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Instruction Manual

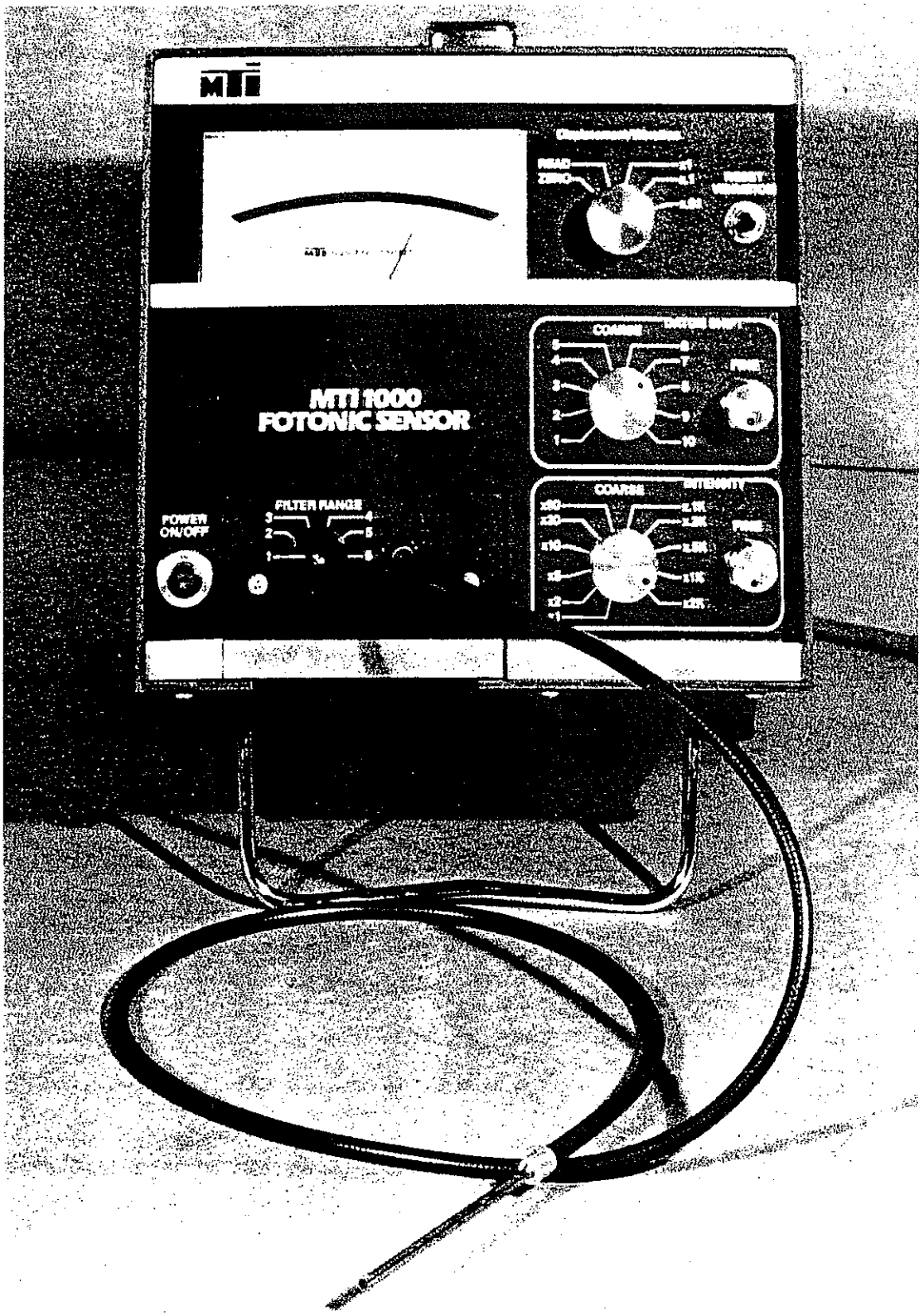
# MTI 1000
# FOTONIC™ SENSOR

Revision 1.0

## Fiber Optic Displacement Vibration Measurement Instrument

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**MTI-1000 Fotonic Sensor**



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## Warranty

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# MTI 1000 Fotonic™ Sensor Specifications

## Probe/Plug-in Module

**Probe Operating Temperature Range**
-100 to 300°F

**Probe Tip Length**
3 in.

**Probe Minimum Bend Radius**
1 in.

**Typical Probe Operating Pressure Range**
Vacuum of 29 in. Hg to 500 psig

**Range, Standoff, Frequency Response**
Refer to Table 5-1

**Calibration Data**
Sensitivity and frequency response characteristics supplied with each module

## Displacement Readout

**Stability — 12 Hours (±2°F)**
Drift less than 0.1% of full scale*

**Stability — 60 to 95°F**
Drift less than 1% of full scale*

**Displacement Output Signal**
+10 V dc, 100 Ω output impedance

## General

**Line Voltage Stability — 105 to 130 V ac**
Drift less than 0.1% of full scale*

**Instrument Operating Temperature Range**
50 to 150°F

**Storage Temperature Range**
0 to 150°F

**Readout**
3½-in. taut band meter

**Power Requirements**
Less than 10 W, 115/230 V, 50 to 400 Hz

**Dimensions**
Weight: 8 lb
Size: H = 7 in., W = 7¼ in., L = 10 in.

*Full range = Full scale deflection on unexpanded range, 10 V dc

## Vibration Readout

**Ranges**
x1 — 10 V peak-to-peak full scale
x.1 — 1 V peak-to-peak full scale
x.01 — 0.1 V peak-to-peak full scale

**Accuracy**
x1 Range — Accurate to within 1%
x.1 Range — Accurate to within 1%
x.01 Range — Accurate to within 10%

**Output Signal Ripple**
x1 Range — 10 mV peak-to-peak
x.1 Range — 20 mV peak-to-peak
x.01 Range — 200 mV peak-to-peak

**Offset**
Less than 0.5% of full scale*

**Frequency Response**
x1 Range — Flat within 1% from 10 Hz to 100 kHz
x.1 Range — Flat within 1% from 20 Hz to 100 kHz
x.01 Range — Flat within 1% from 50 Hz to 100 kHz

**Stability — 60 to 95°F**
x1 Range — Drift less than 0.1% of range
x.1 Range — Drift less than 0.5% of range
x.01 Range — Drift less than 5% of full range

**Vibration Output Signal**
10 V dc full scale signal on each range
100 Ω output impedance

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# SECTION 1
# INTRODUCTION

## 1.1 Introduction

A fiber optic measurement system, the MTI 1000 Fotonic Sensor performs non-contact displacement/vibration and surface condition measurements. By using fiber optics to measure target motion, the MTI 1000 imposes no load on the target under measurement and remains unaffected by magnetic and electrical fields. Factory calibrated probe/plug-in modules offer a wide range of probe diameter, sensitivity and frequency response, allowing the user to measure displacement motions ranging from .000001 in. to .25 in. at frequencies ranging from dc to 100 kHz. All measurements are performed without altering the target's natural position or motion. Since the probe/plug-in modules are interchangeable, the MTI 1000 adapts easily to changing application needs. Designed for versatility and accuracy, the MTI 1000 Fotonic Sensor meets the needs of research and industrial measurement applications.

## 1.2 Receiving Inspection Procedure

The main frame instrument is shipped fully assembled and packed in a cardboard carton with foam inserts to guard against shipping damage. The probe/plug-in module is shipped in a separate carton. Immediately upon receipt, perform the following inspection:

1. Inspect the exterior of the shipping cartons. Note any obvious damage. If shipping damage is evident, file a claim with the carrier.

2. Remove the main frame instrument and module from their respective cartons. Insert the module and test instrument operation. Refer to Section 2 in this manual.



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## 1.3 Return Shipment Procedure

Notify MTI Instruments prior to shipping the instrument to receive a return authorization. Reference the instrument's name, model and serial numbers on all correspondence. Place the instrument in the original shipping carton (or equivalent container) and forward the instrument, prepaid to: Supervisor of Manufacturing, MTI Instruments.



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# SECTION 2
# OPERATING INSTRUCTIONS

## 2.1 Introduction

This section describes how to operate the MTI 1000 Fotonic Sensor, by providing information on how to:

- Operate the controls
- Use the calibration curve
- Use the frequency response curve
- Calibrate the instrument
- Perform static measurements
- Perform dynamic measurements
- Increase meter sensitivity through zero suppression

Read the following instructions and observe all procedures to operate the instrument properly.

## 2.2 Controls, Connectors and Indicator

Refer to Figure 2-1 and Figure 2-2 for the locations and operation procedures of the instrument's controls, connectors and indicator. Since certain controls require additional explanation, a detailed description of these controls is provided in Section 2.2.1. You should be familiar with all the controls before operating the instrument.

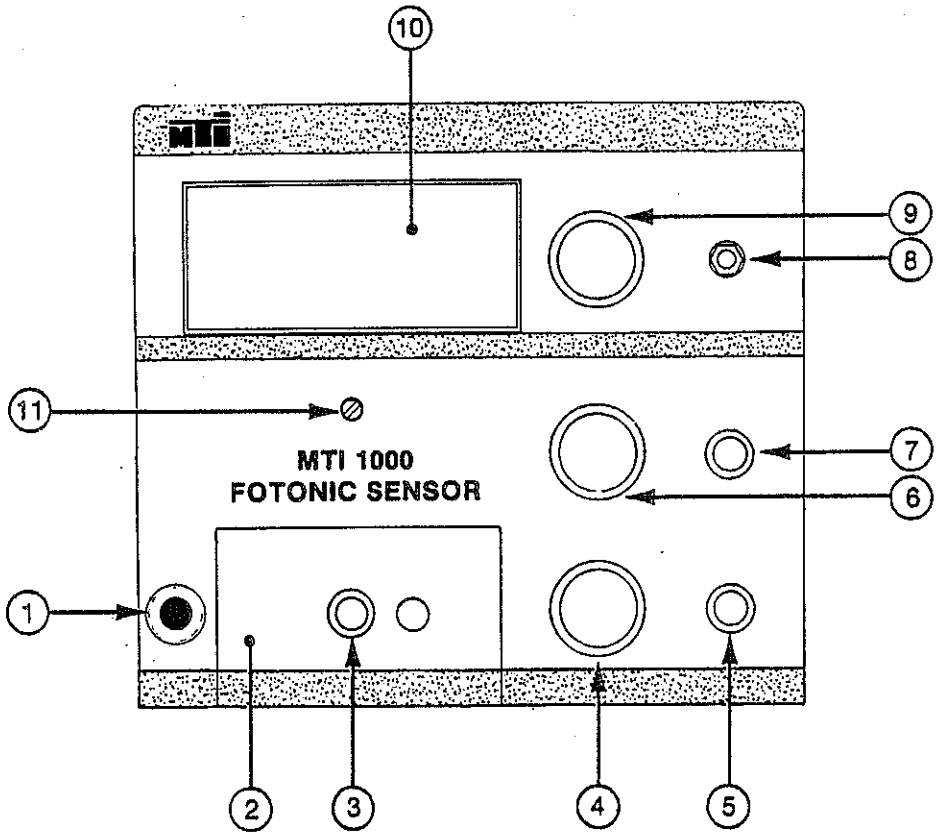
### 2.2.1 Detailed Control Description

The controls described in this section are:

- Probe/Plug-in Module
- Displacement/Vibration control
- Panel Meter



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(1) POWER switch: Push on, push off. Switch lights when ac power is on; switch light extinguishes when ac power is off.

(2)* PROBE/PLUG-IN MODULE: Slide into front panel slot, module must be flush with panel. Senses displacement/vibration of a target.

(3)* FILTER RANGE switch: Use to activate low pass filter to reduce instrument's frequency response.

(4) INTENSITY COARSE control. Eleven position, calibrated switch. Use to control probe light intensity.

(5) INTENSITY FINE control: Vernier control, turn clockwise or counterclockwise. Use in conjunction with Intensity Coarse control to adjust overlap between Intensity Coarse switch positions.

(6) DATUM SHIFT COARSE control: Ten position, calibrated switch. Use to offset electrical zero of instrument.

(7) DATUM SHIFT FINE control: Vernier control, turn clockwise or counterclockwise. Adjusts any overlap between Datum Shift Coarse positions.

(8) VIBRATION RESET control: Push and hold to reset panel meter to "0". Use in conjunction with Displacement/Vibration control positions x1, x.1, and x.01.

(9)* DISPLACEMENT/VIBRATION control: Five position switch, controls panel meter operation. Use to select either a static displacement or dynamic vibration displacement measurement mode.

(10) PANEL METER: Indicates probe displacement in dc volts.

(11) MECHANICAL ZERO ADJUSTMENT SCREW: Turn set screw to manually position panel meter indicator.

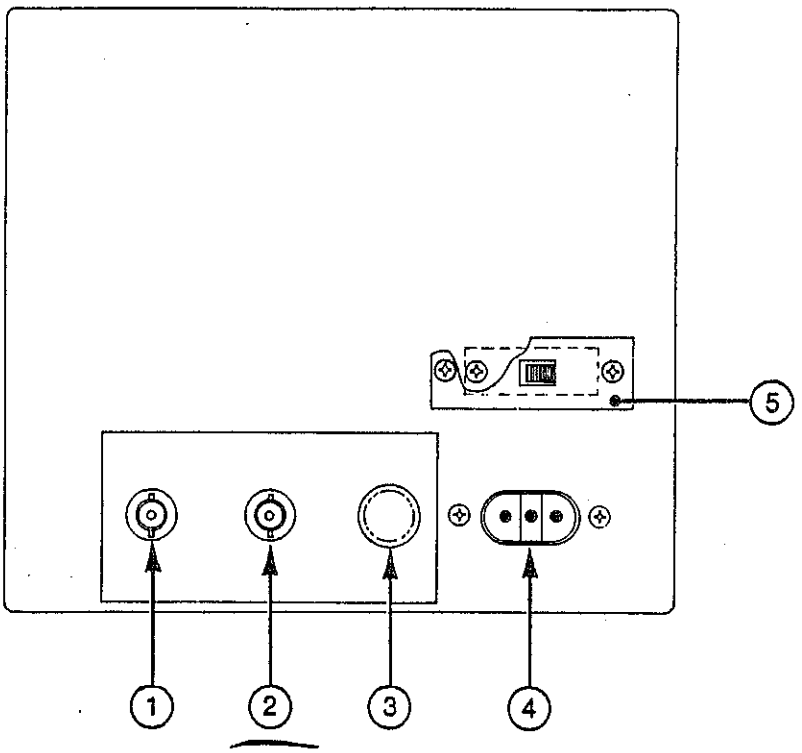
*Refer to Section 2.1.1 for detailed description of these controls.

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**Fig. 2-1 Front Panel Controls**



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(1) VIBRATION OUTPUT CONNECTOR: A BNC female connector that provides a dc volts signal proportional to the peak-to-peak amplitude of the vibration displacement signal.

(2) DISPLACEMENT OUTPUT CONNECTOR: A BNC female connector that transmits the probe output signal as a dc volts signal. Connect to an oscilloscope or other external read-out device to observe amplitude, waveshape and frequency.

(3) FUSE HOLDER: Holds standard 3AG fuse.

(4) AC POWER INPUT CONNECTOR: A 3-pin male connector, mates with a Belden No. 17258-5 line cord. Supplies ac input power.

(5) VOLTAGE SELECTION switch: Use to set instrument's line voltage to either 115 V or 220 V. Remove trimplate to change switch position.

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**Fig. 2-2 Rear Panel Controls**



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## PROBE/PLUG-IN MODULE

The probe/plug-in module transmits light to and receives light from a target surface. A module assembly contains a light source, two light detectors and a fiber optic probe. Selection of a probe/plug-in module depends on the displacement range, frequency response and probe diameter requirements. Refer to Section 5 for probe/plug-in module specifications and selection criteria. Each probe/plug-in module offers unique sensitivity and slope capabilities and the instrument must be properly adjusted to ensure that these characteristics are obtained in use. A CALIBRATION CURVE is supplied with each module to identify the particular optical peak area operating range and front slope sensitivity of the module. The calibration curve also depicts the relationship between the module's output in volts and the probe-to-target gap in mils. For easy reference, the front slope of a module is imprinted on the bottom plate of the module assembly.

The FILTER RANGE switch connects the probe/plug-in module to a low pass filter that reduces the frequency response of the instrument. The filter is an intentional attenuator, which improves signal-to-noise ratio by attenuating the instrument response to frequencies above the target frequency operation. Switch setting "1" allows full bandwidth operation, with the instrument frequency response matching that shown on the module's frequency response curve. The other switch settings decrease the high frequency response of the module. Refer to the module's frequency response curve to determine frequency values at each switch setting.

## DISPLACEMENT/VIBRATION CONTROL

The displacement/vibration control is a five position switch that controls the operation of the panel meter and allows you to select either a static displacement or a dynamic vibration displacement measurement for display on the panel meter.



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ZERO - In the ZERO position, the probe light is extinguished to permit adjustment of the instrument's electrical zero with the Datum Shift controls. Use this setting prior to instrument calibration.

DISPLACEMENT READ - In the READ position, the panel meter will register static displacement and indicate the probe-to-target gap in dc volts. Use the READ setting during instrument calibration to set the probe-to-target gap and to perform static displacement measurements. The READ setting also connects the panel meter to the displacement output connector, where the displacement signal is available to be read on an oscilloscope or other external readout device. The static displacement signal is available at the displacement output connector even when the x1, x.1 and x.01 switch settings are in use.

VIBRATION x1, x.1, x.01 - The VIBRATION x1, x.1 and x.01 positions convert a dynamic displacement signal to a dc level signal, which can be read on the panel meter. The reading shown on the panel meter is proportional to the amplitude of the vibration signal. The three switch settings signify different levels of sensitivity to vibration signals. The x1 setting gives a full scale sensitivity of 10 V peak-to-peak, the x.1 setting gives a full scale sensitivity of 1.0 V peak-to-peak and the x.01 setting gives a full scale sensitivity of .10 V peak-to-peak. The dc voltage proportional to the peak-to-peak dynamic vibration amplitude is available at the VIBRATION OUTPUT CONNECTOR, for use with an external readout or recording device.



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### PANEL METER

The PANEL METER indicates the probe amplifier output in dc volts and can provide measurement resolution to 1.0 microinch (μin.) with a suitable probe/plug-in module. The meter has a full scale sensitivity of +10 V. The meter scale also contains "Set/Cal," "Front Slope Operate" and "Back Slope Operate" zones to aid in calibrating the instrument. The "Set/Cal" zone helps you establish the sensitivity of the probe/plug-in module to the value shown on the module's calibration curve. The "Front Slope Operate" zone helps you position the probe to the proper gap required to operate on the front slope range of the module. The "Back Slope Operate" zone helps you position the probe to the proper gap required to operate on the back slope range of the module.*

## 2.3 Calibration Curve

Each probe/plug-in module displays unique output and gap characteristics, which are depicted on the module's CALIBRATION CURVE. The calibration curve shows the particular response curve of the module and compares the amount of reflected light seen by the probe's receiving fibers (OUTPUT) in dc volts to the amount of displacement between the probe tip and the target surface (GAP) in mils.

Use the calibration curve when you:

- Calibrate the instrument to a probe/plug-in module
- Perform static measurements

Read Section 2.3.1 and become familiar with the features of the calibration curve before operating the instrument.

---

*Meters on certain models are marked with "Operate" zone only.



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### 2.3.1. Calibration Curve Features

The CALIBRATION CURVE is a two-plot curve with the following features. See Figure 2-3.

#### PLOT A

Plot A shows the FRONT SIDE and optical peak of the particular probe/plug-in module response characteristic. The gap scale for plot A is the smaller of the two horizontal ranges (X axis).

#### PLOT B

Plot B shows the front side, optical peak and back side response characteristic. The gap scale for plot B is the larger of the two horizontal ranges (X axis).

#### FRONT SIDE

The FRONT SIDE of the curve is defined as the operating area between probe-to-target contact and the optical peak, and shows the initial rise in the module's response.

#### FRONT SIDE SLOPE

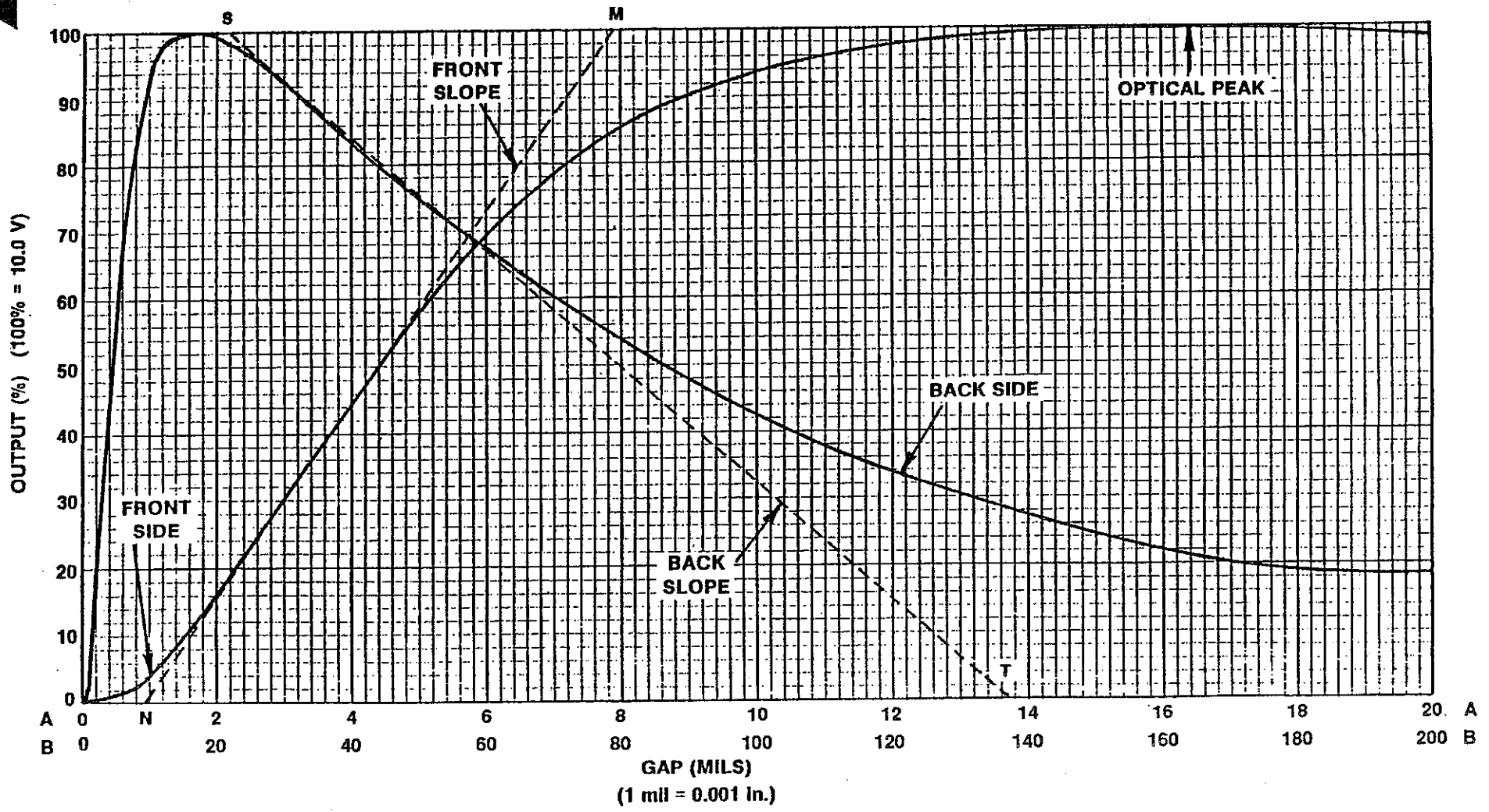
The FRONT SIDE SLOPE is plotted on the most linear rise of the curve's Front Side and indicates the probe's Front Side OPERATING RANGE.

#### OPTICAL PEAK

The OPTICAL PEAK is the area where the probe output becomes insensitive to gap changes. This area is used to calibrate the instrument response to be independent of target reflectivity characteristics. The optical peak area is also used for applications that require sensing of surface reflectance and not gap.



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**Fig. 2-3 Calibration Curve**



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### BACK SIDE

The BACK SIDE of the response curve is the area from the optical peak on out to large gaps.

### BACK SIDE SLOPE

The BACK SIDE SLOPE is the most linear portion of the BACK SIDE of the curve and indicates the probe's Back Side OPERATING RANGE.

### NOISE LEVEL VALUE

The instrument's NOISE LEVEL is the peak-to-peak value of the dynamic portion of the internal signal, independent of target vibration and generated within the module and main frame circuitry. This value has been determined with the probe-to-target gap set at the front slope midpoint.

## 2.4 Frequency Response Curve

The FREQUENCY RESPONSE CURVE depicts the module's frequency response characteristics and its limitations in sensing high frequency vibrations. See Figure 2-4. The linear portion of the curve indicates the area where the instrument responds to a vibration signal without introducing any attenuation. Beyond the linear portion of the curve, the output signal level must be corrected by the degree of attenuation indicated by the curve, to obtain true vibration amplitudes.

When operating in the VIBRATION x1, x.1 and x.01 settings, the panel meter reads only the vibration amplitude portion of the displacement signal. To observe the vibration frequency portion of the output signal, the DISPLACEMENT OUTPUT CONNECTOR must be connected either to an oscilloscope or a frequency meter/counter.



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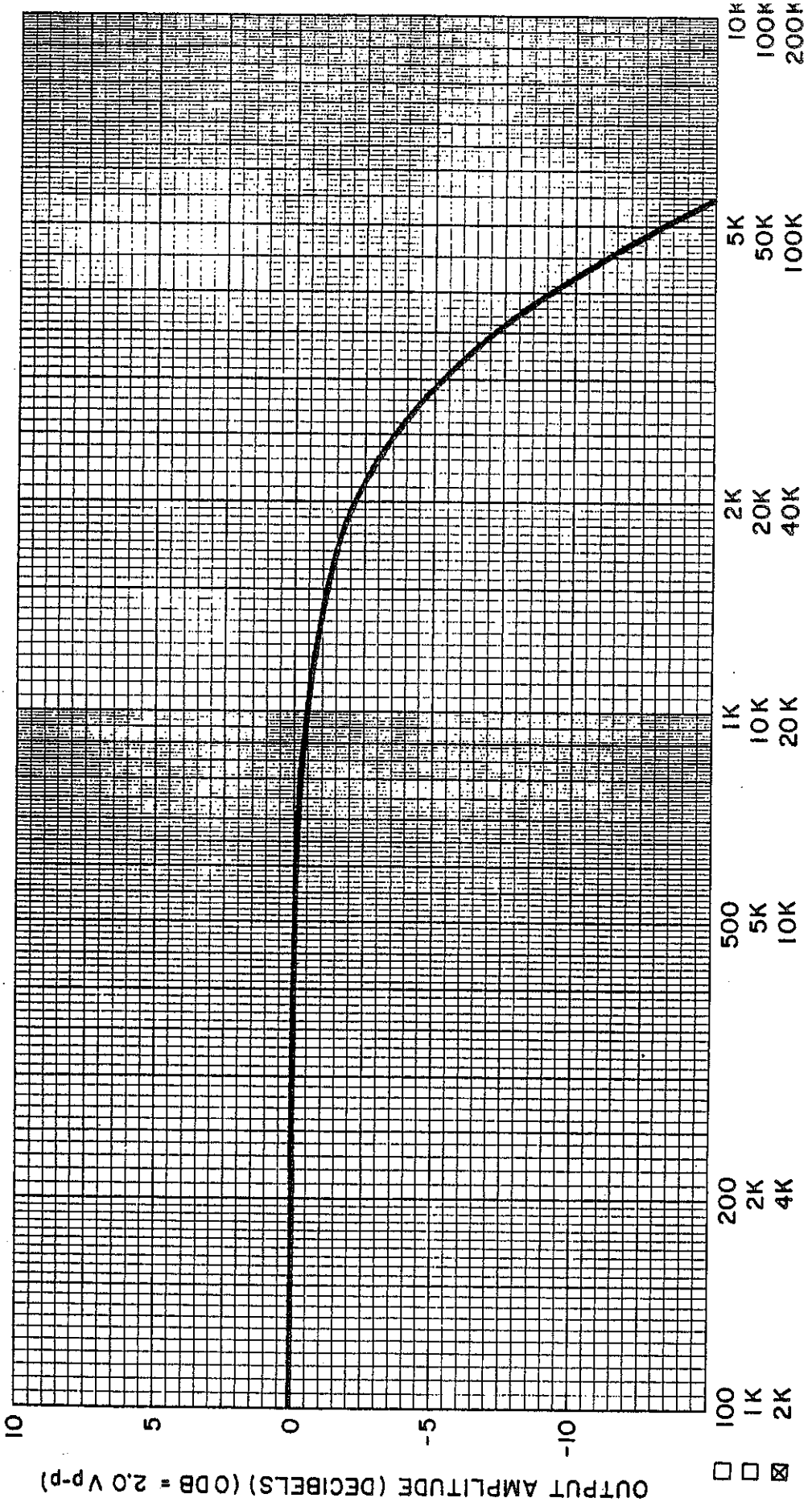



**Fig. 2-4 Frequency Response Curve**



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## 2.5 Instrument Installation

Proceed as follows to install the instrument.

1. Plug the line cord into the ac power input connector and connect the cord to a grounded ac receptacle.

> **CAUTION**
>
> CONNECT THE LINE CORD TO A GROUNDED RECEPTACLE ONLY.

2. Check the line voltage selector switch to ensure that it matches the power source voltage.

> **NOTE**
>
> The switch trim plate is labeled on both sides. One side of the trim plate is labeled: "Set for 115 Volts - Use 1/10A Fuse", the reverse side is labeled: "Set for 220 Volts - Use 1/16A Fuse". To change the switch position, remove the two 4-40 Phillips head screws that secure the trim plate to the rear panel. Then remove the trim plate, change the switch position and reverse the trim plate to install. Since the switch slot is offset to prevent an incorrect switch setting, the trim plate must be reversed to line up with the screw holes in the panel.

> **CAUTION**
>
> TO PREVENT BURN-OUT OF THE INPUT POWER TRANSFORMER, THE LINE VOLTAGE MUST MATCH THE POWER SOURCE VOLTAGE.

3. Check that the correct fuse size is installed for the voltage selected. The fuse size is indicated on the voltage selector switch trimplate.

## 2.6 Instrument Warm-Up and Electrical Zeroing

Perform the following steps before calibrating the instrument, to set the electrical zero and allow for probe/plug-in module warm-up.



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1. Check that the panel meter reads "0". If the indicator is not at "0", use a screwdriver and turn the mechanical adjustment set screw to position the indicator to "0".

2. Slide the desired probe/plug-in module into the instrument's front panel. The module must be flush with the panel.

**CAUTION**

HANDLE THE PROBE/PLUG-IN MODULE ASSEMBLY WITH CARE TO AVOID DAMAGING THE FIBER OPTIC PROBE.

3. Check that the probe tip and the target surface are free from debris, such as dirt or grease.

**NOTE**

If debris is present clean the probe tip with a solvent (acetone or alcohol).

4. Set the INTENSITY COARSE switch to the x10 position and turn the INTENSITY FINE control to mid-range.

5. Press the POWER switch to turn the instrument "ON". Allow 5 minutes for warm-up of the module assembly circuit.

6. Set the DISPLACEMENT/VIBRATION control to "ZERO" to turn off the probe light source.

7. Shield the probe tip to prevent it from sensing any ambient light. You may cover the probe tip with your hand or contact the probe directly to a target.



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8. Turn the DATUM SHIFT COARSE control to the "10" position and turn the DATUM SHIFT FINE vernier to the maximum clockwise rotation. This sets the electrical zero of the instrument.

9. Turn the INTENSITY COARSE control to the xl position.

## 2.7 Calibration Procedure For First-Time User

The following procedure is recommended for first-time users, to illustrate how to calibrate the instrument to a probe/plug-in module.

Equipment Required:

Calibration Fixture (use of the KD-CH-III calibration fixture is recommended).

1. Perform instrument warm-up and electrical zeroing as described in Section 2.6.

2. Rotate the micrometer barrel counterclockwise several turns. Reverse the barrel rotation to clockwise and set the micrometer to a zero reference rotation position.

3. Insert the probe into the vee notch of the calibration fixture. Position the probe so that the probe tip lightly contacts the target surface.

4. Tighten the probe clamp evenly and ensure that the probe remains aligned with the target and centered in the vee notch.

5. Rotate the micrometer barrel counterclockwise to move the target away from the probe tip. Reverse the barrel rotation to clockwise and turn the barrel until the target face contacts the probe tip. Complete probe-to-target contact sets ZERO GAP.

6. Check the panel meter, the indicator should read "0".



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7. Turn the Displacement/Vibration control to the "READ" position. Check the panel indicator - it should remain at "0" when switching to the "READ" position. If the indicator moves up scale of the "0", zero gap has not been set. Check to ensure that the probe is aligned and centered on the target.

8. Refer to the module's calibration curve and find the Optical Peak area on plot A or B.

9. Rotate the micrometer barrel counterclockwise and observe the panel indicator. The indicator will move up scale as the target moves away from the probe. The indicator will stop moving when the optical peak is reached.

> **NOTE**
>
> If the indicator goes off scale before reaching the optical peak, then the INTENSITY COARSE control is set too high. Reduce this control setting until the indicator "peaks out" (somewhere between one-half and full scale) when passing through the optical peak area. Leave the micrometer set at the gap corresponding to the approximate midpoint of the optical peak.

10. Turn the INTENSITY FINE control clockwise to move the indicator to the "Set/Cal" mark on the scale. If the INTENSITY FINE control reaches full stop and the indicator has not reached the "Set/Cal" mark, then the light intensity of the probe must be increased by changing the INTENSITY COARSE control setting.

> **NOTE**
>
> Turn the INTENSITY FINE control completely counterclockwise before changing the INTENSITY COARSE control setting. This will prevent the probe's light intensity from going off scale, when the INTENSITY COARSE control setting is changed.



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11. Turn the INTENSITY COARSE control to the next higher switch setting. Then turn the INTENSITY FINE control clockwise to bring the indicator to the "Set/Cal" zone. If this intensity level is still not sufficient, repeat the above procedure until the "Set/Cal" zone is reached.

**CAUTION**

DO NOT CHANGE THE POSITION OF THE INTENSITY FINE CONTROL, ONCE THE CORRECT LIGHT INTENSITY LEVEL HAS BEEN ESTABLISHED.

12. Turn the micrometer barrel clockwise to decrease the gap and move into the front slope operating range. Observe the indicator, it will move down scale of the "Set/Cal" zone as the target moves towards the probe. Continue to move the micrometer barrel until the indicator is positioned in the "Operate" zone on the scale. The gap is now calibrated to the front side slope shown on the calibration curve.

13. If the back slope area is to be used to obtain more range or standoff distance, then the micrometer must be rotated counterclockwise in Step 12 rather than clockwise. This will increase the gap and move the probe into the back side operating area. Refer to the probe/plug-in module calibration curve to determine the meter reading necessary for operation on the most linear portion of the back slope. The meter reading will usually be higher than that indicated for the front slope operating position.

## 2.8 Normal Calibration Procedure

1. Perform instrument warm-up and electrical zeroing as described in Section 2.6.

2. Mount the probe in a suitable holding fixture. The probe tip must be horizontal to the target face.

3. Contact the probe tip to the target face.



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4. Turn DISPLACEMENT/VIBRATION control to the "READ" setting.

5. Refer to the module's calibration curve and determine the optical peak area.

6. Move the probe away from the target until the panel indicator reaches the optical peak area.

7. Turn the INTENSITY FINE control clockwise to move the indicator to the "SET/CAL" mark on the scale. Increase INTENSITY COARSE control setting if indicated.

**CAUTION**

ONCE THE CORRECT LIGHT INTENSITY LEVEL HAS BEEN ESTABLISHED, DO NOT CHANGE THE POSITION OF THE INTENSITY FINE CONTROL.

8. Move the probe towards the target until the panel indicator reaches the "Front Slope Operate" zone on the scale, when using the front side response area. Move the probe away from the target until the indicator reaches the "Back Slope Operate" zone, when using the back side response area.

**NOTE**

The operating and optical peak areas shown on the sample calibration curves (Figures 2-3, 2-5, and 2-6) have been determined with air as the probe-to-target gap medium and with a polished stainless steel surface of approximately 4 in. AA. Depending on your application needs, the medium in the probe-to-target gap may be a fluid medium (oil or water) and thus have a different index of refraction than air. Since the operating and optical peak areas of a module will not be the same for a fluid medium, you must perform an in-place calibration to determine these areas, instead of relying on the module's calibration curve. Calibrate the instrument with the KD-CH-III calibration fixture as described in Section 2.7. Use the calibration fixture in a vertical position and place the fluid medium directly on the fixture target. Also, for unusual target surface conditions, i.e., a translucent target or an unusually rough target surface, an in-place calibration must be performed. If you experience difficulty calibrating the instrument to a fluid medium or to an unusual target surface, contact MTI Instruments for assistance.



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## 2.9 Performing Static Measurements

Proceed as follows to perform static measurements on the FRONT SLOPE operating range.

1. Calibrate the instrument as described in Section 2.8.

2. Turn the DISPLACEMENT/VIBRATION control to the "READ" position and observe the voltage indicated on the panel meter. Refer to the module's calibration curve to determine the probe-to-target gap in mils.

   EXAMPLE See Figure 2-5. The meter indicates 3 Volts output. Find this value on the calibration curve. Draw a straight line from the output point to the front slope line (1). Then, from the front slope line, draw a straight line down to the gap scale (2). The probe-to-target gap (target reference position) is 3.0 mils.

3. Move the target and observe the new panel meter reading.

4. Refer to the module's calibration curve to determine the target displacement position.

   EXAMPLE See Figure 2-6. The meter indicates 5 Volts output. Find this value on the calibration curve. Draw a straight line from the output point to the front slope line. From the front slope line draw a straight line down to the gap scale (2). The probe-to-target displacement position is 4.4 mils.

5. Use the following formula to determine the target displacement value.

   Target Displacement Position - Target Reference Position = Target Displacement Value



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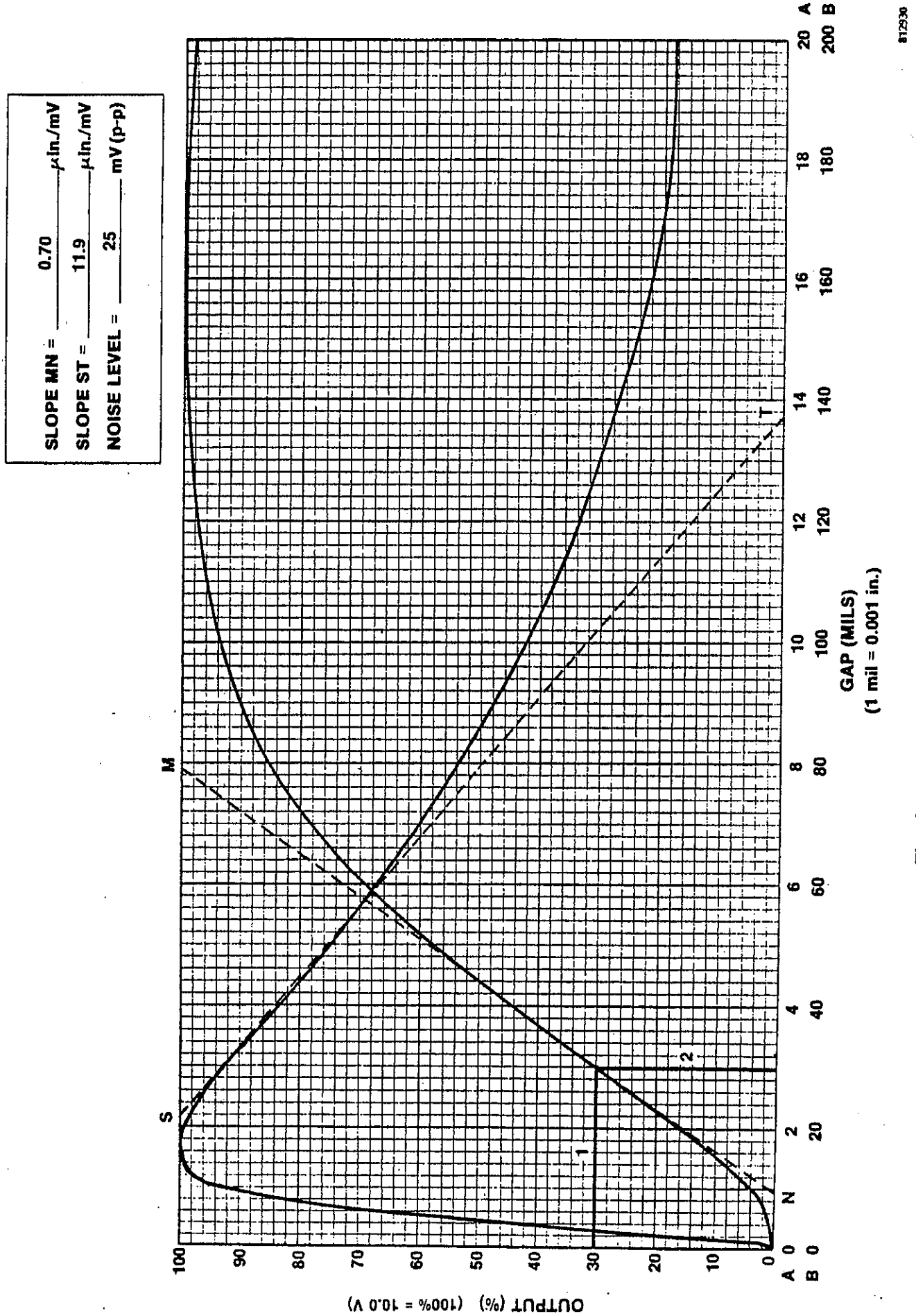



Fig. 2-5 Probe-to-Target Gap Determination



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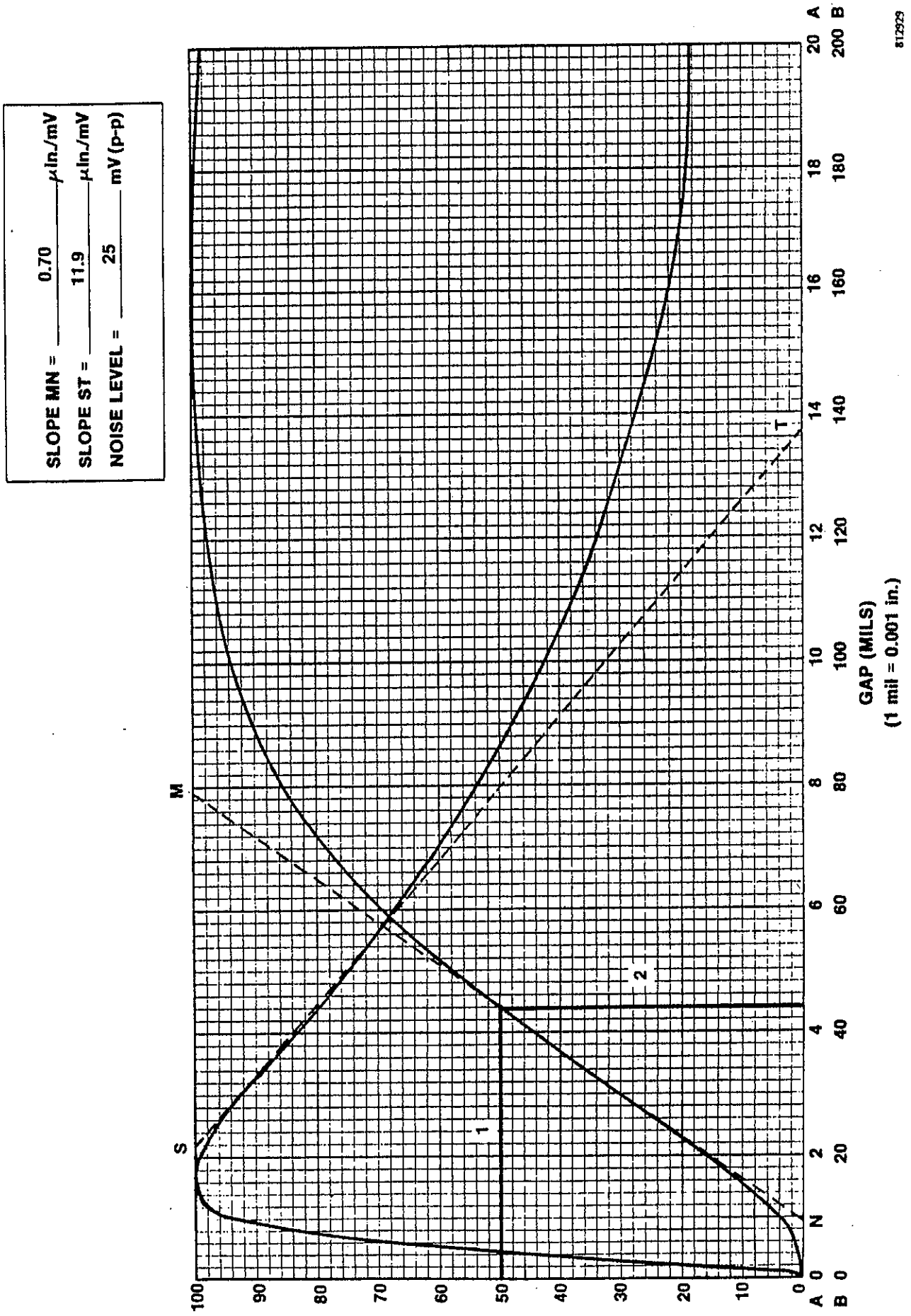



Fig. 2-6 Target Displacement Position



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EXAMPLE 4.4 mils - 3.0 mils = 1.4 mils

6. Instrument sensitivity can be increased when performing static measurements. Refer to Section 2.10 for this procedure.

> **NOTE**
>
> When performing static measurements on the BACK SLOPE operating range, follow the above procedure but locate intersection points on the back slope area of the calibration curve.

## 2.10 Performing Dynamic Measurements

Dynamic measurements may be performed with the DISPLACEMENT/VIBRATION control in either the "READ" setting or any of the "x" settings (x1, x.1, x.01).

### 2.10.1 Dynamic Measurement Using "READ" Setting

1. Calibrate the instrument as described in Section 2.8.

2. Set the DISPLACEMENT/VIBRATION control to the "READ" setting.

3. Connect the DISPLACEMENT OUTPUT CONNECTOR to an oscilloscope.

4. Observe the magnitude of the peak-to-peak vibration amplitude, displayed on the oscilloscope, to determine the target's dynamic displacement.

5. Use the following formula to determine the target displacement value.

   Peak-to-Peak Amplitude x Probe Slope = Peak-to-Peak Dynamic Displacement

   EXAMPLE Peak-to-peak Amplitude = 200 mV
   Probe Slope = 1 µin./mV

   200 mV x 1 µin./mV = 200 µin. Peak-to-Peak Dynamic Displacement



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NOTE

Use the Front Slope sensitivity factor when operating with the probe-to-target distance corresponding to the Front Slope operating region. Use the Back Slope sensitivity factor when operating on the Back Slope operating region.

## 2.10.2 Dynamic Measurement Using "x" Settings

1. Calibrate the instrument as described in Section 2.8.

2. Determine circuit noise level as follows.
   a. Ensure that the target is NOT vibrating and turn the DISPLACEMENT/VIBRATION control to the x.01 setting (100 mv peak-to-peak full scale)
   b. The noise level indicated on the panel meter should correspond to the noise level indicated on the module's calibration curve.

EXAMPLE Probe Noise Level: 25 mV
Meter Reading: 2 V; translate to 20 mV

   c. A major discrepency between the noise level value indicated on the panel meter and that shown on the calibration curve indicates either a target or a probe mounting fixture vibration or an instrument malfunction. To eliminate possible target or probe vibration as a high noise level cause, mount the probe in a calibration fixture, calibrate the probe to the fixture target and perform another noise level reading. If high noise level is still present, instrument malfunction is indicated. Refer to Section 4.3 for troubleshooting information.

3. Set the DISPLACEMENT/VIBRATION control to the vibration "x1" position. If the panel meter indicates less than a 1 V reading on the scale, use the next higher switch setting.

4. Vibrate the target and observe the panel meter reading.



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5. Use the following formula to determine the vibration displacement of the target.

[Meter Reading (mV) - Noise Level (mV) ] x Module Slope (µin./mV)
= Peak-to-Peak Vibration ( µin.)

EXAMPLE x.1 setting (1.0 V peak-to-peak full scale)
Probe Slope = 0.8 µin.
Noise Level = 20 mV
Meter Reading = 3.0
[300 mV - 20 mV] x .8 µin./mV = 224 µin. peak-to-peak

6. Increased dynamic sensitivity may be obtained during dynamic measurements by following the zero suppression procedure in Section 2.11.

## 2.11 Meter Sensitivity Increase and Zero Suppression

Instrument sensitivity can be increased by using increased intensity and suppressing the electrical zero of the instrument with the DATUM SHIFT controls. Proceed as follows.

1. Calibrate the instrument as described in Section 2.8

2. Note the INTENSITY COARSE control position multiplier number.

3. Turn the INTENSITY COARSE control to the setting that will provide the desired sensitivity.

EXAMPLE The module's sensitivity is 1.0 µin./mV and the desired sensitivity is 0.10 µin./mV. The INTENSITY COARSE switch setting is x20. Turning the INTENSITY COARSE switch to the x.2K (x.2K = x200) setting will increase module sensitivity by 10 times. The instrument sensitivity will now be 0.10 µin./mV.



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**CAUTION**

DO NOT ADJUST THE INTENSITY FINE CONTROL OR YOU WILL HAVE TO RECALIBRATE THE INSTRUMENT.

4. A sensitivity increase in excess of panel meter readout capability will drive the indicator off scale. To offset this increase, turn the DATUM SHIFT FINE and/or COARSE control counterclockwise, until the panel indicator comes back on scale or is deflected to the opposite side of the scale.

5. Use the DATUM SHIFT FINE control to position the indicator at "0" on the panel meter scale.

**NOTE**

To re-establish normal sensitivity, set the DISPLACEMENT/VIBRATION control to "ZERO" and turn the DATUM SHIFT COARSE control to position "10". Turn the DATUM SHIFT FINE control clockwise until the indicator is positioned at "0". Turn the INTENSITY COARSE switch setting to the original calibration setting and the DISPLACEMENT VIBRATION control to the "READ" position. Resume normal instrument operation.



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# SECTION 3

# INSTRUMENT DESCRIPTION

## 3.1 Introduction

This section describes the components of the MTI 1000 Fotonic Sensor and discusses how these components operate.

The instrument is of modular construction and its main components are the mother board and five printed circuit boards:

- A1 Mother board
- A2 Amplifier board
- A3 Vibration Detector board
- A4 Power Supply board
- A5 Switch board
- A6 Plug-in Module board

Refer to Figure 3-1. The A2, A3 and A4 boards plug directly into the mother board and the A5 board is connected to the mother board by cable.

The instrument also contains three main circuits:

- Lamp Control circuit
- Measuring circuit
- Vibration Detector circuit

The lamp control circuit regulates the light source intensity and the measuring circuit produces an output signal proportional to the received light intensity. The vibration detector circuit measures the peak-to-peak amplitudes of a variable displacement signal. All three circuits utilize a common power supply.



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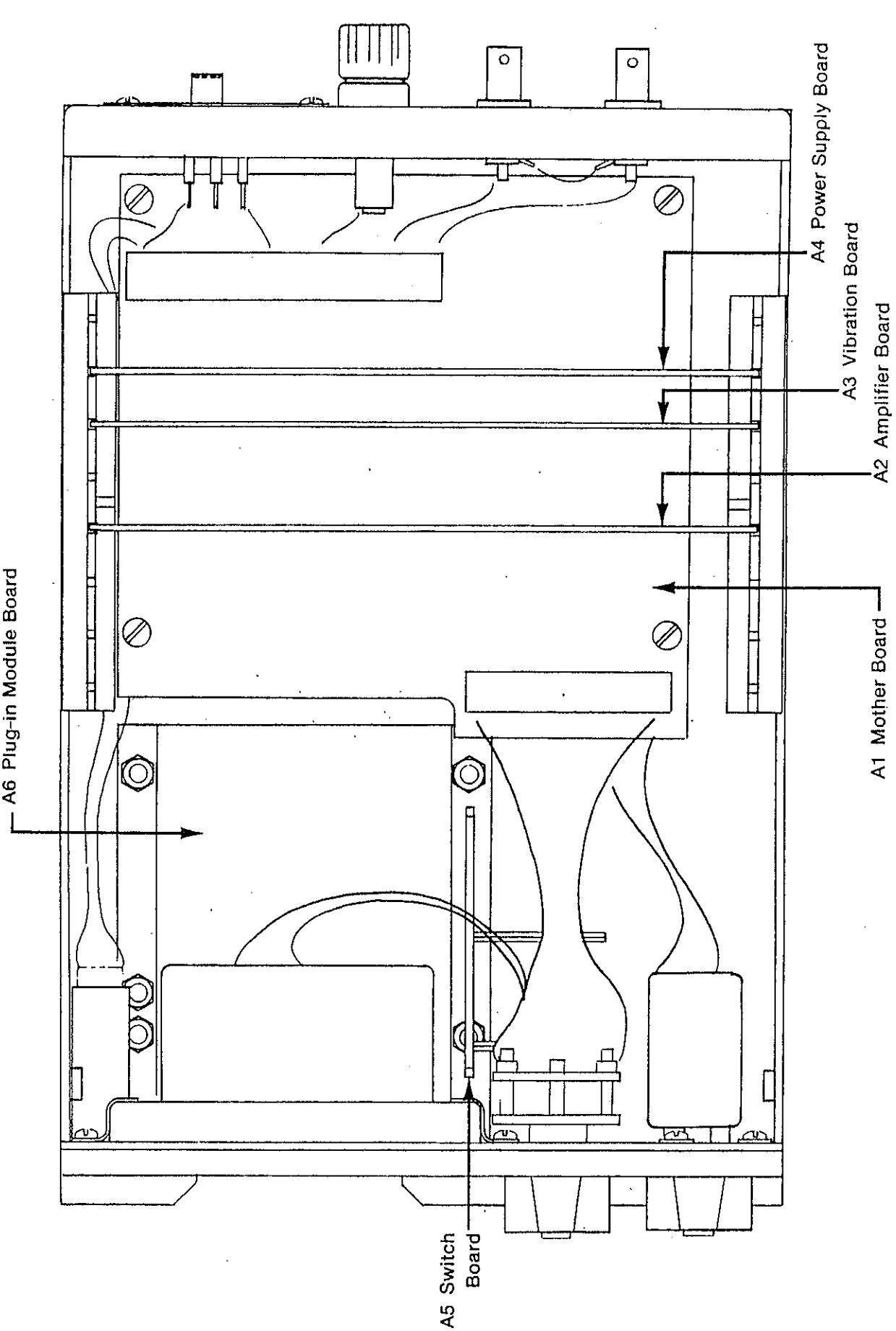



**Fig. 3-1 Instrument Circuit Boards**



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## 3.2 Lamp Control Circuit

The lamp control circuit controls the lamp intensity and maintains it constant at the level selected by the operator with the Intensity Coarse and Fine controls. See Figure 3-2. This circuit consists of:

- Intensity sensor
- Reference signal amplifier
- Error amplifier
- Integrator amplifier
- Power amplifier

### 3.2.1 Intensity Sensor

Amplifier U3 and diode D2 combine to form the circuit's intensity sensor. Initially, the light sensitive diode D2 senses the lamp intensity. Since this diode is located close to the lamp, it receives a portion of the lamp light output and produces a current proportional to the incident intensity. This current is applied to the input of amplifier U3, which functions as a current-to-voltage converter. The output voltage is equal to the diode current multiplied by the value of the intensity coarse resistor. The feedback resistor value is adjusted by the Intensity Coarse control and allows the operator to select the desired lamp intensity.

The output voltage is applied as one input to the error amplifier and to a voltage divider formed by $R_1$ and $R_2$. A buffer amplifier applys the output of the voltage divider to the Intensity Coarse control, thus completing the feedback path. The voltage divider is necessary to keep the resistor values of the Intensity Coarse control within reasonable limits.

### 3.2.2 Reference Signal Amplifier

The lamp intensity is maintained at the selected value by comparing the intensity signal (U3 output) to a reference voltage. This reference voltage is produced by zener diode CR1 and the variable reference signal amplifier. The diode is temperature-compensated to minimize the effects of ambient temperature.



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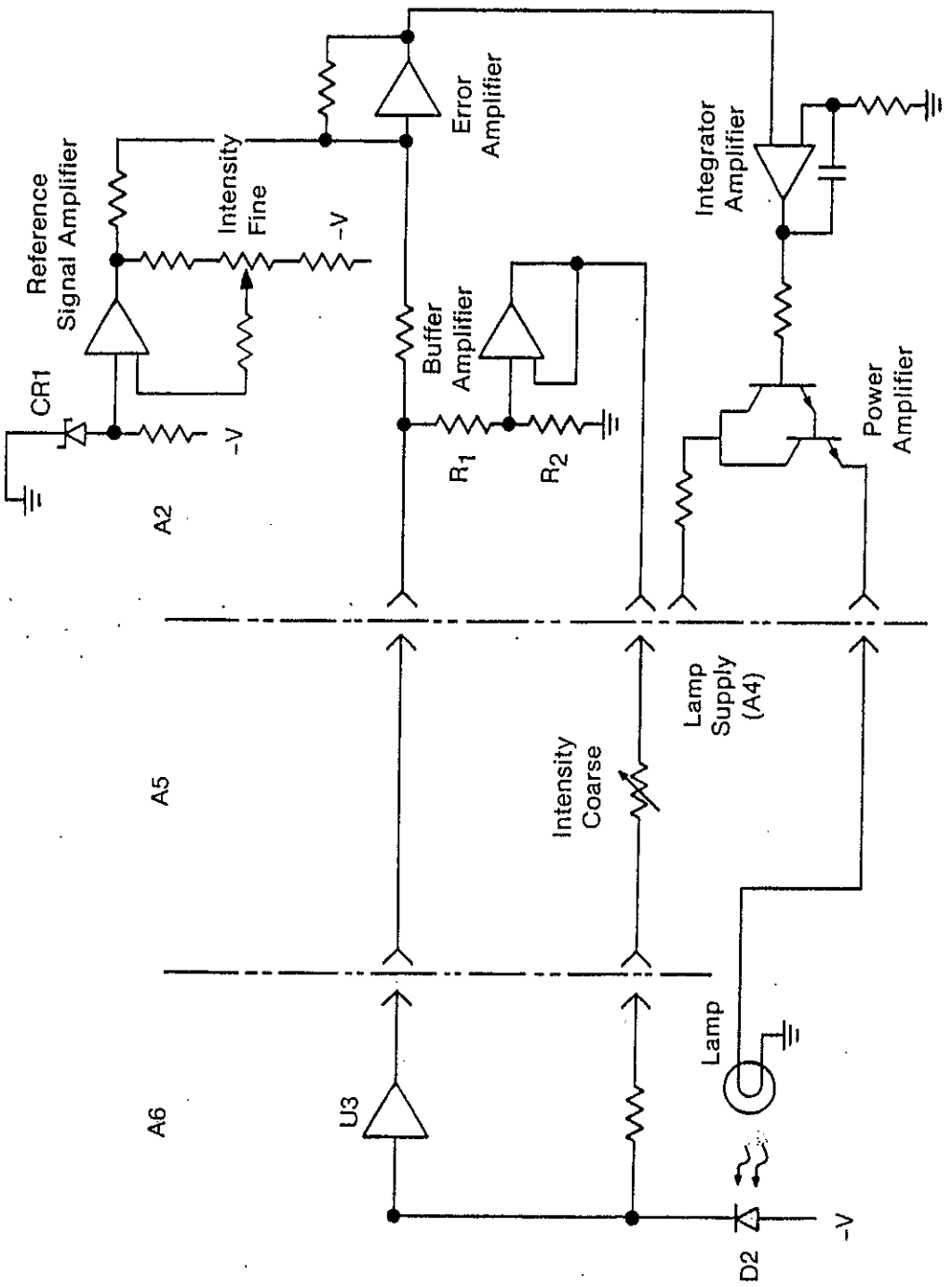



**Fig. 3-2 Simplified Lamp Control Circuit Schematic**



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The reference signal amplifier is adjusted by the Intensity Fine control resistor. The output of the reference signal amplifier provides the second input to the error amplifier.

### 3.2.3 Error Amplifier

The error amplifier compares the intensity signal to the reference signal and provides an output proportional to the difference between the two signals. The output of the error amplifier is then applied to the integrator amplifier.

### 3.2.4 Integrator Amplifier

The slow intensity response of an incandescent lamp to an applied voltage requires that a lead network be included in the control circuit. The control loop equations also require that a zero be provided to control the lamp properly. Both of these requirements are provided by the non-inverting integrator amplifier. The output of the integrator is then applied to the power amplifier.

### 3.2.5 Power Amplifier

The power amplifier is a power darlington transistor that controls the amount of current supplied to the lamp. The lamp voltage is supplied by a regulated supply located on the power supply board. The control of the lamp current (intensity) completes the control loop since the intensity is measured by diode D2, which provides the error signal.

## 3.3 Measuring Circuit

The measuring circuit produces an output signal proportional to the received light intensity. See Figure 3-3. The measuring circuit consists of:

- Converter amplifier
- Datum shift amplifier
- Meter amplifier
- Meter calibration circuit



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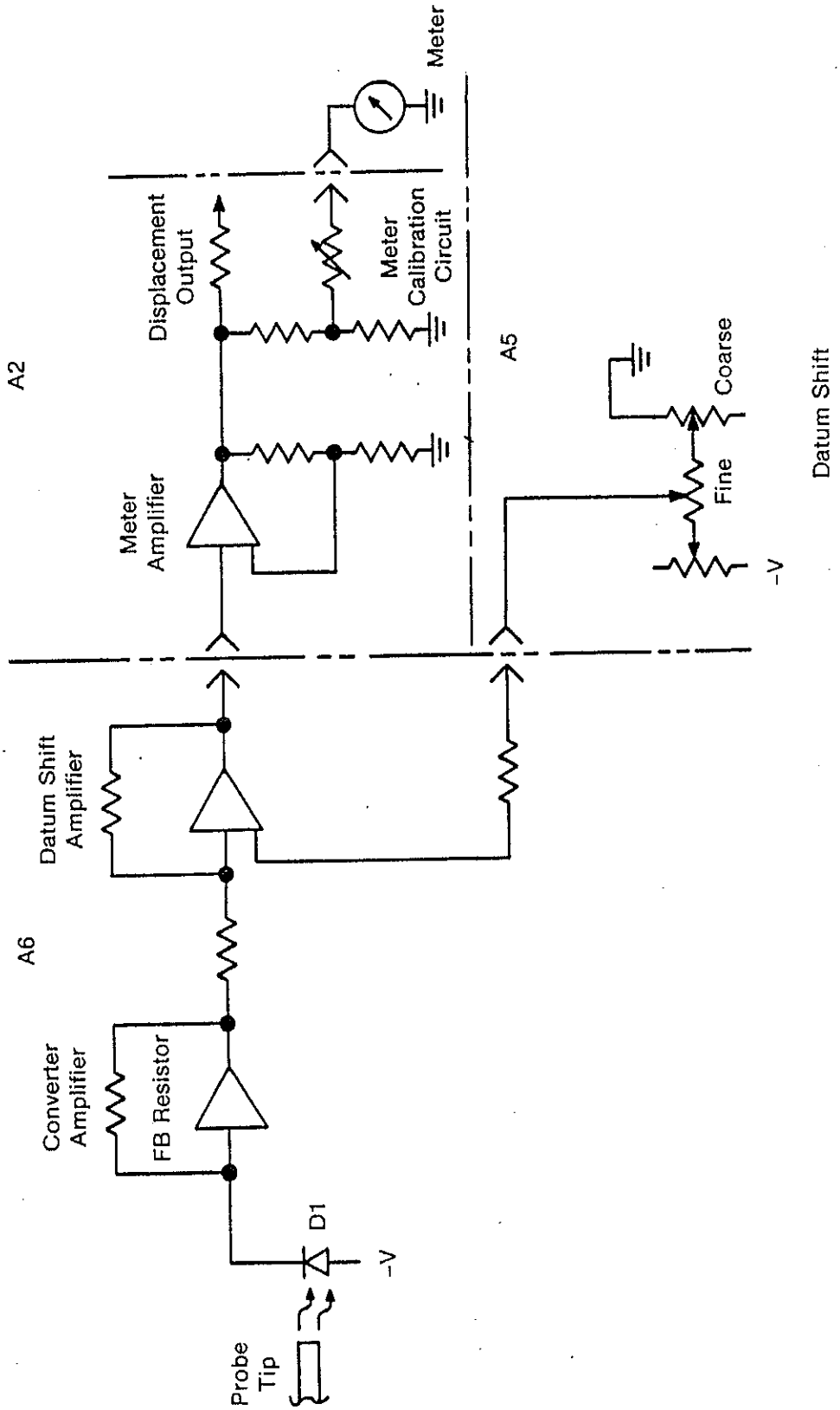



**Fig. 3-3 Simplified Measuring Circuit Schematic**



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The measuring circuit also consists of a special fiber optic cable, connected to the optical interface module. The plug-in module accommodates various probe sizes and contains the circuitry necessary to convert the received intensity to a voltage output.

### 3.3.1 Converter Amplifier

The light reflected into the receiver fibers of the probe falls on a light sensitive diode (D1), located in the optical interface module. The diode is connected to an amplifier that operates as a current-to-voltage converter. Thus, the output voltage is proportional to the received light intensity.

The value of the feedback resistor is adjusted to match the probe size. Smaller probes require higher resistance values. The maximum frequency response is limited by this stage and is lower for the smaller diameter probes because of the higher resistance required.

### 3.3.2 Datum Shift Amplifier

The converter stage output is connected to a datum shift amplifier that provides additional gain and the ability to offset or shift the original reference point. The calibrated datum shift amplifier retains measurement accuracy even if the measurement exceeds the scale. The datum shift also provides a gain of 10X for the signal and selectable frequency rolloff characteristics.

### 3.3.3 Meter Amplifier

The signal from the datum shift is applied to the meter amplifier, which provides a gain of two. This amplifier drives the output meter and provides the input signal to the vibration detector. The amplifier configuration is non-inverting.

### 3.3.4 Meter Calibration Circuit

The meter calibration circuit is a conventional resistor divider network that provides damping for a D'Arsonval type meter and a current shunt for calibration. The resistor network is designed to provide the proper voltage for the digital panel meter option.



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## 3.4 Vibration Detector Circuit

The vibration detector circuit measures the peak-to-peak amplitude of a variable displacement signal. See Figure 3-4. Due to the long time constant, the circuit measures the average of the peak-to-peak value and will not measure single event peaks.

The circuit operates as follows. When the input signal at pin 7 of U1 exceeds that of pin 5, pin 13 is driven to 0 V causing Q1 to conduct. This raises the voltage on the gate of Q2 so that Q2 conducts, charging C6. The voltage on C6 is measured by Q3 and applied to pin 5 of U1, thus completing a feedback loop. The voltage at the source of Q3 is equal to the positive peak of the input waveform. This voltage is applied to the negative input of U2, which along with Q4, Q5 and Q6, operates as a combination negative peak detector and summing circuit. The output of this circuit (Q6-S) is applied to Q3 which acts as a buffer (gain = 1) or an amplifier (gain = 10, 100), depending on the setting of the Displacement/Vibration control. The output of Q3 is then applied to the meter, which reads peak-to-peak volts. This output level is also available at the Vibration Output Connector on the rear panel.

## 3.5 Instrument Accessories and Options

Several accessories and options are available for use with the MTI 1000 Fotonic Sensor and may be used to enhance or expand instrument performance. The accessories are shown on Figure 3-5 and include:

- KD-DRO Digital Readout Option (1)
- FS-1 Fixture Stand (2)
- Special Probe Configurations (3)
- KD-CH-III Calibration Fixture (4)
- KD-CR Extension Cable (5)
- KD-LS-1 Optical Extender (6)



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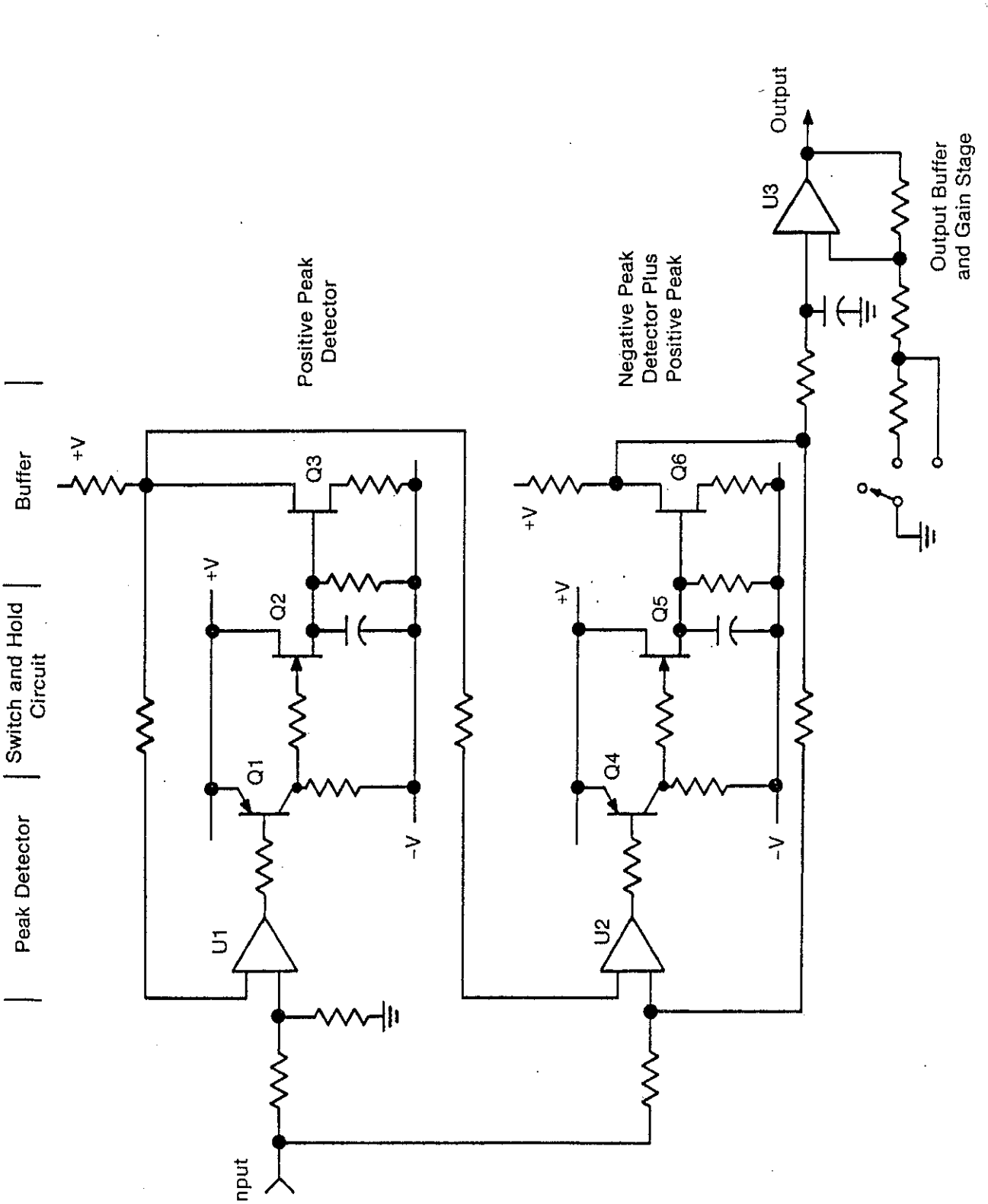



**Fig. 3-4 Simplified Vibration Detector Circuit Schematic**



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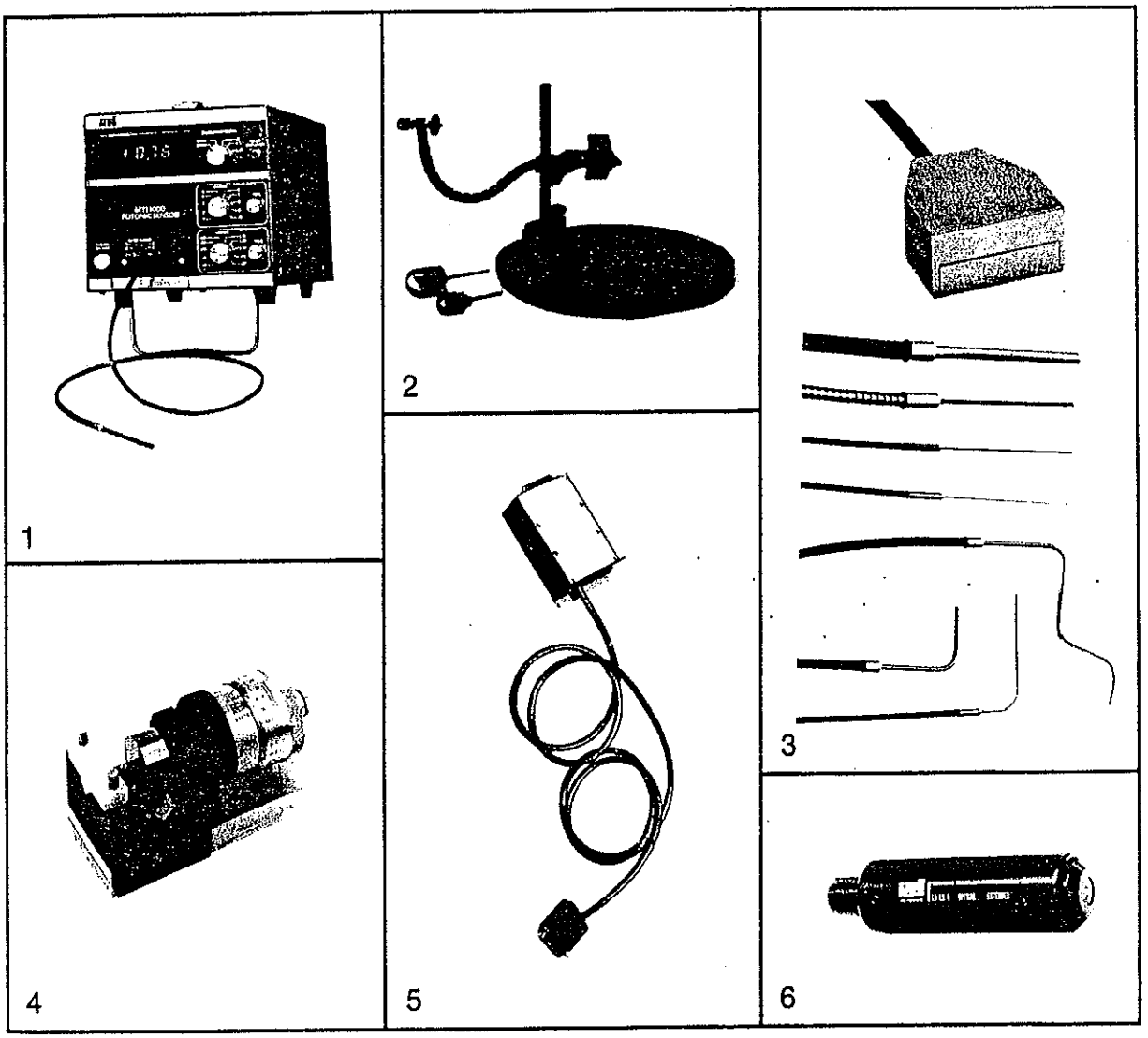



**Fig. 3-5 MTI-1000 Accessories and Options**



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## KD-DRO DIGITAL READOUT OPTION

The KD-DRO 3.5 digit LED display provides a 5X improvement in panel meter readability. A BCD output is also available with this option.

## FS-1 FIXTURE STAND

The FS-1 fixture stand provides a stationary mounting fixture for any diameter probe and may be placed in a variety of positions to accomodate difficult access areas. The stand's magnetized base and flexible mounting arm offer a versatile means for probe mounting.

## SPECIAL PROBE CONFIGURATIONS

Special probe configurations may be fabricated in various shapes to accomodate difficult access areas and high temperature ratings (500°F - 600°F). Consult MTI Instruments if your application requires a special probe configuration.

## KD-CH-III CALIBRATION FIXTURE

The KD-CH-III Calibration Fixture provides a means for securing the fiber optic probe and calibrating the instrument to a nonrotating target. The calibration fixture consists of:

- Axial and radial probe mounting blocks
- Nonrotating target
- Horizontal or vertical mounting base
- Calibrated micrometer barrel

The movable fixture target can be used to perform actual displacement measurements. Use of this accessory is recommended for:

- First-time user calibration procedure
- Calibration of the instrument to a fluid medium
- In-place calibration checks



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## KD-CR EXTENSION CABLE

The KD-CR extension cable connects the module assembly to the instrument and provides for remote probe operation at a maximum distance of 25 ft.

## KD-LS-1 OPTICAL EXTENDER

The KD-LS-1 Optical Extender consists of a precision lens system, which can be attached directly to any of the standard probes. This accessory allows the probe to be operated at a greater stand-off distance from the target, while retaining the probe's sensitivity and frequency response.



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# SECTION 4
# MAINTENANCE

## 4.1 Introduction

This section provides maintenance and troubleshooting information. Observe the following recommendations to maintain the instrument properly.

## 4.2 General Maintenance

The MTI 1000 Fotonic Sensor uses all solid-state circuitry and therefore requires minimal maintenance. Refer to the following sections for case maintenance, cover removal, lamp replacement and lamp adjustment procedures.

### 4.2.1 Case Maintenance

The instrument case is painted with a two part epoxy paint. Clean the case with a damp cloth and mild detergent when necessary.

> **CAUTION**
>
> DO NOT USE ORGANIC SOLVENTS ON THE FRONT PANEL. ORGANIC SOLVENTS WILL ATTACK THE PLASTIC METER FACE.

### 4.2.2 Cover Removal

Remove the instrument cover as follows to gain access to the printed circuit boards for inspection and troubleshooting.

1. Remove the four screws at each of the bottom four corners of the case.
2. Remove the four screws at each of the top four corners of the case.
3. Lift the cover straight up until it clears the instrument.



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### 4.2.3 Lamp Replacement Procedure

The incandescent lamp illuminates the fiber optic probe and is the only non solid-state component in the instrument. The lamp is located on the plug-in module circuit board (A6). Proceed as follows to remove the lamp. Refer to Figure 4-1.

1. Remove the probe/plug-in module assembly from the instrument's front panel.

2. Remove the 8 screws (1) securing the module cover to the module. Lift off the module cover.

3. Remove the Filter Range switch (3) from the front of the module housing.

4. Remove the 2 screws (2) that secure the front panel to the case.

5. Remove the 4 screws (7) holding the A6 board to the bottom of the module and lift the board out of the module. Leave the fiber optic probe attached.

6. Unsolder the two lamp leads.

7. Loosen the set screw holding the lamp and remove the lamp (8).

8. Replace the lamp with a Gilway L1005 lamp.

9. Adjust the lamp voltage to 2.7 V. Follow the lamp adjustment procedure in Section 4.2.4.



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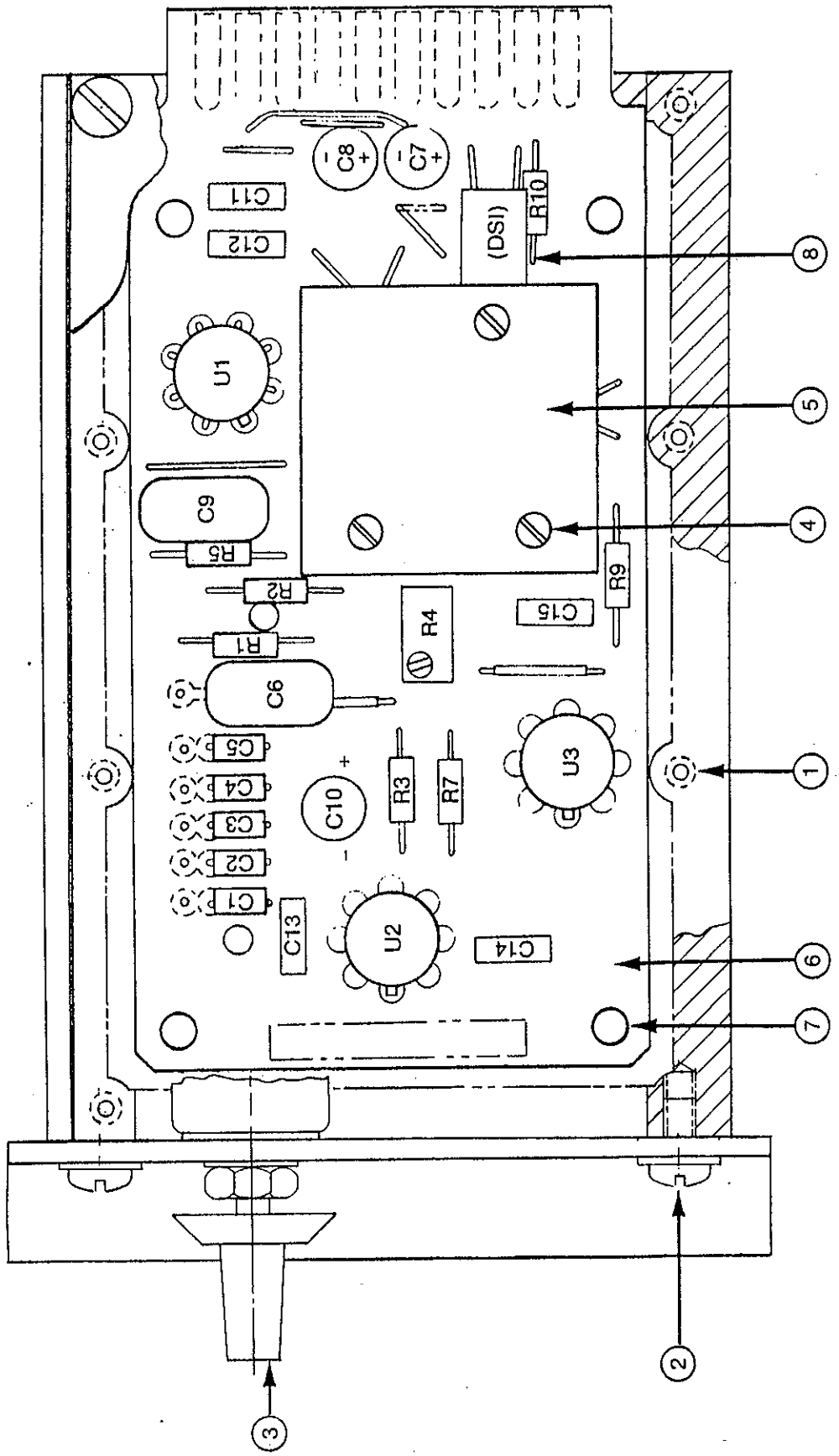



**Fig. 4-1 Probe/Plug-in Module Circuit Board (A6)**



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### 4.2.4 Lamp Adjustment Procedure

The relative position of the lamp, light sensitive diode and the transmit and receiver fiber bundles effect the maximum lamp voltage that can be attained. The MTI 1000 is designed to produce a maximum lamp voltage of 2.7 V, a voltage level consistent with good lamp brightness and long lamp life. Perform the following adjustment procedure after replacing the lamp or the diode.

> **NOTE**
>
> If the fiber optic probe has <u>not</u> been removed, perform only steps 1, 2, 4, 5, and 6. It should be possible to obtain a lamp voltage of 2.8 V. If this cannot be done, start with step 1.

1. Remove the probe/plug-in module and install the KD-CR extension cable. Connect the extension cable to the module.

2. Remove the module and instrument covers.

3. Remove the fiber optic probe.

4. Turn the INTENSITY COARSE and the INTENSITY FINE controls to their maximum clockwise position.

5. Turn on the POWER switch and measure the lamp voltage between TP 7 and TP 1 on the A2 Amplifier board.

6. Position the lamp both axially and rotationally, so that maximum voltage at TP 7 and TP 2 is produced. The lamp barrel should show approximately 1/2 in. and the lamp voltage should be 2.3-2.5 V dc.

7. Replace the fiber optic probe. Position the receiver side so that the diode is just at contact.



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8. Position the transmit side to produce a lamp voltage of approximately 2.8 V. The metal tip of the probe should show about 1/8 in. Tighten the set screw.

9. Reduce the lamp voltage to produce an on-scale deflection.

10. Position the receiver side to produce maximum meter deflection. Tighten all set screws.

## 4.3 Troubleshooting

Use the troubleshooting information in this section to determine the cause of an instrument malfunction. The troubleshooting charts address the following areas:

- Lamp Control Circuit (Figure 4-2)
- Lamp Malfunctions:
  - No lamp output; lamp does not emit any light (Figure 4-3)
  - Maximum lamp output; lamp emits maximum brightness with no controllable intensity (Figure 4-4)
- Measuring Circuit:
  - No meter indication but lamp control circuit operates properly (Figure 4-5)

Remove the instrument's cover (Section 4.2.2) before you begin troubleshooting.

Complete schematics are provided to assist you in troubleshooting. The A2 Amplifier board (Figure 4-6), the A3 Vibration Detector board (Figure 4-7), the A4 Power Supply board (Figure 4-8) and the A6 Plug-in Module board (Figure 4-9) schematics should be used in conjunction with the troubleshooting charts. The Interconnect diagram (Figure 4-10) and the A5 Switch board schematic (Figure 4-11) are provided for reference.



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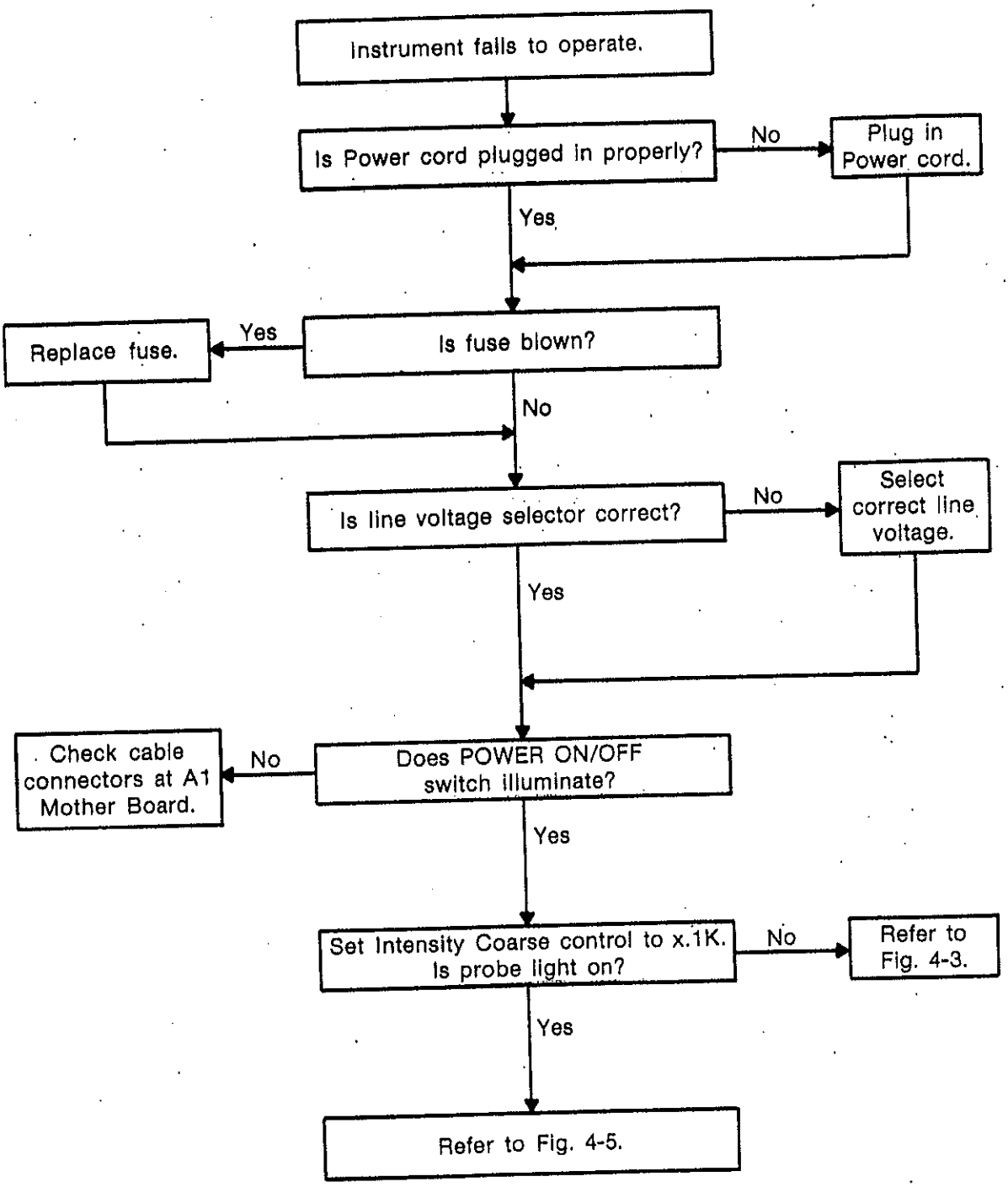



**Fig. 4-2 Lamp Control Circuit Troubleshooting**





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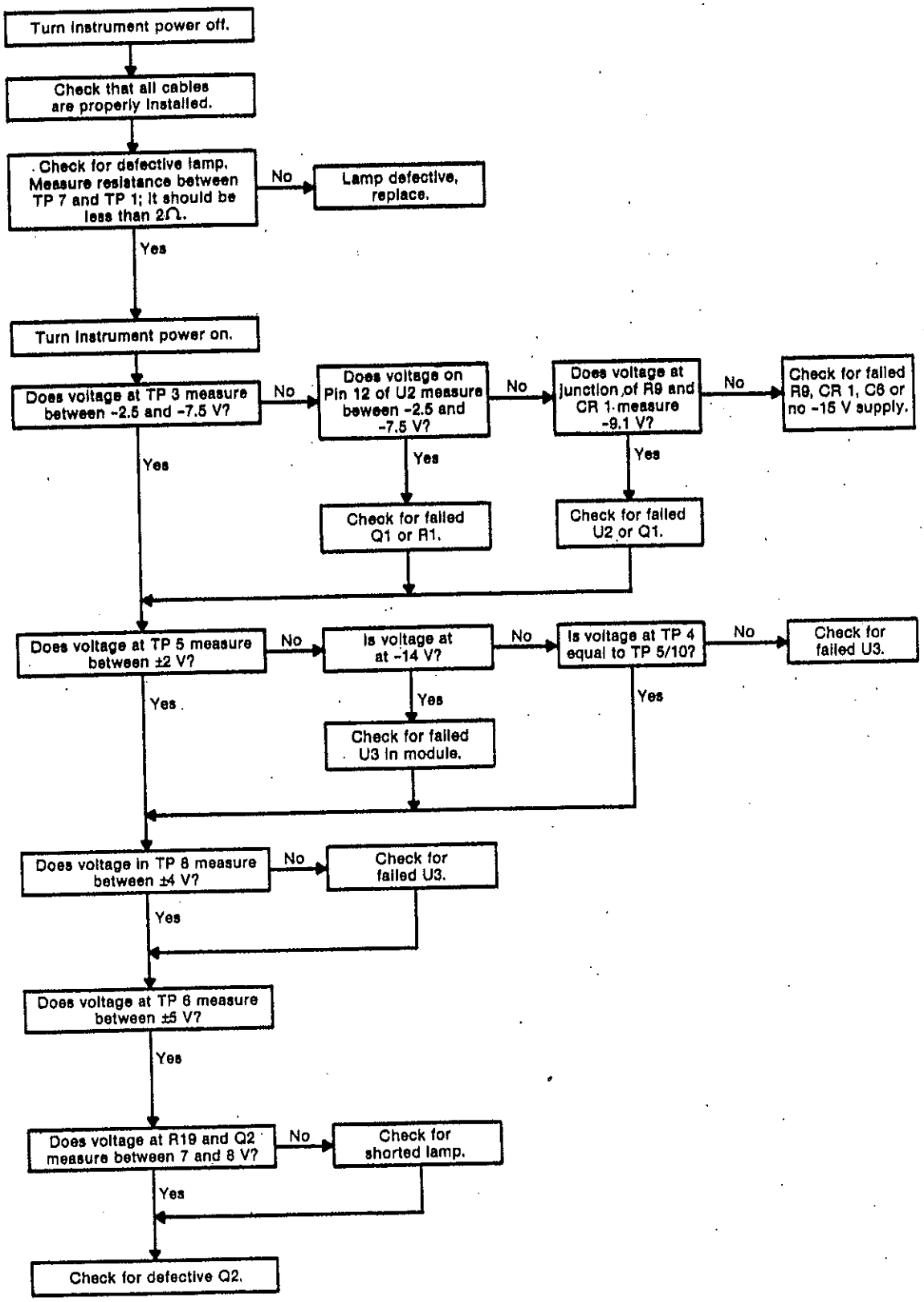
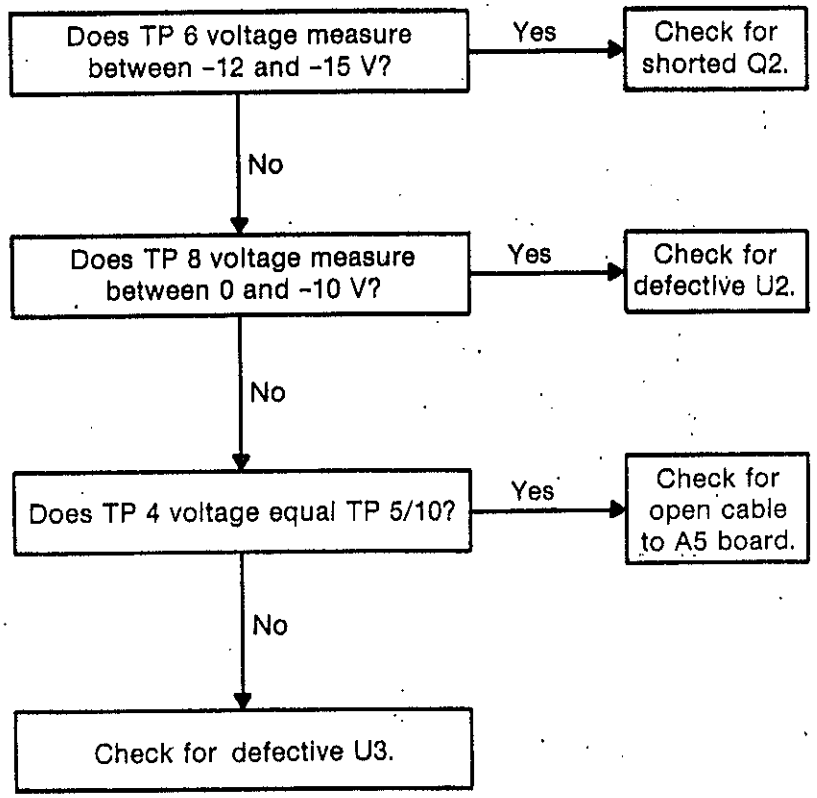



**Fig. 4-3 No Lamp Output Troubleshooting**



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**WARNING**

**DO NOT OPERATE LAMP AT MORE THAN 3 V FOR EXTENDED PERIODS OF TIME. REDUCED LAMP LIFE WILL RESULT. LAMP VOLTAGE IS MEASURED AT TP 7.**

**Fig. 4-4 Maximum Lamp Output Troubleshooting**



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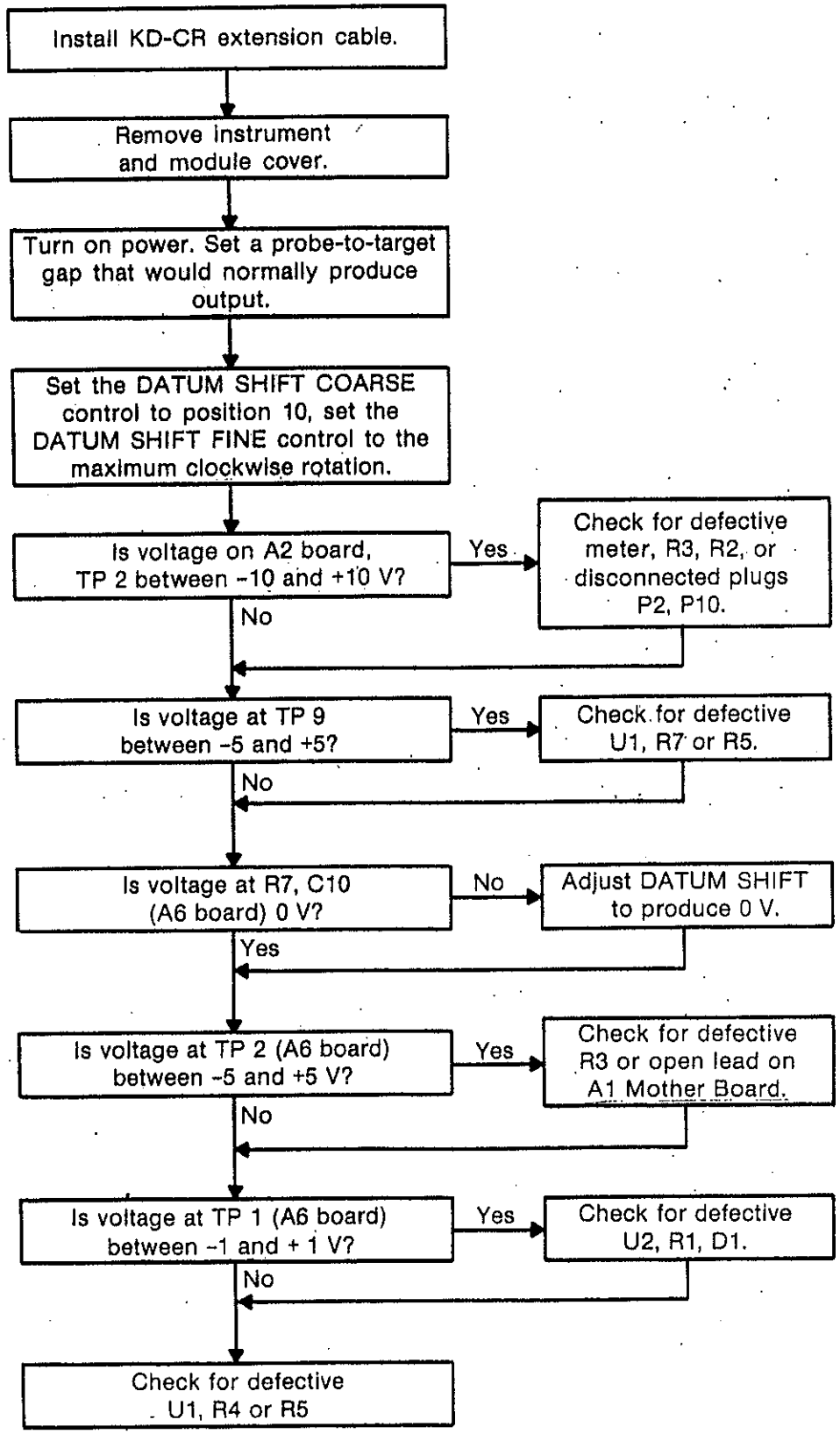



**Fig. 4-5 Measuring Circuit Troubleshooting**



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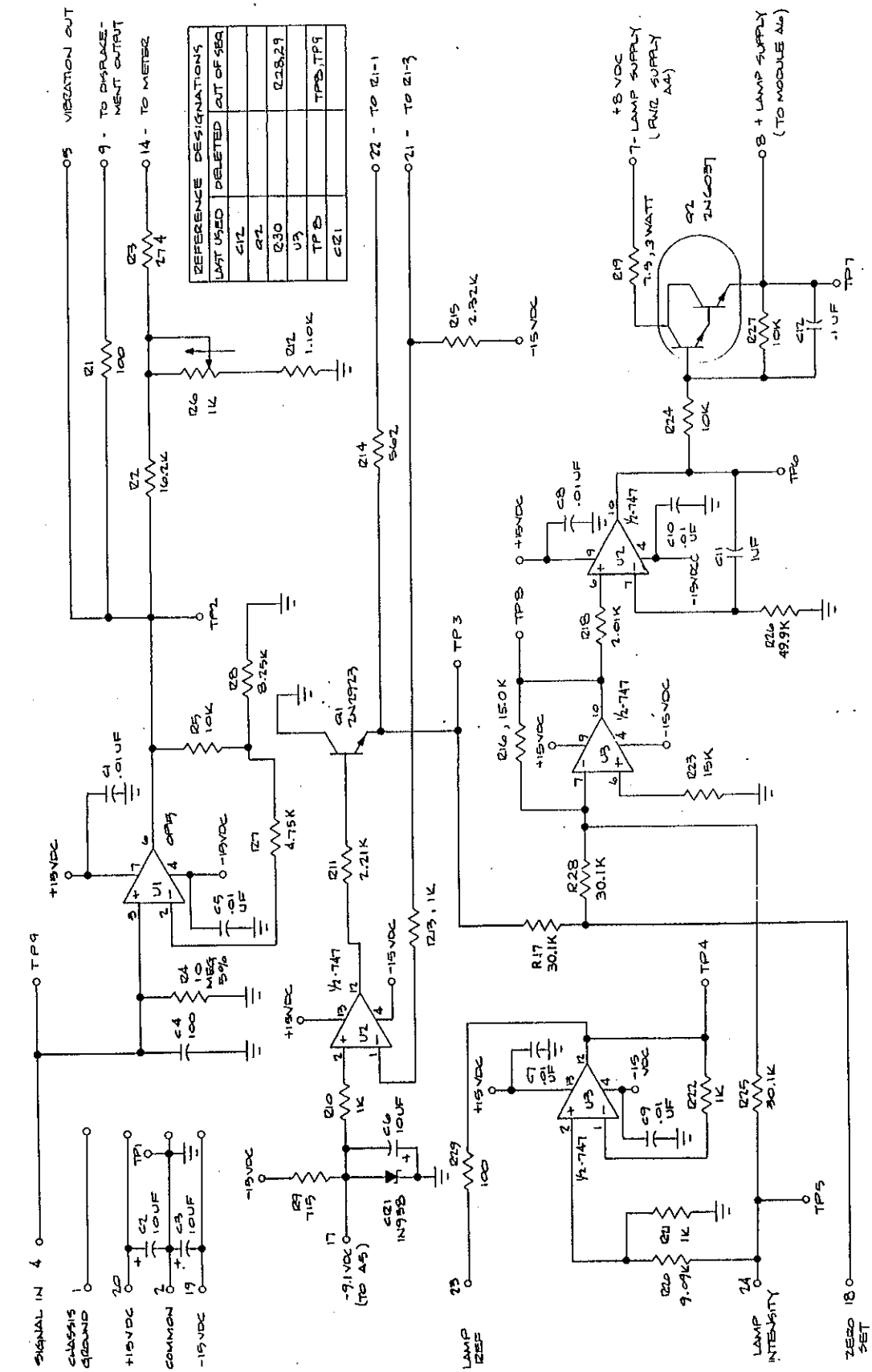



**Fig. 4-6 A2 Amplifier Board Schematic**



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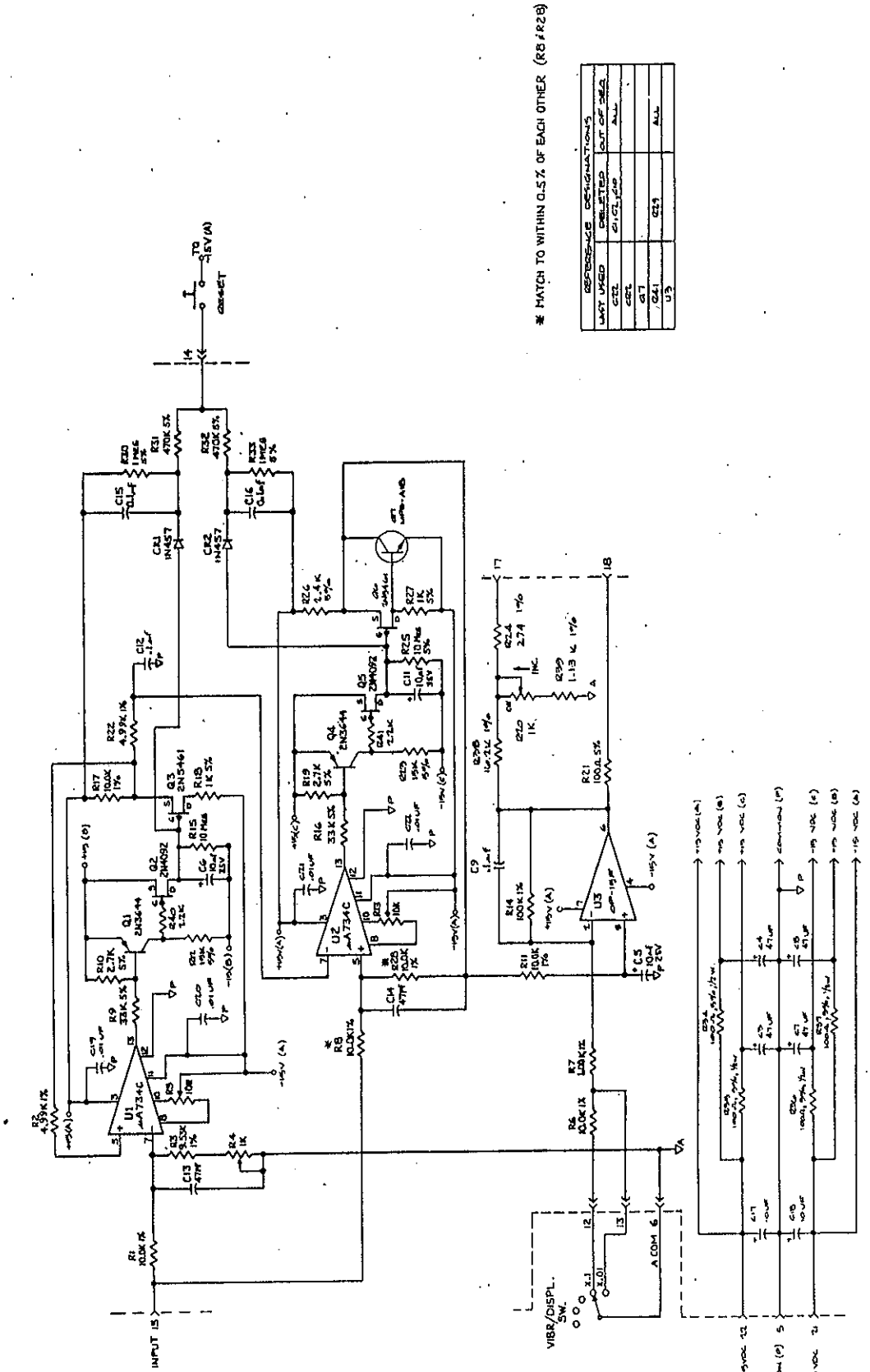
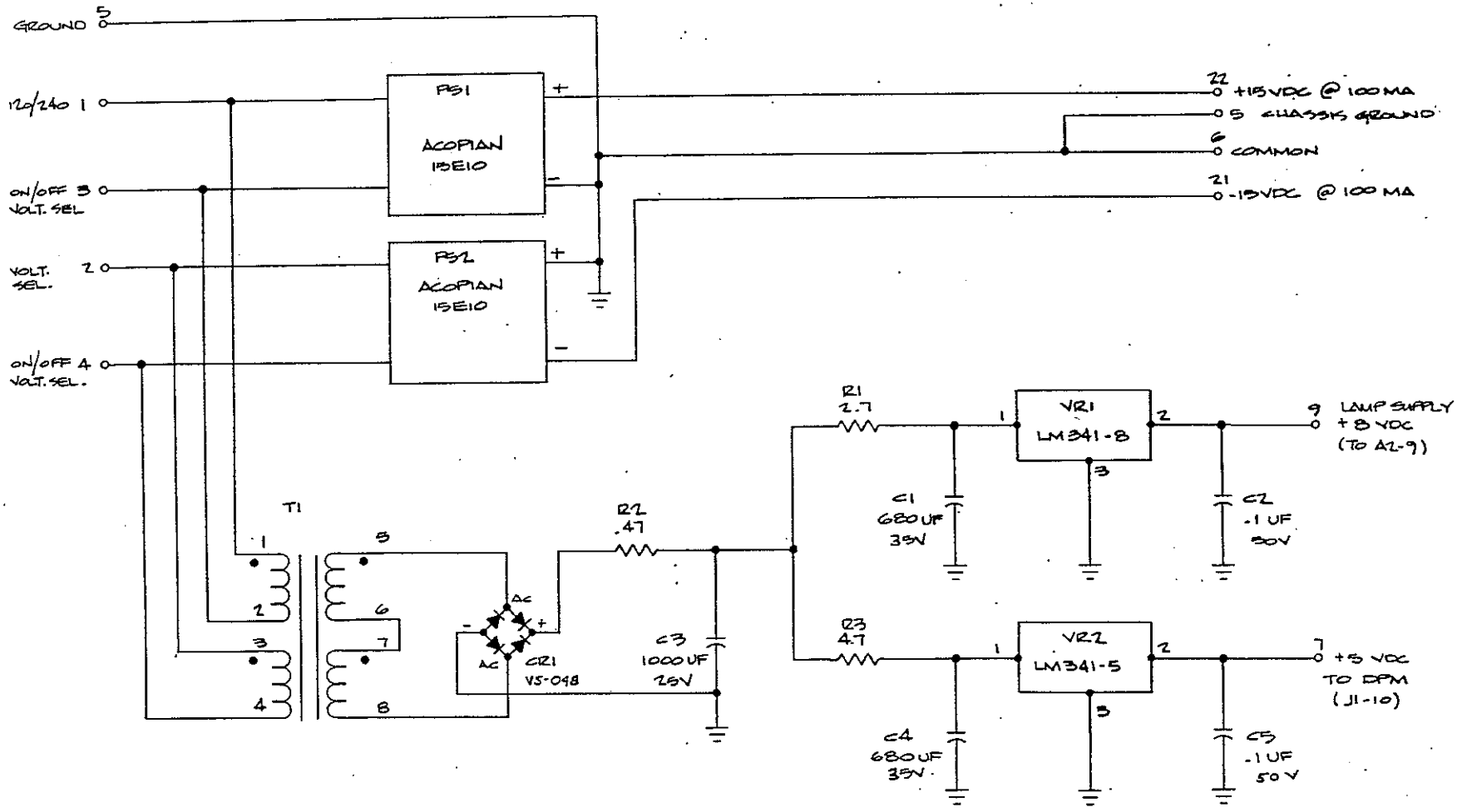



**Fig. 4-7 A3 Vibration Detector Board Schematic**



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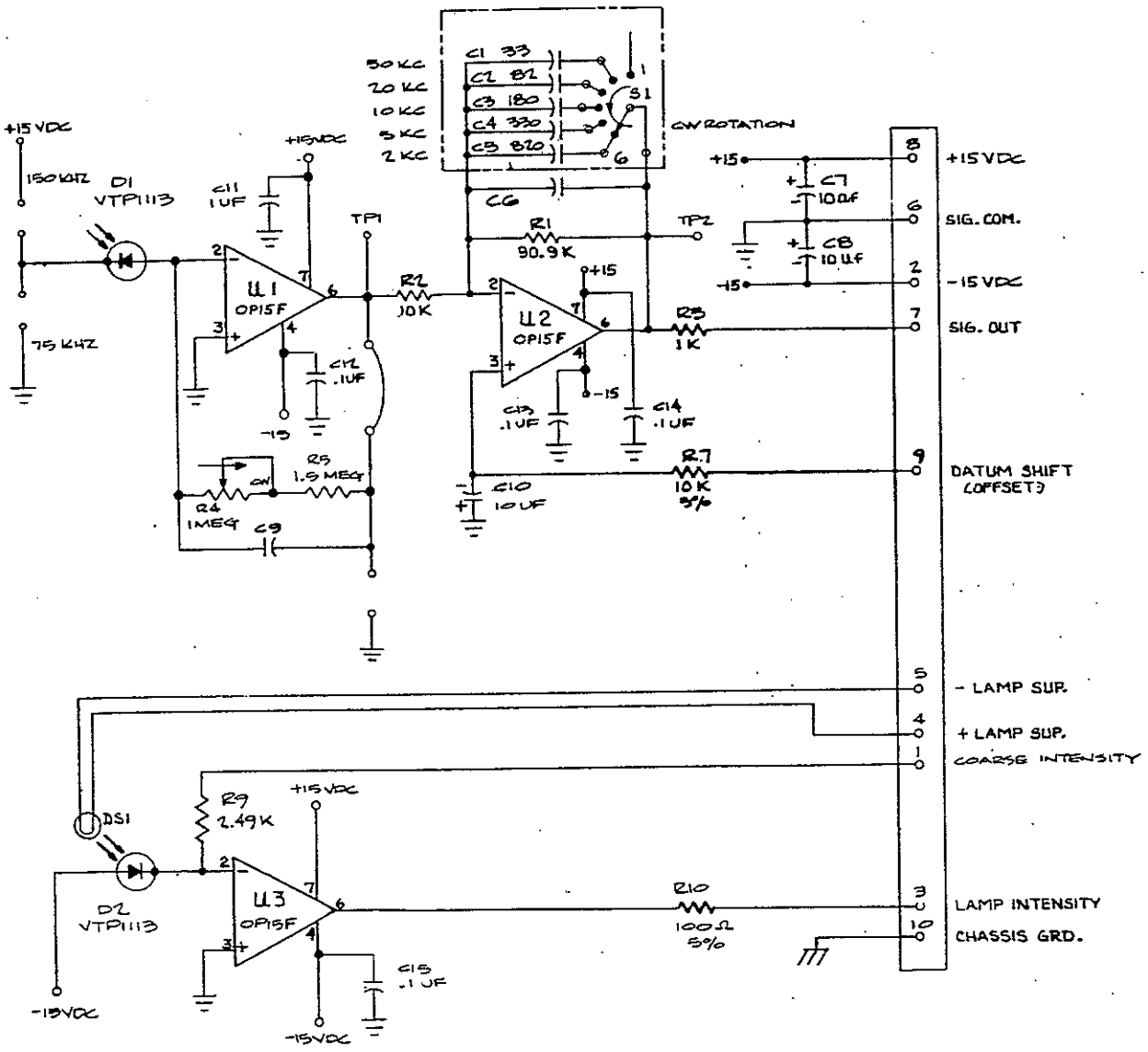

| REFERENCE DESIGNATIONS | | |
|---|---|---|
| LAST USED | DELETED | OUT OF SEQ |
| C5 | | |
| CR2 | CR2 | |
| PS2 | | |
| R3 | | |
| T1 | | |
| VR2 | | |

**Fig. 4-8 A4 Power Supply Board Schematic**

MTI-20754



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| REFERENCE DESIGNATIONS | | |
|---|---|---|
| LAST USED | DELETED | OUT OF SEQ |
| C15 | | C11 THRU C14 |
| D2 | | |
| DS1 | | |
| R14 | R6,8,11,12,13,14 | |
| U3 | | |
| TP4 | TP3, 4 | |

| COMPONENT TABULATION | | |
|---|---|---|
| REF DES | 75K | 150K |
| C6 | 10 PF | 5 PF |
| C9 | 2 PF | 1 PF |
| DS1 | L1005 | L1006 |
| | | |
| | | |
| U2 | OP15F | OP17 |

**Fig. 4-9 A6 Plug-in Module Board Schematic**

MTI-20757



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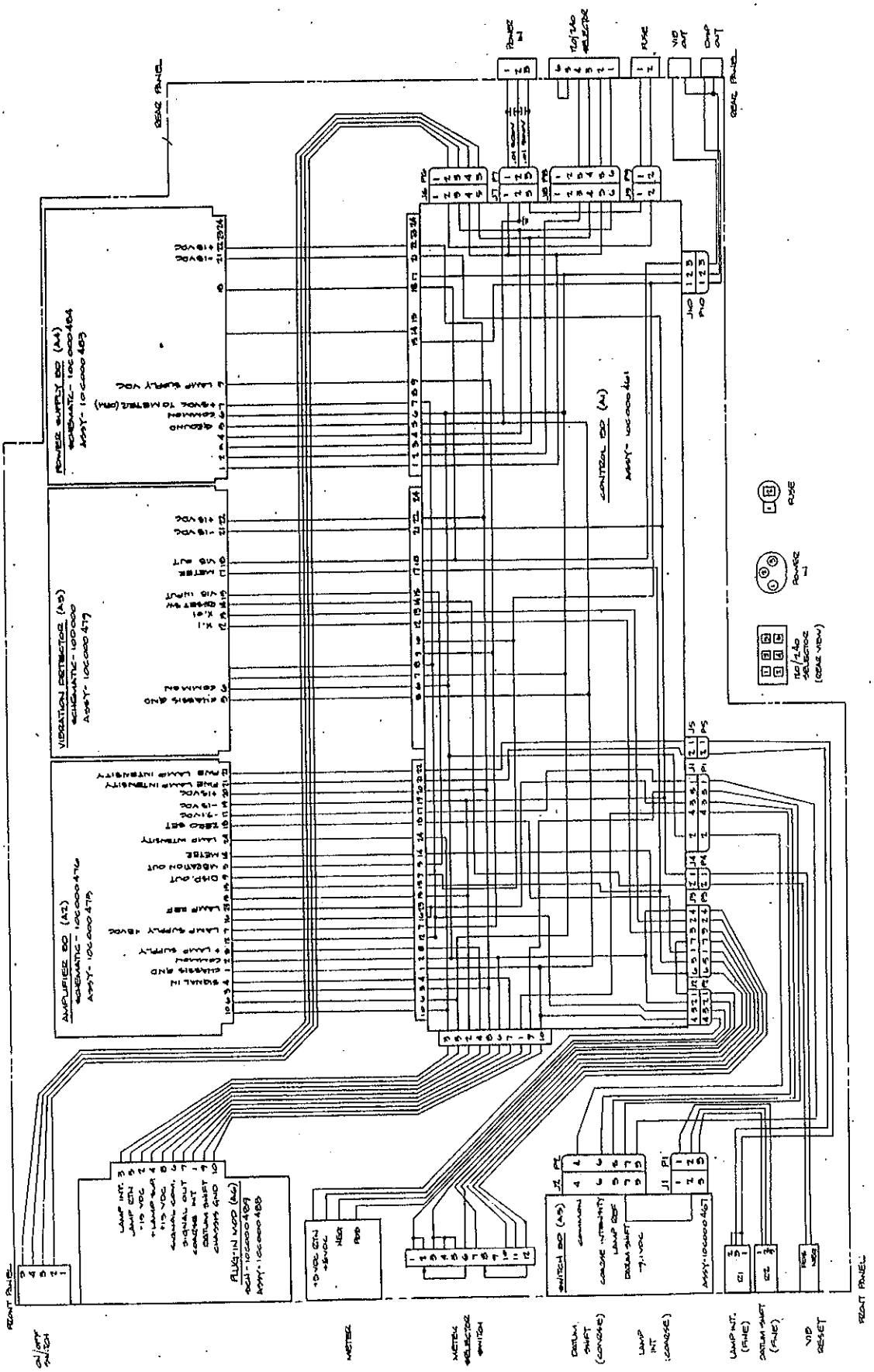
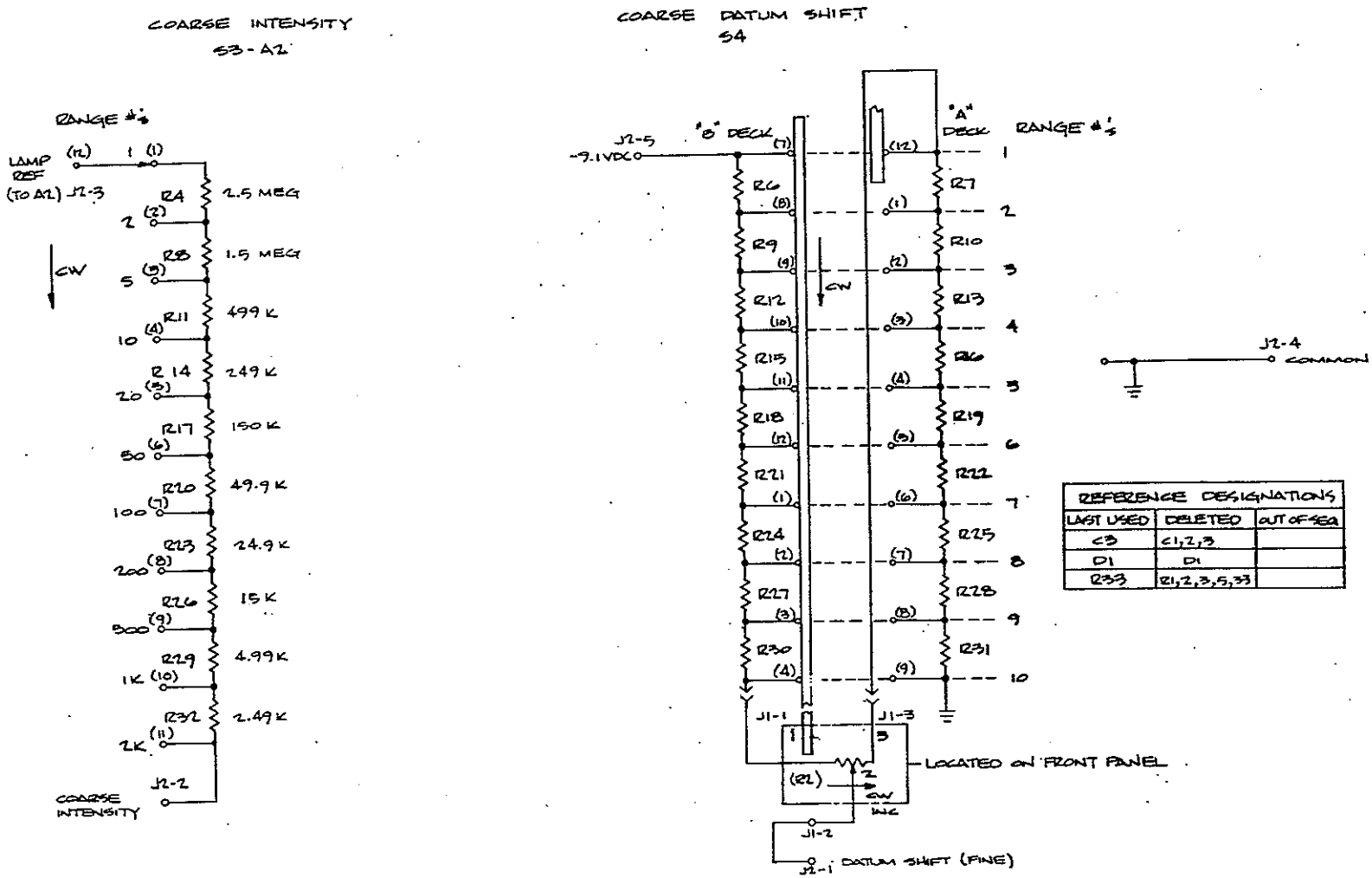


**Fig. 4-10 Interconnect Diagram**



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| REFERENCE DESIGNATIONS | | |
|---|---|---|
| LAST USED | DELETED | OUT OF SEQ |
| C3 | C1,2,3 | |
| D1 | D1 | |
| R33 | R1,2,3,5,33 | |

NOTES; UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 WATT, ±1%.
2. ALL RESISTORS ON SWITCH S4 ARE 909 OHMS, 1/4 WATT, 1%.
3. SWITCHES SHOWN IN NO. 1 POSITION.

**Fig. 4-11 A5 Switch Board Schematic**





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# SECTION 5
# PROBE/PLUG-IN MODULE SELECTION CRITERIA AND SPECIFICATIONS

## 5.1 Introduction

This section describes how to select the probe/plug-in module suitable for your application needs. A list of the various modules and their specifications is also provided to assist you in selecting the correct module.

## 5.2 Probe Tip Fiber Distribution

There are three fiber distribution configurations available in the fiber optic probe tips:

- Random (R)
- Hemispherical (H)
- Concentric Transmit Inside (CTI)

These configurations are determined by the distribution of the TRANSMITTING and RECEIVING fiber optic filaments in a probe tip.

A RANDOM fiber distribution is a random intermix of the transmitting and receiving fibers. Probe tips with a Random fiber distribution demonstrate a high displacement sensitivity but also have a short range. A HEMISPHERICAL fiber distribution separates the transmitting and receiving fibers into two distinct groups, with one half of the probe tip composed of all transmitting fibers and the other half composed of all receiving fibers. Hemispherical probe tips offer a long range but a low displacement sensitivity. A CONCENTRIC TRANSMIT INSIDE fiber distribution contains a group of transmitting fibers located at the center of the probe tip and surrounded by a concentric group of receiving fibers. This probe tip offers an intermediate choice between the high sensitivity/short range Random probe tip and the long range/low sensitivity Hemispherical probe tip and also minimizes rotational and tilt effects. Choice of a particular probe tip configuration will depend on your application needs.



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## 5.3 Probe/Plug-in Module Selection Criteria

Analyze your measurement requirements before selecting a probe/plug-in module for a particular application. Select the module based on your expectations of the estimated displacement/vibration of the target. Consider the following criteria when selecting a probe/plug-in module:

- Probe Range
- Frequency Response
- Probe Size
- Target Reflectance
- Stand-off Distance

Probe range and frequency response are the primary criteria to consider when selecting a module assembly. Although probe size, target reflectance and stand-off distance are secondary criteria, these factors still influence module selection and should always be considered.

### PROBE RANGE

Select a module assembly with a probe range compatible with your application needs. For example, if you estimate a small target displacement of .004 in., a MTI-3812 module and a 125R probe with a 4 mil range would meet your range requirement.

### FREQUENCY RESPONSE

The frequency response of the selected module should adequately cover the vibration frequencies under investigation.

### PROBE SIZE

Choice of probe diameter depends on the target size and the probe mounting requirements. Generally, the probe diameter should be smaller than the minimum dimension of the target area. The access area available for probe mounting will also determine probe size selection. If the available space is limited, you will have to select a small diameter probe, regardless of the target size.



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## TARGET REFLECTANCE

Target reflectance also influences probe selection. Any of the standard module assemblies perform well with a highly reflective target. However, the small diameter probes are generally not suitable for use with targets of low reflectivity. Such targets would require the higher light level of a large diameter probe.

> **NOTE**
>
> To increase the reflectivity of a translucent or transparent target, apply a reflective tape to the target area. Use either the patterned target material supplied with the instrument or Scotch® brand polyester film tape No. 850 (silver or white).

## STAND-OFF DISTANCE

The stand-off distance of the module must be suitable for the application. If the distance supplied by the probe is not adequate, you may use a probe with a larger range to provide greater stand-off distance. However, the large range probe offers less sensitivity. To avoid the sensitivity loss and increase the stand-off distance, use the KD-LS-1 optical extender accessory. This optical extender will allow the probe to operate at a greater probe-to-target stand-off distance without a loss in the module's sensitivity and frequency response.

## 5.4 Probe/Plug-in Module Specifications

Table 5-1 lists the standard probe/plug-in modules and their specifications. When selecting a module assembly, refer to these specifications and follow the selection criteria discussed in Section 5.3.



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# Table 5-1
# Probe/Plug-in Module Specifications

| Plug-in Model Number | Probe Number | Probe Tip Diameter (in.) | | Probe Length (in.) | Frequency Response (-3 db) (kHz) | Output[1] Signal Ripple (mV p-p) | Resolution[2] (% of Range) | | Front Slope Characteristics | | | Back Slope Characteristics | | | Optical Peak[8] (mils) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Active | | | | Dynamic[3] | Static[4] | Sensitivity[4] (µin./mV) | Linear[6] Range (mils) | Standoff[7] (mils) | Sensitivity[4] (µin./mV) | Linear[6] Range (mils) | Standoff[7] (mils) | Midpoint[8] | Range[7,10] ±5% |
| MTI-3802 | 020R | .020 | .007 | 36 | 10 | 50 | .4 | .1 | .5 | 3 | 2 | 2.5 | 15 | 15 | 10 | 3 |
| MTI-3804 | 032R | .032 | .019 | 36 | 30 | 40 | .3 | .07 | .55 | 3 | 2 | 5 | 25 | 25 | 12 | 6 |
| MTI-3806 | 047R | .047 | .027 | 36 | 40 | 35 | .3 | .05 | .6 | 3.5 | 2.5 | 8 | 30 | 30 | 14 | 11 |
| MTI-3808 | 062R | .063 | .047 | 36 | 60 | 30 | .2 | .05 | .6 | 3.5 | 2.5 | 10 | 35 | 35 | 16 | 12 |
| MTI-3810 | 062H | .063 | .047 | 36 | 60 | 30 | .4 | .1 | 3.0 | 14 | 10 | 12 | 55 | 90 | 50 | 30 |
| MTI-3812 | 125R | .125 | .086 | 36 | 70 | 20 | .2 | .05 | .6 | 4 | 2.5 | 18 | 70 | 55 | 18 | 20 |
| MTI-3814 | 125H | .125 | .086 | 36 | 70 | 20 | .3 | .1 | 7.0 | 30 | 25 | 30 | 150 | 200 | 120 | 60 |
| MTI-3816 | 125CTI | .125 | .086 | 36 | 70 | 20 | .3 | .1 | 3.5 | 15 | 12 | 25 | 80 | 140 | 75 | 50 |

NOTES:
[1]On unexpanded range, increases with range expansion but overall signal-to-noise ratio improves (see resolution).
[2]Utilizing full range expansion, % of front and back slope range, when measuring to a 2 µin. AA electroformed GAR surface finish comparator block.
[3]Using vibration display oscilloscope or external recorders, 5x improvement on 3800 series when filter is used.
[4]Direct reading on panel meter, 5x improvement using digital readout option (KD-DRO).
[5]Nominal value, may vary ±10%.
[6]For approximate ±1% linear range, multiply by 0.75.
[7]Nominal value, may vary ±5%.
[8]Optimum standoff for reflectivity/surface finish measurements.
[9]Nominal value, may vary ±15%.
[10]Displacement range producing 5% change from peak output when making reflectivity/surface finish measurements.



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