

Model 431

X-Y POSITION INDICATOR

P/N 79-10-009
Revision C
August 1992

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Notes:

1. All references in this manual to "Graseby Optronics" should be replaced with "UDT Instruments".

Product Warranty

Warranty Provisions

UDT Instruments warrants the items delivered hereunder to be free from defects in material and workmanship, and to conform to current UDT Instruments specifications at the time of sale. Purchaser shall have a period of one year from date of acceptance of the items to return deficient items to UDT Instruments for correction. Material will be considered accepted 30 days after receipt by purchaser unless UDT Instruments is notified of acceptance earlier.

UDT Instruments agrees to repair or replace at the place of manufacture, without charge, all items returned, transportation prepaid, for inspection at the UDT Instruments factory within the warranty period, provided: (1) such inspection discloses to the satisfaction of UDT Instruments that the defects are as above specified; and, (2) the material has not been subjected to misuse, improper maintenance, negligence or accident, damaged by excessive radiation, voltage, current or otherwise damaged by misuse.

The item returned shall only be accepted when accompanied by a written statement setting forth the nature and suspected cause of the alleged deficiencies.

This warrant is expressly in lieu of all other warranties, express, implied or statutory, and all other obligations or liabilities on the part of UDT Instruments. In no event shall UDT Instruments be liable for claims, demands or damages of any nature, however denominated, except that UDT Instruments liability shall be to repair defective items at its factory, or supply replacement parts in accordance with the terms of this warranty.

When equipment is shipped FOB UDT Instrument's factory, and when said equipment fails to perform according to specifications upon receipt, a claim should be made immediately against the shipping agency.

SHIPMENT AND PAYMENT

UDT Instruments payment terms are NET 30 days.
Shipment will be made FOB Baltimore, Maryland.

Warranty Return Procedures

Note: If this device has warranty and calibration seals, all warranties and calibrations are void if these seals are broken.

1. Please review terms of purchase and date of shipment to determine if product is warranted and whether or not it is within warranty period. Adjustment cannot be made for product out of warranty.

2. If product is subject to warranty, prior to return of product, telephone, write or fax UDT Instruments at the above address.

Product malfunctions should be reported to the Sales Department at the earliest possible time, since there are many occasions when technical assistance may obviate the need for returning products or can prevent product damage. Upon verification that warranty service is required, the Sales Department will issue a Return Material Authorization number (RMA number). The RMA number must appear on the outside of the shipping container for proper receipt.

3. It is necessary in all instances that the "return report" form be completed. Please photocopy and fill out the return report located in your product manual.

4. Repack the product carefully in the same manner it was originally packaged, preferably using the original shipping carton and packaging material. Pack the completed "return report" with the product making sure the RMA number is clearly visible on the outside of the container. Ship the product prepaid to UDT Instruments.

5. UDT Instruments will advise your company of its findings as to warranty consideration at the earliest possible time.

ADDENDUM: CE MARK EXCLUSIONS

1. The instrument is not intended for use in high humidity, high pollution, or explosive environments.
2. The instrument and related accessories are “CE” compliant when operated in the manufacturer’s recommended configuration, and in accordance with the exclusions described in this addendum. UDT Instruments does not accept responsibility for “CE” compliance if the instrument is used in a non recommended configuration.
3. All semiconductor devices are susceptible to electrostatic discharges (ESD). Ensure that the unit is switched off before connecting or disconnecting any cable(s) or accessories. Failure to do so can cause “ESD” damage and reduce the lifetime of the instrument drastically.
4. Units with ieee-488 capability must use a shielded cable; similar to Hewlett-Packard part number HP10833x or Io-Tech part number CA-7-X, to maintain compliance.
5. All coaxial cables must be less than 3 meters long.
6. All battery-operated units have batteries that are not replaceable by the customer, and can only be charged with the battery charger supplied with the unit by UDT Instruments.
7. **Cleaning:** Special care must be used when cleaning the instrument. The body, or any labels, should only be cleaned with a soft damp cloth, and a very light concentration of mild soap. Failure to do so may scratch the surface or damage any anti-glare coatings.

Never use alcohol, acetone, or other chemical solvents to clean any part of the unit.

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CAUTIONS

1 This instrument is set up for 115 VAC 50/60 Hz operation unless specified otherwise. For 230 VAC operation, set the rear panel line voltage selector to 230 VAC, and replace the fuse with a 1/8A AGC (supplied). The instrument may be severely damaged if operation is attempted with 230 VAC while the selector switch is set for 115VAC.

2 Before removing top cover, remove AC line cord to prevent electrical shock hazard.

1.0 GENERAL INFORMATION

1.1 Introduction

The UDT Model 431 X-Y Position Indicator offers an inexpensive, simple, yet powerful system for remote optical sensing of position and angle. When used with a UDT lateral effect photodiode or quadrant detector the 431 system senses the position of a light spot on the detector surface. Both digital and analog indications of the x-y coordinates of the light spot are provided by the 431.

Uses of the Model 431 include:

- o Robotics and position sensing on production equipment
- o Machine tool alignment
- o Bioengineering
- o Profilometry
- o Angle sensing
- o Automatic QC of parts
- o Stress monitoring

The Model 431 can be adapted to almost any imaging system or optical arrangement. These range from complex camera systems to using the bare detector with a laser beam. With microscopic objectives the 431 can measure displacements as small as .00001 inch. With telescopes or other long focal length lenses, distant objects can be sensed (e.g., star tracking). See section 4 for applications.

1.2 Features and Specification

- o Very high resolution - better than 1 part in 4000 resolution across the detector surface in both x and y directions when used with a lateral effect photodiode
- o High Speed. The standard Model 431 has a bandwidth of 1 kHz. With modification the bandwidth can become 7 kHz.
- o Wide dynamic range. The 431 can accommodate a 1,000,000:1 range of light levels.
- o Does not require precise focus. Since the detector senses the "centroid" of the light spot on its surface, exact focus on the object is not necessary.
- o Wide range of detectors. The 431 can be used with over a dozen different detectors including bi-cells, quadrant detectors and both single and dual axis lateral effect photodiodes, common cathode or common anode.
- o A full complement of accessories is available to meet specific application needs.
- o The 431 provides digital meter readouts as well as analog meters for alignment and analog voltage signals.
- o The 431 can be calibrated to read directly in inches or mm
- o LED's provide over and under range indications.
- o The 431 is housed in a 19 inch rack mount case and includes a folding metal stand for bench top use.

SPECIFICATIONS

Meters: 2 - 3 1/2 digit LCD's
 2 - analog meters (trend indicators)

Input Current Range (per input)

Sensitivity				Detector Load
Light Level Range		X1	X3	Resistance
X	1	1-1.5 mA	.33-1.66 mA	<1 Ω
X	10	100-500 μ A	33-166 μ A	<1 Ω
X	100	10- 50 μ A	3.3-16.6 μ A	1 Ω
X	1000	1- 5 μ A	.330-1.66 μ A	10 Ω

Input voltage error: 5 μ V from ground

Input current error: 10 pA (at 25°C)

Bandwidth: DC - 1KHz
 DC - 7KHz optional

Analog Output:

- x-y position 0 \rightarrow + 2 V
- difference 0 \rightarrow \pm 10 V
- sum 0 \rightarrow \pm 10 V

Zero Drift using SC-10/D detector, fixed zero, 0.1970[°] full scale (inch/°C), not including detector errors or mechanical drift.

resolution			
light level		X1	X10
X1, X10, X100		10 ⁻⁴	10 ⁻⁵
X1000		10 ⁻⁴	10 ⁻⁵
			5 X 10 ⁻⁶

Scale Factor Drift: 0.04% of full scale/°C

Linearity:

- instrument only \pm 0.5%
- SC 10/D detector (not included)
 - 0.5% in central 10% of detector
 - 10% in central 75% of detector

Power: 95 - 125 VAC or 190 - 250 VAC (switch selectable)

50 - 60 Hz, 10 W use 1/4A AGC for 115 VAC, 1/8A AGC for 230 VAC

Size: 3.48 in (8.8 cm) x 19 in (48 cm) x 11 in (28 cm)

Weight: 8.2 lbs. (3.72 kg)

2.0 THEORY OF OPERATION

Figure 2.0 shows a block diagram of the Model 431.

2.1 Optics and Detector

The Model 431 is an indicator unit for either a lateral effect or quadrant detector. The two-axis "lateral effect photodiode" has four electrodes on its edges. When a light spot is imaged onto its surface, the photocurrent divides up among the four electrodes in proportion to the distance of the light spot from those electrodes. (see figure 2.1)

The detector normally used with the Model 431 is the UDT SC/10D. It has a 1 cm x 1 cm active area and will detect light from 350-1100 nm. Its peak responsivity is typically 0.5 A/W at 900 nm. The spectral response is similar to most silicon photodiodes.

Because of geometrical considerations involving electrode placement, the most linear region of the detector is the central 25%. However, in addition to slight systematic nonlinearities, the precise positional response varies from detector to detector. In order to obtain the maximum accuracy from these devices, a mapping of the surface may be required.

Since the detector proportions the photocurrent among its electrodes irrespective of image detail, precise optical focus is usually not necessary. The 431 gives the positional coordinates of the "centroid" of the light spot on its surface.

Operation with a quadrant cell is similar in theory except that each of the 4 elements in a quad cell is electrically separate from the other elements. The 431 processes the signals according to a different instrument function. Quadrant cells are used for very precise centering applications (e.g. sensing laser beam position) over small distances. Lateral effect diodes are used where the light spot must move over a wider area.

When the light spot imaged onto the detector contains more than about 1 mW of optical power, the 431 should be switched to biased operation (see section 3.4.12). At high flux levels, the detector starts to saturate if it is in the normal photovoltaic mode. Saturation leads to a nonlinear output current that may give faulty positional information.

UDT makes other position sensing detectors, all of which can be adapted for use with the 431. Consult UDT for information on these detectors. In addition, many different optical imaging systems can be used with the 431. See section 5 for examples.

2.2 Electronics

The UDT Model 431 accurately measures the short circuit current from each element or area of the detector and converts it to a voltage.

This occurs at amplifiers A and B (D & E for y axis) (see figure 2.0 and schematics). The gain, in volts out per amp in, is determined by the feedback resistors selected by the light level sensitivity switch.

These voltages, are added and subtracted (in amplifiers A5, A7, A9 and A11) to obtain voltages $A - B$, $D - E$, $A + B$ and $D + E$.

The resolution amplifiers (A6 and A8) and gain resistors selected by the differential resolution switch (X1, X10, X100 & X3) provide increased gain of the $A - B$ and $D - E$ signals.

The polarity switch causes the polarity amplifiers (A10 & A14) to invert or not invert the sum signals $A + B$ and $D + E$ so they are positive.

The continuous/quad selector and sum amp (A13, A14 and A15) provides

X AXIS CHANNEL (IDENTICAL TO Y AXIS, NOT SHOWN)

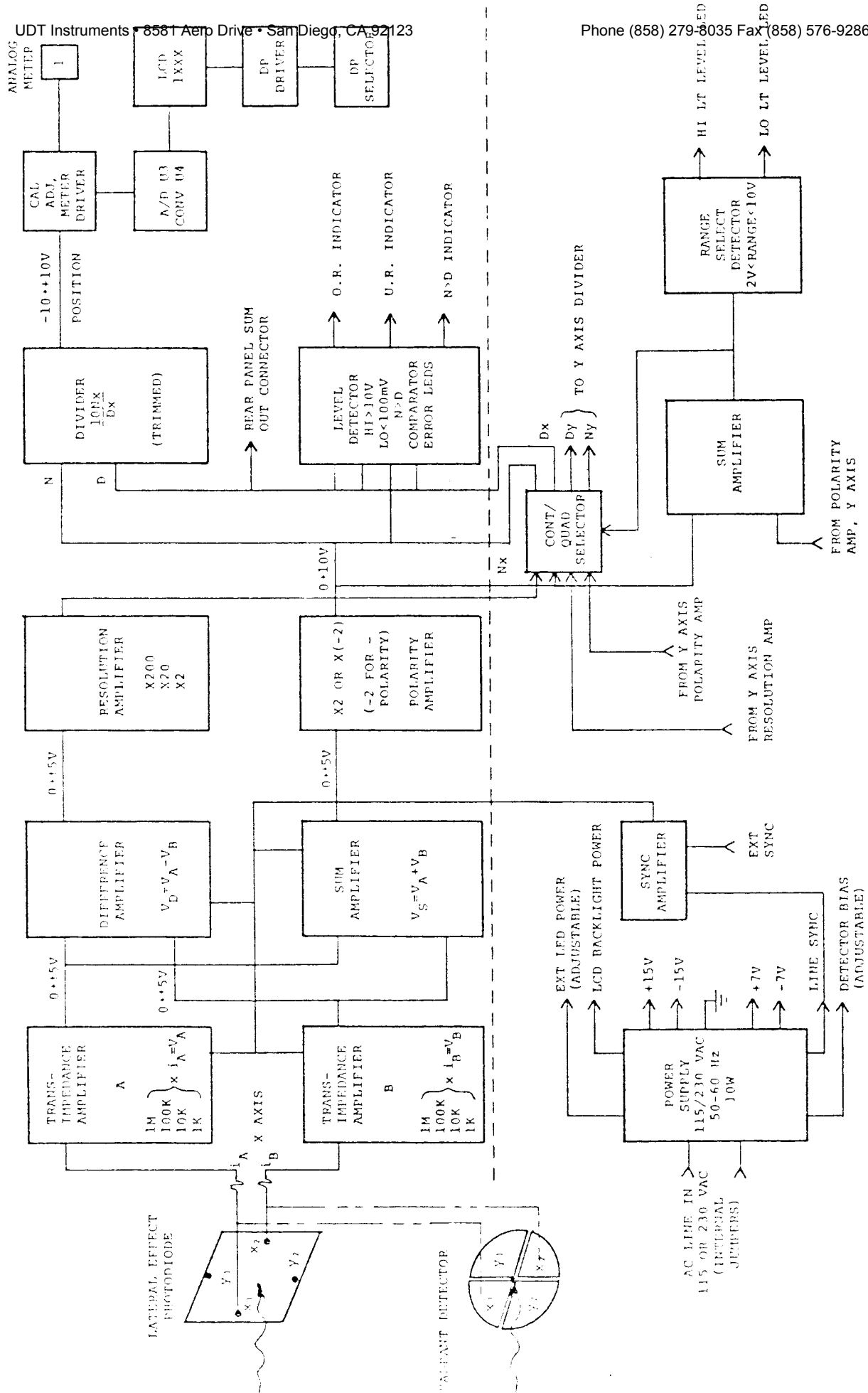


FIGURE 2.0 BLOCK DIAGRAM - UDT MODEL 431

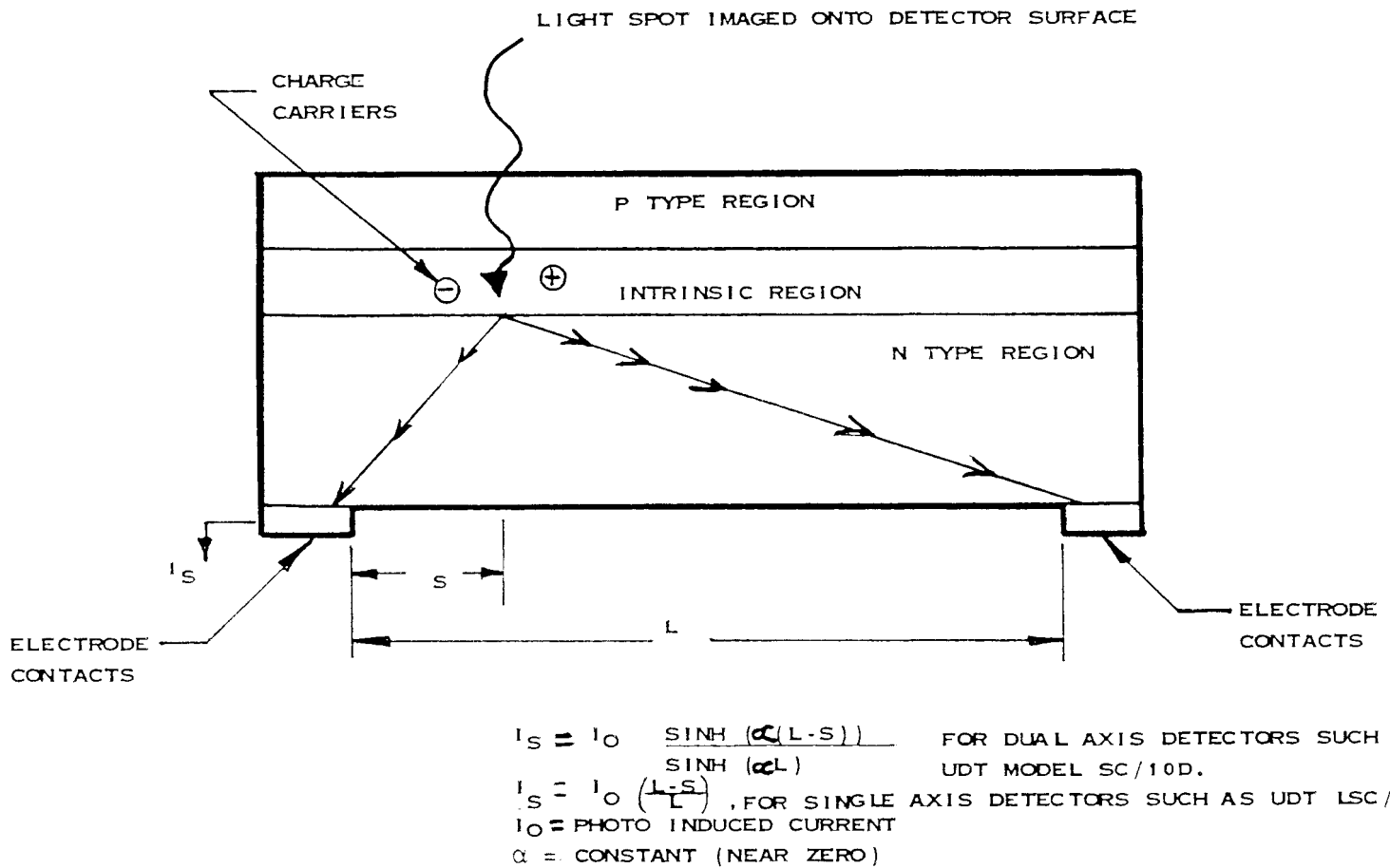
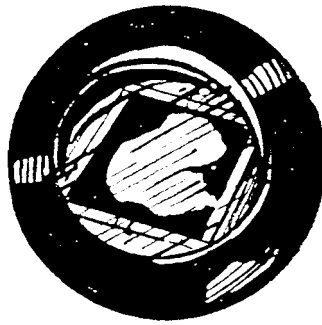


FIGURE 2.1
LATERAL EFFECT PHOTODIODE TYPICAL DEVICE CROSS SECTION

$(A - B) - (D - E)$, $(A - B) + (D - E)$ and $A + B + D + E$ voltages.

The range select detector (A16) detects high or low light level conditions based on $A + B + D + E$, and powers front panel light level led's.

The quadrant/continuous switch selects the instruments function as:

$$\begin{array}{ll} x \propto \frac{A - B}{A + B} & \text{Continuous} \\ y \propto \frac{D - E}{D + E} & \text{(e.g., SC 10/D)} \\ x \propto \frac{(A - B) - (D - E)}{A + B + D + E} & \text{Quadrant} \\ y \propto \frac{(A - B) + (D - E)}{A + B + D + E} & \text{(e.g., Spot 9D)} \end{array}$$

The ratios are obtained by the analog divider circuits (U1 and U2).

Level detector amplifiers (A22, A23 and A24) generate error signals for indicating low level, high level and $N > D$ (numerator greater than denominator) on the red front panel LED's.

Scale factors are determined by the resolution switch (S-12 E and F) and the front panel cal adjust trimpots.

U3 and U4 perform A/D conversion and drive displays LCD1 and LCD2 directly.

Decimal point location is determined by jumpers at J-4 and decimal point drivers U4 and U6.

The power supply consists of transformer T1, rectifier and filter circuits and regulators VR1 to VR4. VR4 provides -100 mA to drive external LED's, A27 provides +7 volts for operating the chopper stabilized amplifiers A1, A2, A3, A4, A5, A7, A9, A11, A21 and A25.

A26 provides a clock synchronized to the AC line which avoids interference and synchronizes the chopper stabilized amplifiers.

3.0 INITIAL PREPARATION

3.1 Unpacking and Mechanical Checkout

Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for damage that may have occurred in transit. If damage is found, a claim should be filed with the carrier immediately and UDT should be notified. (See Appendix A)

The model number and serial number of the instrument are located on a tag attached to the back panel. This serial number is kept in the UDT files to correlate the instrument with manufacturing and quality assurance records and procedures.

Standard equipment for the Model 431 is:

- o Model 431 Chassis
- o AC Line Cord
- o Carrying Case
- o Instruction and Operation Manual

The Model 431 does not include a detector. The detector must be separately specified depending upon the individual application. See the position sensor data sheet in Appendix C.

3.2 Electrical Checkout and Preparation for Use

The Model 431 as received from the factory is set to operate with the following conditions:

- o 115 VAC Power input 50/60 Hz
- o No decimal points selected on readout
- o Calibration - 1000 counts at edge of detector
- o Detector input connector wired for standard UDT detectors

See section 3.3 in order to change these conditions.

See section 3.4 for and continuation of checkout.

3.3 Internal Adjustments and Calibration

3.3.1 AC Line Voltage

Line voltage is determined by switch selection on the rear panel of the instrument, and installation of the proper fuse. Use a 1/4A AGC fuse for 115 VAC operation, use a 1/8A AGC fuse for 230 VAC operation.

CAUTION

Before removing top cover, remove AC line cord to prevent electrical shock hazard.

3.3.2 Offset Null and Analog Divider Potentiometers

Normally these trim pots are set at the factory and do not need to be readjusted. They are located inside the unit near each front end sum and difference amplifier (OP-07) and near the analog dividers.

3.3.3 Decimal Point Selector

As set at the factory the 431 x and y LCP displays have no decimal points on the display. The decimal point selector is located inside the 431 chassis on header P4 which plugs into the PC board near the differential resolution switch.

Decimal points may be selected to change with the position of the "diff resolution" switch or they may be selected to remain unchanged when the resolution is switched. See figure 3.3.3 for examples of header wiring for different decimal point locations.

3.3.4 Detector Hookup

Figure 3.3.4 shows the relation between detector input connector pins and device axis orientation. When using standard UDT detectors no change is required in the connector wiring. Note then when imaging a light spot onto the detector with a lens, + and - directions will appear interchanged.

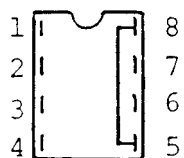
3.3.5 Displacement Calibration - Lateral Effect Devices

Position calibrations may be obtained with or without the use of a calibrated displacement device, such as a mechanical stage.

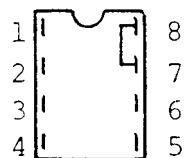
If the application uses the whole area (resolution = X1) of a detector or it is a linear single axis detector, the calibration potentiometers may be adjusted using a resistor connected to the input connector to generate a current which simulates light on the edge of the detector. The resistor (typ 100 K Ω) is connected between the H pin and one of the input pins A, B, D, or E and the bias voltage and range are selected for proper signal levels. The "cal adj" potentiometers may be adjusted to indicate the actual distance from the center of the detector to the edge, which may be obtained from the detector data sheet. For example the UDT Model SC10P detector (included with the Model 1233 detector cable assembly) may be adjusted for a full scale displacement of ± 0.1970 (1970 counts on the display) for each axis. See Table 3.3.5 for displacements of typical UDT lateral effect photodiodes.

However, if the central region is of the most importance, the instrument should be calibrated in the region of interest with a precision mechanical stage as reference. This is the preferred method of calibration since most 2 axis lateral effect devices are display degraded linearity outside of the central 25% region. Use the same "cal adj" potentiometers to match actual displacement to digital meter readings.

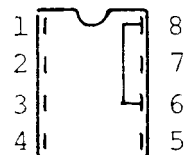
Rear panel accessible dip switches select attenuation factors to aid in locating a good operating region of the front panel cal adjust potentiometers. Attenuation ratios are indicated on the rear panel.

Fixed Decimal Point Selector Wiring

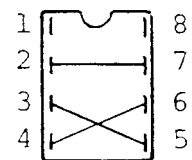
1.XXX



1X.XX

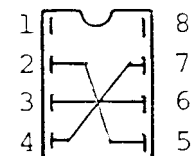


1XX.X

Switched Decimal Point Selector Wiring Examples

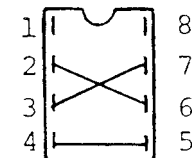
<u>Diff Res</u>	<u>Decimal Pt. Location</u>
X1	1X.XX
X10	1.XXX
X100	1XX.X

UDT P/N 68-11-326



X1	1.XXX
X10	1XX.X
X100	1X.XX

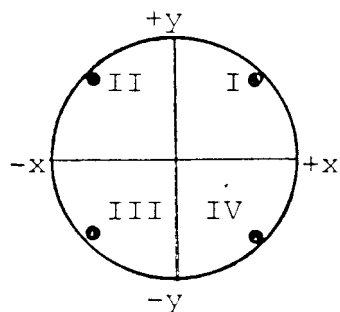
UDT P/N 68-11-324



X1	1XX.X
X10	1X.XX
X100	1.XXX

UDT P/N 68-11-325

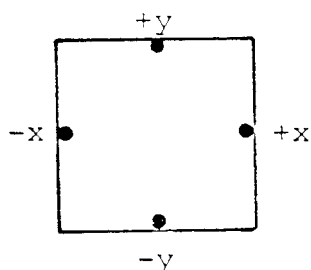
FIGURE 3.3.3 DECIMAL POINT LOCATION

Quadrant Detectors

(Note: Angle of pins to axes is shifted 45° from lateral effect axes.)

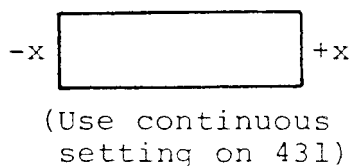
Amp Pin	Detector Quadrant	
	Common Cathode	Common Anode
A	III	I
B	I	III
D	IV	II
E	II	IV
F	Shield	Shield
H	Zero or bias	Zero or bias

UDT Spot 9D and other
UDT quadrant detectors

Lateral Effect Detectors

Amp Pin	Detector Pin	
	Common Anode (P on N)	Common Cathode
A	+x	-x
B	-x	+x
D	+y	-y
E	-y	+y
F	Shield	Shield
H	Zero or bias	Zero or bias

UDT SC 10/D and other UDT
lateral effect detectors

Bicells or Single Axis Lateral Effect Detectors

Amp Pin		Common Anode	Common Cathode
1st detector	{ A	+x	-x
	{ B	-x	+x
2nd detector	{ D	+x	-x
	{ E	-x	+x
(optional) F		Shield	Shield
H		Zero or bias	Zero or bias

FIGURE 3.3.4 DETECTOR CONNECTOR PINS AND
DETECTOR AXIS ORIENTATION

<u>DETECTOR</u>	<u>LSC/4</u>	<u>LSC/30D</u>	<u>LSC/5D</u>	<u>SC/50</u>	<u>SC/10D</u>	<u>SC/4D</u>
1/2 Width, (inches)	2	0.59	0.105	0.875	0.197	0.05
full scale displacement Whole Det. (inches)	1.999	0.590	0.1050	0.875	0.1970	0.0500
Best Resolution (inches)	1.999	0.1999	0.1050	0.1999	0.1970	0.01999
Max Resolution, X100 Whole Det. (inches)	10 ⁻⁵	10 ⁻⁵	10 ⁻⁶	10 ⁻⁵	10 ⁻⁶	10 ⁻⁶
Best Resolution (inches)	10 ⁻⁵	10 ⁻⁶	10 ⁻⁶	10 ⁻⁶	10 ⁻⁶	10 ⁻⁷
1/2 Width, (mm)	50.8	15	2.67	22.2	5	1.27
full scale displacement Whole Det. (mm)	50.8	15.00	2.67	22.2	5.00	1.270
Best Resolution (mm)	19.99	15.00	1.999	19.99	1.999	1.270
Max. Resolution, X100 Whole Det. (mm)	10 ⁻³	10 ⁻⁴	10 ⁻⁴	10 ⁻³	10 ⁻⁴	10 ⁻⁵
Best Resolution (mm)	10 ⁻⁴	10 ⁻⁴	10 ⁻⁵	10 ⁻⁴	10 ⁻⁵	10 ⁻⁵

TABLE 3.3.5 LINEAR DISPLACEMENTS AND RESOLUTIONS FOR VARIOUS LATERAL EFFECT PHOTODIODES

3.3.6 Displacement Calibration - Dual and Quadrant Detectors

These detectors are generally used for centering applications. The instrument may be adjusted as above with a resistor or light spot on one element at a time, and the displays adjusted to indicate 1000 counts.

However, it is recommended that the calibration be performed with a precision mechanical stage to obtain maximum linearity for small displacements near the center of the detector. Again use the "cal adj" pots to match actual displacement to digital meter readings.

3.4 Front Panel Controls, Adjustments, Indicators and Connectors Indicators and Connectors (See Figure 3.4)

3.4.1 "Power On-Off"

Internal jumpers select 115 or 230 VAC line voltage.

3.4.2 LCD Displays

See section 3.3.3 for decimal point location and sections 3.3.5 and 3.3.6 for calibration. The LCD displays are backlit to allow instrument usage in low light level surroundings.

3.4.3 Analog Meters

Intended for aid in initial optical alignment and trend indication the full scale analog meter display corresponds to ± 1.999 on the digital meters.

3.4.4 "Hi Lo Error" LED's

These LED's indicate when erroneous readings may occur. If the sum signal on either axis is less than 100 mV or greater than 10 V the LED's light, indicating that the analog divider denominators are out of range for accurate readings. Either adjust the light level sensitivity or move the light spot away from the edge of the detector.

3.4.5 "X - Y cal" Pots

These trim pots will calibrate the LCD displays, analog meters and analog output simultaneously. See sections 3.3.5 and 3.3.6.

3.4.6 "Diff Reslon" Switches

These switches increase position resolution from X1 to X10 or X100 for increased sensitivity near the center of the detector. See section 3.3.3 for decimal point location on LCD displays.

3.4.7 "N > D" LED's

These LED's indicate when the gain of the resolution switch is set too high and the light spot is located outside of the indicated range.

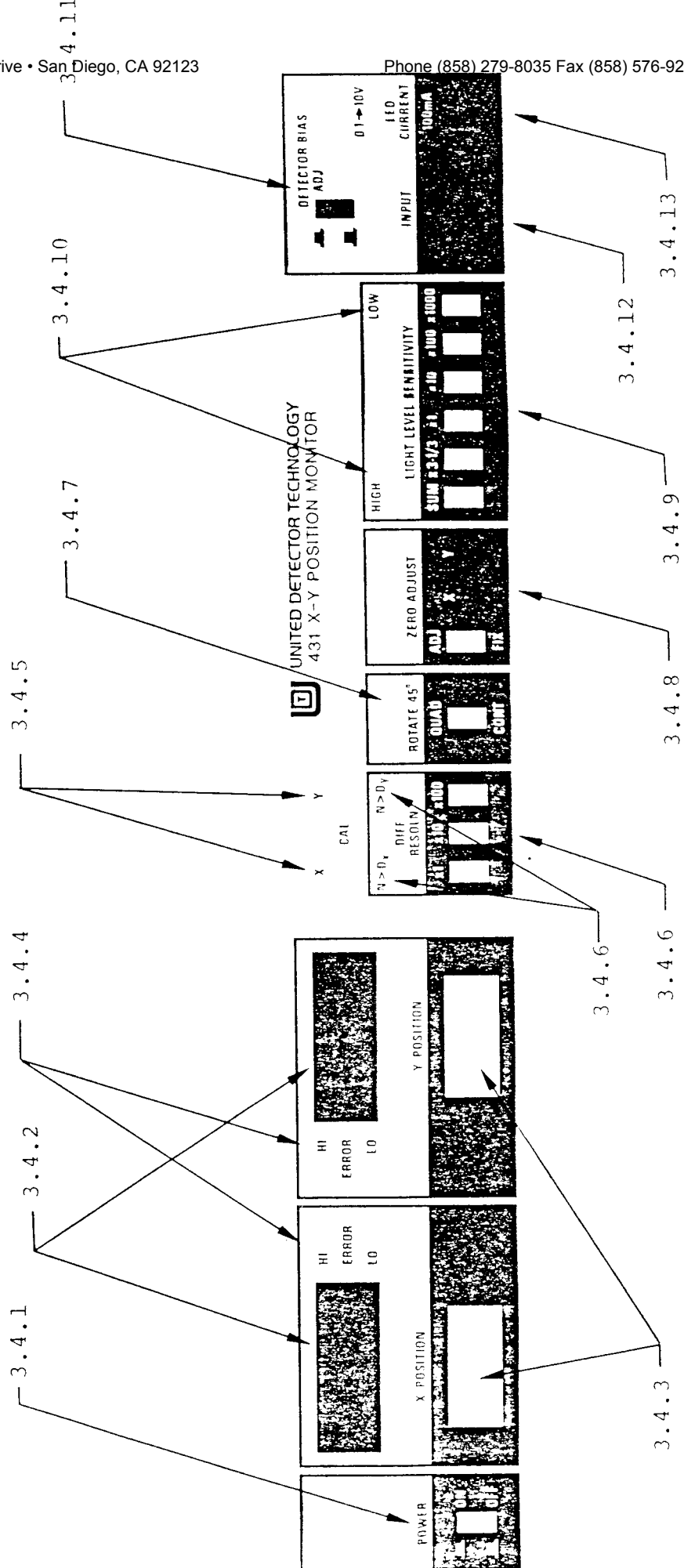


FIGURE 3.4 FRONT PANEL CONTROLS

3.4.8 "Quad-Cont" Switch

Choose the appropriate switch position for either quadrant detectors or continuous lateral effect detectors. The 431 instrument function will be changed accordingly. Note that there is a 45° difference in x-y axis orientation versus pin position between quad and continuous detectors.

3.4.9 "Zero Adjust"

In the "fixed" position the zero LCD reading will be obtained at the electrical center of the detector, i.e., the place where all 4 current outputs are equal.

In the "0" position the zero position can be made to correspond to any point on the detector when in the X1 resolution position. Screwdriver adjustments are provided for each axis.

3.4.10 "Light Level Sensitivity" Switches

When the "sum" switch is depressed the total relative input current is displayed on the y-axis display.

The X3, X1, X10, X100, and x1000 switches should be depressed in order to bring the sum display on the y-channel between 300 and 1000 cts (ignoring decimal points). The X3 switch may be depressed in combination with any of the decimal switches.

3.4.11 "High-Low" Sensitivity LED's

These LED's indicate when the sum of all x and y inputs is above or below the recommended level for accurate analog divider operation. The light level sensitivity switch should be adjusted so neither of these LED's are lit.

3.4.12 "Detector bias" Switch and Trim-pot

Zero biased operation is normally used for low light level lateral effect and quadrant detector measurements.

The "adj" position (switch depressed) allows 0.1 to 10 V bias voltage for use with detectors at higher light level (e.g. Helium Neon lasers and high power LED's). When the light level as monitored by the "sum" switch and the y channel LCD is not constant as the light spot is moved across the surface, then bias should be applied to the detector until the response is relatively flat.

3.4.13 Input Connector

See section 3.3.4 for details of the connector pin arrangement.

3.4.14 "LED Current"

A BNC connector is provided which supplies -100 mA for use with common anode (+ ground) LED's. The UDT Model 266 high power LED (~ 6 mW) plugs directly into this connector with a standard BNC cable.

3.5 Rear Panel Connections

3.5.1 AC Line Connector

An IEC standard line input connector is provided.

3.5.2 Detector Polarity Switch

This switch selects common anode or common cathode detectors. See section 3.3.4 for proper polarity for UDT detectors.

3.5.3 BNC Connectors

X Y position and X Y sum signals as well as the total sum signal are all available on BNC connectors.

3.5.4 Calibration Dip Switches

Four poles select attenuations of 1, 10, or 100 for x and y position cal pots to aid in calibration.

Four poles are also available for test and alignment.

3.5.5 Fuseholder

Fuse with 1/2A 3AG at 115 VAC or 1/4A 3AG at 230 VAC.

3.5.6 Edge Connector

Table 3.5.6 shows the edge connector outputs and inputs as well as voltage ranges. If power is supplied to the unit via the 15 V connections then an external clock input is required. This input should be a square wave with approximately + and - 100mV amplitude. The clock frequency should be between 10 and 500 Hz.

3.6 Operating Instructions

Initial Conditions:

<u>Function</u>	<u>Condition Light</u>
Light Level Sensitivity	X1, X3 out (off)
Detector Bias	Out (Zero)
Zero Adjust Switch	Out (Zero)
Cont/Quad Switch	In for Quadrant Out for Lateral Effect
Diff Resolution	X1
<u>Rear Panel</u>	
Polarity	Out for Common Anode In for Common Cathode
Line Voltage	Corresponds to voltage indicated On rear panel
Power	On (In)

TABEL 3.5.6 REAR PANEL EDGE CONNECTOR

Edge Connector Letter		Edge Connector Number	
A	- 7 V	1	Amplified A output (0-5 V)
B	+ 7 V	2	Amplified B output (0-5 V)
C	- 15 V	3	Amplified D output (0-5 V)
D	+ 15 V	4	Amplified E output (0-5 V)
E	total sum (0-10 V)	5	
F	100 mV (ref)	6	
H	LED current (-100 mA)	7	x pos (scaled) (0-2 V)
J	Clock (input or output)	8	y pos (scaled) (0-2 V)
K		9	x numerator (0- ± 10 V)
L		10	x denominator (sum) (0-10 V)
M		11	x position (0- ± 10 V)
N		12	y numerator (0- ± 10 V)
P		13	y denominator (sum) (0- ± 10 V)
R		14	y position (0- ± 10 V)
S	GND	15	GND

1. Connect the detector and illuminate it with a light spot close to its center.
2. Adjust the light level switches. Set the switches for highest gain without the amber "High Light Level" Indicator on. A number between 333 and 1000 should be obtained using the sum switch and the y axis panel meter.
3. FOR LATERAL EFFECT DETECTORS: To determine if a reverse bias voltage is required, move the light across the detector while watching the level of the sum signal. If a reduced sum level is obtained towards the center of the detector, then a reverse bias is required. Push the detector bias switch in and adjust the bias voltage level for a uniform sum level. Darken the detector and note that the sum level approaches zero. This means that the detector bias current will not affect position measurement. Should the sum level indicate more than 500 counts, the detector is excessively leaky or the rear panel polarity switch is reversed. Schottky barrier photodiodes will last longer with at least minimum bias, due to contact problems which occur with time.
4. After the light level sensitivity and bias are selected, the light spot can be moved around on the surface of the detector. Near the center of the detector the resolution may be increased to X10 or X100.
5. See sections 3.3.5 and 3.3.6 for calibration data.

4.0 APPLICATIONS

4.1 General Conditions-Lateral Effect Photodiodes (SC10/P)

The notes that follow contain measured performance data for some of the more common Model 431 system configurations. These are intended to act as guides to the user designing his own system. UDT can supply almost all of the building blocks of these systems.

In designing a position sensing system the user should be aware of some general rules:

1. The primary consideration is light collection. The brighter the source and the more efficient the collection optics, the better will be the resolution, drift, and ease of alignment.
2. The signal-to-noise ratio and the isolation from ambient light can usually be increased by installing wavelength selective filters in front of the detector. The position sensing detector is sensitive from 300-1100 nm.
3. Imaging of the optical spot onto the detector is usually not critical since the detector will sense the centroid of the spot independent of the spot size.
4. For maximum linearity the center 25% of the detector should be used. Minimum linearity is at the corner of the detector and it improves as the spot moves towards the center. See the UDT position sensing detector data sheet for specifications. To achieve the maximum accuracy of the 431, mapping of the detector surface response may be necessary.
5. Detector linearity will also be affected by interference in the optics (i.e., spurious reflections) and by the uniformity of the manufacturing processing of the detector. Consult UDT for advice on detectors for systems that require very high linearity.
6. To obtain the true positional information about the light spot being observed, the required algebraic manipulations of the four detector outputs (x_1 , x_2 , y_1 , y_2) are:

$$x \propto \frac{x_1 - x_2}{x_1 + x_2}$$

$$y \propto \frac{y_1 - y_2}{y_1 + y_2}$$

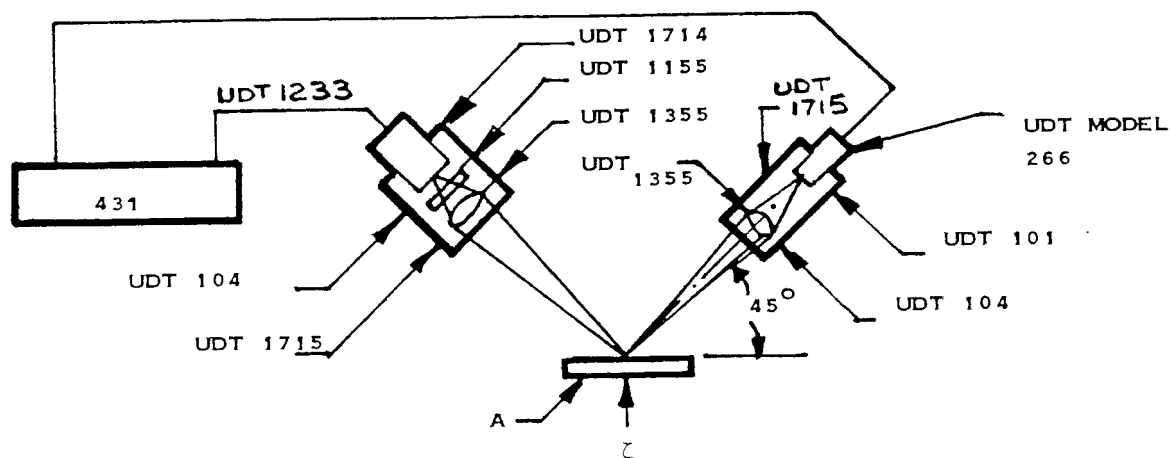
The resulting algebraic quantities are independent of changes in the light source intensity. If the light source being used does not change by more than the positional accuracy required, the difference signals ($x_1 - x_2$, $y_1 - y_2$) may be used as the x and y positions.

7. 10 mW is the highest recommended optical power level.

The following applications mainly concern lateral effect photodiodes although quad cells can be used in most of the same application but with reduced positional coverage.

In general, quadrant and bi-cell detectors are recommended for applications requiring very precise nulling or centering or for tracking position over a small range. Lateral effect Units are more appropriate when a wider range of coverage is desired since position information is available over the entire active area.

4.2

Sensing Small Displacements of Specular or Diffuse Surfaces

In this example, the 431 is used to determine the position of a flat metal surface (A). The same approach can be used to detect the level of a liquid or the position of almost any object, depending on the light source and the object reflectivity.

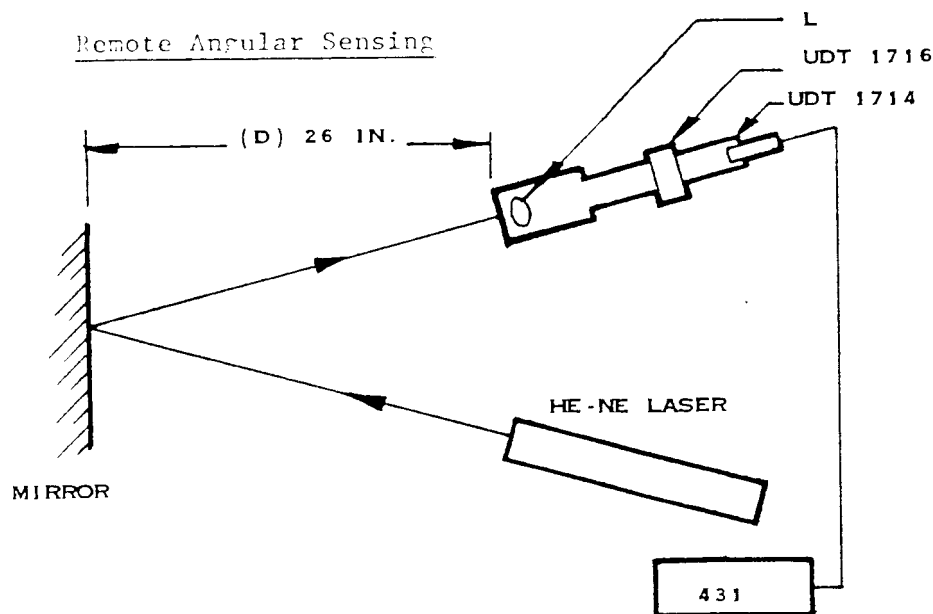
The light source in this example is a high power narrow angle LED (Xciton XC-88PD). At 100 mA this diode emits 12 mW at 880 nm into a 15° beam. A BNC cable connects the LED to the LED supply connection (100 mA) on the 431. Alternately, an incandescent lamp or a laser could be used as the source.

In the present configuration, the LED is imaged onto the surface being measured using a 1.0 inch diameter, 15 mm focal length lens (UDT 1355). The distance between the lens and the detector is about 1.0 inch. A visible blocking filter (1155) is used to reduce detector sensitivity to ambient light.

The setup has a range of $C=0.75$ inches and a resolution of better than 0.0003 inches. The exact gain setting will depend greatly upon the reflectivity of the surface being measured (A).

If an infrared source is used it is recommended that an infrared viewer be used for setup of the equipment. For maximum stability the source and detector apparatus should be rigidly coupled to each other.

4.3

Remote Angular Sensing

One of the principle uses of position sensing detectors is for measuring angles, usually of mirrors but sometimes of relatively diffuse surfaces. UDT manufactures the model 1000 electronic autocollimator for use in most situations where manual autocollimators are used. The model 1000 connects directly to the 431. However, under special situations where the distance to the mirror is large or where the mirror itself is small, the configuration outlined here is recommended.

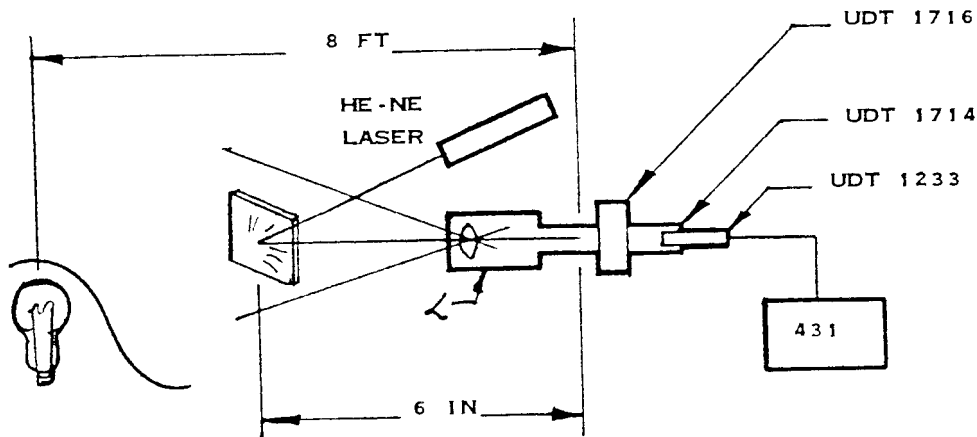
The source used is a 2 mW helium-neon laser positioned approximately two feet from the mirror under test.

The receiving lens (L) and the distance (D) can be chosen to provide the desired mirror angular coverage. In this example, a 2 inch diameter 135 mm focal length lens would cover a mirror tilt of 38 milliradians.

The 431 should be modified to operate in the biased mode when a relatively high power light source such as a HeNe laser is used. Otherwise, the detector will saturate and not give a linear reading.

The focal distance of lens L may be varied to adjust the CP-EYE angular sensitivity. Alternatively even the bare detector may be used, but an angular coverage of only 7.5 milliradians (at a resolution of less than 1.8 microradians) will be obtained with the present example.

4.4

Sensing the Posititon of Macroscopic Objects

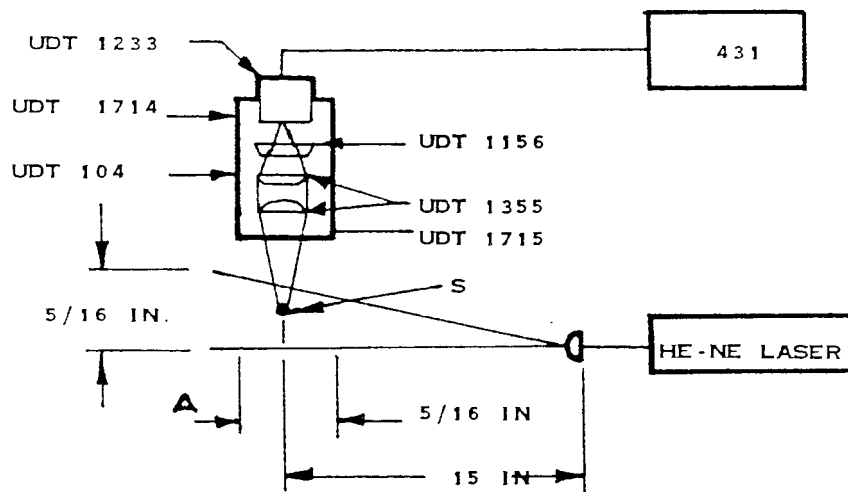
In the example, two cases need to be considered: in case I the object is being remotely illuminated by a helium-neon laser. In case II a tungsten lamp is attached to the object being measured and the lamp position is actually monitored. Both cases use the same detector configuration. With the data from these cases the user can deduce the system response for virtually any light source and distance. Applications for this configuration include sensing the position of machine tools, robot arms, and monitoring movement in bioengineering.

Case I: The light source is a 20 mW helium-neon laser shining onto a white, diffuse, approximately lambertian surface.

Using a 28 mm focal length $f/2.8$ camera lens as L, the field of view of the lens system at 6 inches is 2.1 inches with a standard 0.4 inch x 0.4 inch detector. A narrow band 633 nm filter (UDT 1156) can be used to reduce detector sensitivity to ambient light.

With the 431 set on low light level (X1000 + X3) and without a filter, the signal is slightly above minimum detectable level. By choosing a faster lens or shorter distance, the 431 accuracy can be more fully utilized (e.g., an $f/1.4$ lens would give 4 times the signal level).

Case II: Using a 1000 W tungsten lamp with a DC supply as the source, measurement distances up to or greater than 80 feet can be achieved. For instance with the 431 set on X10 and X3 light level at 8 feet with an $f/1.4$ lens the signal level is within range. On low light level (X1000 + X3) the same performance can be achieved at 80 feet. Obviously, using a reflector and optics around the lamp will further extend the range.

4.5 Sensing the Small Scale Displacement of a Wire

Position sensing detectors are often used in measurement situations where the sample is too delicate, small, or otherwise unsuitable for contact measurement techniques. In this example, the position of a 0.010 inch diameter nickle wire (S) is determined in one dimension. The location information can then be used to servo control equipment, such as wire take-up reels, etc.

The light source is a 2 mW helium-neon laser, the beam of which is expanded by lens L (25 mm focal length cylindrical lens) into a fan of light. The width of this fan is 5/16 inch by the time it arrives at the sample which is 15 inches from L.

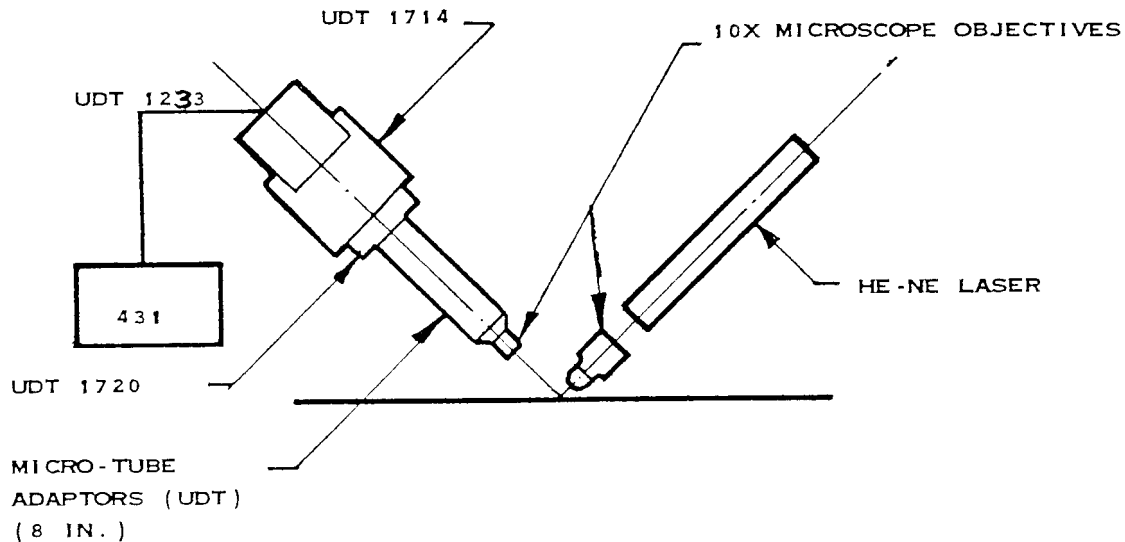
Although the sample in this case is a 0.010 inch diameter wire, anything of approximately the same size will produce approximately the same signal. For instance, the sample could be a glass fiber from a fiber furnace, or a thread, or a liquid stream, or a stream of solid particles.

Also, a higher intensity light source can be used, or the light source area coverage can be reduced to increase the signal level and the resolution.

The collection system consists of two very short focal length lenses (15 mm focal length, 1.0 inch diameter), (UDT 1355). A 633 nm narrowband filter (UDT 1156) is used to decrease the detector sensitivity to ambient light.

With the 431 set for low light level (X1000 + X3), the signal strength is slightly above the minimum useable level. The field of view is 5/16 inch.

4.6 Profilometry



An optical setup similar in principal to that shown in section 4.2 is useful for measuring ultrasmall displacements as in profile measurement.

A Helium-Neon laser is focused onto the surface being measured by a microscope objective in order to provide a small measurement spot. The laser spot is imaged onto the detector by a similar microscope objective giving a magnification of approximately 15 times. Depending upon the reflectivity of the surface being measured, the 431 will require either X1000 + X3 or X1000 light level. Useable resolutions between .000001 and .00001 inch are obtainable.

4.7 Electronic Autocollimator

The UDT Model 1000 Electronic Autocollimator is a versatile instrument building block designed to measure very small angular displacements of surfaces. Applications of the Model 1000 include automatic mirror alignment and servo control, QC and testing of surface plates, machine surfaces, and optical components, vibration measurement and determining pointing stability. The Model 1000 finds use wherever flatness, angles, or parallelism must be easily and accurately established.

The UDT Model 1000 is similar in concept to the classical autocollimator except that a position sensing photodetector is used in place of the observer's eye. As shown in figure 4.7B a high power infrared light emitting diode (LED) generates a 15° beam of light which is reflected through a beamsplitter (B) and then collimated by lens (L). This parallel beam is reflected off the device under test H, back through the lens and beamsplitter to the detector assembly (D). (A visible light blocking filter (F) is used to prevent ambient light from biasing the detector readings.)

With a 135 mm f/2.8 lens as (L) and with a X100 light level on the 431 the readings will be in range. A 135 mm lens will provide a 74 mrad angular coverage. The resolution will be .37 microradians.

FIGURE 4.7A AUTOCOLLIMATOR HEADS
WITH 135MM, 400MM, AND 200MM
CAMERA LENS. 200MM VERSION SHOWN
IN OPTIONAL GIMBAL MOUNT.



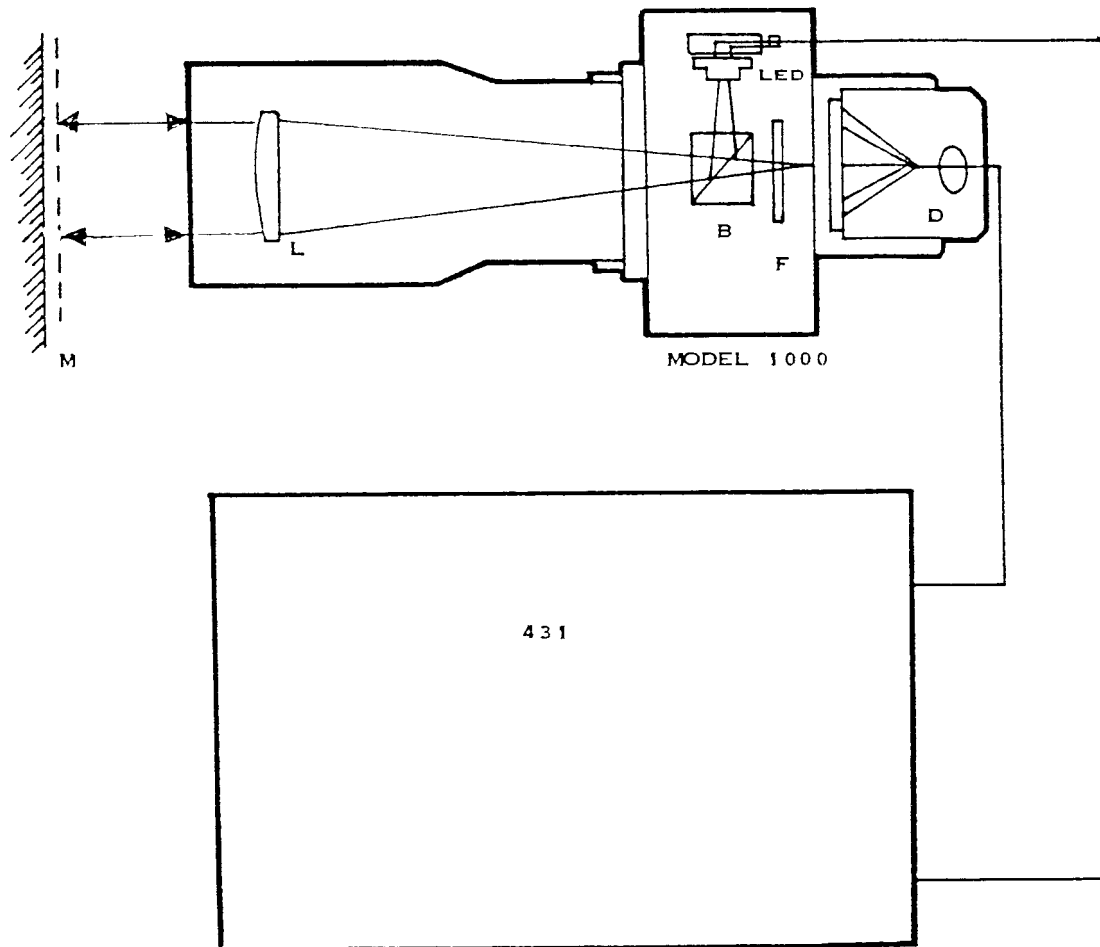


FIGURE 4.7B TYPICAL MODEL 1000 SYSTEM

5.0 ACCESSORIES AND OPTIONS5.1 UDT Position Sensing Accessories

See figure 5.1 for outline drawings.

UDT POSITION SENSING ACCESSORIES

<u>Model Number</u>	<u>Description</u>
101	Universal Housing (Adapts LED Assemblies to standard UDT threads)
103	Detector Strand
104	Filter Holder/Female Coupler
108	Male Coupler
266	LED Assy (BNC Interconnect) 880nm
267	PIN SC/10D Detector/Lens Assy
1000	Autocollimator (Integral LED Source)
1112	Narrow Bandpass Filter (632.8nm) \pm 15nm
1113	Narrow Bandpass Filter (905nm) \pm 15nm
1114	Narrow Bandpass Filter (1060nm) \pm 15nm
1115	Narrow Bandpass Filter 514.5nm) \pm 15nm
1155	Visible Blocking Filter (in threaded ring)
1156	633nm Narrowband Filter (in threaded ring)
1232	PIN-SC/25D detector/Cable Assy
1233	PIN-SC/10D detector/Cable Assy
1237	PIN-SC/50 detector/Cable Assy
1238	PIN-LSC/5D detector/Cable Assy with 35mm lens adapter
1239	PIN-LSC/30D detector/Cable Assy with 35mm lens adapter
1240	PIN-SPOT/9D detector/Cable Assy
1241	PIN-SC/4D detector/Cable Assy
1242	PIN-SPOT/4D detector/Cable Assy
1350	50mm Camera lens
1351	50mm Macro Camera lens
1352	135mm Camera lens
1353	400mm Camera lens
1354-1 to 10	1X to 10X Microscope Objective (specify)
1354-20 to 60	20X to 60X Microscope Objective (specify)
1354-75	75X Microscope Objective
1355	15mm Focal length lens assy in threaded ring(1 inch diameter)
1356	28mm Wide Angle Camera Lens
1700	X-Y Translation Stage and Stand
1701	1233 Detector Holder (for mounting in Model 1700)
1702	1234 Detector Holder (for mounting in Model 1700)
1703	1232 Detector Holder (for mounting in Model 1700)
1704	1237 Detector Holder (for mounting in Model 1700)
1706	Tripod
1714	1233 and 1234 Adapter (to UDT standard threads)
1715	1 inch Diameter Lens Adapter (to UDT standard threads)
1716	35mm Camera Lens Adapter (to UDT standard threads)
1720	Microscope Adapter (to UDT standard threads)

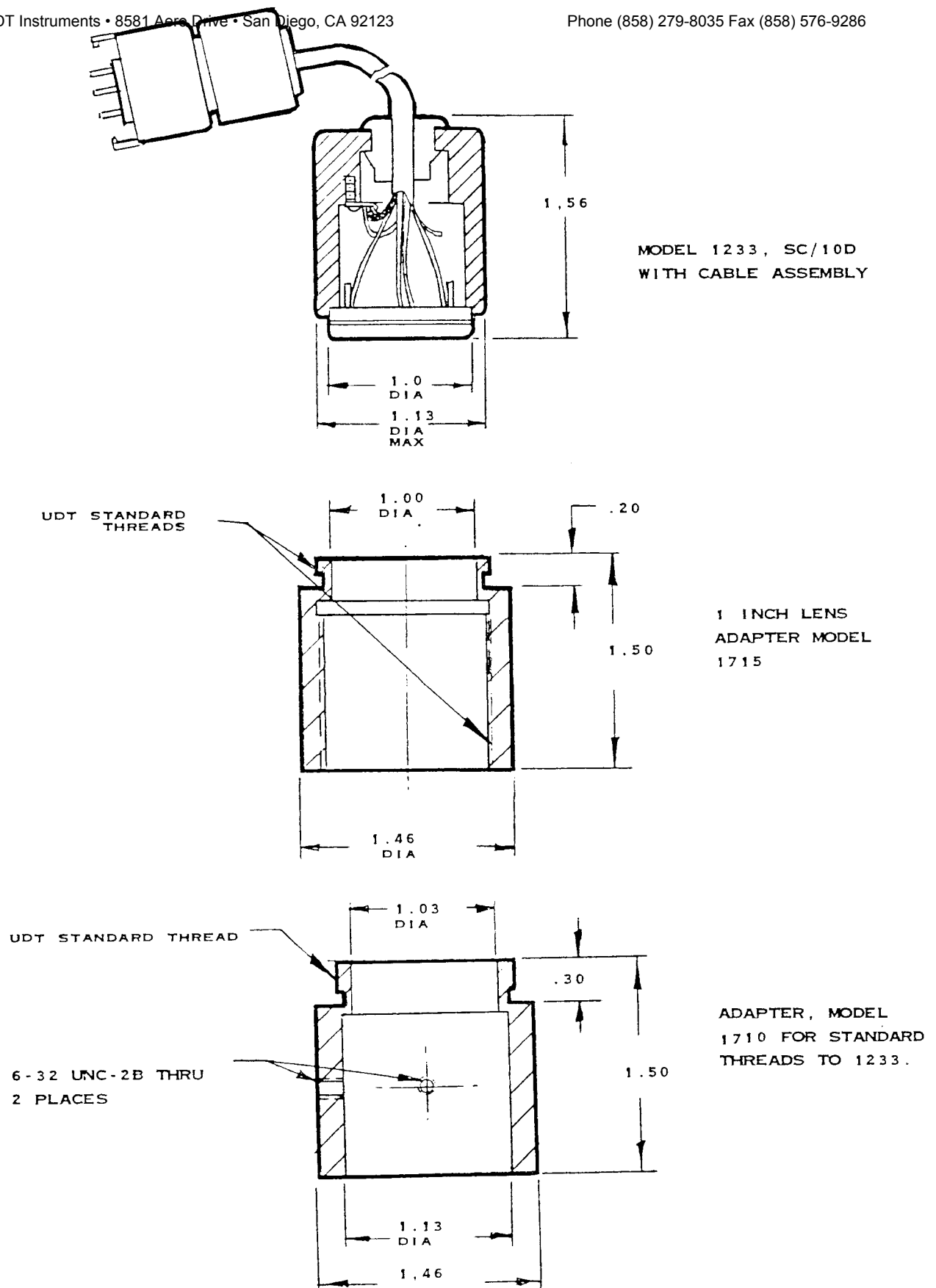
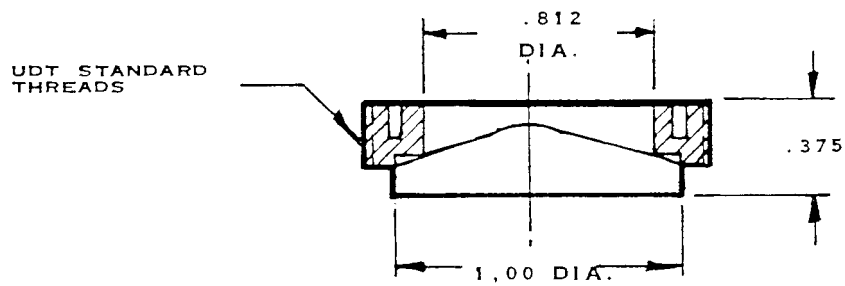
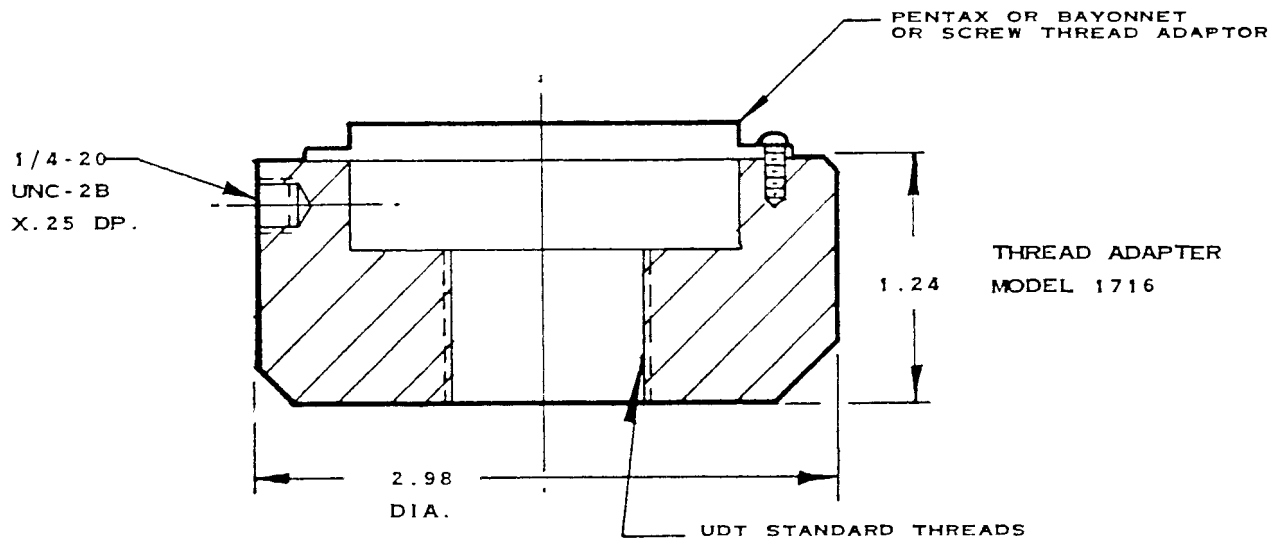
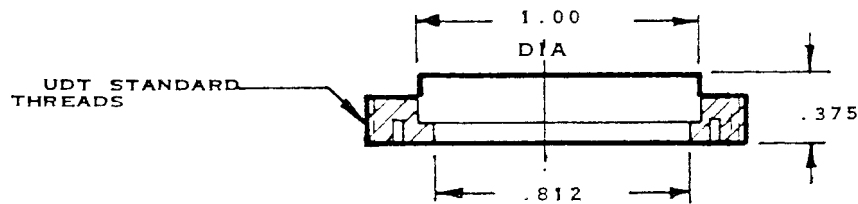


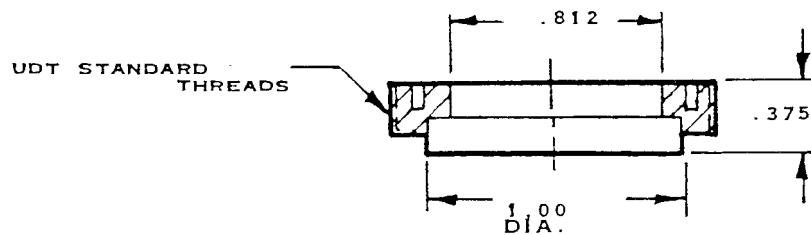
FIGURE 5.1A



MODEL 1355 1 INCH
DIAMETER, 15MM FOCAL
LENGTH LENS ASSEMBLY



MODEL 1156
633 NM NARROW BAND
FILTER ASSEMBLY



MODEL 1155
VISIBLE BLOCKING
FILTER

FIGURE 5.1B

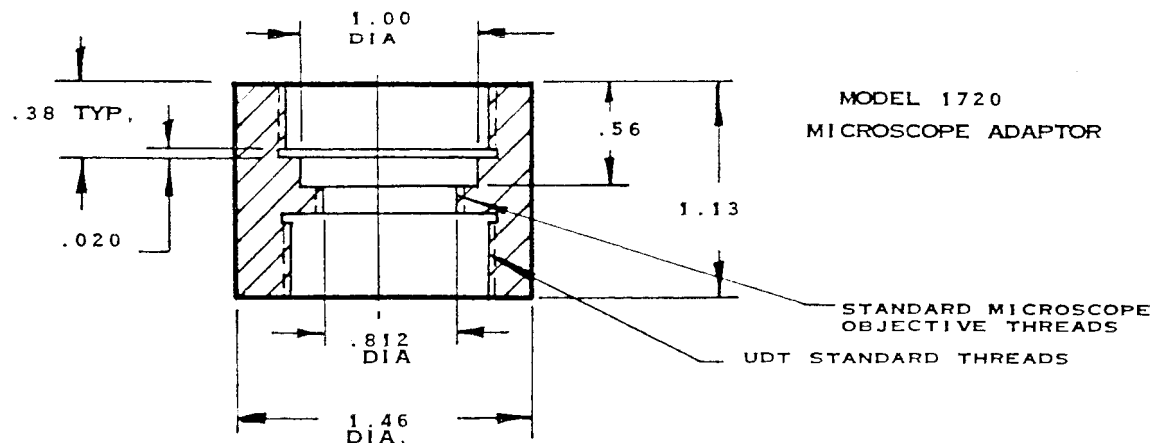
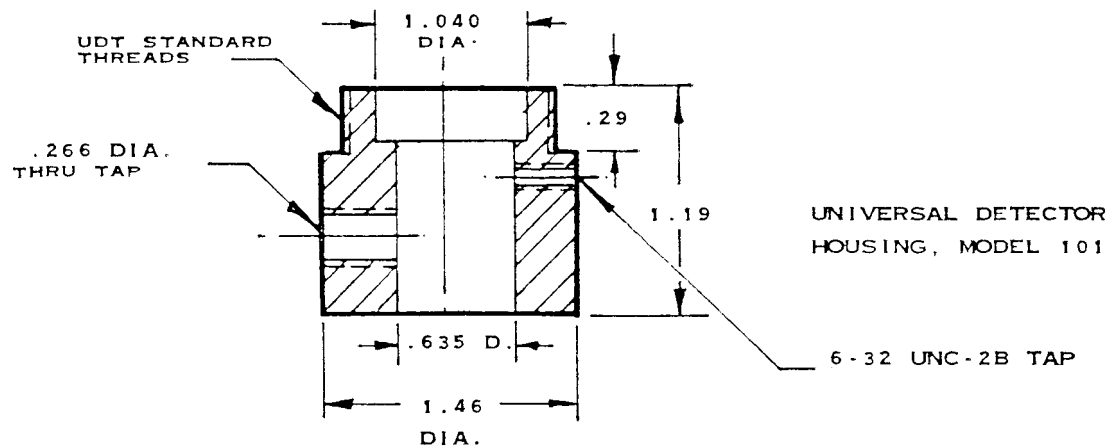
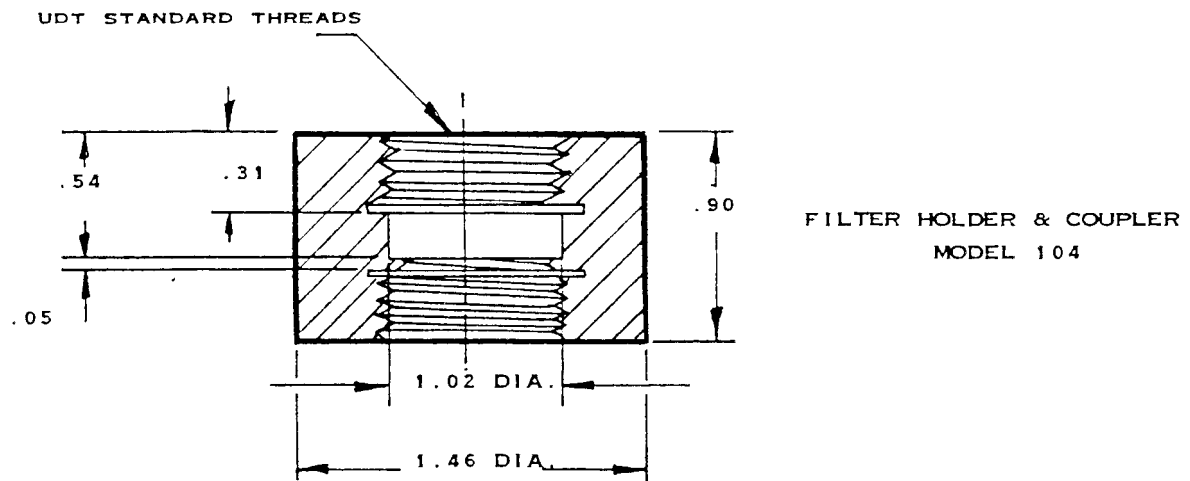


FIGURE 5.1.C