DAYBREAK

Systems for TL Research

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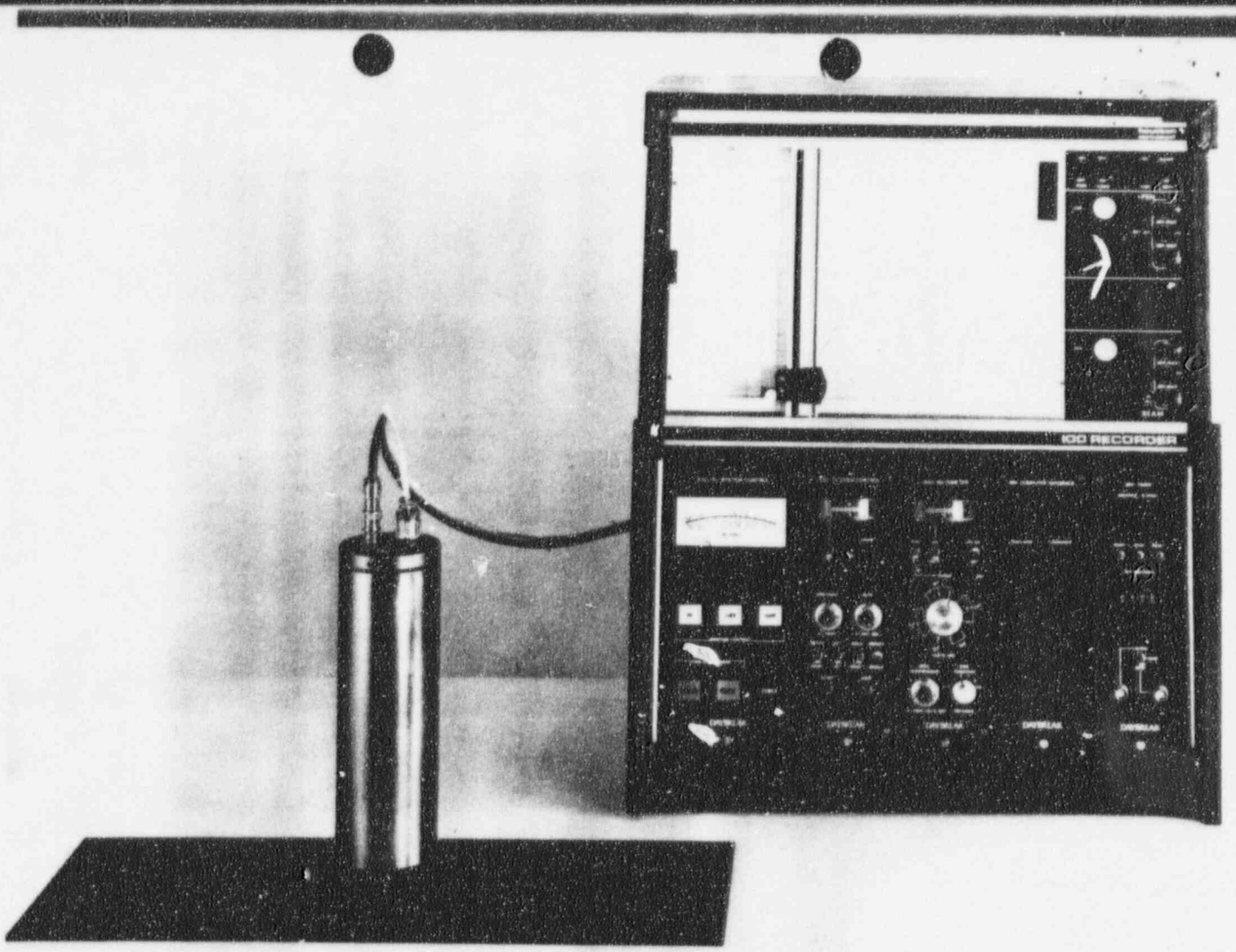


Daybreak thermoluminescence reader system

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

The 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 counter, 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 0-25C/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.

We 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

glow oven heating plate at a fixed 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 determine the U-Th ratio. From all three counters — 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 250 counting intervals in non-volatile memory. At the end of counting, 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 occurence 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.

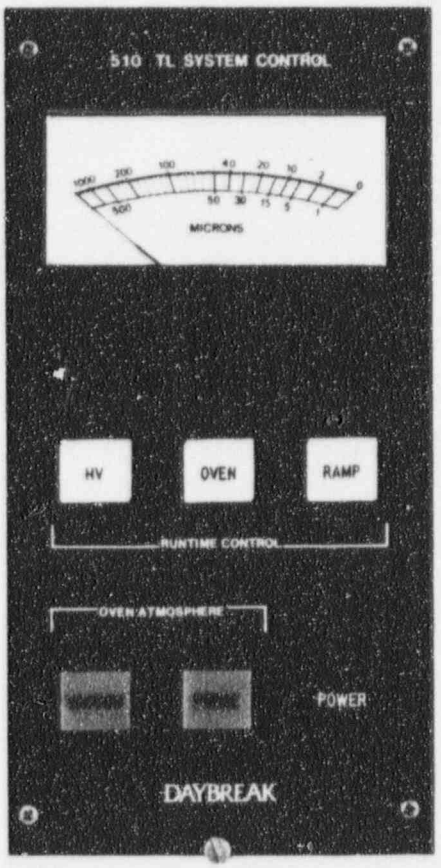
You will also need radioisotope sources and irradiators for calibration exposures, but their choice will depend on your application.

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.

510 System Controller

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 afte. 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

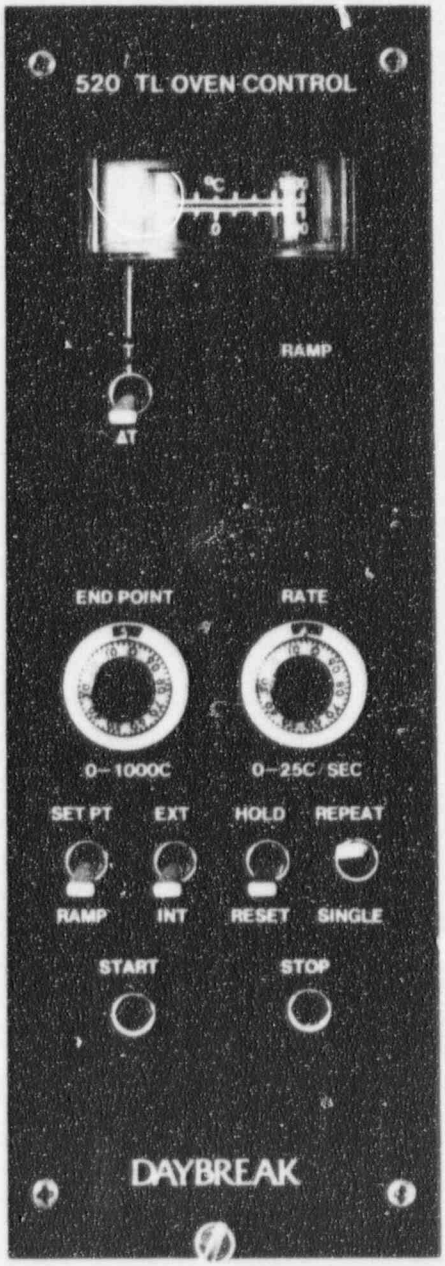
Power: 115/230 VAC 50-60 Hz, 10W, plus glow oven power

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.

SINGLE/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 ± 10C error, selector switch on front panel.

TC connector: Omega Engineering type SMP-K

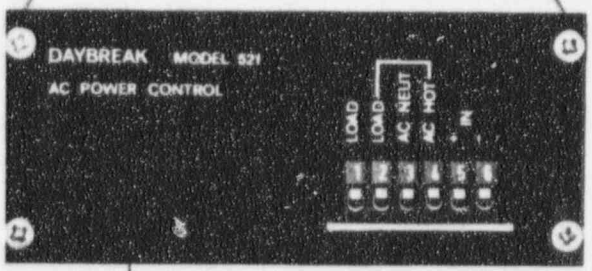
Power: 115/230 VAC 50-60 Hz, 6 W.

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

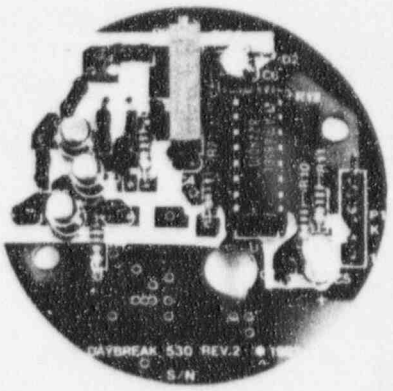
Physical: 2" x 4.5" x 3.5"

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

530
Amplifier/Discriminator

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.

540 Ratemeter

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,

TRUE RATE = OBSERVED RATE / (1 - 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 10^6 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 2×10^7 counts/sec (usable with the standard 9635 PMT only up to about 10^7 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 2×10^6 counts/sec full scale, plus divide by 10 (front panel switch) for 5×10^1 to 2×10^7 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.

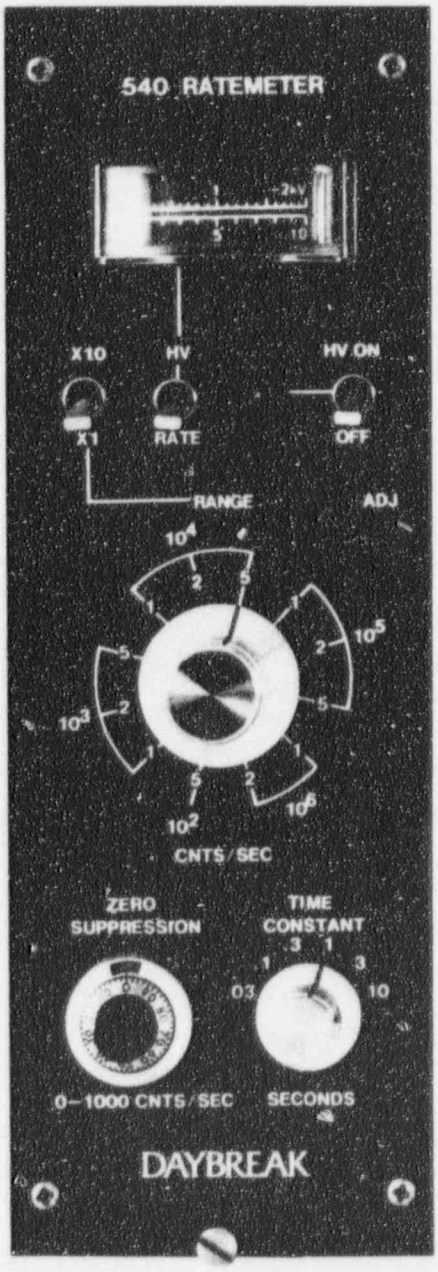
Meter: displays 0-100 per cent full scale and 0-2000 V, selectable by front panel switch.

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.

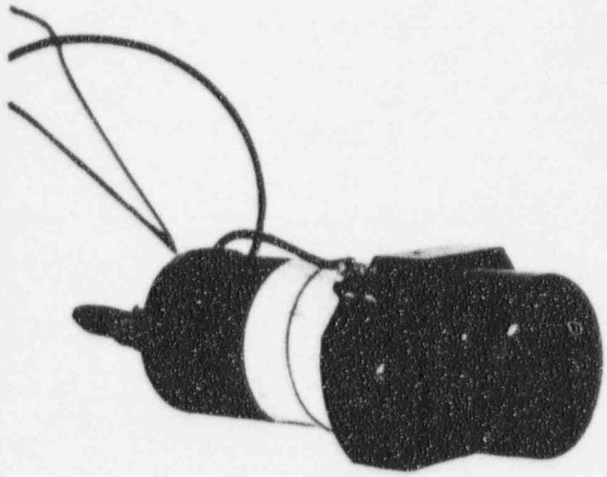
Physical: 3.05" wide standard Daybreak module.



582 Alpha Counter

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: 2×10^{10} and 2×10^{11} V/coulomb sensitivity, unipolar gaussian pulse out, 2 μsec width, pole-zero compensation.

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

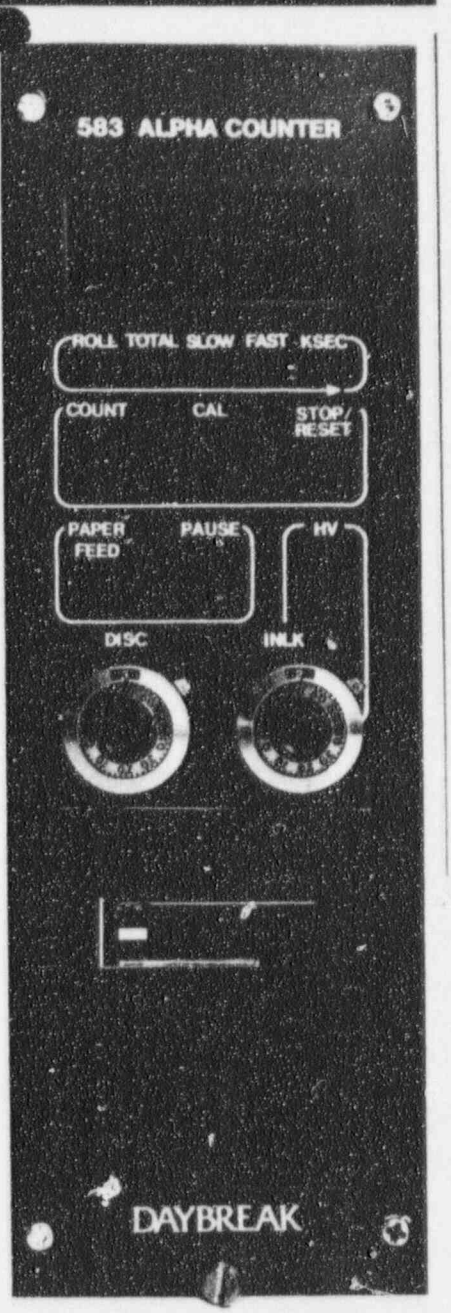
HV power supply: positive, 600-1600 V at 0.5 mA, set by front panel 10 turn pot, HV on/off switch and LED indicator on front panel, safety interlock. Maximum output ripple, 50 mV P-P.

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 occurence 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: 2×10^{10} and 2×10^{11} V/coulomb sensitivity, unipolar gaussian pulse out, 2μsec 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.

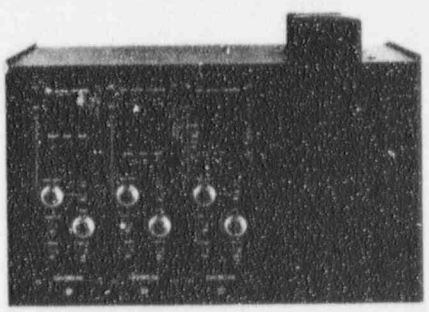
Keyboard: COUNT, CALIBRATE, PAUSE, STOP/RESET, HV ENABLE, DISPLAY ROLL, and PAPER ADVANCE.

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

Data retention time: 10 years minimum.

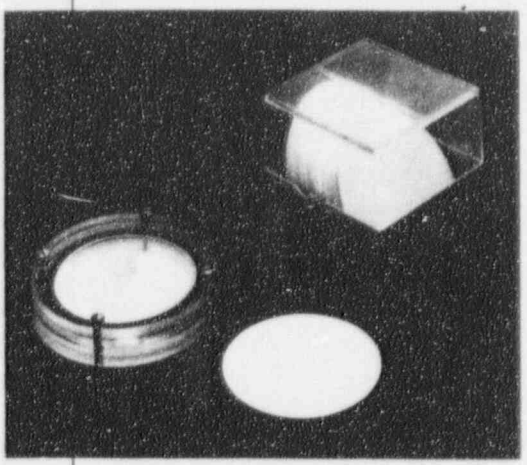
Power: 115/230 VAC 50-60 Hz, 15W.

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



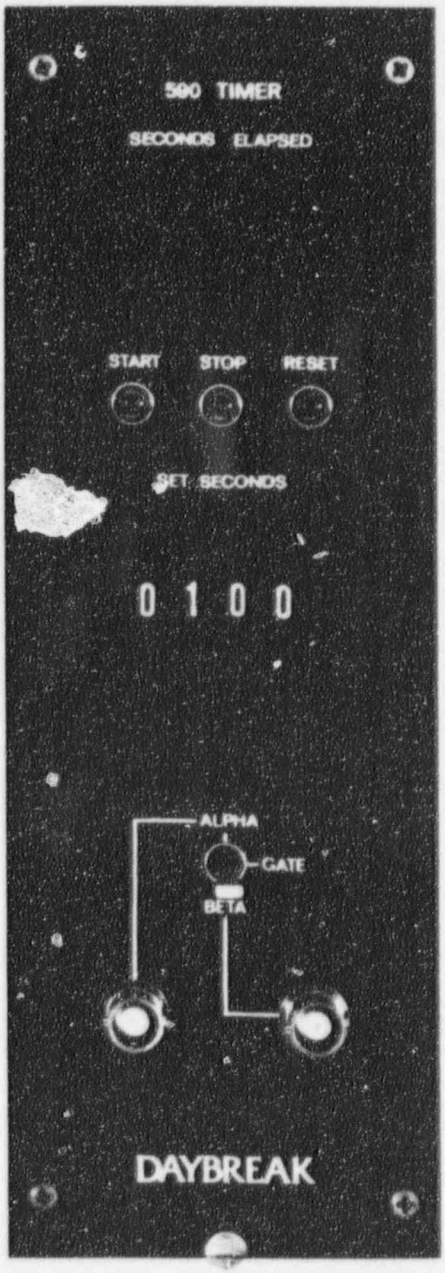
Alpha counting accessories. Sealed cell and Zn S on mylar scintillation screens.

Features

- Provides intelligent functions of 583 for 580-series counters
- Controls host alpha counter
- Unaffected 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 1913 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 Daybreak module

900 Computer Interface

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	**Read Status**	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	**Read Counter**	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	**Write DAC**	Data present on the data bus is written into the chosen DAC latch (Xhigh, Xlow, Yhigh, Ylow).
128, 129	**Pen Mode**	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	**Move**	The X and Y DAC registers increment or decrement in combination to produce pen motion in one of eight directions.
160+N	**Set Space**	DATA READY goes high every N RAMP CLOCK pulses, where N = 1-15C/data point.
176	**Data Mode**	XY Recorder connected to TL system signals.
177	**Graph Mode**	XY recorder is connected to DACs.
224	**System Reset**	Initializes interface.
240	**Ramp Start**	Starts the 520 ramp.
182-207	**Reserved**	For expansion system commands.

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

The interface function is complete in 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 Daybreak TL system. The ramp clock option 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

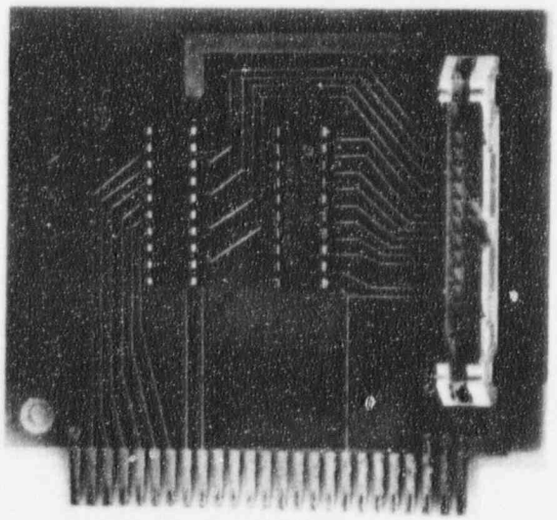
- Connects 900 interface to Apple II computer
- Shielded ribbon cable for low EMI

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 interface. 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.



700 TL Glow Oven

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.

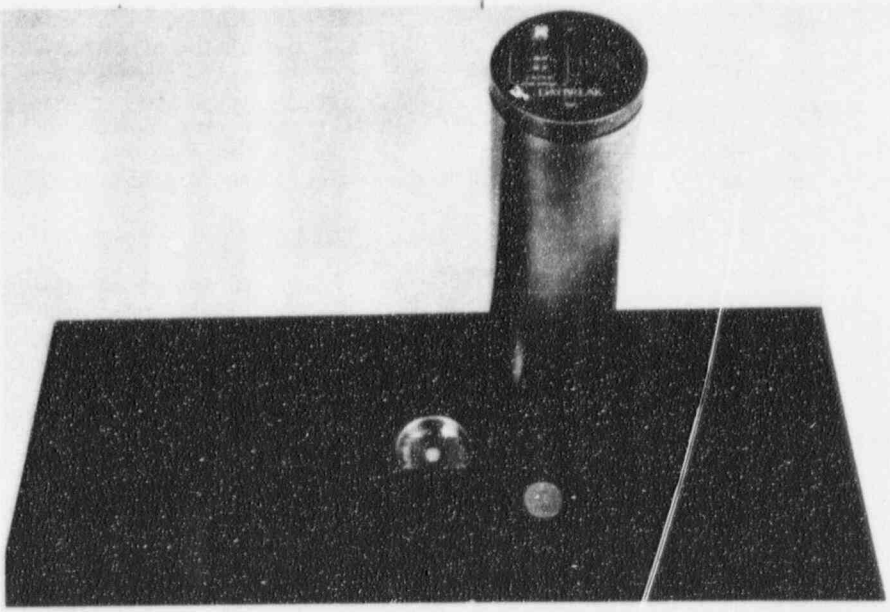
The glow oven is mounted on a plate measuring 8" by 20" along with the heating plate transformer, vacuum and purge gas solenoid valves, purge gas pressure relief valve, and vacuum gauge tube. It is intended for mounting in a bench or desk cut out, but the mere 3.5" depth under the mounting plate permits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

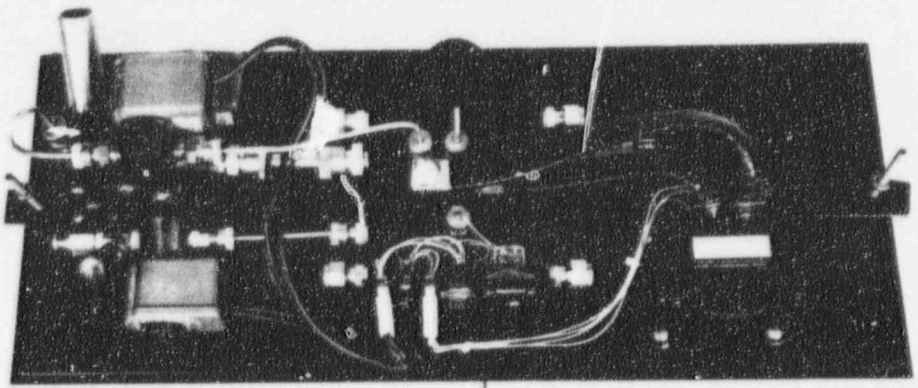
Sample to photocathode distance is approximately 0.5" for high light collection efficiency, yet the low heating power and purge gas movement across the heating plate prevent photocathode heating.

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

701/721 High 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

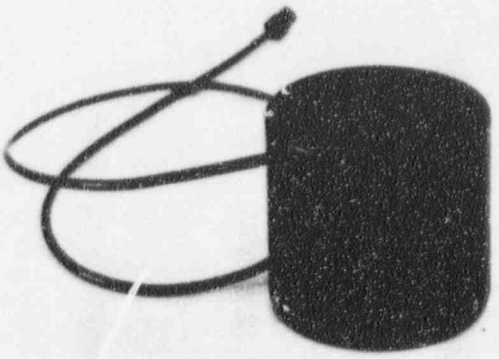
- Integral amp/disc for single photon counting
- EMI 9635QA standard
- Easy optional filter exchange

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.

740 Beta Irradiator



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 bremsstrahlen 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 doserate 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

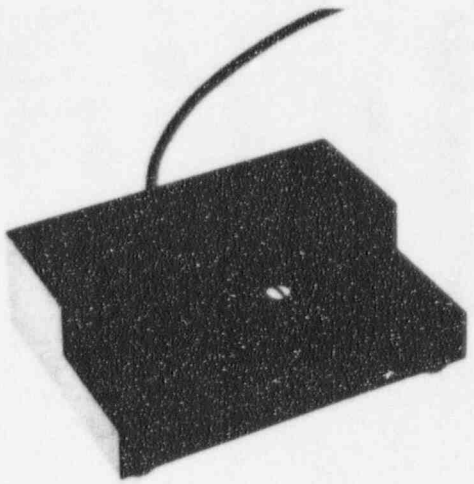
Shielded cavity: 0.410" diameter, 0.250" deep, others on request.

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. Doserate 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

Specifications

Power: 12 VDC at 350 mA

Physical: 4" diameter, 2.3" high.

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 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.

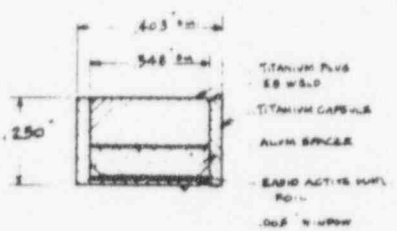
SR-90 Strontium Source

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 for pre-dose calibrations.

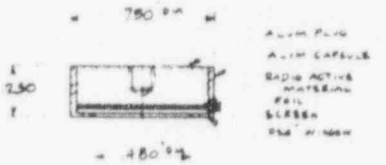
CM-244 Curium Source

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

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 microprocessor, 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 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 doserate with the CM-244 is about 100 rads/sec.

Front panel: 20 character alphanumeric display. Keyboard: numbers 0-9, LOAD, ENTER, EXIT, CLEAR ENTRY, ← →, 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

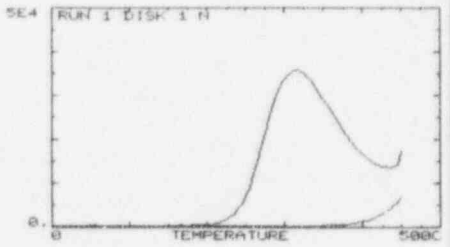
Physical: 8" high, 15" wide, 17" deep, weight 34 lb.

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

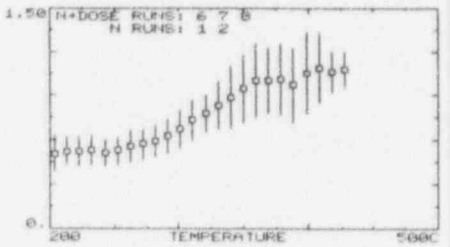
9900 Data Acquisition and Reduction System

Software Features

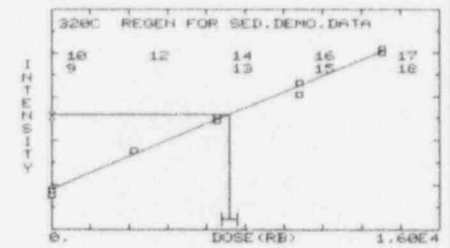
- Complete turn-key computer system for archaeological and geological dating
- Menu-driven (single keystroke) hierarchical organization provides flexible, 'user-friendly' operating environment
- Complete USCD p-system running in 128K memory
- Segmented (memory overlay) architecture for maximum efficiency 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



Printout of glowcurve raw data



Plateau with errors



Regeneration growth curve and ED determination

The 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. 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 (ARCHAEOMETRY **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[illegible], 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.

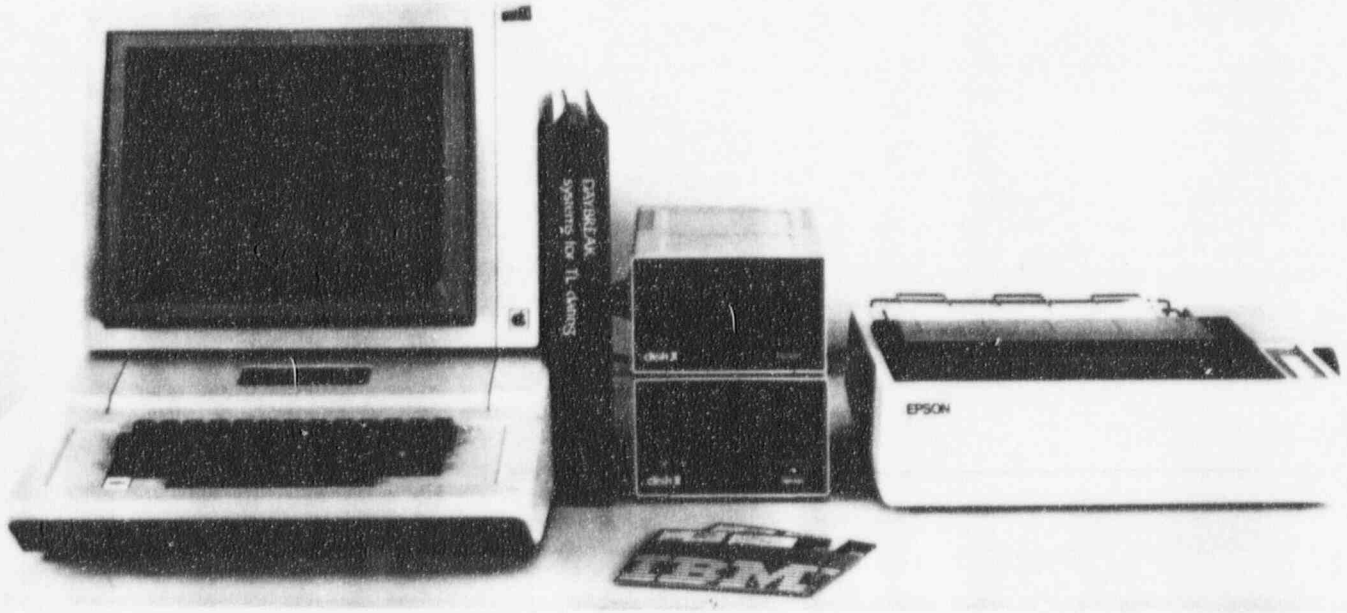
The second, and much more complex, function of TLAPPLIC is data reduction. Up to 80 glowcurves (of which one at least must be a background curve) are supported. After specifying an input file, it is read in and a directory of curves within the file is generated and printed, and may be displayed at several 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+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 + 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.



9900 Computer System

"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 affriction 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.

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.
50 Denison Drive
Guilford, Connecticut 06437 USA
(203) 453-3299

enclosure from 1981 renewal application

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

PRODUCT DESCRIPTION

THERMOLUMINESCENCE APPARATUS FOR ARCHAEOLOGICAL DATING

The Daybreak TL system has been designed to accommodate the particular needs of archaeological dating. It has evolved over six years of laboratory use, and the electronics has been recently updated; state-of-the-art, complex integrated circuits make high performance and high reliability now possible at a very moderate cost.

The Daybreak TL system has advantages beyond price over other TL systems. It is compact, modular, and expandable, and designed from the beginning with a coherent overall plan for the contemporary TL laboratory. You can start with a basic system and add to it as your needs and sophistication in dating grow. For example, the system is upwards compatible with an inexpensive computer system, the Daybreak 9900, that will record glow curves on disk, do the data reduction, and perform error analysis.

Among the features unique to the Daybreak system are a stable, reproducible digital ramp for heating rates 0.1-25C/sec, automatic repeat ramp for background, a low-power, low-volume oven for fast cooling and evacuation, and a pile-up compensating ratemeter that extends the single photon counting dynamic range to 10^7 counts/sec. Both ratemeter and alpha counters have integral HV power supplies.

The system is packaged in two parts - an electronics enclosure (19" wide x 22" high x 14" deep) housing five system modules and the XY recorder, and the glow oven assembly (18" x 8" x 3" deep, including transformer) which is intended for mounting by the purchaser in a table or bench cutout. An attractive desk (model 502) will be made available if desired. A typical system will include the 700 glow oven, 720 PMT housing with 9636 PMT and 530 photon amp/disc, 50 liter/min vacuum pump, XY recorder, and the following modules: 510 system controller, 520 temperature controller, 540 ratemeter, 580 (or 581) alpha counter, and another 580/1 or 590 irradiation timer with 740 beta sample irradiator and 750 alpha sample irradiator. If more counters are required, or if counters are to be located apart from the TL measurement apparatus, a separate enclosure can be provided. For large labs, the 800/1 multiple sample irradiator may be a disirable accessory.

Modules will be made available also in NIM packaging (AC power only) and rackmount versions for those wishing to upgrade existing systems. 115/230 VAC power versions are standard for all models, except for the 510 and 800/1 for which there is a modest price adder.

Physical and utility requirements - at least 36" bench space, 115/230 VAC 50-60 Hz, 200W, plus power for vacuum pump ($\frac{1}{4}$ Hp motor), regulated, pre-purified nitrogen for oven purging, and cooling water (unnecessary unless continuous operation in excess of two hours is expected).

37 North Street, North Branford, CT 06471 (203) 481-3970

510 TL SYSTEM CONTROLLER

The model 510 TL system controller module contains a thermocouple vacuum gauge, the 521 AC power control, switches for vacuum and nitrogen solenoid valves, HV, OVEN POWER, MAIN POWER, and RAMP START switches.

Physical: 8.75" high, 4.5" wide, 10.5" deep module.

520 TL OVEN TEMPERATURE CONTROLLER

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 (0-10 mA) proportional to temperature error, and is intended for use with the model 521 AC power control. A number of features, such as automatic background run and setpoint operation, have been incorporated for operator convenience.

SPECIFICATIONS

TC amplifier: gain set for chromel-alumel thermocouple. Negative input. Nonlinear transient filter. Back panel ZERO. Output to XY recorder is 200 mV/100 C.

Ramp: linear ramp, 0-25 C/sec (1J turn pot). V-F converter plus 12-bit DAC with clock pulse out every degree C. Stability better than 500 ppm/C. Endpoint 0-500 C (10 turn pot).

Error amplifier: variable gain (back panel control), maximum sensitivity 2 mA/C error (about half oven power). Controlled rate of power application to minimize half cycling in fast response (less than 10 msec) ovens.

Programming:

RAMP/SETPOINT: permits use of the 520 as a setpoint controller, using the endpoint pot.

INTERNAL/EXTERNAL: ramp or arbitrary T(t) from external source.

RESET/HOLD: action at end of ramp.

SINGLE/REPEAT: on REPEAT, ramp will restart once after cooling to near ambient temperature (settable 0-100 C) for background run.

START: initiates ramp. A remote START (switch closure to ground) is also provided.

STOP: aborts ramp.

Pen lift out: TTL compatible, active high or low (selectable internally).

Meter: 0-500 C, or ±10 C error. Switch on front panel.

Power: 115/220 VAC, 6 W.

Physical: 8.75" high, 3" wide, 10.5" deep.

521 AC POWER CONTROL

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 control input signal is a current (0-10 mA), optically coupled to the AC circuitry. Load capability of the triac should not greatly exceed actual load for best performance. A 3A triac is normally provided unless otherwise specified.

The 521 is normally provided as part of the model 510 system controller. It is packaged separately for those purchasing the 520 temperature controller alone.

Physical: 2" X 4.5" X 3.5"

530 PHOTON AMPLIFIER/DISCRIMINATOR

The model 530 amp/disc converts the low level current pulses from 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, troublefree voltage comparator. Output is ECL-compatible, single-ended or differential, capable of driving 50 ohms. This device is compact and mounts in the PMT housing. The sensitivity is sufficient for all PMTs commonly used for single photon counting. We also make available the 531 amp/disc which has a TTL-compatible output (50 ohms) with standard width pulses (50-1000 nsec) for use with slow input counters and ratemeters. Contact Daybreak for details on this product.

SPECIFICATIONS

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

Amplifier rise time: 4 nsec.

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

Output level: negative-going ECL (-900 mV to -1800 mV), driving 50 ohms. Complementary outputs permit differential driving of twisted pair line.

Power: +5 V at 35 mA, -5 V at 65 mA; or +5 V at 75 mA, +12 V at 25 mA.*

Physical: 2.45" diameter, 0.6" high to fit within PMT housing. Also available in alternative cased packaging 0.75" x 1" x 4" at extra cost.

* When the +5, +12 V option is selected, the output levels are +4.1-3.2 V, compatible with the 540 ratemeter input.

540 PHOTON RATEMETER

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

TRUE COUNT RATE = OBSERVED COUNT RATE/(1-DEAD TIME FRACTION).

For fairly slow PMTSs such as the EMI 9635 which we recommend for TL measurement, dead time per detected photon is 40-100 nsec depending on discriminator threshold, and dead time losses amount to 4-10 per cent at 10^6 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 2×10^7 counts/sec (usable only up to 10^7 with the 9635 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 an external counter.

SPECIFICATIONS

Input: negative-going ECL, differential (standard) or single-ended.

Ranges: 12 ranges 5×10^2 to 2×10^6 counts/sec full scale, plus divide-by-ten (front panel switch) for 5×10^3 to 2×10^7 counts/sec.

Pile-up compensation: within 1 per cent 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 range and 0-2000 V HV, front panel selection switch.

HV power supply: negative, 600-1600 V at 0.5 mA, front panel screwdriver adjust, HV ON/OFF switch with LED indicator. Remote enable (switch closure to ground).

Front Panel Controls: RANGE, TIME CONSTANT, ZERO SUPPRESSION, X1/X10, METER (RATE/HV), HV ON/OFF, HV adjust.

Rear Panel Connectors: System power/control, HV (SHV), AMP/DISC power and twisted pair signal.

Power: 115/220 VAC, 10 W.

Physical: 8.75" high, 3" wide, 10.5" deep.

580/1 ALPHA COUNTER

Daybreak provides two models of low-level alpha counter for TL dating applications. The 580 has a single 4-digit counter; the 581 has an additional 4-digit counter with pairs detection for determination of the uranium/thorium ratio (Turner et al.. Brit. Journal Radiology, 31, 397 (1958)). Both include preamplifier, shaping amplifier, integral discriminator, counter, and HV power supply in one compact module. The charge sensitive amplifier is highly insensitive to RFI and AC line noise, so that a printer is not required. The 2" PMT is housed externally to the module in a magnetically shielded enclosure with HV interlock. These counters are powered independently of the remainder of the TL system.

SPECIFICATIONS

Amplifier: 2×10^{10} and 2×10^{11} V/coulomb sensitivity, unipolar gaussian pulse out (T = 2 usec).

Integral discriminator: 0-5V (10 turn pot).

HV power supply: +600 to 1600 V at 500 μA, set by front panel 10 turn pot, HV ON/OFF switch and LED indicator on front panel with interlock.

Counter: 4-digit, to 1 MHz. START, STOP, and RESET pushbuttons, READY indicator. Gated mode: GATE ON/OFF switch on front panel. 581 only: additional 4-digit counter with pairs detection, 0.02-0.40 sec acceptance period for 95 per cent detection efficiency for Th-232, while discriminating against the faster pair in the U-235 decay chain.

Front panel controls: AMP GAIN X1/X10, DISC LEVEL (10T), HV (10T), HV ON/OFF, GATE MODE ON/OFF, START, STOP, RESET, POWER.

Rear panel connectors: HV(SHV), AMP IN (BNC), AMP OUT (BNC), GATE IN (BNC), HV interlock (RCA).

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

Physical: 8.75 x 3 x 10.5" module, 8" high x 4" diameter PMT housing.

590 IRRADIATOR TIMER

The model 590 timer controls the 740, 750, and 760 sample irradiators, opening shutters for periods of 0.01 - 99.99 minutes. A 4-digit thumbwheel switch sets the time, and a 4-digit display indicates elapsed time. Exposure may be interrupted without resetting timer, and then resumed. A front panel switch selects alpha, beta, or gate mode (for 580/1 counter). Output is 12 V, 1 A.

700 GLOW OVEN

The model 700 glow oven is of an advanced design, constructed from a substantial aluminum block for high thermal inertia, thus reducing cooling requirements. Water cooling is standard, but not necessary unless the oven is in constant use for more than two hours. The low power consumption of the heating plate, typically 60W for 20C/sec run up to 500C, further contributes to fast cooling. The small internal volume, 2 in^3, of the oven makes evacuation fast as well.

The glow oven is mounted on a plate measuring 8" x 18"along with heating plate transformer, solenoid vacuum and nitrogen valves, nitrogen pressure relief valve, and vacuum gauge tube. It is intended for mounting in a bench or desk cutout, but the mere 3" depth under the mounting plate permits above bench mounting as well.

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 collecting efficiency. A reflective aluminum cone placed around the sample increases light gathering by about 50 per cent for about 75 per cent of ideal 2π geometry, disregarding reflective losses at filter surfaces.

Total power consumption is 120W maximum, 115/230 VAC 50-60 Hz.

720 PMT HOUSING

The 720 PMT housing is of conventional design having magnetic and electrostatic shielding. The filter pack, single or multiple optical filters, is easily changed without housing disassembly. The 530 photon amp/disc is mounted within this housing.

The 720 is normally supplied with an EMI 9635B PMT, others optional, and with one filter pack made up of Corning 7-59 and 4-69 filters 2.40" dia. Others will be made 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.

Dimensions are 3" diameter, 8" high. There is an SHV connector for HV (negative standard supply), and an Amphenol hex connector for amp/disc power and ECL twisted pair output.

740 BETA IRRADIATOR

The model 740 beta irradiator is a shielded enclosure with electrically-operated shutter for a customer-supplied beta source. The shutter is a composite for low bremsstralung and is spring-loaded for failsafe return. The 740 mounts on the glow oven for on-plate irradiations at a 1.7 cm SSD. Beta dose rate is approximately 4 rad/sec for a 100 mCi Sr-90 source. It is reccommended that the 740 be stored on a lead block to stop radiation escaping through the shutter (about 1 R/hr measured at the shutter surface) and behind another to shield any lateral radiation (less than 30 mR/hr at case surface).

Use of this sort of source container is helpful in fulfilling the stringent radiation safety requirements of the NRC since the source is completely shielded while the shutter is closed, and protected from physical damage.

Power: 12 VDC, 350 mA

Physical: 3.75" diameter, 2" high, weight 5 lbs.

NOTE: customer must furnish source drawing.

750 ALPHA IRRADIATOR

The model 750 alpha irradiator is a shielded enclosure for a customer-supplied alpha source. The source is mounted on a solenoid-actuated arm that brings the source out of the housing into position over the sample well. Source-to-sample distance is 0.2 cm. The active surface of the source cannot be accessed without disassembly of the enclosure. Dose rate is approximately 90 rad/sec for a 500 μCi Am-241 source (12.5" active diameter).

Power: 12 VDC, 350 mA.

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

NOTE: customer must furnish source drawing.

760 VACUUM ALPHA IRRADIATOR

The 760 alpha irradiator is similar to the 750, but follows the recommendations of Singhvi and Aitken (Ancient TL, No. 3, Spring 1978) in performing irradiation under vacuum at a source-to-sample distance of 1 cm. Vacuum is obtained by mounting on the glow oven and using its valves. If desired, an alternative configu r ation with separate vacuum and air toggle valves can be built to order.

800 MULTIPLE SAMPLE IRRADIATOR

The Daybreak model 800 multiple sample irradiator is a time saving accessory for the TL dating laboratory where many samples may require long beta 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 800 exposes up to 20 samples sequentially for periods each settable to be 0-9999 seconds. Operation after data entry and sample loading is completely automatic. The system is controlled by a single-board microcomputer, and includes a 20 character alphanumeric display for operator prompts and system status (sample no., 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.

The irradiator may also be used for a single sample, and external electrically-shuttered exposure devices, such as the Daybreak 740 and 750, may be accommodated as well.

Because of isotope licensing restrictions, the model 800 cannot be supplied with the beta source installed. Daybreak can order the source and have it shipped directly by the manufacturer for customer installation, or the customer may order it himself, and thereby save our handling charge. If the customer orders the source, it is necessary that Daybreak be forwarded an accurate drawing so that the source shielding can be made to proper size.

The size of sample accommodated is determined by inserts which fit into the revolving sample carrier disk. One size is supplied with the 800, to customer specification, and others may be purchased as an option. Sizes may be intermixed on the carrier disk. A maximum diameter of 12.5 mm is recommended because of source intensity fall-off beyond that diameter.

SPECIFICATIONS:

No. of samples accommodated: 20
Exposure time: each sample set separately, 0-9999 seconds
Exposure rate: depends on source. For 100 mCi Sr-90 (ICN 75129, 6 mm active dia.) at 15 mm SSD, approximately 4 rads/sec to quartz.
Front panel: 20 character alphanumeric display. Keyboard: 0-9, LOAD, ENTER, EXIT, CLEAR ENTRY, NEXT, SINGLE, RUN, STOP. Indicators: SAFE, RADIATION. Key-operated swith for power on/off.
Printer: 20 char/line thermal printer
Physical: 14.0 x 32.3 x 43.4 cm (5.51 x 12.73 x 17.1 in, HxWxD)
Weight: 15 kgm (34 lb)
Power requirement: 115 or 230 VAC, 60 Hz, 70 W maximum, 50 Hz optional.

OPTION (model 801): additional exposure mechanism for alpha source so that both beta and alpha doses may be given to the set of samples. There is an additional ALPHA/BETA key for data entry.

OPTION: 50 Hz operation.

900 TL SYSTEM/COMPUTER INTERFACE

The model 900 provides a means of communication between the TL system and a computer, both for recording glow curves and for presenting digital plot data, via DACs, to the system XY recorder. The contents of a 24-bit photon counter and an 8-bit system status register are read by the computer each 1,2,5, or 10°C of temperature rise, or every 50 msec after ramp start for non-Daybreak systems. Data from the computer can be written into doubly buffered 12-bit DACs for output to the system XY recorder, or to the EXTERNAL temperature programming input of the 520 oven temperature controller.

The interface plugs into the Daybreak TL system bus, and becomes the XY recorder controller, taking over from the 510 system controller. Communication with the computer is via one 8-bit control input port and one 8-bit bidirectional data port. No handshake is required, although timing loops in the control computer program are required for plotting functions. The I/O section of the interface may be configured, on request, to be compatible with PDP-11 and LSI-11 I/O requirements.

The control word is decoded in the 900 to produce the following command set:

Set up read address(status or scaler bytes)
Set up write address to DAC register (LoX, HiX, LoY, HiY)
Pen up/down
Pen motion, move one plot space in one of 8 directions
Load input registers into DAC register (move absolute)
Set data spacing 1,2,5, or 10°C
Set data or plot mode
Ramp start
System reset.

The 900 is housed in a 3" wide Daybreak system module and requires 115/230 VAC (50-60 HZ) at 15W.

A parallel interface plug-in card to connect the 900 to an Apple II computer is available from Daybreak. In addition to the two 8-bit ports dedicated to the 900, it contains two 16-bit interval timers available to the user.

9900 COMPUTER SYSTEM FOR TL DATA ANALYSIS

The Daybreak TL system was designed from the ground up to work hand-in-hand with a computer to cut analysis time and to improve the precision of TL date determinations. The computer system configured by Daybreak for this purpose is based on the ixexpensive but powerful Apple II computer. Besides the 900 TL interface, there is the Apple II computer with 48Kword memory, PASCAL compiler and operating system, two floppy disk drives, black and white TV monitor for alphanumeric and high resolution graphics display, 80 column line printer, and software for glow curve recording on disk, data reduction, date computation, and error analysis. The software is written in UCSD PASCAL, a very powerful and fast structured language (50-100 times faster than BASIC), rapidly becoming the new standard language for small systems. As a bonus, the computer with its PASCAL software is available for general laboratory use as well, and may be interfaced to other lab instruments.

A NOTE ON RADIOISOTOPE SOURCES

Daybreak does not stock and resell the alpha and beta sources necessary for TL dating, due to the very high cost and the red tape involved in obtaining a byproduct materials distribution license from the USNRC. We can, however, order sources to the specifications of our sample irradiators for direct shipment to the purchaser (who must then install them himself, a simple task). We must charge a 20 per cent mark up on such orders to cover our administrative costs. To enter an order, we must have a copy of the purchaser's radioisotope license (in the US, at least, this must specify the type of source, manufacturer, and encapsulation), as the manufacturer cannot ship without it.

ALPHA

We use an Am-241 source from Amersham/Searle Corp., 2636 S. Clearbrook Drive, Arlington, IL 60005. The description is: Am-241 alpha foil source, 500 μCi, 12.5 mm active diameter in SIP-1 aluminum alloy case, to be tapped 6-32. This has been quite satisfactory. Cm-244, with a halflife of 18 years and 5.8 MeV alpha energy, is reported to be available from some manufacturers now, and if not too expensive, would be a better choice for irradiation of samples in air.

BETA

Some years back we purchased a Sr-90 source from Amersham/Searle (100 mCi in SIP-1 case, 12.5 mm active diameter), but this is no longer available in the US. We have heard that this source may still be obtained in Europe from the Radiochemical Centre, Amersham, Bucks., England. Recently we purchased for our own use another Sr-90 source (100 mCi with 6.3 mm active diameter) and installed it in our 740 beta irradiator. At a 15 mm source-to-sample distance, there is a 5-10 per cent falloff in intensity at the edge of a 9.5 mm disk. While this is satisfactory for authenticity work, for more demanding dating the larger diameter Amersham source is to be preferred for its better uniformity. Alternatively, the source-to-sample distance could be increased for the smaller source at a penalty of decreased dose rate to the sample. The 6.3 mm source was obtained from ICN Radiopharmaceuticals, Inc., Chemical and Radioisotope Division, 2727 Campus Drive, Irvine, CA 92715, as their model 75129 Sr-90 100 mCi in 8S capsule, no handle, no shield, tapped 10-24 in back. Another possible source of Sr-90 which might make up a custom sealed source at reasonable cost is Isotope Product Laboratories, 1800 N. Keystone St., Burbank, CA 91504.

U.S. RADIOISOTOPE LICENSES

A license to possess and use radioisotope sources is required before they can be shipped to you by the manufacturer. You should contact the USNRC or your state nuclear regulatory agency for information. In addition to information about the sources you intend to use and their application, you must submit a very detailed radiation safety program. We can offer advice on this from our own experience. Licensing takes time, so start about six months before you expect to need the sources. Some states may be faster than the federal government, and if you are a university lab, you may be able to get in under an existing blanket university license.

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

PRODUCT DESCRIPTION

MODEL 9900 COMPUTER SYSTEM FOR TL DATA ANALYSIS

The Daybreak 9900 computer system integrates with the Daybreak TL system to record glowcurves on floppy disk media, to reduce these glowcurves to equivalent dose, intercept, and alpha efficiency measurements, and to compute TL age with complete error analysis. Raw or background-subtracted data may be plotted on the system xy recorder or on the graphics printer (with optional printer/plotter). A useful TL utility package is callable by user programs from the system library. As a bonus, the 9900 may also be used as a general purpose scientific computer with outstanding graphics capabilities.

COMPUTER HARDWARE

The computer system is based on the powerful Apple II microcomputer running the UCSD Pascal language and operating system in 64Kbytes of memory. Two 5.25" double density floppy disk drives are included, together with a high quality black and white video monitor for the high resolution graphics display (280x192 dots), and an 80-column line printer. As an option, the standard printer may be replaced with a printer/plotter having dot graphics capability and software for 560x386 plots. The 900 interface with 910 cable/parallel drive card is also included.

900 INTERFACE

The model 900 interface provides the means of communication between the TL system and the computer, transfering information to the computer for glowcurve recording, and from the computer, via DACs, to the system xy recorder. It 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 900 is housed in a 3 inch Daybreak system module which occupies slot 4 or 5 of the 501 module cage. Power requirement is 115/230 VAC, 15W.

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 locations in the computer address space. There are nine basic functions:

READ STATUS (addr=0). When this address is read, the status byte (DATA READY, RAMP ON, RAMP CLOCK, FIRST RAMP, PEN READY, and three expansion bits) is put onto the data bus.

READ COUNTER (addr=16). When DATA READY goes high, the first byte of the photon counter is available for reading. Subsequent reads access the other counter bytes sequentially.

WRITE DAC LATCH (addr=64,80,96,112). Data present on the data bus is written into the chosen DAC latch (Xhigh, Xlow, Yhigh, Ylow).

PEN MODE (addr=128+penstate). Penstate=0 causes the xy recorder pen to drop if graphics mode is invoked (otherwise, the 520

temperature control is in control).

MOVE INCREMENTALLY (addr=certain of 144-159). The x and y DAC registers increment or decrement in combination to produce pen motion in one of eight directions.

SET DATA SPACING (addr=160+N where N=1-15 is the spacing ^{o}C/point). DATA READY goes high every N RAMP CLOCK pulses.

MODE (addr=176 for data acquistion, 177 for graphics). This function controls the electronic switching of signals going to the xy recorder.

SYSTEM RESET (addr=224). Initializes interface.

RAMP START (addr=240). Starts the 520 ramp.

An optional plug-in board enables the 900 to generate a ramp voltage (0 to 5 or 10V) and emulates the 520 control signals so that the interface can accommodate non-Daybreak TL apparatus.

The interface function is completed by the 910 cable/driver card which plugs into the Apple II.

COMPUTER SOFTWARE

Applications software has been written in UCSD Pascal, a fast, block structured compiled language which is becoming the stadard for serious programming of small computers. The Pascal operating system included is extremely versatile and easy to use. FORTRAN is available as an option for user programs.

The Daybreak 9900 software package includes a number of highly interactive programs for data taking, for dose and date computations, and for incorporation into user programs. They are written to be immediately usable by someone with a knowledge of thermoluminescence but with no special know - ledge or experience regarding computers.

The major program, TLAPPLIC, takes glowcurve data and records it on disk, and afterwards processes it to obtain plateau information, equivalent dose, and alpha efficiency, while providing useful hard-copy plots as desired. Version I.0 takes data in the format of 100 point arrays, 5^{o}C/ point, while soon to be released versions will accommodate 250 points at 2^{o}C/point and 140 points at 5^{o}C/point. A second program, TLDATE, computes the TL age and errors according to Aitken (Archaeometry 18(2), 233 (1976)) with all correction through June 1980 (Aitken, private communication). A file editing program, TLEDIT, is provided to correct data entry errors and to merge files. Lastly, a set of utility routines for control of the interface and for plotting resides in the system library for use by user Pascal programs.

TLAPPLIC has two major functions. The first is data taking. Very little beyond the usual set up time for a glowcurve is required to enter runtime information. Data for sample ID, irradiation source information, and general running parameters is entered, mostly menu-fashion with single keystrokes, on openning a new data file. For each glowcurve, a run type (N, N+Beta, etc.), irradiation time if applicable, and optional remark are entered before starting the ramp. A very useful feature is automatic entry of the background glowcurve without operator intervention.

The second, and much more complex, function of TLAPPLIC is data reduction. Currently, up to 50 glowcurves (25 TL curves maximum, 25 back-

ground curves maximum) 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 put on the video display at several points in the program for reference. The operator may then look over the raw data, and plot on the system xy recorder or optional printer/plotter as desired. Background subtraction is then performed, with automatic correction for the temperature shifts that can occur at high ramp rates because of variable contact of the sample disk with the heating plate. Because of this possibility, it is usually recommended that a background be recorded with every TL glowcurve; the automatic background ramp feature combined with the fast cooling rate of the Daybreak 700 glow oven facilitate this. The subtracted glowcurves are written onto their own disk file for further use, and may be inspected and plotted. The plateau and integration procedures operate on this data. The plateau is computed in the usual fashion, but up to five each of N and N+Beta curves may be averaged together for the plateau. Once a region, or regions, of interest have been chosen, the integrals are found, and sorted out according to irradiation type and dose. Categories are N, N+Beta (up to five different doses), N+Alpha (up to three different doses), and all Beta curves together for second glows. Up to eight curves in each category are supported. The integrals in each category together with their average and standard deviation are displayed and printed, and bad data may be discarded. Once done for all categories, the equivalent dose and alpha efficiency are computed for all dose combinations. Second glow integrals, and their values normalized to the accompanying N integrals are computed for intercept determination.

In order to run such a large program as TLAPPLIC in the environment of a small computer, a sophisticated memory overlay technique was employed. Only that segment of the program actually in use resides in memory, being read off disk when needed.

TLDATE follows the method of Aitken very closely, and the program text file is included for alteration as required by the user's special 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 file is under 15 minutes, plus plotting time, and an age computation using TLDATE should be less than five minutes.

Except for TLDATE, software is provided in binary form only. Special programming and customer assistance is available, and software updates for one year after installation will be provided free of charge (except for air shipment).

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

PRICE LIST

1 August 1980

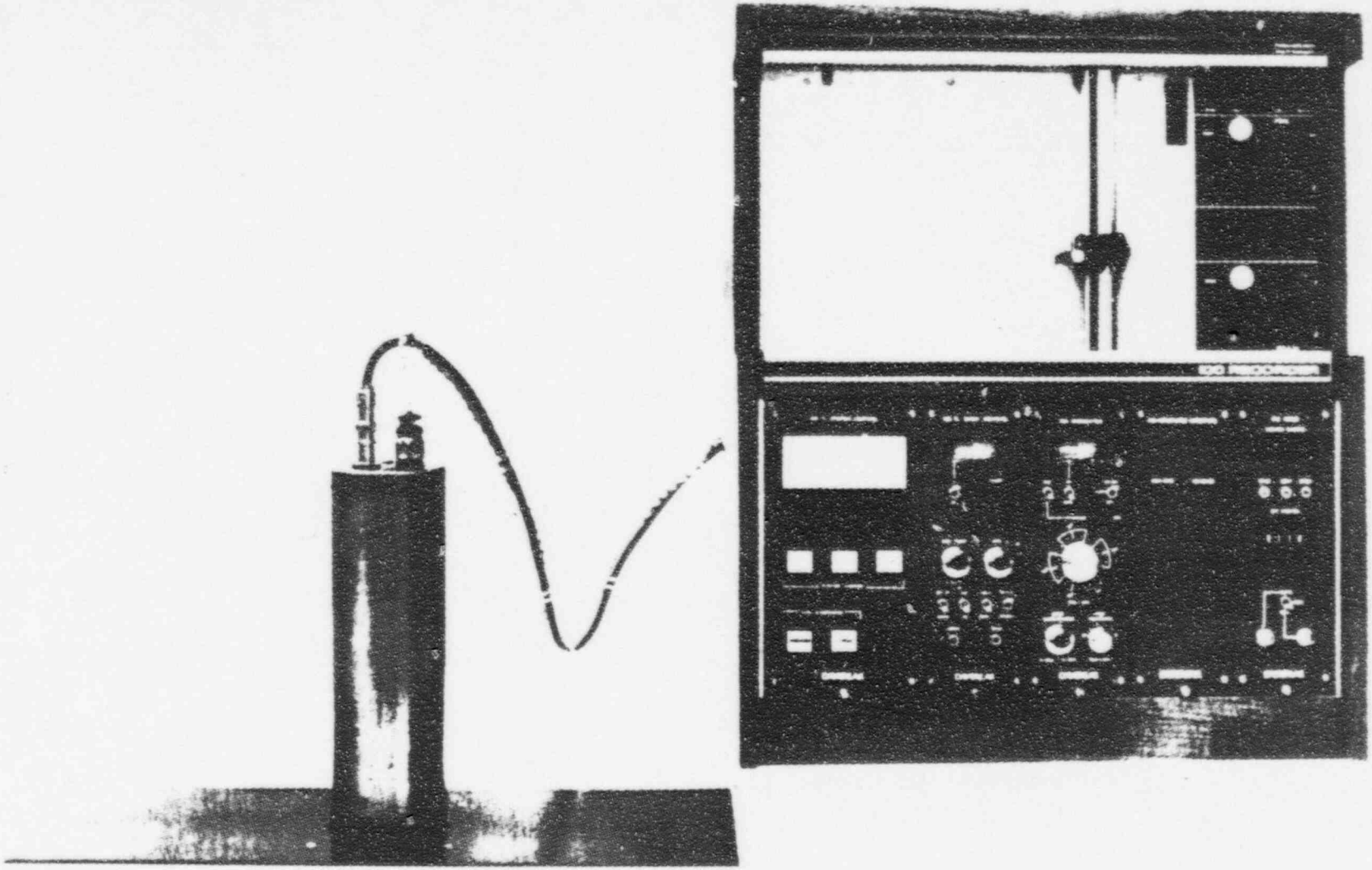
Prices subject to change without notice. Prices in $US.

501	System enclosure	625
502	Desk fitted out for TL system	450/575
503	Separate alpha counter enclosure	420
510	TL system controller (220VAC, +$35)	1125
520	Temperature controller	1700
521	AC power control	175
530	Photon amplifier/discriminator	430
540	Photon ratemeter	1875
580	Alpha counter	1875
581	as 580, but with pairs counter	2000
590	Irradiation timer	825
700	Glow oven	2700
720	PMT housing with EMI 96358 and 530 amp/disc	2000
740	Beta irradiator, less source	650
750	Alpha irradiator, less source	525
760	Vacuum alpha irradiator, less source	775
800	Multiple sample beta irradiator, less source	5250
801	as 800, with additional provision for alpha source	5750
900/910	Computer interface with Apple II card/cable	3250
9900	Computer system	12,850
	Graphics printer option	800
	Module service cable	75
	NIM or rackmount option, per module	60
	Basic TL system	14,650

A wide range of TL sytem accessories is available from Daybreak. Details and prices on request.

All items F.O.B. North Branford, CT (plus crating where applicable). Delivery 60 days on modules, 120 days on mechanical assemblies and systems.

37 North Street, North Branford, CT 06471 (203) 481-3970



DAYBREAK
systems for TL dating

Daybreak Nuclear and Medical Systems, Inc.
North Branford, CT 06471 (203) 481-3970

Enclosure from 1981 renewal application

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

PRODUCT DESCRIPTION

THERMOLUMINESCENCE APPARATUS FOR ARCHAEOLOGICAL DATING

The Daybreak TL system has been designed to accommodate the particular needs of archaeological dating. It has evolved over six years of laboratory use, and the electronics has been recently updated; state-of-the-art, complex integrated circuits make high performance and high reliability now possible at a very moderate cost.

The Daybreak TL system has advantages beyond price over other TL systems. It is compact, modular, and expandable, and designed from the beginning with a coherent overall plan for the contemporary TL laboratory. You can start with a basic system and add to it as your needs and sophistication in dating grow. For example, the system is upwards compatible with an inexpensive computer system, the Daybreak 9900, that will record glow curves on disk, do the data reduction, and perform error analysis.

Among the features unique to the Daybreak system are a stable, reproducible digital ramp for heating rates 0.1-25C/sec, automatic repeat ramp for background, a low-power, low-volume oven for fast cooling and evacuation, and a pile-up compensating ratemeter that extends the single photon counting dynamic range to 10^7 counts/sec. Both ratemeter and alpha counters have integral HV power supplies.

The system is packaged in two parts - an electronics enclosure (19" wide x 22" high x 14" deep) housing five system modules and the XY recorder, and the glow oven assembly (18" x 8" x 3" deep, including transformer) which is intended for mounting by the purchaser in a table or bench cutout. An attractive desk (model 502) will be made available if desired. A typical system will include the 700 glow oven, 720 PMT housing with 9636 PMT and 530 photon amp/disc, 50 liter/min vacuum pump, XY recorder, and the following modules: 510 system controller, 520 temperature controller, 540 ratemeter, 580 (or 581) alpha counter, and another 580/1 or 590 irradiation timer with 740 beta sample irradiator and 750 alpha sample irradiator. If more counters are required, or if counters are to be located apart from the TL measurement apparatus, a separate enclosure can be provided. For large labs, the 800/1 multiple sample irradiator may be a disirable accessory.

Modules will be made available also in NIM packaging (AC power only) and rackmount versions for those wishing to upgrade existing systems. 115/230 VAC power versions are standard for all models, except for the 510 and 800/1 for which there is a modest price adder.

Physical and utility requirements - at least 36" bench space, 115/230 VAC 50-60 Hz, 200W, plus power for vacuum pump ($\frac{1}{4}$ Hp motor), regulated, pre-purified nitrogen for oven purging, and cooling water (unnecessary unless continuous operation in excess of two hours is expected).

37 North Street, North Branford, CT 06471 (203) 481-3970

510 TL SYSTEM CONTROLLER

The model 510 TL system controller module contains a thermocouple vacuum gauge, the 521 AC power control, switches for vacuum and nitrogen solenoid valves, HV, OVEN POWER, MAIN POWER, and RAMP START switches.

Physical: 8.75" high, 4.5" wide, 10.5" deep module.

520 TL OVEN TEMPERATURE CONTROLLER

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 (0-10 mA) proportional to temperature error, and is intended for use with the model 521 AC power control. A number of features, such as automatic background run and setpoint operation, have been incorporated for operator convenience.

SPECIFICATIONS

TC amplifier: gain set for chromel-alumel thermocouple. Negative input. Nonlinear transient filter. Back panel ZERO. Output to XY recorder is 200 mV/100 C.

Ramp: linear ramp, 0-25 C/sec (10 turn pot). V-F converter plus 12-bit DAC with clock pulse out every degree C. Stability better than 500 ppm/C. Endpoint 0-500 C (10 turn pot).

Error amplifier: variable gain (back panel control), maximum sensitivity 2 mA/C error (about half oven power). Controlled rate of power application to minimize half cycling in fast response (less than 10 msec) ovens.

Programming:

RAMP/SETPOINT: permits use of the 520 as a setpoint controller, using the endpoint pot.

INTERNAL/EXTERNAL: ramp or arbitrary T(t) from external source.

RESET/HOLD: action at end of ramp.

SINGLE/REPEAT: on REPEAT, ramp will restart once after cooling to near ambient temperature (settable 0-100 C) for background run.

START: initiates ramp. A remote START (switch closure to ground) is also provided.

STOP: aborts ramp.

Pen lift out: TTL compatible, active high or low (selectable internally).

Meter: 0-500 C, or ±10 C error. Switch on front panel.

Power: 115/220 VAC, 6 W.

Physical: 8.75" high, 3" wide, 10.5" deep.

521 AC POWER CONTROL

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 control input signal is a current (0-10 mA), optically coupled to the AC circuitry. Load capability of the triac should not greatly exceed actual load for best performance. A 3A triac is normally provided unless otherwise specified.

The 521 is normally provided as part of the model 510 system controller. It is packaged separately for those purchasing the 520 temperature controller alone.

Physical: 2" X 4.5" X 3.5"

530 PHOTON AMPLIFIER/DISCRIMINATOR

The model 530 amp/disc converts the low level current pulses from 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, troublefree voltage comparator. Output is ECL-compatible, single-ended or differential, capable of driving 50 ohms. This device is compact and mounts in the PMT housing. The sensitivity is sufficient for all PMTs commonly used for single photon counting. We also make available the 531 amp/disc which has a TTL-compatible output (50 ohms) with standard width pulses (50-1000 nsec) for use with slow input counters and ratemeters. Contact Daybreak for details on this product.

SPECIFICATIONS

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

Amplifier rise time: 4 nsec.

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

Output level: negative-going ECL (-900 mV to -1800 mV), driving 50 ohms. Complementary outputs permit differential driving of twisted pair line.

Power: +5 V at 35 mA, -5 V at 65 mA; or +5 V at 75 mA, +12 V at 25 mA.*

Physical: 2.45" diameter, 0.6" high to fit within PMT housing. Also available in alternative cased packaging 0.75" x 1" x 4" at extra cost.

* When the +5, +12 V option is selected, the output levels are +4.1-3.2 V, compatible with the 540 ratemeter input.

540 PHOTON RATEMETER

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

TRUE COUNT RATE = OBSERVED COUNT RATE/(1-DEAD TIME FRACTION).

For fairly slow PMTSs such as the EMI 9635 which we recommend for TL measurement, dead time per detected photon is 40-100 nsec depending on discriminator threshold, and dead time losses amount to 4-10 per cent at 10^6 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 2×10^7 counts/sec (usable only up to 10^7 with the 9635 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 an external counter.

SPECIFICATIONS

Input: negative-going ECL, differential (standard) or single-ended.

Ranges: 12 ranges 5×10^2 to 2×10^6 counts/sec full scale, plus divide-by-ten (front panel switch) for 5×10^3 to 2×10^7 counts/sec.

Pile-up compensation: within 1 per cent 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 range and 0-2000 V HV, front panel selection switch.

HV power supply: negative, 600-1600 V at 0.5 mA, front panel screwdriver adjust, HV ON/OFF switch with LED indicator. Remote enable (switch closure to ground).

Front Panel Controls: RANGE, TIME CONSTANT, ZERO SUPPRESSION, X1/X10, METER (RATE/HV), HV ON/OFF, HV adjust.

Rear Panel Connectors: System power/control, HV (SHV), AMP/DISC power and twisted pair signal.

Power: 115/220 VAC, 10 W.

Physical: 8.75" high, 3" wide, 10.5" deep.

580/1 ALPHA COUNTER

Daybreak provides two models of low-level alpha counter for TL dating applications. The 580 has a single 4-digit counter; the 581 has an additional 4-digit counter with pairs detection for determination of the uranium/thorium ratio (Turner et al.. Brit. Journal Radiology, 31, 397 (1958)). Both include preamplifier, shaping amplifier, integral discriminator, counter, and HV power supply in one compact module. The charge sensitive amplifier is highly insensitive to RFI and AC line noise, so that a printer is not required. The 2" PMT is housed externally to the module in a magnetically shielded enclosure with HV interlock. These counters are powered independently of the remainder of the TL system.

SPECIFICATIONS

Amplifier: 2×10^{10} and 2×10^{11} V/coulomb sensitivity, unipolar gaussian pulse out (T = 2 usec).

Integral discriminator: 0-5V (10 turn pot).

HV power supply: +600 to 1600 V at 500 μA, set by front panel 10 turn pot, HV ON/OFF switch and LED indicator on front panel with interlock.

Counter: 4-digit, to 1 MHz. START, STOP, and RESET pushbuttons, READY indicator. Gated mode: GATE ON/OFF switch on front panel. 581 only: additional 4-digit counter with pairs detection, 0.02-0.40 sec acceptance period for 95 per cent detection efficiency for Th-232, while discriminating against the faster pair in the U-235 decay chain.

Front panel controls: AMP GAIN X1/X10, DISC LEVEL (10T), HV (10T), HV ON/OFF, GATE MODE ON/OFF, START, STOP, RESET, POWER.

Rear panel connectors: HV(SHV), AMP IN (BNC), AMP OUT (BNC), GATE IN (BNC), HV interlock (RCA).

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

Physical: 8.75 x 3 x 10.5" module, 8" high x 4" diameter PMT housing.

590 IRRADIATOR TIMER

The model 590 timer controls the 740, 750, and 760 sample irradiators, opening shutters for periods of 0.01 - 99.99 minutes. A 4-digit thumbwheel switch sets the time, and a 4-digit display indicates elapsed time. Exposure may be interrupted without resetting timer, and then resumed. A front panel switch selects alpha, beta, or gate mode (for 580/1 counter). Output is 12 V, 1 A.

700 GLOW OVEN

The model 700 glow oven is of an advanced design, constructed from a substantial aluminum block for high thermal inertia, thus reducing cooling requirements. Water cooling is standard, but not necessary unless the oven is in constant use for more than two hours. The low power consumption of the heating plate, typically 60W for 20C/sec run up to 500C, further contributes to fast cooling. The small internal volume, 2 in^3, of the oven makes evacuation fast as well.

The glow oven is mounted on a plate measuring 8" x 18"along with heating plate transformer, solenoid vacuum and nitrogen valves, nitrogen pressure relief valve, and vacuum gauge tube. It is intended for mounting in a bench or desk cutout, but the mere 3" depth under the mounting plate permits above bench mounting as well.

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 collecting efficiency. A reflective aluminum cone placed around the sample increases light gathering by about 50 per cent for about 75 per cent of ideal 2π geometry, disregarding reflective losses at filter surfaces.

Total power consumption is 120W maximum, 115/230 VAC 50-60 Hz.

720 PMT HOUSING

The 720 PMT housing is of conventional design having magnetic and electrostatic shielding. The filter pack, single or multiple optical filters, is easily changed without housing disassembly. The 530 photon amp/disc is mounted within this housing.

The 720 is normally supplied with an EMI 9635B PMT, others optional, and with one filter pack made up of Corning 7-59 and 4-69 filters 2.40" dia. Others will be made 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.

Dimensions are 3" diameter, 8" high. There is an SHV connector for HV (negative standard supply), and an Amphenol hex connector for amp/disc power and ECL twisted pair output.

740 BETA IRRADIATOR

The model 740 beta irradiator is a shielded enclosure with electrically-operated shutter for a customer-supplied beta source. The shutter is a composite for low bremsstralung and is spring-loaded for failsafe return. The 740 mounts on the glow oven for on-plate irradiations at a 1.7 cm SSD. Beta dose rate is approximately 4 rad/sec for a 100 mCi Sr-90 source. It is recommended that the 740 be stored on a lead block to stop radiation escaping through the shutter (about 1 R/hr measured at the shutter surface) and behind another to shield any lateral radiation (less than 30 mR/hr at case surface).

Use of this sort of source container is helpful in fulfilling the stringent radiation safety requirements of the NRC since the source is completely shielded while the shutter is closed, and protected from physical damage.

Power: 12 VDC, 350 mA

Physical: 3.75" diameter, 2" high, weight 5 lbs.

NOTE: customer must furnish source drawing.

750 ALPHA IRRADIATOR

The model 750 alpha irradiator is a shielded enclosure for a customer-supplied alpha source. The source is mounted on a solenoid-actuated arm that brings the source out of the housing into position over the sample well. Source-to-sample distance is 0.2 cm. The active surface of the source cannot be accessed without disassembly of the enclosure. Dose rate is approximately 90 rad/sec for a 500 μCi Am-241 source (12.5" active diameter).

Power: 12 VDC, 350 mA.

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

NOTE: customer must furnish source drawing.

760 VACUUM ALPHA IRRADIATOR

The 760 alpha irradiator is similar to the 750, but follows the recommendations of Singhvi and Aitken (Ancient TL, No. 3, Spring 1978) in performing irradiation under vacuum at a source-to-sample distance of 1 cm. Vacuum is obtained by mounting on the glow oven and using its valves. If desired, an alternative configuration with separate vacuum and air toggle valves can be built to order.

800 MULTIPLE SAMPLE IRRADIATOR

The Daybreak model 800 multiple sample irradiator is a time saving accessory for the TL dating laboratory where many samples may require long beta 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 800 exposes up to 20 samples sequentially for periods each settable to be 0-9999 seconds. Operation after data entry and sample loading is completely automatic. The system is controlled by a single-board microcomputer, and includes a 20 character alphanumeric display for operator prompts and system status (sample no., 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.

The irradiator may also be used for a single sample, and external electrically-shuttered exposure devices, such as the Daybreak 740 and 750, may be accommodated as well.

Because of isotope licensing restrictions, the model 800 cannot be supplied with the beta source installed. Daybreak can order the source and have it shipped directly by the manufacturer for customer installation, or the customer may order it himself, and thereby save our handling charge. If the customer orders the source, it is necessary that Daybreak be forwarded an accurate drawing so that the source shielding can be made to proper size.

The size of sample accommodated is determined by inserts which fit into the revolving sample carrier disk. One size is supplied with the 800, to customer specification, and others may be purchased as an option. Sizes may be intermixed on the carrier disk. A maximum diameter of 12.5 mm is recommended because of source intensity fall-off beyond that diameter.

SPECIFICATIONS:

No. of samples accommodated: 20
Exposure time: each sample set separately, 0-9999 seconds
Exposure rate: depends on source. For 100 mCi Sr-90 (ICN 75129, 6 mm active dia.) at 15 mm SSD, approximately 4 rads/sec to quartz.
Front panel: 20 character alphanumeric display. Keyboard: 0-9, LOAD, ENTER, EXIT, CLEAR ENTRY, NEXT, SINGLE, RUN, STOP. Indicators: SAFE, RADIATION. Key-operated swith for power on/off.
Printer: 20 char/line thermal printer
Physical: 14.0 x 32.3 x 43.4 cm (5.51 x 12.73 x 17.1 in, HxWxD)
Weight: 15 kgm (34 lb)
Power requirement: 115 or 230 VAC, 60 Hz, 70 W maximum, 50 Hz optional.

OPTION (model 801): additional exposure mechanism for alpha source so that both beta and alpha doses may be given to the set of samples. There is an additional ALPHA/BETA key for data entry.

OPTION: 50 Hz operation.

900 TL SYSTEM/COMPUTER INTERFACE

The model 900 provides a means of communication between the TL system and a computer, both for recording glow curves and for presenting digital plot data, via DACs, to the system XY recorder. The contents of a 24-bit photon counter and an 8-bit system status register are read by the computer each 1,2,5, or 10°C of temperature rise, or every 50 msec after ramp start for non-Daybreak systems. Data from the computer can be written into doubly buffered 12-bit DACs for output to the system XY recorder, or to the EXTERNAL temperature programming input of the 520 oven temperature controller.

The interface plugs into the Daybreak TL system bus, and becomes the XY recorder controller, taking over from the 510 system controller. Communication with the computer is via one 8-bit control input port and one 8-bit bidirectional data port. No handshake is required, although timing loops in the control computer program are required for plotting functions. The I/O section of the interface may be configured, on request, to be compatible with PDP-11 and LSI-11 I/O requirements.

The control word is decoded in the 900 to produce the following command set:

Set up read address(status or scaler bytes)
Set up write address to DAC register (LoX, HiX, LoY, HiY)
Pen up/down
Pen motion, move one plot space in one of 8 directions
Load input registers into DAC register (move absolute)
Set data spacing 1,2,5, or 10°C
Set data or plot mode
Ramp start
System reset.

The 900 is housed in a 3" wide Daybreak system module and requires 115/230 VAC (50-60 HZ) at 15W.

A parallel interface plug-in card to connect the 900 to an Apple II computer is available from Daybreak. In addition to the two 8-bit ports dedicated to the 900, it contains two 16-bit interval timers available to the user.

9900 COMPUTER SYSTEM FOR TL DATA ANALYSIS

The Daybreak TL system was designed from the ground up to work hand-in-hand with a computer to cut analysis time and to improve the precision of TL date determinations. The computer system configured by Daybreak for this purpose is based on the ixexpensive but powerful Apple II computer. Besides the 900 TL interface, there is the Apple II computer with 48Kword memory, PASCAL compiler and operating system, two floppy disk drives, black and white TV monitor for alphanumeric and high resolution graphics display, 80 column line printer, and software for glow curve recording on disk, data reduction, date computation, and error analysis. The software is written in UCSD PASCAL, a very powerful and fast structured language (50-100 times faster than BASIC), rapidly becoming the new standard language for small systems. As a bonus, the computer with its PASCAL software is available for general laboratory use as well, and may be interfaced to other lab instruments.

A NOTE ON RADIOISOTOPE SOURCES

Daybreak does not stock and resell the alpha and beta sources necessary for TL dating, due to the very high cost and the red tape involved in obtaining a byproduct materials distribution license from the USNRC. We can, however, order sources to the specifications of our sample irradiators for direct shipment to the purchaser (who must then install them himself, a simple task). We must charge a 20 per cent mark up on such orders to cover our administrative costs. To enter an order, we must have a copy of the purchaser's radioisotope license (in the US, at least, this must specify the type of source, manufacturer, and encapsulation), as the manufacturer cannot ship without it.

ALPHA

We use an Am-241 source from Amersham/Searle Corp., 2636 S. Clearbrook Drive, Arlington, IL 60005. The description is: Am-241 alpha foil source, 500 μCi, 12.5 mm active diameter in SIP-1 aluminum alloy case, to be tapped 6-32. This has been quite satisfactory. Cm-244, with a halflife of 18 years and 5.8 MeV alpha energy, is reported to be available from some manufacturers now, and if not too expensive, would be a better choice for irradiation of samples in air.

BETA

Some years back we purchased a Sr-90 source from Amersham/Searle (100 mCi in SIP-1 case, 12.5 mm active diameter), but this is no longer available in the US. We have heard that this source may still be obtained in Europe from the Radiochemical Centre, Amersham, Bucks., England. Recently we purchased for our own use another Sr-90 source (100 mCi with 6.3 mm active diameter) and installed it in our 740 beta irradiator. At a 15 mm source-to-sample distance, there is a 5-10 per cent falloff in intensity at the edge of a 9.5 mm disk. While this is satisfactory for authenticity work, for more demanding dating the larger diameter Amersham source is to be preferred for its better uniformity. Alternatively, the source-to-sample distance could be increased for the smaller source at a penalty of decreased dose rate to the sample. The 6.3 mm source was obtained from ICN Radiopharmaceuticals, Inc., Chemical and Radioisotope Division, 2727 Campus Drive, Irvine, CA 92715, as their model 75129 Sr-90 100 mCi in BS capsule, no handle, no shield, tapped 10-24 in back. Another possible source of Sr-90 which might make up a custom sealed source at reasonable cost is Isotope Product Laboratories, 1800 N. Keystone St., Burbank, CA 91504.

U.S. RADIOISOTOPE LICENSES

A license to possess and use radioisotope sources is required before they can be shipped to you by the manufacturer. You should contact the USNRC or your state nuclear regulatory agency for information. In addition to information about the sources you intend to use and their application, you must submit a very detailed radiation safety program. We can offer advice on this from our own experience. Licensing takes time, so start about six months before you expect to need the sources. Some states may be faster than the federal government, and if you are a university lab, you may be able to get in under an existing blanket university license.

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

PRODUCT DESCRIPTION

MODEL 9900 COMPUTER SYSTEM FOR TL DATA ANALYSIS

The Daybreak 9900 computer system integrates with the Daybreak TL system to record glowcurves on floppy disk media, to reduce these glowcurves to equivalent dose, intercept, and alpha efficiency measurements, and to compute TL age with complete error analysis. Raw or background-subtracted data may be plotted on the system xy recorder or on the graphics printer (with optional printer/plotter). A useful TL utility package is callable by user programs from the system library. As a bonus, the 9900 may also be used as a general purpose scientific computer with outstanding graphics capabilities.

COMPUTER HARDWARE

The computer system is based on the powerful Apple II microcomputer running the UCSD Pascal language and operating system in 64Kbytes of memory. Two 5.25" double density floppy disk drives are included, together with a high quality black and white video monitor for the high resolution graphics display (280x192 dots), and an 80-column line printer. As an option, the standard printer may be replaced with a printer/plotter having dot graphics capability and software for 560x386 plots. The 900 interface with 910 cable/parallel drive card is also included.

900 INTERFACE

The model 900 interface provides the means of communication between the TL system and the computer, transfering information to the computer for glowcurve recording, and from the computer, via DACs, to the system xy recorder. It 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 900 is housed in a 3 inch Daybreak system module which occupies slot 4 or 5 of the 501 module cage. Power requirement is 115/230 VAC, 15W.

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 locations in the computer address space. There are nine basic functions:

READ STATUS (addr=0). When this address is read, the status byte (DATA READY, RAMP ON, RAMP CLOCK, FIRST RAMP, PEN READY, and three expansion bits) is put onto the data bus.

READ COUNTER (addr=16). When DATA READY goes high, the first byte of the photon counter is available for reading. Subsequent reads access the other counter bytes sequentially.

WRITE DAC LATCH (addr=64,80,96,112). Data present on the data bus is written into the chosen DAC latch (Xhigh, Xlow, Yhigh, Ylow).

PEN MODE (addr=128+penstate). Penstate=0 causes the xy recorder pen to drop if graphics mode is invoked (otherwise, the 520

temperature control is in control).

MOVE INCREMENTALLY (addr=certain of 144-159). The x and y DAC registers increment or decrement in combination to produce pen motion in one of eight directions.

SET DATA SPACING (addr=160+N where N=1-15 is the spacing ^{o}C/point). DATA READY goes high every N RAMP CLOCK pulses.

MODE (addr=176 for data acquistion, 177 for graphics). This function controls the electronic switching of signals going to the xy recorder.

SYSTEM RESET (addr=224). Initializes interface.

RAMP START (addr=240). Starts the 520 ramp.

An optional plug-in board enables the 900 to generate a ramp voltage (0 to 5 or 10V) and emulates the 520 control signals so that the interface can accommodate non-Daybreak TL apparatus.

The interface function is completed by the 910 cable/driver card which plugs into the Apple II.

COMPUTER SOFTWARE

Applications software has been written in UCSD Pascal, a fast, block structured compiled language which is becoming the stadard for serious programming of small computers. The Pascal operating system included is extremely versatile and easy to use. FORTRAN is available as an option for user programs.

The Daybreak 9900 software package includes a number of highly interactive programs for data taking, for dose and date computations, and for incorporation into user programs. They are written to be immediately usable by someone with a knowledge of thermoluminescence but with no special know - ledge or experience regarding computers.

The major program, TLAPPLIC, takes glowcurve data and records it on disk, and afterwards processes it to obtain plateau information, equivalent dose, and alpha efficiency, while providing useful hard-copy plots as desired. Version I.0 takes data in the format of 100 point arrays, 5^{o}C/point, while soon to be released versions will accommodate 250 points at 2^{o}C/point and 140 points at 5^{o}C/point. A second program, TLDATE, computes the TL age and errors according to Aitken (Archaeometry 18(2), 233 (1976)) with all correction through June 1980 (Aitken, private communication). A file editing program, TLEDIT, is provided to correct data entry errors and to merge files. Lastly, a set of utility routines for control of the interface and for plotting resides in the system library for use by user Pascal programs.

TLAPPLIC has two major functions. The first is data taking. Very little beyond the usual set up time for a glowcurve is required to enter runtime information. Data for sample ID, irradiation source information, and general running parameters is entered, mostly menu-fashion with single keystrokes, on openning a new data file. For each glowcurve, a run type (N, N+Beta, etc.), irradiation time if applicable, and optional remark are entered before starting the ramp. A very useful feature is automatic entry of the background glowcurve without operator intervention.

The second, and much more complex, function of TLAPPLIC is data reduction. Currently, up to 50 glowcurves (25 TL curves maximum, 25 back-

ground curves maximum) 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 put on the video display at several points in the program for reference. The operator may then look over the raw data, and plot on the system xy recorder or optional printer/plotter as desired. Background subtraction is then performed, with automatic correction for the temperature shifts that can occur at high ramp rates because of variable contact of the sample disk with the heating plate. Because of this possibility, it is usually recommended that a background be recorded with every TL glowcurve; the automatic background ramp feature combined with the fast cooling rate of the Daybreak 700 glow oven facilitate this. The subtracted glowcurves are written onto their own disk file for further use, and may be inspected and plotted. The plateau and integration procedures operate on this data. The plateau is computed in the usual fashion, but up to five each of N and N+Beta curves may be averaged together for the plateau. Once a region, or regions, of interest have been chosen, the integrals are found, and sorted out according to irradiation type and dose. Categories are N, N+Beta (up to five different doses), N+Alpha (up to three different doses), and all Beta curves together for second glows. Up to eight curves in each category are supported. The integrals in each category together with their average and standard deviation are displayed and printed, and bad data may be discarded. Once done for all categories, the equivalent dose and alpha efficiency are computed for all dose combinations. Second glow integrals, and their values normalized to the accompanying N integrals are computed for intercept determination.

In order to run such a large program as TLAPPLIC in the environment of a small computer, a sophisticated memory overlay technique was employed. Only that segment of the program actually in use resides in memory, being read off disk when needed.

TLDATE follows the method of Aitken very closely, and the program text file is included for alteration as required by the user's special 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 file is under 15 minutes, plus plotting time, and an age computation using TLDATE should be less than five minutes.

Except for TLDATE, software is provided in binary form only. Special programming and customer assistance is available, and software updates for one year after installation will be provided free of charge (except for air shipment).

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

PRICE LIST

1 August 1980

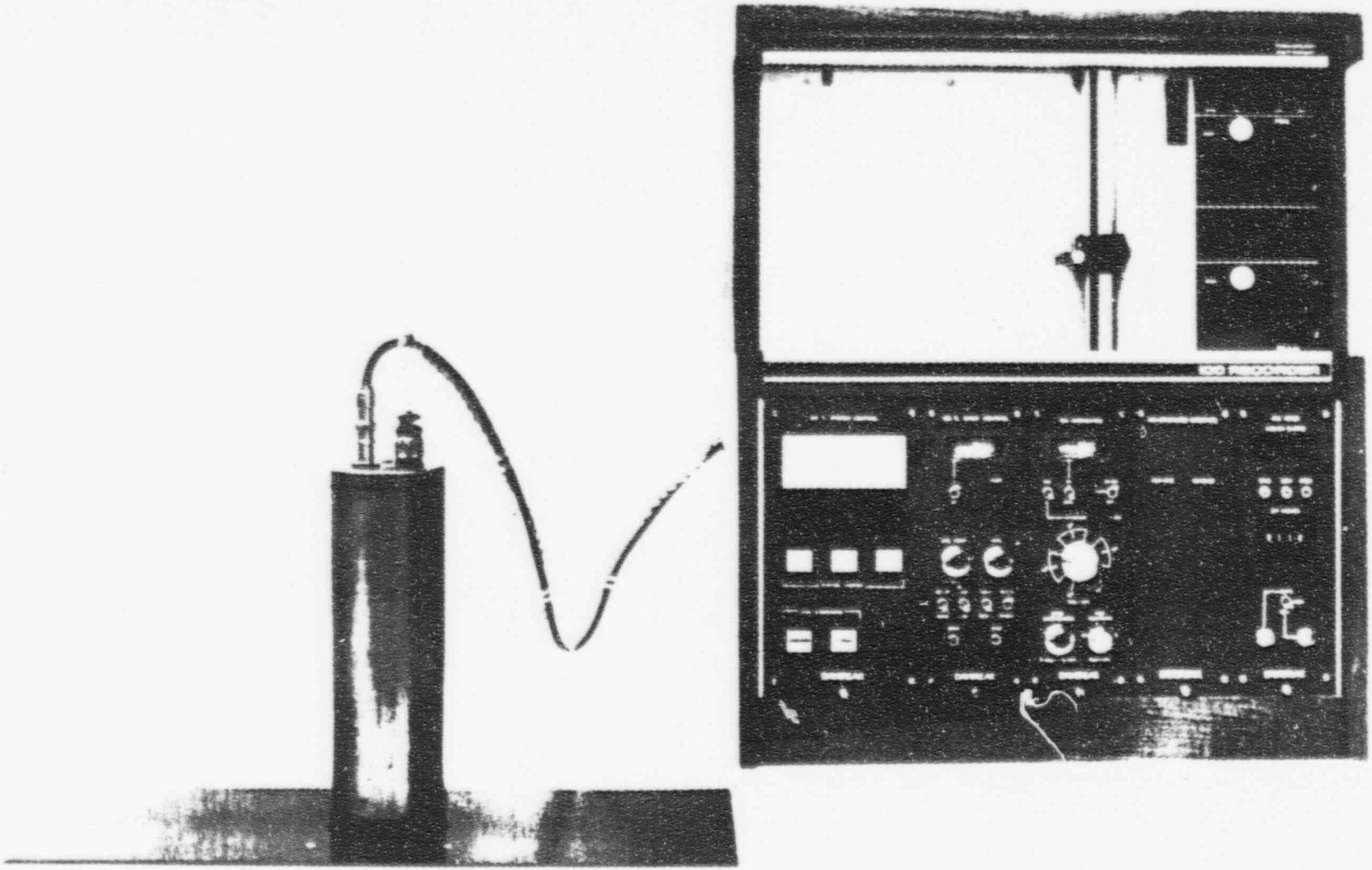
Prices subject to change without notice. Prices in $US.

501	System enclosure	625
502	Desk fitted out for TL system	450/575
503	Separate alpha counter enclosure	420
510	TL system controller (220VAC, +$35)	1125
520	Temperature controller	1700
521	AC power control	175
530	Photon amplifier/discriminator	430
540	Photon ratemeter	1875
580	Alpha counter	1875
581	as 580, but with pairs counter	2000
590	Irradiation timer	825
700	Glow oven	2700
720	PMT housing with EMI 96358 and 530 amp/disc	2000
740	Beta irradiator, less source	650
750	Alpha irradiator, less source	525
760	Vacuum alpha irradiator, less source	775
800	Multiple sample beta irradiator, less source	5250
801	as 800, with additional provision for alpha source	5750
900/910	Computer interface with Apple II card/cable	3250
9900	Computer system	12,850
	Graphics printer option	800
	Module service cable	75
	NIM or rackmount option, per module	60
	Basic TL system	14,650

A wide range of TL sytem accessories is available from Daybreak. Details and prices on request.

All items F.O.B. North Branford, CT (plus crating where applicable). Delivery 60 days on modules, 120 days on mechanical assemblies and systems.

37 North Street, North Branford, CT 06471 (203) 481-3970



DAYBREAK
systems for TL dating

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Enclosure from 1981 Report

THERMOLUMINESCENCE DOSIMETRY IN MEDICINE AND ARCHAEOLOGY

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WHEN certain minerals and other crystalline materials are exposed to ionizing radiation and subsequently heated they emit light. This phenomenon is known as thermoluminescence (TL). Electrons dislodged by the ionizing radiation are attracted to crystal-lattice defects, called electron traps, and accumulate there. The application of heat agitates the lattice and empties the traps, each electron giving off a photon as it recombines with a lattice atom. This light may be detected in the laboratory by a photomultiplier tube, amplified, and recorded along with the temperature to produce a "glow curve" (Figure 1). The TL observed is a measure of the total dose of radiation absorbed by the phosphor since it was last heated and can be evalu-

This study was supported by the Hoffman Radiation Research Fund, N. Y., N. Y.

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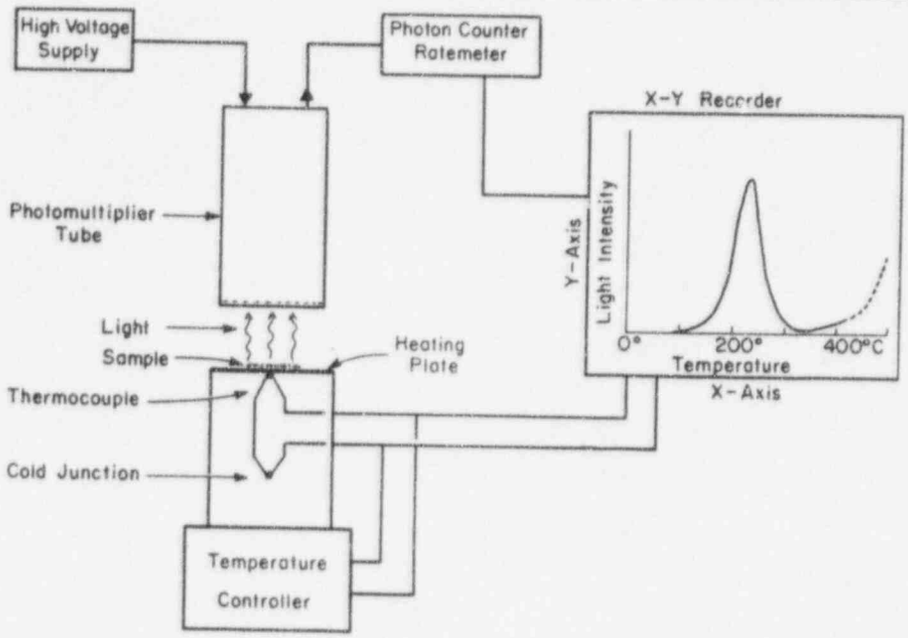

Fig. 1. TL measurement apparatus. A sample of lithium fluoride which has been exposed to Co^{60} gamma rays is placed on a nichrome plate and heated electrically at a rate of 20°C./sec. Light emitted by the sample is detected by the photomultiplier tube and plotted on the y axis of an x-y recorder, while the temperature is recorded on the x axis. The height of the peak is proportional to the dose of radiation. When the sample is heated a second time ony the thermal background ("red-hot glow") appearing above 400°C. is recorded.

ated in rads (1 rad = 100 ergs of absorbed energy/gram) if the TL sensitivity of the phosphor is determined by means of a calibrated radioisotope source.

Thermoluminescence was first described by the British scientist Robert Boyle in the 17th century, but it has been put to extensive use in radiation dosimetry only during the past 20 years. Perhaps the most dramatic of these applications was the determination of the distribution of the radiation that emanated from the atomic bombs dropped on Hiroshima and Nagasaki.[1] By heating small samples of ceramic roof tiles from these cities the TL induced by the bombing was measured. The dose of radiation was then estimated by comparison with the TL in the sample by a known dose of gamma rays.

Soon after the potential of TL dosimetry became apparent, commercial dosimeter systems were developed to measure on a routine basis the exposure of laboratory personnel to radiation and the radiation dose absorbed by patients being treated for cancer. The thermoluminescent

ial used most widely for these purposes is lithium fluoride by v of its tissue equivalence: that is, its absorbed dose to exposure relation closely matches that of human tissue at the x-ray and gamma energies usually encountered. The material may be used to measure doses from a few thousandths of a rad to several thousand rads. Other substances such as calcium sulfate with rare earth metal impurities and natural fluorite are much more sensitive but require special shielding techniques modifying their energy dependence to produce tissue equivalence.

TL dosimetry has been studied extensively in our city by Bernard Roswit and his colleagues at the Veterans Administration Hospital in the Bronx. These investigators have inserted miniaturized dosimeters into many organs, blood vessels, and bronchi, in order to measure directly the absorbed dose in patients treated with external beams of radiation.[2]

Direct measurements *in vivo* are especially important when, for biological reasons, the usual estimates are inaccurate. It is especially difficult to calculate or estimate the dose of radiation absorbed by a given tissue when the uptake of radioactive material is not uniform as, for example, in the thyroid and the liver.[3] Miniaturized dosimeters placed within the patient are also of value in checking computer simulation of dose distribution in the treatment of uterine cancer by means of intracavitary radiation.

The pioneering work of Daniels in the late 1940s and early 1950s in search of good materials for dosimetry had shown that of several thousand mineral samples tested, more than half—the major clay-forming minerals among them—had thermoluminescent properties.[4] Daniels then predicted that TL dating of ceramics was possible, but it was not until 1959 that the potential of the technique was appreciated.[5] Since then a great research effort has been mounted both here and abroad,[6-9] the most notable success having been achieved by Aitken and his co-workers at the Research Laboratory for Archaeology and the History of Art, Oxford.[6, 11, 12] We ourselves have recently begun TL dating of ancient pottery in addition to our work in clinical TL dosimetry at The Mount Sinai Hospital.

Pottery is made by firing clay in a kiln to a temperature of 600-1000°C. This empties all the electron traps in the clay, in effect setting the TL "clock" to zero. Over a period of years ionizing radiation from

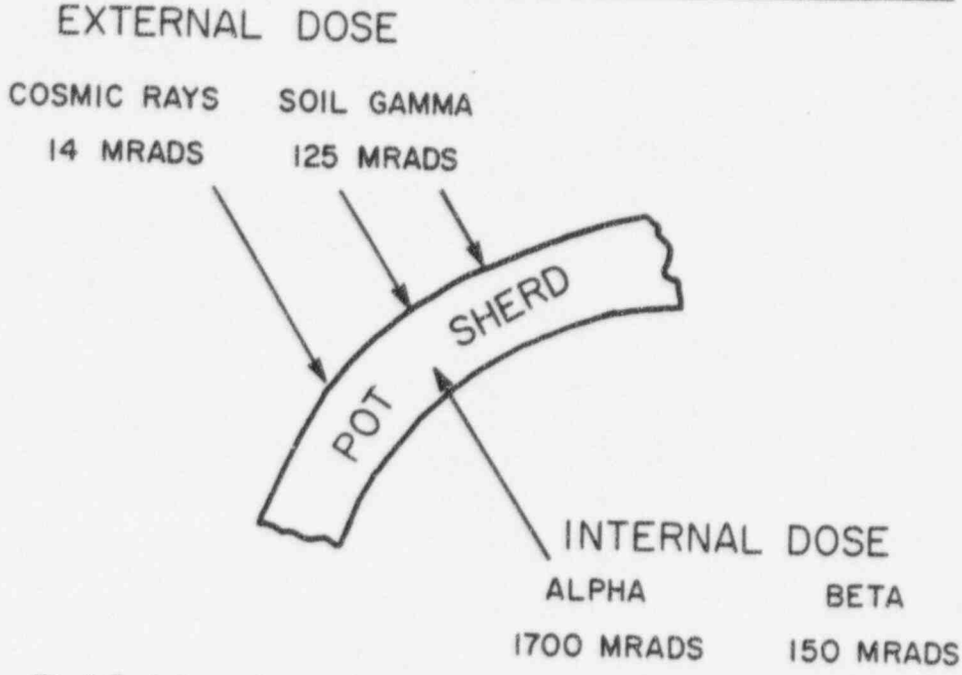

Fig. 2. Typical annual radiation dose for a potsherd buried in soil; both pot and soil have uranium and thorium series contents of 3 and 12 ppm., respectively, and K_2O 1%. The total dose is 1,989 mrads, but as the TL efficiency of alpha particles is typically about ... % that of betas and gammas, the *effective* dose is 629 mrads (54% alpha, 24% beta, and 22% gamma).

sources inside and outside a buried pottery sherd gradually fills the traps. If the radiation dose rate (rads per year) is known, and the dose absorbed by the pottery is estimated from the TL, then the length of time since the pottery was last fired is given by the simple expression,

$$\text{age (years)} = \frac{\text{accumulated dose (rads)}}{\text{dose rate (rads/year)}}$$

The radiation environment of a typical sherd is shown in Figure 2. A few parts per million of the uranium and thorium radioactive series and potassium 40 are present in both pottery and burial soil. Since alpha and beta particles have ranges that are short in comparison to the dimensions of a sherd, the alpha and beta doses absorbed, except in a thin surface layer, are due solely to radioactivity within the sherd. Penetrating gamma rays from the soil around the pottery and a small contribution from cosmic rays comprise the remainder of the dose.

The uranium and thorium content of pottery and soil is measured in the laboratory by alpha counting and the potassium content by flame photometry. As shown in Figure 2, the major part of the dose is derived

from alpha particles. However, these are typically a tenth to a third as effective as beta and gamma rays in producing TL. Hence in the denominator of the age equation above, one uses an effective dose rate in which the dose from alpha particles is multiplied by their relative TL efficiency. A method of measuring environmental gamma radiation directly makes use of sensitive TL dosimeters buried at the archaeological site for a period of weeks or months, long enough to accumulate a measurable dose.[10]

TL dating was originally conceived as a simple, accurate, straightforward technique, but it has proved to be as complex as radiocarbon dating, or even more so. The difficulties stem in part from the inhomogeneity of the pottery, which is a mixture of fine opaque clay grains and coarser sand inclusions, some added as "temper" by the potter to improve the working qualities of the clay. Most of the alpha radioactivity of the clay is contained in the fine grains, but the TL is due mainly to the less radioactive inclusions. Since the range of the alpha particles (20 to 50 μ) is less than the diameter of the larger inclusions, the dose absorbed varies with the size of the inclusions. Hence TL measurements of the aggregate clay will be misleading.

To avoid this problem, one may select either the larger inclusions (above 100 μ diameter) which have a negligible alpha dose but which have all absorbed the same beta and environmental gamma doses,[11] or the fine grains which have received the full alpha dose.[12] In the latter alternative, errors due to uncertainties in environmental radiation are minimized (since the internal dose rate is effectively increased) and preparation and handling of the sample are simpler. At present we are using the Oxford fine-grain technique, as outlined below.

About a gram of pottery is crushed gently in a vise. The fine grains (up to 10 μ in diameter) are selected by their sedimentation time in acetone and are deposited as a film of powder on a number of small aluminum discs—about 1 mg. of sample on each disc. Each is placed on a heating plate, heated rapidly (20°C./sec.), and the TL-glow curve is recorded. Some of the sample discs are first exposed to known doses of beta and alpha radiation in order to obtain standards for sensitivity calibration and to determine the relative efficiency of these particles in inducing TL in the sample. The calibration exposures are made prior to heating, as the sample characteristics may be changed by heat treatment. The remainder of the sample is used to determine the content of radio-

Fig. 8. A Mochica (Peru) jar depicting a man chewing coca, said to date from 450 to 650 A.D. Its height is 27 cm.

active material in the sherd. The amount of uranium and thorium radioactivity is determined by alpha counting, and the alpha and beta contribution to the dose rate is calculated, taking into account radon losses, attenuation of radiation by absorbed water in the pottery, and other effects. Flame photometry yields the weight fraction of K_2O from

which the potassium 40 beta dose is computed. The environmental gamma dose rate must be measured, or uncertainties up to about 30% can result. In test programs, the Oxford group has obtained dates that differ typically by only 5 to 10% from the radiocarbon age of the layer containing the sherds.

Since deceptive reproductions or fakes are now flooding the museums and galleries of the world, authentication of the age of ancient pottery is becoming increasingly important. TL dating provides the museum curator or private collector with a means of ascertaining age absolutely. This is especially important when a piece is stylistically questionable.

If a ceramic piece is valuable, approximate determination of age (i.e., whether the specimen is authentic or is a recent forgery) may be performed on a fairly small sample, 25 to 50 mg., obtained by drilling a 2-mm. hole in the object at an inconspicuous place. Since the drilled sample is a mixture of fine grains and broken-up inclusions, it will not have received the full alpha dose, and one must make some assumption about the fraction absorbed. Satisfactory results have been obtained by assuming that the relative TL efficiency of alpha to beta radiation is one half its measured value.[13] If the sample has been heated appreciably during the drilling, some of the TL will drain away, reducing the apparent dose and hence the age. However, even in rather hard ceramics the temperature reached in drilling is insufficient to affect the high-temperature part of the glow curve used in the TL analysis[14] (Figure 4).

As examples of authenticity testing, we present two typical cases.

1) *Mochica figure jar (Peru).* The jar shown in Figure 3 is modeled in the form of a man who appears to be adjusting a wad of coca leaves in his mouth, or perhaps applying some lime to it with a small spatula. In his left hand he carries a pouch containing his supply of the drug. This piece is dated stylistically 450-650 A.D. A small sample (25 mg.) was drilled from its base; the fine grains were separated for TL analysis, the remainder used for alpha counting. The accumulated dose was found to be 592 rads by comparison with a known beta dose, as shown in Figure 4. The relative TL efficiency of alpha to beta radiation is 0.23, but it is assumed to be half that, 0.11, to allow for the presence of broken-up inclusions in the sample.

The uranium and thorium content of the clay was determined by the thick-source counting method of Turner,[15] and the resulting dose

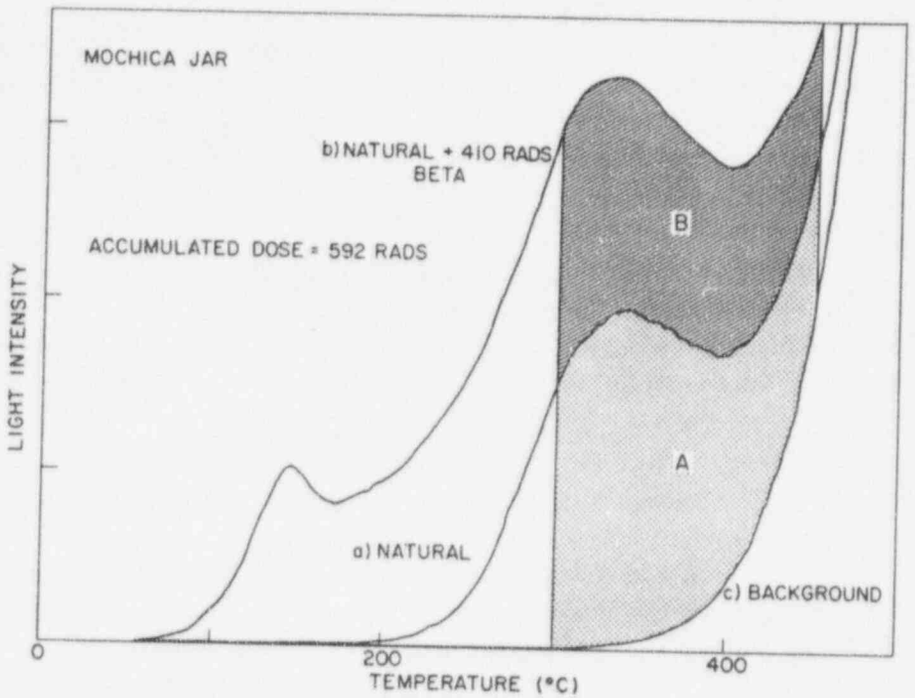

Fig. 4. The thermoluminescent glow curve of the jar shown in Figure 2. The intensity of light emitted by the sample is plotted against temperature. Curve *a* is the natural thermoluminescence of the pottery, curve *b* is that due to the natural accumulated dose plus an additional 410 rad Sr^{90} beta dose, and *c* is the thermal background. Thus area A corresponds to the natural dose, while area B corresponds to the calibration dose alone. The ratio of the two areas determines the natural accumulated dose of the pottery, in this case 592 rads. The effective annual dose is 0.53 rads, giving the piece an age of 1,120 years, consistent with its purported date.

Since the low-temperature part of the TL-glow curve is subject to decay at normal environmental temperatures, its shape will differ markedly between a fresh dose of radiation and one that had accumulated over the course of centuries. It is therefore necessary to choose for analysis only the temperature region where the glow curve is thermally stable. This region is conveniently found by taking the ratio of the natural glow curve and the natural plus calibration dose glow curve. At some temperature the ratio will reach a plateau, indicating that the two curves have the same shape. The region above this temperature is thermally stable.

rates were found to be 1.82 rads/year alpha, and 0.074 rad/year beta. Some soil still adhering to the interior of the jar was analyzed in the same way and gave an environmental gamma-dose rate of 0.115 rad/year plus an estimated dose rate of 0.014 rad/year due to cosmic rays. The K_2O content of the pottery was not measured but was assumed to be 2%, contributing 0.142 rad/year. The total dose rate then is 2.17 rads/year; the *effective* dose rate is 0.53 rad/year (35% alpha, 40% beta, and 24% gamma).

The TL age of the object therefore is 1,120 years (the accumu-

Fig. 5. Monte Albán-type votive incense burner considered to be fake, but dating from C. 900 A.D. if genuine. Its height is 12 cm.

lated dose of 592 rads divided by the effective dose rate of 0.53 rad/year), consistent with the presumed date. The precision here is limited to an estimated ± 40%, but the minimum age of 670 years still indicates that the piece is authentic, since forgeries of this type of pottery were not made until the present century.

2) *Incense burner from Monte Albán (Mexico).* The mold-made votive incense burner in Figure 5 is in a decadent Monte Albán style, and on stylistic grounds was considered probably fraudulent. The manner of firing, however, suggested that the piece might in fact be genu-

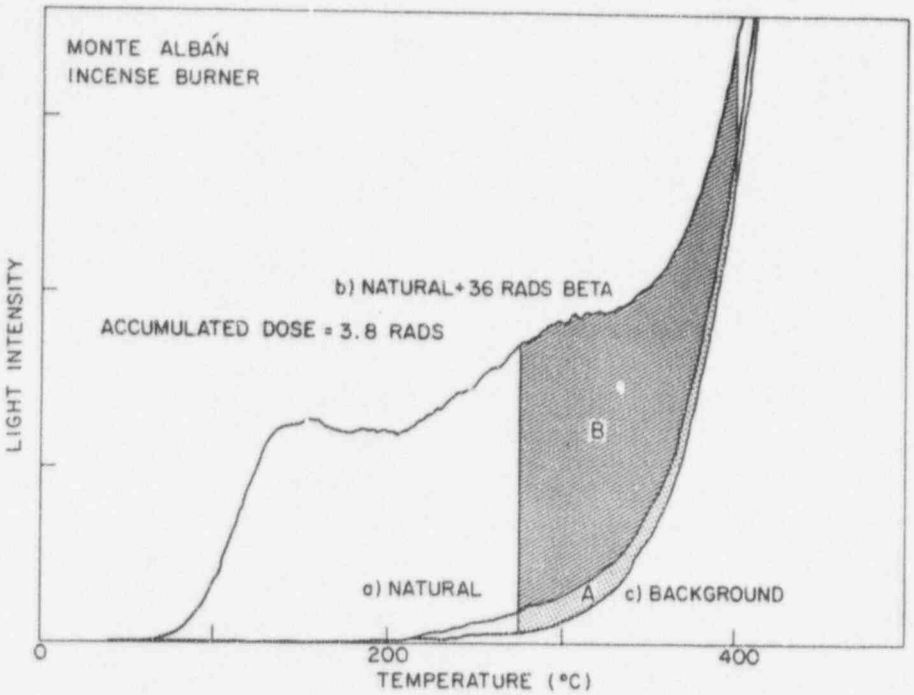

Fig. 6. The TL-glow curve of the figurine shown in Figure 4. The curves are labeled as in Figure 3. Here the calibration dose is 36 rads, and the equivalent beta dose is 3.8 rads. Even if the only source of radiation were cosmic rays, the figure could be no older than 270 years. Since the typical effective dose rate to pottery is 0.5 rad/year, the actual age of this piece is about eight years. The object has definitely been fired recently.

ine, though of poor quality, and thus about 1,100 years old. TL analysis of a small drilled sample indicated that the accumulated dose is only 3.8 rads (Figure 6). At the least, the dose rate is 0.014 rad/year from cosmic rays and the maximum age is just 270 years. The object has been recently fired and is without doubt a fake. In such cases as this, it is unnecessary to proceed further with radioactivity measurements. Since the typical effective dose rate is about 0.5 rad/year, the actual age of the object is only about eight years.

TL dating of pottery will not replace radiocarbon dating. It is not yet sufficiently accurate to shed light on many of the problems of interest to the archaeologist, and it cannot be used beyond 9,000 years ago, when pottery first was manufactured, except in isolated early occurrences of burnt clay. Other materials, such as burnt flints, have been used, but these are comparatively rare. There are, however, many other problems, especially in New World archaeology, in which the tech-

nique will prove useful. This is particularly true when no organic material for radiocarbon dating is encountered in an excavation. Pottery is almost always found in abundance. Besides supplementing the archaeologist's information on dating by stratigraphy, radiocarbon, and tree rings, TL can distinguish fakes from originals and, with some limitations in accuracy, objects of unknown provenance can be dated.

At present there are few thermoluminescence laboratories that undertake the dating of ancient ceramics, while there are many equipped to make dose determinations of radiation in medicine. But TL dating is a young field, and when the complexities of thermoluminescence in ceramic materials become better understood, authentication of an ancient pot may one day be as simple as the determination of the dose of radiation in the bladder of the patient treated with radioactive material for cancer of the cervix or the uterus.

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sample material yourself.

We request that all samples be submitted with an information form, available on request, and two photographs. One photo is retained in our files for future reference; the other is annotated with the test result, signed, and returned with the test report. A Polaroid snapshot is adequate; it is necessary only that the object be readily identified from its picture. If the sample is taken other than by Daybreak or its representative, it is recommended that the sampling be witnessed (as provided for on the sample submission form), asserting that the sample is indeed from the piece depicted in the photo. Otherwise, the test report must state that the object submitted is "a chip (or powder) sample said to be from a _____ of the _____ culture."

It is extremely important to note if the piece is known or is suspected to have been exposed to x-rays or neutrons, as this would alter the result. Also, if the piece has been heated for some purpose during restoration, TL results may be affected. In either case, consultation is required to determine whether the object can be accepted for test.

Please be assured that all information about objects submitted is held in the strictest confidence.

HOW LONG DOES IT TAKE?

Usually test results are available within two or three days after sampling, and the final written report within a week. If there is a necessity for immediate results, arrangements can be made for an answer within 12 hours.

WHAT IS THE COST OF A TL TEST?

We charge $180 per object submitted for routine authenticity testing, covering multiple samples from a piece if required. In the rare event that no reliable date can be obtained for an object, a substantial reduction is made in this fee.

Quantity rates are available to those in frequent need of this service. We offer a pre-payment plan, eight tests for $1200 without time limit, and reduced rates for large numbers of objects submitted at one time: $150 per test (5-9), and $130 (10-up).

If you have need of any further information, please contact Dr. Victor Bortolot, our director of research.

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THERMOLUMINESCENCE

AUTHENTICITY TESTING

DAYBREAK
Nuclear and Medical Systems, Inc.

37 North St.
North Branford, CT 06471
(203) 481-3970

Brochure from 1981 Archaeology

HOW DOES THERMOLUMINESCENCE DATING WORK?

The thermoluminescence technique is the only physical means of determining the age of pottery presently available. It is an absolute dating method, and does not depend on comparison with similar objects (as does obsidian hydration dating, for example).

Most mineral materials, including the constituents of pottery, have the property of thermoluminescence (TL), where part of the energy from radioactive decay in and around the mineral is stored and later released in the form of light upon strong heating. By comparing this light output with that induced by known calibration doses of radiation, the amount of radiation absorbed by the material may be found.

When pottery is fired, it loses all its previously acquired TL, and the TL begins again to build up on cooling. Thus, when one measures dose in pottery, it is the dose accumulated since it was fired, unless there was subsequent reheating. If the radioactivity of the pottery itself, and its surroundings, is measured, the dose rate, or annual increment of dose, may be computed. The age of the pottery, in principle, may then be determined by the relation

$$\text{AGE} = \frac{\text{ACCUMULATED DOSE}}{\text{DOSE PER YEAR}}$$

Although conceptually straightforward, TL has proven to be far from simple in practice. In all, about a dozen physical quantities must be accurately measured to establish the relationship between doses of different kinds of radiation and light output, and to compute dose rate. A leaflet from Daybreak describing the TL technique in more detail and giving a bibliography will be provided to interested persons.

The phenomenon of thermoluminescence was first described by the English chemist Robert Boyle in 1663. It was employed in the 1950's as a method for radiation dose measurement, and soon proposed for archaeological dating. By the mid-1960's, its validity as an absolute dating technique was established by workers at Oxford and Birmingham in England, Risö in Denmark, and the University of Pennsylvania in the U.S. The Research Laboratory for Archaeology at Oxford, in particular, has been a leader in TL research.

While not so accurate as radiocarbon dating, which cannot date pottery, TL has found considerable usefulness in the authenticity testing of ceramic art objects where high precision is not necessary.

Since the university laboratories involved with TL are research facilities, they generally will not accept art objects for authentication on a routine basis. The TL laboratory at Daybreak was established to make TL available to the art community in general.

WHAT IS THE ACCURACY OF TL DATING?

Studies at Oxford indicate that when all quantities entering the age equation are measured, the TL date of a single potsherd will typically fall within 15 per cent of the known date. When dates of a number of sherds associated together are averaged, the error is reduced typically to 7-10 per cent.

Unfortunately, it is not possible to achieve this precision for the majority of art objects. Among the reasons for this is the small amount of material that may be taken for testing. Drilling, the usual method of sampling, introduces some uncertainty. It is also rare that any information about the radiation from the burial soil can be obtained, as art objects are usually thoroughly cleaned. This radiation may in some cases contribute over half the total dose. Finally, one has to make measurements whether the clay is well-behaved or not. Some clays are hardly thermoluminescent; some may not have a straight-line relationship between dose and TL; spurious luminescence due to chemical or pressure effects may mask the radiation-induced TL; occasionally, a condition called "anomalous fading" may lessen the reliability of the dose measurement.

Generally speaking, when a sample is drilled and no burial soil is found on the piece, one may expect up to 40-50 per cent uncertainty. This is adequate for the purposes of authentication where the question is whether the piece was fired in antiquity or recently; it will not differentiate, say, between a classic Greek terra cotta and a Roman copy.

WHAT MATERIALS CAN BE DATED BY TL?

Nearly any mineral material which has been heated above 500°C at a time one wishes to know is a candidate for TL dating. This includes all forms of pottery. Porcelains, however, are often not thermoluminescent to a useful degree and are extremely hard to sample, but some early proto-porcelains which are neither so pure nor hard as the later ware have been dated. The clay cores from lost wax metal castings may readily be tested. Heated stone material, such as hearths, pot boilers, and burnt flints, have been dated as well.

HOW IS A SAMPLE TAKEN?

When the TL test is for routine authentication, a sample of about 100 mg, roughly the size of a pencil-end eraser, is drilled out of an inconspicuous part of the object with a carbide dental burr. If the object is extremely small, some reduction in sample size can be tolerated with an accompanying increase in error margin. It is preferable, whenever possible, to obtain a fragment the size of a nickel and ¼" thick, as the precision attainable is better. This is necessary whenever the age, if genuine, is less than twice that of the earliest forgeries.

If the object to be tested has been restored, it is usually advisable to take a number of samples, as the component parts may differ in age.

Any burial dirt clinging to the object should be saved, as it will help improve dating precision.

Sampling does not lessen the value of a piece; indeed, proof of authenticity by TL generally enhances an object's value considerably. The site of the sample may easily be restored if desired.

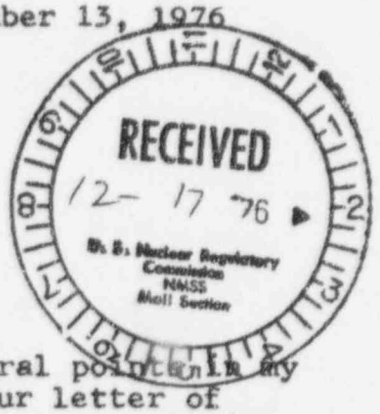
HOW IS AN OBJECT SUBMITTED FOR A TL TEST?

First, you should contact Daybreak to discuss the advisability of testing and to arrange sample-taking. We make regular trips to New York City for this purpose; travel elsewhere is by arrangement. You may also bring the piece to Daybreak, located just outside New Haven, CT. If these alternatives are not practical, we will provide detailed instructions for obtaining the

Wright 367

VICTOR J. BORTOLOT 37 North Street North Branford, CT 06471 (203) 481-3970

December 13, 1976



Mr. Earl G. Wright
U.S. Nuclear Regulatory Commission
Radioisotopes Licensing Branch
Division of Fuel Cycle and Material Safety
Washington, D.C. 20555

Dear Mr. Wright;

This letter is intended to clarify several points in my application (control no. 84200) raised in your letter of November 24, 1976. My responses will follow your numbering.

1. The americium-241 source is ICN model 74101. The number given in the application was that of the capsule type. The source will be stored and used in a shield fixture as shown in Figure 1. The 60 KeV gamma component will be used as a calibration for TLD personnel monitoring. The surface exposure rate on the device is anticipated to be less than 1 mR/hr. A wipe test on the exposure device will be made every three months when the source is in use.

2a. The 100 mCi strontium-90 source (ICN 75129) will be stored and used in a shielded device having a solenoid operated spring return shutter. This will guard against mechanical damage and prevent personal contact with the source. A drawing of the proposed device is shown in Figure 2.

A survey was made to determine optimum shutter composition and thickness, given the exposure geometry required. A source identical to the one applied for was located at Yale-New Haven Hospital and was used for this survey. The results have been corrected to a present 100 mCi activity. The source was viewed through various absorbers by an Eberline RO-1 ionization-type survey meter in contact with the absorbing material. The chamber center is 1.75" behind its front surface.

A composite shutter consisting of 1/16" aluminum and 3/16" lead was judged most effective in reducing brehmstralung production and then absorbing it. In the survey geometry described, the exposure rate was 45 mR/hr. The actual device will have a spacing ring which will prevent approach closer than about ½" to the brehmstralung-producing region of the shutter. I estimate that the actual exposure rate at the bottom of this ring will be no more than 100 mR/hr. When not in use, this assembly will sit on a 2" lead brick. The exit exposure rate will be under 10 mR/hr.