NRC FORM 374 (7-94)

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE

Amendment No. 04

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 36, 39, 40, and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

OFFICIAL RECORD COPY

Licensee	
1. Victor J. Bortolot, Ph.D. Bortolot Daybreak Corporation 2. 50 Denison Drive Guilford, Connecticut 06437	In accordance with the letter dated March 20, 1992, 3. License Number 06-17253-01 is amended in its entirety to read as follows:
	4. Expiration Date February 28, 2002
	5. Docket or Reference No. 030-12440

6. Byproduct, Source, and/or Special Nuclear Material	7. Chemical and/or Physical Form	8. Maximum Amount that Licensee May Possess at Any One Time Under This License
A. Strontium 90	A. Sealed source (ICN Pharmaceuticals Inc. Model 75129)	A. Not to exceed 100 millicuries per source and 100 millicuries total
B. Americium 241	B. Sealed source (Amersham/Searle Model AMM)	B. Not to exceed 1 millicurie per source and 1 millicurie total
C. Strontium 90	C. Sealed source (ICN Model 77241)	C. Not to exceed 0.01 microcurie per source and 0.01 microcurie total

9. Authorized use

A and B. For use in devices described in the application dated December 23, 1981, for thermoluminescence sensitivity calibration of materials for the purpose of archeological dating.

C. Calibration reference source.

CONDITIONS

10. Licensed material may be used only at the licensee's facilities located at 50 Denison Drive, Guilford, Connecticut.

11. A. Licensed material shall be used by, or under the supervision of, Victor J. Bortolot.

B. The Radiation Safety Officer for this license is Victor J. Bortolot.

12. This license does not authorize commercial distribution of licensed material.

13. Sealed sources or detector cells containing licensed material shall not be opened or sources removed from source holders by the licensee.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License Number 06-17253-01

Docket or Reference Number 030-12440

Amendment No. 04

14. A. Sealed sources and detector cells containing licensed material shall be tested for leakage and/or contamination at intervals not to exceed six months or at such other intervals as are specified by the certificate of registration referred to in 10 CFR 32.210, not to exceed three years.

B. Notwithstanding Paragraph A of this Condition, sealed sources designed to emit alpha particles shall be tested for leakage and/or contamination at intervals not to exceed three months.

C. In the absence of a certificate from a transferor indicating that a leak test has been made within six months prior to the transfer, a sealed source or detector cell received from another person shall not be put into use until tested.

D. Each sealed source fabricated by the licensee shall be inspected and tested for construction defects, leakage, and contamination prior to any use or transfer as a sealed source.

E. Sealed sources and detector cells need not be leak tested if:

(i) they contain only hydrogen-3; or

(ii) they contain only a radioactive gas; or

(iii) the half-life of the isotope is 30 days or less; or

(iv) they contain not more than 100 microcuries of beta and/or gamma emitting material or not more than 10 microcuries of alpha emitting material; or

(v) they are not designed to emit alpha particles, are in storage, and are not being used. However, when they are removed from storage for use or transfer to another person, and have not been tested within the required leak test interval, they shall be tested before use or transfer. No sealed source or detector cell shall be stored for a period of more than 10 years without being tested for leakage and/or contamination.

F. The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. If the test reveals the presence of 0.005 microcurie or more of removable contamination, a report shall be filed with the U.S. Nuclear Regulatory Commission and the source or detector cell shall be removed immediately from service and decontaminated, repaired, or disposed of in accordance with Commission regulations. The report shall be filed within five days of the date the leak test result is known with the U.S. Nuclear Regulatory Commission, Region I, ATTN: Chief, Nuclear Materials Safety Branch, 475 Allendale Road, King of Prussia, Pennsylvania 19406. The report shall specify the source or detector cell involved, the test results, and corrective action taken.

G. The licensee is authorized to collect leak test samples for analysis by the licensee. Alternatively, tests for leakage and/or contamination may be performed by persons specifically licensed by the Commission or an Agreement State to perform such services.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License Number
06-17253-01

Docket or Reference Number
030-12440

Amendment No. 04

15. The licensee shall conduct a physical inventory every six months to account for all sealed sources and devices containing licensed material received and possessed under the license.

16. The licensee shall not acquire licensed material in a sealed source or device unless the source or device has been registered with the U.S. Nuclear Regulatory Commission pursuant to 10 CFR 32.210 or equivalent regulations of an Agreement State.

17. The licensee is authorized to transport licensed material in accordance with the provisions of 10 CFR Part 71, "Packaging and Transportation of Radioactive Material."

18. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents, including any enclosures, listed below. The Nuclear Regulatory Commission's regulations shall govern unless the statements, representations, and procedures in the licensee's application and correspondence are more restrictive than the regulations.

A. Application dated December 23, 1981
B. Application dated December 24, 1986
C. Letter dated June 10, 1992
D. Letter dated December 11, 1995

For the U.S. Nuclear Regulatory Commission

Date FEB - 3 1997

By Original Signed By:
Elizabeth Ullrich

Division of Nuclear Materials Safety
Region I
King of Prussia, Pennsylvania 19406

FEB - 3 1997

License No. 06-17253-01
Docket No. 030-12440
Control No. 116381

Victor J. Bortolot, Ph.D.
Bortolot Daybreak Corporation
50 Denison Drive
Guilford, Connecticut 06437

Dear Dr. Bortolot:

Please review the enclosed document carefully and be sure that you understand all conditions. If there are any errors or questions, please notify the U.S. Nuclear Regulatory Commission, Region I Office, Licensing Assistance Team, (610) 337-5093 or 5239, so that we can provide appropriate corrections and answers.

Please note that your use of sealed sources was determined to best fit the category of "measurement systems analytical instruments". Although the sources are used to irradiate materials, they do not clearly fit the types, quantities, or hazards typical of the category of "irradiators". The types of radionuclides utilized and the low activities used are more like those used in analytical instruments than irradiators. In addition, due to the low risk involved with the use of these sources in your devices, the licensing and inspection of your activities is performed using guidance for analytical instruments, not the guidance for irradiators.

Please be advised that your license expires at the end of the day, in the month, and year stated in the license. Until your license is terminated, you must conduct your program involving byproduct materials in accordance with the conditions of your NRC license, representations made in your license application, and NRC regulations. In particular, note that you must:

1. Operate in accordance with NRC regulations 10 CFR Part 19, "Notices, Instructions and Reports to Workers; Inspections," 10 CFR Part 20, "Standards for Protection Against Radiation," and other applicable regulations.

2. Notify NRC, in writing, within 30 days:

   a. when an authorized user or Radiation Safety Officer, permanently discontinues performance of duties under the license or has a name change; or

   b. when the mailing address on the license changes (no fee is required if the location of byproduct material remains the same).

3. In accordance with 10 CFR 30.36(b) and/or license condition, notify NRC, promptly, in writing, and request termination of the license when you decide to terminate all activities involving materials authorized under the license.

4. Request and obtain a license amendment before you:

   a. permit anyone to work as an authorized user under the license;

   b. change Radiation Safety Officer;

   c. order byproduct material in excess of the amount, or radionuclide, or form different than authorized on the license;

   d. add or change the areas of use, or address or addresses of use identified in the license application or on the license; or

   e. change ownership of your organization.

5. Submit a complete renewal application with proper fee or termination request at least 30 days before the expiration date of your license. You will receive a reminder notice approximately 90 days before the expiration date. Possession of byproduct material after your license expires is a violation of NRC regulations. A license will not normally be renewed, except on a case-by-case basis, in instances where licensed material has never been possessed or used.

In addition, please note that NRC Form 313 requires the applicant, by his/her signature, to verify that the applicant understands that all statements contained in the application are true and correct to the best of the applicant's knowledge. The signatory for the application should be the licensee or a certifying official of the licensee rather than the Radiation Safety Officer or a consultant.

You will be periodically inspected by the NRC. Failure to conduct your program in accordance with NRC regulations, license conditions, and representations made in your license application and supplemental correspondence with NRC will result in enforcement action against you. This could include issuance of a notice of violation, or imposition of a civil penalty, or an order suspending, modifying or revoking your license as specified in the "General Statement of Policy and Procedure for NRC Enforcement Actions," (Enforcement Policy), NUREG 1600.

Since serious consequences to employees and the public can result from failure to comply with NRC requirements, prompt and vigorous enforcement action will be taken when dealing with licensees who do not achieve the necessary meticulous attention to detail and the high standard of compliance which NRC expects of its licensees.

Thank you for your cooperation.

Sincerely,

Original Signed By:

Elizabeth Ullrich, Senior Health Physicist
Division of Nuclear Materials Safety

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License No. 06-17253-01
Docket No. 030-12440
Control No. 116381

Enclosures:
1. Amendment No. 04
2. 10 CFR Parts 2, 19, 20, 30, 32, 36 and 170
3. NRC Forms 3 and 313

DOCUMENT NAME: R:\WPS\MLTR\L0617253.01
To receive a copy of this document, indicate in the box: "C" = Copy w/o attach/encl "E" = Copy w/ attach/encl "N" = No copy

OFFICE	DNMS/RI	N	DNMS/RI					
NAME	ULLRICH/exu							
DATE	01/31/97		01/ /97		01/ /97		01/ /97	

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 24, 1997

MEMORANDUM TO: John Kinneman, Chief
Nuclear Material Safety Branch
Division of Radiation Safety and Safeguards

FROM: Steven Baggett, Chief
Sealed Source Safety Section
Medical, Academic, and Commercial
Use Safety Branch
Division of Industrial and Medical
Nuclear Safety

SUBJECT: RESPONSE TO TECHNICAL ASSISTANCE REQUEST CONCERNING VICTOR J. BORTOLOT, Ph.D.

This memorandum is in response to your technical assistance request dated April 26, 1994, concerning the devices being used and proposed for use by the licensee, Victor J. Bortolot, Ph.D., License No. 06-17253-01, Control No. 116381. Since the receipt of this request, the Sealed Source Safety Section has corresponded with Dr. Bortolot concerning review and registration of his devices. Two letters were sent to Dr. Bortolot: the first, March 1, 1995, requested additional information on the devices currently in use; and the second, November 16, 1995, requested information within 30 days, otherwise the application would be considered abandoned. Dr. Bortolot responded with a letter dated December 11, 1995, stating that he would like to resubmit the license application renewal in its original form without the additional sources and devices, that is, as submitted in his previous license renewals.

The technical assistance request contained three requests for assistance in properly categorizing and authorizing the activities of Dr. Bortolot's license. These requests and responses are as follows:

1. Please confirm the categorization of the two devices currently in use by Dr. Bortolot. The devices are categorized as "measurement instruments," however, Dr. Bortolot believes they should be categorized as "irradiators."

Response:

The two devices utilized by Dr. Bortolot more closely meet the classification of "Irradiators Self Shielded Less Than 10,000 Curies," Program Code 03510. These devices are designed to irradiate materials. Once irradiated, the materials are heated and analyzed using a thermoluminescence measurement system. The radiation utilized does not measure anything. The "measurement" is made subsequent to the irradiation. The radiation is used to alter/modify the material, similar to the purpose of the generic irradiator. However, the isotopes utilized and the low activities are not characteristic of the generic irradiator.

CONTACT: Brian Smith
(301) 415-5723

116381

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thermoluminescence measurement system. The radiation utilized does not measure anything. The "measurement" is made subsequent to the irradiation. The radiation is used to alter/modify the material, similar to the purpose of the generic irradiator. However, the isotopes utilized and the low activities are not characteristic of the generic irradiator.

Measuring systems" are designed to measure resulting radiation levels once the radiation has passed through or backscattered from the material of interest. This measurement then relates to a certain quantity, level, or amount. Also included in measuring systems are gas chromatographes and x-ray fluorescence devices. The two devices used by Dr. Bortolot do not utilize radiation in the same manner as devices classified as "measuring systems."

It is our conclusion that these devices do not fit exactly into either category. After reviewing the information submitted with the 1992 renewal, the two devices used by Dr. Bortolot appear to be adequately designed and the procedures listed for the safe use of these appears sufficient. In addition, Dr. Bortolot states that his annual exposure has not been greater than 250 mR during the term of his current license. Due to the three year inspection period for "irradiators," categorization as "irradiators" would be imprudent and would be a poor use of agency resources. Therefore, due to the low risk involved with the use of these two devices and the more appropriate inspection frequency of once every seven years, the two devices should be categorized as "Measuring Systems Analytical Instruments," Program Code 03122.

2. Please determine if any irradiators, or devices used with the irradiators, require a review. Specifically, the application dated March 20, 1992, contains descriptions of additional devices that may be distributed in the future.

Response:

No, these new irradiators do not need to be reviewed. Dr. Bortolot, in his letter dated December 11, 1995, to Region I with cc to Steven Baggett, stated that he wishes "to re-submit his license application renewal in its original form without the additions, that is, as submitted in 1981 and 1986." In the 1981 and 1986 applications, only two devices are requested to be used in his analytical laboratory. Therefore, since these new devices will neither be used by Dr. Bortolot or distributed to other licensees, a device review is not necessary. However, at such time in the future that Dr. Bortolot determines that he will require the use of these devices or any others, or wishes to distribute these to other licensees, a device review will be required for those models.

3. Please confirm if a device review and registration is necessary for possession and use of the sources in devices in Dr. Bortolot's analytical laboratory as he has been licensed in the past.

Response:

No, review and registration of these devices is not necessary. These two devices have been in Dr. Bortolot's possession and licensed for use since 1981. At the time of obtaining his materials possession and use license, he supplied sufficient safety information on the two devices for the license reviewer to approve their use in Dr. Bortolot's analytical laboratory. The requirements for a licensee to apply for a review and registration of a device became effective in August 1987. In the preamble to the amendment to 10 CFR Parts 30 and 32 incorporating these

requirements, it states that the amendment is merely a codification of current administrative practice and requires no additional action for sources and devices presently used because necessary safety information was evaluated before issuance of the specific license to the user. However, if a user modifies a device currently licensed for use or wishes to manufacture and distribute commercially a new device, a safety review of the device and registration is necessary.

Dr. Bortolot may still distribute the devices commercially without sources since this is outside NRC authority. The purchasers of the devices would be required to apply for a custom review and registration for their devices. We highly discourage this practice. One of his devices, a model 801 sample irradiator, has been reviewed and registered for custom use in the past. However, Dr. Bortolot may continue to distribute his devices with sources commercially to holders of research and development and broad scope licenses. Policy and Guidance Directive 84-22 permits those holders of research and development and broad scope licenses with the license condition to use byproduct material in "any form" to use sealed sources in devices without the device being reviewed and registered.

cc: Ms. Elizabeth Ullrich, Region I

BORTOLOT DAYBREAK

CORPORATION

030-12440

U.S. Nuclear Regulatory Commision, Region I
Nuclear Materials Safety Section B
475 Allendale Road
King of Prussia, PA 19406

11 December 1995

Dear Sirs:

Back in March 1992, I requested renewal of my radioisotopes license 06-17253-01 and paid the appropriate renewal fee. At that time I thought it worthwhile to include additional sources and irradiation devices that might be needed in case of expanded business. Mr. Steven Baggett, of the sealed source safety section in Washington, informed me by letter earlier this year that certificates would be needed for all additional devices. The expense for certification is not justified at this time, and in fact, the need for additional sources and devices has not materialized. I have wished to discuss this with Mr Baggett, but I have been unable in repeated attempts to reach him by phone.

In order to bring the renewal to a conclusion, I wish to re-submit the application in its original form without the additions, that is, as submitted in 1981 and 1986. According to the submission procedure for 1992, only changes from the previous application need be included. Therefore, as you have those earlier applications on file, please use them as the current submission. I understand that no further information is needed at this time.

Please note the change in mailing address: the TL authenticity dating business has been separated from Daybreak Nuclear and Medical Systems for business reasons (though, as the license is mine personally, it doesn't much matter which corporate name is used: I own both).

Thank you very much.

Sincerely,

Victor J. Bortolot, Ph.D.
Technical Director

116381

DEC 18 1995

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cc: Steve Baggett

50 Denison Drive Guilford, CT 06437 USA phone/fax +1 (203) 453-3299

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 16, 1995

Dr. Victor J. Borolot
Daybreak Nuclear and Medical Systems, Inc.
50 Denison Drive
Guilford, CT 06437

Dear Dr. Borolot:

This letter is in response to your letters dated March 4, 1993, and March 20, 1992, requesting registration of the Model TL Measurement System and my letter dated March 1, 1995, which requested additional information in order to continue our evaluation of your request. In addition, a member of my staff called you on September 22, 1995, and informed you that we have not received the requested information. To date, the requested information has not been received. If we do not receive the requested information within (30) days of the date of this letter we will have considered your application as having been abandoned by you. This is without prejudice to the resubmission of a complete application.

If you have any questions, please contact Thomas Rich at (301) 415-7893 or Mr. Steven Baggett at (301) 415-7273.

Sincerely,

Steven L. Baggett, Section Chief
Sealed Source Safety Section
Source Containment and
Devices Branch
Division of Industrial and
Medical Nuclear Safety
Office of Nuclear Material Safety
and Safeguards

cc: SKimberley, LFDCB
Betsy Ullrich, RI

6/10/96 called Tom Rich - left message: What Happened?

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116381
11/21/95

REQUEST FOR A SEALED SOURCE OR DEVICE EVALUATION

Instructions: Send this request AND a copy of all related letters/applications and drawings to: The Sealed Source Safety Section, ATTN: Steven Baggett, OWFN Mail Stop 6-H-3. Change the License Tracking System milestone to I2 and assign to reviewer code I-5. NOTE: Retain a copy of this request with the application and background files.

REQUESTOR: Betsy Ullrich
PHONE NO.: 610-337-5040
APPLICANT'S NAME: Victor J. Bonacci PhD
MAIL CONTROL NO.(S): IIC381

REGION: (I) II III IV V, HQ or LFDCB
DATE: APR 26 1994
LETTER/APPLICATION DATE: 3/20/92
LICENSE NO.(S): 06-17253-01

TYPE OF ACTION REQUESTED (CHECK APPROPRIATE ACTION(S))

( ) SOURCE REVIEW (X) DEVICE REVIEW ( ) CUSTOM REVIEW
( ) AMENDMENT OF REGISTRATION SHEET NO.(S) _____

COMMENTS: Please see attached

FOR SSSS USE ONLY

DATE RECEIVED: _____ ASSIGNED NO.: _____ DATE TO FEES: _____
MODEL NUMBERS: _____
REVIEWER: _____ DATE ASSIGNED: _____

TYPE OF ACTION (INDICATE NUMBER OF EACH TYPE)

( ) COMMERCIAL DISTRIBUTION (FORMAL)

SOURCE (9C)	DEVICE (9A)
___ NEW	___ NEW
___ AMENDMENT	___ AMENDMENT

( ) USE BY A SINGLE APPLICANT (CUSTOM)

SOURCE (9D)	DEVICE (9B)
___ NEW	___ NEW
___ AMENDMENT	___ AMENDMENT

( ) NO SAFETY EVALUATION REQUIRED - NO FEES REQUIRED

( ) LICENSING ACTION REQUIRED IS KNOWN: YES / NO

( ) OTHER: _____

TOTAL NUMBER OF REVIEWER HOURS: _____
NUMBER OF DEFICIENCY LETTERS: _____
NUMBER OF DEFICIENCY CALLS: _____

NOTES: _____

FOR BILLING PURPOSES ONLY

( ) NAME CHANGE ( ) ADDRESS CHANGE ( ) NEW REGISTRATION - ADD TO BILLING
( ) PRODUCT INACTIVE - REMOVE FROM BILLING

FOR FEE USE ONLY

TYPE OF FEE: _____
AMOUNT RECEIVED: _____
DATE OF CHECK: _____
APPROVED BY: _____

FEE CATEGORY: 9A 9B 9C 9D
CHECK NUMBER: _____
LOG: _____
DATE RETURN: _____
DATE: _____

( )MATANN UPDATED AS REQUIRED
( )MATSYS UPDATED AS REQUIRED

COMMENTS: _____

AN SSSS PRODUCTION 1/92

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APR 2 6 1994

MEMORANDUM FOR: Steven Baggett, Chief
Sealed Source Safety Section
Source Containment and Devices Branch, IMNS, DRSS

FROM: Ronald R. Bellamy, Chief
Nuclear Materials Safety Branch
Division of Radiation Safety and Safeguards, RI

SUBJECT: REQUEST FOR A DEVICE EVALUATION
CONTROL NO. 116381, LICENSE NO. 06-17253-01,
VICTOR J. BORTOLOT, Ph.D.

As you requested, attached are the renewal application and supplementary information regarding the devices currently being used, and proposed for use by the licensee, Victor J. Bortolot, Ph.D., License No. 06-17253-01, Control No. 116381. Work on this renewal has been delayed due to non-payment of fees. Dr. Bortolot submitted payment with his letter dated March 4, 1993 but disputes the fee category and fees assessed based on three major concerns listed below. Although the regional staff is not involved in the assessment of fees, we request assistance in the following areas to properly categorize and authorize the activities of this licensee:

1. He disagrees with the categorization of his device as a "measurement instrument" but states that it should be an "irradiator".

   Please confirm which is the correct categorization of this device. As requested, the following documents are enclosed which describe the device through its licensing history:

   * Cover page of the 1976 application which includes Item 7, describing the purpose of the sources as thermoluminescent sensitivity calibration.

   * A letter dated December 13, 1976 providing additional information about the sources and devices.

   * Enclosures from the 1981 renewal application: "Daybreak Nuclear and Medical Systems Inc, Product Description, Thermoluminescence Apparatus for Archeological Dating"; "Thermoluminescent Dosimetry in Medicine and Archeology"; and "Thermoluminescent Authenticity Testing".

   * The product brochure "Daybreak Systems for TL Research" from the 1986 renewal application.

2. He does not understand why a device review is needed because of the change to the 1100 automated TL measurement system. As he states, the TL measurement system does not contain licensed sources. However, his application does request use of a new source in an improved irradiator; the irradiator is attached to the 1100 automated TL measurement system.

   Please be specific as to which devices require review, if any. Although the 1100 automated TL measurement system may NOT require review, the improved irradiator may. It is described in the application dated March 20, 1992, Items 8 and 9 including diagrams and description, and is identified as the strontium-90 irradiator II and Daybreak Model 740. A copy of the "Product Description, Model 1100 Automated TL System" is also enclosed with this application. Please note that on Page 2, it states that the Model 1100 is "intended for use with the 801 multiple sample irradiator."

   Please determine if any additional irradiators, or devices used with the irradiators, require a device review. Currently, the only device manufactured by Daybreak which has been reviewed is the custom device possessed by the Detroit Institute of Arts; this device is Sample Irradiator Model 801 (referred to as the 801 Multiple Sample Irradiator" in the 1986 product brochure). In addition to this device, the brochure also describes a Model 740 Beta Irradiator, a Model 750 Alpha Irradiator, a Model 760 Vacuum Alpha Irradiator, and a Model 765 Vacuum On-Plate Alpha Irradiator.

3. He states that he does not manufacture devices with sources, however he does manufacture devices which customers may load themselves with sealed sources. Instructions for source loading are stated in the "Daybreak Model 740 Beta Irradiator, Revision 2, 21 November 1984" submitted with the March 20, 1992 renewal application. For this reason, he believes that he is not required to have the device reviewed. He further states that, if a device review is required in order for commercial distribution, his sales volume does not justify the expense of maintaining the device registration and he will withdraw his request for distribution and will make his device drawings publicly available.

   Based on past correspondence, we understand that a device review and registration is needed for distribution of the devices. Please confirm if a device review and registration is needed for possession and use of the sources in devices in his analytical laboratory as he has been licensed in the past.

If you have any additional questions or need further information, please contact Betsy Ullrich, the technical reviewer for this action, at 610-337-5040.

Sincerely,
Original Signed By:
Ronald R. Bellamy

Ronald R. Bellamy, Chief
Nuclear Materials Safety Branch

Enclosures:
1. Letter dated March 4, 1993 to Glenda Jackson, NRC from Victor Bortolot, Ph.D. of Daybreak Nuclear and Medical Systems, with enclosures
2. Letter dated March 20, 1992 requesting renewal, with enclosures
3. "Daybreak Systems for TL Research" brochure from the 1986 renewal
4. Daybreak Nuclear and Medical System, Inc "Product Description - Thermoluminescence Apparatus for Archeological Dating" from the 1981 renewal
5. "Thermoluminescence Dosimetry in Medicine and Archaeology" paper from the 1981 renewal
6. "Thermoluminescence Authenticity Testing" brochure from the 1981 renewal
7. Letter dated December 13, 1976 providing additional device information
8. Page 1 of the application received October 21, 1976

DRSS:RI	DRSS:RI	DRSS:RI
Ullrich/gc	Shanbaky	Bellamy
04/ /94	04/ /94	04/ /94

DAYBREAK

Systems for TL Research

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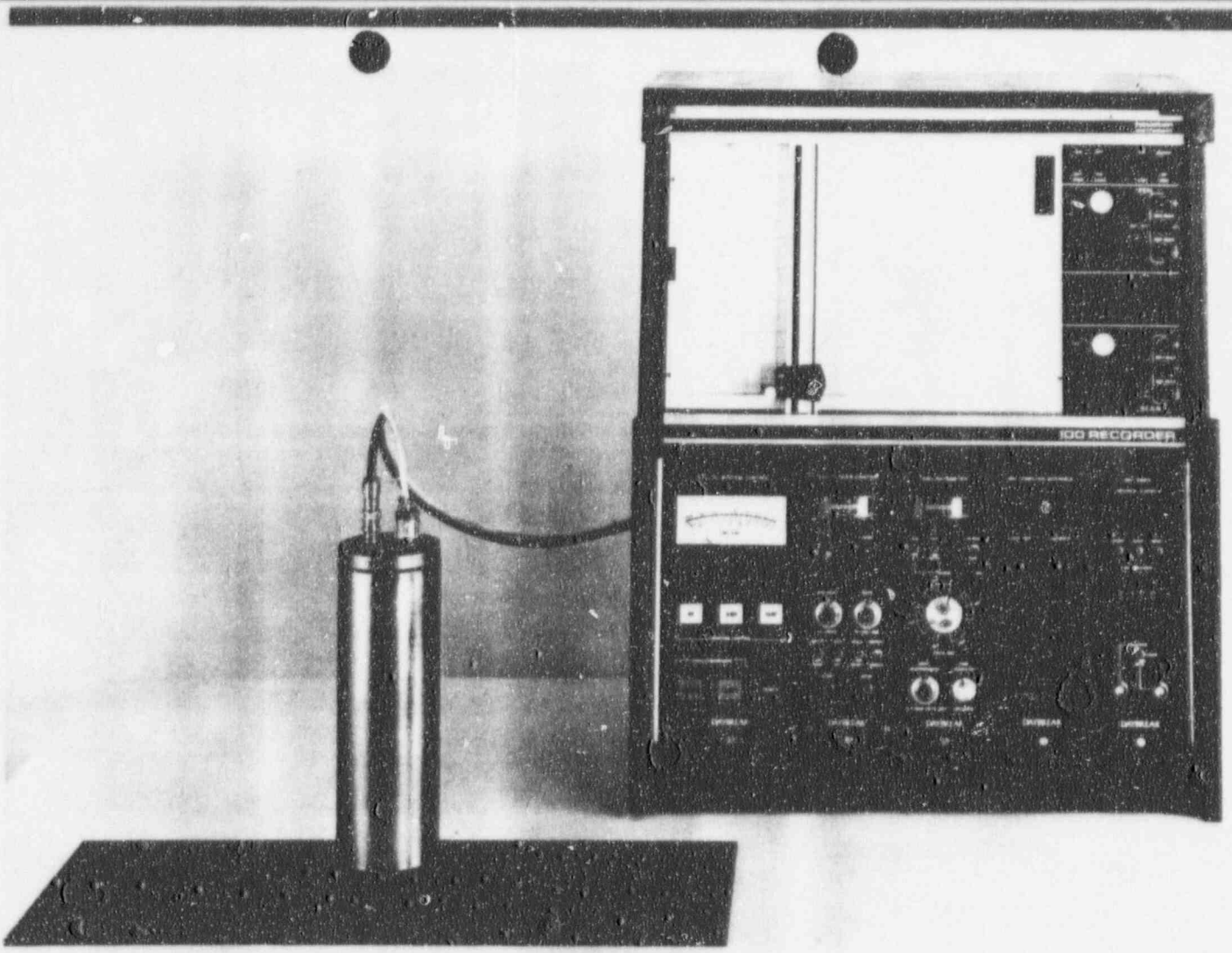
Daybreak Nuclear and Medical Systems, Inc. 50 Denison Drive Guilford, Connecticut 06437 USA (203) 453-3299



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.

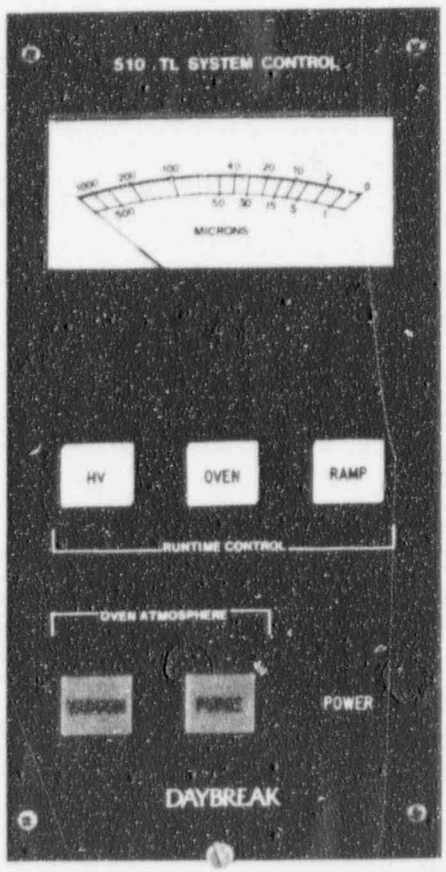
You will also need radioisotope sources and irradiators for calibration exposures, but their choice will depend on your application.

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 after a 0-10 second delay adjustable internally), HV enable, RAMP start, MAIN POWER, and OVEN POWER. All switch functions except main and oven power are controllable from the computer for future automated glow ovens.

Specifications

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

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

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

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

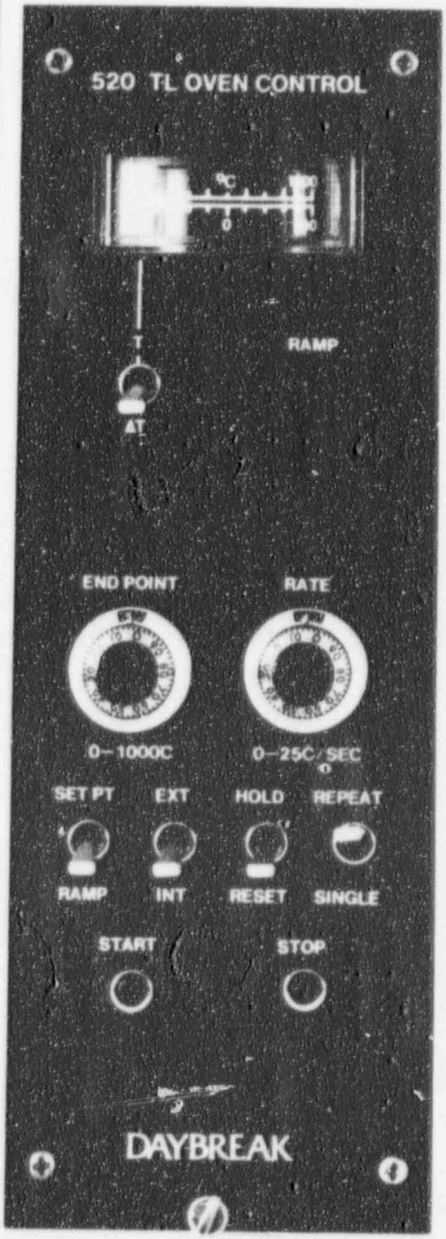
Power: 115/230 VAC 50-60 Hz, 10W, plus glow oven power

Physical: 4.55" wide standard Daybreak module

520 Oven Temperature Control

Features

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



The model 520 temperature controller programs the temperature of a TL glow oven in a ramp of variable rate and endpoint. Its output is a current proportional to the temperature servo loop error, and is intended for use with the 510 system controller or with the 521 AC power control. A number of features, such as automatic background run and setpoint operation, have been incorporated for user convenience. A number of logic control lines are connected to the system bus for computer control of the ramp. An icepoint compensator and ultra-lowdrift thermocouple amplifier are now included as a standard feature. Also standard is a 0-1000C control range to accommodate the 701 high temperature glow oven; for safety, an internal control limits the maximum endpoint or setpoint temperature attainable to a value settable between 400 and 1000 C.

Specifications

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

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

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

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

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

RESET/HOLD: action at end of ramp.

SINGLE/REPEAT: on REPEAT, the ramp will restart 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.

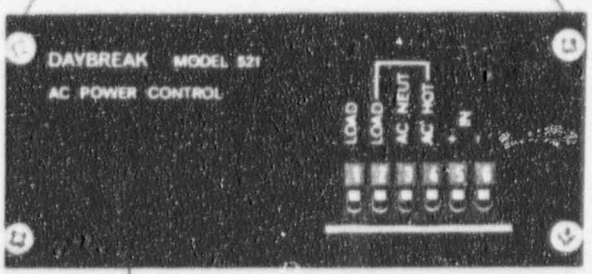
Power: 115/230 VAC 50-60 Hz, 6 W.

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

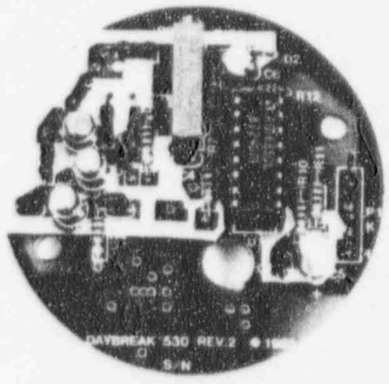
Physical: 2" x 4.5" x 3.5"

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.

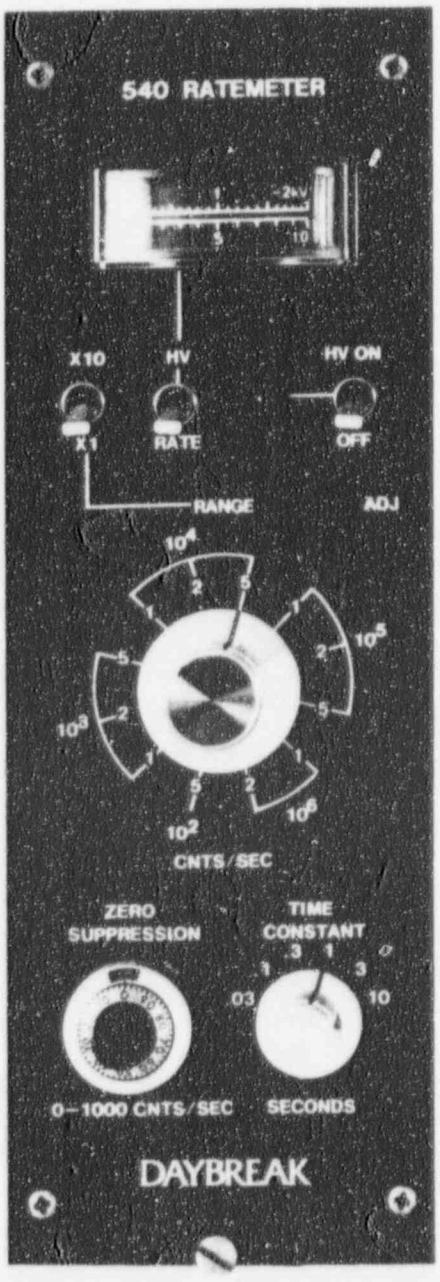
Meter: displays 0-100 per cent full scale and 0-2000 V, selectable by front panel switch.

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.

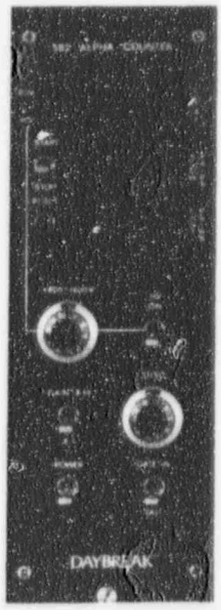
Physical: 3.05" wide standard Daybreak module.

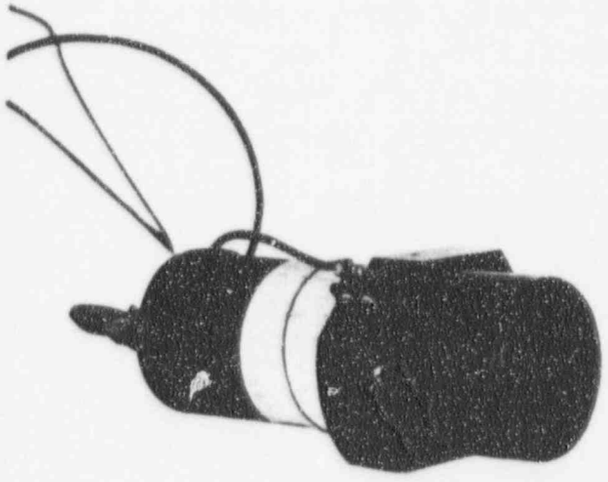


582 Alpha Counter

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).

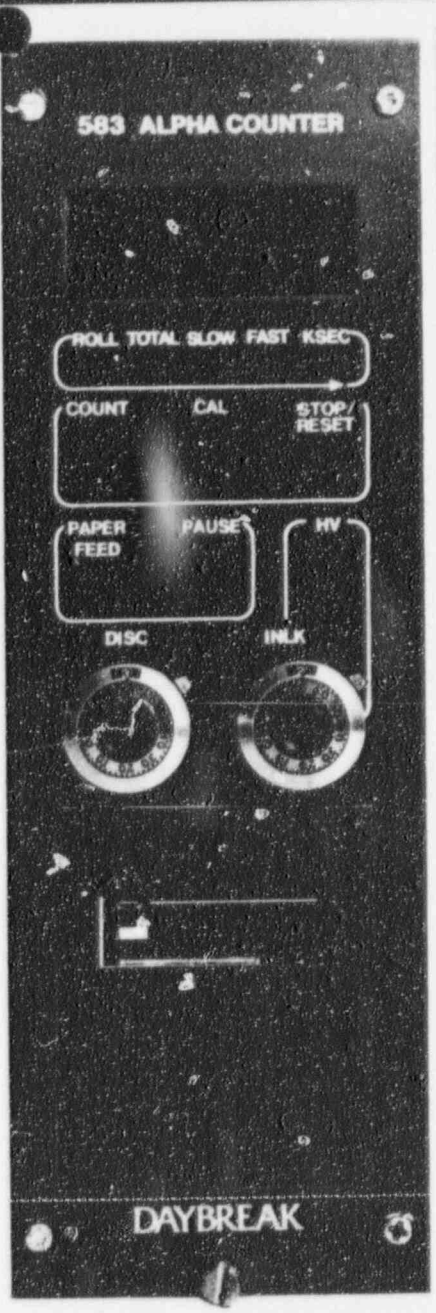
HV power supply: positive, 600-1600 V at 0.5 mA, set by front panel 10 turn pot, HV on/off switch and LED indicator on front panel, safety interlock. Maximum output ripple, 50 mV P-P.

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.

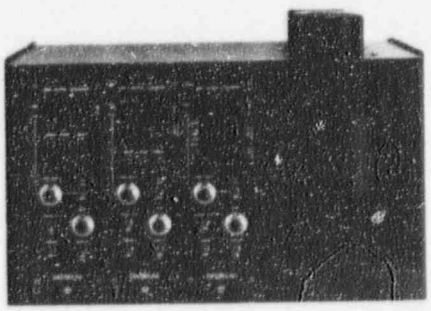
Keyboard: COUNT, CALIBRATE, PAUSE, STOP/RESET, HV ENABLE, DISPLAY ROLL, and PAPER ADVANCE.

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

Data retention time: 10 years minimum.

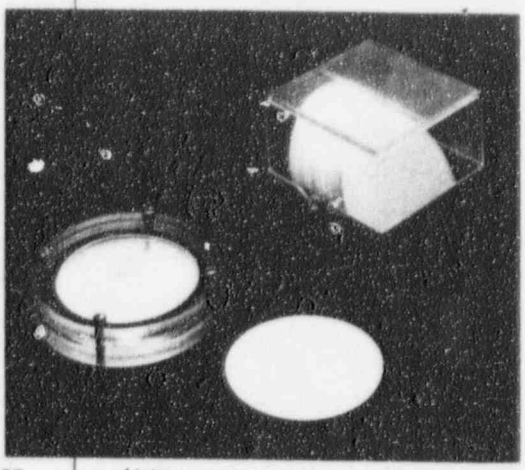
Power: 115/230 VAC 50-60 Hz, 15W.

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



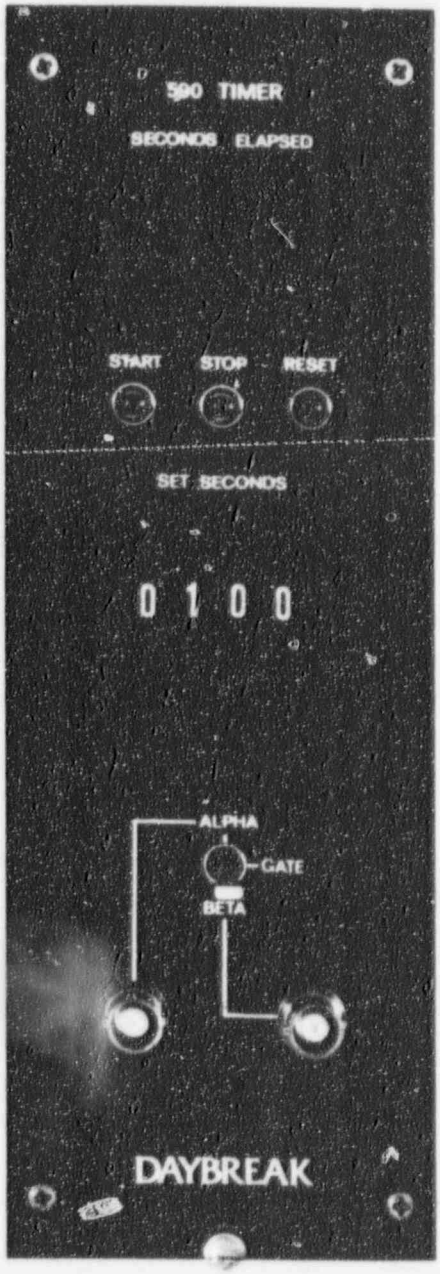
Alpha counting accessories. Sealed cell and Zn S on mylar scintillation screens.

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 1983 come with a connector for the 584, those units shipped prior to that will need a simple modification which may be done by the user.

590 Irradiation Timer



Features

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

The model 590 timer controls the 700-series sample irradiators, opening shutters for periods settable to 1-9999 seconds. (Various other clock division ratios can be implemented to permit counting by 1 or 10 second, 0.1 or 1 minute intervals. Options other than the standard 1 second increment must be specified on the order.) A four-digit thumbwheel switch sets the time, and a 4-digit display shows the time elapsed. Exposure may be interrupted without resetting the timer, and then resumed. A front panel switch selects alpha, beta, or gate mode. Output is 12 VDC at 1 A.

Specifications

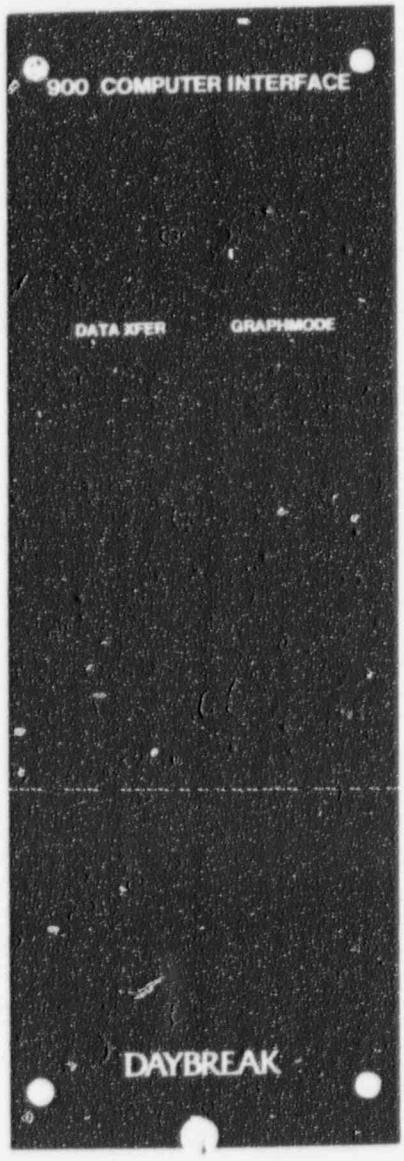
Power: 115/230 VAC 50/60 Hz, 15 W

Physical: 3.05" wide standard 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[illegible] 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

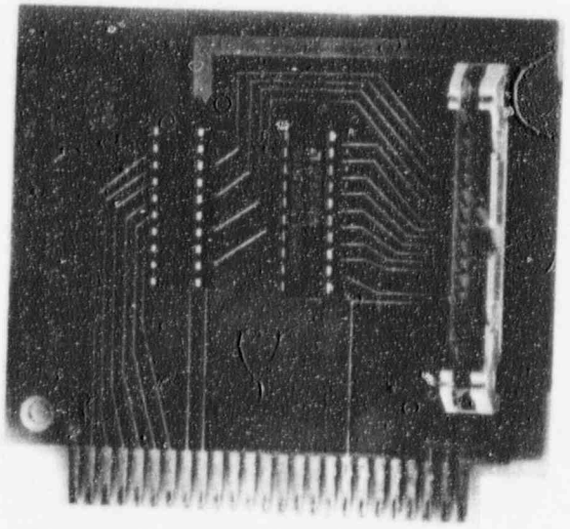
- Connects 900 interface to Apple II computer
- Shielded ribbon cable for low EMI

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.

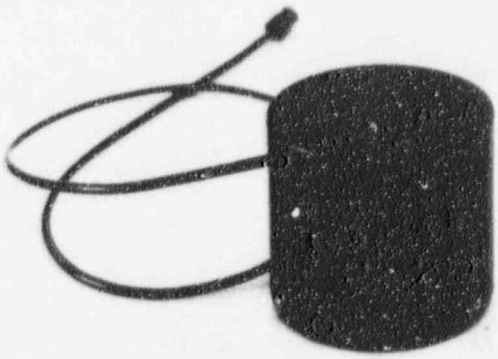
Specifications

Length of cable: 6 feet.

Power: +5 V derived from Apple II slot.



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

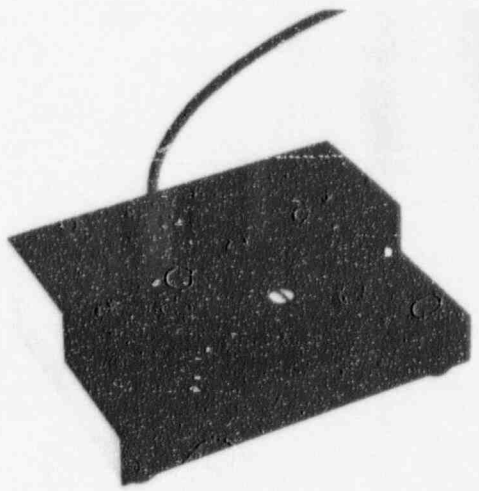
Shield cavity: 0.410" diameter, 0.250" deep, others on request

Irradiation aperture: 0.50"

SSD: 0.75" from active surface to heating plate

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

750 Alpha Irradiator



Features

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

The model 750 alpha irradiator is a shielded enclosure for a sealed foil alpha source. Daybreak supplies a 0.5 mCi Cm-244 source for this device, but customers' own sources may be accommodated if a drawing is submitted with the order. The source is mounted on a solenoid-actuated arm that, when energized, brings the source out of the housing into position over the sample well. Source-to-sample distance is approximately 0.040". The active surface of the source cannot be accessed without disassembly of the enclosure. 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

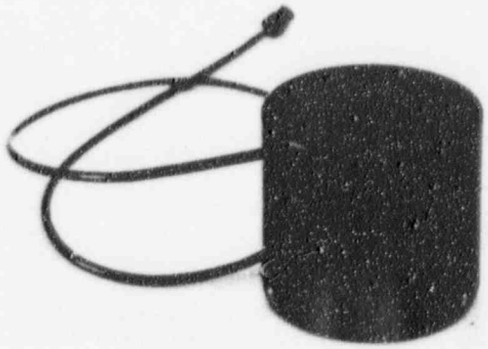
SSD: less than 0.050".

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

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

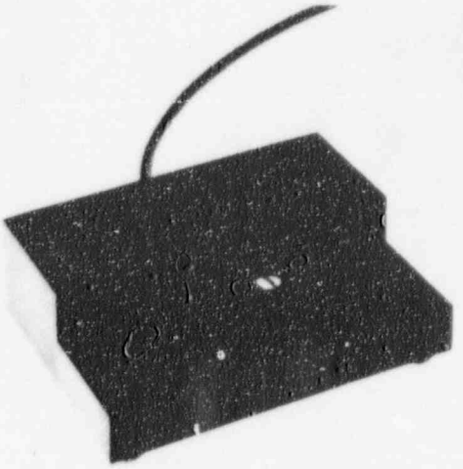
Shield cavity: 0.410" diameter, 0.250" deep, others on request.

Irradiation aperture: 0.50"

SSD: 0.75" from active surface to heating plate.

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

750 Alpha Irradiator



Features

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

The model 750 alpha irradiator is a shielded enclosure for a sealed foil alpha source. Daybreak supplies a 0.5 mCi Cm-244 source for this device, but customer 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.

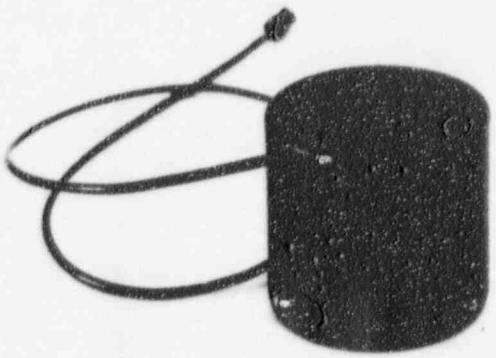
Source dimensions: 0.875" diameter max, 0.25" high max.

Sample well: 0.400" diameter, 0.030" deep.

SSD: less than 0.050".

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

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

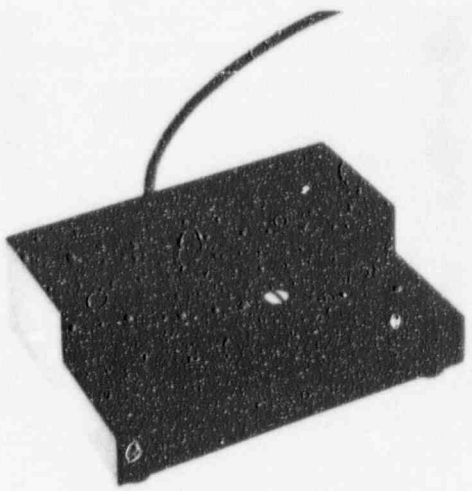
Shield cavity: 0.410" diameter, 0.250" deep, others on request

Irradiation aperture: 0.50"

SSD: 0.75" from active surface to heating plate.

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

750 Alpha Irradiator



Features

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

The model 750 alpha irradiator is a shielded enclosure for a sealed foil alpha source. Daybreak supplies a 0.5 mCi Cm-244 source for this device, but customers' own sources may be accommodated if a drawing is submitted with the order. The source is mounted on a solenoid-actuated arm that, when energized, brings the source out of the housing into position over the sample well. Source-to-sample distance is approximately 0.040". The active surface of the source cannot be accessed without disassembly of the enclosure. 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.

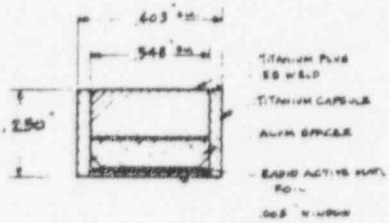
SR-90 Strontium Source

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 2 mCi activity for pre-dose calibrations.

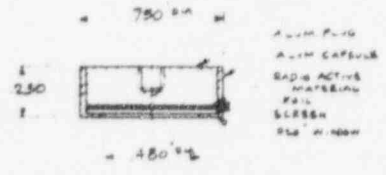
CM-244 Curium Source

Nominal activity: 0.5 mCi

Overall dimensions: 0.75" diameter x 0.25" thick

Active diameter: 0.48"

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



801 Multiple Sample Irradiator

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

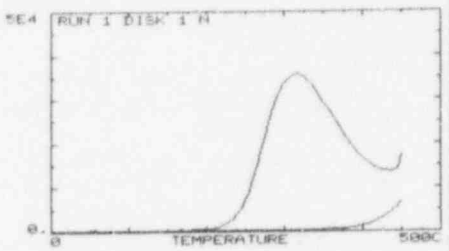
Physical: 8" high, 15" wide, 17" deep, weight 34 lb.

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

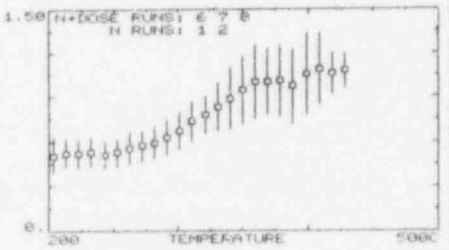
9900 Data Acquisition and Reduction System

Software Features

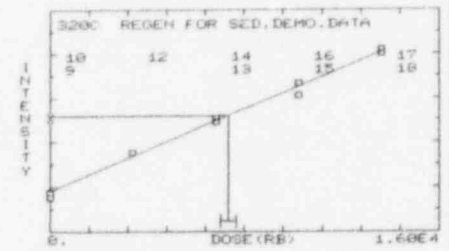
- Complete turn-key computer system for archaeological and geological dating
- Menu-driven (single keystroke) hierarchical organization provides flexible, 'user-friendly' operating environment
- Complete USCD p-system running in 128K memory
- Segmented (memory overlay) architecture for maximum efficiency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

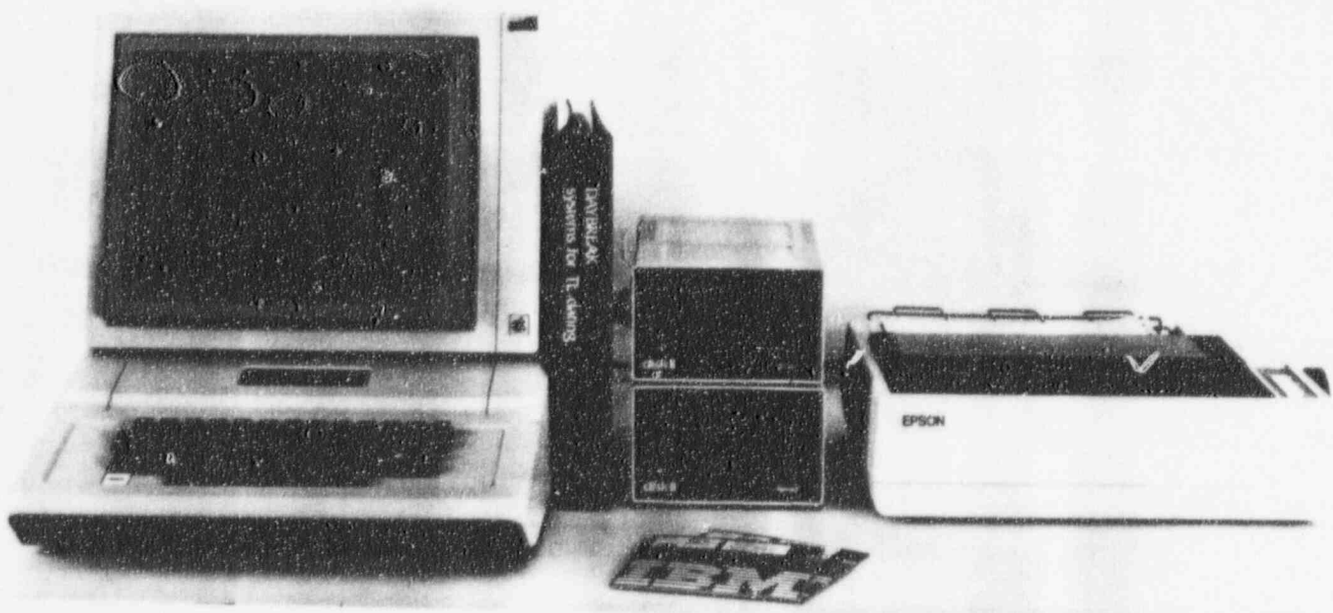
The second, and much more complex, function of TLAPPLIC is data reduction. Up to 80 glowcurves (of which one at least must be a background curve) are supported. After specifying an input file, it is read in and a directory of curves within the file is generated and printed, and may be displayed at several 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 U.S.A.
(203) 453-8289

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

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.

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.

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.

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.

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

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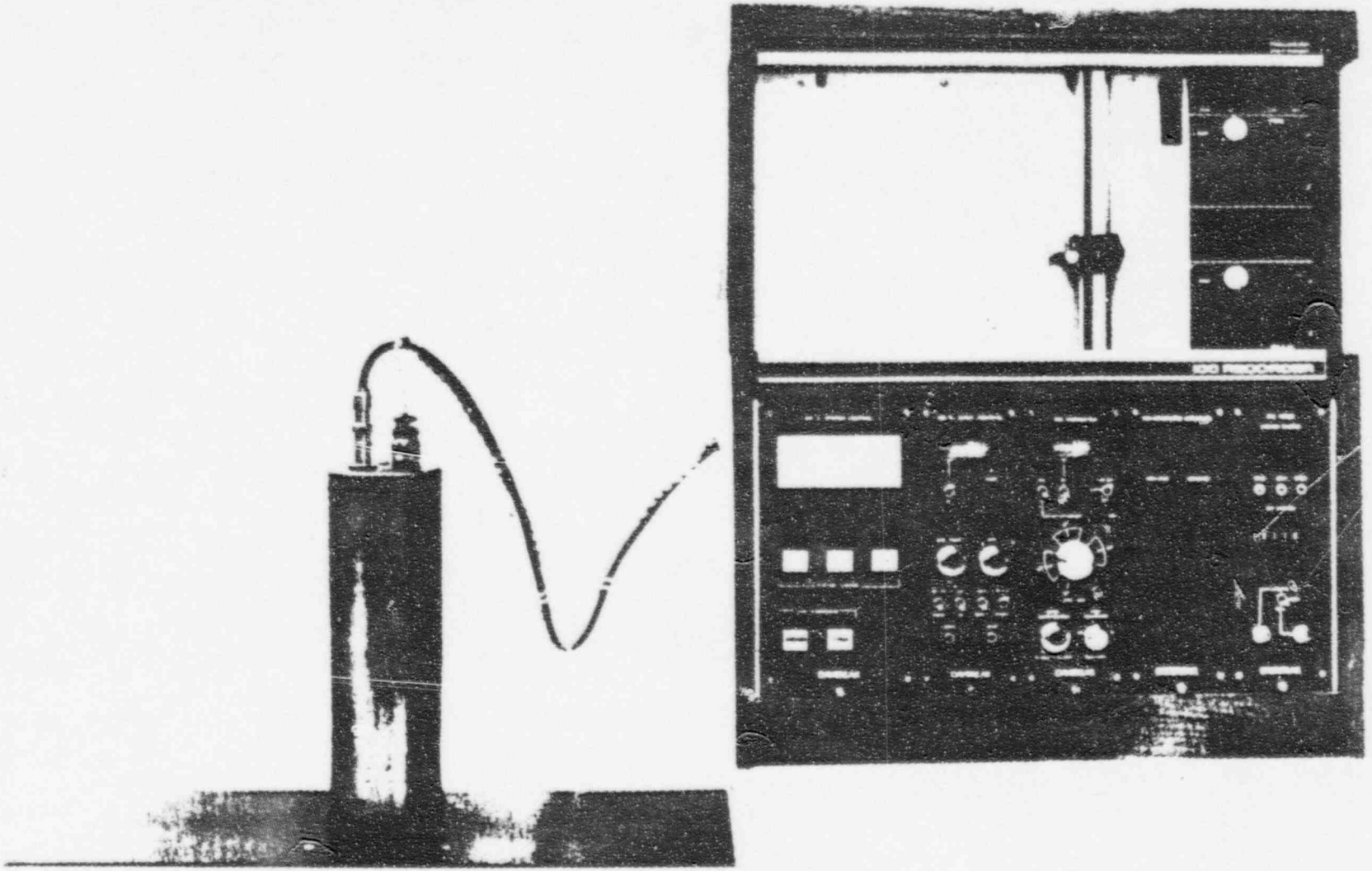
ground curves maximum) are supported. After specifying an input file, it is read in and a directory of curves within the file is generated and printed, and may be put on the video display at several points in the program for reference. The operator may then look over the raw data, and plot on the system 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
systems for TL dating

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Enclosure from
1981 request

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-

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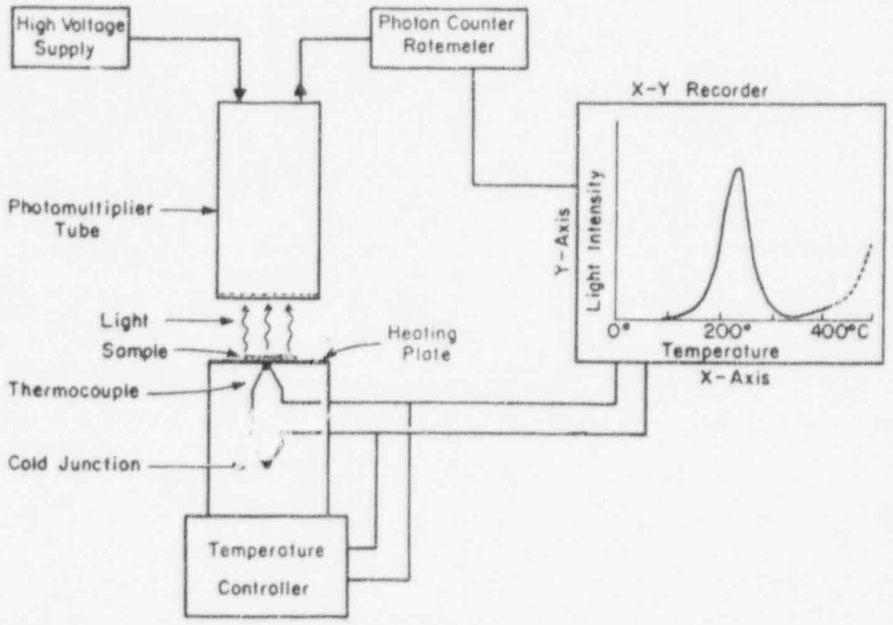

Fig. 1. TL measurement apparatus. A sample of lithium fluoride which has been exposed to Co^{60} gamma rays is placed on a nichrome plate and heated electrically at a rate of 20°C./sec. Light emitted by the sample is detected by the photomultiplier tube and plotted on the y axis of an x-y recorder, while 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

material used most widely for these purposes is lithium fluoride by virtue 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

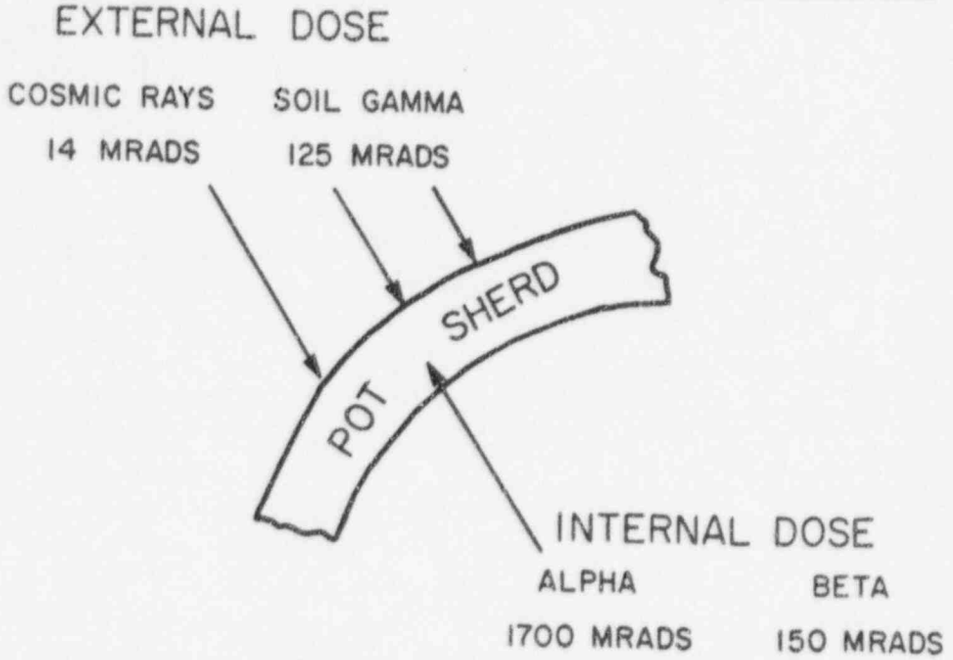

Fig. 2. Typical annual radiation dose for a potsherd buried in soil; both pot and soil have uranium and thorium series contents of 3 and 12 ppm., respectively, and K_2O 1%. The total dose is 1,989 mrads, but as the TL efficiency of alpha particles is typically about 20% that of betas and gammas, the *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

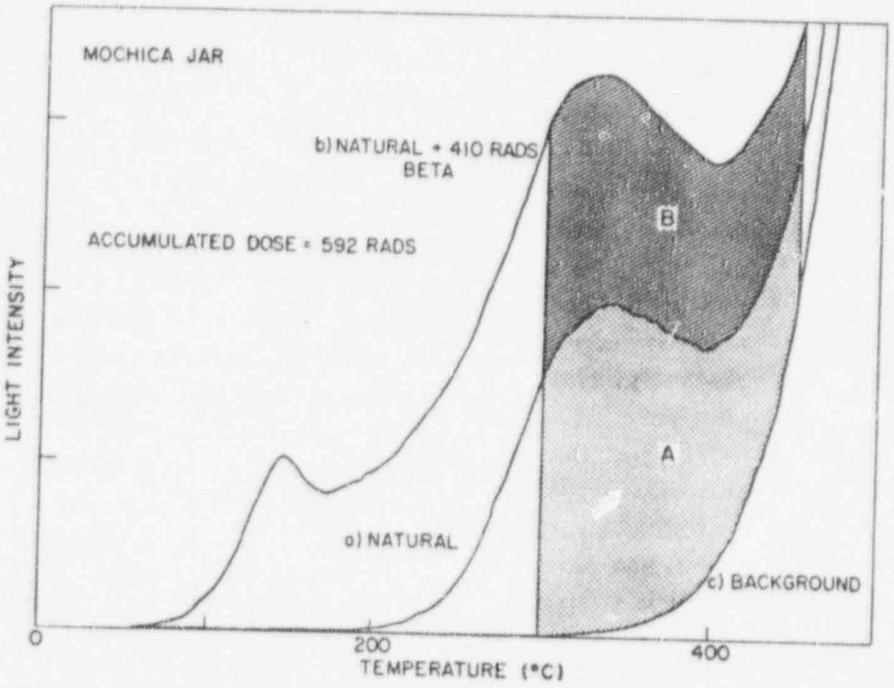

Fig. 4. The thermoluminescent glow curve of the jar shown in Figure 2. The intensity of light emitted by the sample is plotted against temperature. Curve *a* is the natural thermoluminescence of the pottery, curve *b* is that due to the natural accumulated dose plus an additional 410 rad Sr^{90} beta 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-

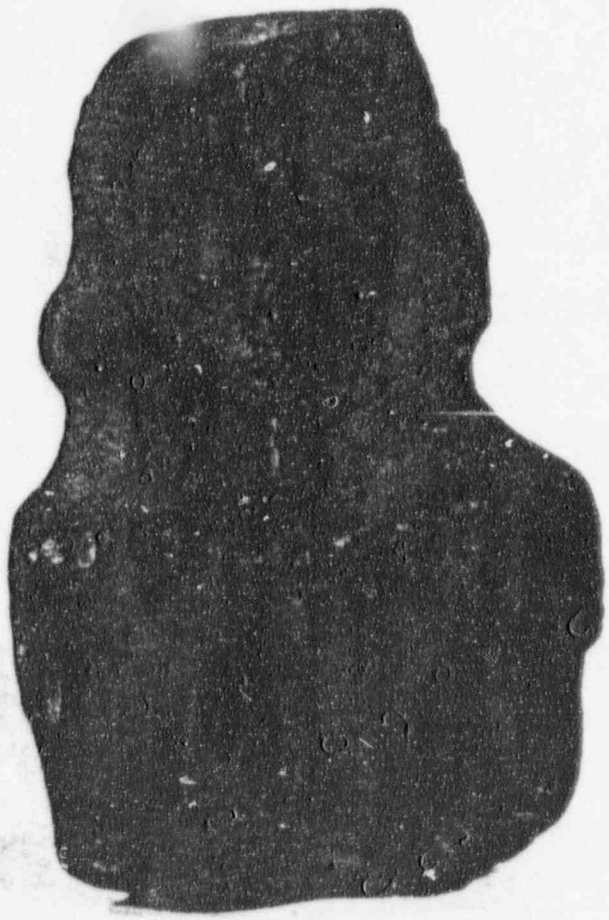

Fig. 5. Monte Albán-type votive incense burner considered to be fake, but dating from C. 900 A.D. if genuine. Its height is 12 cm.

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-

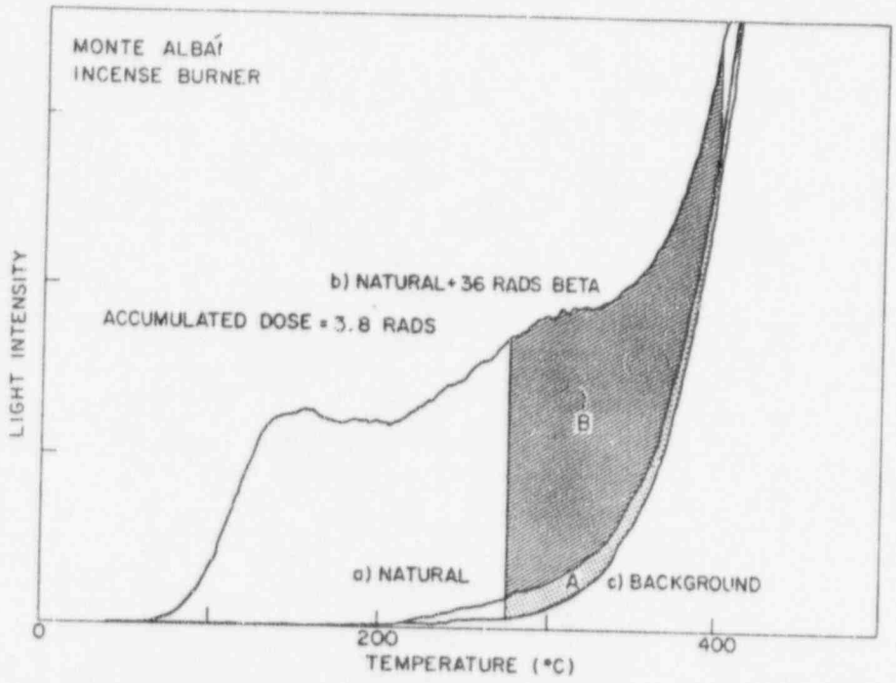

Fig. 6. The TL-glow curve of the figurine shown in Figure 4. The curves are labeled as in Figure 3. Here the calibration dose is 36 rads, and the equivalent beta dose is 3.8 rads. Even if the only source of radiation were cosmic rays, the figure could be no older than 270 years. Since the typical effective 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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10. Aitken, M. J.: Low-level environmental radiation measurements using natural calcium fluoride. *Proc. Second Int. Conf. Luminescence Dosimetry:*281-90, 1968.
11. Fleming, S. J.: Thermoluminescent dating: Refinement of the quartz inclusion method. *Archaeometry 12:*133-45, 1970.
12. Zimmerman, D. W.: Thermoluminescent dating using fine grains from pottery. *Archaeometry 13:*29-52, 1971.
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14. Fleming, S. J.: Thermoluminescent authenticity testing of ancient ceramics: the effects of sampling by drilling. *Archaeometry 13:*159-69, 1971.
15. Turner, R. C., Radley, J. M., and Mayneord, W. V.: The alpha-ray activity of human tissues. *British J. Radiol. 31:*397-407, 1958.

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.

GENERAL REFERENCES

Thermoluminescence and the Archaeologist, Martin Aitken, Antiquity, LI, 11-19, 1977.

Thermoluminescence Dating of Pottery, V.J. Bortolot, Indian Notes, X(1), 18-32, 1974.

Thermoluminescent Dating of Ceramic Materials, E. G. Ehlers, Archaeology, 28, 98-101, 1975.

THERMOLUMINESCENCE

AUTHENTICITY TESTING

DAYBREAK
Nuclear and Medical Systems, Inc.

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

Brochure from 1981 reissued

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

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.

The top and sides of the source capsule will likewise be shielded. A ½" layer of lead reduced the top or side exposure rate to 12 mR/hr. Approximately 1" lead will be used.

By way of comparison, the maximum exposure rate measured at the surface of the source storage box (it is a medical eye applicator) was 13 mR/hr. Thus, in terms of surface radiation, the proposed exposure device, when placed on its lead block, should be similar to the standard eye applicator storage box.

Considering the expected levels of radiation, and the degree of protection afforded the source, a survey meter should not be required during routine use. A survey will, however, be made when the device is built and the source first installed.

The expected use of the source should be less than 500 hours per year. A layout of the TL lab is shown in Figure 3.

2b. Source protection is described above. According to the manufacturer, the source is robust, having a double stainless steel encapsulation. The activity is incorporated in a rolled silver layer. This sealed source qualifies as special form material.

2c. The presence of a survey meter during routine use of the source is judged unnecessary, as argued above.

2d. An expanded description of personnel monitoring program. The TL phosphor to be used in the monitor badges is Harshaw LiF-7 material, 1/8" X 1/8" X 0.035", three per badge. The badge will be an opaque delrin capsule with ¼" walls. There will be no post-readout annealing, only the natural cooling from 400°c under nitrogen in the readout instrument sample oven.

The readout instrument has been constructed by the applicant. It consists of an evacuable sample oven with prepurified nitrogen purge, a temperature controller with linear temperature ramp (0-50°C/sec) to 500°C and automatic background glowcycle, an EMI 9635B PMT and single photon counting signal chain (full scale ranges 5×10^2 - 2×10^6 photons/sec.), and an X-Y recorder.

An earlier version of this instrument has been in use at Mt. Sinai School of Medicine, New York City, for about 4 years. Typical performance is ± 6% precision at 8 mrads with 1/8" sq. LiF-7 dosimeters, and ± 12% at 25 rads with 30 mg $CaSO_4$:Dy powder.

Readout of the personnel monitor will be made monthly when the sources are in use. Calibration will be performed using the americium-241 source applied for. The sample holder well of the exposure device will have a removable 1 mm thick lucite insert with a space underneath for the LiF dosimeters. The lucite acts as an alpha particle absorber and electron

build-up for the 60 KeV gammas.

This gamma source and exposure device will be calibrated as an intercomparison standard with a 10.13 mg. radium capsule (0.5 mm. platinum filtration) at Yale-New Haven Hospital Radiation Therapy Dept., New Haven, CT (Union Miniere du Haut Katanga, certificat no. 19261).

Calibration exposure of 25, 100, and 500 mR will be made to three groups of three "annealed by cooling" LiF dosimeters in $\frac{1}{4}$" wall delrin capsules. An Eberline RO-1 survey meter in integration mode will provide a check on exposure (capsule at chamber center line).

These dosimeters will be read out, exposed to the americium-241 source for various times, then re-read to obtain the exposure rate.

The read-out procedure for monitoring purposes is similar. The three dosimeters in the badge are each read out, exposed to a similar gamma calibration dose, then re-read and replaced in the badge capsule.

2e. Due to the degree of mechanical protection of the source as described above, survey and wipe tests after each use are considered unnecessary.

I hope that these modifications and amplifications meet with your approval. If any further details are required, I would appreciate a speedy reply.

Sincerely yours,

Victor J. Bortolot

Victor J. Bortolot, Ph.D.

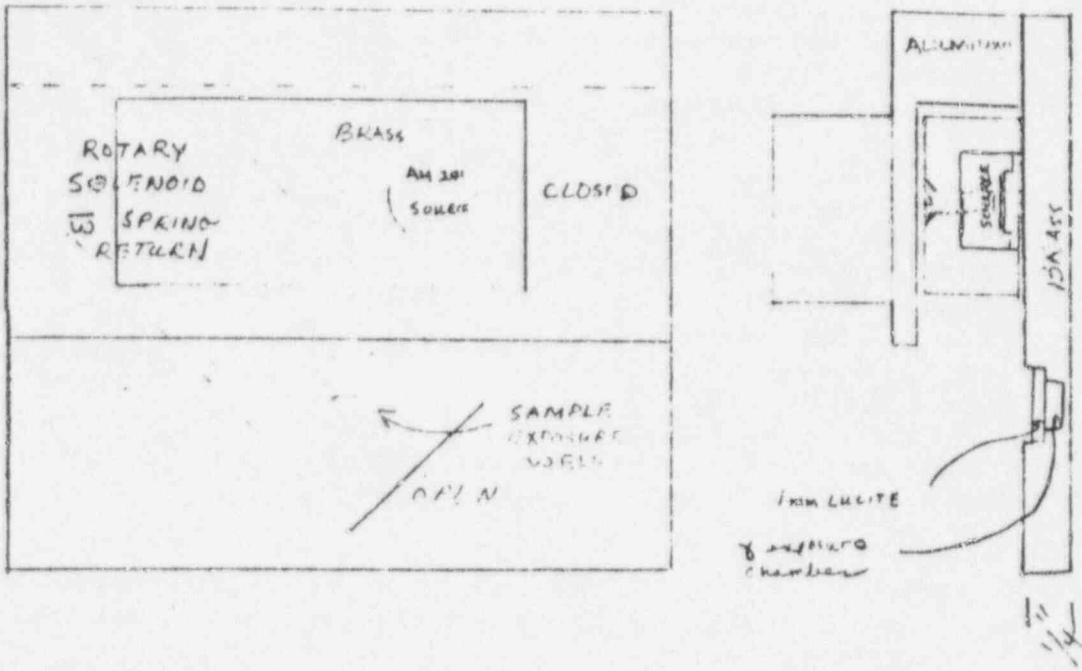
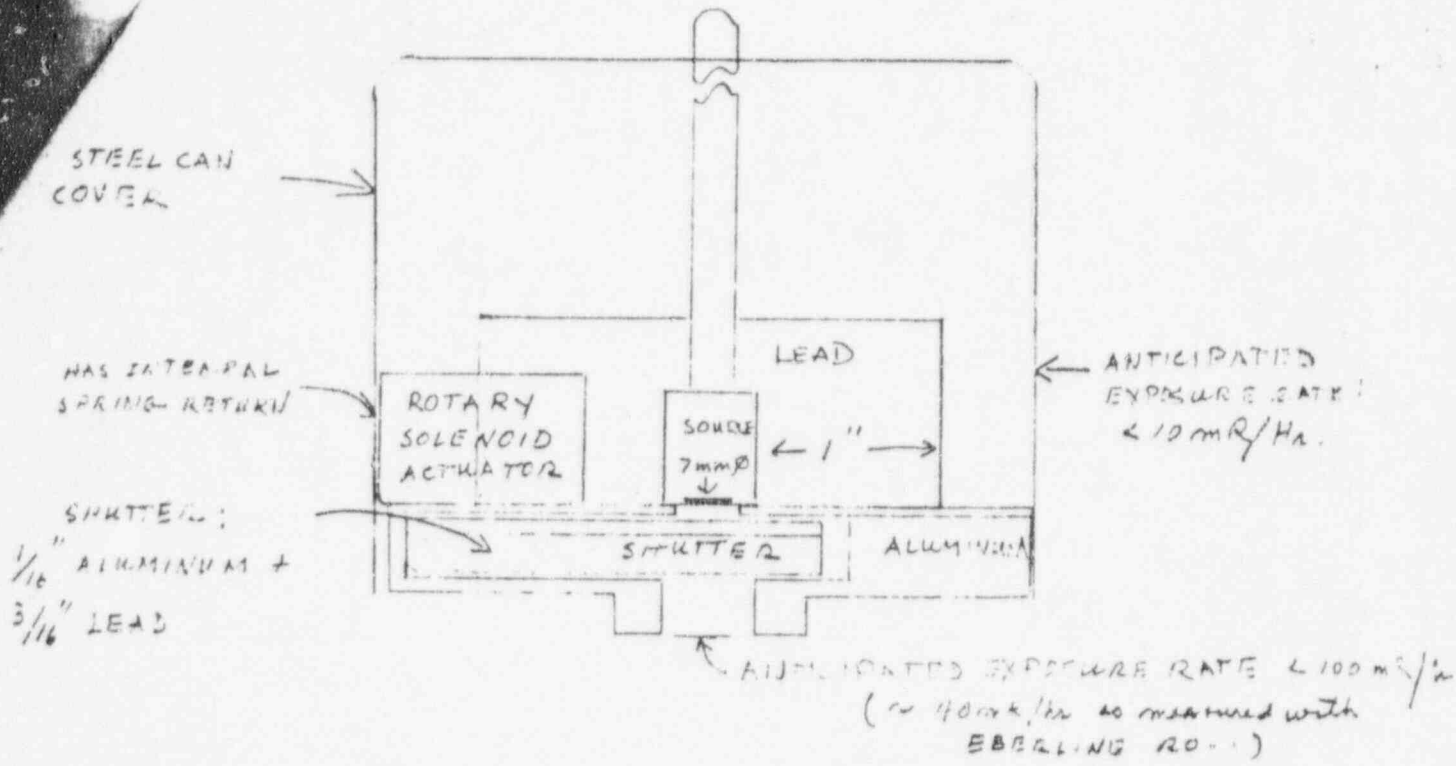


FIGURE 1. Am-241 alpha/gamma exposure device
ANTICIPATED SURFACE EXPOSURE RATE 21 mR/hr.



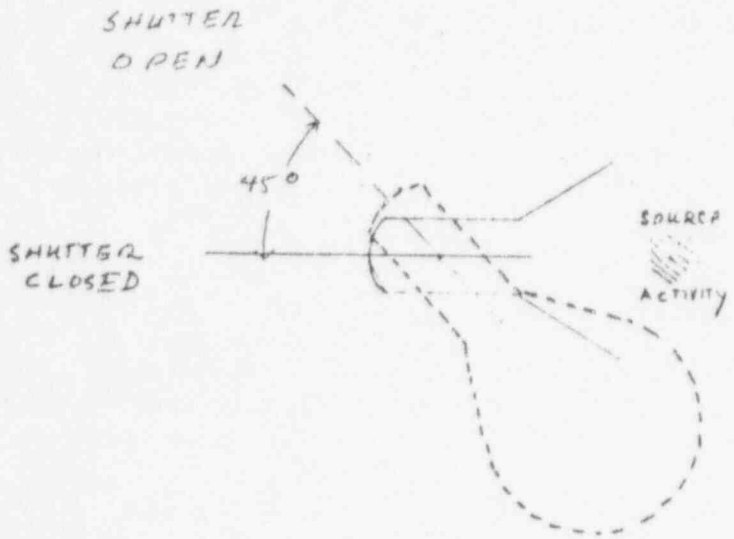
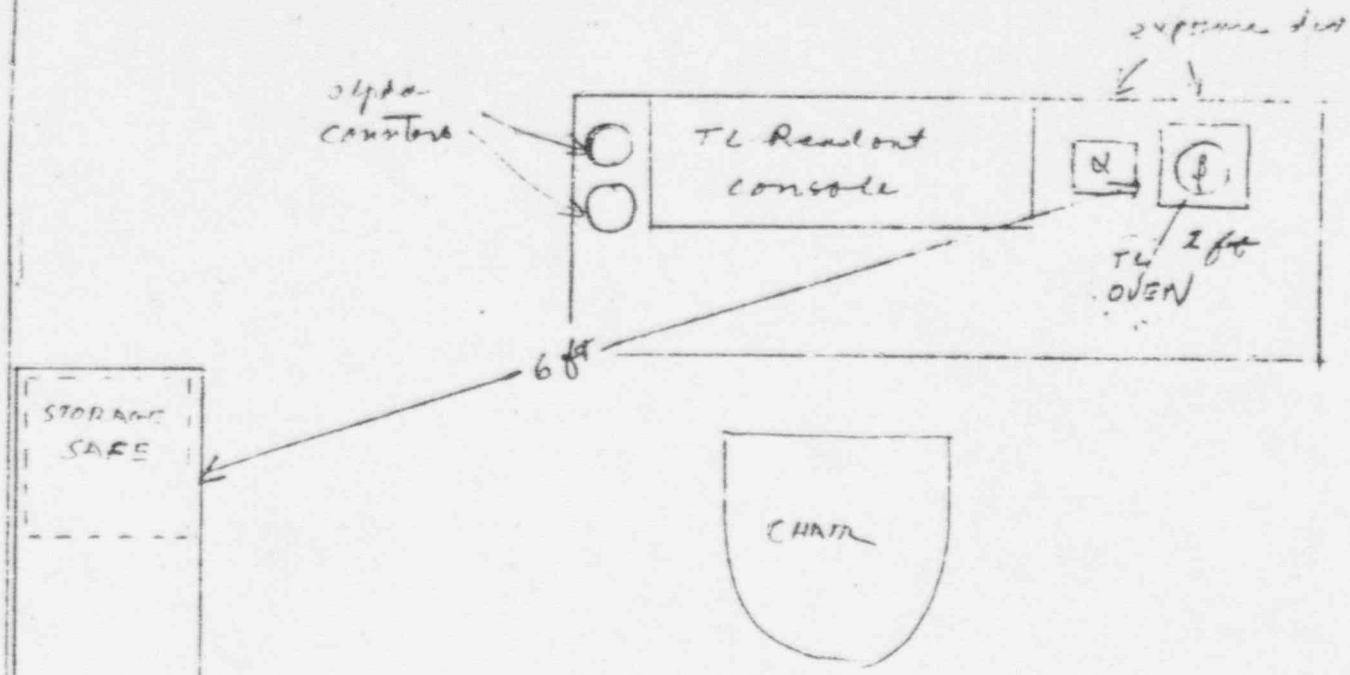


FIGURE 2. Sr^{90} SHIELDED EXPOSURE DEVICE, ACTUAL SIZE.

WHEN NOT IN USE, DEVICE WILL SIT ON 2" LEAD BRICK.

WHEN IN USE, DEVICE WILL SIT ON TL READOUT OVEN (≈ 1" ALUMINUM).

TL LAB. LAYOUT



DOOR

SAMPLE PREP AREA

1976 Application (3)

Form AEC-313 (2-73) 10 CFR 30

UNITED STATES ATOMIC ENERGY COMMISSION

APPLICATION FOR BYPRODUCT MATERIAL LICENSE

Form approved Budget Bureau No. 38-R0027

INSTRUCTIONS —Complete items 1 through 16 if this is an initial application or an application for renewal of a license. Information contained in previous applications filed with the Commission with respect to Items 8 through 15 may be incorporated by reference provided *references are clear and specific.* Use supplemental sheets where necessary. Item 16 must be completed on all applications. Mail two copies to: U.S. Atomic Energy Commission, Washington, D.C., 20545, Attention: Materials Branch, Directorate of Licensing. Upon approval of this application, the applicant will receive an AEC Byproduct Material License. An AEC Byproduct Material License is issued in accordance with the general requirements contained in Title 10, Code of Federal Regulations, Part 30, and the Licensee is subject to Title 10, Code of Federal Regulations, Part 20, and the license fee provisions of Title 10, Code of Federal Regulations, Part 170. The license fee category should be stated in Item 16 and the appropriate fee enclosed. (See Note in Instruction Sheet).

1. (a) NAME AND STREET ADDRESS OF APPLICANT. *(Institution, firm, hospital person, etc. Include ZIP Code and telephone number.)*

Victor J. Bortolot Ph.D.
Consulting Physicist
37 North St.
North Branford, CT 06471
(203) 481-3970

(b) STREET ADDRESS(ES) AT WHICH BYPRODUCT MATERIAL WILL BE USED. *(If different from 1(a). Include ZIP Code.)*

W & L 17253

030 - 12440

2. DEPARTMENT TO USE BYPRODUCT MATERIAL

Thermoluminescence Laboratory

3. PREVIOUS LICENSE NUMBER(S). *(If this is an application for renewal of a license, please indicate and give number.)*

RECEIVED BY LFMB
Date 10-21-76
By ...
From ...
Cy to ...
Action Complete 10-21-76

4. INDIVIDUAL USER(S). *(Name and title of individual(s) who will use or directly supervise use of byproduct material. Give training and experience in Items 8 and 9.)*

Victor J. Bortolot, Ph.D.

5. RADIATION PROTECTION OFFICER. *(Name of person designated as radiation protection officer if other than individual user. Attach resume of his training and experience in Items 8 and 9.)*

6. (a) BYPRODUCT MATERIAL. *(Elements and mass number of each.)*

(b) CHEMICAL AND/OR PHYSICAL FORM AND MAXIMUM NUMBER OF MILLICURIES OF EACH CHEMICAL AND/OR PHYSICAL FORM THAT YOU WILL POSSESS AT ANY ONE TIME. *(If sealed source(s), also state name of manufacturer, model number, number of sources and maximum activity per source.)*

Strontium-90	1 sealed source, 100 mCi ICN model 75129 (BS capsule)	100 mCi
Americium-241	1 sealed source, 1 mCi ICN model 1111	

COPIES SENT TO OFF. OF INSPECTION AND ENFORCEMENT

Applicant ..... 1 mCi
Check No. 101
Amount $50.36
Date of Check 10-14-76
Date Check Rec'd 10-21-76
Received By ...

7. DESCRIBE PURPOSE FOR WHICH BYPRODUCT MATERIAL WILL BE USED. *(If byproduct material is for "human use," supplement A (Form AEC-313a) must be completed in lieu of this item. If byproduct material is in the form of a sealed source, include the make and model number of the storage container and/or device in which the source will be stored and/or used.)* The two sealed sources listed above will be used in the thermoluminescence sensitivity calibration of ceramic materials for the purpose of archaeological dating (cf. appended article). The response of geological materials to alpha and beta particles is different and varies greatly from sample to sample, necessitating both alpha and beta calibration curves for each sample examined. Dating is not possible without such data. The sources will be stored in 4 cm wall lead containers and removed manually (about 30 cm distance) to shielded sample exposure jigs of the applicant's manufacture. When the sources are not in use, the containers are to be kept in a fire resistant safe within a locked cabinet.

84200

116381

OFFICIAL RECORD COPY MI. 10

(Continued on reverse side)

2076 p.9

NMSB TELEPHONE CONVERSATION RECORD

DATE OF CALL: 4/16/93

TIME OF CALL: 10:15

PERSON CALLED: Victor J. Bertolot (OUTGOING CALL)

PHONE NUMBER: 203 453-3299

PERSON CALLING: T E Thompson (INCOMING CALL)

FACILITY NAME: Victor J. Bertolot

LICENSE NO. 06-17253-01

DOCKET NO.

SUBJECT: Fee

SUMMARY: Discussed with Dr. Bertolot that it did appear to me that the device was a type of irradiator, because there is not a detector in the unit. (and therefore should not be considered a measuring system).

ACTION REQUIRED/TAKEN: Referred to S. Kimberly

SIGNATURE: T E Thompson

MAIL CONTROL NO. 116381

MAR 11 1993

Docket No. 030-12440

License No. 06-17253-01

Control No. 116381

Daybreak Nuclear & Medical Systems
ATTN: Victor J. Bortolot, Ph.D.
50 Denison Drive
Guilford, Connecticut 06437

Dear Dr. Bortolot:

SUBJECT: LICENSE RENEWAL APPLICATION

This is to acknowledge receipt of your application for renewal of material(s) license identified above. Your application is deemed timely filed, and accordingly, the license will not expire until final action has been taken by this office.

Any correspondence regarding the renewal application should reference the control number specified above.

Sincerely,

Original Signed By:
Sheryl Villar

Sheryl Villar, Chief
Licensing Assistance Section
Division of Radiation Safety
and Safeguards

mal 3/11/93 BD 3/11/93

BORTOLOT OFFICIAL RECORD COPY ML 10 Pg 1 April 14, 1992

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

030-12440

U.S Nuclear Regulatory Commission, Region I
Nuclear Materials Safety Section B
475 Allendale Road
King of Prussia, PA 19406

10 June 1992

Sirs:

In reviewing my license application for renewal (no. 06-17253-01), I realized that source C, an SR-90 wipe test standard having an activity of 0.005 uCi (0.0075uCi when purchased), is an exempt quantity and should be taken off the license. This source has an activity only 5 per cent of the exempted quantity under 10 CFR 30.71. I therefore request that this source be removed from my license.

The original ammendment to include the source was made to comply with California regulations that the manufacturer ship only to purchasers licensed for the source, whereas there was no need from a federal standpoint, as at that time the quantity was exempt.

I enclose a copy of a description of this wipe test standard, and the packing slip, for your information, as well as a corrected attachment sheet covering the application item 8. This should replace the page in the application submitted last 20 March.

Thank you very much.

Sincerely yours,

Victor J. Bortolot
Technical Director

enclosures.

ADDENDUM: In the original ammendment request and in subsequent renewals, the request for licensed material was 0.01 uCi maximum for the Sr-90 wipe test standard. This quantity was disregarded, and the license reads '1 source not to exceed 1 microcurie'. (Copy of first page of 1981 renewal application enclosed).

116381

50 Denison Drive Guilford, CT 06437 (203) 453-3299

06-17253-01 Renewal application 20 March 92
corrected 10 June 92

Item 8. Radioactive Material (including additions to current license)
(* covered by current license)

A. Strontium 90*	ICN Pharmaceuticals Sealed source model 75129	1 source of 100 mCi
B. Americium 241*	Amersham/Searle Sealed source model AMM	1 source of 500 uCi
C. Strontium 90	ICN Pharmaceuticals Sealed source model 75144	1 source of 100 mCi
D. Curium 244	Isotope Products Labs. Sealed source model AFR-244	1 source of 500 uCi

Item 8E. Purposes for which licenced material will be used

All sources are intended solely for irradiation of mineral materials. The response of these materials to radiation is measured, and used in archaeological dating by thermoluminescence.

Sources A. and B. are stored and used in the irradiators described in the applicaiton dated 23 December 1981. Source C. is to be stored and used in a very similar beta irradiator with improved shielding. Source D. is to be stored and used in an alpha irradiator identical in design to that in the 1981 application.

Sources C. and D. are required to cope with increased numbers of samples. We now have 500 clients, and remain the only commercial laboratory in North America for thermoluminescence dating of ceramics. The additional sources are for use in conjunction with an automated measurement system for routine and predictable samples, while the originally licensed sources (A. and B.) will continue to be used for the less routine samples that require individual attention and adjustment of irradiation during the measurement procedure..

9. Storage of sealed sources
All irradiators are built by the applicant.

A. Sr-90 beta irradiator I (as described in original application 1977, and renewals)
C. Sr-90 beta irradiator II (see enclosure, identified as Daybreak model 740)
B. and D. alpha irradiator (as described in original application and renewals)

ORIGINAL

Radiochemical Data and Analyses

ICN Chemical & Radioisotope Division

2727 Campus Drive
Irvine, California 92715

Telephone 714/833-2500
Telex: 68-55-80

LEAK TEST COMPARISON STANDARDS - 0.005 MICROCURIES

This convenient set of standards contains three discs - Strontium-90, Cobalt-60 and Cesium-137, and two rods - Cobalt-60 and Cesium-137. These sources are designed to be used as comparison standards when using filter paper discs or cotton tipped swabs to perform smear tests. Each of the standards has an OUTPUT of 0.005 microcuries. Calibration accuracy is ± 10%. The sources can thus be used to convert counts per minute readings to microcuries as required by the AEC and Agreement States.

$$\frac{\text{CPM of Standard}}{\text{uc in Std.(0.005)}} = \frac{\text{CPM of Smear}}{\text{uc in Smear}}$$

The set consists of the following:

^{90}Sr, ^{137}Cs and ^{60}Co discs - the radioactivity is deposited on filter paper discs 1" diameter and laminated between plastic discs 0.010" thick by 1 $^{15}/_{16}$" or 1" diameter. Three 2" x $^{1}/_{8}$" cupped planchets (our Cat. No. 83030 are included to provide identical counting geometries for the comparison standards and the filter paper smear.

^{60}Co and ^{137}Cs rods - the radioactivity is deposited and sealed onto a cotton tipped applicator which is permanently fixed in a standard plastic vial (our Cat. No. 80001) 2 $^{5}/_{16}$" long by $^{1}/_{2}$" diameter.

	PRICES	CATALOG NO.
Set of 5 in convenient carrying case	$95.00	77239
Each individual source - Rod	20.00	77238
Each individual source - Disc	20.00	77241
(Specify 1" or 1 $^{15}/_{16}$")		

CHEMICAL & RADIOISOTOPE
2727 Campus Drive, Irvine, California 92715
Phone (714) 833-2500

CUSTOMER ORDER NO.	ACCT. NO.	LICENSE #
52		06-17253-01

SOLD TO SAME

F.O.B. POINT	SHIPPED VIA	PPD AD.	PPD.	COL.	D.O.R.	DATE OF ORDER
XX Source ☐ Destination		X			12-28-77	12-20-77

CATALOG NO.	QUANTITY ORDERED	QUANTITY SHIPPED	DESCRIPTION	LOT NO.	AMOUNT
77241	1		Sr-90, Wipe test Standard disc 1" dia		[redacted]

SV

TECHNICAL DATA (AS OF REFERENCE DATE)

ITEM				
CHEMICAL FORM				
CONCENTRATION				
VOLUME				
SOLIDS CONTENT				
SPECIFIC ACTIVITY				
RADIOCHEMICAL PURITY				
SPECIAL SPECIFICATIONS				
LOT NO.				
REFERENCE DATE				
TRANSPORT RADIOACTIVE GROUP				

HEALTH PHYSICS SURVEY: Radiation measurements on 3/9/78 after the above materials were completely packaged show less than (1) mr/hr on contact at all sides of the external container and less than _____ mr/hr at three feet from any point on the package. Spreadable contamination less than 200 d/m/100cm². APPROVED FOR SHIPMENT X Don Klos

CAUTION: This material has not been sterilized or tested for pyrogenic material. For laboratory or manufacturing use only.

Form ICN NSD 1001

1981 Renewal appl.

FORM NRC-313 I (3-80) 10 CFR 30

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR BYPRODUCT MATERIAL LICENSE
INDUSTRIAL

See attached instructions for details.

Completed applications are filed in duplicate with the Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety, and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555 or applications may be filed in person at the Commission's office at 1717 H Street, NW, Washington, D. C. or 7915 Eastern Avenue, Silver Spring, Maryland.

1. APPLICATION FOR: *(Check and/or complete as appropriate)*

	a. NEW LICENSE
	b. AMENDMENT TO: LICENSE NUMBER
x	c. RENEWAL OF: LICENSE NUMBER 06-17253-01

2. APPLICANT'S NAME *(Institution, firm, person, etc.)*

Victor J. Bortolot, Ph.D

TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION
(203) 453-3299

3. NAME AND TITLE OF PERSON TO BE CONTACTED REGARDING THIS APPLICATION

same

TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION

4. APPLICANT'S MAILING ADDRESS *(Include Zip Code)*
(Address to which NRC correspondence, notices, bulletins, etc., should be sent.)

Daybreak Nuclear & Medical Systems, Inc.
50 Denison Drive Guilford, CT 06437

5. STREET ADDRESS WHERE LICENSED MATERIAL WILL BE USED *(Include Zip Code)*

50 Denison Drive
Guilford, CT 06437

(IF MORE SPACE IS NEEDED FOR ANY ITEM, USE ADDITIONAL PROPERLY KEYED PAGES.)

6. INDIVIDUAL(S) WHO WILL USE OR DIRECTLY SUPERVISE THE USE OF LICENSED MATERIAL
(See Items 16 and 17 for required training and experience of each individual named below)

	FULL NAME	TITLE
a.	Victor J. Bortolot, Ph.D.	Research Director
b.		
c.		

7. RADIATION PROTECTION OFFICER

Victor J. Bortolot, Ph.D.

Attach a resume of person's training and experience as outlined in Items 16 and 17 and describe his responsibilities under Item 15.

8. LICENSED MATERIAL

LINE NO.	A ELEMENT AND MASS NUMBER	B CHEMICAL AND/OR PHYSICAL FORM	C NAME OF MANUFACTURER AND MODEL NUMBER *(If Sealed Source)*	D MAXIMUM NUMBER OF MILLICURIES AND/OR SEALED SOURCES AND MAXIMUM ACTIVITY PER SOURCE WHICH WILL BE POSSESSED AT ANY ONE TIME
(1)	Americium 241	sealed source	Amersham/Searle AMM	1 mCi (1 source)
(2)	Strontium 90	sealed source	ICN model 75129	100 mCi (1 source)
(3)	Strontium 90	wipe test std.	ICN model 77241	.01 microcurie
(4)				

E DESCRIBE USE OF LICENSED MATERIAL

(1) Thermoluminescence sensitivity calibrations of ceramic and [illegible] mineral materials
(2) for the purpose of archaeological dating, where alpha and beta response must both
(3) be determined (see attachments). Daybreak is one of two commercial labs in the
(4) world (only in US) doing art authentication, and has over 150 international clients.

FORM NRC 313 I (3-80)

OFFICIAL RECORD COPY MD. 10

116381

APR 14 1992

Docket No. 030-12440

License No. 06-17253-01

Control No. 116381

Daybreak Nuclear & Medical Systems
ATTN: Victor J. Bortolot, Ph.D.
50 Denison Drive
Guilford, Connecticut 06437

Dear Dr. Bortolot:

SUBJECT: LICENSE RENEWAL APPLICATION

This is to acknowledge receipt of your application for renewal of material(s) license identified above. Your application is deemed timely filed, and accordingly, the license will not expire until final action has been taken by this office.

Any correspondence regarding the renewal application should reference the control number specified above.

Sincerely,

Original Signed By:
Sheryl Villar

Sheryl Villar, Chief
Licensing Assistant Section
Division of Radiation Safety
and Safeguards

OFFICIAL RECORD COPY ML 10

CONVERSATION RECORD

TIME

DATE 4/14/92

TYPE

☐ VISIT ☐ CONFERENCE ☐ TELEPHONE ☐ INCOMING ☐ OUTGOING

Location of Visit/Conference:

ROUTING	
NAME/SYMBOL	INT

NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU	ORGANIZATION (Office, dept., bureau, etc.)	TELEPHONE NO.
DOUG BROADDUS	NMSS	

SUBJECT

Clarification of licensee's authorized use.

SUMMARY

Dome Pinellas RI, called Mr. Bartelet to clarify their use. They train people to take samples of paintings at different locations. Mr. Bartelet then takes the samples back to his location to "date". He does not manufacture - but uses 1 machine which he built.

Doug Broaddus stated the authorized use is considered X-ray flourescence - and is a type of measurement -- not an irradiation authorization. (Many machines are irradiators, but use is measurement.)

(Detroit Institute of Art applied for a SS&D for the machine which Detroit Institute uses.)

ACTION REQUIRED

NAME OF PERSON DOCUMENTING CONVERSATION	SIGNATURE	DATE
	S. Kimberly	4/14/92

ACTION TAKEN

(3P)

SIGNATURE	TITLE	DATE

50271-101

☆ U.S. GPO: 1987—181-247/60121

CONVERSATION RECORD

OPTIONAL FORM 271 (12-76)
DEPARTMENT OF DEFENSE

OFFICIAL RECORD COPY ML 10

116381

CONVERSATION RECORD

TIME 09:15 | DATE 4/09/92

TYPE

☐ VISIT ☐ CONFERENCE ☒ TELEPHONE ☐ INCOMING ☒ OUTGOING

Location of Visit/Conference:

NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU	ORGANIZATION (Office, dept., bureau, etc.)	TELEPHONE NO.
Victor J Bertolet, PhD	Dosimetric Nuclear Medicine	203-453-3299

SUBJECT Renewal.

ROUTING	
NAME/SYMBOL	INT

SUMMARY Utilizing TLD. as a means to gauge a material since the last time it was heated up. What is required is to take samples + and send them back to him in the laboratory.

The sealed sources will (not) be ~~[illegible]~~ an integral part of the automated thermoluminescence measurement system described on the application for renewal dated 20 March 1992.

ACTION REQUIRED

NONE

NAME OF PERSON DOCUMENTING CONVERSATION	SIGNATURE	DATE
DIMITRIADIS	A. Dimitriadis	4/9/92

ACTION TAKEN

SIGNATURE	TITLE	DATE

50271-101 ★U.S. G.P.O. 1983-381-526/6346 CONVERSATION RECORD OPTIONAL FORM 271 (12-76) DEPARTMENT OF DEFENSE

OFFICIAL RECORD COPY ML 10

116381

030-12440

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

U.S. Nuclear Regulatory Commission, Region I
Nuclear Materials Safety Section B
475 Allendate Road
King of Prussia, PA 19406

20 March 1992

Dear sirs:

I am requesting renewal of my radioisotopes license 06-17253-01 in accordance with your letter of 2 January. Neither uses of the sealed sources in my possession, nor personnel, nor protection program need change at this time. Accordingly, I am enclosing a duplicate copy of my last aplication and supporting documents.

In the next year, due to an increase of business regarding authenticity dating of art objects, I intend to bring an additional, automated thermoluminescence measurement system on-line (Daybreak model 1100, brochure enclosed). To support this system, I will want to purchase an additional set of sources (alpha and beta sealed sources) that will be stored and used in irradiators similar to those I have already in use, but with improved shielding. I enclose as well drawings and specifications of the beta irradiator (a commercial design Daybreak has sold since 1979 in small quantities). The proposed alpha and beta irradiators will be placed over a sample changer (rotating wheel) and controlled by the computer which handles the automated TL system. In no way does this proposal represent a qualitative difference from my existing program, but simply a modest increase in the number of sources. This will enable me to increase productivity without bringing in personnel in addition to myself (I prefer to be the only one permitted to work with the sources, to keep control simple).

I am therefore enclosing a document detailing the two additional sources proposed for licensing, and details (including an exposure rate survey) on the beta irradiator for the proposed beta source.

I enclose a check for $480, the fee for renewal of a license in fee category 3E.

Sincerely yours,

Victor J. Bertolot, Ph.D.
Technical Director

enclosures.

Log Apr 5 I
Remitter
Check No. 3931
Amount $480
Fee Category 3E
Rec'd At Rem.
Date Check Rec'd 3/23/92
Date Completed

116381

50 Denison Drive Guilford, CT 06437 (203) 453-3299

1992 RENEWAL
ITEMS. 8, 9, 13 updated.

FORM NRC-313 I (3-80) 10 CFR 30 — U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR BYPRODUCT MATERIAL LICENSE
INDUSTRIAL

See attached instructions for details.

Completed applications are filed in duplicate with the Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety, and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555 or applications may be filed in person at the Commission's office at 1717 H Street, NW, Washington, D. C. or 7915 Eastern Avenue, Silver Spring, Maryland.

1. APPLICATION FOR: *(Check and/or complete as appropriate)*

	a. NEW LICENSE
	b. AMENDMENT TO: LICENSE NUMBER
x	c. RENEWAL OF: LICENSE NUMBER 06-17253-01

2. APPLICANT'S NAME *(Institution, firm, person, etc.)*
Victor J. Bortolot, Ph.D
TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION
(203) 453-3299

3. NAME AND TITLE OF PERSON TO BE CONTACTED REGARDING THIS APPLICATION
same
TELEPHONE NUMBER AREA CODE – NUMBER EXTENSION

4. APPLICANT'S MAILING ADDRESS *(Include Zip Code)*
(Address to which NRC correspondence, notices, bulletins, etc., should be sent.)
Daybreak Nuclear & Medical Systems, Inc.
50 Denison Drive Guilford, CT 06437

5. STREET ADDRESS WHERE LICENSED MATERIAL WILL BE USED *(Include Zip Code)*
50 Denison Drive
Guilford, CT 06437

(IF MORE SPACE IS NEEDED FOR ANY ITEM, USE ADDITIONAL PROPERLY KEYED PAGES.)

6. INDIVIDUAL(S) WHO WILL USE OR DIRECTLY SUPERVISE THE USE OF LICENSED MATERIAL
(See Items 16 and 17 for required training and experience of each individual named below)

	FULL NAME	TITLE
a.	Victor J. Bortolot, Ph.D.	Research Director
b.		
c.		

7. RADIATION PROTECTION OFFICER
Victor J. Bortolot, Ph.D.

Attach a resume of person's training and experience as outlined in Items 16 and 17 and describe his responsibilities under Item 15.

8. LICENSED MATERIAL

LINE NO.	A. ELEMENT AND MASS NUMBER	B. CHEMICAL AND/OR PHYSICAL FORM	C. NAME OF MANUFACTURER AND MODEL NUMBER *(If Sealed Source)*	D. MAXIMUM NUMBER OF MILLICURIES AND/OR SEALED SOURCES AND MAXIMUM ACTIVITY PER SOURCE WHICH WILL BE POSSESSED AT ANY ONE TIME
(1)	Americium 241	sealed source	Amersham/Searle AMM	1 mCi (1 source)
(2)	Strontium 90	sealed source	ICN model 75129	100 mCi (1 source)
(3)	Strontium 90	wipe test std.	ICN model 77241	.01 microcurie
(4)				

	E. DESCRIBE USE OF LICENSED MATERIAL
(1)	Thermoluminescence sensitivity calibrations of ceramic and other mineral materials
(2)	for the purpose of archaeological dating, where alpha and beta response must both
(3)	be determined (see attachments). Daybreak is one of two commercial labs in the
(4)	world (only in US) doing art authentication, and has over 150 international clients.

ITEMS 8, 9 updated

8
Item 8. Radioactive Material (including additions to current license)
(* covered by current license)

A. Strontium 90*	ICN Pharmaceuticals Sealed source model 75129	1 source of 100 mCi
B. Americium 241*	Amersham/Searle Sealed source Model AMM	1 source of 500 uCi
C. Strontium 90*	ICN sealed wipe test standard	1 source of 0.005 uCi
D. Strontium 90	ICN Pharmaceuticals Sealed source model 75144	1 source of 100 mCi
E. Curium 244	Isotope Products Labs. Sealed source Model AFR-244	1 source of 500 uCi

8E
Item 8. Purposes for which licensed material will be used
With the exception of source C. (for beta wipe test measurements in our radiation safety program), all sources are intended solely for irradiation of mineral materials. The response of these materials to radiation is measured, and used in archaeological dating by thermoluminescence.

Sources A. and B. are stored and used in the irradiators described in application dated 23 December 1981. Source D. is to be housed and used in a very similar, but improved, beta irradiator. Source E. is to be housed and used in an alpha irradiator identical to that in the 1981 application.

Sources D. and E. are required to cope with increased numbers of samples. We now have 500 clients, and remain the only commercial laboratory in North America for thermoluminescence dating of ceramics. The additional sources are for use with an automated measurement system for routine and predictable samples, while the originally licensed sources (A. and B.) will continue to be used for the less routine samples that require individual attention and adjustment of calibration doses during the measurement procedure.

9. Storage of sealed sources
All irradiators are built by the applicant.

A. Sr-90 beta irradiator I (as described in original application 1977, and renewals)
D. Sr-90 beta irradiator II (see enclosure, identified as Daybreak model 740)
B. and E. alpha irradiator (as described in original application and renewals)

9. STORAGE OF SEALED SOURCES

LINE NO.	A. CONTAINER AND/OR DEVICE IN WHICH EACH SEALED SOURCE WILL BE STORED OR USED.	B. NAME OF MANUFACTURER	C. MODEL NUMBER
(1)	Sr-90 beta irradiator (see attachment)	applicant	n.a.
(2)	Am-241 alpha irradiator (see attachmt)	applicant	n.a.
(3)			
(4)			

10. RADIATION DETECTION INSTRUMENTS

LINE NO.	A. TYPE OF INSTRUMENT	B. MANUFACTURER'S NAME	C. MODEL NUMBER	D. NUMBER AVAILABLE	E. RADIATION DETECTED (alpha, beta, gamma, neutron)	F. SENSITIVITY RANGE (milliroentgens/hour or counts/minute)
(1)	scint. counter	applicant	n.a.	2	alpha, beta	2-5x10^8 alpha/hr 200-10^7 beta/min
(2)	TL reader	applicant	n.a.	1	alpha, beta, gamma	integrated 25 uR-10^4 R
(3)	(see item 11 attachments for	description)				
(4)						

11. CALIBRATION OF INSTRUMENTS LISTED IN ITEM 10

☐ a. CALIBRATED BY SERVICE COMPANY

NAME, ADDRESS, AND FREQUENCY

☒ b. CALIBRATED BY APPLICANT

Attach a separate sheet describing method, frequency and standards used for calibrating instruments.

12. PERSONNEL MONITORING DEVICES

A. TYPE (Check and/or complete as appropriate.)	B. SUPPLIER (Service Company)	C. EXCHANGE FREQUENCY
☐ (1) FILM BADGE ☒ (2) THERMOLUMINESCENCE DOSIMETER (TLD) ☐ (3) OTHER (Specify): _____	applicant	☐ MONTHLY ☒ QUARTERLY ☐ OTHER (Specify):

13. FACILITIES AND EQUIPMENT (Check were appropriate and attach annotated sketch(es) and description(s).

☒ a. LABORATORY FACILITIES, PLANT FACILITIES, FUME HOODS (*Include filtration, if any*), ETC.
☐ b. STORAGE FACILITIES, CONTAINERS, SPECIAL SHIELDING (*fixed and/or temporary*), ETC.
☐ c. REMOTE HANDLING TOOLS OR EQUIPMENT, ETC.
☐ d. RESPIRATORY PROTECTIVE EQUIPMENT, ETC.

14. WASTE DISPOSAL

a. NAME OF COMMERCIAL WASTE DISPOSAL SERVICE EMPLOYED

n.a.

b. IF COMMERCIAL WASTE DISPOSAL SERVICE IS NOT EMPLOYED, SUBMIT A DETAILED DESCRIPTION OF METHODS WHICH WILL BE USED FOR DISPOSING OF RADIOACTIVE WASTES AND ESTIMATES OF THE TYPE AND AMOUNT OF ACTIVITY INVOLVED. IF THE APPLICATION IS FOR SEALED SOURCES AND DEVICES AND THEY WILL BE RETURNED TO THE MANUFACTURER, SO STATE.

This application is for sealed sources. In the event of leakage, they will be returned to the manufacturer for repair or disposal.

INFORMATION REQUIRED FOR ITEMS 15, 16 AND 17

Describe in detail the information required for Items 15, 16 and 17. Begin each item on a separate page and key to the application as follows:

15. RADIATION PROTECTION PROGRAM. Describe the radiation protection program as appropriate for the material to be used including the duties and responsibilities of the Radiation Protection Officer, control measures, bioassay procedures *(if needed)*, day-to-day general safety instruction to be followed, etc. If the application is for sealed sources also submit leak testing procedures, or if leak testing will be performed using a leak test kit, specify manufacturer and model number of the leak test kit.

16. FORMAL TRAINING IN RADIATION SAFETY. Attach a resume for each individual named in Items 6 and 7. Describe individual's formal training in the following areas where applicable. Include the name of person or institution providing the training, duration of training, when training was received, etc.

    a. Principles and practices of radiation protection.

    b. Radioactivity measurement standardization and monitoring techniques and instruments.

    c. Mathematics and calculations basic to the use and measurement of radioactivity.

    d. Biological effects of radiation.

17. EXPERIENCE. Attach a resume for each individual named in Items 6 and 7. Describe individual's work experience with radiation, including where experience was obtained. Work experience or on-the-job training should be commensurate with the proposed use. Include list of radioisotopes and maximum activity of each used.

18. CERTIFICATE

(This item must be completed by applicant)

The applicant and any official executing this certificate on behalf of the applicant named in Item 2, certify that this application is prepared in conformity with Title 10, Code of Federal Regulations, Part 30, and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.

WARNING.–18 U.S.C., Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

a. LICENSE FEE REQUIRED *(See Section 170.31, 10 CFR 170)*	b. CERTIFYING OFFICIAL *(Signature)* Victor J. Bortolot
$ 150.00	c. NAME *(Type or print)* Victor J. Bortolot, Ph.D.
(1) LICENSE FEE CATEGORY: $ 150	d. TITLE Director of Research
(2) LICENSE FEE ENCLOSED: $ 150	e. DATE 12/23/81

FORM NRC-313 I (3-80)

ITEM 9. Source storage.

α SOURCES B, E

(1) The Am-241 sealed source is housed and used in the device shown in Figure 1. This has an electrically-operated (solenoid) arm with a fail-safe spring return that carries the source out of the housing over the sample to be irradiated. At all times the active surface of the source is inaccessible to human contact. By use of an alpha absorber, the gamma component alone is available for use as a calibrator for TL personel monitor badges. This source has been standardized against radium using the same TLD material.

β SOURCE A

(2) The Sr-90 sealed source is stored and used in the shielded device shown in Figure 2. This, like the alpha housing above, is electrically operated. The spring return shutter protects the source against mechanical damage and human contact. When the solenoid is not energized, the shutter remains closed in all orientations, and cannot be opened without dissassembly of the device. The shutter is a composite of 1/16" aluminum alloy and 3/16" lead to minimize brehmstrahlung production. As measured with an Eberline RO-1 ionization type survey meter, the closed shutter exit exposure rate is 45 mR/hr and the surface exposure rate on the steel enclosure can is about 10 mR/hr. The device is stored in a fireproof safe on and behind lead brick. In use, the device is placed 2 feet from the TL reader on and behind lead brick. When a sample calibration is to be done, the device is placed on the TL reader glow oven directly over the sample, and the shutter opened by an electronic timer. The exposure on the under surface of the glow oven during irradiations is 20 mR/hr. The source is in use about 200 hours annually. Dose monitoring of the applicant has shown less than 250 mR exposure per year during the term of the current license.

β SOURCE D

(3) A new beta irradiator is to be built for source D. Details are given in the enclosure following this page. This irradiator is to be used seated on a sample changing mechanism approximately 30cm square with the irradiator at the rear edge. The irradiator/changer will be covered with a box to exclude light, and act as a barrier to casual access. The source will abut a concrete foundation wall with rock/fill on the other side. The irradiator will be removed and stored when not in use as in item (2) above.

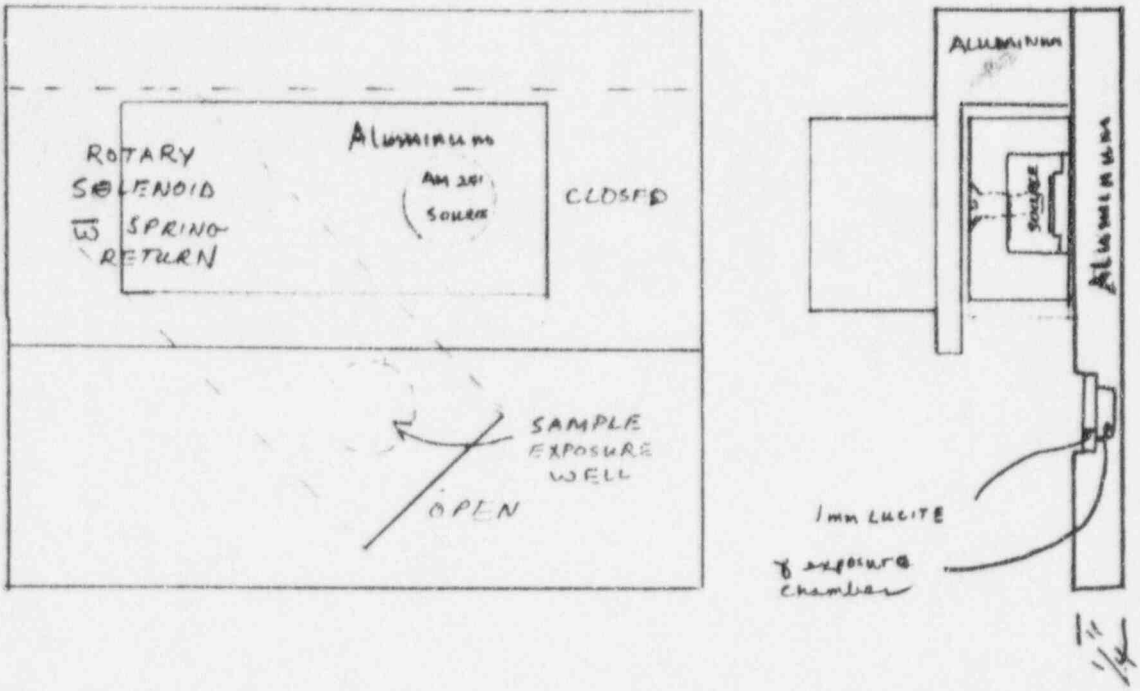


FIGURE 1. Am-241 alpha/gamma exposure device
ANTICIPATED SURFACE EXPOSURE RATE 21 MR/hr.

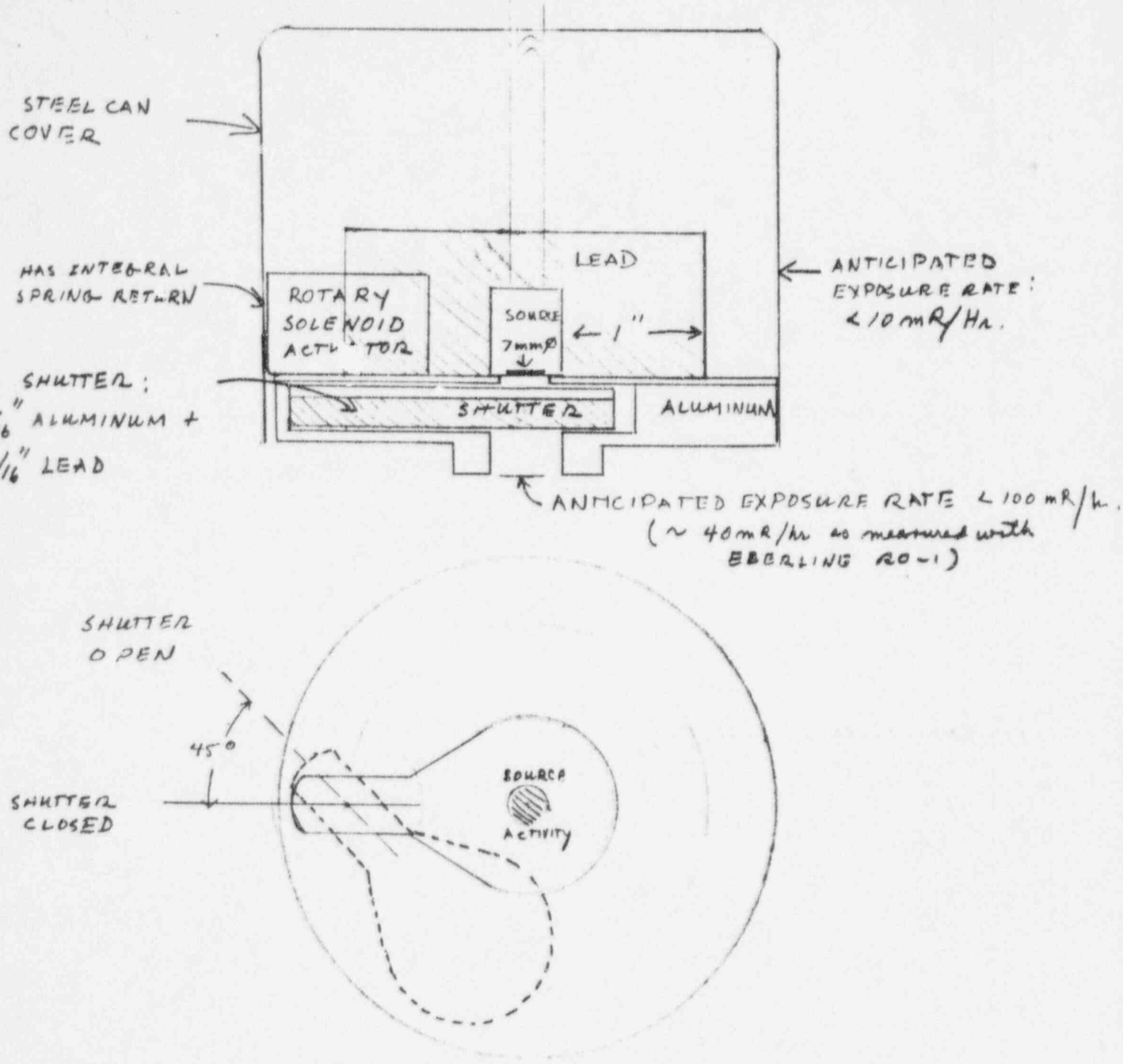


FIGURE 2. Sr^{90} SHIELDED EXPOSURE DEVICE, ACTUAL SIZE.
WHEN NOT IN USE, DEVICE WILL SIT ON 2" LEAD BRICK.
WHEN IN USE, DEVICE WILL SIT ON TL READOUT OVEN (~ 1" ALUMINUM).

DAYBREAK MODEL 740 BETA IRRADIATOR Revision 2 21 November 1984

SUMMARY DESCRIPTION

The 740 beta irradiator is a shielded, solenoid-actuated shutter device for irradiating samples for thermoluminescence dating in place on the glow oven heating plate. The shutter is a composite of aluminum (0.050 in) and lead (0.200 in) to minimize bremstrahlen production, and has a failsafe spring to return the shutter to the closed position when actuating power is removed. The rotary shutter counterweight, together with the failsafe spring, prevent opening without power in any orientation. The shutter is in the form of a disk with an aperture offset 68 degrees from the position of the source. When power is applied, the disk rotates to place the aperture beneath the source, permitting sample exposure to occur. Top and side views of the device are shown in figure 1 and details of the shutter and shield in figure 2. Approximate surface exposure rates measured with an ionization- type survey meter in contact with the surface are given also in figure 1. Because of the relatively high exit exposure rate under the shutter with the shutter in the closed position, it is recommended that the device be stored on and behind 2" lead blocks when not in use. The exposure rate at knee level directly beneath the when the device is in use on the glow oven and the shutter open is under 1 mR/hr. The prototype of this irradiator was approved for use in this application in NRC license 06-17253-01 (V.J. Bortolot, Daybreak Nuclear and Medical Systems, Inc. Guilford, CT 06437). The shield incorporated in the 740 is about twice the thickness of the prototype device. The device is installed in several agreement states, and several foreign countries, but aside from the prototype, none of these has fallen under the purview of the NRC.

The SR-90 source recommended for use in this device is Isotope Products Laboratory, Inc. (Burbank, CA) model SK-236 having a nominal 125 mCi activity.

HEALTH AND SAFETY DATA

The 740 beta irradiator is ruggedly built, able to withstand extended use in a normal laboratory environment. The solenoid actuator is permanently lubricated and requires no maintainance. All parts except the power cable insulation are metallic and not subject to degradation with exposure to radiation. In case of fire, the lead shield could melt, but the source would remain inside the cover can and baseplate, so that activity would not escape. Because the device is small, any likely explosion would most probably result in translation, rather than fragmentation. In an impact, the soft lead shield surrounding the source would deform and cushion the source, thus tending to protect it.

Leak testing is recommended at six month intervals and no attempt should be made to wipe the source directly (to avoid personnel exposure), but rather to wipe the exterior of the shutter surface, as well as the immediate storage area and glow oven heating plate, which is immediately below the source when in use.

It should be noted that though the source is above a heating plate while in use, this low-power heater is at room temperature at the time. If by accident, the temperature ramp were started during the exposure, the source (at 0.70 in source to sample distance) would not be exposed to temperatures exceeding about 40C.

Pertinent exposure rate measurements at the device surface are given in figure 1.

SOURCE LOADING

Loading the source requires some disassembly of the 740 irradiator. The device was designed purposively to make access to the source difficult, for the protection both of personnel and the source itself.

Before starting, place a piece of tape on the underside of the shutter (the lead shutter shield shows though the aperture in the black anodized base of the irradiator). This prevents the shutter from rotating after the solenoid and shield are removed, making reassembly easier.

First, remove the cover can by removing the three 4-40 screws at its

lower edge. Slide the cover off the base plate carefully to avoid stress on the wires connecting the coax cable to the solenoid. Next, unscrew the four 6-32 shoulder screws that secure the solenoid mounting plate to the hex mounting posts. Lift the solenoid assembly straight up and set aside. The lead source shield is then removed. Three 6-32 screws with washers secure it to the base plate. Note that the hole in the shield though which the solenoid actuating post passes is over the hole in the base plate which exposes the shutter coupling slot. The actuating post fits into this slot and onto the 0.125" steel dowel in the slot.

Place the beta source, active surface down, in the shallow recess provided at the center of the top plate over the shutter opening. BE CAREFUL! OBSERVE EVERY SAFETY PRECAUTION. RADIOISOTOPE SOURCES ARE DANGEROUS WHEN IMPROPERLY HANDLED AND MAY ALSO BE DAMAGED. It would be wise to work from behind a 0.5 inch plexiglass sheet which would absorb any stray beta radiation as the source was handled should the source accidentally be turned toward the installer.

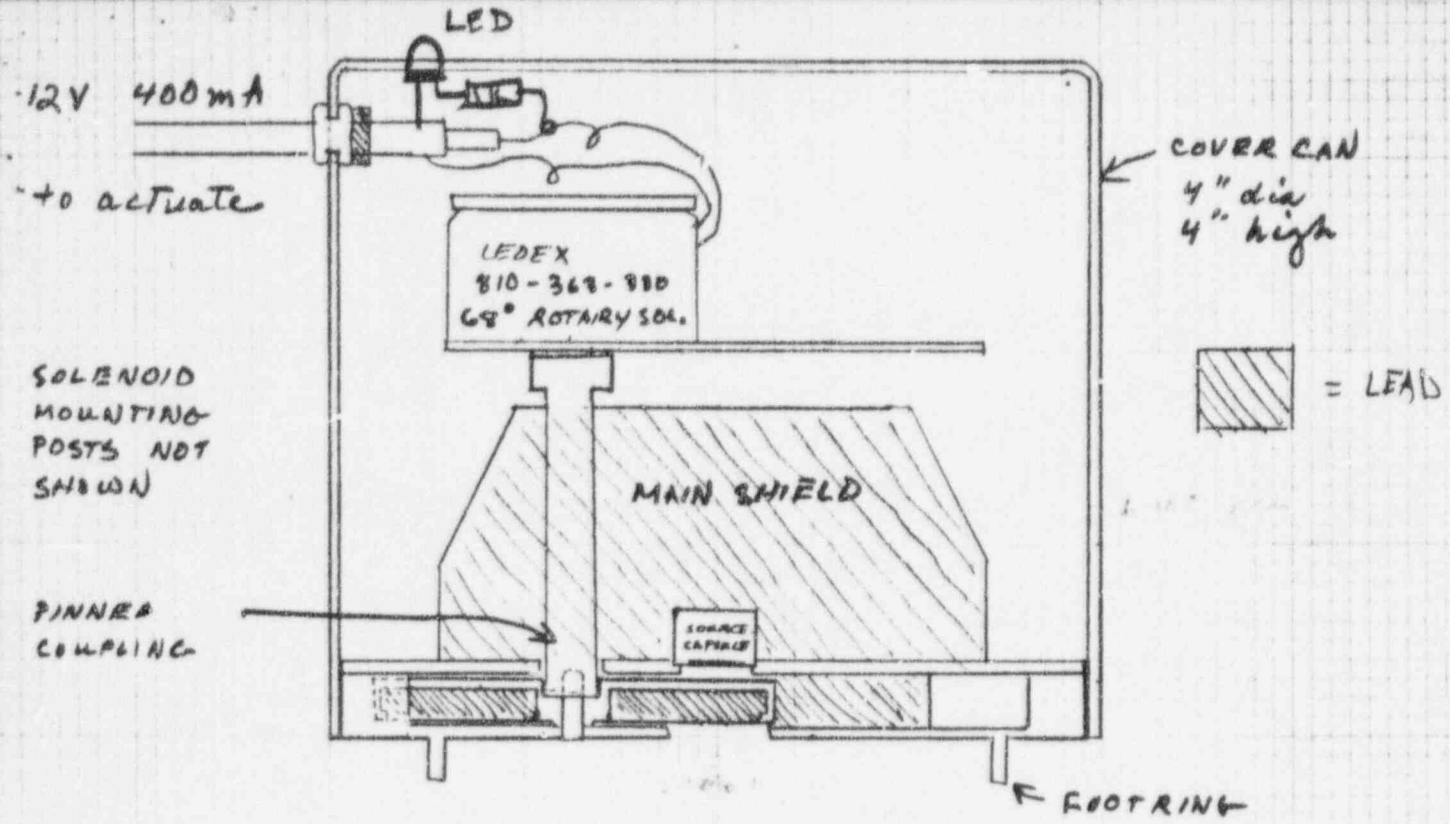
Now, reassemble. Place the shield over the source, taking care not to jostle it out of its recess. Orient the shield so that the holes line up with those in the base plate and re-secure with the three 6-32 screws with washers. Insert the solenoid actuator post though the hole in the shield, and by feel seat it in the shutter. If the shutter was taped before disassembly, the holes on the solenoid assembly will line up with the four posts. Replace the four shoulder screws. The solenoid assemble must have some free play on the shoulder screws. Replace and secure the cover can, making certain that the wires inside are not trapped between the top of the solenoid and the can, as that may prevent the solenoid from moving properly. Remember to remove the tape from the bottom surface of the irradiator.

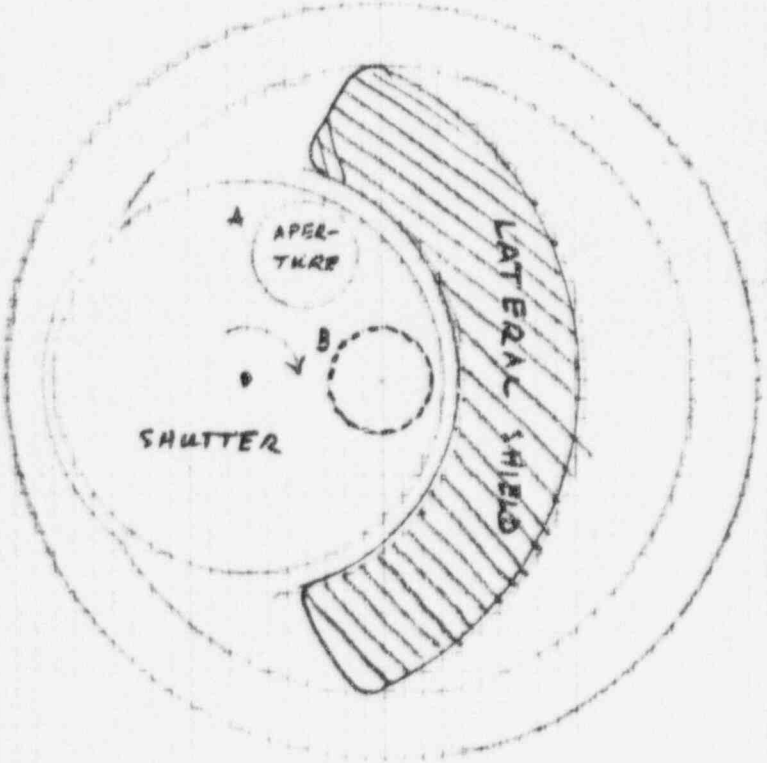
INSTRUCTIONS FOR OPERATION

The 740 is designed to be powered by a Daybreak 590 timer, or other DC source providing 12 V at 400 mA. The BNC connector on the cable is plugged into the BETA socket on the 590 timer front panel and this module's START and STOP pushbutton switches then control the operation of the 740. The 740 solenoid will make an audible "thunk" when power is applied (590 START pressed) and the timer display will be active. The solenoid release is also audible, and the timer display goes to "0000".

For use in irradiating a sample, the foot-ring of the beta irradiator is inserted into the light baffle groove surrounding the glow oven, so that the irradiator sits on the glow oven o-ring, with the active surface of the source facing down toward the sample but blocked by the shutter. This ensures that the irradiator is centered on the sample and that the source to sample distance is always the same. While the surface exposure rates at the irradiator are quite low, whether the shutter is open or not, it would be best for the operator to move away a short distance (say, three feet) from the irradiator. Alternatively, a "castle" shield, made of a U of lead bricks around the glow oven opening will reduce lateral exposure to background while still allowing easy access to the glow oven. Likewise, while the irradiator is not in use during a series of glowcurves, and is to be kept within convenient reach, it should be kept on a lead brick and behind one as well.

THE SHUTTER SHOULD NEVER BE OPENED WHILE THE IRRADIATOR IS OFF THE GLOW OVEN, NOR SHOULD IT BE REMOVED FROM THE GLOW OVEN WHILE AN IRRADIATION IS IN PROGRESS.

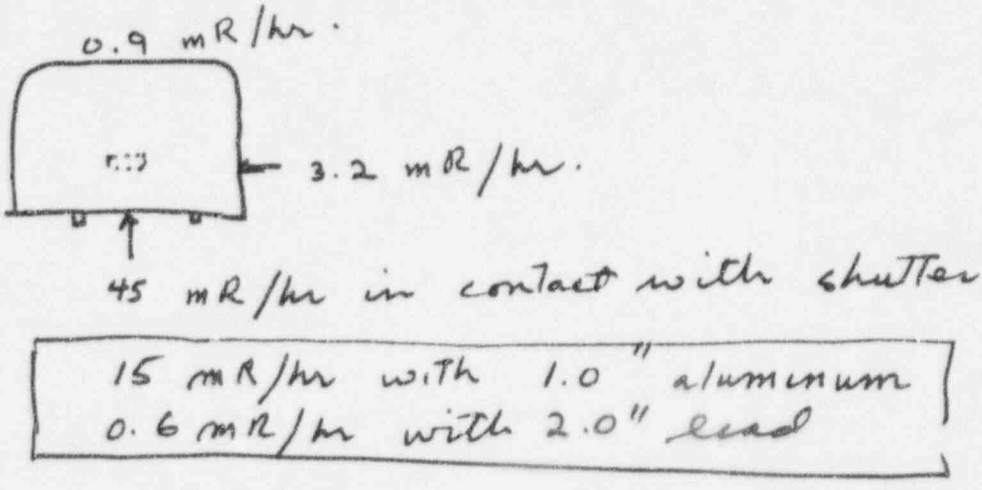

LED
12V 400mA
+0 actuate
COVER CAN
4" dia
4" high
LEDEX
810-363-810
68° ROTARY SOL.
SOLENOID MOUNTING POSTS NOT SHOWN
= LEAD
MAIN SHIELD
PINNED COUPLING
SOURCE CAPSULE
FOOTRING

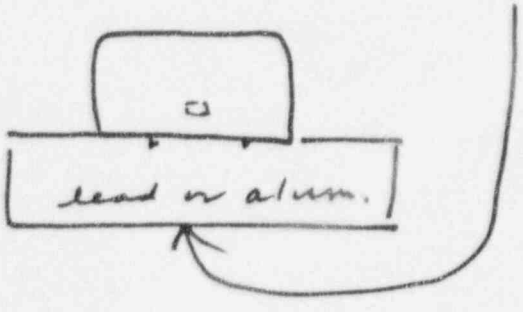

A = CLOSED POSITION
B = OPEN POS.
A
APER-TURE
B
SHUTTER
LATERAL SHIELD
0
1
2"

116381

SURVEY OF 740 BETA IRRADIATOR

Loading : 100 mCi SR-90 (Amersham SIF. 1177)
measurements made with ionization meter
at York college (Queens, NY) by V. J. Bartolet
on Aug. 1988





ITEM 11. Calibration of instruments.

1. The scintillation counters used in the TL dating laboratory for alpha activity measurements are used additionally for wipe tests using standards for comparison. The counters consist of a scintillator (Wm. Johnson ZnS alpha screens, or a Nuclear Enterprises NE810 plastic foil beta scintillator), PMT (EMI 9656), and NIM-packaged electronics with pulse amplifiers after Lampton and Primsch (RSI 42, 731 (1971)) and conventional integral discriminators and counters. For additional description, see the page on the Daybreak 580-series counters which are functionally the same (see attachment).

These counters were developed by the applicant while he ran the TL laboratory at Mt. Sinai School of Medicine (New York), and have proven successful for low level alpha measurements in dating, and for both alpha and beta wipe tests. Since all wipe tests are made by comparison with standards, there is no need for absolute calibration.

For alpha wipe tests, the amplifier gain and discriminator level are normally set for 85 per cent detection efficiency of alphas from a 1 per cent Th thick source (NBL analyzed sample #79-A) on a ZnS screen. Typical background is 2 counts/hr. For the purpose of wipe tests, the comparison source is a plated planchet containing 1440 dpm of Pu-239 (approximately 0.001 uCi) standardized at the NRC Health and Safety Laboratory in New York.

Beta wipe tests are performed with the plastic scintillator foil, with the gain increased and discriminator threshold lowered to give approximately 4000 counts/min for the wipe test standard and 200 counts/min background.

2. A description of the TL reader system is given in the Daybreak brochure attached, as it is the prototype model. This is a high performance photon-counting TL system capable of measurements down to 25 uR with $CaSO_4$:Dy phosphor with 12 per cent precision, and 1mR with LiF with 3 per cent precision. This instrument is used for personnel monitoring where the gamma component of the Am-241 sealed source is used for calibration each time a TL phosphor is read out. The gamma calibration is by comparison with exposure to a 10 mg radium source at the Yale-New Haven Radiotherapy Dept. LiF-7 1/8" square dosimeters enclosed in $\frac{1}{4}$" delrin wall capsules were placed on the centerline of an Eberline RO-1 survey meter in integration mode during exposure.

updated for 1992 renewal

ITEM 13. Laboratory facilities.

The laboratory is devoted both to TL authenticity testing and to the development and production of high-performance apparatus for TL dating. It consists of 500 square feet of basement level space in a residential building owned by the applicant, divided into three rooms. The two front rooms house office space, electronics assembly area, and machine shop, while the thirdcontains the TL lab. The equipment here includes a high sensitivity photon counting TL detection apparatus with vacuum/N_2 purge sample oven, linear temperature rise of 0-50C/sec, xy recorder, scintillation counters for alpha activity measurements and ancillary sample preparation and calibration equipment. A flame photometer measures potassium content for K-40 activity. A Daybreak 9900 computer system ~~will shortly~~ is installed to do data reduction and age computations. The fireproof safe for the sealed sources covered in this application is within a lokked cabinet in this room. The door to the lab may be locked.

In 1992, a Daybreak model 1100 automated TL measurement system will be installed to increase productivity in routine authenticity studies. (see enclosure.)

ITEM 15. Radiation protection program.

The radiation protection program at this laboratory complies with the standards set forth in Part 20 of the U.S. Nuclear Regulatory Commission Rules and Regugations, and will be described below under four headings: security, leak testing, personnel monitoring, and action in case of source leakage.

(a) Security. The section of basement level occupied by Daybreak Nuclear and Medical Systems, Inc. is accessable from the remainder of the basement by one locked solid core door equipped with deadbolt lock, and from the outside by a steel door with deadbolt lockset (main entrance). The door to the TL laboratory where the sources are stored and used is labeled with a "Caution-Radioactive Materials" sign and is locked when the lab is not in use. The sources, in their shielded irradiator housings are kept in a fireproof safe within a locked cabinet which is against a subterrean concrete foundation wall. Access to the sources is limited to the applicant, and no other person is permitted in the TL lab when the sources are in use.

(b) Leak testing is performed by the applicant semi-annually when the sources are in use. Each source housing is wiped on the surfaces where any leakage is liable to collect with a moistened cotton swab. As described under item 11, a scintillation counter is used to measure leakage activity for each swab by comparison to a wipe test standard (alpha: Pu-239 0.001 uCi plated source, beta: Sr-90 0.0076uCi* leak test standard, ICN model 77241). The results are to be kept on file indefinitely.

(c) Personnel dosimetry. A badge ($\frac{1}{4}$" wall delrin cylinder) containing three 1/8" square LiF-7 TL dosimeters is worn by the applicant whenever the source housings are used, and the dosimeters are read out quarterly when the sources are in use by the TL reader described in item 11. The gamma component of the Am-241 source has been calibrated relative to radium and is used to calibrate the dosimeters at each read out. The results are to be kept on file indefinitely. During the term of this license the dose to the applicant did not exceed 250 mrad/year. Because of the robust construction of the sealed sources, and their being housed in shielded enclosures that prevent mechanical damage, no survey meter or alarm is necessary to supplement the dosimeter badge.

(d) If, in the course of leak testing, removable activity in excess of 0.005 uCi should be discovered, the source will be examined (with plastic gloves worn). The beta source can be checked for a broken window by inspection with a mirror with the shutter energized open. The alpha source has a rolled gold coating that could conceivably become scratched (although the mechanical design of the source arm--the source is slightly recessed--is meant to prevent this). The arm would be removed by disassembling the housing, and the source surface inspected using a mirror. Wipe tests of the safe, shield area near the TL reader, and the path between would then be made to determine the extent of any contamination. A telephone report will be made to the Region I USNRC Office of Inspection and Enforcement, King of Prussia, PA, within 24 hours. A report will also be made to the manufacturer. The source will be kept in the storage safe pending instructions on safe transport to the manufacturer for repair or disposal.

* present activity 0.005 μCi 1/92

ITEM 16. Formal training in radiation safety.

The basics of radioactivity measurement and instrumentation and the mathematics thereof was covered in a modern physics course taken by the application at Boston College in 1963-1964. About two weeks and four laboratory sessions were devoted to this section of the course. A semi-formal course of radiation protection practice, standardization and measurement, and a review of the math and calculations, which consisted both of text reading and practical experience with all instruments and therapy devices available in the department, was given over a two-week period in 1971 at Mount Sinai School of Medicine when the applicant was first employed there. This course of study was given by Howard Hazelkorn, radiation safety officer of the radiotherapy department. The biological effects of radiation were not covered formally, although a great deal of reading in gynecological cancer and its treatment done in preparation for this employment did in fact cover most of the basics.

ITEM 17. Experience.

As research physicist with the radiotherapy department of Mount Sinai School of Medicine in New York, the applicant was concerned with setting up a TL laboratory for high sensitivity *in vivo* dosimetry of radiotherapy treatment of gynecological cancers by afterloading, where tubes to hold Cs-137 sources are positioned in the uterus, adjusted, their position measured by stereo x-ray, then finally loaded with the radioisotope. A further use of the TL lab was research into TL dating of art objects, then a new field of research. The major sources used in the TL lab were a 100 mCi strontium-90 and a 500 uCi Americium-241 sealed source, used for four years. a 10 mg radium source was used for a six-month period for low level radiation calibrations of TL phosphors. For the entire 4½ year period of employment at Mount Sinai, the applicant did dosimetry on, and unloaded patients having up to 0.5 Ci of Cs-137, and had responsibility for control of this material.

Having founded Daybreak Nuclear and Medical Systems, Inc. in 1977, the applicant has built up one of two commercial TL authenticity testing services in the world, and the only one in this country, having an international clientele of over [redacted] museums, collectors, and dealers. 502
Since mid-1977, a 100 mCi Sr-90 and 500 uCi Am-241 source have been used for the sensitivity calibration of ceramic materials. The major activity of the applicant is the development and manufacture of TL systems for archaeological dating, including various shielded irradiator devices. Since 1979, more than [redacted] TL labs have been completely equipped by the applicant in locations throughout the world.

Resume. ITEMS 16 and 17.

Victor J. Bortolot
50 Denison Drive
Guilford, CT 06437
(203) 453-3299

Born 8/11/44 Norwalk, CT

EDUCATION: Boston College BS (physics) cum laude 1965

Columbia University MA (physics) 1969

New York University Ph.D. (physics) 1972
Dissertation under P. Thaddeus: The Interstellar line Spectra of Zeta Ophiuchi and Zeta Persei and their Relation to the Cosmic Background Radiation.

WORK EXPERIENCE

summers 1963-1966: Perkin-Elmer Corp. Norwalk, CT. applcations engineering in differential scanning calorimetry and electron spin resonance.

3/66-10/71: NASA (Goddard Institute for Space Studies, New York) Research assistant. Graduate research including extensive interactive computer programming, microwave spectroscopy, high resolution stellar spectroscopy including 45 nights observation at Lick and Kitt Peak Observatories, low level light detection, and digital electronics design.

11/71-6/76: Mount Sinai School of Medicine, New York. Radiation research physicist. Set up TL lab for *in vivo* dosimetry for radiotherapy and archaeological dating research. Development of high sensitivity photon counting TL detection system. Design and engineering development of high intensity Cs-137 remote afterloading device for treatment of cervical and uterine cancer under N. Simon. High speed data acquisition and processing in nuclear medicine. Considerable digital and analog electronic design experience.

7/76-1/77: consultant in nuclear medicine instrumentation. Developed respiratory motion correction instrument for gamma cameras, later brought into production and marketed by Daybreak Nuclear and Medical Systems, Inc.

1/77-present: Daybreak Nuclear and Medical Systems, Inc. Founder and director of research. Built apparatus and set up TL lab for authenticity testing of art objects. Development and production engineering of modular TL system for archaeology. Development of computer interface and software system for reduction of TL data and date computation.

PUBLICATIONS

Five papers published on interstellar line spectra and four on TL dating and instrumentation.

DAYBREAK
systems for TL dating

Daybreak Nuclear and Medical Systems, Inc., is a small, privately held corporation founded in 1977, which specializes in thermoluminescence (TL) dating instruments and services. We are the world's leading manufacturer of systems for TL dating in geology and archaeology with more than 50 systems installed worldwide. Daybreak makes available a wide range of automated and conventional TL systems and accessories, and has developed outstanding applications software for TL. We shortly will introduce the world's first commercially available single sample and automated OSL (optically stimulated luminescence) reader systems.

At a recent international TL specialist meeting, more than 40 per cent on the papers presented data taken with Daybreak instruments.

Another side of Daybreak's TL activities includes authenticity testing of art objects. We are the only commercial TL authenticity service in the Americas, and have the distinct advantage of continually updated state-of-the-art equipment. All dating studies are done by our technical director, Victor J. Bortolot, Ph.D., who has nineteen years' experience in this field. Authenticity studies are made with careful attention to technique, yet quickly enough to assist curators, dealers, and collectors with their decisions. We endeavor to have dating results available within two weeks of obtaining samples, and rush service is available at a premium. Daybreak has trained conservators available for taking samples in many cities, and Dr. Bortolot is available by appointment for sampling in New York City and Guilford, CT. This authenticity dating service is completely confidential, so it is not possible to name our clients (and results are never made available except by the express permission of the client commissioning the study). Certain public institutions, mostly museums, use our services, and where the results are on public record, they may be mentioned. Some of these are listed below.

Metropolitan Museum, New York
Detroit Institute of Art
Houston Museum of Fine Arts
Dallas Museum of Art
Museum of Fine Arts, Boston
National Gallery, Washington
Freer Gallery, Washington
Hirshhorn Museum, Washington
Indianapolis Museum
Cleveland Art Museum
Cinncinati Art Museum
New Orleans Museum of Art
Yale Art Gallery, New Haven
Brooklyn Museum
St. Louis Art Museum
Virginia Art Museum, Richmond

We presently have over 400 clients for our dating services.

50 Denison Drive Guilford, CT 06437 (203) 453-3299

Daybreak Nuclear and Medical Systems, Inc.
Guilford, CT 06437 USA

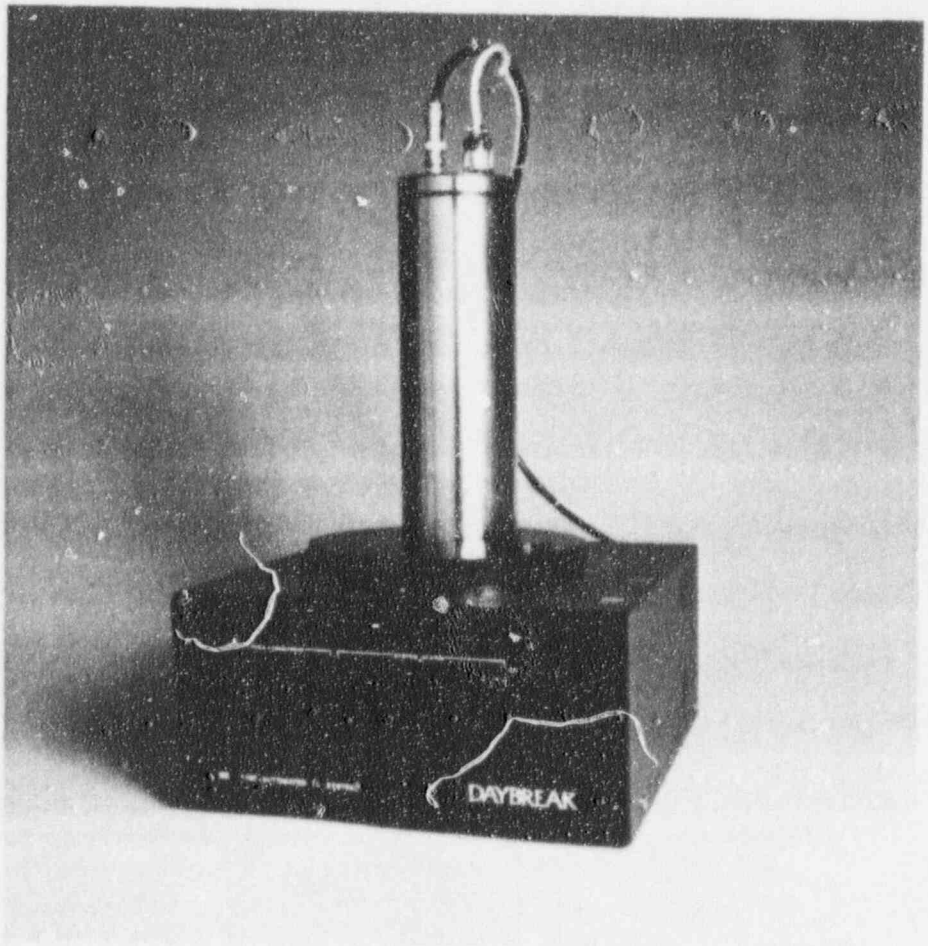
Partial customer list by country:

AUSTRALIA:	Commonwealth of Australia, Jabiru, NT
	University of Adelaide, Adelaide, NSW
	Australian National University, Canberra
AUSTRIA:	Hochschule fur Angewandte Kunst, Vienna
	International Atomic Energy Agency, Vienna
BULGARIA:	Bulgarian Academy of Sciences, Sofia
CANADA:	Simon Fraser University, Burnaby, BC
	University of British Columbia
	University of Quebec at Montreal
CHINA:	State Bureau of Seismology, Beijing
	Chinese Academy of Sciences, Xian
FED. REP. GERMANY:	Staatliche Museen, Berlin
	Kernforschungszentrum, Karlsruhe
	Ges. f. Strahlen-u. Umweltforschung, Munich
FRANCE:	Musée du Louvre, Paris
HUNGARY:	Hungarian Academy of Science, Budapest
INDIA:	Physical Research Laboratory, Ahmedabad
	Indian Institute of Technology, Kharagpur
ITALY:	Universita di Napoli, Naples
	Istituto di Cosmo-Geofisica, Torino
THE NETHERLANDS:	ECN, Petten
PANAMA:	University of Panama
UNITED KINGDOM:	Cambridge University
	Oxford University
	Paisley College of Technology
	University College of Wales
	University of London
	University of Edinburgh
	University of Aberdeen
USA:	City University of New York
	Harvard University
	Metropolitan Museum, New York
	Oklahoma State University
	University of Colorado
	University of Washington
	University of Miami
	University of Maryland
	University of Florida, Gainesville
	University of Pennsylvania
	University of Utah
	University of Arkansas
	Western Washington University
	Beta Analytic, Inc., Miami
	Founder's Society Institute of Arts, Detroit
	Los Angeles County Museum of Art
	State University of New York, Albany
	Western Maryland College
	U.S. Geological Survey. Denver
	Ohio State University

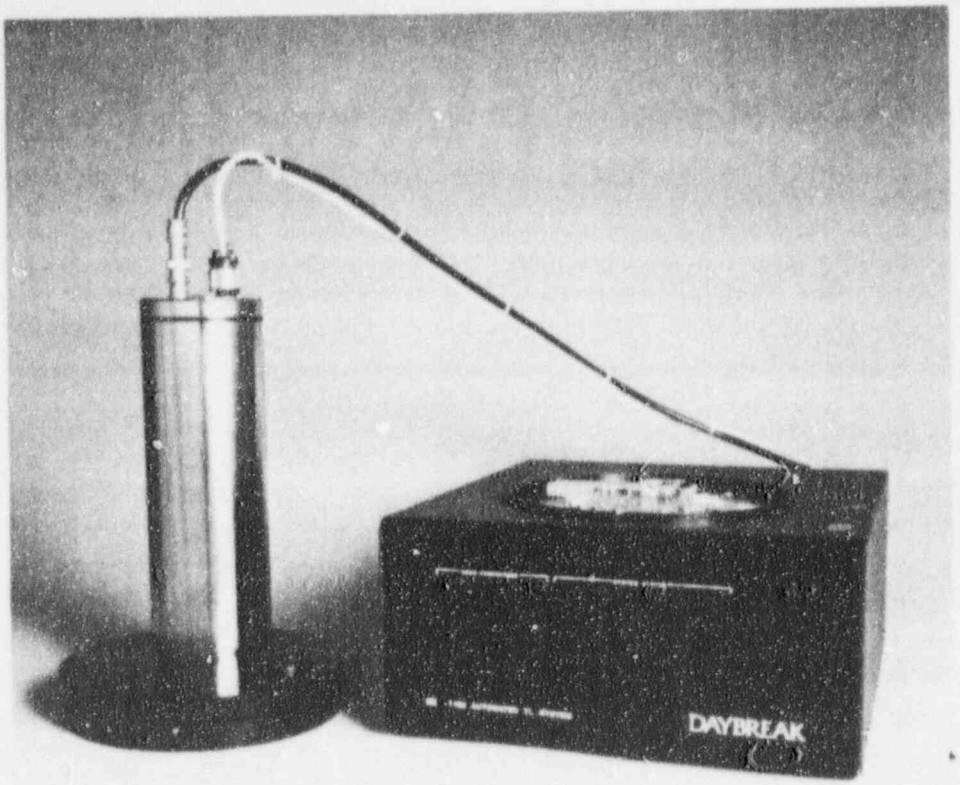
DAYBREAK

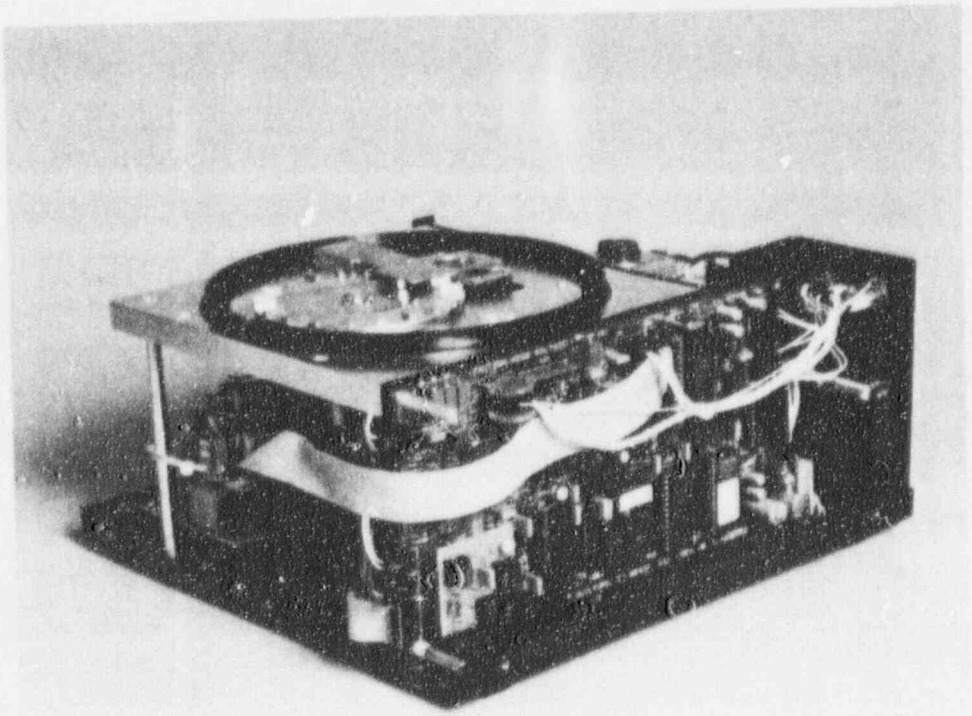
Systems for TL Research

Product Description
Model 1100 Automated TL System



Daybreak Nuclear and Medical Systems, Inc. 50 Denison Drive Guilford, CT 06437 USA (203) 453-3299





Product Description
Model 1100 Automated TL System

Features

- 20 sample automated glow oven
- on-board computer with 19K memory
- RS-232 serial interface to host computer
- software control of all operating parameters
- exceptionally flexible "soft machine"
- single photon counting with digital dead-time correction
- electronic PMT calibration with temperature compensated LED at photocathode
- all major analog signals digitized
- full size heating plate
- 1 to 25C/sec ramp rate with endpoints up to 700C
- thermocouple fault alarm
- hardware overtemperature interlock settable 400-700C
- hardware interlocks of HV and oven power
- cooling jet for fast cool down
- low volume glow oven for fast evacuation
- very compact, takes less than one square foot of bench space
- firmware definition of control function makes updates or re-configuration economical
- hardware expansion capabilities
- timer control and power for auxilliary irradiator

The Daybreak model 1100 combines the best features of the original Daybreak modular TL system with an automatic 20-sample glow oven and integrated supervisory microcomputer to produce a new generation of thermoluminescence equipment for the 1990's. Coupled with the Daybreak TLAPPLIC software, and our extensive line of alpha counters and automatic and manual sample irradiators, you have an integrated TL dating environment that will increase data production dramatically. It presents a combination of performance and price that cannot be beaten, and has enough flexibility and expandability to ensure that it never will. All of our instruments are designed with the end user's needs in mind, based on 16 years' experience in TL and more than 35 Daybreak systems installed throughout the world.

By designing the 1100 around an embedded microcomputer, we have accomplished a number of desirable objectives. These include simplicity of hardware, flexibility, autonomy from host computer, increased reliability, and perhaps most noticable, a great reduction in physical size. Analog circuitry is reduced to a minimum (just the heating plate temperature control loop, vacuum gauge amplifier, and deadtime detection), and all major analog signals are digitized so that the on-board computer can assume complete control. This reduction in circuit complexity, and the use of highly complex digital and data conversion building blocks, has the effect of increased reliability due to fewer packages and interconnections and decreased size while actually increasing functionality. Compact mechanical design, and the use of high frequency switching power supplies for system and heating plate power, together with the small size of the electronics (only one sixth the printed circuit board space for the equivalent function of the original modular TL system), has led to an extraordinarily compact system size: 10.5 inches wide, 11.7 inches deep, 5.6 inches high, plus 3 inch diameter by 9 inch high PMT housing. In doing this, we have paid considerable attention to modular construction techniques to ensure easy access for service and adjustment.

Since all control functions are implemented in firmware, with a rich set of control codes, a great degree of flexibility is possible and most future updating may be done with only a change of firmware or host computer software. There is also the potential for the 1100 to operate alone, as there is sufficient memory onboard to hold more than 20 glow curves, making networking a feasible goal with the present hardware.

Expansion has been allowed for as well, since we fully expect future research to engender need for even greater capabilities. Up to 8 additional input/output ports (up to 128 input and output lines) can be added within the system architecture,and there are 3 additional analog inputs available on the board.

Physical controls have been

replaced by a "soft front panel" on the host computer CRT monitor, using a function key pad (or optional "mouse") to control the 1100. This "front panel" display includes status information for thermocouple vacuum gauge, HV, rate, temperature, and temperature error, as well as "pushbuttons" and the "XY recorder". The 1100 continuously sends 21-byte packets of information to the host computer for continuously monitoring 1100 operation. (For reassurance, we also put a status display panel on the 1100.) With this arrangement, even dramatic changes in system configuration may be made economically.

The sample changing mechanism of the 1100 is simple and reliable. It uses a floating sweep arm to move samples on the turntable to and from a full-size heating plate. Both flat (0.010 inch thickness and above) and dished sample disks from 0.375 inch to 1.0 cm diameter are accommodated (other diameters by special order). Fine grain and inclusion samples may both be analysed due to the smooth motion afforded by precision DC micromotors and worm gear drive. Dynamic braking motor control ensures positional reproducibility. Single samples may also be measured. The small volume of the glow oven (6.0 " diameter by 0.4" deep) makes for fast evacuation. The glow oven is designed for use up to 700C for brief periods, and water cooling is built in. As in the modular system, low heating plate power reduces cooling requirements.

Since the computer industry has been moving quickly toward increased function, lower cost, and greater diversity, we have configured the 1100 with serial interface (RS-232 at 9600 baud) for easy communication with any computer. The parallel, bus- oriented approach to data transmission of our original modular system is certainly fast, but limits the user's choice of computer hardware. TLAPPLIC was originally developed on the Apple II, and we have now ported it to IBM-compatibles, taking advantage of their increased speed (with floating point co-processor), and larger memory and storage space, as well as higher resolution graphics. We chose the UCSD pascal system for development for its ability to handle very large programs (TLAPPLIC source code now exceeds 250 pages), and its portability, making transfer to other computers a relatively simple task.

The 1100 TL system is the flagship of Daybreak's new generation, carrying on our tradition of high quality and reliability, and elegance of design. We are introducing at the same time an economical single sample version, the model 1000, which differs only in having a 701 type of glow oven in place of the automated glow oven. The 1100 is aimed specifically at geological dating where automation is now a virtual necessity, and is intended for use with the 801 multiple sample irradiator. A future model will include a beta irradiator for pre-dose dating. We will continue to produce and support the modular system for those wanting a low-cost stand-alone TL system, and for those building their own systems, who wish to purchase the electronics.

We are quite excited about the 1100 and 1000, but to be honest, they are not revolutionary; they represent a distillation of the concepts pioneered by the Daybreak modular TL system and our experience gained from more than 35 Daybreak systems installed throughout the world. The capabilities built into these small packages are the result of recent advances in the semiconductor and computer industries, and are a logical extension of our original system. Back in 1980, we had complete computer control of the TL system, looking forward to automation. This degree of control, together with many of the features designed into the modular system from its beginnings in 1978, has lately been touted as something new and remarkable. We've had it for years without making much noise, and will continue quietly to add features and new instruments. One thing we promise not to change is our standard of quality, reliability, and customer service, and our one year warranty.

1100 Firmware Specification

Command set

The firmware architecture is that of a command-driven state machine incorporating a generalized ramp whose controller is another state machine. The actual ramping function is timer interrupt driven and subject to hardware and software interlocks for safety. Command codes from the host computer consist of an ASCII character (the set '@'..'_' including the upper case alphabetic characters, 32 altogether), and up to two integer parameters (ASCII decimal strings) as required by the control function, as shown in Table 1. There is sufficient space both in the command character set and the firmware PROM for significant expansion in the future.

The general form of a command is 'c xx yy ' where c is the control character, and xx and yy are ASCII positive decimal integer strings. <space> characters are used as delimiters, and the command string may end with any non-digit character.

Command name	Form	Parameters
Set data space	'D' xx	xx = 1-20 (C/point)
Set ramp rate	'R' xx	xx = 1-25 (C/sec)
Vacuum	'V' xx	xx = 0 (both off) 1 (bleed on, changes to main after partial evacuation) 2 (main on)
Purge	'P' xx	xx = 0 off 1 on
Cool	'C' xx	xx = 0 on 1 off
Ramp ('Go')	'G' xx	xx = 0 stop 1 start
Preheat ('Wash')	'W' xx yy	xx = 0-700 (temperature) yy = preheat time (seconds)
Stage	'S' xx yy	xx = 0-700 (temperature) yy = stage time (seconds)
Endpoint	'E' xx yy	xx = 0-700 (temperature) yy = hold time (seconds)
Cool-temp ('Low')	'L' xx	xx = temperature to start ramp for BG
Send ('Query')	'Q' xx	xx = 0 current status 1 send last curve
HV	'H' xx	xx = 0 high voltage off 1 high voltage on
Calibrate	'K' xx	xx = 0 calibrate off > 0 time on (seconds)
Irradiate	'I' xx	xx = time (seconds)
Advance	'A' xx	xx = sample number. Advances to xx and loads sample
Home ('Base')	'B'	goes to sample 0, no load
Jump	'J' xx	goes to sample xx, no load (for future automated irradiator)
Reset ('Zero')	'Z'	initialize controller
Setpoint ('at')	'@' xx	xx = 0-700 (setpoint temperature)
Oven	'O' xx	xx = 0 oven off 1 oven on

Table 1. 1100 command set

Additional commands for test, alignment, and data communications have been added.

Generalized ramp

The 1100 ramp consists of nine stages, most of which encompass the optional preheat, stage, and hold cycles.

0: idle (ramp off, ambient temperature)
1: ramp up to preheat temperature
2: hold for preheat time
3: cool down to cool temperature (with jet)
4: ramp from ambient to stage temperature
5: hold for stage time
6: resume ramp up to end point temperature
7: end point hold time
8: cool down to cool temperature (with jet)
0: resume idle

Only stages 6, 8, and 0 are required. If preheat or stage hold time is zero, the preheat or stage portions of the ramp cycle are bypassed. The ramp rate may be changed at any time during the ramp.

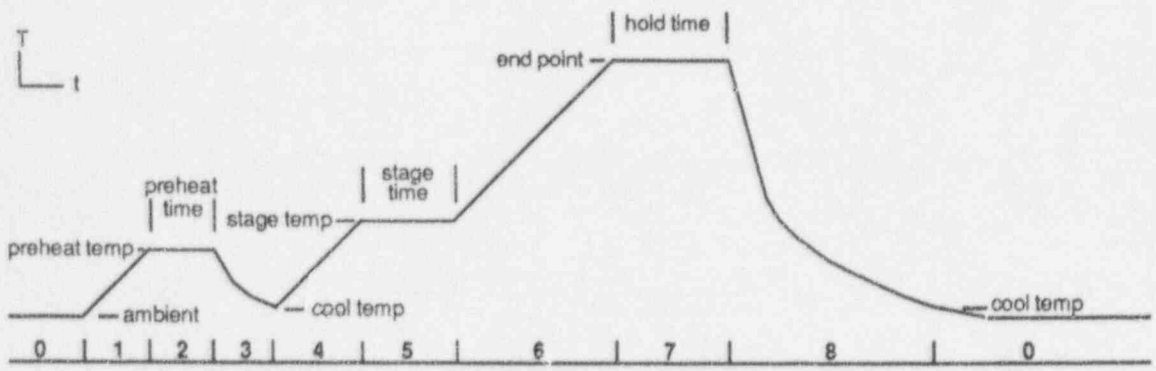
Serial output format

A 42 character string is sent to the host computer every second, or every data point, whichever comes sooner. The data is transmitted in hexadecimal ASCII format, where the characters '0'..'9', 'A'..'F' map onto decimal integers 0..15.

String character assignments

Chars 1-6 = photon count, most significant hex digit first
7-8 = data point number (corresponding temperature depends on data spacing)
9-10 = sample number (0..19)
11-12 = ramp segment or stage number (see above)
13-14 = error code (0 = OK)
15-30 = eight 8-bit ADC channels:
0 = Tmax
1 = T
2 = T error
3 = vacuum gauge
4 = vacuum gauge current
5 = ramp voltage
6 = livetime duty factor
7 = HV sense

31-38 = 32 status bits
39-42 = time since start of operation
<return> s



Generalized ramp

1100 Hardware Specification

Temperature control sub-system
Chromel-alumel thermocouple welded to heating plate
Ice point compensation
Low-drift TC amplifier
TC open alarm
Hardware overtemp detector and interlock settable 400-700C
Hardware and software interlock of heater power supply
Ramp rate software settable 1-25C/second
Endpoint software settable 0-700C (overridden by overtemp)
Arbitrary T(t) software controlled
Fast response switching power supply for heater
1.45 inch long by 1.00 inch wide (active area) heating plate, channeled for stiffness
Analog temperature, temperature error, ramp (for checking) digitized to 8 bits]

Photon counter sub-system
EMI 9635QA PMT
AMP/DISC: 4 nsec risetime, 6 nsec delay time discriminator with 20-1000mV threshold. ECL differential output capable of driving 50 ohm lines
Negative high voltage (600-1600V), software enabled with hardware interlock
24-bit photon counter
Analog dead-time detector, software compensation
Temperature compensated LED photon calibration with fiber optic light guide to photocathode, software controlled
Easily changed optical filter pack, 2.00 inch diameter. Standard pack supplied is Corning 7-59 + Schott BG-39
Digitized HV and dead-time compensation

Glow oven
20-sample changer with 7-second cycle time
Sample form: disks flat or dished 0.010-0.060 inch thickness, 0.375-0.400 inch diameter (other sizes by special order)
Software control of atmosphere control solenoid valves
Two-stage vacuum control (bleed and main)
Heating plate cooling jet
Needle valves for control of purge and cooling jet
Thermocouple vacuum gauge with low-drift, low offset amplifier, digitized output
Low volume for fast evacuation
Expansion relief for heating plate to prevent flexure at high temperature
Water cooling
Purge, cooling, water intake fittings 0.25 inch Swagelock
Vacuum outlet 0.85 inch tube stub for 3/4 inch ID rubber vacuum hose

Microcontroller
2 Mhz 65F12 running FORTH kernal
8 kbytes RAM, 11 kbytes firmware in PROM
Very fast, compact control code
RS-232 serial interface at 9600 baud
Expandable by 8 additional I/O ports, 3 analog inputs
Status panel to show state of valves, sample change, HV, calibration, overtemp/TC fault, and power

Rear panel
HV: SHV connector
AMP/DISC/CAL: 7-pin Amphenol 126-series female connector

Serial port: standard DB-25 female connector

Irradiator: 9-pin Amphenol 126-series female connector

Reset switch

Power input: IEC standard cord set, 115/230 VAC selection, ON/OFF switch, fuse

General

Size: 10.5 inch wide, 11.7 inch deep, 14.6 inch high overall

Weight: 17.7 lb. (7.9 kg)

Power: 115/230 VAC 50-60 Hz, 250 VA

Auxiliary irradiator control: 24V at 400 mA power available, timer output and two sensor inputs

Designed to meet UL, CSA, VDE requirements

Standard host computer configuration

See price list for current hardware configuration. Daybreak is presently using the Dell 210 12MHz AT-compatible as its basic platform for TLAPPLIC.

CURRENT computer PLATFORM IS DELL 316SX 1 MB RAM, 40MB HHD, 1 5¼" FDD, Super VGA color monitor, Epson-compatible printer

MS-DOS operating system

UCSD p-System (complete Pascal development system from Pecan Software Systems, including advanced word processor and print formatter, print spooler, RAM disk support, MS-DOS compatibility)

Daybreak TLAPPLIC software license (for single TL system. Additional systems in department licensed at small additional cost.) Two years' free software updates. The software is configured as a group of utilities in the system library, with source code for the major computational portions provided, as it is intended that users who need special procedures and modifications should have the tools necessary to write customized applications code quickly and easily. A complete description of all utilities and pre-declared data structures is contained in the manual, and parts of the growth curve analysis are commented line-by-line as an aid to programmers. The program structure for non-linear fits is in place and a general user-specified functional fit is the next enhancement scheduled.

Additional standard equipment

75 l/min two-stage vacuum pump (0.1 uHg ultimate vacuum), Precision D-75 (69076 for 120VAC/60Hz, 69088 for 230VAC/50Hz
200 sample disks

NOTE: This computer configuration available for U.S. only. Overseas purchasers may buy computer hardware to the specifications above locally, or purchase equivalent IBM or NEC computers from us (prices will vary) in accordance with availability of local service and preference.

TL Applications Software

TLAPPLIC FEATURES

- Complete turn-key computer system for archaeological and geological dating
- Mouse-driven (or single keystroke) hierarchical organization provides flexible, 'user-friendly' operating environment
- Complete UCSD p-system running in 640K 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 (720 x 348)
- 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

Flexible batch program generation and editing
Data and status presented graphically in real time

The Daybreak TLAPPLIC software package integrates with the Daybreak1100 automated TL system to record glowcurves on hard or 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 an enhanced version of the UCSD p-system.

SOFTWARE DESCRIPTION

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. FORTRAN is available as an option, and Pascal and FORTRAN code may be mixed in this implementation.

The Daybreak TLAPPLIC software package integrates a number of highly interactive procedures for data taking, for dose and date 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+Beta, 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.

For the 1100 automated system, the run type information for all the samples is entered interactively as a batch file, and the host computer will then oversee operation of the TL reader and issue commands unattended. At all times a virtual front panel with mouse or keystroke control of all functions and data display (graphical if in data-taking mode) by hitting the right hand mouse button. This is available no matter what part of the program you happen to be executing, and you will resume at that point when finished with the front panel.

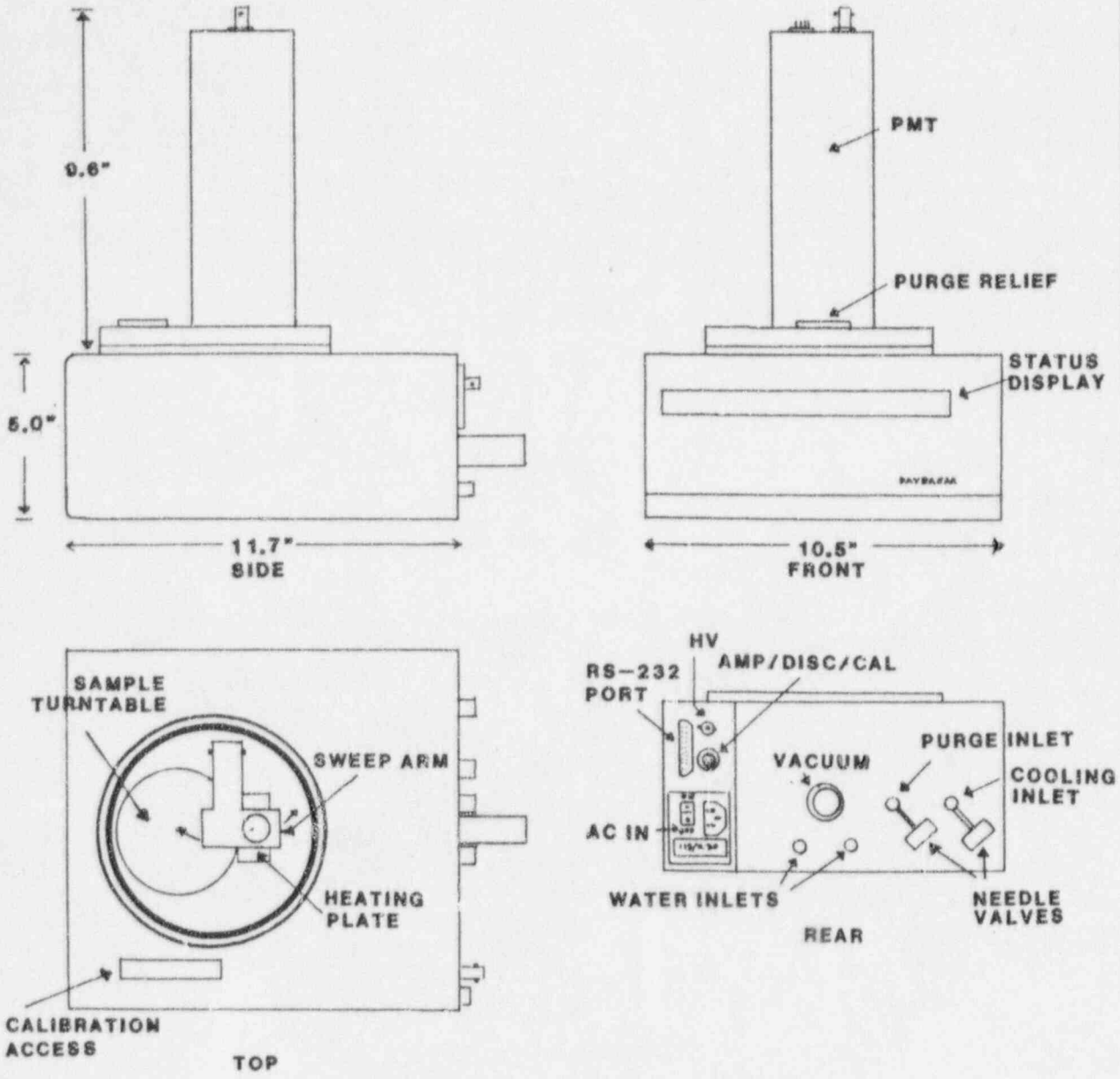
The second, and much more complex, function of TLAPPLIC is data reduction. Up to 80 glowcurves (of which one at least must be a background curve) are supported. After specifying an input file, it is read in and a directory of curves within the file is generated and printed, and may be displayed at several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



DAYBREAK MODEL 1100

SMALL WONDERS.

Daybreak's new integrated TL systems, automated and otherwise

We are introducing two major additions to our extensive line of TL measurement instruments, the *1100 Automated TL System* with 20 sample glow oven (and full sized heating plate) and the *1000 Single Sample System*. They each take up less than one square foot of bench space, a feat of packaging made possible by integrating all the electronics around a powerful microcontroller on a single small board. Both are "soft machines" completely characterized by firmware for easy updates, and communicate via a fast serial channel with the host computer, an IBM PCXT or compatible with 30Mb hard disk running Daybreak's versatile TLAPPLIC software. System control is by a mouse or function keypad on a "virtual front panel" displayed on the computer monitor. We can't begin to tell you about the features of these systems in an ad. Write or phone us for a brochure.

P.S. The other good news is that they also cost less, function for function, than our original modular system.

Daybreak Nuclear and Medical Systems, Inc.
50 Denison Drive
Guilford, CT 06437 USA
(203) 453-3299

DAYBREAK

MAR 1 1993

Daybreak Nuclear and Medical Systems, Inc.
ATTN: Victor J. Bortolot, Ph.D.
Technical Director
50 Denison Drive
Guilford, CT 06437

Dear Dr. Bortolot:

This is a follow-up to your December 22, 1992, telephone conversation with Sandra Kimberley of this office, and to our letter dated June 12, 1992, advising you of the additional fees required for License 06-17253-01.

In your December 22, 1992, telephone conversation with Ms. Kimberley you again stated that you use the licensed equipment for irradiation purposes and therefore should be subject to fee Category 3E, not 3P. You also indicated that your historical records show that NRC owes you money. Following your telephone call, we again discussed your license with the Region I Licensing staff. They have confirmed that License 06-17253-01 correctly authorizes the use of sealed sources in devices for the measurement of materials and that the license does not authorize the irradiation of materials. Therefore, as stated in our June 12, 1992, letter, License 06-17253-01 is subject to the fees specified in fee Category 3P of 10 CFR 170.31 and 10 CFR 171.16.

Our review of the payment history shows that all overpayments of license fees were previously refunded, and that no overpayments of inspection fees occurred. Therefore, you are not due any additional refunds of these past fees. For your convenience, the fee payment information is summarized below. Please note that the activities currently covered by fee Category 3P were covered by fee Category 3L prior to June 20, 1984, when the regulations in 10 CFR 170 were revised to include additional fee categories.

License Fees

Amendment Number	Date of Application	Fee Category	Fee Amount	Amount Paid	Amount Refunded
03	12/24/86	3P	$120	$170	$50
02	12/23/81	3L	$110	$150	$40
01	10/7/77	3L	(Amendment fees not required prior to 3/78)		
New License	10/14/76	3L	$ 50	$ 50	-0-

MAR 1 1993

Inspection Fees

Date of Inspection	Invoice Number	Invoice Amount	Amount Paid
9/8/86	MA0699-87	$530	$530
6/28/78	MX0203-79	$390	$390

In our June 12, 1992, letter, we advised you that an additional fee of $20 is required for your March 20, 1992, application for renewal. However, your March 20, 1992, application referenced the addition of a new source. We have been advised by the Licensing staff that if you wish to add this source to your license for your own use, a custom device evaluation for the Model 1100 is necessary, for which an application fee of $1,700 is required as specified in fee Category 9B of 10 CFR 170.31. This is based on the finding that Daybreak does not plan to make the Model 1100 device commercially available. Please note that if this situation changes, Daybreak will be required to obtain a product registration pursuant to 10 CFR 32.210 and a license amendment authorizing manufacturing/distribution, for which application fees of $3,500 and $3,600 as specified in fee Categories 9A and 3B of CFR 170.31 will be required.

The additional $20 fee requested in our June 12, 1992, letter to process your renewal application has not been received as of this date. Please remit the $20 within 15 days from the date of this letter, otherwise your renewal request will be considered abandoned, resulting in expiration of your license. In addition, if you wish to pursue your request for the addition of the Model 1100, the $1,700 application fee specified above should also be remitted with the additional $20 renewal fee. Additionally, the outstanding balance for your FY-1991 annual fee Invoice No. AM01173-91 through March 1, 1993, is $431.53. We acknowledge your payment of $400 for Invoice No. AM01046-92.

Payment of fees specified above should be made payable to the U.S. Nuclear Regulatory Commission and mailed to the attention of Sandra Kimberley, License Fee and Debt Collection Branch, OC/DAF, Mail Stop MNBB 4503, Washington, DC 20555.

Sincerely,

/S/

Glenda Jackson
Senior Policy Analyst
License Fee & Debt Collection Branch
Division of Accounting & Finance
Office of the Controller

MAR 1 1993

DISTRIBUTION:
Materials Annual Fee Correspondence FY 91 - w/incoming
Invoice AM01173-91 w/incoming copy
GJackson w/o incoming
DBDandois w/o incoming
DWeiss w/o incoming
DWhite, RI w/o incoming
SBaggett, NMSS, w/o incoming
SKimberley w/o incoming
LFDCB R/F (2)
DAF R/F
Invoice AM01046-92 w/o incoming
Pending Fee File
LTremper

OFFICE :	OC/LFDCB	OC/LFDCB	OC/LFDCB	OC/LFDCB
SURNAME:	SKimberley	GJackson	DWeiss	DBDandois
DATE :	2/22/93	2/23/93	2/27/93	2/25/93

Disk:Bortolot.memo

JUN 12 1992

Daybreak Nuclear & Medical Systems
Attn: Victor J. Bortolot, Ph.D.
Technical Director
50 Denison Drive
Gullford, Connecticut 06437

Gentlemen:

This refers to your letter dated March 20, 1992, for renewal of Materials License 06-17253-01.

We received your check for $480 which accompanied your March 20, 1992, application. However, a renewal fee of $500 is required as specified in fee Category 3P of §170.31, 10 CFR 170, effective August 9, 1991, copy enclosed. Accordingly, an additional fee of $20 is required for your application.

We note that a corrected copy of Amendment No. 03 was issued December 3, 1991, and that the letter transmitting the corrected copy to you stated that your license is subject to fee Category 3E. Since License No. 06-17253-01 does not authorize "irradiation of materials," but rather authorizes the use of irradiation devices for thermoluminescence sensitivity calibration, fee Category 3P is the correct fee category for your license. I apologize for the incorrect fee information you were given.

We also acknowledge your $1,228.42 payment for Invoice No. AM01173-91; however, an annual fee of $1,400 is required as stated on the invoice for fee Category 3P. In our letter dated April 27, 1992, we informed you that an additional fee of $307.77 was due by May 8, 1992, and that if payment was not received, interest and other charges would continue to accrue. Since no payment was received, the amount now due through June 29, 1992, for Invoice AM01173-91 is $320.57.

Payment of the additional fees totalling $340.57 specified above should be made to the U.S. Nuclear Regulatory Commission and mailed to the following address:

U.S. Nuclear Regulatory Commission
ATTN: Sandra Kimberley
License Fee and Debt Collection Branch, OC/DAF
Mail Stop MNBB 4503
Washington, D.C. 20555

Your March 20, 1992, application will be processed by the Region I Licensing staff located at 475 Allendale Road, King of Prussia, Pennsylvania 19406. The additional fees are required prior to issuance of the renewal. When submitting the fee, please refer to CONTROL NUMBER ~~113110.~~ 11638

If you have any questions, please contact Sandra Kimberley at 301-492-8743.

Sincerely,

Glenda Jackson, Chief
Materials License Fee Section
License Fee and Debt Collection Branch
Division of Accounting and Finance
Office of the Controller

Enclosure:
July 10, 1991, **Federal Register** notice

DISTRIBUTION:
Materials Annual Fee Correspondence FY 91 w/inc.
Invoice AM01173-01
GJackson w/o inc.
DDandois w/o inc.
DWeiss
LFDCB R/F (2)
DAF R/F

b:28:borto.ltr

OFFICE:	LFDCB	LFDCB	LFDCB
NAME:	SKimberley	GJackson	DDandois
DATE:	6/8/92	6/11/92	6/12/92

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

Ms. Glenda Jackson
Senior Policy Analyst
License Fee and Debt Collection Branch
USNRC
Washington, DC 20555

4 March 1993

Dear Ms. Jackson;

Having received your letter dated 1 March kindly listing fees paid and refunds made by the USNRC, I find that some of my recollections as recounted to Ms. Sandra Kimberley last December were in error, and I am enclosing checks to cover the difference in renewal fees and the 1991 annual fee.* I do intend, however, to pursue a change in my license in order to have it read "irradiation of materials" instead of "measurement of materials", since this is the actual intention scientifically for the technique I employ, and it seems clear to me from my license applications and all supportive material that this should be so. In fact, my request for a reclassification was granted by the Region I licensing people in a letter dated 3 December 1991. I have been operating under the assumption that commonsense would prevail in this case eventually, even though someone in Washington (your office?) apparently later told Region I to keep out of it.

In reviewing my license, in particular the 1987 renewal and the "corrected copy" of 3 December 1991, I find that no changes were made at all in the authorized use. I had discussed changes to be made by phone with them at length; they agreed with my reasoning, and changed the programming code to 3E. I believe that the changes that the Region I licensing people had intended, to make the 3E fee category appropriate, were inadvertently left out. This may in fact be the source of all the confusion.

Just in case your impression might have been that a grant of a change in fee category would lead to a stampede of similar licensees seeking the same, I believe that I am the only licensee under NRC jurisdiction working in TL dating with a specific license, rather than a broad license.

Certainly, in the past the difference in fees between the categories was negligible, but now the fee for inspections between 3P (a catch-all category including all the "difficult" situations) and 3E exceeds $800. I know that with my two sealed sources, housed in

* sent separately to Ms. Kimberley, per your instructions.

50 Denison Drive Guilford, CT 06437 (203) 453-3299

irradiators where the sources are not removed from their shields, the actual inspection time related to my radiation safety program did not exceed 45 minutes, and the remainder was devoted to a discussion of other matters. These included discussion of irradiators, vis a vis my license, and other topics including reminiscences about acquaintances in common, to fill in some time before Duncan White's next scheduled appointment. Even with some paperwork at the home office, $1300 seems unjustified. This in itself suggests that the fee category is inappropriate, when for a little more I could be inspected as a manufacturer or broadly licensed user, rather than a user of sealed sources (that are not used as an integral part of a measurement apparatus, but serve in a way analogous to check sources) in very safe shielded irradiators, and one wipe test standard. Since fee category 3E fits the application, and was the original intent when I first applied for my license in 1977 (The irradiators I used were designed with this in mind, in consultation with the person in the licensing division handling the application, Earl Wright), it makes sense that the license category should be changed. In fact, since the NRC never actually informed me of a fee category, I assumed in good faith that it was 3E, and paid the renewal fees accordingly. Now, since I do not handle the book keeping, I was not aware of the refunds made, and there was apparently no correspondance with it.

Parenthetically, it might be useful to put the fee category on the license itself (it is nowhere stated), and include criteria for inclusion in a particular category, so that licensees could petition for a change if they considered it justified, and not get sandbagged, as I was.

As far as additional fees for device review pertaining to the 1100 automated TL measurement system, I should like to inform you that this is not a device that contains radioactive material, nor is intended to incorporate a sealed source. The intent was to have the option of placing my present irradiator, or one of the same design, on top of it, using the mechanism of the 1100 as a sample changer. At present the irradiator is placed on a metal plate that centers the sample to be irradiated; in the license application, the use originally specified was using the irradiator atop the TL glow oven, the configuration of which was never specified, nor was I asked to provide detailed drawings. My interpretation of this is that the irradiator may be used on a TL glow oven or such other fixture as may hold the sample, whether it is my original glow oven, long since junked, or a replacement, which includes the 1100. If one takes the logic behind a request to evaluate the 1100 as a device one step further, I should be asked to pay $1700 for an evaluation of the lab bench the irradiator sits on. I enclose a copy of the relevant parts of my original application (carried over into subsequent renewals) for your information, not because your office has any jurisdiction regarding licensing matters, but because I wish to convey to you the fact that my reasoning is no stretch of fact or interpretation. I likewise make the interpretation that building a second irradiator identical to the first would not require an evaluation. To require it would be serve little purpose beyond raising revenue. I therefore decline to pay this evaluation fee without further discussion with the licensing people, and the application timely submitted last year may be revised so as to

ensure reclassification and no imposition of further fees.

In regard to commercial production of irradiators, my comments largely concern applicability of 10 CFR 32.210 and NRC jurisdiction. First of all, I do not (as Daybreak Nuclear or personally) manufacture nor am I first distributor of any sealed source or device containing a sealed source; I do not intend to do so. I do manufacture devices that the customer may load with sealed sources himself, at his pleasure. Secondly, the greater part of my business is for export, and in the past 14 years, only one device (in 1982) came under NRC jurisdiction as a specifically licensed item. If the solution is to decline sales to any entities where a device review is necessary, then so be it. I can make drawings of the devices public domain. A registration fee of $3500/device where there are five variations, each selling worldwide at no more than one/year at at price of $600-800 is not affordable, nor within the realm of financial prudence for my size company. My specialized market is very small. Back in 1982, the last time (and only time before now) I was asked about device registration, the NRC opinion (given informally) was that the quantity was too low to justify registration, and characterization as a custom device was justifiable. One of the topics covered during my last inspection, in December, was this. In a review of all devices sold domestically since 1979 when I commenced manufacturing of TL instruments, NRC jurisdiction was found only for the one mentioned above. Also, during that period of time, these devices have undergone considerable evolution, and customizing for particular customers, with certain parts remaining standard. In light of the President's stated aim to have government encourage business, I believe that the continuation of a policy holding these devices to be custom-made would be appropriate.

While this is not the place, nor my intent here, to criticize your fee structure, the need for which was imposed upon you by Congress, I would like to state that the annual fees and large flat inspection fees are an onerous burden upon the small business licensee. I am literally a "mom and pop" operation. I, personally, am the licensee rather than my little corporation, so I naturally take all of this rather to heart. The invoice for the FY1991 annual fee came the first month ever I could not pay my mortgage. I think that the people in Washington have not been truly aware of real life conditions in recent years.

Although I am paying fees as stated above, I do intend to pursue the change in category, a change retroactive at least to FY1991. In doing so, I will be requesting a refund of these fees, which are being paid solely to keep my license from expiring.

I honestly have no axe to grind with the NRC beyond this question of fee category; I believe that in general you are doing a fine job. However, I do feel that like most government organizations, the NRC is not very efficient, resulting in excessive expenditure for the work accomplished. It comes as a shock when I have to pay for it.

Sincerely yours,

Victor J. Bortolot, Ph. D.

cc: Commissioner Gail de Plangue
Jenny Johansen, Region I
Duncan White, Region I

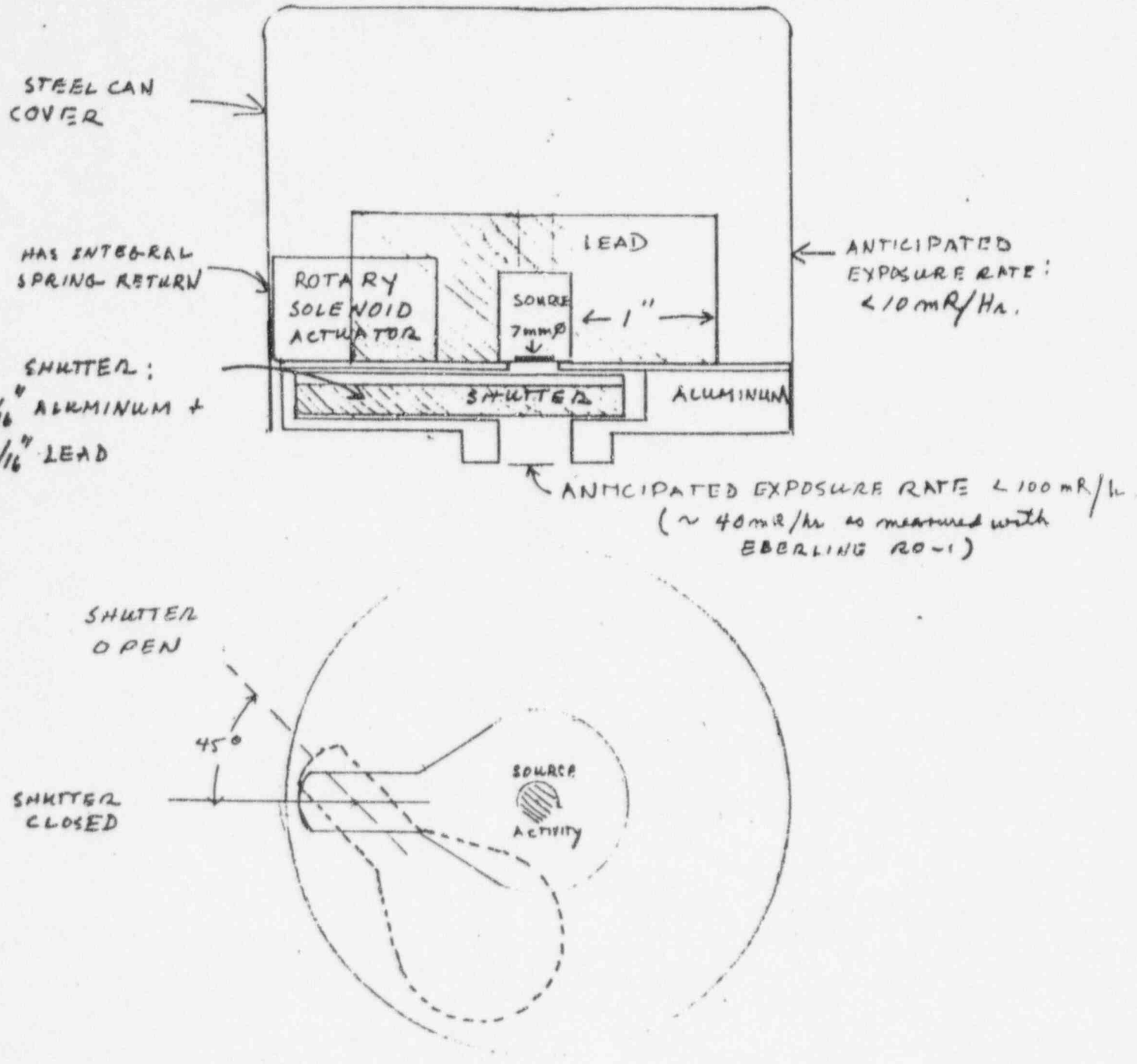


FIGURE 2. Sr^{90} SHIELDED EXPOSURE DEVICE, ACTUAL SIZE.

WHEN NOT IN USE, DEVICE WILL SIT ON 2" LEAD BRICK.

WHEN IN USE, DEVICE WILL SIT ON TL READOUT OVEN (~ 1" ALUMINUM).

from 1977 application or subsequent renewals

ITEM 9. Source storage.

(1) The Am-241 sealed source is housed and used in the device shown in Figure 1. This has an electrically-operated (solenoid) arm with a fail-safe spring return that carries the source out of the housing over the sample to be irradiated. At all times the active surface of the source is inaccessible to human contact. By use of an alpha absorber, the gamma component alone is available for use as a calibrator for TL personel monitor badges. This source has been standardized against radium using the same TLD material.

(2) The Sr-90 sealed source is stored and used in the shielded device shown in Figure 2. This, like the alpha housing above, is electrically operated. The spring return shutter protects the source against mechanical damage and human contact. When the solenoid is not energized, the shutter remains closed in all orientations, and cannot be opened without dissassembly of the device. The shutter is a composite of 1/16" aluminum alloy and 3/16" lead to minimize brehmstralung production. As measured with an Eberline RO-1 ionization type survey meter, the closed shutter exit exposure rate is 45 mR/hr and the surface exposure rate on the steel enclosure can is about 10 mR/hr. The device is stored in a fireproof safe on and behind lead brick. In use, the device is placed 2 feet from the TL reader on and behind lead brick. When a sample calibration* is to be done, the device is placed on the TL reader glow oven directly over the sample, and the shutter opened by an electronic timer. The exposure on the under surface of the glow oven during irradiations is 20 mR/hr. The source is in use about 200 hours annually. Dose monitoring of the applicant has shown less than 250 mR exposure per year during the term of the current license.

*this wording is loose, and scientifically incorrect, but in 1977, it didn't matter.

MAR 11 1993

Daybreak Nuclear & Medical Systems, Inc.
ATTN: Victor J. Bortolot, Ph.D.
Technical Director
50 Denison Drive
Guilford, CT 06437

Dear Mr. Bortolot:

We received your letter of March 4, 1993, and your $451.53 check in payment of the additional $20 fee for your March 20, 1992, application for renewal of License 06-17253-01, and the $431.53 balance due for annual fee invoice AM01173-91.

Since your March 4, 1993, letter raises issues relating to possible modifications to License 06-17253-01, and to the need for a device review, we have forwarded it to the Licensing staffs for appropriate processing.

Sincerely,

Glenda Jackson
Senior Policy Analyst
License Fee & Debt Collection Branch
Division of Accounting & Finance
Office of the Controller

cc:
John Glenn, NMSS, HQ
Steve Baggett, NMSS, HQ
Duncan White, RI
Jenny Johansen, RI

DISTRIBUTION:
GJackson
DDandois
DWeiss
SKimberley
LFDCB R/F (2)
DAF R/F

Materials Annual Fee Corres. w/incoming
Invoice AM01773-91 w/incoming
LF 93-555
LTremper

OFFICE :	LFDCB	LFDCB	LFDCB	LFDCB
SURNAME:	SKimberley	DWeiss	DDandois	GJackson
DATE :	3/11/93	3/11/93	3/11/93	3/11/93

DAYBREAK NUCLEAR AND MEDICAL SYSTEMS, INC.

8 March 1993

Dear Ms. Kimberley;

I am enclosing a check for a total of $451.53, covering the residue of invoice AM1046-2 plus renewal license fees. This should keep the federal marshalls from carrying me off in chains. However, I consider this to be a strategic retreat, and will renew my efforts to get my license fee category changed to the one I feel is appropriate for my activities.

Yours, till next time,

Victor J. Bortolot, Ph.D.
Technical Director.

50 Denison Drive Guilford, CT 06437 (203) 453-3299

BETWEEN:

LICENSE FEE MANAGEMENT BRANCH, ARM
AND
REGIONAL LICENSING SECTIONS

(FOR LFMS USE)
INFORMATION FROM LTS

PROGRAM CODE: 03122 ~~03620~~
STATUS CODE: 2
FEE CATEGORY: 3P
EXP. DATE: 19920430
FEE COMMENTS: 3P CORRECT--SEE 4/92
DECOM FIN ASSUR REQD: N

LICENSE FEE TRANSMITTAL

A. REGION I

1. APPLICATION ATTACHED
APPLICANT/LICENSEE: BORTOLOT, PH.D., VICTOR J.
RECEIVED DATE: 920323
DOCKET NO: 3012440
CONTROL NO.: 116381
LICENSE NO.: 06-17253-01
ACTION TYPE: RENEWAL

2. FEE ATTACHED
AMOUNT: $480.00
CHECK NO.: 3931

3. COMMENTS

RI —
Please note additional information in Mar. 4, 1993 letter.
SL

SIGNED M. A. Perkins
DATE 3/22/92

B. LICENSE FEE MANAGEMENT BRANCH (CHECK WHEN MILESTONE 03 IS ENTERED / JJ)

1. FEE CATEGORY AND AMOUNT: 3P $500

2. CORRECT FEE PAID. APPLICATION MAY BE PROCESSED FOR:
AMENDMENT
RENEWAL ✓
LICENSE

3. OTHER

SIGNED
DATE 3/11/93