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An Automated Fresnel Lens Tester System

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Gary S. Phipps

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Abstract

An automated data collection system controlled by a desktop computer has been developed for testing Fresnel concentrators (lenses) intended for solar energy applications. The system maps the two-dimensional irradiance pattern (image) formed in a plane parallel to the lens, whereas the lens and detector assembly track the sun. A point detector silicon diode (0.5-mm-dia active area) measures the irradiance at each point of an operator-defined rectilinear grid of data positions. Comparison with a second detector measuring solar insolation levels results in solar concentration ratios over the image plane. Summation of image plane energies allows calculation of lens efficiencies for various solar cell sizes. Various graphical plots of concentration ratio data help to visualize energy distribution patterns.

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An Automated Fresnel Lens Tester System

Introduction

The energy contained in sunlight is relatively diffuse, occasionally approaching 1000 W/m^2 measured normal to the incident rays. Conversion of this diffuse energy directly to electricity by photovoltaic solar cells is possible, but relatively expensive. A concentrator system greatly reduces the area and cost of the needed cells, but a tracking system is required. The cost of a concentrator system must be low to offset the added expense of the tracking system. Fresnel lens-like concentrators may be suitable for such a system because they are lightweight, and mass production may make them relatively inexpensive.

An ideal lens forms an irradiance pattern in its image plane that has a one-to-one spatial correspondence to the radiance of the object being imaged. An ideal image of the sun's disc will be a circular pattern of nearly uniform irradiance. Solar Fresnel concentrators rarely produce such a uniform circular pattern on their cells. The typical Fresnel concentrator will be designed to produce a desired pattern on a particular size and shape of cell. That cell may well be square. The diameter of the sun's image formed by a lens is roughly 9 mm for each meter of focal length. To minimize the physical size of concentrator systems, the cell is normally much larger than an imaging system would allow, and it is placed not at an image plane but somewhat closer to the concentrator. In addition, different areas of the concentrator may have different "focal lengths" to produce the desired energy distribution on the cell plane. For these reasons, the typical solar Fresnel concentrator is not really a "lens," but in common usage it is referred to as a "Fresnel lens." The distance between the solar Fresnel lens and the cell, or measurement plane, will be called lens-to-cell distance.

Discussion of the Problem

Lens efficiency of a solar concentrator is defined as the amount of light energy concentrated on a test cell area compared with the amount of light energy incident on the total lens surface. Absorption in the lens material and light falling outside the designated cell areas are the two main loss mechanisms. Different sized test cell areas normally will give different

efficiency numbers. A common method of measuring lens efficiency assumes linearity of test cell short-circuit current. The short-circuit current of a large area test cell irradiated by the lens under test, while tracking the sun, is compared to the test cell short-circuit current from one sun irradiance. If the test cell is larger than desired, an aperture is inserted to physically restrict the active area of the cell. This method of testing, although useful for comparing lenses, provides no means to separate any effects of spatial nonuniformities of the lens image and/or test cell uniformity. The Fresnel lens tester system was developed to measure the lens effects independently. At the request of Sandia's Photovoltaic Projects Division, a Fresnel Lens Tester System (Figures 1 and 2) was designed and built. To be compatible with other Sandia photovoltaic data collection systems, the controlling element of the system is a Hewlett-Packard 9845 Desktop Computer. A point detector PIN silicon photodiode detector mounted on a two-axis (X-Y) motorized positioning table allows raster scans of a selected cell plane parallel to the lens. This table diode signal is compared to an identical PIN reference photodiode baffled by a 32-mm (1.25-in.)-dia flat black tube. The reference diode tube is normal to the cell plane with a length-to-diameter ratio of 20:1. Test lenses are held to an aluminum carriage mounted on three 19-mm (0.75-in.)-dia, case-hardened steel rods. The rods move in linear ball-bushing pillow blocks for lens-to-cell distance adjustments. The X-Y table and lens carriage assembly is suspended in a Celestron-14 telescope equatorial fork and mount drive, allowing the table and lens to track the sun accurately with the Celestron clock drive. The mount and all system electronics are bolted to a wheeled base for portability. The base has attached locking feet that hold the system stationary during operation.

By sampling the cell plane irradiance with a point detector while tracking the sun, the system of Figure 2 characterizes the performance of lenses as they would actually be used. Because of variable weather conditions it would be desirable to test lenses with an artificial source. Development of the present system using a tracking mount does not compromise the

possible future use of a solar simulator. A suitable simulator could be used by turning off the lens tester clock drive. By taking advantage of system portability, laboratory tests and outdoor tests could be intermixed with ease. This intermixture of tests would be useful in determining the magnitude of the problems, if any, introduced by a particular simulator.

Figure 1. Definition of Lens Tester Components

Figure 2. Fresnel Lens Tester System

Detailed System Description

Hardware

Both photodiodes are UDT PIN-020A silicon detectors which have an active diameter of 0.5-mm(0.020 in.). Each diode is mounted directly to a preamplifier which produces approximately 8 V for one sun insolation. The high-level preamplifier signals are fed to identical Analog Devices ADC 1130 14-bit high-speed analog-to-digital converters (ADCs). The ADCs are mounted in an aluminum chassis attached to the underside of the X-Y table to minimize the length of analog signal lines. Simultaneous conversions by the ADCs give a pair of 14-bit binary data words for each sampling location. The reference diode 20:1 baffle tube is attached to the tracking mount declination axis and is shimmed to be normal to the X-Y table top. A pinhole sun sight attached to the reference tube is adjusted to be collinear with the reference tube axis. When the sun's disc is centered on the sighting circle, the tracking yoke is aligned with the sun. An additional pinhole in the lens carriage has its own crosshair on the table carriage as a check for proper alignment of the reference tube.

The X-Y motorized table is a Summit Engineering Model 21610404 with double-ended motor shafts and dampers. Each axis has a 100 mm (4-in.) travel and is positioned by a stepper motor coupled to a 5 thread-s/in. lead screw. Step size for each motor is 1.8° (200 steps/rev), resulting in a table step size of 0.025-mm(0.001 in.). Each motor has its own Summit Model 21808300 Translator mounted on the wheeled cart baseplate. A small fan on each translator enclosure provides the needed cooling. Limit switches prevent the translators from attempting to step the table into the stops at the end of travel in either direction. A Summit Model 6-05 Return-to-Zero Encoder on each motor allows accurate centering of the table for initial setup. The table motors are capable of a maximum stepping rate near 10000 steps per second (10000/sec), but must be started and stopped below 500/sec. Attempting to start above 500/sec will produce either no movement or the loss of several steps while the motor accelerates to the pulse rate. Stopping at high pulse rates causes the motor to overrun. Since the absolute table position is determined by counting steps, either case is undesirable. High-speed movements are controlled by the charging and discharging of a capacitor. Starting is at 400/sec with a nearly linear ramp-up to 4000/sec. An exponential ramp-down to 400/sec is necessary before stopping. Short movements at low speed are controlled directly from a 500-Hz clock. The mass moved by the Y-motor

is roughly twice the mass moved by the X-motor. When the Y-motor is used in the fast mode, its power is marginal to move the table vertically. A helper spring has been installed around the Y-axis lead screw to assist the Y-motor in its fast uphill movement.

Signals from the two photodiodes are of similar magnitude because of a set of 25-mm(1-in.)-dia Inconel neutral density filters used over the table diode. With only one sun irradiance on the table diode, its temperature never rises appreciably above ambient even with no cooling. Because of this slight temperature rise, there should be no detector temperature effects to consider. Filters are available for measuring concentration ratios in the range of 10 to 2000. Each glass laminated filter is glued in a 6.3-mm(0.25-in.)-thick aluminum filter carrier. Each carrier is held in the filter holder by the pressure exerted from a 6-32 ball plunger in the side of each filter slot. Two slots allow the use of two neutral density filters with a loss of total accepted angle. The calibration will be invalid for two filters because of multiple reflections between the mirror-like surfaces. A single filter should be used in the bottom slot to allow the widest angular light acceptance. A set of narrow bandpass interference filters at 50 nm intervals from 400 to 1100 nm has also been mounted in filter carriers for measurement of relative pattern shapes. A table of characteristics for all filters is in Appendix A. The bandpass filters are not suitable for calibrated measurements because their bandpass is dependent upon the angle of incidence. If used with a neutral density filter, they may physically restrict the angular acceptance because both filter slots are used. They can, however, give an idea of the energy distribution at different wavelengths. For calibration purposes, empty filter carriers and 10:1 and 20:1 baffles in filter carriers are available. The baffles restrict the field of view of the table diode to approximate that of the reference diode. To minimize the decrease in off-axis diode sensitivity the glass lens assembly has been removed from the table diode. The diode is recessed 9.5-mm(0.375 in.) in the bottom of the filter holder to protect the exposed diode chip. The inside of the filter holder is flat black to reduce stray light reflections. The filter holder is attached to the X-Y table so it will be directly under the lens carriage center when the X-Y table is also centered. The use of any filter in the system effectively increases the lens-to-cell distance because of the lower speed of light in the filter material. The amount of increase depends on the refractive index of the filter glass, n . A graph indicating the amount of change for $n=1.5$ is in Appendix A.

The maximum clear aperture of the lens carriage is 0.47 m (18.5 in.) square. Lenses are attached to the carriage by 3-mm(0.125 in.)-thick lens boards specially made for each lens. During initial assembly, the lens carriage was shimmed to assure that the lens surface was parallel to the X-Y table top. Lens-to-cell distance is adjusted manually by moving the carriage while measuring the lens-to-filter holder distance. Thumbscrews on the linear ball-bushing pillow blocks lock the carriage in position. As the carriage is moved out, two 6.8-kg (15-lb) steel counterweights are moved rearward to preserve the balance of the tracking system. The range of available lens-to-cell distances is 0.10 to 0.76 m (4 to 30 in.). Lenses to be tested can gather more than 200 watts of solar energy, creating a thermal problem for both the filters and the detector. All components (except filters) exposed to the concentrated beam are painted with Nextel diffuse white paint which can withstand 149° C (300° F). In addition, a shutter on a rotary solenoid keeps the filter holder covered when measurements are not being taken. Exposure to concentration ratios in excess of 1000 can destroy stationary, uncooled Inconel filters in short order. No stationary filter should be exposed to a concentrated beam. The filter is exposed to the high energy flux for the shortest possible time by taking measurements only while moving at high speed (100 mm/sec).

Table movements, shutter control, A/D conversions, and data communications with the computer interface are handled by the Digital Control Chassis found below the base of the Celestron mount. The translator mounted cooling fans also supply cooling air to the Digital Control Chassis. An HP-98032A (Option 445) 16-bit parallel interface is used with a 15-m (50-ft) extension cable to allow a 20-m (60-ft) separation between the HP-9845 computer and the tester. The physical layout of the control chassis and wire wrap cards and complete system schematics are contained in Appendix A. No routine electrical adjustments should have to be made.

Theory of Operation

An HP-98032A interface using Select Code 2 is used with either an HP-9845A or HP-9845B computer to control the system. The signal nomenclature and terminology used here to describe this interface is that used by HP in their Hewlett-Packard 98032A 16-bit Interface Installation and Service Manual, HP part 98032-90000, May 4, 1979. Seven jumpers must be installed on the Configuration Board located inside the rear housing of the interface card. Access to these

jumper locations is by removing the screws and disassembling the housing. Jumper 2 causes output data to be in positive true logic. Jumpers 3 and 5 complement the logic sense of the signal PCTL and PSTS, respectively. Jumpers 8 and E allow data transfers on the transistion of PFLG from ready to busy, while jumpers B and F make all data transfers in words of 16-bits. The interface connects to the Digital Control Chassis with a 53-pin LJT00 23-53S connector. There are 16 data output lines, 16 data input lines, 10 control lines, and various ground and shield lines. The discussion below makes reference to the schematics of Appendix A.

Data sent from the ADCs to the computer are placed on the data input lines (DI_s); values output to the tester are found on the data output lined (DO_s). The control lines consist of 5 sending information to the tester (PCTL, I/O, CTL1, CTL0, and RESET) and 5 returning to the computer (PFLG, PSTS, STI0, STI1, and EIR). Any data transfer is controlled by a "handshake". This handshake is a means to insure that both computer and interface are ready to transfer the data. A handshake is initiated by PCTL and completed by PFLG. I/O indicates the direction of data transfer. All handshakes of the Fresnel lens tester are full handshakes. The detailed timing diagrams for OUTPUT... and ENTER... are shown in Figures 3 and 4. PFLG is multiplexed by CTL0: CTL0 low allows OUTPUT handshakes; CTL0 high allows ENTER handshakes. Attempting to perform an I/O with CTL0 in the wrong state will tie up the calculator waiting for a handshake that will not happen. CTL1 controls the shutter opening and closing. If the computer is not plugged into the tester, CTL1 is pulled high, closing the shutter. RESET stops any table motion and resets the ADC multiplexer circuitry. PSTS is connected to an inverter output, U11 (8), whose input, U11 (9), is tied to +5V to provide an indication if the tester power is tuned on. STI0 is an indicator that all table movements have been completed; STI1 is a monitor of the various table limit switches and encoder signals. EIR is used only during DMAs; since no DMAs are used, EIR is grounded.

The Digital Control Chassis uses mostly standard TTL integrated circuits of the 54/74 family installed in DIP wire wrap sockets. There are three binary counters in the control chassis: 12-bit X (U12, U13, U14) and Y (U17, U18, U19) movement counters and an 8-bit interval counter (U15, U16). Each time a stepper motor is stepped, its corresponding counter is decremented. When a movement counter reaches zero no more movement is allowed in that axis until a nonzero value is loaded to that counter. Each step of either motor also decrements the interval counter.

Figure 3. Hardware Timing Diagram for Output 2 WHS...

Figure 4. Hardware Timing Diagram for Enter 2 WFHS... (Pulse Widths are Labelled in Microseconds.)

When the interval count reaches zero, a Convert pulse, U44 (13), is sent to each ADC. The lower 8 bits of the data output lines are also loaded to the interval counter after each convert pulse. Six one-bit control registers contained in U28 and U29 are used to enable the X, Y, and interval counters, select X and Y directions of movement, and determine the speed of table motion (fast or slow). Data output to the tester is in 16-bit positive true binary words. The lower 12 bits are used as a data bus to the 3 counters and 6 control registers. The upper 4 bits control the destination of the other 12 by use of a 7442 4-line-to-10-line decoder, U36. Three combinations of the upper 4 bits (D012 to D015) have special meanings other than controlling data destinations. D08 is also used as a multiplex control signal for table encoder signals. Diode data are sent to the computer in pairs of 16-bit words, one from each ADC, alternately. Four 74157s

in the A/D box do this digital multiplexing, but they are controlled by a 74S112, U45, in the control chassis. Timing details of this flip-flop are included in the ENTER timing diagram of Figure 4.

The X and Y motor encoders consist of a slotted disc attached to each motor shaft. The slotted disc is used as the light interruptor for an optical source-sensor assembly. Besides the + and - limit switches for each motor there is a third switch for each axis that indicates the table is within one revolution (200 steps) of its centered position. After this switch has been located, the encoder TTL signal can be used to locate the centered position within one step. The procedure is done separately for each axis after locating the -X, -Y corner by using the limit switches. The translator limit switch inputs use pull-up resistors to their CMOS +12V supply. Likewise, the control chassis uses pull-ups to +15V on the zero switches. All four switch signals are filtered and converted to 5V signals by a CMOS 4009 hex inverter, U46. The two minus direction limit switch signals are NANDed to form $X_H \cdot Y_H$, U7 (3). The X and Y encoder and zero switch signals are multiplexed to a single line $X0 + Y0$, U2 (1), by D08 and their respective counter enable signals. The $X0 + Y0$ and $X_H \cdot Y_H$ signals are multiplexed to STI1, U33 (9), by D08, U36 (5), and CTL0. STI1 is described by Table 1.:

Table 1. Determination of STI1 (X = Don't Care)

CTL0	U36 (5)	(256-bit)	D08	X	Y	STI1
				Enable	Enable	
X	Lo	X	X	X	X	$X_H \cdot Y_H$
X	Hi	X	Lo	Lo	Lo	?
X	Hi	Lo	Lo	Lo	Hi	X Zero Switch
X	Hi	Lo	Hi	Hi	Lo	Y Zero Switch
X	Hi	X	Hi	Hi	Hi	Hi
X	Hi	Hi	Lo	Lo	Hi	X Encoder Signal
X	Hi	Hi	Hi	Hi	Lo	Y Encoder Signal

The stepping signal applied to the motor and counter circuits, U8 (6), is gated on and off by U34 (10). The minimum stepping pulse width acceptable to the translators is 30 μ sec. Computer commands and the control chassis clock must be synchronized to avoid a first pulse shorter than 30 μ sec. The computer controls flip-flop U35, which in turn allows U34 to be set only by an oscillator positive-going transition. This assures that no short pulses are passed by U8 (4,5,6). Which of two clocks is used as the oscillator for the stepping signal is determined by the speed control register U29 (15). The low-speed clock, U34(6), is a 500-Hz square wave obtained by dividing by two a 1 kHz oscillator, U38 with U34. The high-speed clock is generated by a voltage-to-frequency converter (V-F), U42, whose pulse rate is ramped

between 400 Hz and 4000 Hz by charging and discharging an RC network. A 4053 analog multiplexer, U37, controls the frequency by connecting a charging resistor to +15V, U37 (2), or a discharge resistor to ground, U37 (1). A buffer amplifier, U41, between the capacitor and V-F input provides gain and offset control of the ramping voltage. The signal which initiates the stepping signal, U3 (1), also causes the V-F to ramp-up, even if the low speed is selected. In order for the motor not to lose its position, the stepping rate must be ramped below 500 Hz by the time the counter reaches zero. $X = 352$, U5 (13), and $Y = 352$, U4 (10), are NORed to produce a ramp-down signal, U5 (1), for the V-F. If both motors are moving simultaneously, they move at the same speed. The motor that reaches 352 first causes both to ramp-down. Movements at slow speed that exceed 352 steps cause the V-F to ramp-down, even though the V-F signal was not being used. If slow movements shorter than 352 steps are executed, a ramp-down signal will not occur, leaving the V-F at 4000/sec. Before any fast movement, the V-F must be at 400/sec. If a short, slow movement has left the V-F at 4000/sec it must first be ramped-down by loading a 352 in one of the counters, enabling that counter, and waiting 300 msec to allow the capacitor to discharge. In the software section that follows, this resetting of the V-F is called Screw Fast Reset.

The step and direction inputs to the translator are CMOS inputs with pull-up resistors to +12V. Interfacing between the TTL logic and the translator CMOS is by open collector 7426 NAND gates, U31. The upper four bits of the data output word, D012-D015, control a 7442 decoder, U36. Three of the 7442 outputs denote special control functions which send stepping signals directly to the translators, bypassing all other registers and counters. U36 (5) is the Go-To-Hard-Stops signal that, in addition to multiplexing STI1, forces both the X and Y motors to step in the minus direction at 500/sec. U36 (6) is the Step-X signal which, when taken low for 30 μ sec and high again, causes the X motor to take one step in the direction specified by the normal X direction register, U28 (16). U36 (7) is the corresponding Step-Y. For single steps it is much easier to use Step-X or Step-Y than to load, enable, and start the counters in the normal manner.

To take a line of data points, the movement and interval counters are loaded and enabled as necessary. The movement must be at least one step longer than needed to reach the last data point or handshake failure will occur; this means a minimum 2-step movement. By proper programming, the points can be on a line in the X or Y direction, or on a 45°

diagonal. Before the ENTER, it is necessary to set CTL0 high. When the ENTER is executed, PCTL goes to a Control Set and requests the first data word. A Control Set on PCTL while CTL0 is high sets U35 (10), enabling U34 to gate on the stepping signal, U8 (6), in sync with the selected clock, as well as starting the V-F ramp-up. When the interval counter reaches zero a convert pulse is generated, U44 (13), and two digital diode readings are taken as the table moves. Total convert time is 25 μ sec or less, and maximum table speed is 100 mm/sec. The maximum movement of the table during the convert time is 25 μ . The STATUS signal of the table ADC, U49 (4), together with PCTL complete the handshake for the pair of data words (Figure 4). The computer Data Output lines remain latched with the last data word that was OUTPUT. The data on DO0-DO7 are loaded to the interval counter during the convert cycle. For multiple data readings, the last OUTPUT before the ENTER must have been the interval count in order to reload the proper interval. (If only a single pair of data values is desired, this is not required.) The computer is forced to wait one stepping interval before another CONVERT/STATUS cycle handshake a pair of data words through the interface. Once all data have been taken, the computer can go on to other operations. If the movement counters reach zero before all requested data have been collected, the computer will be tied up waiting for data that never arrives. If data taking is completed before the programmed table movement is finished, it is advisable to wait until the motion has ceased before attempting to communicate with the lens tester to avoid interrupting the table movement.

Since an ENTER initiates movement as well as data taking, it is necessary to perform an ENTER to make any table movements. If no data are wanted, a dummy variable is used to start the table in motion. Once started, the motion will continue until the movement counters reach zero unless a computer I/O interrupts. As with data taking, although it is possible to do so, no I/O should be attempted with the lens tester until the programmed movement has ceased.

Software

All lens tester functions are controlled by an HP Enhanced BASIC program written for the HP 9845A/B desktop computer system. The program is written in a conversational style with prompts to the operator indicating the proper inputs needed at any time. In this respect the normal system operating instructions are contained in the program itself. The program consists of roughly 1600 lines and when STOREd on

either tape or flexible disc occupies 285 records of 256 bytes. The size of the complete program prohibits loading it into a 9845A as a single unit. A version of the program for a 9845A with 64K of memory, two tape drives, graphics, and I/O capability (actually a 9845S) is available which LINKs various parts of the program to core only as they are needed. The 9845A program is similar in execution to the 9845B program except that 3-D plots are done with a maximum dimension of 50 x 50 because of memory limitations. (If the data array is larger than 50 x 50, a subset of alternate lines of the array is used for plotting.) If the 9845A program segments are stored on flexible discs, little difference from the 9845B program will be noticed. If the 9845A segments are stored on tape, the LINKing process sometimes will cause noticeable delays. A listing of the 9845B program is contained in Appendix B. References to line numbers below are to the 9845B program of Appendix B although variations of the program exist. Also in Appendix B is a table of variable names used in the program. Variable names used in the text will be in *italics* to avoid confusion. The program is in OPTION BASE 1 and has five parts:

1. Parameter initialization and task definition, lines 10 - 400
2. All subroutines, GO SUBs, lines 510 - 1530
3. ACQSTN for collection of raw data, lines 1650 - 6670
4. ANALYS for analysis and display of reduced data, lines 6790 - 11820
5. All subroutine subprograms, CALLED SUBs, lines 11940 - 16100

Program line number 30, (30), dimensions certain variables as SHORT to conserve memory space. Z (102,102) is the reduced data array which has no more than 5-decimal-digit accuracy. The limitation of 102 lines of 102 points each comes from this DIM statement. All raw diode data are integer data, two values per location. (40) defines the raw data array as integer A (204). Reference and diode data are stored in alternate locations of A (*). The filter factors that are used for conversion of raw data to solar concentration ratios are contained in the DATA statement of (90). They are read into the SHORT array F (20) at (100). The medium used for data storage or retrieval is defined by a MASS STORAGE IS statement in lines 250-300. Control is transferred to the desired program section in lines 310-400. Before program execution is terminated, the standard mass storage is returned to T15 as it would be at power on.

The subroutine Mass (510) handles errors encountered while writing to or reading from mass storage units. Most common errors are handled in a way that minimizes operator action. Any error not specifically anticipated results in the message ERROR NOT RECOGNIZED...(650). These errors require more operator knowledge and interaction. Subroutine Ioerr (1170) is used for I/O failures. It anticipates mostly TIMEOUT errors caused by a loss of handshake between the computer and lens tester. TIMEOUT interrupts are not allowed during an ENTER WFHS, however. Any handshake failures during a WFHS data entry will cause the computer to lock up. Subroutine check (1460) makes sure any computed table movements will not exceed the (100- x 100-mm) (4- x 4-in.) table travel. If the proposed movement would place the table more than 2000 steps from the centered position, a warning message is printed on the CRT and return parameter S is left = 0. Check is mostly used in the routine to center the lens pattern on the data-taking array. The limit switches are actually more than 2000 steps from the center position. Maximum table movement is more nearly 4100 steps. A small increase in utilized area could result if limit switch locations were measured more accurately and their true position entered into Check.

When data acquisition is desired, control is transferred to line 1650. The STATUS of #2 interface card is checked by line 1670 to be sure #2 is a 16-bit parallel interface. If no #2 card is present, or if it is not a 98032A, the program cannot proceed. Once the proper interface has been verified, the PSTS line is checked to see if the lens tester is connected and turned on (1720). The SET TIMEOUT statement of line 1770 allows a 0.5-sec wait for completion of a handshake before the I/O error causes a GO SUB Ioerr (1790). The first I/O attempted to the lens tester that requires a handshake is in line 1800. If 1800 is successfully completed, there should be no problems with further I/O. The table-centering routine is entered at Zero (1840). Table movements with no data gathering are done by a call to subroutine subprogram Move (15600). Movements must be at least two steps in length (0.002 in. = 0.051 mm) or the ENTER statement never receives its handshake. By line 2060, the X centering is completed. The centered position of 0, 0 is reached at Yzero (2220). If the centering routine was performed because of invalid data, the original X and Y offset distances are reentered in lines 2240-2310. Various operator inputs between lines 2320 and 3430 specify a rectilinear raster scan of data locations as well as other information about the test. The scan lines in either the X or Y direction are done at high speed, with the stepping between lines

done at 500/sec. Between scan lines, the raw data array, A (*), is written to MASS STORAGE by a random PRINT. If this print is to tape, a momentary delay will be evident. Disc storage is faster and may not produce noticeable delays. The scan lines are longer than the required data area to always park the filter outside the concentrated beam during this mass storage wait time. The amount of overscan, A, at each side of the data area is calculated in lines 3200-3310. Smaller scan areas should produce more highly concentrated beams than larger scan areas. For this reason, A gets larger as the maximum scan dimension decreases. At the 4000/sec rate the inertia of the stepper motor causes the rotor to lag 2 steps behind the expected position. Line 3240 makes a software correction for this motor lag to avoid any misalignment of data-taking locations. The linear spacing between data points in the X and Y directions, Int, is always the same. A rectangular grid of points is always taken even if the scan area is circular.

A unique file base name for the test data is requested at line 3430. Three files of the proper size and names are CREATED on the standard mass storage device starting at Create (3490). The request for time-of-day input (3600) is after the file creation to place it closer to the actual data taking. Instructions for aligning the mount are contained in 3690-3800 but are displayed on the CRT only on request. Measurement of diode dark current and gain ratio is accomplished between 3810 and 4180. Instructions for lens installation are contained in 4250-4420 and as before are displayed only if requested. Between 4460 and 5720, raw data are taken in two prepending scans through the X and Y centers of the scan area. These raw data are plotted on the CRT for operator observation within axes drawn and labelled by subroutine subprogram Scale (15890). This process can be repeated indefinitely to determine the needed filter and centering offsets. Once the operator is satisfied, preparations for the raster scan are begun at 5730. A graphical display of the raster scan is presented on the CRT in scale during the data scan. As each line of data is taken a new line is added to the CRT. This informs the operator that handshake failures have not occurred and also indicates the portion of data still to be taken. The graphics statements of 5820-5890 prepare for this plot.

All raster scans start at the -X, -Y corner of the scan area; movement of the table toward a motor is in the negative direction. Scan lines are oriented in the direction that will maximize their length. The data area scanned has dimensions of Xscan by Yscan. If Yscan > Xscan, the long scan lines are in the Y direction. If Xscan ≥ Yscan, the long lines are in the X

direction. A square pattern will produce X direction lines, but by adding 0.001-in. to the Yscan dimension the array of data locations will probably be unchanged but scan lines will be in the Y direction. If X-direction scan lines are used, Lns scans with two data words from each of Pts locations are taken starting at Xscan (5960). Otherwise, Pts Y-direction scans with two data words from Lns locations are started at Yscan (6190). After the raster scan is completed the table is returned to its centered position at Xxyz (6410). The operator is asked to check that the table is indeed centered (6570). If it is not, a new scan using all old scan parameters will be repeated. If the operator's answer indicates the table is centered, the test directory file is written to mass storage (6650) and the acquisition phase ends.

The analysis section begins by requesting a file base name (6790). The proper three files are AS-SIGNed (6820-6900) and the directory file (#1) is read (6910). General information about the file is displayed on the CRT (7030-7080). If the raw data have already been reduced, the resulting information is also displayed (7130-7190). If the raw data have not been reduced, various operator inputs are needed before reduction can begin (7210-7490). The raw data (file #2) consist of pairs of integer variables in the range of 0-16383. 16383 indicates no light, while 0 is a maximum irradiance. Conversion to single, floating point, SHORT variable, concentration ratios is done in the 7510-7650 loop. The raw data are taken with adjacent lines from scans done in opposite directions. The conversion loop reverses alternate lines to make all reduced data appear to have been from scans done in the positive direction. Once reduced, the concentration ratio data are written to mass storage file #3 (7670). Lens efficiencies and average concentration ratios for the previously defined cell areas are calculated in 7710-7980. If the cell area is defined to be circular, data points from the corners of the square scan area are ignored (7780,7810). After reduction is completed, line 8000 allows the entire process to be repeated with different parameters if desired. When no more reduction is desired, the most recent calculated values are stored to file #1 (8020). If plots of the reduced data are desired, control is transferred to line 8250; otherwise, the analysis phase ends (8110).

For plotting purposes the concentration ratio data file #3 is READ from mass storage at 8270. Four types of plots are available to be performed in any order or combination: a one-dimensional slice through the data along either X or Y directions (1-D), a two dimensional contour plot of iso-concentration values (2-D), a three-dimensional representation of energy

distribution (3-D), and a histogram of concentration ratio distributions (HIST). Once NONE is given in answer to a plot request (8290), the analysis of the current test files ends (8380). A sample 3-D plot is shown in Figure 5. The 3-D plot routine (8440-9040) calls subroutine subprogram Tdplt (12690) to do the actual plotting. Operator inputs concerning the viewing position, lines to be drawn, and where to make the plot are requested at Param3 (8560). Plotting is done at 8760 with labels being added after the plot is finished. Tdplt reserves an area for labels on either the right side or below the plot, whichever would make more efficient use of available space. Labels are added to the right margins at Ylbl (8820) while labels below the plot are added at Xlbl (8870). If the plot was done on the CRT, a paper printer copy of the display can be generated using GOSUB Therml at 8950-8990. Additional 3-D plots using different parameters can be generated ad infinitum. When no further 3-D plots are wanted, selection of other plot types is allowed (9030). The perspective plot with hidden line removal was written using the algorithm described by N.Y. Graham in Perspective Drawing of Surfaces With Hidden Line Elimination, The Bell System Technical Journal, April 1972, pp 843-861. The technique orders the surface patches between data points in such a way "that no part of any patch occurring earlier in the ordering is obscured from the vantage point by any part of a patch occurring later". The patches are then plotted in that order. "The delineation of the hidden region of the projection plane, after each patch is drawn, by means of two piecewise linear continuous functions" accomplishes the hidden line identification. Subroutine subprograms Ptloc (15350) and Infill (15440) are used by Tdplt.

Figure 5. Sample 3-D Plot

The 1-D plot (9100-10100) draws the reduced concentration ratio data for up to five lines (Figure 6.) The lines to be plotted are operator-specified before each plot (9130-9190). Axes are drawn (9280-9530) and the lines are plotted on the same axes (9560-9670). Labels are added between 9740 and 9930. A paper plot (10030) or a 9872A plotter copy (10060) can be generated. The 2-D plot (10160-10990) produces up to 10 two-dimensional iso-irradiance contour plots. A sample 2-D plot is shown in Figure 7. The number of contours (10210) and their values (10240) are operator specified. The plot is produced on either the CRT (10340) or an HP 9872A plotter (10360). Labels are added on the axes (10530) and the right margin (10830). The data plotting (10770) is performed by subroutine subprogram Contour (11940) within the area reserved by the SHOW statement of line 10410. Paper plots of the CRT are produced if requested (10980). Plotting starts at the left edge of the area and draws all contour lines between the first and second columns before moving one column to the right and repeating the process. Histogram plots such as Figure 8 are done between lines 11050 and 11820. Points within the specified cell area are counted (11070-11140) to generate the integer histogram values, A (50). Axes (11240) and labels (11490) are drawn much as before. The histogram bars are drawn by repeated CLIP and FRAME operations (11320-11350). Either printer (11750) or 9872A (11780) paper copies are available.

Figure 6. Sample 1-D Plot

Figure 7. Sample 2-D Plot

Figure 8. Sample Histogram Plot

Two files of documentary information are stored as programs but are entirely comment statements intended to be read as text when LISTed. One 21 records long (DCMSPC) produces a 1-½ page brief description of lens tester specifications. The other (DCMOPB) is 135 records long and is an 8+ page monograph of operating and programming instructions pertaining to the 9845B program. Copies of both these LISTings are contained in Appendix B.

Operational Characteristics

Calibration of the Fresnel lens tester relies on the linearity of the short circuit current of a silicon PIN photodiode with incident energy. However, because of its small physical size, uniformity of response over its area is not a factor. (The resulting silicon cell measurements may, or may not, be appropriate for other detectors of different spectral response, such as gallium arsenide, etc.) One sun irradiance on the 0.5-mm-dia active area produces approximately 40 μ A of photocurrent. Maximum specified dark current for the diodes is 150 pA, a factor of 250000 X lower. The photocurrent for each diode is amplified by a linear op amp with an electrical bandpass of 5kHz. At maximum table speed, 5 msec is required for the table diode to move one active area diameter. The 5kHz bandpass should have no effect on measured spatial resolution, but it reduces high frequency noise produced by the motor translators, etc. Spatial resolution is limited only by the diode diameter. Likewise, the 14-bit A/D conversion process limits the analog dynamic range of each diode to a theoretical 16383:1. At times there is a slight interaction between the two signals. The average digitized dark current for either diode may change ± 2 LSBs depending on the signal level from the other diode. The cause of this change is unknown; it does not always occur. It is on the order of 0.01% of full scale, giving a more realistic dynamic range of 10000:1. After being digitized, only data transmission errors can occur. Detection of bit errors in the LSBs might be difficult; errors in the MSBs would be obvious. Bit errors should occur equally often in MSBs and LSBs making random bit error detection simpler. HP would not recommend a cable length of more than 15m (50 ft) for their 98032A interface. Several tests conducted using the 5-m standard cable length with and without the 15-m extension cable indicated no problems with the 20-m (60 ft) cable.

In an attempt to improve the angular off-axis response of the table diode, its metal can and lens assembly was removed, leaving the bare die on a T0-18 header. Even then a falloff in response approximating $\cos \theta$ is to be expected. The measured angular response using the sun ($1/2^\circ$ dia) as a source is shown in Figure 9. The mount was allowed to track the sun in hour angle while the declination axis was raised in steps of 5° . The response falls only slightly below $\cos \theta$ up to 45° . The edge of the filter holder physically blocks the incoming light at 50° . Light coming in at the corners of the rectangular holder will be admitted to nearly 60° but the largest unobstructed cone will be 45° . Included in Figure 9 with a different scale is

the reference diode response. The full angle viewed by the reference diode in its 20:1 tube is roughly 3° . Because of the restricted field of view, the metal can and lens assembly is left on the reference diode. The data of Figure 9 are the scattered skylight for Albuquerque, NM, 1400 MST, 23 December 1980. Skylight varies greatly with atmospheric conditions, with Figure 9 being typical for a "clear" Albuquerque day. Besides admitting a 45° cone the filter holder has one open side. The stray light thus admitted to the filter is also dependent on atmospheric conditions. The data of Figure 10 were collected with an opaque lens board blocking the lens carriage aperture. This is a measurement of not only the open side stray light but also that part of the 45° acceptance cone that falls outside the lens carriage. Larger lens-to-cell distances admit more stray skylight because more of the 45° cone is outside the carriage. Even then only large measurement areas or low concentration ratios will have a significant percentage of stray light contributions.

In order to characterize the linear response of each photodiode detector it is necessary to locate two points on the response curve of each. These points are measured with no light (dark current) and one sun irradiance (light current) on each diode. Since only relative measurements are attempted, these four readings are condensed to only three stored variables:

T_z = Table diode dark current

R_z = Reference diode dark current

Ratio = Relative gain ratio between diodes

Ratio includes contributions due to preamplifier gain differences, photodiode sensitivity differences, and the absorption of the glass lens over the reference diode. Standard industry practice for measuring direct solar insolation (light current) physically restricts the field of view of the detector with a baffle tube painted flat black whose length is 10 times its diameter, i.e., a 10:1 baffle. For calibration purposes, a baffle is required for each system diode. The reference diode is permanently mounted in a 20:1 tube painted flat black on the inside which acts as its baffle. The table diode must be easily inserted and removed. A modified filter holder with a solid disc containing a small circular hole is used in the top filter slot. Because the concentration ratio is unity, a blank filter holder is used in the bottom filter slot to exclude stray skylight during the light current readings. This creates a flat black cavity over the table diode with an opening to the sun.

Figure 9. Diode Off-Axis Response for Both System Diodes. (The sun's disc was used as a source.)

Figure 10. Typical Stray Skylight Admitted to Open Filter Holder with Lens Carriage Blocked

Ratio not only reflects differences in the electrical hardware for each diode, but differences in the baffle structure as well. By restricting the field of view of each diode to a 20:1 cone it would seem reasonable to assume that *Ratio* would remain the same unless preamplifier gains change. Such is not the case. A

20:1 cavity baffle on the table diode when compared to a 20:1 tube baffle on the reference diode will produce a *Ratio* that may vary by 5% depending upon atmospheric conditions. This can be explained by the difference in spectral absorption and reflections of the two filter holders. The spectrum of light reaching each diode will be different. This may cause a *Ratio* change as the input insolation spectrum changes. Since the spectral response to silicon is nonuniform, the cell output current will change. If not corrected, the *Ratio* change will cause concentration ratio and efficiency errors of an equal percentage. Figure 11 indicates the typical magnitude of this error caused by approaching clouds. As the insolation decreases not only do the absolute numbers decline but so does *Ratio*. The purpose of the reference diode is to correct for changes in insolation as a test is being made. Referring to Figure 11, a 60% decrease in insolation, when corrected by the reference diode reading, will give concentration ratios that are still 5% low. This is better than no correction, but points to the need to measure lens efficiencies only when the atmospheric conditions are fairly stable.

Figure 11. *Ratio* vs Reference Measurement. (Reference varied by approaching clouds.)

A filter holder identical to the table holder was built and used as a reference diode holder. With these identical holders, *Ratio* did not show the variation present with the different holders. Retaining the 20:1 tube baffle for the reference diode is operationally easier. Regardless of what reference baffle is used, the concentrated beam measured by the table diode is unaffected. It was experimentally verified that if the *Ratio* for current conditions is measured before every test, the absolute numbers may be different for different reference diode holders, but the measured efficiencies will be similar provided the insolation changes during the test are small.

If spectral shifts during testing are neglected, the type of baffle used on the reference diode is immaterial since it is left in place during the entire test and is taken into account by *Ratio*. The type of baffle used on the table diode is significant for accurate measurements. Tests with identical cavity holders indicate that a tube baffle may deliver 5% to 10% more light to the diode than will a comparable cavity type. The exact amount would depend upon the reflecting properties of its inner surface. A one-sun table calibration measured with a tube-type baffle would have more energy/area than a similar cavity calibration. This measurement defines one-sun insolation. A cavity measurement will define fewer watts/m² as one sun than would a flat black tube because of the absence of reflections. Identical table readings of the concentrated beam would give different efficiency values, depending upon which type of baffle was used for calibration. A similar but less important factor is the baffle size; i.e., 10:1, 20:1, etc. The reference diode baffle size is not as critical for the same reasons as above. Measurements on "clear" days indicate as much as 0.5% less light is admitted by a 20:1 as compared to a 10:1 cavity baffle. This 0.5% is highly dependent on the scattering conditions on test day. A 20:1 baffle will define a one-sun reference of ~0.5% less energy density with corresponding higher concentration ratio and efficiency numbers than would a 10:1. To more closely approximate industry standard, the table diode baffle is 10:1, but it is a cavity, not a tube baffle.

The effect upon the cell plane pattern caused by varying atmospheric conditions is difficult for a human observer to estimate. Conditions that appear "clear" can cause subtle changes to the measured pattern. These subtle changes can take place from day to day or in a matter of minutes with no obviously apparent atmospheric changes. 1-D plots through the center of each of the patterns may seem similar at first

glance, but closer observation will indicate that one is spread over a slightly larger area than the other. If there is light spillage outside the measured areas, it is easy to explain why slight shape changes can affect efficiency by a percent or two for seemingly identical scans. An appreciable change in *Ratio* from one scan to another is a good indication that conditions have changed, and different shapes and efficiencies may result. If the shapes for two identical scans of the same lens are the same, the efficiencies will normally agree quite well. More pronounced but still small shape changes were observed when a pair of large polarizing sheets were placed in front of a lens and used to adjust cell plane energy densities. Nonuniformities in the polarizing sheets tended to randomize the rays, creating a consistently larger pattern. It is not recommended that polarizers be used in this manner because of the relatively large shape changes. Very obvious shape changes can occur for short lens-to-cell distances if the lens carriage, table top, and reference tube are not well aligned. If they are not aligned to 20 arc minutes (or better), very noticeable skewed patterns can result.

The concentration ratio is calculated on a point-by-point basis by using *Ratio*, *Rz*, *Tz*, and filter factors predetermined and stored in the BASIC program. If the lens and cell plane areas are equal, an efficiency of 100% is achieved when the average cell area concentration ratio is unity. A cell only 1/100 the size of the lens would require an average concentration ratio of 100 for the same efficiency. We do not have complete information about the cell plane patterns, but rather a two-dimensional sampling of the pattern. An average concentration ratio, *Avcon*, is calculated for the *N* points that fall within or on the boundary of the area of interest. Each point represents a square of dimension *Int*. Method 1 for calculating efficiency, *Eff*, would be:

$$Eff_1 = (Int)^2 (N) (Avcon) / (Lens Area)$$

This assigns *Avcon* to a square of area *Int*² for each of *N* points. Unfortunately, a point on the boundary is assigned a full-size square even if some of its area lies outside the desired area. Method 2 would assign *Avcon* to the designated area only. This might be larger or smaller than the calculated (*Int*)² (*N*) depending on the particular dimensions:

$$Eff_2 = Avcon * (Cell Area) / (Lens Area)$$

Arguments could be made for either method. An ideal lens design would have zero spillage of light, i.e., its concentration ratio outside the boundary would be zero. With no energy, the *Eff* contribution from outside the boundary should be zero also. The

average concentration ratio would be the same for this ideal lens using either Method 1 or 2. (The boundary points can not be left out of *Aucon*, especially for cases with nonzero boundary values, or *Aucon* would be too high.) If this cell area were 1 x 1 in. with *Int* = 0.020 in. an array of 51 x 51 points would result ($N = 51 \times 51 = 2601$, $(Int)^2 = 4 \times 10^{-4}$). Method 1 would overstate the efficiency by a factor of $N \cdot Int^2$ compared to Method 2. For our hypothetical example:

$$Eff_1 = 1.0404 \cdot Eff_2.$$

Neither method is perfect for efficiency calculation, but the limitations of both arise from the sampling process. The lens tester uses Method 2 for all efficiency calculations.

Any change in the filter factors of the neutral density filters directly affects the efficiency values calculated. The filter factors are the attenuation factors of each filter used with the table diode to measure a concentrated solar spectrum. Different spectral sensitivities and attenuations can give different filter factors when the same filter is used with a different detector or source. For high density filters, it is difficult to measure the attenuation accurately by using

the lens tester itself because of limited dynamic range. The method employed for relative calibration of higher density filters is to scan a concentrated pattern with both a known and an unknown filter. If, in both cases, the scans are the same size and large enough to include the entire pattern (no spillage), the efficiency for both scans must be the same. The filter factor of the unknown filter will be correct when the calculated efficiencies are equal.

Conclusions

An automated Fresnel lens tester system was designed, built, and is in use which can quickly characterize the silicon cell plane irradiance pattern and efficiency of various Fresnel concentrator elements as they track the sun. The precision of such measurements approaches 0.01%, but the calculated lens efficiency accuracy depends upon several operational and philosophical decisions. The spatial distribution information as presented in four graphical outputs is highly useful both for concentrator design and evaluation purposes.

APPENDIX A

System Characteristics and Schematics

Table A-1. Fresnel Lens Tester Filter Characteristics

NEUTRAL DENSITIES:

FILTER #	THICKNESS (in)	FILTER FACTOR
1	.064	11.7
2	.105	25.8
3	.092	35.5
4	.084	54.8
5	.1	77.6
6	.085	114
7	.21	314
8	.209	550
9	.208	843
10	.205	1515
11	.127	2788

BANDPASS FILTERS (Normal Incidence):

PASS WAVELENGTH (nm)	PASS BANDWIDTH (nm)	TRANSMISSION (%) AT PEAK	THICKNESS (in)	ORIEL Co. PART #.
485	80	58	.121	5751
450	70	87	.123	5753
500	70	54	.108	5755
540	65	52	.178	5757
610	80	68	.108	5758
650	80	60	.10	5761
685	90	62	.105	5763
740	97	62	.108	5765
800	82	65	.145	5767
850	86	62	.115	5769
889	77	63	.148	5771
950	99	65	.2	5773
1001	74	87	.234	5775
1051	12	58	.208	G-522-10500
1101	10	54	.222	G-522-11000

Figure A-1. Filter Thickness Correction. (Add to Lens-to-cell distance.)

Figure A-2. Physical Layout of Digital Control Chassis for Fresnel Lens Tester System (Bottom View)

Figure A-3. Wire Wrap Locations (View from socket side)

Figure A-4. Component Carrier Details (Top View). (Rs in ohms, Cs in microfarads.)

Figure A-6. Schematic of Fresnel Lens Tester System

APPENDIX B

Listing of 9845B Program

Lens Tester Program

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10  OPTION BASE 1
20  DIM C$(80),W$(80),Fitr$(2)(3)
30  SHORT F(20),P(10),Z(102,102)
40  INTEGER A(204),Da(400)           !  INITIALIZE VARIABLES, ETC.
50  PRINTER IS 16
60  WRITE IO 2,5;32                 !  CLOSE SHUTTER IF OPEN, RESET.
70  Valid$="NONE"
80  Zerloc=0
90  DATA 11.7,25.9,35.5,54.8,77.6,114,314,550,643,1515,2790,0,0,0,0,0,0,0,0
100 MAT READ F
110 PRINT PAGE,"      This is a Fresnel lens tester program developed by G. Phipps",
120 PRINT "of the Photometrics Div., Sandia National Laboratories, Albuquerque,
130 PRINT "New Mexico, October, 1980.  A 2-dimensional array of image plane data"
140 PRINT "is taken for each lens to be tested.  The array has variable dimen-"
150 PRINT "sions to suit the test requirements as specified by the operator."
160 PRINT "Three data files are stored and retrieved from either a HP9885 floppy"
170 PRINT "disk (:F8,0), or the left tape cartridge (:T14)of the 9845 for each"
180 PRINT "test.  These files contain:",LIN(3),TAB(18),"1.  Test directory, assorted test info"
190 PRINT TAB(18),"2.  Raw data from test",LIN(1),TAB(18),"3.  Reduced data in solar concentration ratios",LIN(2)
200 PRINT "A disk can have 352 data files (117 tests) while a tape can have only"
210 PRINT "42 files (14 tests).  Storage capacity will probably limit the number",LIN(1),"of tests to less than these numbers for normal size data arrays."
220 PRINT "No data file can have more than 102 lines, or 102 data locations per line."
230 DISP "Press 'CONT' to proceed."
240 PAUSE
250 PRINT PAGE," Do you wish your mass storage to be floppy disk (F8) or tape (T14"
260 LINPUT "F8 OR T14?",M$
270 IF NOT ((M$="F8") OR (M$="T14")) THEN GOTO 250
280 PRINT TAB(20),M$
290 IF M$="F8" THEN MASS STORAGE IS ":F8,0"
300 IF M$="T14" THEN MASS STORAGE IS ":T14"
310 What:PRINT PAGE,"Do you wish to acquire a new data file, analyze already recorded",LIN(1),"data, or end program execution?"
320 PRINT LIN(4)," Please answer with HCU, ANL, or END followed by 'CONT'."
330 INPUT A$
340 PRINT TAB(43),A$
350 IF A$="END" THEN PRINT PAGE,"H-P RECOMMENDS TO RE-WIND YOUR TAPES BEFORE STORAGE.",LIN(2),"PLEASE STORE ALL EQUIPMENT IN ITS PROPER PLACE.",LIN(2),"BYE."
360 IF A$="END" THEN MASS STORAGE IS ":T15"
370 IF A$="END" THEN STOP
380 IF A$="ACQ" THEN GOTO Acq
390 IF A$="ANL" THEN GOTO Anl
400 GOTO What
410 !
420 !
430 !
440 !  GGGGGGG  0000000  SSSSSSS  UU  UU  BBBBBBB
450 !  GG      00  00  SS      UU  UU  P-  BB
460 !  GG  GGG  00  00  SSSSSSS  UU  UU  8
470 !  GG  GG   00  00      SS  UU  UU  88
480 !  GGGGGGG  0000000  SSSSSSS  UUUUUU  SBBB  S
490 !
500 !
510 Mass: F14=1
520 REEP
530 IF ERRN=53 THEN GOTO impnam

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540 IF ERRN=54 THEN GOTO Dup
550 IF ERRN=55 THEN GOTO Full
560 IF ERRN=56 THEN GOTO Undef
570 IF ERRN=64 THEN GOTO Over
580 IF ERRN=80 THEN GOTO Mt
590 IF ERRN=82 THEN GOTO Mt
600 IF ERRN=83 THEN GOTO Prot
610 IF ERRN=84 THEN GOTO Record
620 IF ERRN=85 THEN GOTO Init
630 IF ERRN=86 THEN GOTO Not45
640 Flg=2
650 PRINT " ERROR NOT RECOGNIZED",ERRM$
660 PRINT LIN(1)," CORRECT THE ERROR AND PRESS 'CONT'."
670 PAUSE
680 RETURN
690 Record: IF M$="F8" THEN PRINT " ERROR 84",LIN(1)," YOU PROBABLY HAVE NOT I
INITIALIZED YOUR DISK."
700 IF M$="T14" THEN GOTO G50
710 GOTO Init
720 Not45: IF M$="F8" THEN PRINT " DISK F8 IS NOT RECOGNIZED AS A 9845B UNIT. I
INITIALIZATION WILL DESTROY",LIN(1)," DATA IT MIGHT CONTAIN."
730 IF M$="T14" THEN PRINT " TAPE T14 IS NOT RECOGNIZED AS A 9845B UNIT. INIT
IALIZATION WILL DESTROY",LIN(1)," DATA IT MIGHT CONTAIN."
740 Init: IF M$="F8" THEN PRINT " DO YOU WISH TO INITIALIZE F8?"
750 IF M$="T14" THEN PRINT " DO YOU WISH TO INITIALIZE T14?"
760 INPUT "Y or N 'CONT'",A$
770 IF A$="Y" THEN GOTO 790
780 IF A$="N" THEN GOTO Mt
790 IF M$="F8" THEN PRINT " INITIALIZING F8"
800 IF M$="T14" THEN PRINT " INITIALIZING T14"
810 IF M$="F8" THEN INITIALIZE ":F8"
820 IF M$="T14" THEN INITIALIZE ":T14"
830 RETURN
840 Mt: IF M$="F8" THEN PRINT " INSTALL A DISK IN F8 AND PRESS 'CONT'"
850 IF M$="T14" THEN PRINT " INSTALL A TAPE IN T14 AND PRESS 'CONT'"
860 PAUSE
870 RETURN
880 Prot: IF M$="F8" THEN PRINT " F8 IS WRITE PROTECTED. EITHER INSTALL ANOTHER
DISK OR REMOVE PROTECTION.",LIN(1)," PRESS 'CONT' TO PROCEED."
890 IF M$="T14" THEN PRINT " T14 IS WRITE PROTECTED. EITHER INSTALL ANOTHER T
APE OR REMOVE PROTECTION.",LIN(1)," PRESS 'CONT' TO PROCEED."
900 PAUSE
910 RETURN
920 Over: IF M$="F8" THEN PRINT " TOO MUCH DATA FOR THIS DISK. INSTALL NEW DISK
AND PRESS 'CONT'."
930 IF M$="T14" THEN PRINT " TOO MUCH DATA FOR THIS TAPE. INSTALL A NEW TAPE
AND PRESS 'CONT'."
940 PAUSE
950 RETURN
960 Undef: IF M$="F8" THEN PRINT " THE FILE NAME YOU SELECTED IS UNDEFINED FOR T
HIS DISK.",LIN(1)," IS THE NAME PROPER?? IS THIS THE PROPER DISK??"
970 IF M$="T14" THEN PRINT " THE FILE NAME YOU SELECTED IS UNDEFINED FOR THIS
TAPE.",LIN(1)," IS THE NAME PROPER?? IS THIS THE PROPER TAPE??"
980 PRINT LIN(1)," PRESS 'CONT' TO TRY AGAIN."
990 Flg=2
1000 PAUSE
1010 RETURN
1020 Full: IF M$="F8" THEN PRINT " THE DISK HAS ITS LIMIT OF FILES ALREADY.",LIN
(1)," INSTALL ANOTHER DISK AND PRESS 'CONT'."
1030 IF M$="T14" THEN PRINT " THE TAPE HAS ITS LIMIT OF FILES ALREADY.",LIN(1),
" INSTALL ANOTHER TAPE AND PRESS 'CONT'."
1040 PAUSE
1050 RETURN
1060 Dup: PRINT " THE FILE NAME YOU HAVE SELECTED IS NOT UNIQUE!! TO PROCEE. PR
ESS 'CONT'."
1070 Flg=2

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1080 PAUSE
1090 RETURN
1100 Impnam:PRINT "  IMPROPER FILE NAME.  PRESS 'CONT' TO TRY AGAIN."
1110 Flg=2
1120 PAUSE
1130 RETURN
1140 !
1150 !
1160 !
1170 Ioerr:BEEP
1180 IoFlg=1
1190 IF TIME OUT(2) THEN GOTO Timeout
1200 PRINT "  INTERRUPT NOT RECOGNIZED."
1210 PRINT LIN(1),"  CORRECT THE ERROR(?) AND PRESS 'CONT'"
1220 PAUSE
1230 RETURN
1240 Timeout: PRINT "  INTERFACE OR LENS TESTER TIMEOUT FAILURE.",LIN(1),"  WHEN
  PROBLEM IS CORRECTED PRESS 'CONT'.  YOU MAY NEED TO START PROGRAM OVER."
1250 PAUSE
1260 RETURN
1270 !
1280 !
1290 !
1300 Therm1: PRINTER IS 0
1310 PRINT PAGE
1320 DUMP GRAPHICS
1330 PRINT USING 1340;Q$,D$,T$,Numflt,W$,C$,Ratio,Fltfac,Fltr$(*)
1340 IMAGE //////////"File ",K," recorded on "K" at ",K" used ",K" filter(s)."/"W$
  = "K/"C$ = "K/"Ratio = "K,4X,"Fltfac = "K,4X,3A,2X,3A
1350 PRINT USING 1360;Pts,Lns
1360 IMAGE "Pts = ",DDD,"  Lns = ",DDD
1370 IF Arlens$="Circular" THEN PRINT USING 1380;Xlens,Meas$
1380 IMAGE /"This circular lens has a diameter of "K" ",K,"."
1390 IF Arlens$="Rectangular" THEN PRINT USING 1400;Xlens,Ylens,Meas$
1400 IMAGE /"This rectangular lens has dimensions of "K" by ",K," ",K,"."
1410 PRINTER IS 16
1420 RETURN
1430 !
1440 !
1450 !
1460 Check: S=0
1470 IF INT((Pts-1)*Int/2)+A+Int+ABS(Xoff+X)>2000 THEN GOTO 1510
1480 IF INT((Lns-1)*Int/2)+A+Int+ABS(Yoff+Y)>2000 THEN GOTO 1510
1490 S=1
1500 GOTO 1530
1510 PRINT LIN(1),"  This combination of scanned area, step size, and/or offset
  cause the starting",LIN(1),"  table location to exceed the table travel."
1520 PRINT LIN(1),"  Please reenter smaller numbers!"
1530 RETURN
1540 !
1550 !
1560 !
1570 !  AAAAAAA  CCCCCC  QQQQQQQ  SSSSSSS  TTTTTTT  NN  NN
1580 !  AA  AA  CC  QQ  QQ  SS  TT  NNN  NN
1590 !  AAAAAA  CC  QQ  QQ  SSSSSS  TT  NN  NN  NN
1600 !  AA  AA  CC  QQ  Q  QQ  SS  TT  NN  NNNN
1610 !  AA  AA  CCCCCC  QQQQQQQ  SSSSSS  TT  NN  NN
1620 !
1630 !
1640 !
1650 Acq:STATUS 2;S  !  IS 98032A CARD PLUGGED IN?
1660 Mask$="10XXXX"
1670 IF BIT(S,Mask$) THEN GOTO Okcard
1680 PRINT PAGE,LIN(10),"  MAKE SURE THE INTERFACE CARD IS PLUGGED INTO THE 9845
  !!!"
1690 PRINT "  IF THE CARD IS PLUGGED IN IT IS NOT RECOGNIZED AS A 98032A."

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1700 PRINT LIN(2),"  TURN OFF THE 9845 AND INSTALL THE LENS TESTER 98032A CARD W
ITH A SELECT",LIN(1),"  CODE 2, THEN START THIS PROGRAM AGAIN FROM POWER ON."
1710 GOTO 1710
1720 Okcard:IF BIT(S,8) THEN GOTO Okbox      ! IS THE TESTER OPERATIONAL?
1730 PRINT PAGE,LIN(10),"  EITHER THE INTERFACE CABLE IS NOT PLUGGED INTO THE LE
NS",LIN(1),"  TESTER, OR THE AC POWER HAS NOT BEEN APPLIED TO THE LENS TESTER."
1740 PRINT "  WHEN EITHER OR BOTH OF THESE DEFECTS ARE CORRECTED PRESS 'CONT'."
,LIN(1)
1750 PAUSE
1760 GOTO Acq
1770 Okbox:SET TIMEOUT 2;500                ! WAIT 1/2 SEC FOR TIMEOUT ERROR.
1780 SERIAL
1790 ON INT #2 GOSUB Ioerr                  ! TIMEOUT IS AN EOL BRANCH,USE INT
1800 WRITE IO 2,5;33                       ! STOP CLK, ALLOW OUTPUT, RESET.
1810 Ioflag=0
1820 OUTPUT 2 WHS USING "#,W";12288        ! DISABLE COUNTERS.
1830 IF Ioflag=1 THEN GOTO 1810
1840 Zero!C=0
1850 IF (Zero!C=1) AND (Valid$="Y") THEN GOTO Yzero
1860 WRITE IO 2,5;33                       ! ALLOW OUTPUT, RESET
1870 PRINT PAGE,"  We are now searching for table position (0,0)."
```

1880 OUTPUT 2 WHS USING "#,W";16384 ! GO TO Hd Stps, MUX Lim Sws.

1890 STATUS 2;S

1900 IF NOT BIT(S,1) THEN GOTO 1890

1910 PRINT LIN(2)," That was the extreme upper left hand corner of table travel

."

1920 WAIT 500 ! X0,Y0 SEARCH

1930 CALL Move(1,1,2500,0) ! MOVE +X 2.5"

1940 OUTPUT 2 WHS USING "#,W";8193 ! Int=1, MUX X0 SWITCH

1950 STATUS 2;S

1960 IF NOT BIT(S,1) THEN GOTO 1950

1970 OUTPUT 2 WHS USING "#,W";12288 ! STOP TABLE, DISABLE COUNTERS

1980 WAIT 500

1990 Xstep:OUTPUT 2 WHS USING "#,W";12368 ! X ENABLE (-)

2000 OUTPUT 2 WHS USING "#,W";20480 ! STEP

2010 OUTPUT 2 WHS USING "#,W";0 ! -X

2020 OUTPUT 2 WHS USING "#,W";8449 ! MUX X0 ENCODER

2030 WAIT 20

2040 STATUS 2;S

2050 IF NOT BIT(S,1) THEN GOTO 2000

2060 Xzero:PRINT LIN(2)," The table is now positioned with X=0."

2070 WAIT 500

2080 CALL Move(0,1,2500,0) ! MOVE +Y 2.5"

2090 OUTPUT 2 WHS USING "#,W";8193 ! Int=1,MUX Y0 SWITCH

2100 STATUS 2;S

2110 IF NOT BIT(S,1) THEN GOTO 2100

2120 OUTPUT 2 WHS USING "#,W";12288 ! STOP TABLE, DISABLE COUNTERS

2130 WAIT 500

2140 Ystep:OUTPUT 2 WHS USING "#,W";12448 ! Y ENABLE (-)

2150 OUTPUT 2 WHS USING "#,W";24576 ! STEP

2160 OUTPUT 2 WHS USING "#,W";4096 ! -Y

2170 OUTPUT 2 WHS USING "#,W";8448 ! MUX Y0 ENCODER

2180 WAIT 20

2190 STATUS 2;S

2200 IF NOT BIT(S,1) THEN GOTO 2150

2210 Zero!C=1

2220 Yzero:PRINT LIN(2)," The table is now at its center position, (0,0)."

2230 WAIT 1000

2240 IF (Valid\$="Y") OR (Valid\$="NONE") THEN GOTO Msys

2250 IF Xoff=0 THEN GOTO 2280 ! IF DATA WAS INVALID THEN:

2260 CALL Move(1,SGN(Xoff),ABS(Xoff),0) ! MOVE TO Xoff

2270 WAIT 2*ABS(Xoff) ! and/

2280 IF Yoff=0 THEN GOTO 4560 ! or

2290 CALL Move(0,SGN(Yoff),ABS(Yoff),0) ! MOVE TO Yoff

2300 WAIT 2*ABS(Yoff)

2310 GOTO 4560


```

2320 Msys:PRINT LIN(3)," Which measurement system would you prefer to use for y
our input:",LIN(1),TAB(25),"1. Inches",LIN(1),TAB(25),"2. Millimeters"
2330 A$=""
2340 INPUT " 1 or 2 'CONT'",A$
2350 Meas$="In"
2360 IF A$="2" THEN Meas$="Mm"
2370 IF NOT ((A$="1") OR (A$="2")) THEN GOTO 2320
2380 PRINT USING 2390;Meas$
2390 IMAGE " YOU SELECTED "2A"."
2400 PRINT LIN(3)," The aperature of the fresnel lens that transmits light is:"
,LIN(1),TAB(25),"1. Circular",LIN(1),TAB(25),"2. Rectangular"
2410 A$=""
2420 INPUT " 1 or 2 'CONT'",A$
2430 IF A$="1" THEN GOTO Round
2440 IF NOT (A$="2") THEN GOTO 2400
2450 Square: Arlens$="Rectangular"
2460 PRINT LIN(1)," What are the X and Y dimensions of the lens?",Meas$
2470 INPUT "X,Y 'CONT'",Xlens,Ylens
2480 IF (Xlens<=0) OR (Ylens<=0) THEN GOTO 2520
2490 PRINT TAB(30),"X = ",Xlens
2500 PRINT TAB(30),"Y = ",Ylens
2510 GOTO 2630
2520 PRINT " POSITIVE NONZERO NUMBERS PLEASE!"
2530 GOTO 2460
2540 Round: Arlens$="Circular"
2550 PRINT LIN(1)," What is the diameter of the lens area?",TAB(61),Meas$
2560 INPUT " Diameter 'CONT'",Xlens
2570 IF Xlens<=0 THEN GOTO 2610
2580 PRINT TAB(25),"Diameter = ",Xlens
2590 Ylens=Xlens
2600 GOTO 2630
2610 PRINT " POSITIVE NONZERO NUMBERS PLEASE!"
2620 GOTO 2550
2630 PRINT LIN(2)," The table will always perform a rectangular scan in the ima
ge plane but",LIN(1)," efficiency data can be calculated from either;"
2640 PRINT TAB(25),"1. A circular image area",TAB(25),"2. A rectangular image
area",LIN(1)," Which do you prefer?",LIN(1)
2650 A$=""
2660 INPUT " 1 or 2 followed by 'CONT'",A$
2670 Area$="Rectangular"
2680 IF A$="1" THEN Area$="Circular"
2690 IF NOT ((A$="2") OR (A$="1")) THEN GOTO 2630
2700 PRINT " YOU SELECTED",Area$
2710 IF Area$="Circular" THEN GOTO Circ
2720 Rect: PRINT LIN(2)," WHAT ARE THE X AND Y DIMENSIONS OF THE SCANNED AREA?"
,Meas$
2730 INPUT "Xscan,Yscan 'CONT'",Xscan,Yscan
2740 IF (Xscan>4) AND (Meas$="In") OR (Xscan>1016) AND (Meas$="Mm") THEN GOTO La
rge
2750 IF (Yscan>4) AND (Meas$="In") OR (Yscan>1016) AND (Meas$="Mm") THEN GOTO La
rge
2760 PRINT TAB(30)," Xscan=",Xscan
2770 PRINT TAB(30)," Yscan=",Yscan
2780 IF (Xscan>0) AND (Yscan>0) THEN GOTO Step
2790 PRINT " POSITIVE NONZERO NUMBERS PLEASE!"
2800 GOTO 2730
2810 Large: PRINT " Xscan or Yscan TOO LARGE, TRY AGAIN."
2820 GOTO 2730
2830 Circ: PRINT LIN(2)," WHAT IS THE DIAMETER OF THE CIRCULAR SCANNED AREA?",M
eas$
2840 INPUT "Diameter 'CONT'",Xscan
2850 IF (Xscan>4) AND (Meas$="In") OR (Xscan>1016) AND (Meas$="Mm") THEN GOTO Bi
g
2860 PRINT TAB(25),"Diameter = ",Xscan
2870 Yscan=Xscan
2880 IF Xscan>0 THEN GOTO Step

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2890 PRINT " POSITIVE NONZERO NUMBERS PLEASE!"
2900 GOTO 2840
2910 Big: PRINT " Diameter IS TOO LARGE, TRY AGAIN"
2920 GOTO 2840
2930 Step:PRINT LIN(3)," WHAT IS THE Interval BETWEEN DATA POINTS?",Meas$,LIN(1
),TAB(25),"Interval<=.255 In (.47 Mm) & >=.002 In (.051 Mm)"
2940 INPUT "Interval 'CONT'",Step ! Step NOT integered, In OR Mm.
2950 PRINT " Interval=",Step
2960 Int=Step*1000 ! Int,
2970 Xs=Xscan*1000 ! Xs,
2980 Ys=Yscan*1000 ! and Ys ALWAYS 1/1000's OF In.
2990 IF Meas$="In" THEN GOTO 3030
3000 Int=Int/25.4 ! CONVERT TO In.
3010 Xs=Xs/25.4 ! if
3020 Ys=Ys/25.4 ! necessary.
3030 Int=INT(Int) ! Int ALWAYS integered 1/1000's In.
3040 IF (Int>=2) AND (Int<=255) THEN GOTO 3070
3050 PRINT " PLEASE CHECK YOUR Interval!"
3060 GOTO 2940
3070 Pts=INT(Xs/Int)+1
3080 Lns=INT(Ys/Int)+1
3090 IF MAX(Pts,Lns)<103 THEN GOTO 3130
3100 PRINT " THIS MAY BE REASONABLE, BUT THIS FILE IS TOO LARGE FOR PROGRAM DIM
ENSIONS."
3110 PAUSE
3120 GOTO 2710
3130 N=Pts*Lns
3140 PRINT USING 3150;N
3150 IMAGE /"THIS INVOLVES TAKING DATA AT "10D" LOCATIONS. DOES THIS SEEM REASO
NABLE?"
3160 A$=""
3170 INPUT " Y or N 'CONT'",A$
3180 IF A$="N" THEN GOTO 2710
3190 IF NOT (A$="Y") THEN GOTO 3150
3200 S=Ys
3210 IF Xscan>Yscan THEN S=Xs
3220 S=.6*(3000-S)
3230 IF S<0 THEN S=0
3240 A=-2 ! 4000 PPS MOTOR RUNS 2 STEPS OUT IF SYNC!
3250 Da=0
3260 A=A+Int
3270 Da=Da+1
3280 IF A<S THEN GOTO 3260
3290 Xoff=Yoff=X=Y=0
3300 GOSUB Check
3310 IF S=1 THEN GOTO 3340
3320 IF Area$="Rectangular" THEN GOTO Rect
3330 IF Area$="Circular" THEN GOTO Circ
3340 PRINT LIN(2)," WHAT IS TODAY'S DATE?"
3350 LINPUT "MO/DA/YR 'CONT'",D$
3360 PRINT " ",D$
3370 PRINT LIN(1)," WHAT ARE THE WEATHER CONDITIONS?"
3380 LINPUT W$
3390 PRINT " ",W$
3400 PRINT " ANY COMMENTS ON THIS TEST?"
3410 LINPUT C$
3420 PRINT " ",C$
3430 Name:PRINT " UNIQUE FILE NAME FOR TEST DATA (5 CHARS)"
3440 Q$=""
3450 INPUT Q$[1,5]
3460 IF Q$="" THEN GOTO Name
3470 PRINT USING 3480;Q$[1,5]
3480 IMAGE " FILE NAME SELECTED WAS "5A". DISK FILES ARE BEING CREATED."
3490 Create:ON ERROR GOSUB Mass ! CREATE 3 UNIQUE DATA FILES
3500 Flg=0

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3510 CREATE Q$&"1",2
3520 IF Flg=2 THEN GOTO Name
3530 IF Flg=1 THEN GOTO 3500
3540 IF Xscan>Yscan THEN CREATE Q$&"2",Lns,8*Pts
3550 IF Yscan>Xscan THEN CREATE Q$&"2",Pts,8*Lns
3560 IF Flg=1 THEN GOTO 3500
3570 IF Xscan>Yscan THEN CREATE Q$&"3",Lns,4*Pts
3580 IF Yscan>Xscan THEN CREATE Q$&"3",Pts,4*Lns
3590 IF Flg=1 THEN GOTO 3500
3600 PRINT LIN(1)," WHAT IS THE LOCAL TIME?"
3610 INPUT "HR:MN 'CONT'",T$
3620 PRINT " ",T$
3630 PRINT LIN(2)," The next step is aligning the mount to the sun."
3640 PRINT LIN(3)," DO YOU NEED INSTRUCTIONS FOR ALIGNING THE MOUNT?"
3650 A$=""
3660 INPUT "Y or N 'CONT'",A$
3670 IF A$="N" THEN GOTO 3810
3680 IF NOT (A$="Y") THEN GOTO 3660
3690 PRINT PAGE," Align the tester cart so that it is in a North-South orientat
ion",LIN(1)," and lower the 4 support feet."
3700 PAUSE
3710 PRINT LIN(2)," Loosen locks on both axes and roughly align the reference t
ube to the sun."
3720 PAUSE
3730 PRINT LIN(2)," Turn on the tracking motor and do fine alignment using the
reference tube",LIN(1)," mounted sight and the fine alignment motors."
3740 PAUSE
3750 PRINT LIN(2)," Check to be sure that the alignment pinhole in the upper le
ns carriage member",LIN(1)," casts its image on the table reference mark."
3760 PAUSE
3770 PRINT LIN(2)," If the two sun sight pinholes do not align simulataneously
the reference tube",LIN(1)," must be realigned to the table."
3780 PAUSE
3790 PRINT LIN(2)," If the alignment is proper the mount should now track the s
un. "
3800 PAUSE
3810 PRINT PAGE," We will now measure the dark current and gain ratio of the tw
o diodes."
3820 PRINT LIN(2)," Install the opaque cover on the reference tube and in the l
ower filter holder slot.",LIN(1)," PRESS 'CONT' TO PROCEED."
3830 PAUSE
3840 Rz=Tz=Ratio=0
3850 OFF INT #2 ! OFF INT TO ALLOW WFHS
3860 REDIM A(200)
3870 FOR J=1 TO 2
3880 WRITE IO 2,5;35 ! OPEN SHUTTER, ALLOW OUTPUT, RESET
3890 WAIT 500
3900 OUTPUT 2 WHS USING "#,W";101 ! X=.101"
3910 IF J=1 THEN OUTPUT 2 WHS USING "#,W";12369 ! X ENABLE (-), Int ENABLE
3920 IF J=2 THEN OUTPUT 2 WHS USING "#,W";12353 ! X ENABLE (+), Int ENABLE
3930 OUTPUT 2 WHS USING "#,W";8193 ! Int=1
3940 OFF INT #2
3950 WRITE IO 2,5;2 ! ALLOW ENTER
3960 ENTER 2 WFHS 200 NOFORMAT;A(*) ! MOVE TABLE, ENTER DATA
3970 WAIT 20
3980 ON INT #2 GOSUB Ioerr
3990 WRITE IO 2,5;33 ! CLOSE SHUTTER, ALLOW OUTPUT, RESET
4000 IF J=2 THEN GOTO 4090
4010 FOR I=1 TO 100
4020 Rz=Rz+(16383-A(I*2-1))/100
4030 Tz=Tz+(16383-A(I*2))/100
4040 NEXT I
4050 PRINT "Tz = ",Tz," Rz = ",Rz
4060 PRINT LIN(2)," REMOVE THE TWO OPAQUE COVERS FROM THE DIODES.",LIN(1),"
INSURE THE TABLE BAFFLE IS INSTALLED, THEN PRESS 'CONT'."

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4070 PAUSE
4080 IF J=1 THEN GOTO 4130
4090 FOR I=1 TO 100
4100     Ratio=Ratio+(16383-A(I*2-1)-Rz)/((16383-A(I*2)-Tz)*100)
4110 NEXT I
4120 PRINT LIN(1),"Ratio = ",Ratio
4130 NEXT J
4140 Fltfac=0
4150 ON INT #2 GOSUB Ioerr          ! TIMEOUT IS AN EOL BRANCH,USE INT
4160 WRITE IO 2,5;33              ! RESET, ALLOW OUTPUT
4170 OUTPUT 2 WHS USING "#,W";12288 ! DISABLE COUNTERS
4180 WRITE IO 2,5;33              ! RESET, ALLOW OUTPUT
4190 PRINT LIN(2)," The next step is lens installation and mount balancing."
4200 PRINT LIN(2)," DO YOU NEED INSTRUCTIONS FOR INSTALLING THE LENS?"
4210 A$=""
4220 INPUT "Y or N 'CONT'",A$
4230 IF A$="N" THEN GOTO Flt
4240 IF NOT (A$="Y") THEN GOTO 4220
4250 PRINT PAGE," NEVER USE THE SIDE MOUNTED DIODE TUBE AS A HANDLE.",LIN(2)
4260 PAUSE
4270 PRINT " While HOLDING the X-Y platform, loosen the locks on the azimuth
axis, and",LIN(1)," rotate -90 deg. to bring the carriage rods horizontal."
4280 PAUSE
4290 PRINT LIN(2)," Apply the locks to both axes to prevent rotation of the mo
unt."
4300 PAUSE
4310 PRINT LIN(2)," The lens and mask assembly is now placed on the front of t
he carriage",LIN(1)," and secured with the 4 wing nuts,"
4320 PAUSE
4330 PRINT LIN(2)," While HOLDING the lens carriage, loosen 3 thumbscrews on
the pillow blocks",LIN(1)," adjust lens-cell distance, and re-tighten."
4340 PAUSE
4350 PRINT PAGE," Hold the carriage assembly to prevent rotation and loosen the
2 counter",LIN(1)," weights by turning them in opposite directions."
4360 PAUSE
4370 PRINT LIN(2)," While supporting the carriage by the counter weight rod, ad
just the",LIN(1)," counter weights for balance."
4380 PAUSE
4390 PRINT LIN(2)," To check final balance release the azimuth locks and see if
the yoke",LIN(1)," rotates. Balanced elevation will not turn azimuth."
4400 PAUSE
4410 PRINT LIN(2)," Rotate the weights together to lock. Install the lens cap
and align the",LIN(1)," mount to track the sun as instructed previously."
4420 PAUSE
4430 PRINT PAGE
4440 Flt:Numflt=10
4450 Fltr$(1)=Fltr$(2)=""
4460 INPUT " HOW MANY FILTERS DO YOU WISH TO USE?",Numflt
4470 IF Numflt=0 THEN GOTO 4560
4480 IF Numflt=1 THEN GOTO 4510
4490 IF Numflt=2 THEN GOTO 4540
4500 GOTO 4460
4510 INPUT "ENTER THE NUMBER OF THE FILTER BEING USED, F? 'CONT'",Fltr$(1)
4520 PRINT LIN(1)," THE FILTER BEING USED IS",Fltr$(1)
4530 GOTO 4560
4540 INPUT "ENTER THE NUMBERS OF THE 2 FILTERS BEING USED, F?,F? 'CONT'",Fltr$(1
),Fltr$(2)
4550 PRINT LIN(1)," THE 2 FILTERS BEING USED ARE",Fltr$(1),Fltr$(2)
4560 PRINT PAGE," 2 LINES OF DATA AT X0 & Y0 WILL CHECK FOR DIODE SATURATION &
CENTERING."
4570 PRINT USING 4580;Numflt
4580 IMAGE /" BE SURE THAT THE "K" FILTER(S) ARE INSTALLED IN THE HOLDER,"
4590 PRINT LIN(1)," also THAT THE MOUNT IS PROPERLY TRACKING THE SUN ,"
4600 PRINT LIN(1)," then MOMENTARILY REMOVE THE LENS CAP AND PRESS 'CONT'."
4610 PAUSE
4620 IF C=1 THEN GOTO 4650

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4630 CALL Move(1,-1,INT((Pts-1)*Int/2)+Int+A,0)      ! MOVE TO X SCAN
4640 WAIT 2*(INT((Pts-1)*Int/2)+Int+A)                ! STARTING LOCATION
4650 CONTROL MASK 2;2                                ! PREVENTS ENTER FROM CLOSING SHUTTER
4660 REDIM Da(2*Da),A(2*Pts)
4670 FOR K=1 TO 2
4680   IF K=2 THEN REDIM A(2*LnS)
4690   WRITE IO 2,5;35                                ! OPEN SHUTTER, ALLOW OUTPUT, RESET
4700   WAIT 200
4710   IF K=1 THEN OUTPUT 2 WHS USING "#,W";2*A+Int*(Pts+1)      ! X=***
4720   IF K=2 THEN OUTPUT 2 WHS USING "#,W";4096+2*A+Int*(LnS+1) ! Y=***
4730   IF K=1 THEN OUTPUT 2 WHS USING "#,W";12355                ! FAST +X
4740   IF K=2 THEN OUTPUT 2 WHS USING "#,W";12419                ! FAST +Y
4750   OUTPUT 2 WHS USING "#,W";8192+Int                      ! LOAD Int
4760   WRITE IO 2,5;2                                          ! OPEN SHTR, ENTER
4770   OFF INT #2
4780   IF K=1 THEN ENTER 2 WFHS 2*(Pts+Da) USING "#,W";Da(*),A(*) !TAKE X DATA.
4790   IF K=2 THEN ENTER 2 WFHS 2*(LnS+Da) USING "#,W";Da(*),A(*) !TAKE Y DATA.
4800   BEEP
4810   ON INT #2 GOSUB Ioerr
4820   WRITE IO 2,5;1                                          ! CLOSE SHUTTER, OUTPUT
4830   WAIT Int+A
4840   IF K=2 THEN GOTO 5040
4850   CALL Move(0,-1,INT((LnS-1)*Int/2)+Int+A,0)
4860   WAIT 2*(INT((LnS-1)*Int/2)+Int+A)
4870   CALL Move(1,-1,A+Int*Pts-INT((Pts-1)*Int/2),0)
4880   WAIT A+Int*Pts-INT((Pts-1)*Int/2)
4890   PLOTTER IS 13,"GRAPHICS"                                ! DRAW PLOT AXES AND SCALE
4900   GRAPHICS
4910   SCALE 0,1.5*Pts,-1000,17383
4920   CLIP 1,Pts,0,16383
4930   FRAME
4940   LONG 5
4950   LDIR 0
4960   CSIZE 2.5
4970   CALL Scale(Int,Pts,K,Meas$)
4980   MOVE 1+(Pts-1)/2,0
4990   LINE TYPE 4
5000   DRAW 1+(Pts-1)/2,16383
5010   LINE TYPE 1
5020   N=Pts
5030   GOTO 5110
5040   CALL Move(1,-1,INT((Pts-1)*Int/2)+A+Int,0)
5050   WAIT 2*(INT((Pts-1)*Int/2)+Int+A)
5060   CALL Move(0,-1,A+Int*LnS-INT((LnS-1)*Int/2),0)
5070   SCALE 1-(LnS-1)/(Pts-1),1+(1.5*Pts-1)*(LnS-1)/(Pts-1),-1000,17383
5080   CALL Scale(Int,LnS,K,Meas$)
5090   CLIP 1,LnS,0,16383
5100   N=LnS
5110   FOR I=1 TO 2                                ! PLOT RAW DIODE DATA
5120     MOVE 1,16383-A(I)
5130     FOR J=2 TO N
5140       IF (4*(4*K+I+J) MOD 44=0) AND (K=1) THEN LABEL USING "K";"X0"
5150       IF (4*(4*K+I+J) MOD 44=0) AND (K=1) THEN MOVE J-1,16383-A(2*J+I-4)
5160       IF (4*(4*K+I+J) MOD 44=0) AND (K=2) THEN LABEL USING "K";"Y0"
5170       IF (4*(4*K+I+J) MOD 44=0) AND (K=2) THEN MOVE J-1,16383-A(2*J+I-4)
5180       DRAW J,16383-A(2*J+I-2)
5190     NEXT J
5200   NEXT I
5210 NEXT K
5220 MOVE 1.25*LnS,12000
5230 ON KEY #0 GOTO 5340                                ! ON KEY TO EXIT DIODE PLOT
5240 ON KEY #5 GOSUB Therm1
5250 CSIZE 3
5260 LABEL USING "K";"DIODE OUTPUT PLOTS"
5270 LABEL USING "K"
5280 LABEL USING "K";"PRESS KEY 5 FOR"

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5290 LABEL USING "K";"PAPER PLOT"
5300 LABEL USING "K";""
5310 LABEL USING "K";"PRESS KEY 0 TO"
5320 LABEL USING "K";"PROCEED"
5330 GOTO 5330
5340 OFF KEY #0
5350 OFF KEY #5
5360 EXIT GRAPHICS
5370 C=1
5380 PRINT LIN(1),"  CONSIDERING THE IMAGE CENTERING AND DYNAMIC RANGE, DO YOU W
ISH TO TRY AGAIN?"
5390 A$=""
5400 INPUT "  Y or N 'CONT'",A$
5410 IF A$="N" THEN GOTO 5730
5420 IF NOT (A$="Y") THEN GOTO 5380
5430 PRINT PAGE,"  THE MINIMUM NONZERO OFFSET IN EITHER DIRECTION IS .002In (.05
1Mm). "
5440 PRINT "  DO YOU WISH TO OFFSET THE IMAGE CENTER IN X OR Y?"
5450 A$=""
5460 INPUT "Y or N 'CONT'",A$
5470 IF A$="N" THEN GOTO 4460
5480 IF NOT (A$="Y") THEN GOTO 5440
5490 PRINT LIN(1),"  HOW MUCH OFFSET IS DESIRED IN ",Meas$,"?"
5500 INPUT "Xoff,Yoff",X,Y
5510 PRINT LIN(1),"Xoff = ",X,"Yoff = ",Y
5520 IF Meas$="Mm" THEN X=X/25.4
5530 IF Meas$="Mm" THEN Y=Y/25.4
5540 X=INT(X*1000)
5550 Y=INT(Y*1000)
5560 IF NOT ((X=1) OR (Y=1)) THEN GOTO 5590
5570 PRINT "  ONE OR BOTH OF YOUR OFFSETS ARE OF A SINGLE STEP."
5580 GOTO 5490
5590 IF ABS(Xoff+X)=1 THEN X=X+1
5600 IF ABS(Yoff+Y)=1 THEN Y=Y+1
5610 GOSUB Check
5620 IF S=1 THEN GOTO 5640
5630 GOTO 5490
5640 IF X=0 THEN GOTO 5670
5650 CALL Move(1,SGN(X),ABS(X),0)
5660 WAIT 2*ABS(X)
5670 IF Y=0 THEN GOTO 5700
5680 CALL Move(0,SGN(Y),ABS(Y),0)
5690 WAIT 2*ABS(Y)
5700 Xoff=Xoff+X
5710 Yoff=Yoff+Y
5720 GOTO 4460
5730 IF Xscan=Yscan THEN CALL Move(0,-1,INT((Lns-1)*Int/2),0)
5740 IF Yscan>Xscan THEN CALL Move(0,-1,INT((Lns-1)*Int/2)+Int+A,0)
5750 WAIT 2*(INT((Lns-1)*Int/2)+Int+A)
5760 IF Xscan>Yscan THEN GOTO 5790
5770 CALL Move(1,1,Int+A,0)
5780 WAIT 2*(Int+A)
5790 OUTPUT 2 WHS USING "#,W";352
5800 OUTPUT 2 WHS USING "#,W";12352
5810 ASSIGN Q$&"2" TO #2
5820 PLOTTER IS 13,"GRAPHICS"
5830 SHOW 1,Pts,Lns,1
5840 LORG 5
5850 MOVE 1,1
5860 LABEL USING "K";"0"
5870 MOVE Pts,Lns
5880 LABEL USING "K";"0"
5890 MOVE 1,1
5900 PRINT LIN(3),"  CHECK THE SIGHT TO BE SURE THAT THE MOUNT HAS BEEN TRACKING
THE SUN.",LIN(1),"  WHEN READY TO SCAN, REMOVE LENS CAP AND PRESS 'CONT'."

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5910 PAUSE
5920 GRAPHICS
5930 WRITE IO 2,5;2 ! OPEN SHUTTER
5940 WAIT 50
5950 IF Yscan>Xscan THEN GOTO Yscan
5960 Xscan:REDIM A(2*Pts)
5970 FOR I=1 TO Lns ! TAKE DATA IN Lns X SCANS.
5980 WRITE IO 2,5;35 ! RESET, ALLOW OUTPUT
5990 OUTPUT 2 WHS USING "#,W";2*A+Int*(Pts+1) ! X=***
6000 OUTPUT 2 WHS USING "#,W";12371-16*(I MOD 2) ! FAST +-X
6010 OUTPUT 2 WHS USING "#,W";8192+Int ! Int=**, SCAN X.
6020 OFF INT #2 ! DISABLE INTERRUPT
6030 WRITE IO 2,5;2 ! ENTER
6040 ENTER 2 WFHS 2*(Pts+Da) USING "#,W";Da(*),A(*)!TAKE DATA,TIMEOUT DISABLED
6050 BEEP
6060 ON INT #2 GOSUB Ioerr ! TIMEOUT IS EOL BRANCH,USE INT
6070 DRAW Pts*(I MOD 2)+(I+1) MOD 2,I
6080 WAIT Int+A
6090 MAT PRINT #2,I;A ! WRITE DATA TO TAPE.
6100 WRITE IO 2,5;3 ! OUTPUT
6110 IF I=Lns THEN GOTO 6170
6120 CALL Move(0,1,Int,1) ! MOVE +Y BY Int
6130 WAIT 2*Int
6140 DRAW Pts*(I MOD 2)+(I+1) MOD 2,I+1
6150 OUTPUT 2 WHS USING "#,W";352 ! SCREWY
6160 OUTPUT 2 WHS USING "#,W";12352 ! FAST RESET
6170 NEXT I
6180 GOTO Xxyz
6190 Yscan:REDIM A(2*Lns)
6200 FOR I=1 TO Pts ! TAKE DATA IN Pts Y SCANS.
6210 WRITE IO 2,5;35 ! RESET, ALLOW OUTPUT
6220 OUTPUT 2 WHS USING "#,W";4096+2*A+Int*(Lns+1) ! Y=***
6230 OUTPUT 2 WHS USING "#,W";12451-32*(I MOD 2) ! FAST +-Y
6240 OUTPUT 2 WHS USING "#,W";8192+Int ! Int=**, SCAN Y.
6250 OFF INT #2 ! DISABLE INTERRUPT
6260 WRITE IO 2,5;2 ! ALLOW ENTER
6270 ENTER 2 WFHS 2*(Lns+Da) USING "#,W";Da(*),A(*)! TAKE DATA, TIMEOUT OFF
6280 BEEP
6290 ON INT #2 GOSUB Ioerr ! TIMEOUT EOL BRNH,USE INT
6300 DRAW I,Lns*(I MOD 2)+(I+1) MOD 2
6310 WAIT Int+A
6320 MAT PRINT #2,I;A ! WRITE DATA TO TAPE
6330 WRITE IO 2,5;3 ! ENTER
6340 IF I=Pts THEN GOTO 6400
6350 CALL Move(1,1,Int,1) ! MOVE +X BY Int
6360 WAIT 2*Int
6370 DRAW I+1,Lns*(I MOD 2)+(I+1) MOD 2
6380 OUTPUT 2 WHS USING "#,W";352 ! SCREWY
6390 OUTPUT 2 WHS USING "#,W";12352 ! FAST RESET
6400 NEXT I
6410 Xxyz:WRITE IO 2,5;1 ! CLOSE SHUTTER, OUTPUT
6420 IF Yscan>Xscan THEN CALL Move(1,-1,Int*(Pts-1)-INT((Pts-1)*Int/2),0)!RTN X
6430 IF (Xscan=Yscan) AND (I MOD 2=0) THEN CALL Move(1,-1,A+Pts*Int-INT((Pts-1)*Int/2),0)
6440 IF (Xscan=Yscan) AND (I MOD 2=1) THEN CALL Move(1,1,A+INT((Pts-1)*Int/2)+Int,0)
6450 WAIT 2*(A+Pts*Int-INT((Pts-1)*Int/2))
6460 IF Xscan=Yscan THEN CALL Move(0,-1,Int*(Lns-1)-INT((Lns-1)*Int/2),0)!RTN Y
6470 IF (Yscan>Xscan) AND (I MOD 2=1) THEN CALL Move(0,1,A+INT((Lns-1)*Int/2)+Int,0)
6480 IF (Yscan>Xscan) AND (I MOD 2=0) THEN CALL Move(0,-1,A+Int*Lns-INT((Lns-1)*Int/2),0)
6490 WAIT 2*(A+Int*Lns-INT((Lns-1)*Int/2))
6500 EXIT GRAPHICS
6510 IF Xoff=0 THEN GOTO 6540
6520 CALL Move(1,-SGN(Xoff),ABS(Xoff),0) ! RETURN TO X0

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6530 WAIT 2*ABS(Xoff)
6540 IF Yoff=0 THEN GOTO File1
6550 CALL Move(0,-SGN(Yoff),ABS(Yoff),0) ! RETURN TO Y0
6560 WAIT 2*ABS(Yoff)
6570 File1:PRINT LIN(1)," PLEASE REPLACE THE LENS CAP, and CHECK THAT THE TABLE
IS AT X0,Y0."
6580 PRINT LIN(1)," IF THE TABLE IS NOT AT X0,Y0 ERRORS IN THE SCAN MAKE THE DA
TA INVALID.",LIN(1)," A NEW SCAN WILL BE MADE IF YOU ANSWER 'N'."
6590 INPUT " DATA VALID? Y or N 'CONT'",Valid$
6600 IF Valid$="N" THEN GOTO Zero
6610 IF NOT (Valid$="Y") THEN GOTO 6590
6620 ASSIGN * TO #2
6630 ASSIGN Q$&"1" TO #1
6640 Anal$="HAS NOT"
6650 PRINT #1;Xscan,Yscan,Step,Xeff,Yeff,Effsch,Ratio,Numflt,Fltr$(*),Meas$,Area$
,C$,W$,T$,D$,Q$,Anal$,Avcnsh,Imax,Xlens,Ylens,Arlens$,Eff,Aucon,Tz,Rz,Fltfac
6660 ASSIGN * TO #1
6670 GOTO What
6680 !
6690 !
6700 !
6710 ! AAAAAAA NN NN AAAAAA LL YY YY SSSSSSS
6720 ! AA AA NNN NN AA AA LL YY YY SS
6730 ! AAAAAA NN NNNN AAAAAA LL YY SSSSSSS
6740 ! AA AA NN NNN AA AA LL YY SS
6750 ! AA AA NN NN AA AA LLLLLL YY SSSSSSS
6760 !
6770 !
6780 !
6790 An1:PRINT PAGE," WHAT IS THE NAME OF THE FILE YOU WISH TO ANALYZE?",LIN(1)
6800 ON ERROR GOSUB Mass
6810 INPUT " 5 CHARACTERS 'CONT'",Q$[1,5] ! DETERMINE INPUT DATA FILE.
6820 Flg=0
6830 ASSIGN #1 TO Q$&"1" ! ASSIGN PROPER DATA FILES.
6840 IF Flg=1 THEN GOTO 6820
6850 IF Flg=2 THEN GOTO 6790
6860 Flg=0
6870 ASSIGN #2 TO Q$&"2"
6880 IF Flg=1 THEN GOTO 6820
6890 ASSIGN #3 TO Q$&"3"
6900 IF Flg=1 THEN GOTO 6820
6910 READ #1;Xscan,Yscan,Step,Xeff,Yeff,Effsch,Ratio,Numflt,Fltr$(*),Meas$,Area$
,C$,W$,T$,D$,Q$,Anal$,Avcnsh,Imax,Xlens,Ylens,Arlens$,Eff,Aucon,Tz,Rz,Fltfac
6920 IF Area$="Circular" THEN Yscan=Xscan
6930 Int=Step*1000
6940 Xs=Xscan*1000
6950 Ys=Yscan*1000
6960 IF Meas$="In" THEN GOTO 7000
6970 Xs=Xs/25.4
6980 Ys=Ys/25.4
6990 Int=Int/25.4
7000 Int=INT(Int)
7010 Pts=INT(Xscan*1000/Int)+1
7020 Lns=INT(Yscan*1000/Int)+1
7030 PRINT USING 7040;Q$,D$,T$,Numflt,Anal$,Xscan,Meas$
7040 IMAGE @"File ",K," recorded on ",K," at "K" using ",K," filter(s) "K" bee
n"/" data reduced. The area which was scanned was ",K,X,K
7050 IF Area$="Circular" THEN PRINT USING 7060;Area$,C$,W$,Pts,Lns,Fltr$(*)
7060 IMAGE 2X,K". "/"Comment = ",K/"Weather = ",K/"Pts = ",K," Lns = ",K/K,2X,K
/
7070 IF Area$="Rectangular" THEN PRINT USING 7080;Yscan,Meas$,Area$,C$,W$,Pts,Ln
s,Fltr$(*)
7080 IMAGE " by ",K,X,K,X,K". "/"Comment = ",K/"Weather = ",K/"Pts = ",K," Lns
= ",K/K,2X,K/
7090 S=Lns*(Xscan>Yscan)+Pts*(Yscan>Xscan) ! A(2*Pts) or A(2*Lns)

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7100 T=Pts*(Xscan>Yscan)+Lns*(Yscan>Xscan) ! depending upon scan direction
7110 REDIM A(2*T),Z(Lns,Pts) ! ALWAYS Z(Y,X)=Z(Lns,Pts)
7120 IF Anal$="HAS NOT" THEN GOTO 7240
7130 PRINT USING 7140;Arlens$,Area$,Effsch,Avcnsh
7140 IMAGE " This ",K," lens which forms a "K" image area had a SCANNED AREA"/
10X,"Efficiency = "DDD.DD"% and"/10X,"Ave concentration = "DDDD.DD/
7150 IF Area$="Circular" THEN PRINT USING 7160;Xeff,Meas$,Eff,Aucon
7160 IMAGE " The smaller Circular image area of diameter ",K,X,K," had an IMAGE
AREA"/11X,"Efficiency = ",DDD.DD,"% and"/11X,"Ave Concentration = ",DDDD.DD
7170 IF Area$="Rectangular" THEN PRINT USING 7180;Xeff,Yeff,Meas$,Eff,Aucon
7180 IMAGE " The smaller Rectangular image of dimensions "K" by ",K,X,K" had an
IMAGE AREA"/11X,"Efficiency = ",DDD.DD,"%"/11X,"Ave Concentration = ",DDDD.DD
7190 PRINT LIN(1)," FILTER FACTOR = ",Fltfac
7200 A$=""
7210 INPUT " DO YOU WISH TO RECOMPUTE EFFICIENCY? Y or N 'CONT'",A$
7220 IF A$="N" THEN GOTO 8010
7230 IF NOT (A$="Y") THEN GOTO 7210
7240 PRINT LIN(1)," What area <= the scanned area do you wish to use for calcul
ations?",LIN(1),TAB(20),"In units of ",Meas$
7250 IF Area$="Circular" THEN INPUT "Diameter = ? 'CONT'",Xeff
7260 IF Area$="Circular" THEN PRINT TAB(15),"Diameter = ",Xeff
7270 IF Area$="Rectangular" THEN INPUT " X,Y = ? 'CONT'",Xeff,Yeff
7280 IF Area$="Rectangular" THEN PRINT TAB(10)," Xeff = ",Xeff,"Yeff = ",Yeff
7290 IF Anal$="HAS NOT" THEN GOTO 7350
7300 PRINT " DO YOU WANT TO RECALCULATE CONCENTRATION RATIOS ALSO?"
7310 A$=""
7320 INPUT "Y or N 'CONT'",A$
7330 IF A$="N" THEN GOTO 7690
7340 IF NOT (A$="Y") THEN GOTO 7300
7350 Fltfac=Ratio ! CALCULATE PROPER FILTER FACTOR.
7360 IF Numflt=0 THEN GOTO 7400
7370 FOR I=1 TO Numflt
7380 Fltfac=Fltfac*F(VAL(Fltr$(I)[2,3]))
7390 NEXT I
7400 PRINT USING 7410;Numflt,Fltr$(*),Ratio,Fltfac
7410 IMAGE "/" The "K" filter(s) used: ",3A,X,3A/" together with the diode ga
in ratio of "K/" result in a filter factor of "K
7420 PRINT LIN(1)," DO YOU WISH TO ALTER THIS FILTER FACTOR?"
7430 A$=""
7440 INPUT " Y or N 'CONT'",A$
7450 IF A$="N" THEN GOTO 7500
7460 IF NOT (A$="Y") THEN GOTO 7420
7470 PRINT LIN(1)," WHAT FILTER FACTOR WOULD YOU PREFER? (Fltfac=Ratio*F(N).)"
7480 INPUT " Filter Factor = ? 'CONT'",Fltfac
7490 PRINT " FILTER FACTOR = ",Fltfac
7500 PRINT LIN(1)," CONCENTRATION RATIOS are now being calculated."
7510 FOR J=1 TO S
7520 READ #2,J;A(*)
7530 FOR I=1 TO T
7540 IF Yscan>Xscan THEN GOTO 7600
7550 IF J MOD 2=0 THEN GOTO 7580
7560 Z(J,I)=(16383-A(2*I)-Tz)*Fltfac/(16383-A(2*I-1)-Rz)
7570 GOTO 7640
7580 Z(J,I)=(16383-A(2*(T-I+1))-Tz)*Fltfac/(16383-A(2*(T-I+1)-1)-Rz)
7590 GOTO 7640
7600 IF J MOD 2=0 THEN GOTO 7630
7610 Z(I,J)=(16383-A(2*I)-Tz)*Fltfac/(16383-A(2*I-1)-Rz)
7620 GOTO 7640
7630 Z(I,J)=(16383-A(2*(T-I+1))-Tz)*Fltfac/(16383-A(2*(T-I+1)-1)-Rz)
7640 NEXT I
7650 NEXT J
7660 READ #3,1
7670 MAT PRINT #3;Z
7680 GOTO 7710
7690 READ #3,1

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7700 MAT READ #3;Z
7710 Eff:Eff=Effscn=N=Nscn=0
7720 PRINT LIN(2)," Lens Efficiency is now being calculated."
7730 Imax=-999999999999
7740 FOR J=1 TO Lns
7750   FOR I=1 TO Pts
7760     Imax=MAX(Imax,Z(J,I))
7770     IF Area$="Circular" THEN Rad=SQR((Int*(I-1)-INT(Xs/2))^2+(Int*(J-1)-INT
(Ys/2))^2)
7780     IF (Area$="Circular") AND (Rad>Xscan*500) THEN GOTO 7860
7790     Effscn=Effscn+Z(J,I)
7800     Nscn=Nscn+1
7810     IF (Area$="Circular") AND (Rad>Xeff*500) THEN GOTO 7860
7820     IF (Area$="Rectangular") AND (ABS(Int*(I-1)-INT(Xs/2))>Xeff*500) THEN G
OTO 7860
7830     IF (Area$="Rectangular") AND (ABS(Int*(J-1)-INT(Ys/2))>Yeff*500) THEN G
OTO 7860
7840     Eff=Eff+Z(J,I)
7850     N=N+1
7860   NEXT I
7870 NEXT J
7880 IF Arlens$="Circular" THEN Ylens=Xlens*PI/4
7890 IF Area$="Circular" THEN Yscan=Xscan*PI/4
7900 IF Area$="Circular" THEN Yeff=Xeff*PI/4
7910 IF N=0 THEN Avcon=0
7920 IF N=0 THEN GOTO 7940
7930 Avcon=Eff/N
7940 IF Nscn=0 THEN GOTO 7960
7950 Avcnsh=Effscn/Nscn
7960 Effscn=100*Avcnsh*Xscan*Yscan/(Xlens*Ylens)
7970 Eff=100*Avcon*Xeff*Yeff/(Xlens*Ylens)
7980 Anal$="HAS"
7990 PRINT PAGE," DATA CONVERSION COMPLETED. Max concentration ratio = ",Imax,
LIN(1)
8000 GOTO 7130
8010 READ #1,1 ! REPOSITION FILE POINTER TO BEGINNING.
8020 PRINT #1;Xscan,Yscan,Step,Xeff,Yeff,Effscn,Ratio,Numflt,Filtr$(*),Meas$,Area
$,C$,W$,T$,D$,Q$,Anal$,Avcnsh,Imax,Xlens,Ylens,Arlens$,Eff,Avcon,Tz,Rz,Fltfac
8030 ASSIGN * TO #1
8040 ASSIGN * TO #2
8050 PRINT LIN(2)," DO YOU WISH TO PRODUCE ANY DISPLAYS?"
8060 A$=""
8070 INPUT "Y or N? CONT",A$
8080 IF A$="Y" THEN GOTO 8250
8090 IF NOT (A$="N") THEN GOTO 8050
8100 ASSIGN * TO #3
8110 GOTO What
8120 !
8130 !
8140 !
8150 !      PPPPPPP      LL      0000000      TTTTTTT      SSSSSSS
8160 !      PP      PP      LL      00      00      TT      SS
8170 !      PP      PP      LL      00      00      TT      SS
8180 !      PPPPPPP      LL      00      00      TT      SSSSSSS
8190 !      PP      LL      00      00      TT      SS
8200 !      PP      LL      00      00      TT      SS
8210 !      PP      LLLLLLL      0000000      TT      SSSSSSS
8220 !
8230 !
8240 !
8250 DISP " The CONCENTRATION RATIOS are being loaded."
8260 READ #3,1
8270 MAT READ #3;Z ! READ CONCENTRATION RATIOS FROM DISK.
8280 DEG
8290 Displa:PRINT PAGE," Please indicate which display you wish to produce."

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8300 PRINT "      1D,2D,3D,HIST or NONE  'CONT'."
8310 A$=""
8320 INPUT A$
8330 IF A$="1D" THEN GOTO Slice
8340 IF A$="2D" THEN GOTO Contur
8350 IF A$="3D" THEN GOTO Thdplt
8360 IF A$="HIST" THEN GOTO Histog
8370 IF NOT (A$="NONE") THEN GOTO 8290
8380 GOTO What
8390 !
8400 !
8410 !                               3-D PLOT
8420 !
8430 !
8440 Thdplt: Imin=999999999999
8450 PRINT PAGE
8460 PRINT "  This 3-D plot is a perspective view of the solar concentration da
ta",LIN(1),"taken from a distance of 6*(Diagonal length of image area).",LIN(1)
8470 PRINT "The viewer is located between the lens tester and the sun as the te
ster tracks."
8480 PRINT "The view orientation to the table is described by Az and El, both i
n degrees.",LIN(1)
8490 PRINT "El=0 places the viewer in the plane of the table's surface.  El=90
puts",LIN(1),"the viewer perpendicularly over the center of the diode."
8500 PRINT "With Az=0 the viewer is looking at the table as it would be at sola
r noon.",LIN(1),"Positive Az rotates the image CW about the image center."
8510 FOR J=1 TO Lns
8520   FOR I=1 TO Pts
8530     Imin=MIN(Imin,Z(J,I))
8540   NEXT I
8550 NEXT J
8560 Param3: PRINT LIN(1),"SPECIFY El AND Az PLEASE."
8570 INPUT "El,Az -- 45,45 etc. 'CONT'",El,Az  ! GET NECESSARY INFO FOR PLOT.
8580 PRINT USING 8590;El,Az
8590 IMAGE 7X,4D,4X,4D
8600 PRINT "WHICH TYPE OF LINES DO YOU WISH IN THE 3-D PLOT?"
8610 PRINT TAB(20),"1. Horizontal only",LIN(1),TAB(20),"2. Vertical only",LIN(1
),TAB(20),"3. Both"
8620 INPUT "1 or 2 or 3 'CONT'",A
8630 IF NOT ((A=1) OR (A=2) OR (A=3)) THEN GOTO 8620
8640 PRINT LIN(1),"PLEASE SPECIFY WHERE THE PLOT IS TO BE MADE: 9845 or 9872A."
8650 INPUT "9845 or 9872A 'CONT'",A$
8660 IF A$="9872A" THEN GOTO 8690
8670 PLOTTER IS 13,"GRAPHICS"
8680 GOTO 8730
8690 PRINT "  IS 9872A PLOTTER 'ON' AND PAPER LOADED?"
8700 INPUT "Y or N 'CONT'",A$
8710 IF A$="N" THEN 8690
8720 PLOTTER IS 7,5,"9872A"
8730 PRINT TAB(50),A$
8740 DISP "THERE WILL NOW BE A SHORT DELAY BEFORE THE PLOTTING BEGINS."
8750 COLLECT
8760 CALL Tdplt(Pts,Lns,Imax,Imin,El,Az,A,lim,Z(*))
8770 COLLECT
8780 CSIZE 3
8790 LNTR 0
8800 LORG 5
8810 IF Lim=1 THEN GOTO X1b1
8820 Y1b1: SCALE 0,130,0,100      ! ADD LABELS ON RIGHT MARGIN.
8830 MOVE 115,80
8840 LABEL USING 8850;Q$,El,Az,Effsch
8850 IMAGE "3-D PLOT"/"OF FILE "5A//"El = "3D//"Az = "3D,5/,"  Scan Efficiency
y ="/2X,DDD,DD%"
8860 GOTO 8930
8870 X1b1: SCALE 0,100,0,120      ! ADD LABELS ON BOTTOM MARGIN.

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8880  LORG 5
8890  MOVE 46,15
8900  LABEL USING 8910;Q$,E1,Az,Effsch
8910  IMAGE " 3-D PLOT OF FILE "5A//"E1 = "4D,6X,"Az = "4D/" Scan Efficiency =
      "DDD.DD,"%"
8920  PEN 0
8930  WAIT 2000
8940  EXIT GRAPHICS
8950  PRINT "DO YOU WANT A HARD COPY OF THIS PLOT?"
8960  IF A$="9845" THEN PRINT "          A 9872A PLOT REQUIRES ANOTHER 3D PLOT, BUT
      NOT A COMPLETE 3D RUN."
8970  INPUT "Y or N 'CONT'",A$
8980  IF A$="N" THEN GOTO 9010
8990  GOSUB Therm1                      ! GET HARD COPY OF PLOT.
9000  GOTO 8950
9010  PRINT PAGE," DO YOU WANT ANOTHER 3D PLOT OF THIS FILE?"
9020  INPUT "Y or N 'CONT'",A$
9030  IF A$="N" THEN Displa
9040  GOTO Param3
9050  !
9060  !
9070  !                      1-D PLOT
9080  !
9090  !
9100  Slice: PRINT USING 9120;Lns,Pts      ! DO PLOTS OF INDIVIDUAL LINES OF DATA.
9110  COLLECT
9120  IMAGE "// " You can obtain a plot of as many as 5 of "K" slices in the X-d
      irection"/" or "K" slices in the Y-direction."
9130  INPUT " HOW MANY LINES, AND IN WHAT DIRECTION (X or Y)? #,ltr",N,P$
9140  IF NOT ((P$="X") OR (P$="Y")) THEN 9130
9150  T=Pts*(P$="X")+Lns*(P$="Y")
9160  S=Pts*(P$="Y")+Lns*(P$="X")
9170  IF (N>5) OR (N<1) THEN GOTO 9130
9180  PRINT USING 9190;N
9190  IMAGE /5X,"What are those "K" LINE numbers?"
9200  REDIM P(N)
9210  INPUT "1,2,3,etc. 'CONT'",P(*)
9220  FOR I=1 TO N
9230    IF (P(I)>S) OR (P(I)<1) THEN GOTO 9190
9240  NEXT I
9250  PRINT USING 9260;P(*)
9260  IMAGE "      Lines to be plotted are: "K/4(30X,K/
9270  PLOTTER IS 13,"GRAPHICS"          ! MAKE PLOT ON CRT.
9280  Linsca:GRAPHICS
9290  SCALE =.15*T,1.5*T,-.15*Imax,1.1*Imax
9300  B(1)=INT(T/20)
9310  IF B(1)=0 THEN B(1)=1
9320  CLIP 1,T,0,Imax
9330  AXES B(1),Imax/20,1,0,2,2          ! ADD AXES TO PLOT.
9340  AXES B(1),Imax/20,T,-2*Imax/20,2,2
9350  AXES B(1),Imax/20,1-2*B(1),Imax,2,2
9360  LORG 8
9370  CSIZE 2
9380  FOR I=0 TO Imax STEP Imax/10      ! NUMBER VERT AXIS.
9390    MOVE 0,I
9400    IF Imax>1000 THEN GOTO 9460
9410    IF Imax>100 THEN GOTO 9440
9420    LABEL USING "DDD.DD";I
9430    GOTO 9470
9440    LABEL USING "DDD.D";I
9450    GOTO 9470
9460    LABEL USING "DDDD";I
9470  NEXT I
9480  LDIR 90
9490  COLLECT
9500  FOR I=1 TO T STEP B(1)*2          ! NUMBER HORIZ AXIS.

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9510  MOVE I,-Imax/50
9520  LABEL USING "DDD.DDD";(I-1)*Int/1000
9530  NEXT I
9540  LORG 5
9550  LDIR 0
9560  FOR K=1 TO N                ! DO ACTUAL DATA PLOTTING.
9570    IF P$="X" THEN MOVE 1,Z(P(K),1)
9580    IF P$="Y" THEN MOVE 1,Z(1,P(K))
9590    FOR I=2 TO T
9600      IF P$="Y" THEN Stor=Z(I,P(K))
9610      IF P$="X" THEN Stor=Z(P(K),I)
9620      DRAW I,Stor
9630      IF NOT (I MOD INT(T/3.5)-K*INT(T/20)=0) THEN GOTO 9660
9640      LABEL USING "K";P(K)
9650      MOVE I,Stor
9660    NEXT I
9670  NEXT K
9680  COLLECT
9690  CSIZE 3
9700  LORG 5
9710  LDIR 0
9720  SCALE 0,160,0,125
9730  MOVE 132,110
9740  LABEL USING 9750;P(*)        ! ADD PLOT LABELS.
9750  IMAGE "PLOT OF SLICES:"5(</K>
9760  IF Area$="Circular" THEN LABEL USING 9770;Q$,Xeff,Eff,Aucon
9770  IMAGE "OF FILE "5A,////" Image Diameter = "/5X,DDD.DDD,/" Lens efficiency
    = "/5X,DDD.DD"%"/," Ave concentration = "/5X,DDDD.DD
9780  IF Area$="Rectangular" THEN LABEL USING 9790;Q$,Xeff,Yeff,Eff,Aucon
9790  IMAGE "OF FILE "5A,////" Image Dimensions = "/X,DDD.DDD,","DDD.DDD/" Lens ef
    ficiency = "/5X,DDD.DD"%"/," Ave concentration = "/5X,DDDD.DD
9800  LABEL USING 9810;Effsch,Imax,Avcnsh
9810  IMAGE ////"Scan Efficiency = "/5X,DDD.DD,"%"/"Max scan conc = "/5X,DDDD.DD/"
    Ave scan conc = "/5X,DDDD.DD
9820  MOVE 0,63
9830  LDIR 90
9840  LORG 6
9850  LABEL USING "K";"SOLAR CONCENTRATION RATIO"
9860  MOVE 60,0
9870  LDIR 0
9880  LORG 4
9890  IF P$="Y" THEN GOTO 9920
9900  LABEL USING "K";"X DIMENSION (<","Meas$,")"
9910  GOTO 9930
9920  LABEL USING "K";"Y DIMENSION (<","Meas$,")"
9930  PEN 0
9940  WAIT 2000
9950  EXIT GRAPHICS
9960  PRINT LIN(2)," DO YOU WISH A HARD COPY OF THIS PLOT?"
9970  A$=""
9980  INPUT "Y or N 'CONT'",A$
9990  IF A$="N" THEN GOTO Displa
10000  IF NOT (A$="Y") THEN GOTO 9960
10010  PRINT " 9845 PRINTER or 9872A?"
10020  INPUT "9845 or 9872A 'CONT'",A$
10030  IF A$="9845" THEN GOSUB Thrm1
10040  IF A$="9845" THEN GOTO 9960
10050  IF NOT (A$="9872A") THEN GOTO 10020
10060  PRINT " IS 9872A PLOTTER 'ON' AND PAPER LOADED?"
10070  INPUT "Y or N 'CONT'",A$
10080  IF NOT (A$="Y") THEN GOTO 10060
10090  PLOTTER IS 7,5,"9872A"      ! MAKE PLOT ON 9872A.
10100  GOTO Linsca
10110  !
10120  !
10130  !

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2-D PLOT

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10140 !
10150 !
10160 Contur:PRINT ,PAGE," The viewer's position for this 2-D plot is standing
between the",LIN(1)," lens tester and the sun looking directly at the table."
10170 PRINT LIN(1)," The Y motor will be vertical as it would be while tracking
at solar noon.",LIN(1)
10180 PRINT USING 10190;Q$
10190 IMAGE // " You can obtain a 2-D plot of as many as 10 of the iso-intensity
"/5X" contours of file "5A". "/" How many contours do you wish?"
10200 N=0
10210 INPUT " HOW MANY CONTOURS?",N
10220 IF (N<1) OR (N>10) THEN GOTO 10210
10230 PRINT USING 10240;N
10240 IMAGE /5X,"What are those "K" contour values as a percentage of maximum?"
10250 REDIM P(N)
10260 INPUT "10,56,79,99, etc. 'CONT',P(*)"
10270 PRINT USING 10280;P(*)
10280 IMAGE " Contour values to be plotted are: "K/9(39X,K/)
10290 PRINT " WHERE DO YOU WANT THIS PLOT TO APPEAR?",LIN(2)." ON THE 98
72A OR THE 9845?"
10300 A$=""
10310 INPUT "9872A or 9845 'CONT',A$"
10320 IF A$="9872A" THEN GOTO 10360
10330 IF NOT (A$="9845") THEN GOTO 10310
10340 PLOTTER IS 13,"GRAPHICS" !SELECT 9845 PLOTTER.
10350 GOTO Consca
10360 PRINT " IS 9872A PLOTTER 'ON' AND PAPER LOADED?"
10370 INPUT "Y or N 'CONT',A$"
10380 IF NOT (A$="Y") THEN GOTO 10360
10390 PLOTTER IS 7,5,"9872A" !SELECT 9872A PLOTTER.
10400 Consca:GRAPHICS
10410 SHOW -.15*Pts,1.5*Pts,1.1*Lns, -.15*Lns ! SET PLOTTING SCALE.
10420 B(1)=INT(Pts/20)
10430 IF B(1)=0 THEN B(1)=1
10440 B(2)=INT(Lns/20)
10450 IF B(2)=0 THEN B(2)=1
10460 CLIP 1,Pts,1,Lns
10470 AXES B(1),B(2),1,1,2,2
10480 AXES B(1),B(2),1-2*B(1),Lns,2,2
10490 AXES B(1),B(2),Pts,1-2*B(2),2,2
10500 LORG 2
10510 CSIZE 2
10520 LDIR 90
10530 FOR I=1 TO Pts STEP 2*B(1) ! NUMBER HORIZ AXIS.
10540 MOVE I,0
10550 IF Meas$="Mm" THEN GOTO 10580
10560 LABEL USING "D.DDD";(I-1)*Int/1000
10570 GOTO 10590
10580 LABEL USING "DDD.DD";(I-1)*Int/1000
10590 NEXT I
10600 LDIR 0
10610 LORG 8
10620 FOR J=1 TO Lns STEP 2*B(2) ! NUMBER VERT AXIS.
10630 MOVE 0,J
10640 IF Meas$="Mm" THEN GOTO 10670
10650 LABEL USING "D.DDD";(J-1)*Int/1000
10660 GOTO 10680
10670 LABEL USING "DDD.DD";(J-1)*Int/1000
10680 NEXT J
10690 CSIZE 3
10700 LORG 4
10710 MOVE Pts/2, -.12*(Lns*(1.25*Lns*RATIO>1.65*Pts)+Pts*(1.25*Lns*RATIO<=1.65*P
ts))
10720 LABEL USING "K";"X DIMENSION (" ,Meas$," )" ! LABEL HORIZ AXIS.
10730 LDIR 90
10740 MOVE -.12*(Lns*(1.25*Lns*RATIO>1.65*Pts)+Pts*(1.25*Lns*RATIO<=1.65*Pts)),L

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ns/2
10750 LABEL USING "K"; "Y DIMENSION (" , Meas$ , ")" ! LABEL VERT AXIS.
10760 COLLECT
10770 CALL Contour(N,Pts,Lns,Imax,Z(*),P(*))
10780 COLLECT
10790 CSIZE 3
10800 LORG 2
10810 SCALE -.15,1.5,-.15,1.1
10820 MOVE 1.05,.9
10830 LABEL USING 10840;P(*)
10840 IMAGE "PLOT OF CONTOURS(%):"10(/8X,K)
10850 IF Area$="Circular" THEN LABEL USING 10860;Q$,Xeff,Eff,Effsch
10860 IMAGE " OF FILE "5A,4/"Image diameter ="/8X,DDD.DDD/"Lens Efficiency ="/
8X,DDD.DD,"%",//,"Scan efficiency ="/8X,DDD.DD,"%"
10870 IF Area$="Rectangular" THEN LABEL USING 10880;Q$,Xeff,Yeff,Eff,Effsch
10880 IMAGE " OF FILE "5A,4/"Image dimensions ="/DDD.DD"," ,DDD.DD/" Lens Effici
ency ="/8X,DDD.DD,"%",//,"Scan efficiency ="/8X,DDD.DD,"%"
10890 PEN 0
10900 WAIT 2000
10910 EXIT GRAPHICS
10920 IF A$="9872A" THEN GOTO Displa
10930 PRINT LIN(2)," DO YOU WANT A HARD COPY OF THIS PLOT?",LIN(1)," A 987
2A PLOT REQUIRES AN 'N' AND ANOTHER 2D CALCULATION."
10940 A$=""
10950 INPUT "Y or N. 'CONT'",A$
10960 IF A$="N" THEN GOTO Displa
10970 IF NOT (A$="Y") THEN GOTO 10930
10980 GOSUB Therm1
10990 GOTO 10930
11000 !
11010 !
11020 ! HISTOGRAM PLOT
11030 !
11040 !
11050 Histogram:REDIM A(50)
11060 PRINT LIN(2)," THE HISTOGRAM DATA IS NOW BEING CALCULATED."
11070 MAT A=ZER
11080 FOR J=1 TO Lns
11090 FOR I=1 TO Pts ! CALCULATE HISTOGRAM VALUES.
11100 IF (Area$="Circular") AND (SQR((Int*(J-1)-INT(Xs/2))^2+(Int*(I-1)-INT(Y
s/2))^2)>Xeff*500) THEN GOTO 11130
11110 IF Z(J,I)<0 THEN Z(J,I)=0
11120 A(INT(49.99*Z(J,I)/Imax)+1)=A(INT(49.99*Z(J,I)/Imax)+1)+1
11130 NEXT I
11140 NEXT J
11150 K=0
11160 FOR I=1 TO 50 ! DETERMINE MAX HISTOGRAM OCCURRENCE VALUE.
11170 K=MAX(K,A(I))
11180 NEXT I
11190 IF K=10*INT(K/10) THEN GOTO 11210
11200 K=10+10*INT(K/10)
11210 PLOTTER IS 13,"GRAPHICS" ! MAKE HISTOGRAM ON 9845.
11220 Hisplt:GRAPHICS
11230 SCALE -8,76,-10,102
11240 CLIP -8,1,0,100 ! ADD AXES TO GRAPHS.
11250 AXES 1,10,1,-50,10,1
11260 CLIP 1,51,0,-10
11270 AXES 1,5,-49,0,10,2
11280 CLIP 51,76,0,100
11290 AXES 1,10,51,-50,10,1
11300 CLIP 1,51,0,100
11310 FRAME
11320 FOR I=1 TO 50 ! DRAW HISTOGRAMS.
11330 CLIP I,I+1,0,100*A(I)/K
11340 FRAME
11350 NEXT I

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11360 LDIR 0
11370 LORG 5
11380 CSIZE 2
11390 FOR I=0 TO 10          ! NUMBER VERTICAL AXIS.
11400 MOVE -2,I*10
11410 LABEL USING "DDDDD";I*K/10
11420 NEXT I
11430 FOR I=1 TO 51 STEP 10  ! NUMBER HORIZONTAL AXIS.
11440 MOVE I,-3
11450 LABEL USING ".DDE";(I-1)*Imax/50
11460 NEXT I
11470 CSIZE 3.5
11480 MOVE 25,-7
11490 LABEL USING "K";"SOLAR CONCENTRATION RATIO" ! LABEL AXES.
11500 LDIR 90
11510 MOVE -6,50
11520 LABEL USING "K";"FREQUENCY OF OCCURRENCE"
11530 LORG 2
11540 MOVE 53,85
11550 LDIR 0
11560 CSIZE 3
11570 LABEL USING 11580;Area$,Q$
11580 IMAGE " HISTOGRAM PLOT OF"/"DATA POINTS WITHIN"/K" IMAGE"/"AREA OF FILE ",
5A,///
11590 IF Area$="Circular" THEN LABEL USING 11600;Xeff,Eff,Aucon
11600 IMAGE "Image diameter ="/8X,DDD.DDD/"Lens efficiency ="/8X,DDD.DD,"%/"Ave
concentration ="/8X,DDDD.DD
11610 IF Area$="Rectangular" THEN LABEL USING 11620;Xeff,Yeff,Eff,Aucon
11620 IMAGE "Image dimensions ="/DDD.DDD",",DDD.DDD/"Lens efficiency ="/8X,DDD.D
D,"%/"Ave concentration ="/8X,DDDD.DD
11630 LABEL USING 11640;Effsch,Imax,Auconh
11640 IMAGE ///"Scan efficiency ="/8X,DDD.DD,"%/", "Max scan conc ="/8X,DDDD.DD/"
Scan ave conc ="/8X,DDDD.DD
11650 PEN 0
11660 WAIT 2000
11670 EXIT GRAPHICS
11680 PRINT LIN(2)," DO YOU WANT A HARD COPY OF THIS PLOT?"
11690 A$=""
11700 INPUT "Y or N 'CONT'",A$
11710 IF A$="N" THEN GOTO Displa
11720 IF NOT (A$="Y") THEN GOTO 11680
11730 PRINT " 9845 or 9872A?"
11740 INPUT "9845 or 9872A 'CONT'",A$
11750 IF A$="9845" THEN GOSUB Therml
11760 IF A$="9845" THEN GOTO 11630
11770 IF NOT (A$="9872A") THEN GOTO 11730
11780 PRINT " IS 9872A PLOTTER 'ON' AND PAPER LOADED?"
11790 INPUT "Y or N 'CONT'",A$
11800 IF NOT (A$="Y") THEN GOTO 11780
11810 PLOTTER IS 7,5,"9872A" ! MAKE PLOT ON 9872A.
11820 GOTO Hspltt
11830 !
11840 !
11850 !
11860 ! CCCCC AAAAARA LL LL SSSSSS UU UU BBBBBB ///
11870 ! CC AA AA LL LL SS UU UU BB BB ///
11880 ! CC AAAAARA LL LL SSSSSS UU UU BBBBBB /
11890 ! CC AA AA LL LL SS UU UU BB BB
11900 ! CCCCC AA AA LLLLL LLLLL SSSSSS UUUUUU BBBBBB S
11910 !
11920 !
11930 !
11940 SUB Contour(Nc,Nx,Ny,Imax,SHORT Z(*),F(*))
11950 OPTION BASE 1
11960 CSIZE 2
11970 LDIR 0

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11980 LONG 5
11990 SHORT H(2,Ny,Nc),V(2,Ny,Nc),C(Nc)
12000 FOR I=1 TO Nc
12010   C(I)=F(I)*Imax/100
12020 NEXT I
12030 FOR X=1 TO Nx
12040   IF X=1 THEN GOTO 12310
12050   FOR Y=1 TO Ny
12060     FOR N=1 TO Nc
12070       IF Z(Y,X)=Z(Y,X-1) THEN GOTO 12100
12080       IF (Z(Y,X)>C(N)) AND (Z(Y,X-1)<C(N)) THEN GOTO 12120
12090       IF (Z(Y,X)<C(N)) AND (Z(Y,X-1)>C(N)) THEN GOTO 12120
12100       H(1,Y,N)=0
12110       GOTO 12290
12120       Yp=Y
12130       Xp=X-1+(C(N)-Z(Y,X-1))/(Z(Y,X)-Z(Y,X-1))
12140       IF V(1,Y,N)=0 THEN GOTO 12180
12150       MOVE V(1,Y,N),V(2,Y,N)
12160       DRAW Xp,Yp
12170       GOSUB Numbr
12180       IF Y=1 THEN GOTO 12270
12190       IF V(1,Y-1,N)=0 THEN GOTO 12230
12200       MOVE V(1,Y-1,N),V(2,Y-1,N)
12210       DRAW Xp,Yp
12220       GOSUB Numbr
12230       IF H(1,Y-1,N)=0 THEN GOTO 12270
12240       MOVE H(1,Y-1,N),H(2,Y-1,N)
12250       DRAW Xp,Yp
12260       GOSUB Numbr
12270       H(1,Y,N)=Xp
12280       H(2,Y,N)=Yp
12290     NEXT N
12300   NEXT Y
12310   FOR Y=2 TO Ny
12320     FOR N=1 TO Nc
12330       IF Z(Y,X)=Z(Y-1,X) THEN GOTO 12360
12340       IF (Z(Y,X)>C(N)) AND (Z(Y-1,X)<C(N)) THEN GOTO 12380
12350       IF (Z(Y,X)<C(N)) AND (Z(Y-1,X)>C(N)) THEN GOTO 12380
12360       V(1,Y-1,N)=0
12370       GOTO 12560
12380       Xp=X
12390       Yp=Y
12400       Yp=Y-1+(C(N)-Z(Y-1,X))/(Z(Y,X)-Z(Y-1,X))
12410       IF X=1 THEN GOTO 12540
12420       IF H(1,Y,N)=0 THEN GOTO 12460
12430       MOVE H(1,Y,N),H(2,Y,N)
12440       DRAW Xp,Yp
12450       GOSUB Numbr
12460       IF H(1,Y-1,N)=0 THEN GOTO 12500
12470       MOVE H(1,Y-1,N),H(2,Y-1,N)
12480       DRAW Xp,Yp
12490       GOSUB Numbr
12500       IF V(1,Y-1,N)=0 THEN GOTO 12540
12510       MOVE V(1,Y-1,N),V(2,Y-1,N)
12520       DRAW Xp,Yp
12530       GOSUB Numbr
12540       V(1,Y-1,N)=Xp
12550       V(2,Y-1,N)=Yp
12560     NEXT N
12570   NEXT Y
12580 NEXT X
12590 GOTO 12650
12600 Numbr: Numbr=Numbr+1
12610 IF NOT (Numbr MOD 36=0) THEN RETURN
12620 LABEL USING "K";F(N)

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12630 MOVE Xp,Yp
12640 RETURN
12650 SUBEND
12660 !
12670 !
12680 !
12690 SUB Tdplt(X,Y,Mxz,Mnz,E1,Az,R,Lim,SHORT Z(*)) ! 3-D ROUTINE.
12700 OPTION BASE 1
12710 DEG
12720 SHORT Mx(560),Mn(560),C(2,102),Xc(4,2),Yc(4,2),Xp,Yp,Xt,Yt
12730 INTEGER I,J,K,Ii,Jj,Xstep,Ystep,Hstep,Vstep
12740 Scaz=SQR(X^2+Y^2)/(4*(Mxz-Mnz)) ! SCALE FACTOR FOR Z DISPLAY HEIGHT.
12750 V1=-6*SQR(X^2+Y^2)*COS(E1)*SIN(Az) ! LOCATE VIEWER POSITION.
12760 V1dim=INT(-V1+1+(X-1)/2)
12770 V1=-V1dim+1+(X-1)/2
12780 V2=INT(6*SQR(X^2+Y^2)*COS(E1)*COS(Az))
12790 V2dim=INT(V2+1+(Y-1)/2)
12800 V2=V2dim-(1+(Y-1)/2)
12810 V3=6*SQR(X^2+Y^2)*SIN(E1)
12820 X1=Y1=999999999999
12830 X2=Y2=-999999999999
12840 D2=V1^2+V2^2+V3^2
12850 D1=SQR(V1^2+V2^2)
12860 IF D1=0 THEN E1=E1-.1
12870 IF D1=0 THEN GOTO 12750
12880 Calsc: FOR J=1 TO Y ! CALCULATE PLOT POINTS FOR SCALE.
12890 FOR I=1 TO X
12900 R=D2/(D2-(V1*(-I+1+(X-1)/2)+V2*(J-(1+(Y-1)/2))+V3*Scaz*Z(J,I)))
12910 Xp=R*((J-(1+(Y-1)/2))*V1-(-I+1+(X-1)/2)*V2)/D1
12920 Yp=(V3+R*(Scaz*Z(J,I)-V3))*SQR(D2)/D1
12930 IF Yp>Y2 THEN Y2=Yp
12940 IF Yp<Y1 THEN Y1=Yp
12950 IF Xp>X2 THEN X2=Xp
12960 IF Xp<X1 THEN X1=Xp
12970 NEXT I
12980 NEXT J
12990 IF 1.3*455*(X2-X1)/(560*(Y2-Y1))>1.2*560*(Y2-Y1)/(455*(X2-X1)) THEN GOTO X
lim
13000 Ylim:X1=X1-(X2-X1)/100 ! LABEL AREA RESERVED ON RIGHT.
13010 X2=X1+(X2-X1)*1.3
13020 Y1=Y1-(Y2-Y1)/100
13030 Y2=Y2+(Y2-Y1)/100
13040 Lim=2
13050 GOTO Scale
13060 Xlim:X1=X1-(X2-X1)/100 ! LABEL AREA RESERVED AT BOTTOM.
13070 X2=X2+(X2-X1)/100
13080 Y2=Y2+(Y2-Y1)/100
13090 Y1=Y2-(Y2-Y1)*1.2
13100 Lim=1
13110 Scale:SHOW X1,X2,Y1,Y2 ! SCALE PLOTTING AREA.
13120 IF V1dim<=1 THEN GOTO Right ! HOW MANY DATA PLANE PLOTTING AREAS, N.
13130 IF V1dim>X THEN GOTO Left
13140 Xc(1,1)=Xc(2,1)=Xc(3,1)=Xc(4,1)=V1dim ! DEFINE CO-ORDS OF PLOT AREAS.
13150 Xc(1,2)=Xc(4,2)=X
13160 Xc(2,2)=Xc(3,2)=1
13170 IF V2dim>Y THEN GOTO S2
13180 IF V2dim<=1 THEN GOTO S6
13190 GOTO S1
13200 Right:Xc(1,1)=Xc(2,1)=1
13210 Xc(1,2)=Xc(2,2)=X
13220 IF V2dim>Y THEN GOTO S9
13230 IF V2dim<=1 THEN GOTO S7
13240 GOTO S8
13250 Left:Xc(1,1)=Xc(2,1)=X
13260 Xc(1,2)=Xc(2,2)=1

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13270      IF V2dim>Y THEN GOTO S3
13280      IF V2dim<=1 THEN GOTO S5
13290      GOTO S4
13300 S1:N=4                                ! VIEW POINT OVER PLANE OF IMAGE.
13310      Yc(1,1)=Yc(2,1)=Yc(3,1)=Yc(4,1)=V2dim
13320      Yc(1,2)=Yc(2,2)=Y
13330      Yc(3,2)=Yc(4,2)=1
13340      Sc=1
13350      GOTO Loops
13360 S2:N=2
13370      Yc(1,1)=Yc(2,1)=Y
13380      Yc(1,2)=Yc(2,2)=1
13390      Sc=1
13400      GOTO Loops
13410 S3:N=1
13420      Yc(1,1)=Y
13430      Yc(1,2)=1
13440      Sc=1
13450      GOTO Loops
13460 S4:N=2
13470      Yc(1,1)=Yc(2,1)=V2dim
13480      Yc(1,2)=Y
13490      Yc(2,2)=1
13500      Sc=2
13510      GOTO Loops
13520 S5:N=1
13530      Yc(1,1)=1
13540      Yc(1,2)=Y
13550      Sc=1
13560      GOTO Loops
13570 S6:N=2
13580      Yc(1,1)=Yc(2,1)=1
13590      Yc(1,2)=Yc(2,2)=Y
13600      Sc=1
13610      GOTO Loops
13620 S7:N=1
13630      Yc(1,1)=1
13640      Yc(1,2)=Y
13650      Sc=1
13660      GOTO Loops
13670 S8:N=2
13680      Yc(1,1)=Yc(2,1)=V2dim
13690      Yc(1,2)=Y
13700      Yc(2,2)=1
13710      Sc=2
13720      GOTO Loops
13730 S9:N=1
13740      Yc(1,1)=Y
13750      Yc(1,2)=1
13760      Sc=1
13770 Loops:IF Sc=2 THEN GOTO Yloop
13780 Xloop:GRAPHICS
13790      FOR K=1 TO N                                ! PLOTTING LOOP FOR N AREAS.
13800      FOR I=1 TO 560
13810          Mn(I)=999999999999
13820          Mx(I)=-999999999999
13830      NEXT I
13840          Xstep=Ystep=Hstep=1
13850          IF Yc(K,2)-Yc(K,1)<0 THEN Ystep=-1
13860          IF Xc(K,2)-Xc(K,1)<0 THEN Xstep=-1
13870          FOR J=Yc(K,1) TO Yc(K,2) STEP Ystep      ! Y PLOT LOOP.
13880          FOR I=Xc(K,1) TO Xc(K,2) STEP Xstep      ! X PLOT LOOP.
13890      IF Sc=3 THEN CALL Ptlloc(V1,V2,V3,(I),(J),Scaz*Z(I,J),D1,D2,X,Y,Xp,Yp)
13900      IF Sc=1 THEN CALL Ptlloc(V1,V2,V3,(I),(J),Scaz*Z(J,I),D1,D2,X,Y,Xp,Yp)
13910          H=INT((Xp-X1)*559/(X2-X1))+1

```



```

13920      Hstep=1
13930      IF H1>H THEN Hstep=-1
13940      B=INT((C(1,I)-X1)*559/(X2-X1))+1 ! IS LINE HIDDEN?
13950      Vstep=1
13960      IF B>H THEN Vstep=-1
13970      IF (I=Xc(K,1)) AND (J=Yc(K,1)) THEN GOTO Corner !!! HORIZ LINES.
13980      IF I=Xc(K,1) THEN GOTO Edge
13990      IF J=Yc(K,1) THEN GOTO Front
14000      IF (Yp>Mn(H)) AND (Yp<Mx(H)) AND (C(2,I-Xstep)>Mn(H1)) AND (C(2,I
-Xstep)<Mx(H1)) THEN GOTO Hob ! TOTALLY OBSCURED.
14010      IF ((Yp<=Mn(H)) OR (Yp>=Mx(H))) AND ((C(2,I-Xstep)<=Mn(H1)) OR (C
(2,I-Xstep)>=Mx(H1))) THEN GOTO Hor1 ! TOTALLY VISIBLE.
14020      IF (Yp>Mn(H)) AND (Yp<Mx(H)) THEN GOTO Rhid
14030      Lhid: FOR P=I-Xstep+Xstep/10 TO I-Xstep/10 STEP Xstep/10 ! L END HIDDEN
14040      IF Sc=3 THEN Zt=Scaz*Z(I-Xstep,J)+(P-(I-Xstep))*(Z(I,J)-Z(I-Xstep,J))*X
step*Scaz
14050      IF Sc=1 THEN Zt=Scaz*Z(J,I-Xstep)+(P-(I-Xstep))*(Z(J,I)-Z(J,I-Xstep))*X
step*Scaz
14060      CALL Ptloc(V1,V2,V3,(P),(J),Zt,U1,U2,X,Y,Xt,Yt)
14070      Ht=INT((Xt-X1)*559/(X2-X1))+1
14080      IF (Yt>=Mx(Ht)) OR (Yt<=Mn(Ht)) THEN GOTO Hor2
14090      Nxlhd: NEXT P
14100      GOTO Hob
14110      Rhid: FOR P=I-Xstep/10 TO I-Xstep+Xstep/10 STEP -Xstep/10 ! R END HIDDEN
14120      IF Sc=1 THEN Zt=Scaz*Z(J,I-Xstep)+(P-(I-Xstep))*(Z(J,I)-Z(J,I-Xstep))*X
step*Scaz
14130      IF Sc=3 THEN Zt=Scaz*Z(I-Xstep,J)+(P-(I-Xstep))*(Z(I,J)-Z(I-Xstep,J))*X
step*Scaz
14140      CALL Ptloc(V1,V2,V3,(P),(J),Zt,D1,D2,X,Y,Xt,Yt)
14150      Ht=INT((Xt-X1)*559/(X2-X1))+1
14160      IF (Yt>Mx(Ht)) OR (Yt<Mn(Ht)) THEN GOTO Hor3
14170      Nxrhd: NEXT P
14180      GOTO Hob
14190      Hor3: P1=H1+Hstep ! DRAW WITH RIGHT END HIDDEN.
14200      P2=Ht
14210      IF A=2 THEN GOTO Infil1
14220      DRAW Xt,Yt
14230      GOTO Ckver
14240      Hor2: P1=Ht ! DRAW WITH LEFT END HIDDEN.
14250      P2=H-Hstep
14260      IF A=2 THEN GOTO Infil1
14270      MOVE Xt,Yt
14280      GOTO Hor4
14290      Front: Infil2=0
14300      F=1
14310      Hor1: P1=H1+Hstep ! DRAW TOTALLY VISIBLE.
14320      P2=H-Hstep
14330      IF A=2 THEN GOTO Ckver
14340      Hor4: DRAW Xp,Yp
14350      GOTO Ckver
14360      Hob: Infil1=0 ! TOTALLY OBSCURED, MOVE ONLY.
14370      Ckver: MOVE Xp,Yp
14380      IF J=Yc(K,1) THEN GOTO Infil2 !!!! VERTICAL LINES.
14390      IF (Yp>Mn(H)) AND (Yp<Mx(H)) AND (C(2,I)>Mn(B)) AND (C(2,I)<Mx(B)
) THEN GOTO Infil1 ! TOTALLY HIDDEN.
14400      IF I=Xc(K,1) THEN GOTO Edge
14410      IF ((Yp<=Mn(H)) OR (Yp>=Mx(H))) AND ((C(2,I)<=Mn(B)) OR (C(2,I)>=
Mx(B))) THEN GOTO Ver1 ! TOTALLY VISIBLE.
14420      IF (Yp<Mn(H)) OR (Yp>Mx(H)) THEN GOTO Bhid
14430      Thid: FOR P=J-Ystep/10 TO J-Ystep+Ystep/10 STEP -Ystep/10 ! TOP HIDDEN.
14440      IF Sc=1 THEN Zt=Scaz*Z(J-Ystep,I)+(P-(J-Ystep))*(Z(J,I)-Z(J-Ystep,I))*Y
step*Scaz
14450      IF Sc=3 THEN Zt=Scaz*Z(I,J-Ystep)+(P-(J-Ystep))*(Z(I,J)-Z(I,J-Ystep))*Y
step*Scaz
14460      CALL Ptloc(V1,V2,V3,(I),P,Zt,D1,D2,X,Y,Xt,Yt)

```

```

14470          Ht=INT((Xt-X1)*559/(X2-X1))+1
14480          IF (Yt>Mx(Ht)) OR (Yt<Mn(Ht)) THEN GOTO Ver2
14490 NxtHd:    NEXT P
14500          GOTO Infil1
14510 Bhid:    FOR P=J-Ystep+Ystep/10 TO J-Ystep/10 STEP Ystep/10! BOT HIDDEN.
14520          IF Sc=1 THEN Zt=Scz*Z(J-Ystep,I)+(P-(J-Ystep))*(Z(J,I)-Z(J-Ystep,I))*Y
step*Scz
14530          IF Sc=3 THEN Zt=Scz*Z(I,J-Ystep)+(P-(J-Ystep))*(Z(I,J)-Z(I,J-Ystep))*Y
step*Scz
14540          CALL Ptlc(V1,V2,V3,(I),P,Zt,D1,D2,X,Y,Xt,Yt)
14550          Ht=INT((Xt-X1)*559/(X2-X1))+1
14560          IF (Yt>Mx(Ht)) OR (Yt<Mn(Ht)) THEN GOTO Ver3
14570 Nxbhd:    NEXT P
14580          GOTO Infil1
14590 Ver3:    P3=Ht          ! DRAW WITH BOTTOM HIDDEN.
14600          P4=H-Vstep
14610          IF A=1 THEN GOTO Infil2
14620          DRAW Xt,Yt
14630          GOTO Infil2
14640 Ver2:    P3=B+Vstep      ! DRAW WITH TOP HIDDEN.
14650          P4=Ht
14660          IF A=1 THEN GOTO Infil2
14670          MOVE C(1,I),C(2,I)
14680          DRAW Xt,Yt
14690          GOTO Infil2
14700 Edge:    Infil1=0
14710          F=1
14720          IF H=B THEN F=0
14730          MOVE Xp,Yp
14740 Ver1:    P3=B+Vstep      ! DRAW TOTALLY VISIBLE.
14750          P4=H-Vstep
14760          IF A=1 THEN GOTO Infil2
14770          DRAW C(1,I),C(2,I)
14780 Infil2:  IF Infil2=0 THEN GOTO Infil1 ! UPDATE Mx,Mn ARRAYS.
14790          IF (H=B) OR (H=B+Vstep) THEN GOTO Infil1
14800          CALL Infil1((P3),(P4),H,B,F,(C(2,I)),Mx(*),Mn(*),Yp,Vstep)
14810 Infil1:  IF Infil1=0 THEN GOTO Mov1
14820          IF (H=H1) OR (H=H1+Hstep) THEN GOTO Mov1
14830          CALL Infil1(P1,P2,H,H1,F,(C(2,I-Xstep)),Mx(*),Mn(*),Yp,Hstep)
14840          GOTO Mov1
14850 Corner:  F=1
14860 Mov1:    MOVE Xp,Yp
14870          Infil1=Infil2=1          ! STORE DATA FOR USE ON NEXT LINE.
14880          H1=H
14890          IF (Yp>Mx(H)) OR (F=1) THEN Mx(H)=Yp
14900          IF (Yp<Mn(H)) OR (F=1) THEN Mn(H)=Yp
14910          F=0
14920          C(1,I)=Xp
14930          C(2,I)=Yp
14940          NEXT I
14950          NEXT J
14960 NEXT K
14970          IF Sc=1 THEN GOTO Subend
14980 Yloop: IF Sc=3 THEN GOTO 15000
14990          GOSUB Reversy          ! REVERSE Y FOR PROPER Y PLOTS.
15000          Stor=X
15010          X=Y
15020          Y=Stor
15030          IF Sc=2 THEN GOTO 15060
15040          GOSUB Reversy          ! PUT Y BACK IN PROPER PLACE.
15050          IF Sc=3 THEN GOTO Subend
15060          Stor=Y1
15070          V1=Y2
15080          V2=-Stor
15090          FOR Ii=1 TO N
15100          FOR Jj=1 TO 2

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15110      Stor=Xc(Ii,Jj)
15120      Xc(Ii,Jj)=Yc(Ii,Jj)
15130      Yc(Ii,Jj)=Stor
15140      NEXT Jj
15150      NEXT Ii
15160      Sc=3
15170      ON A GOTO Sw1,Sw2,Xloop
15180 Sw1: A=2
15190      GOTO Xloop
15200 Sw2: A=1
15210      GOTO Xloop
15220 Reversy:FOR I=1 TO X
15230      FOR J=1 TO Y
15240      Mx(Y-J+1)=Z(J,I)
15250      NEXT J
15260      FOR J=1 TO Y
15270      Z(J,I)=Mx(J)
15280      NEXT J
15290      NEXT I
15300      RETURN
15310 Subend:SUBEND
15320 !
15330 !
15340 !
15350 SUB Ptloc(V1,V2,V3,A1,A2,A3,D1,D2,X,Y,SHORT Xp,Yp)
15360 !          ! CALCULATE PLOT POSITION OF DATA POINT.
15370 R=D2/(D2-(V1*(-A1+1+(X-1)/2)+V2*(A2-(1+(Y-1)/2))+V3*A3))
15380 Xp=R*((A2-(1+(Y-1)/2))*V1-(-A1+1+(X-1)/2)*V2)/D1
15390 Yp=(V3+R*(A3-V3))*SQR(D2)/D1
15400 SUBEND
15410 !
15420 !
15430 !
15440 SUB Infill(P1,P2,H,H1,F,Y1,SHORT Mx(*),Mn(*),Yp,INTEGER Hstep)
15450 INTEGER P          ! FILL IN Mx, Mn ARRAY VALUES.
15460 IF P1=P2 THEN GOTO Equal
15470 FOR P=P1 TO P2 STEP Hstep
15480 Mxt=Y1+(P-H1)*(Yp-Y1)/(H-H1)
15490 IF (Mxt>Mn(P)) OR (F=1) THEN Mx(P)=Mxt
15500 IF (Mxt<Mn(P)) OR (F=1) THEN Mn(P)=Mxt
15510 NEXT P
15520 GOTO End
15530 Equal:Mxt=Y1+(Yp-Y1)/2
15540 IF (Mxt>Mn(P1)) OR (F=1) THEN Mx(P1)=Mxt
15550 IF (Mxt<Mn(P1)) OR (F=1) THEN Mn(P1)=Mxt
15560 End:SUBEND
15570 !
15580 !
15590 !
15600 SUB Move(X,Dir,Dist,Shtr)          !!!!! NO WAIT ADDED, BE CAREFUL
15610 !
15620 ! X=1 Xmove, X=0 Ymove; Dir=1 MOVE(+), Dir=-1 MOVE(-)
15630 ! Dist=MOVEMENT IN .001" ; Shtr=1 SHUTTER OPEN, =0 CLOSED
15640 ! Dist CANSNOT BE =1 !!
15650 !
15660 IF Dist=1 THEN RETURN
15670 IF Shtr=0 THEN WRITE IO 2,5;33          ! ALLOW OUTPUT, RESET, SHR CLSD
15680 IF Shtr=1 THEN WRITE IO 2,5;35          ! ALLOW OUTPUT, RESET, SHR OPEN
15690 IF X=0 THEN GOTO Ymove
15700 Xmove:OUTPUT 2 WHS USING "#,W";Dist          ! X=***
15710 OUTPUT 2 WHS USING "#,W";12353          ! ENABLE X(+) & Int
15720 IF Dir=-1 THEN OUTPUT 2 WHS USING "#,W";12369 ! ENABLE X(-) & Int
15730 GOTO Doit
15740 Ymove:OUTPUT 2 WHS USING "#,W";4096+Dist          ! Y=***
15750 OUTPUT 2 WHS USING "#,W";12417          ! ENABLE Y(+) & Int

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15760 IF Dir=-1 THEN OUTPUT 2 WHS USING "#,W";12449 ! ENABLE Y(-) & Int
15770 Doit:OUTPUT 2 WHS USING "#,W";8193 ! Int=1
15780 IF Shtr=0 THEN WRITE IO 2,5;0 ! ALLOW ENTER, SHUTTER CLSD
15790 IF Shtr=1 THEN WRITE IO 2,5;2 ! ALLOW ENTER, SHUTTER OPEN
15800 OFF INT #2
15810 ENTER 2 WFHS 1 NOFORMAT;S ! MOVE TABLE, ENTER DUMMY
15820 IF Shtr=0 THEN WRITE IO 2,5;1 ! ALLOW OUTPUT, SHUTTER CLOSED
15830 IF Shtr=1 THEN WRITE IO 2,5;3 ! ALLOW OUTPUT, SHUTTER OPEN
15840 ON INT #2 GOSUB Ioerr
15850 SUBEND
15860 !
15870 !
15880 !
15890 SUB Scale(Int,Pts,K,Meas$)
15900 R=Int*(Pts-1)/1000
15910 C=.2*(Meas$="In")+5/25.4*(Meas$="Mm")
15920 IF R<=2 THEN C=.1*(Meas$="In")+3/25.4*(Meas$="Mm")
15930 IF R<=1 THEN C=.05*(Meas$="In")+2/25.4*(Meas$="Mm")
15940 IF R<=.4 THEN C=.02*(Meas$="In")+1/25.4*(Meas$="Mm")
15950 IF R<=.4 THEN C=.02*(Meas$="In")+1/25.4*(Meas$="Mm")
15960 IF K=1 THEN AXES C*1000/Int,16000,1+(Pts-1)/2-11*C*1000/Int,16383,1,1,3
15970 IF K=2 THEN AXES C*1000/Int,16000,1+(Pts-1)/2-11*C*1000/Int,0,1,1,3
15980 FOR I=1 TO 21 STEP 2
15990 IF 1+(Pts-1)/2+(I-11)*C*1000/Int>Pts THEN GOTO 16050
16000 IF 1+(Pts-1)/2+(I-11)*C*1000/Int<1 THEN GOTO 16050
16010 IF K=1 THEN MOVE 1+(Pts-1)/2+(I-11)*C*1000/Int,16738
16020 IF K=2 THEN MOVE 1+(Pts-1)/2+(I-11)*C*1000/Int,-400
16030 IF Meas$="In" THEN LABEL USING "K";(I-11)*C
16040 IF Meas$="Mm" THEN LABEL USING "K";INT(.5+(I-11)*C*25.4)
16050 NEXT I
16060 IF K=1 THEN MOVE 1+(Pts-1)/2,17138
16070 IF K=2 THEN MOVE 1+(Pts-1)/2,-800
16080 IF K=1 THEN LABEL USING "K";"X SCALE"
16090 IF K=2 THEN LABEL USING "K";"Y SCALE"
16100 SUBEND

```

Table of Variables for Lens Tester Program

1	*****					
2	*****					
3		**	MAIN PROGRAM SECTION		**	
4	MAIN PROG	**			**	VARIABLE
5	VAR NAME	**	ACQSTN	ANALYS	**	REPRESENTS
6						
7						
8	ALPHA					
9	A\$		X	X		Answer string
10	C\$(80)		X	X		Comment string
11	D\$		X	X		Date string
12	M\$		X	X		Mass storage specifier
13	P\$			X		1-D slice direction
14	Q\$		X	X		Test file base name
15	T\$		X	X		Time string
16	W\$(80)		X	X		Weather string
17	Anal\$		X	X		State of data analysis
18	Area\$		X	X		Shape of lens image area
19	ERRM\$		X	X		System error message
20	Filtr\$(2)(3)		X	X		# of filters used
21	Mask\$		X			Interface type mask
22	Meas\$		X	X		Measurement system
23	Valid\$		X			Proper scan accomplished
24	ArLens\$		X	X		Shape of lens
25						
26	INTEGER					
27	A(2*Ln\$)		X			Scan line raw data
28	(2*Pts)		X			Scan line raw data
29	(200)		X			Zero/Ratio raw data array
30	(2*T)			X		Scan line raw data
31	(50)			X		Histogram data array
32	Da(2*Da)		X			Dummy data array
33						
34	SHORT					
35	F(20)			X		Filter factors
36	P(N)			X		Line #'s, contours, etc.
37	Z(Ln\$,Pts)			X		Converted data array
38						
39	FULL PREC					
40	A		X			# steps of table overscan
41				X		3-D plot parameter
42	B(2)			X		Plotting variables
43	C		X			Filtr chk tried once
44	I		X	X		Counter
45	J		X	X		Counter
46	K		X	X		Counter
47				X		Max histogram value
48	N		X			# of pts in scan area
49			X			Either = Pts or Ln\$
50				X		# of pts in Eff scan
51				X		# of lines or contours
52	S		X			Status word
53			X			Intermediate var
54			X			SUB Check return variable
55				X		Number of scan lines
56				X		= Pts or Ln\$ for 1-D plot
57	T			X		# of pts per scan line
58				X		= Pts or Ln\$ for 1-D plot
59	X		X			Trial X offset in .001"
60	Y		X			Trial Y offset in .001"
61	Az			X		3-D plot parameter
62	Da		X			Dimension/2 of Da(*)
63	EI			X		3-D plot parameter


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64 | *****
65 | *****
66 | **      MAIN PROGRAM SECTION      **
67 | MAIN PROG **                      **      VARIABLE
68 | VAR NAME  **      ACQSTN          ANALYS      **      REPRESENTS
69 |
70 |
71 | FULL PREC
72 | Rz      X      X      Ref zero reading
73 | Tz      X      X      Table zero reading
74 | Xs      X      X      # image steps in X dir
75 | Ys      X      X      # image steps in Y dir
76 | Eff     X      X      Eff(%) of image area
77 | Flg     X      X      Mass satorage error flag
78 | Int     X      X      # .001" steps btwn data pt
79 | Lim     X      X      3-D return parameter
80 | Lns     X      X      # data pts in Y direction
81 | Pls     X      X      # data pts in X direction
82 | Rad     X      X      Radius of pt from center
83 | Imax    X      X      Max concentration
84 | Nscn    X      X      # of pts in scan area
85 | Step    X      X      Distance between data pts
86 | Xeff    X      X      X dim(diam) of image
87 | Yeff    X      X      Y dimension of image
88 | Xoff    X      X      X offset for centering
89 | Yoff    X      X      Y offset for centering
90 | Ioflg   X      X      Timeout INT flg
91 | Avcon   X      X      Ave conc of image
92 | Ratio   X      X      Diode gain ratio
93 | Xlens   X      X      X dim(diam) of lens
94 | Ylens   X      X      Y dimension of lens
95 | Xscan   X      X      X dim(diam) of scan
96 | Yscan   X      X      Y dimension of scan
97 | Avcnsh  X      X      Ave conc of scan area
98 | Effscn  X      X      Efficiency(%) of scan area
99 | Fltfac  X      X      Total filter factor
100 | Numflt  X      X      # of filters used
101 | Zerloc  X      X      Is 0,0 located yet
102 |
103 | OTHER
104 | ERRN    X      X      System error number
105 |
106 |
107 | *****
108 | *****
109 | **      MAIN PROGRAM SECTION      **
110 | **      ACQSTN                    **
111 | **                                **
112 | **      SUBROUTINE Move           **
113 | MAIN PROG **                      **
114 | VAR NAME  **      SUB VAR        **      VARIABLE REPRESENTS      **
115 |
116 |
117 | FULL PREC
118 | S      Dummy variable for ENTER
119 | X      Which axes is to be moved:
120 |      X=1 x moves, X=0 y moves
121 | Dir    Which direction to be moved:
122 |      Dir=1 move(+), Dir=-1 move(-)
123 | Dist   Distance to be moved in .001"
124 | Shtr   Shutter state indicator:
125 |      Shtr=1 shutter to be open
126 |      Shtr=0 shutter to be closed

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127 ! *****
128 ! *****
129 !          **          MAIN PROGRAM SECTION          **
130 !          **          ACQSTN                      **
131 !          **                                          **
132 !          **          SUBROUTINE Scale              **
133 !          **          **                          **
134 ! MAIN PROG  **          **                          **
135 ! VAR NAME   **          SUB VAR    **          VARIABLE REPRESENTS  **
136 !
137 !
138 !          ALPHA
139 !          Meas$          Meas$          Measurement system being used
140 !
141 !          FULL PREC
142 !          A          Length of data scan line
143 !          C          Interval for axis tick marks
144 !          I          Counter
145 !          K          Indicator of X or Y trial scan
146 !          Int        Interval between data points
147 !          Pts        Number of points in scan line
148 !
149 !
150 ! *****
151 ! *****
152 !          **          MAIN PROGRAM SECTION          **
153 !          **          ANALYS                      **
154 !          **                                          **
155 !          **          SUBROUTINE Contour            **
156 ! MAIN PROG  **          **                          **
157 ! VAR NAME   **          SUB VAR    **          VARIABLE REPRESENTS  **
158 !
159 !
160 !          SHORT
161 !          C(Nc)        Concentration contour values
162 !          P(N)         # contours to be plotted
163 !          H(2,Ny,Nc)   Horizontal contour segment locations
164 !          V(2,Ny,Nc)   Vertical contour segment locations
165 !          Z(Lns,Pts)   Data array with values to be plotted
166 !
167 !          FULL PREC
168 !          I          Counter for contour #
169 !          N          Counter for contour #
170 !          X          Counter for X position
171 !          Y          Counter for Y position
172 !          N          # of contour values
173 !          Pts        # of points per line
174 !          Lns        # of lines in image scan
175 !          Xp          Calculated contour X location
176 !          Yp          Calculated contour Y location
177 !          Imax        Max concentration value
178 !          Numbr       Counter to add #'s to plot

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179 ! *****
180 ! *****
181 !          **          MAIN PROGRAM SECTION          **
182 !          **          ANALYS          **
183 !          **          **
184 !          **          SUBROUTINE Tdplt          **
185 ! MAIN PROG **          **          **
186 ! VAR NAME  **          SUB VAR          **          VARIABLE REPRESENTS          **
187 !
188 !
189 ! SHORT
190 ! Z(Lns,Pts)          Z(*)          Concentration data for plotting
191 !          C(2,50)          Plot co-ords of points in last line
192 !          Mn(560)          Max Y co-ord values in 560 plot cols
193 !          Mx(560)          Min Y co-ord values in 560 plot cols
194 !          Xc(4,2)          X co-ords of 4 data plane areas
195 !          Xp          X plot co-ord of data point
196 !          Xt          X plot co-ord of hidden line end
197 !          Yc(4,2)          Y co-ords of 4 data plane areas
198 !          Yp          Y plot co-ord of data point
199 !          Yt          Y plot co-ord of hidden line end
200 !
201 !
202 ! INTEGER
203 !          I          Counter for X
204 !          J          Counter for Y
205 !          K          Counter for data plane areas
206 !          Ii          X counter for reversing array
207 !          Jj          Y counter for reversing array
208 !          Hstep          Horiz Infill direction indicator
209 !          Vstep          Vert Infill step direction indicator
210 !          Xstep          X plotting step direction indicator
211 !          Ystep          Y plotting step direction indicator
212 !
213 ! FULL PREC
214 !          A          A          3-D plot parameter
215 !          B          Plot col of pt below in last line
216 !          F          Forced infill parameter
217 !          H          Plot_col for current data point
218 !          N          # of data plane plotting areas
219 !          P          Counter for hidden search and reveal
220 !          R          Intermediate plot scaling calc var
221 !          Pts          X          # of points per line
222 !          Lns          Y          # of lines per image
223 !          Az          Az          Azimuth of viewer position
224 !          B1          Plot col for pt in line below corr H1
225 !          D1          Intermediate plot scaling calc var
226 !          D2          Intermediate plot scaling calc var
227 !          E1          E1          Elevation of viewer position
228 !          H1          Plot col for pt last plotted
229 !          Ht          Plot col of trial hidden pt calc
230 !          P1          Beginning col for horiz Infill
231 !          P2          Ending col for horiz Infill
232 !          P3          Beginning col for vert Infill
233 !          P4          Ending col for vert Infill
234 !          Sc          X-Y or Y-X plotting indicator
235 !          V1          X co-ord of viewer in data plane
236 !          V2          Y co-ord of viewer in data plane
237 !          V3          Z co-ord of viewer above data plane
238 !          X1          Variable for plotting plane scaling

```

```

239 | *****
240 | *****
241 |          **          MAIN PROGRAM SECTION          **
242 |          **          ANALYS                        **
243 |          **
244 |          **          SUBROUTINE Tdplt                **
245 | MAIN PROG  **          **
246 | VAR NAME   **          SUB VAR      **  VARIABLE REPRESENTS  **
247 |
248 |
249 | FULL PREC
250 |          X2          Variable for plotting plane scaling
251 |          Xp          X plotting co-ord for current point
252 |          Y1          Variable for plotting plane scaling
253 |          Y2          Variable for plotting plane scaling
254 |          Yp          Y plot co-ord for current data point
255 |          Zt          Interpolated Z value for hidden calc
256 | Lim          Lim          Put labels on 1) bottom, 2) right
257 | Imax         Mnz          Minimum concentration value
258 | Imin         Mxz          Maximum concentration value
259 |          Scsz          Scale factor for Z data
260 |          Stor          Temporary storage variable
261 |          Xdim          X dimension of data in Z
262 |          Ydim          Y dimension of data in Z
263 |          V1dim          Viewer position in cols of Z
264 |          V2dim          Viewer position in rows of Z
265 |          Infill1       Horiz Infill indicator
266 |          Infill2       Vert Infill indicator
267 |
268 |
269 |
270 | *****
271 | *****
272 |          **          MAIN PROGRAM SECTION          **
273 |          **          ANALYS                        **
274 |          **
275 |          **          SUBROUTINE Ptloc                **
276 |          **          called from                    **
277 |          **          SUBROUTINE Tdplt                **
278 |          **          **
279 | Tdplt       **          **
280 | VAR NAME    **          Ptloc VAR      **  VARIABLE REPRESENTS  **
281 |
282 |
283 | SHORT
284 | Xp,Xt       Xp          X plot co-ord of data point
285 | Yp,Yt       Yp          Y plot co-ord of data point
286 |
287 | FULL PREC
288 | X           X           # of pts of * data per line
289 | Y           Y           # of lines of data
290 | D1          D1          Intermediate plot calc
291 | D2          D2          Intermediate plot calc
292 |          R           Intermediate calculation
293 | I,P         A1          X data point co-ord
294 | J,P         A2          Y data point co-ord
295 | Scsz*Z(J,I),Zt A3          Z height above data plane

```

```

296 | *****
297 | *****
298 |          **          MAIN PROGRAM SECTION          **
299 |          **          ANALYS                        **
300 |          **
301 |          **          SUBROUTINE Ptloc              **
302 |          **          called from                  **
303 |          **          SUBROUTINE Tdplt              **
304 |          **          **                            **
305 |          **          **                            **
306 |          Tdplt          **          **              **
307 |          VAR NAME      **          Ptloc VAR      **          VARIABLE REPRESENTS **
308 |
309 |
310 |          FULL PREC
311 |          D1              Intermediate calc variable
312 |          D2              Intermediate calc variable
313 |          V1              V1              X co-ord of viewer in data plane
314 |          V2              V2              Y co-ord of viewer in data plane
315 |          V3              V3              Z co-ord of viewer above data plane
316 |
317 |
318 |
319 | *****
320 | *****
321 |          **          MAIN PROGRAM SECTION          **
322 |          **          ANALYS                        **
323 |          **
324 |          **          SUBROUTINE Tdplt              **
325 |          **          calling                      **
326 |          **          SUBROUTINE Infill            **
327 |          Tdplt          **          **              **
328 |          VAR NAME      **          Infill VAR      **          VARIABLE REPRESENTS **
329 |
330 |
331 |          SHORT
332 |          Mn(*)           Mn(*)           Array with Min plot col values
333 |          Mx(*)           Mx(*)           Array with Max plot col values
334 |          Yp              Yp              Y plot co-ord of point
335 |
336 |          FULL PREC
337 |          F               F               Forced Infill parameter
338 |          H               H               Plot column of point
339 |          P               P               Infill counter
340 |          H1,D            H1              Plot col of last previous point
341 |          P1,P3            P1              Start plot col for Infill
342 |          P2,P4            P2              End plot col for Infill
343 |          C(2,I),C(2,I-Xstep) Y1          Y plot co-ord of last previous point
344 |          Mxt              Mxt              Intermediate variable
345 |          Hstep,Vstep      Hstep           Direction of Infill step

```


DCMSPC

10 ! SANDIA'S FRESNEL LENS TESTER SYSTEM
20 !
30 !
40 ! The Fresnel Lens Tester System (Lens Tester) is an automated system
50 ! designed and built by Sandia National Laboratories, Albuquerque, New
60 ! Mexico, to map the cell plane irradiance pattern (image) produced by a
70 ! fresnel concentrator lens. A point detector diode of active diameter
80 ! .020" is mounted on a 2 axis (X-Y) motorized positioning table. This al-
90 ! lows a raster scan of points in a plane parallel to the lens. Maximum
100 ! diode movement in each axis is 4 inches. The fresnel lenses are mounted
110 ! on an aluminum carriage with a square, clear aperture of 18 1/2 inches.
120 ! Lenses are mounted on the carriage by use of 1/8 inch thick aluminum lens
130 ! boards which are specially constructed for each lens shape. The carriage
140 ! is mounted on three, 3/4 inch diameter case hardened steel rods which
150 ! move in linear ball bushing pillow blocks for lens to diode distance ad-
160 ! justments. The range of lens to diode distances is 4 to 30 inches.
170 !
180 ! The X-Y table and lens carriage assembly is suspended in a Celestron-
190 ! 14 telescope fork and mount drive which has been modified by the addition
200 ! of two 1/2 inch spacers to widen the yoke by 1 inch, allowing the table
210 ! its full 4 inch travel. Two fixed and two 15 pound moveable counter-
220 ! weights balance the system allowing the table and lens to accurately
230 ! track the sun during test operations using the Celestron clock drive. As
240 ! the lens carriage is moved forward the two steel counterweights are moved
250 ! to the rear to preserve balance. The Celestron mount is bolted to a
260 ! wheeled base for portability. The base has attached locking feet that
270 ! securely hold the system in position during operation.
280 !
290 ! The signal from the table mounted diode is compared to that of an
300 ! identical reference diode mounted in a 1 1/4 inch aluminum tube mounted
310 ! to the declination axis of the Celestron mount. The reference tube has
320 ! been painted flat black on the inside to reduce reflections. A peep
330 ! sight mounted on the reference tube is used for proper tracking alignment
340 ! of the system. A set of calibrated inconel neutral density filters is
350 ! used over the table mounted diode to keep its maximum signal comparable
360 ! to the reference diode one sun signal. The maximum measureable image
370 ! concentration ratio is 2000. The acceptance angle of the diode detector
380 ! has been increased by removing the front of the diode can. The accep-
390 ! tance angle of the system is then limited by the filter holder assembly.
400 ! With one filter in the lower position the accepted cone is +-45 degrees;
410 ! with two filters the angle is nearer +-35 degees.
420 !
430 ! The system is controlled by a Hewlett Packard 9845 calculator through
440 ! an H-P 98032A 16-bit parallel duplex interface. Custom digital control
450 ! electronics mounted on the tester baseplate accept the calculator output
460 ! commands, and perform the table movements, shutter control, data acq-
470 ! uisition, etc., required for system operations. The two diode signals
480 ! pass through identical preamps mounted directly under each diode. Two
490 ! identical 14-bit analog to digital converters (ADC's) are mounted in
500 ! a box on the bottom side of the table platform. The convert lines of
510 ! both ADC's are tied together allowing simultaneous sampling of both
520 ! the table and reference diode signals. The two digital data words are
530 ! then multiplexed to the 9845 calculator for storage on either mag tape
540 ! or floppy disk. Each image data sample has an accompanying reference
550 ! sample to compensate for minor insolation fluctuations.
560 !
570 ! Data is taken from a rectilinear grid of data points whose size and
580 ! sampling interval are determined by operator keyboard input. The X and
590 ! Y data sampling intervals are identical. Calibration necessary for later
600 ! data reduction is performed by taking dark (insolation=0) readings and
610 ! light (one sun) readings for each diode. Data reduction calculates a
620 ! concentration ratio value for each pair of data values for each point on

630 ! the data grid. The individual concentration ratio values are summed over
640 ! the entire image area, as well as a smaller specified area, to calculate
650 ! lens efficiencies for different size solar cells. If a circular image
660 ! area is desired the data values in the corners of the scan, outside the
670 ! desired circular areas, are ignored. Both efficiency areas must be the
680 ! same shape: circular or rectangular.
690 !
700 ! After data conversion, various plots of the concentration ratios can
710 ! be produced on either the 9845 CRT or an attached X-Y plotter. Plots in-
720 ! clude single lines of data, 2-D contour plots of iso-irradiance, 3-D re-
730 ! presentations of the image, and a histogram of the frequency of occurrence
740 ! of concentration ratio values.

DCMOPB

FRESNEL LENS TESTER OPERATOR'S PRIMER (9845B)

NOTE: The below discussion assumes that the reader is familiar with the Hewlett Packard Model 9845 calculator and its extended BASIC programming language.

OPERATIONAL DETAILS

The Lens Tester software is made up of two BASIC program sections, ACQSTN and ANALYS. A short segment at the beginning of the program in lines 10-1530 dimensions variables, initializes variables, contains a mass-storage error handling routine, decides which of the two sections is needed, and has assorted GO SUB's. The program can use either the 9845's left tape cartridge (T14) or an HP 9885 floppy disk (F8,0) for data storage and retrieval. The program is written in a conversational style with prompts to the operator indicating the proper inputs needed at any time. The two functions of the Lens Tester are data acquisition and data analysis. They will be discussed in that order.

Acquiring data

The program section used for data acquisition is called ACQSTN. Data is acquired by a 2-D rectilinear scan of a point detector diode (diameter = .020") through a selected plane below the lens while the lens is tracking the sun on an equatorial telescope mount. This diode signal is compared to a reference diode looking at the sun through a tube baffle. These diode signals are digitized by two 14 bit A/D converters while the table is in motion. Data conversion is rapid enough that no motion affects are detectable. The data is stored in digital form. Manual lens-to-cell distance adjustments are accomplished with the aid of appropriate length spacers positioned between the top of the filter holder dark slide and the bottom of the lens. The diode detector is 3/8" (9.5mm) below the dark slide upper surface requiring all spacers to be 3/8" shorter than the desired lens-to-cell distance. If critical lens-to-cell distances are required, it will be necessary to adjust the length of the spacers for the added optical path length of the filters used for the measurement. A 5 mm thick filter of refractive index 1.5 would increase the optical path length by $5 \times (1 - (1/1.5)) = 1.66\text{mm}$, requiring the spacer to be cut to the desired lens-to-cell distance, minus 9.53mm, minus 1.66mm. The proper procedure for adjusting the lens-to-cell distance is contained in the text of the program. It should be the only adjustment necessary for routine operations. If the tester alignment has been disturbed it will need to be realigned by the procedure described in the following 7 steps:

1. Connect a VOM with a 10 volt scale to the black and red terminals of the A/D box under the table carriage.
2. Using the meter, align the reference tube peep sights so that the voltage fall-off with track misalignment agrees with the indicated peep sight image.
3. Using an inclinometer, adjust the rotation angle of the reference tube until the tube is perpendicular to the table top. (Check the other tube axis and shim the table if adjustments are needed.)
4. Rotate the mount -6 hours in hour angle and adjust the carriage for "18" lens-to-cell distance. Return the yoke to a more normal upright position and check that the carriage is parallel to the table top. If not parallel it may be necessary to shim the pillow blocks with washers, etc.

610 ! 5. Align the reference tube peep sights to again track the
620 ! sun. With no lens board on the lens carriage make sure that
630 ! the sun's image, projected by the 1/16" hole in the upper edge of
640 ! the lens carriage, is centered on the cross, etched into the
650 ! table platform near the Y motor. If the sun's disk does not fall
660 ! on this cross, re-do steps 1 to 4 above.
670 ! 6. With the mount tracking the sun adjust the table calibration
680 ! baffles(s) using the VOM on the blue and black terminals of the
690 ! A/D box in the manner described in steps 1 and 2 above.
700 ! 7. Don't EVER bump, hold, or disturb the reference tube.

710 !
720 ! Once the lens-to-cell distance has been adjusted and the mount is
730 ! tracking the sun, the scan dimensional parameters must be determined
740 ! from operator keyboard inputs. Two measurement systems can be used:
750 ! inches (In) or millimeters (Mm). Once a measurement systems has been
760 ! selected all dimensions for that test (scan) must be in the units
770 ! selected. Any and all parameters can be selected differently for other
780 ! tests. No matter what system is selected or what scan parameters are
790 ! entered the X-Y table can only make movements in steps of .001". All
800 ! scan lengths and data taking intervals are converted to an integer
810 ! number of 1/1000's in. to avoid any rounding errors due to non-integer
820 ! step sizes, etc. For this reason the number of data points per line
830 ! may vary from your intended value because of integer arithmetic.

840 !
850 ! To avoid damage to the filters from the concentrated sunlight the
860 ! filters must never be exposed to the high flux area unless they are mak-
870 ! ing a high speed scan (4"/sec). One pulse to a translator results in
880 ! a table movement of .001". Because of mechanical limitation the table
890 ! cannot be stopped or started above 500 pps (1/2" per sec). It must be
900 ! started below 1/2" per sec and gradually 'ramped up' to 4"/sec.
910 ! To accomplish this ramping-up the table is always backed away from the
920 ! designated image area by an amount proportional to the expected concen-
930 ! tration ratio of the image. The table must also be ramped-down
940 ! before stopping. To ramp-down outside the image area, the table is
950 ! allowed to proceed past the image area a distance equal to the original
960 ! backup. It is reasoned that the larger the image area, the lower
970 ! the possible concentration ratio that can result. The back-up distance,
980 ! H, is calculated as $H = .6 * (3000 - S)$ where S is the largest image area dimen-
990 ! sion in .001". For $S > 3000$ the backup is 0. This results in a minimum
1000 ! scan line length of nearly 3 inches. When the filter stops at the end of
1010 ! each line it should be well outside the image area. The ramp-up and down
1020 ! is accomplished by charging and discharging a capacitor whose voltage
1030 ! controls a V-F converter. The capacitor charges toward 15 volts, but a
1040 ! 4.7 volt zener diode limits the voltage. Because of zener limiting, the
1050 ! ramp-up is nearly a linear 350 msec ramp, with full speed attained in 400
1060 ! msec. The discharge to low speed is an exponential decay with ~150 msec
1070 ! time constant. Selection of V-F converter components result in a ramped-
1080 ! down speed of ~400 pps (.4"/sec) and a high speed of ~4000 pps (4"/sec).
1090 ! The ramp-up and down times were selected experimentally as the shortest
1100 ! times possible that consistently did not cause the table to lose pos-
1110 ! ition on either ramp-up or ramp-down.

1120 !
1130 ! The reason for the inequality in the expression for A above is due to
1140 ! the manner in which the lens tester hardware is built. The tester has
1150 ! been built so that the A/D converter receives a convert pulse every Int
1160 ! number of steps during the entire table movement. In order for the sys-
1170 ! tem timing to be proper the only way to initiate a table movement is to
1180 ! perform an ENTER... and begin taking data after Int steps. Since each of
1190 ! our scan lines begins well outside the desired image area we are re-
1200 ! quired to take several data points that we really don't care to have.
1210 ! Also we must require that the backup interval is an integral number of
1220 ! Int's so that our first desired data point is where we really think it

1230 ! should be. The inequality for A arises from the fact that we search for
 1240 ! the smallest integer multiple of Int that is $\geq .6*(3000-S)$. Once a table
 1250 ! movement has been initiated it can continue to its completion without any
 1260 ! data taking, provided an appropriate length WRIT has been included in the
 1270 ! program. The data collected before the scan reaches the desired area
 1280 ! is placed in a dummy data array Da(*) and discarded. The data samples
 1290 ! taken after the desired image area are ignored because the ENTER state-
 1300 ! ment has already fulfilled its required amount of data before then.
 1310 ! This same data taking requirement explains the ENTER statement using the
 1320 ! dummy data variable, S, in SUB Move.
 1330 !
 1340 ! The input area of the lens is calculated from the lens dimensions
 1350 ! supplied by the operator. If the lens is neither circular nor rectang-
 1360 ! ular, or some special gadget or feature restricts the light transmission,
 1370 ! the operator must calculate the equivalent round or rectangular unob-
 1380 ! structed lens aperture that would be appropriate. Data will always be
 1390 ! collected over a rectangular image area. The largest image dimension is
 1400 ! used to select the direction in which the scans will be made. Scan lines
 1410 ! are always taken in the longer direction, or in the X direction if the
 1420 ! image dimensions are equal. If a circular image is specified a square
 1430 ! array of data points is taken with a resulting X scan direction. For the
 1440 ! circular case the entire square data array is taken, but the unneeded
 1450 ! corner information is ignored in the efficiency calculations made later.
 1460 ! The rectangular area need not be a square. Long, narrow areas in either
 1470 ! the X or Y directions are permissible.
 1480 !
 1490 ! Once the scan parameters have been decided dark current and no-lens
 1500 ! light current data are taken to characterize the two diode detectors.
 1510 ! After installation of the lens and appropriate filters, a scan line of
 1520 ! data is taken through the center of the image area in both the X and the
 1530 ! Y directions. This serves the dual purposes of checking for saturation
 1540 ! of the diode detectors as well as checking to see how well centered the
 1550 ! image is in the scan area. This centering routine can be repeated any
 1560 ! number of times with various table offsets and/or filters until the oper-
 1570 ! ator is satisfied. Once the operator gives the OK the complete data scan
 1580 ! is taken. If one of the data scan lines goes through the center of the
 1590 ! image area it will be identical to one of the centering scan lines. If
 1600 ! the number of scan lines is even, none of the scan lines go through the
 1610 ! center of the image area. In this latter case the centering scan line
 1620 ! may not look like any of the data scan lines. After the scan has been
 1630 ! completed, additional data acquisitions or analyses can follow. There
 1640 ! is no requirement to immediately perform data reduction.
 1650 !
 1660 ! Analysis of stored data
 1670 !
 1680 ! Data analysis is performed by the section ANALYS and depends upon
 1690 ! the linearity of silicon PIN photodiode detector response to incident
 1700 ! radiation. The Ratio and Tz,Rz readings taken before the lens was
 1710 ! installed, along with the filter factors stored at the beginning of the
 1720 ! program are all that is required to convert the pairs of reference and
 1730 ! table diode readings to image area concentration ratios. This concen-
 1740 ! tration ratio conversion process is done for the entire rectangular
 1750 ! array. The lines of data are taken by table scans going in alternating
 1760 ! directions. During the data conversion process every other line of data
 1770 ! is reversed to make it appear that all data was taken from the same dir-
 1780 ! ection. Once concentration ratios are calculated, lens efficiency is
 1790 ! computed. An average concentration ratio for all the data points that
 1800 ! fall within the desired image area is computed, as well as the trans-
 1810 ! mitting area of the lens and area of the desired image. Efficiency
 1820 ! is calculated from these three values. All pertinent results and details
 1830 ! are stored for later use.

1840 ! At this point data analysis can be terminated or graphical displays
1850 ! of the concentration ratio data can be produced. In either case ad-
1860 ! ditional displays can be produced at a later date without the need to
1870 ! re-do the time consuming data reduction described above. Four graphical
1880 ! plots are available: A histogram of concentration ratio distributions,
1890 ! a 1-D plot of individual scan line data, A 2-D contour plot of iso-
1900 ! irradiance values, and an unscaled 3-D representation of concentration
1910 ! ratio data displayed as height above the image plane. They can be per-
1920 ! formed, repeatedly, in any order.

1930 !
1940 !
1950 !
1960 !
1970 !

ELECTRICAL DETAILS

1980 ! Electrical configuration of the Lens Tester system is a bit in-
1990 ! volved but a brief description will be attempted here. Complete elec-
2000 ! trical schematics, sketches of the system components, and additional
2010 ! necessary information are available. A Hewlett Packard 98032A 16-Bit
2020 ! parallel interface card is used to talk to and from the Lens Tester.
2030 ! The HP 98032A 16-Bit Interface Installation and Service Manual describes
2040 ! the operation and use of the interface and its registers. The BASIC
2050 ! statements necessary to communicate with the interface are described
2060 ! in the HP Series 9800 Desktop Computer I/O ROM Manual. The Standard
2070 ! 98032A Interface card comes from HP with a select code of 2. This can be
2080 ! easily changed, but with no reason for change, the Lens Tester Program
2090 ! uses a select code of 2 for 98032A communications. The operational
2100 ! descriptions here are those used by the Lens Tester Program and are not
2110 ! necessarily the only way that some of these functions can be performed.
2120 ! Data written to, or read from the interface is not to be confused with
2130 ! control functions and status characters which can also be written to,
2140 ! and read from the interface registers. In addition the actual interface
2150 ! is only the small box that plugs into the rear of the 9845. The Lens
2160 ! Tester itself is a peripheral that communicates with the calculator
2170 ! through the 98032A interface card. There are registers in the interface,
2180 ! and there are registers in the Lens Tester itself. The two should not
2190 ! be confused.

2200 !

2210 ! Data, two 8 bit bytes of information, can be written to the 98032A
2220 ! interface using an OUTPUT statement. Once written to the interface card
2230 ! this data is presented to the peripheral (Lens Tester) as 16 parallel TTL
2240 ! latched data lines. Data is read from the peripheral by using an ENTER
2250 ! statement. This reads the 16 interface data input lines that are con-
2260 ! trolled by the Lens Tester. Register 5 of the 98032A card is used as
2270 ! both the control 'out' register from the 9845, and the status 'in' reg-
2280 ! ister to the 9845. Information can be written to this register using
2290 ! WRITE IO 2,5;X, where X represents the information to be written.
2300 ! Information is read from the interface by using STATUS 2,5;S, where S
2310 ! contains the returned information. Register 5 of the 98032A is a 16
2320 ! bit register but only the lower 8 bits are meaningful. When writing to
2330 ! register 5, the upper 8 bits are ignored. When reading register 5, the
2340 ! upper 8 bits are always 0's. The Lens Tester uses only 3 of the control
2350 ! bits of register 5: RESET=32, CTL1=2, and CTL0=1. If a combination of
2360 ! these functions is desired their arithmetic sum is written to the
2370 ! register, i.e. a WRITE IO 2,5;33 performs both a RESET and sets the CTL0
2380 ! control bit to a 1. A WRITE IO 2,5;35 would do that in addition to set-
2390 ! ting CTL1 to a 1. When reading from register 5 the 1 and 2 bits are
2400 ! the Extended Status Input Lines, STI0 and STI1, respectively. These bits
2410 ! are used to pass information from the peripheral to the 9845 indirectly,
2420 ! and independently of the data lines. All data inputs and outputs of the
2430 ! 98032A are normally negative true logic unless appropriate Configuration
2440 ! Jumpers have been installed to perform data inversion of those values.
2450 ! In most cases these jumpers have been installed in an attempt to use pos-
2460 ! itive true logic.

2470 ! A 53 conductor cable, either with or without the 50' extension cable,
 2480 ! may be used with the system. The 16 parallel calculator data output
 2490 ! lines are used to communicate with the different counters and registers
 2500 ! within the Digital Control Chassis. The lower 12 bits are used as data
 2510 ! to be transmitted, while the upper 4 bits are used as addresses to multi-
 2520 ! plex the data to its proper destination. When reading data from the
 2530 ! tester all 16 of the calculator data input lines are used as data, al-
 2540 ! though only the lower 14 bits contain information. The upper two bits
 2550 ! are allowed to float high. WFHS is used for all Lens Tester data entry
 2560 ! operations. The 16 calculator data input lines are read in negative
 2570 ! true logic because the 9845 does not allow data inversion for WFHS's.
 2580 ! The two high order bits being high results in them always being read as
 2590 ! zeroes. The A/D outputs are in positive true logic. A 0 from the A/D
 2600 ! is read as a 16383 by the 9845, and a 16383 is read as a 0. Proper
 2610 ! A/D values are obtained by subtracting the read value from 16383.
 2620 !
 2630 ! There are two 12 bit and one 8 bit binary count down counters in
 2640 ! the Digital Control Chassis. The two 12 bit counters are to keep track
 2650 ! of X and Y table movements, while the 8 bit counter controls the data
 2660 ! taking interval. 12 bit resolution allows 4095, .001" steps in either
 2670 ! X or Y, while 8 bit resolution allows the data taking interval to be as
 2680 ! large as 255, .001" steps. The data taking interval is strictly a pos-
 2690 ! ition count and is insensitive to ramp-up or ramp-down conditions. Data
 2700 ! can be taken at any time the table is moving. There are additional reg-
 2710 ! isters to enable the X, Y, or Int counters, program fast or slow move-
 2720 ! ment, and control the direction of movement in each axis. There are
 2730 ! three special MUX control words which cause actions regardless of the 12
 2740 ! data lines. These three commands cause the table to move slowly in -X
 2750 ! and -Y simultaneously, or to take a single step in the X or Y directions.
 2760 !
 2770 ! The peripheral control lines CTL0 and CTL1 are used to control the
 2780 ! read/write and shutter functions of the tester. The interface control
 2790 ! line logic levels cannot be inverted by Configuration Jumper selection.
 2800 ! Setting a CTL to zero actually sets the hardware line in the Digital
 2810 ! Control Chassis to a one. Program-wise, CTL1=0 will close the shutter,
 2820 ! while CTL1=1 will open the shutter. CTL0=0 enables an ENTER operation,
 2830 ! while a CTL0=1 enables an OUTPUT while disabling an ENTER. The proper
 2840 ! control line must be set before attempting a data transfer or an I/O
 2850 ! TIMEOUT error will hang up the calculator. (CTL0 is used to multiplex,
 2860 ! MUX, the Handshake circuitry between in and out Handshakes.) A simple
 2870 ! RESET (WRITE IO 2,5;32) of the interface card sets both control lines to
 2880 ! zero, closing the shutter and allowing ENTER operations. Hardwired
 2890 ! circuits handle the actual Handshake for the data transfers. Timing
 2900 ! diagrams for both OUTPUT and ENTER Handshakes are included for trouble-
 2910 ! shooting purposes.
 2920 !
 2930 ! An alternate method to write a control word, X, to register 5 of
 2940 ! interface card #2 is to execute:
 2950 !
 2960 ! 10 CONTROL MASK 2;X
 2970 ! 20 CARD ENABLE 2
 2980 !
 2990 ! There is a control mask for each interface, and at POWER-ON they are all
 3000 ! set to zero. A control mask statement is needed if a mask other than 0
 3010 ! is desired. This CARD ENABLE statement loads the current control mask
 3020 ! into register 5 of a 98032A interface #2. In our case the same function
 3030 ! is performed by simply executing:
 3040 !
 3050 ! 10 WRITE IO 2,5;X
 3060 !
 3070 ! Definition of the WRITE IO control word, X, is the same as the for the
 3080 ! CONTROL MASK described previously. The mask does not change unless a

3090 ! new CONTROL MASK is executed. If the same control word, X, were always
 3100 ! used, there would be little difference which method were used. If X
 3110 ! changes often, as it does in our case, the WRITE IO approach uses fewer
 3120 ! program lines. After an ENTER WHS is performed, the current control
 3130 ! mask is loaded to the card from which the data was ENTER'ed. If no
 3140 ! CONTROL MASK has been executed, this mask will be a 0, permitting ENTER
 3150 ! handshakes from the Lens Tester, but causing the shutter to close. To
 3160 ! prevent the shutter from closing after each line of data, a CONTROL MASK
 3170 ! 2;2 is executed before starting the data scan. Even though no CARD
 3180 ! ENABLE's are ever used, this mask=2 keeps the shutter open until explic-
 3190 ! itly told to close with a WRITE IO 2,5;0 after the scan is completed.

3200 !
 3210 ! Information going to the Lens Tester is transferred using the
 3220 ! command OUTPUT 2 WHS USING "#,W";XXXXX, where the X's can be numerical
 3230 ! digits. The USING "#,W" portion outputs a 16 bit binary word without
 3240 ! the carriage return and line feed normally used by the 9845. If the
 3250 ! number output is in the range of 0-4095 the data is MUX'ed to the X
 3260 ! counter. In order to write to the Y counter, 4096 must be added to
 3270 ! the desired Number. (4096 loads a 2 in the Y counter.) The Interval
 3280 ! counter is addressed by adding 8192 to the proper interval. The control
 3290 ! data registers are addressed by adding 12288 to the sum of the values
 3300 ! of all the control bits that are to be set high. (Data inversion is
 3310 ! performed for a WHS allowing all values OUTPUT with WHS to be in positive
 3320 ! true logic.) The weights for the various control registers are listed
 3330 ! below:

CONTROL REGISTER	
BIT WEIGHTS	
12288 +	Control Function
1	Enable Interval Counter
2	High Speed Movement
16	Move in the -X direction
32	Move in the -Y direction
64	Enable X counter
128	Enable Y counter

3440 !
 3450 ! The absence of setting a bit performs the complement of that control
 3460 ! function. By not setting the -Y direction, the +Y direction is selected.
 3470 ! Of course the +Y direction could be selected, but if the Y counter is not
 3480 ! enabled, or if a non-zero number has not been loaded in the Y counter, no
 3490 ! Y movement can take place. If a control register has been written to,
 3500 ! it retains that value until written to again with a different value.
 3510 ! A 12288 command not only addresses the control registers but also stops
 3520 ! the counter clock. For this reason it is a good idea to always perform
 3530 ! a 12288 before writing to the tester.

3540 !
 3550 ! In addition to the above multiplex codes there are three codes used
 3560 ! for finding the table 0,0 location. Writing a 16304 forces the table
 3570 ! to travel -X and -Y at slow speed, regardless of the position counters or
 3580 ! enabling circuitry. This command is called 'GO TO HARD STOPS' and is
 3590 ! useful when trying to locate the 0,0 position. There are six signals
 3600 ! that are used for locating the table 0,0 position: The -X and -Y limit
 3610 ! switches, X and Y zero position switches, and X and Y zero position en-
 3620 ! coder signals. The X and Y limit switch signals are NAND'ed together to
 3630 ! form NOT(Xh*Yh). The zero position switches and encoder signals are
 3640 ! multiplexed by the 256 bit of the calculator data output lines, as well
 3650 ! as the X and Y enable signals. If the 256 bit is high, zero encoder
 3660 ! signals are selected; if the 256 bit is low, zero switch signals are sel-
 3670 ! ected. The two signals thus selected by the 256 bit are NOR'ed with their
 3680 ! respective X and Y enable signals to produce one signal that is either an
 3690 ! encoder or switch signal from the one axis that is enabled. This signal
 3700 ! is normally STI1. However, any time the 'GO TO HARD STOPS' command has
 3710 ! been ordered the NOT(Xh*Yh) signal is instead multiplexed to STI1.

3720 ! A test of STI1 during a 16384 command will indicate when the limit
 3730 ! switches have been reached. Once the corner has been reached a movement
 3740 ! in +X is programmed with the 256 bit of Int remaining low. This selects
 3750 ! the X zero switch for STI1. A continuous test of STI1 then indicates
 3760 ! when the zero switch has been reached. X motion is stopped at this time
 3770 ! by OUTPUTting a 12288 (disable counter). A command of 20480 causes the
 3780 ! table to take one step in the X direction. By now enabling -X, OUTPUT-
 3790 ! ting 20480, and subsequently setting the 256 bit high, a test of STI1
 3800 ! will indicate if the zero encoder indicates a true zero position. This
 3810 ! single step process avoids any problems of possibly missing an encoder
 3820 ! signal between two table steps because of delays in I/O to the 9845. A
 3830 ! similar process is repeated for Y using the 24576 command which is a
 3840 ! single step in the Y axis.
 3850 !
 3860 ! To make the table move .500" in the -X direction in the fast mode,
 3870 ! a 500 is loaded into the X counter. The X enable, -X, fast speed, and
 3880 ! Int enable are selected by OUTPUTting a $(12288+64+16+2+1)=12371$. No
 3890 ! movement will occur until an ENTER WFHS... statement is executed. The
 3900 ! ENTER list need only contain one variable name to start the table in
 3910 ! motion. The 9845 cannot perform any other function until the ENTER...
 3920 ! statement data list is satisfied. The data list must be satisfied before
 3930 ! the table movement is completed. The movement must proceed at least one
 3940 ! count beyond the last data taking location. Since the minimum Int value
 3950 ! is .001", the minimum movement is one beyond, or .002". If the last data
 3960 ! location coincides with the end of movement the last handshake will not
 3970 ! be completed and the calculator will hang up. If the table movement
 3980 ! goes far beyond the last data location, it may be necessary to add an
 3990 ! appropriate WAIT to the program to avoid attempts to OUTPUT new data
 4000 ! while the table is still moving. (Any RESET OR 12288 command sent to the
 4010 ! 98032A disables the clock circuit causing all table movements to cease.)
 4020 ! The X counter will count down one digit each time the table steps.
 4030 ! When the counter reaches zero, the gate that passes step pulses to the
 4040 ! X counter and translator is disabled, stopping the table at -.500" in X,
 4050 ! with the X counter at zero. The X and Y counters work independently
 4060 ! allowing movements in both axes simultaneously. Since there is only
 4070 ! one clock circuit both axes must move in the same speed mode. To allow
 4080 ! the table sufficient ramp-down time there are circuits to indicate
 4090 ! when 352 counts remain. The first enabled position counter to reach
 4100 ! a count of 352 sends a ramp-down signal to the V-F converter. If a fast
 4110 ! movement in both axes was less than .352" no ramp-down signal would
 4120 ! occur, causing an abrupt table stop with resultant loss of position.
 4130 ! For this reason fast table movements should be used only if the travel
 4140 ! will be over .352". If the other position counter has more than
 4150 ! 352 counts left when the ramp-down starts, it may have to finish its
 4160 ! count at the 400 pps rate of the ramped-down fast clock.
 4170 !
 4180 ! Because of the way the fast/slow speed selection is made, the ramp-
 4190 ! up process is initiated on the first stepping pulse after every ENTER
 4200 ! statement, whether the movement is fast or slow. If the move is shorter
 4210 ! than .352", no ramp-down signal is generated. In this case the V-F con-
 4220 ! verter is left in the 4000 pps mode, even if the move was slow. If a
 4230 ! fast scan is selected with no intervening action, the table will attempt
 4240 ! to start at 4000 pps. The result will be a stalled motor with no move-
 4250 ! ment, even though the calculator thinks the movement has occurred. To
 4260 ! reset the V-F back to its slow mode after short movements, it is nec-
 4270 ! essary to perform a SCREWY FAST RESET. This consists of enabling one
 4280 ! of the position counters and loading 352 into that counter. This gives
 4290 ! a signal to the V-F converter to ramp-down. The only other requirement
 4300 ! is that the capacitor be given approximately 300 msec to discharge.
 4310 ! This returns the pulse rate to 400 pps allowing a proper ramp-up for
 4320 ! a fast scan.

4330 ! The interval count (Int) is the last numerical data entry made to the
4340 ! tester. This leaves the 12 calculator data output lines latched with
4350 ! Int. The interval counter sends a CONVERT pulse to the A/D box when the
4360 ! interval count reaches zero. When a CONVERT pulse is generated it is not
4370 ! only sent to the A/D box, but it is also used to load the lower 12 bits
4380 ! of the current calculator Data Output word to the interval counter.
4390 ! The interval counter continues to count down as long as either of the
4400 ! two position counters continue to count. Both A/D's convert simultan-
4410 ! eously and take approximately 25 microseconds to complete their conver-
4420 ! sions. The STATUS signal from the reference diode converter is used as a
4430 ! data ready signal for the interface. If the calculator is requesting
4440 ! data this signal initiates the hardware timing to multiplex first the
4450 ! reference diode data word, then the table diode data word back to the
4460 ! 9845. If the 9845 is not requesting more data this STATUS signal is
4470 ! ignored.

4500 ! SAMPLE BASIC PROGRAM STATEMENTS

4530 ! A sample of all the BASIC statements necessary to move the table
4540 ! is demonstrated below. A brief explanation of what each statement does
4550 ! is also included, if deemed necessary.

4580 ! 10 INTEGER S	Define integer dummy variable, S.
4590 ! 20 WRITE IO 2,5:33	Write to control register 5 of inter- face #2. Reset, Allow OUTPUT, Shutter remains closed.
4620 ! 30 OUTPUT 2 WHS USING "#,W";100	Set X=.1" travel. (Must be >=.002")
4630 ! 40 OUTPUT 2 WHS USING "#,W";12353	Enable +X and Int, move slow.
4640 ! 50 OUTPUT 2 WHS USING "#,W";8193	Int=.001"
4650 ! 60 WRITE IO 2,5:0	Allow ENTER, shutter closed.
4660 ! 70 OFF INT#2	Used only if an ON INT#2 statement has previously been used. WFHS and TIMEOUT interrupts aren't compatible.
4700 ! 80 ENTER 2 WFHS 1 NOFORMAT;S	Enter 1, 16 bit binary dummy var- iable, S, from interface #2 using fast handshake.
4730 ! 90 WAIT 2*100	Wait 2 ms for each step since move is in the slow mode.

4770 ! A similar sequence for a data entry would look like:

4800 ! 10 INTEGER A(102), D(30)	Dimension integer data arrays.
4810 ! 20 CONTROL MASK 2;2	Needed to prevent shutter from clos- ing between lines of data if more than 1 line is being taken. Need only be executed once per program.
4850 ! 30 WRITE IO 2,5:35	Write to register 5 of card #2. Reset, open shutter, allow OUTPUT.
4870 ! 40 WAIT 50	Allow 50 msec for shutter to open.
4880 ! 50 OUTPUT 2 WHS USING "#,W";3280	X=3.28" travel. (>>.002")
4890 ! 60 OUTPUT 2 WHS USING "#,W";12371	Enable -X and Int, move fast.
4900 ! 70 OUTPUT 2 WHS USING "#,W";8232	Int=.04"
4910 ! 80 WRITE IO 2,5:2	Allow ENTER with shutter open.
4920 ! 90 OFF INT #2	Used only if ON INT #2 has been used previously. WFHS and TIMEOUT int- errupt don't mix.

```

4950 ! 100 ENTER 2 WFHS 132 USING "#,W";D(*),A(*) ENTER 2 data values from each
4960 !                                     of 15 dummy data locations into
4970 !                                     array D, and from each of 51 data
4980 !                                     locations into array A. The 16
4990 !                                     bit binary words come from inter-
5000 !                                     face #2 using fast handshake.
5010 ! 110 WAIT 600 Will WAIT 40 msec for each of the
5020 !                                     15 Int's that occur after the last
5030 !                                     data values were taken to allow
5040 !                                     table to stop. This allows an
5050 !                                     average pulse rate of 1000 pps
5060 !                                     during the ramp-down phase.
5070 ! 120 WRITE IO 2,5;0 Close Shutter.

```

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