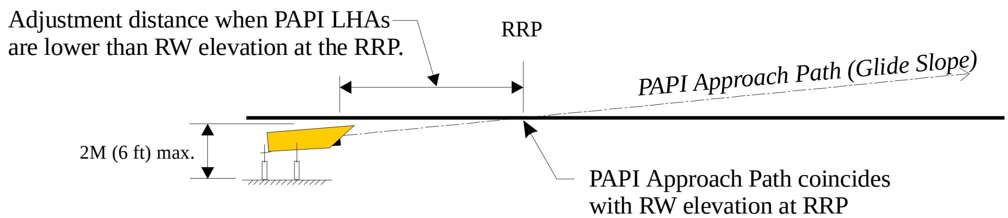
<u>PAPI FRONT (APPROACH) VIEW</u>



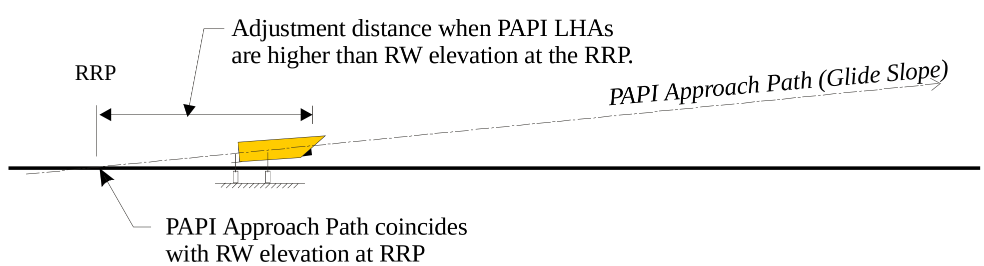
<u>PAPI SIDE VIEW</u>

ADJUSTMENTS TO PAPI LOCATION

A. When lens is **below** RW elevation at RRP.



B. When lens is **above** RW elevation at RRP.



8.3.5.2 Separation Between Light Units

Provide lateral separation of 9 meters (30 feet) between light units. This may be reduced to no less than 6 meters (20 feet) if warranted by conditions. The distance between light units shall be equal and not vary by more than 0.3 meters (1 foot).

8.3.5.3 Azimuth Aiming

Each light unit shall be aimed towards the approach zone on a line parallel to the runway centerline, within a tolerance of ± one-half degree.

8.3.5.4 Mounting Height Tolerance

The beam centers of the four light units shall be within ±2.5 centimeters (±1 inch) of a horizontal plane. This plane shall be within ±0.3 meters (±1 foot) of the elevation of the runway centerline at the intercept point of the visual glide path with the runway (RRP), except for adjustments under conditions in snow or rapid terrain fall off.

8.3.5.5 Tolerance Along Line Perpendicular to Runway

The front face of each light unit in a bar shall be located on a line perpendicular to the runway centerline within a tolerance of ±15 centimeters (±6 inches).

8.3.5.6 Vertical Aiming of Light Beams

For a Type L-880 PAPI system, the units are aimed as shown in Table 8.2. The aiming for a Type L-881 PAPI system is shown in Table 8.3. All angles are in relation to the nominal glide path angle.

Table 8.2 Aiming of Type L-880 PAPI relative to a preset glide path.

	Aiming Angle (in minutes of arc)	
Light Unit	**Standard Installation**	**Height Group 4 Aircraft On runways with ILS**
Unit Nearest Runway	30' Above glide path	35' Above glide path
Next Adjacent Unit	10' Above glide path	15' Above glide path
Next Adjacent Unit	10' Below glide path	15' Below glide path
Unit Farthest from Runway	30' Below glide path	35' Below glide path

Table 8.3 Aiming of Type L-881 PAPI relative to a preset glide path.

Light Unit	Aiming Angle (in minutes of arc)
Unit Nearest Runway	15' Above glide path
Unit Farthest from Runway	15' Below glide path

9 INSTALLATION

9.1 Lamp Housing Assembly Mounting

The PAPI system, like any precision system, requires that the light units be set on a firm and permanent foundation. The LHAs can be set up on three 12" diameter columns of reinforced concrete or on a reinforced concrete pad approximately 48" long x 42" wide. Whether columns or pads are used, the foundations must extend below the local frost line. The PAPI includes universal mounting leg brackets, which allow the PAPI Lamp Housing Assemblies to be mounted on foundation spacings of 16, 18, and 22 inches for the front legs, and 16 or 28 inches front to rear for the rear leg. A typical foundation layout for a 22-inch mount is shown in Figure 10.8.

9.1.1 LHA Mechanical Installation

9.1.1.1 Mounting Leg Assembly

Refer to Figure 10.8 for the assembly of the mounting leg hardware. The installation contractor must supply the 2" EMT to the required length. Refer to Table 9-1 for length references for the conduit.

9.1.1.2 Foundation Mounting

The mounting legs are installed on floor flanges, Multi P/N 5556-19, attached to the concrete base. The installation contractor supplies the mounting hardware for the floor flange. Approved methods of mounting are the use of 3/8" expansion bolt or cast 3/8" threaded anchors with flat washers, lock washers and hex head nuts or bolts. Other methods may be used depending on local codes and customs. Refer to Figure 10.16 for details.

9.1.1.3 LHA Mounting Leg Attachment

The hardware supplied with the mounting leg assembly is used to connect the assembly to the T-Frame on the bottom of the LHA. The two-piece angle brackets can be adapted for each mounting width configuration. New installations are recommended to have a 22" front spread and a 16" spacing from front to back. The pivot points where the two brackets attach are left snug, but not tightened, until aiming in order to relieve stresses caused by leveling and setting of the angles. The bottom bracket should be positioned at approximately the center of the threaded rod on the leg cap to allow sufficient adjustment.

9.1.2 LHA Electro-Mechanical Installation

9.1.2.1 Style A Electrical Mounting

The Style A electrical mounting requires connections between the LHAs and the PCU. The best way to accommodate these connections is by use of a 12" lamp base. This lamp base with cover can contain all cable splices and interconnect wiring terminations. A two-hole cover with 1 1/2" pipe threads may be used with the base. One hole can accommodate the power leads for the lamps, and the other can be used for the tilt signal connections. The electrical connections are made using the Multi Electric 964-P frangible couplings at the base, and 1" liquid tight flexible conduit (provided by the installer) terminated at the rear of the LHA. The lamp power should enter the LHA on the right side, and the tilt signals on the left as viewed from the rear of the unit. Knockouts are provided on the rear cover of the LHA to allow entrance to the unit using a liquid tight conduit connector. The wiring in the flex conduit is 6-foot long cable (longer cable can be ordered is required) with L823 connectors (provided with unit). The wiring should be shortened to the minimum length required before termination. Mating L823 connectors (ordered separately) are used at the base to provide a clean breakaway point.

Table 9.1 Standard Cut Chart for PAPI 2-inch EMT Mounting Legs.

Elevation above Grade In Inches	Front Leg Inches	Rear Leg with 16 in T-Bar Nominal Glide Path				Rear Leg with Long T-Bar Nominal Glide Path			
		2°	4°	6°	8°	2°	4°	6°	8°
24 - 26	11	11	11	10	10	11	11	10	9
26 - 28	13	13	13	12	12	13	13	12	11
28 - 30	15	15	15	14	14	15	15	14	13
30 - 32	17	17	17	16	16	17	17	16	15
32 - 34	19	19	19	18	18	19	19	18	17
34 - 36	21	21	21	20	20	21	21	20	19
36 - 38	23	23	23	22	22	23	23	22	21
38 - 40	25	25	25	24	24	25	25	24	23
40 - 42	27	27	27	26	26	27	27	26	25
42 - 44	29	29	29	28	28	29	29	28	27
44 - 46	31	31	31	30	30	31	31	30	29
46 - 48	33	33	33	32	32	33	33	32	31
48 - 50	35	35	35	34	34	35	35	34	33
50 - 52	37	37	37	36	36	37	37	36	35
52 - 54	39	39	39	38	38	39	39	38	37
54 - 56	41	41	41	40	40	41	41	40	39
56 - 58	43	43	43	42	42	43	43	42	41
58 - 60	45	45	45	44	44	45	45	44	43
60 - 62	47	47	47	46	46	47	47	46	45
62 - 64	49	49	49	48	48	49	49	48	47
64 - 66	51	51	51	50	50	51	51	50	49
66 - 68	53	53	53	52	52	53	53	52	51
68 - 70	55	55	55	54	54	55	55	54	53
70 - 72	57	57	57	56	56	57	57	56	55
72 - 74	59	59	59	58	58	59	59	58	57

** All dimensions are in inches. A level-mounting base is assumed. Adjust all measurements as required by variations in site conditions.

Note: *The front legs can be adjusted for + 2 inches variation in elevation. Care should be exercised to maintain the relative height of each LHA to the runway crown.*

9.1.2.2 Style B Electrical Mounting

In order to contain the 300W isolation transformers required for the Style B system, a lamp base measuring 16" in diameter and 24" deep should be installed as close as is practical to the rear leg of each PAPI LHA. A single-hole cover is used when tilt switches are not required at each PAPI LHA. When tilt switches are required, two-hole covers are used with 1-1/2" pipe threads. The series power interconnects are terminated at the base through a 1-1/2" pipe thread hole using a Multi 964-P frangible coupling and a cable with L-823 connectors. All tilt switch connections are made through the remaining Multi 964P couplings. The connections to the LHA are made in the rear panel with 1-1/2" knockouts for liquid tight connectors. The installation contractor supplies the 1" liquid tight flexible conduit and connectors at the LHA as required.

9.2 Style A Power and Control Unit Mounting

Figures 10.9, 10.10 and 10.11 show the PAPI PCU mounting options. The PCU is mounted as close to the LHA furthest from the edge of the runway as is practical. The PCU may be mounted behind or beside the LHA farthest from the runway. Mounting in front of the LHA should be avoided.

9.3 Aiming the Lamp Housing Assemblies

It is imperative that the PAPI Boxes be positioned properly. The aiming device, shown in Figure 10.14, is used to accurately adjust the LHAs to their proper settings. After the visual glide path angle has been determined, the PAPI units are aimed to define the glide path. The standard aiming angles for Type L-880 and Type L-881 systems are shown in Tables 8.2 and 8.3. Alternate angles may be required due to unique site conditions.

9.3.1 Removing the Lamp Housing Assembly Hood

To aim the PAPI unit, the hood must first be removed. This is done by loosening the two thumbscrews at the back of the unit and sliding the cover forward slightly while lifting it from the unit.

9.3.2 Leveling the Front of the Lamp Housing

Set the Aiming Device to "0" as indicated on the Cam Scale located on the channel side, and lock it in this position with the knurled nut. Check the horizontal adjustment of the unit by placing the Aiming Device across the front lens holder castings and adjusting the nuts on the continuously threaded studs on the leg cap assembly until the bubble in the level on the aiming device is centered. Tighten the jam nuts on the bottom and top of the lower bracket. Check to see that the bubble is still centered. Refer to Figure 10.13.

9.3.3 Setting The Lamp Housing Angle

Determine the proper aiming angle for each Lamp Housing Assembly. Set the aiming device to the proper angular setting for each Lamp Housing Assembly. The precision cam has markings at intervals of 10 minutes of arc between the angles from 0 to 10 degrees. Center the pointer between the divisions for 5 minutes increments. Place the aiming device on the left side of the PAPI box (facing the box from the lens side--refer to Figure 10.14), bridging across the lens holder casting and the filter holder bracket top surface. There are notches in the lens holder casting to properly position the aiming device. Use the adjusting nuts on the threaded stud of the rear leg assembly to center the bubble in the level. Tighten the jam nuts on the bottom and top of the lower bracket. Check to see that the bubble is still centered. Then tighten the pivot nuts on all three mounting legs. Re-check the aiming angle and make any corrections as necessary.

9.3.4 Setting The Tilt Switch

Once the PAPI unit is set to the proper angle, the tilt switch must be set. Power must be applied to the PAPI system while adjusting the tilt switch. Loosen the two locking screws that hold the Tilt Switch Assembly to its mounting bracket approximately one turn. Turn the adjustment screw (the screw closest to the back cover) in either direction such that the Tilt Switch Assembly is perpendicular to the ground, and the green LED is illuminated on the printed circuit board (Tilt Driver PCB assembly for Style A, Tilt Switch Buffer PCB assembly for Style B) inside the LHA. Next, turn the adjusting screw counterclockwise until the green LED is no longer lit. Then turn the adjusting screw clockwise just until the LED lights up again. While making certain not to shake the LHA or the Tilt Switch Assembly, continue turning the adjusting screw clockwise for another ½ turn, or until the LED lights steadily. The lit LED indicates that the unit is NOT in tilt. The LED should not waver due to minimal vibrations, such as those produced by lightly tapping on the top of the Tilt Switch Assembly with one's fingertip. If the LED does respond to such minimal vibrations, the tilt should be re-adjusted. Finally, secure the two locking screws. Repeat this procedure for each of the LHAs.

9.4 Electrical Connections - Style A

Typical electrical connections for a Style A system are shown in Figures 10.2 and 10.3.

9.4.1 Power and Control Unit

The Power and Control Unit requires a three wire power feed with a solid neutral. The required connections for the PCU include:

A. A 120/240vac power supply at TB-1 positions L1-L2-N.
B. Power connections from X1-X2-X3 of the transformer to the PAPI housings.
C. Tilt signal connections between the PCU and the LHAs. For example, TB-1 positions 1+ and 1- should be connected to PCU+ and PCU- in LHA 1, 2+ and 2- to LHA 2, and so forth.
D. Connection of the Photo Cell. The red lead connects to TB-1 position 12V, the black lead connects to TB-1 position 0V and the blue lead to TB-1 position SGL.

9.4.2 Power and Control Unit with Night Sentinel Option

The Power and Control Unit with Night Sentinel option requires:

A. Connections as per 9.4.1 A thru D.
B. Connection of an L830 Isolation Transformer primary to the runway circuit.
C. Connection from the L830 Isolation Transformer secondary to TB-1 positions C1 and C2.

9.4.3 Transformer Configuration And Setup

The PCU is pre-configured for 240V and standard night intensity operation. The PCU transformer comes with multiple input taps to configure the input voltage to local site conditions, and to select an ultra-low night intensity where ambient conditions would warrant its use. To make these settings follow table 9.2 below:

Table 9.2 Power Transformer Configuration Options.

Nominal Input Voltage	Range		Move the Wire	
	Low	High	From	To Tap
216 Vac	216	218	H1	1
224 Vac	218	228	H1	2
232 Vac	228	236	H1	3
Factory Set 240 Vac	236	244	H1	H1
248 Vac	244	251	H1	4
254 Vac	251	258	H1	5
262 Vac	258	265	H1	6
268 Vac	265	268	H1	7
Night Intensity Options				
Standard Night	Factory Setting		H3	H3
Ultra-Low Night	Option		H3	H2

9.4.4 PAPI Lamp Housing Assembly

The PAPI Style A Lamp Housing Assembly requires:

A. Connection of power leads (Power and Control Unit X1-X2 or X2-X3) to the large Terminal Block Assembly, Multi P/N 5900-500-02. The lamps are connected to the opposite side of the Terminal Block Assembly.
B. Connection of the tilt signal leads to the Terminal Block, Multi P/N 2-140, marked PCU. The + and – positions in the LHA correspond to the + and – positions on the PCU, respectively.

9.4.5 Wire and Cable Sizes

Properly sized wire and cable are critical to proper performance of the PAPI system. Variations in run lengths and installation practices have a direct impact on the size of the cabling required. Table 9.3 below is a standard reference point to select cable sizes.

Table 9.3 Wire Size Recommendations

Connection	Run Length Point to Point	Recommended Cable Size
Primary Power L-880	10 to 100 feet	# 8 AWG
	100 to 500 feet	# 6 AWG or Larger
	500 to 1000 feet	# 4 AWG or Larger
	1000 to 2000 feet	# 1 AWG or Larger
	2000 +	Use of Step-Up /Step-Down Transformers recommended
Primary Power L-881	10 to 100 feet	# 10 AWG
	100 to 500 feet	# 6 AWG or Larger
	500 to 1000 feet	# 4 AWG or Larger
	1000 to 2000 feet	# 2 AWG or Larger
	2000 +	Use of Step-Up /Step-Down Transformers recommended
Lamp Loops L-880	10 to 50 feet	# 6 AWG or Larger
	50 to 100 feet	2 - # 6 AWG or Larger or 1 - # 4 AWG or Larger
	100 to 200 feet	2 - # 4 AWG or Larger
Lamp Loops L-881	10 to 50 feet	# 8 AWG or Larger
	50 to 100 feet	# 6 AWG or Larger
	100 to 200 feet	# 4 AWG or Larger
Tilt Switch	Up to 200 feet	# 14 AWG or Larger

9.5 Electrical Connections - Style B

Airport lighting circuits typically use #8 AWG 5000V copper wire. This cable run connects the secondary of the regulator to the primary of the isolation transformers in each of the lamp bases. One cable connector kit, Multi #965-3, is required in each of the lamp bases to connect the cable entering and exiting the lamp base. The primary leads of the isolation transformers provide the other connectors required. A single 300-watt transformer is used with a cable and L823 plug for each PAPI unit. Typical connections are shown in Figures 10.5 and 10.6.

9.5.1 PAPI Lamp Housing Assembly

The Style B PAPI Lamp Housing Assembly requires:

A. Connection of a 300-watt isolation transformer secondary to the Terminal Block marked “6.6A/300W”.
B. Connection of the tilt signal circuit loop. This is effectively a series circuit loop, with each “OUT” position on an LHA connected to the “IN” position on the next LHA in the loop.

Figure 10.1 *Style A LHA Parts Illustration*

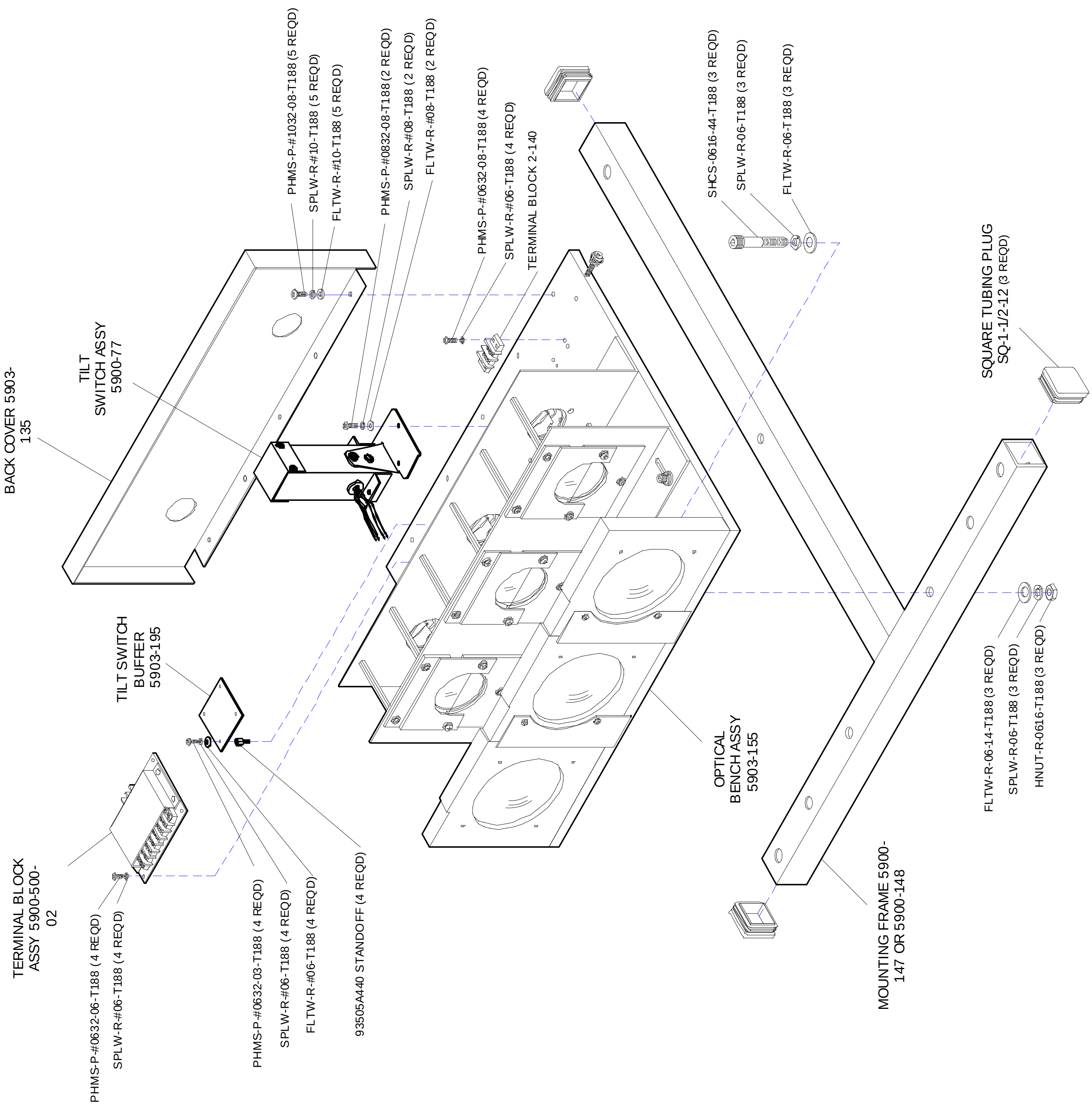


Figure 10.2 *L-880 Style A Wiring Diagram*

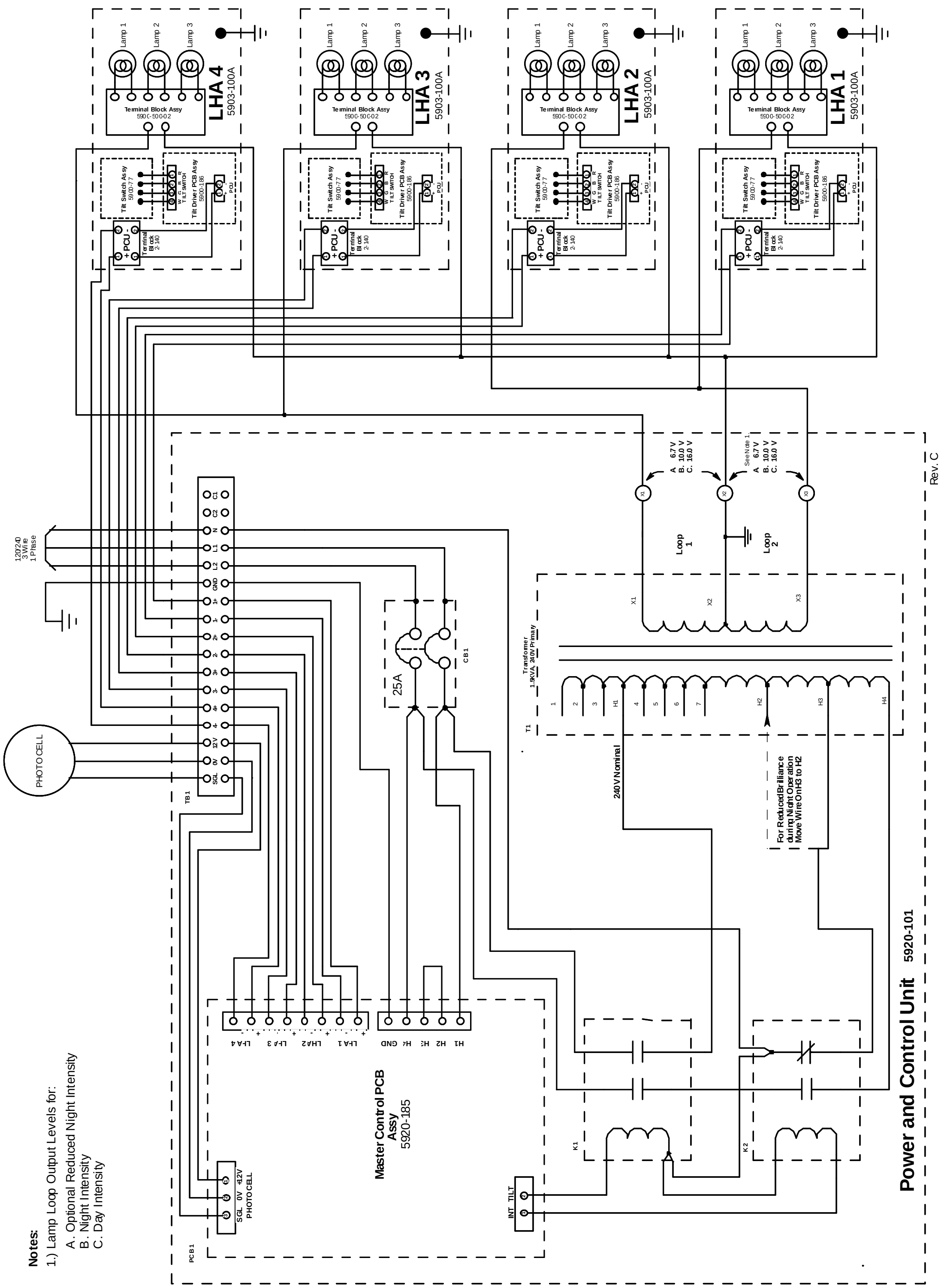


Figure 10.3 *L-881 Style A Wiring Diagram*

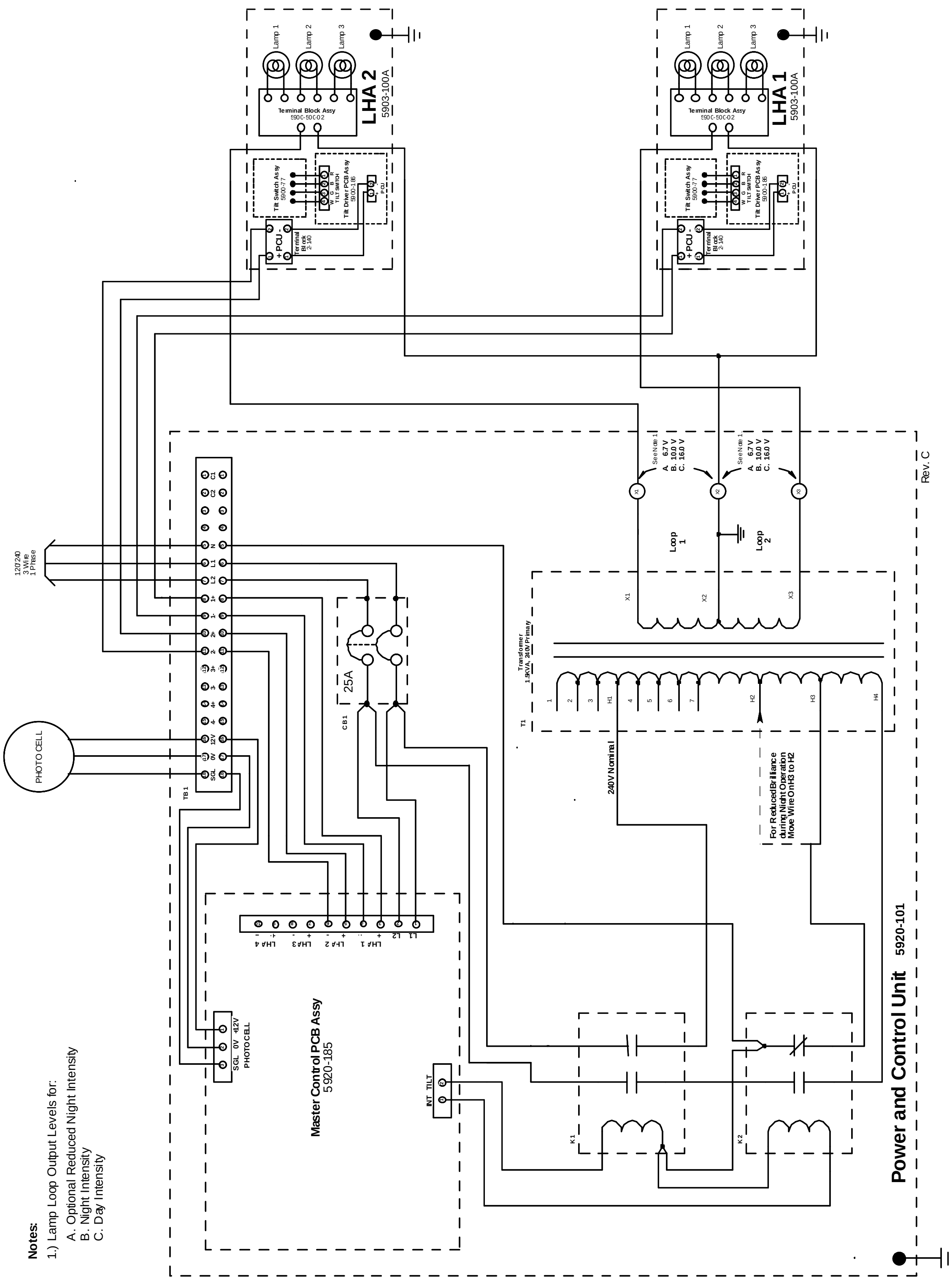


Figure 10.4 *Style B LHA Parts Illustration*

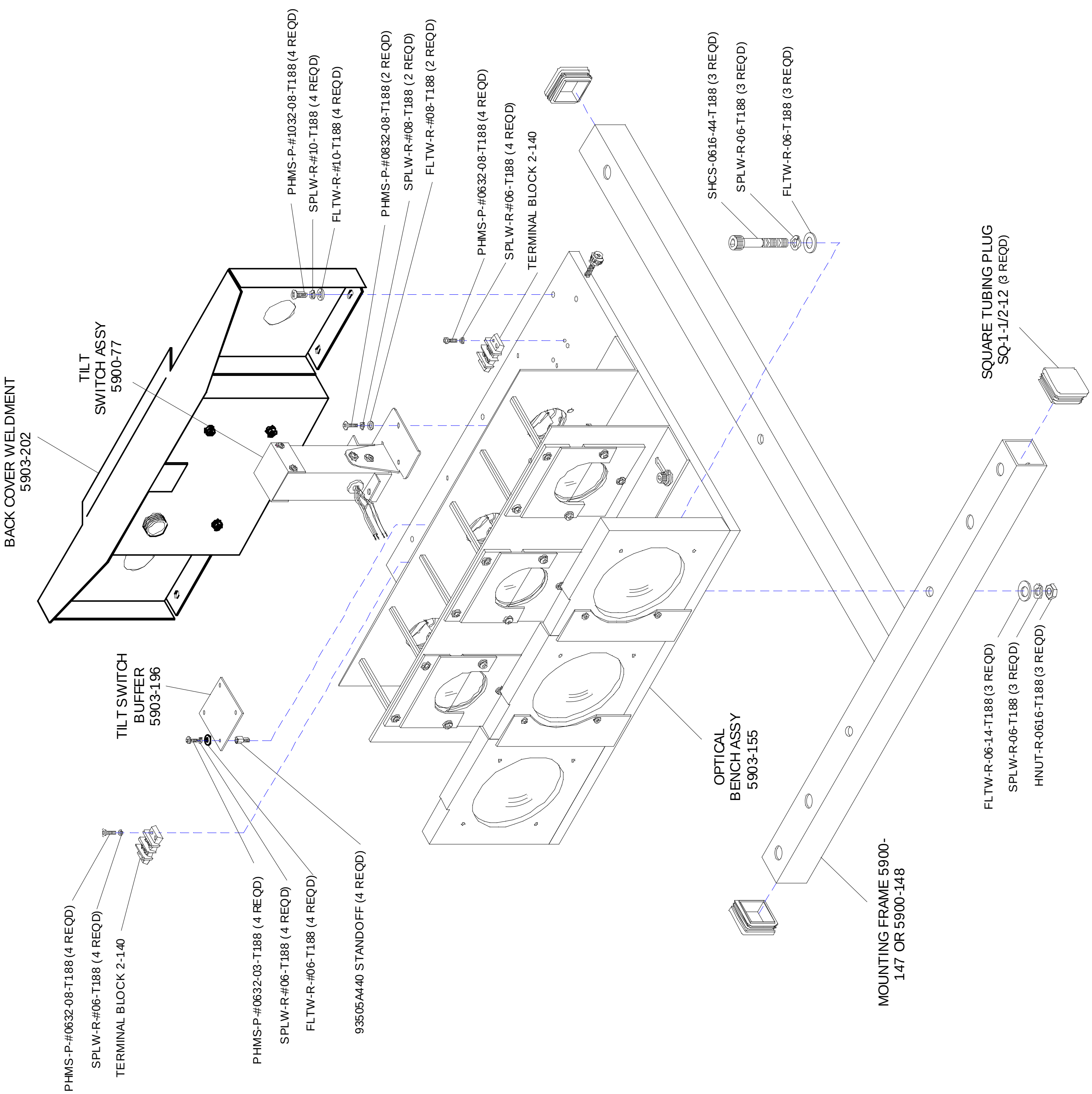


Figure 10.5 *L-880 Style B Wiring Diagram*

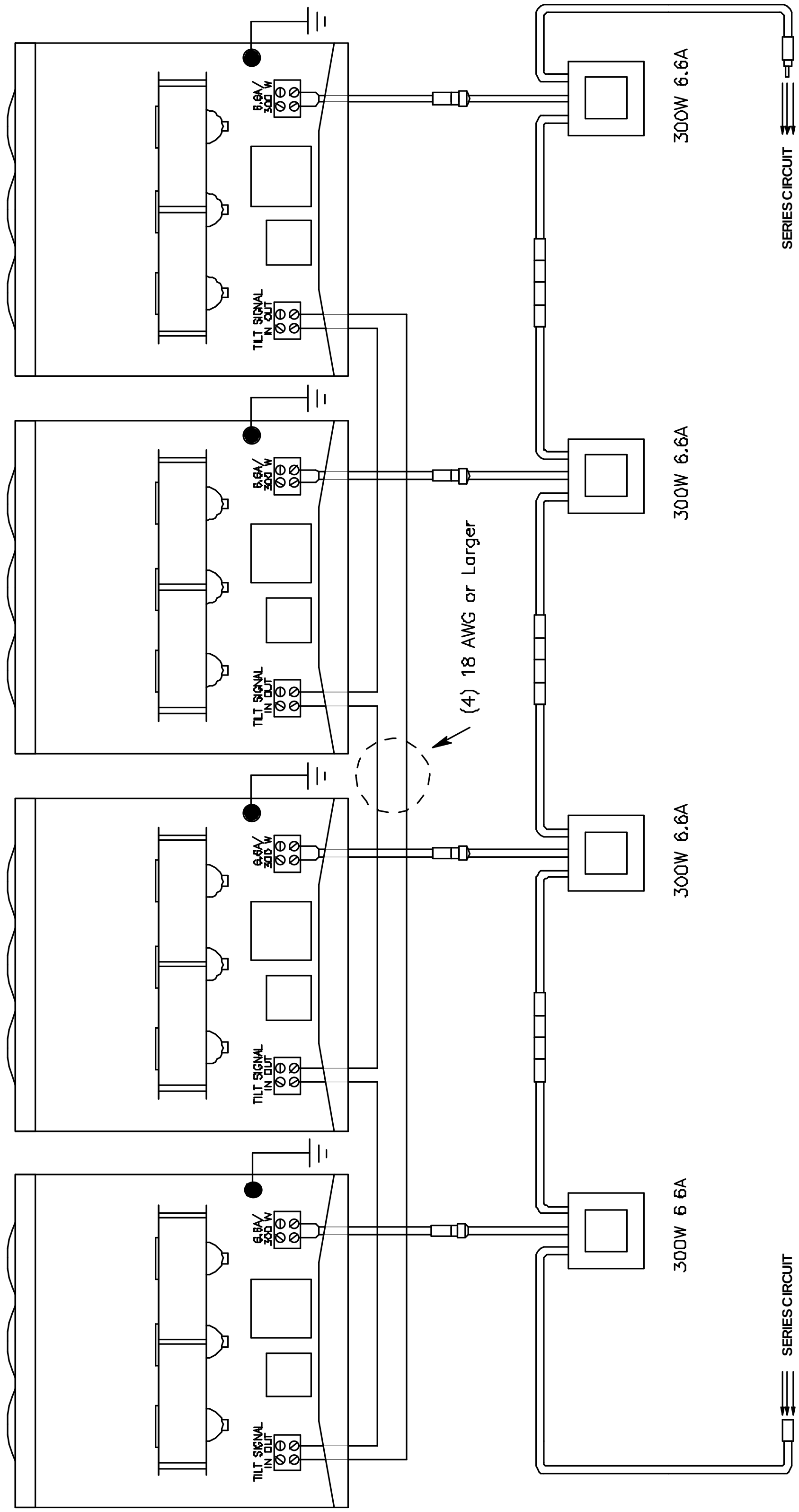


Figure 10.6 *L-881 Style B Wiring Diagram*

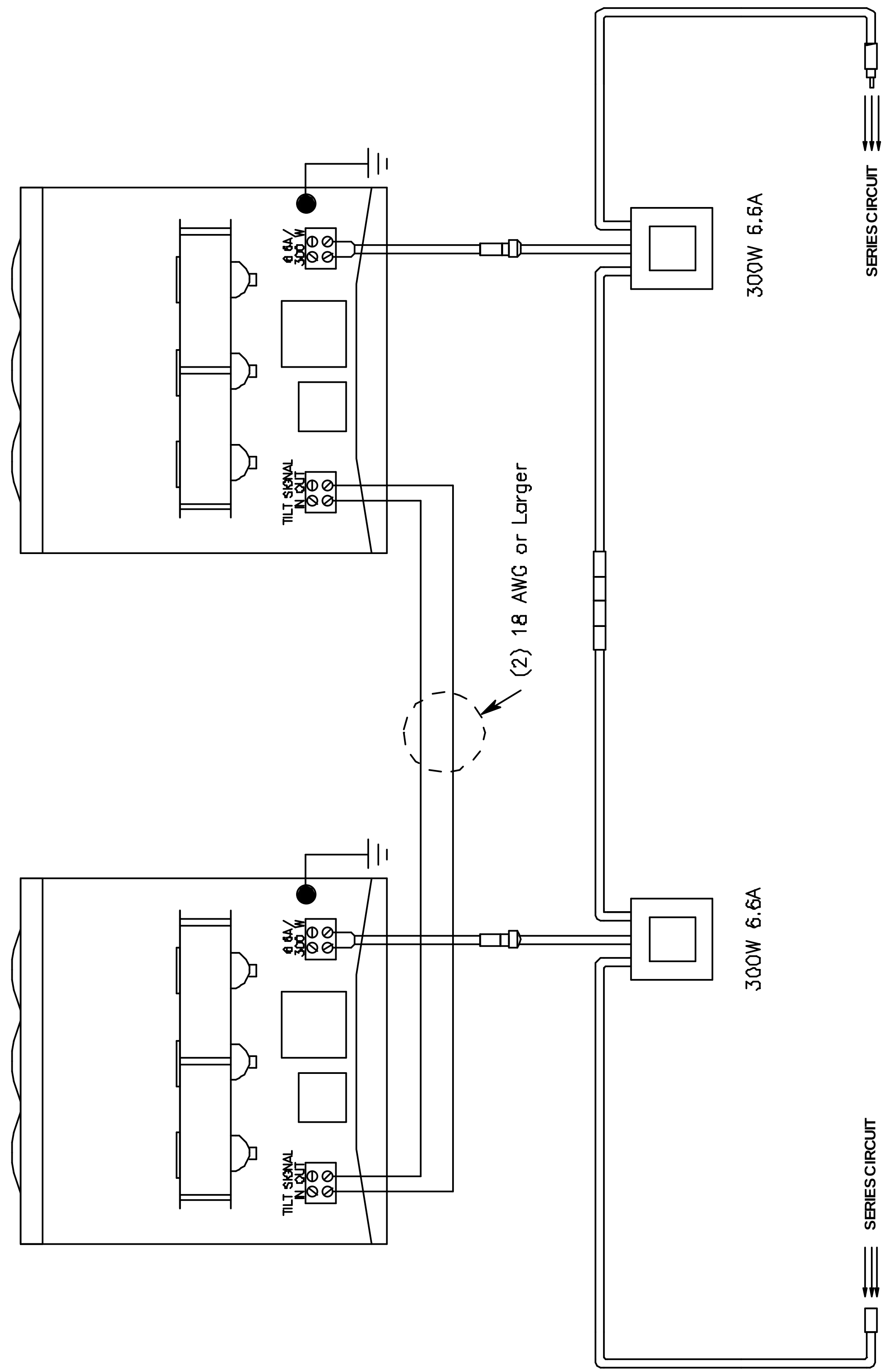


Figure 10.7 *Style B LHA Wiring Detail*

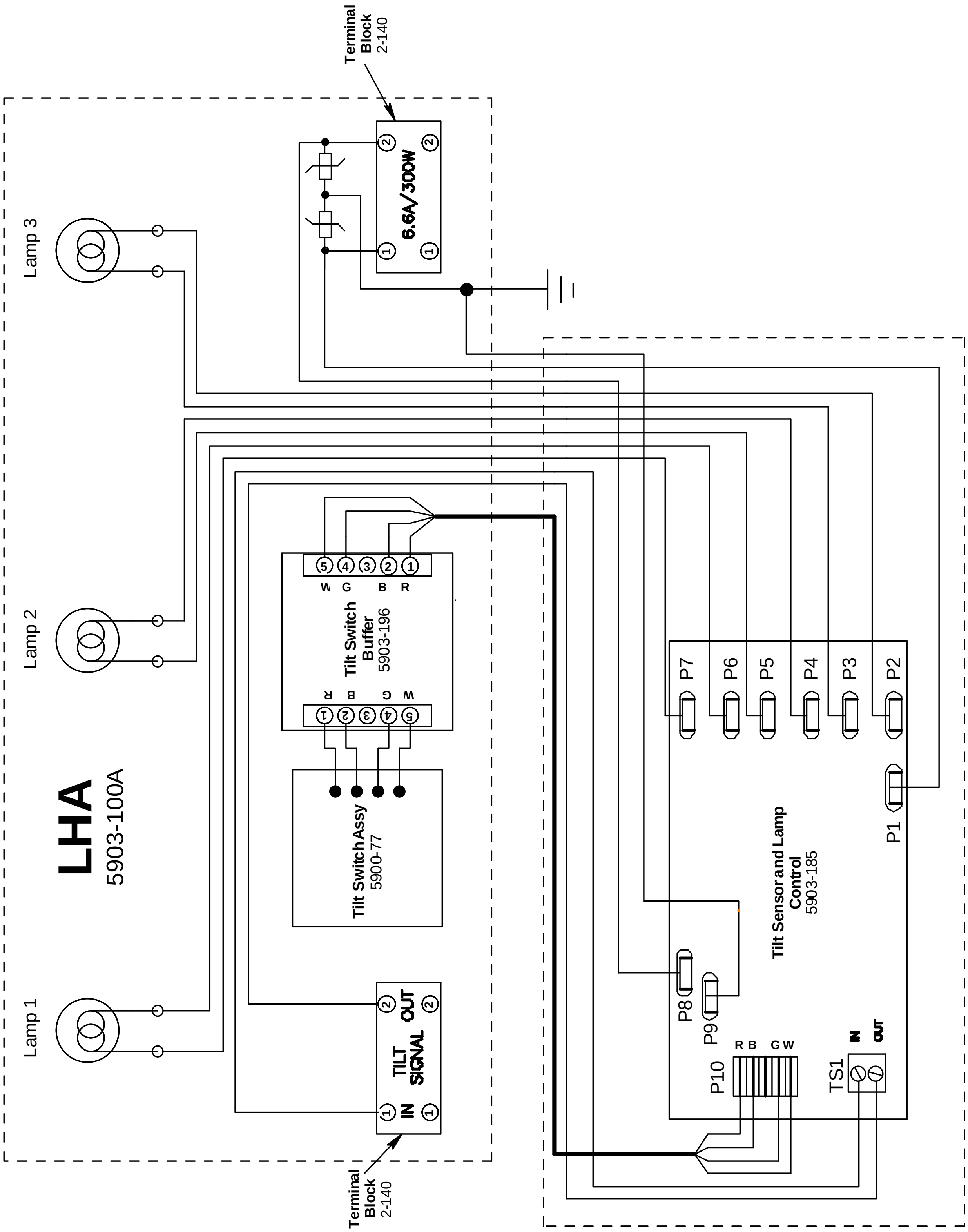
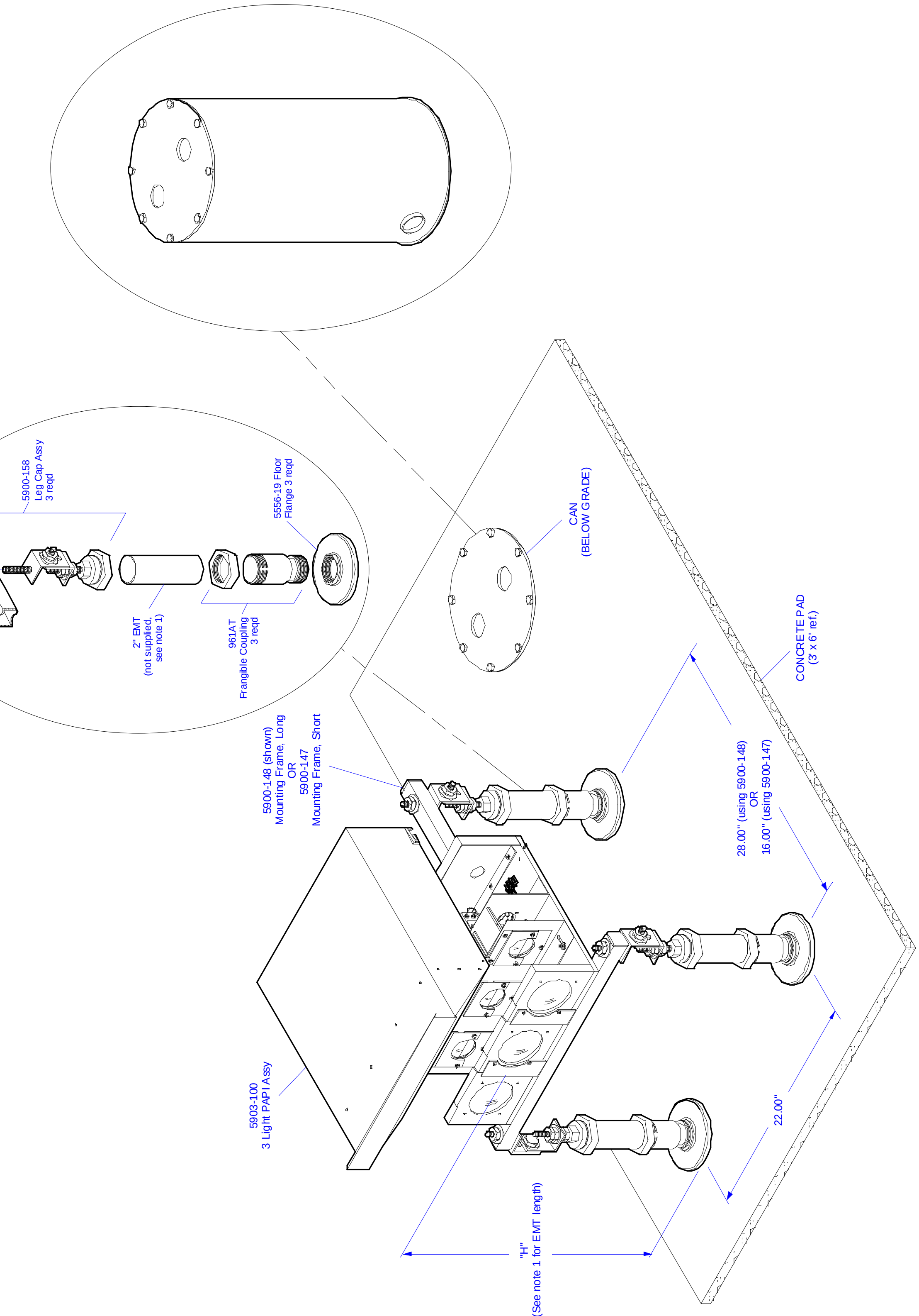


Figure 10.8 *LHA Foundation Layout*



NOTES:

1. To calculate EMT length required, subtract 15.50 inches from desired overall height. Example, if "H" = 51.50", 51.50" - 15.50" = 36.00 EMT length.

Figure 10.9 *Channel Mounted PCU*

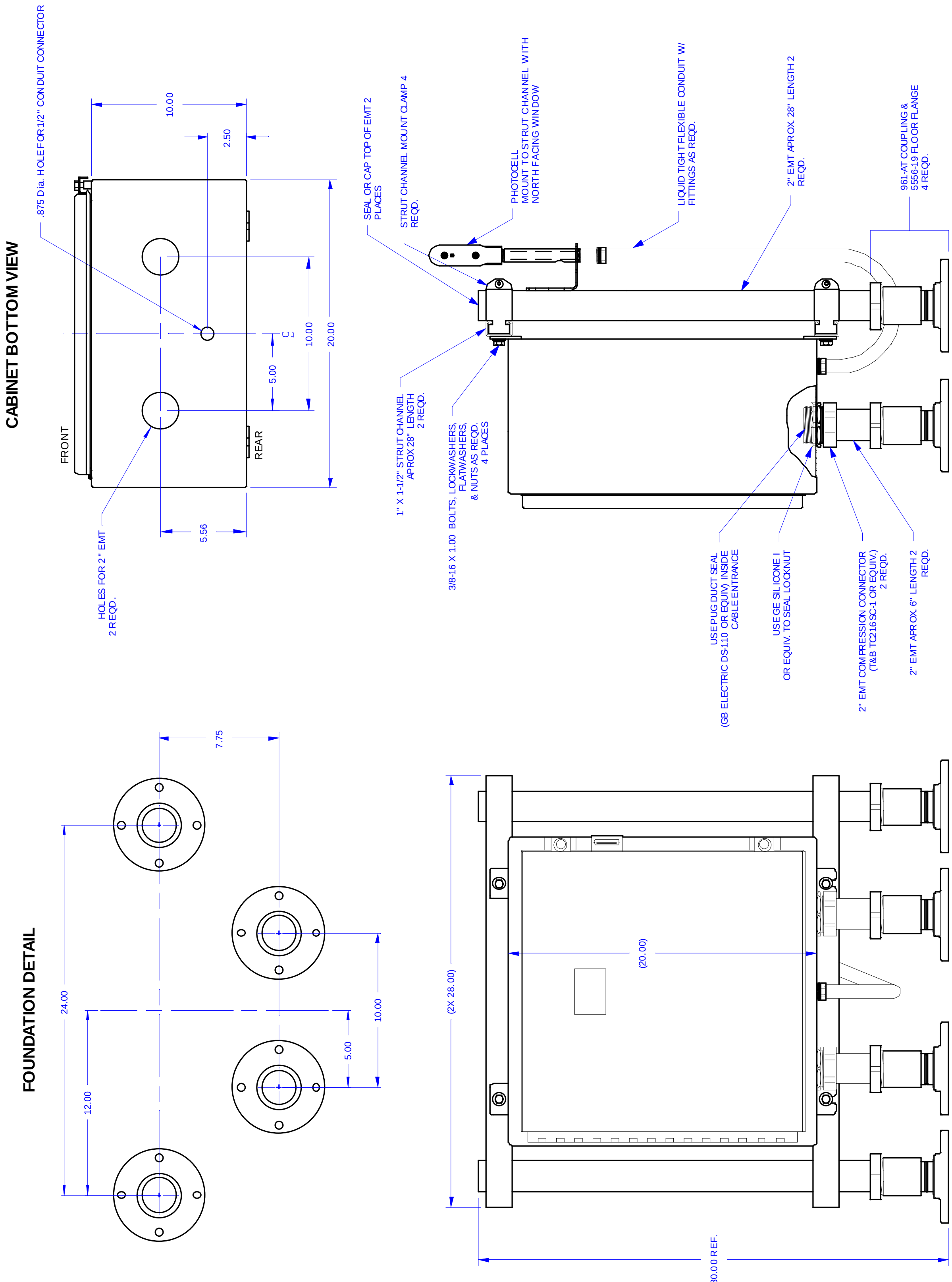


Figure 10.10 *Low Profile PCU Mount (Option 1)*

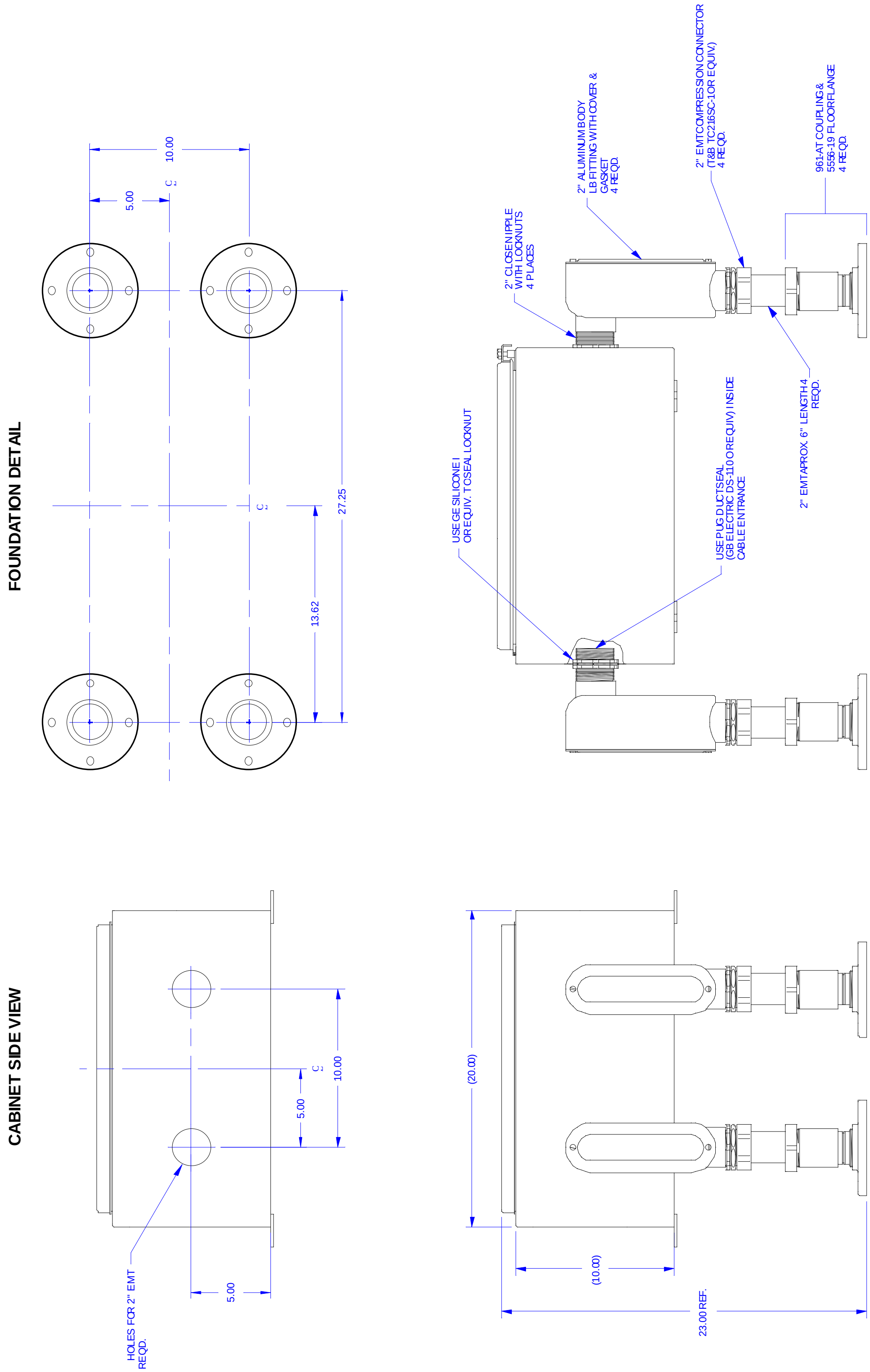


Figure 10.11 *Low Profile PCU Mount (Option 2)*

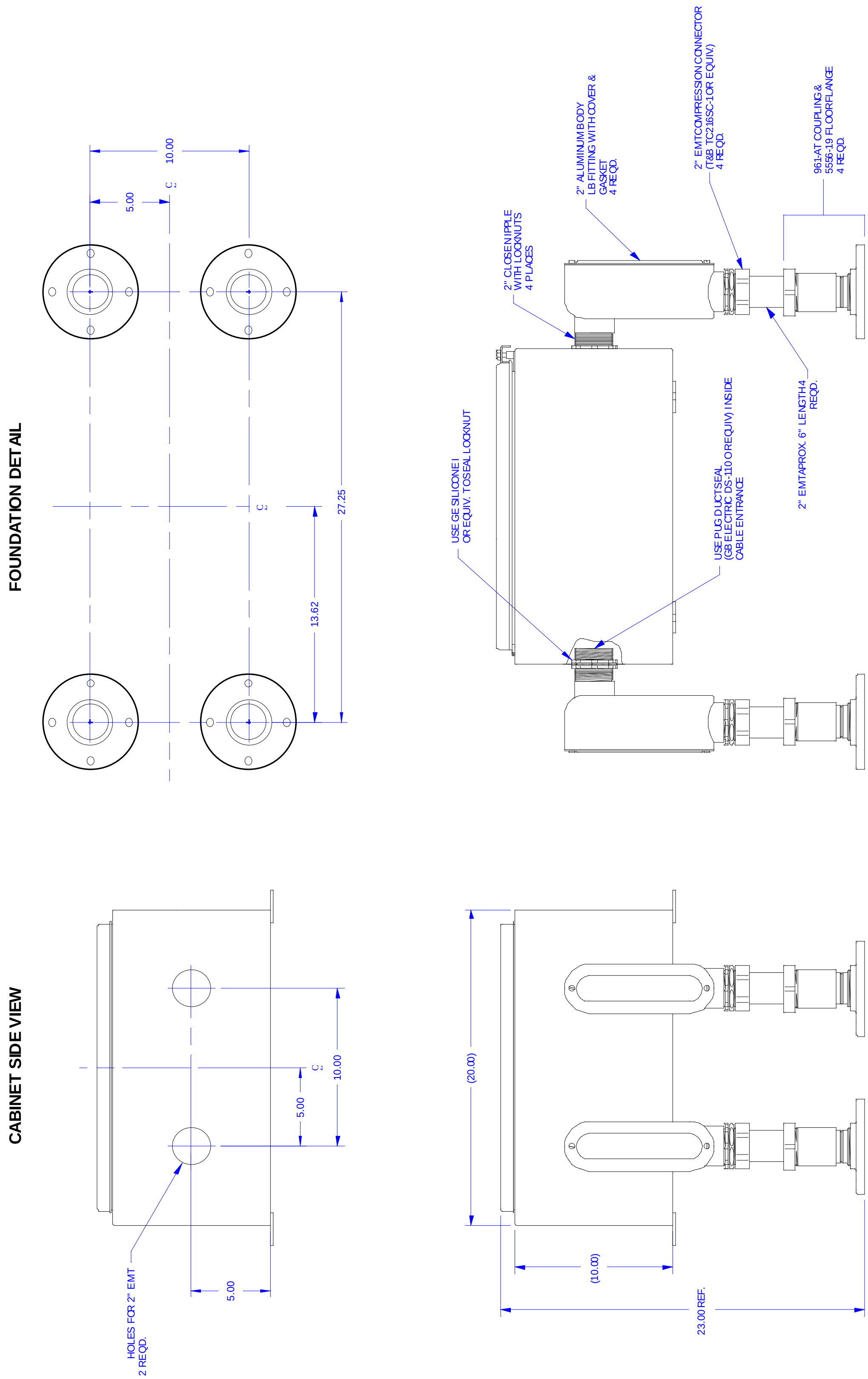


Figure 10.12 *Aiming Instrument*

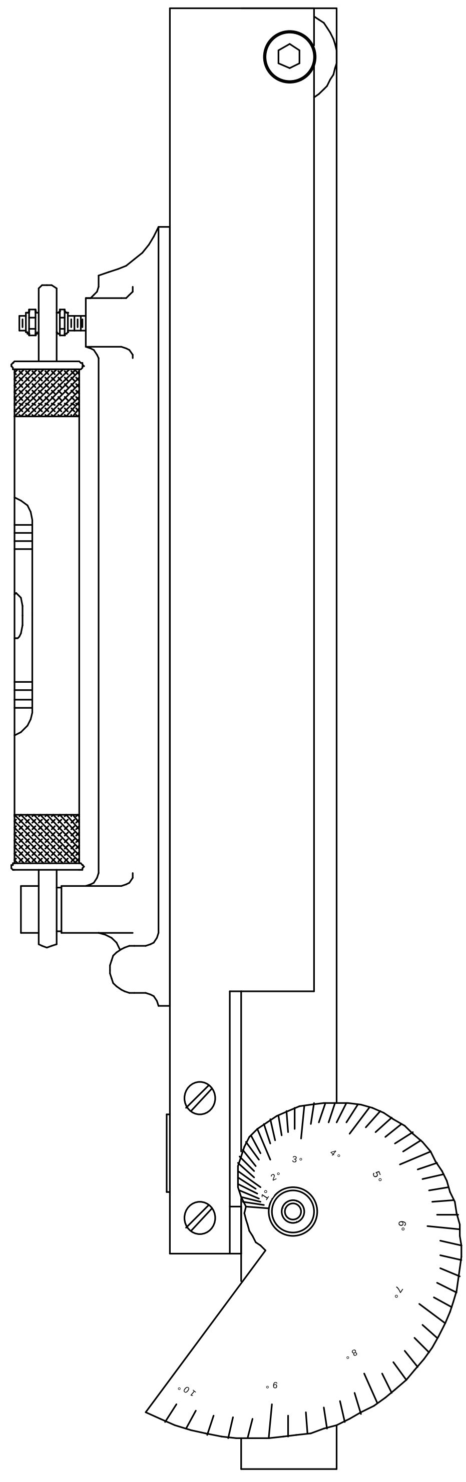


Figure 10.13 *Front Leveling*

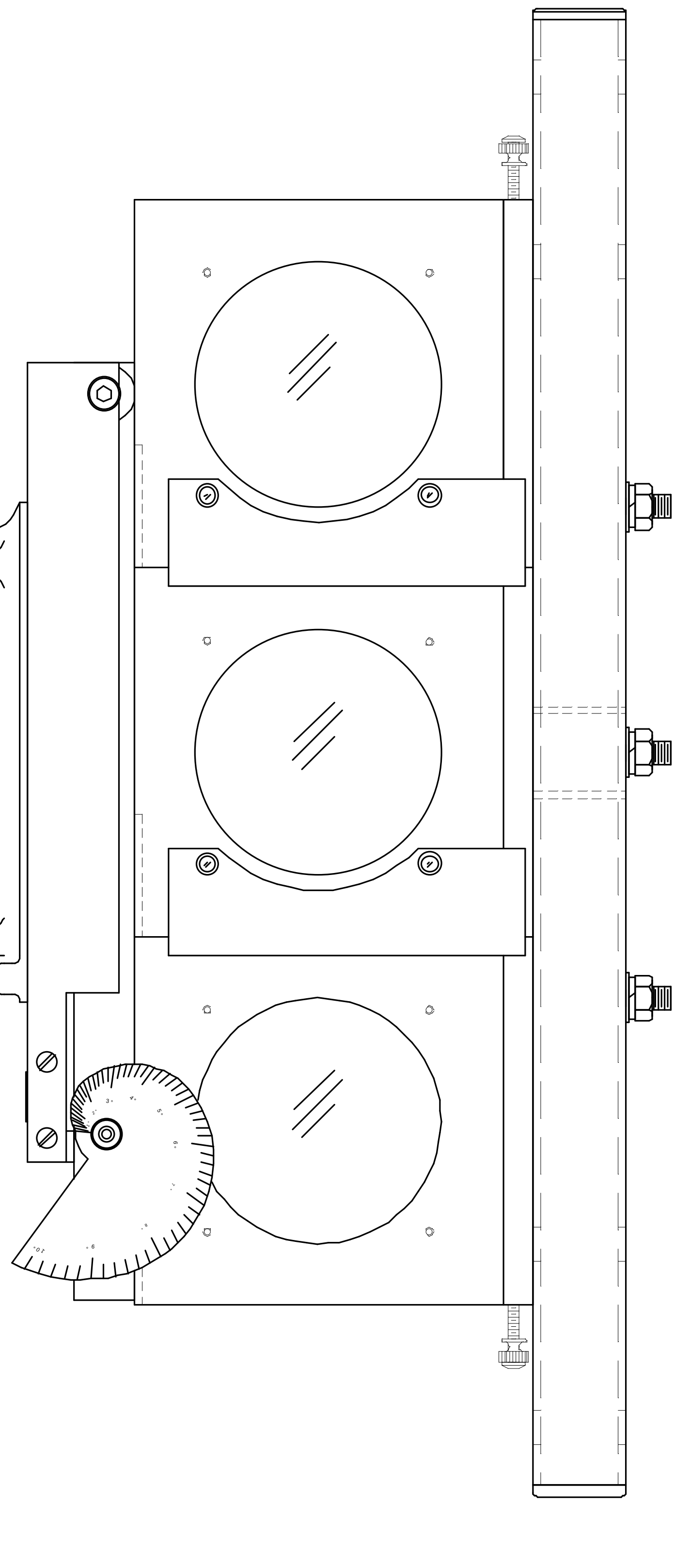


Figure 10.14 *Positioning Aiming Device for Setting Angle of the LHA*

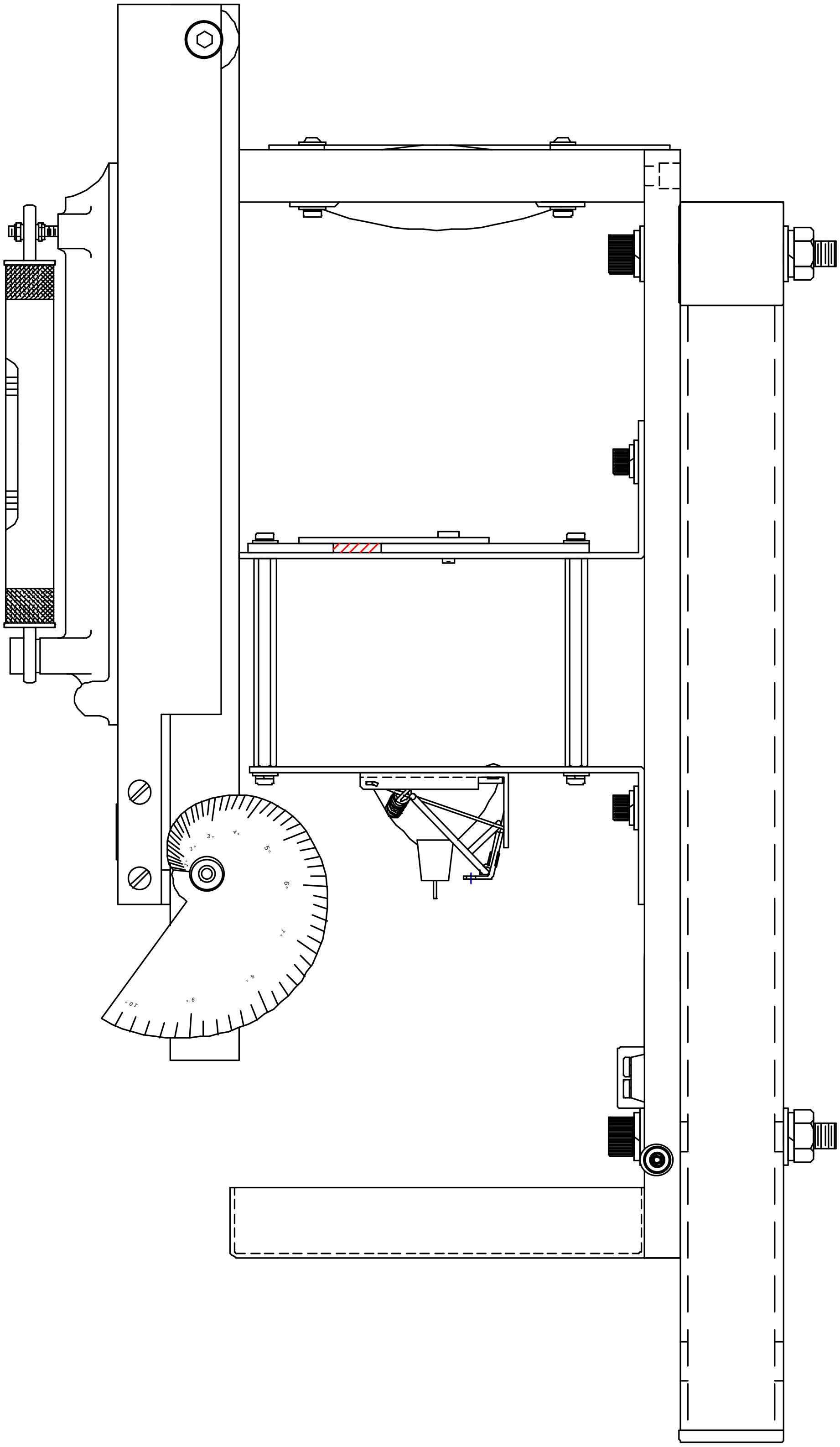


Figure 10.15 *Red Filter Replacement*

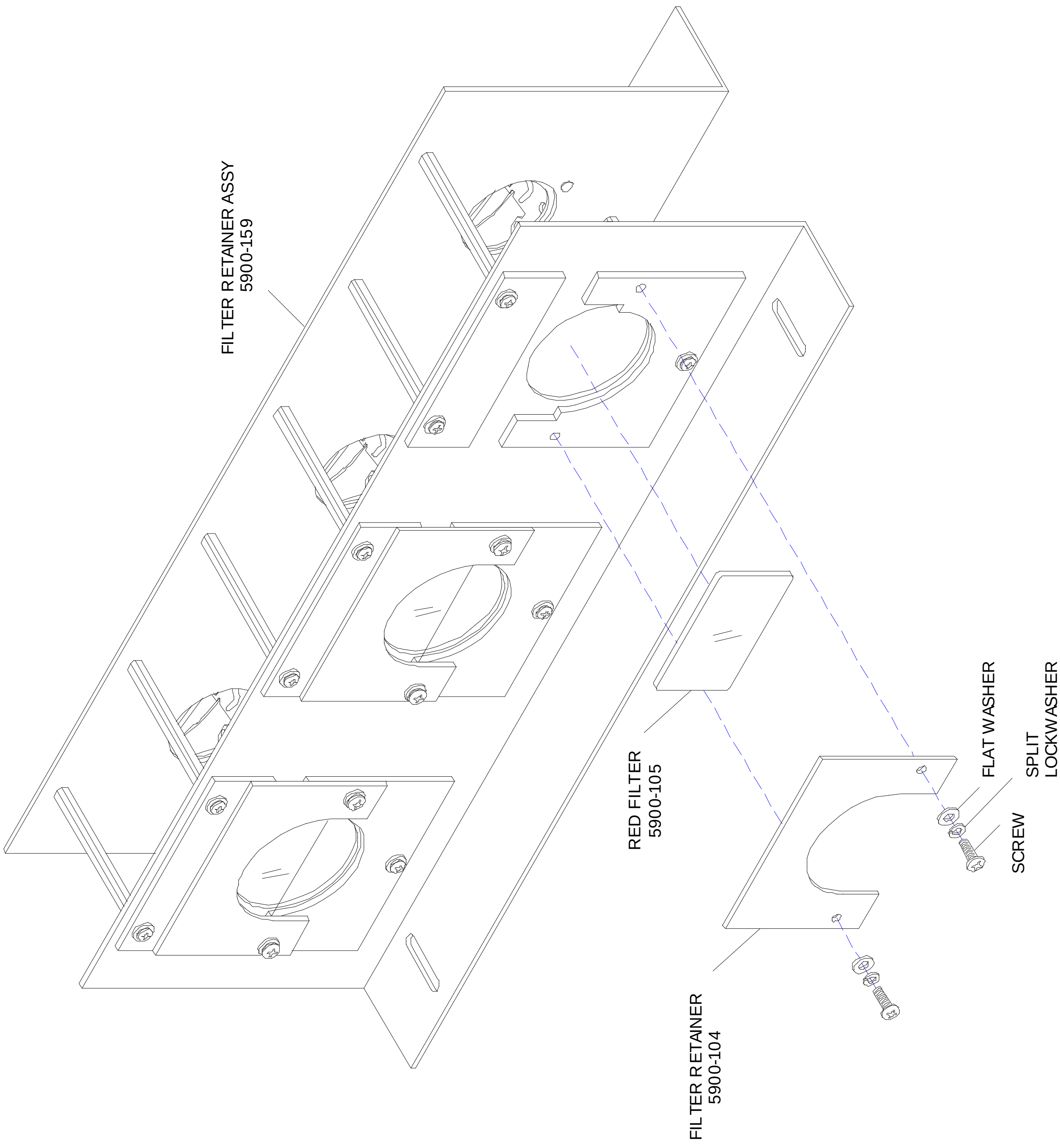


Figure 10.16 *Foundation Detail*