

Errata

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**HEWLETT
PACKARD**

OPERATING AND SERVICE MANUAL

5501A LASER TRANSDUCER SYSTEM

SERIAL PREFIXES

This manual applies to 5501A Laser Transducer Systems with serial prefix 2208A. For serial prefixes above 2208A, a change sheet is included with the manual. For serial prefixes below 2208A, refer to Appendix E, Backdating.

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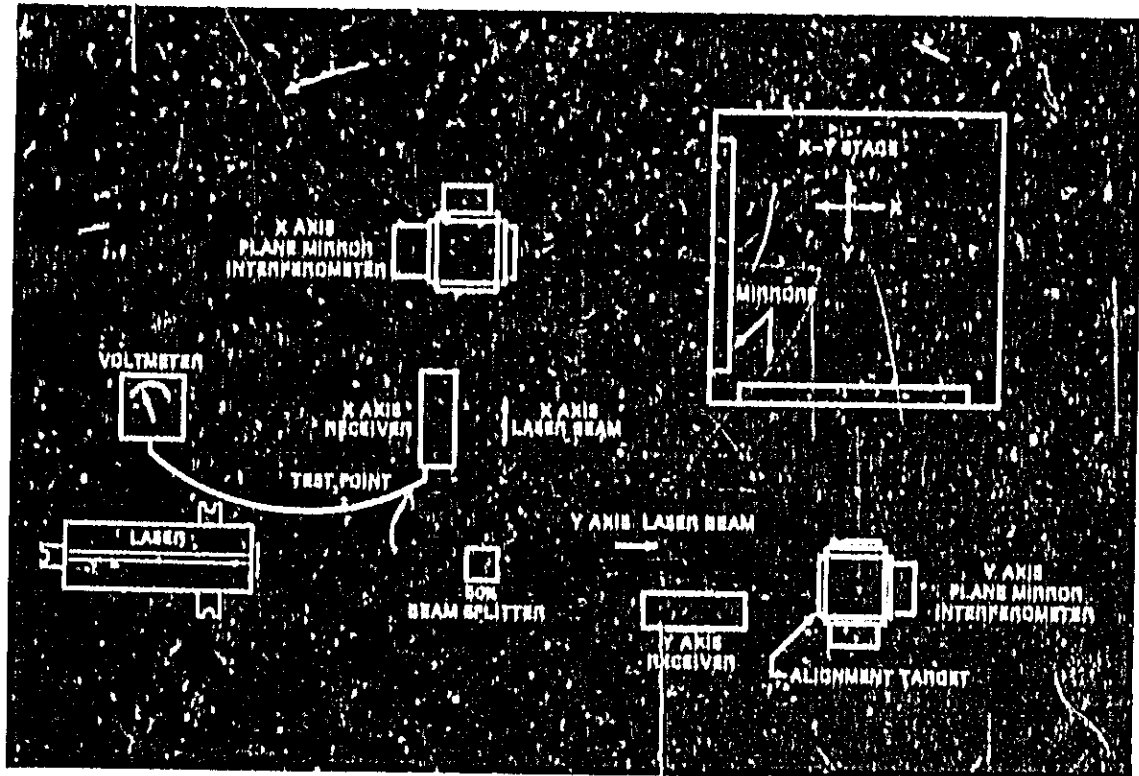


Figure 2-55. Plane Mirror Interferometer Alignment

NOTE

Steps 1 through 10 constitute the Y-axis alignment.

1. Place the interferometer alignment target on the laser side of the Y-axis plane mirror interferometer and the receiver alignment target on the receiver (Figure 2-53c, position 7). Place a piece of opaque material between the Y-axis plane mirror interferometer and the mirror.
2. Adjust the laser head until the laser beam passes through the 50% beam splitter, enters one hole of the interferometer alignment target and exits the other centered on the receiver alignment target. Lock down the laser head securely.
3. Select the small aperture of the front turret of the laser head and install the alignment aid on the output of the plane mirror interferometer in the correct orientation. Remove the opaque material from between the plane mirror interferometer and the mirror.
4. The laser beam will now exit the interferometer and be reflected by the mirror upon itself back into the interferometer. Angularly adjust the plane mirror interferometer until the beams reflected from the mirror returns through the plane mirror interferometer and back to the small aperture of the laser head. Slight lateral adjustments of the plane mirror interferometer may be required to ensure that the reference beam is still centered on the receiver alignment target. If the distance between the mirror and the laser head is at least 0.5 metres (20 inches) then the formula given in the section on Visual Alignment determines the cosine error based on the offset of the return beam at the laser head.

NOTE

For high accuracy alignment and installations where there is less than 0.5 metres (20 inches) between the laser and mirror, perform steps 5 through 7.

5. Remove the receiver alignment target and plane mirror interferometer alignment target and rotate the turret of the laser head to select the large aperture. Do not remove the plane mirror interferometer alignment aid on the output side of the plane mirror interferometer.
6. With a fast responding voltmeter (preferably a meter type) attached to the receiver test point, fine adjust the plane mirror interferometer angularly until a signal is received on the receiver. (The voltmeter will suddenly jump to some value greater than 0.25 volts.) This is a critical adjustment and may initially require great care to achieve the desired result.
7. Peak the voltmeter reading (which will be fluctuating) by fine adjusting the plane mirror interferometer in both angular axes. This aligns the laser beam to within ± 15 arcseconds to the mirror. If the mirror has been aligned to the direction of travel within ± 15 arcseconds, the laser beam will be aligned to the direction of travel within ± 30 arcseconds, or approximately 0.04 parts per million. That is, 0.04 micrometre of travel (0.04 microinches per inch) of cosine error.
8. Lock down the plane mirror interferometer securely, making sure the alignment is not disturbed.
9. Remove the plane mirror interferometer alignment target and alignment aid. The reference beam and the measurement beam must be centered on the receiver alignment target.
10. Remove the receiver alignment aids and rotate the turret on the laser head to the large aperture. Verify that the LED indicator on the receiver is illuminated and the voltage at the receiver test point is between 0.6 and 1.5 Vdc.

NOTE

Steps 11 through 20 constitute the X-axis alignment.

11. With the laser head turret in the large aperture position, place the plane mirror interferometer alignment target on the laser head side of the X-axis plane mirror interferometer and the receiver alignment target on the receiver (Figure 2-53c, position 1). Place a piece of opaque material between the X-axis plane mirror interferometer and the mirror.
12. Angularly adjust the 50% beam splitter until the laser beam enters one hole of the plane mirror interferometer alignment target and exits the other centered on the receiver alignment target (do not adjust the laser head). Slight lateral adjustments of the 50% beam splitter may be necessary to ensure there is no beam clipping. Lock down the 50% beam splitter securely.
13. Select the small aperture on the front turret of the laser head and install the alignment aid on the output of the plane mirror interferometer in the correct orientation. Remove the opaque material from between the plane mirror interferometer and the mirror.

14. The laser beam now exits the interferometer and is reflected by the mirror back upon itself into the interferometer. Angularly adjust the plane mirror interferometer until the beam reflected from the mirror returns through the plane mirror interferometer and back to the small aperture of the laser head. Slight, lateral adjustments of the plane mirror interferometer may be required to ensure that the reference beam is still centered on the receiver alignment target. If the distance between the mirror and the laser head is at least 0.5 metres (20 inches) then the formula given in the section on Visual Alignment will determine the cosine error based on the offset of the return beam at the laser.

NOTE

For high accuracy alignment and installation where there is less than 0.5 metres (20 inches) between the laser and mirror, perform steps 15 through 17.

15. Remove the receiver alignment target and plane mirror interferometer alignment target and rotate the turret of the laser head to select the large aperture. Do not remove the plane mirror interferometer alignment aid on the output side of the plane mirror interferometer.
16. With a fast responding voltmeter (preferably a meter type) attached to the receiver test point, fine adjust the plane mirror interferometer angularly until a signal is received on the receiver. (The voltmeter will suddenly jump to some value greater than 0.25 volts.) This is a critical adjustment and may initially require great care to achieve the desired result.
17. Peak the voltmeter reading (which will be fluctuating) by fine adjusting the plane mirror interferometer in both angular axes. This aligns the laser beam to within ± 15 arcseconds to the mirror. If the mirror has been aligned to the direction of travel within ± 15 arcseconds, the laser beam will be aligned to the direction of travel within ± 30 arcseconds, or approximately 0.04 parts per million. That is, 0.04 micrometre of travel (0.04 microinches per inch) of cosine error.
18. Lock down the plane mirror interferometer securely. Make sure the alignment is not disturbed.
19. Remove the plane mirror interferometer alignment target and alignment aid. The reference beam and the measurement beam must be centered on the receiver alignment target.
20. Remove the receiver alignment aids and rotate the turret on the laser head to the large aperture. Verify the LED indicator on the receiver is illuminated and the voltage at the receiver test point is between 0.6 and 1.5 Vdc.

ELECTRONICS

section III

System Electronics

3.1 INTRODUCTION

This section contains the theory of operation of the Laser Transducer System electronics and of the individual units that make up the different systems. The optics are common to all systems and are covered in Section II.

The output electronics for the 5501A Laser Transducer System are available in a wide variety of configurations. General-purpose interface electronics include a universal binary interface for virtually any digital processor or controller; an HP-IB interface based on the Hewlett-Packard Interface Bus (HP-IB) and HP programmable calculators; and a universal English/Metric pulse output for most numerical controllers. A very basic quarter-wave pulse output is also available. Other electronic modules provide for manual or automatic velocity-of-light compensation and for the special needs of some closed-loop systems. The information is organized as follows:

- a. Theory of operation of a simplified Laser Transducer System
- b. A functional description of each type of system.
- c. Theory of operation of the individual units that make up the different systems

After reading the simplified theory of operation and the functional description of the type system you have, read the theory of operation of the individual units that are contained in your system. You will find this information very helpful in both programming and troubleshooting your system.

3.2 SIMPLIFIED THEORY OF OPERATION

A low-power helium-neon laser (Figure 3-1) emits a coherent light beam composed of two slightly different optical frequencies, f_1 and f_2 , of opposite circular polarizations. After conversion to orthogonal linear polarizations the beam is expanded and collimated, then directed to the reference beam-splitter where a small fraction of both frequencies is split off.

The split off portion of the beam is used both to generate a reference frequency and to provide an error signal to the laser cavity tuning system. The difference in amplitude of f_1 and f_2 is used for tuning while the difference in frequency between f_1 and f_2 (about 2 MHz) is used for the reference signal.

The major portion of the beam passes out of the 5501A Laser Transducer to an interferometer. All HP Interferometers measure relative displacement of two reflectors by splitting the beam into f_1 and f_2 , directing them to the two reflectors, and returning the resultant signals to a common point where they are made to interfere with each other. These combined beams are directed to a photodetector in the receiver.

Relative motion between the reflectors causes a Doppler shift in the difference frequency which is detected by the receiver. This Doppler shifted difference frequency ($f_1 - f_2 \pm \Delta f$) is the measurement signal.

Each output accessory (e.g., pulse converter, counter, etc.) receives the reference and measurement signals and compares them cycle-by-cycle in a dual output mixer. The mixer produces an appropriate up or down output pulse whenever one of the signals gets one-half cycle ahead of or behind the other. Each pulse corresponds to a reflector movement of one-quarter wave length of light. The pulses are accumulated in either a customer-supplied reversible counter or counters in one of the output accessories.

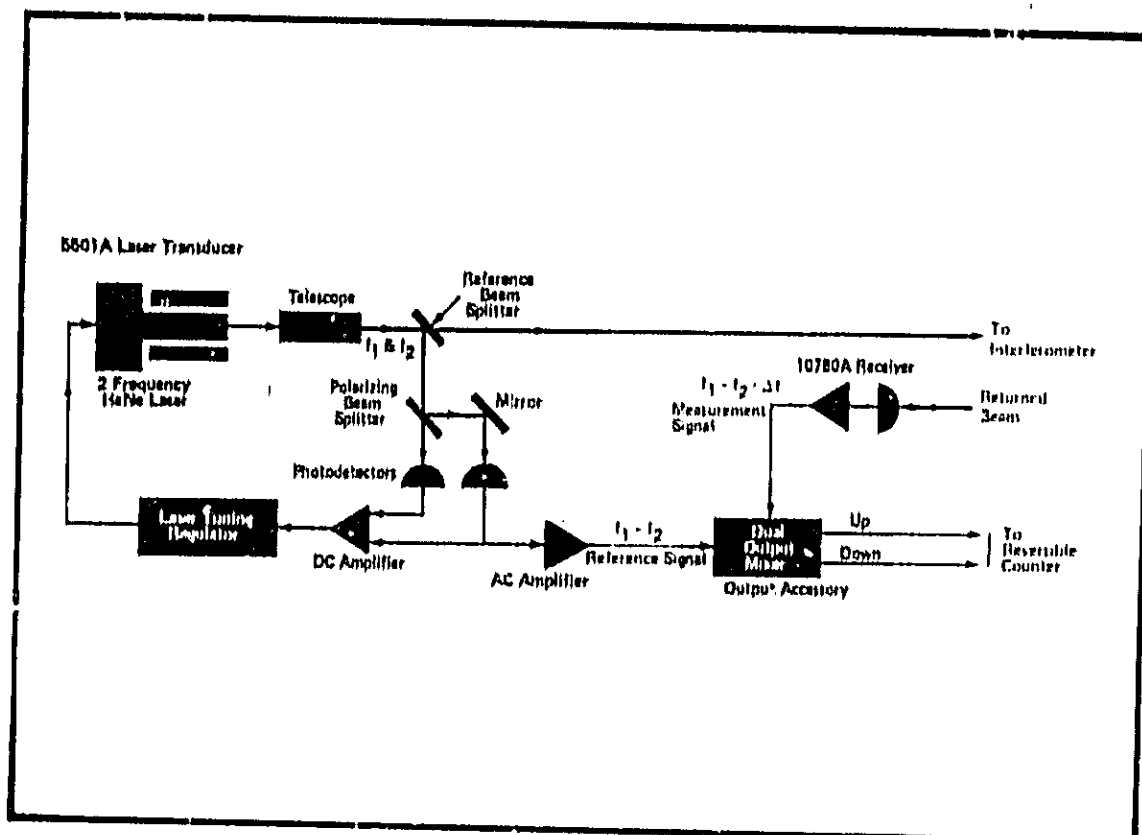


Figure 3-1. Simplified Block Diagram

3.3 FUNCTIONAL DESCRIPTIONS

The functional descriptions are subdivided as follows:

- HP-IB Interface Electronics
- Computer Interface Electronics,
- English/Metric Pulse Output Electronics,
- 10781A Pulse Converter Electronics,

3.4 HP-IB Interface Electronics

The HP-IB Interface Electronics (Figure 3-2) for the Laser Transducer System is an interface between the laser head and any digital controller compatible with Hewlett Packard Interface Bus (HP-IB). A typical system contains the following electronic equipment:

- One 9800 Series Calculator with HP-IB Interface,
- One 5501A Laser Transducer,
- Two 10780A Receivers,
- One 10740A Coupler,
- Two 10760A Counters,
- One 10745A HP-IB Interface,
- One 10755A Compensation Interface,
- One 10756A Manual Compensator,
- Two power supplies ($\pm 15V$ and $+5V$).

For additional capabilities the following can be selected:

- Up to two additional measurement axes (10760A Counter and 10780A Receiver),
- Automatic compensation (replace 10756A manual compensator with 5510A Opt 010 Automatic Compensator and 10563A Material Temperature Sensor),
- Numeric displays (10783A).

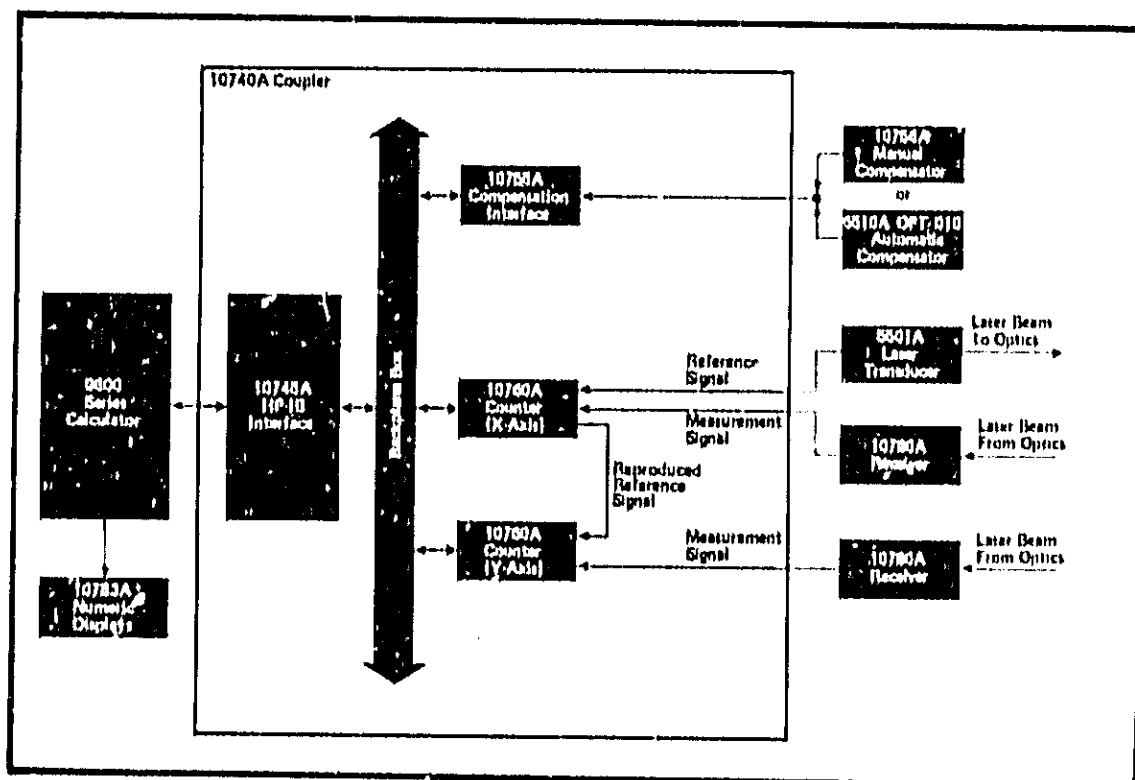


Figure 3-2. HP-IB Interface Electronics Block Diagram

The 9800 series calculator serves as a system controller (Figure 3-2). The reference and measurement signals from the laser head and receivers are compared continuously by the 10760A counters. These signals are approximately 2 MHz and are driven by line drivers to ensure noise immunity. Upon command from the calculator, the accumulated counts for each measurement axis can be sampled independently or simultaneously. Pulses are generated and accumulated in the counters only when movement has occurred. Refer to Table 3-1 for typical system specifications.

The 10755A compensation interface is used with either the 10756A manual compensator or the 5510A Opt 010 automatic compensator. In typical installations the choice of manual or automatic compensation is determined by the stability of the ambient environment.

The 10783A numeric displays can be used to display the relative movement on each axis. The displays are interfaced to the 9800 series calculator via the HP-IB and receive and display information only on calculator command. (Refer to the individual unit theory of operation for additional information.)

Table 3-1. Typical HP-IB Interface Electronics System Specifications

Number of Measurement Axes: Up to 6 measurement axes, subject to optical configuration restrictions. Measurement Resolution/Maximum Allowable Velocity: The measurement resolution and velocity depend on the type of interferometer used. 10702A Linear Interferometer 10705A Single Beam Interferometer			
Resolution	$\lambda/4$	$\lambda/40$	$\lambda/24$
Maximum Velocity mm/sec (in/sec)	304(12)	30.4(1.2)	51(2)
10706A Plane Mirror Interferometer			
Resolution	$\lambda/8$	$\lambda/80$	$\lambda/48$
Maximum Velocity mm/sec (in/sec)	152(6)	15.2(0.6)	25(1)
Measurement Accuracy: ± 0.5 parts per million ± 1 count in conjunction with the 5501A Laser Transducer. Atmospheric and Material Temperature Compensation Input: Manual Compensation factor input (tables supplied); Automatic Compensator.			

3.5 Computer Interface Electronics

The Computer Interface Electronics for the Laser Transducer System is designed to interface a wide variety of digital processors. The individual components are selected and assembled by the user for a specific measurement application.

The following discussion subdivides the Computer Interface Electronics into two typical types of systems; a 10760A Counter-based system and a 10762A Comparator-based system (closed-loop).

3.6 COUNTER-BASED SYSTEMS. A typical counter-based system (Figure 3-3) contains the following electronic equipment:

- One system controller (calculator or mini-computer).
- One 5501A Laser Transducer.
- Two 10780A Receivers.
- One 10740A Coupler.
- Two 10760A Counters.
- A system controller interface (typically a 10746A Binary Interface; however a 10745A HP-IB Interface can be used).
- One 10755A Compensation Interface.
- One 10756A Manual Compensator.
- Two power supplies ($\pm 15V$ and $+5V$).

Additional capability can be selected by adding the following equipment:

- Up to two additional measurement axes (10760A Counter and 10780A Receiver).
- Automatic compensation (replace 10756A manual compensator with the 5510A Opt 010 Automatic Compensator and 10563A Material Temperature Sensor).
- Numeric displays (10783A can be used only if the system controller is HP-IB compatible).

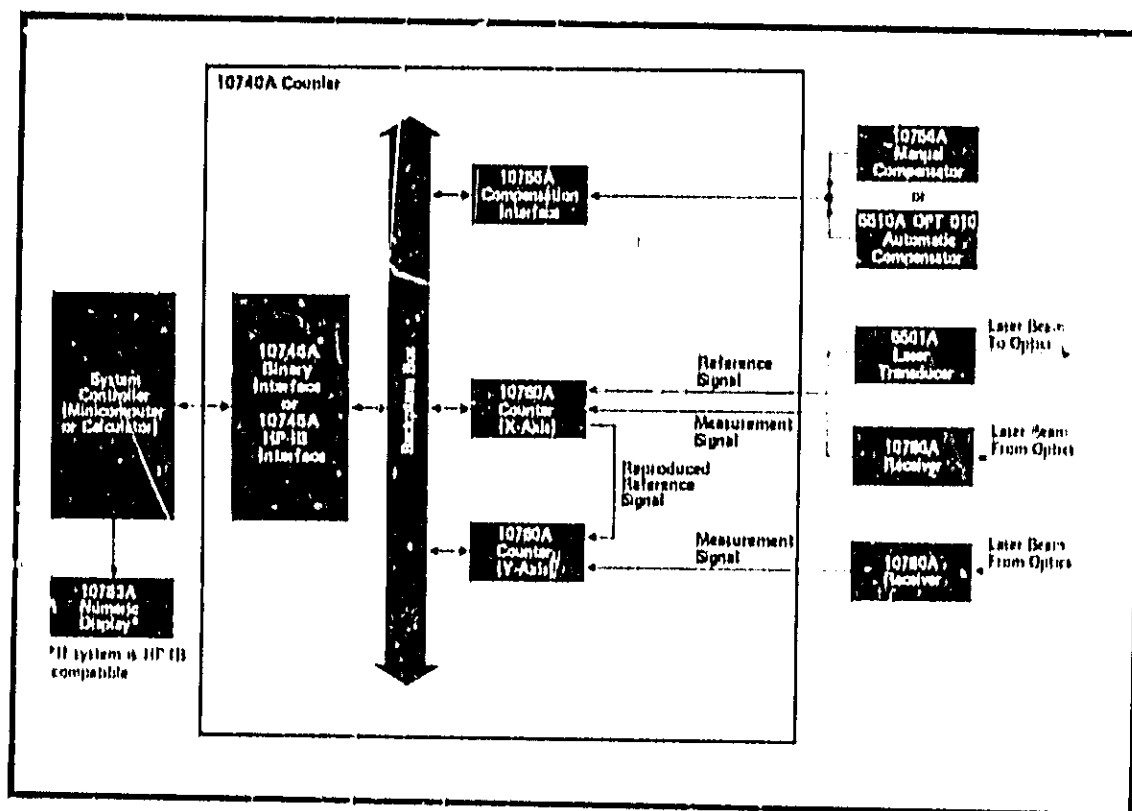


Figure 3-3. Counter-Based Computer Interface Electronics Block Diagram

This interface is used where high-speed position input to a computer based control system is desired. Since the output format can be either 8- or 16-bit words, the computer interface electronics are compatible with almost any digital processor. Refer to Table 3-2 for typical specifications.

Upon command from the system controller (Figure 3-3), the contents of the 10760A Counters are sampled. This can be accomplished independently or simultaneously on the X- and Y-axis.

The 10755A Compensation Interface is used with either the 10756A Manual Compensator or the 5510A Opt 010 Automatic Compensator. In typical installations, the choice of manual or automatic compensation is determined by the stability of the ambient environment.

Table 1-2. Typical Counter-Based Computer Interface System Specifications

Number of Measurement Axes: Up to six 10760A counters may be used subject to optical configuration restrictions.			
Measurement Resolution/Maximum Allowable Velocity: The measurement resolution and velocity depend on the type of Interferometer used.			
10702A Linear Interferometer 10705A Single Beam Interferometer			
Resolution	Normal $\lambda/4$	X10 $\lambda/40$	X6 $\lambda/24$
Maximum Velocity mm/sec (in/sec)	304(12.0)	30.4(1.2)	51(2.0)
10706A Plane Mirror Interferometer			
Resolution	Normal $\lambda/8$	X10 $\lambda/80$	X6 $\lambda/40$
Maximum Velocity mm/sec (in/sec)	152(6.0)	15.2(0.6)	25(1.0)
Measurement Accuracy: ± 0.5 parts per million ± 1 count measurement resolution in conjunction with 5501A Laser Transducer.			
10760A Counter Output: The contents of the 28-bit counter on the 10760A along with four status bits are available for transfer to the system controller via the 10746A Binary Interface.			
Format: 32-bit word; 28-bit position word with four status bits which allow detecting measurement or reference signal errors, counter overflow, and decimal point. Can be transferred to system controller as two 16-bit words or four 8-bit bytes.			
Output Rate: Nine individual operations at typically one microsecond each are required to transfer two 32-bit words (two axes of measurement data) to the system controller using the two 16-bit word format in conjunction with the 10746A Binary Interface.			
Atmospheric and Material Temperature Compensation Inputs: Transferred to the system controller as a 28-bit word from the 10755A Compensation Interface via the 10746A Binary Interface. Can be transferred as either two 16-bit words or four 8-bit bytes. Two types of inputs are available: Manual - 10756A Manual Compensator for thumbwheel input (tables supplied) Automatic - 5510A Opt 010 Automatic Compensator and 10563A Material Temperature Sensor.			
System Control Functions: Input from system controller via 10746A Binary Interface.			
Reset: Initializes all interface electronics. Presets 10760A counters to 160 counts.			
Sample: Places counter contents of 10760A in output buffer for transfer to system controller. Can be initiated either externally (TTL level signal) or by the system controller.			

3.7 COMPARATOR-BASED (CLOSED-LOOP) SYSTEMS. A special case of laser transducer applications occurs in certain comparator-based (closed-loop) systems, such as that shown in Figure 3-4. The system controller sends the laser transducer system a digital representation of the destination of the object under control. The transducer system then takes over the task of measuring the object's position on a real-time basis, comparing it with the desired position, controlling the drive motor, and indicating when the object under control has arrived at its destination.

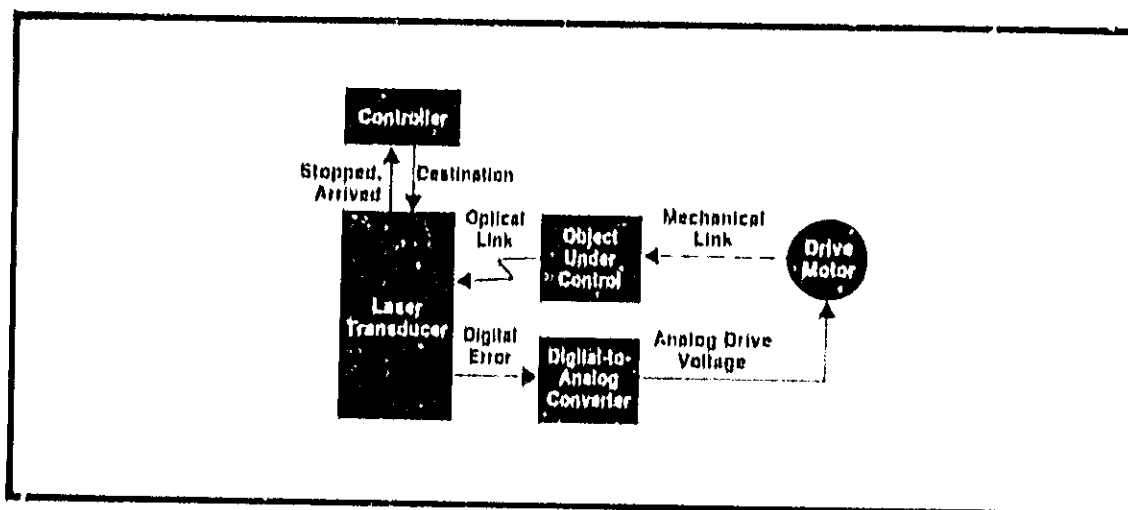


Figure 3-4. Comparator-Based (Closed-Loop) System Simplified Block Diagram

A typical comparator-based system (Figure 3-5) contains the following electronic equipment:

- a. A system controller (calculator or mini-computer).
- b. A 5501A Laser Transducer.
- c. Two 10780A Receivers.
- d. A 10740A Coupler.
- e. Two 10762A Comparators.
- f. A 10764B Fast Pulse Converter.
- g. 10746A Binary Interface.
- h. A 10755A Compensation Interface.
- i. A 10756A Manual Compensator.
- j. Two power supplies (+15V and +5V).

Additional capability can be selected by adding the following electronic equipment:

- a. Provide additional measurement axis (10762A Comparator and 10764B Fast Pulse Converter. Note that each axis uses only one-half of the 10764B Fast Pulse Converter. Therefore, two additional axes would require only one additional fast pulse converter).
- b. Automatic compensation (replace 10756A Manual Compensator with the 5510A Opt 010 Automatic Compensator and 10563A Material Temperature Sensor).

This interface is used for applications where high-speed control functions are required. The 10764B Fast Pulse Converter (Figure 3-5) operates in conjunction with two 10762A comparators. The 10764B provides up/down position counts to the two 10762A comparators and allows resolution extension by factors of from 1 to 6 and 8 and 10 with high allowable slew rates. Refer to Table 3-3 for typical specifications.

The 10755A Compensation Interface is used with either the 10756A Manual Compensator or the 5510A Opt 010 Automatic Compensator. In typical installations, the choice of manual or automatic compensation is determined by the stability of the ambient environment.

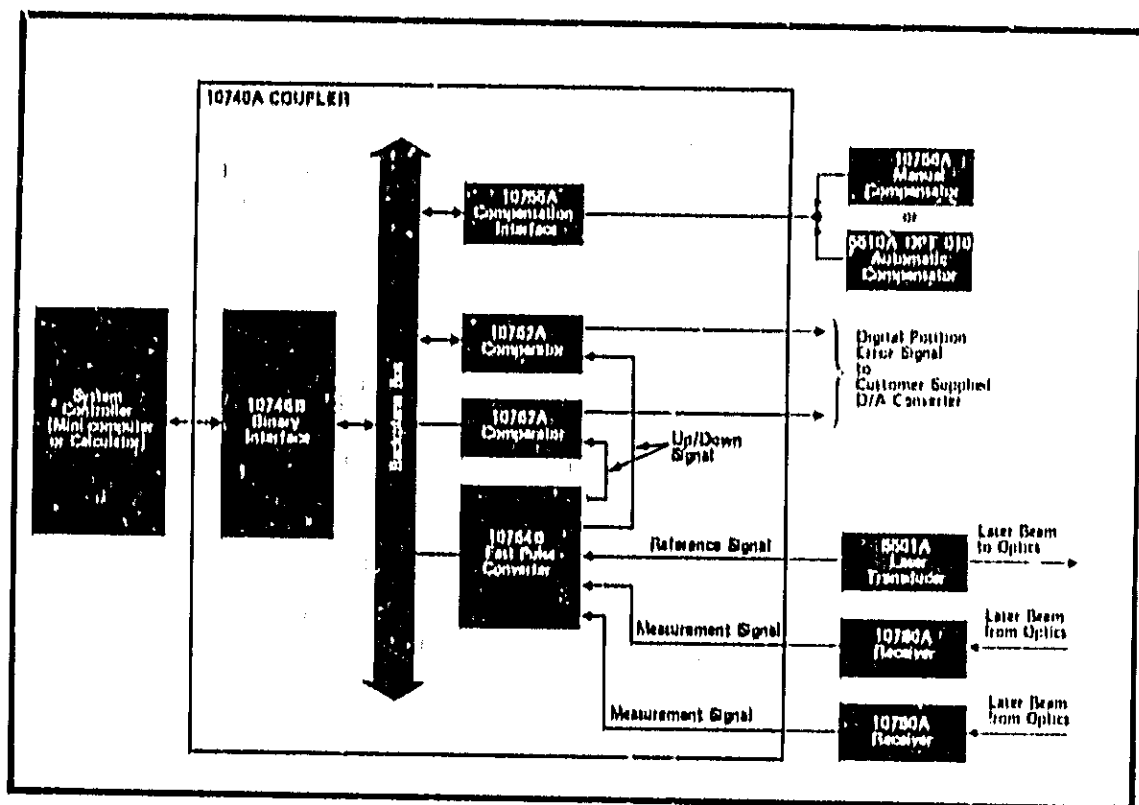


Figure 3-5. Comparator-Based Computer Interface Electronics Block Diagram

Table 3-3. Typical Comparator-Based Computer Interface System Specifications

Number of Measurement Axes: Up to 4 measurement axes, subject to optical configuration restrictions. 10764B FAST PULSE CONVERTER Input Requirements: Reference Signal: Compatible with 5501A Laser Transducer. Measurement Signal: Compatible with 10780A Receiver. (The 10764B is a two-axis device and will accept inputs from two 10780A Receivers.) Maximum Acceleration: 19.6 m/s ² or 64 ft/s ² (2 g's). Resolution/Maximum Allowable Velocity: The 10764B provides the capability for increasing the measurement resolution. The allowable resolution and maximum measurement velocity depends on the type of Interferometer used.									
10706A Plane Mirror Interferometer									
Resolution	$\lambda/8$	$\lambda/16$	$\lambda/24$	$\lambda/32$	$\lambda/40$	$\lambda/48$	$\lambda/64$	$\lambda/80$	$\lambda/120$
Maximum Velocity mm/sec (Inches/sec)	190 (7.5)	190 (7.5)	152 (6.0)	142 (5.5)	114 (4.4)	95 (3.7)	71 (2.7)	57 (2.2)	36 (1.4)
10702A Linear Interferometer 10705A Single Beam Interferometer									
Resolution	$\lambda/4$	$\lambda/6$	$\lambda/12$	$\lambda/16$	$\lambda/20$	$\lambda/24$	$\lambda/32$	$\lambda/40$	$\lambda/60$
Maximum Velocity mm/sec (Inches/sec)	381 (15)	361 (15)	304 (12.0)	285 (11.2)	228 (9.0)	190 (7.4)	142 (5.5)	114 (4.4)	71 (2.8)
Output: Compatible with 10762A Comparator. Up/Down pulses: TTL differential line driver output. Pulse width 67 ± 10 nanosecond, maximum 9 MHz. The 10764B Fast Pulse Converter will drive two 10762A Comparators. Coaxial Interconnection cables for 10762A Comparators are supplied.									

Table 4-1. Typical Comparator-Based Computer Interface System Specifications (Continued)

Error Check:

External: TTL level signals are available when Reference or Measurement errors are detected.

System Controller: An error code is available to the system controller via the 10746A Binary Interface for Reference or Measurement errors.

10762A COMPARATOR

Input Signal: Up/down or Phase-quadrature (A-Quad-B) Pulses, Minimum 50 nanosecond pulse width, maximum 10 MHz.

Measurement Accuracy: ± 0.5 PPM ± 1 count in conjunction with 5501A Laser Transducer and 10764B Fast Pulse Converter, ± 2 counts if hysteresis circuit selected.

Destination and Tolerance: Input from system controllers via 10764B Binary Interface. The digital difference output is automatically forced to a Null or zero difference when the destination and tolerance are loaded.

Format: 32-bit word. Four tolerance bits (± 15 counts) and 28 position bits can be transferred from system controller as either two 16-bit words or four 8-bit bytes.

Input Rate: Nine individual operations at typically 1 microsecond each are required to transfer two 32-bit words from the system controller to two 10762A Comparators using the two 16-bit word format in conjunction with the 10746A Binary Interface.

Digital Difference Output: Available at card edge connector.

Format: 28-bit TTL level. Sign-magnitude; binary negative-true representation. Twenty-four most-significant bits can be wired-OR'ed for variable linearity.

Response: One microsecond typical for constant velocity; 2 microseconds typical under acceleration conditions; relative to motion detected by the interferometer.

Null Output: Occurs when the 28-bit counter agrees with the 28-bit destination within the four tolerance bits (± 15 counts). This signal is available both externally at the card edge connector and to the system controller via the 10746A Binary Interface.

External Null Output: TTL level change, active low.

Response: 1.1 microsecond typical for constant velocity; 2.1 microseconds typical under acceleration conditions; relative to motion detected by the interferometer.

System Null: Available to system controller when all 10762A Comparators are at a null condition.

Zero Speed Output: Occurs when no counts have entered the Up/Down Counter within 17 msec (variable from 1 to 100 msec); TTL level change, active high.

Reset: Initializes Up/Down counter at 160 counts. Can be initiated either externally or by the system controller via the 10746B Binary Interface. Reset also activates a Forced Null condition on the Digital Difference Output.

External: TTL level change, active low. Reset condition will be maintained until returned to the high state.

System Controller: The counter on a specific 10762A Comparator can be reset or all 10762A Comparator Counters in the system can be reset simultaneously under program control.

Sample: Places Up/Down counter contents in output buffer for transfer to system controller. Also releases the forced Null on the digital difference output after loading destination and tolerance. Can be initiated either externally or by the system controller via the 10746A Binary Interface.

External: TTL level change; active low. Minimum 40 nanosecond pulse width.

Table 3-1. Typical Comparator-Based Computer Interface System Specifications (Continued)

System Controller: The counter on a specific 10762A Comparator can be sampled or all 10762A Comparator counters can be sampled simultaneously under program control. External Forced Null: TTL level change, active low; forces the digital difference output to zero difference regardless of the actual difference and the Null Output to a low state. The External Forced Null will be maintained until returned to the high state. Forced Zero Speed: TTL level change, active low; forces the Zero Speed Output to a high state regardless of actual conditions. This Forced Zero Speed condition will be maintained for the duration of the Zero Speed time constant after being returned to the high state. Counter Output: The contents of the 28-bit counter of the 10762A Comparator along with 4 status bits from both the 10762A Comparator and the 10764B Fast Pulse Converter are available for transfer to the system controller via the 10746A Binary Interface. Format: 32-bit word; 28-bit position word with 4 status bits which allow detecting measurement or reference signal errors, counter overflow, system Null and decimal point. Can be transferred to system controller as two 16-bit words or four 8-bit bytes. Output Rate: Nine individual operations at typically 1 microsecond each are required to transfer two 32-bit words to the system controller from two 10762A Comparators using the two 16-bit word format in conjunction with the 10746A Binary Interface. Atmospheric and Material Temperature Compensation Input: Manual Compensation factor input standard (Tables supplied); Automatic Compensator.

3.8 English/Metric Pulse Output Electronics

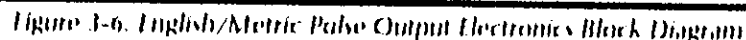
The English/Metric Pulse Output Electronics (Figure 3-6) is an interface configured for two axes of measurement providing micrometre or microinch value pulses. A typical system contains the following electronic equipment:

- A 5501A Laser Transducer.
- Two 10780A Receivers.
- A 10740A Coupler.
- Two 10760A Counters.
- A 10761A Multiplier.
- Two 10763A English/Metric Pulse Output Cards.
- A 10755A Compensation Interface.
- A 10756A Manual Compensator.
- Two power supplies ($\pm 15V$ and $+5V$).

Equipment can be selected to provide the following additional capabilities:

- Up to two additional measurement axis (10760A Counter and 10763A English/Metric Pulse Output).
- Automatic compensation (replace 10756A Manual Compensator with 5510A Opt 010 Automatic Compensators and 10563A Material Temperature Sensor).

The English/Metric Pulse Output Electronics (Figure 3-6) provide a universal interface for almost all numerical controls for machine tools. Refer to Table 3-1 for typical system specifications.



The 10763A English/Metric Pulse Output cards are the system controllers for the coupler backplane. They issue instructions to the 10760A Counters, the 10761A Multiplier, and the 10755A Compensation Interface. These cards convert the incoming reference and measurement signals into compensated displacement information. The 10763A English/Metric Pulse Output cards use this data to generate up/down or A-Quad-B signals representing total change in position. When there is more than one axis, the 10761A Multiplier is shared by each of the pulse output cards. Control of the backplane is transferred from one pulse output card to the next in a regular sequence that is set during initial configuration.

- a. Start. Initiates system operation and automatically initializes all circuit cards.
- b. Error. A signal is available for error indication from any of the measurement axes.
- c. Ready. Indicates pulse output has been enabled on this axis.
- d. Stop. Halts pulse output and all system operation.
- e. Reset. Slaved to 10740A Coupler Bus reset. Intended to reset external pulse counting device.

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Table 3-4. Typical Specifications for English/Metric Pulse Output System

Output Format: Phase Quadrature (A-Quad-B) or Up/Down Pulses; TTL differential line driver output, 100 nanosecond pulse width. Maximum Output Rate: 1.6 MHz Number of Measurement Axes: 1 to 4. Output Resolution: Metric Normal, 0.1 micrometre to 25 micrometre in 0.1 micrometre increments. English Normal, 10 microinch to 2500 microinch in 10 microinch increments. Metric Extended, 0.01 micrometre to 2.5 micrometre in 0.01 micrometre increments. English Extended, 1 microinch to 250 microinch in 1 microinch increments. Maximum Measuring Velocity:				
NORMAL RESOLUTION				
Interferometer	10702A, 10705A		10706A	
Resolution	0.1 micrometre	all other	0.1 micrometre	all other
Maximum Velocity mm/sec (in/sec)	0.15(6)	0.3(12)	0.15(6)	0.15(6)
EXTENDED RESOLUTION				
Interferometer	10702A, 10705A		10706A	
Resolution	0.01 micrometre	all other	0.01 micrometre	all other
Maximum Velocity mm/sec (in/sec)	0.015(0.6)	0.03(1.2)	0.015(0.6)	0.015(0.6)
Measurement Accuracy: ± 0.5 parts per million ± 1 count output resolution ± 1 count measurement resolution in conjunction with the 5501A Laser Transducer System. Measurement resolution depends on the type of interferometer used and if extended resolution is selected. Measurement Response Time: 11 microseconds per axis; relative to motion detected by the interferometer. Atmospheric and Material Temperature Compensation: Manual thumbwheel input (tables supplied), or Automatic Compensation. Control Functions: Available at control connector (mate supplied). Start: Initializes measurement system. Stop: Halts measurement signal output. Error Output: TTL level error signal from any measurement axis. A variety of troubleshooting signals are also available at the control connector.				

3.9 10781A Pulse Converter

The 10781A Pulse Converter is the simplest method of getting useful information from the Laser Transducer to external equipment. A typical system contains the following electronic equipment:

- A 5501A Laser Transducer.
- Two 10780A Receivers.
- Two 10781A Pulse Converters.
- Two power supplies ($\pm 15V$ and $+5V$).

The 107b1A Pulse Converter (Figure 3-7) converts the measurement and reference signals to pulses that can be counted by an external counter. The output consists of up/down or A-Quad-B pulses of 1/4-wave length value. Refer to the unit manual for additional information and specifications.

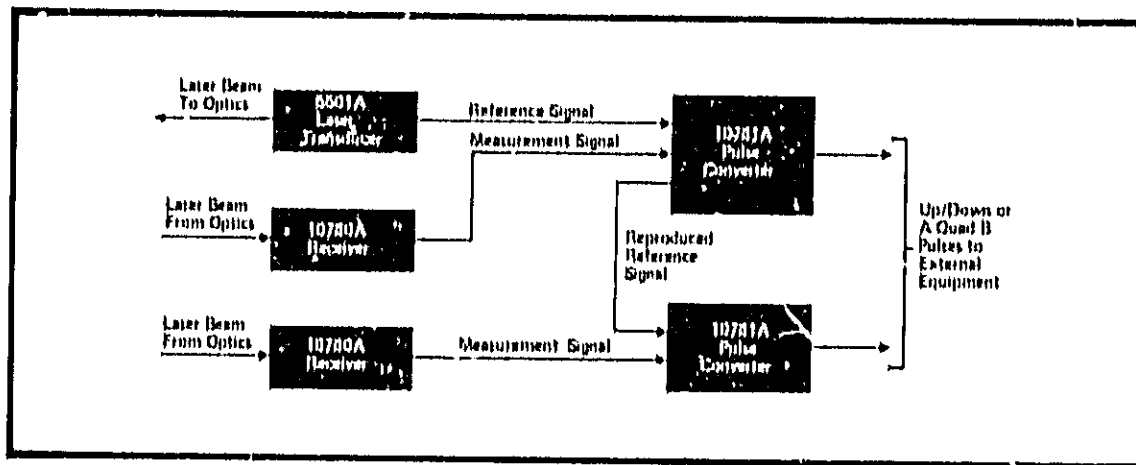


Figure 3-7. 107B1A Pulse Converter Electronics Block Diagram

3.10 DETAILED THEORY OF OPERATION

The detailed theory of operation is subdivided as follows:

- a. 5501A Laser Transducer.
- b. 10780A Receiver.
- c. 10740A Coupler.
- d. 10745A HP-IB Interface.
- e. 10746A Binary Interface.
- f. 10760A Counter.
- g. 10762A Comparator.
- h. 10764B Fast Pulse Converter.
- i. 10761A Multiplier.
- j. 10781A Pulse Converter.
- k. 10763A English/Metric Pulse Output.
- l. 10755A Compensation Interface.
- m. 10756A Manual Compensator.
- n. 5510A Opt 010 Automatic Compensator.
- o. 10783A Numeric Display.
- p. 5501A Power Supplies.

3.11 5501A Laser Transducer

The 5501A Laser Transducer (laser head) is the source of the laser light for the system. The laser head package meets the NEMA-12 standard for industrial packages. Figure 3-8 is the laser head block diagram.

The laser tube has the advantages of very long life-time, instant-on service, and automatic tuning. It is a two-frequency laser source; that is, the laser beam contains two components at slightly different frequencies, polarized at right angles to each other. The frequency split is about 2×10^6 Hz, compared to the laser frequency of some 10^{14} Hz, and is produced by an axial magnetic field which causes Zeeman splitting in the energy levels of the laser medium (helium-neon gas).

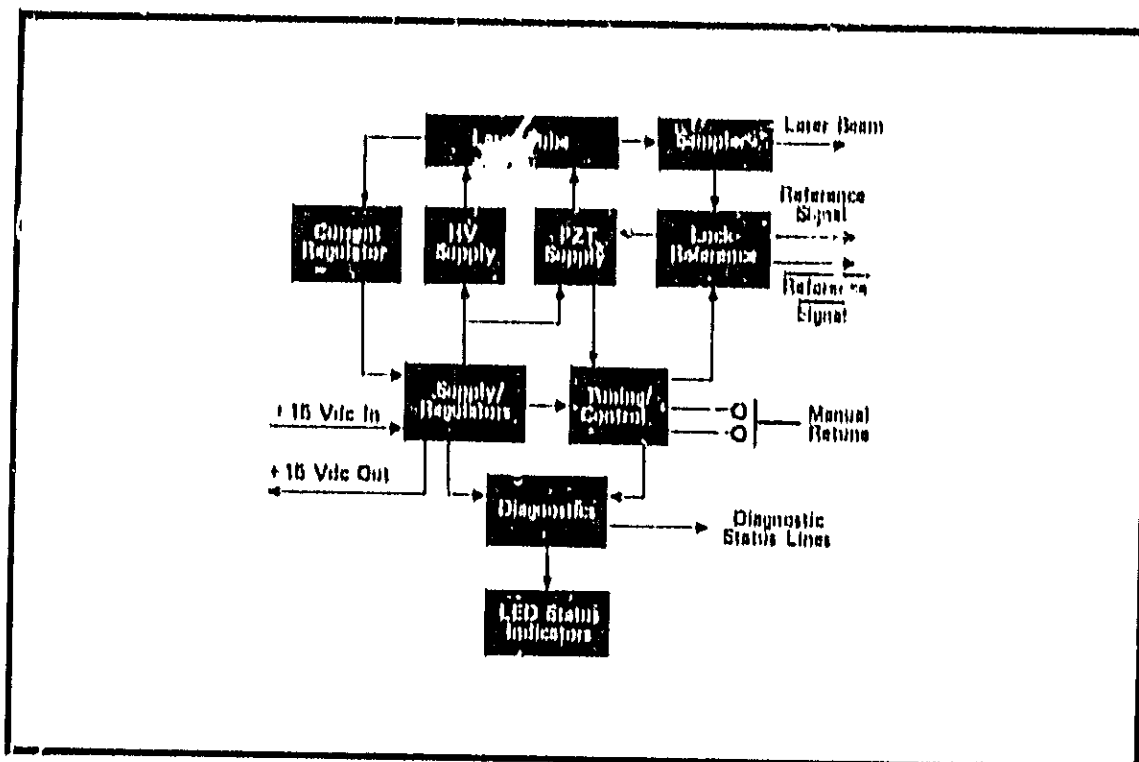


Figure 3-6. 5501A Laser Transducer Block Diagram

The laser system measures displacements by looking at the Doppler shift induced by the motion of the displacements. Both frequencies of laser light come from the laser head to the interferometer, where they are separated optically. One of the two frequency components is directed to the object whose motion is being measured. There it is reflected by a mirror or retroreflector (cube-corner) and returned to the interferometer. The effect of the motion is to cause a Doppler shift in the frequency of the reflected component. The two laser light components now differ in frequency by the original frequency split plus or minus the Doppler frequency shift. By integrating the total positive and negative excursions in the difference frequency, the system can find the net displacement in wave lengths of laser light.

The primary advantage of the two-frequency "ac" measurement system is its large dynamic range. For example, in the laser transducer system, the nominal output power is 120 microwatts, but the power returned to the laser receiver can be as low as four microwatts and the laser will continue to operate the system. The 5501A Laser Transducer System takes advantage of this wide dynamic range by moving the receiver from inside the laser head, where space considerations would limit the number of receivers, to the outside world. As a result, a single laser head can drive up to six linear measurement axes. Furthermore, the remote receivers can be mounted wherever most convenient; the laser light need not be returned to the laser head.

The laser head provides TTL-logic-level diagnostic signals that indicate the status of its auto-tune circuit and supply voltages to the system controller. Eight rear-panel light-emitting diodes give the same information in visible form. A RETUNE pushbutton provides for manual tuning whenever the laser exceeds its auto-tune range. The same function can also be commanded by an external controller.

For additional information and schematics, refer to the 5501A Laser Transducer Operating and Service Manual.

3.12 10780A Receiver

The 10780A Receiver (Figure 3-9) converts the Doppler-shifted laser light into electrical signals that can be processed by the rest of the laser system. The receiver contains a photodiode, an amplifier and level translator, a line driver, a level sensor (comparator), and local voltage regulators.

A lens on the front end of the receiver focuses the laser light onto the active chip of a silicon PIN photodiode. Between the lens and the diode is a small piece of polarizing material oriented at 45 degrees to the horizontal and vertical axes of the receiver. When the receiver is mounted properly—vertical axis parallel or perpendicular to the axes of the laser head—the polarizer passes one-half the incident power from each of the two incoming orthogonally polarized components of the received laser beam. The resulting power on the photodiode chip is an amplitude-modulated sine wave; its frequency is the Doppler-shifted split frequency, and its amplitude is proportional to the product of the incident powers of the two orthogonal components. The photodiode generates an ac current, which is converted to an ac voltage at a frequency of 100 kHz to 5 MHz.

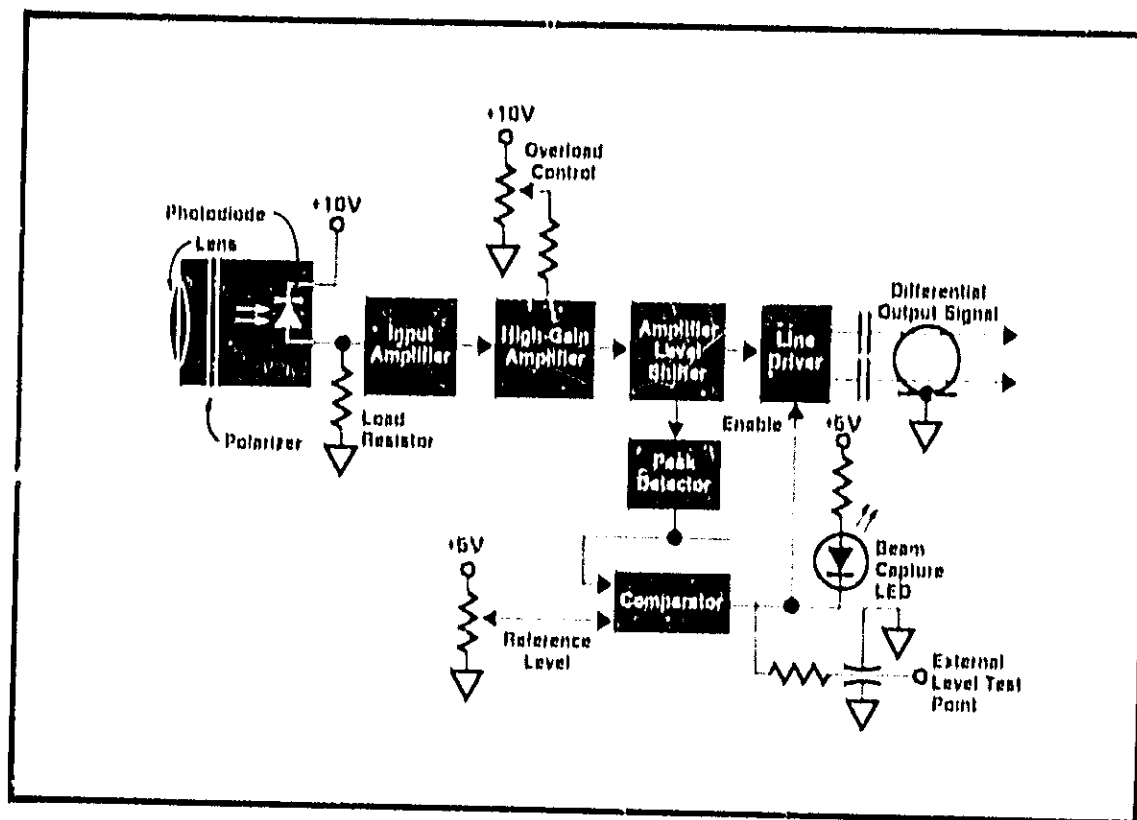


Figure 3-9. 10780A Receiver Block Diagram

The detected signal voltage goes through a stage of impedance transformation, two stages of voltage gain, and a stage of level translation. The result, a TTL-level signal, goes to a TTL differential line driver, which is ac-coupled to the rest of the 5501A system by a shielded twisted-pair cable. The output of the line driver is a differential square wave at the Doppler-shifted split frequency (measurement signal).

The level sensor (comparator) disables the line driver unless the incident laser power is four microwatts or more.

The receiver enclosure is designed to meet NEMA-12 standards for industrial packages. The receiver is mounted by its two aluminum end caps. Four plastic spacers (part of the end caps) separate the receiver case from its mounting plate and allow full air circulation around the receiver to carry away the heat it generates (nominally two watts). By using Nylon mounting screws, the entire receiver is electrically isolated from its mounting plate, breaking any ground loops. This can be important when there are large electrical transients in the dc power lines or large ac ground currents running through a machine.

For additional information and schematics, refer to the 10780A Receiver Operating and Service Manual.

3.13 10740A Coupler

The 10740A Coupler serves as a housing and communications facility for the other electronic modules of the Laser Transducer System. Figure 3-10 shows the inputs and outputs to the different modules. Electrical interconnection of the modules is provided by the 86-pin connectors on the coupler's printed circuit backplane. The other system modules are plugged into the backplane connectors. The coupler has no internal power supplies, but supplies power to the modules from external power supplies connected to a barrier strip on its rear panel. Three dc voltages are required: +5V, +15V, and -15V. (The $\pm 15V$ is required only if the 5510A Opt 010 Automatic Compensator is used in place of the 10756A Manual Compensator or if the system includes 10764H Fast Pulse Converter).

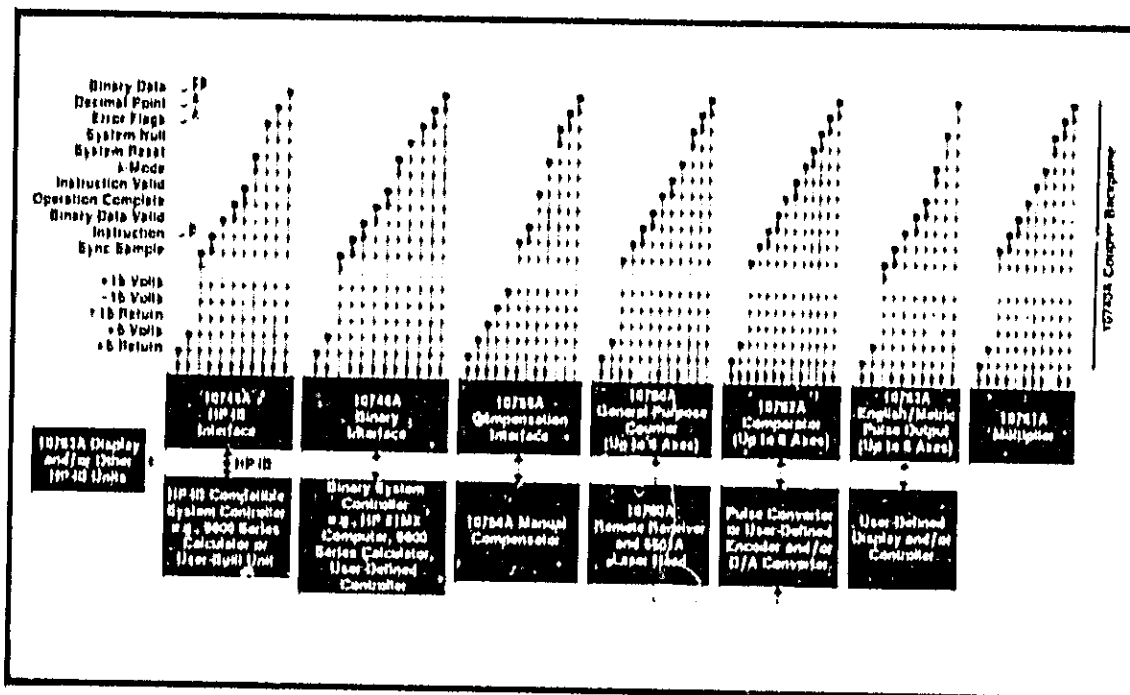


Figure 3-10. 10740A Coupler Backplane Signals

Numerical data is transferred between cards over a 28-bit parallel data bus on the coupler backplane. Binary coding is used. A four-bit-wide bus carries decimal point position information, and another four-bit bus carries error flags that indicate the existence of conditions that might make the data invalid. Associated with the data, decimal point, and error flag lines is a status line called Binary Data Valid (BDV).

Instructions are sent from card to card over an eight-bit-wide instruction bus and two status lines called Instruction Valid (INSV) and Operation Complete (OPC). Instructions consist of two parts: a four-bit alpha address and a four-bit numeric command. Each card in the system has its own address, fixed in some cases and selectable by means of jumpers or switches in others. The modules and their addresses are:

Module	Address
10745A HP-IB Interface	C
10746A Binary I/O	P
10755A Compensation Interface	V
10760A General-Purpose Counter	X,Y,Z,A,B, or C
10761A Multiplier	M
10762A Comparator	X,Y,Z,A,B, or C
10763A English/Metric Pulse Output	X,Y,Z,A,B, or C
10764B Last Pulse Converter	X,Y,Z,A,B, or C

In general, a particular numeric command always has the same meaning. However, different modules respond differently to the same command. An important concept here is that of implied talkers and listeners.

One way to handle communications in a bus-oriented system is to address one module as talker and one or more modules as listeners. This requires two modes of operation, one for addressing and one for data transfer.

For example, we can make the instruction lines separate from the data lines and agree that all modules will continuously monitor the instruction lines, looking for and reacting to only those instructions that concern them and ignoring those that do not. This means that a particular instruction will have any of several meanings, depending upon a particular card's point of view.

As an example, consider the instruction "2X". The address portion is "X", which could designate an X-axis counter card in the system. From the point of view of the X-axis counter the instruction "2X" means that it should enable its data output buffers, its decimal point position code drivers, and its error flag drivers to the 10740A backplane and set the Binary Data Valid line true. To a 10745A HP-IB Interface card it means load this information into your data register, decimal point code register, and error flag register, and issue a service request (SRQ) if there has been an error. To a 10761A Multiplier, however, it says take the data being output, multiply it by the laser light wavelength corrected for changes in the index of refraction of air, and store the result. The X-axis counter card was the implied talker and the multiplier and I/O card were the implied listeners. It was not necessary to address the counter as a talker or the I/O and multiplier as listeners.

There are four lines on the 10740A backplane that are dedicated to particular functions and always have the same meaning. Two are nonaddressed commands and two are status lines. System Reset is the command to initialize to some starting condition. This command is generated by the interface modules during power-up; it can also be sent by the system controller. Synchronous Sample is the command to take present displacement information and load it into output buffers. It is used to get a simultaneous sample from all axes. λ -Mode is a status code from counters and comparators, indicating to the multiplier card whether quarter-wave ($\lambda/4$) or eighth-wave ($\lambda/8$) resolution is being used in the system. System Null is a status code from comparators, indicating the system has arrived at the required destination. For additional information and schematics, refer to the 10740A Coupler Operating and Service Manual.

3.14 10745A HP-IB Interface

The 10745A HP-IB Interface is an appropriate laser transducer input/output (I/O) module for any system controller that is compatible with the HP Interface Bus (IEEE Standard 488-1975). Such controllers include Hewlett-Packard Models 9815A, 9820A, 9821A, 9825A, 9830A, 9835A, and 9845A Calculators, HP 2100 Series Computers with the 59310B I/O card, or any HP-IB compatible user-built controller. Figure 3-11 is a block diagram of the HP-IB card.

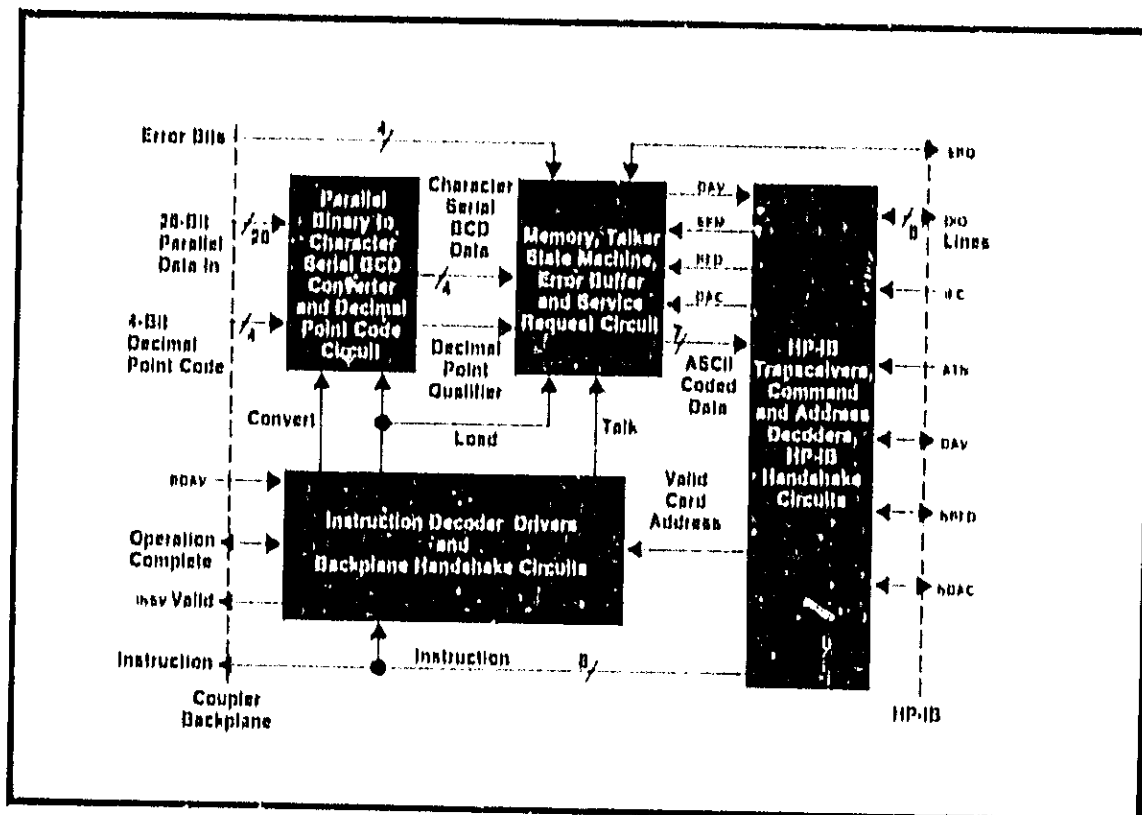


Figure 3-11. 10745A HP-IB Interface Block Diagram

The HP-IB card can operate as either a talker or a listener on the HP-IB. As a talker, it has two modes of operation. First, when addressed to talk, it outputs a string of nine ASCII (American Standard Code for Information Interchange) numeric digits followed by ASCII carriage return (CR) and line feed (LF) codes. A decimal point, also in ASCII, can occur anywhere in the string of digits.

The HP-IB card's second mode of operation as a talker is related to the service request capability and the serial poll mode. When an error in the laser transducer system is noted by any card, the card involved stores the occurrence in a buffer. When that card is instructed to output its data, it also outputs the contents of its error buffer. This error information is loaded into an error register on the HP-IB card and can only be cleared with a reset command. The presence of the error condition causes the HP-IB line called SRQ to be set true. The controller should be programmed so that, when it recognizes this condition, it executes a serial poll, that is, it untalks and unlistens everything on the bus, then addresses itself to listen and sends the universal command SPE (Serial Poll Enable). Then it begins polling devices on the HP-IB capable of responding to SPE by sequentially addressing them to talk. Responding to serial poll, the HP-IB card outputs an eight-bit status byte. The controller takes the decimal value of the status byte and examines it to see if bit 6, the service request bit, is set or not. If it is, bits 0 through 3 are examined to see what combination of errors has occurred. The controller may then send a reset command to clear the error register of the HP-IB card.

As a listener, the HP-IB card receives a four-bit-wide command and a four-bit-wide address and combines them into an eight-bit-wide instruction that is sent out over the instruction bus on the backplane of the coupler. Each time its address buffer is loaded, the HP-IB card sets a backplane line called Instruction Valid (INSV) to the true state to inform cards in the coupler to look at this instruction. Whenever INSV is true, the HP-IB card will not allow new data to be loaded into its command and address buffers. It sets the HP-IB Not Ready for Data (NRFD) line low whenever INSV is true and it is addressed to listen. This informs the talker on the HP-IB that the HP-IB card is not ready for data.

There are two algorithmic state machines (ASM) on the HP-IB card. They operate essentially independently but because they share some common circuits they do not operate simultaneously. One ASM controls the binary-to-BCD converter and the other controls the talker function.

Whenever an output instruction for another card occurs on the coupler's instruction bus, the HP-IB card takes the binary data, the decimal point position code, and the error flags that are put on the backplane as a result of the instruction and loads this information into its input data register, its decimal point register, and its error bit register, respectively. Then if a conversion instruction occurs, the conversion flip-flop is set and a signal is sent to the coupler backplane indicating that the instruction need not be held. The output of the conversion flip-flop is logically ANDed with a signal from the talker ASM signifying that it is not presently talking. The result is a qualifier input to the converter-control state machine. When this qualifier goes true, the converter-control state machine starts through its sequence of clocking the binary-to-BCD converter and loading its output into a random-access memory. Once started, it proceeds on its own until the conversion is complete, at which time it clears the conversion flip-flop.

The binary-to-BCD converter takes the 28-bit binary word in the input data register and, each time it receives a clock pulse, outputs a four-bit BCD character. This conversion takes place least-significant bit first to most-significant bit last. The 28-bit binary word translates a nine-character BCD word and therefore it takes nine clock pulses to complete the conversion.

Before clocking the converter each time, the converter-control ASM checks to see if the RAM address counter output agrees with the decimal point position code stored in the decimal point register. If it does, the converter is not clocked but the RAM address counter is advanced one. This leaves a space in the data string for the decimal point.

The converter-control ASM is clocked by a two-phase clock with a frequency of 3.33 MHz $\pm 20\%$. Thus the time required for a complete conversion of the 28-bit parallel binary number to a nine-character BCD number with decimal point information is between 7 μ s and 10.5 μ s. The typical value is 8.4 μ s. To date, there is no controller that can call for a conversion and issue a second command before the conversion is finished. But just in case one is built, the converter-control ASM and the talker ASM are interlocked so they will not try to operate simultaneously. In addition, the HP-IB card will hold up a data transfer on the backplane until it finishes converting the number. To take the converted data in the RAM and transfer it to the controller, all that is necessary is for the controller to address itself to listen and the HP-IB card to talk, and put the HP-IB into the data mode (ATN false). When this happens the talker ASM takes the four-bit-wide BCD data in the RAM, adds to it three additional bits to make it seven-bit ASCII, and outputs it on the HP-IB. The talker ASM monitors the NRFD line and the NDAC line on the HP-IB and drives the DAV line in accordance with the rules of the HP-IB. For additional information and schematics, refer to the 10745A HP-IB Interface Operating and Service Manual.

3.15 10746A Binary Interface

The 10746A Binary Interface (Figure 3-12) is the appropriate input/output (I/O) interface for a wide variety of computers and controllers that require an 8- or 16-bit binary interface.

The binary interface transmits data to the controller in the form of two 16-bit binary words. There are 16 lines for data output, so all 16 bits may be transmitted in parallel. Alternatively only 8 lines may be used and the data sent as four 8-bit words. Data from the controller is sent to the interface card in the same format, using either the same lines or a separate set of tri-state buffered lines that are turned off during data output from the card.

Instructions come into the binary I/O card in the form of eight-bit words on the same lines as data.

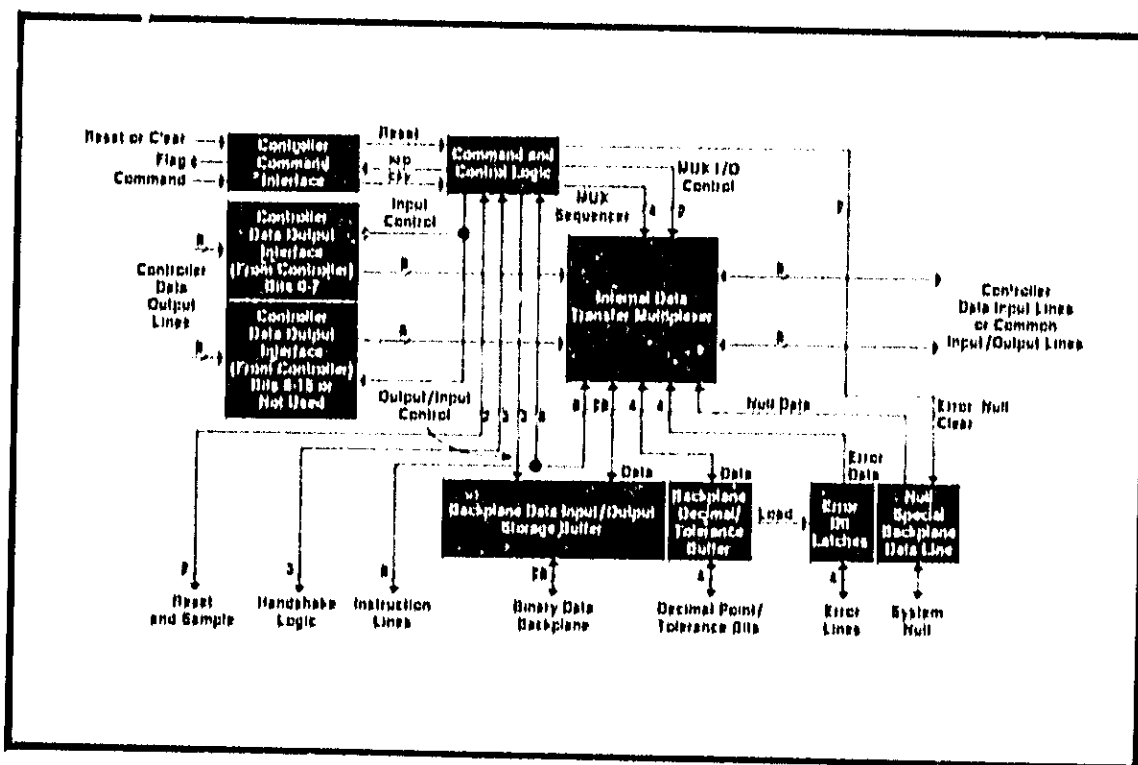


Figure 3-12. 10746A Binary Interface Block Diagram

The transfer of an instruction or data word is controlled by a command line, which indicates to the I/O card that the bit pattern on the input lines is valid information, and a flag line, which indicates to the controller that the data bits have been accepted. When data is transferred to the controller the flag line indicates valid information and the command line indicates data accepted, a convention common to many I/O structures.

Because instructions and data share the same lines, the I/O structure has two modes of operation, called command mode and data mode. In the command mode, information from the controller is clocked into an instruction register and placed on the system backplane as an instruction to all the cards in the system, including the binary I/O card. The binary I/O card's control logic then interprets the instruction from the backplane and performs the required operation (if any). Once the instruction is clocked into the instruction buffer the controller is free to set up the next instruction even though the transducer system may not have completed execution of the preceding one. This allows operation with a fast controller in an interrupt environment.

There is a 36-bit data register on the binary interface card; 28 bits are used for binary data, four bits are used as a decimal point location buffer, and four bits are used as error status buffers. This register has two separate tri-state I/O ports, one for backplane input/output, and one for controller input/output.

When an instruction is received from the backplane to transfer data to or from the controller, the control logic switches to the data mode. In the case of data input from the controller, the data register is sequenced by the control logic so that each time valid data is available, that data is clocked into part of the data register. If the card has been set (jumper selectable) for 16-bit words, the first 16 bits of data are loaded into the upper bits of the register with the four most-significant bits being the decimal point location code. The next 16-bit word is loaded into the remaining half of the data register and the control logic immediately switches back to the command mode (error status bits cannot be loaded from the controller). If the card has been set for 8-bit words, the first word is placed in the upper portion of the data register and again the four most-significant bits are the decimal point location. Then three more data words are accepted and placed in successively lower bit locations with the last word in the least-significant eight bits. The control logic switches immediately back to the command mode after the fourth word.

If data is to be sent to the controller, the sequence is the same except that the control logic sequences the data register to put data onto the interface lines, most-significant word first. If an error has been detected, the upper four bits (decimal point bits) of the transmitted data contain all ones to indicate that an error is being transmitted and the four status bits replace the data in the next four bits. This allows the same sequence to be used for error transmission as for regular data transmission.

A jumper-selectable data-mode-only configuration causes the binary interface to ignore commands from the controller. It will still transfer data, however, so it can be used as an I/O device for some peripheral other than the system controller. For additional information and schematics, refer to the 10746A Binary Interface Operating and Service Manual.

3.16 10760A Counter

The 10760A Counter is a general-purpose counter consisting of line drivers and receivers, a resolution extender, a pulse converter, and a reversible counter (see Figure 3-13).

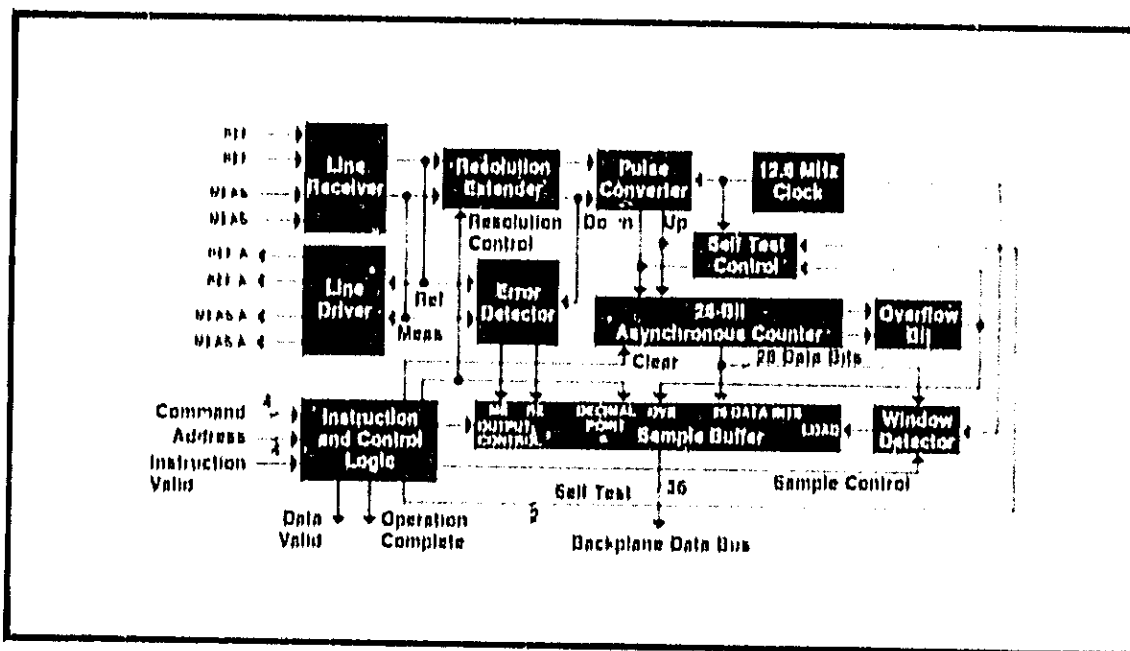


Figure 3-13. 10760A Counter Block Diagram

The line receivers accept two differential RF signals, one from the laser source (reference signal), and one from the remote receiver (measurement signal), and convert them to TTL signals. The input signals are then amplified by the line drivers for use by other cards in the system. For example, the reference signal must be sent to each counter card and must be daisy-chained because the line impedance matching requirement and available line driving power do not allow parallel connection. The measurement signal is also reproduced, and may be used for other signal processing, such as differential measurement using one measurement signal at the reference input.

The resolution extension circuit allows a user to select normal resolution of 0.16 micrometre (6 microinch) or extended resolution of 0.016 micrometre (0.6 microinch) under program control. The only drawback of the resolution extender is the 1.2-inch-per-second slew rate limitation imposed when resolution extension is in use. This is more than compensated for by the real time extension in resolution and resulting increase in positioning accuracy.

After the measurement signal has been resolution extended (or not, depending upon program control), the measurement and reference signals are converted to displacement information in the form of up/down pulses, which are fed to a counter. This is done by the pulse converter circuit.

The next functional block on the counter card is a 28-bit binary counter that counts the up/down pulses from the converter to give total displacement information. The delay between a position change on the measurement axis and a change in the counter is on the order of 0.4 microseconds depending on the length of cable between the receiver and the counter card.

In addition to these signal processing blocks, the counter card also has several control and error functions. The error circuits constantly monitor the status of the counter and the conditions of the reference and measurement signals at the input to the pulse converter. If the reference signal is interrupted for more than 6 microseconds a reference error bit is set. If the measurement signal is interrupted or becomes invalid because of excessive slew rate, a measurement error bit is set. The error circuits monitor the frequencies of the two signals and set the respective error bit if prescribed limits are exceeded.

The counter status error bit is set whenever the counter chain overflows or underflows. This error is recoverable, that is, it can be corrected by moving the retroreflector in the direction opposite to that which caused the overflow or underflow until the condition is reversed. Thus no counter information is lost. This is not the case for reference or measurement signal errors. Should one of these occur, the measurement axis must be returned to some gage point to re-define the zero point.

The control circuits interpret system instructions and cause the counter to perform the required operation. Test functions are included on the counter card to allow the system controller to check the operation of the counter chain and error bits, the output buffer, and the pulse converter clock. For additional information and schematics, refer to the 10760A Counter Operating and Service Manual.

3.17 10762A Comparator

In a comparator system, the 10762A Comparator cards, one for each axis, replace the general-purpose counter cards. A compensation interface card, a binary I/O card, and a fast pulse converter complete the electronics package in the 10740A Coupler. Also required for each axis are an external digital-to-analog (D/A) converter (not supplied with the system).

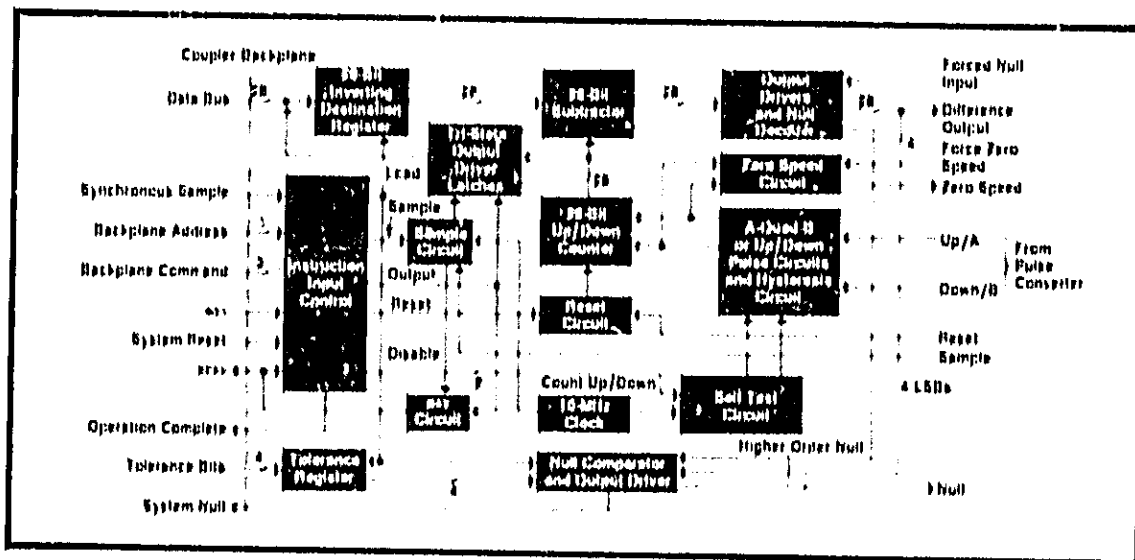


Figure 1-14. 10762A Comparator Block Diagram



NOTE

See 10764B manual for differences between 10764A and 10764B cards. Power supply requirements, jumpers/switches, and operating temperatures are different.

3.18 10764B Fast Pulse Converter

The 10764B Fast Pulse Converter is used in a comparator-based computer interface system in conjunction with a comparator card to increase the measurement resolution and velocity of the Laser Transducer System. Refer to Table 3-3 typical comparator-based computer interface specifications for allowable resolution and maximum velocity specifications for specific interferometers.

The fast pulse converter (Figure 3-15) provides a means of converting the reference and measurement signals from two axes to pulses that can be counted by the comparator card. The reference and measurement signals are applied to signal reception and isolation circuits. These circuits contain photo-isolation devices which convert the differential input signal pairs to single-ended signals with ECL logic levels. Additional immunity to external noise is obtained by applying these signals to Schmitt trigger circuits.

15. The pulse generation circuit compares the input signals (derived from the incoming reference and measurement signals) with respect to frequency and outputs a pulse for each 1/2 cycle difference between the reference and measurement signals. If the reference signal frequency is higher, pulses occur on the down-pulse line; if the measurement signal frequency is higher, pulses occur on the up-pulse line.

Error detect circuits monitor the incoming reference and measurement signals for extreme frequency. If the frequency deviates from its nominal value by greater than preset limits, an error signal is generated. The only instructions that the fast pulse converter responds to are reset error bits and output error bits.

For additional information and schematics, refer to the 10746B Fast Pulse Converter Operating and Service Manual.

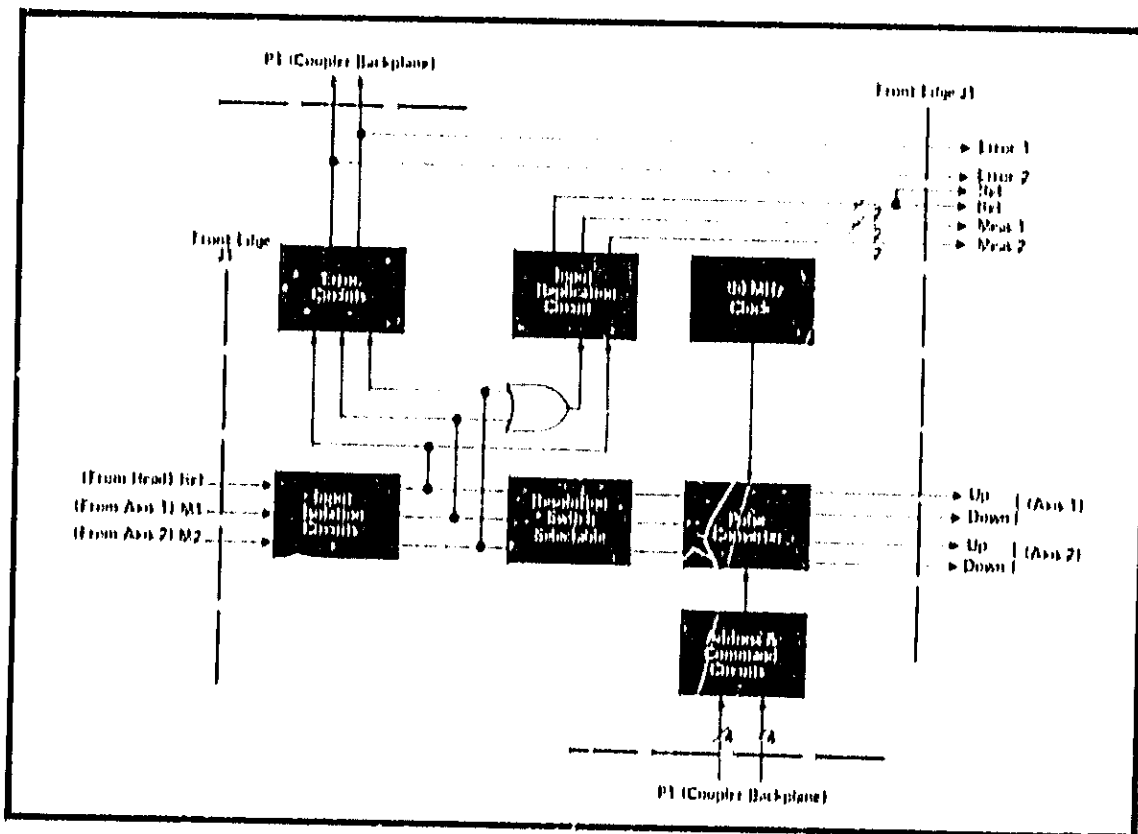


Figure 3-15. 10764A Fast Pulse Converter Block Diagram

3.19 10761A Multiplier

The 10761A Multiplier card is used only with the English/Metric system. Its main purpose is to perform the conversion of uncompensated fringe (quarter-wave) displacement data to either metric units (in millimetres) or English units (in inches) for output to a controller.

Figure 3-16 is a block diagram of the multiplier card. The input buffer accepts and holds data available from the coupler backplane. This may be velocity-of-light information from a compensation interface card (described later), displacement information from a counter card, or any other applicable backplane data. The next part of the multiplier is a group of AND gates used as data control for the magnitude data stored in the input buffer. These gates control the add-shift/shift-only function (multiplication is accomplished by repeated shifting and adding). From here the data goes to the adder-shifter section of the card. The inputs to the adder are the outputs of the AND gates and the output of the accumulator. The resulting addition is fed back to the inputs of the accumulator, which is a 29-bit register. The 29th bit is an overflow bit used to indicate that the result of multiplication has a magnitude greater than 28 bits. The multiplier register is a shift register that can be loaded from the accumulator or from a constants ROM (read-only-memory) which contains all the conversion constants for the multiplier. This shift register's least significant bit controls the input buffer AND gates.

Besides the main adder there is a four-bit decimal point adder that handles the conversion of the decimal point code for the appropriate measurement units. These circuits are directed by the control logic, which interprets backplane instructions and controls the execution of indicated operations. The control logic has a 10-MHz clock, which allows a complete multiplication in less than 5 microseconds.

Instructions recognized by the binary multiplier card include reset, English units, metric units, velocity-of-light (VOL) output, counter output, and multiplier output. The VOL output in-

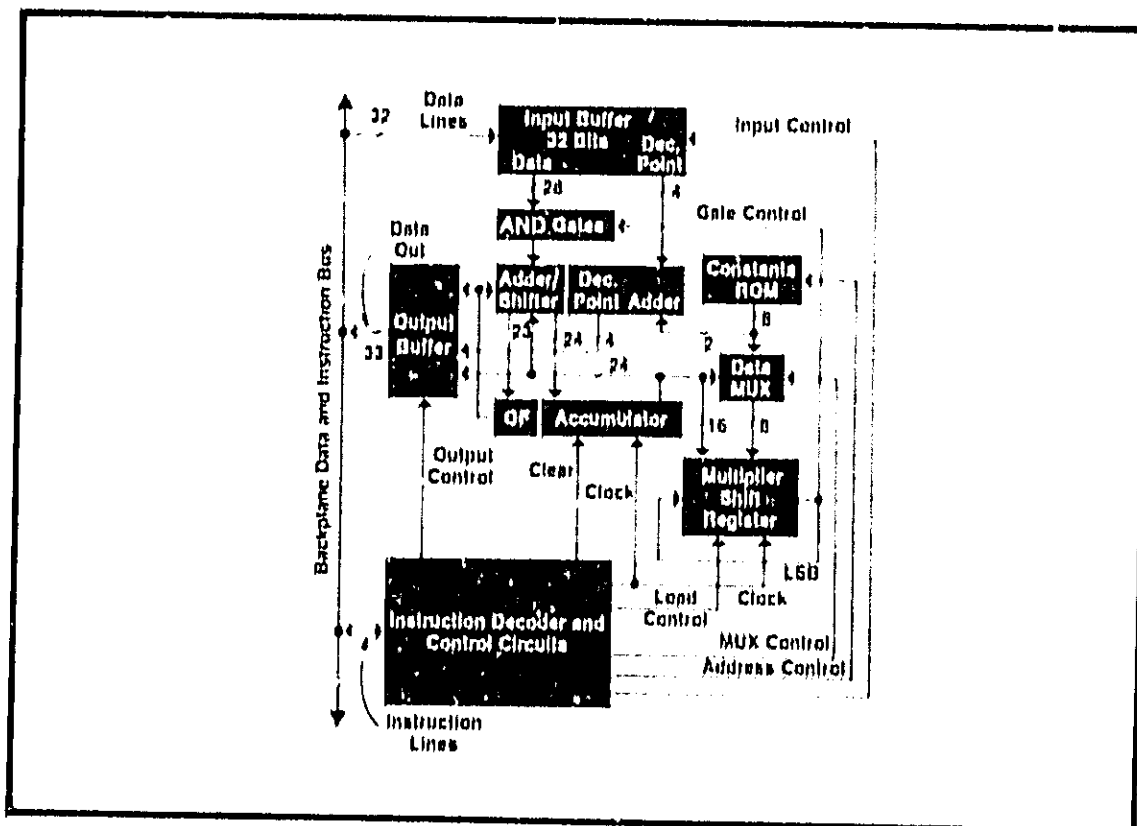


Figure 4-16. 10761A Multiplier Block Diagram

struction is interpreted by the multiplier card as an input operation. The VOL data is loaded into the buffer and then multiplied by the preselected units constant from the constants ROM. The product is stored in the shift register for future use. This result represents a compensated units-conversion number for converting fringe displacement data from the counter cards to the preselected unit of measure. For additional information and schematics, refer to the 10761A Multiplier Operating and Service Manual.

3.20 10781A Pulse Converter

The 10781A Pulse Converter (Figure 3-17) is a quarter-rack size electronic module for 5501A Laser Transducer systems which accepts the REF (reference) and MEAS (measurement) signals and outputs displacement information in pulse or A-Quad-B format. The A-Quad-B output is designed to interface to some hardwired controllers and other closed-loop systems which contain reversible counters.

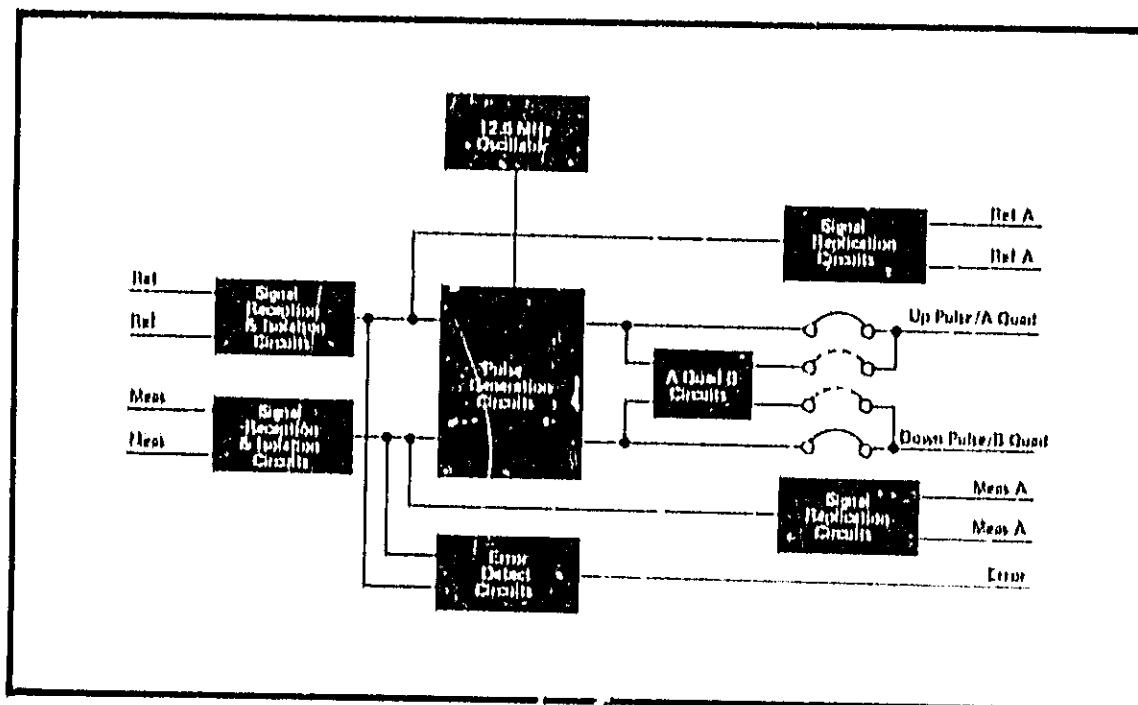


Figure 3-17. 10781A Pulse Converter Block Diagram

Resolution of 10781A Pulse Converter output is one-quarter wavelength (approximately 6.23×10^{-6} inches). If desired, pulse pairs may be generated to create an apparent resolution of $1/8$ wavelength. A pair of jumper wires allows selection of either up and down pulses or A-Quad-B format output; another jumper wire allows the pulse output to be disabled in the event of an error detection on the axis being monitored (error trip). The pulse converter is designed to provide a simple method of converting the reference and measurement signals to pulses that can be counted by a user's counting electronics.

The reference and measurement signals are applied to signal reception and isolation circuits. These circuits contain photo-isolation devices which convert the differential input signal pairs to single-ended signals with TTL logic levels. Additional immunity to external noise is obtained by applying these signals to Schmitt trigger circuits.

The pulse generation circuits compare the two input signals (derived from the incoming reference and measurement signals) with respect to frequency. The outputs from these circuits are 40 ns pulses (one pulse represents 1/2 cycle difference between the reference and measurement signals). If the reference signal frequency is higher, pulses occur on the down-pulse line; if the measurement signal frequency is higher, pulses occur on the up-pulse line.

Error detect circuits monitor the incoming reference and measurement signals for extreme frequency excursions. If the frequency deviates from its nominal value by greater than preset limits, a panel light illuminates and the two input signals are inhibited from passing to the pulse generation circuits. These extreme frequency excursions occur when the system optical devices are moved at too rapid a rate.

For additional information and schematics, refer to the 10781A Pulse Converter Operating and Service Manual.

3.21 10763A English/Metric Pulse Output

The 10763A English/Metric Pulse Output card is the system controller for the coupler backplane. It issues instructions to the counter, multiplier, and compensation cards, which convert the incoming reference and measurement signals into compensated displacement information in the form of a 28-bit binary number on the backplane. The pulse output card uses this data to generate up-down or A-Quad-B signals representing total change in position. Figure 3-18 is a block diagram of the 10763A.

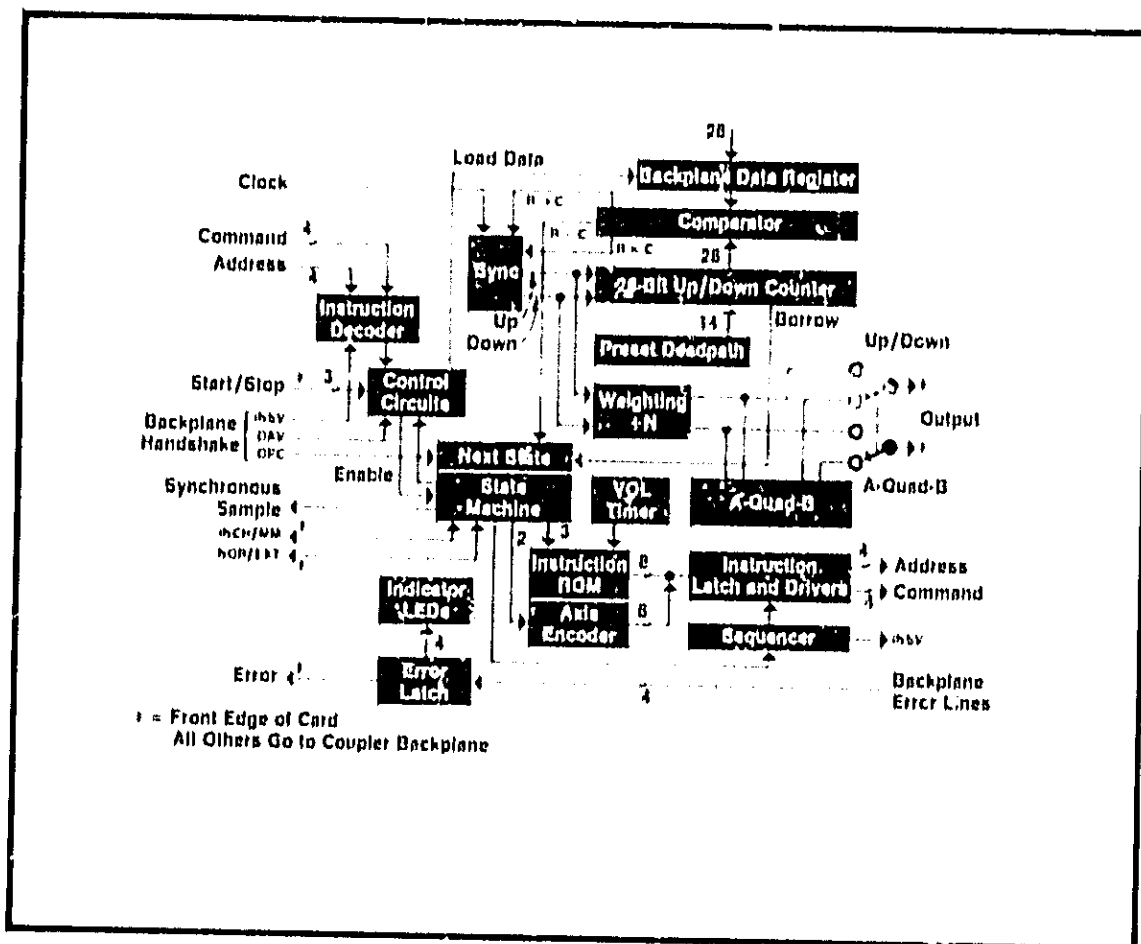


Figure 3-18. 10763A English/Metric Pulse Output Block Diagram

The heart of the pulse output card is a 28-bit comparator, which compares the 28 bits of backplane displacement information with the contents of a 28-bit up-down counter. Should the displacement number increase, the comparator enables up counts into the up-down counter until its contents are equal to the displacement. These up counts (or down counts for a negative displacement) each represent 0.1 micrometre (10 microinches in the case of English units). These same count pulses are routed through a divide-by-N counter that allows the scaling factor to be selected by the user, so that each output pulse can represent any even 10th micrometre from 0.1 to 25.6 micrometres (or 10 to 2560 microinches). A quadrature coding circuit allows the user to select A-Quad-B output coding instead of the weighted up and down pulses. The A-Quad-B output consists of two square waves in quadrature, with up/down information supplied by their relative phase: wave A lags wave B for an upward displacement and vice versa.

An algorithmic state machine (ASM) controls the internal functions of the card and generates the proper sequence of backplane instructions: synchronous sample; counter card output; multiplier card output; and return. If there are two, three, or more axes, the multiplier card is shared by the several pulse output cards, and control of the backplane is transferred from one pulse output card to the next in a regular sequence that is set during initial configuration.

A feature of the pulse output card is its ability to enter a preset number into the general-purpose counter card. This is used to allow for environmental compensation of the deadpath of the measurement axis. Deadpath is measured during machine installation and converted to a code that is entered into switches on the pulse output card. During initialization, the contents of these switches are preset into the up-down counter portion of the pulse output card. At the proper time in the initialization sequence, the pulse output card sends a count up instruction to its assigned counter card. When the pulse output card counts down to zero, it stops the counter, which now contains the deadpath, measured in quarter-wave fringe counts.

It is necessary to preset the pulse output card to a displacement count equivalent to the fringe count in the counter. This is easily done by causing the counter to output to the multiplier, and the multiplier to convert the fringe count to a compensated deadpath displacement and output it to the pulse output card. The pulse output card clocks this displacement into its 28-bit data register, and begins a special up count to equalize the up-down counter and the data register. During this time no pulses are sent to the external controller. When the special up count is complete the normal displacement data transfer begins. Should environmental conditions change, the new compensation factor will operate on both the measured displacement and the preset deadpath. This additional accuracy can be useful in some installations where physical limitations make it impossible to reduce the deadpath to the desired absolute minimum.

During each data transfer the pulse output card currently in control of the backplane looks at the four error lines on the backplane. Should one of these be true, an error latch is set and an LED lamp is lighted on the pulse output card to show which card has the error state and what kind of error it is. A user option allows the system to ignore errors on axes not currently being used, or to shut down the axis at the first error on any axis in use, or any combination. Each pulse output card has an ERROR status line brought out to the front of the card: these may be looked at individually for each axis or wire-ORed together. A backplane reset resets the error latch.

The pulse output card also allows the user to select slow or fast maximum output pulse rate, and normal or extended resolution (x6 or x10) for each axis individually.

Because each axis does a complete data input to pulse output cycle in approximately 11 microseconds (33 μ s for a three-axis system) the output pulses are a real-time measure of the displacement. For additional information and schematic, refer to the 10763A English/Metric Pulse Output Operating and Service Manual.

3.22 10755A Compensation Interface

Changing environmental conditions that result in a change in the index of refraction of air cause a change in the velocity of light and therefore in the wavelength of laser light. Accurate measurements require compensation for this effect.

The 10755A Compensation Interface Card (Figure J-19) places the required compensation factor on the coupler backplane when commanded by the system controller. Most coupler-based systems will include one compensation interface card.

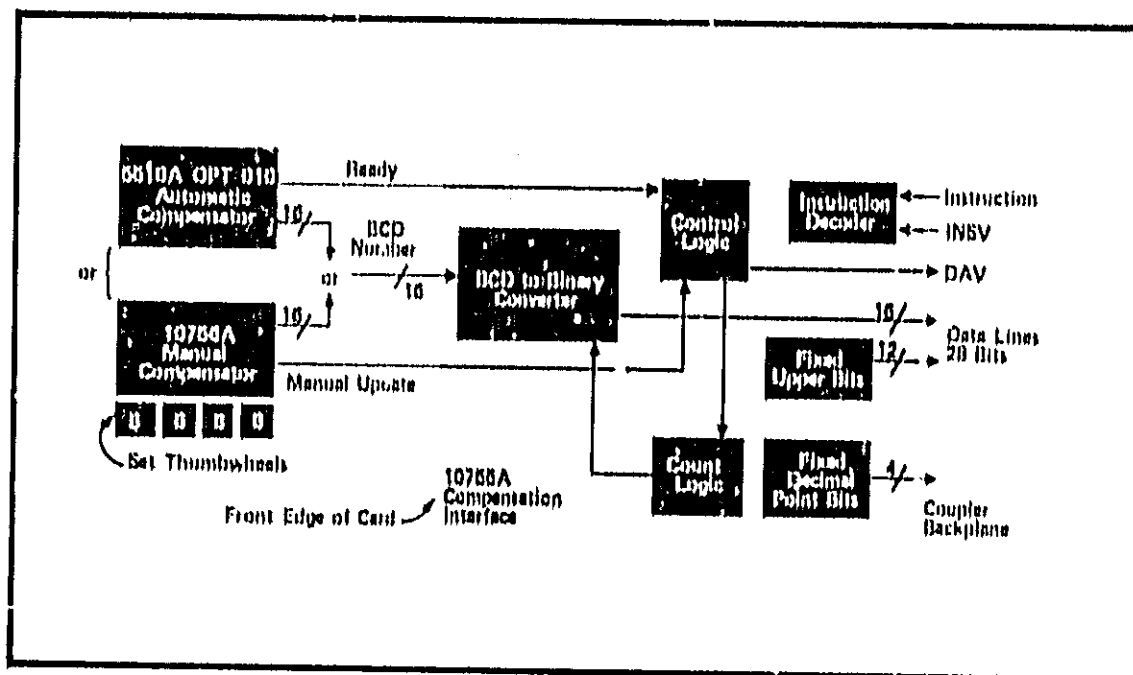


Figure J-19. 10755A Compensation Interface Block Diagram

The compensation interface gets the compensation factor either from the 5510A Opt 010 Automatic Compensator, a separate unit, or from the 10756A Manual Compensator module, which plugs into the coupler. The automatic compensator measures the temperature, pressure, and humidity of air and computes the index of refraction of air, n , and the compensation factor, $1/n$, which is between 1.0000000 and 0.9990000 for all earth-type atmospheres. Because only the four-least-significant digits change, the compensator presents only these digits to the compensation interface card in binary-coded-decimal format on 16 parallel lines. The compensation interface converts the data to a form usable by the laser transducer system and outputs it to the coupler backplane when commanded to do so.

In typical installation (workshops, laboratories, machine shops, etc.) the compensation factor can change over a period as short as a few minutes. The 5510A Opt 010 Automatic Compensator can compute a new number as often as twice each second. Where the environment is closely controlled, such as in metrology labs, the compensation factor changes very little during a day, and the data can be entered instead from a 10756A Manual Compensation module. This module presents the compensation factor, computed from a formula or derived from tables in a handbook, to the compensation interface in BCD bit-parallel, digit-parallel format identical to that of the 5510A Opt 010. A small cutout in the front panel of the coupler allows access to the thumb-wheel switches that set the number, and an update pushbutton tells the compensation interface that a new number has been entered and should now be converted into the proper format for the backplane.

The 10755A Compensation Interface Card recognizes two instructions, output and update. Update comes from the coupler backplane, from the manual module's pushbutton, during system reset, and after each output to the backplane.

When an update command occurs the interface card waits for the completion of the next compensator computation cycle. It then presets four BCD down-counters with the 16 bits from the compensator. At the same time it presets four binary up-counters with a 16-bit word representing the least-significant 16 bits of the binary representation of 9990000. The BCD down-counters are then clocked down toward zero, and simultaneously the binary up-counters are counted up. When the BCD counters reach zero, the binary counters hold a binary representation of the lower 16 bits of a binary representation of the compensation factor.

Operation with the manual compensation module proceeds in similar fashion.

In addition to compensating for the variable speed of light, the use of the compensation factor allows the operator to correct for thermal expansion of the part being measured or worked. All dimensions are normally referenced to their values at 20.0°C (68.0°F); at higher temperatures they measure longer or shorter than this, depending on whether the part has a positive or negative coefficient of thermal expansion. The 5510A Opt 010 Automatic Compensator has a special thermal probe for sensing part temperature. The coefficient of thermal expansion is entered on the front of the unit through a set of thumbwheel switches. The compensator does the required computation automatically and modifies the compensation factor accordingly. The same principle can be applied when using the 10756A Manual Compensation module.

A special check mode of the automatic compensator causes it to output the measured values of pressure, temperature, and humidity. These numbers can be placed on the backplane by the compensation interface, and can be accessed by the system controller for setup or system checkout. For additional information and schematics, refer to the 10755A Compensation Interface Operating and Service Manual.

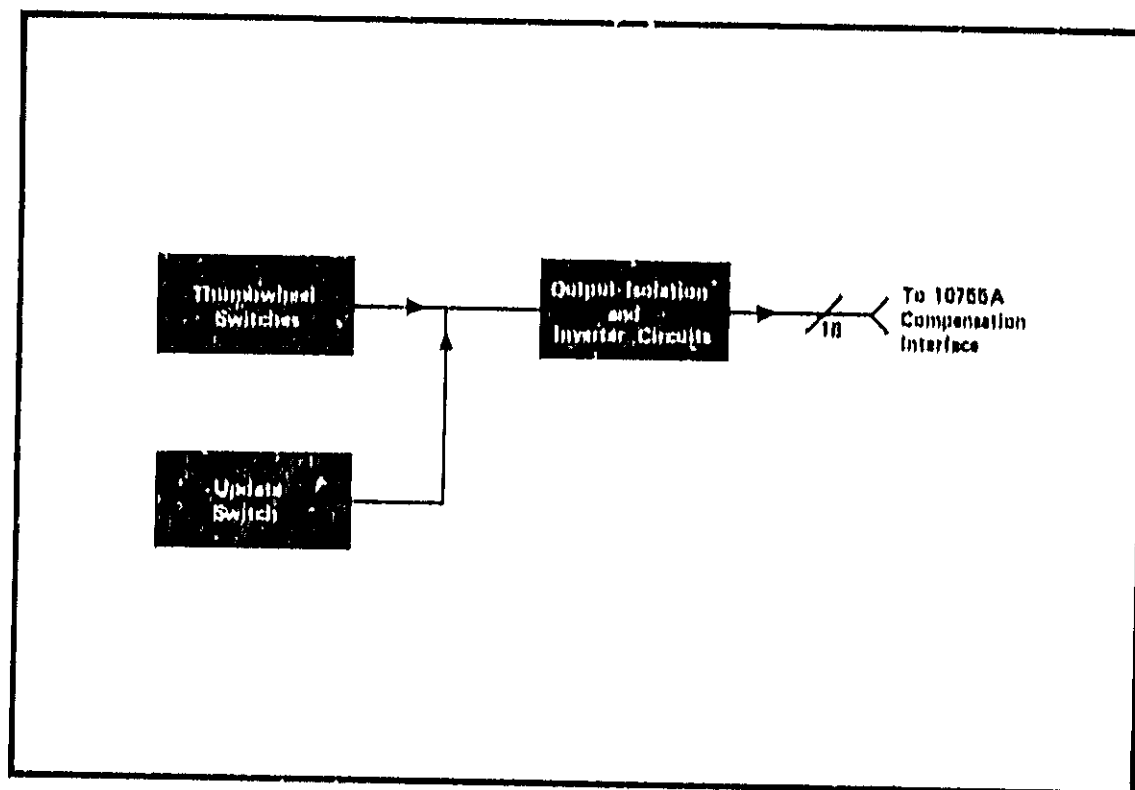


Figure 3-20. 10756A Manual Compensator

3.23 10756A Manual Compensator

The 10756A Manual Compensator is a small panel and circuit board unit (figure 3-20) designed to plug directly on the 10755A Compensation Interface. The 10756A has four thumb-wheel operated switches that allow the calculated compensation factor number to be set. The four BCD bits from each switch are then inverted and applied to the 10755A Compensation Interface. For additional information and schematics, refer to the 10756A Manual Compensator Operating and Service Manual.

3.24 5510A Opt 010 Automatic Compensator and 10563A Material Temperature Sensor

The 5510A Opt 010 Automatic Compensator itself is identical to the standard 5510A Automatic Compensator. The difference in models is that when used in the 5501A Laser Transducer System, the following cable changes are made:

- a. Delete the 562A-16 Cable.
- b. Add the 05510-60022 Interface Cable between the 5510A and the 10755A Compensation Interface;
- c. Add the 10740-60005 Power Cable between the 10740A Coupler and the $\pm 15V$ power supply.

Overall, the 5510A Opt 010 Automatic Compensator makes atmospheric measurements and the 10563A Material Temperature Sensor makes material temperature measurements and supplies four BCD compensation digits to the 10755A Compensation Interface. For operating instructions refer to Section IV, Programming and Operation. For additional information and schematics refer to the HP 5510A Operating and Service Manual.

3.25 10783A Numeric Display

NOTE

The 10783A can only be used in the "ADDRESSABLE" mode when used in the 5501A system.

The 10783A Numeric Display provides the laser transducer system with digital display of single or multiple-axis displacement data. It is driven from the Hewlett-Packard Interface Bus in either the "Listen Always" mode or the "Addressable" mode.

Fourteen 7-segment LED indicators with left-hand decimal points allow ample capacity for displaying more than one axis of data. Six axis identifiers (A, B, C, X, Y, Z) are supplied with each display module and may be inserted into the specially designed front panel. As an example, one 10783A can display six digits with sign and decimal point for the X-axis and five digits with sign and decimal point for the Y-axis, with a space between the two numbers. The "X" and "Y" identifiers can be placed in the front panel below the appropriate digits.

The characters that can be displayed are the digits 0 to 9, a minus sign, the letter L and the decimal point. Front panel indicators include an ON light indicating when the 10783A is "Addressed" and an overflow light that indicates when more than 14 characters have been received. In an overflow condition, the 14-least-significant digits are displayed. In addition to these indicators, there is a lamp test switch for checking all segments and indicators not already energized.

Flicker-free output is obtained by employing both input and output data storage. The display digits are strobed at a constant rate independent of input data transfer rate.

3.26 5501A Power Supply Options

The 5501A Laser Transducer Systems require a $\pm 15\text{V}$ Power Supply and a $+5\text{V}$ Power Supply. The Hewlett-Packard power supplies that can be used with the system are 62000 series power supplies with an LED indicator added as required by FED, REGIST., July 31, 1975, Vol. IV-0-140, part 2.

The 5501A power supply options all contain overcurrent, overtemperature, overvoltage, reverse voltage, and remote sensing protection.

Table 3-6 lists the power supplies available. For additional information and schematics, refer to the applicable Operating and Service Manual.

Table J-5. Power Supplies Available for 5501A Laser Transducer System

HP Model No.	Description	Input Voltage
10700A	62215E $\pm 15\text{V}$ Power Supply and 62605L $\pm 5\text{V}$ Power Supply	115V
10700B	62215E $\pm 15\text{V}$ Power Supply and 62605L $+5\text{V}$ Power Supply	230V

PROGRAMMING AND OPERATION

section IV

Programming and Operation

4.1 INTRODUCTION

This section provides the information necessary to program and operate your system. It is organized as follows:

- a. A general discussion of the objectives and methods of programming the Laser Transducer System. This includes a general system operating discussion from the viewpoint of the system programming requirements.
- b. A table of individual commands for each unit of the system that is programmable. Instruction formats for both ASCII characters and the decimal equivalent of the binary command are included.

- c. Commented programs and examples of measurements and data movement using the 9825A Calculator as the system controller and the 10745A HP-IB Interface to the Laser Transducer System.
- d. Commented programs and examples of measurements and data movement using the 10746A Binary Interface. The 9825A Calculator is used as the system controller but the program illustrates how a computer could be used instead of the 9825A.
- e. A general discussion with examples of data handling after the data has been transferred to the system controller.
- f. A general discussion of how to debug (remove errors from) your program.

NOTE

The operating procedures (other than initial turn on) for the Laser Transducer System are dependent on the programming and design of the system controller.

- B. Initial turn on, general operating instructions for a typical system, and brief explanations of the controls and indicators on the receiver, the laser head, the numeric displays, and the 5510A OPT 010 Automatic Compensator.

4.2 PROGRAMMING OBJECTIVES AND METHODS

The objective of programming is to obtain the defined results from the system under control. The methods of programming are dependent on the requirements of the system controller and the capabilities of the system under control. Therefore, in order to effectively program the Laser Transducer System you must understand and be able to use the following information:

- a. LANGUAGE OF THE SYSTEM CONTROLLER. For example, when the HP 9825A Calculator is used as the system controller the operating and control manuals supplied with the calculator contain complete descriptions and examples of the commands and syntax used with the 9825A. Note that since the Laser Transducer System also requires the 98213A I/O ROM and the 98034A HP-IB Interface, you must also familiarize yourself with the additional commands and capabilities of these units. Separate operating and programming manuals provide this information. If any other unit is used as the system controller (e.g., a computer or other calculator), you must have a complete understanding of the capabilities and limitations of its control language.
- b. OPERATION OF THE LASER TRANSDUCER SYSTEM. Prior to attempting to program the system you should be familiar with the information in Sections II and III that applies to your system. In addition there are general discussions of system operation from programming viewpoint contained in this section.
- c. Finally, you must know the specific addresses and commands that make up the instructions that are applicable to the units in your system. This information is contained in Tables 4-2 through 4-11.

After you have reviewed this information, study the commented programs and illustrations in this section to gain the necessary insight into information flow within the Laser Transducer System. These programs are written using the 9825A as a system controller. However, the illustrated examples of data flow apply to any system containing the specified units.

4.3 GENERAL SYSTEM OPERATING DESCRIPTION

Most laser transducer systems are based on the 10740A Coupler (with associated plug-in modules) and a calculator or computer which is used as the system controller and data processor. The plug-in modules interface the various laser system components to the coupler backplane bus, and the coupler backplane bus carries all signals (data and control) between the plug-in modules.

Basically, a counter-based laser transducer system operates as follows. Displacement information, which is updated continuously in an operating system, is transferred, upon command, from the counters on the 10760A Counter plug-in module to the coupler backplane bus. This data is then transferred from the bus to the system controller for later processing. Next, velocity-of-light compensation data is transferred to the controller. The controller then manipulates the data (using its processing capabilities) so that the raw data represents meaningful displacement data. The controller then outputs the data to a printer or display unit or compares the data to predetermined limits or setpoints for automatic machine positioning applications.

One of the two plug-in modules (either the binary interface or the HP-IB interface, depending upon specific application) is used to interface the coupler backplane to the controller/processor. The controller commands the system, via the selected interface card, to perform each function necessary to make a measurement. The controller does this by issuing instructions that contain four bits of module address information and four bits of module command information. Each module in the coupler recognizes its unique address and responds to commands associated with that address. Additionally, some modules automatically respond to commands sent to other modules. For example, when a counter card is instructed to output measurement data to the coupler backplane bus, the HP-IB interface card automatically inputs that data and holds it until instructed to output the data to the controller (or other device connected to the HP-IB). This feature allows faster processing of data with fewer instructions.

The following programming information describes the coupler backplane instruction set that is available to control operation of a laser measurement system. Additionally, sample programs are supplied to demonstrate the sequence of operations required to control the system. This information and a thorough understanding of the system controller characteristics will allow you to generate programs for your specific measurement application.

4.4 Sample Outline for a Three-Axis Counter-Based System

The following steps outline the general programming requirements for a simple three-axis counter-based system:

OPERATION	RESULT
a. Backplane Reset	Initializes all cards. Presets counters to 160.
b. Output Compensation	Puts compensation data on backplane which is accepted by 10745A HP-IB Interface.
c. Format Data	10745A HP-IB Interface converts binary data to BCD and stores in RAM.
d. Read into Calculator	Compensation data stored in Calculator.
e. Backplane Sample	Samples all counters simultaneously. Puts counter contents in output buffer.
f. Output X-Axis Data	Puts X-axis data on backplane which is accepted by 10745A HP-IB Interface.
g. Format Data	10745A HP-IB Interface converts binary data to BCD and stores in RAM.

- | | |
|---|---|
| h. Read into Calculator | X-axis data stored in Calculator. |
| i. Subtract 160 from X-axis data; multiply by compensation data and constant for inches conversion (6.23023×10^{-4}) | Calculates compensated measurement value in inches. |
| j. Output on HP-IB to 107B3A Display | Displays X-axis measurement. |
| k. Repeat i through j for Y-Axis | Displays Y-Axis measurement. |
| l. Repeat i through j for Z-Axis | Displays Z-Axis measurement. |
| m. Go to h to repeat cycle. | |

4.5 General Coupler Interface Description

4.6 COUPLER BUS STRUCTURE. The 10740A Coupler backplane consists of 86 lines (refer to *Table 4-1*). Some of these lines are tied together for special functions (for example lines 37-40 and 47-50 are all tied together and used as +5 volt return). Each of these lines has a dedicated function and any card which requires that function uses that line (refer to 10740A theory of operation in Section III). For this reason, any given card can be connected to any one of the backplane connectors.

The structure can be divided into three parts; data related lines, instruction related lines, and power lines.

The data lines consist of 28 lines for binary magnitude, 4 decimal point lines, 4 error lines, one special line for indicating $\lambda/4$ or $\lambda/8$ mode, and a special line for indicating a special function labeled "system nulled" which is used with the comparator-based systems.

The instruction lines consist of 4 command lines, 4 card address lines, 2 lines used as instruction valid (INSV), 2 lines used as data valid (DAV), and 2 lines used as operation complete (OPC), one line for system reset, and one line for the synchronous sample command.

The power lines consist of 2 lines of +15V, 2 lines for -15V, 2 lines for $\pm 15V$ return, 6 lines for +5 volts, and 8 lines for +5 volt return.

4.7 BUS LANGUAGE. The basic transducer language consists of instructions. Each 8-bit instruction is composed of a 4-bit address and a 4-bit command. The execution of an instruction represents an operation. (*Tables 4-2 through 4-11* lists the instructions for each card.)

There are two possible sequences that may occur as a result of an instruction depending on whether or not the instruction requested data to be transferred on the backplane. In general the sequence will be:

1. An instruction is placed on the command and address lines.
2. INSV goes low to indicate the instruction is valid.
3. Each card looks at the instruction to determine if it is involved.
 - a. If it is not involved, go to step 8.
 - b. If it is involved, continue.
4. The instruction is interpreted and the indicated operation begun.
 - a. If no data transfer is required, go to step 8.
 - b. If data is transferred, continue.

Table 4-1. 10740A Coupler Bus Lines

FUNCTION	PINS	NAMES	PINS	NAMES
POWER	1	+15 VOLTS	2	+15 VOLTS
	3	-15 VOLTS	4	-15 VOLTS
	5	± 15 RETURN	6	± 15 RETURN
ADDRESSES INSTRUCTIONS COMMANDS	7	SPARE	8	SPARE
	9	CARD ADDRESS-A	10	CARD ADDRESS-B
	11	CARD ADDRESS-C	12	CARD ADDRESS-D
	13	CARD CMD-A	14	CARD CMD-B
	15	CARD CMD-C	16	CARD CMD-D
STATUS	17	DATA VALID	18	DATA VALID
	19	INSTRUCTION VALID	20	INSTRUCTION VALID
	21	OPERATION COMPLETE	22	OPERATION COMPLETE
	23	SAMPLE	24	PWR-UP/SYSTEM RESET
ERRORS	25	REF ERROR-BIT	26	MEAS ERROR-BIT
	27	V.O.L. ERROR-BIT	28	OVFL-BIT
DECIMAL POINT	29	D.P.-BIT-1	30	D.P.-BIT-0
	31	D.P.-BIT-3	32	D.P.-BIT-2
MODE-STATUS	33	A-MODE BIT	34	SYSTEM NULLED
	35	SPARE	36	SPARE
POWER	Key --		Key --	
	37	+5V RETURN	38	+5V RETURN
	39	+5V RETURN	40	+5V RETURN
	41	+5 VOLTS	42	+5 VOLTS
	43	+5 VOLTS	44	+5 VOLTS
	45	+5 VOLTS	46	+5 VOLTS
	47	+5V RETURN	48	+5V RETURN
DATA	49	+5V RETURN	50	+5V RETURN
	51	SPARE	52	SPARE
	53	DATA BIT 1	54	DATA BIT 0
	55	DATA BIT 3	56	DATA BIT 2
	57	DATA BIT 5	58	DATA BIT 4
	59	DATA BIT 7	60	DATA BIT 6
	61	DATA BIT 9	62	DATA BIT 8
	63	DATA BIT 11	64	DATA BIT 10
	65	DATA BIT 13	66	DATA BIT 12
	67	DATA BIT 15	68	DATA BIT 14
	69	DATA BIT 17	70	DATA BIT 16
	71	DATA BIT 19	72	DATA BIT 18
	73	DATA BIT 21	74	DATA BIT 20
	75	DATA BIT 23	76	DATA BIT 22
	77	DATA BIT 25	78	DATA BIT 24
	79	DATA BIT 27	80	DATA BIT 26
	81		82	
	83	MAKE NO CONNECTION	84	MAKE NO CONNECTION
	85		86	

- The indicated card (data transmitter) puts data, decimal point information, and error information on the backplane.
- The indicated card (data transmitter) drives $\overline{DAV}$ low to indicate backplane data is valid.
- The indicated card (data receiver) accepts the data on the backplane.

8. Each card releases (allows to go high) OPC as soon as it is able,

NOTE

In step 6 this card may drive $\overline{DAV}$ low at the same time or before it lets OPC go high. However the card in step 7 may not let OPC go high until it has accepted the backplane information. OPC remains low until all cards have released it.

9. When all cards have released OPC, $\overline{NSV}$ is returned high to terminate instruction.
10. $\overline{DAV}$ goes high. If an output was involved, $\overline{DAV}$ remains high if no output was involved. OPC is driven low by all cards.
11. Sequence starts over at step 1.

4.8 HP-IB BASED SYSTEM PROGRAMMING

HP-IB based transducer systems are supplied with the 9825A Calculator (for information on other HP calculators, see Appendix A). The calculator systems include an HP-IB interface module and appropriate ROM modules. The calculator documentation includes information for these devices.

Tables 4-2 through 4-11 show the instructions that can be issued to the laser system to control system operation. These instructions are issued from the calculator via the HP-IB interface module to the 10740A Coupler backplane bus. Instructions consist of a numeric command and an alphabetical address (e.g., 2X causes the 10760A Counter card that has its address jumper in the X position to output its last sample to the couple, backplane bus). The instructions must be sequenced in the order that will cause the desired operations.

NOTE

In all programming instructions, 0 is zero and O is the letter O.

Instructions can be combined in one calculator program step. An example of this is the instruction sequence 1O2X3O. From the tables it can be seen that the 1O instruction generates a backplane sample command, the 2X instruction causes the X-axis counter card to output its sampled data and causes the HP-IB interface card to input that data, and the 3O instruction causes the HP-IB interface card to convert that data to BCD and prepare to send the data to the calculator upon receipt of further program statements.

Because the displacement data contained in the 10760A Counter cards (and, consequently, the data sent to the calculator) is in units of $\frac{1}{4}$ wavelengths of the laser light, the calculator must convert this to a useable unit of measure -- either inches or millimetres. Additionally, the counters are preset to 160 counts so the effects of vibration do not cause the counters to underflow. The calculator, therefore, must also subtract 160 counts from the displacement data prior to converting the data to inches or millimetres. One last data-manipulation requirement must be satisfied by the calculator program: the displacement data must be multiplied by the velocity-of-light compensation factor. The following formula demonstrates the procedure for conversion of input counts from the 10760A Counter to compensated inches or millimetres. For accurate measurements, the formula must be included in all calculator programs. Subsequent samples show how this is done.

$$\text{FORMULA: } X = (D - 160) (K) (C)$$

Where: X is compensated inches or millimeters of displacement data,
 D is uncompensated counts from the 10760A Counter card,
 K is the inch or millimeter conversion factor (6.23023×10^{-6} for inches and 1.58248×10^{-4} for millimeters),
 C is the velocity-of-light compensation factor from the manual or automatic compensator.

NOTE

If the system is operated in the "X10" extended resolution mode, the formula must be changed to subtract 16 counts instead of the 160 counts specified above.

4.9 COMPUTER-BASED SYSTEM PROGRAMMING

Several different configurations of laser transducer systems can be controlled by a digital computer. The following discussion refers specifically to a system using the 10740A Coupler and the 10746A Binary Interface.

The binary interface module allows a digital computer to control the laser transducer system if the computer has its own input/output circuits or has other means for accomplishing the following:

- It must send a "command" signal to the binary interface module to start each functional operation.
- It must accept a "flag" signal from the binary interface module. The "flag" signal signifies completion of a function by the binary interface module.
- It must have a set of data lines to allow passage of binary data to and from the binary interface module.

The data lines between the binary interface module and the computer can be separated into input and output lines, or can use common input/output lines. In either case, only one operation can take place at a time. Data words can consist of either 8 or 16 bits; 12-bit computers must use 8-bit words and pack them, if desired, by software means.

The general sequence for a computer-controlled operation is as follows:

- The computer outputs an instruction to a register on the computer output interface circuit assembly.
- The computer sends a "command" signal to the 10746A Binary Interface. The "command" signal causes the 10746A to accept the instruction and perform the associated function.
- The 10746A returns a "flag" signal to the computer to indicate acceptance of the instruction.
- The computer can now proceed to other program steps. For example, the steps required to input data from its interface register if the original instruction specified a data transfer from the 10746A to the computer.

If the "command" signal is removed by the computer, the "flag" signal from the 10746A will be immediately reset. The signal therefore, should not be removed until all flag-dependent transfers have been completed.

In the "command" mode, the 10746A treats all computer outputs as commands. If a command from the computer instructs the 10746A to go to the "data" mode, the 10746A treats the next two 16-bit words (or four 8-bit words, if jumper selected) as data. The most-significant word must be transferred first.

Two instructions cause "data" mode operation. These instructions initiate computer data outputs and computer data inputs. At the end of a data transfer, the 10746A returns to the "command" mode.

If the 10746A is in "command" mode, all instructions sent by the computer are passed on to the 10740A Coupler backplane. The instructions are also examined simultaneously by the 10746A to determine if they require specific responses by the 10746A.

Use Tables 4-2 through 4-11 to organize the operating sequence necessary to provide desired system operation. For example, Table 4-3 shows that an OP instruction generates a backplane reset signal and clears the error-bit buffer on the 10746A Binary Interface. To generate this instruction from the computer, output the binary equivalent of the decimal number shown for OP in Table 4-3 (decimal 255 or binary 11111111) for a negative-true interface card. The 10746A Binary Interface uses positive-true logic. The decimal instructions in Tables 4-2 through 4-11 show the decimal negative-true logic value in black and the positive-true logic in red.

Table 4-2. 10745A HP-IB Interface Instructions

BACKPLANE CARD ADDRESS IS 0		
ADDRESSED INSTRUCTIONS		
HP-IB Instruction	Response	Decimal Instruction
00	Generate system reset, clear error-bit buffers and initialize all state machines	15 240
*00	Clear error bit buffer	—
10	Generate simultaneous sample command	14 241
20	Handshake and do nothing	13 242
*20	Load HP-IB data buffer and handshake in response to BP-DAV	—
30	Convert data stored in data buffer from binary to BCD and store in RAM. Output according to HP-IB rules	12 243
70	Do nothing. This instruction causes HP-IB to drive instruction lines passive - high	0 255
NONADDRESSED INSTRUCTIONS		
System Reset	Same as 00 instruction	
Sample	Do nothing	

*20 means CMD 2 and any card address except 0

Table 4-3. 10746A Binary I/O Interface Instructions

BACKPLANE CARD ADDRESS IS P		
ADDRESSED INSTRUCTIONS		
HP-IB Instruction	Response	Decimal Instruction
*0P	Generate backplane reset and clear error bit buffer	255 0
*0P	Clear error bit buffer	—
1P	Generate simultaneous sample command	254 1
2P	Output data to backplane data bus from I/O buffer	253 2
*2P	Load data from backplane data bus into I/O buffer	—
3P	Send data and/or error bits to computer from I/O buffer	252 3
*3P	Load addressed card with data via backplane data lines	—
4P	Load Data into 10746A I/O buffer	251 4
All Other Instructions	Do Nothing	—
NONADDRESSED INSTRUCTIONS		
System Reset	Same as 0P instruction	—
Sample	Do Nothing	—

*0P means CMD 0 and any card address except P.

**For 16-bit mode, three sequential 0P commands are required; for 8-bit mode, five sequential 0P commands are required.

Table 4-4. 10755A Compensation Interface

BACKPLANE CARD ADDRESS IS V		
ADDRESSED INSTRUCTIONS		
HP-IB Instruction	Response	Decimal Instruction
0V	Initialize state machine and take new reading	159 06
*2V	Output VOL compensation information to 0P data bus and start new measurement	157 08
All Other Instructions	Handshake immediately and do nothing	—
NONADDRESSED INSTRUCTIONS		
System Reset	Same as 0V	—
Sample	Do Nothing	—

*This is the compensation number for the last time a 2V or 0V was given. Therefore, if a 2V command is given every 15 minutes, the compensation value is 15 minutes old.

Table 4-5. 10760A Counter Instructions

BACKPLANE ADDRESS IS SELECTABLE, MAY BE X, Y, Z, A, B, OR C (Mutually Exclusive)		
ADDRESSED INSTRUCTIONS		
HP-IB Instruction	Response	Decimal Instruction
0X	Preset counter to 160, clear error bits, and set normal revolution	See Table 4-11 Instruction is address-dependent
1X	Load contents of counter into output data buffer	
2X	Output last sample, decimal point, and error bits to HP Data Bus	
4X	Count DOWN	
5X	Go to normal revolution mode, preset counter, clear error bits, Does not clear HP-IB error bits	
6X	Go to extended revolution mode, preset counter, clear error bits	
7X	Count UP	
NONADDRESSED INSTRUCTIONS		
System Reset	Preset counter to 160, clear error bits, and set normal revolution	—
Sample	Load contents of counter into output data buffer	—

*Address "X" is used in this table as an example. To have instruction apply to another counter card replace "X" with that card's address.

Table 4-6. 10761A Multiplier Instructions

BACKPLANE CARD ADDRESS IS M		
ADDRESSED INSTRUCTIONS		
HP-IB Instruction	Response	Decimal Instruction
0M	Reset multiplier and set up λ/λ multiplication mode.	47 200
2V	Accept VOL number and do conversion constant correction	157 98
2 ABC XYZP	Accept Displacement number and perform conversion	Refer to Table 4-11
2M	Output conversion results to backplane	45 210
3M	Accept user generated conversion constant from binary I/O card	44 211
3V	Accept user generated VOL compensation numbers from binary I/O card	156 99
4M	Clear registers, go to mm units and set multiplier constant for non-VOL system - mm mode, clear error bit	43 212
6M	Clear registers, go to inches units and set multiplier constant for non-VOL system - inches mode, clear error bit	41 214
All Other Instructions	Do Nothing	—
NONADDRESSED INSTRUCTIONS		
System Reset	Same as 0M	—
Sample	Do Nothing	—

Table 4-7. 10762A Comparator Instructions

BACKPLANE ADDRESS IS SELECTABLE, MAY BE Y, Y, Z, A, B, OR C (Mutually Exclusive)		
ADDRESSED INSTRUCTIONS		
HP-10 Instruction	Response	Decimal Instruction
*0X	Reset count register to 160 counts, force digital difference output to null, clear OVER-BUFFER, terminate self-check (if in progress)	Refer to Table 4-11 as instruction is address-dependent
1X	Load contents of counter into output buffer as soon as there is a window wide enough to insure that a count is not propagating through the count chain	
2X	Output contents of output buffer to backplane data bus, output A mode (A/Z or X/Z), output decimal point code, output contents of OVER-ERROR buffer. Data valid signal goes true only if sample circuit is not in the process of taking a sample	
3X	Load destination register with 20-bit number and tolerance register with 4-bit number on 10740A backplane when binary DAV goes true. X is implied Listener -- 10746A implied Talker	
4X	Disable UP/A and DWN/B inputs and count down at 10 MHz. (Terminates with a reset, or an underflow in count register)	
5X	NOP	
6X	NOP	
7X	Disable UP/A and DWN/B inputs and count up at 10 MHz. (Terminates with reset or an overflow in count register)	
NONADDRESSED INSTRUCTIONS		
System Reset	Same as 0X instruction	—
Sample	Same as 1X instruction	—

"X" used as an example of the address in this table. To make instruction apply to another comparator simply replace "X" with that card's address.

Table 4-8. 10764B Fast Pulse Converter Instructions

BACKPLANE ADDRESS IS SELECTABLE, MAY BE X, Y, Z, A, B, OR C (Mutually Exclusive)		
ADDRESSED INSTRUCTIONS		
HP-10 Instruction	Response	Decimal Instruction
*0X	Reset error bits and sample resolution switches	Refer to Table 4-11 as instruction is address-dependent
2X	Output contents of buffer register error bits to backplane data bus	
NONADDRESSED INSTRUCTIONS		
System Reset	Same as 0X instruction	—

"X" used as an example of the address in this table. To make instructions apply to another fast pulse converter simply replace "X" with that card's address.

At least two reset pulses are required after power on or resolution change.

Table 4-9. 10763A Responses to Instructions

BACKPLANE ADDRESS IS SELECTABLE, MAY BE X, Y, Z, A, B, OR C (Mutually Exclusive)		
ADDRESSED INSTRUCTIONS		
HP-IB Instruction	Response	Decimal Instruction
*3X	Accepts control of coupler bus from previous 10763A controller	See Table 4-11 as instruction is address dependent

*In a multiaxis system one 10763A is in control until it updates its displacement data and then it passes control to the next 10763A.

Table 4-10. Possible Instructions by 10763A English/Metric Pulse Output

BACKPLANE ADDRESS IS SELECTABLE, MAY BE X, Y, Z, A, B, OR C (Mutually Exclusive)			
ADDRESSED INSTRUCTIONS			
HP-IB Instruction	To	Response	Decimal Instruction
5X	10760A	Set normal resolution	N/A
6X	10760A	Set extended resolution	N/A
4M	10761A	Select millimeter conversion factor	N/A
6M	10761A	Select inch conversion factor	N/A
2V	10755A	Output most recent data	N/A
7X	10760A	Count up	N/A
1X	10760A	Load count in output buffer	N/A
2X	10760A	Output count to coupler bus	N/A
2M	10761A	Output product to coupler bus	N/A
*3Y	*Next 10763A	Accepts control of coupler bus	N/A
NONADDRESSED COMMANDS			
System Reset	All Units on Bus	Returns all units to original RESET condition	N/A
Sample	10760A only respondent	Loads count in output buffer	N/A

*In a multiaxis system one 10763A is in control until it updates its displacement data and then it passes control to the next 10763A.

Table 4-11. Instruction Set Conversion from Alphanumeric to Decimal

NOTE										
The numbers shown in black are negative-true logic interface cards. The numbers shown in red are for positive-true cards. The 10746A Binary Interface is a positive-true card. If you are in doubt as to which numbers to use, the easiest way to determine the polarity of your I/O card is to program a simple command and note the system response.										
Address Command	A	B	C	M	O	P	V	X	Y	Z
0	239	223	207	47	15	255	159	127	111	95
	16	12	40	200	240	0	96	128	144	160
1	238	222	206	--	14	254	--	126	110	94
	17	11	49		241	1		129	145	161
2	237	221	205	45	13	253	157	125	109	93
	18	14	50	210	242	2	98	130	146	162
3	--	--	--	44	12	252	156	124	108	92
				211	243	3	99	131	147	163
4	235	219	203	--	--	251	--	123	107	91
	20	16	52			4		132	148	164
5	234	218	202	--	--	--	--	122	106	90
	21	17	53					133	149	165
6	233	217	201	41	--	--	--	121	105	89
	22	18	54	214				134	150	166
7	232	216	200	--	--	--	--	120	104	88
	23	19	55					135	151	167

4.10 TYPICAL PROGRAMS

Two typical programs (Tables 4-12 and 4-13) are provided to illustrate how to program the 10745A HP-IB Interface and the 10746A Binary Interface respectively. Both programs are commented. Reference is made in these programs to data movement figures to further illustrate the data flow within the Laser Transducer System. In these figures each specific instruction and the associated data movement is shown in red. Note that the decimal instructions used in the binary interface program are positive-true values. Table 4-14 lists the Binary Interface Typical Program Variables. The sequence of drawings in Figure 4-2 assumes that you will go to a subroutine the first time it is referenced to determine its function.

Table 4-12. 10745A HP-IB Interface Typical Program using HP 9825A Calculator

PROGRAM	COMMENT
0: clr 7; rem 7	Send Device Clear to all devices on the HP-IB. Send Remote Enable to all devices on the HP-IB.
1: wrt 709, "006X"	Send to 10745A. 7 = Select Code of 98034A HP-IB Interface. 09 = Address of 10745A. 00 = System Initialization via HP-IB. 6X = Set X-axis to extended resolution. See Figures 4-1A and B.
2: wrt 709, "2VJO"	Send to 10745A. 2V = transfer VOL number. JO = Setup to output VOL to HP-IB. See Figures 4-1C and D.
3: red 709,C	VOL transferred via HP-IB to variable C.
4: B←E	Set loop counter for compensation update to 8.
5: "loop": E←E+1; if E=10; goto -3	Increment loop counter. If 10 times through loop go read in new compensation value.
6: wrt 709, "102XJO"	Send to 10745A. 10 = sample X, Y axis via HP-IB. 2X = Transfer X to 10745A. JO = set up to output X to HP-IB. See Figures 4-1E, F, and G.

Table 4-12. 10745A HP-IB Interface Typical (Cont'd)

PROGRAM	COMMENT
7: rcl 709,X	X transferred via HP-IB to variable X
8: if rds(7)<120; gto +2	If no device on HP-IB is requesting service, skip the next line.
9: 0→A;gsh "status"	A=0 for X-Axis. Go find out if 10745A is requesting service.
10: (X-16)*6.23023e-6°C→X	-16 is the subtract preset for extended resolution. X6.23023e-6 is the conversion of $\lambda/4$ to microinches C compensates for VOL + Material Temperature.
11: fnt 1,f12,6	Format No. 1. Fixed point 12 characters wide, 6 digits to the right of the decimal.
12: wrt 717,1,X	Send X to X-Display. Format 1 is used, 7 = select code of 98034A 17 = address of 10703A X-Display. See Figure 4-111.
13: wrt 709, "2YJO"	Send to 10745 via HP-IB. 2Y = transfer to 10745A via HP-IB. JO = set up to output Y to HP-IB. See Figure 4-11 and J.
14: rcl 709,Y	Y transferred via HP-IB to variable Y.
15: if rds(7)<120;gto +2	If no device on HP-IB is requesting service skip the next line.
16: 1→A;gsh "status"	A=1 for Y-Axis to find out if 10745A is requesting service.
17: (Y-160)*6.23023e-6°C→Y	-160 is the subtract preset for normal resolution.
18: wrt 717,1,Y	Send Y to Y-display. Format 1 is used, 7 = select code of 98034A 18 = address of 10703A Y-Display. See Figure 4-11K.
19: gto "loop"	Go to top of display "loop"
20: "status":rds(709)→B	Get status byte from 10745A.
21: if B>=64;gsh "check"	If bit 6 set then 10745A has requested status. Go check what kind of error.
22: wrt 709, "0P"	Send to 10745A. 0P = clear error bits on 10745A via HP-IB. See Figure 4-11.
23: ret	subroutine "status" return statement.
24: "check":B-112→B	Clear Bits 6,5,4.
25: if B>=0;gsh "ovl"	If Bit 3 is set, go to subroutine "ovl"
26: if B>=4;prt "VOL OUT OF RANGE";B-4→B; B→D	If Bit 2 is set, VOL error irrecoverable.
27: if B>=2; prt "MEAS ERROR";B-2→B;B→D	If Bit 1 is set, MEAS error B→D is irrecoverable error.
28: if B-1;prt "REF ERROR" B→D	If Bit 0 is set, reference error B→D is irrecoverable error.
29: if D=1;ret	If D=1 then the error is an overflow which is recoverable.
30: if A=0;prt "X-AXIS ERROR"	
31: if A=1;prt "Y-AXIS ERROR"	
32: dsp "GO TO GAGE";stp	Display "GO TO GAGE" and stop.
33: gto B	When CONTINUE is pressed the program restarts at the beginning of the program.
34: "ovl":B-B→B;1→D	1→D. Perhaps recoverable error. Clear Bit 3.
35: if A=0;X-z120/10→X	X-Axis complement all bits of X and Add 1.
36: if A=1;Y-z120→Y	Y-Axis complement all bits of Y and Add 1.
37: ret	
38: end *19613	

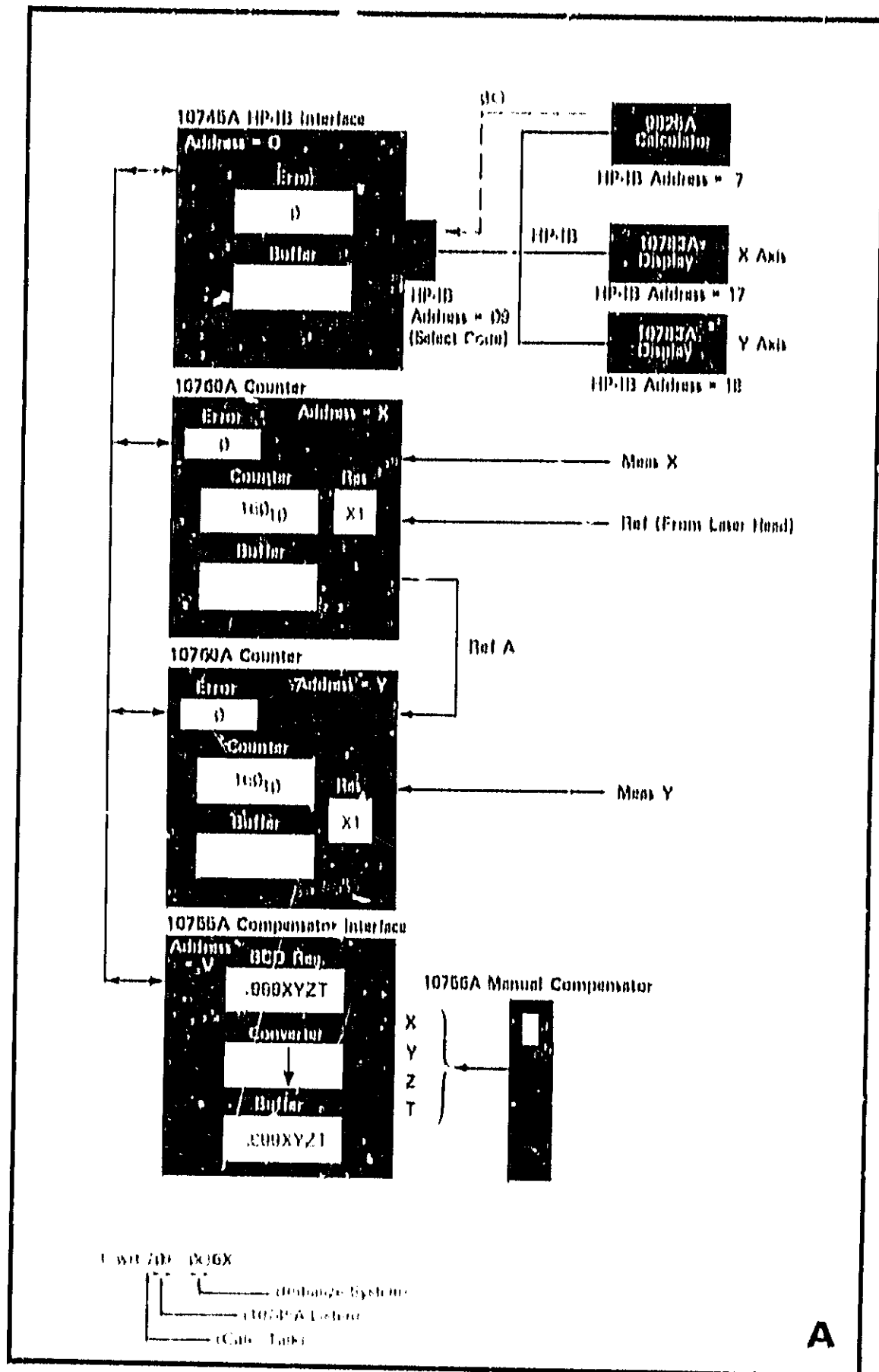


Figure 4-1. Counter-Based System Data Flow

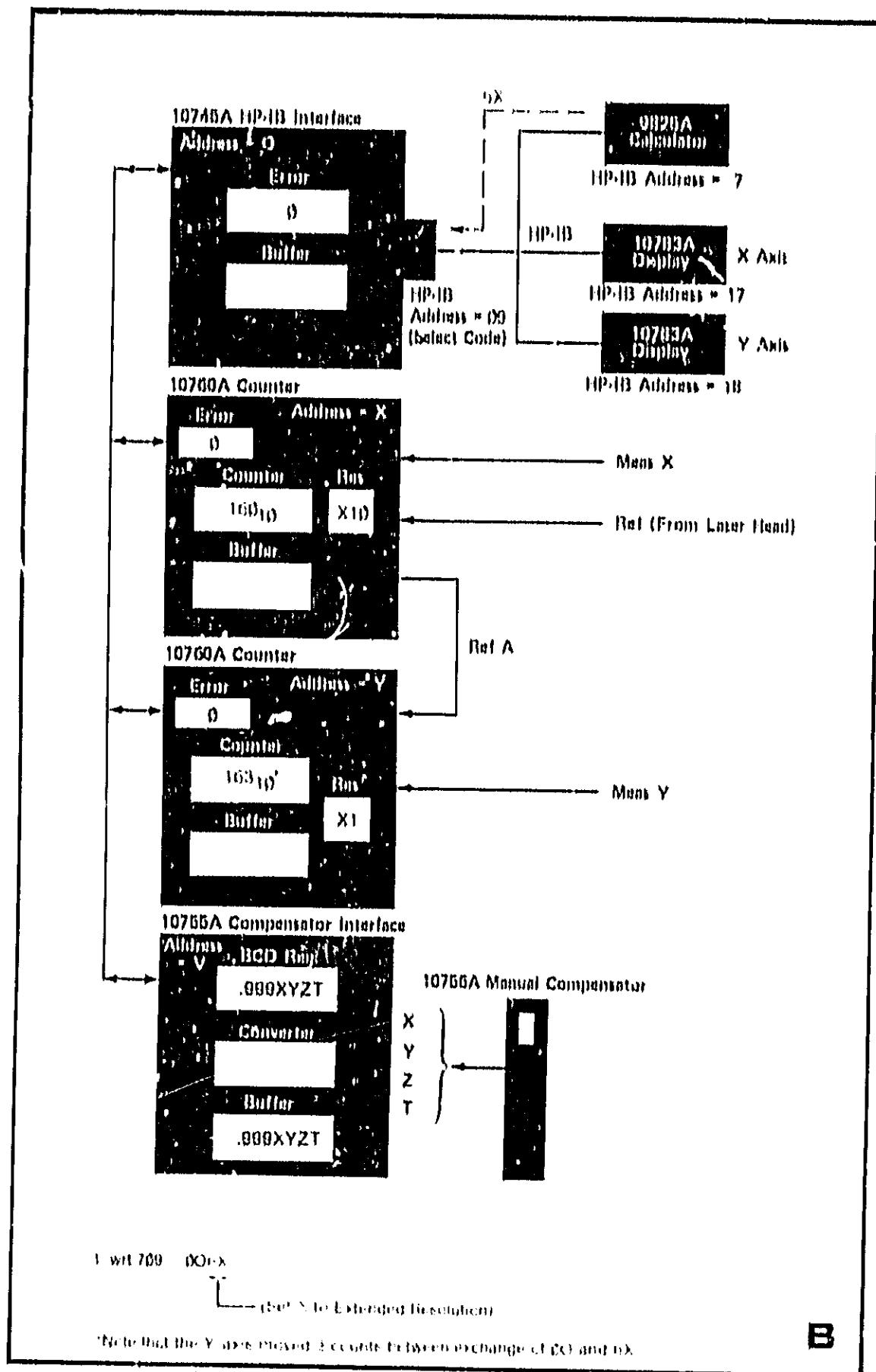


Figure 4-1. Counter-Based System Data Flow (Continued)

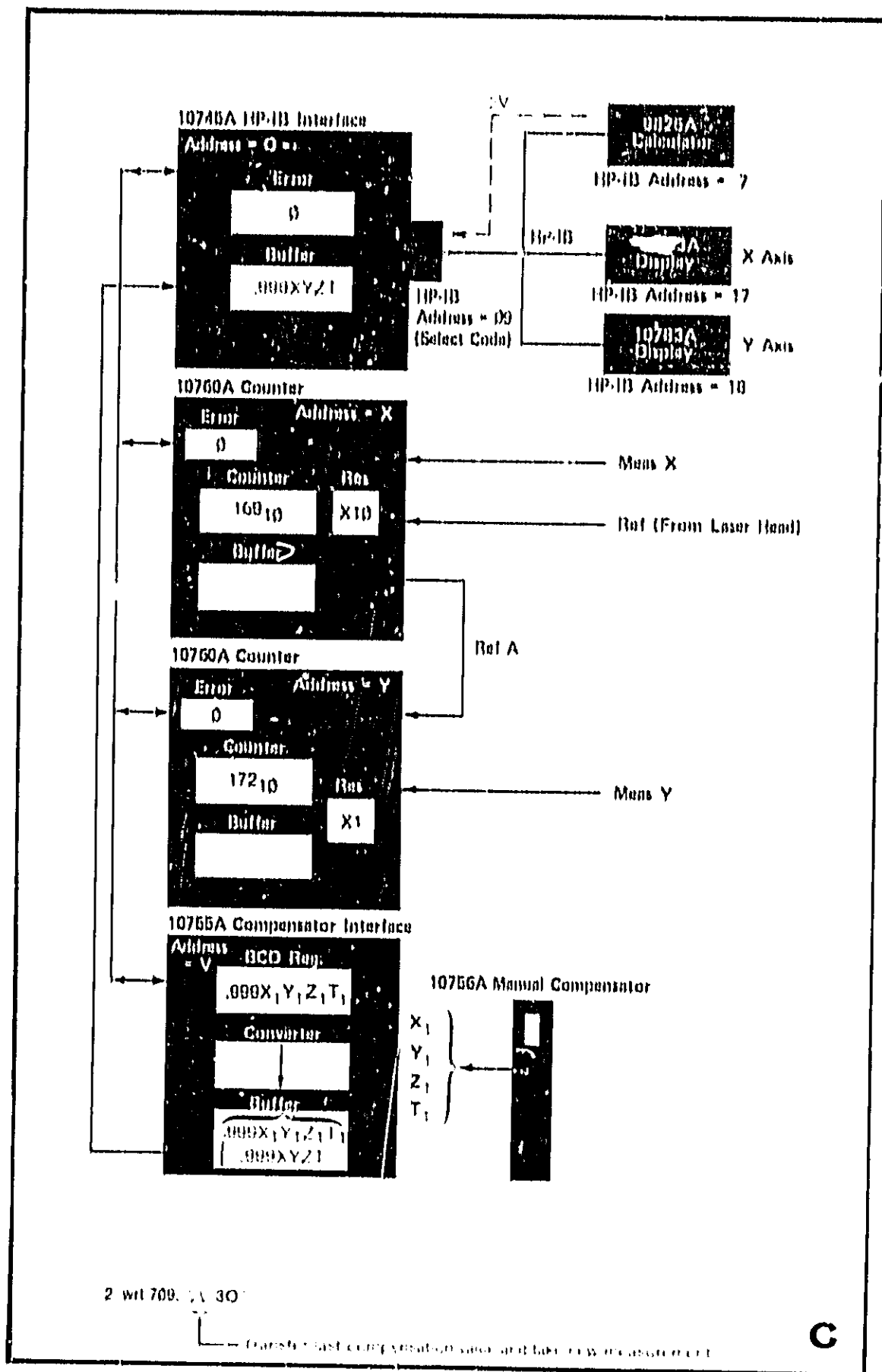


Figure 4-1. Counter-Based System Data Flow (Continued)

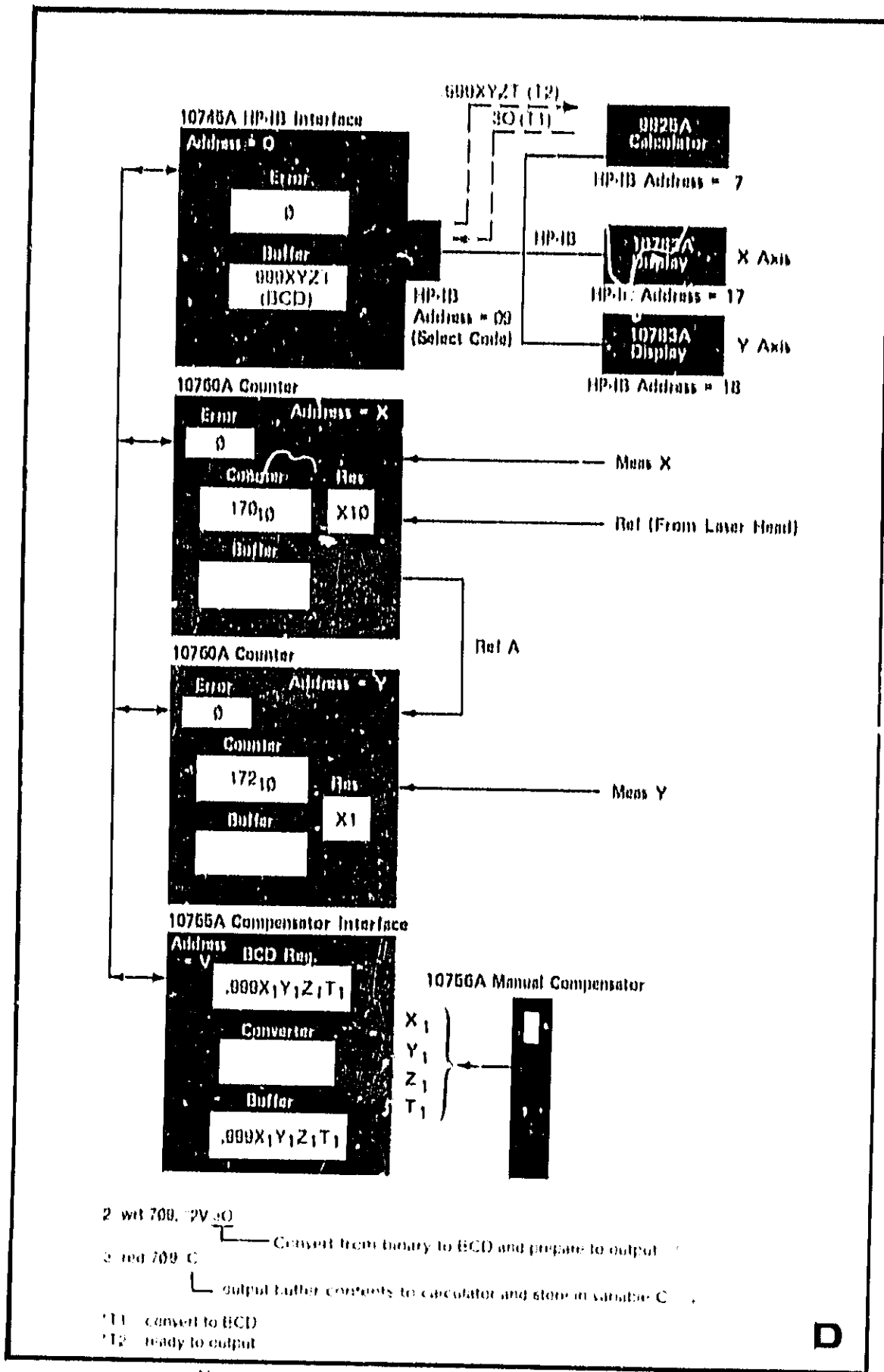
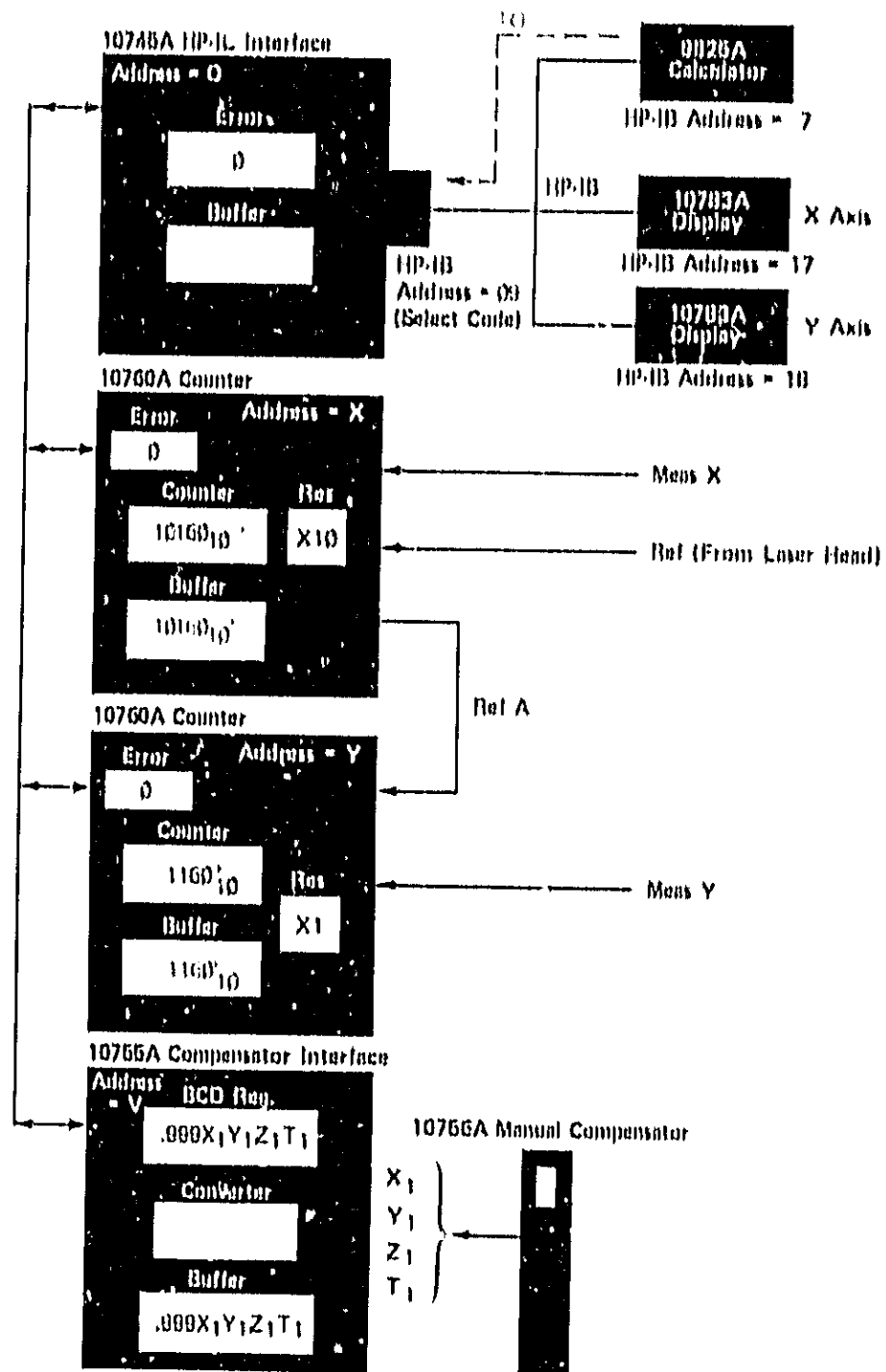


Figure 4-1. Counter-Based system Data Flow (Continued)



6 wr 700 102X30

Enter to 10745A Interface with X and Y count data from display of X and Y axis to multiply 10 times the counts into the counter

Sample all counters simultaneously

E

Figure 4-1. Counter-Based System Data Flow (Continued)

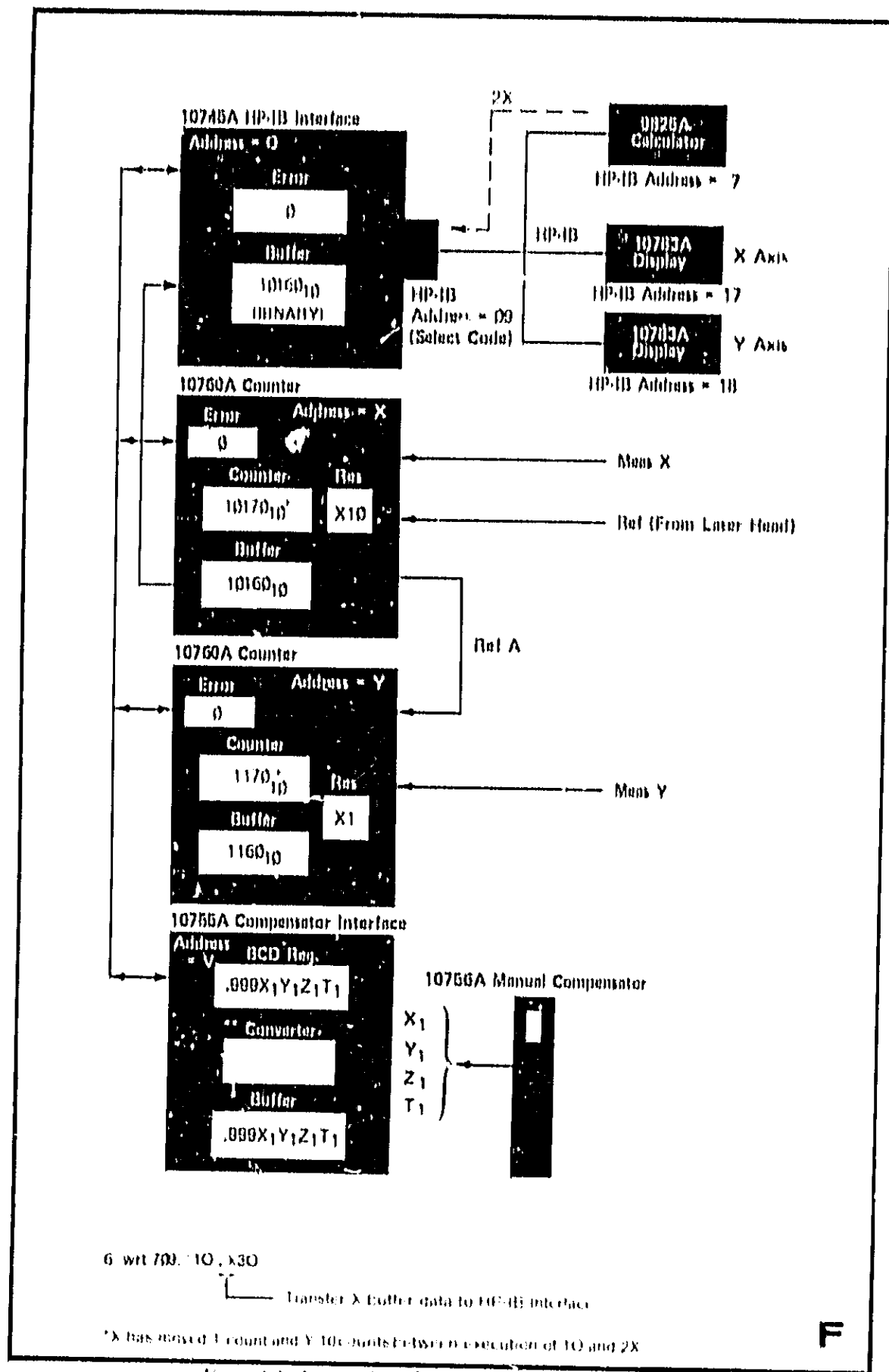


Figure 4-1. Counter-Based System Data Flow (Continued)

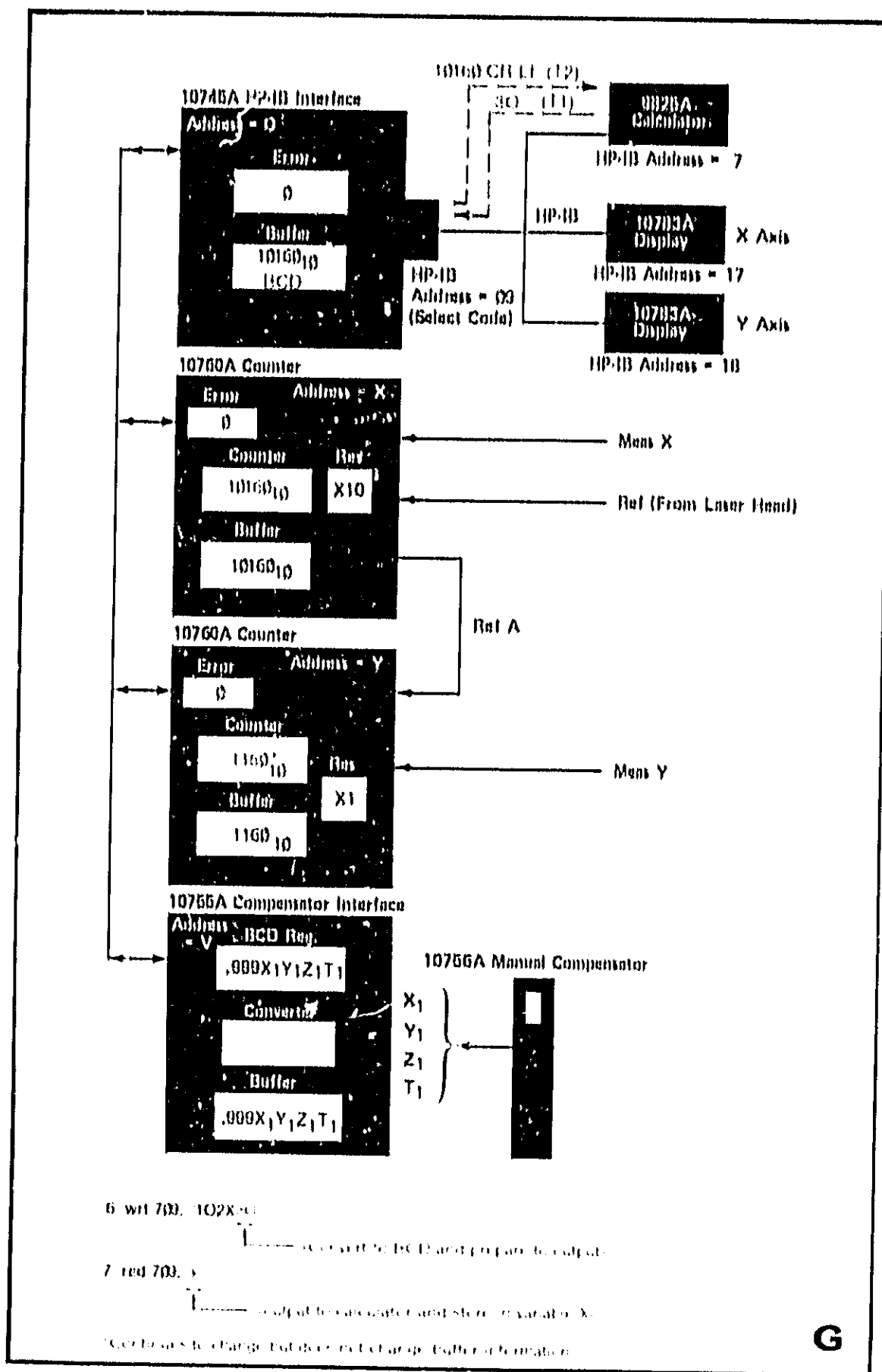


Figure 4-1. Counter-Based System Data Flow (Continued)

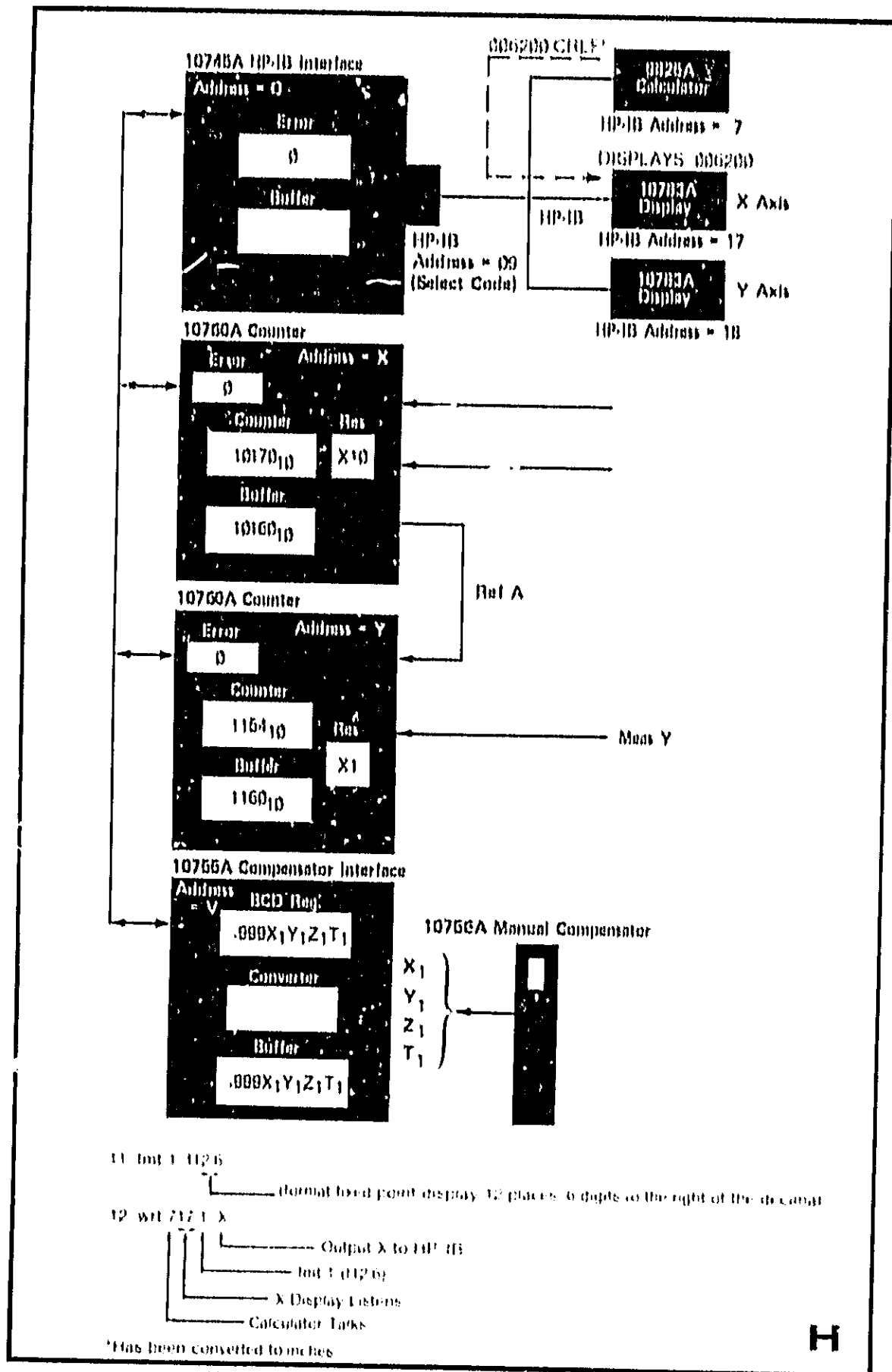


Figure 4-1. Counter-Based System Data Flow (Continued)

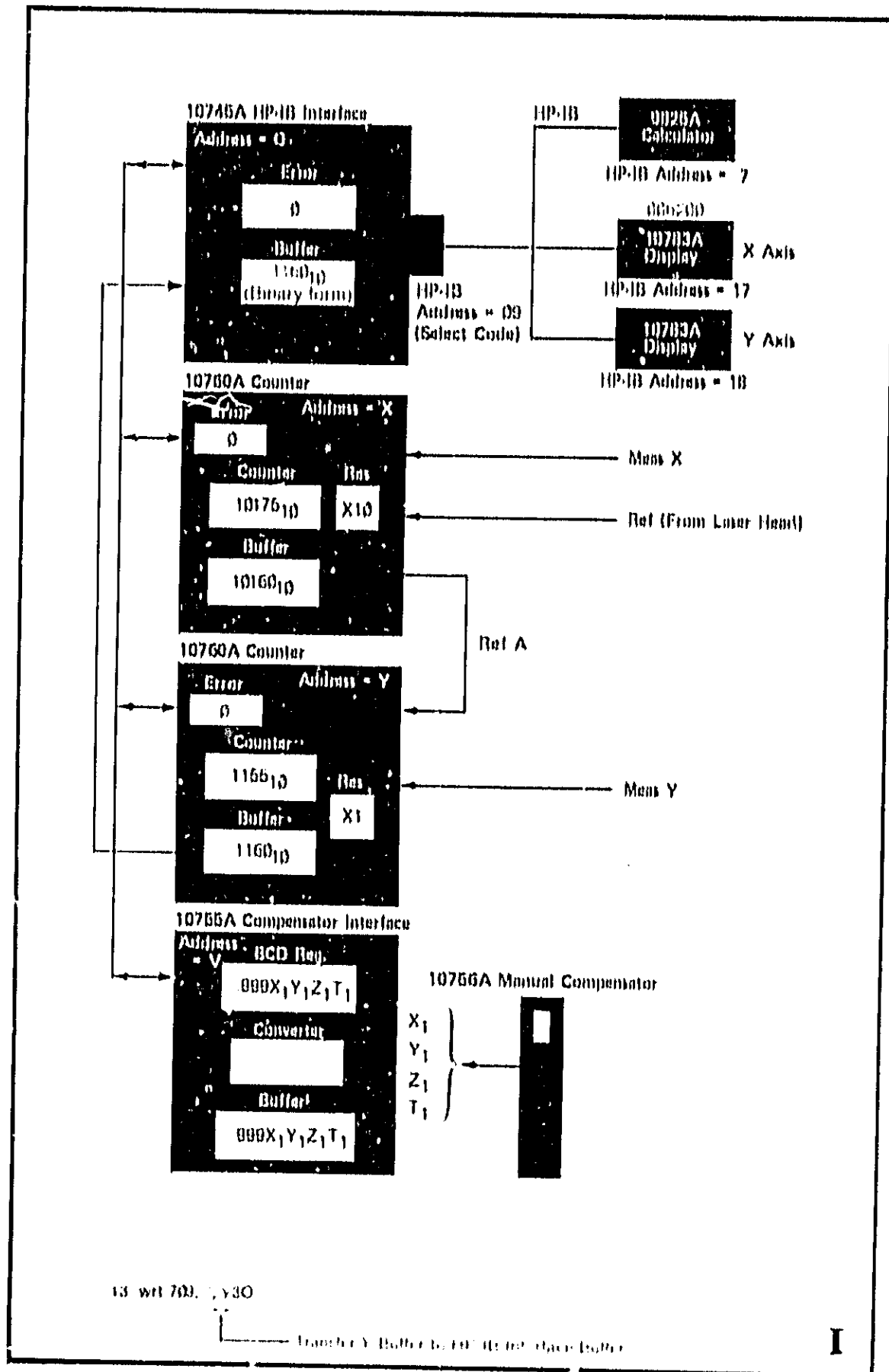


Figure 4-1. Counter-Based System Data Flow (Continued)

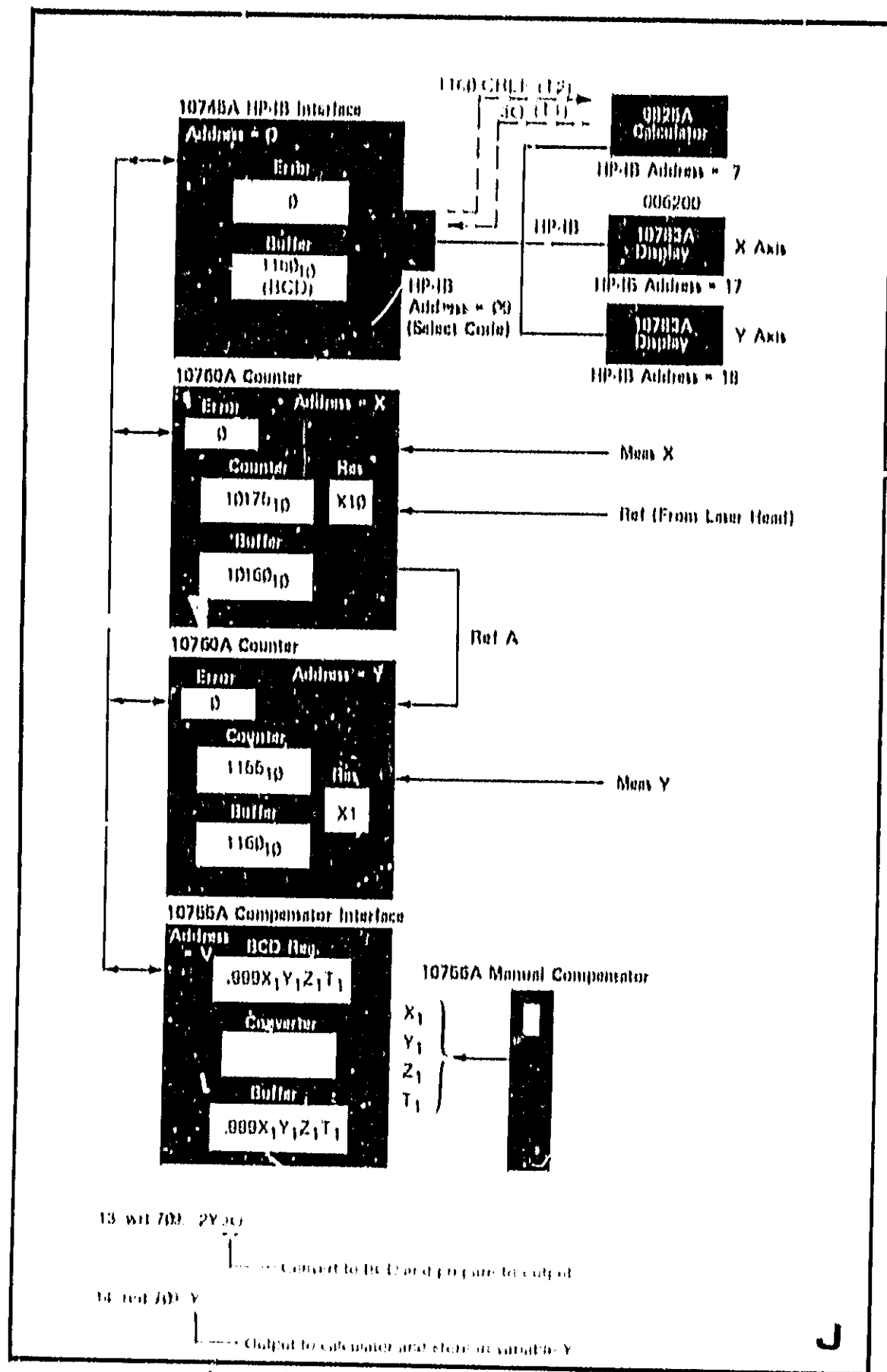


Figure 4-1. Counter-Based System Data Flow (Continued)

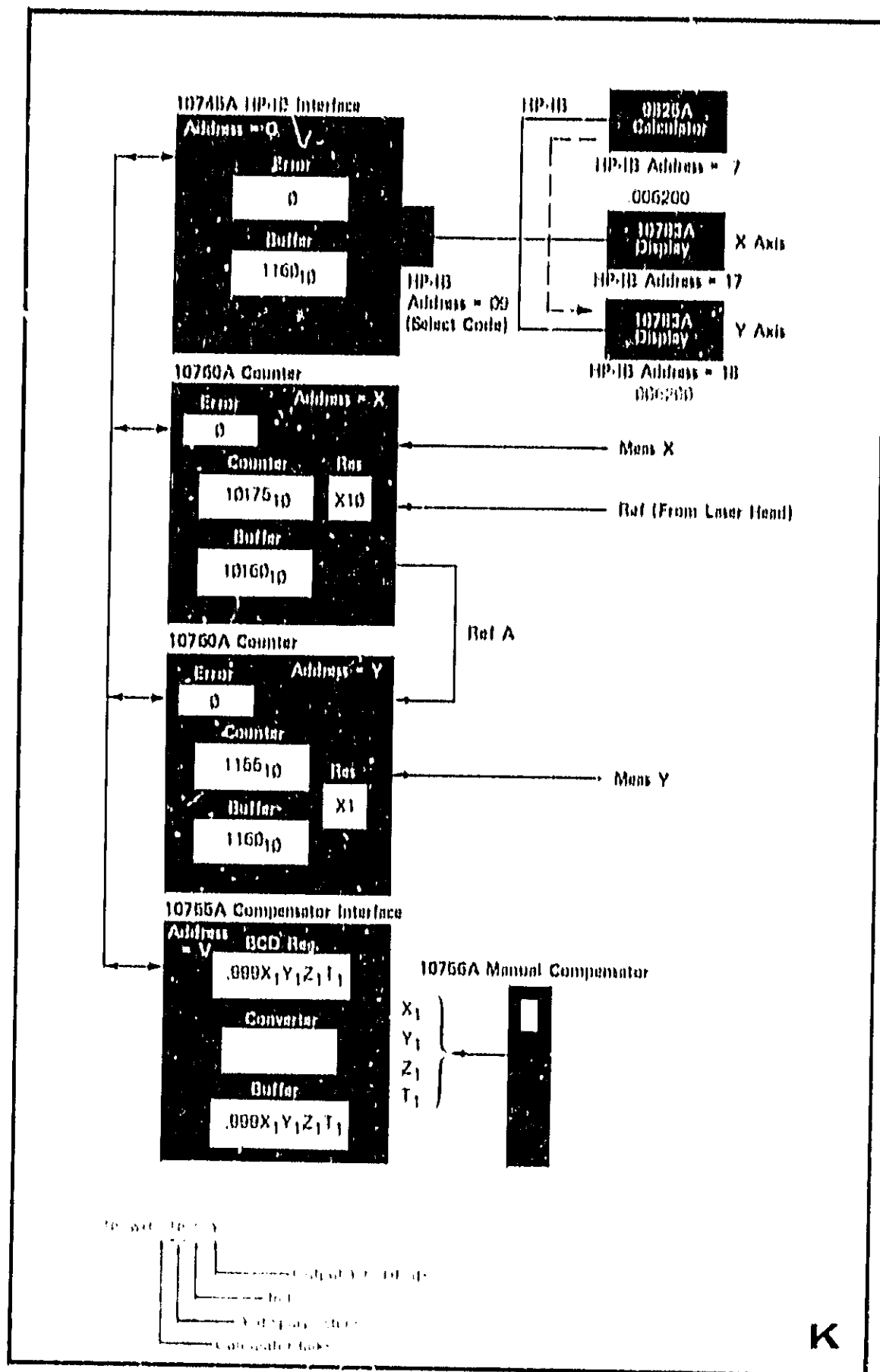


Figure 4-1. Counter-Based System Data Flow (Continued)

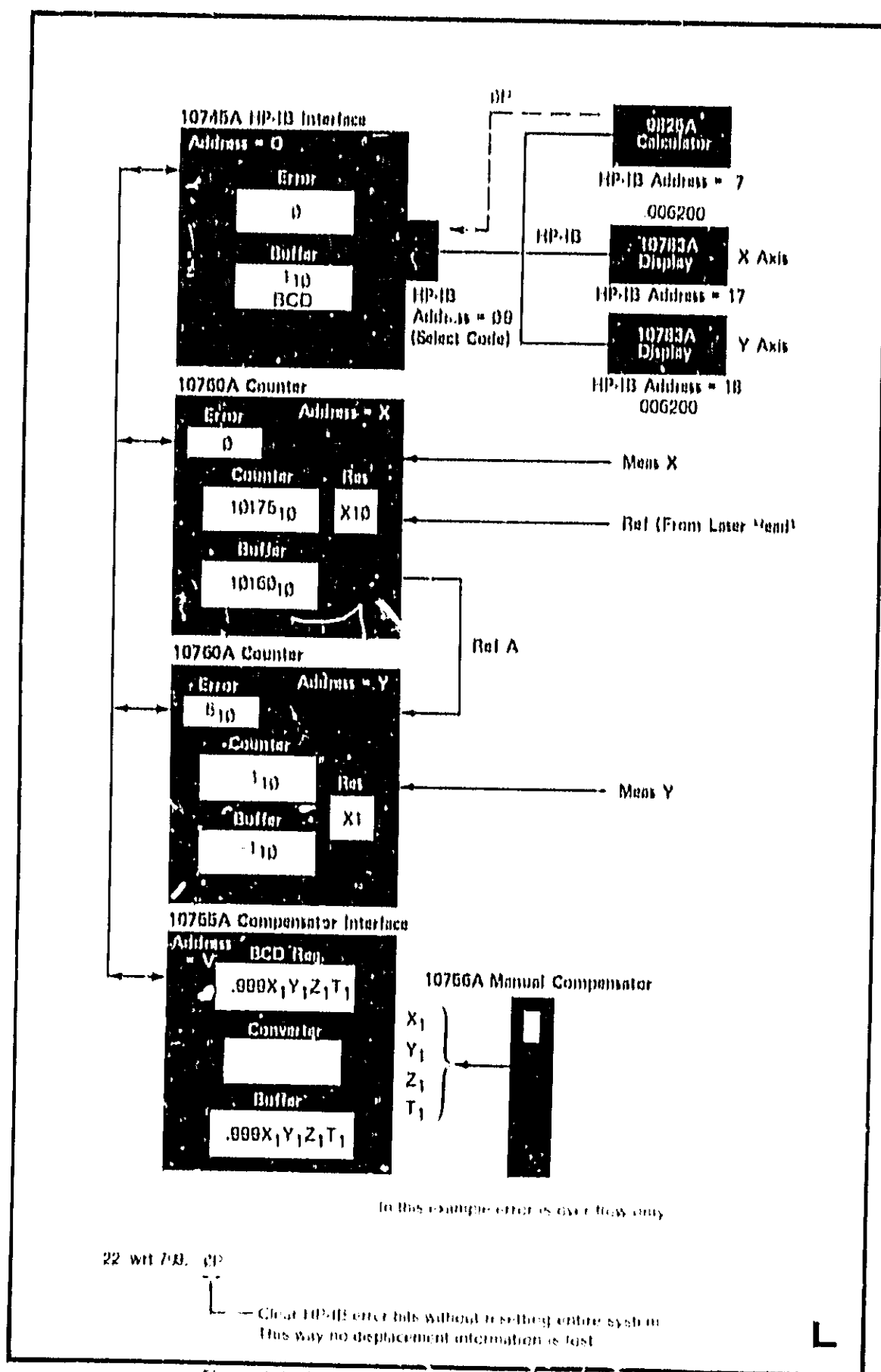


Figure 4-1. Counter-Based System Data Flow (Continued)

Table 4-11. 10746A Binary Interface Typical Program

PROGRAM	COMMENT
0: wib 2, 0,0,0,90,3	000 = 0P,0P,0P. Guarantees System Reset. 90 = 2V = sample compensation reading 3 = 3P = prepare to output See Figures 4-2A, B, and C.
1: gsb "in"	"in" is a subroutine which inputs the number and places it in variable B. Refer to step 32.
2: B ← C	C = Compensation Number.
3: ent "X TOLERANCE IN MICRONS", r1	r1 = X Tolerance (refer to Table 4). No safeguards are provided.
4: ent "Y TOLERANCE IN MICRONS", r2	r2 = Y Tolerance
5: "newdest":B ← X;ent "X DESTINATION IN MM",X	Top of Loop. X is X-Axis destination in millimetres B is default value.
6: B ← Y;ent "Y DESTINATION IN MM",Y	Y is Y-Axis destination in millimetres. B is default value.
7: "comp":wib 2, 90,3	90 = 2V = sample compensation reading. 3 = 3P = prepare to output. See Figures 4-2B and C.
8: gsb "in"	"in" inputs the number and places it in variable B. Refer to step 32.
9: B ← C	C = Compensation Number.
10: X ← A;gsb "cnv"	"cnv" converts X to fringes. Refer to step 38.
11: A ← X	X = destination in fringes.
12: Y ← A;gsb "cnv"	"cnv" converts Y to fringes. Refer to step 38.
13: A ← Y	Y = Destination in fringes.
14: int(r1/1.58240e-1) *2128 + X → A	Add X-tolerance in fringes to X-destination bits 20-31.
15: gsb "out"	Output to 10746A Card. Refer to step 39.
16: wib 2, r31	31 = 3X = transfer to X-destination register. See Figure 4-21.
17: int(r2/1.58240e-1) *2128 + Y → A	Add Y-tolerance in fringes to Y-destination bits 20-31.
18: gsb "out"	Output to 10746A Card.
19: wib 2, 147	147 = 3Y = transfer to Y-destination register. See Figure 4-21.
20: "newsample":wib 2, 1, 130,3	1 = 1P = sample X and Y to compare X,Y location with X-Y destination. 1P releases difference signals. 130 = 2X = transfer from X comparator to 10746A Binary Interface. 3 = 3P = prepare to transfer to calculator. See Figure 4-21, K, and L.
21: B ← 1	1 = 0 for X-Axis.
22: gsb "in"	Subroutine to input the number from the 10746A Card.
23: B ← r3	Store the X-location in r3.
24: wib 2, 146,3	146 = 2Y = transfer Y to 10746A. See Figure 4-2M. 3 = 3P = prepare to transfer to calculator. See Figure 4-2N, O.

Table 4-11 10746A Binary Interface Typical Program (Cont'd)

PROGRAM	COMMENT
25: 1 ← I	I ← 1 for Y-Axis.
26: gsh "in"	Subroutine to input the number from the 10746A Card.
27: B ← r4	Store the Y-location in r4.
28: fnt 1,2010.0,110.7	X format fixed 0 places to right of decimal. Y format. C Compensation format. Fixed 7 places to right of decimal.
29: wrt 1,1,1-160,r4-160,C	Display raw counts.
30: if abs(X-r3) > 1/(.150°C) and abs(Y-r4) > 1/(.150°C) gto "newdev"	If X and Y are within tolerance, get another destination; if not, resample. This could also be done by checking for system null. The error checking subroutine ("er") picks this up as an error, but drops out of the routine for system null.
31: gto "newsample"	Sample again.
32: "in": rdb(2) → B; if B > 0; 65536 + B → B	Reads in bits 31-16. Complements if negative.* See Figure 4-2f).
33: if B > 61440; gto "er"	If bits 31-20 are all 1's go to error checking routine. Refer to step 45.
34: rdb(2) → C; 0C → B; 65536 + C → C	Read in bits 15-0. Complements if negative. See Figure 4-2f.
35: int (B/4096) → D	D contains bits 31-20 decimal point information.
36: B ← 3096 * D → B	B ← Bits 27-16
37: (65536 * B + C) * int(2/D) → B; ret	B* 316 ← bits 15-0. 2-D applies decimal point.
38: "conv": A/(1.50240e-4°C) + 160 → A; ret	Subroutine to convert destination to fringes and add preset (160).
39: "out": wrb 2,4	"out" is a subroutine to output a 32-bit number in 2's complement form from two 16-bit words in positive-true form. 4-4P load data into 10746A I/O buffer. See Figure 4-2f.
39.1: int(A) → A	
40: int(A/65536) → B; if B > 32767; B-65536 → B	B is bits 31-16
41: wrb 2,B	Output bits 31-16 to 10746A. See Figure 4-2c.
42: A-65536*int(A/65536) → B; if B > 32767; B-65536 → B	B is bits 15-0. Convert to 2's complement.
43: wrb 2,B	Output bits 15-0 to 10746A. See Figure 4-2c, from step 15.
44: ret	Output is completed. Transfer command needs to be given.
45: "er": int(B/256) → 240 → B; 15 → B → B	B ← Bits 31-16. Initially 240 clears bits 31-20 which indicates an error. Bits 27-24 need to be complemented by subtracting from 15.
46: if B > 0; prt "vol error"; B ← B - B; B → B	If Bit 27, Vol error clear bit 27.

*Range of 9825 16 bit words = +32,767 to -32,768.

Table 4-11. 10746A Binary Interface Typical Program (Cont'd)

PROGRAM	COMMENT
47: if B<=4; B<4-B; 1->D	If Bit 26, D=1 as possible recoverable error. Clear Bit 26.
48: if B>=2; prt "ret error"; B->D	If Bit 25, D=0 as irrecoverable error. Clear bit 25.*
49: if B=1; prt "meas error"; B->D	If Bit 24, D = 0 as irrecoverable error. Print "meas error".
50: if D=0; goto "piter"	go to "piter" if irrecoverable error. Refer to step 61.
51: rdb(2)->B	Overflow only. Read in bits 15-0 to complete previous JP command.
52: wtb(2,240,3)	240 = BC = clear error bits on 10746A so 28 bits of data can be transferred with JP command. 3 = JP = prepare to transfer.
53: rdb(2)->B; if B<0; 655.16+B->B	Read in bits 31-16. Complement if negative.
54: rdb(2)->C; if C<0; 655.16+C->C	Read in bits 15-0. Complement if negative.
55: int((1/4096)*D)	D contains bits 11-20 decimal point information
56: B=4096*D->B	B = Bits 27-16.
57: (655.16*B+C)*int(2-D)->B	B*216 + Bits 15-0. 2-D applies decimal point.
58: if 1=0 and B=160*0, B=2128->B	Correct for overflow. (Really underflow).
59: if 1=1 and B=160*0, B=2128->B	Correct for overflow. (Really underflow).
60: ret	
61: "piter":cll->B; prt "X-AXIS ERROR"	
62: if 1=1; prt "Y-AXIS ERROR"	
63: dtp "go to page" :stp	Irrecoverable error -> stop and go to page.
64: goto B	
65: end	

*It should be noted when a reference error occurs both measure and error signals will also go true. In this example X and Y will both show a measure error although no measure error has occurred

If using a 5510A Automatic Compensator, a (VTP6) command must be sent to guarantee update of data (this should be done at beginning of program)

Table 4-12. Binary Interface Typical Program Variables

VARIABLE	CONTENTS
T1	X Tolerance in Microns
T2	Y Tolerance in Microns
X	X Destination in MM or Fringes
Y	Y Destination in MM or Fringes
C	Compensation Number for VOT and Material Temperature
T4	Current X Location in Fringes
T4	Current Y Location in Fringes

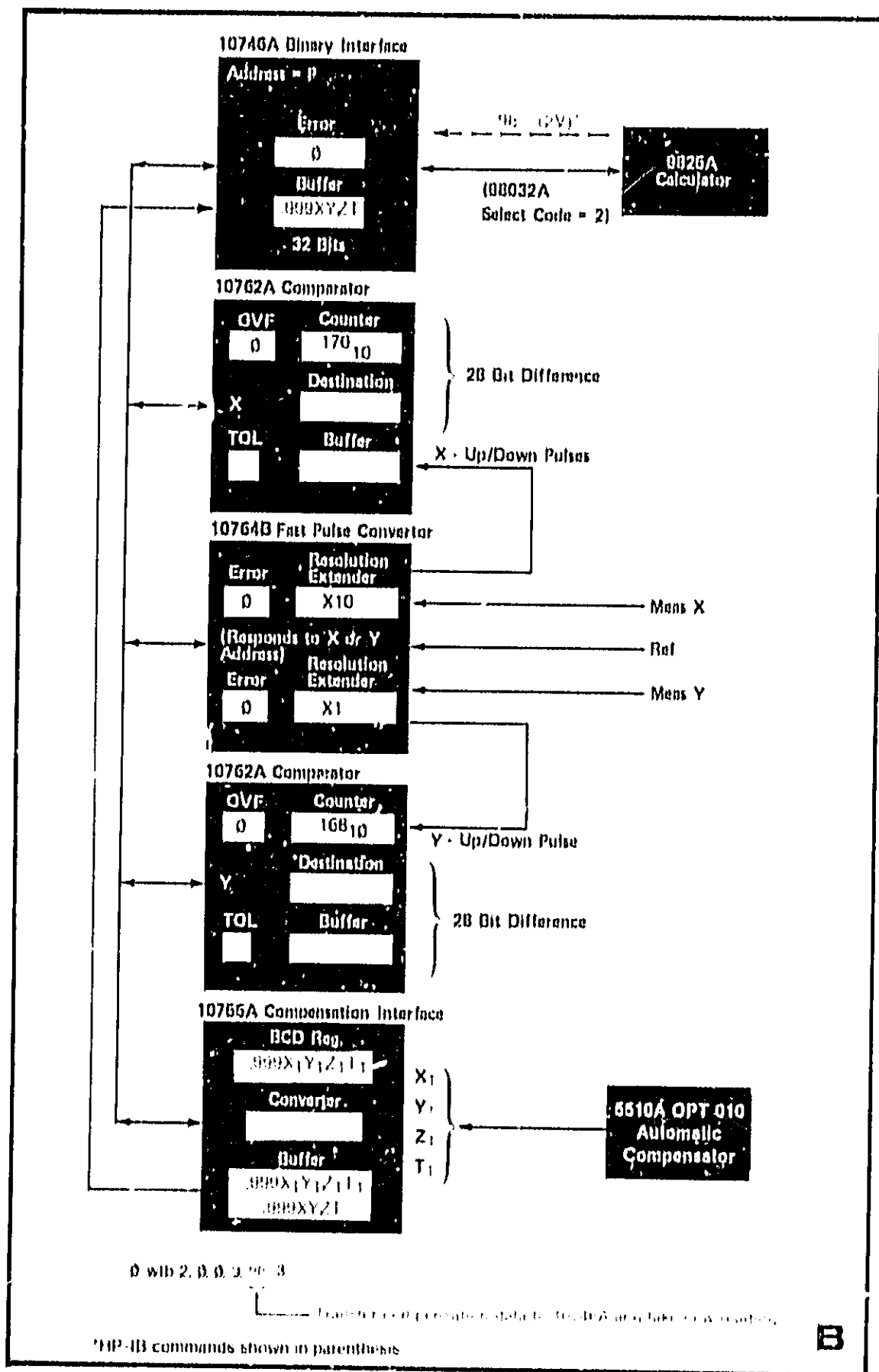


Figure 4-2. Comparator-Based System Data Flow (Continued)

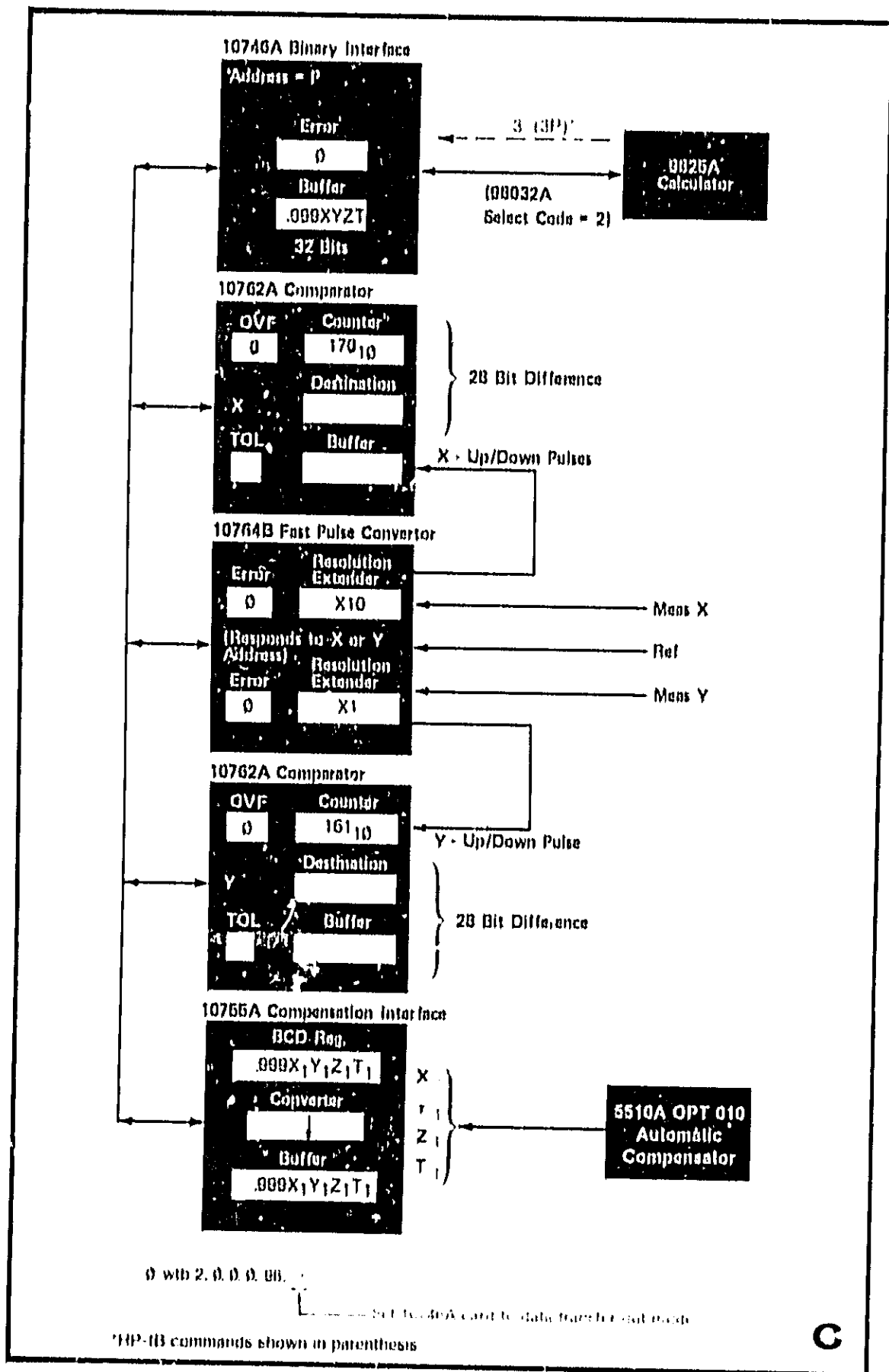


Figure 4-2. Comparator-Based System Data Flow (Cont'd)

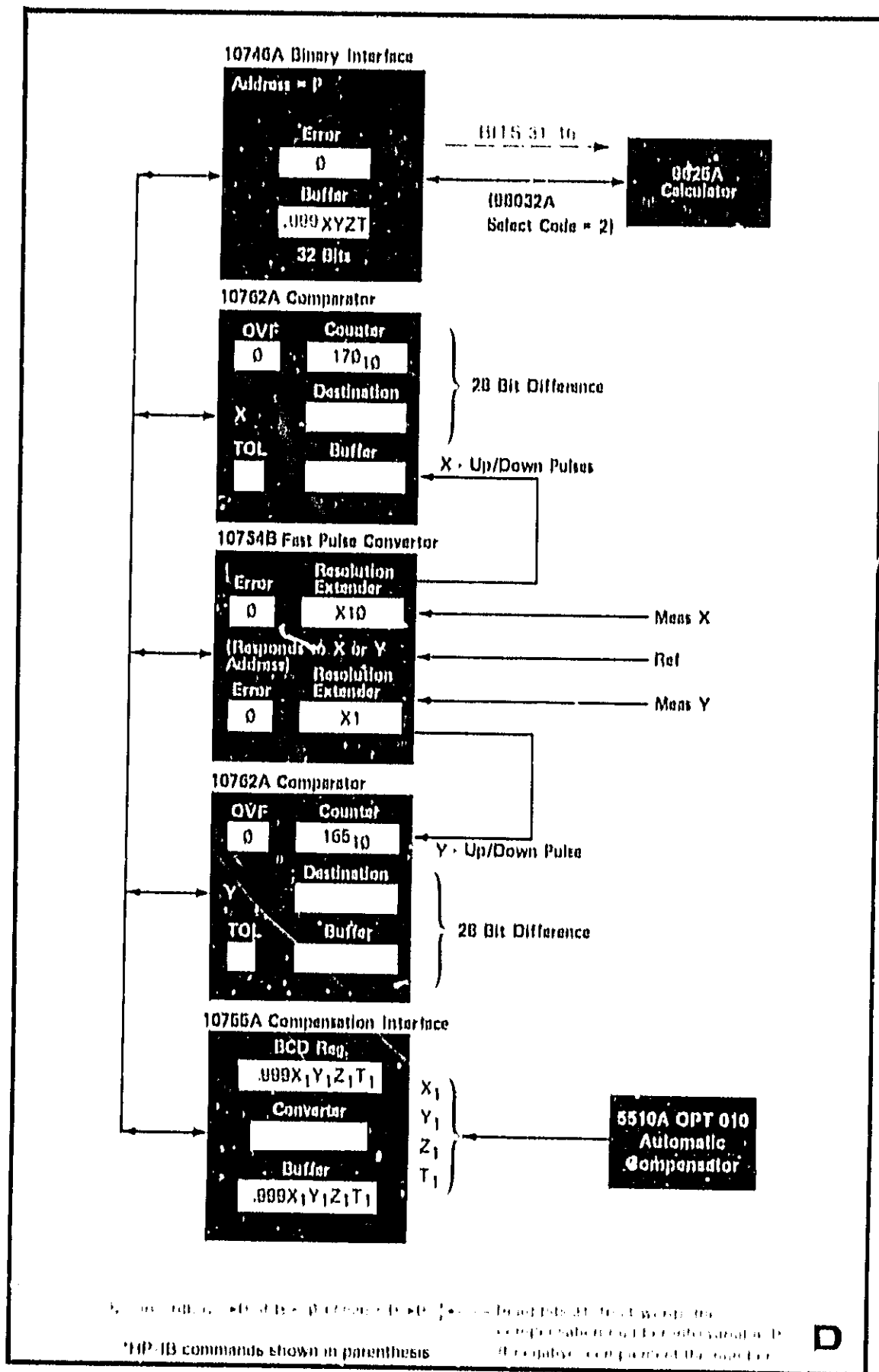


Figure 4-2. Comparator-Based System Data Flow (Cont'd)

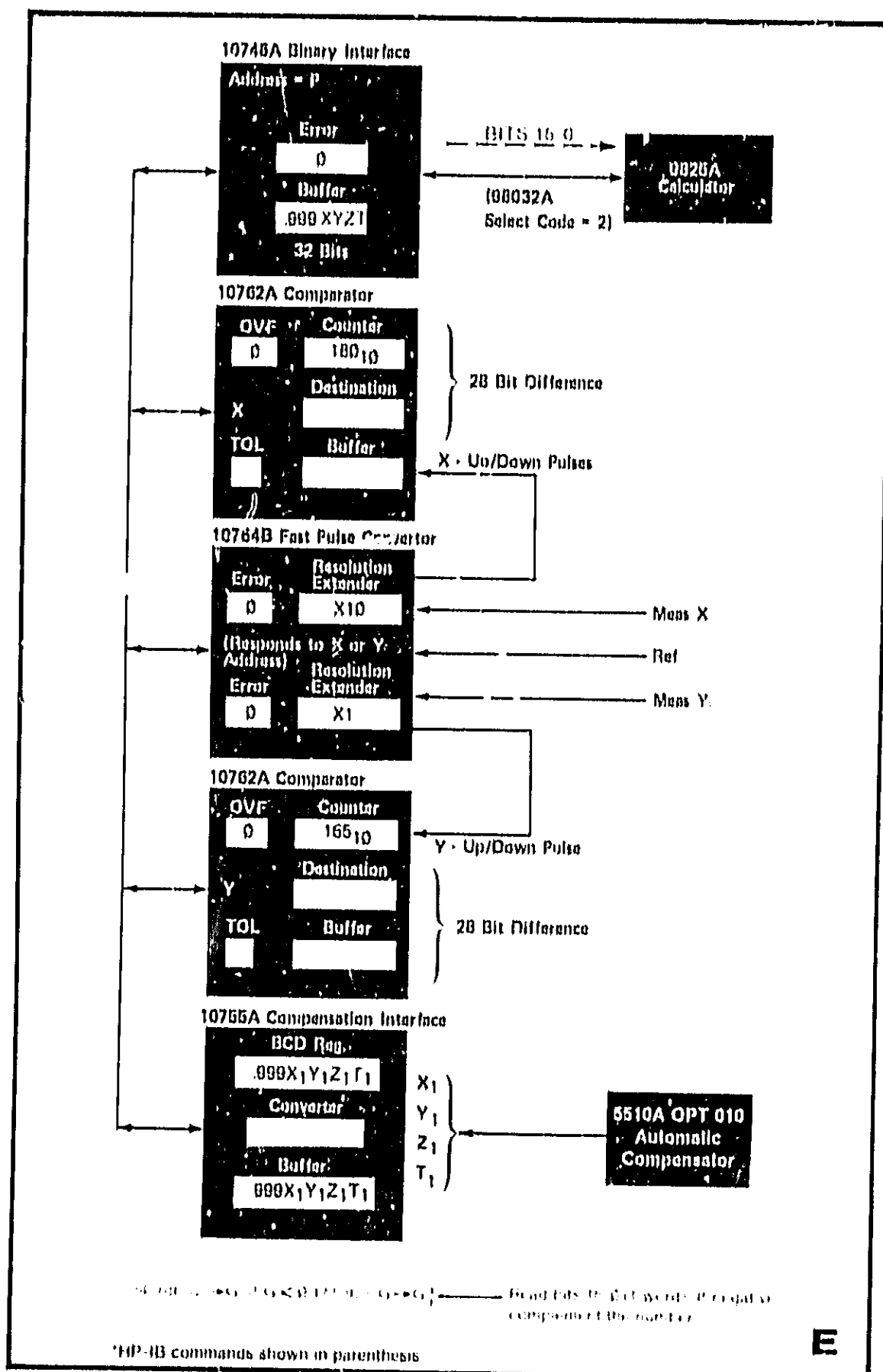


Figure 4-2. Computer-Based System Data Flow (Cont'd)

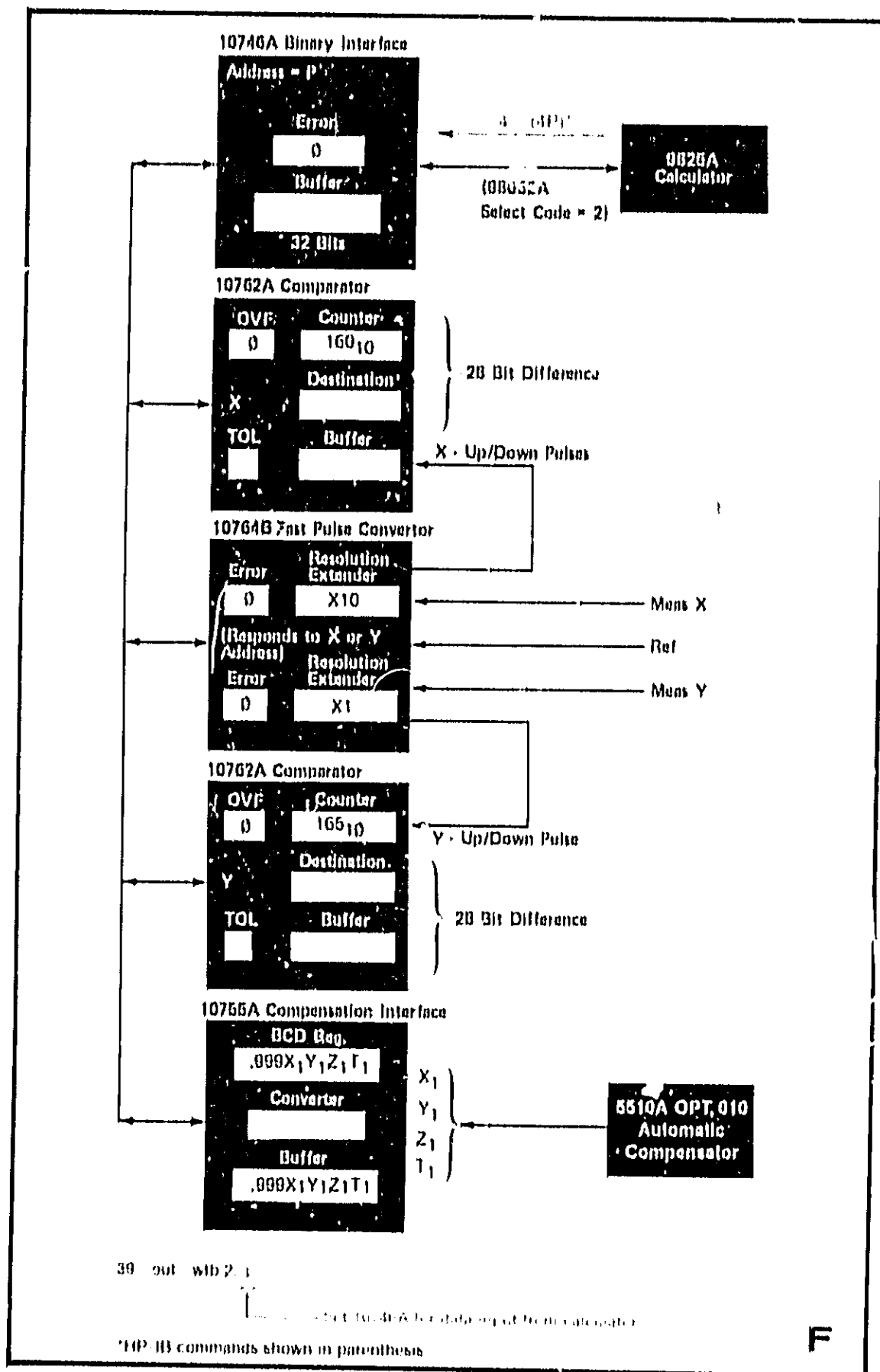


Figure 4-2 Comparator-Based System Data Flow (Cont'd)

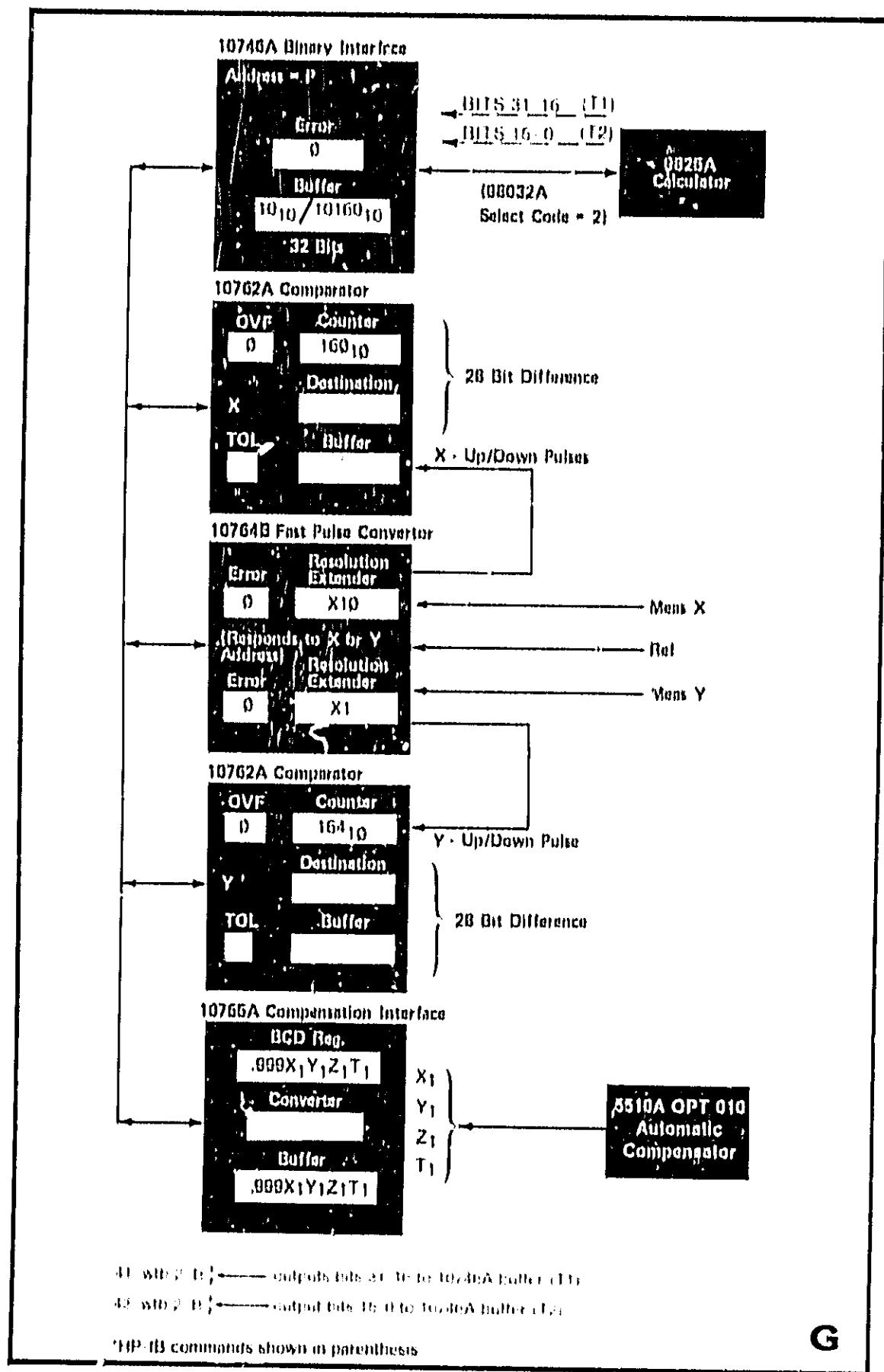


Figure 4-2: Comparator-Based System Data Flow (Cont'd)

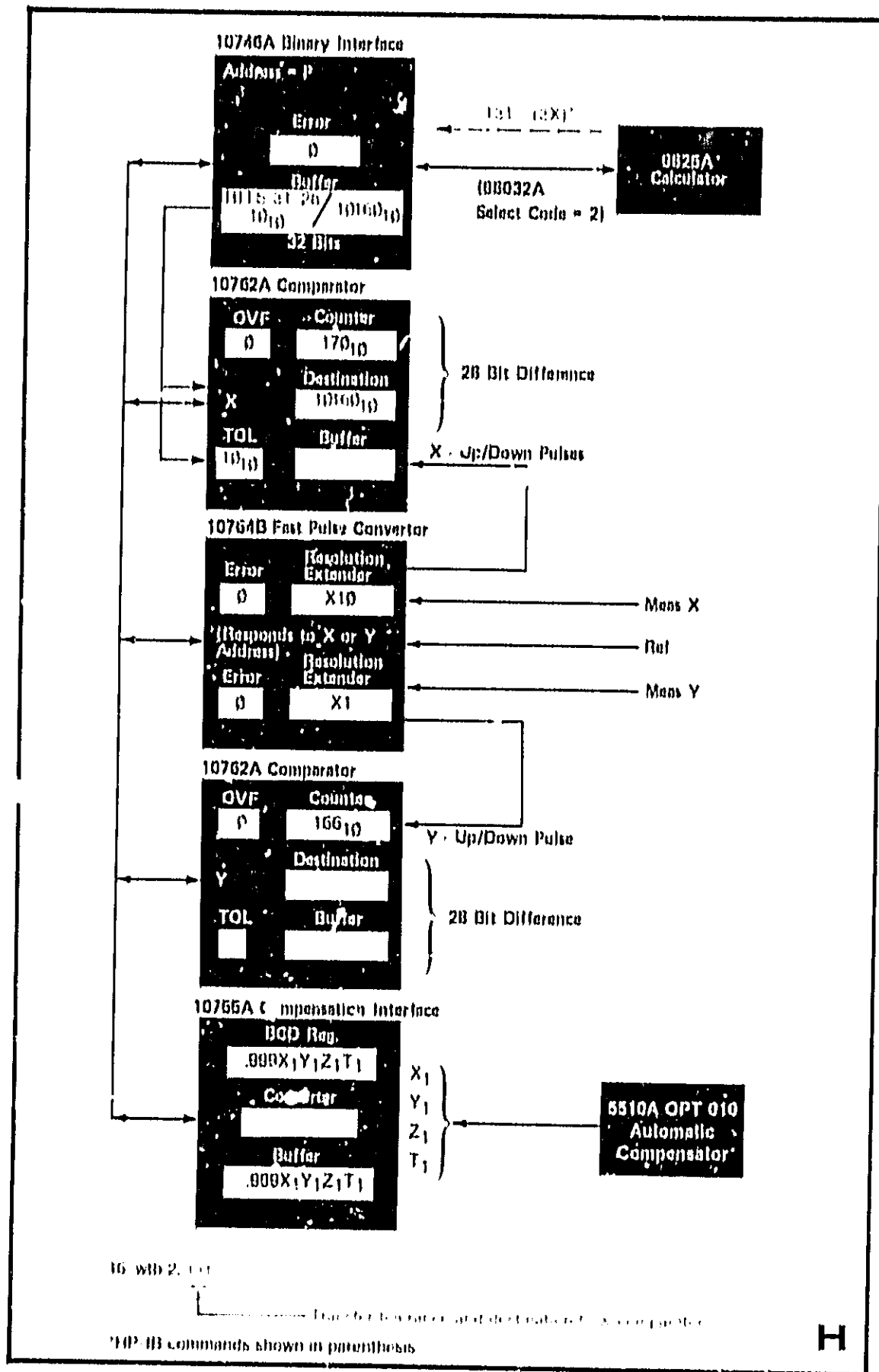


Figure 4-2. Computer-Based System Data Flow (Cont'd)

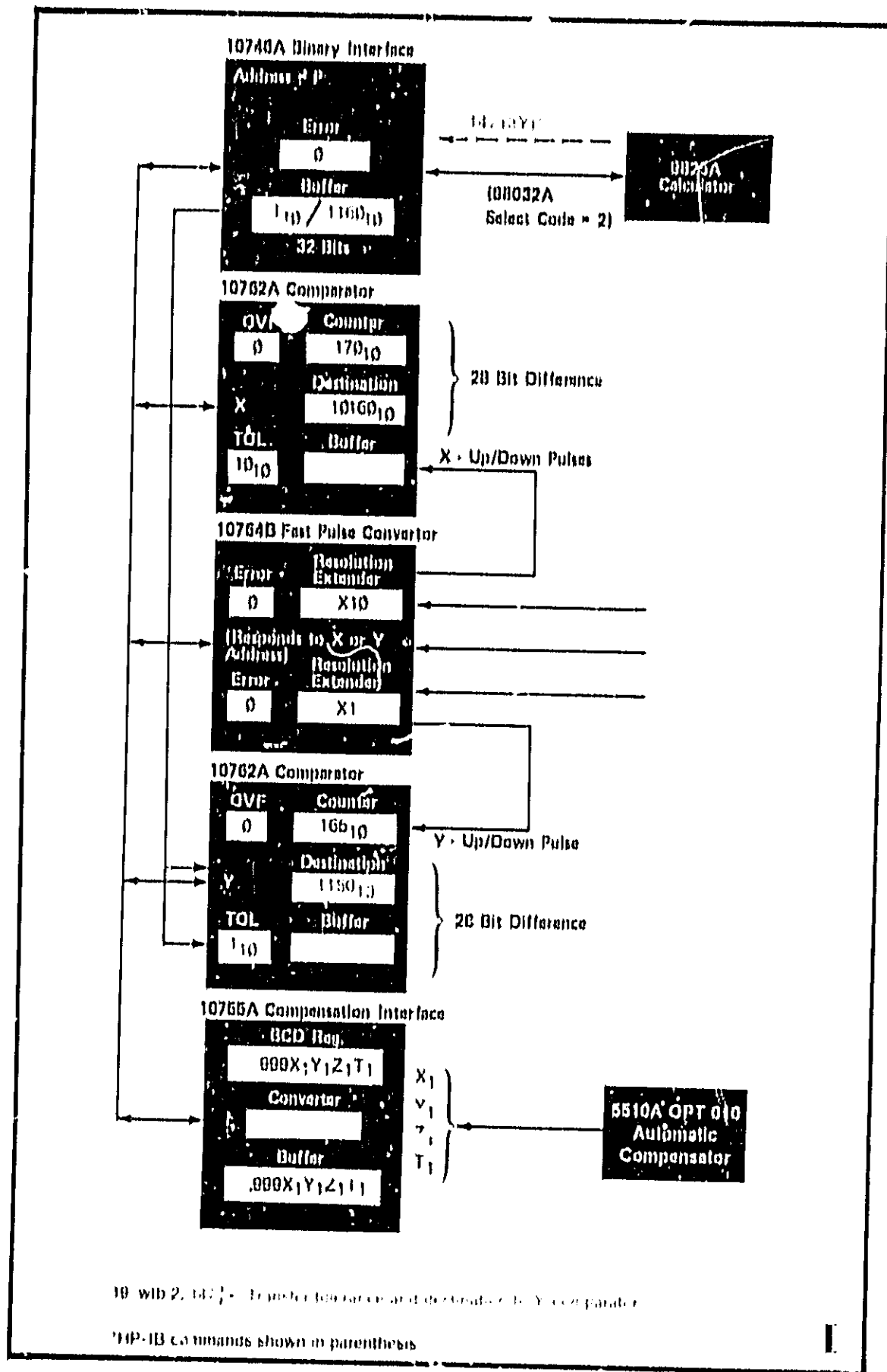


Figure 4-2 Commutator-based System Data Flow (Cont'd)

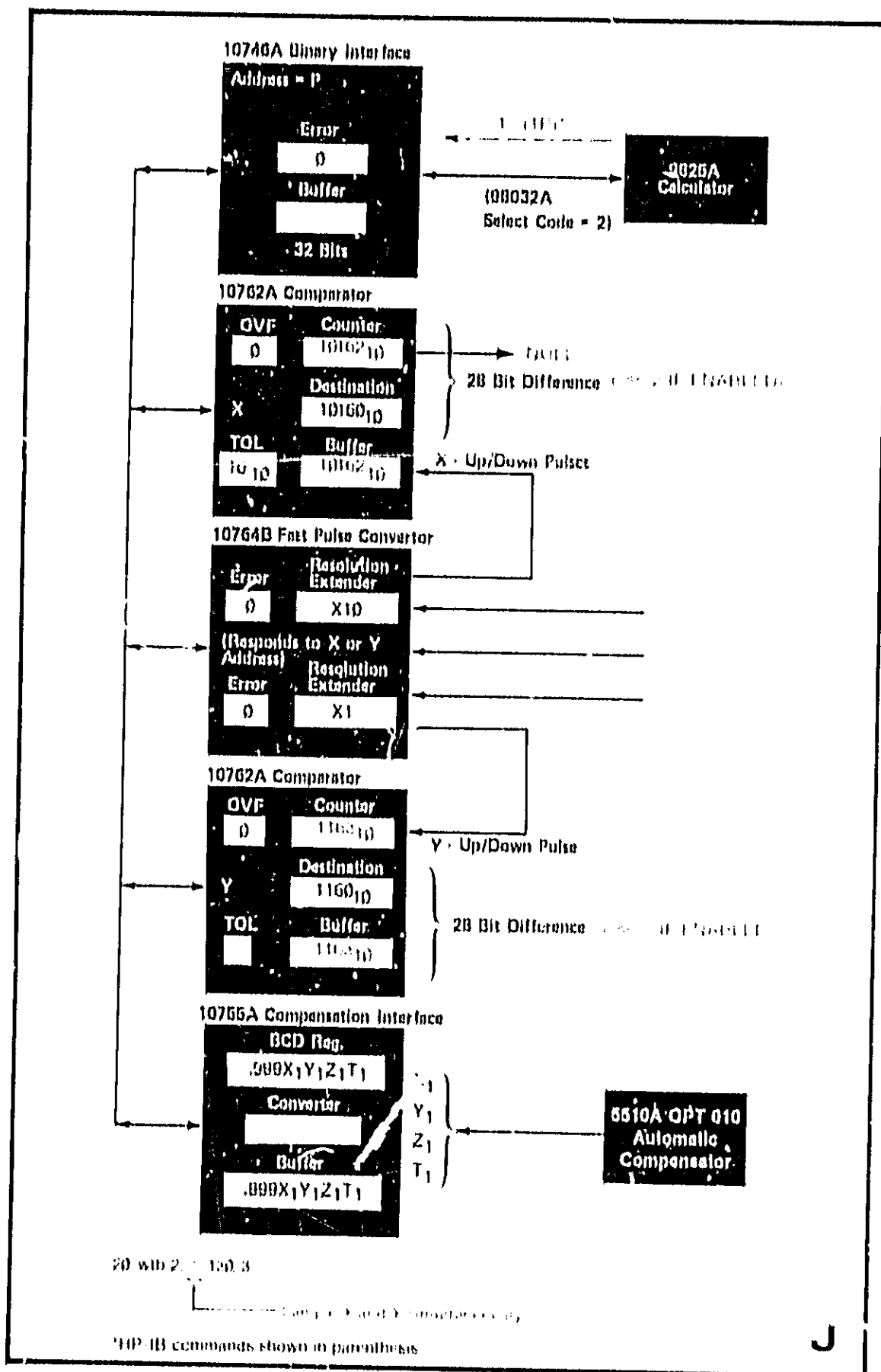


Figure 1-2 Comparator-Based System Data Flow (Cont'd)

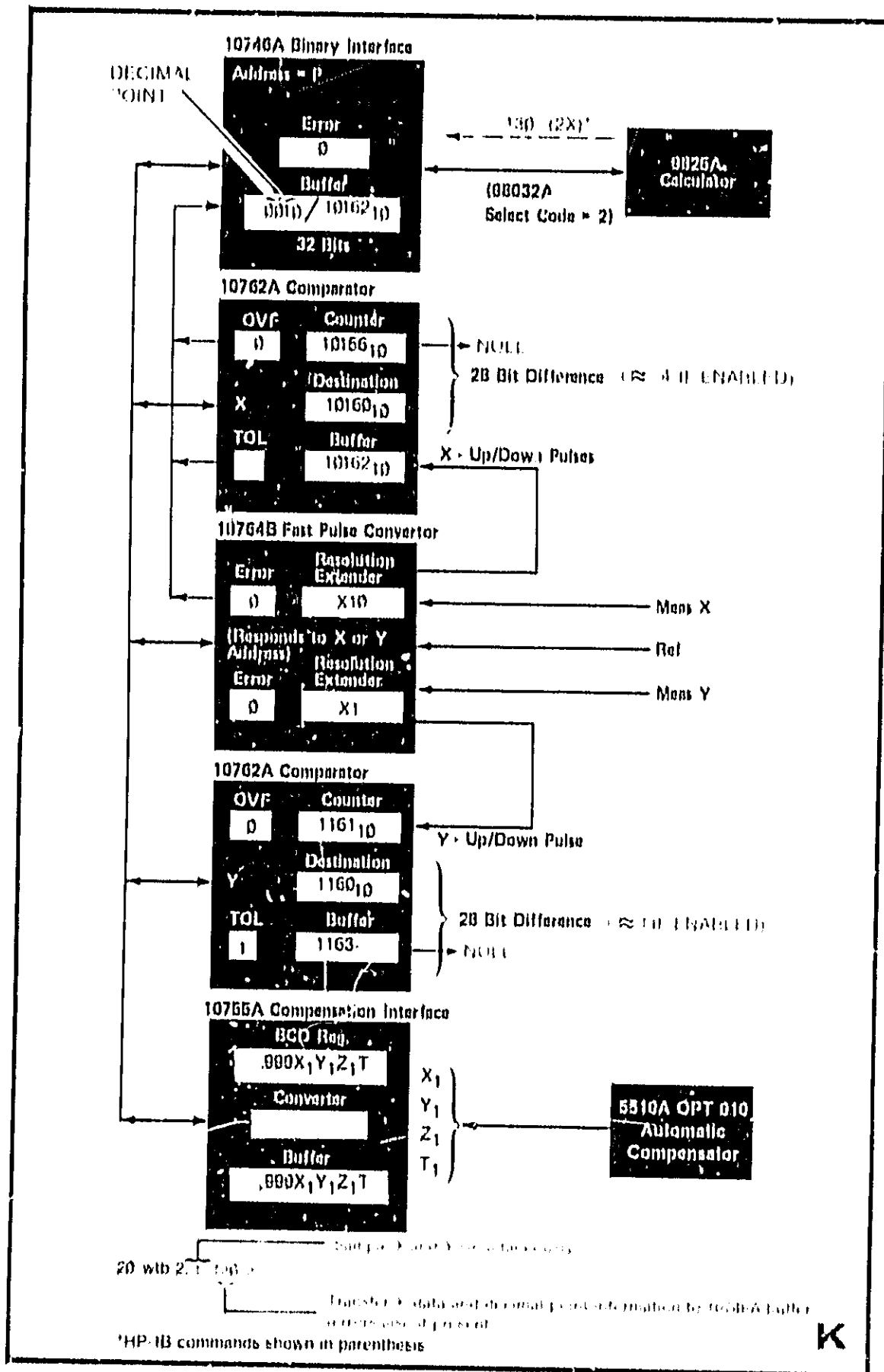


Figure 4-2. Comparator-Based System Data Flow (Cont'd)

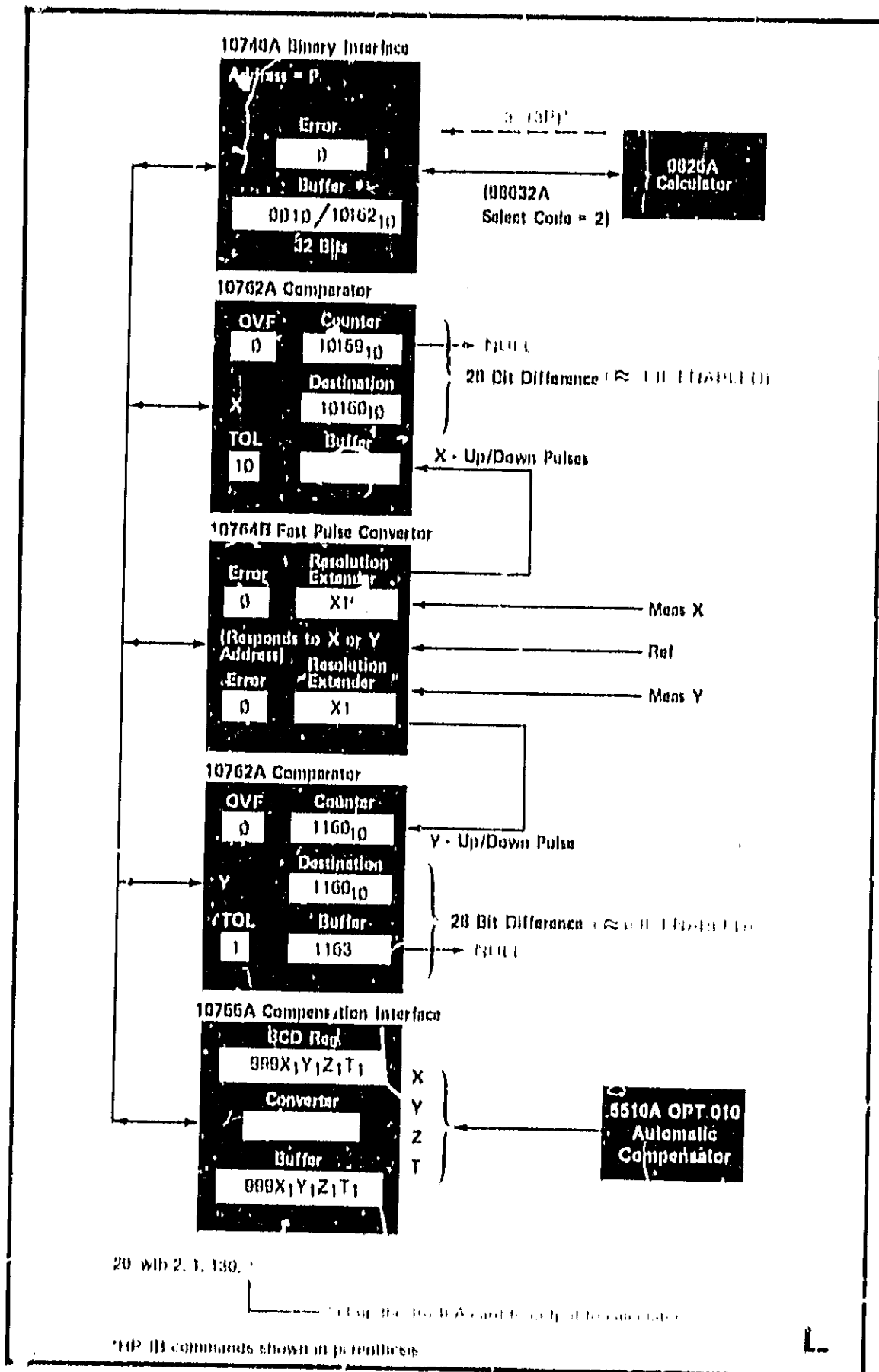


Figure 4-2. Comparator-Based System Data Flow (Cont'd)

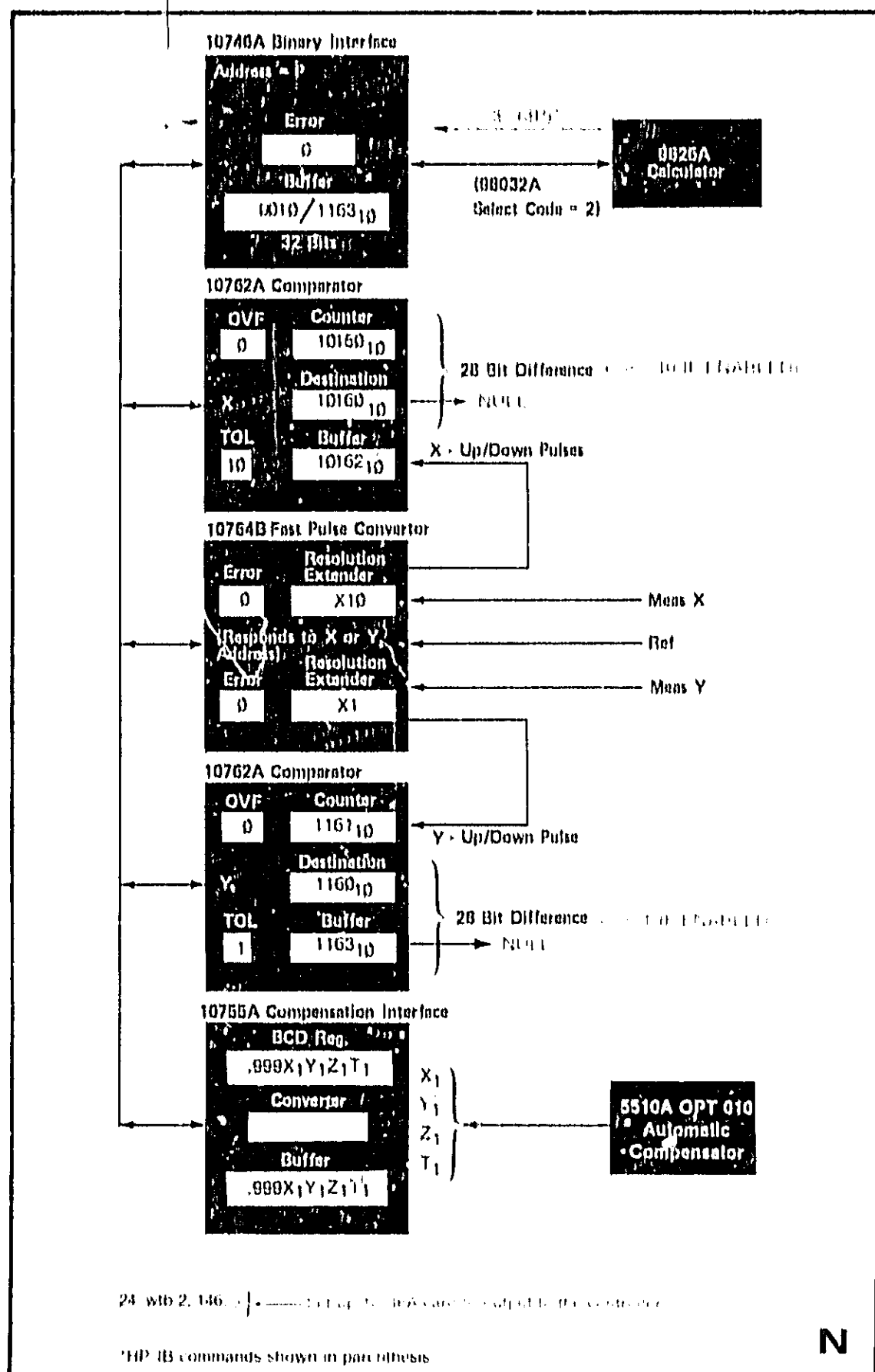


Figure 4-2. Comparator Based System Data Flow (Cont'd)

4.11 DATA HANDLING TIPS

When writing application programs for a specific Laser Transducer System, the applicable following paragraphs should be read in addition to reviewing the typical programs in Tables 4-12 and 4-13.

- a. Subtraction of preset numbers
- b. Conversion to inches or metres
- c. Conversion when deadpath is included
- d. Handshaking routine between a controller and the 10746A Binary Interface
- e. Conversion of destination and displacement information when using the 10762A Comparator
- f. 10762A Comparator/10764B Fast Pulse Converter I/O format

4.12 Subtraction of Preset Numbers

When using the 10745A HP-IB interface subtract the following counts:

- a. 160 counts if in normal mode.
- b. 16 counts if in extended resolution.

When using the 10746A Binary Interface, the program is such that you must subtract 160 counts from the raw number that is transferred. The decimal point information is contained in D (bits 31-28). After subtracting the 160 counts, multiply the result by $10^{(2-D)}$ to obtain a calibrated result.

4.13 Conversion to Inches or Millimetres

In the case of displacement data (X,Y,Z, etc.), it is normally necessary to convert the raw data to compensated millimetres or compensated inches. First the number must have the correct preset number subtracted (and in the case of a binary number, the decimal information applied) as explained in the previous paragraphs. The resulting number must then be multiplied by the compensation factor and the proper conversion factor. The conversion factors are as follows:

- a. Multiply by 6.23023×10^{-6} to convert to inches.
- b. Multiply by 1.58248×10^{-4} to convert to millimetres.

The compensation number corrects for the velocity-of-light (VOL) factor and possibly material temperature (if the 5510A Opt 010 is used to monitor this factor). The material temperature compensation converts the information back to a length at 20°C (68°F). These multiplication numbers assume there is no deadpath.

4.14 Conversion when Deadpath is Included

Deadpath is defined as the distance between the interferometer and the cube-corner at the 0 (gage) position (see Figure 4-3). It is assumed in the following discussion that you have read and understand the discussions in Section II that explain deadpath and VOL errors.

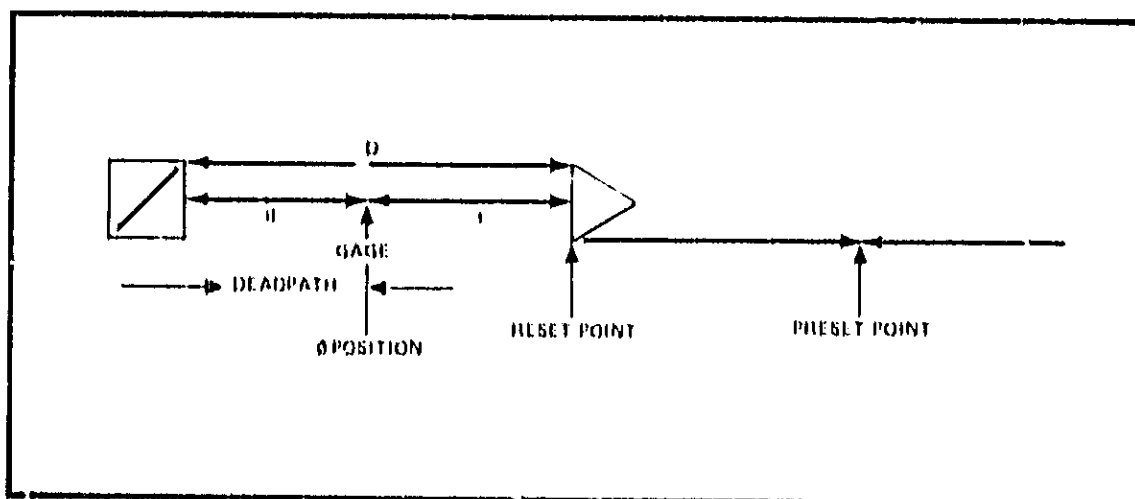


Figure 4-3. Conversion when Deadpath is Included

As was discussed in the Deadpath error compensation section, the gage or Ø position should be a defined machine position. At this Ø position, the distance between the interferometer and the retroreflector must be known. The distance "D" which is the total distance consists of 2 parts "d" and "t".

It is very important that the distance "t" be determined as the absolute distance and all software presets and resets be referenced from the gage or Ø position.

This expression is provided so λd can be computed

$$d = k(C_0 - \lambda_d)$$

d must be measured manually. Must be related to 20°C (68°F)

$$t = (k)(C_0)(\lambda_p)$$

λ_d and λ_t are vacuum wavelengths

$$D = (k)(C_0)(\lambda_p + \lambda_d)$$

λ_d should be approximated by $\frac{d}{k(C_0)}$

$$t = D - d$$

$$t = (k)(C_0)(\lambda_d + \lambda_p) - d$$

Total
Compensated
Distance

Deadpath
Distance
Related to 20°C (68°F)

NOTE

1. k is the conversion constant (see 4.13).
2. C_0 is compensation number when gage originally determined.
3. Remember that $\lambda_t + 160^\circ$ is the count from the 10760A Counter or from the 10762A Comparator.
4. The variable "c" in the above expressions is the ratio of air wavelength to vacuum wavelength, i.e., that number provided by 10756 or 5510, e.g., 9997324.

*16 if extended resolution and 10745A HP-IB Card is being used.

Quite often the location is measured on a relative basis; that is, a certain location on a part is a zero or reference. For example, assume that a zero is required at distance "t" from the gage or 0 position of the machine.

$$X = t + s$$

X = the number currently displayed,
t = compensated distance from the gage,
s = a normalized software offset.

$$X = t - t_0$$

For reset, $s = t$
and $t_0 = t$ at time of reset

If preset (P) desired, $t_0 = -P + t$ at time of reset,
where P is the preset number.

4.15 Handshaking Routine between a Controller and the 10746A Binary Interface

In these examples, the 10746A Binary Interface is inputting from and outputting to an HP 12566B μ circuit interface card. Figure 4-4 shows how to send data or instructions to the 10746A, and Figure 4-5 shows how to obtain data from the 10746A.

Since the flag and control signals from the 10746A are very fast, care must be taken to interface simply to the 12566B μ circuit interface card. As the 12566B input latches are not edge triggered, it is necessary to have the input latches follow the data. After a flag is received, the data can be loaded via an LIA instruction and the computer clears the control signal to the computer.

In some applications when the 10746A is used with the 12566B μ circuit interface card, noise can be generated in the system which results in the inability to sample the counters in the laser electronics and looking as if the counters are frozen. If this problem is witnessed in a system, a solution is to jumper W1 on the 12566B to position B and set jumper A on the 10746A card to accept + true command signals.

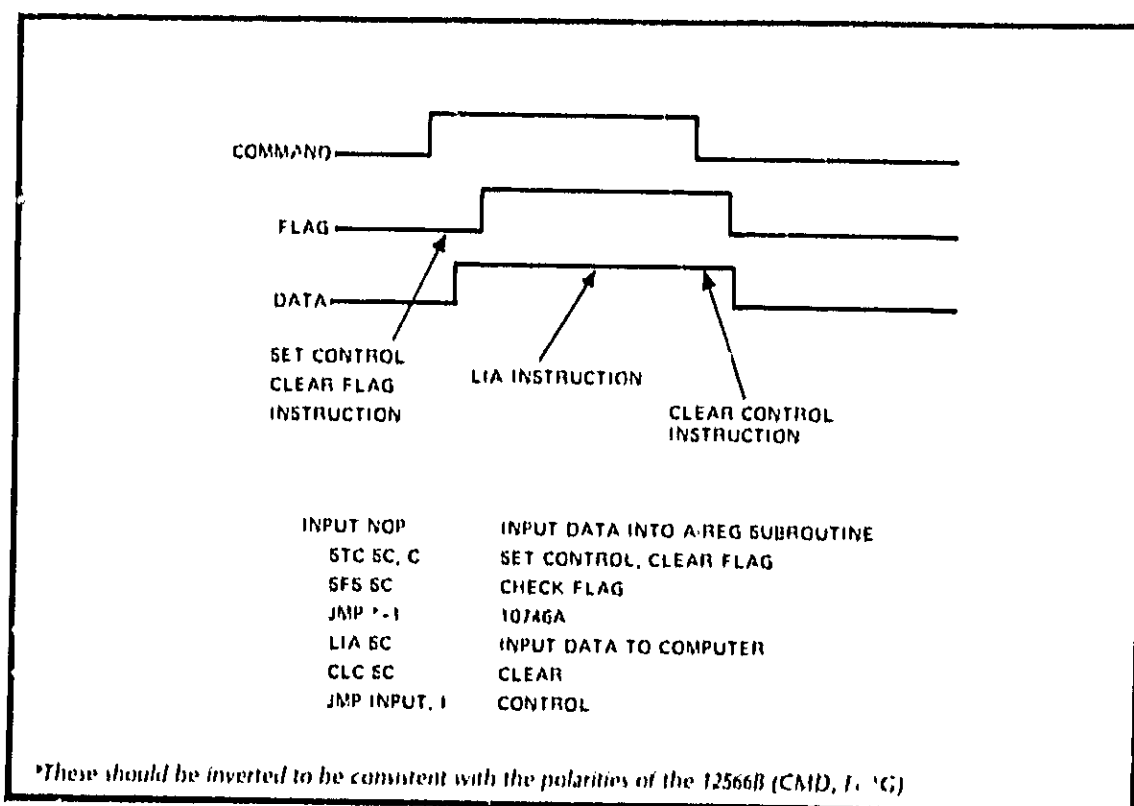


Figure 4-4. Receiving Data from the 10746A*

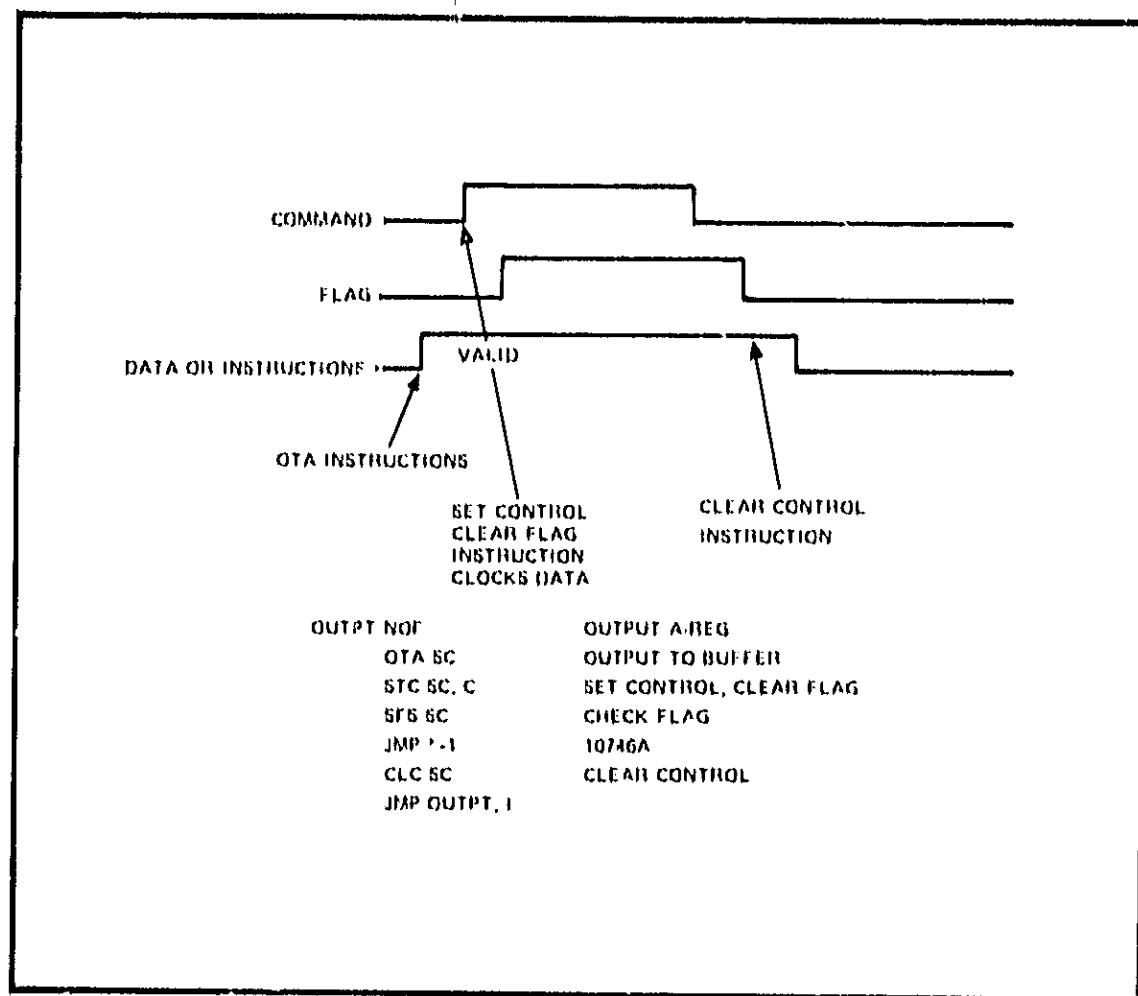


Figure 4-5. Sending Data or Instructions to the 10746A

4.16 Conversion of Destination and Displacement Information When Using the 10762A Comparator

When utilizing the 10762A Comparator, one of the prime functions of the system controller is to transmit to the 10762A Comparator the destination address of the object under control. Since this destination address reflects a displacement in inches or millimetres and the 5501A Laser Transducer System measures in units of some fraction of the wavelength of laser light, a conversion has to be made prior to transmitting the destination address. This wavelength of the laser light is dependent on the environmental conditions under which the measurement is made, therefore, the conversion must take this into account.

The general form for converting to wavelength units is:

$$\text{Destination in wave-length units} = \frac{\text{Destination in inches or millimetres}}{\left(\frac{\text{Environmental}}{\text{Compensation Factor}} \right)} \cdot \left(\frac{\text{Conversion Factor for}}{\text{wavelength units}} \right)$$

*As noted earlier the 160 count preset must be included in this destination.

The environmental compensation factor is a number slightly less than one; i.e., 0.999XYZT, where the digits XYZT are obtained from either the 10756A Manual Compensator or the 5510A Opt 010 Automatic Compensator. The conversion factor for wavelength units depends on the measurement resolution selected in the 10764B Fast Pulse Converter, $\mu/4 = 1.58248 \times 10^{-4}\text{mm}$, $\mu/8 = 7.91239 \times 10^{-5}\text{mm}$, etc.

This destination in corrected wavelength units is computed by the system controller and outputted to the 10762A Comparator via the 10746A Binary Interface where it is constantly compared to the up/down counter.

Conversely, if the up/down counter contents are transferred to the system controller to determine the position of the object under control, the displacement data in fractional wavelength units can be converted to inches or millimetres as follows:

$$\text{Displacement in Inches or Millimetres} = \left(\text{Displacement in Wavelength Units} \right) \left(\text{Environmental Compensation Factor} \right) \left(\text{Conversion Factor for Wavelength Units} \right)$$

4.17 10762A Comparator/10764B Fast Pulse Converter Input/Output Format

Table 4-15 shows the input/output format of the 10762A Comparator and the 10764B Fast Pulse Converter.

4.18 PROGRAMMING AND DEBUGGING TIPS

The first and most important thing to remember about programming the HP 9825A Calculator to act as a system controller is that the documentation for the 9825A Calculator contains extensive examples and techniques of how to properly program and debug the calculator routines.

In addition to that, when specifically programming for the Laser Transducer System keep the following points in mind:

- When in doubt if it is a hardware or software problem, write some very simple programs to input the raw data (e.g., 2V3P to output the compensation number, or 1O2X3O to output, input, and display in decimal).
- Use the least number of cards possible to perform a specific function.
- Make extensive use of STOP, HALT, or PRINT statements that output the results immediately. These statements make it easy to localize a problem within the software.
- Check the handshake routine between the system controller and the system interface card, (either the 10745A HP-IB or 10746A Binary Interface). Make sure you are giving a reset at the start of the program. This can be done by pushing the reset button on the calculator, using an external reset line, or sending reset commands. Note that if the system uses the binary interface and 16-bit words, you should send three BP instructions. If it uses 8-bit words send five BP instructions.

- e. Remember certain instructions (e.g., JO or JP) that request an output from the Coupler require that after the next handshake, the controller must read in the data from the Coupler. With the Binary Interface this is normally done using a RBYTE instruction (the controller reads either four 8-bit bytes or two 16-bit bytes).
- f. In the case of the 4P command the comparator card expects to receive data from the controller with the next handshake. Note that this applies only to the 10746A Binary Interface. The 10745A HP-IB Interface cannot send data and, therefore, cannot be used with the comparator card.
- g. There is one handshake for the instructions (e.g., 3P) and then a handshake for each word or byte of data transfer. For two 16-bit words, two additional handshakes. For four 8-bit bytes, four additional handshakes.
- h. With the Laser Transducer System it is easy to check just a few cards at a time. You can check the display by writing a simple program that enters data from the keyboard and then outputs it to the display. The coupler can be checked by simply inputting compensation numbers. Use the calculator display to observe the data to help simplify the troubleshooting.
- i. Be sure to determine the correct polarity of your interface card (this does not apply to the 10745A HP-IB Interface). Some cards are positive-true (e.g., the 10746A Binary Interface). Other cards are negative-true. The quickest way to check (if there are no other malfunctions in the system) is to send different commands both ways. Refer to Table 4-11 for examples of specific commands.
- j. Remember that with the binary interface it is possible to have an overflow error and still have valid data. In order to strip off the error bits and get the decimal point bits plus the displacement bits, give any command that starts with 0 (e.g., 0O). This clears the binary interface card error bits. Then give a 3P command.
- k. At the beginning of each program using the HP-IB, it is very important to give a device clear and a remote enable instruction (refer to Table 4-12).
- l. Keep in mind that a 2V instruction outputs the previous compensation value. Therefore its accuracy depends on how often the compensation number is updated.
- m. The characters 0 (zero) and O (as in Oslo) are different and not equal.

4.19 OPERATION

The operating procedures (other than initial turn on) for the Laser Transducer System are dependent on the programming and design of the system controller. For your convenience, Figures 4-6 through 4-9 provide locations and descriptions of the controls and indicators on the system units.

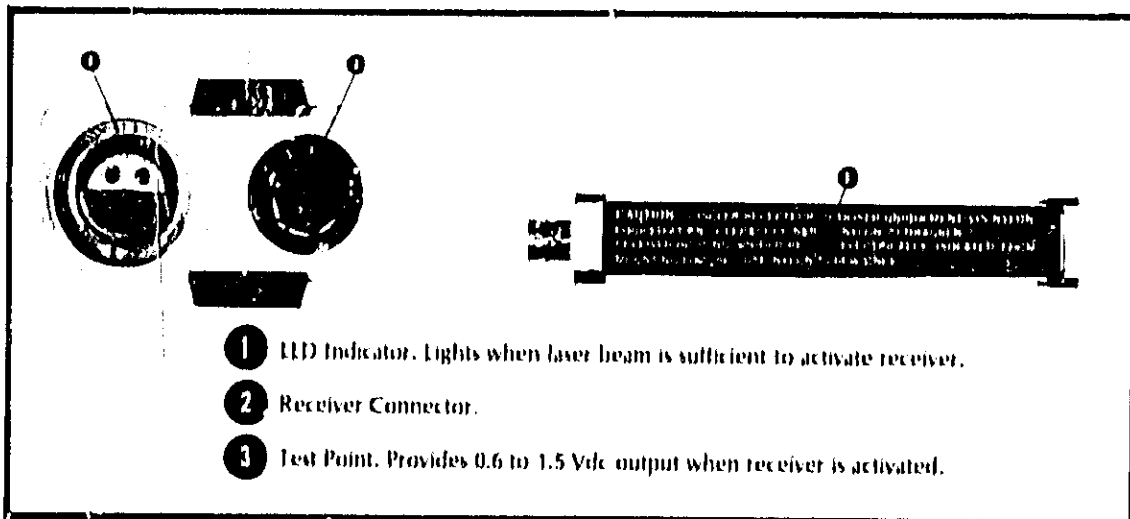


Figure 4-6. 10780A Receiver

Table 4-15. 10762A Comparator/10764B Fast Pulse Converter Input/Output Format

A. DATA FORMAT OF 10746A BINARY INTERFACE

1. The data output of the 10746A Binary Interface includes 28 bits of data plus 4 bits of status/decimal point which come from both the 10762A Comparator and the 10764B Fast Pulse Converter. Format can be either two 16-bit words or four 8-bit bytes, jumper-selectable on the 10746A Binary Interface.

a. Two 16-bit Word Format

This format outputs the position data in two 16-bit words in the following format with the most-significant bits first.

Word 1

MSB $D_7, D_6, D_5, D_4, C_{27}, C_{26}, C_{25}, C_{24}, C_{23}, C_{22}, C_{21}, C_{20}, C_{19}, C_{18}, C_{17}, C_{16}$

Word 2

LSB $C_{15}, C_{14}, C_{13}, C_{12}, C_{11}, C_{10}, C_9, C_8, C_7, C_6, C_5, C_4, C_3, C_2, C_1, C_0$

Where D_7, D_6, D_5, D_4 = Decimal Point Status

$C_{27} - C_0$ = Counter Data

If $D_7, D_6, D_5, D_4 = 1111$, this indicates either a measurement error or the fact that the counter and comparator are within the ± 4 -bit tolerance. Bits $C_{27}, C_{26}, C_{25}, C_{24}$ will determine which condition exists. When bits $C_{27}, C_{26}, C_{25}, C_{24} = 1111$ then the Counter and Comparator are within the ± 4 -bit tolerance. If $C_{27}, C_{26}, C_{25}, C_{24} \neq 1111$, then these bits will be a code indicating the following measurement errors:

If $C_{27} = 0$, a VOL error exists.

If $C_{26} = 0$, an overflow error exists.

If $C_{25} = 0$, a reference error exists.

If $C_{24} = 0$, a measurement error exists.

If $D_7, D_6, D_5, D_4 \neq 1111$ then these bits will indicate a decimal point location (Resolution Extension) and bits $C_{27}, C_{26}, C_{25}, C_{24}$ will then be data.

b. Four 8-bit Byte Format

In this case the data will be inputted in a format of four 8-bit bytes with the first word being the decimal point/status and the 4 most-significant data bits.

Word 1

MSB $D_7, D_6, D_5, D_4, C_{27}, C_{26}, C_{25}, C_{24}$

Word 2

$C_{23}, C_{22}, C_{21}, C_{20}, C_{19}, C_{18}, C_{17}, C_{16}$

Word 3

$C_{15}, C_{14}, C_{13}, C_{12}, C_{11}, C_{10}, C_9, C_8$

Word 4

LSB $C_7, C_6, C_5, C_4, C_3, C_2, C_1, C_0$

The same rules for the decimal point status bits apply here as for the two 16-bit word format.

2. Data Input to Comparator Card

When it is desired to input the Destination and Tolerance data to the 10762A Comparator Card, the data can be inputted in either the two 16-bit word or four 8-bit byte format.

Table 4-15. 10762A Comparator/10764E Fast Pulse Converter Input/Output Format (Cont'd)

The data format would be identical to that discussed for the output mode except that the 4 most-significant bits would now be the tolerance. For example, the two 16-bit words would be as follows:

Word 1

MSB T_{15} T_{14} T_{13} T_{12} T_{11} T_{10} T_9 T_8 T_7 T_6 T_5 T_4 T_3 T_2 T_1 T_0

Word 2

LSB C_{15} C_{14} C_{13} C_{12} C_{11} C_{10} C_9 C_8 C_7 C_6 C_5 C_4 C_3 C_2 C_1 C_0

Where T_i = Tolerance Data

C_i = Command Data

B. INPUT/OUTPUT SEQUENCE

1. Output Sequence

When it is required to sample the counter on the 10762A Comparator Card, the following sequence would be implemented in the form of commands to the 10746A Binary Interface from the System Controller.

- a. Sample Command (either both axes simultaneously or individually, 1P, 1X, etc.).

This samples the Counter and stores the sample in an output buffer on the 10762A Comparator Card (1 microsecond).

- b. Counter Output Command (2X, 2Y, etc.)

This command transfers the contents of the counter and the 4 status bits to the 10746A Binary Interface and formats this into either two 16-bit words or four 8-bit bytes (2 microsecond).

- c. Binary Interface Output Command (3P)

Sets up card to accept a control bit. After the control bit is received, data is placed on the output lines.

When the first word is accepted by the System Controller it will send a control bit back to the 10746A Binary Interface requesting the second word which will then output the second word, etc., (3 operations for 16-bit words, 5 operations for 8-bit words, 1 microsecond per operation).

2. Input Sequence

When it is desired to load the Destination and Tolerance onto the 10762A Comparator, the following sequence is implemented:

- a. Load Data Command (4P)

This command to the 10746A Binary Interface from the System Controller prepares the Binary Interface to accept the four 8-bit bytes, or two 16-bit word Destination and Tolerance (1 microsecond).

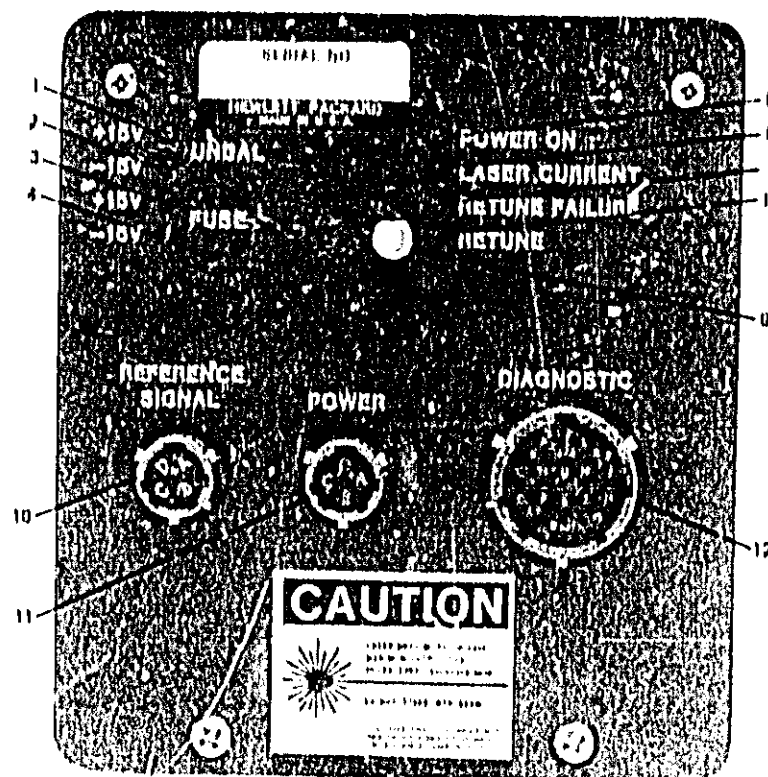
- b. The System Controller then outputs the first data word to the 10746A Binary Interface, sends a control bit acknowledging the action and outputs the next data word, etc., until the destination address is loaded. When the last word is loaded, the 10746A Binary Interface formats the address for transfer to the 10762A Comparator (2 operations for 16-bit words and 4 operations for 8-bit bytes, 1-microsecond per operation.)

- c. Transfer Command (to specific axis, 3X, 3Y, etc.)

Transfers destination address from 10746A Binary Interface to the specific 10762A Comparator Card (1 microsecond).

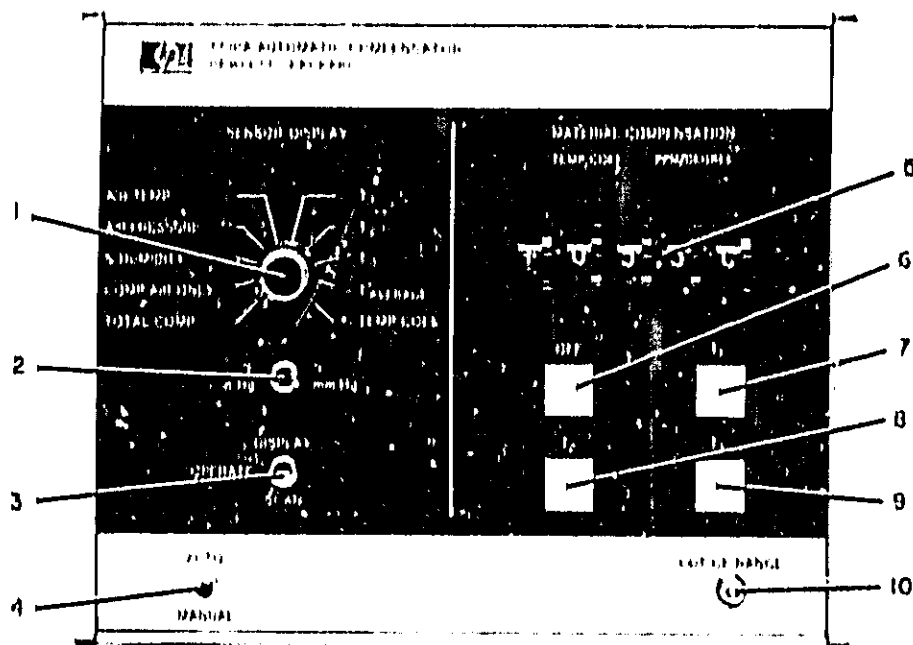
3. Sample Instruction (external or from System Controller, 1P, 1X, 1Y, etc.)

Since the act of loading the Destination and Tolerance will force a Null or Zero difference on the Digital Difference Output, Sample Instruction is required to release the forced null (1 microsecond).



- | | |
|--------------------------------------|---|
| 1. +15V UNBAL (LED Lamp) | Lights when +15V dc power is high by approximately one-volt or more; or when the -15V dc power input is low (i.e., less negative) by one-volt or more. |
| 2. -15V UNBAL (LED Lamp) | Lights when -15V dc power is high (i.e., more negative) by approximately one-volt or more; or when the +15V dc power input is low (i.e., less positive) by one-volt or more. |
| 3. +15V FUSE (LED Lamp) | Lights when +15V dc fuse blows. |
| 4. -15V FUSE (LED Lamp) | Lights when -15V dc fuse blows. |
| 5. POWER ON (LED Lamp) | Lights when external power has been applied to Laser Head. |
| 6. LASER CURRENT (LED Lamp) | Lights to indicate Laser Tube current is not within appropriate operating limits. |
| 7. RETUNE FAILURE (LED Lamp) | Lights to indicate the Laser Tube is not properly tuned or that retune cycle did not retune the laser. |
| 8. RETUNE (LED Lamp) | Lights to indicate that retuning is required or that retune cycle is in progress. Light should go out approximately 9 seconds after the RETUNE pushbutton is depressed. If light remains on, a tuning fault is indicated. |
| 9. RETUNE (Pushbutton) | Manually activates Retune sequence. |
| 10. REFERENCE SIGNAL (Connector, 11) | Allows the reference signals (REF and REF) and +15V power to be interconnected to other system components. |
| 11. POWER (Connector, 12) | Provides connection point for external power supply input. |
| 12. DIAGNOSTIC (Connector, 13) | Allows monitoring of diagnostic signals and application of RETUNE command by external equipment. |

Figure 4-7. 5501A Laser Transducer Rear Panel Controls and Indicators



NOTE

The SENSOR DISPLAY section is not used with most Laser Transducer Systems. If you have a Calculator Interface System a programming routine is included that will display the selected function on the calculator display.

1. SENSOR DISPLAY selector. When the DISPLAY-OPERATE SCAN (3) switch is set to DISPLAY, the SENSOR DISPLAY switch selects a measurement or factor to be displayed on the calculator display. These measurements or factors are as follows:
 - a. TOTAL COMP. Compensation number in parts per million (includes compensation for workpiece temperature).
 - b. (1) COMP AIR ONLY. Compensation number in parts per million due to air measurements only.
 - c. (2) HUMIDITY. Percentage of relative humidity.
 - d. (3) AIR PRESSURE. Barometric pressure in either inches or mm of mercury as determined by the in Hg — mm Hg switch.
 - e. (4) AIR TEMP. Air temperature in degrees Fahrenheit or Centigrade as determined by the °F — °C switch.

NOTE

The calculator will display a reference temperature of 20.0°C (68°F) when a material sensor is not connected to the calculator. However, the pushbutton will only light for those sensors which are connected. If the air probe is not connected, the calculator will display a reference temperature of 20.0°C (68.4°F) and a humidity of 10%.

Figure 4-B. 5510A Opt 010 Automatic Compensator Front Panel Controls and Indicators

1. (5) T_1 , Material temperature measurement of sensor No. 1 in Fahrenheit or Centigrade as determined by the °F — °C switch.
- a. (6) T_2 , Same as T_1 but for sensor No. 2.
- b. (7) T_3 , Same as T_1 but for sensor No. 3.
- i. (8) T AVERAGE, Average temperature of the sensors selected with the white push-button switches (T_1 , T_2 , T_3).
- j. (9) TEMP COEFF, PPM/degree setting on Material Compensation thumbwheel switch.
2. "°F — °C" and "in Hg — mm Hg" switch. Selects either English or Metric units for the display. Only operative in positions (3) through (8) of the SENSOR DISPLAY switch. Setting of this switch does not affect the compensation number.
3. DISPLAY — OPERATE — SCAN switch. In DISPLAY position, the calculator will display the setting of the SENSOR DISPLAY switch. When set to OPERATE, the Laser Interferometer system is operative; the source of the compensation number will be determined by the setting of the AUTO — MANUAL switch. SCAN position, not used with Laser Transducer System.
4. AUTO — MANUAL switch. Always set to AUTO when used with Laser Transducer System to supply compensation numbers to the 10755A Compensation Interface.
5. MATERIAL COMPENSATION thumbwheel switch. Used to enter material temperature coefficients in ppm/degree of Fahrenheit or Centigrade.
6. OFF indicator switch. When lit, indicates that all material temperature sensors are OFF. When pushed, disconnects all material temperature sensors.
7. T_1 Indicator and Switch. When lit, indicates that temperature sensor 1 is operative, when pushed, selects sensor 1.
8. T_2 Indicator and Switch. Same as above for T_2 sensor.
9. T_3 Indicator and Switch. Same as 7 above for T_3 sensor.
10. OUT OF RANGE indicator. Indicates that measurement conditions are out of the range of the compensator.

Figure 4-8. 5510A Opt 010 Automatic Compensator Front Panel Controls and Indicators (Cont'd)

INSTALLATION

section V

Installation and Checkout

5.1 INTRODUCTION

This section provides the information necessary to install and checkout your system. It is organized as follows:

- a. System grounding considerations. A brief discussion on proper grounding techniques. It is very important that the Laser Transducer System be properly grounded to avoid shock hazards and to eliminate ground loop problems.
- b. The preliminary procedures. Checks the power supplies, transducer head, receivers, and system controller prior to installing any equipment. These procedures must be performed for all systems.
- c. The physical installation and alignment of the transducer head, receivers, and optics. Refer to Section II for the background information necessary to ensure that the choice of physical location of the components and the overall measurement path is optimum for your application.

- d. The installation of the electronic interface components. These procedures are divided into major system configurations. Select the procedure that matches your system.
- e. The system checkout procedure. These procedures are divided into major system configurations. Select the procedure that matches your system.
- f. Preventive Maintenance. The system electronics require no preventive maintenance. However, the system optics do require periodic cleaning. The frequency of the cleaning is dependent on the cleanliness of the ambient environment.

The procedures are organized in this manner to make installation and checkout as simple as possible. In addition, they can be used as a basis for detailed troubleshooting either during initial installation or at a later time when a system problem cannot be easily located. Table 5-1 is a list of recommended test equipment needed to install, check out, and troubleshoot the Laser Transducer System. Other equipment can be used if it meets the minimum specifications listed.

Table 5-1. Recommended Test Equipment

Description	Required Characteristics	Recommended Model
DC Voltmeter	$\pm 15V \pm 0.025V$ and $+5V \pm 0.01V$	HP 3435A
Logic Probe	Ability to Indicate TTL and ECL Logic Levels	HP 10525I/10525L
Oscilloscope	Ability to Display Signals between DC and 20 MHz	HP 180A/1801A/1920A

5.2 SYSTEM GROUND CONSIDERATIONS

If proper system grounding techniques are not observed, two adverse situations can occur:

- a. A system can be interconnected so that an electrical shock hazard exists. External parts of various system components can be at different electrical potentials due to incomplete system grounding. (See Figure 5-1).

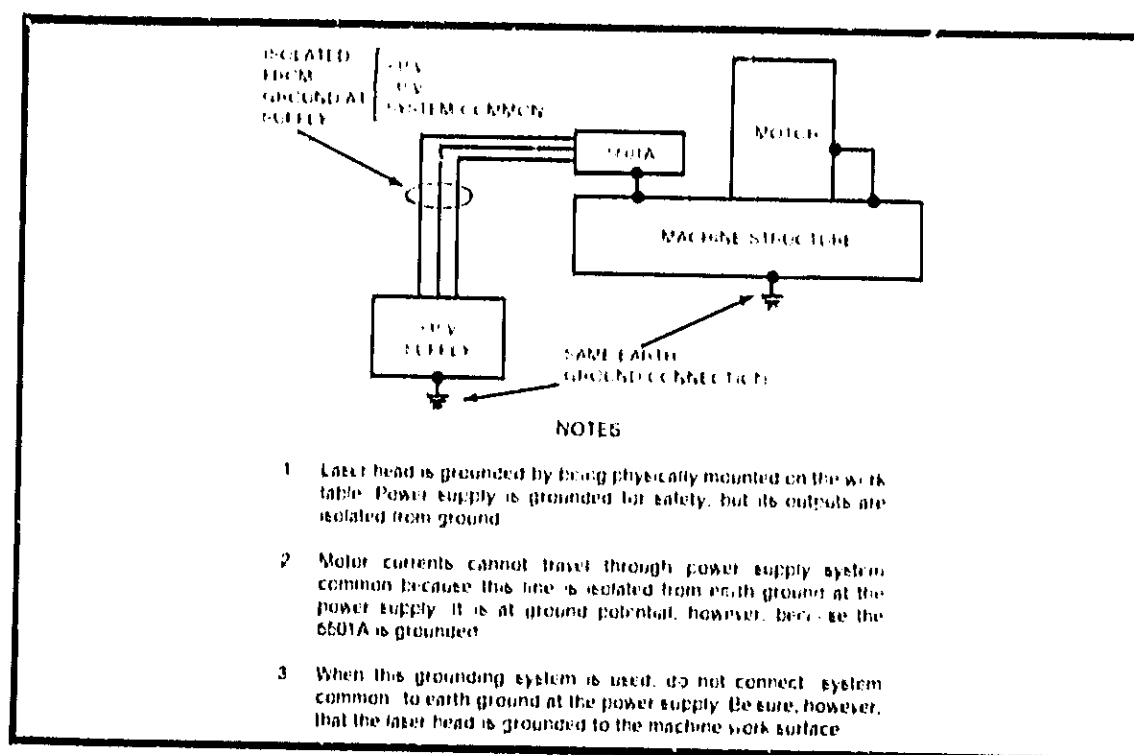


Figure 5-1. AC Power Grounding

- b. The system electronics can become very sensitive to external noise (such as power line switching transients) due to undesirable currents flowing through ground wiring. These currents cause a voltage potential other than zero volts to exist at points in the grounding system. (See Figure 5-2).

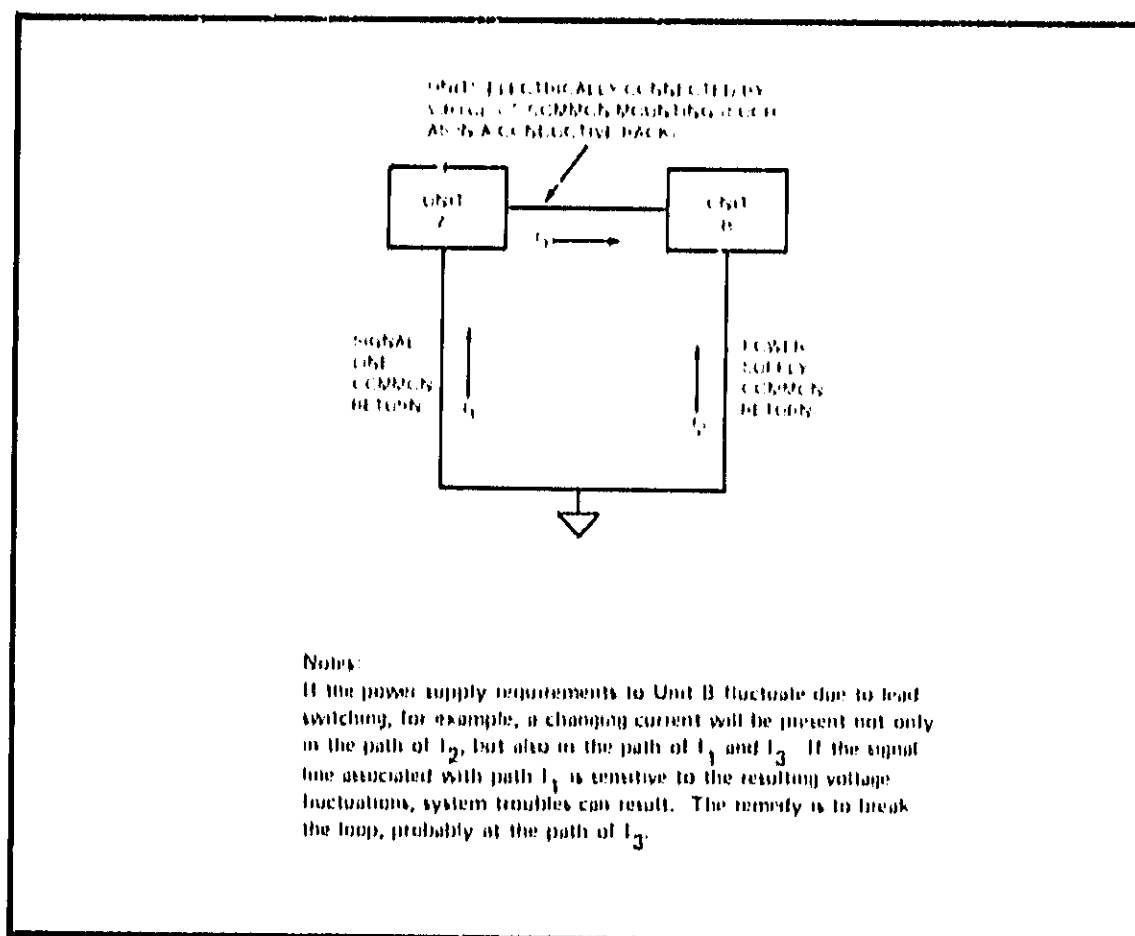


Figure 5-2. Grounding to Avoid Ground Loops

In general, try to avoid unnecessary ground or common return connections while wiring the system. Ensure, however, that all units are grounded. The best approach is to have one common earth ground connection in the system with all system components connected at the single ground. Also, avoid connecting both ends of a signal cable shield to a ground point. This would allow currents to flow through the shield and possibly cause interference with the signal lines within the cable. The shields from the 10780A receiver, for example, should be grounded at one end only, and the receivers should be mounted in such a fashion that they form no electrical connection with the mounting surface. A typical distribution of the +15V power and the reference and measurement signals is shown in Figure 5-3. The correct wiring of the individual units to the terminal strip on the rear of the 10740A coupler is shown in Figure 5-4.

For further information on the subject of system grounding, refer to "Grounding and Shielding Techniques in Instrumentation" by Ralph Morrison. Published by John Wiley and Sons, Inc.

Table 5-2. Required Cables

HP Part Number	Supplied With Or Ordered With	Interconnects		Length	Use
		From	To		
10770A,B,C Note 1	5501A*	5501A	+ 15V 622151	10770A 5M 16.4 ft. 10770B 10M 12.8 ft. 10770C 20M 65.6 ft.	Power
10779A,B,C Note 1	5501A*	5501A	10760A or 10764B or 10781A or 10714A	10779A 5M 16.4 ft. 10779B 10M 12.8 ft. 10779C 20M 65.6 ft.	Reference
10790A,B,C Note 2	10780A*	10780A	10760A or 10764B or 10781A or 10714A	10790A 5M 16.4 ft. 10790B 10M 12.8 ft. 10790C 20M 65.6 ft.	Power & Measurement
10700-60001	10700A/B	10700A	115V/230V	2.29 m 7.5 ft.	Primary Power
10712-60001	10712A	5510A	2100 Computer	4.57 m 15 ft.	Signal & Power
10727-60001	10727A	9025A	10746A	4.57 m 15 ft.	Calculator Interface
10740-60004	10740A	10740A	+ 5V 626051 Power Supply	1.52 m 5 ft.	Power
10740-60005	10740A	10740A	+ 15V 622151 Power Supply	4.57 m 15 ft.	Power
10745-60002	10745A	10745A	9025A via 90014A Interface Cable	1.66 m 5 ft.	Interface
10760-60002	10760A	10760A	5501A or 10760A/10780A	2 ea. @ 0.46 m 1.5 ft. 1 ea. @ 0.1 m 1 ft.	Reference & Doppler
10764-60002	10764A	10764A	External Controller	1 ea. @ 0.9 m 3 ft. 2 ea. @ 4.57 m 15 ft.	Controller Interface
10764-60005	10764B	10764B	5501A or 10764B/10780A	4 ea. @ 1.51 m 5 ft.	Reference & Doppler
10781-60001	10781A	10781A	10780A/5501A	1 ea. @ 0.46 m 1.5 ft.	Reference & Doppler
10781-60004	10781A	10781A	+ 5V Power Supply	4.57 m 15 ft.	Power
10781-60001	10781A	10781A	+ 5V via 10740A	4.57 m 15 ft.	Power
05510-60022	5510A Opt. 010	5510A	10755A	0.3 m 1 ft. 4.57 m 15 ft.	VOL
10641A,B,C	10781A	10781A	HP-IB Controller	0.9 m 3 ft. 1.01 m 6 ft. 1.66 m 5 ft.	Interface
10714-60001	10715A	5501A	10714A Interface		Power Cable

*See Appendix C, CABLEING, for photos and connector pinouts

NOTE 1: The following connectors are supplied with the 5501A for those who desire to fabricate their own cables: see Backdating Section I for cable fabrication information: 4-pin connector HP P/N 1251-1447, 4-pin connector HP P/N 1251-1450, and a Diagnostic Plug 18-pin HP P/N 1251-2797.

NOTE 2: The following connector is supplied with the 10780 for those who desire to fabricate their own cables: see Backdating Section I for cable fabrication information: 4-pin connector HP P/N 1251-2452.



CAUTION

Do not continue with the procedure until the power supplies voltages are within the limits specified in step d. Excessive voltage can cause damage to system components.

- d. Connect the $\pm 15V$ and $+5V$ power supplies to a suitable source of ac power. Verify that the outputs of the $\pm 15V$ power supply are $+15V \pm 0.25V$ dc and $-15V \pm 0.25V$ dc. Verify that the output of the $+5$ -volt power supply is $+5 \pm 0.1, -0.05V$ dc. If out of specification and the HP power supplies are used, refer to the applicable manual. Remove system power.

NOTE

During cable installation, the machine system geometry may require that the ends of the reference and measurement cables fit through spaces too small for the cable connectors. If so, check the laser head and receiver by connecting $\pm 15V$ from the $\pm 15V$ power supply. On the laser head, connect the $+15V$ to pin A, the $-15V$ to pin B, and the return to pin D of the POWER connector (Figure 4-7). On the receiver(s) connect the $+15V$ to pin 4 and return to pin 3 (see Figure 4-6).

WARNING

BEFORE PERFORMING THE FOLLOWING STEPS, BE SURE THAT ALL SYSTEM ITEMS THAT ARE CONNECTED TO AN AC POWER SOURCE HAVE A COMMON EARTH GROUND CONNECTION. IT IS POSSIBLE TO HAVE A DIFFERENCE IN ELECTRICAL POTENTIAL BETWEEN THE VARIOUS SYSTEM COMPONENTS IF A COMMON GROUND IS NOT ENSURED. THIS CONDITION CAN CAUSE INJURY TO OPERATING PERSONNEL AND/OR CAUSE DAMAGE TO THE SYSTEM COMPONENTS. ALSO, BE CERTAIN THAT ANY SURROUNDING EQUIPMENT, SUCH AS A MACHINE TOOL, HAS THE SAME COMMON GROUND FOR ITS POWER SOURCE AS THE LASER SYSTEM GROUND.

- e. Connect the $\pm 15V$ power cable between the $\pm 15V$ power supply and the laser head POWER connector. If you have fabricated your own cables and have any doubt which cable is indicated, refer to Appendix C, CABLING.

NOTE

In step f (except for the 10781A Pulse Converter System) it is not necessary to connect the electronic interface connectors to their respective units (counter, fast pulse converter, etc). The $+15V$ lines of these connectors are replicated within the interface connectors. For the 10781A Pulse Converter, the connector must be connected since the $+15V$ lines are replicated within the pulse converter.

- i. Connect the measurement/reference cable assembly to the laser head and receivers. Connect the reference leg to the REFERENCE SIGNAL connector on the laser head and the measurement leg(s) to each receiver connector.
- g. Apply system power and verify that the laser head emits red light. DO NOT VIEW THE LIGHT DIRECTLY. Instead, place a white paper or card in the beam path and view the beam reflection on the white surface.
- h. Take each receiver, in turn, and position it in front of the laser so that the laser beam is centered on the receiver photodetector. Be sure to rotate the receiver around the laser beam axis to a point where one of its flat sides rests in the same plane as the base of the laser head. False indications can otherwise result. Verify that the LED on each receiver lights and the voltage at the receiver test point is between 0.6 and 1.5V dc.
- i. Block the laser beam and verify the LED indicator goes out.
- j. Verify that the system controller is working properly. Refer to the applicable manuals for checkout and diagnostic procedures.
- k. Remove system power and disconnect all equipment.

5.4 INSTALLATION AND ALIGNMENT OF LASER HEAD, RECEIVER, AND OPTICS

The proper installation and alignment of the laser head, receiver, and optics is one of the most critical procedures in the installation of the Laser Transducer System. For this reason an entire section (Section II) is devoted to considerations of proper measurement path layout, sources of error, mounting, beam protection, and alignment techniques. Only after you have carefully read Section II and have laid out a measurement path should you attempt to install the equipment.

- a. Install the laser head, receiver, and optics in their preplanned positions using the mounting instructions contained in Section II.
- b. Run the measurement/reference cabling as planned. Be very sure that there is no possibility of the cable binding during machine operation. Connect the reference leg to the REFERENCE SIGNAL connector on the laser head and the measurement leg(s) to each receiver connector.
- c. Install the $\pm 15V$ and $+5V$ power supplies. Refer to the applicable manuals for dimensions and mounting instructions.
- d. Connect the $\pm 15V$ power cable between the $\pm 15V$ power supply and the laser head POWER connector. Again, be very sure there is no possibility of the cable binding during machine operation.
- e. Connect the $\pm 15V$ power supply to a suitable source of ac power and apply system power.
- f. Verify that the laser head emits red light. DO NOT VIEW THE LIGHT DIRECTLY. Instead, place a white paper or card in the beam path and view the beam reflection on the white surface.

NOTE

The sequence of the following steps will depend upon the previous decisions you have made regarding the measurement path. If you need laser beam protection such as conduit and junction boxes, you will need to decide whether it will be easier to install the beam protection first and then align the system or vice-versa.

- g. Install beam protection equipment if required. Refer to Section II.
- h. Align the system. Refer to Section II.
- i. Verify that the LED on each receiver lights and the voltage at the receiver test point is between 0.6 and 1.5V dc. Block the laser beam between the interferometer and retro-reflector in each axis and verify the applicable receiver LED goes out.
- j. If the optional 5510A Opt. 010 Automatic Compensator is used, install the unit (refer to the 5510A Automatic Compensator Operating and Service Manual) and place the sensors as determined by the measurement path layout (refer to Section II). For an explanation of the individual controls on the 5510A Opt. 010, see *Figure 4-8*.
- k. Remove system power.

5.5 INSTALLATION OF ELECTRONIC INTERFACE COMPONENTS

The procedures for the installation of the electronic interface are subdivided into the following categories:

- a. Calculator Interface Electronics Installation.
- b. Computer Interface Electronics Installation.
 - 1. Counter-based system installation.
 - 2. Comparator-based system installation.
- c. English/Metric Pulse Output Electronics Installation.
- d. 10701A Pulse Converter Electronics Installation.

Each of these procedures is complete. Therefore, select the procedure that matches your system and perform the indicated steps.

5.6 HP-IB INTERFACE ELECTRONICS INSTALLATION

The HP-IB Interface Electronics is a wired interface between the 5501A Laser Transducer and any digital controller compatible with the Hewlett-Packard Interface Bus (HP-IB). The basic interface system works with a 9025A Programmable Calculator and interface electronics for two axes of measurement. All interconnecting cables between the Calculator Interface Electronics and the 5501A Laser Transducer are supplied.

Perform the installation as follows:

- a. If the 10740A Coupler is to be rack mounted or installed in a cabinet, refer to the 10740A Coupler Operating and Service manual for dimensions and installation instructions.
- b. Connect the +5V power supply cable between the power supply and the 10740A Coupler rear panel terminal strip.
- c. If the optional 5510A Opt. 010 Automatic Compensator is used, connect the $\pm 15V$ power supply cable between the power supply and the 10740A Coupler rear-panel terminal strip. Connect the interface cable between the 5510A Opt. 010 and the 10755A Compensation Interface.
- d. If the 10783A Numeric Displays are used, connect the +5V power cables between the numeric display rear panels and the +5V power source on the back of the 10740A Coupler.
- e. Connect the $\pm 15V$ power supply (if used) and +5V power supply to suitable sources of ac power. Apply system power. Verify the voltage at the coupler rear panel is +15V dc ± 0.25 , -15V dc ± 0.25 , and +5V dc ± 0.10 , -0.05V dc. Remove system power.

NOTE

To connect any hooded connector to a circuit card in the 10740A Coupler, pass the connector through the slot in the rear panel of the coupler and install it on the front edge connector of the applicable card (see Figure 5-5).

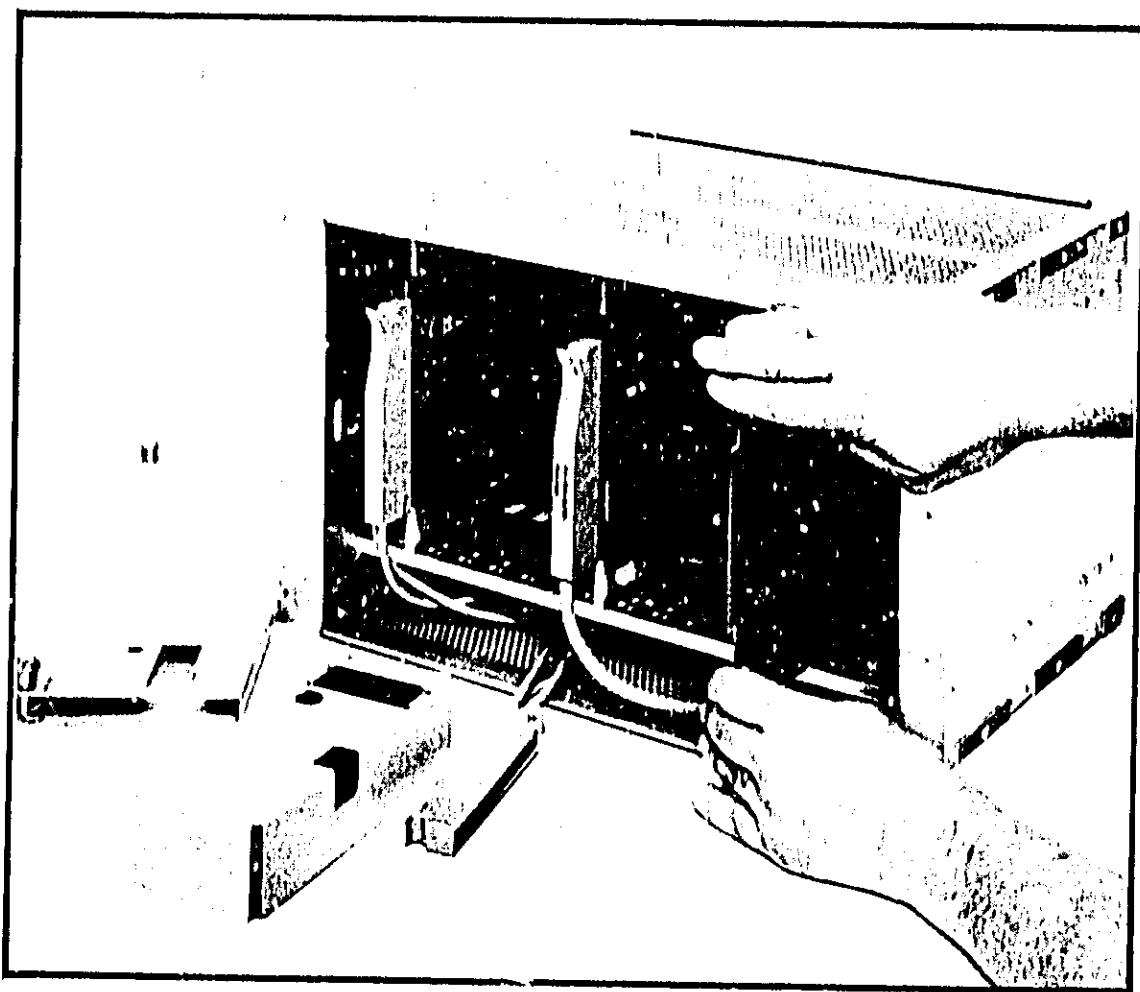


Figure 5-5. Installation of Hooded Connectors and Circuit Cards

- f. Remove the front panel of the coupler.

NOTE

All 10760A Counter cards are supplied with the NORMAL/REVERSE jumper in the NORMAL position. The correct position for the NORMAL/REVERSE jumper is determined during system checkout.

- g. Connect the reference/measurement cables from the laser head and first receiver to the first 10760A Counter card (see *Figure 5-6* for a typical system interconnect).
- h. Connect the hooded connectors in sequence to each of the additional 10760A Counters in the system and daisy-chain the REF connectors as shown in *Figure 5-6*.
- i. Apply system power and verify that the reference and measurement LED indicators located near the bottom front edge of each counter light (the reference LED indicator is the one closest to the front edge). Remove system power.
- j. Connect the system controller to the 10745A HP-IB Interface Card using the interconnect cable (P/N 10745-60002). Refer to the System Controller Operating Manual.
- k. If the 10783A Numeric Displays are used, connect them to the HP-IB Bus using the 10631A, B, or C cables.
- l. Apply system power. At the rear panel of the 10740A Coupler verify that the voltage is $+15V \pm 0.25V$ dc, $-15V \pm 0.25V$ dc, and $+5V \pm 0.10, -0.05V$ dc.

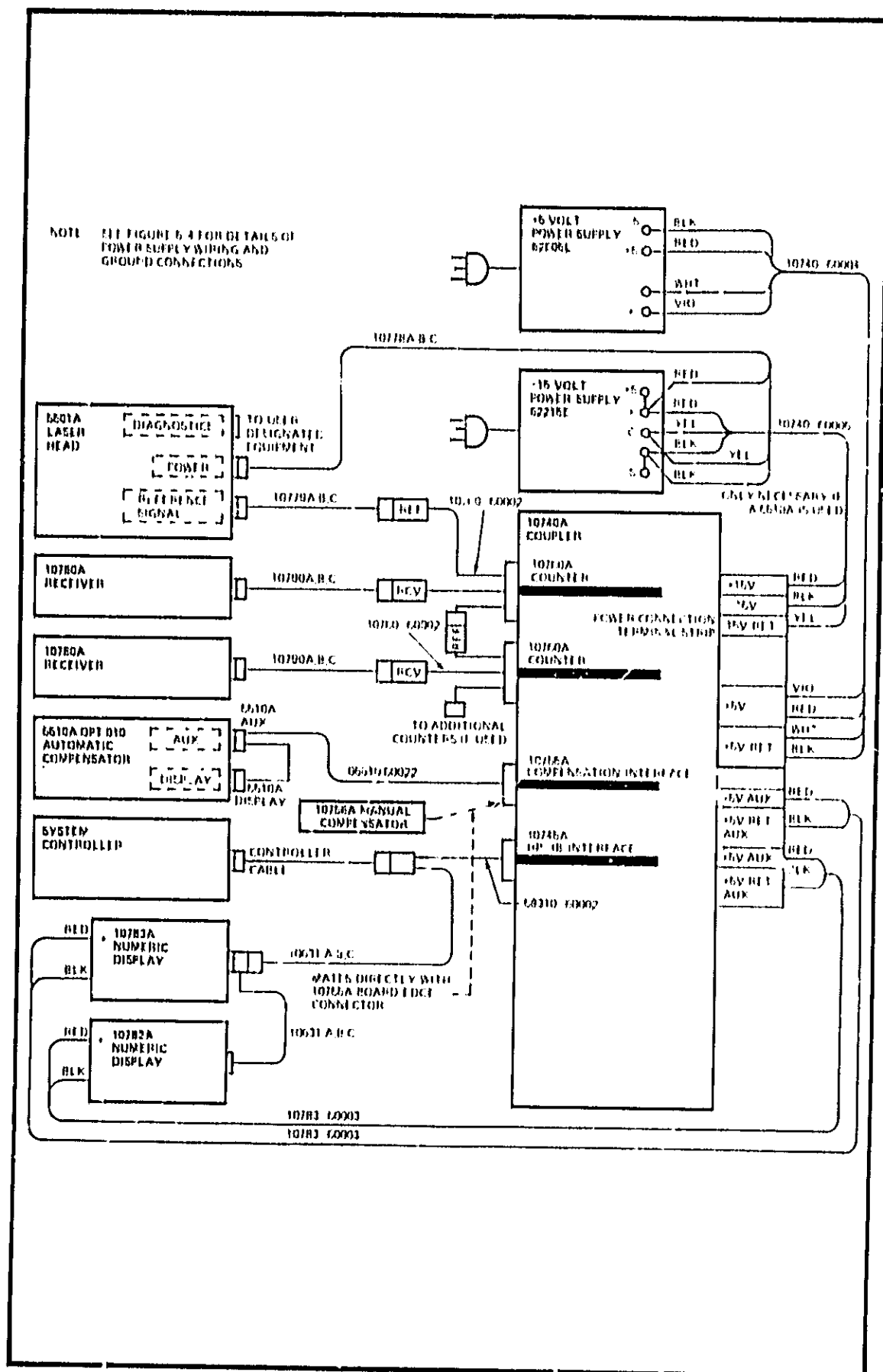


Figure 5-6. Typical HIP-IB Controller Interface Electronics Interconnecting Diagram

5.7 COMPUTER INTERFACE ELECTRONICS INSTALLATION

The computer interface electronics are designed to interface the 5501A Laser Transducer System to a wide variety of digital processors (including a calculator if desired). Oriented toward the Original Equipment Manufacturers (OEM), the individual components are selected and assembled by the user for a specific application.

The computer interface electronics are subdivided into the following two types of systems:

- a. Counter-based system (10760A Counters).
- b. Comparator-based systems (10762A Comparator).

Refer to Section I configuration information to determine what equipment is included in your system and use the applicable installation procedure to ensure proper installation.

The computer interface electronics include any system selected from the equipment specified in Table I-1 of Section I (i.e., wired, configured, and tested by the end user). The reason this distinction is made is that it is very important that you perform the installation very carefully to avoid system damage or malfunctions. If, for example, a power cable is miswired, it can very easily cause equipment damage. Or, if the address jumpers on the cards are not correct, the system will not function properly.

5.8 Counter-Based System Installation

Perform the installation of a counter-based system as follows:

- a. If the 10740A Coupler is to be rack mounted or installed in a cabinet, refer to the 10740A Coupler Operating and Service manual for dimensions and installation instructions.
- b. Connect the +5V power supply cable between the power supply and the 10740A Coupler rear panel terminal strip.
- c. If the optional 5510A Opt. 010 Automatic Compensator is used, connect the ± 1 V power supply cable between the power supply and the 10740A Coupler rear-panel terminal strip. Connect the interface cable between the 5510A Opt. 010 and the 10755A Compensation Interface.
- d. If the 10783A Numeric Displays are used, connect the +5V power cables between the numeric display rear panels and the +5V power source on the back of the 10740A Coupler.
- e. Connect the ± 15 V power supply (if used) and +5V to suitable sources of ac power. Apply system power. Verify the voltage at the Coupler rear panel is +15V dc ± 0.25 , -15V dc ± 0.25 , and +5, +0.10, -0.05V dc. Remove system power.

NOTE

To connect any hooded connector to a circuit card in the 10740A Coupler, pass the connector through the slot in the rear panel of the coupler and install it on the front edge connector of the applicable card (see Figure 5-5).

- f. Remove the front panel of the coupler.

NOTE

All 10760A Counter cards are supplied with the NORMAL-REVERSE jumper in the NORMAL position. The correct position for the NORMAL-REVERSE jumper is determined during system checkout.

- g. Check the addresses and jumpers on all system cards and units. It is advisable to make a list of each of the system addresses for future reference. Refer to the individual unit manuals if it is necessary to change addresses or jumpers.
- h. Install all cards in the 10740A Coupler (see *Figure 5-5*). Be certain that the 10760A Counter cards are in the proper order.
- i. Connect the reference/measurement cable from the laser head and first receiver to the first 10760A Counter card (see *Figure 5-7* for a typical system setup).
- j. Connect the hooded connectors in sequence to each of the additional 10760A Counters in the system and daisy-chain the RLE connectors as shown in *Figure 5-7*.
- k. If the standard 10756A Manual Compensator is used, mount it on the edge connector of the 10755A Compensation Interface.
- l. Apply system power and verify that the reference and measurement LED indicators located near the bottom front edge of each counter light (the reference LED indicator is the one closest to the front edge). Remove system power.
- m. Connect the system controller to the 10746A Binary Interface using the cable fabricated during the preliminary procedure.
- n. If 10783A Numeric Displays are used, connect them to the system controller using the 10631A, B, or C cables. Refer to the 10783A Numeric Display Operating and Service manual.
- o. Apply system power. At the rear panel of the 10740A Coupler, verify that the voltage is $+15 \pm 0.25V$ dc, $-15 \pm 0.25V$ dc, and $+5 (+0.10, -0.05V)$ dc (see *Figure 5-4*).

5.9 Comparator-Based System Installation

Perform the installation of the comparator-based system as follows:

- a. If the 10740A Coupler is to be rack mounted or installed in a cabinet, refer to the 10740A Coupler Operating and Service manual for dimensions and installation instructions.
- b. Connect the +5V power supply cable between the power supply and the 10740A Coupler rear panel terminal strip.
- c. Connect the $\pm 15V$ power supply cable between the power supply and the 10740A Coupler rear-panel terminal strip. Note that if the optional 5510A Opt. 010 Automatic Compensator is used, connect the interface cable between the 5510A Opt. 010 and the 10755A Compensation Interface.
- d. If the 10783A Numeric Displays are used, connect the +5V power cables between the numeric display rear panels and the +5V power source on the back of the 10740A Coupler.
- e. Connect the $\pm 15V$ power supply and +5V to suitable sources of ac power. Apply system power. Verify the voltage at the coupler rear panel is $+15V$ dc ± 0.25 , $-15V$ dc ± 0.25 , and $+5V$ dc $+0.10, -0.05$. For 4-axis 10746A systems, the voltage on the front of the left-most card (output card of the recommended configuration) should be set to 4.8 to 4.9 volts. Remove system power.

NOTE

To connect any hooded connector to a circuit card in the 10740A Coupler, pass the connector through the slot in the rear panel of the coupler and install it on the front edge connector of the applicable card (see *Figure 5-5*).

- f. Remove the front panel of the coupler.
- g. Check the addresses and jumpers on all system cards and units. It is advisable to make a list of each of the system addresses for future reference. Refer to the individual unit manuals if it is necessary to change addresses or jumpers. Refer to Tables 5-2a thru 5-2e for 10764B resolution extension switch settings.
- h. Install all cards in the 10740A Coupler (see Figure 5-5). Be certain that if more than one 10764B Fast Pulse Converter card is used, they are installed in the proper order.

NOTE

If more than one 10764B Fast Pulse Converter card is used the physical configuration of the reference/measurement cable restricts the installation of the hooded connectors to a unique order. Therefore, it is very important that you connect the corresponding measurement legs of the cable to the appropriate receivers. If the optimum optical measurement path layout makes this impossible, it will be necessary to exchange cards in their slot or re-address the 10764B Fast Pulse Converters to conform to the actual system configuration (refer to the 10764B Fast Pulse Converter Operating and Service Manual).

- i. Connect the reference/measurement cable from the laser head and first two receivers to the first 10764B Fast Pulse Converter card (see Figure 5-8 for a typical system setup).
- j. If the system includes more than two measurement axes, connect the hooded connectors in sequence to each of the additional 10764B Fast Pulse Converter cards in the system and the associated pairs of RF cables to the 10762A Comparator cards.
- k. If the standard 10756A Manual Compensator is used, mount it on the edge connector of the 10755A Compensation Interface.
- l. Apply system power and verify that the reference and measurement LED indicators located near the bottom front edge of each counter card lights (the reference LED indicator is the one closest to the front edge). Remove system power.
- m. Connect the system controller to the 10746A Binary Interface. Use the cable fabricated during the preliminary procedure. Connect the interface cables between each 10762A Comparator in the coupler to the drive system of the machine.
- n. If 10783A Numeric Displays are used, connect them to the system controller using the 10631A, B, or C cables. Refer to the 10783A Numeric Display Operating and Service manual.
- o. Apply system power. At the rear panel of the 10740A Coupler, verify that the voltage is $+15 \pm 0.25V$ dc, $-15 \pm 0.25V$ dc, and $+5 \pm 0.10, -0.05V$ dc (see Figure 5-4).

5.9.1 10764B RESOLUTION EXTENSION. Provision is made to select one of 32 resolution factors by means of three switches located on the 10764B. A 4-pole switch labelled P is common to both axes. Two 4-pole switches labelled Q are for the separate measurement axes. The Q switches must have only one switch set up (away from the dot) at any one time. Any combination that results in a number between 8 and 15 may be used on the P switch. The available combinations for the various modes are listed in Tables 5-2a through 5-2e.

NOTE

System resolution = $Q/P \times \lambda/4$ for linear interferometer and $Q/P \times \lambda/8$ for plane mirror.

Table 5-2a. Resolution Extension Factors

RESOLUTION EXTENSION = P/Q									
Q	P	8	9	10	11	12	13	14	15
8	1	1	1.125	1.25	1.375	1.5	1.625	1.75	1.875
4	2	2	2.25	2.5	2.75	3.0	3.25	3.5	3.75
3	4	4	4.5	5.0	5.5	6.0	6.5	7.0	7.5
1	8	8	9	10	11	12	13	14	15

Table 5-2b. Resolution of a Single Beam or Linear Interferometer with the 10764B

Q	P	8	9	10	11	12	13	14	15
8		$\lambda/4$	$\lambda/4.5$	$\lambda/5$	$\lambda/5.5$	$\lambda/6$	$\lambda/6.5$	$\lambda/7$	$\lambda/7.5$
4		$\lambda/8$	$\lambda/9$	$\lambda/10$	$\lambda/11$	$\lambda/12$	$\lambda/13$	$\lambda/14$	$\lambda/15$
2		$\lambda/16$	$\lambda/18$	$\lambda/20$	$\lambda/22$	$\lambda/24$	$\lambda/26$	$\lambda/28$	$\lambda/30$
1		$\lambda/32$	$\lambda/36$	$\lambda/40$	$\lambda/44$	$\lambda/48$	$\lambda/52$	$\lambda/56$	$\lambda/60$

Table 5-2c. Resolution of a Plane Mirror Interferometer with the 10764B

Q	P	8	9	10	11	12	13	14	15
8		$\lambda/8$	$\lambda/9$	$\lambda/10$	$\lambda/11$	$\lambda/12$	$\lambda/13$	$\lambda/14$	$\lambda/15$
4		$\lambda/16$	$\lambda/18$	$\lambda/20$	$\lambda/22$	$\lambda/24$	$\lambda/26$	$\lambda/28$	$\lambda/30$
2		$\lambda/32$	$\lambda/36$	$\lambda/40$	$\lambda/44$	$\lambda/48$	$\lambda/52$	$\lambda/56$	$\lambda/60$
1		$\lambda/64$	$\lambda/72$	$\lambda/80$	$\lambda/88$	$\lambda/96$	$\lambda/104$	$\lambda/112$	$\lambda/120$

Table 5-2d. Maximum Velocity for Non-Differential Mode Single Beam and Linear Interferometer (inches/second)

Q	P	8	9	10	11	12	13	14	15
8		13	13.5	13.5	14	13	10	8	6
4		13	13.5	13.5	14	13	10	8	6
2		11.2	9.4	9	7.5	7.4	6.5	6	5.5
1		5.5	4.7	4.4	3.8	3.5	3.2	3	2.8

Plane mirror interferometer specifications are one-half of these values.

Table 5-20. Maximum Velocity for Differential Mode Single Beam and Linear Interferometer (inches/second)

P	8	9	10	11	12	13	14	16
0	13	13.6	13.6	14	13	10	8	6
4	13	13.6	13.6	14	13	10	8	6
2	21	18.6	12	16	14	12	12	11.6
2	13.2	13.6	13.8	14	13	10.3	8	6
1	11.2	9.4	9	7.7	7.4	6.6	6	6.7
1	13.2	13.0	13.6	14	13	10.3	8	6
	6.6	4.7	4.4	3.8	3.6	2.2	3	2.8

10764B

Max velocity for DIFFERENTIAL MODE SINGLE BEAM & LINEAR INTERFEROMETER. Upper row factors are limits for individual reflection factors and lower row factors, if listed, place additional stress on relative velocity of reflection factors.

The resolution extension factor will only be changed at the time the system reset is enabled on the back plane, or the manual "RESET" switch is raised and lowered, or when a 0X command is received. After changing the resolution, or when powering up, 2 or more reset pulses should be sent to the system to allow for resulting transients to die out.

In addition, check the following switches and jumpers on the 10745A, 10760A, and 10783A (see the individual Operating and Service manuals).

5.10 ENGLISH/METRIC PULSE OUTPUT ELECTRONICS INSTALLATION

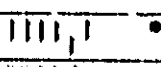
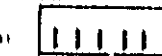
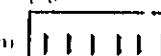
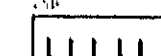
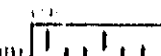
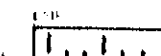
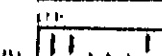
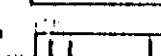
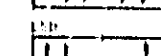
The 5501A English/Metric Pulse Output Electronics provides micrometre or microinch value pulses. The output signal cable lengths are standard at 4.57 m (15 ft.) and are terminated in bare wires. All interconnecting cables between the English/Metric Pulse Output Electronics and the 5501A Laser Transducer are supplied.

NOTE

The jumpers and switches on the 10763A English/Metric Pulse Output cards must be properly set prior to operation (refer to Table 5-3 for a summary of jumper and switch positions). Refer to the 10763A English/Metric Pulse Output Unit manual for detailed information.

- If the 10740A Coupler is to be rack mounted or installed in a cabinet, refer to the 10740A Coupler Operating and Service manual for dimensions and installation instructions.
- Connect the +5V power supply cable between the power supply and the 10740A Coupler rear panel terminal strip.

Table 5-1. Typical Configuration Guide for System Jumpers or Switches

	(Master) X-Axis (Labeled on Card)	Y-Axis (Labeled on Card)	Z-Axis (Labeled on Card)
Set Up Address	Already set at factory but may have moved in shipment. 	Already set at factory but may have moved in shipment. 	Already set at factory but may have moved in shipment. 
Set Up Next Address	Already set at factory but may have moved in shipment. 	Already set at factory but may have moved in shipment. 	Already set at factory but may have moved in shipment. 
Deadpath	Set up by user. See paragraph 5-10.2 or 10761A English/Metric manual for details.	Set up by user. See paragraph 5-10.2 or 10761A English/Metric manual for details.	Set up by user. See paragraph 5-10.2 or 10761A English/Metric manual for details.
Inch	This jumper is installed as the resolution is English. Remove for Metric units.	This jumper is installed as the resolution is English. Remove for Metric units.	This jumper is installed as the resolution is English. Remove for Metric units.
MMR	This jumper is installed as the resolution is normal. Remove for X10.	This jumper is installed as the resolution is normal. Remove for X10.	This jumper is installed as the resolution is normal. Remove for X10.
Fast	This jumper is removed as this is the master card in the system.	This jumper is inserted since X-axis is the master card.	This jumper is inserted since X-axis is the master card.
One Axis	This jumper installed if only one axis system. This jumper is removed.	This jumper is removed.	This jumper is removed.
TRR Stop Co	Installed in the C/O position.	Installed in the C/O position.	Installed in the C/O position.
A UP	Set by user. Set to UP arbitrarily.	Set by user. Set to UP arbitrarily.	Set by user. Set to UP arbitrarily.
B DWN	Set by user. Set to DWN arbitrarily.	Set by user. Set to DWN arbitrarily.	Set by user. Set to DWN arbitrarily.
TEST RUN	Run	Run	Run
800 KHz 1.6 MHz	Set up by user. Set to 1.6 MHz arbitrarily.	Set up by user. Set to 1.6 MHz arbitrarily.	Set up by user. Set to 1.6 MHz arbitrarily.
Axes Select	Same as this axis. 	Same as this axis. 	Same as this axis. 
Weight	Set up by user. Determines resolution of pulses out. Basic resolution is 1 µm.	Set up by user. Determines resolution of pulses out. Basic resolution is 1 µm.	Set up by user. Determines resolution of pulses out. Basic resolution is 1 µm.
Examples	Resolution Switch Settings	Resolution Switch Settings	Resolution Switch Settings
X1 (0-1)	1 µm (10 µm) 	1 µm (10 µm) 	1 µm (10 µm) 
X10 (0-1)	1 µm (100 µm) 	1 µm (100 µm) 	1 µm (100 µm) 
X100 (0-1)	10 µm (1000 µm) 	10 µm (1000 µm) 	10 µm (1000 µm) 

*A 10760A Counter card must be addressed to correspond to each 10761A card (e.g., X, Y, and Z for this example).

- c. If the optional 5510A Opt. 010 Automatic Compensator is used, connect the $\pm 15V$ power supply cable between the power supply and the 10740A Coupler rear-panel terminal strip. Connect the interface cable between the 5510A Opt. 010 and the 10755A Compensation Interface.
- d. Connect the $\pm 15V$ power supply (if used) and $+5V$ power supply to suitable sources of ac power. Apply system power. Verify the voltage at the coupler rear panel is $+15V$ dc ± 0.25 , $-15V$ dc ± 0.25 , and $+5$ ± 0.10 , $-0.05V$ dc. Remove system power.

NOTE

To connect any hooded connector to a circuit card in the 10740A Coupler, pass the connector through the slot in the rear panel of the coupler and install it on the front edge connector of the applicable card (see *Figure 5-5*).

- e. Remove the front panel of the coupler.

NOTE

All 10760A Counter cards are supplied with the NORMAL / REVERSE jumper in the NORMAL position. The correct position for the NORMAL / REVERSE jumper is determined during system checkout.

- f. Connect the reference/measurement cable from the laser head and first receiver to the first 10760A Counter card (see *Figure 5-9* for a typical system setup).
- g. Connect the hooded connectors in sequence to each of the additional 10760A Counters in the system.
- h. Apply system power and verify that the reference and measurement LED indicators located near the bottom front edge of each 10760A Counter light (the reference LED indicator is the one closest to the front edge). Also verify that the ON LED indicator on the 10763A card lights. Remove system power.

CAUTION

Do not connect the twisted pair output cables (part of the 10763-60002 cable) to the system controller or monitoring system until after the correct position for the NORMAL / REVERSE jumper on the 10760A Counter cards is determined. This is done during system checkout.

- i. Connect the control connector (part of the 10763-60002 cable) to the system controller (see *Table 5-4* for signal definitions and *Figure 5-10* for signal timing relations).
- j. Apply system power. At the rear panel of the 10740A Coupler, verify the voltage is $+15$ $\pm 0.25V$ dc, -15 $\pm 0.25V$ dc, and $+5$ ± 0.10 , $-0.05V$ dc.

5.10.1 10763A INTERFACING TO CONTROLLER. *Figure 5-10a* shows the recommended interface between the 10763A and a controller. Special attention should be paid to the required START and STOP switches as shown.

Figure 5-10a Recommended Interface with 10/63A

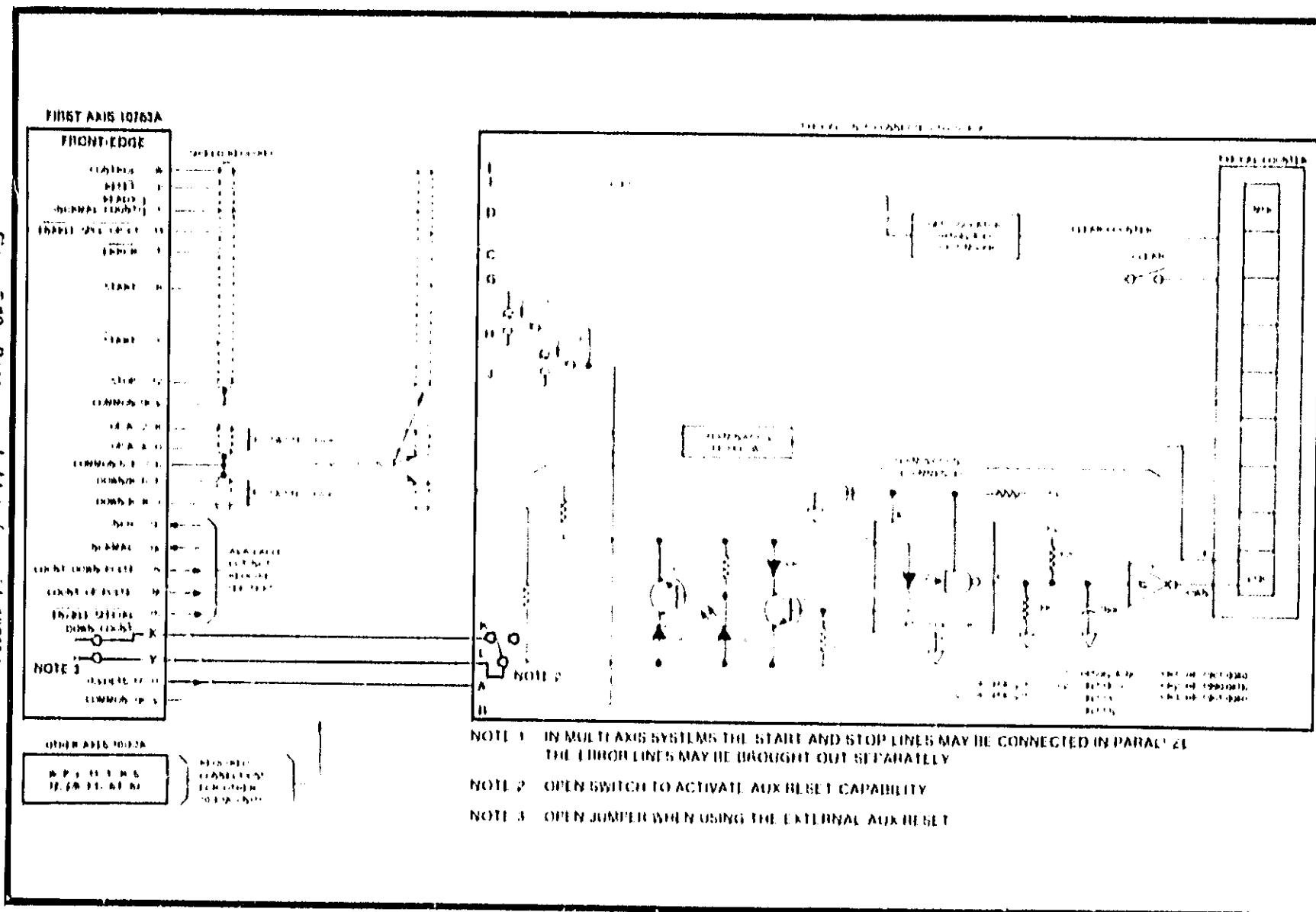


Table 5-4. 10763A Control Connector Functions

Pin*	Name	Input/Output	Description
I	RESET	OUT	Buffered, negative pulse, card and system reset. For initializing external counter or controller at same time as laser transducer system. Monitor only, do not apply signals. Reproduced coupler has RESET.
J	STOP	IN	Stops entire 10763A-controlled system when this line is set low.
H G	START START	IN IN	Starts entire 10763A-controlled system if pin 5 goes high and then 5 returns high and R returns low. Either this signal or power switched on will start the system. See Figure 5-10.
C	ERROR	OUT	Indicates an error has been received for axis of particular 10763A. All axes ERROR lines may be wired (OR) together. Monitor only, do not apply signal.
L	CONTROL	OUT	When HIGH indicates "this" card is in control of 10740A coupler bus at moment. Normally used only for troubleshooting. Monitor only.
D	READY	OUT	Indicates initialization is complete. 10763A is ready to begin measurement.
A B	+5 Volts COMMON	OUT	System power supply lines. May be used for external purposes within original supply limits. The maximum allowable current from one 10763A card is one ampere.
K L	AUX RESET	IN	May be wired to a switch on external controller to allow external setting of deadpath switch when necessary.

*Pinouts on Control Connector

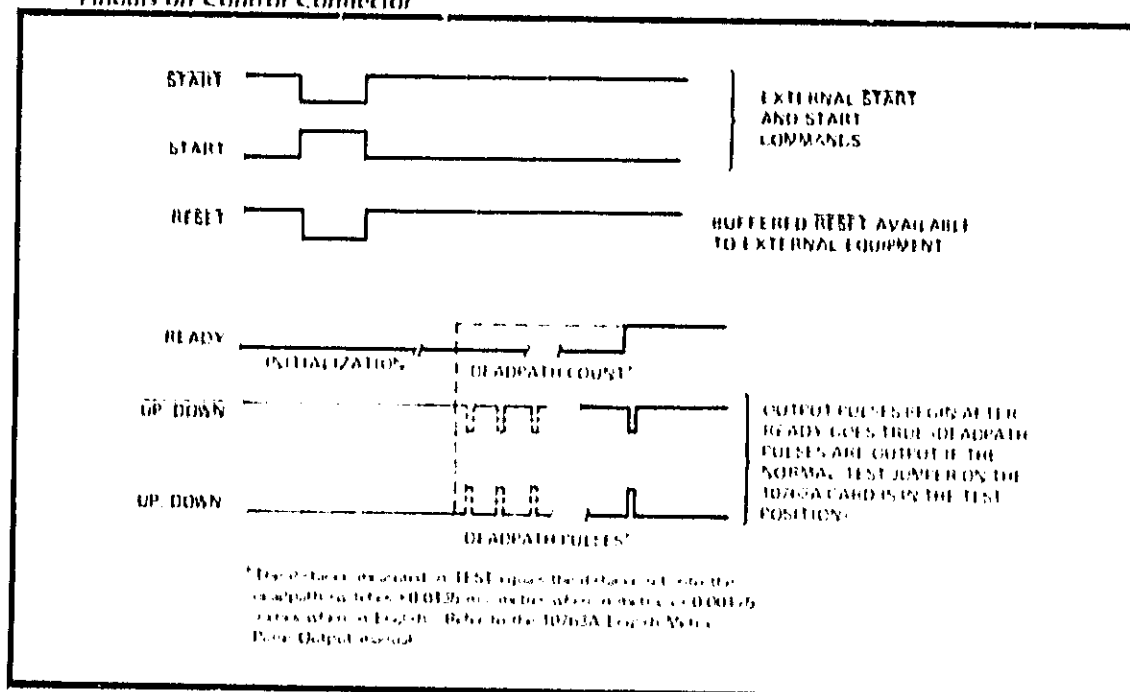


Figure 5-10. Control Connector Signal Timing Diagram

5.10.2 PROCEDURE FOR DEADPATH CONVERSION. For the 10763A installation, deadpath should be carefully measured and set in the 14 DEADPATH switches.

NOTE
Maximum Allowable Deadpath*

	Resolution Selected	
	Normal X1	Extended X10
Metres	21.2	2.12
Inches	0.36	0.036

*Deadpath exceeding these amounts can not be compensated for.

The deadpath in metres or inches must be adjusted and converted to binary numbers before it can be set in the 10763A binary DEADPATH switches. Use the following procedure to adjust and convert the measured deadpath to the switch settings.

Calculate N from this formula:
$$N = \frac{(X)(K)(R)}{\text{CLOCK RATIO}}$$

where:

N = number to be converted to binary

X = deadpath

or
$$K = 1.605 \ 08 \times 10^5 \text{ for } X \text{ in inches} = \frac{10 \ \mu\text{in}}{6.23023 \ \mu\text{in}}$$

$$K = 6.319 \ 202 \times 10^6 \text{ for } X \text{ in metres}$$

or
$$\text{CLOCK RATIO} = 16 \text{ for } 800 \text{ kHz clock selected}$$

$$\text{CLOCK RATIO} = 8 \text{ for } 1.6 \text{ MHz clock selected}$$

or
$$R = 10 \text{ for times 10 resolution selected}$$

or
$$R = 1 \text{ for normal resolution}$$

In the following steps directions will be given to set the 14 deadpath switches to either one (up) or zero (down) after a subtraction has been made. At each step note the correct switch setting in the box for reference.

Step		Set in Switch
1.	(a) If $N_2 \geq 0\ 308\ 608$ set switch 553-13 to 1 and subtract $0\ 308\ 608$ from N_2 to carry to step 2 as N_3 . or (b) If $N_2 < 0\ 308\ 608$ set 553-13 to 0 and carry N_2 to step 2 as N_3 .	☐ 53-13
2.	(a) If $N_3 \geq 4\ 194\ 304$ set 553-12 to 1 and subtract $4\ 194\ 304$ from N_3 to carry to step 3 as N_4 . or (b) If $N_3 < 4\ 194\ 304$ set 553-12 to 0 and carry N_3 to step 3 as N_4 .	☐ 12
3.	(a) If $N_4 \geq 2\ 097\ 152$ set 553-11 to 1 and subtract $2\ 097\ 152$ from N_4 to carry to step 4 as N_5 . or (b) If $N_4 < 2\ 097\ 152$ set 553-11 to 0 and carry N_4 to step 4 as N_5 .	☐ 11
4.	(a) If $N_5 \geq 1\ 048\ 576$ set 553-10 to 1 and subtract $1\ 048\ 576$ from N_5 to carry to step 5 as N_6 . or (b) If $N_5 < 1\ 048\ 576$ set 553-10 to 0 and carry N_5 to step 5 as N_6 .	☐ 10
5.	(a) If $N_6 \geq 524\ 288$ set 553-9 to 1 and subtract $524\ 288$ from N_6 to carry to step 6 as N_7 . or (b) If $N_6 < 524\ 288$ set 553-9 to 0 and carry N_6 to step 6 as N_7 .	☐ 9
6.	(a) If $N_7 \geq 262\ 144$ set 553-8 to 1 and subtract $262\ 144$ from N_7 to carry to step 7 as N_8 . or (b) If $N_7 < 262\ 144$ set 553-8 to 0 and carry N_7 to step 7 as N_8 .	☐ 8
7.	(a) If $N_8 \geq 131\ 072$ set 553-7 to 1 and subtract $131\ 072$ from N_8 to carry to step 8 as N_9 . or (b) If $N_8 < 131\ 072$ set 553-7 to 0 and carry N_8 to step 8 as N_9 .	☐ 7
8.	(a) If $N_9 \geq 65\ 536$ set 554-6 to 1 and subtract $65\ 536$ from N_9 to carry to step 9 as N_{10} . or (b) If $N_9 < 65\ 536$ set 554-6 to 0 and carry N_9 to step 9 as N_{10} .	☐ 6
9.	(a) If $N_{10} \geq 32\ 768$ set 554-5 to 1 and subtract $32\ 768$ from N_{10} to carry to step 10 as N_{11} . or (b) If $N_{10} < 32\ 768$ set 554-5 to 0 and carry N_{10} to step 10 as N_{11} .	☐ 5

Step		Set in Switch
10.	(a) If $N_{10} \geq 16\ 384$ set 554-4 to 1 and subtract 16 384 from N_{10} to carry to step 11 as N_{11} . or (b) If $N_{10} < 16\ 384$ set 554-4 to 0 and carry N_{10} to step 11 as N_{11} .	☐ 4
11.	(a) If $N_{11} \geq 8\ 192$ set 554-3 to 1 and subtract 8 192 from N_{11} to carry to step 12 as N_{12} . or (b) If $N_{11} < 8\ 192$ set 554-3 to 0 and carry N_{11} to step 12 as N_{12} .	☐ 3
12.	(a) If $N_{12} \geq 4\ 096$ set 554-2 to 1 and subtract 4 096 from N_{12} to carry to step 13 as N_{13} . or (b) If $N_{12} < 4\ 096$ set 554-2 to 0 and carry N_{12} to step 13 as N_{13} .	☐ 2
13.	(a) If $N_{13} \geq 2\ 048$ set 554-1 to 1 and subtract 2 048 from N_{13} to carry to step 14 as N_{14} . or (b) If $N_{13} < 2\ 048$ set 554-1 to 0 and carry N_{13} to step 14 as N_{14} .	☐ 1
14.	(a) If $N_{14} \geq 1\ 024$ set 554-0 to 1 and subtract 1 024 from N_{14} . If $N_{14} - 1\ 024 > 512$ add binary 1 to least significant bit and carry the result up.	☐ 0

An example of converting the deadpath to binary is given below:

EXAMPLE: Deadpath = 6.124 metres (extremely large)
Resolution: Normal, 1.6 MHz pulse rate

$$\frac{(6.124) (6.319\ 202) (10^6)}{8} = 4\ 837\ 349$$

		Switch Number
1.	$4\ 837\ 349 < 8\ 388\ 608$	☐ 13
2.	$4\ 837\ 349 > 4\ 104\ 304$	☐ 12
	Result $\begin{array}{r} 4\ 837\ 349 \\ 4\ 104\ 304 \\ \hline 643\ 045 \end{array}$	
3.	$643\ 045 < 2\ 007\ 152$	☐ 11
4.	$643\ 045 < 1\ 048\ 576$	☐ 100
5.	$643\ 045 > 524\ 288$	☐ 9

$$\begin{array}{r} 643\ 045 \\ 524\ 288 \\ \hline 118\ 757 \end{array}$$

6. $118\ 767 < 262\ 144$	☐	8
7. $118\ 767 < 131\ 072$	☐	7
8. $118\ 767 > 66\ 636$ $118\ 767 - 66\ 636 = 53\ 221$	☐	6
9. $53\ 221 > 32\ 768$ $53\ 221 - 32\ 768 = 20\ 453$	☐	5
10. $20\ 453 > 16\ 384$ $20\ 453 - 16\ 384 = 4\ 069$	☐	4
11. $4\ 069 < 9\ 102$	☐	3
12. $4\ 069 < 4\ 096$	☐	2
13. $4\ 069 > 2\ 048$ $4\ 069 - 2\ 048 = 2\ 021$	☐	1
14. $2\ 021 > 1\ 024$	☐	0

NOTE: In step 12, $4\ 069 \approx 4\ 096$. A better approximation can be obtained by rounding upwards to 4 096 and setting switches, thus:

	Switches
☐	2
☐	1
☐	0

5.11 10781A Pulse Converter Electronics Installation

NOTE

Do not confuse the 10781A Pulse Converter installation requirements with those of the 10764B Fast Pulse Converter. The 10764B is a selectable part of the Computer Interface Electronics.

The 10781A Pulse Converter provides the simplest means of outputting position information to existing system controllers. The output consists of Up/Down or phase quadrature pulses of one-quarter wavelength value. One pulse converter is required for each measurement axis. Perform the installation procedures as follows.

- Verify that the jumpers in the 10781A Pulse Converter match your system configuration. Refer to the 10781A Pulse Converter Operating and Service manual.
- If the 10781A Pulse Converters are to be rack mounted or installed in a cabinet, refer to the 10781A Pulse Converter Operating and Service manual for dimensions and installation instructions.
- Connect the reference and measurement cable from the laser head and first receiver to the applicable 10781A Pulse Converter (see Figure 5-11 for a typical system interconnect).
- Connect the additional legs of the cable to the remaining pulse converters.
- Connect 10781A to +5V power source.

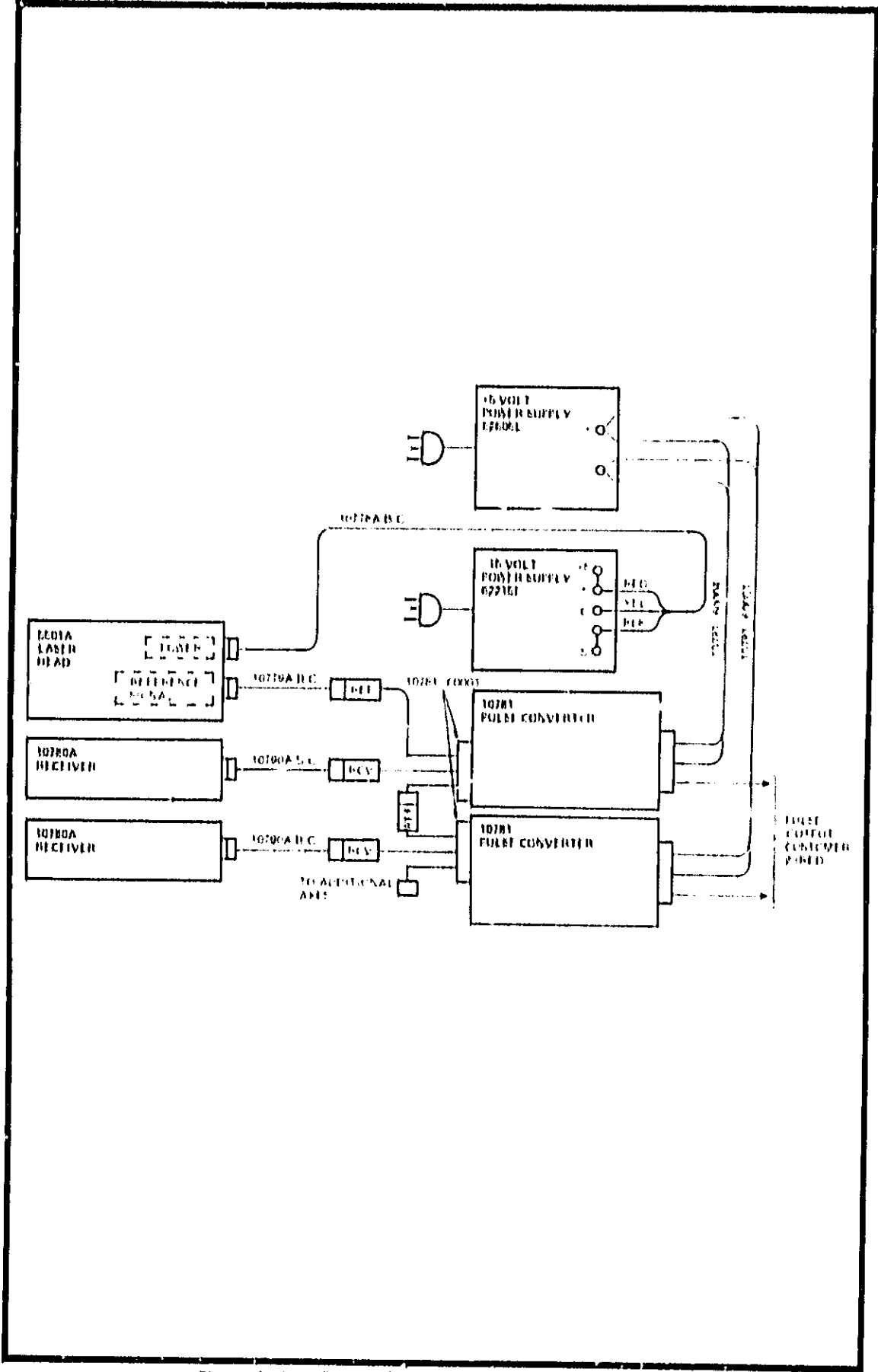


Figure 5-11. 10781A Pulse Converter Electronics Interconnecting

5.12 INTERFACE ELECTRONICS CHECKOUT

Since the computer interface electronics are designed to interface a user selected system to a wide variety of digital processors, it is impossible to give a specific checkout procedure. However, a recommended approach is presented for both the counter-based systems and the comparator-based system.

5.13 HP-IB and/or Binary Controlled Counter-Based System Checkout

When checking out a counter-based system it is necessary to program the system controller to verify specific functions. An example of a typical program is shown in Section IV, Table 4-12. The example shows how to program the system using the 9625A and the HP-IB. Examples of programming using the binary interface card are also shown. Once a system program is written and loaded into the system controller, verify system operation by performing the following steps:

- a. Verify that the two LED indicators on the lower front edge of each 10760A Counter card are lit. These LED's indicate that the reference and measurement signals from the laser head and receivers are present.
- b. If the 10745A HP-IB Interface Card is used, verify that the Talk and Listen lights on the middle front edge of the card are alternately lit when the card is addressed to talk and listen by the system controller.
- c. If the 10746A Binary Interface Card is used, verify that the Data light on the lower front edge of the card lights when an instruction is sent from the system controller to transfer data. Note that this light is not lit when instructions (i.e., not data) are transferred from the system controller to the coupler backplane via the 10746A card.

NOTE

If the displayed data counts down from 160 to 0 and then indicates a large number with only a slight movement of the measurement optics, change the position of the NORMAL/REVERSE jumper on the 10760A Counter card (the jumper is in the NORMAL position when shipped). Refer to the 10760A unit manual for additional information if required.

- d. Displace the measurement optics in each axis a specific distance and verify that the output devices accumulate the appropriate number of counts for the distance moved.
- e. Interrupt the laser beam in each axis and verify the system comes up with an error indication. Reset the system after each error indication.
- f. Replace the front panel of the 10740A Coupler.

5.14 Comparator-Based Systems

When checking a comparator-based system refer to *Table 4-13*. This is a typical comparator program and will verify overall system operation. Once a system program is written and loaded into the system controller, verify system operation by performing the following steps:

CAUTION

Prior to performing checkout of the comparator-based systems disconnect the DAC inputs to the drive motors until the correct position of the NORMAL/REVERSE jumpers are established in each axis. In addition, limit switches or stops should be installed in each axis to prevent the stage from overdriving its preset limits.

- a. Verify that the data light on the upper front edge of the 10746A Binary Interface card lights when an instruction is sent from the system controller to transfer data. Note that this light is not lit when instructions (i.e., not data) are transferred from the system controller to the coupler backplane via the 10746A card.

NOTE

If the polarity of the DAC outputs in the following step is not correct, change the position of the NORMAL/REVERSE jumper on the 10762A Comparator card or change destination via software. Refer to the 10762A unit manual for additional information if required.

- b. Command the system to move the measurement optics a specific distance and verify that the DAC response is appropriate.
- c. Interrupt the laser beam in each axis and verify the system comes up with an error indication. Reset the system after each error indication.
- d. Connect the DAC to the drive motors.
- e. Command the system to move the measurement optics a specific distance and verify the movement is correct.
- f. Replace the front panel of the 10740A Coupler.

5.15 ENGLISH/METRIC PULSE OUTPUT SYSTEMS CHECKOUT

The English/Metric Pulse Output System is primarily controlled by firmware programming on the 10763A English/Metric Pulse Output card. Once the system is connected to a system controller and power is applied, the primary control consists of starting and stopping the system and checking the output for errors (see *Figure 5-12*). To check out the system after it is installed perform the following checks:

NOTE

Disregard any of the following steps if the system controller does not have the required capability.

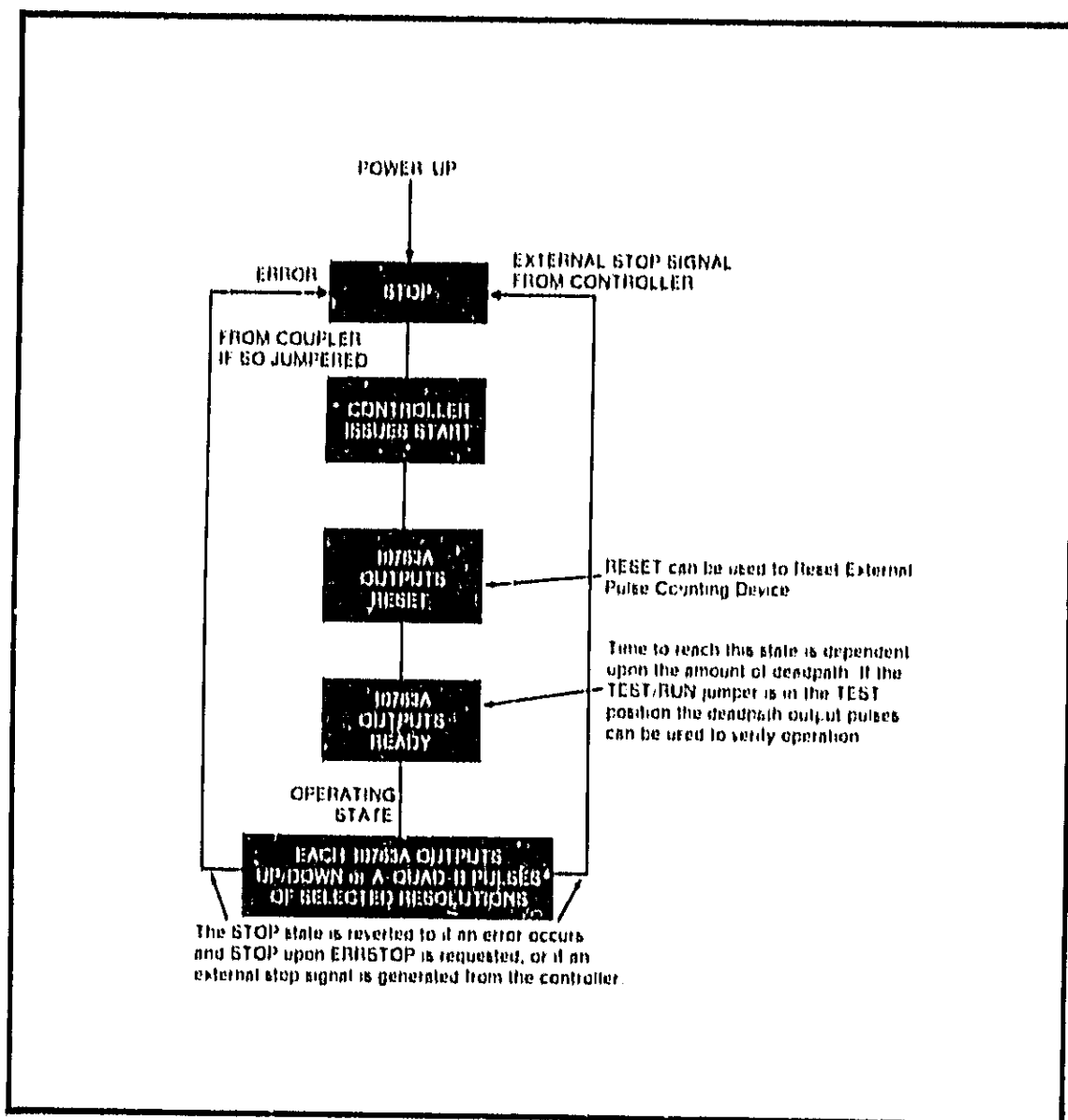


Figure 5-12. English/Metric Pulse Output System State Diagram

- Give a start command from the system controller and verify that a ready response is returned from the English/Metric Output Pulse System (see Figures 5-10 and 5-12).
- Verify that the two LED indicators on the lower front edge of each 10760A Counter card are lit. These LED's indicate that the reference and measurement signals from the laser head and receivers are present.
- Verify that the ON light at the upper edge of each 10763A English/Metric Output Pulse card is lit. This indicates +5V power is applied to the cards.

CAUTION

Verify that the twisted pair output cables (part of 10763-60002 cable) are not connected.

- d. Verify that the CONTROL indicator at the lower, front edge of each 10763A card is lit. These indicators light to show which 10763A card in a multiaxis system is in control of the system at any given time. When the system is operating the indicators appear to be lit at a reduced level as control is passed from board-to-board.

NOTE

If an error indication is generated when the measurement optics are moved, change the position of the NORMAL-REVERSE jumper on the 10760A Counter card (the jumper is in the NORMAL position when shipped). See Figure 5-14. Refer to the 10760A unit manual for additional information if required.

- e. Manually displace the measurement optics in each axis in a positive direction and check if the system comes up with an error indication.
- f. Set the preset deadpath for each axis in the individual 10763A cards (refer to 10763A unit manual).
- g. If the deadpath switch on the 10763A English/Metric Pulse output card has a preset deadpath number set into it and the TEST/RUN jumper is put into the TEST position, the card will output these counts. (See Figure 5-10.) This output can be used to verify the card operation. Refer to the 10763A unit manual for additional information.
- h. Interrupt the laser beam in each axis and verify the system comes up with an error indication. Reset between each beam interruption.
- i. Connect the twisted pair output cables (10763-60002) to the system controller or monitoring system. Refer to the 10763A English/Metric Pulse Output unit manual for additional information.
- j. Displace the measurement optics in each axis a specific distance and verify that the output counting devices accumulate the appropriate number of counts for the distance moved.
- k. Replace the front panel of the 10740A Coupler.

5.16 10781A Pulse Converter Electronics Checkout

The 10781A Pulse Converter Electronics provide a simple means of interfacing the system optics to a customer supplied counting system. The checkout depends on how the pulse converter is used. Therefore determine your system requirements and reference the 10781A Pulse Converter unit manual to determine how to checkout system operation.

Operation of this system results in Up/Down or A-Quad-B signals (which represent movement of the optical devices) being generated from the 10781A Pulse Converter. Checkout consists of verifying the presence of these signals and verifying that an error indication occurs (front-panel indicator lights) when the laser beam is blocked.

5.17 PREVENTIVE MAINTENANCE

The Laser Transducer System electronics require no preventive maintenance. However, the system optics, the laser head lens, and the receiver lens do require periodic cleaning. The frequency of this cleaning is dependent on the cleanliness of the ambient environment.

5.18 Cleaning of Optical Components

Use a soft camel-hair lens brush to remove dust from the optic windows. (A good camera lens brush with a rubber bulb blower is recommended.) Dampen a few optical lens cleaning tissues with optical grade ethyl alcohol, shake off excess alcohol, and wipe across window once. Use fresh tissue dampened with alcohol for each wipe. Allow alcohol to dry naturally.

NOTE

- DO use only camera or better grade lens tissue.
- DO NOT use any of the various impregnated eyeglass tissues.
- DO NOT use harsh solvents such as acetone or MEK for cleaning.
- DO NOT use excessive amounts of alcohol.
- DO NOT wipe window if there is any abrasive dust or grit on it.

TROUBLE- SHOOTING

section VI

Troubleshooting

6.1 INTRODUCTION

This section provides system troubleshooting procedures that will locate a problem to the unit or circuit card level. The procedures determine as quickly as possible whether the trouble lies in the system unit hardware or the system controller. System controller troubleshooting, including all software and standard peripherals is contained in separate manuals (refer to Figure 1-2, Manuals Supplied with Laser Transducer System).

The troubleshooting information is divided into the following categories:

- a. General troubleshooting information. You should use this information when troubleshooting a system that fails after it has been installed and operating. If for any reason you cannot quickly locate the problem, the detailed troubleshooting procedures will prove helpful.
- b. Detailed troubleshooting procedures. You should use these procedures when you are installing your system and cannot obtain the results called out in the installation and checkout procedures. The detailed troubleshooting procedures can also be used if you are having difficulty in locating a problem in a system that has failed. In the latter case, it is not necessary to totally disassemble your system. However, be certain as you read through the installation and checkout procedure that your system meets each of the required responses (e.g., LED on the 10780A Receiver is lit when so specified).

Whatever method of troubleshooting you are using, be sure you read and understand the information contained in the following troubleshooting assumptions paragraph.

6.2 Troubleshooting Assumptions

The troubleshooting procedures make the following assumptions:

- a. That the detailed troubleshooting procedures use the installation and checkout procedures in Section V as a basis for the directed troubleshooting. This means that the further into the installation and checkout procedure you are, the more equipment that you can assume is operating properly. For example, if you are using a 9825A Calculator as the system controller and it has passed its own diagnostic test, the subsequent troubleshooting will assume that it is operating properly. Therefore, if it will not function with the 10745A FIP-IB interface when they are connected together, the initial replacement will be the 10745A.
- b. That all system controls have been double checked to verify that they are in the proper positions.
- c. That all cabling is correctly and firmly connected and that all system cards are correctly addressed and have the proper jumpers installed.
- d. That interconnect wiring will be checked and cabling replaced or repaired as required if the detailed troubleshooting does not correct the malfunction.
- e. That for any repair beyond the circuit board level, the individual unit manuals will be used.
- f. That power is removed prior to replacing any units or circuit boards.
- g. That the system optics are clean. Refer to the paragraph on preventive maintenance in Section V.
- h. That all power supplies have been checked for correct output voltages.
- i. The final and perhaps most important point to remember about troubleshooting procedures is that they cannot cover all possible malfunctions or combination of malfunctions. However, at the very minimum, they will get you to the general area of the problem. At that point, if you have read and understand the information in the manuals, you should be able to determine the cause of the malfunction.

CAUTION

Use of controls, adjustments, or procedures other than those specified herein may result in hazardous radiation exposure.

6.3 GENERAL TROUBLESHOOTING INFORMATION

If a system has previously been operating, the possible troubles can usually be divided into the following general areas:

- a. Malfunction of the laser head.
- b. Malfunction of one of the receivers.
- c. Malfunction, misalignment, or improper application of the optical devices.
- d. Malfunction of the system controller.
- e. Malfunction of the coupler and interface electronics.
- f. Malfunction of a power supply.

If the problem can be isolated to one or more of these problems, perform the appropriate troubleshooting to isolate a trouble to an assembly or device. The information is arranged to correspond to the general trouble areas listed above. If you cannot isolate the problem, refer to the detailed troubleshooting procedures for additional information.

6.4 Laser Head Troubleshooting

The laser head has diagnostic indicators and corresponding signal levels available on the rear panel. Most common malfunctions of the laser head are evidenced by one or the rear-panel diagnostic indicators being lit, by absence of the REFERENCE SIGNAL, or by absence of the laser beam itself. If the RETURN FAILURE indicator is lit, press the RETURN pushbutton. After approximately 9 seconds, the RETURN FAILURE and RETURN indicators should go out. If either indicator remains on or if any of the previously described symptoms of failure exist, refer to the separate laser head operating and service manual for specific trouble isolation procedures.

6.5 Receiver Troubleshooting

The system receivers supply the measurement signals (MAS) for each measurement axis in the system. When a sufficient laser beam signal is received, an IID indicator on the receiver will light and the dc voltage at the external receiver test point will be between approximately 0.6 and 1.5V dc. Additionally, presence of a measurement signal can be verified by observing a lit IID indicator on the 10760A Counter card associated with the suspected receiver. The 10760A contains two IID indicators. The indicator farthest from the front edge of the card, when lit, signifies the presence of a measurement signal. The indicator closest to the front edge of the card signifies presence or absence of the reference signal from the laser head.

Improperly aligned optical devices can also cause a receiver to appear bad. Check for this by either placing the receiver directly in the laser beam path from the laser head, or by reflecting the laser beam onto the receiver's photodetector using only a retroreflector. This isolates all other optical devices from the system. Most systems contain more than one axis and, consequently, more than one receiver. If trouble is suspected with one receiver, exchange it with another receiver to verify the suspected malfunction.

If the receiver or the optical devices are rotated around the laser beam axis, the receiver IID indicator may remain on even if the beam between the interferometer and retroreflector is blocked. This can also occur occasionally with correct optical alignment if the measurement path is very short and few optical devices are used in the measurement path. If this situation occurs, refer to the operating and service manual supplied with the receiver for information regarding the "overload" adjustment.

6.6 Optical Devices Troubleshooting

Problems with the optical devices usually consist of misalignment of the devices. Refer to the alignment procedures in Section II for further information. Air turbulence caused by ventilation equipment or temperature gradients near the laser beam path can also cause measurement problems. If this is suspected, shield the area around the laser beam and optical devices with cardboard tubing, plastic sheet, or other suitable material. Some problems with sporadic counting and drift can be traced to air turbulence around the measurement path. This should be considered as a possibility before troubleshooting other parts of the system. Section II contains extensive information on optical problems and can be used as a basis for additional optics troubleshooting.

6.7 System Controller Troubleshooting

A wide variety of system controllers can be used with a laser measurement system. Diagnostic programs are available for all of the Hewlett-Packard controllers that can be used with the system.

If a controller malfunction is suspected, run the diagnostic programs to determine if the controller operates properly.

6.8 Coupler and Interface Electronics Troubleshooting

The following paragraphs describe some of the methods for isolating a problem to a given plug-in module. For coupler bus signal line information, refer to *Table 4-1* and the 10740A unit manual.

6.9 10745A HP-IB INTERFACE TROUBLESHOOTING. The 10745A interface transfers instructions from a calculator/controller to the 10740A Coupler backplane bus. The instructions are examined by each of the modules plugged into the coupler for applicability to a specific module. These modules function according to the specific instruction and in some cases transfer data back to the controller via the coupler bus and the 10745A interface module. If the system does not respond to any instructions and the controller diagnostics verify proper controller operation, either the 10745A module is the source of the trouble or another module is preventing the backplane handshake lines from operating.

The 10745A has two LED indicators near the front edge of the circuit board. One signifies that the 10745A has been addressed to talk by the HP-IB controller; the other indicator signifies that the 10745A has been addressed to listen. Check these indicators to verify correct addressing by the controller and to verify that the 10745A address switches are properly set.

6.10 10746A BINARY INTERFACE. The 10746A interface transfers instructions and data between the 10740A Coupler backplane bus and a system controller (usually a computer). If communication between these devices does not take place and the controller diagnostics verify proper operation of the controller, either the 10746A is the source of the problem or another module is preventing the backplane handshake lines from operating.

The 10746A contains one LED indicator to signify that the board is in the data mode of operation. Be sure to observe that power is available.

If the problem appears to be within the 10746A module, check that the controller applies a "command" signal to the 10746A prior to replacing the module.

6.11 10755A COMPENSATION INTERFACE. The 10755A, in response to coupler backplane bus instructions, transfers velocity-of-light compensation data to the coupler backplane bus data lines. The 10755A converts the BCD compensation data from a 10756A Manual Compensator or 5510A OPT 010 Automatic Compensator to binary data for placement on the coupler backplane bus. If the compensation number is erroneous, check the compensator for proper operation according to the information given in the separate compensator operating and service manual. If compensation data is not placed on the coupler backplane bus upon command, the 10755A module is probably the source of the trouble.

6.12 10760A COUNTER TROUBLESHOOTING. The 10760A accepts a reference signal from the laser head and a measurement signal from the receiver in a given measurement axis. LED indicators on the 10760A circuit card light when the reference and measurement signals are present. Note, however, that these indicators will light even if the 10760A card is not plugged into the 10740A Coupler. They obtain operating power from the connector on the front edge of the circuit card.

After verifying that the proper reference and measurement signals (approximately 2 MHz, differential) are available at the circuit inputs, you can assume a malfunction of the 10760A if it fails to perform any of its normal operating functions.

Most systems contain more than one measurement axis and, consequently, more than one 10760A Counter. If trouble is suspected with a counter card, exchange it with another card in the system to verify the suspected malfunction. (Remember to change the address jumper and any other jumpers that may be set differently.)

6.13 10761A BINARY MULTIPLIER TROUBLESHOOTING. The 10761A accepts data, via the 10740A Coupler backplane bus, from several sources: 10760A Counter cards, 10755A Compensation Interface, and in some applications, from an external controller via the 10746A Binary Interface. The purpose of this module is to perform the multiplication of measurement data, velocity-of-light compensation factor, and possibly externally entered factors as the application requires. If these arithmetic operations are not properly performed, the binary multiplier card is probably the source of trouble. If all axes exhibit a problem, this card is the likely source of trouble.

6.14 10762A COMPARATOR TROUBLESHOOTING. The 10762A card accepts a measured position signal and a destination signal (both in binary) and supplies a correction signal in binary to a system controller. The correction data is the digital difference between the two inputs. One 10762A card is used for each axis of machine movement. Consequently, after checking the three LED indicators for an indication of trouble, cards can be swapped to verify a problem. (Remember to change the address jumper and any other jumpers that may be set differently.)

The three LED indicators show the presence of +5-volt power, that a null situation exists (destination data and system location data are equal), and zero speed (system not moving). For additional information, refer to the separate unit manual.

6.15 10763A ENGLISH/METRIC PULSE OUTPUT TROUBLESHOOTING. The 10763A controls the other cards in the 10740A Coupler. It does this by issuing backplane instructions in a sequence that is controlled by a ROM on the 10763A card. These instructions cause 10760A Counter cards and the 10755A Compensation Interface to output data to a 10761A Binary Multiplier card. Subsequent instructions cause the multiplier card to output modified measurement data to the 10763A card. This data is outputted by the 10763A card as up/down or A-quad-B signals to external equipment.

Troubles can be isolated by first checking the LED indicators on the card for a malfunction indication and then exchanging the suspect card with another system card. The 10763A card has LED indicators to show the presence of +5-volt power; to indicate which 10763A card is in control of the system at a given time (during normal multi-axis system operation the control LED's on all 10763A cards appear dimly lit); and to indicate any of four possible system errors. Refer to the separate unit manual for additional information.

6.16 10764B FAST PULSE CONVERTER. The fast pulse converter is designed to accept a reference signal from the 5501A Laser Head and a measurement signal from one or two 10780A Receivers. The fast pulse converter then outputs up and down pulses that represent the difference in frequency between the reference signal and the measurement signal(s). Resolution extension factors of 1 through 15 are switch selectable for the 10764B. The number of output pulses for a given physical displacement of the optical devices will be increased by the extension factor selected. The up and down pulses from the card are applied to counting circuits (usually the 10762A Comparator).

After verifying that the proper reference and measurement signals (approximately 2MHz, differential) are available at the circuit inputs, you can assume a malfunction of the 10764B if it fails to perform any of its normal operating functions.

6.17 107B1A Pulse Converter Troubleshooting

The 107B1A Pulse Converter accepts the reference and measurement signals from the 5501A Laser Head and 107B0A Receiver, respectively. The 107B1A compares the frequency of these two signals and supplies difference outputs to user-designed equipment in one of two forms — up/down pulses or phase-related square waves. If the unit does not output these signals when reference and measurement signals are available at the inputs, the trouble lies within the 107B1A circuits. Remember that output signals exist only when the optical devices are in motion and a difference between reference and measurement signal frequency exists.

The front-panel ERROR indicator illuminates when the allowable rate of movement of the optical devices is exceeded or when either the reference or measurement signal is not present at the circuit inputs. Depending upon internal jumper selection, an error condition can disable output pulses. Errors can be cleared and operation can be resumed by correcting the fault and pressing the front-panel RESET pushbutton. For additional information refer to the 107B1A unit manual.

6.18 Power Supply Troubleshooting

Two power supplies are used with most 5501A Laser Transducer Systems — a ± 15 -volt supply and a ± 5 -volt supply. Both supplies are current limiting and, consequently, the output voltage drops to near zero volts if the outputs are shorted. If this condition exists, disconnect the suspect supply and measure the open-circuit output voltage. Use of this method determines if the supply itself is malfunctioning or if a short in the cabling or elsewhere is causing the supply to current limit. If the power supply is found to be defective, refer to the separate operating and service documentation supplied with the power supply. These manuals also contain procedures for adjustment of the output voltages.

6.19 DETAILED TROUBLESHOOTING PROCEDURES

Each of these troubleshooting procedures parallels the corresponding installation and checkout procedure in Section V and is subdivided in the same manner. Since the indications during preliminary procedures and installation and alignment of the laser head, receiver, and optics are minimal, they are repeated for each troubleshooting procedure.

If a malfunction is detected during the installation and checkout of the system (or if you are unable to locate a malfunction in a previously operating system using the general troubleshooting information) use one of the following procedures:

- a. HIP-IB Interface electronics troubleshooting (Table 6-1).
- b. Computer interface electronics troubleshooting:
 1. Counter-based systems troubleshooting (Table 6-2).
 2. Comparator-based systems troubleshooting (Table 6-3).
- c. English/Metric pulse output electronics troubleshooting (Table 6-4).
- d. 107B1A Pulse Converter troubleshooting (Table 6-5).

The most effective method of using these procedures is to note in which procedure (preliminary installation, interface electronics installation, etc.) a problem occurred. Locate the appropriate troubleshooting table (Tables 6-1 through 6-5) for your system. Locate the section of the table that pertains to the procedure being performed at the time the trouble was observed. Troubleshoot according to the procedure given.

PRELIMINARY PROCEDURE

1. If the laser head does not emit red light, check that the rear-panel POWER ON light is lit. If it is not, check for a power line short. This can cause the power supply to current limit and reduce the voltage output level to near zero volts. Also, check for an open circuit in the power supply wiring. If the POWER ON light is lit, check the status of the four rear-panel indicators associated with the ± 15 -volt supplies (two ± 5 BAL indicators and two ± 15 S indicators). If power is available to the laser head but the head does not emit red light, refer to the separate manual for the laser head for further troubleshooting.
2. If the LID indicator on one of the system receivers does not light, verify that the ± 15 volts is present at the system cable connector for the receiver. If it is not, troubleshoot the power supply and the system wiring. If voltage is present at the receiver connector and the LID is not lit, refer to the separate manual for the receiver for further troubleshooting information.

INSTALLATION AND ALIGNMENT OF LASER HEAD, RECEIVER, AND OPTICS PROCEDURE

1. If the laser head does not emit red light, check that the rear-panel POWER ON light is lit. If it is not, check for a power line short. This can cause the power supply to current limit and reduce the voltage output level to near zero volts. Also check for an open circuit in the power supply wiring. If the POWER ON light is lit, check the status of the four rear-panel indicators associated with the ± 15 -volt supplies (two ± 5 BAL indicators and two ± 15 S indicators). If power is available to the laser head but the head does not emit red light, refer to the separate manual for the laser head for further troubleshooting information.
2. If the LID indicator on one of the system receivers does not light, verify that the ± 15 volts is present at the system cable connector for the receiver. If it is not, troubleshoot the power supply and the system wiring. If voltage is present at the receiver connector and the LID is not lit, check optics and alignment (refer to Section II).

ELECTRONIC INSTALLATION PROCEDURE

1. If ± 5 volts is not present at the 10740A Coupler rear panel, check power wiring for a short or open circuit. Also check the output of the power supply with the cables disconnected.
2. If the reference or measurement LID indicators on the 10760A Counter cards do not all light when power is applied, verify presence of reference signal from laser head and measurement signal from each receiver. If either signal is not present, troubleshoot the laser head or associated receiver. If the signals are present, troubleshoot the associated 10760A Counter card. Counter cards can be interchanged at this point to verify trouble source.
3. If ± 5 -volt power is not available after connecting 10783A Numeric Displays, check power wiring and display itself for short or open circuits.

Table 6-1. HP-IB Interface Electronics System Troubleshooting (Cont'd)

CHECKOUT PROCEDURE

Required Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS
Digital Voltmeter	Range: $\pm 15V$ to $\pm 15V$ $\pm .01V$ dc
Logic Probe	TTL Level
Oscilloscope	Ability to display signals between dc and 20MHz.
Individual Circuit Card Operating & Service Manuals	

Load the example program for the typical HP-IB Interface from Section IV (Programming) into the system controller. If the problem disappears, check user's software. If problem remains, continue.

MULTI-AXIS

1. If same problem exists on all axes, check the following possible error sources:

a) Check temperature in coupler environment:

COUPLER TEMPERATURE	SYMPTOMS	ACTION
0° to 55°C	None-electronics should operate as described.	None
Out of range	Counters may jump count erratically.	Ventilate enclosure

b) Check voltage on each circuit card in the coupler:

LOCATION	VOLTAGE
+5V Front-edge Test point	At least +5V $\pm .01V$ on each card

Table 6-1. IIP-IB Interface Electronics System Troubleshooting (Cont'd)

c) 10745 IIP-IB Interface

SYMPTOM	POSSIBLE PROBLEM	ACTION
Neither the talk nor listen LED lights on the interface card when card is addressed to talk or listen.	1. 10745 IIP-IB address incorrect.	Set the switches on 10745 to correct address.
	2. Controller malfunction	Run controller diagnostic (if possible)
	3. User software	Check for proper command sequence (example program, Section IV).
	4. 10745 Malfunction	Replace or troubleshoot 10745.
	5. Interface Cable Malfunction	Replace or troubleshoot cable

d) 10783A Numeric Disp.

SYMPTOM	POSSIBLE PROBLEM	ACTION
Displacement information not being displayed	1. 10783A IIP-IB address incorrect.	Set switches on back of 10783A to correct address.
	2. 10783A not receiving power.	Connect 10783A to +5V on back of coupler. Turn on 10783A.
	3. 10783A malfunction.	Troubleshoot 10783A.

Table 6-1. HP-III Interface Electronics System Troubleshooting (Cont'd)

a) Check I/O cabling from controller to coupler.

b) If the reference or measurement LED indicators on the 10760A counter cards do not all light when power is applied:

ACTION	LOCATION	RESULT	SUBSEQUENT ACTION
Verify presence of reference and measurement signals with oscilloscope.	10760A front-edge	Signal present	If LED is extinguished, troubleshoot 10760A.
	Measurement signal (pins 18, 20)	Signal absent	Troubleshoot receiver or cabling.
These signals are square waves.	Reference signal (pins 22, 24)	Signal present	If LED is extinguished, troubleshoot 10760A.
		Signal absent	Troubleshoot laser head or cabling.

If multi-axis system, 10760A counter cards can be interchanged to isolate problem. (Remember to change card address.)

PROBLEM EXISTS BUT NOT ON ALL AXES

2. If the system is multi-axis but the problem is not present on all axes, substitute known good components to isolate the problem system component. The following may also apply:

a) Check voltage on each coupler card:

LOCATION	VOLTAGE
+5V front-edge test point.	At least +5V $\pm$.01V on each card.

Table 6-1. IIP-IB Interface Electronics System Troubleshooting (Cont'd)

b) Intermittent measurement signal on one or more measurement axes may indicate:

CAUSE	CHECK	ACTION
1. Misalignment of optical components	Reduce beam size by rotating to small aperture on laser head. Place alignment target on receiver lens. Move optics along entire measurement path and verify both return beams overlap on the target along the entire length of movement.	If optics are misaligned and beams do not overlap, refer to Section II for alignment procedure.
2. Misadjustment of 10780A receiver gain	Monitor 10780A test point on back of receiver, voltage should lie in range 0.6-1.0 Vdc. If voltage > 1.1V, receiver could be saturated. If voltage < 0.2V, gain may be too low.	Refer to 10780A manual for adjustment procedure.
3. Low power in frequency used for measurement	Use power meter, if available, and polarizer and check relative power of horizontal and vertical polarization.*	Rotate interferometer 90 degrees and look for increase in test point voltage.
4. 10780A Malfunction, cable intermittent, or 10760A malfunction.	Look at output signal from 10780 and input of 10760	Troubleshoot appropriate component

*Use laser power meter filtered for 6328 Angstroms (e.g. Coated Detector Technology 140A meter (w. filter))

Table 6-1. HP-IB Interface Electronics System Troubleshooting (Cont'd)

DATA ERRORS

Incorrect display or printout results when the measurement optics are displaced a known distance:

SYMPTOM	CAUSE	ACTION
No movement indicated on all measurement axes.	Coupler interface card not placing instructions on coupler backplane.	1. 10745: check HP-IB address. 2. Replace or troubleshoot 10745, or I/O from coupler to controller.
System malfunctions in extended resolution (e.g., laser readings are 6 or 10 times greater or less than known measured distance)	1. 10760A counter fails to receive extended resolution command or resolution circuitry is malfunctioning. 2. 10760A resolution jumpers are incorrectly set	1. Using logic probe, verify 10760A receives extended resolution command. (U47 (9) on 10760 should be a TTL high if in extended resolution) 2. If command not received, check proper command decoder output on 10760 with logic probe. 3. Replace interface card. 4. If command received, verify 10760A is correctly jumpered for desired resolution. 5. Replace 10760A card.
No movement indicated on one but not all axes.	10760A Malfunction	If possible, substitute 10760A from other axis.

Table 6-1. HP-IB Interface Electronics System Troubleshooting (Cont'd)

DATA ERRORS (Cont'd)

SYMPTOM	CAUSE	ACTION
Error in displayed reading is less than one part in 100,000 and is evident on all measurement axes.	1. Compensation circuitry malfunction	1. Check output of compensation circuitry.
Laser system reads a shorter distance than the known movement of the optics.	Misalignment of the optics resulting in cosine error.	2. If Comp. number correct, check for cosine error in optical alignment (Refer to Section II, Laser and Optics). 3. If Comp. number incorrect, replace 10755. If using 5510, check BCD inputs to 10755 using logic probe and verify correct Comp. number is being input.
Error in displayed reading that is less than one part in 100,000 and is evident on a single measurement axis.	1. 10760A Malfunction. 2. Cosine error in optical alignment 3. 10760A Saturation	1. Troubleshoot or replace 10760A 2. Align optics (Section II) 3. Adjust 10760A (Refer to 10760A Manual)

ERROR DETECTION

4. If an error indication does not occur when the laser beam is interrupted in a measurement axis:
 - a) Check LED indicator on associated 10780A receiver. If it extinguishes when beam is interrupted, proceed to step b. If it remains on when beam is interrupted,
 1. Monitor 10780A test point on back of receiver. If voltage is greater than 1.1V dc, refer to 10780A manual to reduce receiver gain.
 2. If voltage is in limits, check for incorrect rotation of optics or receiver (refer to Section II)
 3. If problem continues, troubleshoot or replace 10780A receiver.
 - b) If error does not register on any measurement axis, check, replace or troubleshoot system interface card (10745).
 - c) If error does not register on one measurement axis only, replace or troubleshoot the associated 10760A card.

Table 6-2. Binary Controlled Counter Interface Electronics Systems Troubleshooting (Cont'd)

CHECKOUT PROCEDURE

REQUIRED TEST EQUIPMENT	
INSTRUMENT TYPE	REQUIRED CHARACTERISTICS
Digital Voltmeter	Range: $\pm 15V \pm .01V$ dc
Logic Probe	TTL Level
Oscilloscope	Ability to display signals between dc and 20 MHz.
Individual circuit card operating and service manuals	

MULTI-AXIS PROBLEM

1. If the same problem exists on all axes, check the following possible error sources:
 - a) Check over software (refer to Section IV Programming, for example program).
 - b) Check instruction sequence timing (refer to 10746 manual).
 - c) Check temperature in coupler environment.

COUPLER TEMPERATURE	SYMPTOMS	ACTION
0° to 55°C	None—electronics should operate as described.	None
Out of range	Counters may jump or count erratically	Ventilate enclosure

- d) Check voltage on each coupler card.

LOCATION	VOLTAGE
$\pm 5V$ front-edge test point	At least $\pm 5V \pm .01V$ on each card.

Table 6-2. Binary Controlled Counter Interface Electronics Systems Troubleshooting (Cont'd)

e) 10746 Binary Interface card.

SYMPTOM	POSSIBLE PROBLEM	ACTION
Data LED does not light when controller sends command to transfer data	1. User software	Refer to Section IV for instruction sequence.
	2. I/O cabling	Verify proper connections and no shorting.
	3. Controller malfunction	Run controller diagnostic
	4. 10746 malfunction	Replace or troubleshoot 10746.

f) Check I/O cabling from controller to coupler.

g) If all the reference or measurement LED indicators on 10760A counter cards do not light when power is applied:

ACTION	LOCATION	RESULT	SUBSEQUENT ACTION
Verify presence of reference and measurement signals with oscilloscope. Signals are square waves	10760A front-edge	Signal present	If LED is extinguished, troubleshoot 10760A
	Measurement Signal: Pin 10, 20	Signal absent	Troubleshoot receiver or cabling.
	Reference: pins 22, 24	Signal present	If LED extinguished, troubleshoot 10760A
		Signal absent	Troubleshoot laser head or cabling.

PROBLEM EXISTS BUT NOT ON ALL AXES

2. If the system is multi-axis but the problem is not present on all axes, substitute known good components to isolate the problem system component. The following may also apply:

a) Check user software (refer to Section IV for example program).

b) Check voltage on each coupler card.

LOCATION	VOLTAGE
+5V Front-edge test point	At least +5V $\pm$.01V on each card.

Table 6-2. Binary Controlled Counter Interface Electronics Systems Troubleshooting (Cont'd)

c) Intermittent measurement signal on one or more measurement axes may indicate:

CAUSE	CHECK	ACTION
1. Misalignment of optical components	Reduce beam size by rotating to small aperture on laser head. Place alignment target on receiver lens. Move optics along entire measurement path and verify both return beams overlap on the target along the entire length of movement.	If optics are misaligned and beams do not overlap, refer to Section II for alignment procedure.
2. Misadjustment of 10780A Receiver gain	Monitor 10780A test point on back of receiver, voltage should lie in range 0.5-1.0V dc. If voltage >1.1V, receiver could be saturated. If voltage <.02V, gain may be too low.	Refer to 10780A manual for adjustment procedure.
3. Low power in frequency used for measurement	Use power meter, if available, and polarizer and check relative power of horizontal and vertical polarization.*	Rotate interferometer 90 degrees and look for increase in test point voltage.
4. 10780A malfunction, cable intermittent, or 10760A malfunction	Look at output signal from 10780 and input to 10760.	Troubleshoot appropriate component.

* Use laser power meter filtered for 6328 Angstroms
(e.g. Coated Detector Technology #40X meter w/ filter)

Table 6-2. Binary Controlled Counter Interface Electronics Systems Troubleshooting (Cont'd)

DATA ERRORS

3. Incorrect display or printout results when the measurement optics are displaced a known distance :

SYMPTOM	CAUSE	ACTION
No movement indicated on all measurement axes	Coupler interface card not placing instructions on coupler backplane	1. Replace or troubleshoot 10746, or I/O from coupler to controller.
System malfunctions in extended resolution. (e.g., laser readings are 6 or 10 times greater or less than known measured distance)	10760A counter fails to receive extended resolution command or resolution circuitry is malfunctioning. Can also be software error.	1. Using logic probe, verify 10760A is receiving extended resolution command (U47 (9) on 10760 should be a TTL high if in extended resolution). 2. If command not received, check proper command decoder output on 10760 with logic probe. 3. Replace interface card. 4. If command received verify 10760A is correctly jumpered for desired resolution. 5. Replace 10760A card.
Correct position data is output but in the wrong format. (i.e., least significant data sent in the first data word transmitted).	1. Incorrect grounding.	See Section V for grounding considerations.
	2. Incorrect I/O cabling.	Check I/O cabling.
No movement indicated on one but not all axes.	10760A malfunction	If possible, substitute 10760A from other axis.

Table 6-2. Binary Controlled Counter Interface Electronics Systems Troubleshooting (Cont'd)

DATA ERRORS (Cont'd)

SYMPTOM	CAUSE	ACTION
Error in displayed reading, error is less than one part in 100,000, and is evident on all measurement axes.	1. Compensation circuitry malfunction 2. Software error	1. Check output of compensation circuit by using program that continually outputs the number. (Refer to Section IV.)
Laser system reads a shorter distance than the known displacement of the optics.	Misalignment of the optics resulting in cosine error.	2. If compensation number correct, check for cosine error in optical alignment. (Refer to Section II.) 3. If compensation number is incorrect, replace 10755. If using 5510, check BCD inputs to 10755 using logic probe and verify that correct compensation number is being input. 4. Check software conversion routine.
An error results in the displayed reading that is less than one part in 100,000 and is evident on a single measurement axis.	1. 10760A Malfunction	1. Troubleshoot or replace 10760A.
	2. Software error	2. Check software.
	3. Cosine error in optical alignment.	3. Align optics (Section II)
	4. 10780A saturation.	4. Adjust 10780A (Refer to 10780A manual)

ERROR DETECTION

4. If an error indication does not occur when the laser beam is interrupted in a measurement axis:
 - a) Check LED indicator on associated 10780A receiver. If it extinguishes when beam is interrupted, proceed to step b. If it remains on when beam is interrupted,
 1. Monitor 10780A test point on back of receiver. If voltage is greater than 1.1V dc, refer to 10780A manual to reduce receiver gain.
 2. If voltage is in limits, check for incorrect location of optics or receiver (refer to Section II).
 3. If problem continues, troubleshoot or replace 10780A receiver.
 - b) If error does not register on any measurement axis, check, replace, or troubleshoot system interface card (10746).
 - c) If error does not register on one measurement axis only, replace or troubleshoot the associated 10760A card.

Table 6-1. Binary Controlled Comparator-Based Systems Troubleshooting

PRELIMINARY PROCEDURE

1. If the laser head does not emit red light, check that the rear-panel POWER ON light is lit. If it is not, check for a power line short. This can cause the power supply to current limit and reduce the voltage output level to near zero volts. Also, check for an open circuit in the power supply wiring. If the POWER ON light is lit, check the status of the four rear-panel indicators associated with the ± 15 -volt supplies (two UNBAL indicators and two FUSE indicators). If power is available to the laser head but the head does not emit red light, refer to the separate manual for the laser head for further troubleshooting information.
2. If the LED indicator on one of the system receivers does not light, verify that the ± 15 volts is present at the system cable connector for the receiver. If it is not, troubleshoot the power supply and the system wiring. If voltage is present at the receiver connector and the LED is not lit, refer to the separate manual for the receiver for further troubleshooting information.

INSTALLATION AND ALIGNMENT OF LASER HEAD, RECEIVER, AND OPTICS PROCEDURE

1. If the laser head does not emit red light, check that the rear-panel POWER ON light is lit. If it is not, check for a power line short. This can cause the power supply to current limit and reduce the voltage output level to near zero volts. Also check for an open circuit in the power supply wiring. If the POWER ON light is lit, check the status of the four rear-panel indicators associated with the ± 15 -volt supplies (two UNBAL indicators and two FUSE indicators). If power is available to the laser head but the head does not emit red light, refer to the separate manual for the laser head for further troubleshooting information.
2. If the LED indicator on one of the system receivers does not light, verify that the ± 15 volts is present at the system cable connector for the receiver. If it is not, troubleshoot the power supply and the system wiring. If voltage is present at the receiver connector and the LED is not lit, check optics and alignment (refer to Section II).

ELECTRONIC INSTALLATION PROCEDURE

1. If ± 15 volts is not present at the 10740A Coupler rear panel, check power wiring for a short or open circuit. Also check the output of the power supply with the cables disconnected.
2. If reference LED does not light on the 10764B Fast Pulse Converter card, check for presence of reference signal from laser head and, if the signal is present, replace or troubleshoot the 10764B card. If measurement LED does not light, check for the measurement signal from the associated receiver. If the signal is present, replace or troubleshoot the 10764B card. If either signal is not present, troubleshoot the associated unit.

Table 6-1. Binary Controlled Comparator-Based Systems Troubleshooting (Cont'd)

CHECKOUT PROCEDURE

REQUIRED TEST EQUIPMENT	
INSTRUMENT TYPE	REQUIRED CHARACTERISTICS
Digital Voltmeter	Range: $-15V$ to $+15V \pm .01V$ dc
Logic Probe	TTL Level
Oscilloscope	Ability to display signals between dc and 20 MHz
Individual Circuit Card Operating and Service Manuals	

MULTI-AXIS PROBLEM

1. If same problem exists on all axes, check the following possible error sources:

a) Check temperature in the coupler environment.

COUPLER TEMPERATURE	SYMPTOMS	ACTION
0° to $40^{\circ}C$	None — Electronics should operate as described	None
Out of range	Counters may jump or count erratically	Ventilate enclosure

b) Check voltage on each coupler card.

LOCATION	VOLTAGE
+5V Front-edge test point	At least $+5V \pm .01V$ on each card.

c) Check user software (Refer to Section IV for example Comparator Program.)

d) Check instruction sequence timing (Refer to 10746 manual.)

e) 10746A Binary Interface Card

SYMPTOM	POSSIBLE PROBLEM	ACTION
Data LED does not light when controller sends command to transfer data	1. User software	Refer to Section IV for instruction sequence.
	2. I/O Cabling	Verify proper connections and no shorting.
In normal operation, Data LED is dimly lit (If sampling continuously.)	3. Controller malfunction	Run controller diagnostic.
	4. 10746A Malfunction.	Replace or Troubleshoot 10746A.

Table 6-1. Binary Controlled Comparator-Based System Troubleshooting (Cont'd)

- f) If reference or measurement LED indicators on the 10764B Fast Pulse Converter do not all light when power is applied.

ACTION	LOCATION	ACTION
Verify presence of measurement and reference signals with oscilloscope (These signals are square waves.)	10764B front edge.	Measurement or reference present: troubleshoot 10764B
	Measurement 1: pins 18, 20	Measurement absent: Troubleshoot respective receiver and cabling
	Measurement 2: pins 14, 16	
	Reference: pins 22, 24	Reference absent: troubleshoot laser head and cabling.

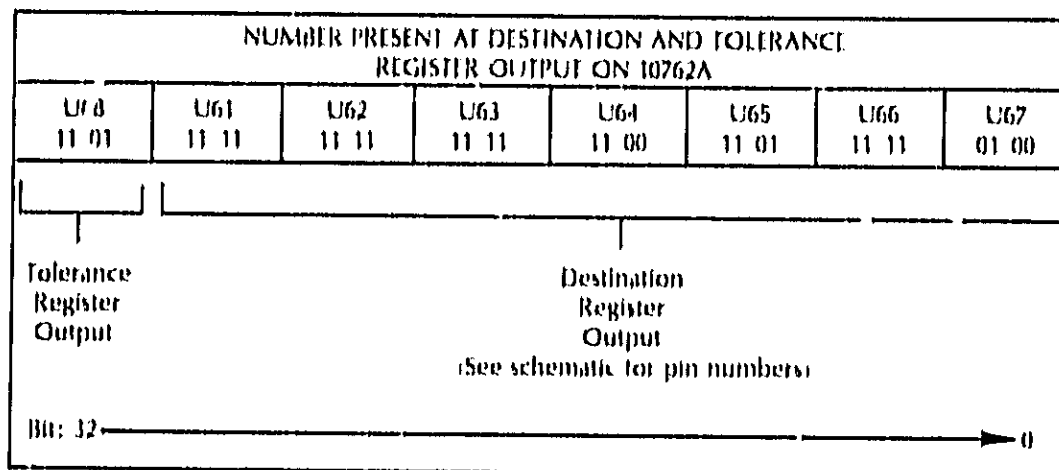
- g) If system does not move to correct destination:

CHECK	LOCATION
1. Compatibility of DAC with output signal from 10762A.	DAC
2. Software for proper conversion of data word containing tolerance and destination.	Software
3. Destination address is being loaded on 10762A card.	Check output of destination register on 10762A card. Data is in binary form and is negative-true. It can be checked with a TTL level logic probe. (See following example.)

Table 6-3 Binary Controlled Comparator-Based System Troubleshooting (Cont'd)

Example: In a system using metric units:
 Destination = 2mm
 Tolerance = 3 micrometers (.000003 meter)

DESTINATION AND TOLERANCE NUMBER SENT TO COMPARATOR (Binary form) FROM CALCULATOR															
00	10	00	00	00	00	00	00	00	11	00	10	00	00	10	11



PROBLEM EXISTS BUT NOT ON ALL AXES

2. If the system is multi-axis but the problem is not present on all axes, substitute known good components to isolate the problem system component. The following may also apply.
 - a) Check user software. (Refer to Section IV for example program.)
 - b) Check voltage on each coupler card.

LOCATION	VOLTAGE
+5V Front-edge test point	At least +5V $\pm$.01V on each card.

Table 6-3. Binary Controlled Comparator-Based System Troubleshooting (Cont'd)

c) Check indicator LEDs on the 10762A Comparator card.

d) Intermittent measurement signal on one or more measurement axes may indicate:

CAUSE	CHECK	ACTION
1. Misalignment of optical components	Reduce beam size by rotating to small aperture on laser head. Place alignment target on receiver lens. Move optics along entire measurement path and verify both return beams overlap on the target along the entire length of movement.	If optics are misaligned and beams do not overlap, refer to Section II for alignment procedure.
2. Misadjustment of 10780A Receiver Gain	Monitor 10780A test point on back of receiver; voltage should lie in range 0.5 - 1.0V dc. If voltage >1.1V, receiver could be saturated. If voltage <.02V, gain may be too low.	Refer to 10780A manual for adjustment procedure.
3. Low power in frequency used for measurement	Use power meter, if available, and measure relative power of horizontal and vertical polarization.*	Rotate interferometer 90 degrees and look for increase in test point voltage.
4. 10780A malfunction, cable intermittent, or 10764B malfunction	Look at output signal from 10780 and input of fast pulse converter 10764B.	Troubleshoot appropriate component

* Use fast power meter filtered for 6328 Angstroms (e.g., United Detector Technology #40X Meter w/ filter.)

Table 6-1. Binary Controlled Comparator-Based System Troubleshooting (Cont'd)

DATA ERRORS

1. If the problem appears to be data related, check the following for the source of error:

SYMPTOM	CAUSE	ACTION
No movement indicated on all measurement axes.	10746A malfunction: coupler interface not placing instructions on backplane.	Replace or troubleshoot 10746A, or I/O cable.
System will not move to desired location.	1. 10746A Malfunction.	Troubleshoot 10746A.
	2. Destination not being correctly converted in program or command sequence incorrect.	Check user software.
System malfunctions in extended revolution.	1. 10762A Malfunction.	Troubleshoot 10762A.
	10764B Malfunction (jumpers and switches may be set incorrectly.)	10764B: verify proper switch settings on card. Repair if problem remains.
Correct position data is output but in wrong format (i.e., least significant data being sent in first word transmitted).	1. Improper system grounding.	1. See Section V for grounding considerations.
	2. Incorrect I/O cabling.	2. Check I/O cabling.
DAC output is incorrect by a small amount on all axes of movement.	1. Compensation Circuitry.	1. Write program to continually output compensation (Comp) data.
	2. Optical misalignment.	2. If Comp number correct, check for cosine error in optical alignment (refer to Section II).
		3. If Comp number incorrect, replace 10755. If using 5510, check BCD inputs to 10755 using logic probe and verify correct Comp number is being output.

Table 6-3 Binary Controlled Comparator-Based System Troubleshooting (Cont'd)

DATA ERRORS (Cont'd)		
SYMPTOM	CAUSE	ACTION
Small measurement errors occurring on one positioning axis	1. 10762A Malfunction	1. Substitute 10762A from another axis.
	2. Optical misalignment	2. Check for cosine error (Refer to Section II).
	3. Receiver Saturation	3. See 10780A Manual for adjustment
Error in displayed reading, error is less than one part in 100,000, and is evident on all axes	1. Compensation circuitry	1. Refer to "action" for DAC errors.
	2. Software error	2. Check software.
	3. Optical misalignment	
Incorrect laser position feedback when system is at null. (Position data is incorrect by a large amount.)	Controller reading status bits as data	1. Write routine in software for null detection.
		2. If position must be read at null, clear error bits through software and then sample.
Laser system reads a shorter distance than the known displacement of the optics.	Optical misalignment resulting in cosine error	Refer to Section II for alignment procedure.

4. If an error does not occur when the laser beam is interrupted in a measurement axis:
 - a) Check LED indicator on associated 10780A Receiver. If it extinguishes when beam is interrupted, proceed to step b. If it remains on when beam is interrupted,
 1. Monitor 10780A test point on back of receiver. If voltage is greater than 1.1V dc, refer to 10780A manual to reduce receiver gain.
 2. If voltage is in limits, check for incorrect rotation of optics or receiver (refer to Section II).
 3. If problem continues, troubleshoot or replace 10780A receiver.
 - b) If error does not register on any measurement axis, check, replace, or troubleshoot system interface card (10746A).
 - c) If error does not register on one measurement axis only, replace or troubleshoot the associated 10746B fast pulse converter and/or 10762A comparator.
 - d) Check user software for correct error checking routine (refer to Section IV).

Table 6-4. English/Metric Pulse Output Electronics System Troubleshooting

PRELIMINARY PROCEDURE

1. If the laser head does not emit red light, check that the rear-panel POWER ON light is lit. If it is not, check for a power line short. This can cause the power supply to current limit and reduce the voltage output level to near zero volts. Also check for an open circuit in the power supply wiring. If the POWER ON light is lit, check the status of the four rear-panel indicators associated with the ± 15 -volt supplies (two UNBAL indicators and two LUSL indicators). If power is available to the laser head but the head does not emit red light, refer to the separate manual for the laser head for further troubleshooting information.
2. If the LED indicator on one of the system receivers does not light, verify that the $+15$ volts is present at the system cable connector for the receiver. If it is not, troubleshoot the power supply and the system wiring. If voltage is present at the receiver connector and the LED is not lit, refer to the separate manual for the receiver for further troubleshooting information.

INSTALLATION AND ALIGNMENT OF LASER HEAD, RECEIVER, AND OPTICS PROCEDURE

1. If the laser head does not emit red light, check that the rear-panel POWER ON light is lit. If it is not, check for a power line short. This can cause the power supply to current limit and reduce the voltage output level to near zero volts. Also check for an open circuit in the power supply wiring. If the POWER ON light is lit, check the status of the four rear-panel indicators associated with the ± 15 -volt supplies (two UNBAL indicators and two LUSL indicators). If power is available to the laser head but the head does not emit red light, refer to the separate manual for the laser head for further troubleshooting information.
2. If the LED indicator on one of the system receivers does not light, verify that the $+15$ volts is present at the system cable connector for the receiver. If it is not, troubleshoot the power supply and the system wiring. If voltage is present at the receiver connector and the LED is not lit, check optics and alignment (refer to Section II).

ELECTRONIC INSTALLATION PROCEDURE

1. If $+5$ volts is not present at the 10740A Coupler rear panel, check power wiring for a short or open circuit. Also check the output of the power supply with the cables disconnected.
2. If the reference or measurement LED indicators on the 10760A Counter cards do not all light when power is applied, verify presence of reference signal from laser head and measurement signal from each receiver. If either signal is not present, troubleshoot the laser head, associated receiver, or optics (refer to Section II). If the signals are present, troubleshoot the associated 10760A Counter card. Counter cards can be interchanged at this point to verify trouble source.
3. If the $+5$ or -15 V dc power source supplies a small voltage (near zero volts) check for a short circuit in the 10740A Coupler or on the 10755A Compensation Interface card.

Table 6-4. English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

CHECKOUT PROCEDURE

REQUIRED TEST EQUIPMENT	
INSTRUMENT TYPE	REQUIRED CHARACTERISTICS
Digital Voltmeter	Range: -15V to +15V ± .01V dc
Logic Probe	TTL Level
Oscilloscope	Ability to display signals between dc and 20 MHz
Frequency Counter	Totalizing Capability (e.g. HP 5301, 5320)
"E-Z mini hook"	Used for test purposes to activate output circuitry
Test Fixture (Front-edge)**	Capable of sending "Start" pulses
Individual circuit card operating and service manuals.	

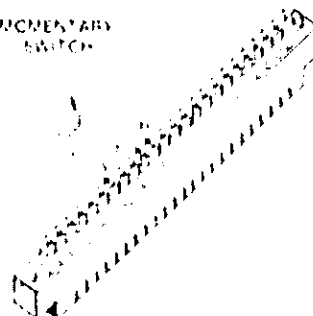
*E-Z mini test hook



**Test Fixture -- To fit on front-edge of 10761A English/Metric card for testing purposes. (to be constructed by user)

Parts: 40-pin connector (e.g. HP P/N 1251-0335)
Momentary switch, SPDT (e.g. HP P/N 3101-1261)

MOMENTARY
SWITCH



The switch sends a "Start" pulse to activate the electronics and initialize the system.

The switch should be wired so that pins 5&V are shorted when the switch is pushed. Pins R&V should be shorted when switch is at rest.

Laser Coupler Cards: The minimum number of circuit cards in the coupler are as follows:

- (1) 10763A English/Metric
- (1) 10760A General Purpose Counter
- (1) 10761A Binary Multiplier
- (1) 10755A Compensation Interface
- (1) 10756A Manual Compensator

Table 6-4 English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

MULTI-AXIS PROBLEM

1. If same problem exists on all axes, check the following possible error sources:

a) System does not work (control LED's on the 10763A's should be dimly lit when system is cycling).

SYMPTOM	CAUSE	ACTION
Upon sending "start" pulse system does not start.	1. "Start" circuitry malfunction	1. Check wiring of switch to send "start" pulse.
Must send a start pulse!	2. Control not passed between 10763A cards (apparent by control LED lit on only "master" card.) 3. Large deadpath will result in long initialization cycle (>20 seconds). Each 10763A must initialize its own axis before it passes control to another 10763A.	2. Check switch and jumper settings on 10763A card. (Should correspond to table 5-2, Section V.) 3. Check OPC line on backplane (see Table 4-1, Section IV), using TTL Logic Probe. This line should be cycling high and low. 4. If OPC is cycling properly, problem is probably a defective 10763A. 5. If OPC is not cycling properly, problem can be a defective 10760A.
Overflow error is flagged after moving the optics a short distance in the positive direction.	10760A counters trying to count in wrong direction (negatively)	Switch normal/reverse jumper on 10760A card.
Laser not providing feedback information to the controller. (Indicated by the controller not appearing to receive data from the laser electronics.)	1. System not starting (see previous page). 2. Controller not recognizing output pulses from electronics.	1. Disconnect controller and hook up freq. counter. (See Table 6-4a, 6-4b) 2. Jumper 10763 for testing (See table 6-4c). 3. Look at output pulse count. (See test a).

Table 5-4. English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

- b) Check system grounding (see Section V).
c) Check temperature in the coupler environment.

COUPLER TEMPERATURE	SYMPTOMS	ACTION
0° to 55°C	None—Electronics should work as described.	None
Out of range	Counters may jump or count erratically	Ventilate enclosure

- d) Check voltage on each circuit card in the coupler.

LOCATION	VOLTAGE
+5V Front-edge test point	At least +5V $\pm$.01V on each card.

- e) If all reference or measurement LED indicators on the 10760A counter cards do not light when power is applied:

ACTION	LOCATION	RESULT	SUBSEQUENT ACTION
Verify presence of reference and measurement signals with oscilloscope	10760A Front-edge	Signal present	If LED is extinguished, troubleshoot 10760A.
	Measurement: signal pins 18, 20	Signal absent	Troubleshoot receiver or cabling.
These signals are square waves.	Reference: signal pins 22, 24	Signal present	If LED is extinguished, troubleshoot 10760A.
		Signal absent	Troubleshoot laser head or cabling.

If multi-axis system, 10760A counter cards can be interchanged to isolate problem. (Remember to change card address.)

PROBLEM EXISTS BUT NOT ON ALL AXES

2. If the system is multi-axis but the problem is not present on all axes, substitute known good components to isolate the problem system component. The following may also apply:
- a) Check 10763A switches and jumpers (refer to Section V, Table 5-2).
b) Check voltage on each coupler card

LOCATION	VOLTAGE
+5V front-edge test point	At least +5V $\pm$.01V on each card.

Table 6-4. English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

c) Intermittent measurement signal on one or more measurement axes may indicate:

CAUSE	CHECK	ACTION
1. Misalignment of optical components	Reduce beam size by rotating to small aperture on laser head. Place alignment target on receiver lens. Move optics along entire measurement path and verify both return beams overlap on the target along the entire length of movement.	If optics are misaligned and beams do not overlap, refer to Section II for alignment procedure.
2. Misadjustment of 10780A receiver gain	Monitor 10780A test point on back of receiver, voltage should lie in range 0.5 - 1.0V dc. If voltage > 1.1V, receiver could be saturated. If voltage < 0.2V, gain may be too low.	Refer to 10780A manual for adjustment procedure.
3. Low power in frequency used for measurement	Use power meter, if available, and polarizer and check relative power of horizontal and vertical polarization.*	Rotate interferometer 90 degrees and look for increase in test point voltage.
4. 10780A malfunction, cable intermittent, or 10760A malfunction.	Look at output signal from 10780 and input of 10760.	Troubleshoot appropriate component

*Use laser power meter filtered for 6328 Angstroms (e.g. United Detector Technology #40A meter w/ filter).

Table 6-4. English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

DATA ERRORS

1. Incorrect display or printout results when the measurement optics are displaced a known distance:

SYMPTOM	CAUSE	ACTION
No movement indicated on all axes	1. "Start" pulse not being sent.	See "Multi-Axis problem."
	2. 10763A jumpered incorrectly	Check Table 5-2
	3. Controller not recognizing output pulses from laser electronics.	1. Use totalizing frequency counter (Table 6-4a, 6-4b). 2. Jumper 10763A's as per Tables 6-4c, 6-4d. 3. Send "start" pulse to each 10763A and verify correct number of output pulses (Test a). 4. If counts are incorrect, see Test b, c, d.
System malfunctions in extended resolution (e.g. Laser readings are 5 or 10 times greater or less than a known measured distance)	1. 10760A Counter fails to receive extended resolution command or resolution circuitry is malfunctioning. 2. Resolution jumpers on 10760A not correctly set.	1. Using logic probe verify 10760A received extended resolution command. (U47 (9) on 10760 should be a TTL high if in extended resolution). 2. If command not received, check proper command decoder output on 10760 with logic probe. 3. If command is received, verify 10760A is correctly jumpered for desired resolution. 4. Replace 10760A.
No movement indicated on one but not all axes.	1. 10760A Malfunction.	1. Substitute 10760A from other axis.
	2. 10763A Malfunction.	2. See Test a.

Table 6-4 English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

DATA ERRORS (Cont'd)		
SYMPTOM*	CAUSE	ACTION
Error in displayed reading, error is less than one part in 100,000 and is evident on all measurement axes.	Compensation circuitry malfunction	1. Check output of compensation circuitry by performing Test b. 2. If compensation number correct, check for cosine error in optical alignment (refer to Section II).
Laser System reads a shorter distance than a known displacement of the optics.	Misalignment of the optics resulting in cosine error.	3. If Comp. number incorrect, replace 10755. If using 5510, check BCD inputs to 10755 using logic probe and verify correct Comp. number is being input. 4. See Section II for optical alignment procedure.
Small error one measurement axis (Error is less than one part in 100,000.)	1. 10761A malfunction.	See Test a
	2. 10760A malfunction.	Troubleshoot or replace 10760A.
	3. Cosine error in optical alignment (If laser reads shorter than known displacement.)	Align optics (See Section II)
	4. 10780A Saturation	Adjust 10780A (Refer to 10780A Manual.)

ERROR DETECTION

4. If an error indication does not occur when the laser beam is interrupted in a measurement axis:
 - a) Check LED indicator on associated 10780A receiver. If it extinguishes when beam is interrupted, proceed to step b. If it remains on when beam is interrupted.
 1. Monitor 10780A test point on back of receiver. If voltage is greater than 1.1V dc, refer to 10780A manual to reduce receiver gain
 2. If voltage is in limits, check for incorrect rotation of optics or receiver (refer to Section II).

Table 6-4. English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

3. If problem continues, troubleshoot or replace 10780A receiver.
- b) If the error does not register on one measurement axis only, replace or troubleshoot the associated 10760A card.
- c) If the controller does not recognize an error occurring on any axis, verify the error output lines from the coupler are being monitored by the controller. The error line is an output from the 10763A.

FREQUENCY COUNTER

Table 6-4a. 5300/5301 Control Settings for Coupler Operation Verification

SET FRONT PANEL CONTROLS AS FOLLOWS:	
GATE	OPEN
WAVEFORM	
COUNTER INPUT LINE	CONNECT TO PIN 4 ON FRONT-EDGE TEST FIXTURE
GROUND FROM INPUT BNC	CONNECT TO PIN 18 ON FRONT-EDGE TEST FIXTURE
SAMPLE RATE	HOLD

Table 6-4b. 5322 Universal Counter Settings

SET FRONT PANEL CONTROLS AS FOLLOWS:	
FUNCTION	START A
FREQ. RESOLUTION/N	1 MHz, 1
SAMPLE RATE	HOLD
(Use channel A input)	
COUNTER INPUT LINE	CONNECT TO PIN 4 ON FRONT-EDGE TEST FIXTURE
GROUND FROM INPUT BNC	CONNECT TO PIN 18 ON FRONT-EDGE TEST FIXTURE
SLOPE	+
AC/DC	DC
ATTEN	1
LEVEL A	ADJUST TOWARD + SO THAT THE COUNTER DISPLAY STABILIZES (NO COUNTING SHOULD TAKE PLACE IF LEVEL IS INCREASED.)
SEP/COM A	SEP

Table 6-4. English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

Table 6-4c: 10763 Initial Jumper and Switch Settings (Single-axis)

SET CARD AS FOLLOWS:	
AXIS SELECT	X
DEADPATH	0 (All switches down)
WEIGHT	1 (All switches down)
AXIS	FIRST SWITCH DOWN, ALL OTHERS UP
PULSES	UP/DOWN
RUN/TEST	TEST
OUTPUT PULSE RATE	1.6MHZ
IRK/STOP/GO	GO
INCH	JUMPER IN
NOR	JUMPER IN
FIRST	JUMPER REMOVED
ONE AXIS	JUMPER REMOVED

Table 6-4d: 10763 Initial Jumper and Switch Settings (Multi-Axis)

CARDS SHOULD BE SET AS ABOVE WITH THE FOLLOWING EXCEPTIONS		
	X-AXIS	Y-AXIS
AXIS SELECT	X	Y
AXIS: THIS AXIS	X	Y
NEXT AXIS	ALL SWITCHES UP	ALL SWITCHES UP

Switch settings are similar for more than two axes.

MULTIPLE-AXIS TEST INSTRUCTIONS

With 10763 cards jumpered correctly, the system can be initialized for testing by sending a "start" pulse to the front edge of each 10763 card by physically moving the test fixture to each card and applying the pulse. Each successive "start" pulse should result in the preset number of counts being sent from the card and detected by the frequency counter.

Table 6-4. English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

TEST A: 10763 OUTPUT COUNT CHECK

In this test, the deadpath switches should be changed one at a time and the output counts compared with those given in the table. A "start" pulse must be sent each time a deadpath switch is set and the counter must be reset before the pulse is sent.

Check for the following:

- 10763 jumpered as per table 6-4c
- 000.0 dialed in 10756 thumbwheels
- deadpath switches numbered as shown:

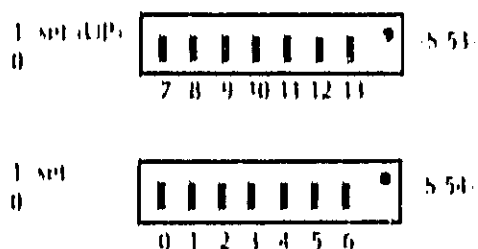


Table 6-4c: 10763A Pulse Output Check

DEADPATH SWITCH SET (UP) (Only Switch Set)	ENGLISH UNITS		METRIC UNITS (inch jumper removed)	
	1.6MHz output	800kHz output	1.6MHz output	800kHz output
•	175 ± 10	260 ± 10	440 ± 10	655 ± 15
0	5280 ± 15	10460 ± 10	13395 ± 20	26536 ± 40
1	10372 ± 15	20655 ± 15	26350 ± 10	52465 ± 40
2	20577 ± 15	41045 ± 40	52267 ± 20	104200 ± 50
3	40980 ± 15	819 ± 50	104090 ± 50	207850 ± 70
4	81790 ± 20	16345 ± 50	207740 ± 50	415180 ± 100
5	163340 ± 150	326725 ± 50	414953 ± 70	829300 ± 500
6	326360 ± 100	653385 ± 100	829620 ± 120	

*all switches down

A-QUAD-B OUTPUT COUNT CHECK

Jumper 10763 for A-Quad-B output pulses. The number of counts detected by the frequency counter can then be multiplied by four to obtain the total number of representative A-Quad-B output counts.

Table 6-4: English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

Example:

With no deadpath switches set (all switches down), the frequency counter should detect the following counts:

English Units (Compare with chart above)

1.6 MHz output	800 kHz output
44 [176]	65 [260]

(Number in brackets represents total equivalent A-Quad-B counts output from 10763.)

TEST B: 10755 COMPENSATION INTERFACE TEST

Equipment needed: logic clip or logic probe
10756 manual compensator

Test procedure: Dial in thumbwheel setting on chart
Press update
Tie U2 (11) and U2 (8) to ground, using 1-Z mini test hook or equivalent (to enable tri-state output buffers)
Compare signal levels with those given on chart (Table 6-4f)
If signal levels do not correspond, check HCD input lines (Table 6-4g)

Table 6-4f: Compensation Interface Output

THUMBWHEEL SWITCH SETTING	OUTPUT LINES											
	U8						U12					
	pins						pins					
	7	5	1	9	11	13	5	7	3	9	13	11
000.0	0	1	1	0	1	1	1	1	0	1	1	1
076.5	1	0	0	1	0	0	0	1	1	0	1	0
212.1	0	1	1	1	0	1	1	1	1	0	1	1

Table 6-4g: Compensation Interface Input

THUMBWHEEL SWITCH SETTINGS	INPUT LINES															
	U17				U13				U9				U5			
	Pins				Pins				Pins				Pins			
	9	10	1	15	9	10	1	15	9	10	1	15	9	10	1	15
000.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
076.5	1	0	0	0	0	1	1	1	0	1	1	0	0	1	0	1
212.1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1

Table 6-4: English/Metric Pulse Output Electronics System Troubleshooting (Cont'd)

TEST C: 10760 GENERAL PURPOSE COUNTER TEST

Equipment needed: logic clip or logic probe

Test procedure: Jumper 10763 as per Table 6-4c
Send "start" pulse
Compare 10760 counter output with Table 6-4h

Table 6-4h: 10760 Counter Output Check

		10760 Counter Output											
10761 CARD JUMPERS	FREQUENCY COUNTER OUTPUT	U 51				U 42				U 52			
		pins				pins				pins			
		7	6	2	1	7	6	2	1	7	6	2	1
metric	1.6MHz	175	0	0	0	0	0	0	0	0	0	0	1
	800kHz	257	0	0	0	0	0	0	0	0	0	1	1
mmv	1.6MHz	417	0	0	0	0	0	0	0	0	0	1	0
	800kHz	665	0	0	0	0	0	0	0	0	0	1	0

0/1 = constantly changing

TEST D: 10761 BINARY MULTIPLIER

Equipment needed: logic clip or logic probe

Test procedure: Jumper 10763 as per Table 6-4c
Send "start" pulse
Compare 10761 output with Table 6-4i. The number in the 10761 buffers is the binary representation of the number that is read on the frequency counter (within a ± 1 tolerance).

Table 6-4i: 10761 Output Buffer Check

10761 Switches and Jumpers	Freq Counter Output	U 1	U 64	U 61	U 64	U 61	U 64	U 61	U 64	U 61	U 64	U 61	U 64	U 61	U 64
		Pins	2	2	4	4	6	6	10	10	12	12	14	14	16
		Pins	2	2	4	4	6	6	10	10	12	12	14	14	16
metric	1.6MHz	175	(174)	0	0	0	0	0	0	0	0	1	0	1	0
	800kHz	257	(256)	0	0	0	0	0	0	1	0	0	0	0	0
metric	1.6MHz	444	(441)	0	0	0	0	0	0	1	1	0	1	1	1
	800kHz	652	(651)	0	0	0	0	0	0	1	0	1	0	0	0
metric	1.6MHz	5276	[1 deadpath switch up]	0	0	0	1	0	1	0	0	1	0	0	1
			(5275)	0	0	0	1	0	1	0	0	1	0	0	1

0/1 = constantly changing

Table 6-5. 10781A Pulse Converter Troubleshooting

PRELIMINARY PROCEDURE

1. If the laser head does not emit red light, check that the rear-panel POWER ON light is lit. If it is not, check for a power line short. This can cause the power supply to current limit and reduce the voltage output level to near zero volts. Also check for an open circuit in the power supply wiring. If the POWER ON light is lit, check the status of the four rear-panel indicators associated with the ± 15 -volt supplies (two UNBAL indicators and two FUSE indicators). If power is available to the laser head but the head does not emit red light, refer to the separate manual for the laser head for further troubleshooting information.
2. If the LED indicator on one of the system receivers does not light, verify that the ± 15 volts is present at the system cable connector for the receiver. If it is not, troubleshoot the power supply and the system wiring. If voltage is present at the receiver connector and the LED is not lit, refer to the separate manual for the receiver for further troubleshooting information.

INSTALLATION AND ALIGNMENT OF LASER HEAD, RECEIVER, AND OPTICS PROCEDURE

1. If the laser head does not emit red light, check that the rear-panel POWER ON light is lit. If it is not, check for a power line short. This can cause the power supply to current limit and reduce the voltage output level to near zero volts. Also check for an open circuit in the power supply wiring. If the POWER ON light is lit, check the status of the four rear-panel indicators associated with the ± 15 -volt supplies (two UNBAL indicators and two FUSE indicators). If power is available to the laser head but the head does not emit red light, refer to the separate manual for the laser head for further troubleshooting information.
2. If the LED indicator on one of the system receivers does not light, verify that the ± 15 volts is present at the system cable connector for the receiver. If it is not, troubleshoot the power supply and the system wiring. If voltage is present at the receiver connector and the LED is not lit, check optics and alignment (refer to Section II).

CHECKOUT PROCEDURE

1. If the up/down or the A-quadr-B pulses are not present at the pulse converter output, first check for the presence of the reference and measurement signal inputs to the pulse converter. If they are not present, troubleshoot the laser head or receiver respectively. If both signals are present, replace or troubleshoot the pulse converter.

APPENDIX

A - B

appendix A

HP 9820A and 9830A Programming

A.1 INTRODUCTION

This appendix contains additional information for programming the Laser Transducer System, using either an HP 9820A or 9830A Calculator.

A.2 Programming with the HP 9820A

Programming the Laser Transducer System using an HP 9820A is very similar to programming with the HP 9825A. The two primary differences are:

1. The 9820A uses negative-true instructions for the Coupler cards and the 9825A uses positive-true instructions (refer to Table 4-11).
2. The 9820A transfers 8-bit bytes to and from the calculator and the 9825A transfers 16-bit words.

There are some minor differences between the two calculators (capital letters vs. lower-case letters) that are explained in the calculator documentation. Data flow within the system is illustrated in Section IV.

A.3 Programming with the HP 9830A

Programming the Laser Transducer System using an HP 9830A is similar to programming with the HP 9825A in the sense that the instructions for the coupler cards are the same. However, since a different level language is used it is first necessary to understand the calculator requirements and then apply them to the Laser Transducer System. Two typical programs are illustrated in Tables A-1 and A-2. Table A-1, Counter-Based System Using HP 9830A, is similar to Table 4-12 in Section I. Table A-2 is similar to Table 4-13. Comparing the tables and data flow illustrations in Section IV to these two examples will help to clarify the techniques of programming with the 9830A.

Table A-1. Counter-Based System Using HP 9830A (BASIC Language)

PROGRAM	COMMENT
10 CMD "?U" 20 FORMAT B 30 OUTPUT (13, 20)768;	Set all devices on HP-IB to remote enable.
40 CMD "?U" 50 FORMAT B 60 OUTPUT (13, 50)256, 20, 512;	
70 CMD "?U", "006X"	00 = preset counters to 160 counts. 6X = set X to extended resolution.
80 CMD "?U", "2V30", "115" 90 ENTER (13,)*C	2V = input compensation. 30 = convert to BCD. Input compensation number to calculator.
100 FOR I=1 TO 10	Loop for 10 times before updating the compensation value.
110 CMD "?U", "102X30", "115"	10 = sample X and Y; 2X = Transfer X to 10745; 30 = convert to BCD.
120 ENTER (13,)*X	Output to Variable X
130 X=(X-16)*6.23023E-06°C	Subtract 16 counts (extended resolution) convert to inches (*6.23E-6) and correct for VOL and material temp (°C)
140 IF NOT ((STAT13=0) OR (STAT13=1)) THEN 165	165 if not status request
150 A=0	Set A = 0 if X-Axis error
160 GOSUB 400	Status request. See HP-IB Calculator manual for programming details. Subroutine 400 processes the status request.
165 CMD "?U1" 170 FORMAT F12.6 180 OUTPUT (13,170)X	Output X to display (calculator to output, display to listen). Fixed 12 characters wide, 6 digits to right of decimal. Microninch resolution. Output to HP-IB).
190 CMD "?U", "2Y30", "115"	
200 ENTER (13,)*Y	2Y = transfer Y to 10745. 30 = convert to BCD
210 Y=(Y-160)*6.23023E-06°C	Output to variable Y
220 IF NOT ((STAT13=0) OR (STAT13=1)) THEN 250	Subtract 160 counts, convert to inch (*6.23E-6) , correct for VOL and material temp. (°C)
230 A=1	If Stat 13 = (0 or 1), status request.
240 GOSUB 400	Set A=1 if Y-Axis error. See 9830 HP-IB calculator manual for programming details
250 CMD "?U2"	Subroutine 400 processes the status request.
260 OUTPUT (13, 170)Y	Output Y to display. Calculator to talk, display to listen
270 NEXT I	Output to HP-IB
280 GOTO 80	Go to 100 to start through display loop again.
400 CMD "?U"	Update the compensation value.
410 FORMAT B	400 start the status request subroutine.
420 OUTPUT (13,410) 256, 95, 53, 24, 512;	Set HP-IB to serial poll enable mode.
430 CMD "I"	I = coupler (10745A) talk address
440 B=RBYTE13	B = Status Byte of 10745A
450 IF B<64 THEN 470	470 if not coupler error
460 GOSUB 600	Process the error

Table A-1. Counter-Based System Using HP 9830A (BASIC Language) (cont'd)

470 CMD "IU"	}	End serial poll							
480 FORMAT 3B									
490 OUTPUT (13,480)256, 25, 512;									
500 CMD "IU", "OP"	}	Overflow only; clear error on HP-IB as overflow can clear itself.							
510 RETURN									
		STATUS BYTE							
					Vol				
				Over	Over	Meas	Ref		
		SRQ	1	1	Flow	Range	Error	Error	BIT
		7	6	5	4	3	2	1	
600 B=B-112	}	Strip off Bits 5, 6, and 7							
650 IF B<0 THEN 700									
670 GOSUB 900		Handle Overflow							
680 B=B-8	}	Overflow Strip off Bit 4 (Subroutine 900)							
690 D=1		D = 1							
700 IF B<4 THEN 740	}								
710 PRINT "VOL-OUT OF RANGE"		Strip off Bit 3							
720 B=B-4		Vol Error							
730 D=0		D = 0 Irrecoverable error							
740 IF B<2 THEN 780	}								
750 PRINT "MEAS ERROR"		Strip off Bit 2							
760 B=B-2		Meas Error							
770 D=0	}	D = 0 Irrecoverable error							
780 IF B<1 THEN 800									
790 PRINT "REF ERROR"		Strip off Bit 1							
795 D=0	}	Ref Error							
		D = 0 Irrecoverable error							
800 IF D=1 THEN 840	}	D = 1 overflow only; a recoverable error. Return							
802 IF A#0 THEN 806		D = 0 Irrecoverable Error							
804 PRINT "X-AXIS ERROR"		Print which Axis							
806 IF A#1 THEN 810		Display							
808 PRINT "Y-AXIS ERROR"									
810 DISP "GO TO GAGE";		"GO TO GAGE" and then stop							
820 STOP									
830 GOTO 10	}								
840 RETURN									
900 IF A#0 THEN 920									
910 X=X-(2120/10)*6.23023E-06°C		If X, make X negative. If counter goes negative.							
920 IF A#1 THEN 940									
930 Y=Y-2120*6.23023E-06°C		If Y, make Y negative. If counter goes negative.							
940 RETURN									
950 END									

Table A-2. Comparator-Based System Using HP 9810A (BASIC Language)

PROGRAM	COMMENT
5 FORMAT 000	Format to output 8-bit binary commands and 8-bit data segments.
10 OUTPUT (2,5)255,255,255, 255,255, 157, 252;	Select code of 11202A TTL Calculator Interface is 2. Format statement 5. 255 "0P" 255 "0P" Guarantees System Reset. 255 "0P" 157 "2V" Sample Compensation Reading. 255 "0P" 252 "3P" Prepare to Output. 255 "0P"
20 GOSUB 2000	"IN" is a subroutine which inputs a number and places it in variable B.
30 C=B	C = Compensation Number.
40 DISP "X TOLERANCE IN MICRONS";	
45 INPUT R1	R1 = X tolerance in microns. No safeguards are provided.
50 DISP "Y TOLERANCE IN MICRONS";	
55 INPUT R2	R2 = Y Tolerance in Microns.
60 X=0	
70 DISP "X DESTINATION IN MM";	
75 INPUT X	X is X-Axis destination in millimetres.
80 Y=0	
90 DISP "Y DESTINATION IN MM";	Y is Y-Axis destination in millimetres.
95 INPUT Y	
100 OUTPUT (2,5)157,252;	157 "2V" sends 2V sample compensator reading. 252 "3P" prepare to output.
110 GOSUB 2000	"IN" is a subroutine which inputs the number and places it in variable B.
120 C=B	C = Compensation Number.
130 A=X	
140 GOSUB 3000	Convert X to fringes.
150 X=A	X = Destination in fringes.
160 A=Y	
170 GOSUB 3000	Convert Y to fringes.
180 Y=A	Y = Destination in fringes.
190 A=(INT(R1/1.50240E-01) *2120)+X	Add X-tolerance in fringes to X-destination in bits 28-31.
200 GOSUB 4000	Output to 10746A card.
210 OUTPUT (2,5)124;	124 "3X" transfer to X-destination register.
220 A=(INT(R2/1.50240E-01) *2120)+Y	Add Y-tolerance in fringes to Y-destination in bits 28-31.
230 GOSUB 4000	Output to 10746A card.
240 OUTPUT (2,5)100;	100 "3Y" transfer to Y-destination register.
250 OUTPUT (2,5)254,125,252;	254 "1P" samples X and Y to compare X, Y Location with X, Y. 125 "2X" transfer X to 10746A.

Table A-2. Comparator-Based System Using HP 9830A

260 F=0	F = 0 for X-Axis
270 GOSUB 2000	Subroutine to input the number from the 10746A card.
280 R3=B	Store the X-location in R3.
290 OUTPUT (2,5) 109,252;	"109" "2Y" transfer Y to 10746A. "252" "3P" prepare to transfer to calculator.
300 F=1	F = 1 for Y-Axis.
310 GOSUB 2000	Subroutine to input the number from the 10746A Card.
320 R4=B	Store Y-location in R4.
340 DISP R3-160,R4-160,C	
350 IF ABS (X-R3)<+R1/(1.50E-0) AND ABS (Y-R4)<+R2/(1.50E-0) THEN 60	If X and Y are within tolerance, get another destination; if not resample.
360 GOTO 250	
2000 B1=255-RBYTE 2	Read in bits 31-24 and complement bits; if bits 31-20 are all 1's go to error checking routine.
2010 IF B1>=240 THEN 2500	
2020 B2=255-RBYTE 2	Read in bits 23-16 and complement.
2030 B3=255-RBYTE 2	Read in bits 15-8 and complement.
2040 B4=255-RBYTE 2	Read in bits 7-0 and complement.
2050 D=INT(B1/16)	D contains bits 31-28 decimal point information.
2060 B1=B1-16*D	B1 = bits 27-24
2070 B=(B1*2124+B2*65536+B3*255+B4)*101(2-D)	Apply proper weighing. 2-D applies decimal point.
2080 RETURN	
2500 B1=15-(B1-240)	B1 = bits 31-24 initially. -240 clears bits 31-28 which indicated an error. Bits 27-24 need to be complemented by subtracting from 15.
2510 IF B1<0 THEN 2540	} If bit 27, VOL Error, clear bit 27.
2520 B1=B1-8	
2530 PRINT "VOL ERROR"	} If Bit 26, D = 1 as possible recoverable error. Clear bit 26.
2540 IF B1<4 THEN 2570	
2550 B1=B1-4	
2560 D=1	
2570 IF B1<2 THEN 2610	} If Bit 25, D = 0 as irrecoverable error. Clear bit 25. Print "REF ERROR".
2580 PRINT "REF ERROR"	
2590 B1=B1-2	
2600 D=0	
2610 IF B1=0 THEN 2640	} If bit 24, irrecoverable error; so D=0. Print "Meas Error".
2620 PRINT "MEAS ERROR"	
2630 D=0	
2640 IF D=0 THEN 5000	5000 If irrecoverable error.
2650 B1=RBYTE 2+RBYTE 2+RBYTE 2	Overflow only. Read byte bit 23-0 to complete previous 3P command.
2660 OUTPUT (2,5)15,252;	15 "BO" clears error bits on 10746A so 28 bits of data can be transferred with "3P" command.

Table A-2. Comparator-Based System Using HP 9830A

2670 B1=255-RBYTE2	Read in bits 31-24.
2680 B2=255-RBYTE2	Read in bits 23-16.
2690 B3=255-RBYTE2	Read in bits 15-8.
2700 B4=255-RBYTE2	Read in bits 7-0.
2710 D=INT(B1/16)	D contains bits 31-28 decimal point information.
2720 B1=B1-16*D	B1 = Bits 27-24.
2730 B=(B1*2124+B2*65536+B3*256+B4)*101(2-D)	Apply proper weighting. (2-D) applies decimal point.
2740 IF F#0 THEN 2760	
2750 B=F*-2128	
2760 IF ' #1 THEN 2780	Correct for overflow - really underflow.
2770 B=B-2128	
2780 RETURN	Return, as this is recoverable error.
3000 A = 160 A/1.58240E-4°C	Conversion to fringes.
3010 RETURN	
4000 OUTPUT (2,5)251;	4000 is a routine to output a 32-bit number in four 8-bit bytes in positive-true form. 251 "4P" prepare 10746A to input a destination and a tolerance.
4010 B1=INT(A/2124)	
4020 OUTPUT (2,5)255-B1;	Output bits 31-24 to 10746A
4030 B1=A-2124*B1	
4040 B2=INT(B1/2116)	
4050 OUTPUT (2,5)255-B2;	Output bits 23-16 to 10746A.
4060 B1=B1-2116*B2	
4070 B2=INT(B1/210)	
4080 OUTPUT (2,5)255-B2;	Output bits 15-8 to 10746A.
4090 B1=B1-210*B2	
4100 OUTPUT (2,5)255-B1;	Output bits 7-0 to 10746A.
4110 RETURN	Output completed. Transfer command needs to be given next.
5000 IF F#0 THEN 5020	
5010 PRINT "X-AXIS ERROR"	
5020 IF F#1 THEN 5040	
5030 PRINT "Y-AXIS ERROR"	
5040 DISP "GO TO GAGE";	
5050 STOP	Irrecoverable error, so stop and go to gage on machine; then hit continue.
5060 GOTO 10	
5070 END	

appendix B

User Application Programs

B.1 INTRODUCTION

This section provides a convenient storage space for the application programs you have generated for your Laser Transducer System.

APPENDIX

C

appendix C

System Cabling

C.1 SYSTEM CABLE REQUIREMENTS

Table 5-2 lists the required system cables and Figures 5-4 through 5-11 show interconnecting information. Figures C-1 through C-18 show photos of the cables, identify the connector markings, and give the pin numbers and corresponding wire color codes. For cable fabrication instructions for systems prior to series prefix 1940A, refer to Appendix E, BACKDATING.

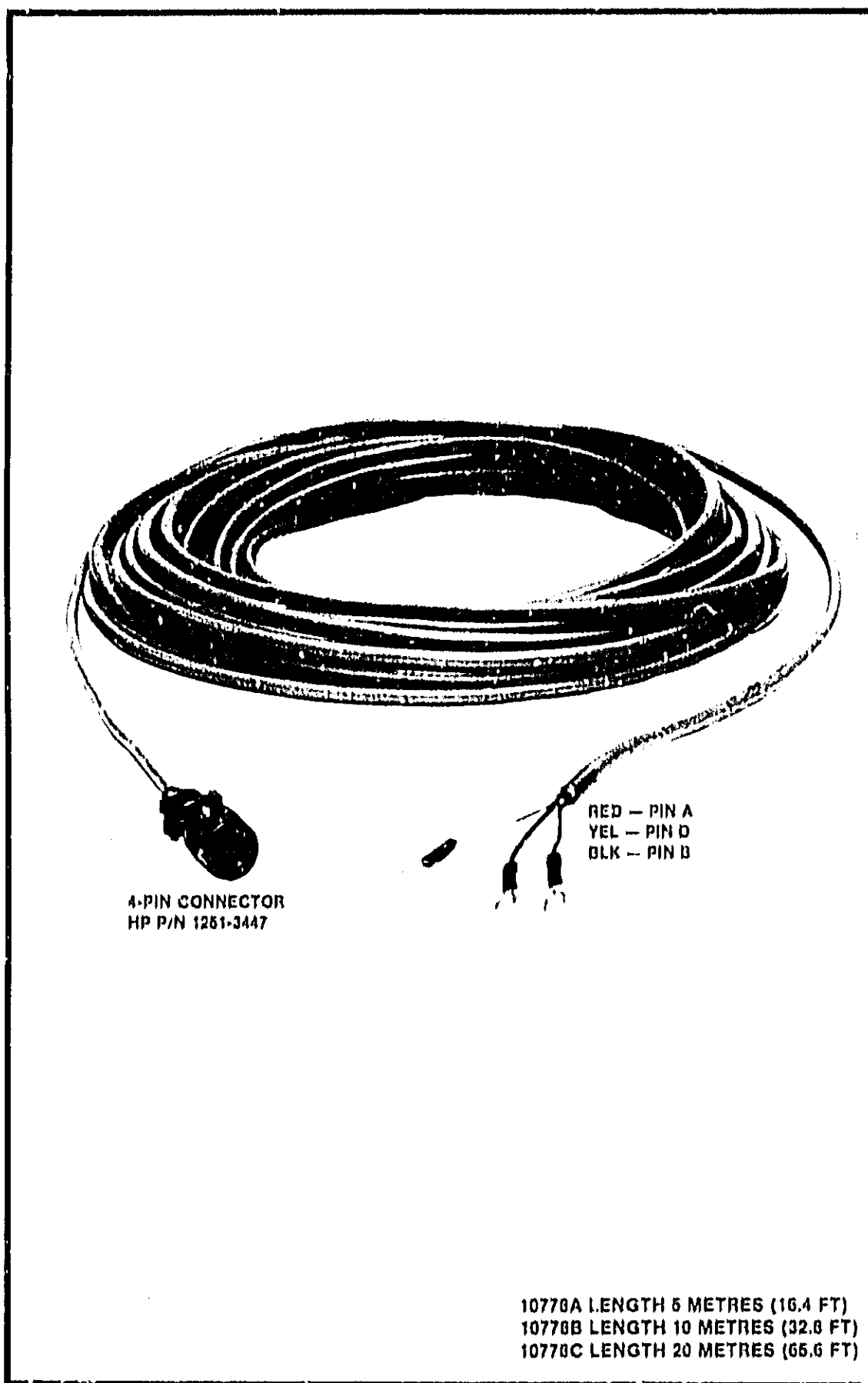


Figure C-1. 10778A,B,C Power Cable

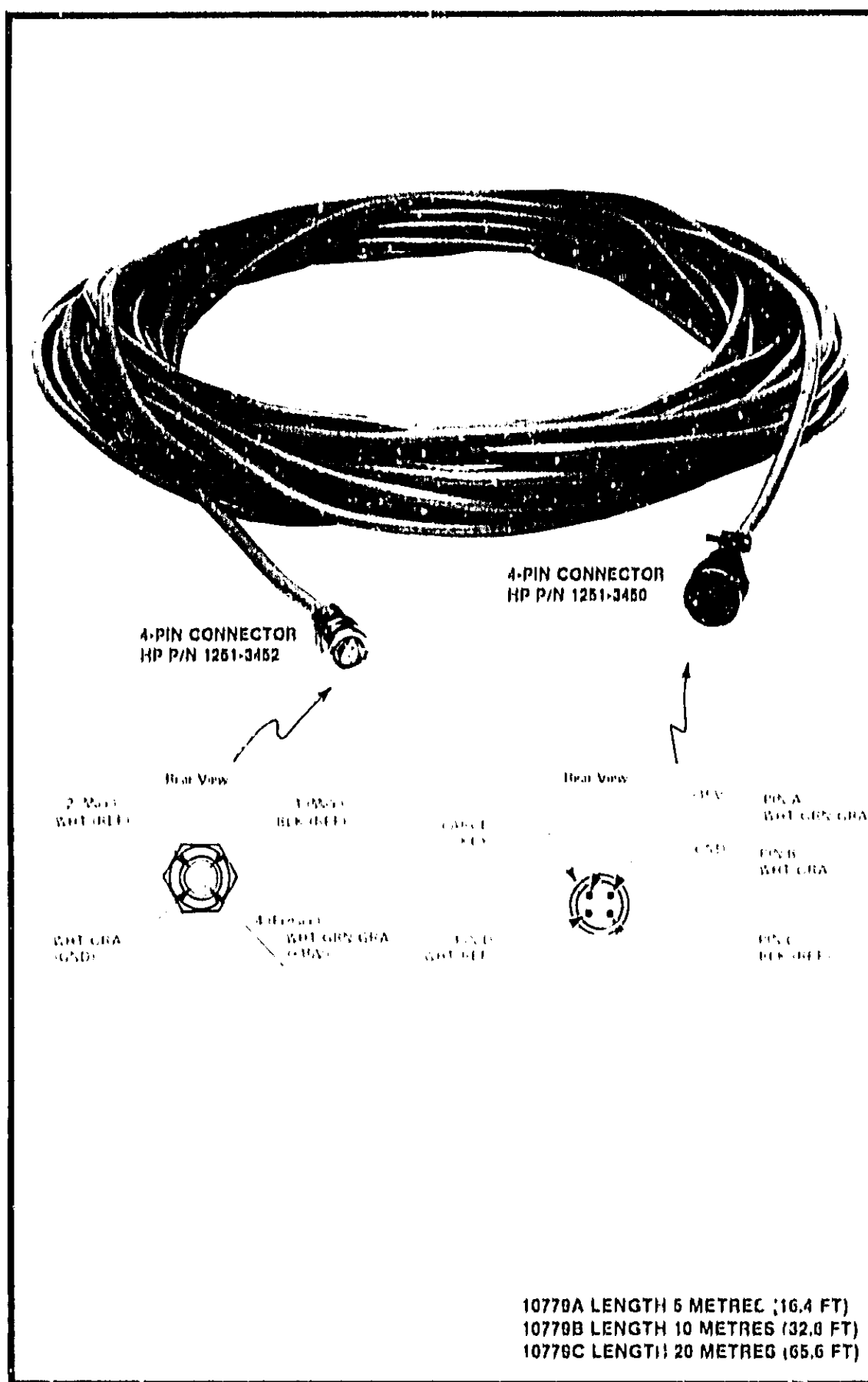


Figure C-2. 10779A,B,C Reference Cable

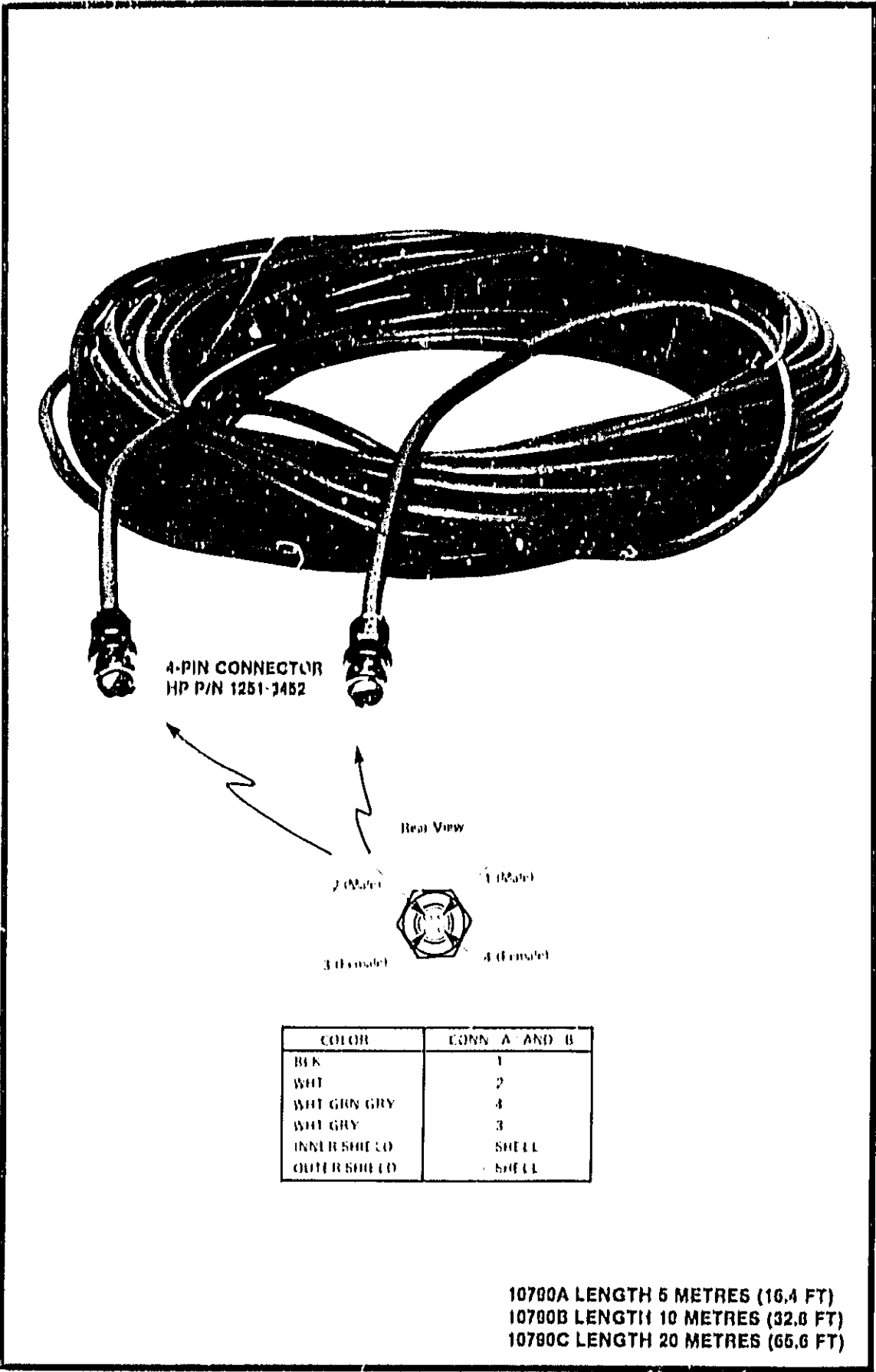


Figure C-3. 10790A,B,C Power and Measurement Cable

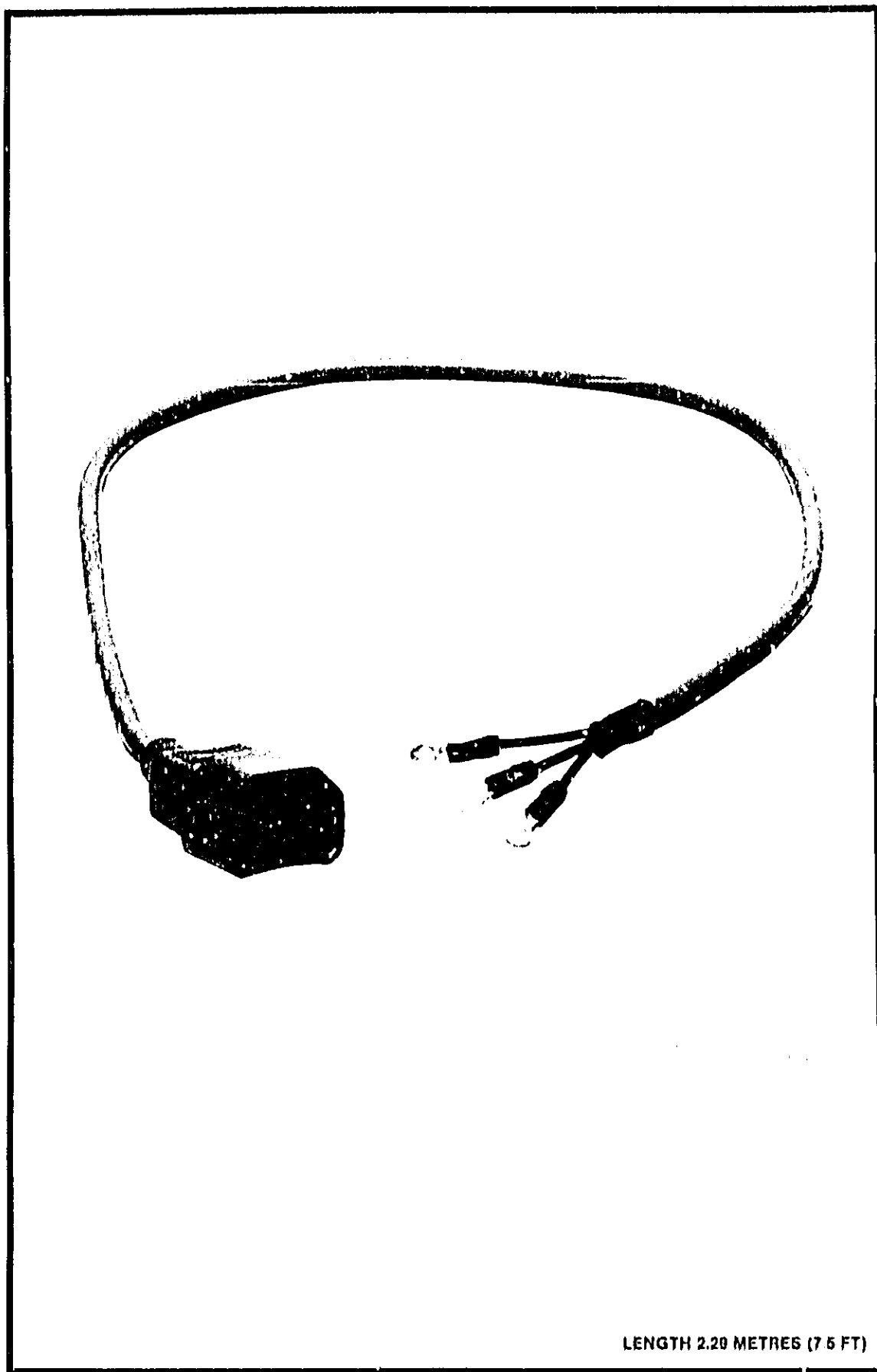
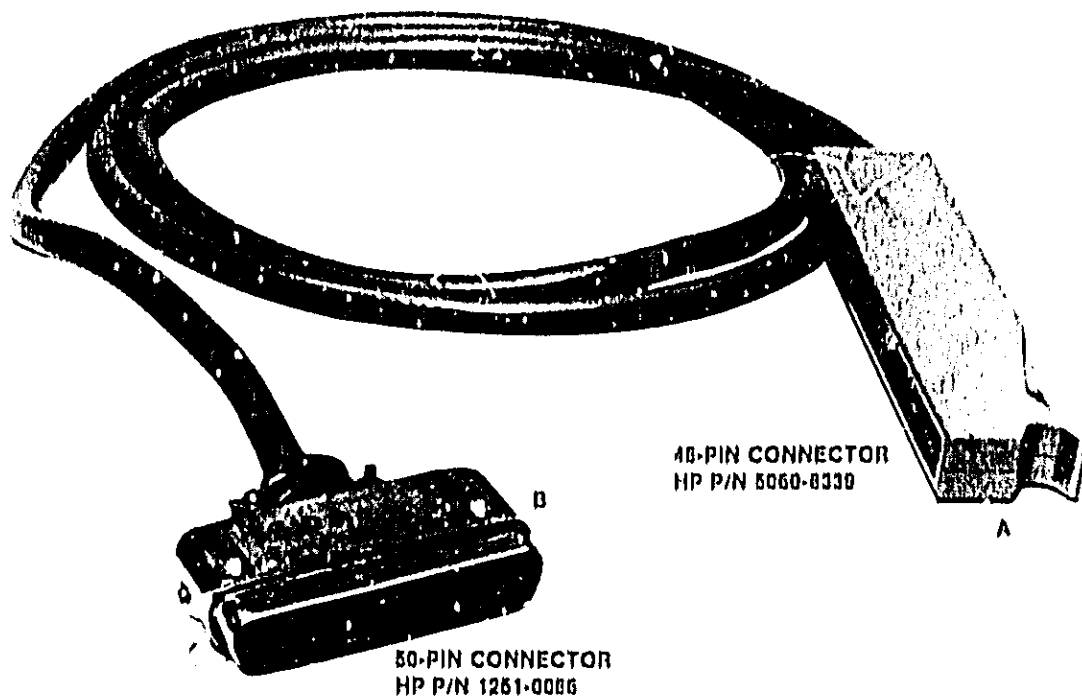


Figure C-4. 10708-60001 Primary Power Cable



CONN A PIN NO.	COLOR	CONN B PIN NO.
1	BRN	9
2	RED	22
3	ORN	47
4	YEL	45
5	GRN	10
6	BLU	21
7	VIO	46
8	GRA	44
9	WHT	16
10	WHT-BLK	23
11	WHT-BRN	49
12	WHT-RED	42
13	WHT-ORN	17
14	WHT-YEL	24
15	WHT-GRN	48
16	WHT-BLU	25
23 AA	WHT-VIO	8
24 BB	SHIELD	3, 10, 26, 35, 46

CONN A PIN NO.	COLOR	CONN B PIN NO.
A	WHT-BLK-BRN	14
B	WHT-BLK-RED	15
C	WHT-BLK-ORN	12
D	WHT-BLK-YEL	32
E	WHT-BLK-GRN	36
F	WHT-BLK-BLU	29
G	WHT-BLK-VIO	30
H	WHT-BLK-GRA	31
K	WHT-BRN-RED	34
L	WHT-BRN-ORN	33
M	WHT-BRN-YEL	35

LENGTH 4.57 METRES (15 FT)

Figure C-5. 10712-60001 Signal and Power Cable

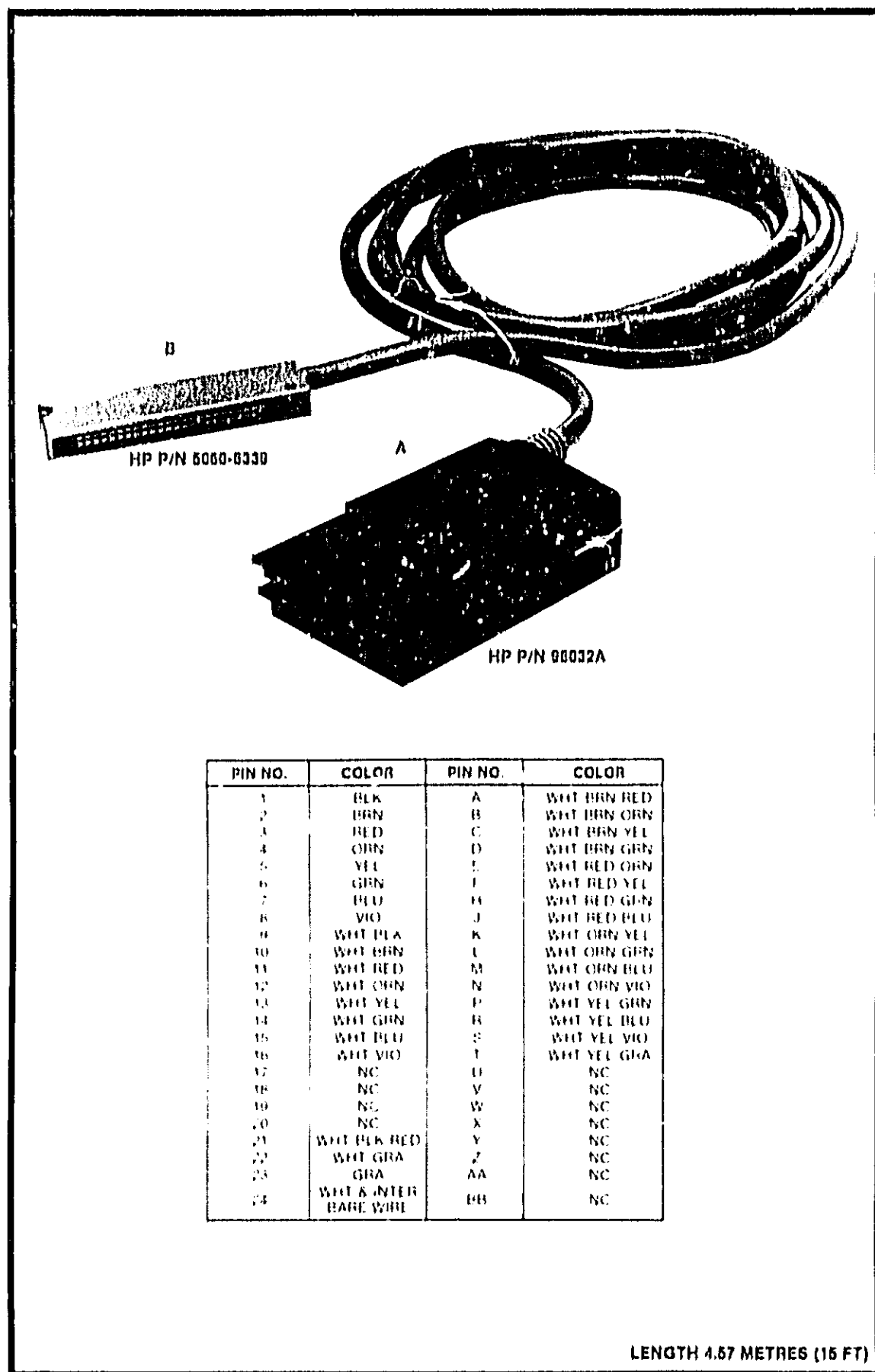


Figure C-6. 10727-60001 Calculator Interface Cable

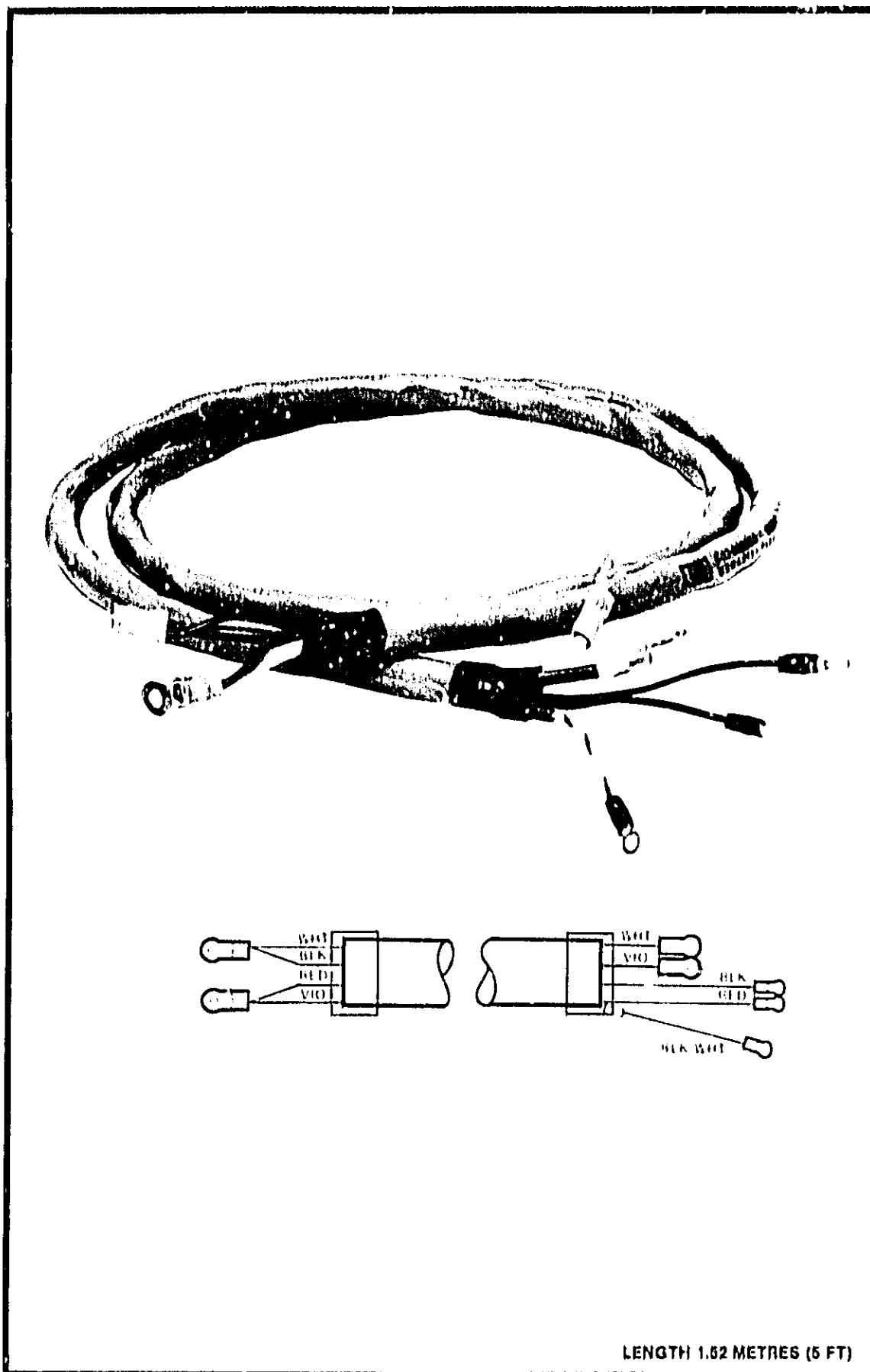


Figure C-7. 10740-60004 Power Cable

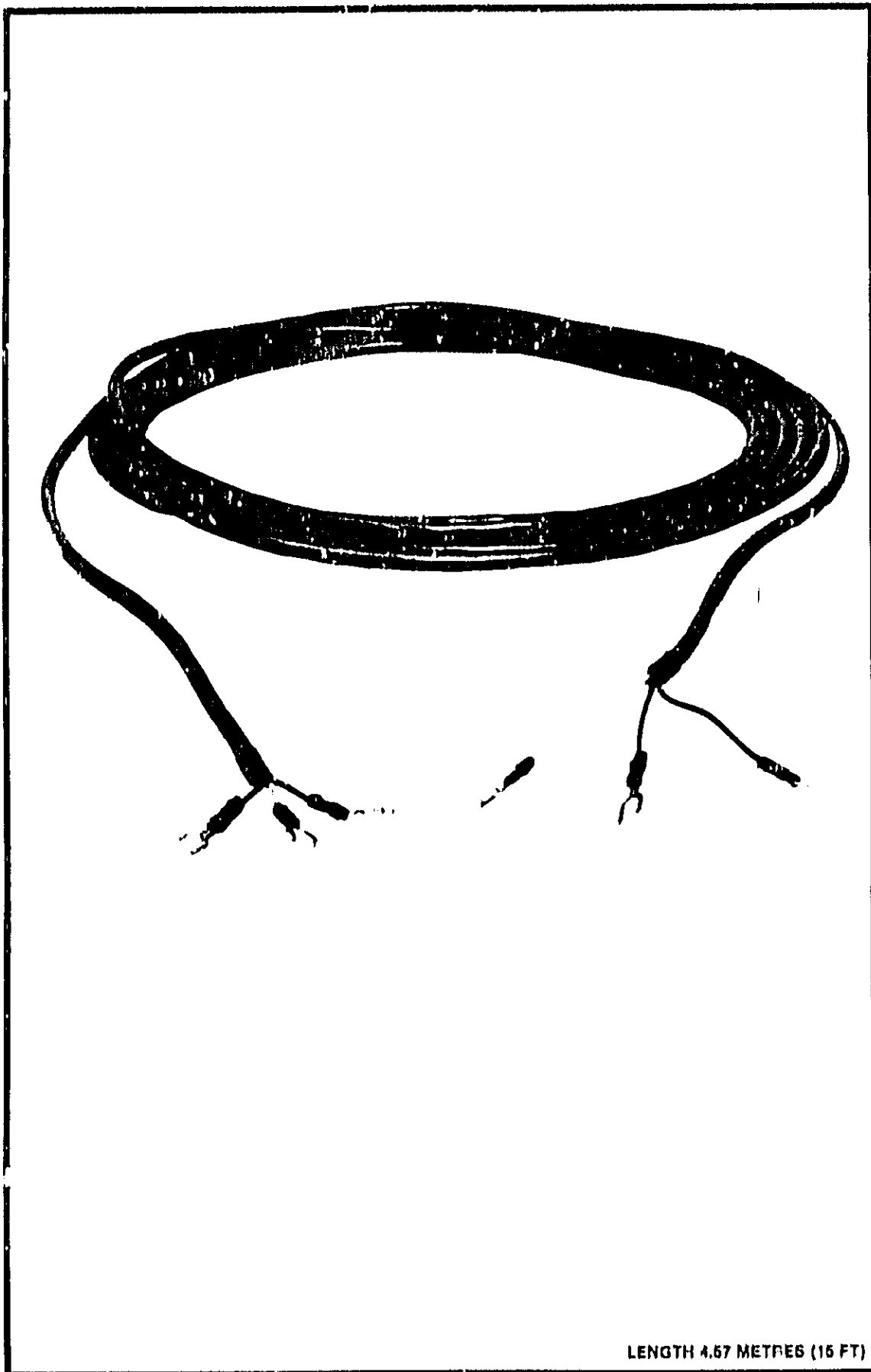


Figure C-8. 10740-60005 Power Cable

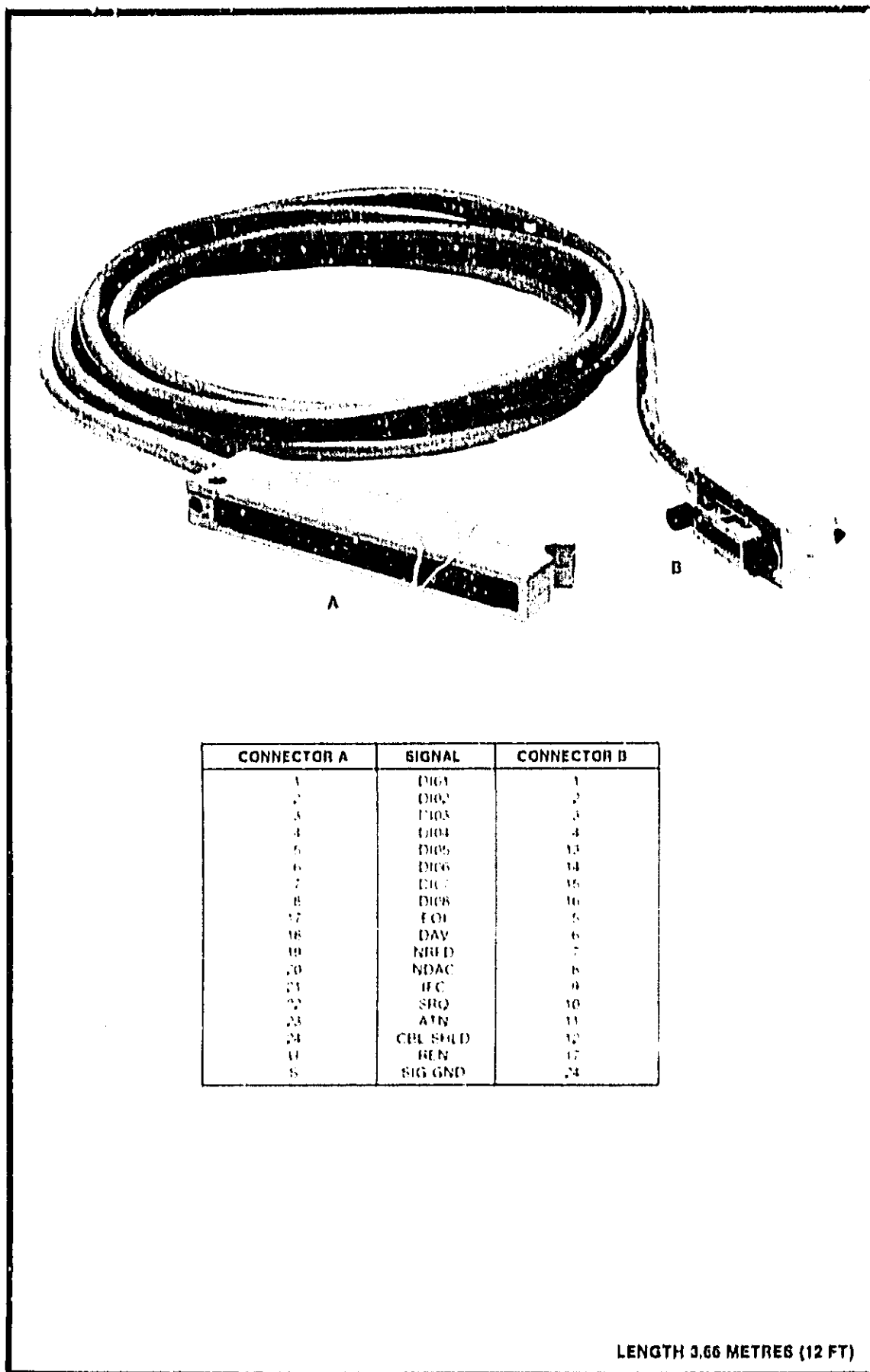


Figure C-9. 10745-60002 Interface Cable

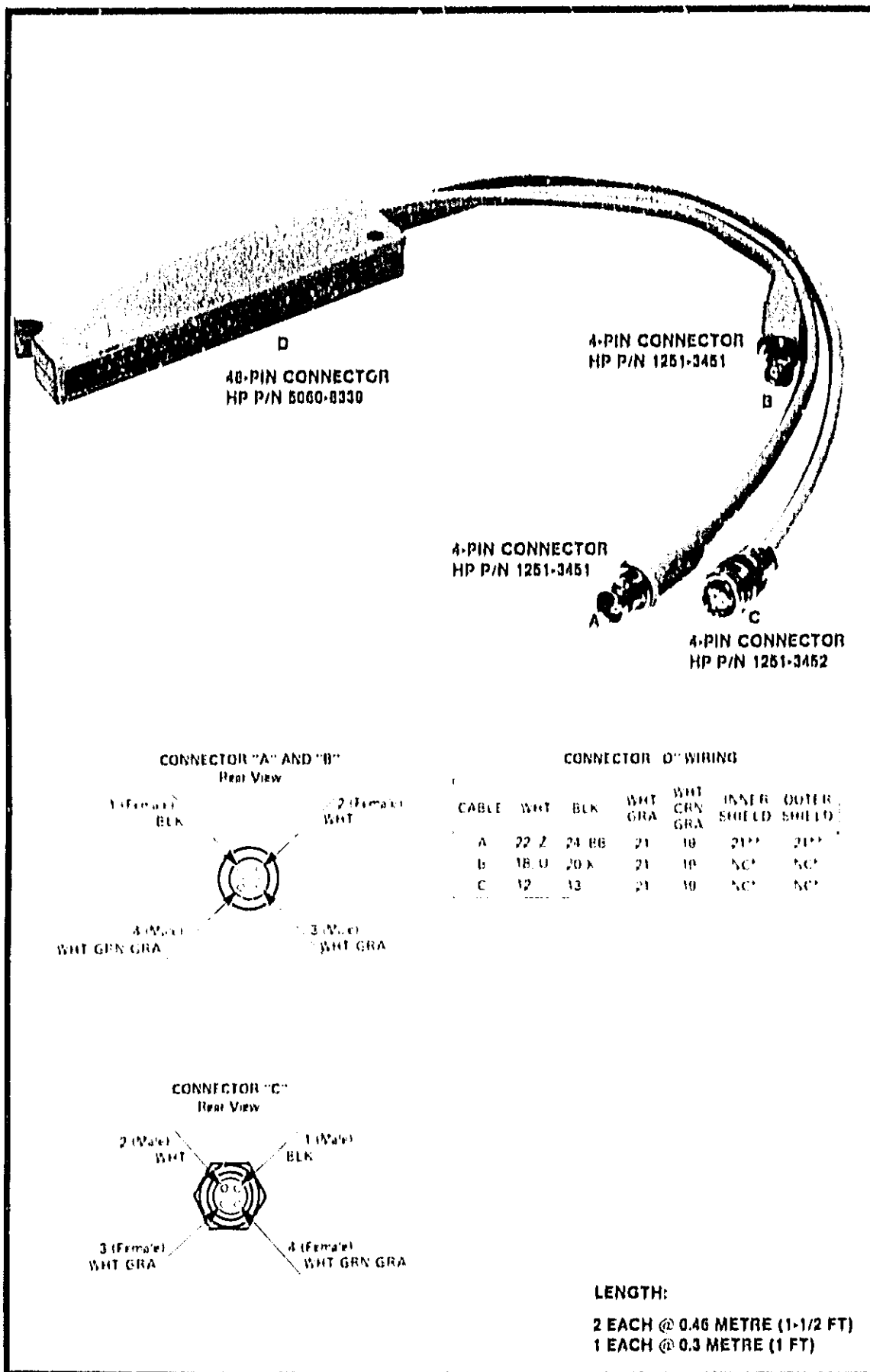


Figure C-10. 10760-60002 Reference Cable

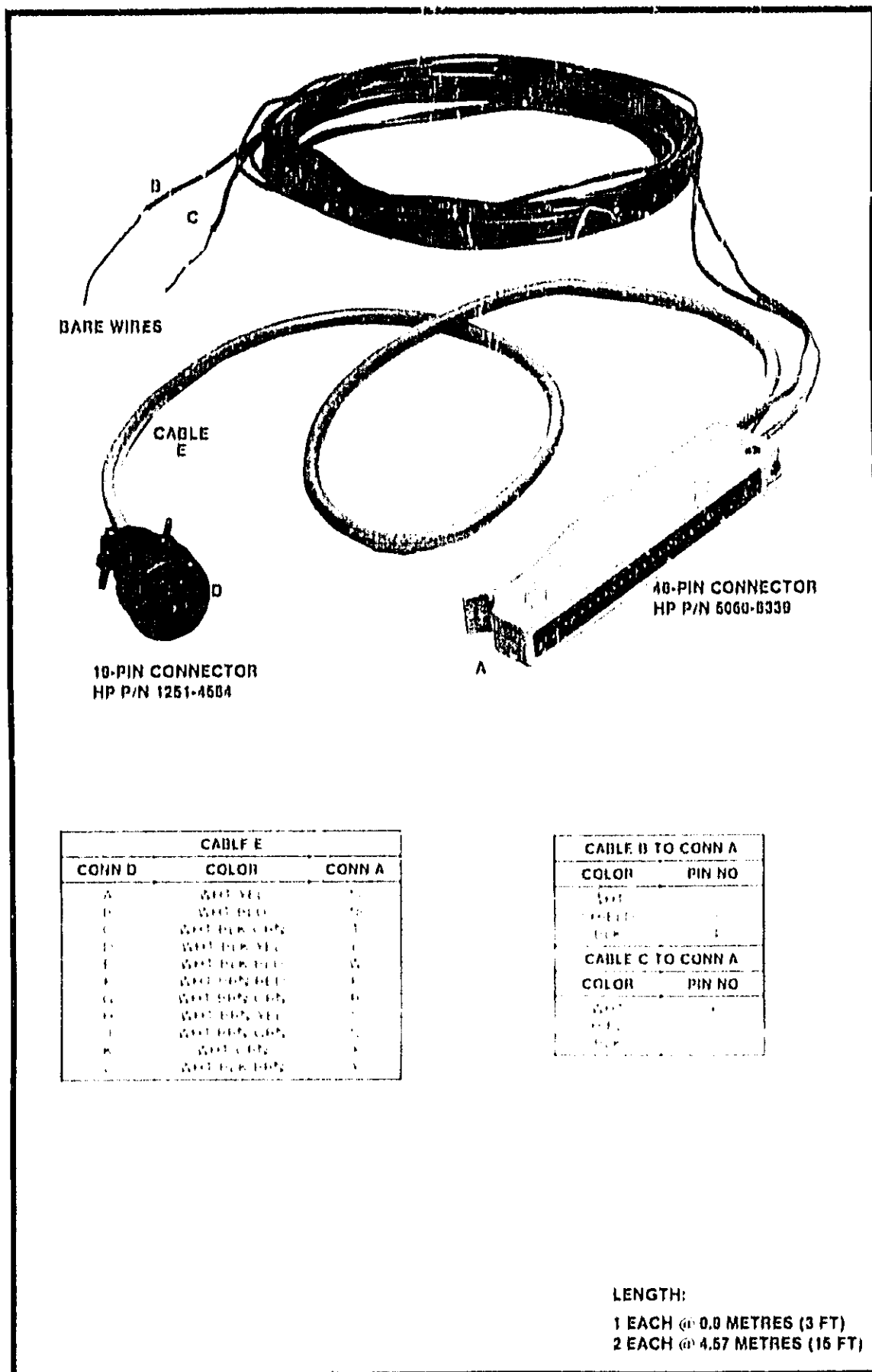


Figure C-11. 10763-60002 Controller Interface Cable

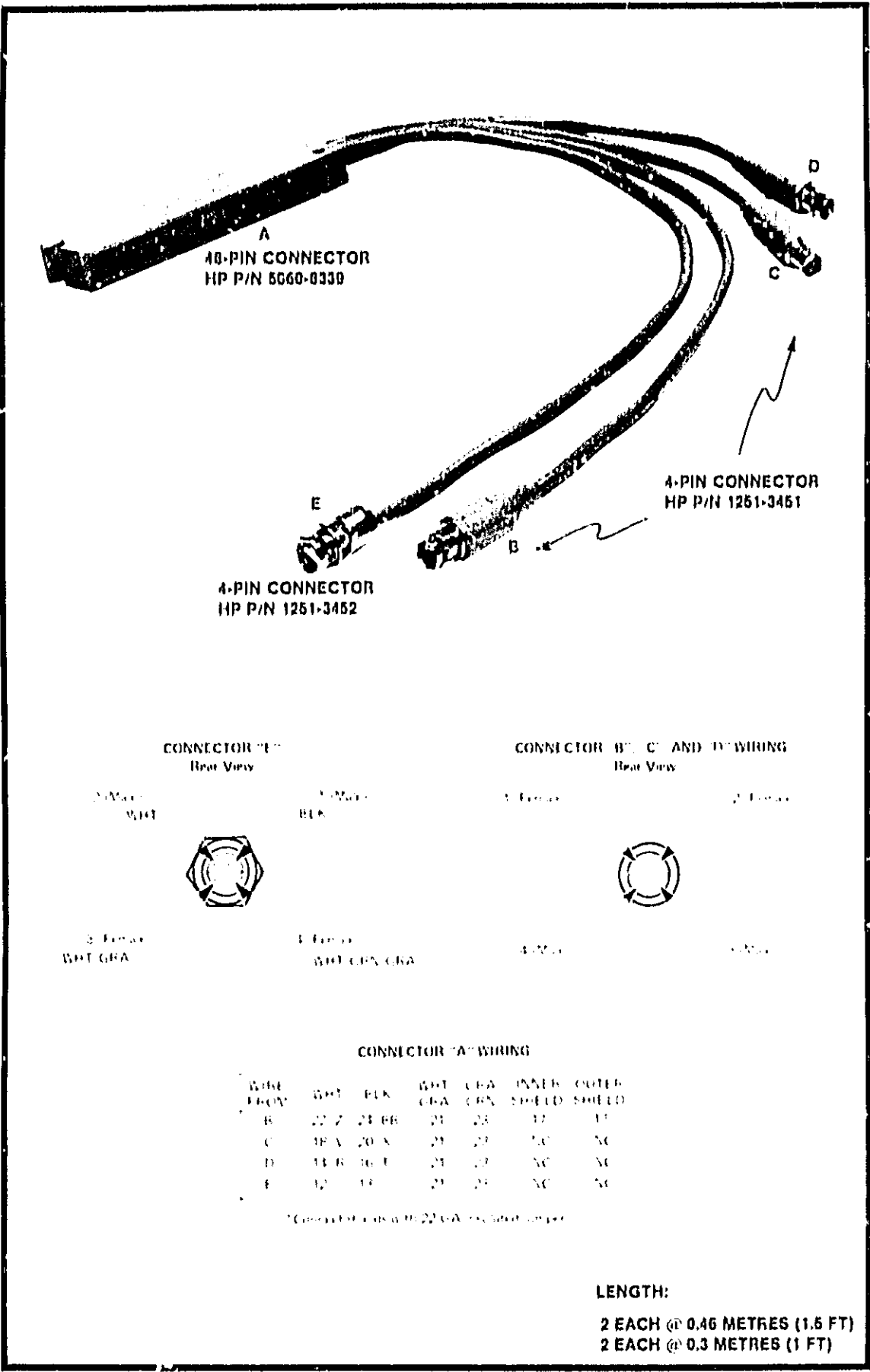


Figure C-12. 10764-60005 Reference and Doppler Cable

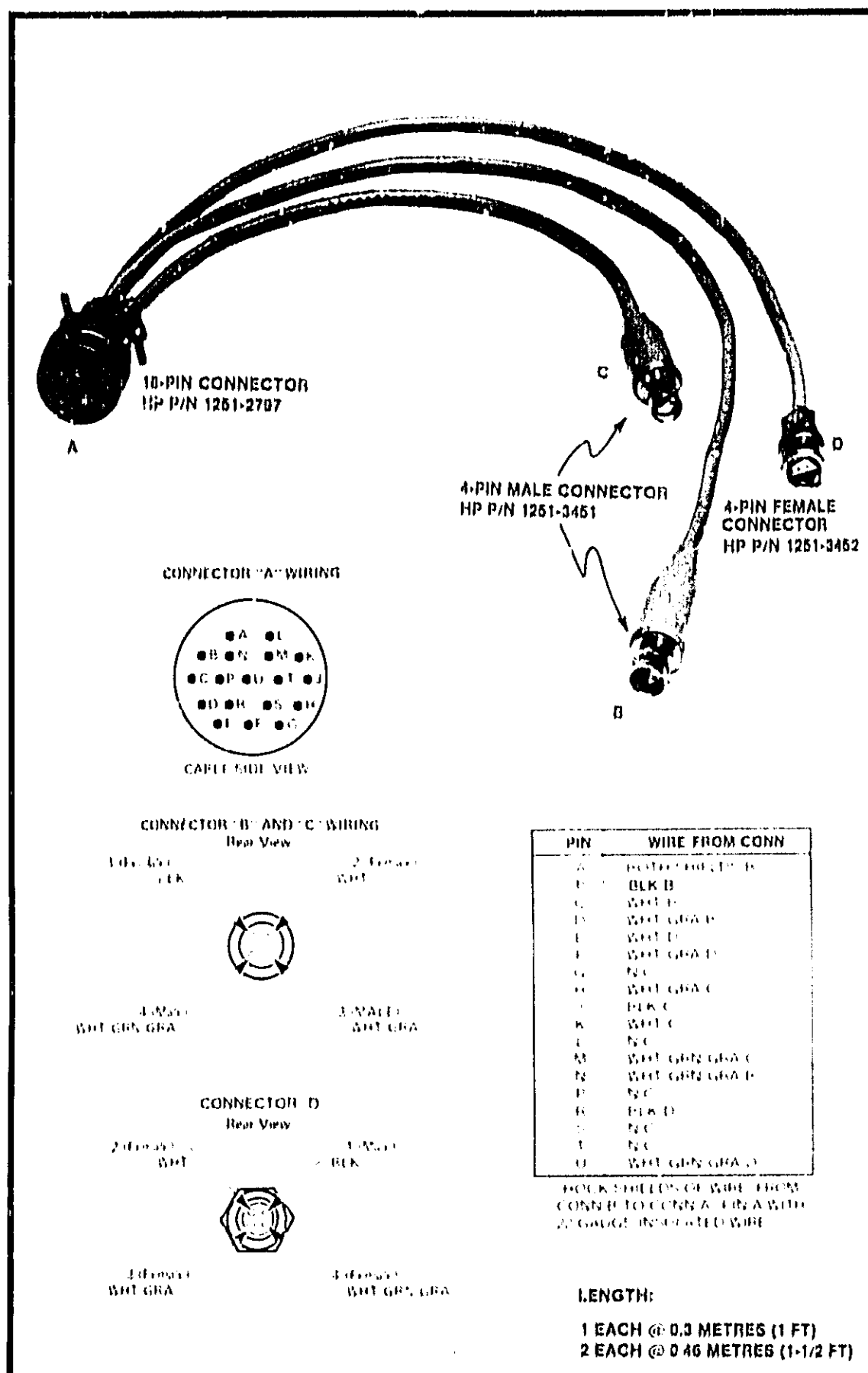


Figure C-13. 10781-60003 Reference and Doppler Cable

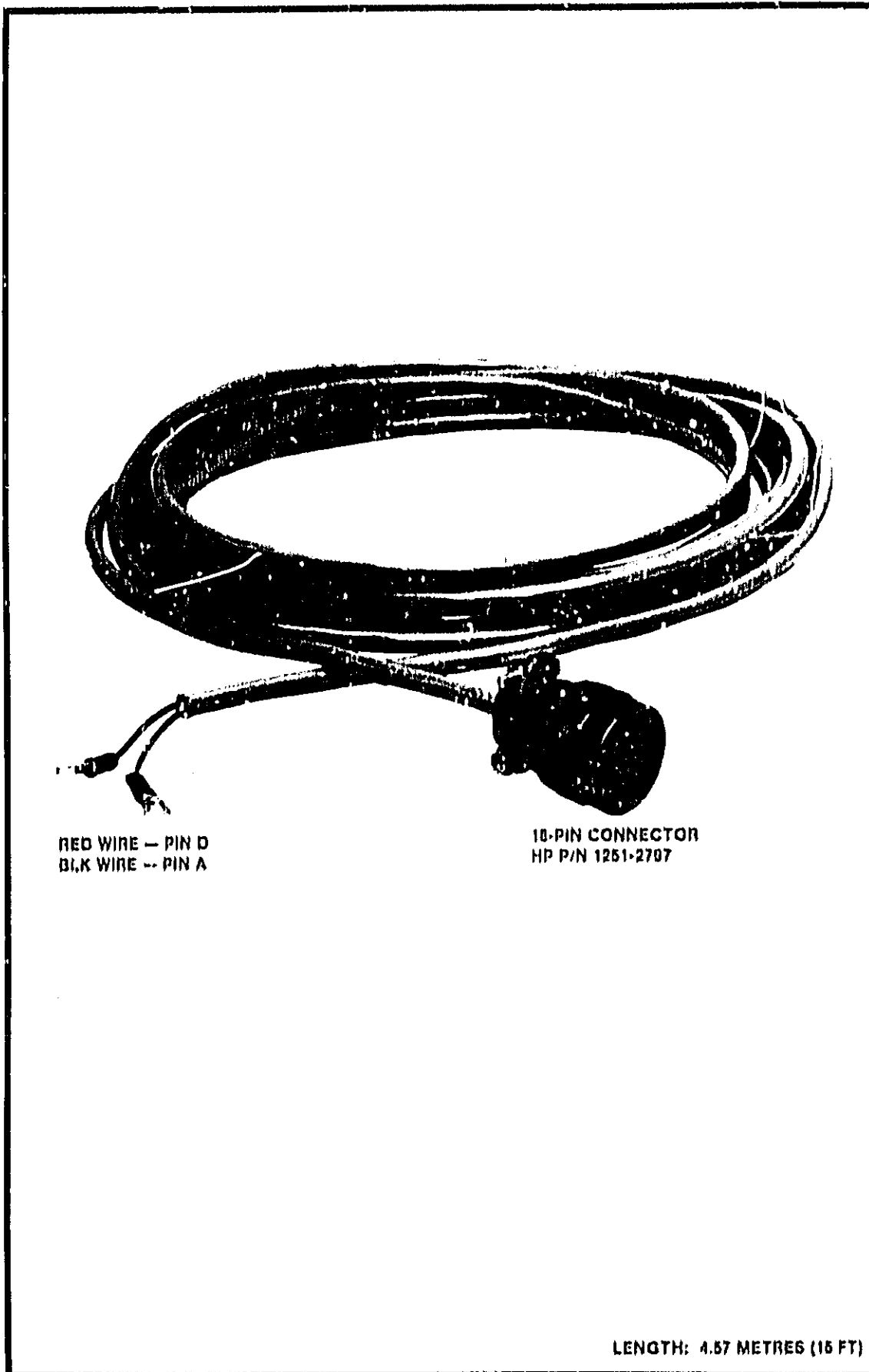


Figure C-14. 10781-60004 Power Cable

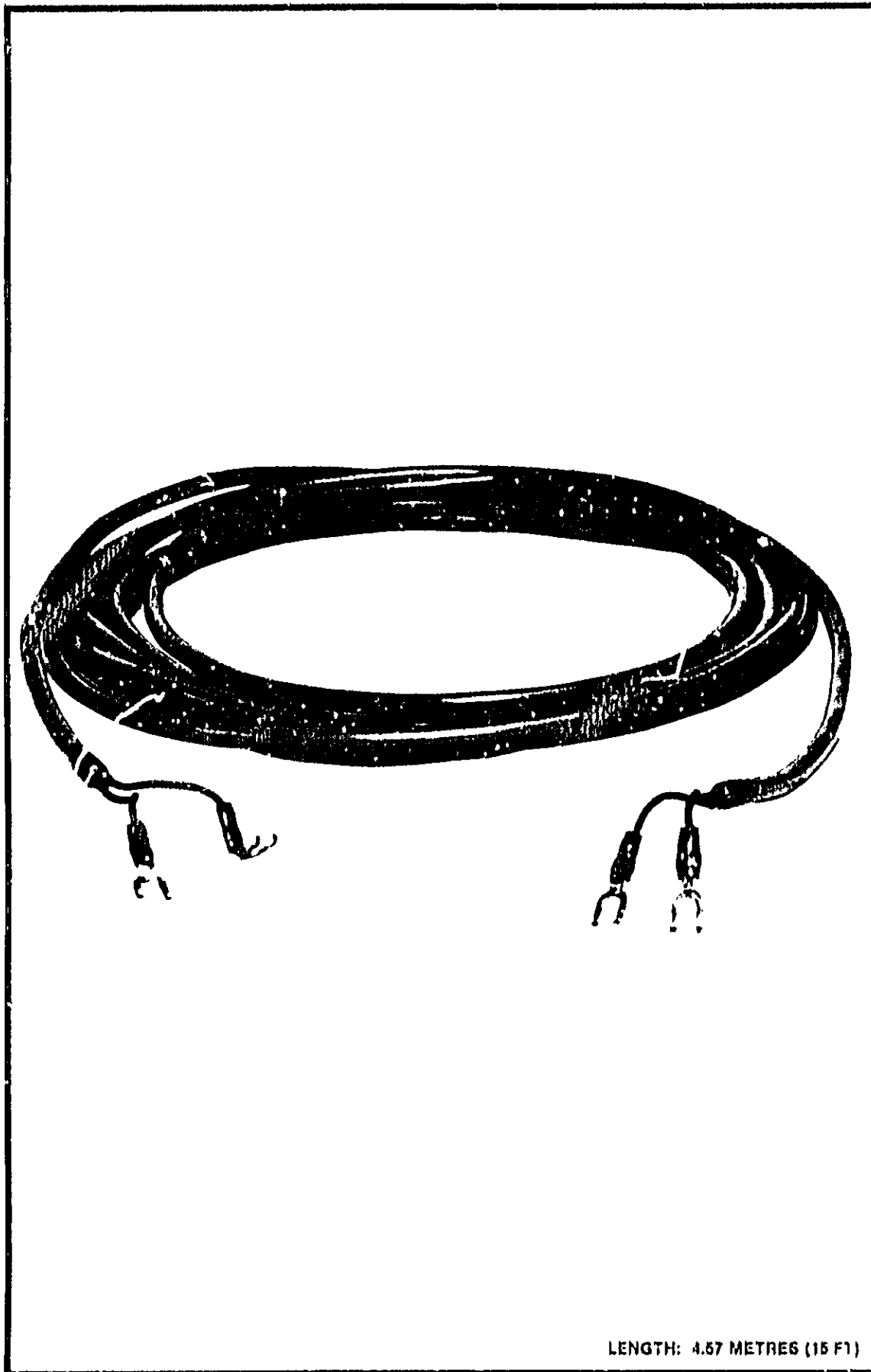


Figure C-15 10783-60001 Power Cable

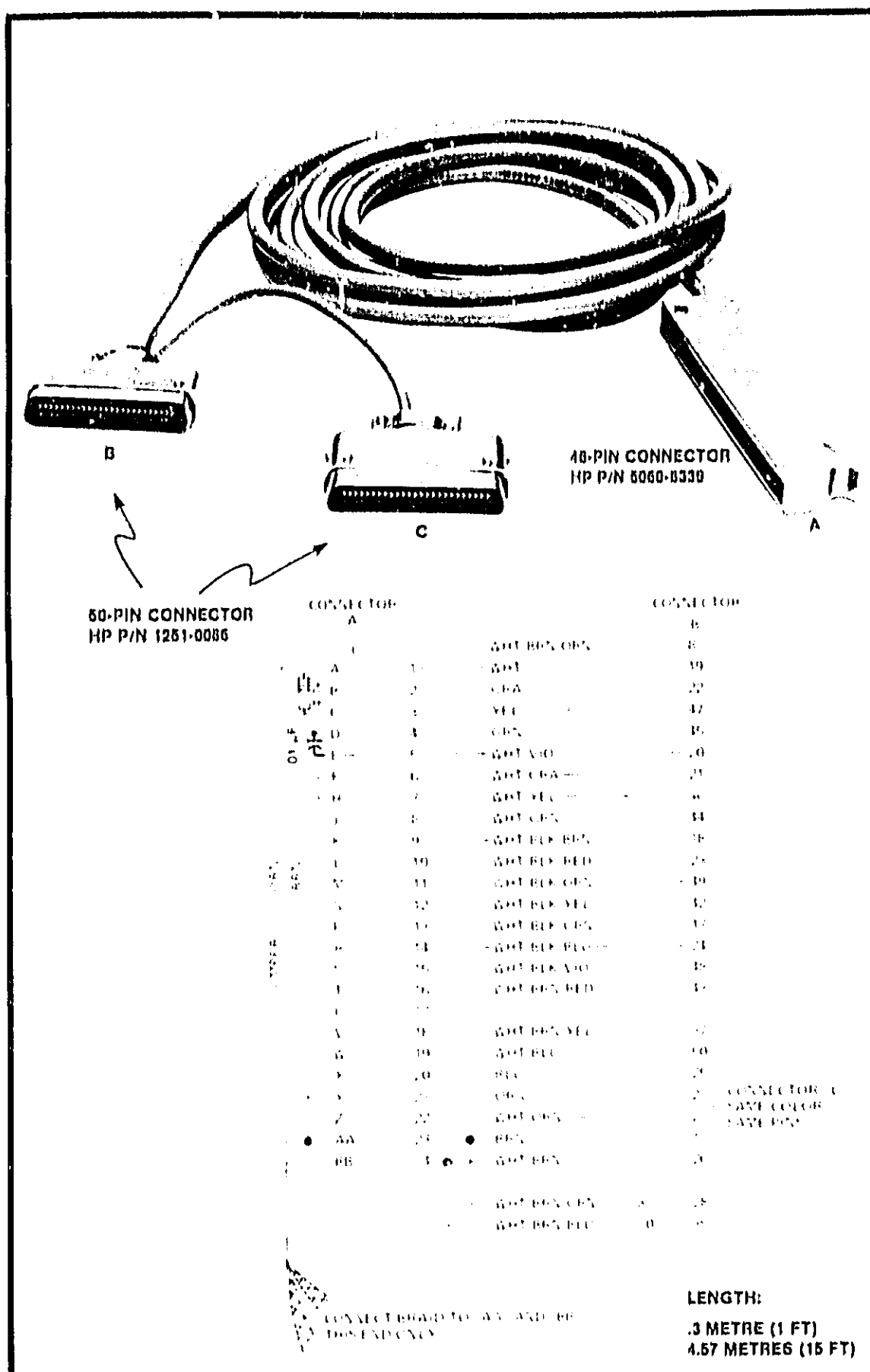
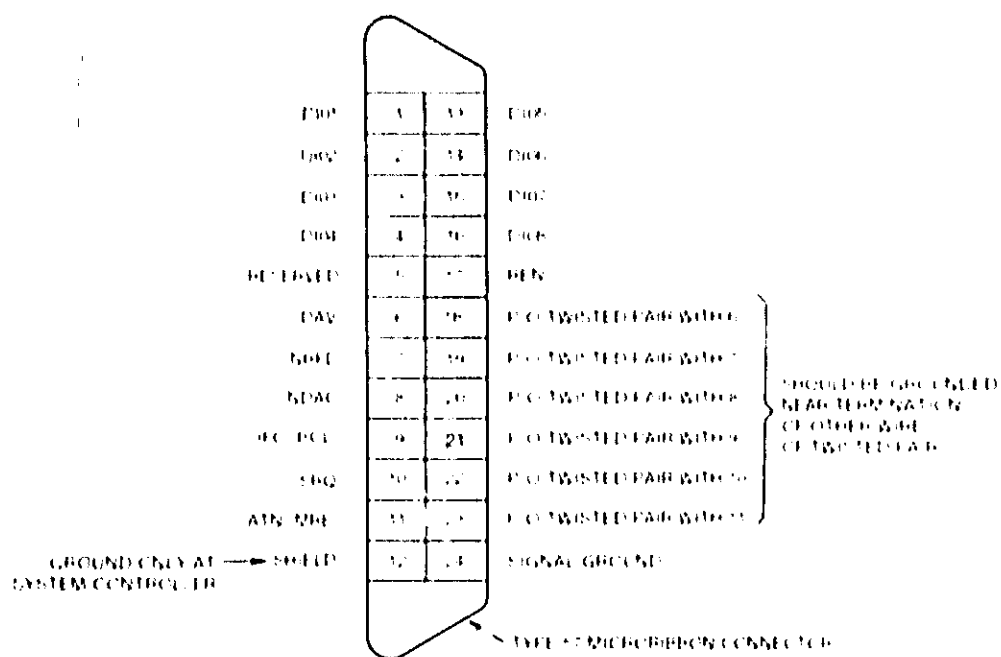
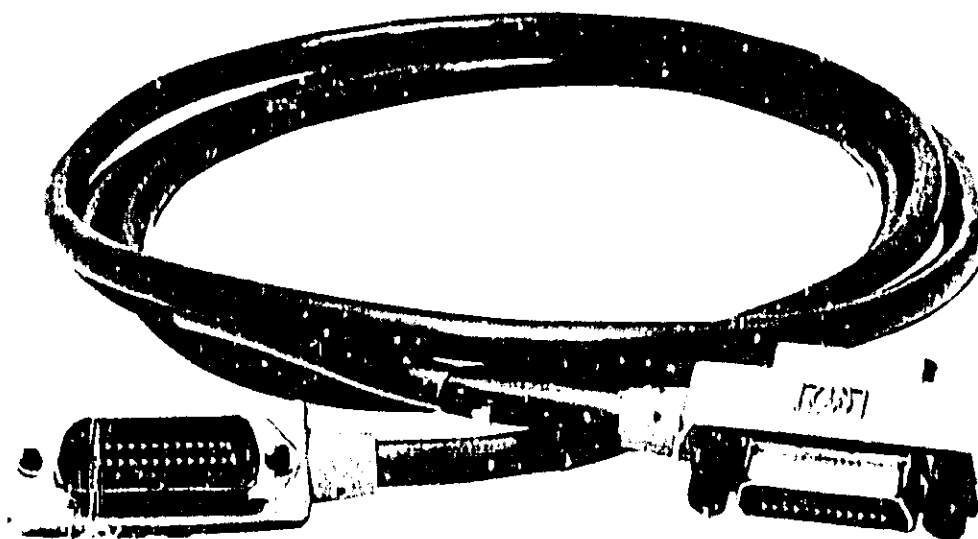


Figure C-16. 05510-60022 V.C.L. Cable



LENGTH:
 .9 METRE (3 FT)
 1.83 METRES (6 FT)
 3.66 METRES (12 FT)

Figure C-17. 10631A,B,C HP-IB Cables

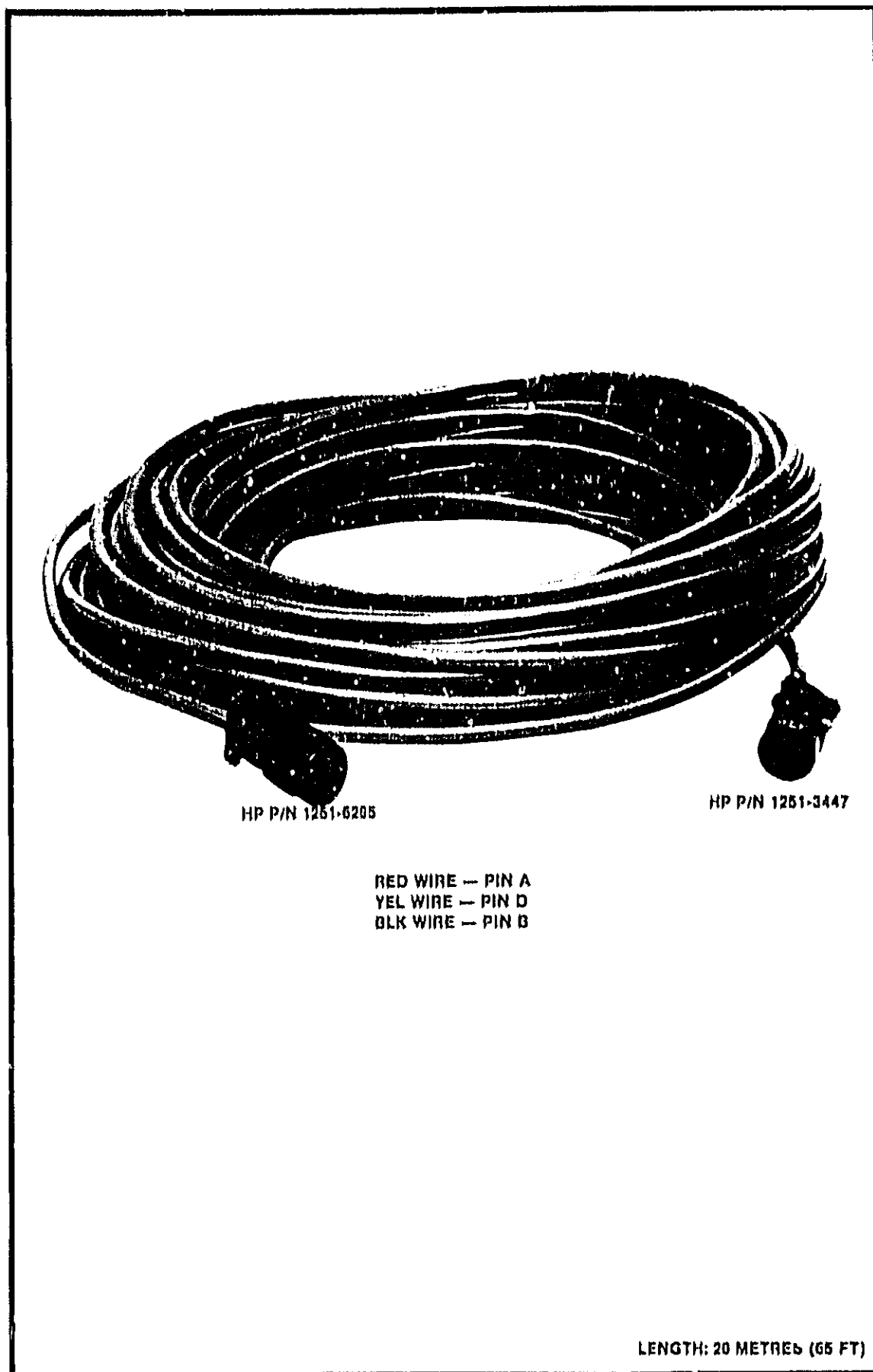


Figure C-18. 10714-60003 Power Cable

APPENDIX

D

appendix D

Expansion Coefficients

For your convenience, *Table D-1* provides the linear thermal expansion coefficients of the most frequently used metals and alloys.

Table D-1. Linear Thermal Expansion Coefficients of Metals and Alloys

Alloy	Coefficient of Expansion		Alloy	Coefficient of Expansion	
	ppm °C	ppm °F		ppm °C	ppm °F
Aluminum and Aluminum Alloys			Wrought Alloys		
Aluminum (99.996%)	23.6	13.1	Gilding, 95%	18.1	10.1
Wrought Alloys			Commercial Bronze, 90%	18.4	10.3
LC 1060 and 1100	23.6	13.1	Jewelry Bronze, 87.5%	18.6	10.4
2011 and 2014	23.0	12.8	Red Brass, 85%	18.7	10.4
2024	22.8	12.7	Low Brass, 80%	19.1	10.6
2218	22.3	12.4	Cartridge Brass, 70%	19.9	11.1
3003	23.2	12.9	Yellow Brass	20.3	11.2
4032	19.4	10.8	Muntz Metal	20.8	11.5
5005, 5050, and 5052	23.8	13.3	Leaded Commercial Bronze	18.4	10.2
5056	24.1	13.4	Low-Leaded Brass	20.2	11.3
5083	23.4	13.0	Medium-Leaded Brass	20.3	11.3
5086	23.9	13.3	High-Leaded Brass	20.3	11.3
5154	23.9	13.3	Extra-High-Leaded Brass	20.5	11.4
5357	23.7	13.2	Free-Cutting Brass	20.5	11.4
5456	23.9	13.3	Leaded Muntz Metal	20.8	11.6
6061 and 6063	23.4	13.0	Forging Brass	20.7	11.5
6101 and 6151	23.0	12.8	Architectural Bronze	20.9	11.6
7075	23.2	12.9	Inhibited Admiralty	20.2	11.3
7090 and 7178	23.4	13.0	Naval Brass	21.2	11.8
Castling Alloys			Leaded Naval Brass	21.2	11.8
A13	20.4	11.4	Manganese Bronze (A)	21.2	11.2
43 and 108	22.0	12.3	Phosphorous Bronze, 5% (A)	17.8	9.9
A108	21.5	12.0	Phosphorous Bronze, 8% (C)	18.2	10.1
A132	19.0	10.6	Phosphorous Bronze, 10% (D)	18.4	10.3
D132	20.5	11.4	Phosphorous Bronze, 1.25%	17.8	9.9
F132	20.7	11.5	Free-Cutting Phosphorous Bronze	17.3	9.6
138	21.4	11.9	Cupro-Nickel, 30%	16.2	9.0
142	22.5	12.5	Cupro Nickel, 10%	17.1	9.5
195	23.0	12.8	Nickel Silver, 65-18	16.2	9.0
B195	22.0	12.3	Nickel Silver, 55-18	16.7	9.3
214	24.0	13.4	Nickel Silver, 65-12	16.2	9.0
220	25.0	13.9	High-Silicon Bronze (A)	18.0	10.0
319	21.5	12.0	Low-Silicon Bronze (B)	17.9	10.0
355	22.0	12.3	Aluminum Bronze (J)	16.4	9.2
356	21.5	12.0	Aluminum-Silicon Bronze	18.0	10.0
360	21.0	11.7	Aluminum Bronze	16.8	9.4
753	23.1	12.9	Beryllium Copper	17.8	9.9
40E	24.7	13.8	Castling Alloys		
Copper and Copper Alloys			88 Cu - 8 Sn - 4 Zn	18.0	10.0
Wrought Coppers			89 Cu - 11 Sn	18.4	10.3
Pure Copper	16.5	9.2	88 Cu - 6 Sn - 1.5 Pb - 4.5 Zn	18.5	10.3
Electrolytic Tough Pitch	16.8	9.4	87 Cu - 8 Sn - 1 Pb - 4 Zn	18.0	10.0
Copper (ETP)			87 Cu - 10 Sn - 1 Pb - 2 Zn	18.0	10.0
Deoxidized Copper, High Resi-	17.7	9.9	80 Cu - 10 Sn - 10 Pb	18.5	10.3
dual Phosphorous (DHP)			78 Cu - 7 Sn - 15 Pb	18.5	10.3
Oxygen-Free Copper	17.7	9.9	85 Cu - 5 Sn - 5 Pb - 5 Zn	18.1	10.0
Free-Machining Copper:	17.7	9.9	72 Cu - 1 Sn - 3 Pb - 24 Zn	20.7	11.5
0.5% Te or 1% Pb			67 Cu - 1 Sn - 3 Pb - 29 Zn	20.2	11.3
			61 Cu - 1 Sn - 1 Pb - 37 Zn	21.6	12.0
			Manganese Bronze (60,000 psi)	20.5	11.4
			Manganese Bronze (65,000 psi)	21.6	12.0

Table D-1. Linear Thermal Expansion Coefficients of Metals and Alloys

Alloy	Coefficient of Expansion		Alloy	Coefficient of Expansion	
	ppm °C	ppm °F		ppm °C	ppm °F
Manganese Bronze (110,000 psi)	19.8	11.0	Nickel and Nickel Alloys		
Aluminum Bronze (Alloy 9A)	17.0	9.5	Nickel (99.95% Ni + Co)	13.3	7.4
Aluminum Bronze (Alloy 9B)	17.0	9.5	Duranickel	13.0	7.2
Aluminum Bronze (Alloys 9C & 9D)	16.2	9.0	Monel	14.0	7.8
Iron and Iron Alloys			Monel (cast)	12.9	7.2
Pure Iron	11.7	6.5	Inconel	11.5	6.4
Fe - C Alloys			Ni-ni-nel	12.9	7.2
0.06% C	11.7	6.5	Hastelloy B	10.0	5.6
0.22% C	11.7	6.5	Hastelloy C	11.3	6.3
0.40% C	11.3	6.3	Hastelloy D	11.0	6.1
0.56% C	11.0	6.1	Hastelloy E	14.2	7.9
1.00% C	10.8	6.0	Hastelloy N	10.4	5.8
1.45% C	10.1	5.6	Hastelloy W	11.3	6.3
Invar (36 Ni)	0 to 2	to 1.1	Hastelloy X	13.8	7.7
13 Mn - 1.2 C	10.0	10.0	Illium G	12.19	6.8
13 Cr - 0.35 C	10.0	5.6	Illium R	12.02	6.7
12.0 Cr - 0.4 Ni - 0.09 C	9.8	5.5	80 Ni - 20 Cr	17.3	9.6
17.7 Cr - 9.6 Ni - 0.06 C	16.5	9.2	60 Ni - 24 Fe - 16 Cr	17.0	9.5
18 W - 4 Cr - 1 V	11.2	6.2	35 Ni - 45 Fe - 20 Cr	15.8	8.8
Gray Cast Iron	10.5	5.7	Constantan	18.8	10.5
Malleable Iron (Pearlitic)	12.0	6.7	Stainless Steels		
Lead and Lead Alloys			301	16.9	9.4
Corroding Lead (99.73% Pb)	29.3	16.3	302	17.3	9.6
5-20 Solder	28.7	16.0	302B	16.2	9.0
20-80 Solder	26.5	14.8	303	17.3	9.6
50-50 Solder	23.4	13.0	304	17.3	9.6
1% Antimonial Lead	28.8	16.1	305	17.3	9.6
Hard Lead (96 Pb, 4 Sb)	27.8	15.5	308	17.3	9.6
Hard Lead (94 Pb, 6 Sb)	27.2	15.2	309	14.9	8.3
8% Antimonial Lead	26.7	14.9	310	14.4	8.0
9% Antimonial Lead	26.4	14.7	314	15.1	8.4
Lead-Base Babbitt:			316	16.0	8.9
SAE 14	19.6	10.9	317	16.0	8.9
Alloy 8	24.0	13.4	321	16.7	9.3
Magnesium and Magnesium Alloys			347	16.7	9.3
Magnesium (99.8%)	25.2	14.1	501	11.15	6.2
Castling Alloys			502	11.15	6.2
AM100A	25.2	14.1	403	9.9	5.5
AZ63A	26.1	14.6	405	10.8	6.0
AZ91A, B, C	26.0	14.5	410	11.0	6.1
AZ92A	25.2	14.1	416	9.9	5.5
HZ32A	26.7	14.9	420	10.25	5.7
ZH42	27.0	15.1	430	10.45	5.8
ZH62A	27.1	15.1	430F	10.45	5.8
ZK51A	26.1	14.6	431	11.7	6.5
EZ33A	26.1	14.6	440A	10.1	5.6
EK30A and EK41A	26.1	14.6	440B	10.1	5.6
Wrought Alloys			440C	10.1	5.6
M1A and A3A	26.0	14.5	446	10.6	5.9
AZ31B and PE	26.0	14.5			
AZ61A and AZ80A	26.0	14.5			
ZK60A, B	26.0	14.5			
HM31A	26.1	14.6			

Table D-1. Linear Thermal Expansion Coefficients of Metals and Alloys

Alloy	Coefficient of Expansion		Alloy	Coefficient of Expansion	
	ppm °C	ppm °F		ppm °C	ppm °F
Titanium and Titanium Alloys					
99.9% Ti	8.41	4.7	Cobalt	13.8	7.7
99.0% Ti	8.55	4.76	Gold	14.2	7.9
Ti - 5 Al - 2.5 Sn	9.36	5.2	Iridium	6.8	3.8
Ti - 8 Mn	8.64	4.8	Lithium	56.0	31.0
Zinc and Zinc Alloys			Manganese	22.0	12.3
Pure Zinc	39.7	22.1	Palladium	11.76	6.6
AC40A Alloy	27.4	15.3	Platinum	8.9	5.0
AC41A Alloy	27.4	15.3	Rhenium	6.7	3.7
Commercial Rolled Zinc: 0.08 Pb	32.5	18.1	Rhodium	8.3	4.6
0.3 Pb, 0.3 Cd	33.9*	18.9	Ruthenium	9.1	5.1
Roller Zinc Alloy (1 Cu, 0.010 Mg)	34.8**	19.4	Silicon	5.0	2.8
Zn-Cu-Ti Alloy (0.8 Cu, 0.15 Ti)	24.9***	13.9	Silver	19.68	11.0
Pure Metals			Tungsten	4.6	2.7
Beryllium	11.6	6.5	Vandium	8.3	4.6
Cadmium	29.8	16.6	Zirconium	5.85	3.3
Calcium	22.3	12.4			
Chromium	6.2	3.5			

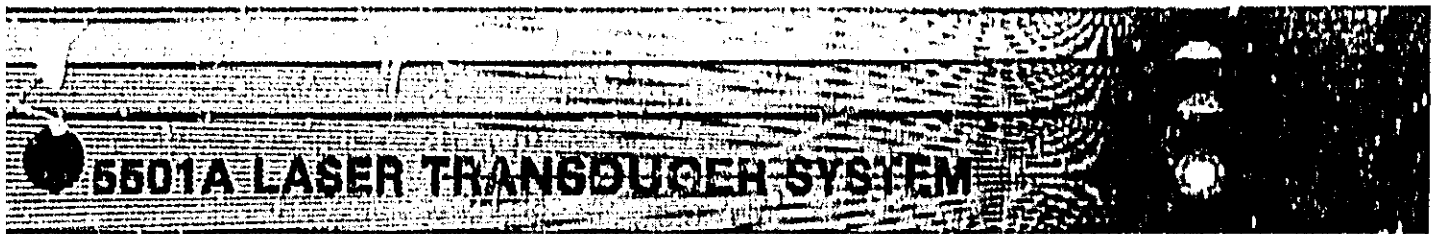
*With the grain; 23.4 across the grain

**With the grain; 21.1 across the grain

***With the grain; 19.4 across the grain

APPENDIX

E



appendix E

Backdating

E.1 INTRODUCTION

Systems purchased prior to December 31, 1979 (serial prefixes below 1948A) were available by option and special option numbers. These have been replaced with a new model number ordering system. *Table E-1* lists the old option numbers and the components that composed them. *Table E-2* lists special option numbers and their corresponding new model numbers.

For calculator-based systems, the calculators and accessories are no longer available as options to the 5501 system, but may be ordered directly by model number. Included in this backdating section is the Calculator Interface Electronics Checkout procedure.

Systems ordered after December 31, 1979 are supplied with all necessary cables fully assembled. Older systems required fabrication of certain cables or ordering special option cables. Included in this backdating section are fabrication instructions for these cables.

Systems prior to series prefix 2020 had different part numbers for certain cables as follows:

IS (Above Series 2020)	WAS (Prior to Series 2020)	Length of Older Cables
10778A,B,C	05501-60009	4.57 METRES (15 FT.)
10779A,B,C	05501-60008	2.0 METRES (65 FT.)
10790A,B,C	10780-60003	20 METRES (65 FT.)
10745-60002	59310-60002	

3.2 PREVIOUS OPTION NUMBERS

Tables E-1 and E-2 list the previous option numbers, descriptions, and equipment.

Table E-1. Description of Options (for systems purchased prior to December 31, 1979)

OPTION NUMBER	DESCRIPTION	EQUIPMENT
250	CALCULATOR INTERFACE ELECTRONICS Includes the 9825A Programmable Calculator and provides capability for input of 2 axes of measurement data with manual compensation input. Additional capabilities can be selected from options below.	9825A Calculator (64K Byte Memory) 98211A CPU ROM 98214A HP-IB Interface 10740A Coupler 10742A Counter driver 10745A HP-IB Interface 10755A Compensation Interface 10756A Manual Compensator 5501A Option 019 + 15V Power Supply 5501A Option 008 + 5V Power Supply
251	HP-IB INTERFACE ELECTRONICS Provides interface between 5501A Laser Transducer and any Hewlett Packard Interface Bus (HP-IB) compatible controller. Configured for two axes of measurement with manual compensation input. Additional capabilities can be selected from options below.	10740A Coupler 10742A Counter driver 10745A HP-IB Interface 10755A Compensation Interface 10756A Manual Compensator 5501A Option 019 + 15V Power Supply 5501A Option 008 + 5V Power Supply

EXTENDED MEASUREMENTS - CAPABILITY FOR OPTIONS 250 AND 251

OPTION NUMBER	DESCRIPTION	EQUIPMENT
400	Additional Measurement axes for Options 250 and 251. Can only be ordered when Options 250 and 251 are ordered.	10740A Coupler
401	Numeric Display for Options 250 and 251.	10701 Numeric Display 10641A HP-IB Cable
402	Automatic Compensation for Options 250 and 251. Also includes 10756A Manual Compensator. Includes interconnecting cables - 15m (15 ft). Can only be ordered when Options 250 or 251 ordered.	C 10740A Automatic Compensation
404	20 Volt Input Power Supplies for Options 250 and 251.	5501A Option 019 + 15V Power Supply 5501A Option 018 + 5V Power Supply

EXTENDED CALCULATOR CAPABILITY FOR OPTION 250

OPTION NUMBER	DESCRIPTION	EQUIPMENT
211	150K Byte Total Memory for 9825A Calculator in Option 250. Can only be ordered when Option 250 ordered.	9825A Option 001 Calculator
212	2122K Byte Total Memory for 9825A Calculator in Option 250. Can only be ordered when Option 250 ordered.	9825A Option 002 Calculator
213	String variables and advanced programming capability for 9825A Calculator in Option 250. Can only be ordered when Option 250 ordered.	98210A String Variables and Advanced Programming ROM
214	Matrix operations capability for 9825A Calculator in Option 250. Can only be ordered when Option 250 ordered.	98211A Matrix ROM

Table E-1. Description of Options (for systems purchased prior to December 31, 1979) (continued)

ENGLISH/METRIC PULSE OUTPUT ELECTRONICS		
OPTION NUMBER	DESCRIPTION	EQUIPMENT
450	ENGLISH/METRIC PULSE OUTPUT Basic two-axis measurement system including Manual Compensation input. Additional electronic axes may be selected from options below.	10780A Counter 10760A Counter down 10761A Multiplier 10761A English Metric Pulse Output down 10755A Compensation 10756A Manual Compensation 5501A Option 039 +15V Power Supply 5501A Option 038 +5V Power Supply
451	Additional Measurement Axis. Provides three-axis measurement capability with Option 450. Greater than three-axis measurement capability available on special request. Can only be ordered when Option 450 is ordered.	30760A Counter 10761 English Metric Pulse Output
402	Automatic Compensation for Option 450. Deletes 10756A Manual Compensation. Includes interconnecting cable — 4.6 m (15 ft.). Can only be ordered when Option 450 is ordered.	C 13-59995A Automatic Compensation
404	230 Volt input Power Supplies for Option 450.	5501A Option 020 +15V Power Supply 5501A Option 018 +5V Power Supply

CABLE SELECTIONS FOR OPTIONS 250, 251 AND 450

REQUIREMENT	CONSIDERATIONS	EQUIPMENT
Reference signal cable for 5501A Laser Transducer	Specify cable length between the 5501A Laser Transducer and the Interface Electronics. One cable required per measurement system. Maximum cable length of 20 m (65 ft.).	C 15-59995A RF Cable 1 metres feet
Measurement Signal Cable for 10780A Receiver	Specify cable length between each 10780A Receiver and the Interface Electronics. One cable required per measurement axis. Maximum cable length of 20 m (65 ft.).	AXIS 1 1 metres feet C 20-59995A RF Cable AXIS 2 1 metres feet C 20-59995A RF Cable AXIS 3 1 metres feet C 20-59995A RF Cable
Power Cable for 5501A Laser Transducer	Specify cable length between the 5501A Laser Transducer and the +15V Power Supply. One cable required per measurement system. Maximum cable length of 20 m (65 ft.).	1 metres feet C 21-59995A Power Cable

CABLES FOR COMPUTER INTERFACE ELECTRONICS

REQUIREMENTS	CONSIDERATIONS	EQUIPMENT
Interconnection between 5501A Laser Transducer, 10780A Receiver, and Output Electronics	Power: What is the distance from 5501A Laser Transducer to its power supplies? Maximum length of 20 m (65 ft.).	1 metres feet total C 07-59995A Cable for Power
	RF Signals: What is distance from 5501A Laser Transducer to the output electronics? Maximum length of 20 m (65 ft.).	1 metres feet total C 15-59995A Cable for RF Signals
	What is the distance from each 10780A Receiver to the output electronics? Maximum length of 20 m (65 ft.) per axis.	1 metres feet total C 08-59995A Cable for Diagnostics
	Diagnostics: If desired, the diagnostic signals in the 5501A Laser Transducer may be transmitted to either the output electronics or to the controller. Maximum length of 20 m (65 ft.).	1 metres feet total C 08-59995A Cable for Diagnostics

Table E-1. Description of Options (for systems purchased prior to December 31, 1979) (continued)

POWER SUPPLY OPTIONS TO 5501A LASER TRANSDUCER

Input Line Voltage	Output Voltage	Output Current	Maximum Input Power	Size	Equipment
115V	+15V	10A 1A Sub*	215W	1/2 rack	5501A Option 009
210V	+15V	10A 1A Sub*	215W	1/2 rack	5501A Option 020
115V	+5V	100A	151W	1/2 rack	5501A Option 007
115V	+5V	160A	101W	1/2 rack	5501A Option 008
115V	+5V	160A	450W	1/2 rack	5501A Option 021
210V	+5V	100A	151W	1/2 rack	5501A Option 017
210V	+5V	160A	101W	1/2 rack	5501A Option 018
210V	+5V	160A	450W	1/2 rack	5501A Option 022

*Output current derated by 2.5A each side with 50 Hz line input. Temperature dependent output current derating factor from 0% at 40°C to 50% at 71°C.

Table E-2. 5501A Special Option Number in Model Number or Part Number Conversion

Old Special Option No.	New Model No.
C10-5510A	5510A Option 010
H05-5510A	(1) 5510A, (1) 10563A Option 001
K15-5510A	Obsolete
C05-59995A	10780-60003 and 05501-60008
C07-59995A	05501-60009
C12-59995A	10712A
C17-59995A	10740-60004
C19-59995A	10740-60005
K14-59995A	10714A
K32-59995A	10722A
K70-59995A	10727-60001

E.3 CALCULATOR INTERFACE ELECTRONICS CHECKOUT

Following is the checkout procedure as removed from Section 5. The Diagnostic Cassette (P/N 05501-10001) is no longer supplied.

5.13 CALCULATOR INTERFACE ELECTRONICS CHECKOUT

The Calculator Interface Electronics are checked by running the diagnostic programs for the Laser Transducer System, Option 250. These programs are stored on the Diagnostic Cassette (P/N 05501-10001) that is shipped with each system. It is assumed in the following discussion that you understand and can operate the 9825A Calculator.

5.14 Diagnostic Cassette File Structure

The diagnostic programs for the 5501A Laser Transducer Option 250 are contained in a cassette tape for the 9825A Calculator. There are several programs stored on the cassette which are used for testing the Calculator Interface Electronics. The file locations for each program are listed below:

File Number	Program
-------------	---------

0	Test Configuration Program (see Figure 5-12)
1	Test Program (see Figure 5-13)
2	Storage File
3	Blank
4	Test Configuration Program Duplication
5	Test Program Duplication
6	User Defined Keys
7	Automatic Compensator Test

NOTE

The cassette is unprotected since both read and write operations take place on the cassette during the running of the test. Take care not to record (rec) anything on this cassette.

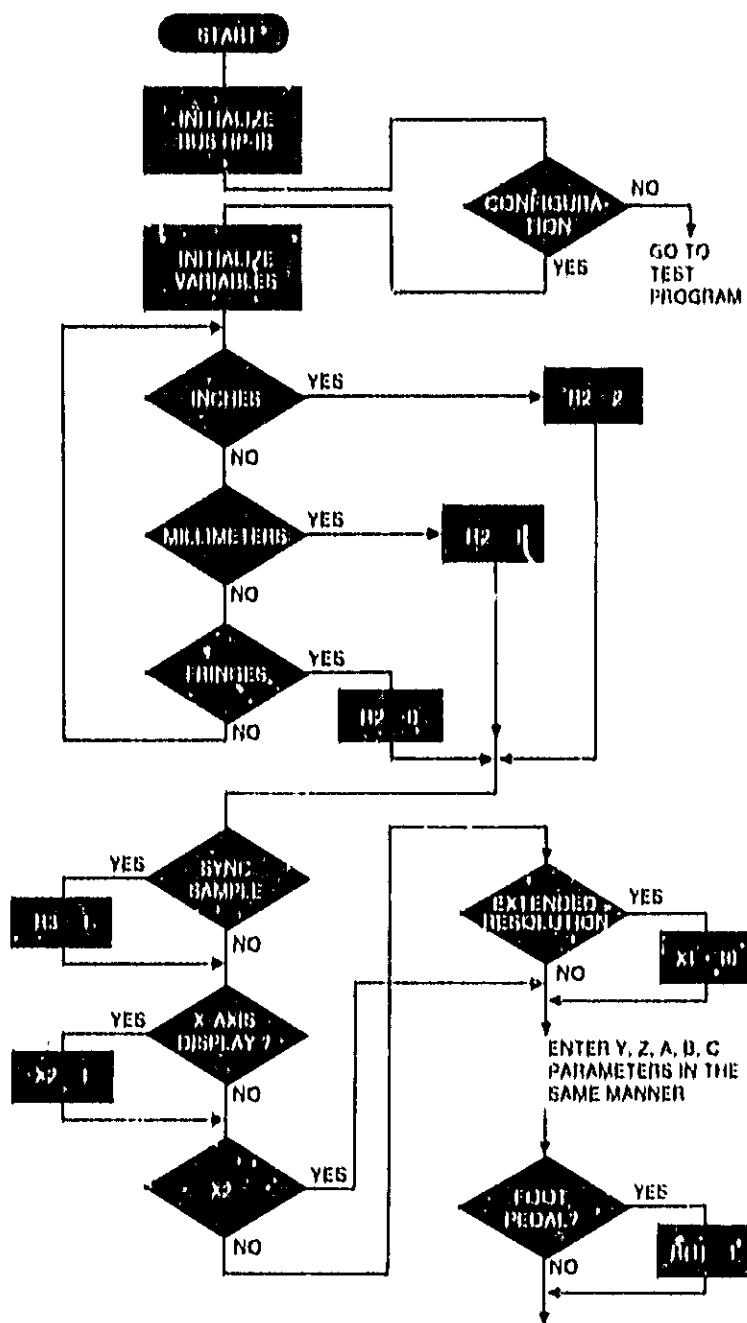


Figure 5-12. Test Configuration Program Flowchart

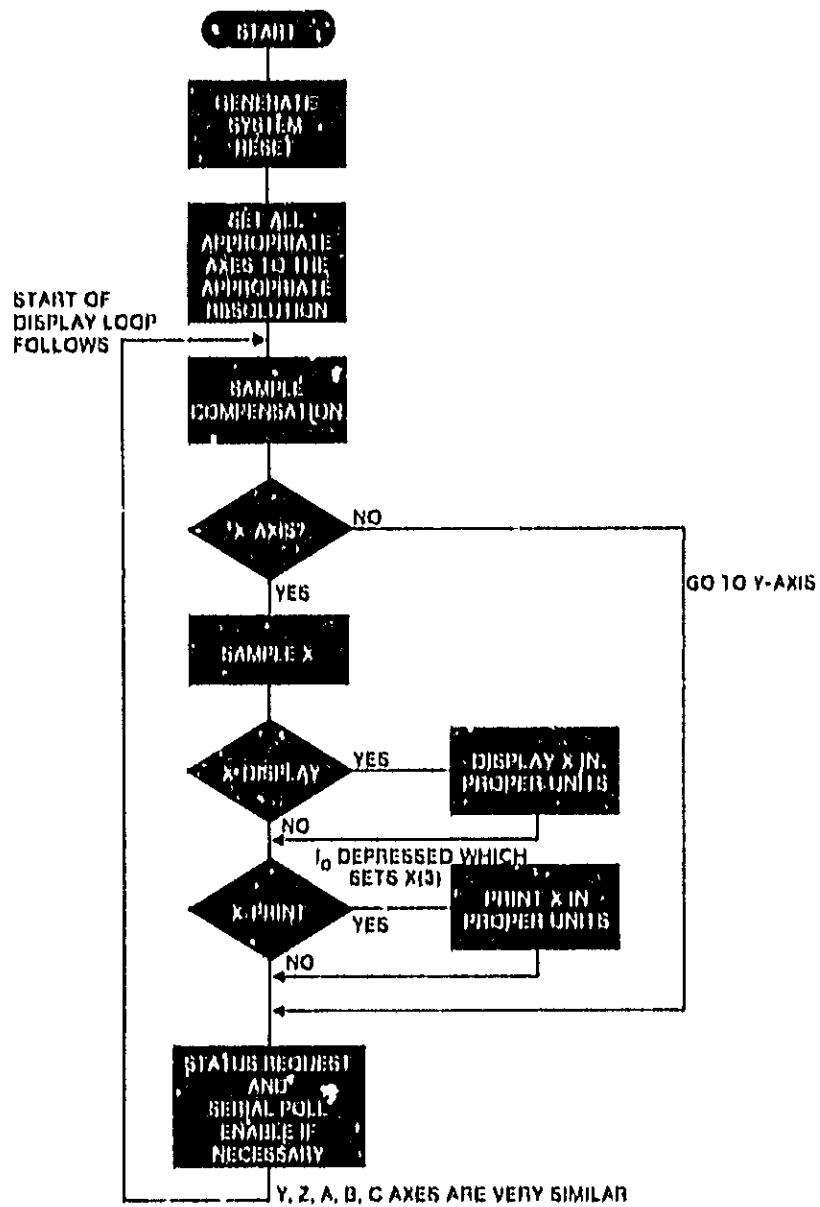


Figure 5-13. Test Program Flowchart

Table 5-4 provides some brief comments on the test program on file 1. To obtain a listing of any of the programs, load it into the calculator and list it on the calculator printer. Table 5-5 provides definitions for the variables used in the programs. Table 5-6 provides the talk/listen address of the HP-1B components.

Table 5-4. Comments on the Diagnostic Routine Located in File 1

Line 1	Loads the common variables which are configuration variables.
Line 5	Simply clears the HP-1B devices, sets the HP-1B devices to the remote enable.
Line 7	Is the system reset which resets all the counters.
Line 8	Calls a subroutine which will allow the different axes to be set to extended resolution if requested in the configuration.
Lines 9 and 10	Check if a foot pedal is available. If so, it sets the ready-to-depress flip-flop.
Lines 11 and 12	Input the compensation values from the coupler box.
Lines 13 to 16	Check to see if the foot pedal has been depressed. If so, K3=1.
Line 18	Does the synchronous sample if requested.
Line 19	Determines if there is any X-axis. Line 21 will sample the X-axis if it was requested independently.
Lines 22 and 23	Input the X-axis information.
Line 25	Goes out and does a status check to see if there are any errors on the X-axis measurement or reference channel or if an overload has taken place.
Line 26	Takes care of the offset. When the counter cards are preset they either go to 160 or to 16.0
Line 28	The subroutine converts the number to the appropriate units, either English, Metric, or fringes. If it is fringes, lines 114 through 121 do the conversion from decimal to octal so that the different bits can be looked at.
Line 29	Determines if X-axis display has been requested.
Lines 30 and 31	Actually does the outputting to the display and the format for the data is chosen.
Line 33	Prints the information. Either the f_0 button has been depressed or the foot pedal has been depressed.

The rest of the program is just duplications of what is required for the X-axis. The only difference is that at the end of the loop Lines 9 and 10 check whether there is a foot pedal and what the status is if it has been depressed. If it has been depressed, the program will go to Line K(3) is set to 0, and K2 is checked — which is an input from the foot pedal card and is checked to see if the foot pedal has been released. Disregard this portion of the program unless you have a foot pedal installed.

Table 5-5. Variable Definitions

R(1) = 1 If Foot Pedal R(1) = 0 If No Foot Pedal R(2) = 0 If Octal Fringes R(2) = 1 If Compensated millimetres R(2) = 2 If Compensated Inches R(3) = 1 Simultaneous Sample R(3) = 0 Independent Sample	
X-AXIS X(1) = 1 Normal Resolution = 10 Extended Resolution X(2) = 0 No Display = 1 Display X(3) = 0 No Printout = 1 Printout Y-AXIS Y(1) = 1 Normal Resolution = 10 Extended Resolution Y(2) = 0 No Display = 1 Display Y(3) = 0 No Printout = 1 Printout Z-AXIS Z(1) = 1 Normal Resolution = 10 Extended Resolution Z(2) = 0 No Display = 1 Display Z(3) = 0 No Printout = 1 Printout	A-AXIS A(1) = 1 Normal Resolution = 10 Extended Resolution A(2) = 0 No Display = 1 Display A(3) = 0 No Printout = 1 Printout B-AXIS B(1) = 1 Normal Resolution = 10 Extended Resolution B(2) = 0 No Display = 1 Display B(3) = 0 No Printout = 1 Printout C-AXIS C(1) = 1 Normal Resolution = 10 Extended Resolution C(2) = 0 No Display = 1 Display C(3) = 0 No Printout = 1 Printout

Table 5-6. HP-IB Talk-Listen Address

Item	Talk Address	Listen Address	A7	A6	A5	A4	A3	A2	A1	9825A Software Address
10783A Display (X-Axis)	—	1	0	—	1	0	0	0	1	17
10783A Display (Y-Axis)	—	2	0	—	1	0	0	1	0	18
10783A Display (Z-Axis)	—	3	0	—	1	0	0	1	1	19
10783A Display (A-Axis)	—	4	0	—	1	0	1	0	0	20
10783A Display (B-Axis)	—	7	0	—	1	0	1	1	1	23
10783A Display (C-Axis)	—	6	0	—	1	0	1	1	0	22
10745A HP-IB Interface	1	1	—	—	0	1	0	0	1	09
9825A Calculator	—	—	—	—	—	—	—	—	—	7

5.15 Operating Procedure for Diagnostics

To operate the diagnostics simply place the cassette into the cassette file and hit LOAD, EXECUTE. Wait approximately 5 seconds for the program to be loaded in, then hit RUN. Then answer the questions about each axis as to whether resolution extension, and/or display is required and does the system need to be reconfigured. Enter 1 and press CONTINUE for Yes or just press CONTINUE for No. After this the 9825A Calculator takes approximately 5 seconds to automatically load the diagnostic routine and will run the system displaying and printing the appropriate data, depending upon how the questions were answered in the configuration guide. While in the diagnostic routine the user may change his configuration. Table 5-5 specifies the variables, (e.g., if you wish to go to a simultaneous sample and have been at independent sample, hit STOP and the program stops). Type 1-r3, EXECUTE, CONTINUE and the program restarts and resets the displays. The system now samples simultaneously.

NOTE

Disregard references to the foot pedal if one is not supplied with your system.

To print an axis, press t_0 for X	X will be printed out
t_1 for Y	Y will be printed out
t_2 for Z	Z will be printed out
t_3 for A	A will be printed out
t_4 for B	B will be printed out
t_5 for C	C will be printed out

To checkout the system after it is running, perform the following steps:

- Verify that the two LED indicators on the lower front edge of each 10760A Counter card are lit. These LED indicate that the reference and measurement signals from the laser head and receivers are present.
- Verify that the Talk and Listen lights on the middle front edge of the 10745A HP-IB Interface card are alternately lit as the program commands the laser system to talk (send data to calculator) and listen (accept instructions from calculator).

NOTE

If the displayed data counts down from 0 to a negative number when the measurement optics are moved in a positive direction, change the position of the NORMAL/REVERSE jumper on the 10760A Counter card (the jumper is in the NORMAL position when shipped). See Figure 5-14. Refer to the 10760A unit manual for additional information if required.

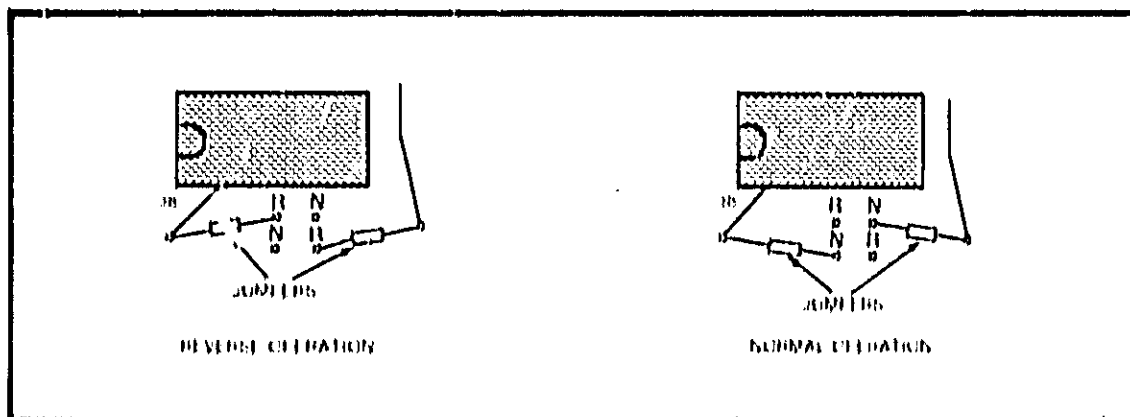


Figure 5-14. NORMAL/REVERSE Jumper Positions

- c. Displace the measurement optics in each axis a specific distance and verify that the output devices accumulate the appropriate number of counts for the distance moved.
- d. Interrupt the laser beam in each axis and verify the system comes up with an error indication. Reset the system after each error indication (press STOP, cont, 5, EXECUTE).
- e. Replace the front panel of the 10740A Coupler.

5.16 C16-5510A Automatic Compensator Display Program

The 5510A Automatic Compensator Display Program is located on File 7 of the Diagnostic Cassette. This program will display the total velocity of light compensation number as determined by the Automatic Compensator as well as readings from the individual environmental sensors.

The program is executed by inserting the Diagnostic Cassette into the Cassette Reader on the 9825A Calculator and performing a 1df, 7, EXECUTE, RUN.

Move the 5510A Automatic Compensator function switch to the DISPLAY position and the Sensor Display switch to the TOTAL COMP position. If any part temperature probes are being used make sure the appropriate sensor switches are lighted (T1, T2, T3).

The 9825A Calculator display will now be showing the total velocity of light compensation number in the following format:

0.999XYZT

The 0.999 portion is hardwired, and the Automatic Compensator computes the XYZT portion (i.e., 0.999 7325). This total compensation number includes air temperature, humidity, air pressure, and the part temperature parameters.

Turn the SENSOR DISPLAY switch to the COMP AIR ONLY position. The calculator display will now show the velocity of light compensation factor for air temperature, air pressure, and humidity only.

Turn the SENSOR DISPLAY switch to the HUMIDITY position. The number .999XYZT will be displayed, but is interpreted as:

ZT % Humidity

Turn the SENSOR DISPLAY switch to the AIR PRESSURE setting. The number .999XYZT will be displayed, but is interpreted as:

XY.ZT inches of mercury

i.e., .9992956 = 29.56 inches of mercury

If the English/Metric switch is in the Metric position the display is interpreted as:

XYZ.T mm of mercury

i.e., .9997567 = 756.7 mm of mercury

Turn the SENSOR DISPLAY switch to the AIR TEMPERATURE setting. The number .999XYZT will be displayed, but is interpreted as:

XYZ.T °F

i.e., .9990713 = 71.3 °F

If the English/Metric Switch is in the Metric position, the display is interpreted as:

YZ.T °C

i.e., .9990202 = 20.2 °C

In the T1, T2, T3, and T average SENSOR DISPLAY switch positions the display is interpreted exactly the same as for the AIR TEMPERATURE switch position.

Turn the SENSOR DISPLAY switch to the TEMP COEF position. The number .999XYZT will be displayed, but is interpreted as:

YZ.T parts per million

i.e., .9990062 = 6.2 ppm

E-4 CABLE FABRICATION

Following is information supplied with older systems (prior to series prefix 1948A) to fabricate the required cables.

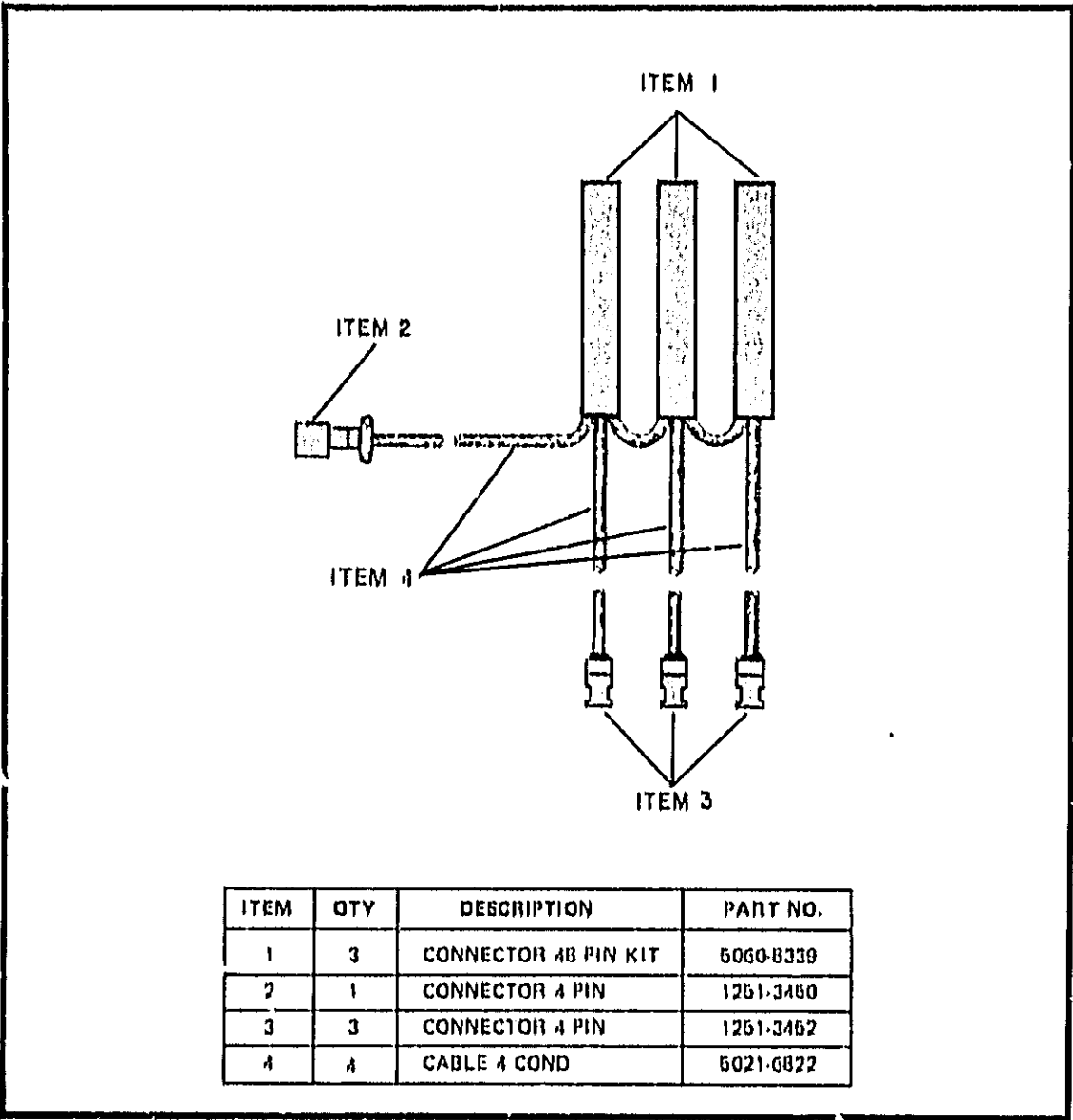


Figure E-1. Typical Reference/Measurement Cable Wiring

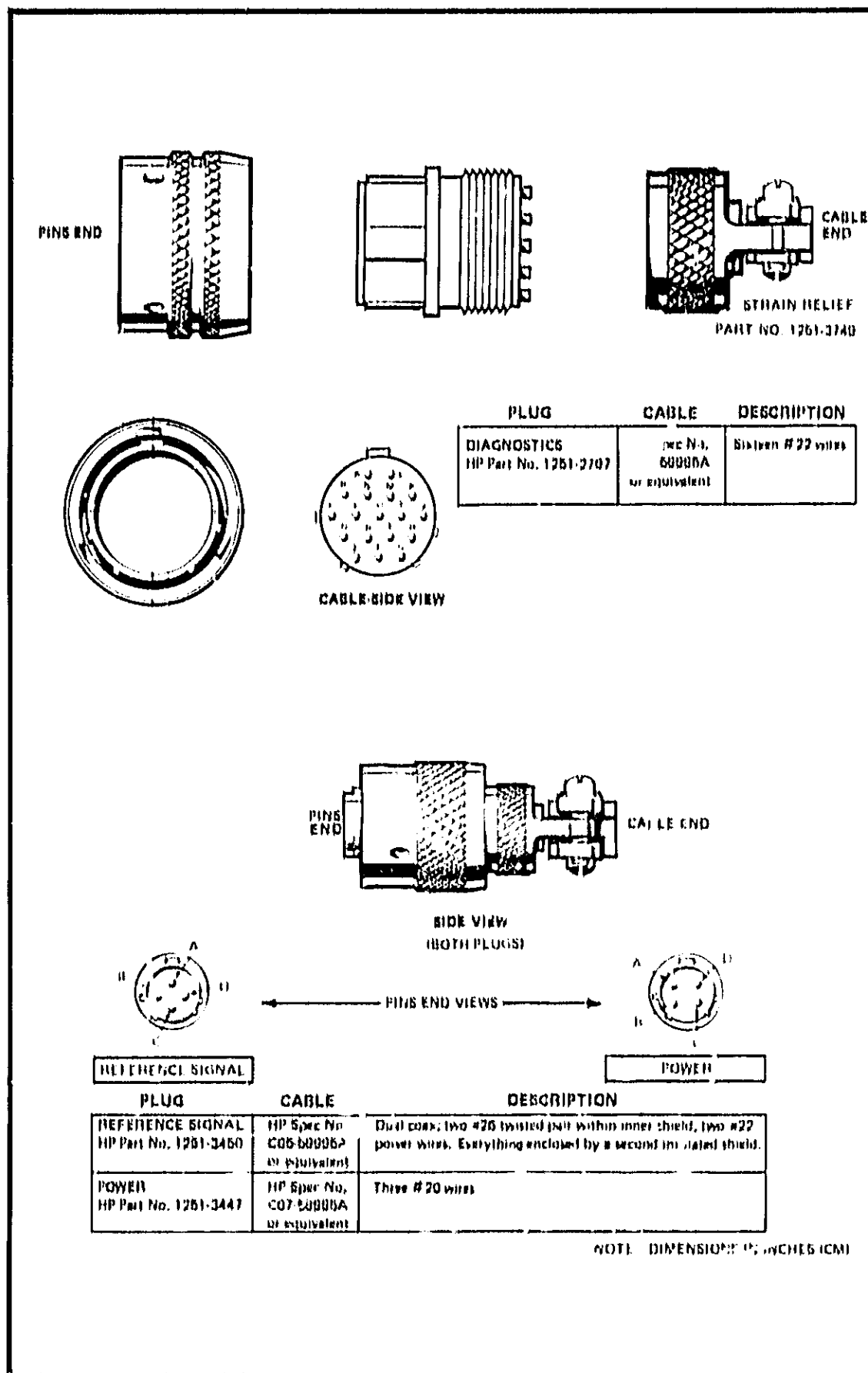
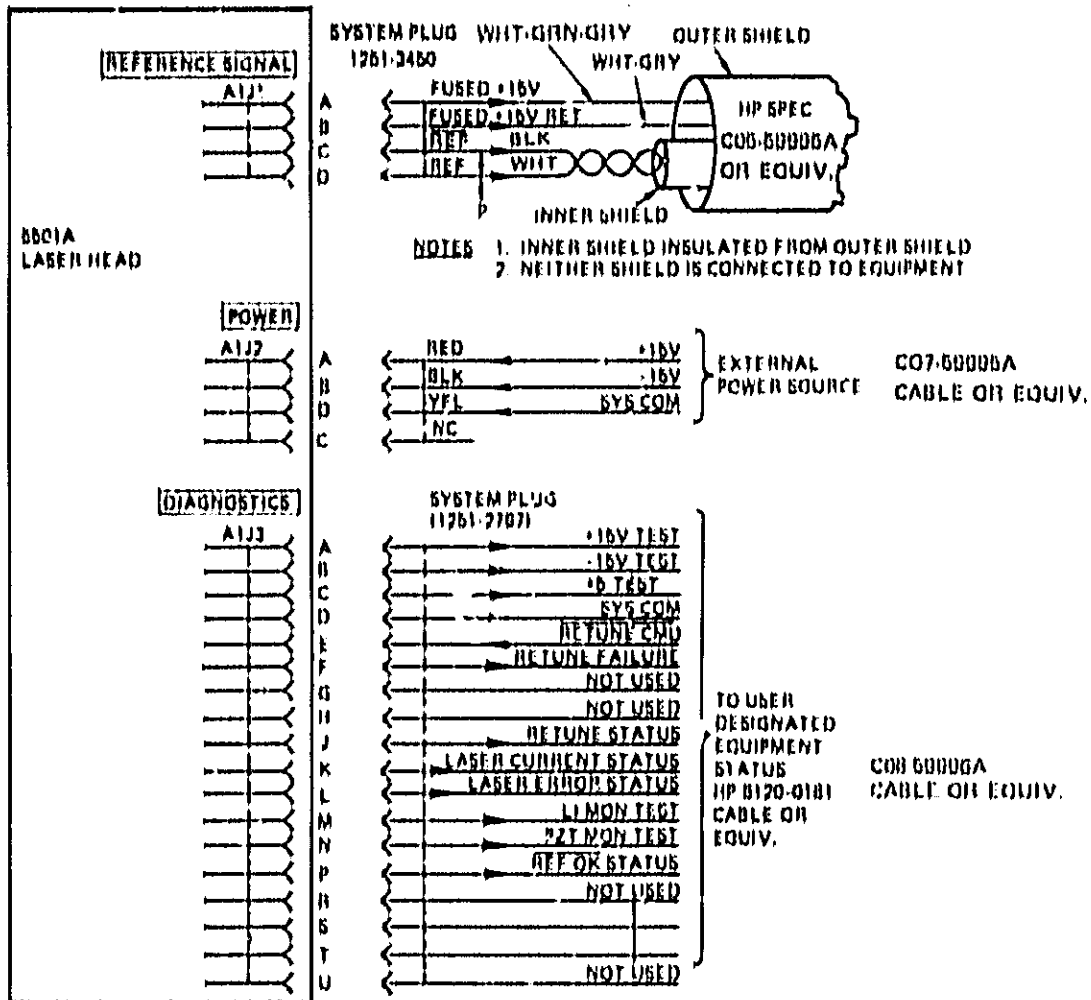


Figure E-2. 5501A Laser Transducer interconnecting Plugs

CAUTION

REF AND REF OUTPUTS ARE CAPABLE
OF DRIVING ONLY ONE UNIT.



NOTE

THE RUBBER COLLAR WHICH GOES OVER THE CABLES
IS A VERY TIGHT FIT. USE SILICON GREASE TO FACILITATE
INSTALLATION ON CABLE.

Figure E-3. 5501A Laser Transducer Rear Panel Wiring

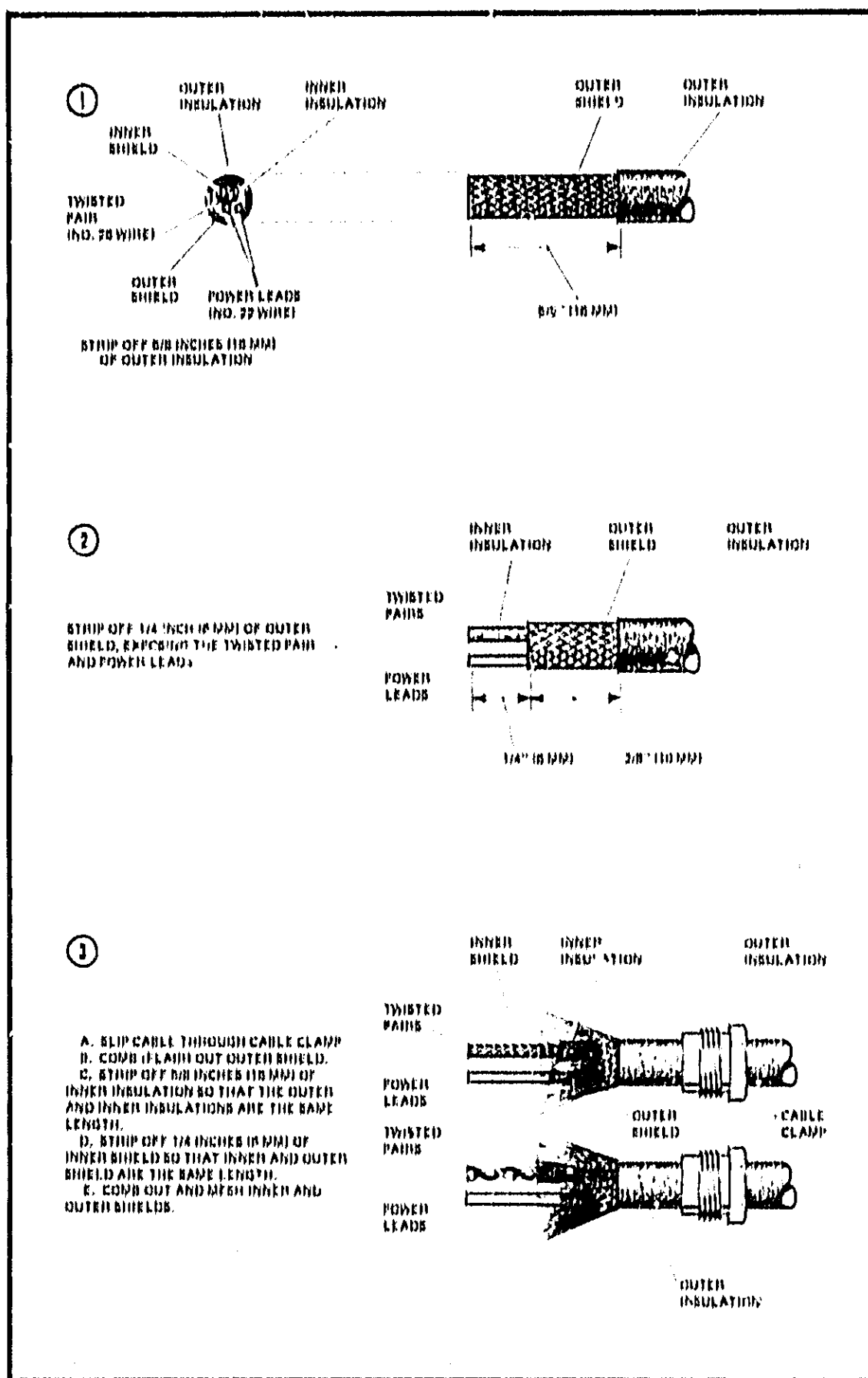
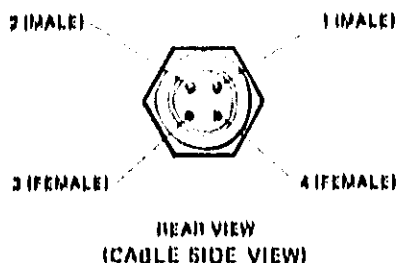
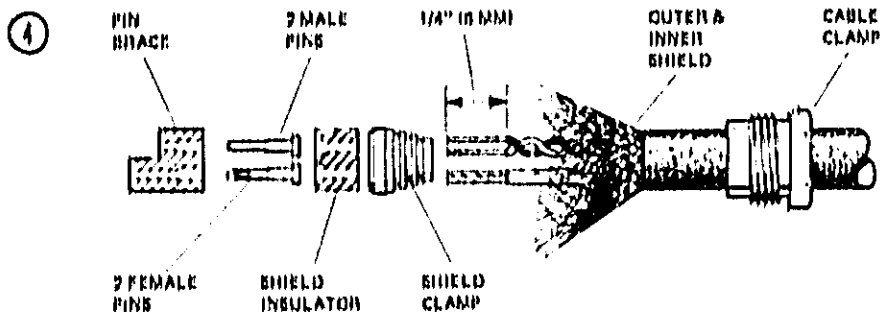


Figure E-4. 10780A Receiver-to-System Plug Wiring

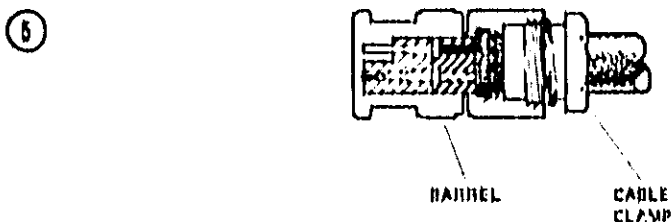


A. STRIP OFF 1/4 INCHES (6 MM) OF INSULATION FROM THE TWISTED PAIR AND 2 POWER LEADS.

B. ROUTE THE TWISTED PAIR AND 2 POWER LEADS THROUGH SHIELD CLAMP AND SHIELD INSULATOR. KEEP SHIELDS AWAY FROM EXPOSED TWISTED PAIR AND POWER LEADS.

C. SOLDER TWISTED PAIR LEADS TO THE MALE PINS AND THE POWER LEADS TO THE FEMALE PINS.

D. INSERT PINS INTO PIN BRACE, MALE PINS ON TOP AND PROTRUDING, FEMALE PINS ON THE BOTTOM. ENSURE THAT THE INSERTED PIN CONFIGURATION CONFORMS TO REAR VIEW ILLUSTRATION.



A. COMB INNER AND OUTER SHIELD OVER SHIELD CLAMP.

B. INSERT ASSEMBLED CABLE INTO BARREL.

C. SCREW CABLE CLAMP INTO BARREL.

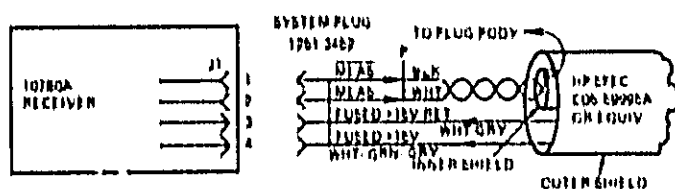
D. CHECK PINS TO ASCERTAIN THAT NO SHORT EXISTS TO THE BARREL OR BETWEEN PINS.

E. CHECK WIRING PER TABLE 2- ON SECTION II OF SYSTEM MANUAL.

PLUG: HP PART NO. 1261-3482

CABLE: HP SPEC COB 60092A

Figure E-4. 10780A Receiver-to-System Plug Wiring (Cont'd)



CAUTION

MEAS AND MEAS SIGNALS ARE CAPABLE OF DRIVING ONLY ONE UNIT (10780A, etc.)

10780A
NOTES

- 1 INNER SHIELD AND OUTER SHIELDS CONNECTED AT PLUG BODY ONLY
- 2 BOTH SHIELDS CONNECTED TO PLUG BODY
- 3 FUSED +15V RET CONNECTED TO BOTH SHIELDS THROUGH RECEIVER CHASSIS GROUND AND PLUG BODY
- 4 FUSED +15V AND +15V RET MAY BE SUPPLIED BY 6601A, OR AN APPROPRIATE +15V POWER SUPPLY
- 6 REFER TO 10780A MANUAL FOR DETAILED 10780A PLUG WIRING INSTRUCTIONS
- 6 DO NOT USE SHIELD AS +15V RETURN LINE

Figure E-5. 10780A Receiver Rear Panel Wiring

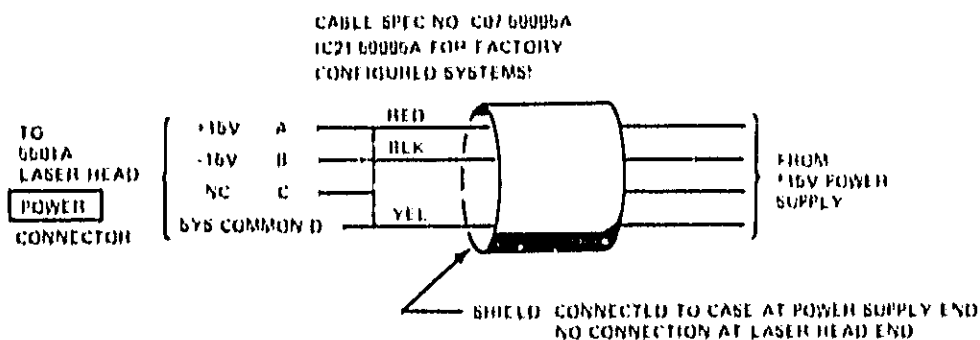


Figure E-6. +15-Volt Power Cable Wiring Diagram

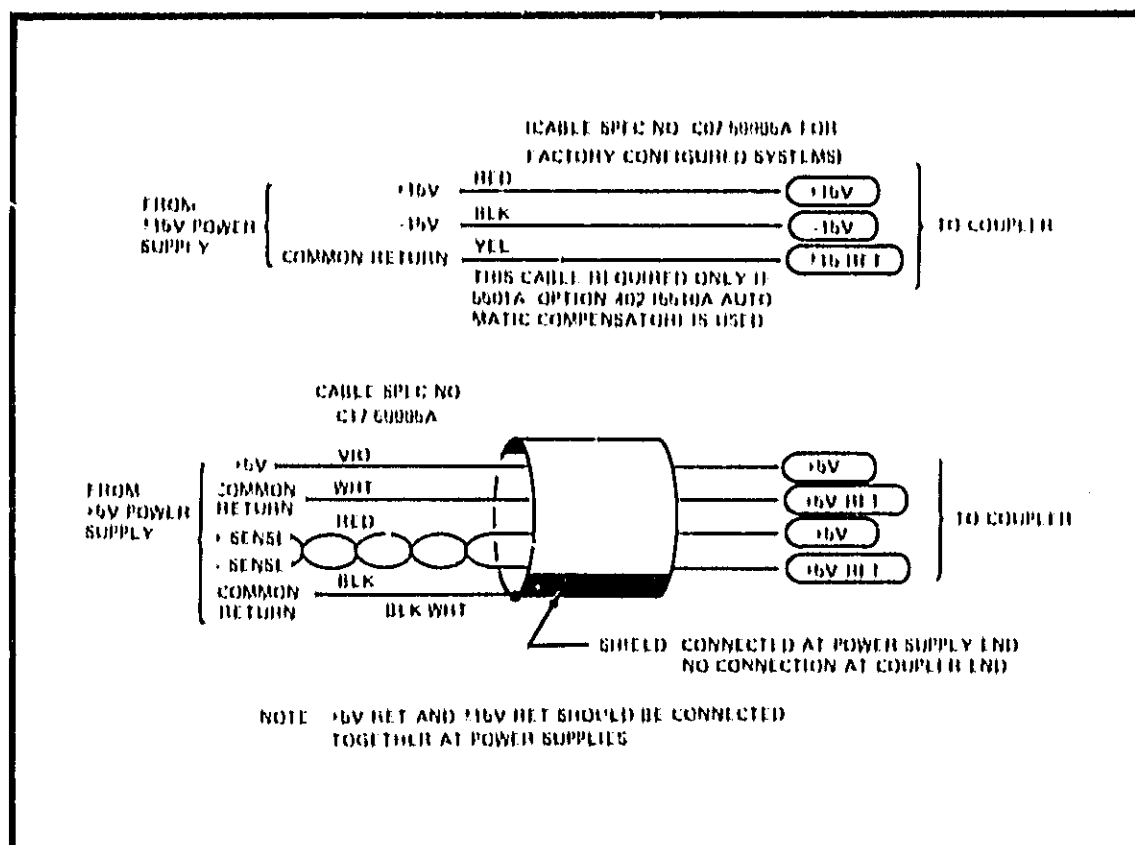
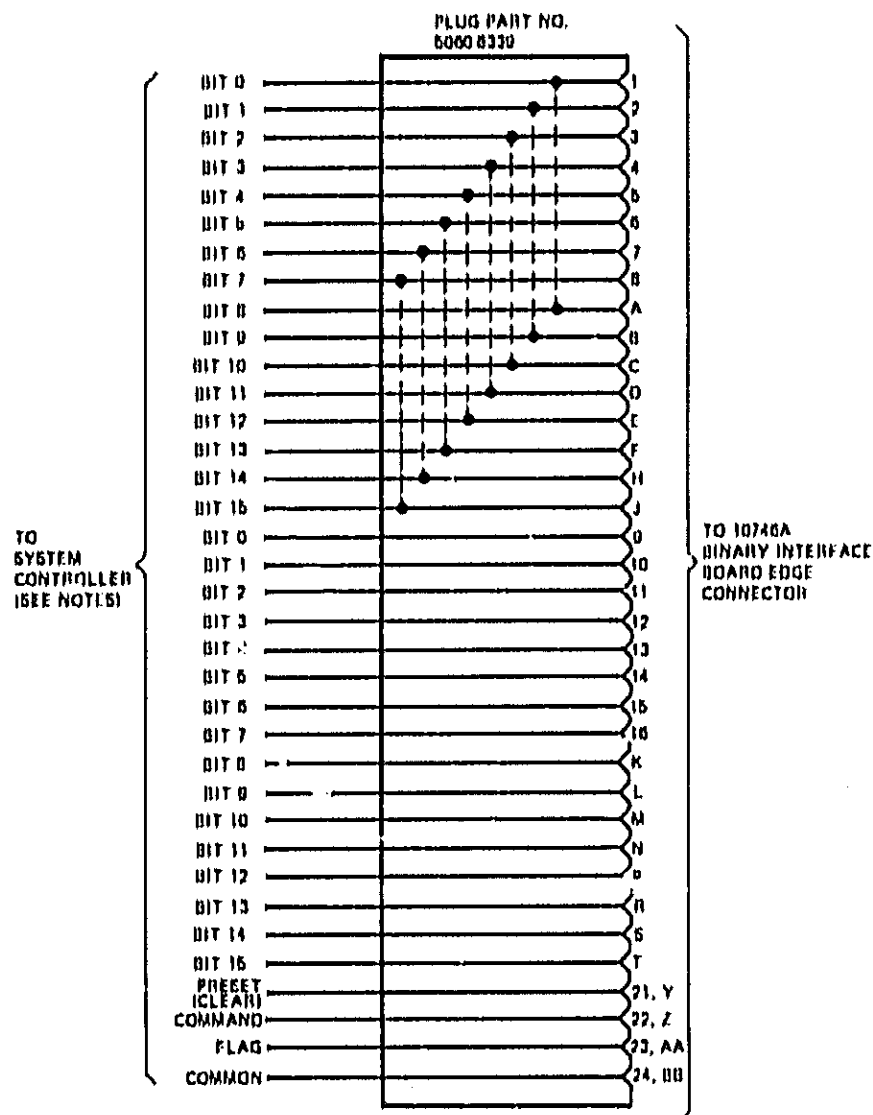


Figure E-7. +5-Volt and ± 15 -Volt Power Cable Wiring Diagram



NOTES

1. JUMPERS INDICATED BY DOTTED LINES ARE ONLY NEEDED IN EIGHT-BIT MODE.
2. PINS 1 THRU 8 AND A THRU J CAN BE USED AS EITHER BIDIRECTIONAL OR UNIDIRECTIONAL LINES BETWEEN THE 10746A BINARY INTERFACE AND THE SYSTEM CONTROLLER. IF USED AS BIDIRECTIONAL LINES, KEEP IN MIND THAT IT IS HALF-DUPLEX OPERATION I.E., YOU MUST SEND OR RECEIVE SEPARATELY. ALSO, PINS 9 THRU 16 AND K THRU T NEED NOT BE CONNECTED. IF USED AS UNIDIRECTIONAL LINES, THEN PINS 1 THRU 8 AND A THRU J ARE THE OUTPUTS TO THE SYSTEM CONTROLLER AND PINS 9 THRU 16 AND K THRU T ARE THE INPUTS FROM THE SYSTEM CONTROLLER. REFER TO TABLE E-3 ON PAGE E-21 FOR AN EXAMPLE OF THE PIN TO PIN WIRING WHEN USING AN HP2100 SERIES COMPUTER AND A 12566B MICROCIRCUIT CARD TO INTERFACE WITH THE 10746A BINARY INTERFACE.

Figure E-8. 10746A Binary Interface Hood Connector Wiring

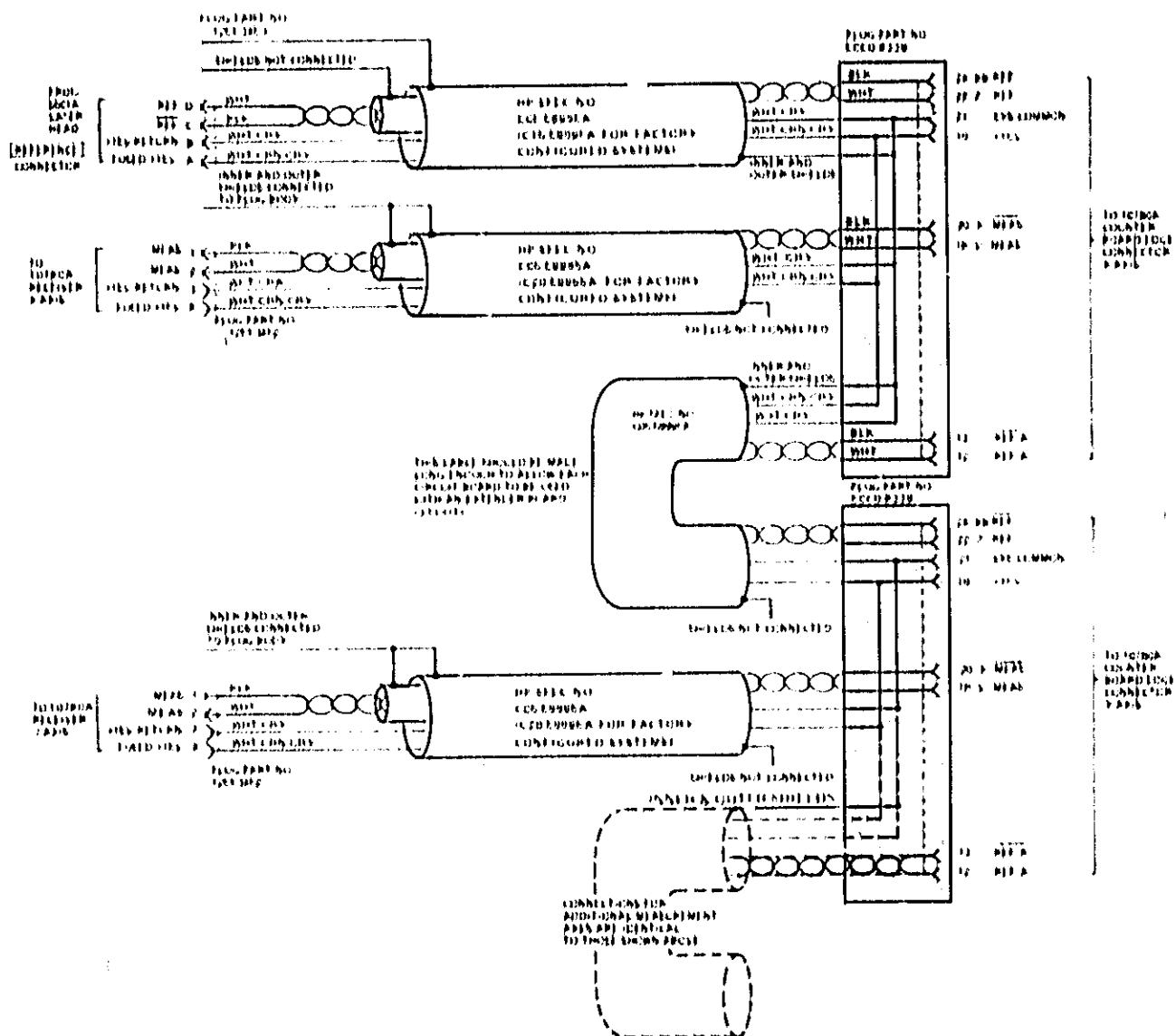


Table E-3. 10746A Binary Interface/12566B Microcircuit Card Pin Connection

12566B PIN		10746A PIN	
To Device (10746A)		From Computer (12566B)	
Bit 15	T	T	Bit 15
Bit 14	S	S	Bit 14
Bit 13	R	R	Bit 13
Bit 12	P	P	Bit 12
Bit 11	N	N	Bit 11
Bit 10	M	M	Bit 10
Bit 9	L	L	Bit 9
Bit 8	K	K	Bit 8
Bit 7	J	16	Bit 7
Bit 6	H	15	Bit 6
Bit 5	F	14	Bit 5
Bit 4	E	13	Bit 4
Bit 3	D	12	Bit 3
Bit 2	C	11	Bit 2
Bit 1	B	10	Bit 1
Bit 0	A	9	Bit 0
From Device (10746A)		To Computer (12566B)	
Bit 15	16	J	Bit 15
Bit 14	15	H	Bit 14
Bit 13	14	F	Bit 13
Bit 12	13	E	Bit 12
Bit 11	12	D	Bit 11
Bit 10	11	C	Bit 10
Bit 9	10	B	Bit 9
Bit 8	9	A	Bit 8
Bit 7	8	8	Bit 7
Bit 6	7	7	Bit 6
Bit 5	6	6	Bit 5
Bit 4	5	5	Bit 4
Bit 3	4	4	Bit 3
Bit 2	3	3	Bit 2
Bit 1	2	2	Bit 1
Bit 0	1	1	Bit 0
Device Command 22,Z Device Flag 23,AA All Signals Return 24,BB		Command 22,Z Flag 23,AA GND COM 24,BB	
For 12566B jumpering see 10746A manual.			

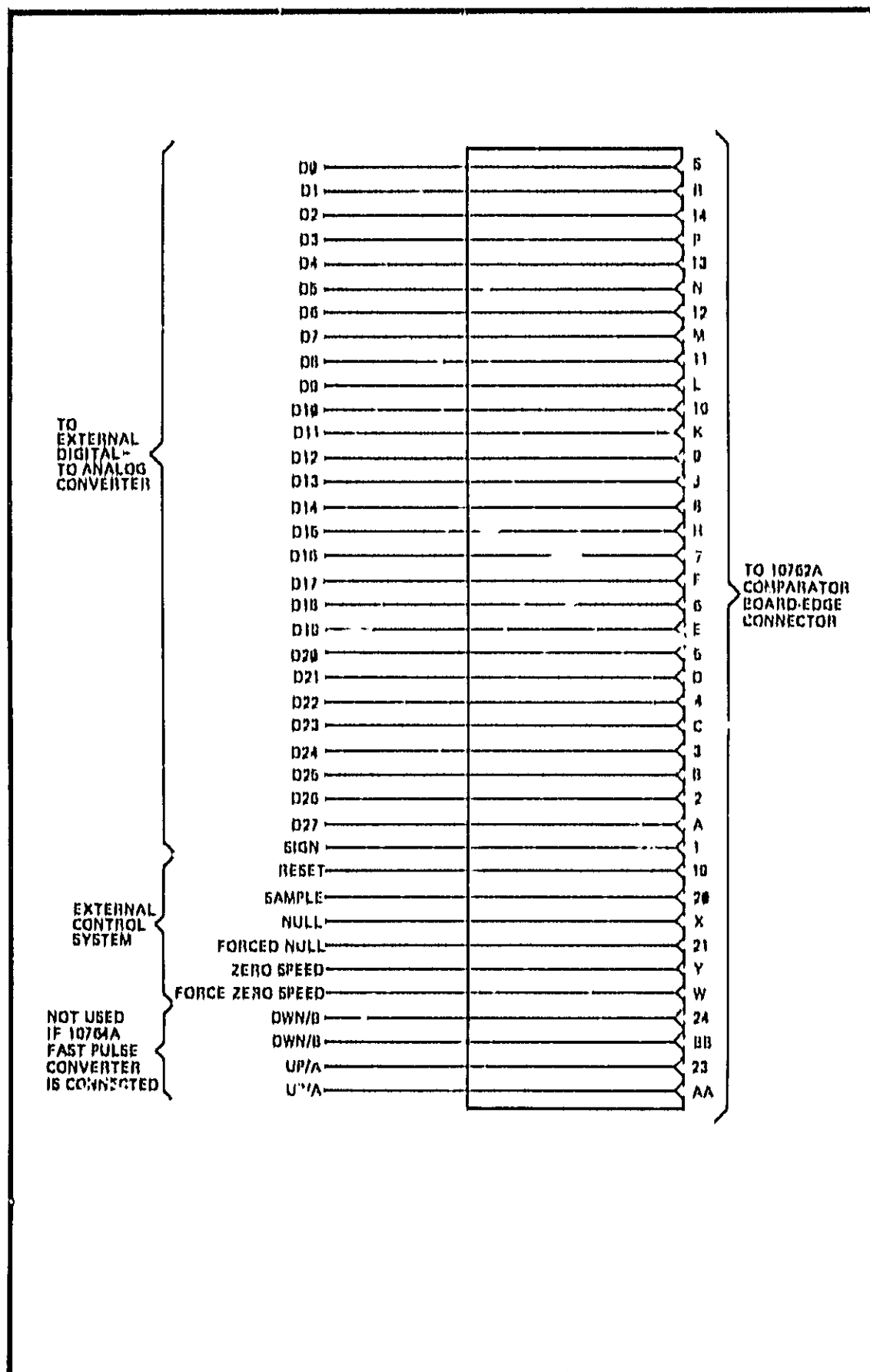
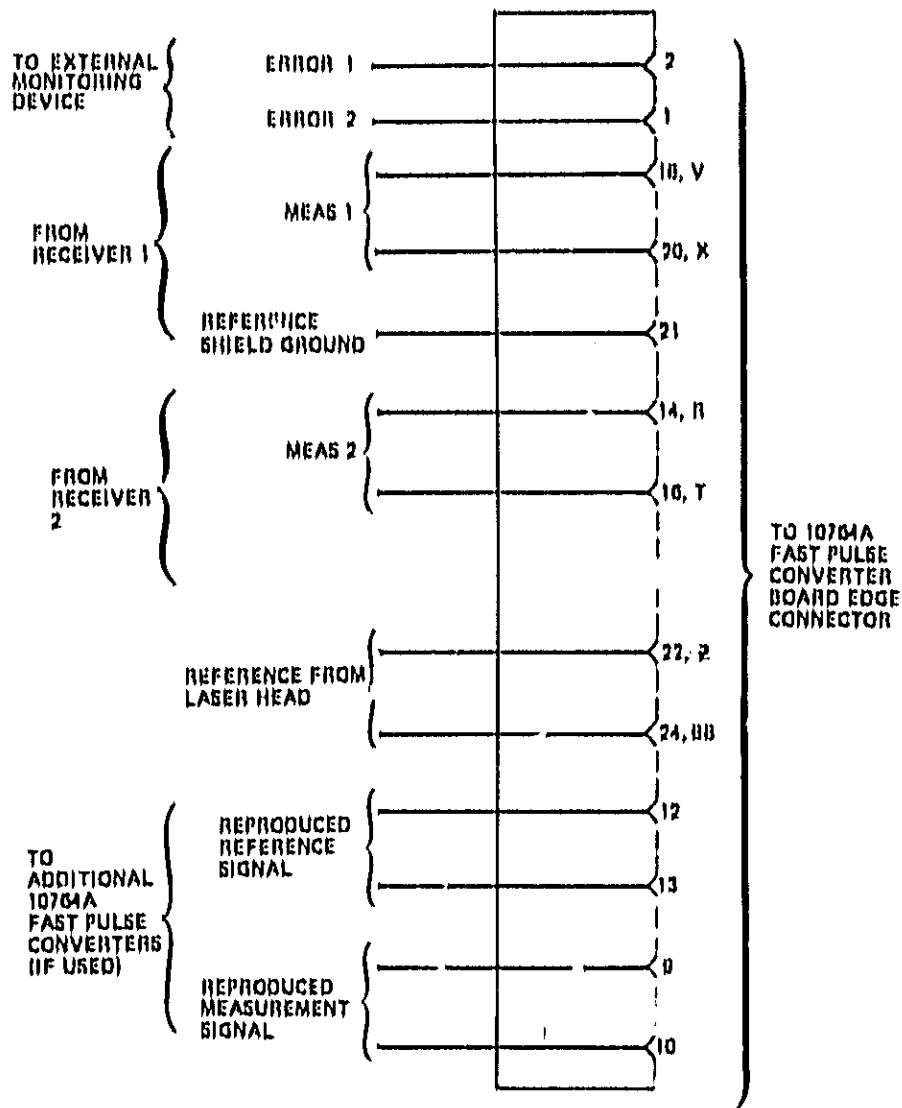
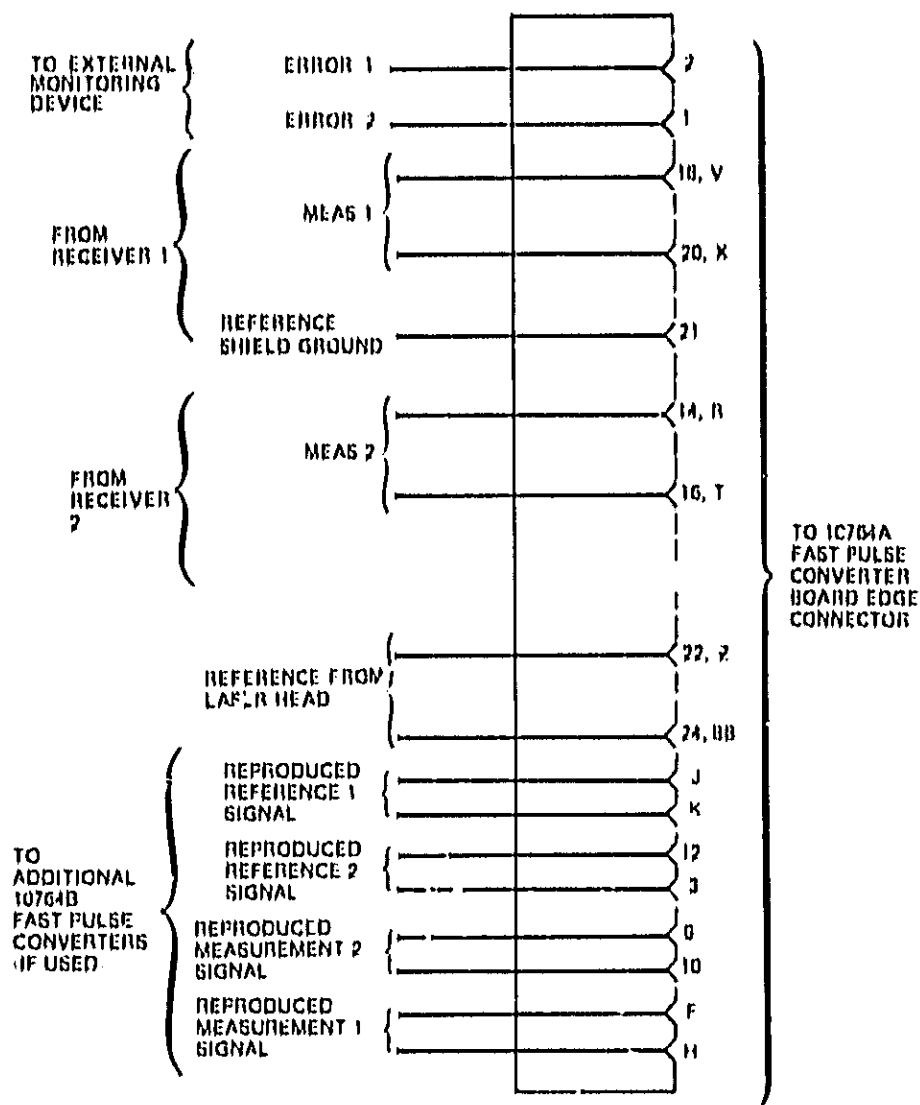


Figure E-10. 10762A Comparator Interface Hood Connector Wiring



*SEE FIGURE C-17 FOR REFERENCE AND MEASUREMENT SIGNAL LINES SHIELD GROUNDING.

Figure E-11. 10764A Fast Pulse Converter Hood Connector Wiring

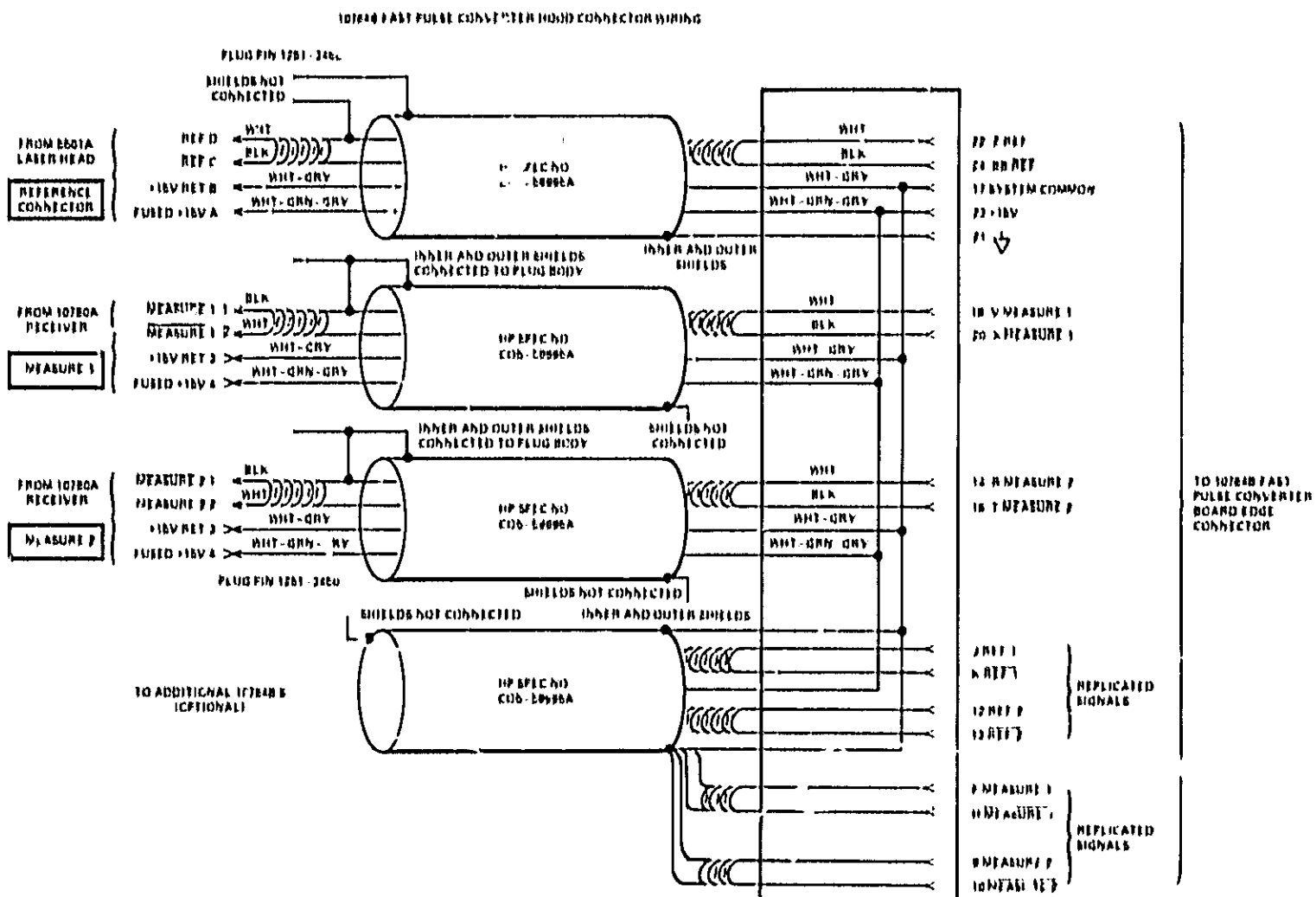


*SEE FIGURE C-17 FOR REFERENCE AND MEASUREMENT SIGNAL LINES SHIELD GROUNDING.

NOTE: Grounds available at J1 are to be used only for cable shields grounded at one end.

Figure E-12. 10764B Fast Pulse Converter Hood Connector Wiring

Figure E-12. 10764B Fast Pulse Converter Hood Connector Wiring (cont'd)



APPENDIX

E

CON'T

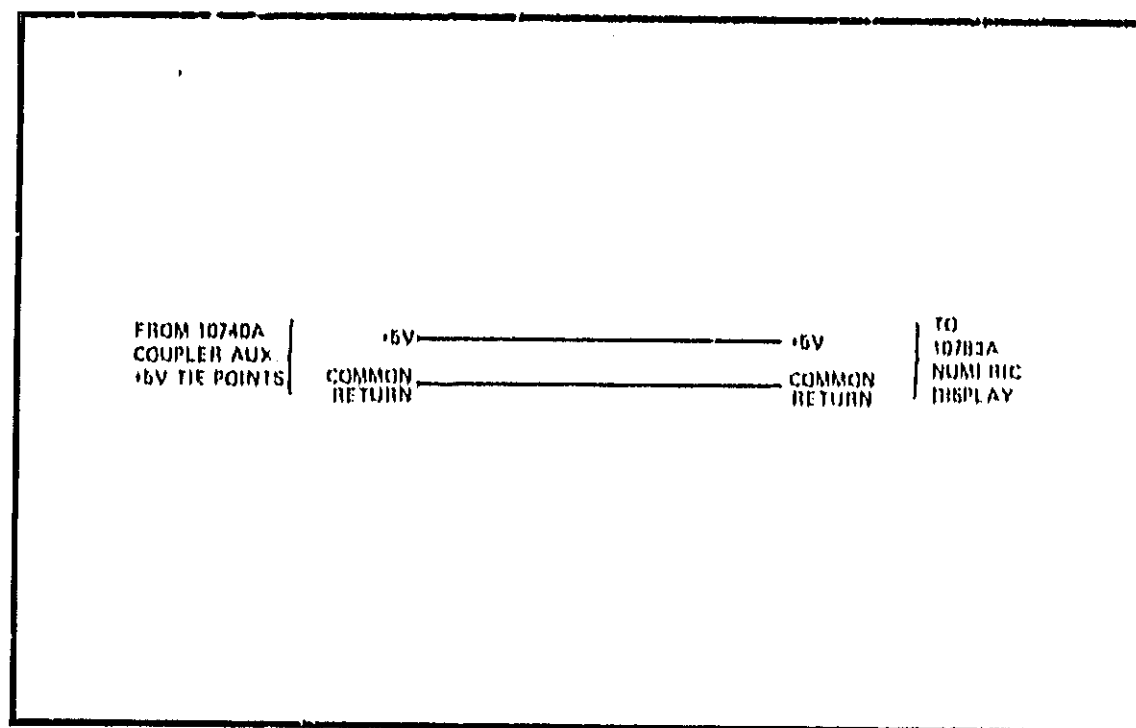


Figure E-13. 10783A Numeric Display Power Cable Wiring

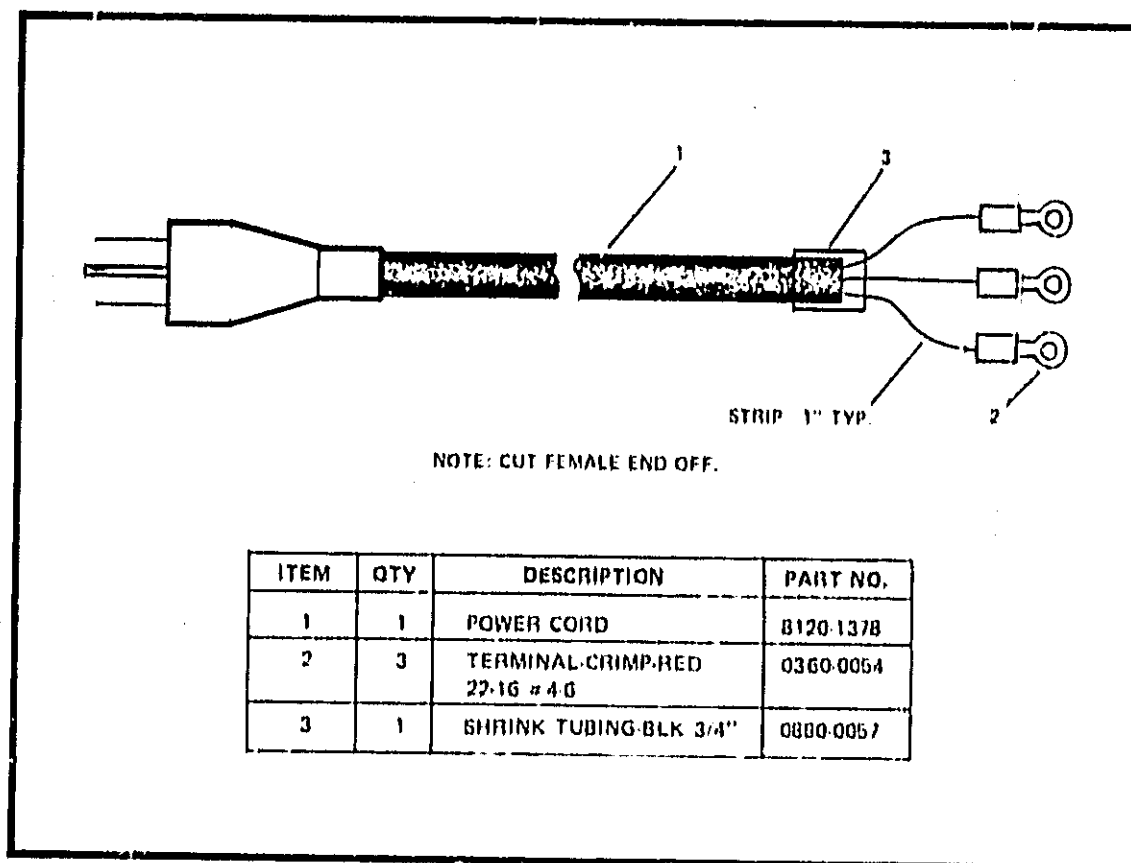
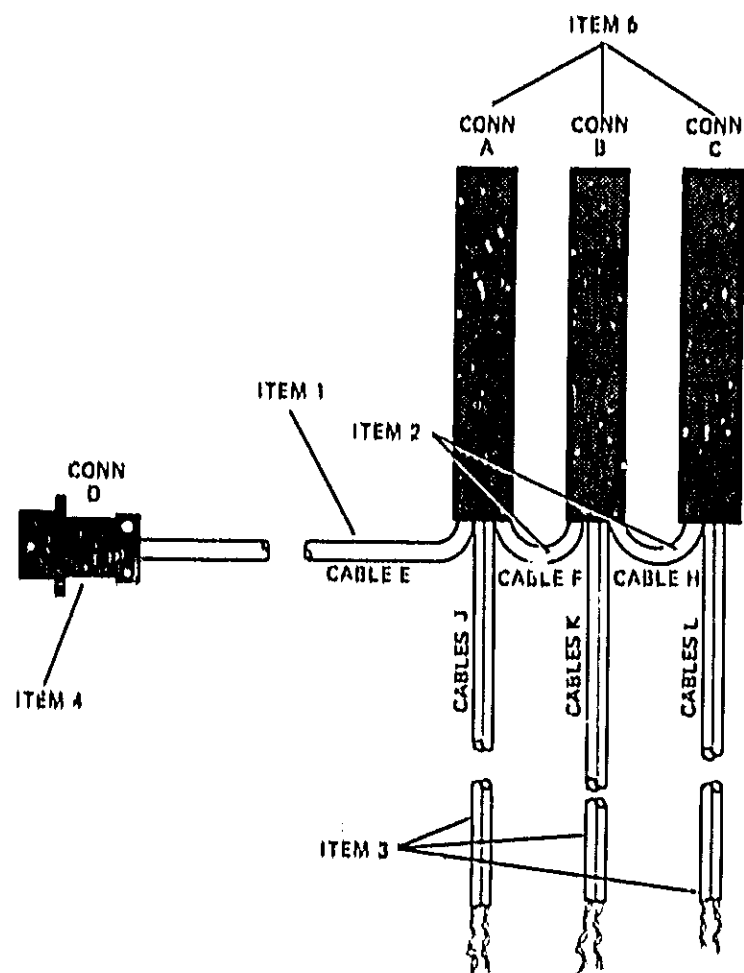


Figure E-14. Power Supply Line Cord



Refer to 10763A English/Metric Pulse output unit manual for recommended termination of twisted pair cables.

ITEM	QTY	DESCRIPTION	PART NO.
1	1	2' CABLE 21 COND. SHD	B120-0181
2	2	3' CABLE 8 COND. SHD	B120-1263
3	6	15' CABLE 2 COND. SHD	B120-0097
4	1	CONNECTOR 19 PIN	1261-4684 (MATE 1261-4683)
5	3	CONNECTOR 48 PIN KIT	6060-8330

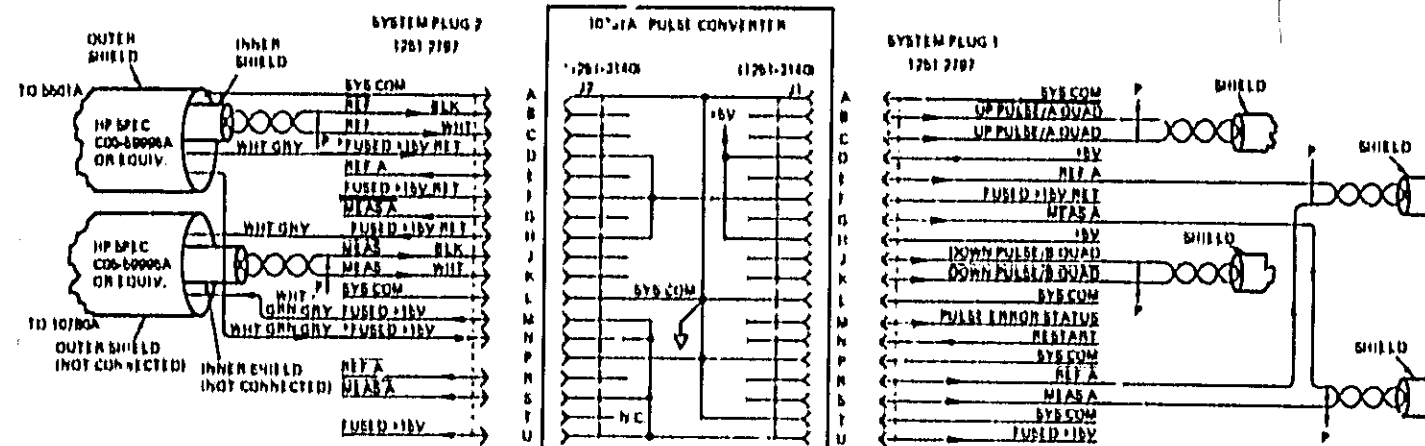
Figure E-15. Control and Output Cable Wiring

CABLE E		CABLE F		CABLE H	
CONN D	COLOR	CONN A		CONN B	CONN C
A	WHT-YEL	17			
B	WHT-BLU	18			
C	WHT-BLK-ORN	T			
D	WHT-BLK-YEL	L			
E	WHT-BLK-BLU	W			
F	WHT-BRN-RED	P			
G	WHT-BRN-ORN	R			
H	WHT-BRN-YEL	S			
J	WHT-BRN-GRN	12			
K	WHT-ORN	X	WHT	17	
L	WHT-BLK-BRN	Y	WHT-BLK	18-R	
M	WHT-BLK-RED	Z	RED	T	
N	WHT-BLK-GRN	AA	GRN	L	
P	WHT-BLK-VIO	BB	VIO	W	
R	BRN	20	BRN	20	BRN 17
S	ORN	21	ORN	21	ORN 18-R
T	YEL	22	YEL	22	YEL T
U	BLU	23	BLU	23	BLU L
V	WHT-BRN	24	WHT-BRN	24	WHT-BRN W
NC	SHIELD	V	SHIELD, CONN B ONLY)	V	SHIELD, CONN C ONLY) V

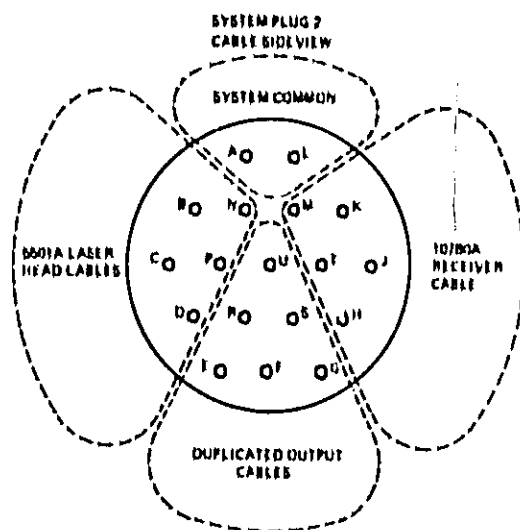
CABLES J TO CONN A CABLES K TO CONN B CABLES L TO CONN C	
PIN NO.	COLOR
2	WHT
3	SHIELD
4	BLK
6	WHT
7	SHIELD
8	BLK

Figure E-15. Control and Output Cable Wiring (cont'd)

Figure E-16. 10781A Pulse Converter Wiring



*FUSED +16V POWER SOURCE MAY BE 6601A OR USER-SELECTED POWER SUPPLY



10781A NOTES

1. INNER SHIELDS MAY OR MAY NOT BE CONNECTED TO SYS COM, DEPENDING ON INSTALLATION.
2. SYS COM PROVIDES POWER RETURN FOR +16V ONLY.
3. FUSED +16V RET NOT CONNECTED TO SYS COM.
4. OUTPUT SIGNAL SHIELDS ARE NOT CONNECTED.
5. DUPLICATED OUTPUTS DENOTED BY AN "A" FOLLOWING SIGNAL NAME, E.G., "REF A" IS DUPLICATED OUTPUT.

ONLY DUPLICATED OUTPUT SIGNALS MAY BE USED TO OR, VE OTHER AXIS. DO NOT JUMP IN INPUT SIGNAL LINES FOR OTHER AXIS.

EXAMPLE:
FOR SECOND AXIS USE REF A AND REF A (DUPLICATED SIGNALS) NOT REF AND REF (ORIGINAL INPUT SIGNALS)

WHEN WIRING P2 POSITION CABLES AROUND PLUG AS SHOWN IN P2 DIAGRAM

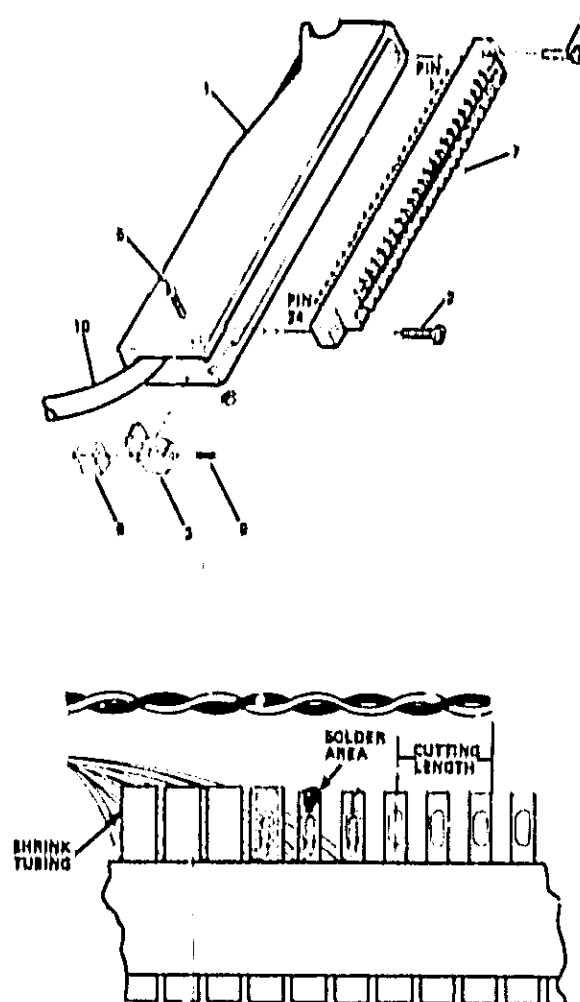
TABLE C. 10781A WIRING

10781A SIGNAL	CONTROLLER	10780A	6601A
SYS COM	+16V POWER RETURN		
+16V FUSED 12M, N		J1 4	A121 A
+16V RET FUSED 12M, F		J1 3	A121 B
+16V (J1 D)	+16V OUTPUT		
REF			A121 D
REF A			A121 E
SYS COM (J2 A)			OUTER CABLE SHIELD
REF A		J1 2	
REF B		J1 1	

E.5 HOODED CONNECTOR WIRING PROCEDURE

Because the 48-pin hooded connectors used in the Laser Transducer System Interface a wide variety of circuit boards, the following procedure only explains how to wire a hooded connector. The individual unit cable requirements reference the applicable cabling drawings for specific wiring. The 48-pin connector kit is furnished as part of the individual boards and provides the required connection at the coupler (or computer) end of the interconnecting cable. Figure E-17 shows details of cable fabrication. The procedure for wiring the 48-pin connector is as follows:

- a. Insert the appropriate cables into the connector hood. See the figures referenced from the individual boards to determine cable requirements.
- b. Strip the outer jacket of the cables back far enough to make the necessary connections.
- c. Connect individual wires of the cables to appropriate pins (see referenced drawings).
- d. Trim off any excess wire and install the 48-pin connector in the connector hood using the two self-tapping screws.
- e. Install the cable clamp and tighten it in place with the setscrew.



ITEM	DESCRIPTION	PART NO.
1	CONNECTOR HOOD	6040-6071
2	SELF-TAPPING SCREW (A)	0624-0088
3	MOUNTING BLOCK	6040-6072
4	SELF-TAPPING SCREW (B)	0624-0088
5	PAN-HEAD SCREW (4-40 x .562")	2200-0091
6	HEX NUT (4-40 x .187")	2260-0002
7	CONNECTOR, 48 PIN	1251-0336
8	CABLE CLAMP	6040-6003 OR 6040-6004
9	SET SCREW	3030-0143
10	CABLE	SEE REFERENCED FIGURES

Figure E-17. Hood Connector Cable Fabrication Diagram and Parts List

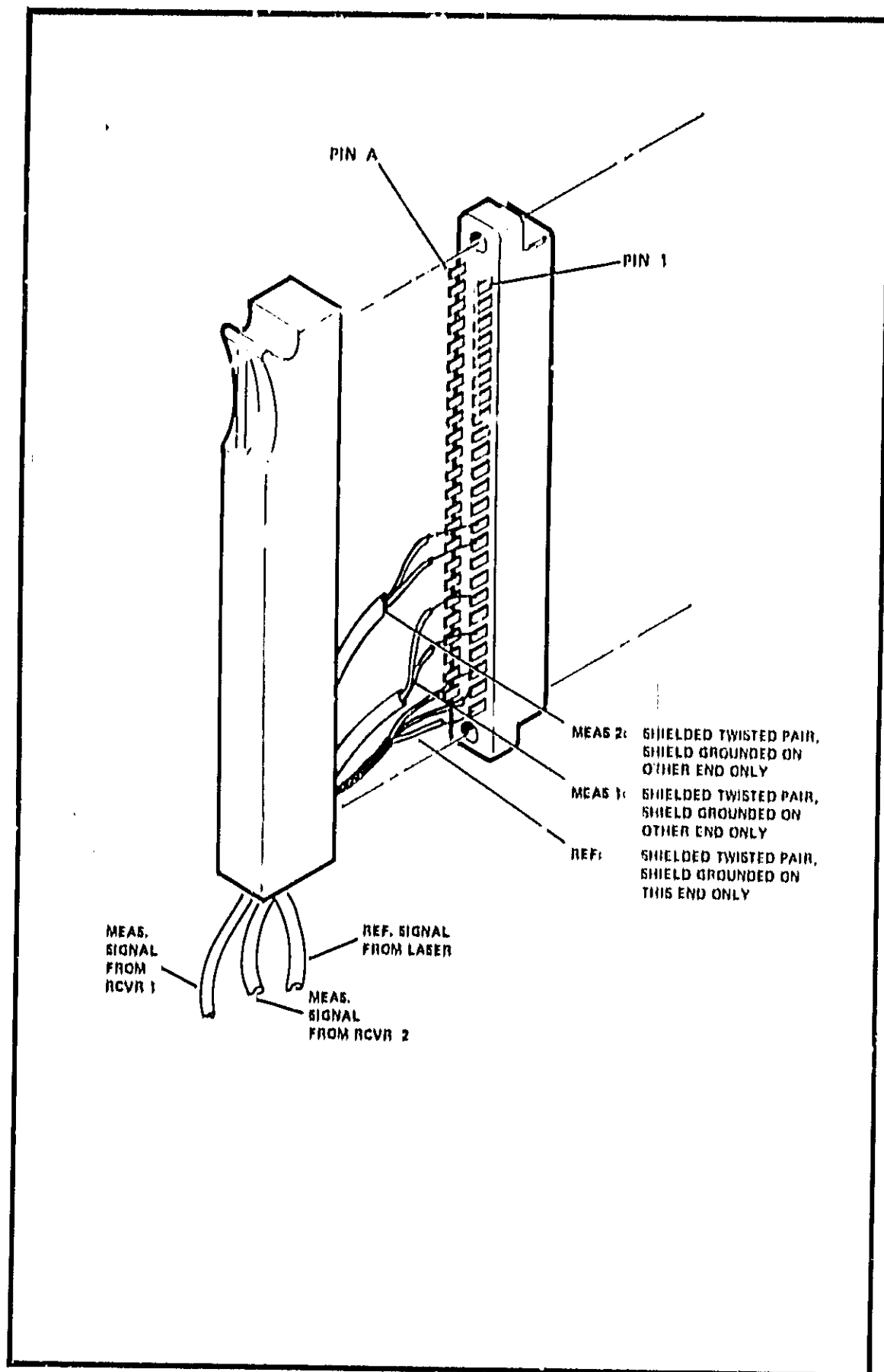


Figure E-18. Connector Wiring for Fast Pulse Converter

MANUAL CHANGES

MANUAL UPDATING CHANGES

CHANGE DATE: September 26, 1985

***** MANUAL UPDATING COVERAGE *****
This supplement adapts your manual
to instruments with serial numbers
prefixed through 2504.

***** MANUAL IDENTIFICATION *****
Instrument: Model 5501A
Laser Transducer System
System Operating &
Service Manual
Manual Part No: 05501-90028
Manual Microfiche: 05501-90029
Manual Print Date: May 1983

ABOUT THIS SUPPLEMENT

The information in this supplement is provided to correct manual errors and to update the manual to instruments containing changes after the manual print date.

Change and correction information in this supplement is itemized by page numbers corresponding to the original manual pages. The pages in this supplement are organized in numerical order by manual page number.

Manual updating supplements are revised as often as necessary to keep manuals as accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies quote the model number, print date, and part number listed at the top of this page.

HOW TO USE THIS SUPPLEMENT

Insert this title page in front of the title page in your manual.

Perform all changes specified for "All Serials", and all changes through the Series Prefix of your instrument or board.

Insert any complete replacement pages provided into your manual in the proper location.

If your manual has been updated according to the last edition of this supplement, you need only perform those changes pertaining to the new series prefix. See List of Effective Pages on the reverse side of this page. New information affecting "All Serials" will be indicated by a "#" in front of the page number.

LIST OF EFFECTIVE PAGES

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*****
#   SERIAL PREFIX OR
#   SERIAL NUMBER          PAGES
*****

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#   All Serials           Front Cover/Warranty Statement

    2312A thru 2504       These changes do not affect the contents of
                           the System Operating & Service Manual.

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