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Victor J. Bortolot, Ph.D.  
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Control No. 120008

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Sincerely,

Original Signed By  
Doris J. Foster

John E. Glenn, Ph.D., Chief  
Nuclear Materials Safety Section B  
Division of Radiation Safety and  
Safeguards

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# DAYBREAK

Systems for  
TL Research

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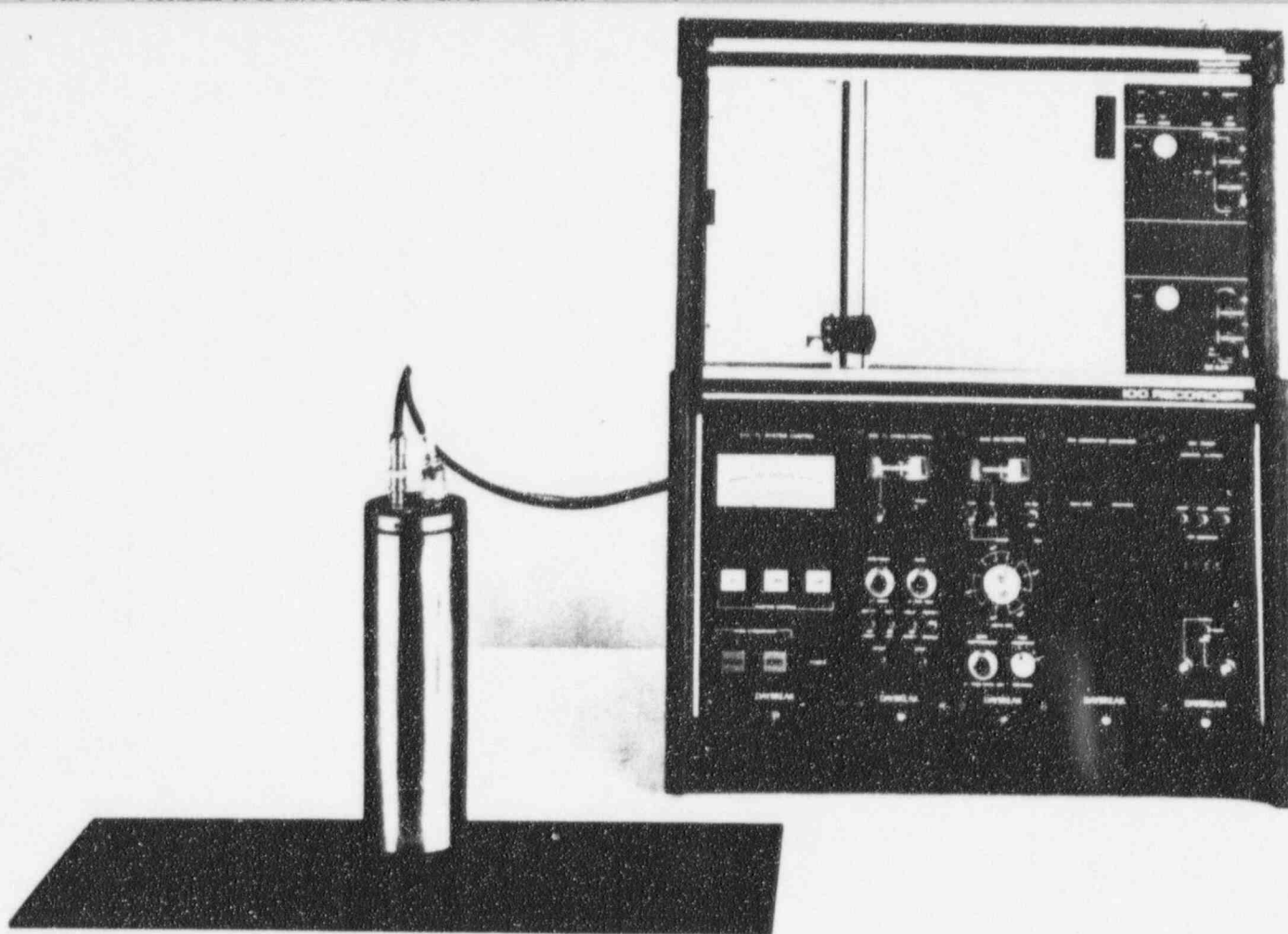
# DAYBREAK

*Systems for  
TL Research*

ML10

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120008



*Daybreak thermoluminescence reader system*

# Product Description Systems for TL Dating Research

## Features

- Worldwide standard for thermoluminescence (TL) dating apparatus
- Over 25 complete systems installed throughout the world
- Designed specifically for TL research in natural materials
- Modular, expandable, and compatible with a wide range of system components
- Very complete line of TL apparatus and accessories from one source
- Advanced data acquisition and reduction computer system
- State-of-the-art electronics and glow oven
- Exceptional reliability
- Backed by over 10 years' experience
- One year warranty

**T**he Daybreak TL system has been designed to address the particular needs of archaeological and geological dating. It evolved over six years' laboratory use before its introduction in 1979. Since that time, over 25 Daybreak TL systems have been installed in laboratories throughout the world. Its high performance and reliability have made it the world standard in its field. This is partly due to Daybreak's initial concept of a modular, expandable system, designed both to stand alone and to integrate with an advanced computer-based data acquisition and reduction system having a full range of TL applications software. Another part, which contributes to our record of reliability, is the conservative yet innovative design with state-of-the-art, complex integrated circuits and an extended burn-in program prior to shipment.

The Daybreak TL system has many advantages beyond its moderate price. It was designed from the beginning with a coherent overall plan for the contemporary TL dating program. Daybreak manufactures a complete and integrated line of TL apparatus, from the basic TL reader to radioisotope sources and irradiators to computer systems, down to alpha counter supplies... and all the parts work together to give you the most for your money. The Daybreak family of TL instruments is growing, but as improvements are made and new products introduced, we ensure that compatibility is maintained. You can start with the Basic TL System which includes the basic TL reader with XY recorder, vacuum pump, and alpha coun-

ter, and add to it as needs require or your sophistication grows. The next major step is up to the 9900 computer system. Simply plug the computer interface into any free slot on the system module bus. The extensive TL applications software package records glowcurves on disk, performs data reduction and age computation, and because we know that TL dating is still advancing, we have configured all the software as a collection of system library units so that the user developing his own specialized computations can take advantage of all the file handling, graphics, and pre-processing utilities built into the system. Example program skeletons are provided so that the user will have to write a bare minimum of software to get his or her special procedures to run within the environment of the Daybreak software system. Most of the more useful procedures are already implemented. Included is a complete growth curve analysis for both conventional TL and a number of optical bleaching techniques. The software has been written in the powerful and popular UCSD p-system implementation of Pascal, a powerful and flexible block structured language, with a FORTRAN compiler available as an option.

Among the features unique to the Daybreak system are direct computer control of virtually every function. The temperature controller has a stable, reproducible digital ramp for heating rates 0-25°C/sec, automatic repeat ramp for the background glowcurve, a low-power, low-volume glow oven for fast cooling and evacuation, and a pile-up compensating ratemeter that extends the single photon counting

dynamic range to beyond ten million counts per second. Both ratemeter and alpha counter have integral high voltage power supplies. The computer interface permits the system XY recorder to emulate a digital plotter for high quality plots of processed or rescaled data. We have made the Daybreak system simple to set up, simple to use, and compact. The Basic TL system reader has only three cables; all interconnects between modules are made via the system bus. The system is packaged in two parts — an electronics enclosure (19 inches wide by 22 inches high by 14 inches deep) that contains the system bin with slots for five modules and the XY recorder, and the glow oven assembly (20 inches wide by 8 inches deep, extending 3.5 inches below the bench mounting surface) and PMT housing (3 inches diameter by 9 inches high). There is room left in the Basic TL reader for two more modules, which can be two alpha counters, or more usually, an irradiator timer and the computer interface.

**W**e have radioisotope irradiators to suit every application. For most archaeological dating, we recommend the 740 beta irradiator for on-plate calibrations. Strontium-90 sealed sources are available in activities of 125 mCi and 2 mCi (for pre-dose dating). Several alpha irradiators are offered with a 0.5 mCi curium-244 source: the close geometry 750 for fast exposures, the 760 vacuum irradiator which is slower, but yields slightly higher precision, and the 765 vacuum alpha irradiator which permits irradiations on the

source-to-sample distance intended primarily for the geological dating program where exposure times are very long, or for the large dating laboratory where the highest efficiency is desirable, the 801 multiple sample irradiator may be a virtual necessity.

Our 582 alpha counter is a unique instrument, and probably our most popular item. It is almost totally immune to electrical noise and is actually three counters in a single module. We have packaged the HV power supply, an amplifier/integral discriminator along with a total events counter and two pulse pairs discriminators with counters, all in one standard module. Using the totals and slow pairs counters, you can deter-

miners — total fast and slow pairs — one may obtain Th-230 and Pa-231 content. Since the major bottleneck in dating is usually the length of time required for alpha counting, most laboratories will need more than the single counter furnished with the Basic TL system. We provide a separate enclosure, the model 503, that accommodates up to three counters with their PMT housings.

New in 1984 is the model 583 alpha counter, the first of our intelligent modules. This instrument combines the function of the 582 with a built-in microcomputer and printer that prints out cumulative and incremental total and pairs counts every 1, 2, 4, or 8 ksec, and stores data of up

to 1000 counts. Data that may be noisy is flagged, and average count rates with errors computed. Long term trends in count rate (thoron decay or radon buildup) are also computed. The counter is immune to power failure, and will resume counting after noting the occurrence when power is again restored. Owners of earlier 580-series counters will appreciate the 584 printer-controller that adds these intelligent functions to existing counters with little or no modification.

The warranty on apparatus manufactured by Daybreak is for one year, covering parts and labor, and service is available in the U.S. and in England (soon, elsewhere in the world).

## Basic TL System

For small laboratories, or those with limited funds, the Basic TL System is a good entry point. It comprises the model 700 glow oven, the 720 PMT housing with 530 single photon amp/disc, EMI 9635QA PMT, and optical filter pack, the 501 enclosure with the 510 system controller, 520 oven temperature controller, 540 ratemeter, and 582 alpha counter. Also provided are a 75 l/min capacity vacuum pump and XY recorder (8.5 by 11 inch chart), and accessory packages for fine grain sample

preparation and alpha counting. Complete service and instruction manuals are included.

You will also need radioisotope sources and irradiators for calibration exposures, but their choice will depend on your application.

Aside from the sources, and a supply of oxy-free purge gas (pre-purified nitrogen or argon) with regulator, the Basic TL system contains everything needed for the simpler applications, such as authenticity

testing. A flame photometer or AA spectrometer for potassium determinations is very desirable, but the use of them is usually not hard to come by. As your laboratory becomes busier, or you get involved with the more data-intensive applications, such as sediment dating, the 9900 computer system will provide a tremendous savings of time, and considerable computational power.

## Features

- Overall system control for most run-time functions
- Thermocouple vacuum gauge
- AC power control of glow oven
- Adjustable delay for two stage vacuum valve
- Computer control of HV enable, and vacuum and purge valves

The model 510 TL system controller module includes most of the controls used in taking data. It contains the glow oven vacuum gauge, triac AC power controller for the glow oven heating plate, and control functions, most of which are also controllable by the computer interface with optional expansion board. The system XY recorder signals are routed through, and its power derived from, this module. Unswitched AC power for alpha counters is also placed on the system bus. The control functions are

all lighted pushbutton switches: VACUUM and PURGE controlling the respective solenoid valves on the glow oven assembly (control of the oven vacuum is two stage, with a bleeder valve opening first, then the main valve after a 0-10 second delay adjustable internally), HV enable, RAMP start, MAIN POWER, and OVEN POWER. All switch functions except main and oven power are controllable from the computer for future automated glow ovens.

## Specifications

**AC oven current:** 6 A maximum 115/230 VAC 50-60 Hz

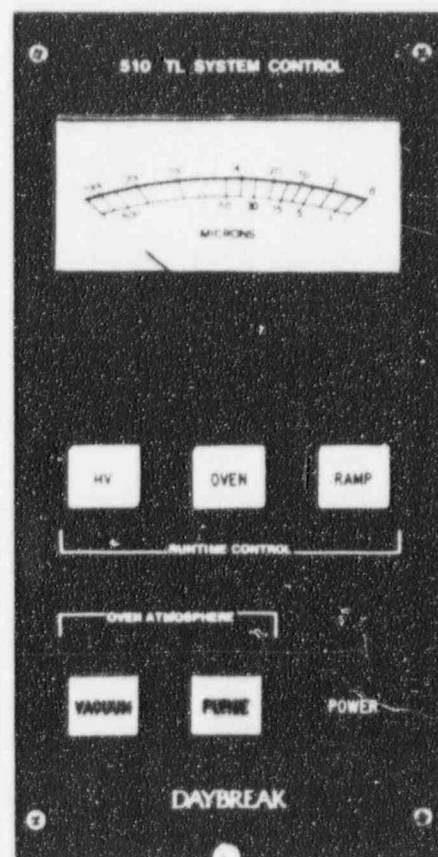
**Solenoid control current:** 1 A maximum, 115/230 VAC 50-60 Hz

**Control logic inputs:** TTL-compatible, active low (for HV, VACUUM, and PURGE)

**Vacuum gauge:** thermocouple type, for tube type 6343/0004

**Power:** 115/230 VAC 50-60 Hz, 10W, plus glow oven power

**Physical:** 4.55" wide standard Daybreak module



# 520 Oven Temperature Control

## Features

- Flexible temperature programming
- Automatic repeat ramp for background
- Digital ramp
- Built-in icepoint compensation
- Ultra-lowdrift TC amplifier
- 0-1000C overall temperature range with absolute maximum settable to 400-1000C by internal adjustment
- Tight servo control
- Non-linear transient filter to suppress AC switch noise
- Computer control of most functions

The model 520 temperature controller programs the temperature of a TL glow oven in a ramp of variable rate and endpoint. Its output is a current proportional to the temperature servo loop error, and is intended for use with the 510 system controller or with the 521 AC power control. A number of features, such as automatic background run and setpoint operation, have been incorporated for user convenience. A number of logic control

lines are connected to the system bus for computer control of the ramp. An icepoint compensator and ultra-lowdrift thermocouple amplifier are now included as a standard feature. Also standard is a 0-1000C control range to accommodate the 701 high temperature glow oven, for safety, an internal control limits the maximum endpoint or setpoint temperature attainable to a value settable between 400 and 1000 C.

## Specifications

**TC amplifier:** gain set for chromel-alumel thermocouple. Negative input. Icepoint compensation. Nonlinear transient filter. Output nominally 200mV/100C, settable 100-200 mV/100C

**Ramp:** linear, digital ramp, 0-25C/sec (10 turn pot). V-F converter plus 12-bit DAC with clock pulse output every degree C. Stability better than 500 ppm/C. Endpoint 0-1000C (10 turn pot), limited to a maximum adjustable between 400 and 1000C

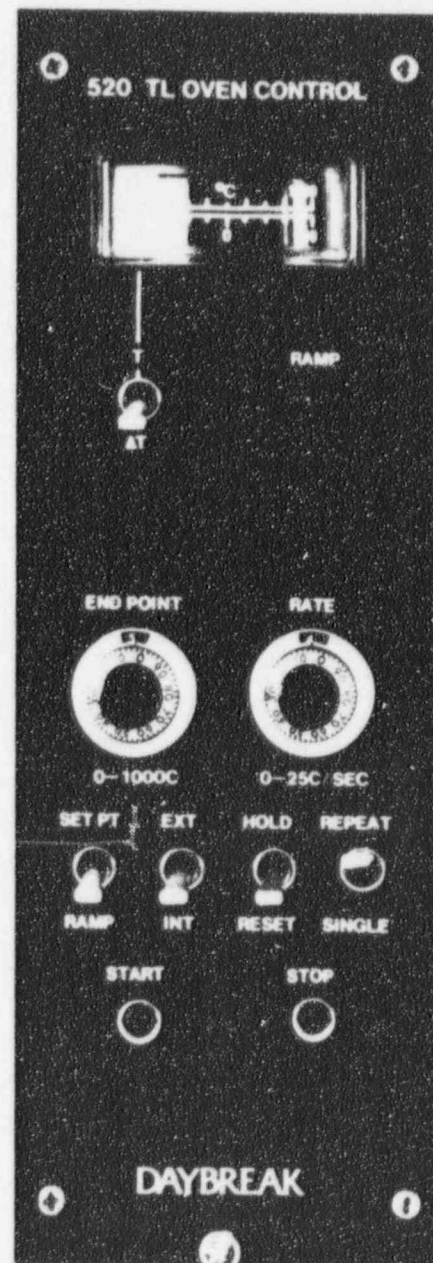
**Error amplifier:** variable gain (rear panel control), maximum sensitivity 2 mA/C error (approximately one half maximum power.)

### Programming:

**RAMP/SETPOINT:** permits use of the 520 as a setpoint controller, using the ENDPOINT control

**INTERNAL/EXTERNAL:** chooses internal ramp or arbitrary T(t) from external source such as 900 interface with ramp clock option. A 0-10 V input corresponds to 0-1000C

**RESET/HOLD:** action at end of ramp



**ONCE-REPEAT-ON-REPEAT:** the ramp will start once after cooling to near ambient temperature (settable internally to 0-100C) for background run.

**START:** initiates ramp. This switch is paralleled by the RAMP switch of the 510 system controller.

**STOP:** aborts ramp.

External logic control: START, STOP, and CLOCK DISABLE lines (TTL active low) permit computer control for special program requirements.

**Pen lift output:** TTL compatible, high or low active level selectable.

**Meter:** 0-1000C, or  $\pm 10C$  error, selector switch on front panel.

**TC connector:** Omega Engineering type SMP-K.

**Power:** 115/230 VAC 50-60 Hz, 6 W.

**Physical:** 3.05" wide standard Daybreak module.

**Option:** Independent setpoint control (in place of RAMP indicator on the front panel). This is useful for preheating and for predose activations.

**NOTE:** The standard model 700 glow oven is warranted only to 500C.

## 521 AC Power Control

### Features

- Phase control of highly inductive transformer loads
- 6 amp capacity, 115 or 230VAC operation
- Isolated input

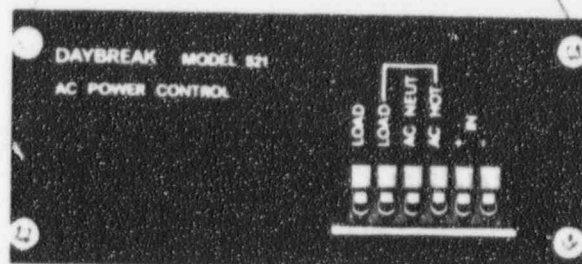
The model 521 AC power control is a phase control triac AC power module developed especially for use with highly inductive loads, such as transformers. The input signal is a current (0-10 mA), optically coupled to the AC circuitry. Load capability of the output triac is 6 amp. The function of the 521 is included in the 510 system controller, and the 521 is intended

primarily for those purchasing the 520 alone for use with their own glow ovens. Purchasers must provide fusing and oven power switch. This controller can also be supplied in a 4.5 inch wide Daybreak module with main and oven power switches and xy recorder connections as the model 511.

### Specifications

**Physical:** 2" x 4.5" x 3.5"

**Electrical:** 115/230 VAC, 2W plus load power



## Features

- High sensitivity single photon discriminator
- Charge sensitive for noise immunity
- ECL output drives 50 ohm cable
- Small size to fit inside PMT housing

The model 530 amp/disc converts the low level current pulses from the anode of the photomultiplier tube to standard logic pulses. It comprises a charge sensitive amplifier, which is highly immune to line noise and radiofrequency interference, and a fast, trouble-free voltage comparator. The output is ECL-compatible,

single-ended or differential, capable of driving 50 ohms (or 100 ohm twisted pair transmission line). This device is compact and mounts within the PMT housing. The sensitivity is sufficient for all PMTs commonly used for single photon counting.

## Specifications

**Sensitivity:** 0.1 pC threshold maximum. Sensitivity may be reduced by internal adjustment.

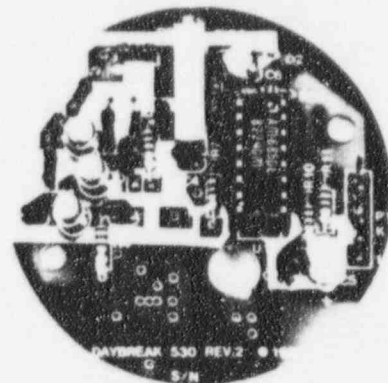
**Amplifier rise time:** 4 nsec.

**Output pulse width:** 7 nsec minimum (measured with mercury pulser); will follow width of input pulse at discriminator threshold.

**Output level:** negative-going ECL (+4.1 V to +3.2V), driving 50 ohms. Complementary outputs permit differential driving of 100 ohm twisted pair line.

**Power:** +5 V at 75 mA, +12 V at 25 mA.

**Physical:** 2.47" diameter, 0.60" high.



## Features

- Converts photon pulses to analog rate voltage
- Automatic dead-time compensation for high analog dynamic range
- Built-in HV power supply
- TTL output to computer interface

The model 540 ratemeter converts the logic pulses from the 530 photon amp/disc to an analog voltage proportional to their rate. It features a proprietary pile-up compensation circuit that automatically and continuously corrects for dead time losses according to the relation:

$$\text{TRUE RATE} = \text{OBSERVED RATE} / (1 - \text{DEAD TIME FRACTION})$$

For fairly slow PMTs such as the EMI 9635 usually used for TL measurements, dead time per detected photon is 40-100 nsec depending on discriminator threshold, and losses amount to 4-10 per cent at  $10^4$  counts/sec. This reduces dynamic range and accuracy, and limits the use of single photon counting in reading high efficiency TL phosphors to low doses. The 540 also includes an integral HV power supply, fifteen ranges to  $2 \times 10^5$  counts/sec (usable with the standard 9635 PMT only up to about  $10^4$  because of dynode string loading), and an active filter output stage with resistor switching to eliminate glitches when changing time constant. A TTL pulse output (the input divided by two) is provided for connection to the model 900 interface or to an external counter.

## Specifications

**Input:** negative-going ECL differential input

**Ranges:** 12 ranges 500 to  $2 \times 10^5$  counts/sec full scale, plus divide by 10 (front panel switch) for  $5 \times 10^4$  to  $2 \times 10^5$  counts/sec

**Pile-up compensation:** within 1 percent to 50 per cent dead time

**Analog output:** 500 mV full scale for 100 mV/inch XY recorders

**Zero suppression:** subtracts 0-1000 counts/sec dark count from output

**Time constant:** 0.03, 0.1, 0.3, 1, 3, 10 seconds

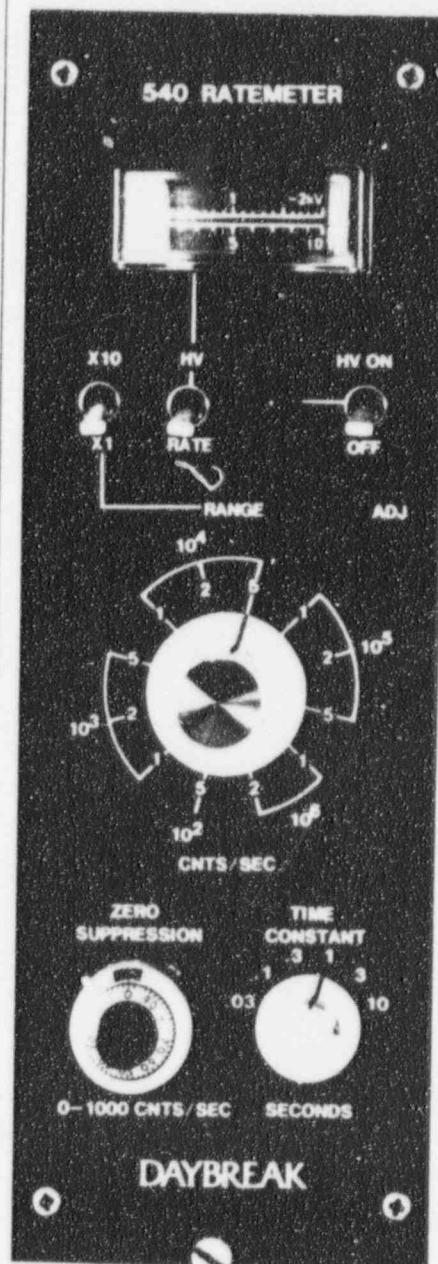
**Meter:** displays 0-100 per cent full scale and 0-2000 V, selectable by front panel switch

**HV power supply:** negative, 600-1600 V at 0.5 mA, front panel screwdriver adjust, HV on/off switch with LED indicator and remote HV enable (switch closure to ground)

**Connectors:** 5 pin Amphenol series 126 connector for amp/disc power and signal, SHV for high voltage

**Power:** 115/230 VAC 50-60 Hz 10 W

**Physical:** 3.05" wide standard Daybreak module



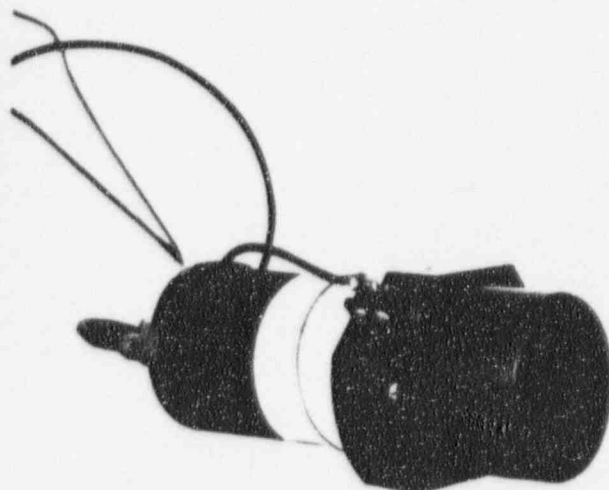
## Features

- Fast and slow pairs discrimination
- Three digital counter/displays
- Built-in HV power supply
- Charge sensitive for immunity to electrical noise
- Highly stable
- HV interlock to prevent PMT damage
- Interface to printer/controller

Daybreak offers a unique low-level alpha counter for TL dating applications. In addition to a 4-digit total events counter, the model 582 has a slow pairs (20-400 msec resolution) and a fast pairs (0-4 msec resolution) discriminator with 3-digit counters. These latter are used to determine U/Th ratio and Th-230 and Pa-231 content for sediment dating by the isotopic ratio technique. In one compact module, the 582 contains a preamp, shaping amplifier, integral discriminator, counters, and HV power supply. The charge sensitive preamp is highly insensitive to electrical and radiofrequency noise, so that a printer is unnecessary, but signals are brought to a rear panel connector for an intelligent printer (model 584) that will record and store in non-volatile memory data from up to 250 counting periods for later processing. The 50mm PMT is

housed externally to the module in a magnetically-shielded enclosure with HV interlock to prevent damage to the PMT. The counter is powered independently of the remainder of the TL system. Accessories for the 582 alpha counter include

acrylic counting rings of 0.50, 1.00, and 1.73" inside diameter and ZnS scintillator powder and cellophane tape for general purpose counting use, and 1.73" I.D. sealed counting cells for use with ZnS-coated mylar scintillation screens.



## Specifications

**Amplifier:**  $2 \times 10^{10}$  and  $2 \times 10^{11}$  V/coulomb sensitivity, unipolar gaussian pulse out, 2  $\mu$ sec width, pole-zero compensation

**Integral discriminator:** 50 mV to 5 V (10 turn pot)

**HV power supply:** positive 600-1600 V at 0.5 mA, set by front panel 10 turn pot, HV on/off switch and LED indicator on front panel, safety interlock. Maximum output ripple, 50 mV P-P

**Counter:** to 1 MHz, 4-digit for totals counter, 3-digit pairs counters, START/STOP and RESET switches, Gate mode in/out switch on front panel, rear panel BNC connector. Slow pairs detector has 20-400 msec acceptance period for 95 per cent detection efficiency of Th-232. Fast pairs detector has 0-4 msec acceptance period.

**Power:** 115/230 VAC 50-60 Hz, 10W

**Physical:** 3.05" wide standard Daybreak module, 8" high by 4" diameter PMT housing.

# 583 Intelligent Alpha Counter

## Features

- Fast and slow pulse pairs discrimination
- Built-in microcomputer and printer in one compact module
- Post-counting data reduction
- Non-volatile memory holds data from up to 250 counting intervals
- Power failure recovery without data loss
- Built-in calibration period timer
- Display of 8 current data registers
- Selectable count and calibration periods

The 583 combines the proven capabilities of the 582 alpha counter with intelligence and a printer. The cumulative and incremental total events and pulse pair counts are printed at intervals of 1, 2, 4, or 8 ksec and stored in non-volatile memory for later processing. After the count has finished, the data is scanned for possibly noisy data, which is flagged. Average count rates and standard deviations are computed both for raw and adjusted data, and long term trends indicating thoron or radon decay and radon build-up are noted. Power

failures are dealt with gracefully; their occurrence is noted and counting resumes exactly where left off, after a short delay, without any loss of data. Counting is suppressed during periods of low power mains voltage. As an added feature, a calibration timer mode for set up of the discriminator threshold is included. The single 4-digit LED display shows cumulative and incremental total events, fast pairs, slow pairs, and elapsed time as chosen by the DISPLAY ROLL key.

## Specifications

**Amplifier:**  $2 \times 10^{11}$  and  $2 \times 10^{12}$  V/coulomb sensitivity; unipolar gaussian pulse out, 2  $\mu$ sec width, pole-zero compensation

**Integral discriminator:** 50 mV to 5 V (10 turn pot)

**HV power supply:** positive, 600-1600 V at 0.5 mA, set by front panel 10 turn pot, HV control switch and LED indicator on front panel, safety interlock with LED indicator. Maximum output ripple, 50 mV P-P.

**Pulse pair discrimination:** Slow pairs detector has 20-400 msec acceptance period for 95 per cent detection efficiency of Th-232. Fast pairs detector has 0-4 msec acceptance period.

**Counting period:** 1, 2, 4, or 8 ksec, settable on rear panel.

**Calibration period:** 100, 200, 400, 800 sec

**Printer:** 20 column thermal, 1.50 inch wide thermal paper

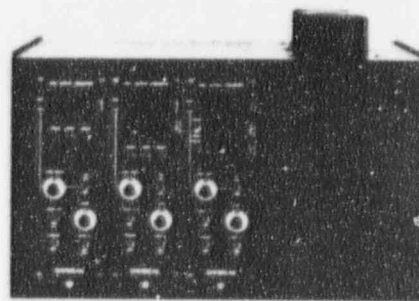
**Keyboard:** COUNT, CALIBRATE, PAUSE, STOP/RESET, HV ENABLE, DISPLAY ROLL, and PAPER ADVANCE

**Display:** 4-digit LED, plus six annunciator LEDs

**Data retention time:** 10 years minimum

**Power:** 115/230 VAC 50-60 Hz, 15W

**Physical:** 3.05" wide standard Daybreak module, 8" high by 4" diameter PMT housing



Model 503 enclosure with three 580-series counters

# 584 Printer/Controller

## Features

- Provides intelligent functions of 583 for 580-series counters
- Controls host alpha counter
- L<sup>1</sup> affected by power failure

The 584 permits upgrading of the 580-series counters to 583-like operation. It is packaged in a form similar to a small printing calculator for convenience. Up to three 584s are powered by a single 585 power supply which also provides power

failure indication. Three printers will fit on top of a 503 enclosure. 580-series counters shipped after the beginning of 1983 come with a connector for the 584; those units shipped prior to that will need a simple modification which may be done by the user.

# 590 Irradiation Timer

## Features

- Controls 700-series electrically-actuated irradiators
- 1-9999 sec exposure times
- Optional 0.1-999.9 min or 1-9999 min ranges
- 1A at 12 VDC output

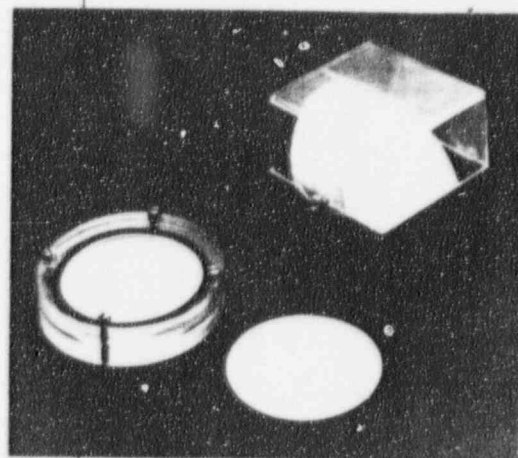
The model 590 timer controls the 700-series sample irradiators, opening shutters for periods settable to 1-9999 seconds. (Various other clock division ratios can be implemented to permit counting by 1 or 10 second, 0.1 or 1 minute intervals. Options other than the standard 1 second increment must be

specified on the order.) A four-digit thumbwheel switch sets the time, and a 4-digit display shows the time elapsed. Exposure may be interrupted without resetting the timer, and then resumed. A front panel switch selects alpha, beta, or gate mode. Output is 12 VDC at 1 A.

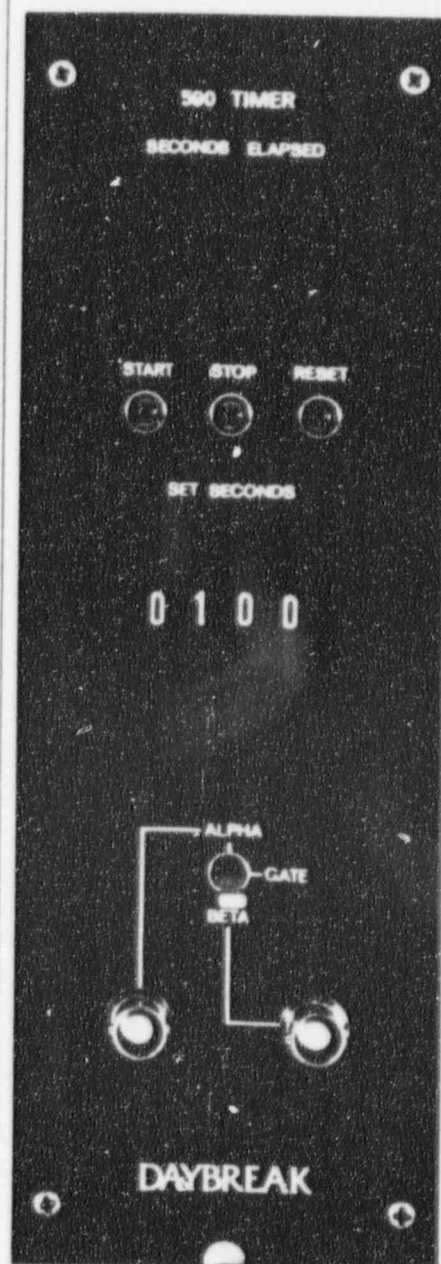
## Specifications

**Power:** 115/230 VAC 50/60 Hz, 15 W

**Physical:** 3.05" wide standard Day-break module.



Alpha counting accessories. Sealed cell and Zn S on mylar scintillation screens.



## Features

- 32-bit photon counter
- TL system status register
- Turns system XY recorder into digital plotter
- Complete computer control of temperature program
- Optional extended control of TL system (valves, HV enable, ramp)
- Installation kits available for connection to other TL readers

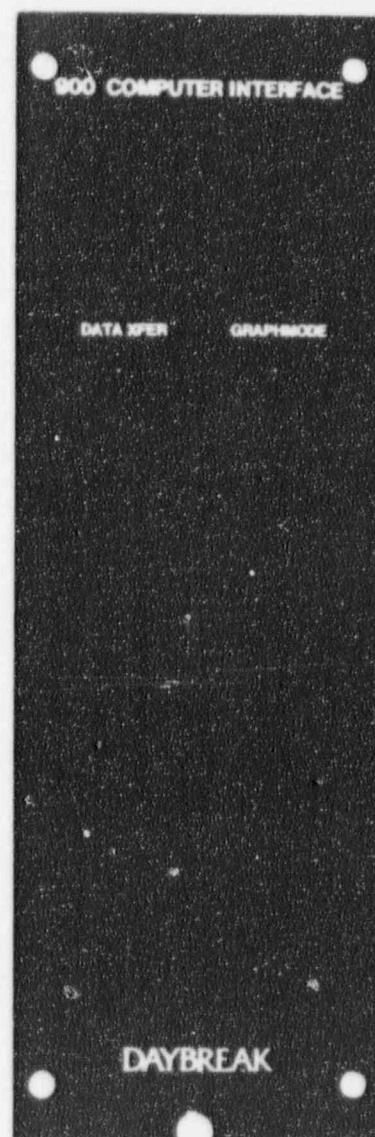
The model 900 interface provides the means of communication between the TL system and the computer, transferring information to the computer for glow-curve recording, and from the computer, via DACs, to the system XY recorder. With optional system control expansion and ramp clock, the interface has total command of the TL system for automated applications. The 900 consists of a 32-bit photon counter, an 8-bit status register, and two 12-bit DACs with data latches, together with the associated control circuitry. The unit is housed in a

standard 3.05" wide Daybreak module and plugs into any free slot in the TL system module bin. The interface may be connected to other photon counting TL readers. Power requirement is 115/230 VAC 50-60 Hz, 15 W.

All control functions are memory-mapped, that is, writing or reading certain memory locations will set or clear the various modes, select data spacing, place data in DAC latches, etc., and together occupy 256 bytes in the computer address space. There are nine basic functions:

ADDRESS*	FUNCTION	
0	<b>Read Status</b>	When this address is read, the status byte (DATA READY, RAMP ON, RAMP CLOCK, FIRST RAMP, PENREADY, and three expansion bits) is placed on the data bus.
16	<b>Read Counter</b>	When DATA READY goes high, the first byte of the photon counter is available for reading. Subsequent reads access the other counter bytes sequentially.
64, 80 96, 112	<b>Write DAC</b>	Data present on the data bus is written into the chosen DAC latch (Xhigh, Xlow, Yhigh, Ylow).
128, 129	<b>Pen Mode</b>	If graphics mode is invoked, 128 causes the XY recorder pen to drop; 129 to lift. Otherwise, the 520 is in control of the pen.
144-159	<b>Move</b>	The X and Y DAC registers increment or decrement in combination to produce pen motion in one of eight directions.
160+N	<b>Set Space</b>	DATA READY goes high every N RAMP CLOCK pulses, where N = 1-15C/data point.
176	<b>Data Mode</b>	XY Recorder connected to TL system signals.
177	<b>Graph Mode</b>	XY recorder is connected to DACs.
224	<b>System Reset</b>	Initializes interface.
240	<b>Ramp Start</b>	Starts the 520 ramp.
182-207	<b>Reserved</b>	For expansion system commands.

\*add to Apple II slot base address \$Cn00 where n = slot #.



the 910 cable/driver card which, for use with Daybreak applications software, plugs into the Apple IIe slot number 4.

The 9900 computer system is compatible with other TL readers besides the Day-

for the 900 interface allows the interface to generate a voltage ramp (0-5 V or 0-10 V) to use in place of that in the original temperature controller. Connection kits for Littlemore TL readers can be provided, others upon receipt of details.

# 910 Apple II Cable/Driver Card

## Features

- Connects 900 interface to Apple II computer
- Shielded ribbon cable for low EMI

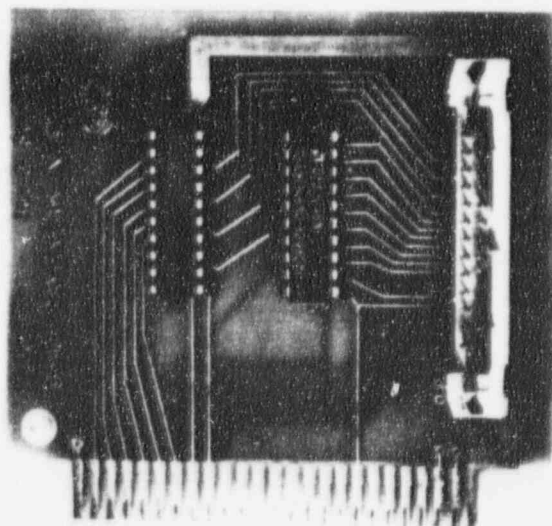
The 910 driver card plugs into one of the Apple II I/O slots (usually #4) and includes address drivers and bidirectional data bus drivers to ensure valid data transmission to and from the 900 inter-

face. A single 26-conductor shielded ribbon cable provided with the 910 connects the computer with the TL reader apparatus.

## Specifications

**Length of cable:** 6 feet.

**Power:** +5 V derived from Apple II slot.



## Features

- Advanced, low power design for fast cooling
- Low volume for fast evacuation
- Two-stage vacuum valve and purge gas surge suppression prevent sample movement
- 500C operation

The 700 glow oven is of an advanced design, constructed from a substantial aluminum block for high thermal inertia, thus reducing cooling requirements. Water cooling channels are provided, but are generally not needed unless the oven is in constant use for several hours. The low power consumption of the heating plate, typically 60W for 20C/sec runs to 500C, further contributes to fast cooling. The small internal volume, 2 cubic inches, of the oven makes evacuation fast as well.

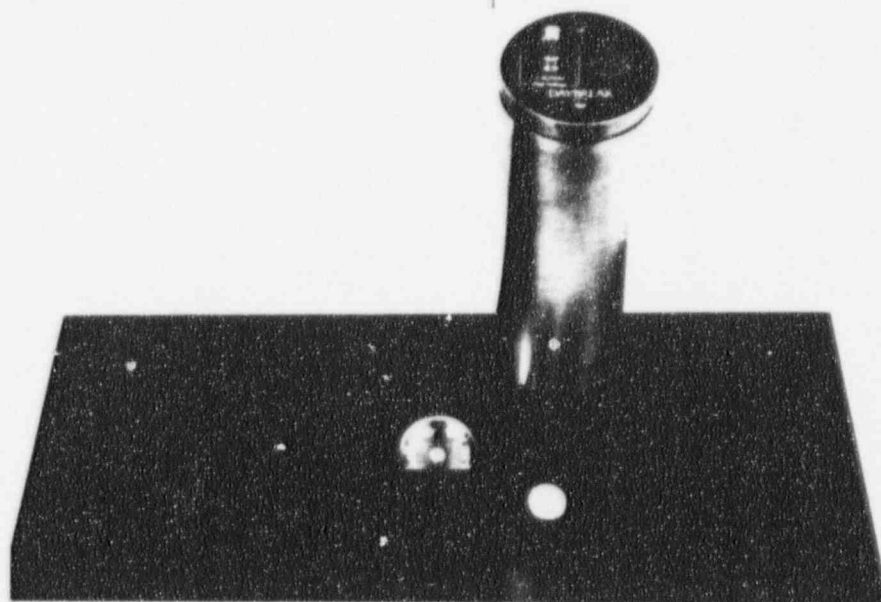
The glow oven is mounted on a plate measuring 8" by 20" along with the heating plate transformer, vacuum and purge gas solenoid valves, purge gas pressure relief valve, and vacuum gauge tube. It is intended for mounting in a bench or desk cut out, but the mere 3.5" depth under the mounting plate permits above bench mounting if necessary.

A fine-gauge chromel-alumel thermocouple is welded to the center of the 1.0" wide, 1.25" long heating plate.

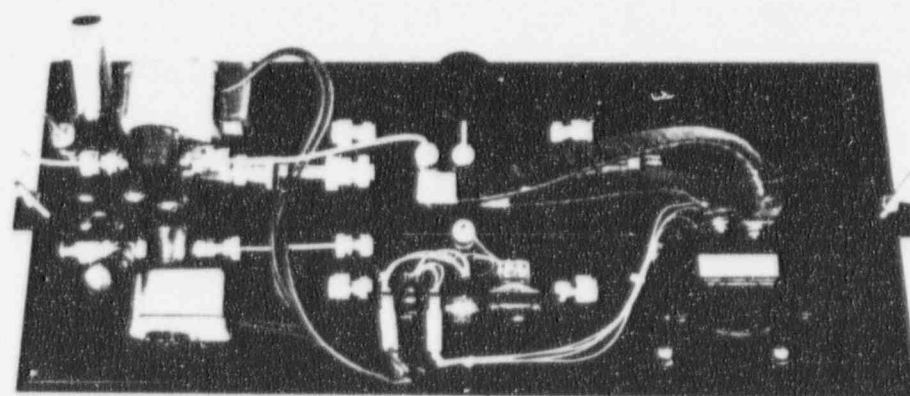
Sample to photocathode distance is approximately 0.5" for high light collection efficiency, yet the low heating power and purge gas movement across the heating plate prevent photocathode heating.

In order to avoid sample movement when evacuating or purging, the evacuation is done in two stages: first a bleeder valve opens to bring oven pressure down to a few mmHg, then after a delay of 0-10 seconds the main vacuum valve opens to speed evacuation; secondly a needle valve on the purge valve prevents surging from gas pressure built up in the supply line.

Total power consumption is 120 W maximum, 115-230 VAC. Solenoids are delivered either with 115 or 230 VAC coils and supply voltage must be specified on the order.



700 Glow Oven with 720 PMT Housing



700 Glow Oven underside

# Temperature Glow Oven/PMT Housing

## Features

- Similar to 700-720, but usable to 800C
- Spectrosil window for PMT protection

The 701 glow oven is similar to the 700 but is designed for use up to 800C. The heating plate is lengthened to 1.60" and the mass of the oven block is increased to maintain a fast cooling rate. The filter pack

holder of the 721 housing has a spectrosil window, reflective light guide, and heat dissipation fins to prevent photocathode heating during extended periods of high temperature operation.

## 720 PMT/Housing

## Features

- Integral amp. disc for single photon counting
- EMI 9635QA standard
- Easy optional filter exchange

The 720 PMT housing is of a conventional design with electrostatic shielding. The filter pack, of single or multiple optical glass filters, is easily changed without housing disassembly. The 530 amp. disc is mounted within the housing as a standard feature.

The 720 is supplied with an EMI 9635QA PMT selected for low dark count and with one filter pack made up of Corning 7-59 and 4-69 filters 2.400" diameter. Others are available on request. One of possible interest to those who expect moderately high light levels is the

Corning 5-58, which together with the 4-69 affords exceptional red rejection, at the penalty of only a 30 per cent peak transmission. Another filter, useful for sediments where feldspars appear to be both more linear and more bleachable than quartz, is the Schott UG-11, used in conjunction with a red-rejecting filter.

Dimensions are 3" diameter, 9" high. There is an SHV for HV input (negative), and an Amphenol 5-pin series-126 male connector for amp. disc power and signal lines. Filter packs up to 9mm thick are accommodated.

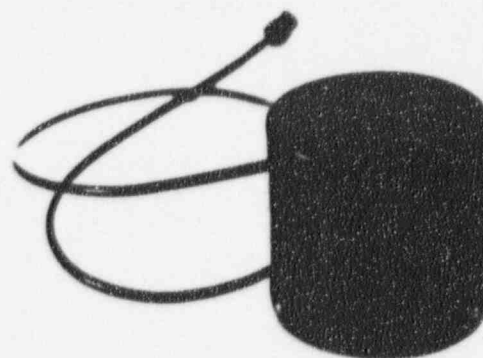
## Features

- On-plate beta irradiation
- Electrically-actuated failsafe shutter
- Lightweight but effective shielding

The model 740 beta irradiator is a shielded enclosure for a beta sealed source with an electrically-operated shutter. Daybreak supplies two strontium sources with different activities, but a customer-supplied source can be accommodated if drawings are submitted with the order. The shutter is a composite for low bremsstrahlung production and is spring loaded for failsafe return. This device and the other 700-series irradiators described below are intended to be controlled by the model 590

timer. The 740 mounts on the glow oven for on-plate irradiations at a 0.75" source-to-sample distance. The beta dose rate is approximately 6 rads/sec for a 125 mCi Sr-90 source. It is recommended that the 740 be stored on a lead brick to stop radiation escaping through the shutter (about 300 mR/hr measured at the outer

surface of the shutter) and behind another to shield against lateral radiation (less than 6 mR/hr at the case surface). This lateral shield is primarily to prevent increased dark count in the TL reader PMT from fluorescence of optical glass filters. The shutter is designed not to open under any orientation when not energized.



## Specifications

**Power:** 12 VDC, 450 mA, coaxial cable with BNC termination

**Shield cavity:** 0.410" diameter, 0.250" deep, others on request

**Irradiation aperture:** 0.50"

**SSD:** 0.75" from active surface to heating plate

**Physical:** 4.00" diameter, 3.75" high, weight 5 lbs

# 750 Alpha Irradiator

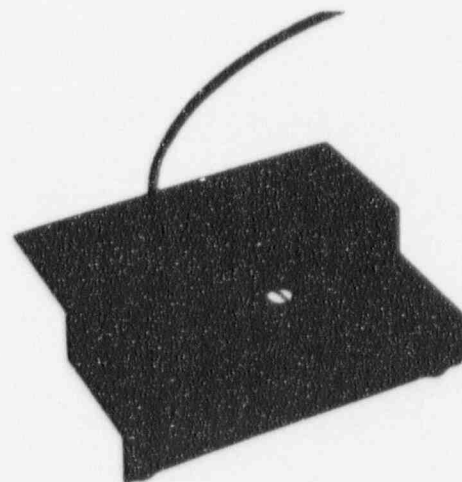
## Features

- Close geometry for fast irradiations
- Electrically-actuated failsafe return shutter

The model 750 alpha irradiator is a shielded enclosure for a sealed foil alpha source. Daybreak supplies a 0.5 mCi Cm-244 source for this device, but customers' own sources may be accommodated if a drawing is submitted with the

order. The source is mounted on a solenoid-actuated arm that, when energized, brings the source out of the housing into position over the sample well. Source-to-sample distance is approximately 0.040". The active surface of the source

cannot be accessed without disassembly of the enclosure. Dose rate is approximately 100 rads/sec for a 0.5 mCi Cm-244 source with 0.48" active diameter.



## Specifications

**Power:** 12 VDC at 350 mA, coaxial cable with BNC termination

**Source dimensions:** 0.875" diameter max, 0.25" high max

**Sample well:** 0.400" diameter, 0.030" deep

**SSD:** less than 0.050"

**Physical:** 4" wide, 1.75" high, 3" deep

# 760 Vacuum Alpha Irradiator

## Features

- Irradiation in vacuum for higher precision
- Uses glow oven vacuum

The model 760 alpha irradiator is similar to the 750, but follows the recommendations of Singhvi and Aitken (ANCIENT TL No. 3, Spring 1978) in performing irradiations

## Specifications

**Power:** 12 VDC at 350 mA.

**Physical:** 4" diameter, 2.3" high

under vacuum at a source-to-sample distance of 1 cm. Vacuum is obtained by mounting this irradiator on the glow oven and using its valves.

# 765 Vacuum On-Plate Alpha Irradiator

## Features

- As 760, but source positioned over heating plate
- Sample need not be moved

The 765 irradiator is essentially the same as the 760, but allows the irradiation to be done with the sample on the heating plate. This device is intended primarily for pre-dose dating of inclusion samples

where the grains cannot be conveniently moved between irradiation and readout. The source-to-sample distance is fixed at 0.400"

# Radioisotope Sources

Daybreak has designed a number of sealed radioisotope sources to be used with the 700-series of irradiators, which are manufactured for us by Isotope Products Laboratories, Burbank, CA. These include strontium-90 sources of two activities, and a curium-244 alpha source.

## SR-90 Strontium Source

**Nominal activity:** 125 mCi in equilibrium with Y-90

**Overall dimensions:** 0.405" diameter x 0.250" thick

**Active diameter:** 0.35"

**Method of calibration:** Beta output measured with thin window ion chamber whose efficiency has been determined using a secondary NBS Sr-90 standard

## SR-90-2 Strontium Source

Specifications identical to SR-90 except 2 mCi activity for pre-dose calibrations.

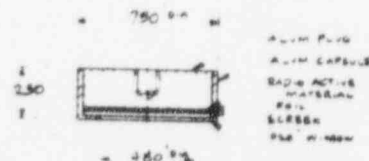
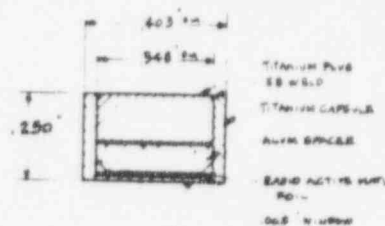
## CM-244 Curium Source

**Nominal activity:** 0.5 mCi

**Overall dimensions:** 0.75" diameter x 0.25" thick

**Active diameter:** 0.48"

**Method of calibration:** measurement of L x-ray output by scintillator



# 801 Multiple Sample Irradiator

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## Features

- Best choice for long exposure times
- Up to 20 samples automatically irradiated
- Choice of alpha or beta irradiation for each sample
- 1-9999 sec exposure time for each sample
- Interactive data entry
- Irradiation program printed out
- Printout of irradiations as performed
- Failsafe shutters with continuous monitoring

The Daybreak model 801 multiple sample irradiator is a time saving accessory for the TL dating laboratory where many samples may require long irradiation times. While this irradiation has customarily been done with the sample on the glow oven heating plate, the time lost from useful work is often excessive when TL dating is routinely done.

The model 801 exposes up to 20 samples sequentially for periods each settable to be 0-9999 seconds, and the choice of beta or alpha exposure settable for each. Operation after data entry and sample loading is completely automatic. The system is controlled by a micro-processor, and includes a 20-character alphanumeric display for operator prompts and system status (sample number, set time, and elapsed time) and a thermal line printer for data logging. Data entry is simple and interactive, and the printer makes a record of the exposure program for double-checking. As each sample is exposed, its actual irradiation time is logged. During exposures, irradiator status is continuously monitored and any anomaly causes the shutter to close and a warning message to be displayed.

The irradiator may also be used for a single sample and external electrically-shuttered exposure devices, such as the Daybreak 700-series of irradiators, may be accommodated as well.

The beta irradiator of the 801 is similar to the 740, with the addition of a minimum of 1 cm of lead shielding around and below the irradiated area. The composite shutter is spring loaded for failsafe return. The alpha irradiator is similar to the 750. The exposure rate at the front panel with a 125

mCi Sr-90 source loaded is less than 0.5 mR/hr and less than 1 mR/hr at any point on the case surface other than the bottom directly beneath the beta source, where the exposure rate rises to 2 mR/hr with the shutter open.

Because of licensing and transportation restrictions, the 801 cannot be shipped with sources installed. This instrument has been designed for ease of source loading, so that it can be done by

the customer in five minutes' time. If the customers' own sources are to be used, we must have accurate drawings furnished with the order so that the shields can be properly sized.

The size of sample accommodated is determined by inserts which are secured to the revolving sample carrier disk. One size is supplied with the 801, nominally 1 cm diameter, and others may be made to order. Sizes may be intermixed on the



carrier disk. A maximum diameter of 100 mm is recommended because of source fall-off beyond that diameter.

## Specifications

**Number of samples accommodated:** 20

**Exposure time:** 0-9999 seconds

**Exposure rate:** depends on source and source to sample distance. With Daybreak SR-90 and a 12.5 mm SSD, the rate to quartz is approximately 8 rads/sec. The alpha dose rate with the CM-244 is about 100 rads/sec.

**Front panel:** 20 character alphanumeric display. Keyboard: numbers 0-9, LOAD, ENTER, EXIT, CLEAR ENTRY,  $\leftarrow \rightarrow$ , RUN, STOP, ALPHA/BETA. Switches: SINGLE/MULTIPLE, INTERNAL/EXTERNAL. Indicators: SAFE, RADIATION for alpha and beta irradiators. Key-operated switch for power on/off.

**Printer:** 20 char/line thermal printer

**Physical:** 8" high, 15" wide, 17" deep, weight 34 lb.

**Power:** 115/230 VAC 50/60 Hz, 70 W maximum.

# 9900 Data Acquisition and Reduction System

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## Software Features

- Complete turn-key computer system for archaeological and geological dating
- Menu-driven (single keystroke) hierarchical organization provides flexible, user-friendly operating environment
- Complete UCSD p-system running in 128K memory
- Segmented (memory overlay) architecture for maximum efficiency of memory use
- All software on line all the time; no reloading of data or program to redo an operation
- Open-ended to support new analysis techniques as they arise
- Software organized as set of fully-documented library units with full complement of utilities for ease of customization
- Example source code for user-written programs provided plus computational portions of application software
- Handles up to 80 glow curves in one file
- Many modes of numerical filtering, temperature shifting, and normalization included
- Hard copy graphics output on printer in two resolutions, and on XY recorder
- Plateau and fade tests allow averaging of multiple curves and computation and display of errors
- Flexible growth curve analysis for conventional equivalent dose and intercept computation and the currently most useful optical bleach techniques of sediment dating with error analysis
- Complete age computation with rigorous error analysis
- System configuration file holds system and source parameters to minimize set-up time
- Free update service for two years

**T**he Daybreak 9900 computer system integrates with the Daybreak TL system to record glowcurves on floppy disk media, to reduce these to equivalent dose, intercept and alpha efficiency measurements, and finally to TL dates with full error analysis. Raw or background-subtracted data as well as graphs of computational results may be plotted either on the system XY recorder or printer. All TL applications software is in the form of fully-documented system library units for the use of those users who need to write special code for their particular applications. The current software version is implemented on a new 128K version of the UCSD p-system. As a bonus, the 9900 may be used as a general purpose scientific or office system computer, with over 10,000 programs available.

## Hardware

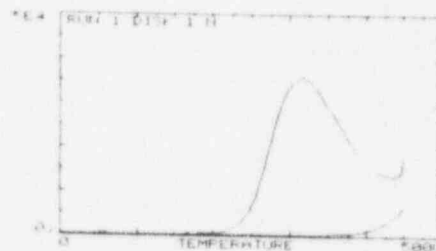
The computer is based on the widely-used Apple IIe microcomputer running the UCSD p-system in 128K memory. There are two 5.25" floppy disk drives and a high resolution 12" video monitor. The standard printer is an Epson FX-80, a fast 80-column dot matrix printer with graphics capability. Software is included for both

280 x 192 pixel screen dumps and higher resolution 560 x 386 plots, together with plotting on the system XY recorder. The 900 interface with 910 cable/driver card is also included.

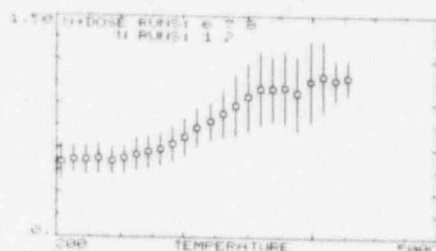
## Software

The applications software has been written in UCSD Pascal, a fast, block structured compiled language which has become the standard for serious programming of small computers. The current version (1.2) implements a 128K memory space, which together with sophisticated memory overlay techniques permits development of extremely large and versatile programs. FORTRAN is available as an option, and Pascal and FORTRAN code may be mixed in this implementation.

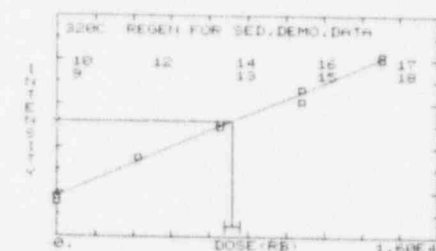
The Daybreak 9900 software package integrates a number of highly interactive procedures for data taking, for dose and data computations, and being organized as system library units with only a short skeleton calling program, makes writing of user special code extremely convenient. The package is written to be immediately usable by someone with experience with TL but no special knowledge or experience with computers.



Printout of glowcurve raw data



Plateau with errors



Regeneration growth curve and ED determination

The software is menu-driven and extensive prompts make it almost self explanatory.

The major program TLAPPLIC takes glowcurve data and records it on disk, afterwards processing it to obtain plateau information, growth curves, equivalent dose, and alpha efficiency, while providing hard copy plots as desired. Data is taken at 5C intervals, in the form of 100-point arrays (0-500C), or for those with high temperature ovens, 140 point arrays (0-700C). A second program, TLDATE, computes the TL age and errors according to Aitken (ARCHAEOLOGY 18 (2), 233 (1976)) with all corrections to date (Aitken, private communication).

TLAPPLIC has two major functions. The first is data taking. Very little beyond the usual setup time for a glowcurve is required to enter runtime information. Data for sample ID, irradiation source information, and general running parameters are entered menu-fashion, mostly with single keystrokes, on opening a new data file (and many of these are on the system configuration file, updated only as required). As a new file is opened, there is a check made to make certain that sufficient space exists on the disk. For

each glowcurve, a run type (N, N+B, etc.), irradiation time and optical bleach parameters if applicable, and optional remark are entered before starting the ramp. A useful optional feature is automatic entry of the background glowcurve without operator intervention. After each glowcurve is recorded, it may be rescaled and plotted on the printer. Finally, on closing the file, disk space for the background subtracted data generated later, and used for subsequent computation, is reserved.

The second, and much more complex, function of TLAPPLIC is data reduction. Up to 80 glowcurves (of which one at least must be a background curve) are supported. After specifying an input file, it is read in and a directory of curves within the file is generated and printed, and may be displayed at several points in the program for reference. In most cases, this is displayed on the right half of the screen, while the current calculation input/output is shown on the left. The operator may then look over the raw data, numerically filter, shift, and plot as desired. Background subtraction is then performed, with filtering and with manual or automatic correction for any temperature shifts that can occur at high ramp rates due to variable thermal contact of the sample with the heating plate. Because of this possibility, it is recommended that a background glowcurve be recorded with each TL curve; the automatic background recording, together with the fast cooling Daybreak glow oven facilitate this. The subtracted glowcurves are then written into their own disk file for further reduction, and may be weight normalized, inspected, and plotted. Further shifting, by lining up curves against one chosen as a 'master', may be done semi-automatically and interactively. The

plateau and integration procedures operate on this data. The plateau is computed in the usual fashion with up to five each of N and N+B dose curves averaged together and displayed and plotted with error bars. Similarly, a fade test can be made. Finally, the growth curve analysis with linear or polynomial fit is made to obtain equivalent dose and alpha efficiency. Here, a menu of the various techniques implemented (standard TL plus the three presently used sediment techniques — R-Beta (or gamma), regeneration, and total bleach (N+B dose - bleached N)) is displayed. After a choice is made, and further choices as to optical bleach parameters if applicable, the categories of growth curves required are set up and then computed interactively to discard bad data, or automatically over a temperature range. During the interactive process, it is possible to back up and redo portions of the calculation, delete or replace points, and plot at will. The end results, equivalent dose, intercept, and alpha efficiency, are plotted against temperature.

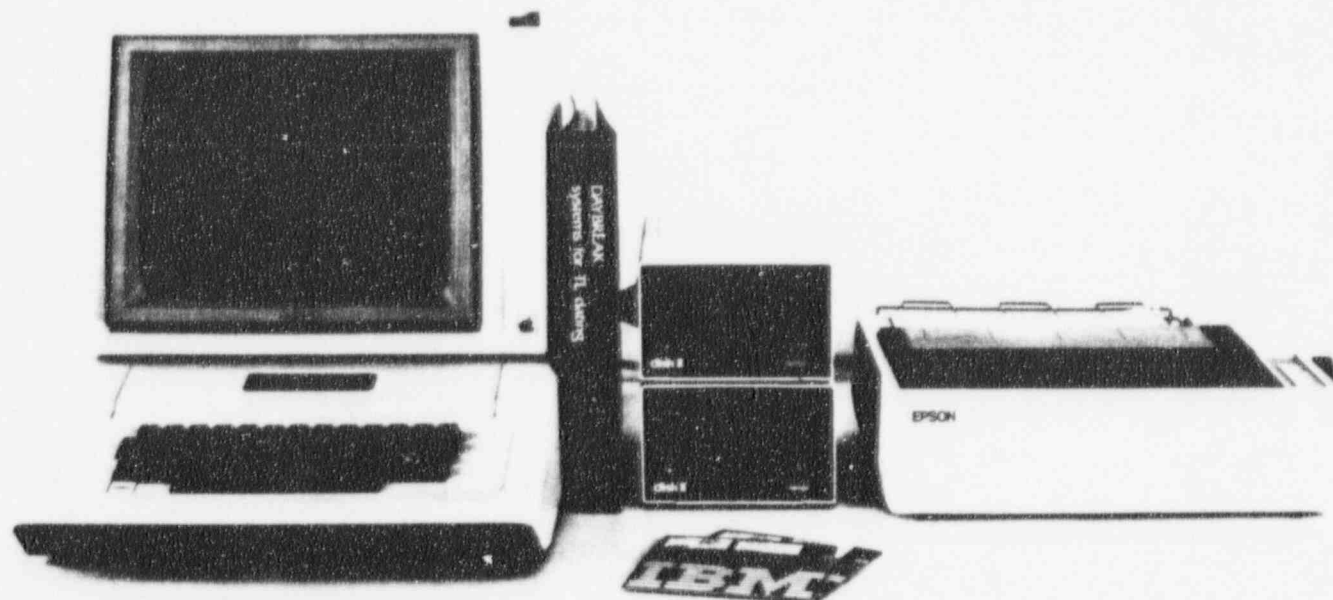
**A** great advantage of the open-ended approach embodied in the Daybreak software is the ease with which new computations can be accommodated. For the active research scientist, a 'canned' program is never enough and certainly we cannot anticipate everyone's special needs, although we have made a great effort to do so. For this reason, we have made it very convenient to add functions or computations by configuring the software as a set of fully-documented library units with a wide range of utilities for file and screen management, graphics, and interface control. Thus, the user has but to embed his own special code using the utilities and predefined data structures in

the library in one of the skeleton calling programs provided. The growth curve procedure is provided with general purpose and flexible sort and fit routines and a model given for adaptation. Up to about 40 user procedure segments can be accommodated, the major limitation being disk space to hold the program code! Of course, you can add more disk drives (user libraries no longer need be on the system boot disk).

The final result, TL age, is then computed. TLDATE follows the method of Aitken very closely, and the program text file is included for alteration as required by the user's specific needs. All data entered, partial doserates, and very detailed error analysis are printed in concise and readable form.

The time required by an experienced operator to go through the data reduction of a routine 50 curve traditional TL file is under 15 minutes, plus plotting time, and an age computation using TLDATE should be less than five minutes' work. For sediment dating, time is difficult to judge, as there are so many options, but the hierarchical structure, with the ability to retrace one's steps at will, makes for efficient and convenient operation.

Except for TLDATE and example user programs, software is provided in binary form only under the terms of the licensing agreement (copy available on request). Special programming and customer assistance are available, and updates are provided free of charge (beyond air express shipping cost) for two years after installation.



But about a little after sunset, whilst the twilight yet lasted, nay, this morning a pretty while after sun rising (but before I had been abroad in the more freely enlightened air of the chamber) I could upon a light attrition easily perceive the stone to shine.

For holding betwixt my fingers a steel bodkin, near the lower part of it, I pressed the point hard against the surface of the diamond, and much more if I struck the point against it, the coruscation would be very sudden, and very vivid, though very vanishing too, and this way, which commonly surprized and pleased the spectators, seemed far more proper than the other, to shew, that pressure alone, if forcible enough, though it were so sudden and short, that it could not well be supposed to give the stone any thing near a sensible degree of warmth, as might be suspected of rubbing, yet it is sufficient to generate a very vivid light.

I also brought it to some kind of glimmering light, by taking it into bed with me, and holding it a good while upon a warm part of my naked body."

SIR ROBERT BOYLE, in *Observations made this 27th of October, 1663, about Mr. Clayton's Diamond*.

May: 'Oh, Have the crystals faults like us?'

Old lecturer: 'Certainly, May. Their best virtues are shown in fighting their faults. And some have a great many faults; and some are very naughty crystals indeed.' "

JOHN RUSKIN, *The Ethics of the Dust, Ten Lectures to Little Housewives on the Elements of Crystallisation*, 1866.