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INSTRUCTION MANUAL

S550

FIBER OPTICS

POWER METER

Dennis Nave
Edwards
Ian

Revision A

UNITED DETECTOR TECHNOLOGY
3939 Landmark Street
Culver City, CA. 90230
(213) 204-2250.

9780516

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1.0 INTRODUCTION - S550

The S550 was specifically designed for the Fiber Optics user to facilitate and simplify the measurement of:

Fiber Cable Transmission
Connector/Splice Loss
Absolute Output Intensity of Fibers/Cables
Efficiency of Receivers
Absolute Intensity of Sources

Dual head capability is standard for absolute or ratio measurements. Silicon and germanium sensors are available to accommodate wavelengths from 250 to 2000 nm. Large area detectors are used to ensure total light collection, thereby eliminating alignment problems.

Sensor heads are supplied with a computer generated calibration traceable to NBS. The calibration includes tabular responsivity and a "Cal Factor" which allows the S550 to be internally adjusted to measure all wavelengths, thus eliminating the need to correct data.

2.0 CONTROL/INDICATOR MODULE - 550

The UDT-550 indicator module has been designed with the flexibility and accuracy necessary to meet the most demanding fiber optics measurements. Particular emphasis has been placed on "human-engineering" to allow these measurements to be made with minimal operator skill and training.

The module is constructed of high impact plastic for lighweight and durability for field applications and incorporates a carry handle to aid portability and act as a tilt stand. RFI shielding is used throughout to minimize interference. The 3½ digit LCD display incorporates a low battery indicator, however, the 550 features automatic battery charging when being used and powered from the AC line, thus eliminating down time for external charging. Battery life is typically 100 hours and greater than 14 hours when the IR source is used.

Other features of the 550 include:

Selectable resolution of 0.1 to 0.01 db on LCD display.

Sample hold function with reset which automates comparison measurements such as splice loss.

Digital and analog outputs available at pads on the PC board.

Build in regulated constant current generator for powering the LED fiber source for cable transmission measurements.

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2.1 550 SPECIFICATIONS

Power Ranges

-90dBmw to + 3dbmw
-60dBμw to +33dBμw

Battery Life (time to lo "Bat on" from fully charged batteries)

LED OFF - 50 hours minimum, 100 hours typical
LED ON - 14 hours minimum.

Batteries

Eveready CH15T or equivalent (Nicad) (7)

Charging Time

16 hours; the instrument may be charged indefinately with minimum degradation of battery life. The unit will charge and operate if the charger is connected.

Charger Required

UDT Model 1555 for 100-120 VAC, 50-60 Hz.
UDT Model 1556 for 200-240 VAC, 50-60 Hz.

Operating Temperature

Range 0 to 60°C.

Acurracy

Reference = 1mA (cal set = 1000 counts), at 25°C.
Error (referred to input) 5% of input typical, 10% of input maximum for input range of 1mA to 1nA DC.
Temperature drift (referred to input), typical:

Signal level	1mA	1μA	1nA
	.1%°C	1%/°C	2%/°C

Drift of sample function .03 db/minute typical.
Frequency response, without spurious readings, DC and greater than 100Hz.

Connections

Signal output connections - 2 BNC front panel connectors (center conductor anode).
LED power - miniature phone jack, front panel, 25mADC, tip negative. Battery charger - minature phone jack, rear panel, tip positive. Analog and digital outputs - available internally at 2 x 16 pinout on P.C. board.
Digital - 7 segment parallel LCD comparable.

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Connections (Cont.)

Analog - log signal, log reference, scale factor.

Dimensions

Height x Width x Depth 2.94" (74.6mm) x 8.5" (215.9mm) x 9.25" (235mm).

Weight

Instrument - 40 oz., charger - 9 oz., total unit in case 6.0 lbs.

3.0 SENSOR HEADS

The silicon photodetectors are manufactured in UDT's own laboratories and are specifically selected for high responsivity, low noise, speed, long term stability, uniformity and linearity over a wide dynamic range.

All sensor heads are supplied in black anodized housings with standard BNC connectors for direct coupling to the 550. For remote use of a sensor head, a BNC cable may be used.

MODEL NUMBER	255	256	257	258
Sensor	Silicon	Germanium	Silicon	Silicon
Application	General Purpose	IR Response	Flat from 450-950nm	CIE Response
Active Area (cm^2)	$0.44cm^2$	$0.25cm^2$	$1cm^2$	$1cm^2$
Range (dBm)	-90 to +3	-50 to 0	-90 to +3	-90 to +3
Spectral Calibration	400-1150nm 50nm intervals	800-1800nm 100nm intervals	Radio-Metric	Photo-Metric
UDT set wavelength	900nm	1200nm	900nm	550nm
CAL Accuracy (%)	±6% 400-900nm ±9% 950-1150nm	±12%	±7%	±2%
Linearity	±1%	±2%	±1%	±1%
Reproducibility	±0.5%	±1%	±0.5%	±0.5%

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Rep
Bob -> Bateman Wade Eng Sales
617 6594915

Detector geometries have been chosen to provide complete light collection from fibers/cables while providing minimum noise for measuring the lowest possible light intensities.

4.0 FIBER OPTIC CABLE ADAPTORS

The adaptors which allow interconnection of standard commercially available fiber optic connectors to the detector heads are machined from a single piece of aluminum and then hard black anodized. This assures maximum lifetime in the field and guarantees exclusion of extraneous light.

Model Number	1708	1709	1710	1711	1712
Connector Manufacturer	Amp	Amphenol	Augat	Siecor	(Blank for user modification)

5.0 PREPARATION FOR USE

1724
Hughes #90

5.1 Inspection

The UDT S550 was mechanically and electrically inspected as well as initially calibrated at the factory in Culver City, California. The standard S550 consists of the following equipment:

550 indicator unit
instruction manual
259 LED source
1555 (110 VAC) or 1556 (230 VAC) battery charger
1620 carrying case

Normal accessories, if ordered with the unit, will arrive packaged with the instrument and consist of:

1 or more sensor heads (see Section 3.0)
1 or more cable adaptors (see section 4.0)
Calibration sheet(s) for sensor heads

The standard 550 calibration is direct reading in dBmw or dBμw at 900nm. For changing detector heads or operating at a difference wavelength see section 11. Verify the contents of the box against packing list or purchase order. Inspect contents for damage and report any damage to your UDT representative or the factory. Please retain the carrying case and shipping carton if reshipment is anticipated.

5.2 Batteries

Batteries for the 550 are installed at the factory and have been charged when the unit was calibrated. The unit should arrive charged unless a long storage or shipment time has elapsed since the last recharge. To recharge simply plug charger into wall outlet and 550. If the battery drain has been slight the low battery indicator will disappear in a few minutes. A full charge requires approximately 16 hours.

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5.2 Batteries (Continued)

To replace dead batteries, remove the four screws holding the feet on the 550. Then remove the top cover and replace the 7 batteries with batteries as listed in section 2.1. Note proper polarity before removing old batteries. In an emergency standard penlight cells can be used instead of rechargeable cells. However, the unit should not be used with the charger if there are not batteries inside.

6.0 OPERATING INSTRUCTIONS

6.1 Definition of Terms

Since the optical power levels of interest in fiber optics cover many orders of magnitude the S550 uses the logarithmically compressed decibel scale. Decibel power is defined as:

$$dB = 10 \text{ Log}_{10} \frac{\text{Psignal}}{\text{Preference}}$$

In particular the 550 provides readings in dBu and dBm which are defined respectively as:

$$dB\mu = 10 \log_{10} \frac{\text{Psignal}}{1\mu W}$$

$$dBm = 10 \log_{10} \frac{\text{Psignal}}{1mW}$$

When the 550 is in the single channel mode the optical power is compared to either a 1μW or 1mW internal reference source (depending on whether the dBu or dBm button is pushed). For example, if a reading of 33 is obtained on the dBμ scale then:

$$33 \; dB\mu = 10 \log_{10} \frac{x}{1\mu W}$$

Solving for x:

$$x = 1995\mu W = 1.995 \text{ mW}$$

However, since many fiber optic quantities are specified in decibels, such a conversion is normally unnecessary.

Two points should be emphasized, although they will be obvious to people familiar with decibel measurements:

(1) Decibels are not additive. If decibel readings must be added they must first be converted back to power in mW or μW, added, and then the sum converted to decibels.

(2) Since a decibel is a ratio it must either have a mutually agreed upon reference power (such as 1μW or 1mW) or be understood to represent the power difference between the two signals.

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If the 550 unit has two detector heads connected, and if the log ratio button is depressed, them the unit is in the dual channel mode. In this mode the 550 reading is defined as:

$$dB = 10 \log_{10} \frac{P \text{ (left channel)}}{\text{(right channel)}}$$

If a single head is used with the sample/hold button depressed and with the reading zeroed by the reset button, then the 550 reading is defined as:

$$dB = 10 \log_{10} \frac{P \text{ (reading after reset button pressed)}}{P \text{ (reading before reset button pressed)}}$$

6.2 Power Switches

There are two power switches on the 550, power for the unit itself and LED power for the LED/fiber optic pigtail. With the power off there is no battery drain. With the LED power on and without the LED source connected there is no LED power consumed. However, if both power switches are depressed and if a LED is connected then 25mA is supplied to the LED and battery life between recharges is about 15 hours. Therefore, the LED source should not be on unless it is being used. Normal battery life with the bias power on but no LED power is about 100 hours.

6.3 LCD display

Two special display modes should be noted:

(1) Low battery indication.

(2) Overrange, which is a single "one" digit at the left of the display. When overrange is indicated either change resolution or reference, reduce input power, or change cal factor.

6.4 Mode Selection

In the single channel mode absolute power measurements are obtained with the reference and resolution switches in the desired positions.

In the dual channel mode for measuring relative outputs the resolution switch can be set as desired but the reference switch is disabled when the log ratio button is pushed.

In the sample/hold mode the initial input signal serves as a reference, therefore the reference button is disabled when the sample/hold button is pushed. The resolution can be set as desired.

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6.5 Detector Head Inputs

The various detector heads available for the S550 are listed in section 3.0. Any head can be used remotely by connecting a standard BNC extension cable. Lengths of 30 feet and more are permissible depending upon signal level and noise environment. The center output connector goes to the cathode of the photodiode. The diodes are used photovoltiacally, therefore biasing of the photodiode is not permitted when used with the 550.

6.6 LED Connections

The Model 259 LED source supplied with the S550 contains a Litronix IRL-55 LED that has been modified for coupling to the optical fiber. This LED emits a minimum of 10μW out of the end of the Pifax PIR-40 cable (see Appendix A). The 550 is set to limit the current through the LED to 25mA. However, the user can modify the instrument to couple 50mA into the diode which will almost double the LED output, but at the cost of decreased battery life. The LED power control is described in section 6.2. Different LED wavelengths are available as non-standard specials from UDT.

7.0 APPLICATIONS

7.1 Absolute Intensity Measurements

When it is desired to measure the absolute intensity of a light source or cable, the single channel sensor is used. Front panel push button switches provide dBμW or dBmW ranges with selectable resolutions of 0.1 or 0.01 dB for each range. Intensities may be measured over 8 decades up to 1 milliwatt.

7.2 Splice/Interconnect Loss Measurements

The "Sample Enable" and "Set" buttons are employed when ratio measurements with a single head are desired. With the "Sample Enable" button depressed, the first measurement is made and subsequently stored when the "Set" button is pushed.

7.3 Simultaneous Comparison of Sources or Cables

For simultaneous ratio measurements dual sensor heads are required. With the "Log Ratio" button depressed, the log ratio of the two input signals are displayed.

7.4 Photoreceiver Measurements

To measure the absolute photocurrent of a photoreceiver a light source of known intensity is required. To facilitate this measurement a 900nm IR LED source with fiber pigtail is provided. The absolute output intensity of the LED/fiber is first measured using the "Single Sensor". The test detector replaces the "Single Sensor" by direct plug-in or with a BNC cable and the pigtail output is directed onto the test

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detector. The absolute photocurrent of the test detector is then measured.

7.5 Fiber Cable Transmission Measurements

The recommended procedure for measuring cable loss is by the cable substitution method. By comparing a short test cable with the transmission through a known longer length, the dB/kilometer loss factor can be established.

The entrance and exit cable losses of the test length is measured using the fiber pigtail as a source and the "Single Sensor". The dB output from the longer cable is then measured, and the dB/kilometer loss factor calculated.

8.0 THEORY OF OPERATION

The detector converts optical radiation to electrical current, whose conversion efficiency is described by a responsivity factor (amps per unit of optical power) which is measured for each detector. The electronics calculates the log, or if two detectors are used simultaneously, the log ratio of the short circuit detector current(s) and digitally displays the results (see schematic). The front end of the 550 consists of a dual fet input operational amplifier (AR1) which has a dual transistor (Q1, Q2) in the feedback circuit. The transistors precisely relate collector current to an exponential function of base-emitter voltage. Being in the feedback loop, the output of each section of the front end is a logarithmic function of the input current. The high voltage gain of AR1 maintains the inputs at analog common potential, to best measure the short circuit detector current.

For single channel inputs, the reference is internal and may be adjusted by the front panel calibration adjust potentiometer R20. The wiper of the potentiometer is the reference voltage and is converted to a reference current by R24 or R25. R24 is enabled by pushing the dBm switch S6. Since R25 is three orders of magnitude higher in resistance, the reference current is three orders of magnitude smaller when S5 is pushed. These reference currents are inputted to the reference log amp AR1B and Q2, to produce an output voltage which is proportional to the log of the reference current. The input of AR1B and Q2 may be accessed directly by pushing the log ratio switch S7. The analog to digital converter, 1C1, determines the difference of the outputs of the signal and reference log amps and ratios the difference to a scale factor. The scale factor determines the resolution of the digital display, and is 0.1 dB or 0.01 dB depending on the position of the resolution switch. Potentiometers R13 and R16 calibrate the scale factors of the 0.01 and 0.1 dB resolutions respectively.

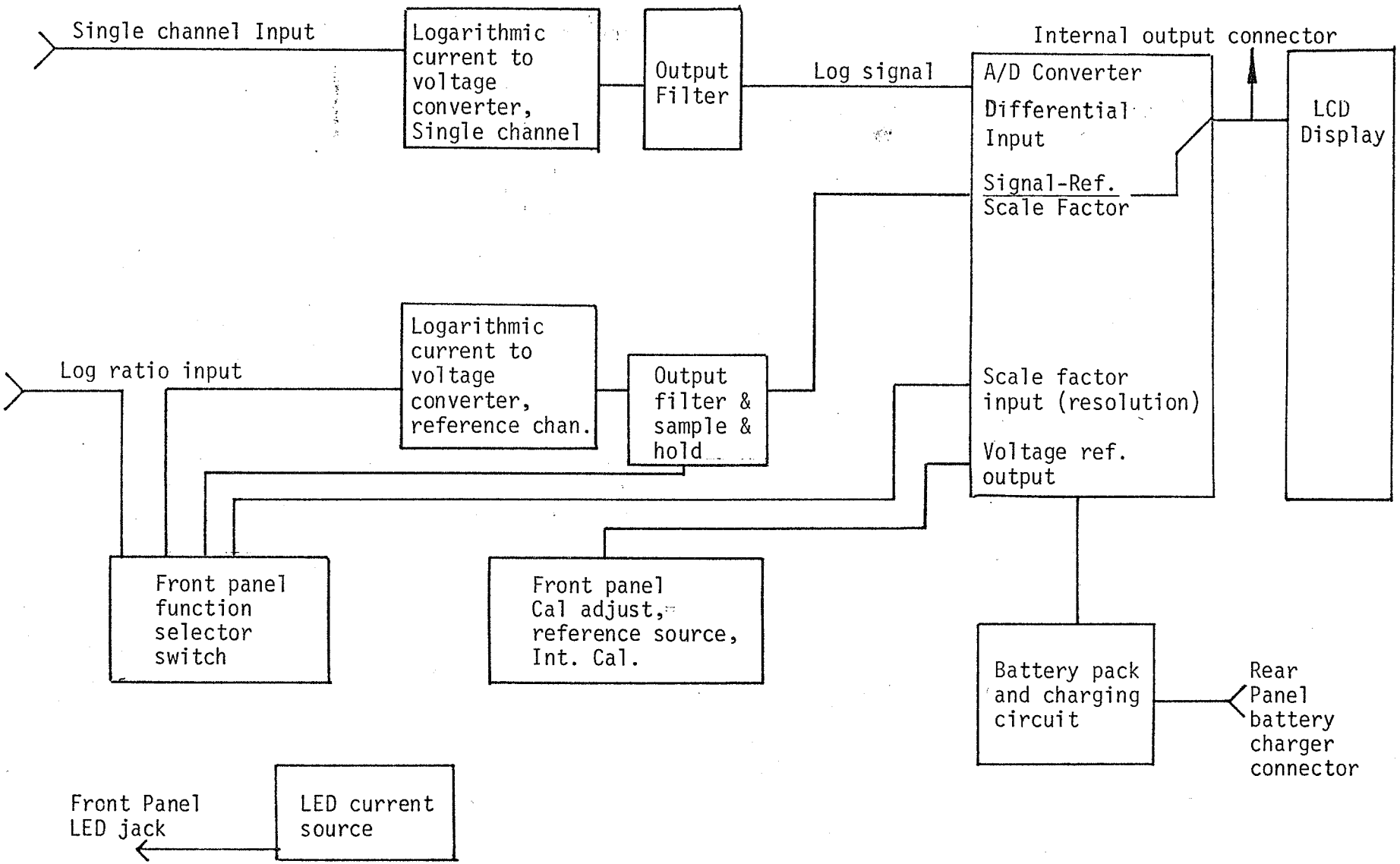
The sample enable switch S8 disconnects the output of the reference amplifier from the A/D converter 1C1. The momentary contact switch, S9, the set switch, stores the present value of the output of the signal channel on capacitor C7. Releasing S9 holds the charge on C7. The 550

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will indicate the log ratio of the signal to the previously stored value of the signal.

Front panel switch S1 connects the front panel LED jack to a 25mA current source, to provide an optical source which may be connected to fibers of the user's choice.

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BLOCK DIAGRAM - MODEL 550

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FRONT PANEL CONTROLS

Panel Label	Schematic Designation	Function
Power, on-off	S2	Instrument power switch
Resolution	S3	Selects 0.1 or 0.01 dB resolution.
Cal	S4	Displays number of counts corresponding to detector responsivity, 1000 counts= 1 A/W; ignore the decimal.
dBμ	S5	Selects μ range at the single channel input.
dBm	S6	Selects m range at the single channel input.
Log ratio	S7	Display is log ratio $10 \log \frac{\text{single channel}}{\text{log ratio channel}}$
Sample enable	S8	Display is log ratio of single channel input to previously stored value of single channel input.
Set	S9	Used with sample enable, stores present value of single channel input.
LED Power	S1	Supplies 25mA DC tp adjacent LED connector.

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9.0 MAINTENANCE

In the following section are procedures for checking and adjusting the MODEL 550.

Item	Recommended Test Equipment
1	Keithley digital microvoltmeter Model 177, 1Vfs, .039% + 1d accuracy, 4½ digit, 1 microvolt ultimate resolution.
2	Keithley DC current source Model 261. 1nA to 0.1mA range, 0.6% accuracy.
3	A stable 10VDC source and 10Kohm 0.1% resistor, as a 1mA current source.
4	DC power supply 0-10VDC or more @ 100 mA or more. Hewlett Packard 6215A or equivalent. (For checking low battery indicator).

Single Channel Accuracy Test (cal set for 1000)

Function	Input Current	Resolution	Display	Max. Error (Least Significant digit).
dBm	1mA	.1	000	±2
	1mA	.01dB	000	±10
	100µA	.1	-10.0	±3
	100µA	.01dB	-10.00	±40
	10µA	.1	-20.0	±3
	1µA	.1	-30.0	±3
	100nA	.1	-40.0	±3
	10nA	.1	-50.0	±3
	1nA	.1	-60.0	±3
dBµ	1mA	.1	+30.0	±3
	100µA	.1	+200	±3
dBµ	10µA	.1	10.0	±3
	10µA	.01	10.00	±10
	1µA	.1	000	±2
	1µA	.01	000	±10
	100nA	.1	-10.0	±3
	100nA	.01	-10.00	±20
	10nA	.1	-20.0	±3
	1nA	.1	-30.0	±3

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After performing the above single channel accuracy test, the lot ratio test may be performed.

Apply 1mA, using the diagramed source, to the normal single channel input. Connect the Keithley current source to the log ratio input. Push the log ratio switch to enable this function. The Keithley may be used as above using the dBa currents.

10.0 ADJUSTMENTS

Following are adjustment procedures which should only be attempted by those knowledgeable in electronic instrumentation. It is preferred to return the instrument to the factory in case of difficulty.

1. The internal cal potentiometer R19 should be checked and adjusted, if necessary, for 1.000 ± 0.005V from the wiper to analog common (at S4), with the dbm button pushed in.

2. Input offset voltage adjust of AR1. Push the cal switch in. Place a short jumper from the output (PIN12, ARIA) to the inverting input (PIN 1, ARIA). Connect the microvoltmeter to the jumper and analog common. Adjust R3 for 0.00 ± 0.01 mVDC on the microvoltmeter. Repeat the above procedure to null AR1B (inverting input is pin 7, output is pin 10).

3. Resolution cal adjust (R13,R16). Check adjustment #1 and adjust the front panel cal display for 1000 counts. Push the dBm switch. Connect the Keithley current to the single ch input source and set it to 1μA. Adjust the R16 for a display of -30.0dbm. Set the Keithley to 100nA. Push the dBu switch and the resolution switch (0.01 dbμ), adjust R13 for a display of -10.00.

4. Low battery indicator threshold. Remove the battery and connect a DC power supply to the battery output connections, making sure to connect the positive DC power supply to positive battery output and the -power supply to the negative battery output. Adjust the output voltage of the power supply to 7.25 ± 0.05 VDC. Check and adjust if necessary, R20 to the threshold of the "low bat" on indicator.

11.0 CALIBRATION

The model 255 and 256 sensor heads contain a label which lists Model number, serial number and cal factor (normally at 900nm). In addition, a calibration sheet is provided similar to that shown below. Note that the cal factor only applies at a specified wavelength for a particular sensor head. If heads are ordered with the 550 the unit will arrive already calibrated at 900nm. All calibrations are NBS traceable.

A unique feature of the 550 is the built-in "Cal Adjust" by which the unit can be field adjusted for directo readout at any wavelength without the need for correction factors. Since this feature is built-in, auxillary test equipment of any kind is not required.

With the front panel cal button pushed, this display is equal to the reference current: e.g. 1000 counts displayed (ignore the decimal point) corresponds to 0 dbm = 1mA, or 0 dbμ = 1μA. The conversion

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effiency of detectors is described by responsivity in amps per watt (A/W) which is the short circuit electrical current produced by irradiating the detector with an optical source of known power and wavelength. Setting the cal adjust to display the cal set factor printed on the calibration sheet references the UDT 550 to display dBm or zero dB_{μ} at the wavelength of calibration. For example, if the detectors response at 850 nm is .421 A/W, the cal set factor is 421 and the instrument should be set to indicate 421, when in the cal position.

If the user does not wish to change the cal set factor but still wishes to accurately determine the power at a wavelength different than 900 nm then the "dB add-on factor" can be used. Simply add this factor to the 550 reading. For example, if the 550 indicates 33 dB when calibrated for 900 nm but when actually measuring light at 800 nm then the true reading is 33 dB+ 0.465 dB = 33.465 dB.

Copies of all calibrations are on file at UDT.

Matched sensor heads which allow very precise channel measurements are available from UDT.

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MODEL255 SERIAL NUMBER 2

UNITED DETECTOR TECHNOLOGY, CULVER CITY, CALIFORNIA 1/15/80

SPECTRAL ANALYSIS DATA:

WAVELENGTH (NM)	RESPONSIVITY (AMPS/WATT)	QUANTUM EFFICIENCY	RELATIVE RESPONSIVITY	CAL SET FACTOR	DB ADD-ON FACTOR
360	0.0280	0.0964	0.0632	28	$$$$$$
400	0.1340	0.4153	0.3025	134	5.193
420	0.1610	0.4753	0.3634	161	4.396
440	0.1730	0.4875	0.3905	173	4.084
460	0.1900	0.5121	0.4289	190	3.677
480	0.2030	0.5244	0.4582	203	3.389
500	0.2130	0.5282	0.4808	213	3.180
520	0.2260	0.5389	0.5102	226	2.923
540	0.2420	0.5556	0.5463	242	2.626
560	0.2550	0.5646	0.5756	255	2.399
580	0.2670	0.5708	0.6027	267	2.199
600	0.2820	0.5827	0.6366	282	1.962
620	0.2960	0.5919	0.6682	296	1.751
640	0.3110	0.6025	0.7020	311	1.536
660	0.3230	0.6068	0.7291	323	1.372
680	0.3360	0.6126	0.7585	336	1.201
700	0.3490	0.6182	0.7878	349	1.036
720	0.3510	0.6044	0.7923	351	1.011
740	0.3700	0.6199	0.8352	370	0.782
760	0.3820	0.6232	0.8623	382	0.643
780	0.3910	0.6215	0.8826	391	0.542
800	0.3980	0.6168	0.8984	398	0.465
850	0.4210	0.6141	0.9503	421	0.221
900	0.4430	0.6103	1.0000	443	0.000
950	0.4130	0.5390	0.9323	413	0.305
1060	0.2370	0.2772	0.5350	237	2.717

SAMPLE CALIBRATION SHEET

FJS

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CALIBRATION REPORT

DETECTOR MODEL 256, SERIAL NUMBER 6170

UNITED DETECTOR TECHNOLOGY, CULVERY CITY CALIFORNIA 3 JUL 80

SPECTRAL RESPONSE DATA:

WAVELENGTH (NM)	RESPOSIVITY (AMPS/WATT)	QUANTUM EFFICIENCY	RELATIVE RESPONSIVITY	CAL SET FACTOR	DB ADD-ON FACTOR
800	0.2800	0.4339	0.3535	280	3.041
825	0.3000	0.4509	0.3788	300	2.742
850	0.3220	0.4697	0.4066	322	2.434
875	0.3400	0.4818	0.4293	340	2.198
900	0.3560	0.4904	0.4495	356	1.998
925	0.3730	0.5000	0.4710	373	1.796
950	0.3940	0.5142	0.4975	394	1.558
975	0.4130	0.5252	0.5215	413	1.353
1000	0.4310	0.5344	0.5442	431	1.168
1025	0.4480	0.5419	0.5657	448	1.000
1050	0.4650	0.5491	0.5871	465	0.838
1075	0.4820	0.5559	0.6086	482	0.682
1100	0.4980	0.5613	0.6288	498	0.540
1125	0.5160	0.5687	0.6515	516	0.386
1150	0.5330	0.5746	0.6730	533	0.246
1175	0.5460	0.5761	0.6894	546	0.141
1200	0.5640	0.5827	0.7121	564	0.000
1225	0.5830	0.5901	0.7361	583	-0.144
1250	0.6060	0.6011	0.7652	606	-0.312
1275	0.6190	0.6019	0.7816	619	-0.404
1300	0.6330	0.6037	0.7992	633	-0.501
1325	0.6480	0.6064	0.8182	648	-0.603
1350	0.6590	0.6052	0.8321	659	-0.676
1375	0.6840	0.6168	0.8636	684	-0.838
1400	0.6980	0.6182	0.8813	698	-0.926
1425	0.7100	0.6177	0.8965	710	-1.000
1450	0.7320	0.6259	0.9242	732	-1.132
1475	0.7510	0.6313	0.9482	751	-1.244
1500	0.7660	0.6332	0.9672	766	-1.329
1525	0.7920	0.6439	1.0000	792	-1.474
1550	0.7730	0.6183	0.9760	773	-1.369
1575	0.6960	0.5479	0.8788	696	-0.913
1600	0.6260	0.4851	0.7904	626	-0.453
1625	0.5660	0.4318	0.7146	566	-0.015
1650	0.5170	0.3885	0.6528	517	0.378
1675	0.4720	0.3494	0.5960	472	0.773
1700	0.4270	0.3114	0.5391	427	1.209
1725	0.3910	0.2810	0.4937	391	1.591
1750	0.3430	0.2430	0.4331	343	2.160
1775	0.2970	0.2075	0.3750	297	2.785
1800	0.2360	0.1626	0.2980	236	3.784

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APPENDIX 'A'

Pifax Data Sheets

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PIFAX FACTS

trademark

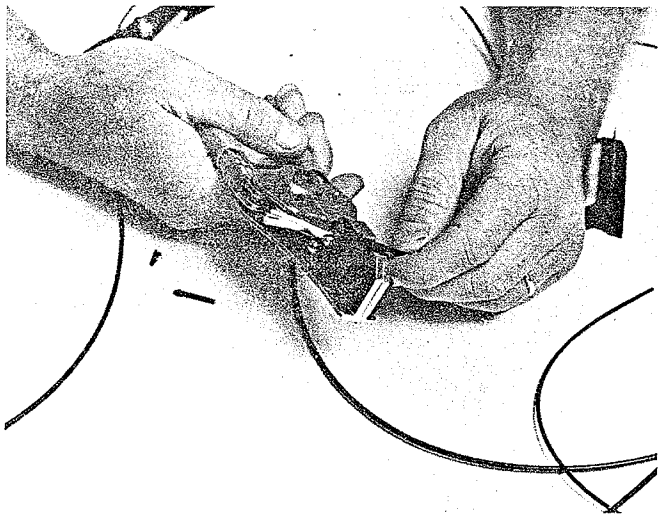
fiber optic cable

NEW CONNECTORING PROCEDURE

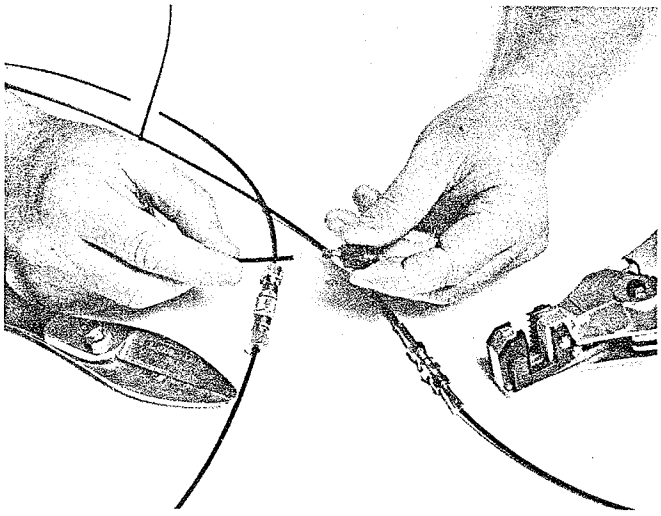
An improved connectoring procedure has been developed for our PIFAX* fiber optic cables. A modification of the standard procedure will increase the area of adhesion between optical-fiber and connector-ferrule. This prevents fiber motion and subsequent damage.

During actual use, a connectored fiber will experience large tensile forces. These forces will come from several origins, such as the main cable being bent, pulled, or thermally stressed. A sufficiently high force can cause a fiber to move with respect to the connector-ferrule. Modifications (steps 2 and 3) of the standard connectoring procedure prevent motion of the fiber subjected to forces:

1. a) Strip off 3 cm of outside jacket (black) and any underlying insulation.
   b) Cut back KEVLAR® aramid fiber to 0.5 cm.



2. Completely fill the connector ferrule with epoxy.



*Du Pont Trademark

DU PONT

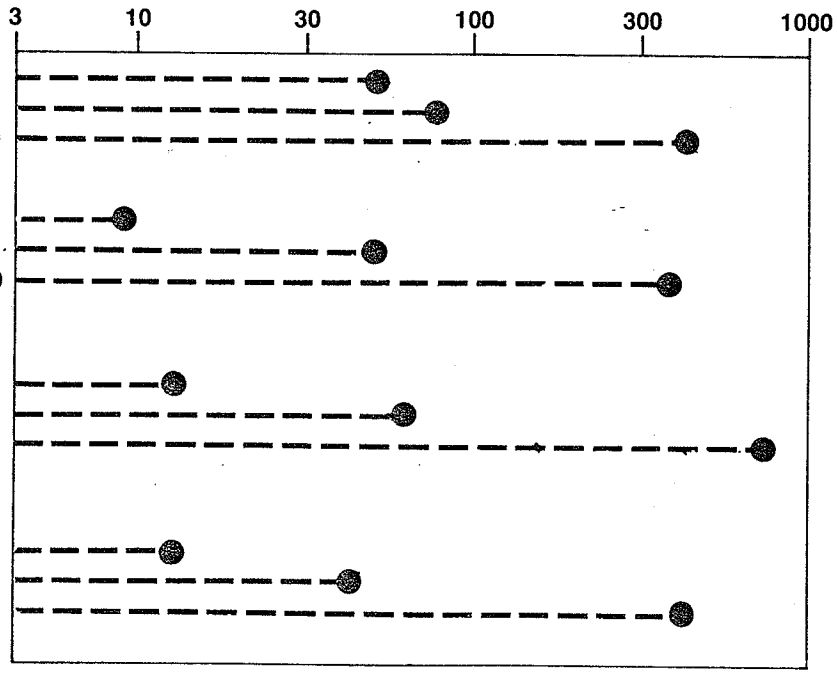
(see over)

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DATA LINKS

You now have an extensive selection of data links to choose from that are compatible with PIFAX* fiber optic cable. To give you a guide on how our cables will perform with these links, we have listed below a small sampling. Next to each data link we have calculated an approximate maximum run length capability for our fiber optic cables. You will notice we have included both of our all-plastic cables for rugged environments, such as the office (P-140 and PIR-140). And for longer run length requirements, where an easily connectorable cable is needed, we have included S-120 type 30. Since this chart is only a guide, you will need to test the data link system out thoroughly for your particular combination of data rates, connector selections, cable configurations, etc. to evaluate its suitability.

			Approximate Maximum Run Length (meters)
			3 10 30 100 300 1000
Burr-Brown Tucson, AZ	3713 series 660 nm 250 kb/s 10^{-9} BER	P-140 PIR-140 S-120 type 30	
RCA Lancaster, PA	C86005 820 nm 20 Mb/s 10^{-9} BER	P-140 PIR-140 S-120 type 30	
Spectronics Richardson, TX	SPX4140 +4141 820 nm 10 Mb/s 10^{-8} BER	P-140 PIR-140 S-120 type 30	
Texas Instruments Dallas, TX	SN74LS462 SN74LS463 790 nm 1 Mb/s serial multiplexed from 100 kb/s	P-140 PIR-140 S-120 type 30	



Whenever you need technical help with PIFAX fiber optic cables, please give us a call.

Ron Ferguson (East)
Jay Uradnisheck (West)
Du Pont Company
Polymer Products Dept.
Wilmington, DE 19898
(302) 774-7850
(302) 774-6339

*Du Pont Trademark

1/80

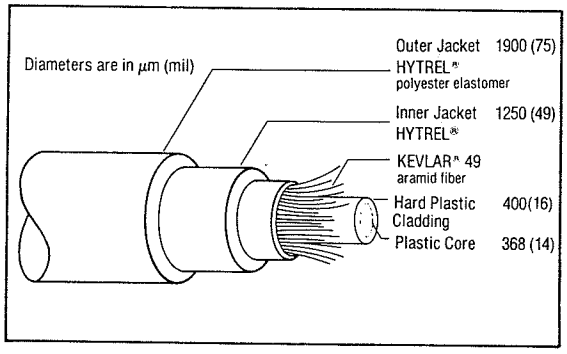
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PIFAX* PIR-140

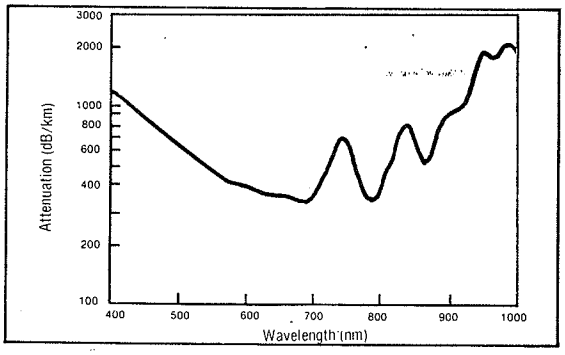
fiber optic cable

PIFAX* PIR-140 fiber optic cable is a single channel, multimode, step-index, plastic-core cable. The optical window at 790 nm allows use of high power GaAlAs LEDs. The visible optical window is lower and broader for longer run lengths, using GaAsP LEDs, compared to our standard plastic fiber optic cable. The large active diameter and large numerical aperture of the fiber provide easy and efficient coupling even with inexpensive connectors. Plastic core cables are the most rugged available. The jacketing material contains flame retardant additives.

NOMINAL PHYSICAL DIMENSIONS



MAXIMUM SPECTRAL ATTENUATION†



PRODUCT CHARACTERISTICS

DESCRIPTION	TYPICAL	MAXIMUM	UNITS	TEST CONDITIONS	NOTES
Attenuation	250	320	dB/km	690 nm	1
Attenuation	270		dB/km	790 nm	1
Numerical Aperture	0.53			material	
Numerical Aperture	0.42			10% intensity	1
Core Refractive Index	1.48				
Risetime (10-90%)	5-6		ns/0.1 km		
Core Concentricity	4		%	based on core diameter	
Core Diameter	368		μm		
Fiber Diameter	400		μm		
Outer Jacket Diameter	1900		μm		
Bend Radius	1.0		mm		2
Cable Break Strength	25		kg		
Cable Weight	4.0		kg/km		

Notes:

1. Steady state value; using monochromator (± 2 nm).
2. Short term bend radius limited only by radius of cable.

*Du Pont's Trademark

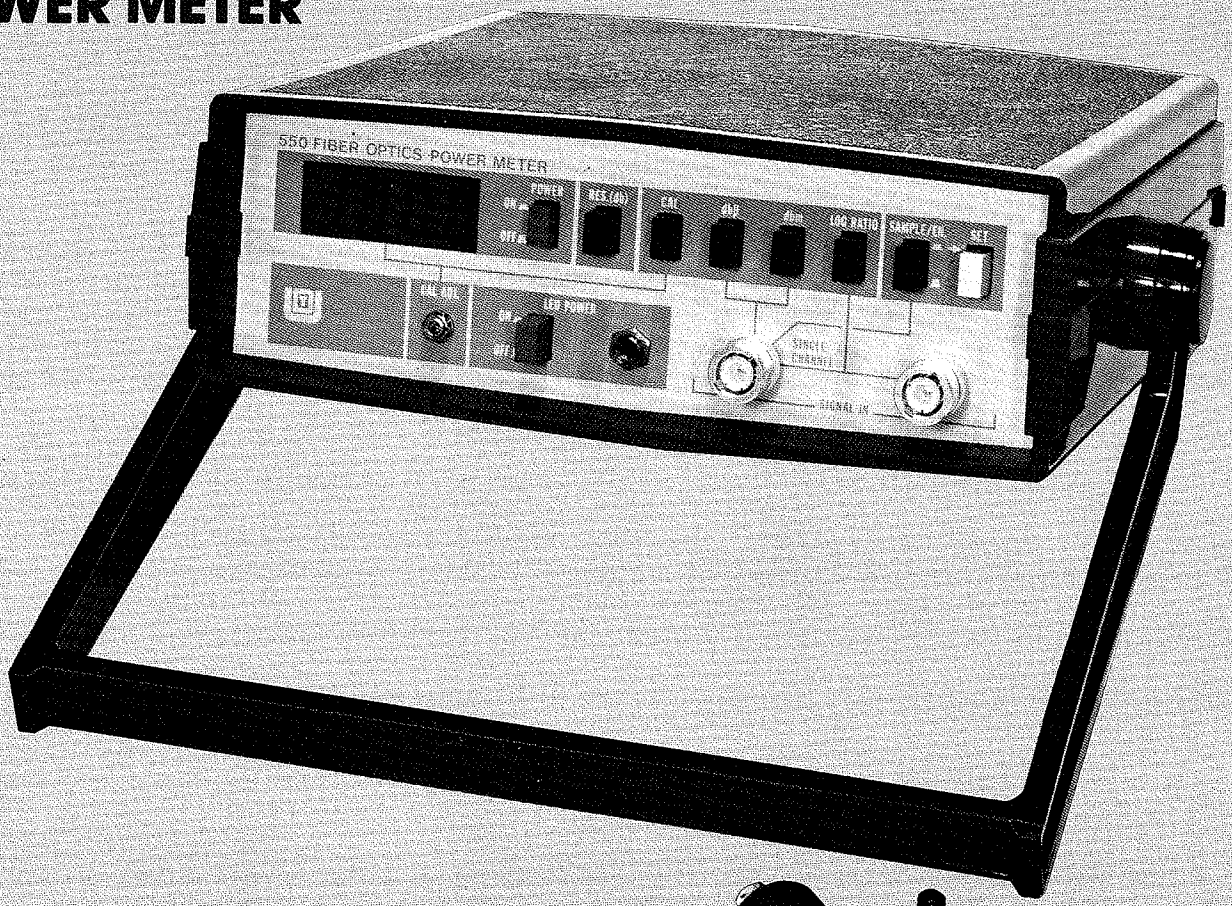
†Curve shown is typical steady-state attenuation of sample at maximum shipping limit of 320 dB/km at 690nm using a monochromator at ambient conditions.

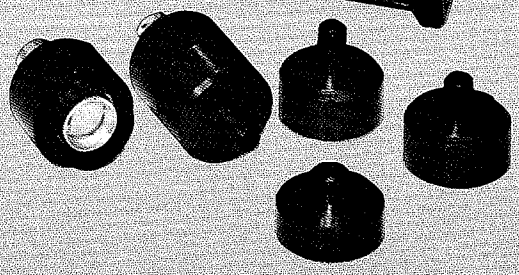
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OUR SECOND DECADE OF LEADERSHIP

UDT S550

FIBER OPTICS POWER METER





Features:

- Direct readout in dBμW or dBmW (–90 to +3 dBm)
- Measurement range of 250 to 2000 nanometers
- Selectable resolution of 0.1 or 0.01 dB
- Absolute or ratio measurements
- Computer generated calibration traceable to NBS
- Unique internal responsivity adjustment
- Battery life of 100 hours

UNITED DETECTOR TECHNOLOGY

Data Sheet 9K-009

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APPENDIX 'B'

Warranty

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

United Detector Technology
3939 Landmark St., Culver City, CA 90230 • (213) 204-2250

WARRANTY RETURN PROCEDURE

FOR USE BY CUSTOMER

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 and hours of operation. Adjustment cannot be made for product out of warranty.

2. If product is subject to warranty, prior to return of product, telephone, write, or wire UDT as noted below for instructions:

United Detector Technology
3939 Landmark St., Culver City, Ca. 90230 USA • Phone (213) 204-2250
Telex Number 18-2458 • Cable Address: SILDETECT, Culver City, California

Product malfunctions should be reported to Customer Service 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. In the event any seals are broken warranty is void.

3. It is necessary in all instances that the "Malfunction Report" form be completed. Please give all the data requested and describe fully what occured at the time of failure, carefully noting the operating conditions and total time the product was in use.

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 "Malfunction Report" with the product. Ship product prepaid to UDT.

5. UDT will advise your company of its findings as to warranty consideration at the earliest possible time. The prompt providing of all information requested above will be appreciated in order to expedite this procedure.

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United Detector Technology
3939 Landmark St., Culver City, CA 90230 • (213) 204-2250

MALFUNCTION REPORT

Please read Warranty Return Procedure before completing this form, (please print or type).

COMPANY NAME_____
ADDRESS_____
CITY, STATE, ZIP_____
TELEPHONE NUMBER_____
INSTRUMENT OPERATOR_____
POSITION_____ PURCHASE ORDER_____
INVOICE NUMBER_____

INSTRUMENT MODEL NUMBER_____
INSTRUMENT SERIAL NUMBER_____
DETECTOR SERIAL NUMBER_____

1. Describe malfunction:_____
2. Total number of operating hours:_____
3. Describe environmental condition instrument was subjected to, i.e. altitude, vibration, shock, high or low temperature, etc.:_____
4. At what power level was the detector operated?_____
5. Application: Laboratory experiment_____ Breadboard_____ Prototype_____ Production_____ Equipment_____
6. If instrument failed catastrophically, note:
   Indication of electrical failure_____
   Indication of mechanical failure_____
7. List any components other than the detector which malfunctioned prior to or simultaneously with the instrument:_____
8. Describe previous servicing of instrument:_____
9. Other comments:_____

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United Detector Technology
3939 Landmark St., Culver City, CA 90230 • (213) 204-2250

NOTE: IF THIS DEVICE HAS WARRANTY AND CALIBRATION SEALS, ALL WARRANTIES AND CALIBRATIONS ARE VOID IF THESE SEALS ARE BROKEN.

PRODUCT WARRANTY

United Detector Technology warrants the items delivered hereunder to be free from defects in material and workmanship, and to conform to current UDT 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 for correction. Materiel will be considered accepted 30 days after receipt by purchaser unless UDT is notified of acceptance earlier.

UDT agrees to repair or replace at the place of manufacture, without charge, all items returned, transportation prepaid, for inspection at UDT's factory within the warranty period, provided that: (1) such inspection discloses to the satisfaction of UDT 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.

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 warranty is expressly in lieu of all other warranties, expressed, implied or statutory, and all other obligations or liabilities on the part of UDT. In no event shall UDT be liable for claims, demands or damages of any nature, however denominated, except that UDT's 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'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 payment terms are Net 30 days. Shipment will be made FOB

TOOLING

All tooling used in performance of this order, whether acquired by UDT for the purpose of fulfilling this order or not, shall be the sole property of UDT.

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APPENDIX C

Bill of Materials

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

UNITED DETECTOR TECHNOLOGY, INC.

BILL OF MATERIALS

DOCUMENT NO. 22-00-072

REV D

PART NAME FIBER OPTICS POWER METER ASSY, MODEL 550

LOT NO.

LOT QTY.

QUALITY CODE

SHEET 2 OF 4

APPROVALS

Gonzalez 2-5-80

Jack Sanders 2-8-80

MWO

KITTED BY DATE

ITEM NO.	QTY	CKT REF	VENDOR PART NO.	DWG SIZE	UDT PART NO.	DESCRIPTION	PROD. CONTROL QTY	PROD. CONTROL B/ORDER
REF	-			D	22-00-072	FIBER OPTICS PWR METER ASSY, MOD. 550		
1	1		CH250	A	69-08-004	CASE ASSY, RFI SHIELDED (COLOR #022 BROWN - PACTEC)		
2	1			C	68-41-244	FRONT PANEL		
3	1			B	77-20-066	CLAMP, LCD		
4	1			B	68-41-243	REAR PANEL		
5	1			D	68-21-311	P.C. BOARD ASSEMBLY		
6	1		43P203		57-01-028	POTENTIOMETER, 20K (SPECTROL)		
7	1		SERIES PB1		68-01-603	SWITCH, PP, NON-LIGHTED WITH MTG. EARS (CENTRALAB)		
8	1		B-305 RD		68-71-302	BUTTON (RED) (CENTRALAB)		
9	2		41 JAX		68-11-321	PHONE JACK, MINIATURE (SWITCHCRAFT)		
10	2		KC79-58		68-11-108	CONN., RECEPTACLE - BNC (KINGS ELECT)		

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

PART NAME	BILL OF MATERIALS	SHT.	DOCUMENT NO.	REV
FIBER OPTICS POWER METER ASSY., MODEL 550		3 OF 4	22-00-072	D

ITEM NO.	QTY	CKT REF	VENDOR PART NO.	DWG SIZE	UDT PART NO.	DESCRIPTION	PROD. CONTROL QTY	PROD. CONTROL B/ORDER
11	1							
12	1			B	77-55-001	BRACKET, SWITCH MOUNTING		
13	1			A	68-51-154	LABEL, BATTERY CHARGER		
14	2				80-15-039	SCREW PH. PAN HD, #4 SELF TAPPING 3/16" LONG		
15	2				80-15-034	" " " ", 4-40 x 3/16 LG (")		
16	4					" , SELF TAPPING #6 (PHILLIPS HD 3/8" LONG)		
17	4					" , PH. PAN HD, 6-32 x 2 1/2 LG (SUPPLIED W/CASE)		
18	2							
19	2				81-20-003	WASHER, FLAT #4		
20	2							
21	1			B	68-51-201	LABEL, IDENTIFICATION		
22	2				PROD. STOCK	WASHER, MYLAR, .251 I.D. ; .375 O.D.		
23	1				PROD. STOCK	TUBING, HEAT SHRINK., 1/4 DIA x 3/32" L		

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PART NAME	BILL OF MATERIALS	SHT.	DOCUMENT NO.	REV
FIBER OPTICS POWER METER ASSY, MODEL 550		4 OF 4	22-00-072	D

ITEM NO.	QTY	CKT REF	VENDOR PART NO.	DWG SIZE	UDT PART NO.	DESCRIPTION	PROD. CONTROL QTY	PROD. CONTROL B/ORDER
24	7		EVEREADY CH500H		23-05-007	BATTERY, 1.2 VOLTS, AA NICAD		
25	1	R28	ALLEN BRADLEY EB-151-5		55-52-115	RESISTOR, CARBON, 150Ω, 1/2W, 5%		
				C		REFERENCE DOCUMENTS		
REF				C	69-00-010	ARTWORK, FRONT PANEL SILKSCREEN		
"				A	69-00-007	ARTWORK, LABEL (BATT. CHG).		
"				B	69-00-011	ARTWORK, LABEL, IDENT.		
"				A	51-0503	PRODUCTION TEST PROCEDURE		
"				D	69-01-002	SCHEMATIC DIAGRAM		
"				C	69-02-002	WIRING DIAGRAM		

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UNITED DETECTOR TECHNOLOGY, INC.

BILL OF MATERIALS

DOCUMENT NO. 68-21-311

REV E

PART NAME: P.C. BOARD ASSEMBLY MODEL 550

LOT NO.

LOT QTY.

QUALITY CODE

SHEET 2 OF 6

MWO

KITTED BY

DATE

APPROVALS	DATE
D. Monicalez	2-6-80
Donna M. Ho	2-8-80
Jack Saunders	2-8-80

ITEM NO.	QTY	CKT REF	VENDOR PART NO.	DWG SIZE	UDT PART NO.	DESCRIPTION	PROD. CONTROL QTY	PROD. CONTROL B/ORDER
REF	-			D	68-21-311	P.C. BOARD ASSY, MODEL 550		
1	1			D	68-21-123	P.C. BOARD		
2	1			B	68-01-604	SWITCH ASSY, NON-LIGHTED, SERIES PB15		
3	1		KEYSTONE 182		68-61-109	BATTERY HOLDER, 4 CELL		
4	1		KEYSTONE 171		68-61-110	BATTERY HOLDER, 3 CELL		
5	2			B	75-21-012	FLAT RIBBON CABLE ASSY		
6	4		PCS-093		77-55-007	SPACER, STAND-OFF (CENTRALAB)		
7	2	R2, R6	RN55D 2492F		55-10-324	RESISTOR, METAL FILM, 24.9K, 1/8W, 1%		
8	2	R1, R5	CB-222-5		55-42-222	RESISTOR, CARBON, 2.2K, 1/4W, 5% ALLEN-BRADLEY		
9	1	R18	RN55D 2213F		55-22-422	" , METAL FILM, 221K, 1/4W, 1%		
10	2	R4, R8	RN55D 1002F		55-10-310	" , " " , 10K, 1/4W, 1%		

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PART NAME	BILL OF MATERIALS	SHT.	DOCUMENT NO.	REV
P.C. BOARD ASSY, MODEL 550		3 OF 6	68-21-311	E

ITEM NO.	QTY	CKT REF	VENDOR PART NO.	DWG SIZE	UDT PART NO.	DESCRIPTION	PROD. CONTROL QTY	PROD. CONTROL B/ORDER
11	1	R9	RCR07G		55-42-147	RESISTOR, CARBON, 470Ω, 1/4W, 5%		
12	1	R10	EB-181-5		55-52-118	" 180Ω, 1/2W, 5% (ALLEN-BRADLEY)		
13	1	R11	RN55D 49R9F		55-22-049	, METAL FILM, 49.9Ω, 1/4W, 1%		
14	1	R12	RN55D 4022F		55-22-340	, " " , 40.2K, 1/4W, 1%		
15	1	R14	Q81N		55-99-010	, TEMP. COMP., 1K (TEL LABS)		
16	1	R15	RN55D 2801F		55-22-228	, METAL FILM, 2.80K, 1/4W, 1%		
17	1	R17	RN55D 1003F		55-10-410	, " " , 100K, 1/4W, 1%		
18	3	R21, 22, 23	RCR07G		55-42-510	, CARBON, 1MEGΩ, 1/4W, 5%		
19	1	R24			55-12-210	, WW, 1K, 1/4W, .025%		
20	1	R25			55-12-510	, WW, 1M, 1/4W, .025%		
21	1	R27	RCR07G		55-42-210	, CARBON, 1.0K, 1/4W, 5% (ALLEN BRADLEY)		
22						"		
23	1	R29	RN55D 1501F		55-22-215	RESISTOR, METAL FILM, 1.5K, 1/4W, 1%		

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PART NAME	BILL OF MATERIALS	SHT.	DOCUMENT NO.	REV
P.C. BOARD ASSY, MODEL 550		4 OF 6	68-21-311	E

ITEM NO.	QTY	CKT REF	VENDOR PART NO.	DWG SIZE	UDT PART NO.	DESCRIPTION	PROD. CONTROL QTY	PROD. CONTROL B/ORDER
24	3	R3,R7,R13	43P103		57-01-005	POTENTIOMETER, 10K, 20T, 10% (SPECTROL)		
25	1	R16	43P202		57-01-038	" , 2K, 20T (SPECTROL)		
26	1	R19	43P104		57-01-023	" , 100K, 20T, 5% (SPECTROL)		
27	1	R20	63M105		57-01-037	POTENTIOMETER, 1M, 1T (SPECTROL)		
28	8				PROD STOCK	SCREW, PHILLIPS PAN HEAD, 4-40 x 3/8" LONG, CAD PLATED		
29	8				"	WASHER, LOCK, #4		
30	2	C1, C2			56-07-310	CAPACITOR, .01μF, 100V, 10%		
31	4	C3, C4, C6, C9			56-09-410	" , CERAMIC DISC, .1μF, 25VDC		
32	1	C5			56-11-110	" , CERAMIC, 100 pF, 100 VDC, 10%		
33	2	C7, C8	32MPC-5004-K-05		56-07-550	" , POLYCARB., 5μF 50 VDC, 10% (WESCO)		
34	1	C10			56-07-422	" , .22μF, 135 VDC, 10%		
35	1	C11			56-12-150	CAPACITOR, CERAMIC, 500 pF, 1200 VDC, 20%		
36	8				81-10-002	NUT, HEX, #4		

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PART NAME	BILL OF MATERIALS	SHT.	DOCUMENT NO.	REV
P.C. BOARD ASSY, MODEL 550		5 OF 6	68-21-311	E

ITEM NO.	QTY	CKT REF	VENDOR PART NO.	DWG SIZE	UDT PART NO.	DESCRIPTION	PROD. CONTROL QTY	PROD. CONTROL B/ORDER
37	2	CR1, CR2	FD333 OR FD300		57-21-319	DIODE, (FAIRCHILD)		
38	1	CR3	IN4001		57-21-317	DIODE		
39	1	VR1	LM317T		57-21-226	VOLTAGE REGULATOR (MOTOROLA)		
40	1	LCD1	MODEL FED0203E		77-55-002	DISPLAY, LIQUID CRYSTAL (AND)		
41	1	Q1	MAT-01-AH		57-21-416	TRANSISTOR, NPN (PRECISION MONOLITHICS)		
42	1		703-4014-01-04-12		68-91-002	IC SOCKET, 14 PIN DUAL-IN-LINE (CAMBION OR TEXAS INST. C821404)		
43	1	IC1	ICL7106 CPL		57-21-707	A/D CONVERTER (INTERSIL)		
44	1	IC2	CD4070BE		57-21-229	QUAD EXCLUSIVE OR GATE, CMOS (RCA)		
45	1	AR1	CA3240 AE-1		57-21-608	OP AMP, DUAL (RCA)		
46	1		C854001		57-11-001	SOCKET, 40 PIN (TEXAS INSTR.)		
						REFERENCE DOCUMENTS		
REF				D	69-01-002	SCHEMATIC DIAGRAM		
REF				C	69-02-002	WIRING DIAGRAM		

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PART NAME	BILL OF MATERIALS		DOCUMENT NO.	REV
P.C. BOARD ASSEMBLY MODEL 550		SHT. 6 OF 6	68-21-311	E

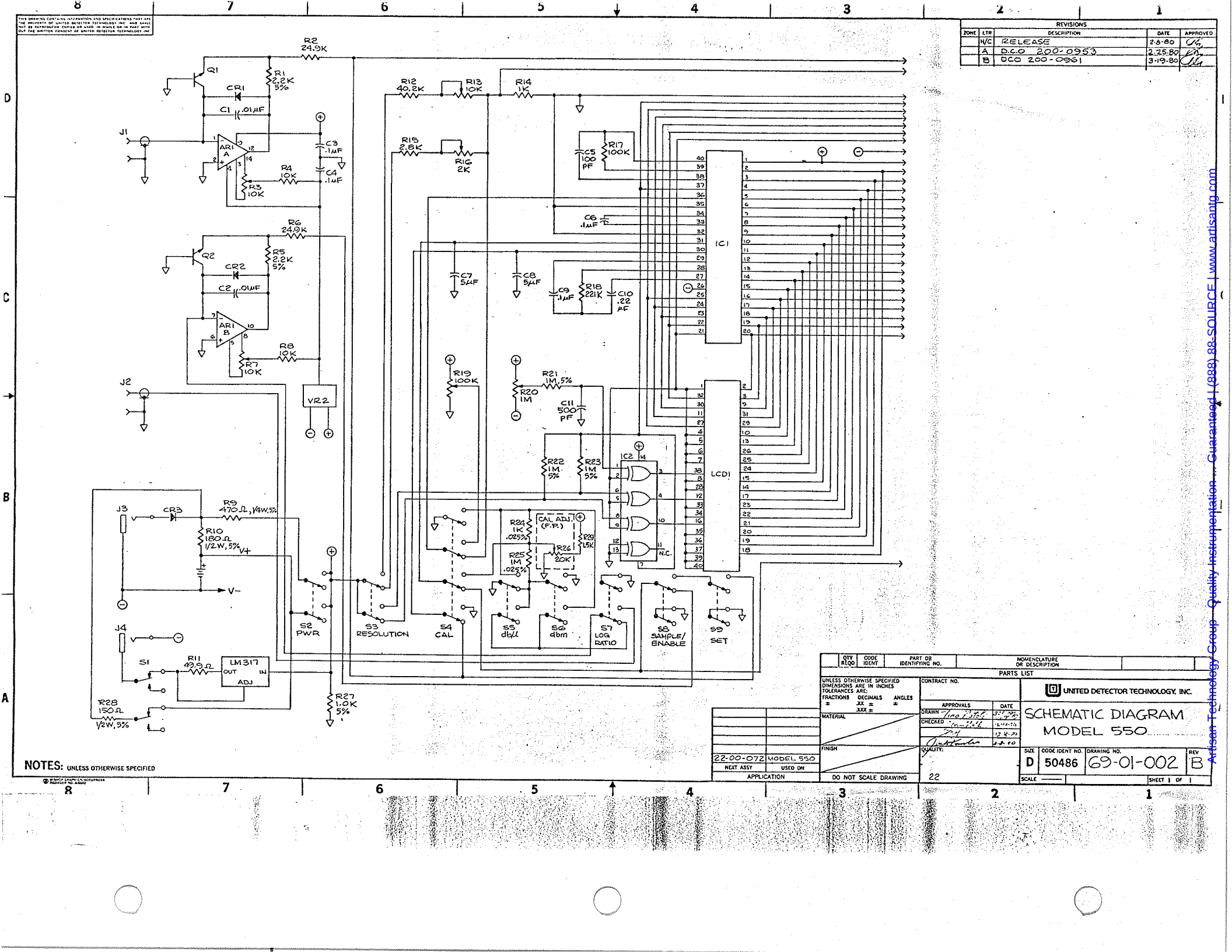
ITEM NO.	QTY	CKT REF	VENDOR PART NO.	DWG SIZE	UDT PART NO.	DESCRIPTION	PROD. CONTROL	
							QTY	B/ORDER
REF				D	69-00-009	ARTWORK, P.C. BOARD		

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APPENDIX D

Schematic

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REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	N/C	RELEASE	2-8-80	
	A	D.C.O 200-0953	2-25-80	
	B	DCO 200-0961	3-19-80	

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

MATERIAL

FINISH

22-00-072	MODEL 550
NEXT ASSY	USED ON
APPLICATION	DO NOT SCALE DRAWING

CONTRACT NO.

APPROVALS	DATE
DRAWN	2-7-80
CHECKED	2-11-80
	12-8-79
	2-8-80
QUALITY	

22

UNITED DETECTOR TECHNOLOGY, INC.

SCHEMATIC DIAGRAM
MODEL 550

SIZE	CODE IDENT NO.	DRAWING NO.	REV
D	50486	69-01-002	B

SCALE —— SHEET 1 OF 1

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USING THE 257 & 258 DETECTOR HEADS WITH THE S550

The 257 and 258 detector heads use the standard UDT 1 cm^2 instrument rated detectors. The only difference between these detector heads and standard UDT radiometer heads is that in the 257 and 258 the center conductor on the BNC jack is the photodiode anode.

The calibration sticker on the side of the 257 heads records the calibration in mA/W. When used with the S550 this three digit calibration number should be set on the cal set pot (see section 11.0). The S550 will then read in dBmW or dBμW over the entire 450-950nm spectral range (with the radiometric filter attached to the 257 head).

The calibration sticker on the side of the 258 head records the calibration in mA/MFC (i.e., milliamps per mega footcandle). This rather ungainly unit is necessary to make sense of the S550 readings. When this three digit calibration number is entered on the S550 cal pot (see section 11.0) and with the photometric filter on the detector, the S550 rads in dBμ(MFC) (i.e., dB footcandles) and dBm(MFC) (i.e., dB kilo-footcandles).

For Example:

(i) Cal number = XYZ mA/MFC

(ii) Enter XYZ on cal set pot.

(iii) When dBμ button is depressed reading is in dB footcandles (i.e., dBμ(MFC) = dB x 10^{-6} x 10^{6} FC = dB footcandles.)

(iv) When dBm button is depressed reading is in dB kilofootcandles (i.e., dBm (MFC) = dB x 10^{-3} x 10^{6} FC = dB 10^{+3} FC = dB kilofootcandles.)

(v) For instance:

12 dBμ MFC = 12 dB footcandles = 15.8 footcandles

or

33 dBμ MFC = 1995 footcandles = 1.995 kilofootcandles = 3 dBm MFC.

For conversion to Lux

10.76 Lux = 1 foot

or

$$\left[\frac{\text{(Cal factor in footcandles)}}{\text{XYZ mA/MFC}}\right] \times .093 \ \frac{\text{FC}}{\text{Lux}} =$$

0.93 XYZ mA/MLux = .93 XYZ mA/10^{5}Lux

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APPENDIX 'E' Detector Heads

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APPENDIX 'F' User's Guide

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USERS GUIDE TO UDT RADIOMETERS/PHOTOMETERS

1.0 Introduction

The purpose of this guide is to describe the most common applications and how typical measurements should be performed.

UDT radiometers and photometers are extremely versatile instruments and have been human engineered for ease of use. The instruments use $1cm^2$ silicon planar diffused detectors which are extremely rugged and stable. This stability permits calibrations to be held for very long periods of time and permits very low noise, sensitive, linear and accurate measurements to be routinely performed. UDT instrument detectors are sensitive from 300 to 1100 nm (200 nm-1100 nm with quartz window), can measure power typically from pico-watts (10^{-12} watts) to milliwatts (10^{-3} watts) and even to many watts with the appropriate accessories.

For the fundamentals of light measurement the user should consult "Radiometry and Photometry: Once over lightly" written by the UDT staff. For features of individual instruments consult the UDT data sheet for that particular instrument.

1.1 Calibrations

When using any UDT instrument always refer to the detector/instrument calibration sheet or calibration module. This tells precisely how the particular instrument was calibrated, the units, the channels used, as well as any multiplication factors. This calibration sheet is fundamental to the proper use of the instrument.

Almost all general purpose UDT radiometers/photometers measure radiant power and energy, illuminance, luminance, and integrated illuminace. In addition all UDT radiometers and photometers have multichannel capability with at least one undedicated channel which can be specified at the time of purchase or re-calibration to be calibrated in whatever units the user wishes. In addition to the calibrations listed on the specific UDT instrument data sheets almost any meaningful instrument calibration can be performed by the UDT Optical Metrology Department.

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1.2 Standard Detector Filters

The radiometric filter supplied with most instruments corrects the intrinsic silicon responsivity shown in Figure 1 to a spectrally flat response from 450 µm to 950 µm as shown in figure 2. This filter, in combination with the UDT instrument detector, permits radiometric (i.e. true thermal power) measurements of either narrowband or wide-band sources, so long as the emitted wavelength is within the flat response range.

The photometric filter supplied with most instruments corrects the silicon curve of figure 1 to the CIE photometric response of figure 3. This filter in combination with the UDT instrument detector permits photometric measurements of light (i.e. measurments of the human visual response to light sources).

1.3 Accessories

All general purpose UDT radiometers and photometers use common detectors and accessories. This enables the user to choose from a very wide range of specialized accessories. These include special narrowband filters to isolate parts of the spectrum, color temperature filter sets to measure the blackbody temperature of incandescent sources, red photometric filters to precisely match the red response of the human eye, fiber optic probes reflex viewing modules to convert the radiometer into a teleradiometer or microradiometer and many other accessories.

In addition special head assemblies are available which allow the user to measure ultraviolet light precisely, as well as heads for measuring Helium-Neon laser compliance and light emitting diode output.

The UDT optional accessories brochure describes the complete range of accessories.

2.0 ILLUMINANCE MEASUREMENTS

2.1 Purpose

To measure the illuminance of a source or sources such as the illumination level in an office or factory.

2.2 Equipment

A - radiometer/photometer
B - detector and cable
C - Photometric filter (model 111)
D - diffuser (model 112)

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2.3 Procedure

1) Connect the radiometer/photometer to the detector using the cable supplied.

2) Screw the photometric filter onto the detector housing and then screw the diffuser onto the filter.

3) Position the head as desired to make the measurement. The conventional measurement of illumination is done with the head positioned at the work plane pointing vertically upwards. (See figure 4).

4) Make sure that the measurement is not affected by shadows from the operator or any other obstacles. The diffuser "sees" objects up to 90° away from the aiming direction.

5) Refer to the calibration sheet or module for the particular instrument/detector combination in use. This will indicate which channel should be used, what multiplication factors are applicable, and what attachments or other conditions apply. (Normally illuminace measurements are made with a diffuser, however sometimes illuminance measurements are done without the diffuser when high sensitivity is required and when the source is within the detector field-of-view).

6) Follow the zeroing procedure outlined in the operating section of the manual.

7) Adjust the range switch until a non-full scale reading is obtained. When measuring time varying sources it is advisable to view the analog output with an oscilloscope to insure that the front end amplifier does not saturate.

2.4 Typical Measurement Units

- footcandles (lumen/ft^2)
- lux (lumen/m^2)

3.0 C W LASER POWER MEASUREMENTS

3.1 Purpose

To determine the total power in a CW laser beam, irradiance from a CW laser, or irradiance from any other CW light source.

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3.2 Procedure

1) The procedure outlined below and the equipment listed above is specifically applicable to sources with the following characteristics:
   - 450 - 950 nm
   - less than 10mW total power
   - less than 500 mW/cm^2 irradiance

   Special cases falling outside this range are discussed separately.

2) Connect the radiometer/photometer to the detector using the cable supplied.

3) Screw the radometric filter onto the detector housing.

4) Position the head in the laser beam or in the measurement field. (See figure 5)

5) Refer to the calibration sheet or module for the particular instrument/detector combination in use. This will indicate which channel should be used, what multiplication factors are applicable and what attachments or other conditions apply.

6) Follow the zeroing procedure outlined in the operating manual.

7) Adjust the range switch until a non-full scale reading is obtained.

8) Verify that the radiant flux and irradiance are less than the values stated in step 1 .

9) Adjust the detector head in translation and also in tilt while observing the meter, in order to verify that the beam is fully on the detector and no unusual shadowing is taking place.

3.4 Typical Measurement Units

- µW , mW
- $\mu W/cm^2$, mW/cm^2

3.5 Procedure For Use With Narrow-band Light Sources Outside The Range 450 - 950 nm

The setup described above can be used for sources out side the 450-950 nm range but inside the range 300-1100 nm with the following procedure:

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1) Obtain a single point calibration from UDT for use without the radiometric filter at the wavelength of interest.

2) Delete the radiometric filter from the test setup and take the reading as outlined above but using the single point calibration.

3.6 Procedure For Use With A Light Source Greater Than 10mW Total or Greater Than 500mw/cm^2 Irradiance

By adding one or more of the accessories listed below the measurement range can be extended by the multiplication factor indicated.

Model#	Description	Multiplier	Comments
105	ND 1 filter	10	May cause inaccuracies because of multiple internal reflections (0.5W max)
105	ND 2 filter	100	
107	ND 3 filter	1,000	
125	Laser Beam Spreader	-	Converts a 1mm diameter beam to a 7mm beam
2500	Laser Integrating Sphere	10,000	Not spectrally flat, needs single point calibration (100 W max
2525	LED Integrating Sphere (can be used with lasers)	1,000	Not spectrally flat, needs single point calibration (10W max)
2550	Laser Attenuator	100	Not spectrally flat, needs single point calibration (0.5W max)

Refer to the UDT optional accessories brochure for a description of the attenuators.

1) Attach the attenuator as shown in figure 5.

2) Perform the measurement as outline in section 3.3.

4.0 PULSED LASER OR FLASHLAMP MEASUREMENTS

4.1 Purpose

To determine the total energy in a laser or flashlamp pulse. Also to determine the total energy in a shuttered light beam.

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4.2 Equipment

Same as section 3.2.

4.3 Procedure

1) The procedure outlined below is specifically applicable to sources with the following characteristics:
   - 450 - 950 nm wavelength
   - greater than 0.5 µsec duration
   - total pulse energy less than full scale reading on the highest radiometer energy range.

2) Connect the radiometer/photometer to the detector using the cable supplied.

3) Screw the radiometric filter onto the detector housing.

4) Position the head in the laser beam or in the measurement field. (see figure 5)

5) Refer to the calibration sheet or module for the particular instrument/detector combination in use. This will indicate which channel should be used, what multiplication factors are applicable and what attachments or other conditions apply. Any calibration in radiant or luminous power is also applicable to radiant or luminous energy with the appropriate change in units.

6) Follow the zeroing procedure outlined in the operating manual.

7) Just prior to measuring the optical pulse reset the radiometer to zero. The environment may need to be darkened if the optical pulse energy is comparable to the integrated ambient light during the measurement.

8) Verify that the radiant energy is less than full scale reading on the radiometer.

9) While making repeated measurements adjust the detector head in translation and also in tilt in order to verify that the beam is fully on the detector and no unusual shadowing is taking place.

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4.4 Typical Measurement Units

J/cm^2

4.5 Procedure For Use With Narrowband Light Sources Outside The Range 450-950 nm

Follow the procedure outlined in section 3.5 but with the radiometer set on the energy ranges.

4.6 Procedure For Use With Pulsed Light Sources With Higher Output Than The Highest Radiometer Full Scale Range

By adding one or more of the accessories listed in section 3.6 the measurement range can be extended by the multiplication factor listed with the accessory.

However, care should be taken that the peak irradiance and irradiance energy do not damage the accessories. In general if the optical pulse can visibily damage black exposed polaroid film, the energy level is too high.

1) Attach the attenuator as shown in figure 5.

2) Perform the measurement as outlined in section 4.3.

5.0 PHOTOMETRIC ENERGY MEASUREMENT

5.1 Purpose

To determine the photometric energy (luminous exposure or integrated illuminance) of a source such as in setting the exposure level for a photographic strobe or measuring the luminous efficacy of a flashing beacon.

5.2 Equipment

Same as section 2.2

5.3 Procedure

1) The procedure outlined below is specifically applicable to sources with the following characteristics:

   - Greater than 0.5 μsec duration
   - Total illuminance energy less than full scale reading on the highest photometer energy range.

2) Connect the radiometer/photometer to the detector using the cable supplied.

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3) Screw the photometric filter onto the detector housing and then screw the diffuser onto the filter.

4) Position the head as desired to make the measurement (see figure 6).

5) Make sure that the measurement is not affected by shadows from the operator or any other obstacles. The diffuser "sees" objects up to 90° away from the aiming direction. When the diffuser is used the instrument will measure the total energy incident on the detector plane. This will usually include light reflected from the walls or other objects. However, illuminance energy measurements may also be made without the cosine diffuser if the user wishes increased sensitivity and wants to reject light more than about 15° from the detector axis. If the user wishes to characterize the source alone (luminance) he should perform the measurement according to section 6.0.

6) Refer to the calibration sheet or module for the particular instrument/detector combination in use. This will indicate which channel should be used, what multiplication factors are applicable, and what attachements or other conditions apply. Any calibration in radiant or luminous power is also applicable to radiant or luminous energy with the appropriate change in units.

7) Follow the zeroing procedure outlined in the operating manual.

8) Just prior to measuring the optical pulse reset the radiometer to zero. The environment may need to be darkened if the optical pulse energy is comparable to the integrated ambient light during the measurement.

9) Verify that the luminous energy is less than full scale reading on the photometer.

5.4 Typical Measurement Units

Footcandle - sec (lumen-sec/ft^2)
lux - sec (lumen-sec/m^2)
talbots (lumen-sec)

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5.5 Procedure For Use When Total Illuminance Energy Exceeds The Full Scale Reading On The Highest Photometer Energy Range

1) Add one of the accessories listed in section 3.6 and use the multiplication factor listed with that accessory. When used with a cosine diffuser only neutral density filters are recommended. The ND filter should be attached between the photometric filter and the diffuser.

2) Perform the measurement as outlined in section 5.3.

6.0 LUMINANCE MEASUREMENTS (ALSO RADIANCE, LUMINOUS AND RADIANT INTENSITY)

6.1 Purpose

To measure the luminance (or radiance) of extended sources such as projection screens, cathode ray tubes, etc. (Also to measure the luminous or radiant intensity of a point source).

6.2 Equipment

A- radiometer/photometer
B- detector and cable
C- photometric filter (model 111)
D- 15° lumilens (model 1153)

6.3 Procedure

1) Connect the radiometer/photometer to the detector using the cable supplied.

2) Screw the photometric filter onto the detector housing and screw the lumilens onto the filter.

3) Point the head towards the extended source as shown in figure 7.

4) Make sure that the source is uniform and subtends at least a 15° angle at the detector.

5) Refer to the calibration sheet or module for the particular instrument/detector combination in use. This will indicate which channel should be used, what multiplication factors and what attachments or other conditions apply.

6) Follow the zeroing procedure outlined in the operating section of the manual.

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7) Adjust the range switch until a non-full-scale reading is obtained. When measuring time varying sources it is advisable to view the analog output with an oscilloscope to insure that the front end amplifier does not saturate.

8) For luminance measurements for sources smaller than 15° use the 1120 reflex viewing module.

6.4 Typical Measurement Units

nit (candela/m^2 (SI unit)

stilb (candela/cm^2)

apostilb ($\frac{1}{\pi}$ candela/m^2)

lambert ($\frac{1}{\pi}$ candela/cm^2)

candela/ft^2
footlambert (3.426 candela/m^2)

6.5 Procedure For Radiance

Perform the same procedure as outlined in section 6.2 but with the radiometric filter in place of the photometric filter. Typical units will be watts/cm^2sr.

6.6 Procedure For Luminous Or Radiant Intensity

Perform the same procedure as outlined in section 6.2 and 6.3 above using the photometric filter for luminous intensity, the radiometric filter for radiant intensity and substituting a point source which subtends less than a 15° angle at the detector in place of the extended source.

Typical units will be:

- candela (lumen/sr)
- watt/sr

7.0 MISCELLANEOUS MEASUREMENTS

Utilizing the procedures outline above numerous other measurements may be performed. A few representative examples are listed below.

7.1 LED Measurements

By using either the UDT model 129 LED shade or by making a laboratory setup as shown in figure 8 the luminous or radiant intensity of an LED or lamp may be measured. The procedure is similar to that of section 3.

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7.2 Transmission And Absorption Measurements

By interposing a sample between the light source and detector as shown in figure 8, the transmission or absorption of a sample may be measured. Many UDT radiometers have channels which can be set to a full scale reading for any light source so that when a sample is viewed the reading is directly in percent transmission.

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APPENDIX A

BIBLIOGRAPHY

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Illuminating Engineering Society,
345 East 47th St.,
New York, NY 10017

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Compiled and Edited by the
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P. O. Box 1146
Pittsfield, Mass. 01201

Focal Encyclopedia of Photography,
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31 Fitzroy Square,
London, W.1

Radiometric Calibration: Theory and Methods,
Clair L. Wyatt,
Academic Press,
111 Fifth Ave.
New York, NY 10003

Handbook of Lasers with Selected Data on Optical Technology
ed. by Robert J. Pressley,
The Chemical Rubber Co.
18901 Cranwood Parkway
Cleveland, Ohio 44128

Color Science, Wyszecki & Stiles,
John Wiley & Sons, Inc., NY

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APPENDIX B

FORMULAS

1. Speed of Photographic Materials

   $E \equiv$ exposure measured in Lux-sec

   ASA index = $1/(5E)$

   DIN index = $(10 \log E)-5$

2. Illumination of camera image plane

   $B \equiv$ brightness of object measured in candelas/sq. ft.

   $I \equiv$ illumination on image plane

   $= \pi B/4(f\#)^2$

   (illumination at object plane

   $= \pi B$)

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APPENDIX C

CONVERSION FACTORS

LUMINANCE (PHOTOMETRIC BRIGHTNESS) CONVERSION FACTORS

1 nit = 1 candela/m^2

1 stilb = 1 candela/cm^2

1 apostilb (international) = 0.1 millilambert = 1 blondel

1 apostilb (German Hefner) = 0.09 millilambert

1 lambert = 1000 millilamberts

Multiply Number of → / To Obtain Number of ↓ (By ↘)	footlambert	Nit	Millilambert	Candela/in^2	Candela/ft^2	Stilb
Footlambert	1	0.2919	0.929	452	3.142	2,919
Nit	3.426	1	3.183	1,550	10.76	10,000
Millilambert	1.076	0.3142	1	487	3.382	3,142
Candela/in^2	0.00221	0.000645	0.00205	1	0.00694	6.45
Candela/ft^2	0.3183	0.0929	0.2957	144	1	929
Stilb	0.00034	0.0001	0.00032	0.155	0.00108	1

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APPENDIX C

CONVERSION FACTORS

ILLUMINATION CONVERSION FACTORS

1 lumen = 1/673 lightwatt

1 lumen-hour = 60 lumen-minutes

1 footcandle = 1 lumen/ft^2

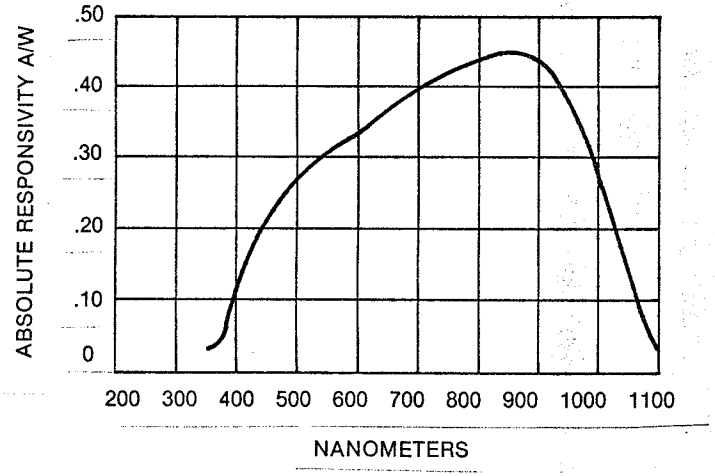
1 watt-second = 10^7 ergs

1 phot = 1 lumen/cm^2

1 lux = 1 lumen/m^2 = 1 metercandle

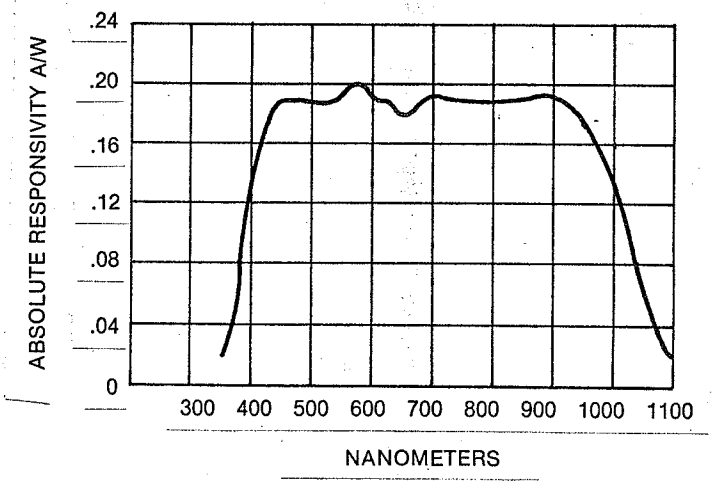
Multiply Number of → To Obtain Number of ↓ By ↘	Footcandles	Lux	Phot	Milliphot
Footcandles	1	0.0929	929	0.929
Lux	10.76	1	10,000	10
Phot	0.00108	0.0001	1	0.001
Milliphot	1.076	0.1	1,000	1

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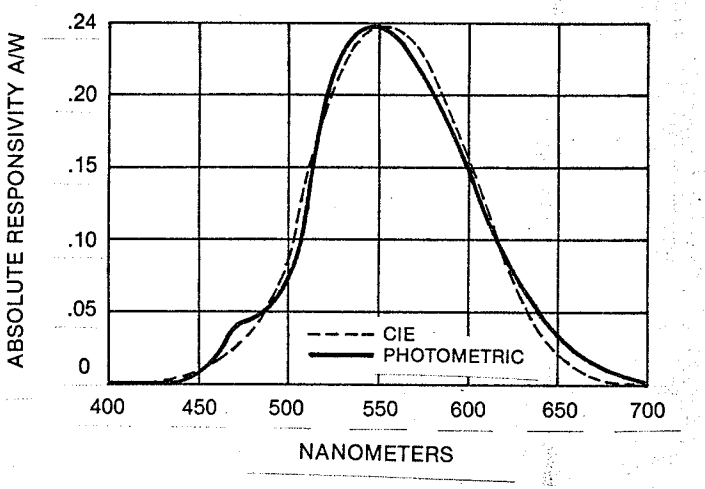
TYPICAL INSTRUMENT DETECTOR RESPONSE

FIG 1



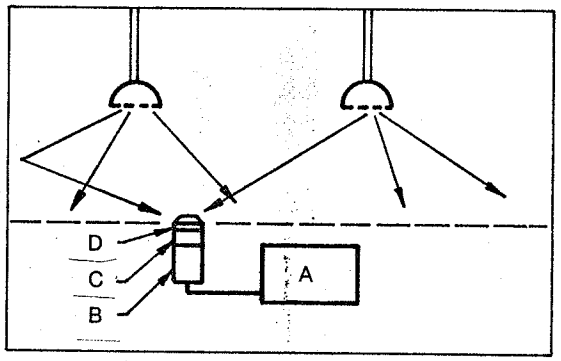
TYPICAL RADIOMETRIC DETECTOR RESPONSE

FIG 2



TYPICAL PHOTOMETRIC DETECTOR RESPONSE

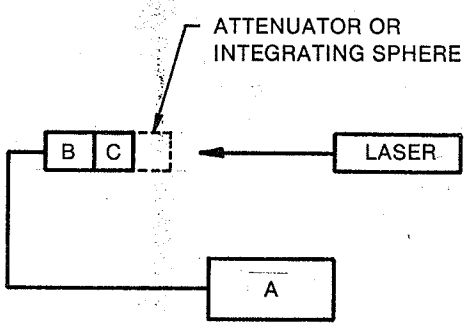
FIG 3



TYPICAL ILLUMINATION MEASUREMENT

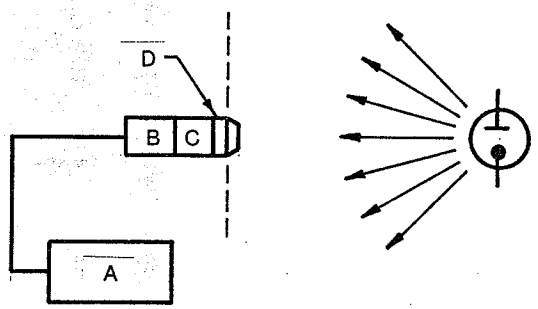
FIG 4

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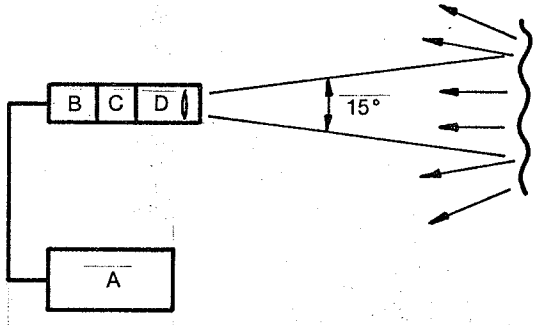
TYPICAL LASER
POWER MEASUREMENT

FIG 5



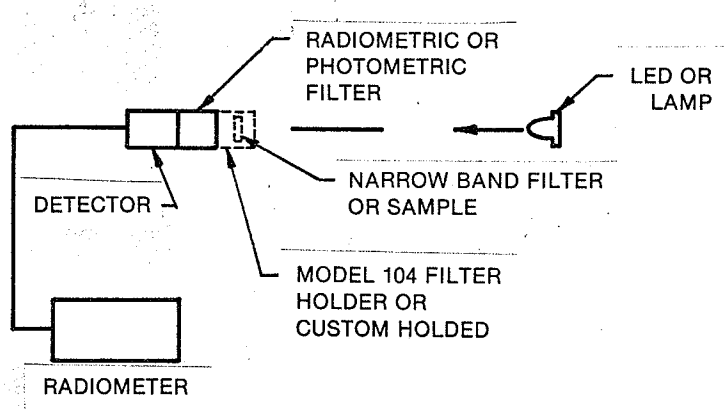
PHOTOMETRIC
ENERGY MEASUREMENT

FIG 6



LUMINANCE MEASUREMENT

FIG 7



LED MEASUREMENT

FIG 8

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United Detector Technology
3939 Landmark St., Culver City, CA 90230 • (213) 204-2250

CERTIFICATE OF COMPLIANCE

INSTRUMENT MODEL: S550 FIBER OPTIC POWER METER

INSTRUMENT SERIAL NUMBER: 55204

DETECTOR MODEL: 255 SILICON HEAD ASSEMBLY

DETECTOR SERIAL NUMBER: V127

THIS IS TO CERTIFY THAT ON 11 SEPTEMBER 1981 THE ABOVE INSTRUMENT/DETECTOR WAS TESTED TO COMPLY WITH THE PUBLISHED SPECIFICATIONS, USING LABORATORY STANDARDS THAT ARE TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS.

TEST RECORDS FOR THIS INSTRUMENT/DETECTOR ARE ON FILE AND CAN BE MADE AVAILABLE FOR EXAMINATION AND VERIFICATION.

*NOTE: CAL SET 0.496 AT 900 NANOMETERS.

*DECIMAL POINT LOCATION SHOULD BE DISREGARDED.

METROLOGY LABORATORY

QUALITY ASSURANCE

543A10

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United Detector Technology
3939 Landmark St., Culver City, CA 90230 • (213) 204-2250

CALIBRATION REPORT

DETECTOR MODEL 255 , SERIAL NUMBER V127

UNITED DETECTOR TECHNOLOGY, CULVER CITY, CALIFORNIA 12 AUG 81

SPECTRAL RESPONSE DATA:

WAVELENGTH (NM)	RESPONSIVITY (AMPS/WATT)	RESPONSE (PERCENT)	LIN CAL SET	LOG CAL SET	DB ADD-ON FACTOR
400	0.1819	38.8	0.550	0.182	4.110
420	0.1729	36.9	0.578	0.173	4.330
440	0.1634	34.9	0.612	0.163	4.577
460	0.1656	35.3	0.604	0.166	4.517
480	0.1857	39.6	0.538	0.186	4.020
500	0.2193	46.8	0.456	0.219	3.298
520	0.2636	56.2	0.379	0.264	2.500
540	0.2972	63.4	0.336	0.297	1.978
560	0.3159	67.4	0.317	0.316	1.713
580	0.3165	67.5	0.316	0.317	1.704
600	0.3137	66.9	0.319	0.314	1.744
620	0.3025	64.5	0.331	0.302	1.902
640	0.2978	63.5	0.336	0.298	1.969
660	0.2945	62.8	0.340	0.294	2.018
680	0.3005	64.1	0.333	0.301	1.930
700	0.3054	65.2	0.327	0.305	1.860
720	0.3241	69.2	0.309	0.324	1.602
740	0.3397	72.5	0.294	0.340	1.398
760	0.3521	75.1	0.284	0.352	1.241
780	0.3755	80.1	0.266	0.376	0.962
800	0.3921	83.7	0.255	0.392	0.775
850	0.4562	97.3	0.219	0.456	0.117
900	0.4687	100.0	0.213	0.469	0.000
950	0.4653	99.3	0.215	0.465	0.031
1060	0.2204	47.0	0.454	0.220	3.276

NOTE: DB ADD-ON FACTOR IS APPLICABLE ONLY WHEN
LOG CAL POT IS SET AT 900 NM VALUE = 0.469

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