SPECTRON ENGINEERING, INC.

OPERATING MANUAL

SE590 FIELD-PORTABLE DATA-LOGGING SPECTRORADIOMETER

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INTRODUCTION

The Spectron Engineering SE590 Field-Portable, Data-Logging Spectroradiometer/Spectrometer is a high performance, instrument for remote sensing, agricultural, forestry, geological and other spectral radiation measurement applications.

The photodiode array based Spectral CE390 detector head simultaneously acquires a continuous spectrum in 256 bands in a fraction of a second. The spectral output goes to a microprocessor based controller, the CE500A, which records data on the built-in tape deck, and also displays and communicates the data. The miniature tape cassettes (1.3 x 2.3 inch) are easily interchanged and each holds over 40 spectra.

The instrument is compact and easy to use. Built-in optics allow simply aiming the spectral head and taking a spectral scan. A scan can be viewed on the internal LED display or on a portable oscilloscope.

Printer and plotter outputs, automatic calculation of reflectance curves and other options make this a potent stand-alone system. The standard RS232C outputs spectra for storage and analysis on your computer. Analysis software for the IBM and Apple computers is available. (Contact us for details on this 3rd party software.)

A adapter with spot or wide angle lens, fiber optic probe, thru the optics viewing and special spectral bandwidths are optional.

Output features are included to enhance the stand-alone operation of the system. The printer provides hardcopy output that includes the scan parameters; the operator has a choice of printing tabular data which gives the energy for each individual spectral band, or of printing a graphic display with up to three curves (two spectra and a reflectance curve). Samples of both printouts are given in Chapter 8. An analog X/Y recorder output provides the other hardcopy output option.

THINGS TO REMEMBER

WARNING: Misuse of the instrument, for example by applying much higher than saturation light levels, may damage the photodiode array detector. Do not apply more than 1 milliwatt peak power from a monochromatic (laser source) as such a high energy or high peak power source may cause damage. The 1 milliwatt applies to pulsed or continuous sources. While short pulses above that power may not cause damage, the damage potential is dependent upon pulse characteristics and how effectively the source is imaged in the entrance slit.

BATTERY CHARGING: When the system is first unpacked, the batteries will not be fully charged. The batteries should be left on the charger for a period of 14-16 hours before being used in the field.

DEEP CYCLE RECHARGING: NICAD battery exhibit some "memory" of their typical use. Their full capacity is therefore maintained by occasionally deep cycling the batteries (bring them to a deep discharge level and then fully recharging them.) The procedure should be performed about once per month. The operator should run the system until the low battery indication occurs (which may take 2-3 hours depending on the operating mode). The system should then be fully recharged on the charger for at least 14 hours.

DISPLAY INFO:

1. '--' in the right display pair indicates the system is ready for an operator command.
2. '--' (flashing) command entry required to complete a sequence already initiated.
3. The left display are used to indicate the keyboard level and function the operator is in.
   - a period displayed with the digits. ('1.C' indicates the 'SCAN' or level one and key 'C' was pressed)
   - no period informs the operator of the last key pressed.

POWER UP: When the system is first turned on, the reset circuitry will normally reset the system. However, it is occasionally necessary to push the reset button. Because it is possible for the unit to not fully reset at turn-on, it is important to turn the machine on without a recorded tape loaded in the tape deck. If a recorded tape is in place when the unit is turned on, there is some risk of destroying the data.

SIGNAL SATURATION: In most cases, the SE590 system will give data that is entirely valid with all channels being usable. In certain cases though, especially with the ability to manually override the automatic integration ranging mode, saturation can be reached. The best way to learn to recognize these characteristics is to set up an incandescent light bulb and look at it with the CE390. The incandescent curve should look approximately like a mound without a partially flattened top. This curve should be attained on shorter manual override integration times (04 or 08). Observe the scope output after a scan sequence -- if flat topping is seen, move camera back from bulb or direct it off to one side to decrease the signal level. After an entirely good trace is attained, increase the manual override integration time step by step displaying the results on the scope. The flat top, or saturated part of the trace should become more evident with increasing integration time.

The operator may purposefully want to operate with some portions of the spectrum in saturation to allow higher sensitivity levels (longer integration time) to get greater resolution in lower energy portions of the spectrum. A series of scans can then be combined in the user's computer to piece together a complete spectrum. It is relevant to note that as ambient temperature increases, the maximum signal available will decrease. This is because the dark current/noise increases proportionally with temperature; this noise is subtracted from the signal used but it does take up a portion of the analog signal range.

Using the FOV options: Whenever you attach either the 1 or 15 degree FOV's you must:

-Remove the four allen head screws on the front of the camera. Place these screws in a safe place because you will need them again when you reattach the plate.

-After the screws are removed attach the proper FOV. Do not remove the cover plate. The plate is required to be in place to provide the proper light column on the optics. This plate stays in place at all times, except when the Thru the Optics Viewing (TOV) attachment is used. The TOV has its own cover plate attached.

Setting Date and Time: Both the Date and Time functions are retained in volatile memory and must be reentered whenever the unit is powered down or reset. Also, in order for the date and time be stamped on the printout they must be entered before the scan is performed. It is always best to set the date and time immediately after power on.

CHAPTER 1

SYSTEM COMPONENTS

The SE590 system includes the CE500 Microprocessor Based Portable Controller and Data-logger, one CE390 Spectral Detector Head (two CE390's may be simultaneously connected), the CE500/CE390 interconnect cable, carrying case, and the battery charger/AC adapter. The system also may include a printer with inter-connect cable if the print/ratio option was selected.

The CE500 controls the operation of the system. The controls, display and connections are listed below on pages 1-02 and 1-03.

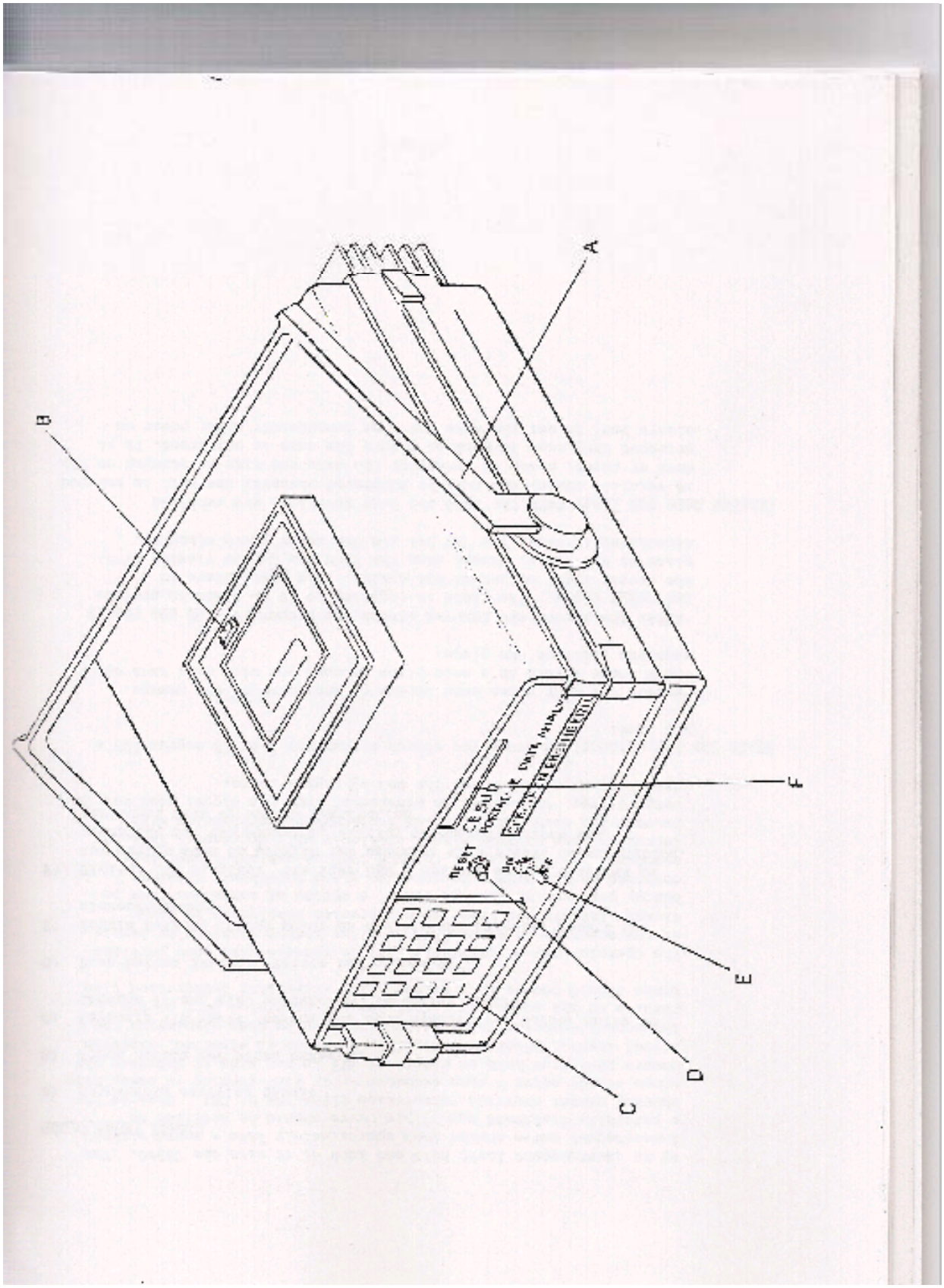
CE390 SPECTRAL DETECTOR:

Microribbon Jack: used for connection of cable from the CE500 rear panel.

The CE500/CE390 cable (microribbon plug on each end) is connected between the units at the identified connectors. The only other connection used for normal operation is the battery charger for recharging the CE500. If the print option was ordered, the printer is connected (with the cable provided) to the printer output connector on the CE500. A separate manual will be provided with the printer. An X/Y plotter and the oscilloscope would be hooked up to the CE500 back panel connectors listed.

CE500 FRONT PANEL:

A) Adjustable carrying handle
B) Eject button for micro cassette
C) Keyboard (16 Key): serves for both hexadecimal number entry (0 through F) and also as function selection control.
D) Push-button switch: resets the processor
E) Toggle switch: turns power on and off and normally resets the microprocessor
F) Digital LED Display: the four LED's operate as two displays of two digits each to provide the operator with visual communication, prompting for the operator, display of operating mode and pertinent data or memory information.


A
B
C
D
E
F

CE500 BACK PANEL:

G) Micro Ribbon connectors (1 and 2), each 14 pin, are used for head cables to attach the CE390 spectral scanner. One or two scanners may be connected at the same time but only one will be operative. The toggle switch located beside the Micro Ribbon connectors selects one or the other CE390.

H) Head Select Toggle Switch: located just to the right of the two head input connectors, this toggle switch selects the head to be used. "Up" connects the top head, "Down" the bottom.

I) Cooling fins for voltage regulator. May become warm to the touch.

J) Power Jack: used to connect battery charger/AC adapter supplied with unit or other external source of +7.5 to +15 volts DC.

K) Scope (BNC): signal IN connector used to connect the oscilloscope.

L) Scope (BNC): sync connector used to trigger the oscilloscope.

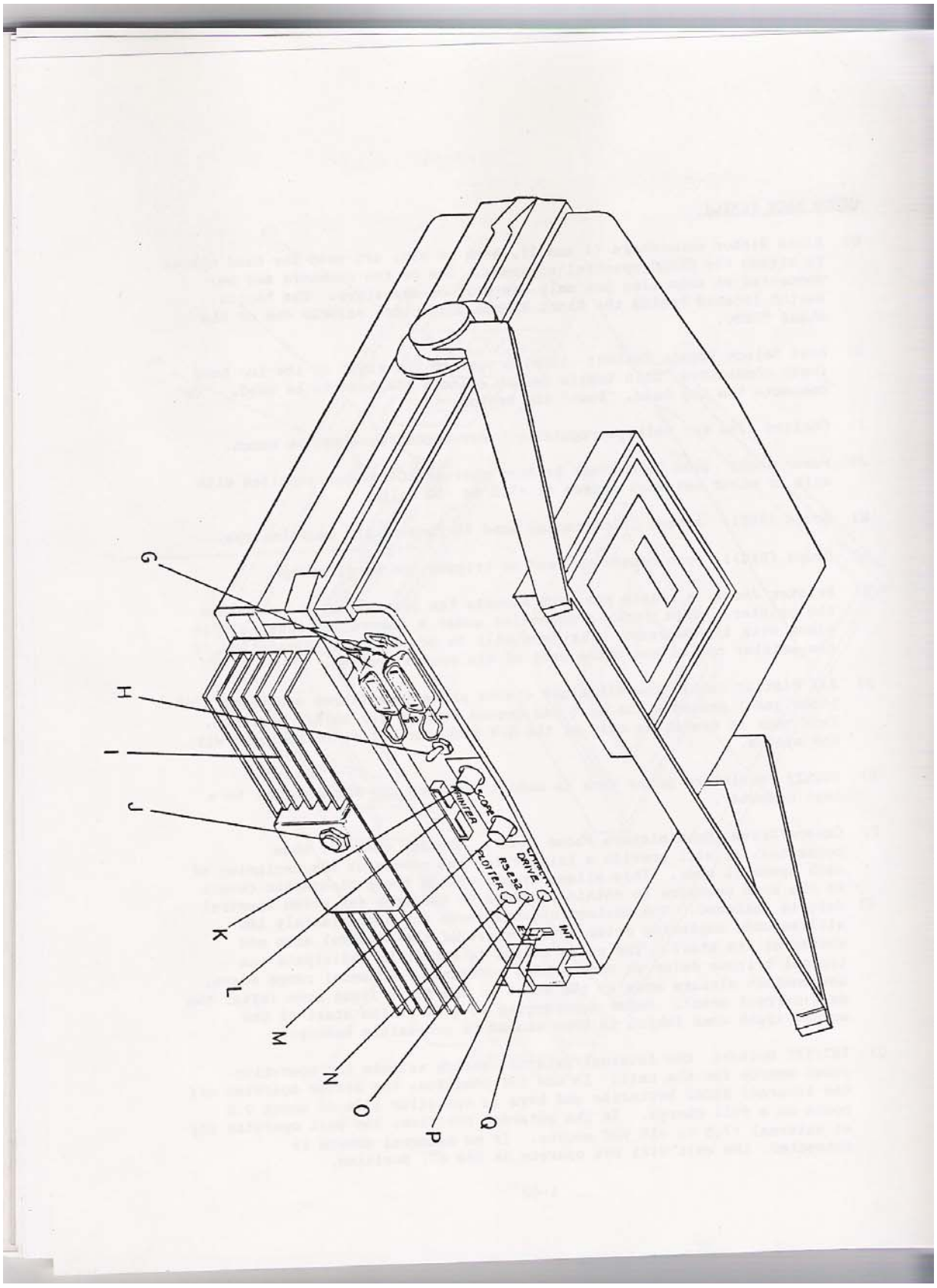
M) Printer Jack: a twenty pin jack accepts the printer cable to operate the printer. This jack is concealed under a removable plate held in place with thumbscrews. The jack will be present but inoperative if the printer option was not a part of the system ordered.

N) X/Y Plotter Jack: the miniature stereo phone jack (three conductor ¼" phone jack) provides the X, Y and ground outputs for an X/Y Recorder. This jack is operative only if the X/Y recorder option is included with the system.

O) RS232: miniature phone jack is used to connect the RS232 output to a host computer.

P) Camera/Drive (Subminiature Phone Jack): shutter control; when connected, it will provide a trigger for the camera at the beginning of each spectral scan. This allows synchronizing the photographic camera to the scan sequence to obtain pictures of the area for which spectral data is gathered. The contact closure lasts for approximately 160 milliseconds beginning prior to the start of the spectral scan and ending at it's start. The pulse timing is set up to anticipate the typical trigger delay on common 35mm cameras. For manual range scans, the contact closure ends at the start of the first light scan (after the dark current scan). Under autoranging it ends at the start of the actual light scan (which is then stored in accessible memory).

Q) INT/EXT Switch: the internal/external switch selects the operating power source for the unit. In the INT position, the system operated off the internal NICAD batteries and have an operating life of about 2.5 hours on a full charge. In the external position, the unit operates off an external +7.5 to +15 VDC source. If no external source is connected, the unit will not operate in the EXT position.


G
H
I
J
K
L
M
N
O
P
Q
PRINTER
SCOPE
EXPANSION DRIVE
RS-232
PLOTTER
INT

CHAPTER 2

SYSTEM DESCRIPTION

The SE590 is a portable battery operated spectroradiometer consisting of a CE500 data analyzer/data logger controller, CE390 series of spectral detector heads and external battery charger/power supply.

CE500 CONTROLLER

The CE500 is a self contained microprocessor based controller which is battery powered and has a built-in digital tape deck for recording spectra in the field.

The controller processes the signal from the head, amplifying and digitizing it with 12 bit resolution. For each spectral scan, the controller actuates the CE390 shutter, measures and stores the dark current, calculates optimum integration time, acquires the spectrum and automatically subtracts the noise for all 256 spectral elements.

Once a spectrum is acquired, it is stored in a temporary register which we term "user accessible memory", or simply "accessible memory". This is a double precision register which saves the entire 12-bit binary spectra. A spectrum can be entered into accessible memory in one of several different ways.

-data is read in from a previously stored scan obtained from the internal tape deck or RS232c port
-a scan is performed using either level one or two of the multi- level keypad
-a spectra is transferred from secondary storage register back to the main accessible memory

The full spectrum remains in accessible memory until either a new scan is performed, a spectra is read from tape or the system is powered down. It is important to remember that a scan residing in accessible memory will be lost when you move to level 3 or 4 of the keypad without first saving the scan to another register (DATA1, REF2, DATA2, REF2). See Chapter 5 concerning these registers.

From the accessible memory, the spectra can be stored to tape, viewed from the internal LED display or oscilloscope via the scope output connector on the rear panel.

The data available on the built-in four digit LED display includes system status information, operator prompts and error indications, spectral amplitude data, and also the operating parameters of the spectral scan under review.

The RS-232C output is provided as standard along with the scope output and the built-in display. The data transmitted is essentially the same as that recorded on the tape and

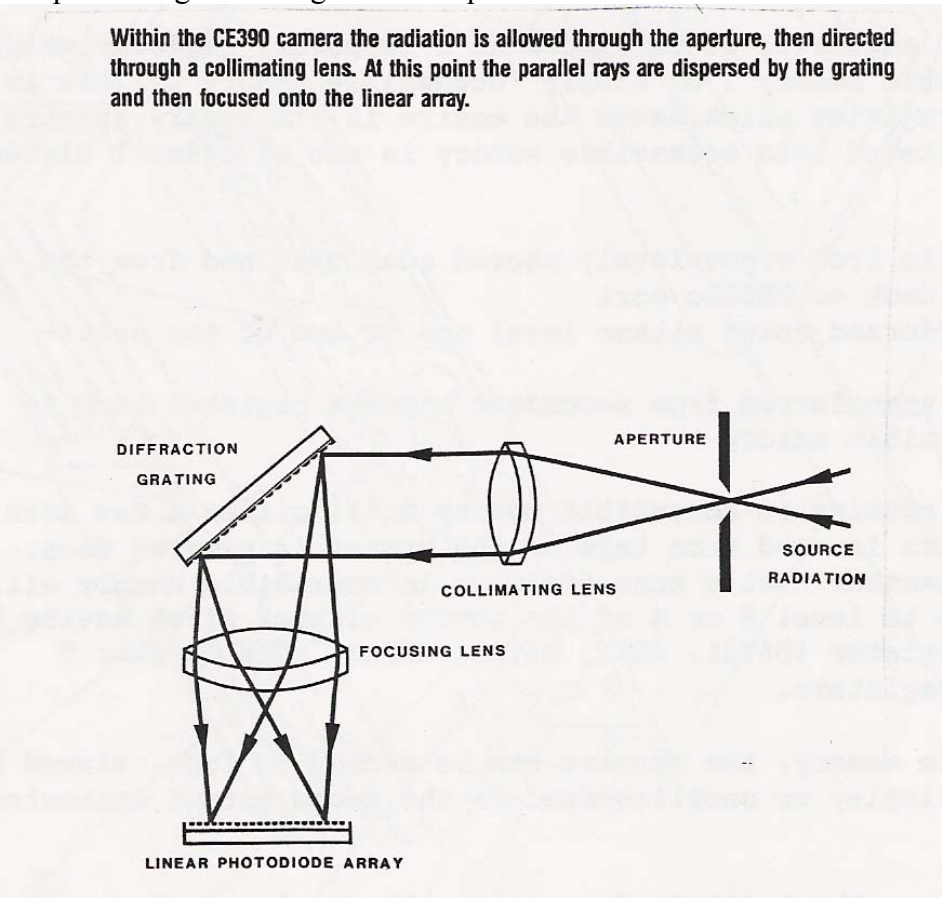
includes the scan parameters and double precision spectral data. The specific tape and RS-232C formats are detailed in Chapter 9.

The operator uses the CE500 keypad to select functions and control operations and consist of four layers (much like sophisticated calculators). The keypad is color coded for easy operation.

Red = Level One -DATA-
Yellow = Level Two -SETUP-
Green = Level Three -FORMAT-
Blue = Level Four -OUTPUT-

CE390 DETECTOR HEAD

The spectral detector head uses a diffraction grating as the dispersive element; the spectrum is imaged onto a 256 element photodiode array. Each element integrates simultaneously acquiring the spectrum in a fraction of a second. The detector head has a standard acceptance angle of 6 degrees with options available.



The interconnect cable from the spectral head to the controller couples the spectral signals to the controller, timing and control signals to the head. A shutter in the head,

operated by the controller, closes the light path for dark current measurement. The normal interconnect cable is 2 meters but up to 10m cables are optional. A series 1/4-20 mounting holes allow for attaching the head to a tripod, hand grip or bracket.

POWER SUPPLY/CHARGER

The CE500 operates on internal rechargeable batteries; a charger/power supply is included. When the batteries are low, a full charge takes approximately 10-16 hours. For extended field use, the CE500 can be plugged into any +7.5-15 Vdc source, maximum 2.5 amp.

The +7.5 to 15 volt range will enable the unit to be attached to an automobile or aircraft 12Vdc electrical system. The system typically draws 1.5 amps during normal operation. When the tape rewind is engaged, this draw increases to 2.0 amps.

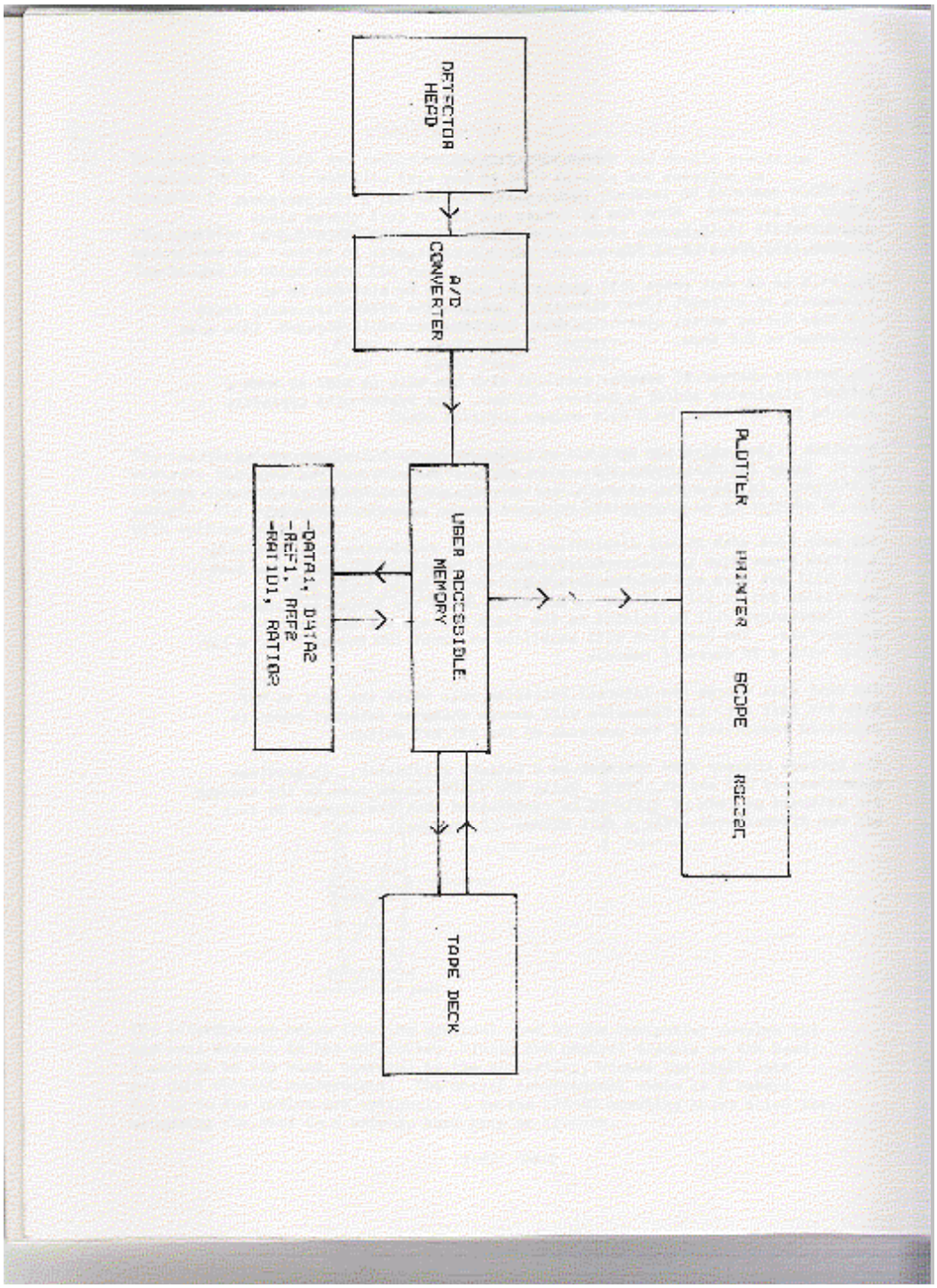
The battery charger/AC adapter supplied with the unit is used as both a battery eliminator and/or a battery charger. The system will typically operate for 4.5 hours on a full charge.

A switch allows selecting internal or external power for operating the unit. Under internal power the system operates totally off the internal batteries. In the external position, only the external power is used so the AC adapter or an appropriate DC power source must be connected.

The rear heat sink allows dissipating heat from regulating the externally supplied power down to the required internal regulated voltage. The heat sink will get warm and even uncomfortable to the touch under some conditions but it will not get so hot as to cause any danger or damage. The temperature will be related to the input voltage and ambient temperature. The heat sink will stabilize at about 130 degree F for a 12V input with a 70 degree F ambient.

The unit will charge the internal batteries only while the unit is OFF. With the unit off, the batteries will charge whenever external power is connected regardless of the position of the INT/EXT switch.

The battery charger also operates as a battery eliminator. It provides approximately 2.5 amp at 12Vdc. While the CE500 can be left on the charger for extended periods of time, it is recommended that the charger be shut off and disconnected after a full charge (10-16 hours).


DETECTOR HEAD
A/D CONVERTER
USER ACCESSIBLE MEMORY
-DATA1, DATA2
-REF1, REF2
-RATIO1, RATIO2
PLOTTER
PRINTER
SCOPE
TAPE DECK

CHAPTER 3

BASIC SCAN PROCEDURE

The following steps illustrate the proper procedure for initiating a spectral scan of a fluorescent lamp, save it to tape and print it out.

1. Make sure the detector head cable is securely attached to the connector on the rear panel.

2. Set head select toggle switch on rear panel to camera number one, or up position.

3. If you are going to operate under battery power, check that the batteries are properly charged and verify that the power select switch on the rear panel of the CE500 is set to INTERNAL.

4. When operating without battery power, verify that the AC power supply cable is attached to the controller unit. Set the toggle switch on power supply to the ON position. Set power select switch on the rear panel of CE500 to EXTERNAL.

5. Set power switch on front panel of CE500 to ON position and press the reset button on front panel. The display will show '0000' which verifies a proper reset.

6. Insert a blank cassette into the tape deck and rewind to start of tape by pressing the REWIND (1) button on keyboard level one.

   The "11" in the left two digits signifies that button number 1 (REWIND) on keyboard level one was pressed.

   CAUTION: The cassette should be inserted into the tape deck after the power is turned on to avoid losing any data on tape due to unstable conditions at power up.

   When the tape is done rewinding, the display will show: '11--'

   The '--' in the right pair of the display indicate the system is ready for the next command.

7. Aim the spectral detector head at a fluorescent lamp and press the SCAN (D) button.

   -For a period of two seconds the left two digits will display the peak amplitude of the spectral scan allowing the operator to view the peak level that was acquired and that will be recorded. These numbers are hexadecimal with FF being the maximum reading.

-The right two digits will display the integration time used by the system to acquire the scan. This will range from 01 to 64 which 3-01 translates to 01/60th sec. to 64/60th sec.

The peak value remains in the left digits but the integration time is replaced with '--' which means the system is ready for the next command.

8. Once the scan has been taken, the spectrum is stored in "user accessible" memory. This is a location in RAM memory where the scan must reside in order to be viewed or stored to tape. It is important to remember that if power is turned off or the reset button is pushed, the data will be lost if it has not been saved to tape.

9. To save the scan to tape, press the TAPE WRITE (9) button on keyboard level one.

-The flashing zeroes indicate the internal counter is set to zero and the system is requesting an ID#. This is a four digit number (0000 thru 9999) that must be entered before the data can be written to tape.

-For this example enter 1-1-1-1. Once the four numbers are entered the display will show '1111' for one second, after which the display will revert to: '11--'. To allow for the mechanical response of the keyboard insert a short pause between key presses.

-The flashing '--' in the right digits are a prompt to the operator that another selection is needed to complete the entry. Press the TAPE WRITE (9) button again in order to complete the write command. You will hear the tape deck turn on and save the data. The LED's will display the following three sets of numbers.

-The left two numbers show the last key that was pressed (keyboard level one and button number 9): '19 '.

-The ID# written to the tape will be displayed, in this example it will be: '1111'

-The final sequence displays the last button pressed in the left side of the display. The '--' in the right digits prompts the operator to select another function.

You have now performed a spectral scan and saved the data to tape. Another scan can now be performed or the data can be read back into the controller for further review.

10. The data contained in "accessible memory" is still valid and identical to the data saved to tape. In order to print the scan confirm that the printer cable is properly attached and the printer is turned on.

11. To enter the output level of the keyboard, press the OUTPUT key (0). The display reads '4.0--', which means you have keyboard level and the unit is ready for another command. When a period is displayed in the left displays, it is indicating the keyboard level you are in.

12. To print a graphic representation of the scan press PRINT CURVE (5) key. The display reads '45 'indicating the last key pressed (level four, key five).

The amplitude will vary depending on how far your camera was from the source, but the peaks should be at the same points across the spectrum.

13. To produce the tabular printout press PRINT DATA (6).

Example:

In this example two spectral scans will be performed and saved in DATA1 and REF1 registers. Data will be transferred to the display stack and a printout of both spectra with their assigned RATIO (reflectance curve) performed.

1. Point the detector head towards sample. For this example use a colored piece of paper as the sample target. Press SCAN (D) button.

2. After scan has been completed press DATA1 (F) key. (This transfers data from "user accessible memory" to the DATA1 register.) All 12 bits of data are transferred.

3. Point the detector at a reference source. For this example it can be either a light bulb or the reflection of a light source off a white sheet of paper. Normally when you wish to measure reflectance values outdoors you measure the solar radiation using a standard white card. REMEMBER! The signal stored in the REF registers must be of equal or greater
value then the signal stored in the DATA registers.

4. Press SCAN (D) button to initiate scan.

5. Press REF1 to transfer data to the reference register. The ratio value is automatically calculated and stored in the RATIO1 register. To access these values and print them out, continue with this example.

6. Enter keyboard level 3 (FORMAT) by pressing the (4) key.

7. The SE590 has a display stack which can contain up to 3 spectra at one time. For this example we will load DATA1, REF1 and RATIO1 into the display stack.

- Press DATA1 (D)

- Wait for "--" to appear in the LED read-out. (This shows that the system is ready for the next command.

- Press REF1 (E)

- Wait for "--"

- Press RATIO1 (F)

8. Enter level four (OUTPUT) keyboard. Press OUTPUT (0) button.

9. Press PRINT GRAPH (5) button to start printout.

No keystroke is required to actually perform the Reflectance Curve calculation. Once the scans have been loaded into DATA1 and REF1, RATIO1 is automatically calculated

CHAPTER 4

KEYBOARD DESCRIPTION

The CE500 controls the operation of the SE590 system including the camera and any peripherals; the 16 key keyboard is the operator interface to implement these control functions. This chapter shows the keyboard layout, a layout that is repeated on the CE500 itself.

Actually a series of keyboard layouts are presented because the system uses one basic keyboard in its standard form, but multiple level keyboards if functional options have been incorporated.

The basic structure with the options is a four level keyboard where the level is selected by pressing one of four keys:

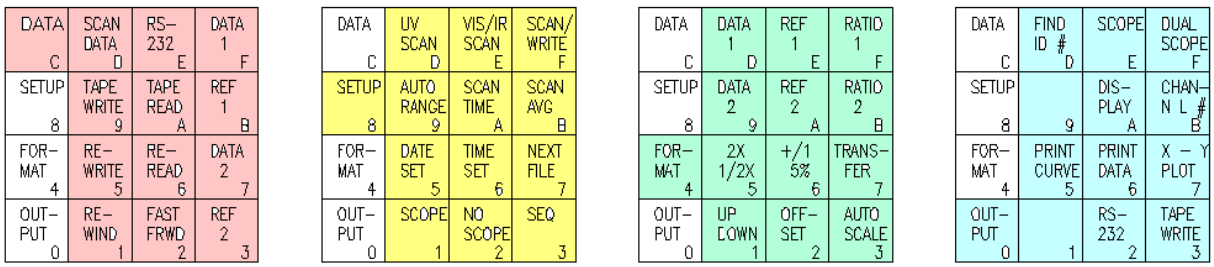
DATA: This selects the first keyboard (function level 1) which includes the direct operating functions such as the scan operation.

SETUP: Function level 2; this keyboard allows the operator to define certain scan parameters prior to the scan and to implement certain scan sequences. Such functions as manual override of the automatic integration time or scan sequencing are at this level.

FORMAT: Function level 3; this keyboard allows the operator to specify output formats and curve modifications.

OUTPUT: The 4th function level; the printout, plot and scope outputs are covered here.

The four level keyboard is implemented whenever any of the functional option packages are ordered with the system. The multiple levels allows keyboard space for the range of functions that can be included with these options. The full range of functions available with the four levels are shown in the figure below. This legend is repeated in a similar label located on the top of the CE500 as a convenient reference.



Standard features are offered in a series of packages. The figure below repeats the four level keyboard legend but adds details about which functions are included with each option package.

DATA C	SCAN DATA D	RS-232 E	DATA 1 F
SETUP 8	TAPE WRITE 9	TAPE READ A	REF 1 B
FOR-MAT 4	RE-WRITE 5	RE-READ 6	DATA 2 □ 7
OUT-PUT 0	RE-WIND 1	FAST FRWD 2	REF 2 □ 3

DATA C	UV SCAN ° D	VIS/IR SCAN ° E	SCAN/ WRITE △ F
SETUP △ + 8	AUTO RANGE + 9	SCAN TIME + A	SCAN AVG + B
FOR-MAT 4	DATE SET △ 5	TIME SET △ 6	NEXT FILE △ 7
OUT-PUT 0	SCOPE △ 1	NO SCOPE △ 2	SEQ △ 3

DATA C	DATA 1 D	REF 1 E	RATIO 1 F
SETUP 8	DATA 2 □ 9	REF 2 □ A	RATIO 2 □ B
FOR-MAT 4	2X 1/2X □ 5	+/1 5% □ 6	TRANS-FER □ 7
OUT-PUT 0	UP DOWN □ 1	OFF-SET □ 2	AUTO SCALE □ 3

DATA C	FIND ID # D	SCOPE E	DUAL SCOPE □ F
SETUP 8	9	DIS-PLAY A	CHAN-NEL # B
FOR-MAT 4	PRINT CURVE 5	PRINT DATA 6	X - Y PLOT □ 7
OUT-PUT 0	1	RS-232 2	TAPE WRITE 3

□ **DATA MANIPULATION OPTION**

Δ **AUTOMATIC SEQUENCING AND CLOCK OPTION**

\+ **SCAN AVERAGING**

° **SECOND CAMERA**

CHAPTER 5

FUNCTION DESCRIPTION

This chapter lists and describes each of the operator controllable functions of the CE500 controller. As shown in the following diagram, the keypad actually consist of four layers (depending on options purchased). To access each level of the keypad you simply press the color coded key associated with function desired:

RED - DATA
YELLOW - SETUP
GREEN - FORMAT
BLUE - OUTPUT

KEYBOARD LEVEL 1 (DATA)

5.1 SCAN (D): When the SCAN (D) key is pressed, the system automatically performs a series of steps. It closes the shutter and takes a dark current measurement which is stored in memory. It takes a spectral scan at 8/60th second storing the spectrum in memory; it then analyzes the peak amplitude of the curve to determine the optimum integration time. If the signal is in saturation, it will shift to a faster integration time; if the signal is below the 50% level, it will shift to a longer integration time (in binary multiples from 1/60th to 64/60th second.) The appropriate time is predicted by the system to give the maximum amplitude without saturating any of the detector elements. The system automatically takes a new dark current and then a spectral scan at the new integration time.

5.2 TAPE WRITE (9): This function writes the current active spectrum and scan parameters from accessible memory to the tape cassette. The data block is written on the tape immediately past the current data block; it does not search for an unwritten file space on the tape.

When the TAPE WRITE key is depressed, the last ID# used for a recorded block of data will appear as a reference, flashing in both display pairs. The operator must make a four digit ID# entry for the data block to be written. Normally, the TAPE WRITE key is depressed again to actually record the data block from memory to tape. The right displays will show blanks ("DD") indicating that the function is in progress. After a short period of time, the ID# will appear on the display. When the tape write function is complete, 19 will appear in left displays and (--) will appear in the right displays.

If the TAPE WRITE key was not selected, the identification number is not saved.

5.3 REWRITE (5): The REWRITE function is almost the same as the TAPE WRITE function except that the data is written back over the last data block instead of going to the next tape location.

5.4 TAPE READ (A): This function reads the next data block from the tape into operator 'accessible memory'. If the read is performed properly, the ID# of the data block will appear on the display pair for a short period of time, then the right display will change to '--', prompting another operator function selection.

5.5 REREAD (6): The REREAD function is the same as the TAPE READ function just defined except that the unit will attempt to read the previous block of data from the tape rather than the next block.

5.6 FAST FORWARD (2): This function winds the tape fast forward until the operator stops the tape by using the DATA key or until the end of tape is reached. During the tape wind, two blanks will appear in the right displays.

When the end of tape is reached, "FF" will flash back and forth between display pairs for a short time and stop with "FF" in the left display and "--" in the right display.

5.7 REWIND (1): Rewinds to the start of the tape or until interrupted by pressing the DATA (C) key. While the tape is rewinding the left display pair will show "11" which shows the last key press. When the tape is done rewinding the right display pair will show "--" which is the operator prompt for additional commands.

5.8 RS232 (E): This function transmits the data from the operator accessible memory to the user's computer on the RS232C. During the transmission, random numbers will appear in the right display. After the transmission is complete, the right displays will show "--".

The data is transmitted at 9600 baud as a continuous stream of binary data 528 bytes long. The specific data format is covered in chapter 5.

5.9 DATE (F), DATA 2 (7), REF 1 (B), REF 2 (3): In the multilevel keyboard, these four keys appear on the first (DATA) keyboard. They identify four double precision registers each able to hold a complete spectral data block including scan parameters. Pressing any of these keys loads the spectral data block from accessible memory into the register identified by the particular key. Recall that the spectrum in accessible memory could be the latest scan or it could have been read from the tape. Loading the block into the dedicated register does not remove it from accessible memory; it is still available for other functions.

KEYBOARD LEVEL 2 (SETUP)

5.10 SCOPE (1): When this key is pressed, the spectrum in "accessible memory" will be output for display on an oscilloscope. The output is repetitive so that a continuous display is available on the scope.

5.11 NOSCOPE (2): The system automatically provides a one-shot spectral curve to the oscilloscope output at the completion of each spectral scan to allow the operator to get a quick visual evaluation of the spectrum just acquired. The NO SCOPE function provides a means to suppress this oscilloscope output. This suppression might be desired if the system were being used in the auto sequence mode, for example, where the scope output might represent an unnecessary (although short) delay.

5.12 SCAN TIME (A): The system is preset for automatic control of integration time. The SCAN TIME key allows the operator to manually override this function and preset a fixed time. When the SCAN TIME key is selected, the integration time of the last automatic ranging or the last preset manual override integration time will appear flashing the right display. At this time, a two digit entry is necessary to manually set the integration time. This setting is used for all following scan data until the unit is reset or this function selected again. The integration times available in sixtieths of a second: 01, 02, 04, 08, 16, 32, and 64.

The unit will not accept commands other than the above entries during this function. The entry will be displayed for a short period of time and then be replaced by "--" indicating that the unit is ready to accept another function.

5.13 AUTO RANGE (9): This key returns the system to the auto integration mode.

5.14 TIME SET (6): One of the system options includes an internal clock that is used to allow automatic recording of the time of each spectral scan. The TIME SET key allows you to preset the internal clock to show the actual time.

The entry of six digits for hours, minutes and seconds is required. After the six digits are entered, the operator would again press the TIME SET key to restart the clock at the entered time. Obviously, the time entered should be at least several seconds away to allow the final step of pushing the TIME SET key. The system provides operator prompts for entering the time data. When the TIME SET key is depressed, the left display will show the function code and will then shift to "1" requesting the first pair of time numbers which is hours. The right display will flash the existing hours setting of the clock; the flashing here as in other instances indicates that an operator entry is needed. The same sequence is repeated for minutes and seconds with the left display showing "2" and then "3" and the right display flashing the existing settings. After the six digits have been entered, the right display will flash "--" indicating that the operator must still press the TIME SET key to enter the time and restart the clock.

The clock operates to 99 hours, 59 minutes and 59 seconds. It does not reset at 24 hours. The internal clock operates from an IC timer, not a crystal, and it is therefore reasonably accurate but not high precision.

When the system is first turned on, the clock is preset to 00:00:00 and 5-03 begins counting immediately. When the TIME SET is entered, it will continue counting but from the entered time. The clock time will be retained as part of the scan parameters for each scan for single scans as well as sequences.

5.15 DATE SET (5): The DATE SET function performs similar to the TIME SET function. The date will be retained until the unit is powered down or reset.

The entry of six digits for month, day and year is required. After the six digits are entered, the operator would again press the DATE SET key.

When the DATE SET key is pressed, the left display pair will show the function code "25" for one second and then shift to "1" requesting the first pair of date numbers which is the month. The right display will flash the existing month setting; the flashing here indicates that operator entry is needed. The same sequence is repeated for day and year with the left display showing " 2" and " 3" respectively, while the right pair flash the existing settings. After the six digits have been entered, the right display will flash "--" indicating that the operator must still press DATE SET to enter the date.

5.16 SEQ (3): This function provides a repetitive sequence of spectral scan record operations. Each scan is unchanged from the single scan operation. In other words, if the system is in its normal autoranging mode of operation, it will follow the same sequence of steps as for the single scan taking a dark current reading followed by a spectral scan with that pair followed by an additional pair of scans if a range shift were required. If the system was preset to a manually controlled integration time, it will sequence at that fixed integration time.

The Sequence function has provision for setting a fixed time delay between individual scans. The delay is set in seconds and is entered as a four digit number from 0001 to 9999 seconds.

When the SEQ key is first pressed, "--" will appear on the right display pair indicating that an operator entry is required. If no delay is desired, the operator would press the SEQ key again to bypass the delay function. The sequence will begin as soon as the SEQ key is pressed; it is not necessary to return to the DATA keyboard.

If a delay between scans is desired, the operator would instead press the TIME SET key. The system will wait for the operator to enter the four digit time delay. The TIME SET key must be pressed again to actually enter the time delay. Once

that is entered, the operator would then press the SEQ key to begin sequenced operation. For units equipped with an internal clock, the time will be recorded on each scan as part of the scan parameters. The system automatically applies sequential ID numbers to each scan.

5.17 SCAN AVG (B): A series of scans can be taken and automatically averaged with that average, then put into accessible memory and handled

like a single individual scan. When the SCAN/AVG key is depressed, the preset number of scans to be averaged will appear flashing in the right display pair. The number of scans that can averaged are 01, 02, 04, and 08; only a proper entry will be accepted. The number to be averaged is retained until it is changed by initiating this function again or by resetting or turning the unit off. The scan averaging feature applies to both auto-ranging and manual override modes. In the auto-ranging mode, the unit will always take more than the number of scans to be averaged because it first determines the integration time used.

5.18 SCAN/WRITE (F): This function is a shortened form of the sequence operation. It takes a scan and then automatically writes it to the next tape block. Control is then returned to the operator. Like the sequence function, the scan begins immediately; it is not necessary to return to the DATA keyboard.

5.19 NEXT FILE (7): This function searches for the next open data block on the tape. It is useful for when the tape has been partially recorded and the operator wants to advance to the first open area.

To begin the function, press NEXT FILE and the display will read "27--"; this is a prompt to enter the next command which is press NEXT FILE again. When the function begins, the right display will show two blanks.

If the tape is empty (has not been written on), E's will scroll across the display for a short period of time and then be replaced with "27--" indicating another function is to be implemented.

If the entire side of the tape is full, the end of tape or full indicator will be displayed; this consists of a flashing 'FFFF' on the display followed by "FF--".

When an unwritten area of the tape is located, the indication is "27--"; at this point you are free to save the next scan to tape.

5.20 UV SCAN (D): This button is used to perform a scan when a UV camera is attached to the CE500. The output format will be graphed and displayed with reference to the UV frequency.

5.21 VIS/IR SCAN (E): This key is used for setup purposes when a VIS or IR detector is attached to the CE500 and the system had previously been used with a

UV detector. The system defaults to this mode at power up or when a reset is initiated.

KEYBOARD LEVEL 3 (FORMAT)

DISPLAY STACK CURVE SELECTION FUNCTIONS

5.22 DATA 1, REF 1, DATA 2, REF 2: On the FORMAT keyboard there are six keys used to load the display stack. These keys DATA1, REF 1, RATIO 1, DATA 2, REF 2, and RATIO 2 represent the six possible curves for display or output. Data was entered into DATA 1, DATA 2, REF 1, and REF 2 registers while in keyboard level one, utilizing input from either the tape deck or a spectral scan.

With the curves in the display stack, the operator has the choice (with proper options installed) of using the various outputs:

-oscilloscope
-X/Y plotter
-dot matrix printer
-RS232C
-writing to tape

5.23 RATIO 1, RATIO 2: ***REFLECTANCE CURVE*** When spectral scans have been entered into the DATA1, REF1, or the DATA2 and REF2 memory locations, a reflectance curve is generated and stored in the corresponding RATIO 1 and RATIO 2 memory locations. This reflectance curve is a division of DATA1 by REF1, (to avoid saturation on the display, the REF scan should always be of the greater amplitude) with a compensation for varying integration times.

5.24 TRANSFER (7): The TRANSFER key allows switching data and reference curves. The operator would press the TRANSFER key and then press the keys of the two curves to be interchanged, for example, DATA 1 with DATA 2. To complete the transfer, press the TRANSFER button again. This would change the reflectance curves because the two ratios are DATA 1/REF 1 and DATA2/REF 2. Interchanging the two data curves would give new reflectance curves.

The transfer key also has another function that allows transmitting or recording double precision ratio data. Pressing the TRANSFER key, the RATIO 1 (or RATIO 2) key and the TRANSFER key again loads the reflectance curve into the user accessible memory and transfers control back to the DATA keyboard (without pressing the DATA key). The reflectance curve can then be transmitted via the RS232 or recorded on tape (TAPE WRITE or REWRITE) and it will be double precision.

The same sequence can be used to return the original (unmodified) data or reference curves from their registers to accessible memory. This is useful if the operator wanted to view the curves (DATA 1, REF 1, DATA 2, or REF 2) prior to recording on tape or transmitting. The ratio, data and reference curves can be recorded or transmitted from the display registers through the OUTPUT keyboard but these registers are single precision, not double precision.

CURVE MODIFICATION FUNCTIONS

Five functions are provided on the FORMAT keyboard that allow the operator to expand, compress or offset any of the six curves that can be loaded into the display stack. The basic sequence is to define the curve modifications and then press the key (such as DATA 2) calling out the curve that the modifications apply to. When the curve is selected, it is also loaded into the display stack. It is important to remember that these modifications are only affecting the curves in the display stack and the data in our six storage registers has not been corrupted.

5.25 2X 1/2X (5): This multiplies or divides the curve by factors of two. Up to three sequential factors can be used giving a total range of 1/8X, 1/4X, 1/2X, 1X, 2X, 4X, 8X. This function can scale data, reference or reflectance curves either up or down.

5.26 +/-5% (6): This key scales the curve up or down by 5% each time up to a maximum of 95%. The percentage function affects only the data and reference curves, not the reflectance curves.

These binary and percentage scale factors may be applied to both the data and reference curves to allow the operator to optimize the curve size for display, printout or plot purposes. The left display prompts the operator in use of these functions showing the direction (+/-), while the factor or percentage changes are indicated in the right display.

5.27 OFFSET (2): The OFFSET key is provided to shift data, reference or reflectance curves without changing their scale. Its use is to separate two curves that overlay so closely as to be otherwise difficult to interpret visually. Each OFFSET step represents 10 units.

5.28 UP/DOWN (1): This controls the direction of the three previous modification keys (2X 1/2X, +/-5%, OFFSET). The default mode is the positive direction and are switched to the negative direction with the UP/DOWN key. Pressing this key repeatedly will toggle the direction between plus and minus each time.

5.29 AUTOSCALE (3): The AUTOSCALE applied to the data or reference curves (not the reflectance curve) automatically scales the curve up to the maximum that can be displayed (with the scaling in binary factors.) This allows the operator to

get the greatest visual resolution although it does make amplitude comparisons of multiple curves more difficult.

KEYBOARD LEVEL FOUR (OUTPUT)

5.30 DUAL SCOPE (F): This function provides a display of two spectral curves (or reflectance curves) simultaneously. The function actually outputs the two curves alternately but the output trigger signal is timed so that the oscilloscope, used in a single trace (not dual trace) mode, shows both curves. The first two curves in the display stack will be shown. The display stack is incremented by using the SCOPE key described below. For example, if there were three curves in the display stock, the DUAL SCOPE would show curves one and two; if the SCOPE KEY were pressed and then the DUAL SCOPE key pressed again, curves two and three would be shown.

5.301 SCOPE (E): The SCOPE key serves as the means for incrementing the stack which shifts the top curve to the bottom making the next curve the one that can be displayed or output. The rotation is continuous so that if the stack had three curves, pushing the SCOPE key three times would return the stack to the original order.

The display identifies when the operator is attempting to overfill the stack. For the three curve stack, it flashes F3 alternately on the right and left display if the operator attempts to enter a fourth curve. With the single display register, F1 flashes alternately on the two displays. The display also indicates the curve selected for display showing 01, 02, or 03 for single curves and 12, 23 or 31 in the dual scope mode identifying both curves.

5.31 DISPLAY: The DISPLAY key sets up the internal four digit LED display to show the scan parameters and spectral data (from operator accessible memory.) The spectrum in memory is the last scan or the last data block read off the tape.

The display can show a single memory location (left display) and amplitude (right display). Each time the DISPLAY key is pressed, the next memory location and value are displayed.

There is also a fast or continuous display mode. If the DISPLAY key is depressed, let up, and then quickly depressed again and held down, the display will step through the operator accessible memory. At each step, it will show the memory location on the left, the amplitude on the right.

As soon as the operator releases the key, this fast access will stop. The single increment access or continuous access may be reinitiated or another function initiated.

The display format is covered in the table below:

ADDRESS (LEFT DISPLAY)	ALTERNATE OPERATION NOTES	DATA DISPLAYED(STANDARD INFORMATIONFOR UNMODIFIED SCAN FROM ACCESSIBLE MEMORY) (RIGHT DISPLAY)
FE	A	A9: Parity check for data integrity
FF	A	A9
0.D		Peak amplitude; range 00-FF hexadecimal
1.D		Integrate time; range 01-64 decimal
2.D		Month (decimal)
3.D		Day (decimal)
4.D		Year (decimal)
5.D		Hour (decimal)
6.D		Minute (decimal); rollover to hours at 60
7.D		Second (decimal); rollover to min. at 60
8.D		ID #, most significant pair
9.D		ID #, least significant pair
A.D		Number of scans averaged; 01-08
B.D		A0=Autorange; 00=Manual
C.D		01=Sequenced operation; 00=Non-sequenced
D.D		01=VIS/PIR; OO=UV
E.D	A	00
F.D	A	00
00	A	A9: Parity check for data integrity
01	A	A9
02		Amplitude, channel 02, range 00 to FF hex
03		Amplitude, #03; OO-FF hex=0-255
.		Amplitude shown for each additional channel
.		from 03 to FD
.		
FD		Amplitude, channel FD (decimal number 253)
FE		Repeats sequence started above
FF		Display will continue to cycle through

[A] ALTERNATE OPERATING MODE: The display information listed below replaces the standard display information for the address listed when the data block is taken from the FORMAT or OUTPUT keyboards where the data may have been modified.

FE Scale Factor: The left bit shows the sign: 8 for divide, 0 for multiply. The right bit shows the factor which is 0, (indicating no modification), 2, 4, or 8. Thus 84 indicates that the amplitude is divided by two or at 1/2 original.

FF Offset: The offset display represents in hexadecimal the eight bit binary number describing the offset. The eight bit indicates the direction of the offset with 0 indicating positive and 1 negative. The first seven bits indicate the magnitude of the offset from 10 to 90 decimal equivalent. So a negative 50 offset would have a binary code of 10110010 and would display as B2 (-2).

E.D \ E.D and F.D show the former ID# of the curve (before transfer to
F.D / the FORMAT keyboard) so that the old ID# can be traced.

00 EE=Normalized with AUTOSCALE key; 00=Non-normalized

01 +/-5%: Shows the modifications as done for the offset function with sign and percent change displayed as the hexadecimal conversion of the binary code.

5.32 CHANNEL # (B): This function allows the operator to specify the starting location for the DISPLAY function. After this starting location has been entered, it will remain the starting location until changed (with this same function) or until the controller is reset.

When the CHANNEL # key is pressed, the preset starting location for the display mode will appear flashing in the right displays (default location is 'FE'). A new starting location is then set by entering two hexadecimal digits. This number will remain in right display for a short period of time and then be shifted into the left display, at the time '--' will appear in the right display indicating that another function may be entered. At this point, you would press the DISPLAY key since the original intent was to select a starting location for the display. If any other key is pressed, the starting location for the display will be lost.

To get starting point as one of header bytes, OD to FD is entered and then channel # key is depressed. This will put a period between the channel # which has already moved to left display.

5.33 FIND ID # (D): A convenience for locating a specific data block, this function searches for Identification Number entered by the operator. When the FIND ID # key is depressed, the right display will blank for a brief period and then both display pairs will show the last ID# written on the tape as a reference for the operator. The operator then must make a four digit ID number entry to specify the data block to be found. The system will always interpret the next four keystrokes as entering this identification number. Once entered, the ID number will flash on the displays showing that an operator action is needed. The operator must again press the FIND ID # key to initiate the search. The operator may abort the search after entering the number by pressing another function key or a keyboard level select key.

When the search is run, the system will run forward on the tape until it finds the entered number, reaches the end of the tape or finds an error on the tape. The system will not rewind to search the full tape; that must be done manually. If the system stops on an error in a data block, the operator can use the Fast Forward function to move past the defective block. While the search is running, the identification number for each sequential data block is shown on the display**.**

5.34 X-Y PLOT (7): An X/Y recorder can be directly run by the CE500 to provide spectral curves or spectral ratios. The curve that will be plotted when implementing this function is the top curve in the display register.

When the X-Y PLOT key is pressed, the plotter output will go to the zero start position and will hold there for approximately two seconds to give the operator time to insert a pen and lower it so that the plotter is ready. (For running multiple curves, this also allows for changing pen colors.) The plot is run after the two second delay. This function can be aborted only by pushing the OUTPUT (0) key.

5.35 PRINT DATA (6): A complete printout of scan parameters and the value at each spectral band is printed with this command. The scan printed will be from the top of the display stack. The printout and explanation is located in the appendix.

5.36 PRINT CURVE (5): This function also prints the scan parameters in the same manner as the PRINT DATA function. However, rather than printing in tabular form the value for each spectral band, it prints curves representing each spectrum or ratio in the display stack. Unlike the above function, the PRINT CURVE function will print the parameters and the curves for one, two or three curves and will print all curves that have been loaded in the display stack.

The resolution is close to that achieved with an X/Y plotter, although multiple curve printouts do not have the advantage of different pen colors. Details on this printout and a sample is contained in section the appendix.

The parameters will be listed for each curve even if three are printed. For reflectance curves, the parameters will be listed for the data curve and for the reference curve against which the reflectance curve was taken. Therefore, if the display stack held a data curve, a reference curve and a reflectance curve of the two, the parameters would be listed for the data curve and the reference curve and then would be repeated for both of those to show the two components of the reflectance curve. The parameters are listed in order for the curve in the display register stack.

5.37 RS232C (2): This function transmits via the RS232 port to an external micro-computer, data from the top of the display stack which could be any of the DATA, REF or RATIO registers. The data transmitted is single precision (8 bit)

in the display stack, verses double precision (16 bit) as contained in user 'accessible memory', which is transmitted using the RS232 on keyboard level one.

5.38 TAPE WRITE (3): This function is identical to the RS232 explained in 5.37 except that the information is written to tape.

CHAPTER 6

PROMPTS AND ERROR CODES

6.0 DISPLAY FACTS: The CE500 has a four digit LED display that, for most display purposes, actually functions as a pair of two digit LED displays. Due to the limited number of segments the LED's will display the digits accordingly.

-hexadecimal code consist of the digits 0-9 and letters A-F.
-digits 0-9 and letters A, C and F are viewed as themselves.
-letter 'B' will be displayed as '-' so that it will not be confused with the number '8'.
-letter 'D' is not displayed; there will be a blank space in its place as not to confuse it with the number '0'.

The CE500 uses five basic types of information display and operator prompts.

6.1 OPERATOR PROMPTS: There are two basic operator prompts.

-a steady '--' indication in the right display pair; this informs the operator that the system is ready to accept a new command.

-a flashing '--' on the right display indicates a specific type of operator entry is required to perform an action already initiated. The flashing prompt occurs on a number of occasions as listed in the descriptions of the individual functions in Chapter 5. Examples are the ID number entry required in the FIND ID# or in the TAPE READ or REREAD or the time or data entries required for those functions.

-flashing of all four digits in the LED display indicate data entry is required for an action already initiated. As an example, entry of an ID# after the operator has started the TAPE WRITE command.

6.2 STATUS: The function status display shows on the left display pair, the key location of the function. This display is retained only for a short period after the function has been selected. The key location will include the keyboard level and the key position. For example, if the function PRINT CURVE were selected, the display would show '45' indicating the fourth keyboard level (OUTPUT) and key 5. For the keyboard level selection keys (DATA, SETUP, FORMAT, and OUTPUT) the display shows the keyboard level and a decimal point followed by the key number. This is to differentiate it from operating functions. Selection of FORMAT, for example, will give an indication of 3.4 on the left display pair for keyboard level 3, hexadecimal key number 4.

6.3 DATA: The data display allows the operator to review the values in the user accessible memory. This display mode uses both display pairs showing the

memory location in the left pair and the value in the right pair. The organization of the data display (memory locations) is shown in a table in paragraph 5.31.

6.4 SCAN SUMMARY: The fifth display type provides the operator with information on the integration time and peak signal amplitude. This information is displayed at the completion of each spectral scan. The right two digits show the actual integration time in 60th's of a second. This is a direct decimal readout rather than a hexadecimal code to make it easier for the operator to interpret. The readings range from 01 for 1/60 second to 64 for 64/60 second. This code will be displayed for about two seconds and will then be replaced by '--', the prompt indicating that the system is ready to perform another function. The left two digits show the highest signal amplitude for any channel for the spectral scan. This allows the operator to see the peak level that was acquired and will be recorded. The range is from OO to FF giving the value of the eight most significant bits (with a decimal equivalent of 0 to 255 levels). The peak signal remains displayed until a new function is initiated.

6.5 ERROR CODES: Error codes are used to indicate specific system operating problems so that the operator can correct the situation.

E1: The data block lead-in was not reached in the required amount of time (within the time allowed in the operating system), or there was no data present.

E2: The data block lead-in was incorrect or it was passed and therefore they system read data as lead-in and interpreted it as being incorrect.

E3: No data was present. This indication implies that the lead-in was correct but data not present soon enough or not enough data was present.

EE: The data format analysis (automatically run to assure the data integrity) was negative indicating that the data was improperly recorded or incorrectly read.

FO: Not actually an error code, the FO indicates that the system is in a read loop reading data from the tape. Any function key can be pressed to exit the read loop.

CA55: No tape installed in tape deck, or the tape is installed improperly.

FFFF: A flashing of 'FF' in the display indicates end of tape.

LOWPOWER: When this condition occurs, '5555' will flash on the display followed by '4444', '3333', '2222', '1111', '0000'. The display will then show two periods.

A limited number of operations may be performed by overriding this low voltage lockout. This is done by depressing the DATA key. Two bars ('BB') will then appear in the right display and another operation may be implemented. It is suggested that only a limited number of operations be attempted. Most batteries have a certain capacity to

recover if the load is removed for a period of time. If there is not another power source available, it is possible to turn off the unit, let the batteries recover, and again use it for a short period of time.

"F3" (flashing): you have attempted to enter too many curves into the display stack. The maximum number of curves is three.

CHAPTER 7

OPERATING SEQUENCE

7.1 The operating sequence consists of several distinct steps. The four level keyboard will typically follow this four step sequence:

1. Perform scan SETUP mode on second level keyboard
2. Perform SCAN sequence using keyboard level one
3. FORMAT of spectra or ratios for optimum display
4. Enter keyboard level four to OUTPUT the data

7.2 The basic scan function runs one scan sequence with automatic integration time and holding of the results in operator accessible memory prior to writing it on tape. The SETUP function allows the operator to modify this sequence by selecting the SCAN AVG mode, the Sequence mode, the SCAN WRITE mode, or to set a manual integration time (which can be used in conjunction with the other three modes). The SETUP also allows the operator to preset the UV or VISIBLE definition for the spectral detector head so that the parameter printouts will be properly labeled. The date and time are also entered during the SETUP. The date and time must be entered before a scan is performed or it will not be recorded in the header information.

If the operating sequence defined in the SETUP mode retains the manual operation, the operator would go next to the DATA keyboard and hit the SCAN key to run the defined sequence. If the scan sequence, or scan- write operation was defined in the setup, the function will run directly from the SETUP keyboard. If a scan was run, the operator has a series of options including defining the spectrum as DATA 1 or 2, or as Reference 1 or 2. These names are used later when the display or output format is defined.

With the spectrum in user accessible memory, the operator can write to the next data block on tape with the TAPE WRITE function or to the previous data block with REWRITE. The spectrum can be output from this keyboard with the RS232 key. Any other action ignores the most recent spectral scan which is stored in user accessible memory, the spectrum will only be lost if some other spectrum is loaded by reading from the tape, taking a new scan, or if the unit is reset.

Other actions available from the DATA keyboard allow for reading a data block from tape into user accessible memory (TAPE READ, or REREAD) or are for handling the tape itself (REWIND or FAST Forward).

The FORMAT keyboard would typically be used after data and reference scans were stored from the DATA keyboard. The FORMAT function takes the ratio of the two pairs of spectra (DATA 1 to REF 1 and DATA 2 to REF 2). The operator has the option of amplifying or attenuating the spectral amplitude and of shifting the curves up or down. The display stack of up to three curves is also loaded with this keyboard prior to moving to the OUTPUT keyboard.

OUTPUT presents the operator with options for displaying data (SCOPE, DUAL SCOPE, DISPLAY), for producing a hardcopy output (PRINT CURVE, PRINT DATA, X-Y PLOT), for transmitting data (RS232), or for writing the curves from the display stack on tape (TAPE WRITE). The other functions on this keyboard include FIND ID# for searching out a specific data block on tape, and CHANNEL # which is used to select the starting channel for the DISPLAY function showing the amplitude of each given channel on the built-in LEDs.

7.3 Several typical operating sequences are shown below. For each sequence the purpose of the sequence is given followed by the keystroke series to implement the routine. All of the sequences assume that the system is turned on and set up following the instructions in Chapters 3, 4, 5.

7.4 This routine will take two scans, one reference and one data. We will assume that we have inserted a tape that is partly recorded and rewound. We will review each spectrum prior to recording it and will also produce a printout of the curves. The time and date is assumed to be 10:30 AM on 1/1/86.

SETUP	Puts us into the second keyboard
DATE SET	Prepares the system for entering the date
0-1-0-1-8-7	This series of entries completes the data entry
TIME SET	Prepares the system to enter the time
1-0-3-0-5-0	Sets 10:30 and 50 seconds at the TIME SET entry
TIME SET	Actually enters time preset above
NEXT FILE	Finds the next empty tape location
DATA	Shifts to the first keyboard
SCAN	Initiates the scan sequence (assume white ref.)
REF 1	Puts spectrum in REF 1 register
TAPE WRITE	Sets up to record scan to next tape data block
1-0-0-1	Four digit ID number to be recorded with spectrum
TAPE WRITE	Writes spectrum and parameters to the tape
SCAN	Initiates scan (assume scan of test sample)
DATA 1	Puts spectrum in DATA 1 register
TAPE WRITE\	
1-0-0-2	>Same record sequence as above
TAPE WRITE/	
FORMAT	Switches to the third keyboard
AUTO SCALE	Scales scan to be identified to highest resolution

REF 1	Applies AUTO-SCALE function to REF 1 and loads it into the display stack
OFFSET	Prepares to offset scan to be identified
UP DOWN	Switches offset to negative direction
OFFSET	Sets offset to 10 units (-10)
OFFSET	Increases offset to -20
DATA 1	Applies offset to DATA 1 and loads it into the display stack
RATIO 1	Loads the reflectance curve (Data 1 and Ref 1) into display stack
OUTPUT	Switches to the fourth keyboard
DUAL SCOPE	Displays Ref 1 and Data 1, the first two curves loaded into the display stack
SCOPE	Switches to single scope display and increments the display stack to the next curve
DUAL SCOPE	Returns to dual display but now displays REF and RATIO since we incremented the stack
PRINT CURVE	Prints parameters and all three curves in the display stack

7.5 In this sample routine, we will take a series of scans, record them on new tape, then read the data blocks from the tape and transmit them on the RS232 output.

SETUP	Enters the second keyboard
SCAN/WRITE	Defines the write-after-scan sequence and shows (flashing) the ID# which is automatically sequenced.
SCAN/WRITE	Initiates the scan sequence followed by recording the spectrum and parameters on tape
SCAN/WRITE	\
SCAN/WRITE	>Acquires and records three more spectra
SCAN/WRITE	/
DATA	Enters the first keyboard
REWIND	Rewinds the tape
TAPE READ	Reads the next data block from the tape into accessible memory
RS232	Transmits data block on the RS232 output
TAPE READ	\
RS232 \	
TAPE READ \	
RS232	>Repeats read/transmit for next 3 spectra
TAPE READ /	
RS232	/

7.6 The final sample operating sequence takes one scan and demonstrates

displaying the amplitude for each accessible memory location on the built-in LED display.

SCAN	Acquires the spectrum
OUTPUT	Enters fourth keyboard
CHANNEL #	Allow setting the starting channel for the display function (to change the preset start from FE)
0-2	Sets 02 as the starting display address: 02 is the start of the spectrum following parameter data
DISPLAY	Displays 02, the address in the left display pair and the amplitude in the right pair
DISPLAY	Advances to the next address, 03, giving the amplitude in the right display pair
DISPLAY/DISPLAY	(Hold) Pressing the DISPLAY key again immediately after releasing it and holding it depressed will give a sequential display of each consecutive address and amplitude

CHAPTER 8

HARDCOPY OUTPUTS

This chapter contains samples of the two types of printout available with the system: PRINT DATA output, and PRINT CURVE output. The third hardcopy output, X/Y PLOT is not shown, but is contained in the data sheet. The X/Y plot does not contain scan parameter information contained in the printouts.

8.1 PARAMETER LISTING: Both printouts start with a listing of the scan parameters showing first the parameter and then the value for each curve. This allows the operator to study factors affecting scan data as well as the data itself. The parameters are shown in the samples in this chapter.

REFL._CURVE_PAIR: This identifies the curve position in the display stack and will be an A, B, or C. If the curve is a ratio, the two curves used will be listed in the parameters for the ratio even if the same curves are also shown separately.

MAXIMUM_SIGNAL: Shows the peak signal amplitude on a scale of 0 to 256.

INTEGRATION_TIME: Lists time in sixtieths of a second.

DATE-MON/DAY/YR: Lists the date in the format entered by the operator. If no date was entered (or if the system is not equipped with the date feature, it will show 00/00/00.

TIME-HR:MIN:SEC: Lists the time at the start of the scan.

IDENTIFICATION_NUMBER: Lists the ID number entered by the operator (or automatically designed by the system in some modes.)

#_OF_SCANS_AVG'D: Lists the number of scans averaged for the spectra curve shown.

AUTORANGING_MODE: Indicates YES or NO.

SEQUENCING_MODE: Also a YES or NO indication.

CAMERA_SPECTRUM: Shows VIS/PIR unless the operator has selected the UV code on the keyboard prior to the scan. This feature does not functionally change the data but the listing alerts the person reviewing the listing and also can be picked up in the transmitted data to appropriately key the analysis program as to the spectral range covered.

NORMALIZE_TO_MAX: Lists YES or NO indicating whether or not the AUTO SCALE function was used. Not used with the reflectance curves.

PERCENTAGE_(+OR-): Indicates the percentage change with direction of manually scaled data. The range is +/-5 to 95% as listed earlier under the function description of the +/-5% key. Not used with the reflectance curves.

MULTIPLY_FACTOR: Shows the factor used to manually scale the data from 1/8X to 8X. A "+" indicates a multiplication and "-" indicates a divide by the digit that follows it.

OFFSET_BY_(+OR-): Shows the manual offset and direction. The offset is in units of 10 and is equivalent to the units used in the PRINT DATA amplitude listing.

8.2 PRINT DATA: For this function, only one spectrum will be listed. Following the parameters, this function lists each spectral channel number, its wavelength and its amplitude.

Column 1 is the channel number, from at 002 through 253.

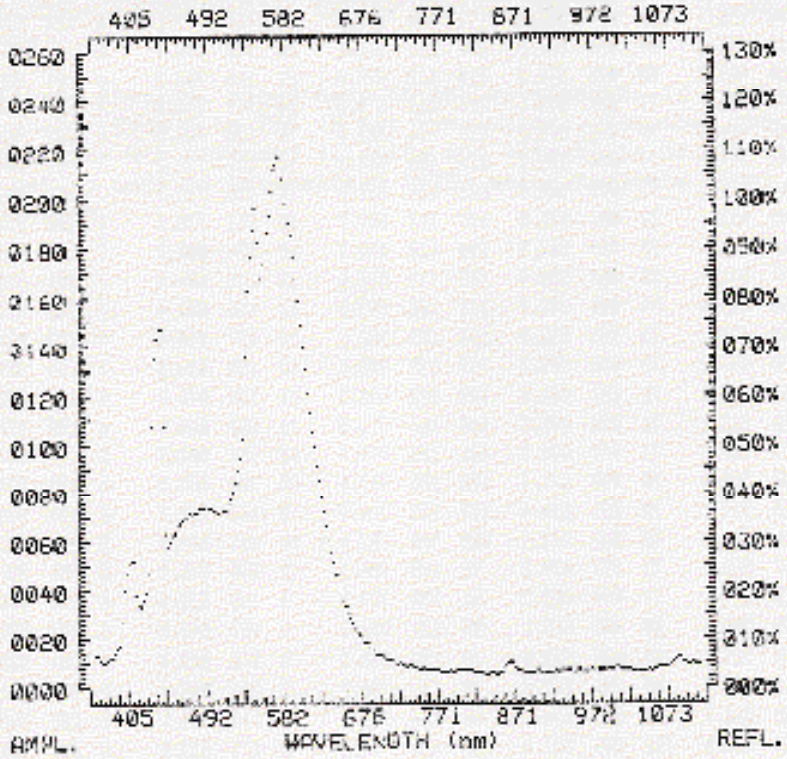
The wavelength is shown next to the channel number. It is expressed in nanometers.

The amplitude listing, shown next to the wavelength, is a three digit decimal number from 0 to 256 (8 bit resolution). Remember that any function on the 4th keyboard (display and output) is only 8 bit. All data stored to tape or transmitted RS232 using keyboard level one is 12 bit resolution.

REFL. CURVE PAIR	A
MAXIMUN SIGNAL	217
INTEGRATION TIME	28
DATE- MON/DAY/YR	00/00/00
TIME- HR:MIN:SEC	00:00:16
IDENTIFICATION #	0000
# OF SCANS AVG'D	1
AUTORANGING MODE	YES
SEQUENCING MODE	NO
CAMERA SPECTRUM	VIS/PIR
NORMALIZE TO MAX	YES
PERCENTAGE(+OR-)	-41%
MULTIPLY FACTOR	1/9
OFFSET BY (+OR-)	-41

#	nm.	AMPL	#	nm.	AMPL	#	nm.	AMPL	#	nm.	AMPL	#	nm.	AMPL	#	nm.	AMPL	#	nm.	AMPL
002	368.4	13	038	463.7	58	074	564.8	193	110	670.2	24	146	777.1	6	182	890.1	6	218	1003.6	8
003	371.8	13	039	466.5	63	075	567.6	203	111	673.1	22	147	780.1	6	183	893.3	6	219	1006.7	8
004	373.6	11	040	469.3	69	076	570.5	212	112	676.0	21	148	783.2	6	184	896.4	6	220	1009.9	7
005	376.2	10	041	472.1	71	077	573.4	214	113	679.0	20	149	786.2	7	185	899.6	6	221	1013.0	7
006	378.0	10	042	474.9	72	078	576.2	217	114	681.9	18	150	789.2	6	186	902.8	7	222	1016.2	7
007	381.4	11	043	477.7	71	079	579.1	216	115	684.9	18	151	792.2	6	187	905.9	6	223	1019.3	7
008	384.0	12	044	480.5	71	080	582.0	209	116	687.8	16	152	795.3	7	188	909.1	6	224	1022.4	7
009	386.5	12	045	483.3	73	081	585.0	199	117	690.7	15	153	798.3	7	189	912.3	6	225	1025.6	6
010	389.2	14	046	486.1	73	082	587.9	190	118	693.7	15	154	801.3	7	190	915.4	6	226	1028.7	6
011	391.7	16	047	488.9	73	083	590.9	185	119	696.6	13	155	804.3	7	191	918.6	6	227	1031.9	5
012	394.3	17	048	491.6	74	084	593.8	176	120	699.6	13	156	807.4	7	192	921.7	6	228	1035.0	6
013	396.9	27	049	494.4	73	085	596.7	168	121	702.5	13	157	810.4	7	193	924.9	6	229	1038.2	6
014	399.5	48	050	497.2	73	086	599.7	159	122	705.5	12	158	813.6	7	194	928.0	7	230	1041.3	6
015	402.1	47	051	500.0	72	087	602.6	149	123	708.5	11	159	816.6	6	195	931.2	6	231	1044.5	6
016	404.7	51	052	502.8	71	088	605.5	140	124	711.5	11	160	820.1	6	196	934.3	7	232	1047.6	7
017	407.3	52	053	505.6	71	089	608.5	131	125	714.4	11	161	823.3	6	197	937.5	6	233	1050.8	6
018	409.9	52	054	508.4	78	090	611.4	121	126	717.4	12	162	826.5	6	198	940.6	7	234	1053.9	7
019	412.5	38	055	511.2	72	091	614.4	113	127	720.4	9	163	829.7	6	199	943.8	7	235	1057.1	7
020	415.1	34	056	514.0	72	092	617.3	105	128	723.4	10	164	832.9	5	200	946.9	6	236	1060.2	8
021	417.7	33	057	516.8	75	093	620.2	99	129	726.3	9	165	836.1	5	201	950.1	6	237	1063.4	8
022	420.3	36	058	519.6	77	094	623.2	91	130	729.3	9	166	839.3	6	202	953.2	6	238	1066.5	8
023	422.8	39	059	522.4	80	095	626.1	85	131	732.2	9	167	842.5	5	203	956.4	7	239	1069.7	8
024	425.4	47	060	525.2	84	096	629.0	78	132	735.3	9	168	845.7	6	204	959.5	6	240	1072.8	8
025	428.0	107	061	527.9	85	097	632.0	72	133	738.2	9	169	848.8	5	205	962.7	6	241	1075.9	9
026	430.6	135	062	530.7	94	098	634.9	66	134	741.2	8	170	852.0	6	206	965.8	6	242	1079.1	10
027	433.2	143	063	533.5	102	099	637.9	60	135	744.2	8	171	855.2	6	207	969.0	6	243	1082.2	11
028	435.8	147	064	536.3	136	100	640.8	55	136	747.1	7	172	858.4	8	208	972.1	7	244	1085.4	12
029	438.5	147	065	539.1	163	101	643.7	51	137	750.1	7	173	861.5	9	209	975.3	6	245	1088.5	12
030	441.1	107	066	541.9	175	102	646.7	46	138	753.1	8	174	864.7	10	210	978.4	6	246	1091.7	10
031	443.7	63	067	544.7	187	103	649.6	41	139	756.1	7	175	867.9	11	211	981.5	7	247	1094.8	10
032	446.3	50	068	547.5	195	104	652.5	38	140	759.0	7	176	871.1	10	212	984.7	7	248	1098.0	9
033	449.0	50	069	550.4	199	105	655.5	35	141	762.0	7	177	874.2	8	213	987.8	7	249	1101.1	9
034	451.6	52	070	553.2	186	106	658.4	33	142	765.0	7	178	877.4	7	214	991.0	6	250	1104.3	10
035	454.2	53	071	556.1	172	107	661.4	30	143	768.0	7	179	880.6	7	215	994.1	7	251	1107.4	9
036	456.8	56	072	558.9	159	108	664.3	28	144	771.1	7	180	883.7	6	216	997.3	7	252	1110.6	10
037	459.4	57	073	561.9	145	109	667.2	26	145	774.1	6	181	886.9	6	217	1000.4	7	253	1113.7	9

REFL. CURVE PAIR	A
MAXIMUM SIGNAL	217
INTEGRATION TIME	06
DATE- MON/DAY/YR	00/00/00
TIME- HR:MIN:SEC	00:00:16
IDENTIFICATION #	0000
# OF SCANS AVG'D	1
AUTORANGING MODE	YES
SEQUENCING MODE	NO
CAMERA SPECTRUM	VIS/PIR
NORMALIZE TO MAX	YES
PERCENTAGE(+OR-)	-41%
MULTIPLY FACTOR	1/5
OFFSET BY (+OR-)	-41



8.3 PRINT CURVE: In this function, all curves in the display stack will print. The curve parameters will be in order (top to bottom of the display stack) and will be labeled A, B and C to differentiate each curve. Since reflectance curves will show the parameters for each component curve, it is possible for up to five sets of parameters to be listed: one for a data or reference curve and two for each of two reflectance curves.

Using the Data Manipulation feature, the operator can use the percentage, scaling and offset functions to optimize the curves and to control the vertical expansion of each. The curve print function takes some time to complete because the printer must make the full excursion to each end of the paper to put in the vertical reference marks. This is equivalent in time to printing a full line. Obviously scaling down the curve will reduce the printing time but will also affect the resolution.

The markings on the left side of the graph indicate the amplitude of the signal. This is the same number as column three using the print data command. The resolution is 8 bit or 256 full max.

The percentage figures on the right of the graph refer to the calculated reflectance curves.

On both the top and bottom of the graph is the wavelength in nanometers. This will vary with the different detectors selected on keyboard level two.

CHAPTER 9

DATA FORMATS

9.0 DATA FORMAT

The same data format is used in the internal tape data block and in the data block transmitted on the RS232C. The internal data block is not directly accessible to the user but an understanding of the output data organization is necessary to allow programming a remote computer to accept and interpret the spectral data.

Each output data word contains eight data bits plus a stop and a start bit or ten bits total. The start bit is 0 (HIGH) and the stop bit is 1 (LOW).

Each data block to be transmitted has 528 ten bit words with each word having a start and stop bit, described above, with an eight bit byte of actual data. These words are numbered 0 through 527 below indicating the sequence of the transmission. Once the RS232 key has been pressed, the 528 words are transmitted continuously until complete. Transmission is at 9600 baud. All 8 bit data is in hexadecimal or binary coded decimal form. There is no ASCII output from unit.

PLEASE REFER TO THE DISPLAY FORMAT TABLE IN CHAPTER 5, SECTION 5.301. The data contained in that table is relevant for the output format. The primary change is that the transmitted data has an additional byte for each spectral channel to give sixteen bit information rather than the eight bits shown in the display. The added byte comes as a separate series of least significant bytes. The comments from Section 5.301 all apply in defining the actual function of some of the channels, for example the first and last two channels of the 256 which have parameter information substituted for unusable amplitude data.

In the following discussion of data formatting, all numbers are assumed to be the base ten unless otherwise noted.

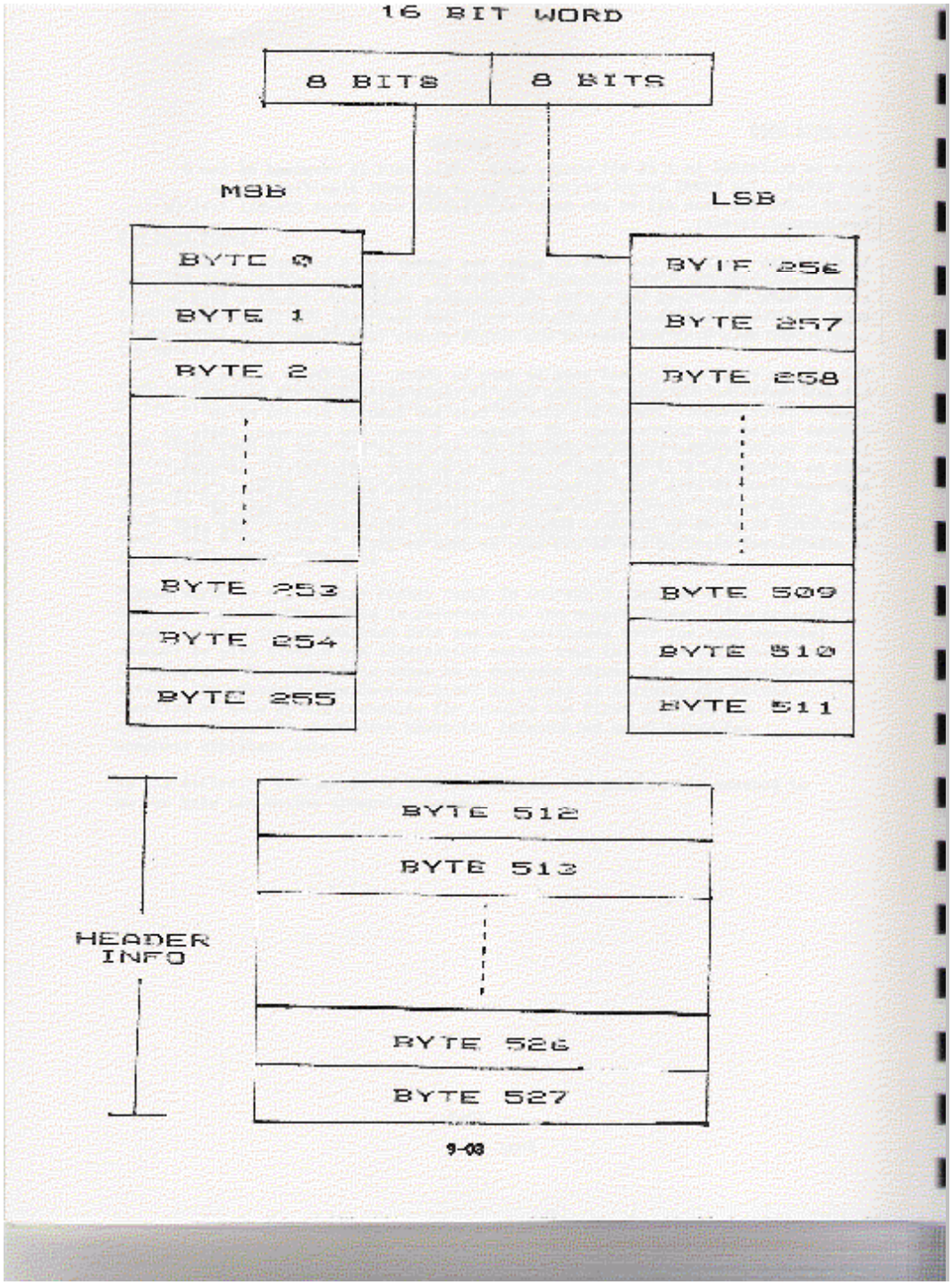
9.1 DATA WORD

Data is contained in a 16 bit binary word. This word is composed of two 8 bit bytes. The RS232 output transmits all of the most significant data bytes 0-255 and then all of the least significant data bytes 256-511 (all in hexadecimal format).

To build the entire 16 bit word of data, the proper two 8 bit bytes of data must be put together. For example: if byte 12 is the most significant 8 bits of data, then byte 268 is the corresponding least significant 8 bits of data. To locate the least significant data byte position, add 256 to most significant data byte position in the output format (see diagram).

The maximum range of a 16 bit word is zero to 65535. The SE590 uses a 12 bit A/D converter and when a single scan is taken only 12 of the 16 bits contain information. The 16 bit word of data may then be divided by 16 without losing any information. If, however, 8 scans are averaged, there is 15 bits which contain relevant information and

the 16 bit word of data can only be divided by 2 if no information is to be lost. Similarly, two scans averaged gives 13 bits (max divide by 8), four scans averaged gives 14 bits (max divide by 4). Also, if the most significant 8 bit byte of data is considered only (as in all data output except 1st keyboard RS232), the user is effectively dividing the 16 bit word of data by 256.



9.2 ZERO OFFSET

The method used to handle the data is of major significance to user. An offset of 1024 is added to the 16 bit data to preserve slightly negative data (instead of a sign bit). This offset is utilized in the scan averaging mode to statistically increase data resolution. The offset is also maintained with data as part of the output so that statistical improvements can be implemented externally by the user if desired.

This offset of 1024 must be subtracted after averaging is completed before any further data manipulations are used to modify data. An example would be: four scans to be averaged for one channel could have values of 992, 976, 1072 and 1088. The average for these four scans is 992+976+1072+1088 divided by 4 which equals 1032. The offset of 1024 is then subtracted and the average value of this channel is 8. If the same values of these four scans were not able to show a slightly negative value, the minimum value could only be zero, the values would be 0, 0, 48, 64 and the average would incorrectly be 28.

All 8 bit only data uses the most significant 8 bit byte and the least significant 8 bit byte should be assumed to be zero. In most cases, the 8 bit only data is displayed as 0 to 255 (the 16 bit number divided by 256) and the offset is 4 (1024 also divided by 256).

WORD	DESCRIPTION
0 - 255	Gives the most significant byte for all 256 spectral channels. Note that channels 0, 1, 254, and 255 actually contain parity check information or, under certain conditions as indicated in 5.11, parameter information.
256 – 511	Gives the least significant byte for each of the 256 channels from 0 to 255. Again, the first two and last two channels (256, 257, 510 and 511) are not valid. If the curve is being transmitted from the display stack as would be done if the curve were modified, there will be only eight bits (one byte) of data for each channel and this section will be set to zero. One exception exists. If the transmission is of a ratio curve, the reference curve used to generate the ratio is significant and the sixteen bytes of parameter data for that reference will appear from 272 to 287 in the same order as they appear in the display.
512-527	These bytes give the 16 bytes of parameter information in the identical format used for the display O.D to F.D addresses as listed in 5.301.

CONVERSION OF 16 BIT HEXIDECIMAL NUMBER TO BASE TEN NUMBER

HEXIDECIMAL DIGIT	BASE TEN EQUIVALENT
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
A	10
B	11
C	12
D	13
E	14
F	15

16 Bit Hexadecimal Number = BTE(1) BTE(2) BTE(3) BTE(4)

Most Significant 8 Bit Byte — Least Significant 8 Bit Byte

Where BTE (#) = Base Ten Equivalent of hexadecimal digit

Base Ten Equivalent of 16 Bit Hexadecimal Number = BTE (1)x4096 + BTE(2)x256 + BTE(3)x16 + BTE(4)

Where:

BTE(1) = Base Ten Equivalent of most significant hexadecimal digit of most significant 8 bit byte

BTE(2) = Base Ten Equivalent of least significant

hexadecimal digit of most significant 8
bit byte

BTE(3) = Base Ten Equivalent of most significant
hexadecimal digit of least significant 8
bit byte

BTE(4) = Base Ten Equivalent of least significant
hexadecimal digit of most significant 8
bit byte

Examples:

Convert 2C 5D(16 bit hex #) to base 10 equivalent
2x4096 + 12x256 + 5x16 + 13 = 11357

Convert OB BB
0x4096 + 11x256 + 11x16 + 8 = 3000

Convert AE FO
10x4096 + 14x256 + 15x16 + 0 = 44784

CHAPTER 10

OSCILLOSCOPE SETUP

The use of an oscilloscope to display the spectral curves has been mentioned in several earlier sections. This section provides some guidance on how it should typically be set up. The guidelines are general; there are some variations between oscilloscopes and the operator should adjust the instructions as needed.

The operator should connect the scope as described earlier. The right BNC connector on the CE500 rear panel connects to the external trigger input on the scope; the left BNC connector to the vertical input on the scope.

The oscilloscope should initially be set up with the time base at 2 milliseconds per division and the vertical deflection at 0.2 or 0.5V per division. It should be set for external trigger (for a positive going trigger pulse) and single channel with only the first vertical channel used. The triggering is usually easy to set-up because the trigger pulse is +5V.

The CE500 should be sending a display if the operator pressed the SCOPE output and there should be a waveform on the oscilloscope screen. The operator next should switch to the uncalibrated position for the time base to bring the full curve onto the scope face. This requires normally decreasing the sweep speed.

In the dual trace mode, the CE500 alternately outputs each of the two waveforms and a trigger pulse for each. On some scopes, there is a considerably extended sweep and a lack of ability to recognize a trigger pulse until the extended sweep is over. The extended sweep can usually be seen by shifting the trace to the left with the horizontal position knob. However, it is not directly possible to know the time span during which the scope will not accept a new trigger signal.

If the time delay is quite short, the DUAL SCOPE mode should appear much like the single scope mode with both traces showing apparently simultaneously. If the dead time is too long, the scope display may show only one trace and may flicker because it is actually picking up every other trigger (because the alternate triggers fall into a dead period on the scope). By adjusting the scope time base in an uncalibrated mode, it is generally possible for the operator to correct the display so that it displays both waveforms without flicker.

CHAPTER 11

THEMATIC MAPPER OPTION

This chapter describes the operation of the multi-band spectroradiometer simulation option. This chapter is required only for systems incorporating the simulation option.

This feature simulates a spectroradiometric output of the four thematic mapper (TM) spectral bands covered by the SE590 and its wideband spectral head (400-1100nm). These thematic mapper bands are as follows:

Band #1 - 450-520nm	Band #2 - 520-600nm
Band #3 - 630-690nm	Band #4 - 760-900nm

The computation of these outputs assumes a square wave filter response of each of the thematic mapper bands; this has been proven empirically to be a reasonable approximation.

The band number and a percent reflectance are the outputs of this function; these results are displayed on the built-in LED display of the SE590. An output of "1124" would indicate band 1, 124%. The operation is somewhat similar to the ratio mode of the system in that the results are based on the data curve RELATIVE to the sample curve. Unlike the ratio mode, both the data and reference curves are normalized as if they were taken at the same integration time. For the above example, "1124" means that the data curve had 124% of the energy of the reference curve in the 450-520nm band.

STEP-BY-STEP_INSTRUCTIONS

These instructions assume that the operator is familiar with the keyboard structure of the SE590 and with routine operations such as taking spectra and storing them as reference or data curves. If necessary, the operator should refer back to those sections of the instruction manual. Data and reference curves are taken in the usual manner. The following specific steps implement the multiband spectroradiometer simulation feature:

DESCRIPTION_OF_TASK	KEY_USED
1) Enter a data curve	DATA 1 (Key "F", Keyboard 1)
2) Enter reference curve	REF 1 (Key "B", Keyboard 1)
3) Enter fourth keyboard	0
4) Implementation spectroradiometric simulation	9 (Keyboard 4)
5) Rotate to next band	9 (Increments each time)
6) Exit to other functions	0, 4, 8 or C

Four digits will appear in the front panel LED displays in steps 4 and 5 above. The left digit will be 1, 2, 3 or 4. This number indicates which band is being displayed. The right three

digits show the spectroradiometric output in percent. The range of this number is from 000% to 199%.

By successively pressing the "9" key, each band will be displayed. The display will return to BAND 1 (the next time the "9" key is pressed) after BAND 4 is displayed. All four main keyboard call up keys ("0", "4", "8", and "C") are available to exit this function.

CHAPTER 12

COMMUNICATIONS OPTION

These instructions describe the operation of the communication option. This chapter is required only for systems incorporating the communication option.

The feature adds an RS232 receive capability and therefore bi-directional communication between other computers/dataloggers and the SE590.

The RS232 information discussed in the main body of the operating manual is still relevant and should be referred to if necessary. The back panel connector that implements the bi-directional RS232 is a subminiature stereo phone jack. This is a three conductor jack. The connections to the mating subminiature stereo phone plug are as follows:

SE590 Stereo Phone_Plug	SE590 Function	Host Communication Device_Function
Tip	Transmit	Receive
Ring	Receive	Transmit
Sleeve	Ground	Ground

This option is implemented by the "1" key from the fourth keyboard. When this key is depressed, the left display pair will show "41" and the flashing right display pair will show "02", "D2", or "03". The left pair "41" indicates the communication option is being implemented. The flashing right pair indicates that the option is in the setup mode and the number contained in the flashing display shows the presently set output parameters. "03" represents write to tape, "02" is an RS232 output, and "D2" is an RS232 output with a display of the identification number (ID#) of each scan operation. The set output can be changed by pressing the "2", "3", or "A" keys. On the fourth keyboard, these keys are labeled appropriately to their function. Key "2" is "RS232", key "3" is "TAPE WRITE", and key "A" is the ID# display during RS232 feature on or off. When this feature is turned on, the left display pair will momentarily show "DA" and then return to "41". When turned off, "OA" will momentarily show in the left display pair and then return to "41". This feature will remain set even though it is not shown when a write to tape output is setup.

The "slave" mode of the communication option can be started from the setup mode by pressing "1" key. A non-flashing ".0.2" will appear in the right display pair. The system is now waiting to receive an RS232 command. An ASCII "S" (hexadecimal $53) received from the host will initiate a spectral scan and data output. This data output will be either a write to tape or an RS232 transmission with or without ID# display as previously chosen in the setup mode. (NOTE: The RS232 output is described in sections 5.301 and 9.0 of the SE590 Operating Manual. As described in these sections, this output

is 528 words transmitted continuously until complete. There is no handshake, hardware or software to interrupt this transmission. If a byte other than "S" is received, a single hexadecimal byte "F2" will be transmitted via RS232. This byte indicates that an incorrect command code was received. The system will reset itself and wait for a proper code. Command codes may be sent at any time, but only one additional code will be acted upon. In the "slave" mode, the display pair indications during the spectral scan are the same as in all other options and modes. During the RS232 transmission of the data, the displays will show "41" (left pr) and flickering digits (right pr). The system will then return to waiting to receive an RS232 command (a "41" and ".0.2" display). All of the scan setup parameters implemented from the second keyboard do apply to the "slave" mode. If a SCOPE output is chosen, not only will one second be used to display to an oscilloscope, the spectrum's maximum amplitude and integration time will be shown on the display pairs. This will occur immediately after the scan is taken. If the ID# display during RS232 was preset, the ID# will next appear on the display pairs for two-thirds of a second -- immediately before the RS232 data transmission. If the display pair indications of the scan parameters and/or ID# is not needed, the total cycle time of a "slave" mode with RS232 output will be proportionately decreased. If the tape output is preset, the scan parameters and ID# will be displayed as part of the write to tape with no time penalty. To escape from the "slave" mode operation, press the "C" key. This will put "1.C" and "--"(BB) onto the display pairs and return operation to the first keyboard.

The communication option also enables the SCAN/WRITE and SEQ functions from the second keyboard to output data via RS232. When power is turned on, the system will initialize in the tape write output mode and these functions will operate exactly as before. After presetting RS232 output from the communication option setup mode, all four function keyboard keys may be used to escape from "slave" mode implementation and perform other operations. If SCAN/WRITE or SEQ is then implemented, it will output the scan data via RS232 similarly to the "slave"mode described above. The exception is that during the data transmission the left display pair will read "1E" instead of "41" to differentiate it from a "slave" mode operation. Also, all RS232 output operations, including the "slave" mode, treat the ID# differently. Since the total number of operations are not limited by tape size, all four digits in the ID# are used in the sequential numbering. Therefore, all digits in an ID# must <u>not</u> include any letters ($A through $F). All four digits are relevant in the SCAN/WRITE ID#. In the SEQ and "slave" mode only the most significant two digits are relevant since the least significant two digits are always started at "01". (The first ID# generated in the SCAN/WRITE, SEQ and "slave" mode after power-on initialization is always
"0001". If a different ID# is desired it can be implemented as follows
without writing to tape. Open the tape deck door or remove tape from tape deck. Select TAPE WRITE on the first or fourth keyboards. Enter desired ID# as is requested in these functions. Try to write to tape. The "CA55" display will appear and the ID# will be entered.)

STEP-BY-STEP INSTRUCTIONS

These instructions assume that the operator is familiar with the keyboard structure of the SE590 and with routine operations such as setting up scan parameters and operating SCAN/WRITE and SEQ functions. If necessary, the operator should refer back to those sections of the Operating Manual.

Several operating sequences which show implementation of the Communication Option are shown below. The purpose of each sequence is given followed by the keystroke series to implement the routine. SEQUENCE A assumes that the system is turned on and set up following the instructions in sections 2.0, 3.0 and 4.0.

SEQUENCE A: The purpose of this sequence is to set scan to operate at 1/60th of a second manual integration time, set oscilloscope output to see scan parameters of maximum signal amplitude and integration time displayed on the LED display pairs, set to display ID# display during RS232 output, and setup to output RS232 in the "slave" mode of the Communication Option.

KEY USED	DESCRIPTION OF TASK
1) SETUP	Puts us into second keyboard
2) SCAN TIME	Prepares system to enter manual integration time
3) 0-1	Sets 1/60th second integration time
4) SCOPE	Sets oscilloscope output
5) OUTPUT	Puts us into fourth keyboard
6) Key "1" (KB#4)	Prepares system for Communication Option setup
7) RS232 (KB#4)	Sets RS232 output during scan-then-output modes
8) DISPLAY	Sets ID# display during RS232 output
9) Key "1" (KB#4)	Puts into "slave" mode-waiting for RS232 command code

SEQUENCE B: The purpose of this sequence is to operate in the SEQ mode at 2/60ths second integration time, RS232 output, no oscilloscope output to see scan parameters, no ID# display, and a 5 second delay between each scan. The system is assumed to be setup from SEQUENCE A above.

1) DATA	Escapes from "slave" mode & puts us into first keyboard
2) OUTPUT	Puts us into the fourth keyboard
3) Key "1" (KB#4)	Prepares system for Communication Option set up
4) DISPLAY	Resets for no ID# display during RS232 output
5) SETUP	Puts us into the second keyboard
6) NO SCOPE	Sets no oscilloscope output
7) SCAN TIME	Prepares system to enter manual integration time
8) 0-2	Sets 2/60ths second integration time
9) SEQ	Prepares system for SEQ mode setup
10) TIME SET	Prepares system for time delay between SEQ mode operations
11) 0-0-0-5	Enters 5 second delay
12) TIME SET	Sets 5 second delay
13) SEQ	Starts SEQ mode operation

SEQUENCE C: The purpose of this sequence is to operate in "slave" mode with tape output with autoranging integration time. The system is assumed to be set up from SEQUENCE B above.

1) DATA	Escapes from SEQ mode & puts us into the first keyboard
2) SETUP	Puts us into the second keyboard
3) AUTORANGE	Sets autoranging integration time feature
4) OUTPUT	Puts us into the fourth keyboard
5) Key "1" (KB#4)	Prepares system for Communication Option set up
6) TAPE WRITE (KB#4)	Sets tape write output during scan-then-output modes
7) Key "1" (KB#4)	Puts into "slave" mode-waiting for RS232 command code

CHAPTER 13

CALIBRATION CURVE OPTION

The spectroradiometric calibration procedure is used to obtain spectral light measurement in absolute light energy units. This is accomplished by using lamps that are traceable to NBS (National Bureau of Standards) light sources. These lamps have a listed light energy at specific wavelengths when run at calibrated constant current on a light bench. The SE590 system is run while looking at these lamps and the data is recorded. This data is then mathematically manipulated to derive constants that will generate the proper light energy levels as listed on the individual NBS lamps. These constants compensate for silicon detector response characteristics and performance differences that might exist between individual diodes.

A separate calibration curve is required for each accessory that is attached to the front of the CE390 detector.

Spectroradiometric Correction Factors

The list of numbers which you received are constants (correction factors), generated for each diode of the array or given area of the spectrum. These constants will convert the readings from the SE590 which are relative amplitude numbers, to the units of irradiance for the equation (micro-watts per cm squared per nanometer). See the equation supplied with the constants.

16 bit data (base 10) - 1024 x 'SI' constant / integration time (base 10)

- the 16 bit data is supplied on the tabular printout of the SE590. Select a diode number from 02 through FD hex, subtract the 1024 offset and multiply by the given constant for that particular diode and divide by the integration time.

The correction factors eliminate the inconsistencies of silicon detectors and optics and supply the effective light energy for the given points of the spectrum.

CHAPTER 14

PARALLEL CONNECTOR DATA

Printer cable with ribbon cable and PB36M (57-30360) connector

CONNECTIONS				
PANS 20			36 PIN	RIBBON
3	ORN	14		GRD
4	YEL	2		DO
6	BLU	3		D1
8	GRY	4		D2
10	BLK	5		D3
5	GRN	6		D4
7	VIO	7		D5
11	BRN(2)	8		D6
13	ORN(2)	9		D7
16	BLU(2)	10		ACK
18	GRY(2)	1		RDY

KEY 1
19

CONNECTOR DESCRIPTION: An earlier chapter described the cables used to hook up the system components. This chapter specifies the connectors and wiring. Plugs are supplied for users to make their own cables for the X/Y Output, RS232 and external power. The connectors are labeled on the rear panel.

PLOTTER: The Plotter or X/Y output accepts a miniature three conductor (stereo) phone plug, such as Radio Shack #274-284. The plug tip is the X channel, the ring is the Y channel and the sleeve ground.

RS232C: Accepts a miniature phone plug such as a Switchcraft #750. The pin-out is: Ring - Power Common; Tip - Signal. (See Chapter 12 for connector data if you have the Communication Option.)

CHARGER/AC ADAPTER: Accepts a two conductor plug common to many adapter power inputs, a Switchcraft 760, Newark catalog number 37F2995. The external sleeve (with the long solder connection) is ground, the internal sleeve (with the short connection) is +7.5 to +15 DC.

CAMERA DRIVE: Accepts a subminiature phone plug, Switchcraft 850 or Newark catalog 22F395. The output is essentially an open or closed connection.

CHAPTER 15

K FACTORS

THIS PAGE IS OBSOLETE, PLEASE SEE THE ENCLOSED CALIBRATION SHEETS

The K factors are generated during the calibration stage of the CE390WB camera by our technician using a Mercury source. Column one CALIB list the diode number in hexadecimal. Column two INPUTS are the wavelengths for each of the diodes. The K factors are generated by dividing the wavelengths between calibration points by the number of diodes.

Example for CE390WB:

Wavelengths between INPUTS 404.7 and 435.8 = 31.1
Range between individual diodes 10.0 and 1C.0 = 12

K(1) - 31.1 / 12 = 2.5916666

This procedure is repeated for K factors (1) - (10). K factors (0) and (11) are estimated numbers because no mercury calibration lines are available.

THIS PAGE IS OBSOLETE, PLEASE SEE THE ENCLOSED CALIBRATION SHEETS

CHAPTER 16

OPTICAL ACCESORIES

There are a variety of optical accessories available for the CE390 series spectral cameras. These include: Cosine Corrected Hemispherical Diffuser, Diffuser with FOV limiting tube, Fiber Optic Probe Adapter, Through the Optics Viewing (TOV) Accessory, 1^{o} Spot Adapter and 15^{o} Wide Field Adapter. The drawing on page 16-02 illustrates these accessories.

Attached to the front of the CE390 camera is a slit plate. This plate is critical to system performance and must be used with all accessories. The only exception to this is the TOV adapter, the TOV has it's own slit plate attached.

COSINE DIFFUSER ASSEMBLY INSTRUCTIONS

1. Remove the (4) 1/4" button head screws which attach the slit plate to CE390 camera.

2. Install the cosine diffuser with the slit plate using the (4) 1" cap screws.

1^{o}, 15^{o}, DIFFUSER ASSEMBLY INSTRUCTIONS

1. Remove the (4) 1/4" button head screws which attach the slit plate to the CE390 camera.

2. Install the optical accessory with the slit plate using (4) 3/4" cap screws.

FIBER OPTIC PROBE ASSEMBLY INSTRUCTIONS

1. Remove the (4) 1/4"button head screws which attach the slit plate to the CE390 camera.

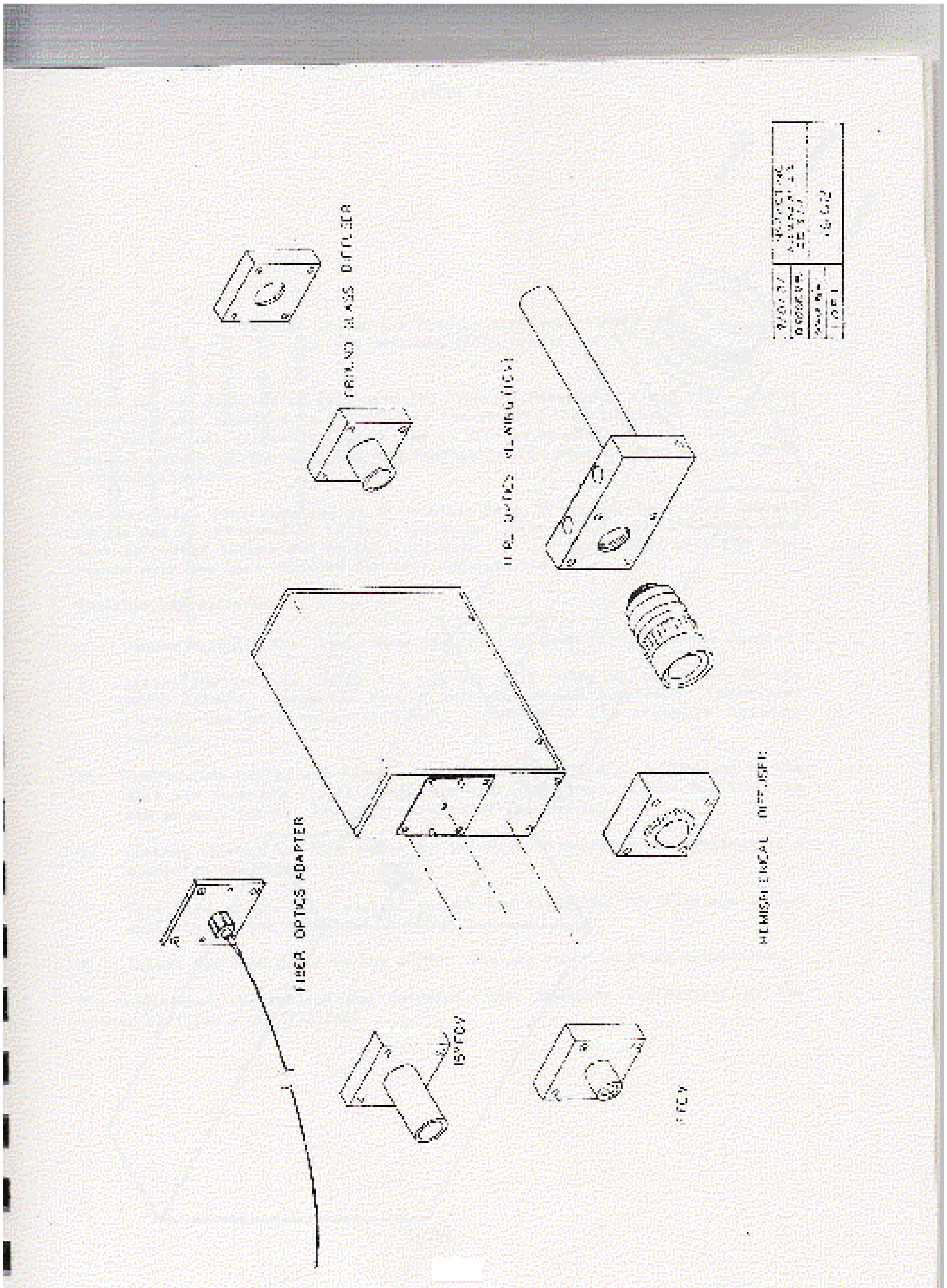
2. Using the same screws attach the fiber optic probe and slit plate to the CE390 camera.

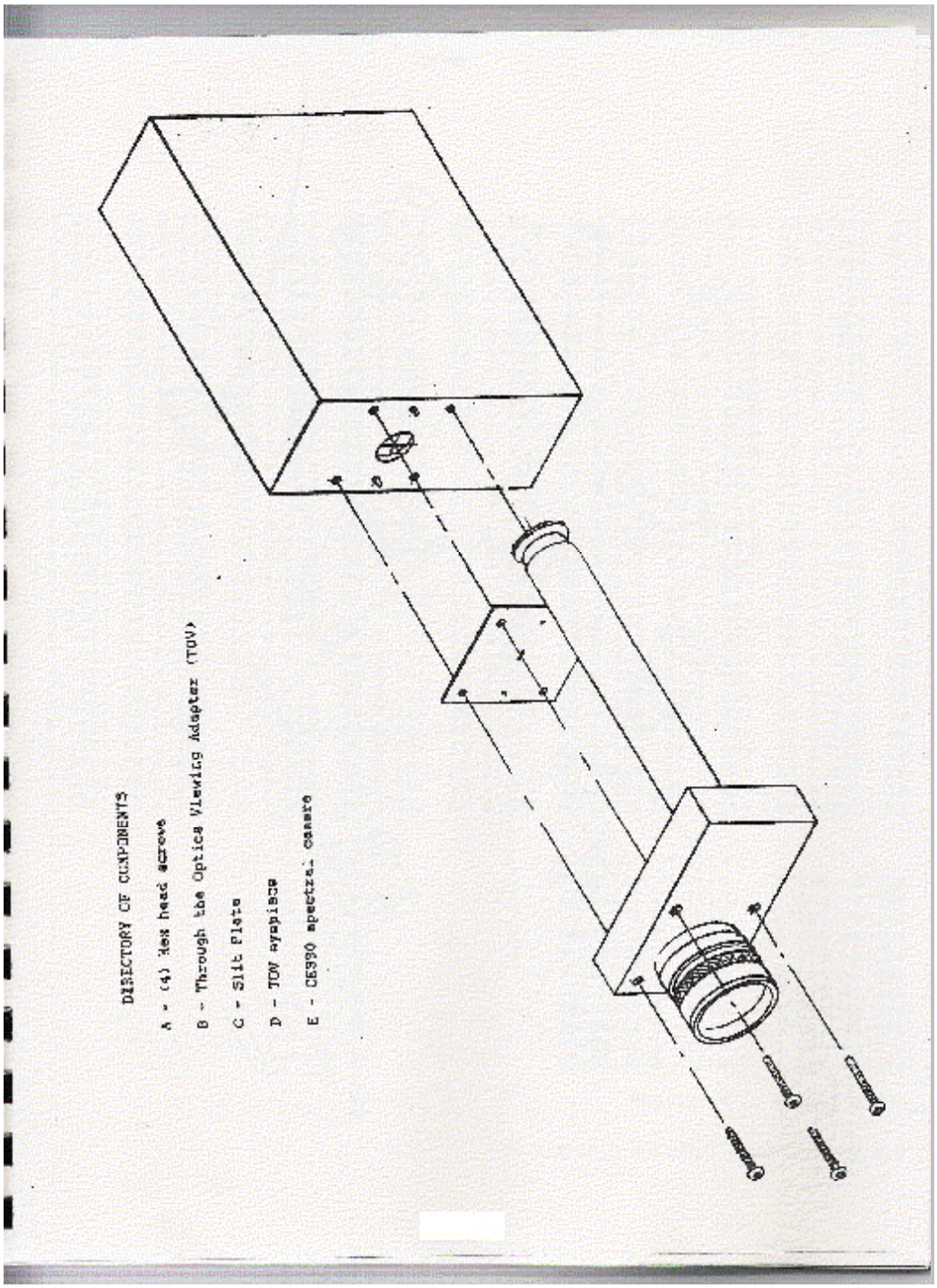
'D 500 WIDEBAND SPECTRUM LIST-3/7/85

ALIB INPUTS K FACTORS

10.0= 404.7 K(0)= 2.59166666
1C.0= 435.8 K(1)= 2.59166666
43.5= 546.1 K(2)= 2.79240506
4F.0= 579.1 K(3)= 2.86956522
77.0= 696.6 K(4)= 2.9375
8D.5= 763.5 K(5)= 2.97333334
9D.0= 810.4 K(6)= 3.02580646
A2.0= 826.5 K(7)= 3.21999998
A7.0= 842.5 K(8)= 3.2
BD.0= 912.3 K(9)= 3.17272727
CE.0= 965.8 K(10)= 3.14705882
K(11)= 3.14705882

00	363.2	20	447.0	40	536.3	60	629.0	80	723.4	A0	820.1	C0	921.7	E0	1028.4
01	365.8	21	449.8	41	539.1	61	632.0	81	726.3	A1	823.3	C1	924.9	E1	1025.6
02	368.4	22	452.6	42	541.9	62	634.9	82	729.3	A2	826.5	C2	928.0	E2	1028.7
03	371.0	23	455.3	43	544.7	63	637.9	83	732.3	A3	829.7	C3	931.2	E3	1031.9
04	373.6	24	458.1	44	547.5	64	640.8	84	735.3	A4	832.9	C4	934.3	E4	1035.0
05	376.2	25	460.9	45	550.4	65	643.7	85	738.2	A5	836.1	C5	937.5	E5	1038.2
06	378.8	26	463.7	46	553.3	66	646.7	86	741.2	A6	839.3	C6	940.6	E6	1041.3
07	381.4	27	466.5	47	556.1	67	649.6	87	744.2	A7	842.5	C7	943.8	E7	1044.5
08	384.0	28	469.3	48	559.0	68	652.5	88	747.1	A8	845.7	C8	946.9	E8	1047.6
09	386.6	29	472.1	49	561.9	69	655.5	89	750.1	A9	848.8	C9	950.1	E9	1050.8
0A	389.2	2A	474.9	4A	564.8	6A	658.4	8A	753.	AA	852.0	CA	953.2	EA	1053.9
0B	391.7	2B	477.7	4B	567.6	6B	661.4	8B	75	AB	855.2	CB	956.4	EB	1057.1
0C	394.3	2C	480.5	4C	570.5	6C	664.3	8C	7	AC	858.4	CC	959.5	EC	1060.2
0D	396.9	2D	483.3	4D	573.4	6D	667.2	8D	7	AD	861.5	CD	962.7	ED	1063.4
0E	399.5	2E	486.1	4E	576.2	6E	670.2	8E	7	AE	864.7	CE	965.8	EE	1066.5
0F	402.1	2F	488.9	4F	579.1	6F	673.1	8F	768.0	AF	867.9	CF	968.9	EF	1069.7
10	404.7	30	491.6	50	582.0	70	676	90	771.1	B0	871.1	D0	972.1	F0	1072.8
11	407.3	31	494.4	51	585.0	71	6	91	774.1	B1	874.2	D1	975.2	F1	1075.9
12	409.9	32	497.2	52	587.9	72	6	92	777.1	B2	877.4	D2	978.4	F2	1079.1
13	412.5	33	500.0	53	590.9	73	6	93	780.1	B3	880.6	D3	981.5	F3	1082.2
14	415.1	34	502.8	54	593.8	74	687.8	94	783.2	B4	883.7	D4	984.7	F4	1085.4
15	417.7	35	505.6	55	596.	75	690.7	95	786.2	B5	886.9	D5	987.8	F5	1088.5
16	420.3	36	508.4	56	59	76	693.7	96	789.2	B6	890.1	D6	991.0	F6	1091.7
17	422.8	37	511.2	57	6	77	696.6	97	792.2	B7	893.3	D7	994.1	F7	1094.8
18	425.4	38	514.0	58	6	78	699.6	98	795.3	B8	896.4	D8	997.3	F8	1098.0
19	428.0	39	516.8	5	8	79	702.5	99	798.3	B9	899.6	D9	1000.4	F9	1101.1
1A	430.6	3A	519.6	5	6	7A	705.5	9A	801.3	BA	902.8	DA	1003.6	FA	1104.3
1B	433.2	3B	522	5	6	7B	708.5	9B	804.3	BB	906.0	DB	1006.7	FB	1107.4
1C	435.8	3C	5	5	6	7C	711.5	9C	807.4	BC	909.1	DC	1009.9	FC	1110.6
1D	438.6	3D		5	6	7D	714.4	9D	810.4	BD	912.3	DD	1013.0	FD	1113.7
1E	441.4	3E	5	5	6	7E	717.4	9E	813.6	BE	915.4	DE	1016.2	FE	1116.9
1F	444.2	3F	533.5	5F	626.1	7F	720.4	9F	816.8	BF	918.6	DF	1019.3	FF	1120.0


FIBER OPTICS ADAPTER
HEMISPHERICAL DIFFUSER


DIRECTORY OF COMPONENTS
A - (4) Hex head screws
B - Through the Optics Viewing Adapter (TOV)
C - Slit Plate
D - TOV eyepiece
E - CE390 spectral camera

TRIPOD MOUNT

There are three 1/4" - 20 tapped screw holes on the bottom of the CE390 camera. These are used for mounting the camera to either a tripod or pistol grip attachment. IMPORTANT: The length of the tripod mounting screw cannot exceed 5/16" (8mm), longer mounting screws will result in damage to the internal camera mechanism.

THROUGH THE OPTICS VIEWING ACCESSORY

The TOV accessory can be attached to either the left or right side of the CE390 camera depending on your personal preference. The reticule, which has numbered concentric rings, is contained in an adjustable eyepiece for ease of positioning on either side of the camera. The eyepiece is also used as a focusing adjustment.

Several points should be kept in mind when working with the TOV:

As you look at the 50mm lens on the TOV you will see two adjustable rings: one for the focus and the other for aperture setting. The aperture setting must always be full open. The adjustment for focus is not critical to camera performance, but should be set to optimum clarity for the operator.

The 50mm objective lens supplied with the system is designed to be mounted on a 'C' mount threaded adapter. In theory another lens with a 'C' mount thread could be attached, but this is not the case. It is recommended that no other lens be used due to possible clearance problems with the beam splitter located directly behind the 50mm lens. Other commercially available lenses may require greater clearance than what is available, resulting in movement or breakage of the internal beam splitter.

THROUGH THE OPTICS VIEWING ASSEMBLY INSTRUCTIONS

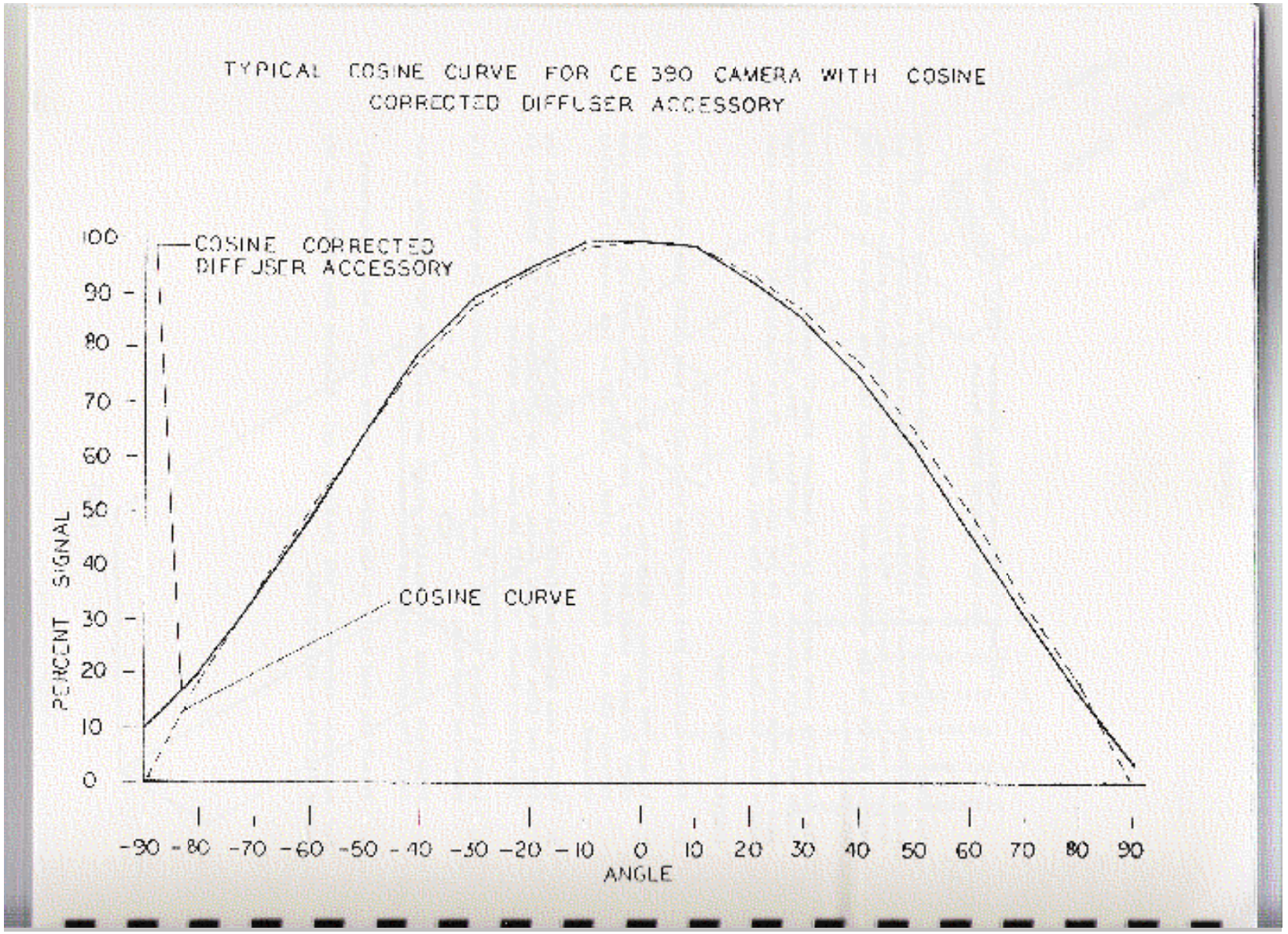
Consult Diagram #1 and familiarize yourself with the system components.

1. Remove the (4) 1/4" button head screws which attach the slit plate to the CE390 camera. Attach TOV adapter (B) to CE390 spectral camera using the four hex head 1" cap screws (A). The existing slit plate (C) is removed because the TOV adapter has its own plate attached. Reinstall the original slit plate when the TOV is removed.

2. Point the spectral camera with TOV attached at a distant object and slide the TOV eyepiece in/out until object is in focus.

3. Install head cable into the CE390 spectral camera.

4.As you look through the eyepiece of the TOV you will see a series of concentric rings. The total included angle of the TOV is 1^{o} FWHP. This represents 2/3 of the inner most ring.


TYPICAL COSINE CURVE FOR CE 390 CAMERA WITH COSINE CORRECTED DIFFUSER ACCESSORY
COSINE CORRECTED DIFFUSER ACCESSORY
COSINE CURVE
PERCENT SIGNAL
100
90
80
70
60
50
40
30
20
10
0
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
ANGLE

DIRECTORY OF COMPONENTS

A - (4) Hex head screws

B - Through the Optics Viewing Adapter (TOV)

C - Slit Plate

D - TOV eyepiece

E - CE390 spectral camera

CHAPTER 17

INTEGRATING SPHERE

Instructions for assembling the CE390/Integrating Sphere Adapter.

1. Remove the four (6-32 x 1/4) BHA screws which attach the slit plate to the front of the CE390 camera.

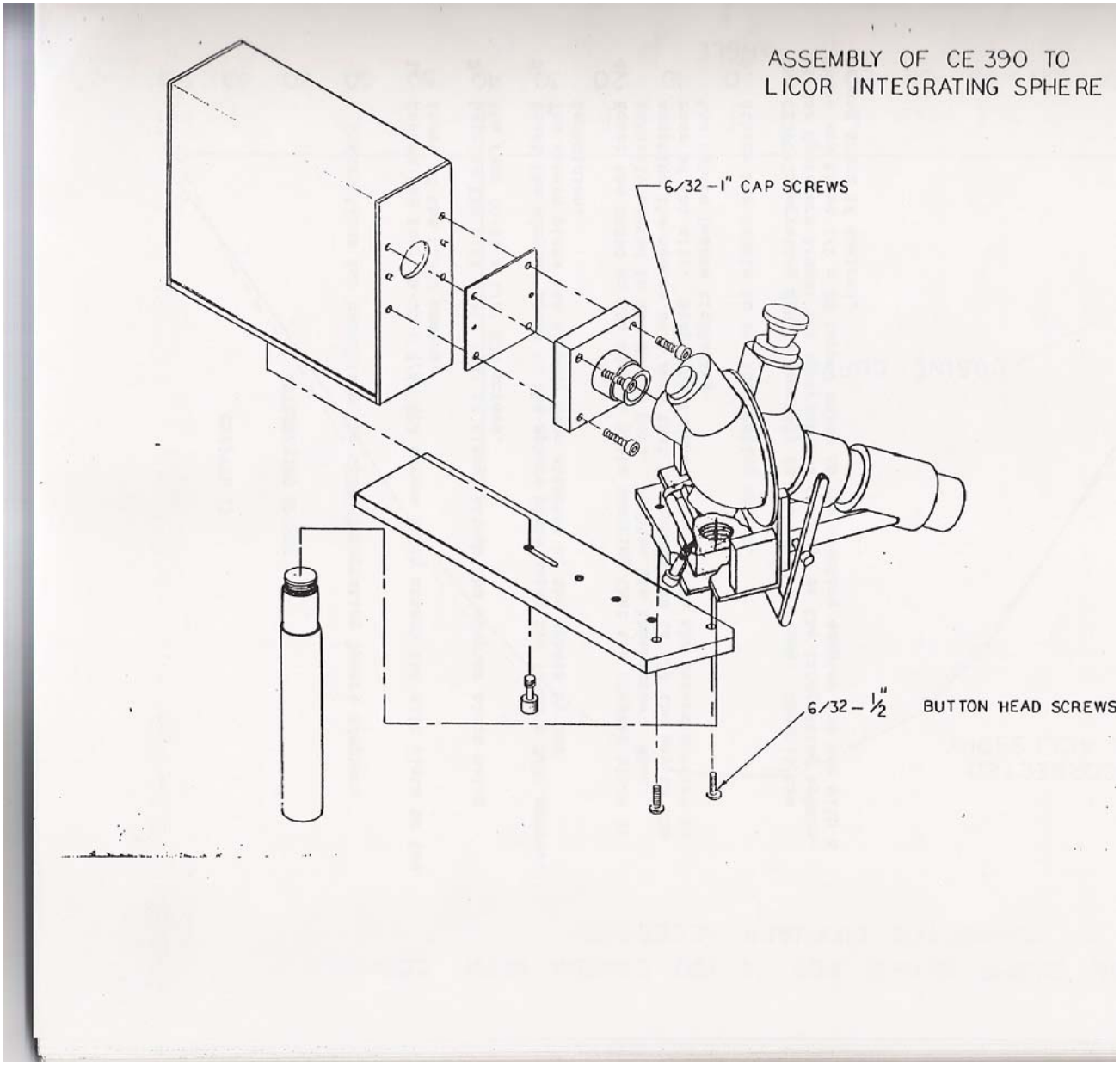
2. Leaving the slit plate (#3) in place, attach the adapter block using the four (6-32 x 1/2) HDA screws.

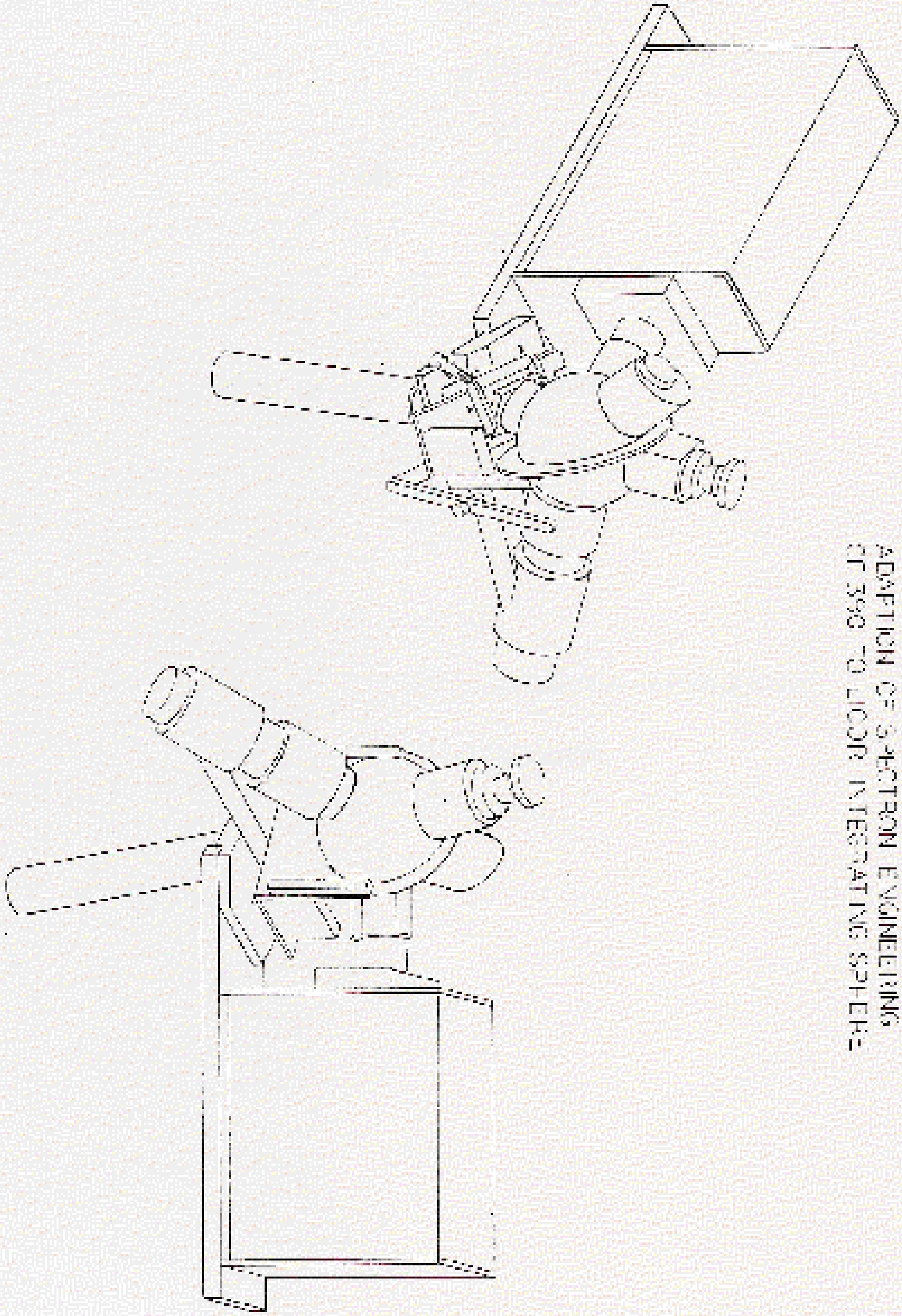
3. Mount the adapter plate to the sphere plate using two (6-32 x 5/8) screws. The sphere plate has already been attached to the sphere by our technician.

4. Mount the CE390 on the adapter plate assuring that the adapter block is securely seated in the sphere port. Tighten the thumbscrew. When mounting the camera make sure that the thumbscrew is all the way to the rear of the slit. Start the thumbscrew and slide the camera forward to the sphere before tightening.

5. Attach the handle to the integrating sphere.

The CE390/Integrating Sphere assembly is now ready for use. Consult the Li-Cor Operators Manual for instructions on usage of the integrating sphere. There are three 1/2 x 20 tapped holes in the mounting adapter for use with a tripod stand if desired.


ASSEMBLY OF CE 390 TO
LICOR INTEGRATING SPHERE
6/32 – 1" CAP SCREWS
6/32 – ½" BUTTON HEAD SCREWS



ADAPTION OF SPECTRON ENGINEERING OF 590 TO LICOR INTEGRATING SPHERE