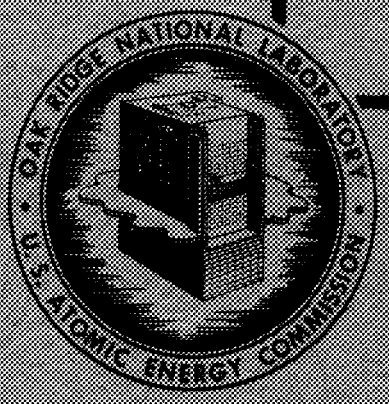
ORNL 1411
Health and Biology

PERSONNEL MONITORING

OPERATING TECHNIQUES



OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
UNC
POST OFFICE BOX P
OAK RIDGE, TENNESSEE

ORNL 1411

This document consists of 124 pages.
Copy 5 of 423 . Series A.

PERSONNEL MONITORING OPERATING TECHNIQUES

- by -

H. R. Craft

J. C. Ledbetter

J. C. Hart

HEALTH PHYSICS DIVISION

Date Issued: JAN 21 [redacted]

October 1, 1952

OAK RIDGE NATIONAL LABORATORY
operated by
CARBIDE AND CARBON CHEMICALS COMPANY
A Division of Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

INTERNAL DISTRIBUTION

1. G. T. Felbeck (C&CCC)
2. Biology Library
3. Health Physics Library
4. Metallurgy Library
5-6. Training School Library
7. Reactor Experimental Engineering Library
8-13. Central Files
14. C. E. Center
15. C. E. Larson
16. W. B. Humes (K-25)
17. L. B. Emlet (Y-12)
18. A. M. Weinberg
19. E. H. Taylor
20. E. D. Shipley
21. K. Z. Morgan
22. F. C. VonderLage
23. R. C. Briant
24. J. A. Swartout
25. S. C. Lind
26. F. L. Steahly
27. A. H. Snell
28. A. Hollaender
29. M. T. Kelley
30. J. S. Felton
31. A. S. Householder
32. C. S. Harrill
33. C. E. Winters
34. D. W. Cardwell
35. E. M. King
36. D. D. Cowen
37. P. M. Reyling
38. G. C. Williams
39. A. D. Warden
40. C. Scott
41. O. D. Teague
42. R. L. Clark
43. D. M. Davis
44. E. D. Gupton
45. P. E. Brown
46. G. C. Cain
47. E. L. Sharp
48. E. J. Kuna
49. L. C. Johnson
50. D. E. Arthur
51. P. O. Martin
52. W. W. Ogg
53. E. D. Durkosh
54. P. Guinn
55. T. H. J. Burnett
56. E. G. Struxness
57. J. Silver
58. L. P. Riordan
59-60. J. C. Ledbetter
61-62. H. R. Craft
63-64. J. C. Hart
65-66. J. T. Sutherland
67-68. H. H. Abee
69-70. B. T. Walters
71-170. E. E. Anderson
171. M. J. Skinner
172. C. E. Haynes

EXTERNAL DISTRIBUTION

173. R. F. Bacher, California Institute of Technology
174-423. Given distribution as shown in TID-4500 under Health and Biology Category

DISTRIBUTION PAGE TO BE REMOVED IF REPORT IS GIVEN PUBLIC DISTRIBUTION

Preface

Immediately following the onset of an accelerated Atomic Energy program, it became apparent that it would be necessary to provide large numbers of specialized workers with various types of personnel meters. This led to the inception of a new technique which was called "Personnel Monitoring". Since methods were changing rapidly and new techniques had to be developed for each method, only a few necessary operating procedures were established in the beginning. In the latter part of 1951, it was thought advisable to consider the importance of standardizing personnel monitoring techniques, and work was begun on this volume.

Personnel Monitoring supervisors assisted by providing many sources of material from their experience and helped in the location and summarization of reports from which much of the preliminary draft was taken. Photographs, tabulations, and drawings are intersperced to illustrate the material.

The major breakdowns are keyed to Arabic numerals and decimal fractions, the latter being used to key different sections. The phases in a section are keyed to capital letters, and the step-by-step procedures are arranged numerically.

Acknowledgement is made for the work of H. H. Abee, J. T. Sutherland, and B. T. Walters, relative to standardizing of methods. Other members of the Health Physics Division also made helpful suggestions relative to the final form.

TABLE OF CONTENTS

INTRODUCTION

Personnel Monitoring, in its broadest sense, is a Health Physics function which includes measurements calculated to determine the extent of external and internal exposure to radiation for persons who work where a significant quantity of radiation is likely to be encountered. At the Oak Ridge National Laboratory, the two chief devices used for external monitoring are badge film meters and pocket type ionization chambers. This volume treats the work of external monitoring including procedures for the distribution, collection, and processing of meters used for this purpose.

The badge film meter utilizes a two-film packet with a practical usable range of 0.03 to 20.0 roentgens when exposed to radium gamma. A portion of the film is covered on both sides by a 1 mm cadmium filter. The remaining portion, or "open window", is covered only by the paper wrapping of the film packet plus the identification inserts, all of which gives an absorber of approximately 45 mg/cm^2. The film is identified with the wearer by fixing an identification number on the films with X rays.

The pocket meters have a practical usable range of 0 to 300 mr when calibrated with radium gamma. They are issued and read daily for persons who regularly work with radiation on a daily basis. Two pocket meters are worn together to decrease the probability of spurious readings. The pocket meter has a wall thickness of approximately 2.5 mm, and measures gamma rays above 0.08 mev. Between 0.08 and 0.2 mev, the readings are about 10% high. The meter wall stops beta of approximately 1.0 mev and under.

A complete running record is maintained on all persons who utilize the Personnel Monitoring service. The active record is catalogued by the use of an assigned index number during the accumulation of data. It is later permanently filed chronologically in alphabetical order by surname. Semi-annually, all records for all personnel involved are summarized statistically, and significant information obtained thereby is catalogued.

The operating techniques described in this work were devised to provide accurate records of personnel exposures. The primary purpose of these procedures is to standardize techniques and to assist in the instruction of new employees.

General Procedure for Charging and Reading The Minometer and Pocket Meters

1.1 Introduction

A. Personnel Monitoring uses the Victoreen Projection Minometer which is essentially a string electrometer calibrated in milliroentgen units through a range of 300 mr.

B. The pocket meter is an ionization chamber, or electrical capacitor. It carries a charge of approximately 150 volts which drops proportionally in a field of radiation. The voltage drop is indicated on the minometer scale and interpreted directly in terms of milliroentgens.

1.2 Apparatus and Equipment

A. Minometer (Fig. 1)

B. Pocket Meters (Fig. 2)

1.3 Procedure

A. Use of Minometer (Preliminary Steps)

1. Plug the line cord of the minometer into a constant voltage socket and turn the master switch to the "on" position. Allow at least ten minutes for the instrument to warm up before use.

2. Adjust the light and focus so that the fiber image is clear and distinct. It should not be necessary to make this adjustment each time the instrument is used.

3. Discharge the minometer by pressing the button on top of the well cap. This operation should send the image from zero position to the position marked "Z" on the scale. If the image falls short or exceeds "Z" use a screw driver to adjust it to the exact "Z" position by turning the small screw located inside the minometer and accessible through a small hole located on the right side of the minometer housing.

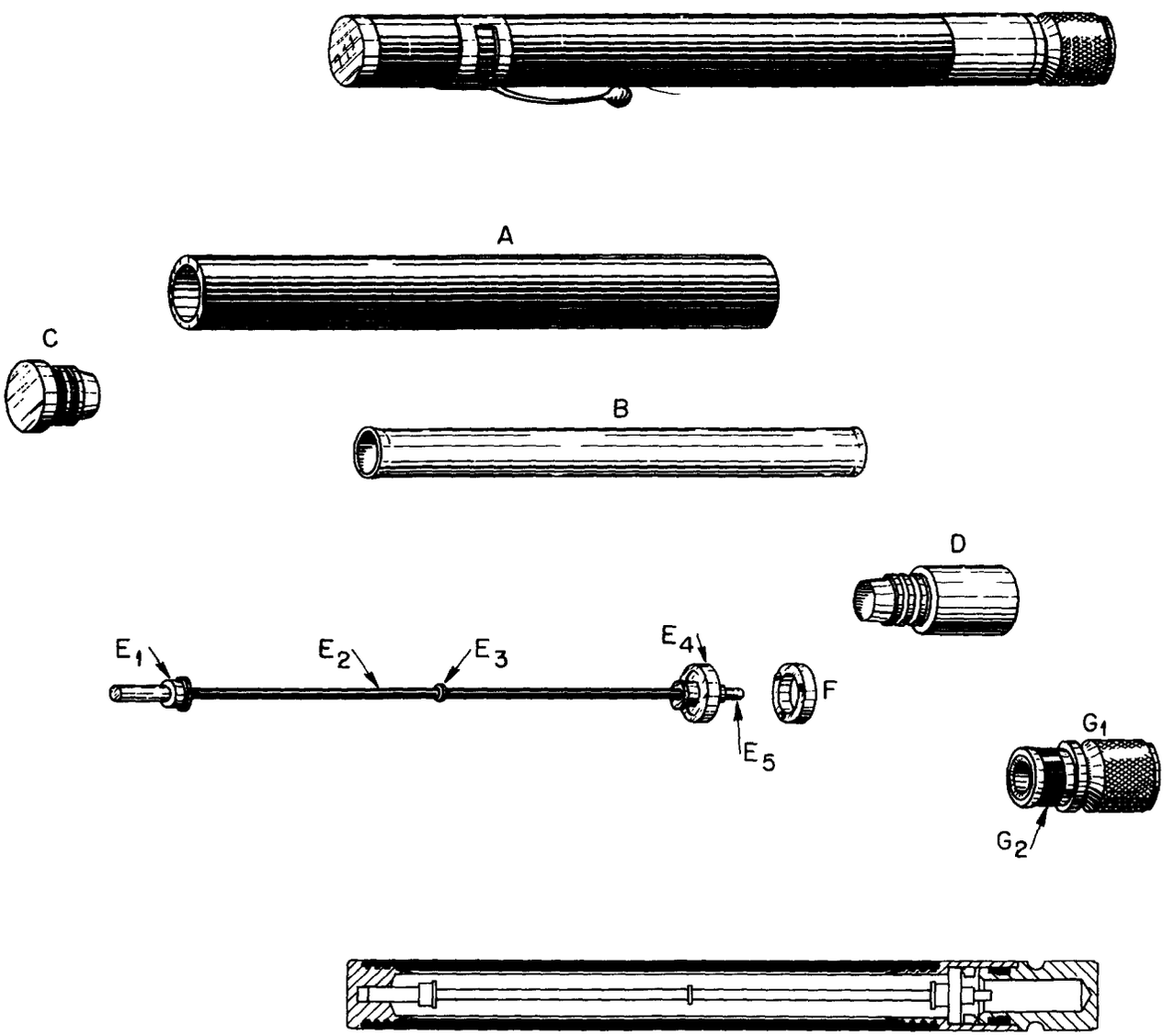
4. While pressing the charge button downward, adjust the voltage until the image comes to rest at zero on the left of the scale. The voltage adjustment may be turned in either direction depending upon the location of the image when first observed. Press the charging button at least twice to make certain the image stays on the zero position. The minometer is now ready for use.

B. Reading and Charging the Pocket Meters

1. Normally, the minometer will be turned on and ready for operation. If not, repeat those parts of phase A which apply. If the minometer has been placed in operation, repeat steps 3 and 4 of phase A.

UNCLASSIFIED
PHOTO 10260

Fig. 1. Victoreen Projection Minometer Modified for ORNL Use.



VICTOREEN POCKET METER, MODEL 352

A. LOW ATOMIC NUMBER WALL
B. GRAPHITE-COATED PAPER SHELL
C. ALUMINUM TERMINAL HEAD
D. ALUMINUM TERMINAL SLEEVE
E_1 POLYSTYRENE SUPPORT BUSHING
E_2 CENTRAL ELECTRODE, GRAPHITE COATED
E_3 POLYETHYLENE INSULATING WASHER
E_4 POLYSTYRENE FIXED BUSHING
E_5 ELECTRODE CONTACT
F. RETAINING RING
G_1 ALUMINUM BASE CAP
G_2 POLYETHYLENE FRICTION BUSHING

Fig. 2. Sectional View of the Pocket Meter Used at ORNL.

2. Remove cap from the pocket meter, taking care that no contact is made with the open end of the meter.

3. Using the right hand insert the pocket meter into the well of the minometer making sure that the electrodes have contacted.

4. Take reading by noting the position of the fiber image.

   NOTE: Set aside for testing all meters which read 30 mr or more.

5. Press the charging button with the right hand, returning the fiber image to zero. Lift the meter momentarily in the well without removing it entirely; then replace it snugly, listening for the "click" which insures contact. Use of the right hand to press charging button lessens the probability of incomplete charging so often encountered when the right hand pulls the meter while the left hand is used for pressing the charging button.

   NOTE: If fiber moves as much as 5 mr either direction off zero, the meter has not been properly charged.

6. Remove pocket meter from well and replace cap. It is now charged and ready for use.

1.4 Operating Peculiarities

A. Some pocket meters will yield image "kicks"; i.e., the image will deflect to right or left (usually left) of zero when the pocket meter is removed from the well. "Kicks" are the result of capacity changes. Some of the more common causes are: (1) loose connection in the minometer well, (2) improper electrode length, (3) loose parts connected with pocket meter core, or (4) dirt in the minometer well.

B. Occasionally, the image will come to rest at "Z" (a point at far right on the scale). This is due to an incompleted circuit somewhere in the system. A "shorted" pocket meter will yield the same results when inserted in the well.

C. Sometimes the image will begin to drift toward "Z". Check for cracked insulators, dirt, or dust in the well.

D. When the image fails to respond to normal operation, the electrical circuit has been disturbed.

E. When the image comes to rest at "Z", with the charging button depressed, and then returns to zero when the charging button is released, the charging button has shifted out of position.

F. A defective pocket meter will lose some of its charge simply on standing after a period of time. Best results are obtained if reading takes place as soon as possible after charging. A maximum of twenty-four hours is usually the allowable time-lapse between charging and reading.

G. Occasionally the electrode will fall out of the pocket meter. When this happens the meter will yield a reading of 20 to 60 mr and to all appearances looks legitimate. To test for this routinely, the meter should be discharged and then inserted in the minometer well. If the image does not go "off scale" examine for a missing electrode.

General Laboratory Tests for Defective Meters

2.1 Introduction

In order to provide the best instrumentation, all high reading pocket meters are retained for testing as "suspected leakers". A visual inspection is made periodically for missing electrodes. When suspected of being defective the meters must pass rigid tests before being issued again.

2.2 Equipment

A. Modified Boerner shaker (Fig. 3)

B. Pocket meters

C. Minometer

2.3 Procedure for Testing

A. Preliminary

1. Set aside all meters reading 30 mr or more as "suspect".

2. Charge "suspect" meters.

B. Shake Test

1. Place charged "suspect" meters (Phase A) in shaker in quantities of 20 or less.

2. Set timer and agitate meters for 1 minute.

3. Remove meters from shaker and read again.

4. Set aside all meters reading 20 mr or more for repair. This is the test for loose electrodes, cracked insulators, and other mechanical defects.

5. Re-charge remaining meters and proceed to Phase C.

C. Leak Test

1. Place re-charged meters (Phase B) in box, labelled "leak" test and allow to "stand" for a minimum of 8 hours.

2. Read, re-charge, and reject for repair all meters reading 20 mr or more.

3. Meters reading less than 20 mr may be set aside for use.

UNCLASSIFIED
PHOTO 10268

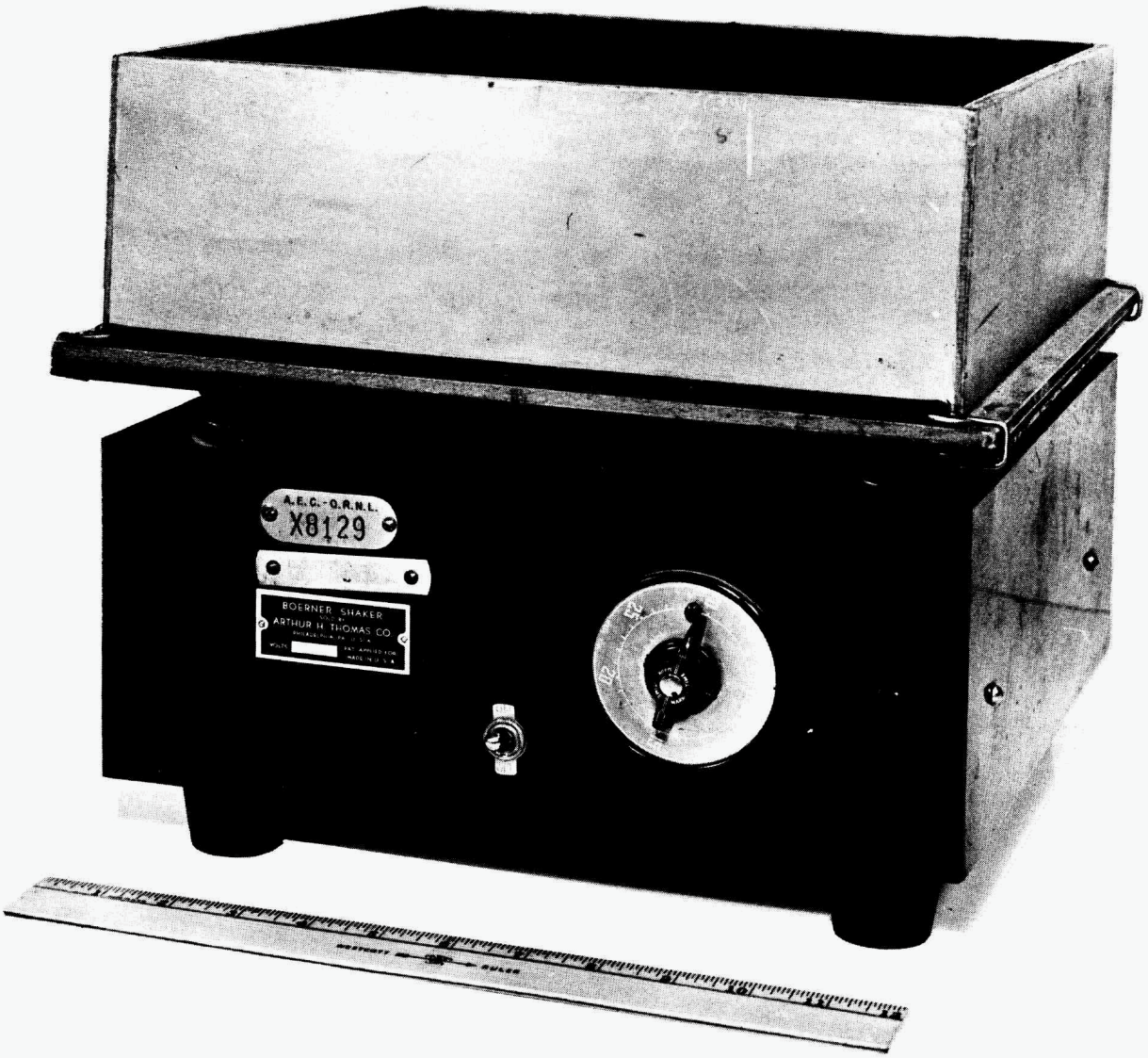


Fig. 3. Boerner Shaker Adapted for Agitating Pocket Meters.

2.4 Procedure for Checking for Defective Electrodes (normally performed on Sunday at ORNL)

A. Charge meter to zero.

B. Discharge meter on "discharge horn".

C. Place discharged meter in minometer well. If the image does not go "off scale", check for a defective electrode. If found to be defective, discard for repair.

D. Re-charge sound meters for re-issue.

2.5 Procedure for Testing Repaired Meters (normally performed by the Repair Unit at ORNL)

Examine meter for obvious defects, correct, and repeat Section 2.3 above.

Reading Pocket Meters as Associated with Distribution and Collection

3.1 Introduction

A. Usually the pocket meter is "charged" after the reading of the meter. Not all of the meters are fit for use after being used once, and some must undergo lengthy testing procedures (See Procedure #2) before being released for further service. However, those meters that do prove sound may be set aside for re-issuance.

B. Pocket meters are obtained from a supply available in the same alley in which the badge film meter is located.

C. Care should be taken not to underestimate the meter supply in order that incoming personnel will suffer no delay in effecting entrance.

D. The pocket meters should be carefully checked for the presence of clips and caps.

E. Meters charged on one minometer should be paired with those charged on another minometer. This lessens the chances of pairing improperly charged meters by reason of a malfunctioning minometer or poor charging technique.

F. When exiting from the Laboratory proper, employees deposit their pocket meters with their badge film meter.

3.2 Apparatus and Equipment

A. Minometer

B. Pocket meters to be read

C. Pencil

D. Minometer work sheet (See Appendix, P. 100)

E. Personnel Exposure Questionnaire Information Sheets (See Appendix, P. 101)

F. Kardex file

G. Collection boxes

H. Notebook or pad

3.3 Procedure

A. Collection of Pocket Meters to be Read After They Are Returned to The Alleys

1. Carry collection boxes to collection points.

2. Remove first badge film meter from rack and place in collection box. Always collect the badge film meter before touching the two pocket meters that go with it; otherwise, it is difficult to properly identify the meters. It should be noted that in this procedure, badge film meters are collected along with the pocket meters mainly to identify the pocket meters.

3. Continue to collect meters in order by index number.

   a. Sometimes a pair of pocket meters will be found with no accompanying badge film meter to identify them. Use notebook or pad to record the index number of the slot. Place note beside pocket meters in collection box in lieu of the badge film meter.

   b. Collect pocket meters in strict numerical order by index number as this facilitates the use of the Kardex file when recording the readings.

4. Carry boxes to reading laboratory.

5. Arrange boxes in order according to index number arrangement of Kardex file.

6. Probe meters thus collected with GM tube for possible contamination. Any pocket meter found to be contaminated should be removed from the collection box immediately. Under no circumstances should a contaminated pocket meter be inserted into the well of the minometer, as this may contaminate other meters as they are read. Supervisor will take action necessary for obtaining a reading in this case. Contaminated meters are reported as damaged meters on the minometer work sheet.

7. Place collection box filled with meters in reading position beside minometer. The X-10 meter collection box contains 50 meter sets.

8. Place Kardex file drawer next to minometer in comfortable writing position for the technician.

   NOTE: The index numbers in this drawer correspond to those on the collected meters.

9. Place suitable box in readiness to receive charged pocket meters acceptable for redistribution.

10. Prepare proper headings on the minometer work sheet.

B. Reading and Recording (See Procedures #4 and #5 for detailed description and use of Kardex Card.)

1. Lift badge film meter partially from collection box and note index number.

2. Remove first pair of pocket meters from collection box.

3. Read first meter of pair and place in distribution box.

4. Record reading in proper square of Kardex card.

NOTE: Record readings of first meter of pair toward center of square so that another entry may be made either above or below. The smaller numerical reading of the pair is the significant reading. It shall be the uppermost of the two readings.

5. Read second meter of pair, and place in distribution box.

6. Record reading above or below the first entry.

NOTE: If larger than first entry, record below; if smaller, record above.

7. When a pocket meter reads 30 mr or more, set aside for tests of possible defects. (See Procedure #2 for testing procedures.)

8. Where a significant reading is 50 mr or more, record immediately the following data on minometer work sheet.

a. Shift worked by employee

b. Name

c. PI (personnel identification) number

d. Both significant and insignificant readings

e. Department

NOTE: Any entry made on the minometer work sheet is added to the individual pocket meter entries for the week recorded previously. This is called the Total Significant Reading, and is recorded on the minometer work sheet.

9. If the Total Significant Reading is 300 mr or more:

   a. Initiate a "Personnel Exposure Questionnaire Information" form.

   b. X-ray PI number on used film and refill badge with dated new film.

10. When a pocket meter reads off-scale after being in the field, keep a talley in space provided on minometer work sheet. Lay the meter aside for investigation and tests.

11. When both pocket meters read off-scale:

   a. Record immediately the data given in B,8 above.

   b. Initiate a "Personnel Exposure Questionnaire Information" form.

   c. X-ray PI number on used film and refill badge with dated new film.

12. When both pocket meters cannot be read because of damage, or when one is damaged and the other is lost:

   a. Record immediately the data given in B,8 above.

   b. List a damaged pair under the heading "No Reading" on the minometer work sheet.

   c. List a damaged meter and a lost meter constituting a pair under "Combination" on the minometer work sheet.

   d. X-ray PI number on used film and refill badge with dated new film.

13. When a pocket meter is presumed to be lost, keep a tally of these single lost meters on minometer work sheet.

14. When a pocket meter is damaged, keep a talley of these damaged meters on minometer work sheet. Also make a notation of the nature of the damage.

15. Keep a record in notebook or pad of the total number of pairs of pocket meters in each collection box.

16. Replace badge film meters, which have been used to identify pocket meters, at the distribution point.

a. Films which have to be processed because of high pocket meter readings and/or pocket meter pairs which cannot be read should be carefully clipped to their respective "Personnel Exposure Questionnaire Information" work sheets and delivered to the darkroom technician.

b. When recording pocket meter readings on Kardex card, much care should be taken by the operator to detect any previous entry for the same Health Physics day. An accumulated total of 300 mr is reported as shown in Step 9 above. An accumulated total of 50 mr or more is recorded on the minometer work sheet as shown in Step 8.

Kardex File and Preparation of Cards

4.1 Purpose and Advantages

A. The Kardex file embraces a single card for every employee on the payroll and Laboratory visitors using the Personnel Monitoring meter service. It is a permanent record of data obtained from the beta-gamma film and pocket meters. It is a record kept day by day and totalled week by weekand provides an official radiation history of the employee from the date of his employment until the date of his termination. Meter service is arranged through supervision. Kardex cards for employees who do not require meter service are kept in an "inactive" file. "Active" cards are filed in numerical order by index number.

B. The Kardex file is adaptable to the record-keeping needs of Personnel Monitoring in the following respects:

1. It is kept in the Laboratory where meters are read. Consequently, it is always accessible for additions, corrections, and deletions.

2. It is readily usable for affording quick reference to authorized personnel.

3. It is flexible in that numerous "one-case-only" details can be recorded as they occur and can be referred to easily as the occasion demands.

C. Kardex records of exposures are maintained on all persons whether they are regular employees or long-term visitors. Such records are kept in an active status for the duration of an individual's stay at the Laboratory.

D. Immediately upon assigning meter service to a regular employee or a long-term visitor, Personnel Monitoring activates a Kardex card for the file. A Kardex card is put in an alphabetical file for persons with PI numbers who use "one-trip" meters.

4.2 General Description of Kardex Card (Fig. 4)

A. A Kardex card provides space to record the radiation history of an employee for six months. A card is printed on both sides and folded in the middle which necessitates turning the card at the end of three months. A card is printed in calendar form and the week ends on the day badge film meters are serviced.

B. On the Kardex cards the weeks are numbered consecutively through a six months period. Week #1 of each year begins with the calendar week in which January 1 falls.

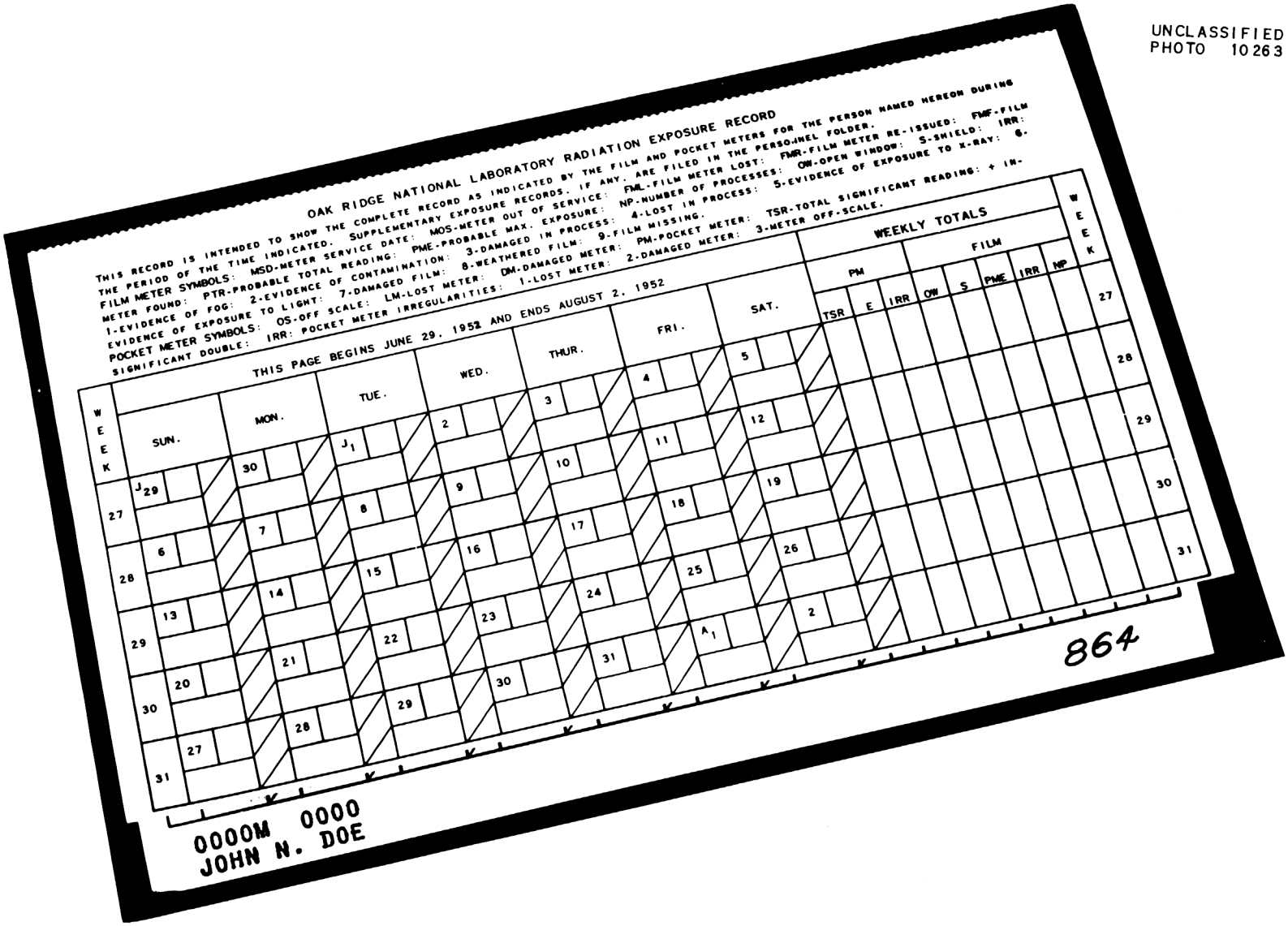


Fig. 4. Photograph Showing One Side of a Folded Kardex Card Ready for Insertion in the Kardex File. The department number, PI number, and name appear in the lower left corner. The index number appears in the lower right corner. The momenclature is printed on one side only.

C. The consecutively numbered weeks are arranged in horizontal lines across the card, starting at the left with Sunday and continuing through Saturday, one week under the other, with days dated, calendar-wise. The left side of the card provides squares in which daily entries are made. The right side of the card provides space for tabulating weekly totals.

D. On both sides of the card there is space for identification. This identification, pertinent data on the individual with meter service, is visible at the bottom of the card when the card is placed in the Kardex file.

4.3 Apparatus and Equipment

A. Supply of Kardex cards properly dated.

B. Pertinent data on badge film meter assignees.

1. Daily Service Log for new employees (See Appendix, P. 102).

2. Personnel Statistics Report - to confirm and check cards heretofore prepared; to prepare cards for persons who have not applied for meter service.

3. Any list of names for whom meter service is requested.

C. Typewriter.

D. Number device.

4.4 Procedure

A. Procure an adequate number of Kardex cards and place beside typewriter.

B. Using Daily Service Log (or other) source of information, type, in two lines, at bottom left of card:

1. Division number and payroll status: i.e., weekly, hourly, or monthly. Payroll status is abbreviated as W, H, or M, respectively.

2. PI number of employee.

3. First name, middle initial, and last name of employee.

C. Type same information on reverse side of Kardex card.

D. Using numbering device, stamp appropriate index number on both sides of the card.

E. Stamp or type "MSD" (meter service date) in proper square of calendar.

F. Place in proper index number order in Kardex file.

NOTE: Personnel with PI numbers who use "one-trip" film meters on a periodic basis should have Kardex cards prepared and filed alphabetically.

Recording Data on Kardex Card

5.1 Introduction

Since a correct interpretation of radiation exposure depends upon the accuracy with which data is recorded on the Kardex Card (Fig. 4), a thorough understanding of this procedure is required.

5.2 Recording Pocket Meter Data

A. The pocket meter entry for the first meter read in a pair is recorded in the space allotted to that date. The entry for the second meter read is made above or below the first, depending upon which is the significant of the two. The significant reading is always uppermost in the allotted space. The space at the top, immediately to the right of the date, is used for meters worn on the two night shifts and the larger, oblong space, below the date, is used for recording meters worn on the day shift.

B. Insignificant pocket meter entries are posted, in the space that applies, below the significant entry. The abbreviations listed on the front of the Kardex card used in making all double insignificant entries are as follows:

OS	Off scale
LM	Lost meter
DM	Damaged meter

C. Weekly summaries of pocket meter readings; symbols used are listed and defined as follows:

1. TSR - Total significant reading.
2. E - Number of pocket meter entries for the week, where an entry consists of one pair.
3. IRR - Pocket meter irregularities.
4. Code 1 - Lost meter.
5. Code 2 - Damaged meter.
6. Code 3 - Meter off scale.

5.3 Recording Film Meter Data

A. Both mrep and mr interpretations are recorded in the oblique sections at the extreme right of each date space. The mrep interpretation is always listed over the density reading. Example: a density of 0.15 which interprets to read 230 mrep is written: 230/0.15. The open window interpretation and density occupy the uppermost oblique space. The shielded interpretation is given as mr and together with the density occupies the lower oblique space.

B. Saturated densities for the sensitive films are recorded as >10,000 mrep. Saturation densities for the insensitive film are recorded as > 20,000 mr. (See High Range Charts, Procedure #22.)

C. An irregularity noted does not necessarily mean that the reading has been lost but that the density of the film has probably been affected, causing a change in the reading.

D. Film irregularities are abbreviated in the spaces which apply, as follows:

	Body of Kardex Card	Description	IBM Code (Weekly Tot. Cal.)
1.	E of F	Evidence of fog	1
2.	E of C	Evidence of contamination	2
3.	DIP	Damaged in process	3
4.	LIP	Lost in process	4
5.	E of X-Ray	Evidence of X-Ray	5
6.	E of L	Evidence of exposure to light	6
7.	D	Film damaged before processing	7
8.	W	Film damaged by exposure to weather	8
9.	M	Film missing from meter when opened	9

E. Weekly summaries of film readings with symbols defined:

1. Sen OW - Sensitive film, open window.

2. Sen S - Sensitive film, shielded portion.

3. Ins S - Insensitive film, shielded portion.

F. The following explanatory codes are used in the date space on which the event occurs:

Code	Interpretation
MSD	Meter service date
MOS	Meter out of service

FML	Film meter lost
FMR	Film meter re-issued
FMF	Film meter found
PTR	Probable total reading
PME	Probable maximum exposure (weekly)
NP	Number of film processes (weekly)

NOTE: The result obtained by subtracting the shield reading from the open window reading is the PTR (probable total reading). The shield reading becomes the PTR when it is greater than the result obtained by subtraction. The PME (probable maximum exposure) is the total of all the PTR's for the week. (Reference work: "Modifications of the Personnel Monitoring Exposure Reporting System ....", July 2, 1951, by J. C. Hart, SM-Memo-113-51).

Weekly Summary and Analysis of Kardex Data

6.1 General

A. It is important that all pocket and badge film meter readings for the week are entered on the card before the summarization of results is begun. This includes the final pickup of badge film meters which is made before 11:30 on Saturday night of each week.

B. Every Kardex card in the active file shall have at least one entry on it for the week and shall be totalled accordingly. This means that each card will have one of the three following badge film meter entries on Saturday of each week:

1. A badge film meter reading of zero.

2. A positive badge film meter reading.

3. A "not serviced" (NS) symbol.

C. Positive badge film meter entries are made on the "Positive Reading Sheets" (See Appendix, P. 103) and thence to Kardex immediately after films are read on the Densitometer and interpreted.

NOTE: Totalling the card at this point is not recommended, as tabulation requires painstaking care and singleness of purpose.

D. All films not serviced after the last pickup on Saturday night are coded NS on the Kardex card. The remainder of the films read zero and are so entered on Kardex card.

6.2 Procedure

A. Weekly Pocket Meter Tabulation

1. Begin with first card in file.

NOTE: If there is more than one tabulator, cards can be checked as they are available; but in all cases they should be inspected in numerical order by index number and clearly labelled as to progress made in the event all cards are not completed by the initial group.

2. Total the significant pocket meter readings for the week and enter sum under TSR. (Total significant reading in "Weekly Total" column.)

a. Place a plus sign after the sum total for each double insignificant entry.

3. Prepare a "Personnel Exposure Questionnaire Work Sheet" (See Appendix, P. 101) for:

   a. Pocket meter totals of 300 or more.

   b. Any double insignificant pocket meter entries.

4. Count the number of pocket meter entries for the week and enter this number under "E" in "Weekly Total" column.

   NOTE: A notation relative to an issued pair of pocket meters that are used constitutes an entry.

5. Use codes only for tabulating double insignificant entries under "IRR" in "Weekly Total" column.

   NOTE: Single insignificant entries are not considered in statistical tabulations.

   a. In the event there is more than one such case during the week, separate each appropriate code with a comma.

      Example: 3, 3, 1, 1.

   b. If there are no irregularities, leave space blank.

      NOTE: Sometimes an employee will report the loss of both pocket meters. This becomes a double insignificant entry and is coded as "1".

B. Weekly Badge Film Meter Tabulations

1. Total all open window sensitive film readings and enter under "OW" in "Weekly Total" column of the Kardex card.

   NOTE: Sometimes there are badge film meter entries during the week in addition to the routine entry on Saturday. Such entries are totalled with the entry on Saturday. Films are processed during the week for the following reasons:

      a. When the accumulated daily significant readings from the pocket meters total 300 mr or more.

      b. When a double insignificant pocket meter entry is recorded.

      c. When there is a special request from a Health Physics representative.

      d. When badge film meter service is being terminated or withdrawn.

e. When the badge film meter is contaminated.

f. When a lost film is recovered.

g. When an employee or visitor has a "one-trip" entry resulting from the use of a "one-trip" meter.

2. Prepare a "Personnel Exposure Questionnaire Work Sheet" when the PTR equals or exceeds 300 mrep.

NOTE: Work sheets have been made out previously for readings that equal or exceed 300 mrep for the weekly routine film entered on the Kardex as of Saturday. (See Weekly Routine Badge Film Servicing, Procedure #23.)

3. Total all sensitive film, shielded readings, and enter under "S" in "Weekly Total" column.

4. In the absence of sensitive film readings, the results of the insensitive film will be substituted.

5. Use codes for tabulating all irregularities under "IRR" in "Weekly Total" column. If there is more than one case, separate appropriate codes with a comma. If there are no irregularities, leave space blank.

6. In the column headed "NP", record the number of film meter entries for the week.

a. Care must be taken to account for persons with two or more badge film meters in service. In this case, a person has two or more entries for the week even though he may not have worn one of the meters.

b. If a badge film meter is not serviced on Saturday and there is no other film entry for the week, enter a zero.

Statistical Studies of Data Taken from Kardex Card

7.1 Introduction

The original data, taken at the time results from the meters are interpreted, are written on the Kardex card by the technician. At the end of six months statistical averages by IBM methods are obtained. Both the original Kardex card record and the IBM resume record are filed in the individual personnel radiation folder as a permanent record.

7.2 Statistics Concerning Each Individual (See Fig. 5, P. 26)

A. Individual IBM Resume

At the end of a 26-week period (first and second halves of a year) the Central Statistical staff prints a weekly resume on a single sheet for each individual for whom a record is maintained.

B. Definitions of Symbols Used on the Individual IBM Resume

1. WK - Health Physics Week.
2. PMI - Pocket meter irregularities.
3. FBI - Badge film meter irregularities.
4. E - Number of pocket meter entries.
5. P - Number of times film meter was processed.
6. TSR - Total significant pocket meter reading.
7. OWMREP - Total open window film meter reading in mreps.
8. SMR - Total shield film meter reading in mr.
9. PME - Probable maximum exposure.

C. Statistical Interpretation

Row "A" includes the total for each column. The one item identified by an asterisk (*) indicates the total number of weeks involved. Row "B" includes statistical data as follows:

1. Item (a) - Ratio of TSR to SMR. ($\frac{TSR}{SMR}$ pointed off to the third decimal place. In Fig. 5, the ratio is 1.307.)

2. Item (b) - Average daily pocket meter reading. ($\frac{TSR}{E}$ pointed off to one decimal place. In Fig. 5, this is 15.7.)

EXPOSURE RECORD SECOND HALF 1951

J. O. DOE DEPT 0003H BADGE 0001

WK	PMI	FBI	E	P	TSR	OWMR	SMR	PME	
27	1		5	1	185	280	100	180	
28			4	1	135	30		30	
29			5	1	70	70	40	40	
30			5	1	170	240	130	130	
31				1					
32				1					
33		2	4	1	175	300	110	190	
34			5	1	95	170	70	100	
35		2	5	1	130	670	330	340	
36			4	1	155	190	100	100	
37			4	1	80	175	55	120	
38		2	5	1	105	240	100	140	
39			5	1	60	130	60	70	
40			5	1	85	160	50	110	
41			5	1	95	200	80	120	
42			5	1	30				
43			5	1	20	90	30	60	
44			5	1					
45			5	1	35				
46			5	1	30				
47	3		4	1	5				
48			4	1	10				
49			4	1					
50			5	1	25				
51			4	1	20	140	50	90	
52			4	1	30	100	30	100	
Row A →2			111	26	1745	3185	1335	1920	26
Row B →			(a)→1307		(b)→157	(c)→1225	(d)→513	(e)→738	

Fig. 5. Individual IBM Resume

3. Item (c) - Average Weekly OW Badge Film Meter Exp. ($\frac{OWMREP}{\#Wks}$ pointed off to the first decimal place. In Fig. 5, this is 122.5.)

4. Item (d) - Average Weekly S Badge Film Meter Exp. ($\frac{SMR}{\#Wks}$ pointed off to the first decimal place. In Fig. 5, this is 51.3.)

5. Item (e) - Average Weekly Probable Maximum Exposure ($\frac{PME}{\#Wks}$ pointed off to the first decimal place. In Fig. 5, this is 73.8.)

NOTE: The coded figures appearing in the columns headed "PMI" and "FBI" (See Procedure #5 for codes) indicate the type of irregularity. In the example shown in Fig. 5 under "PMI", the figures 1 and 3 indicate "lost" and "off-scale" meters respectively. The figure 2 under the "PMI" column in Row "A" indicates that there were two irregularities. Under "FBI", the figures 2 indicate that the film was contaminated. The total number of irregularities as indicated in Row "A" would be three.

7.3 Report Concerning the Laboratory Population as a Whole

At the end of the 26-week period, the Central Statistical staff also prints a continuous sheet showing totals from which a resume for the Laboratory as a whole by "meter day" and "person day" is made. This summary is taken from "Row B" data shown on the Individual IBM Resume. It includes:

A. The average daily reading as determined by the pocket meters.

B. The average weekly reading as determined by the open window of the badge film meter.

C. The average weekly reading as determined behind the shield of the badge film meter.

D. The ratio of the total pocket meter readings of all employees to the total shield readings of all employees.

7.4 Report Showing Exposure Trends

Trends relative to exposure experiences, where an exposure is defined as a reading of 250 mrep or more per week as determined by the badge film meter, are also prepared by the Central Statistical Laboratory and include the following items.

A. The number of weekly exposures per man-year.

B. The number of weekly exposures per man-year broken down by Laboratory Divisions with additional breakdowns into hourly, weekly, and monthly salary rolls.

C. The number of individuals receiving no exposures, 1, 2, 3, exposures, etc.

D. The number of weekly readings where the total lies in the ranges 0-30, 35-60, 65-120, 125-300, and greater than 300.

E. Groupings in per cent showing the Laboratory population whose average weekly total readings as determined by the open window of the film meter were in the range of 0, 30 mrep or less, 60 mrep or less, 120 mrep or less, 300 mrep or less, and over 300 mrep.

7.5 Remarks

The Personnel Monitoring filing system provides that the complete record for an individual be summarized yearly and filed as such. The Personnel Monitoring year begins effectively with the calendar year and the record is closed accordingly with the expiration of the old year. This technique permits the files from becoming overburdened with "inactive" materials since the year's records can be isolated as such, removed to a permanent storage vault, and effectively taken out of circulation to be re-examined only when the occasion demands. In practice, the re-examination of records is rarely necessary.

Cross-File Reference System

8.1 Purpose

Since records are maintained by arbitrarily assigned numbers, it is necessary that cross-references be established which will identify data with the individual on whom they are accumulated.

8.2 General

A. The work of Personnel Monitoring is such that data may be accumulated by name, PI (personnel identification) number, and/or index number. This means that three separate files, consisting of (1) an alphabetical file, (2) a numerical file by PI number, and (3) a numerical file by index number must be maintained.

B. Each file reference consists of a 3 x 5 card (See Appendix, P. 104) on which appears the name, PI number, and department code. If the individual has meter service, the index number also appears on the card.

C. Each file is identified by a color designation as follows:

1. Alphabetical file - yellow card.

2. Numerical file by PI number - pink card.

3. Numerical file by index number - white card.

D. The two numerical files are subdivided into "active" and "inactive" status. The inactive section of these two files is set aside for employees of the Laboratory who do not normally use the metering service. The alphabetical file is not divided, and includes cards for all employees whether they utilize the meter service or not.

8.3 Preparation of Cards

A. Source of Information

1. The Daily Service Log - Since entries on the Daily Service Log are made usually prior to receiving official confirmation from Personnel Statistics, it affords the chief source of information.

2. Personnel Statistics Report - This is an official weekly summary of all new hires, terminations, name changes, PI number changes, and department changes. The report is used primarily to prepare the three 3 x 5 cards for all new hires whether they have badge film meter service or not. It is used also to check the accuracy of the Daily Service Log.

CAUTION: Employee Records issues a monthly report on:

(a) Personnel temporarily on X-10 payroll.

(b) Personnel "on loan" to the Laboratory.

This report is used as a reference only and 3 x 5 cards are not made from this list.

8.4 Maintenance of File

A. Three cards (one of each color, yellow, pink, and white) are typed with identical information on them for all new hires. Data is included as follows:

1. Department code, PI number, and name in upper left of card as follows:

3743M 3613
JOE E. WHITE

2. Index number, if meter user (upper right of card).

3. Meter service date (lower left of card).

B. Cards of persons with no meter service are placed in the inactive file pending request for service.

C. Pink and yellow cards are filed, as described above. Inactive white cards, since they have no index number, are filed alphabetically by first letter of last name. Inactive yellow cards can be identified by the absence of an index number stamped on the card.

D. All changes which affect the identification of an individual are adjusted on all cards. The main changes that occur are:

1. Change in the name.

2. Departmental transfer.

3. Change in index number.

4. Addition or discontinuance of neutron film service. Write NFS (neutron film service) with date on all three cards when service is added. Delete NFS with date when service is discontinued.

8.5 Equipment and Materials

A. Daily Service Log (See Appendix, P. 102).

B. Personnel Statistics Report (where available).

C. Pink, white, and yellow cards.

D. Typewriter.

8.5 Procedure

A. For additions with or without meter service:

1. Obtain pertinent information from Daily Service Log (See Procedure #9) or Personnel Statistics Report and type on three cards in approved manner. (The Appendix, P. 104, shows 3 x 5 cards of the proper form.)

2. File cards in active or inactive file.

B. For terminations:

1. Remove white, pink, and yellow cards.

2. Set aside all three cards until termination proceedings are completed. Then destroy.

NOTE: For security reasons, these cards are sometimes burned.

3. Place blue card stamped with terminated index number in white card file, showing that the number is available for reassignment.

C. For changes:

1. Carefully cancel out-of-date information and add new.

2. Personnel Monitoring is notified of departmental transfers by the Payroll Department. Departmental transfers usually necessitate index number changes as meters are moved from one distribution alley to another.

D. Initial Personnel Statistics Report and file, date-wise.

8.6 Special Note

In practice a 4th 3 x 5 card is prepared showing all pertinent data for all individuals who have meter service. This 4th card is sent to the Guard Post where "temporary meters" are issued. The guards, in turn, use these cards for an alphabetical file which makes index number data available for the issuance of "temporary meters" occasioned by lost or forgotten badges.

Daily Service Log - General

9.1 Purpose

The Daily Service Log is a diurnal record describing all badge film meter transactions. Any matter whatsoever that effects a change in the status of a meter user also is recorded on the Daily Service Log. The Daily Service Log is the final authority for evolving the record into a permanent form. As such, it is highly important to strive for maximum accuracy in making notations on the log and to use it strictly in conformance with established practices.

9.2 General

All transactions should be completed as of 4:00 p.m. each day and a new log put into service. Transactions occurring after 4:00 p.m. should be entered on the new log. This policy ensures that business is transacted in conformity with the Health Physics "day" as defined.

9.3 Materials and Equipment

A. Daily Service Log (See Appendix, P. 102).

B. Clip-board.

C. Typewriter.

D. Personnel Statistics Report (if any).

E. Neutron List (if any).

9.4 Procedure

A. Maintenance

1. Ascertain whether all transactions have been completed on current Daily Service Log. If not, finish all pending transactions.

   NOTE: Use Personnel Statistics Report to confirm transactions that have official status. Use neutron list to add or terminate neutron service.

2. Remove Daily Service Log from clip-board and date a new one.

   NOTE: A generous supply of Daily Service Log forms can be clipped to board so that removal of completed log will expose a fresh one.

3. Present completed log to supervisor for final inspection and signature.

4. Type a transcript of completed Daily Service Log and send to Records Clerk.

5. File original copy in loose leaf notebook.

B. General Use

1. Take information (usually from telephone) and make entries under proper headings on Daily Service Log.

   NOTE: a. Proper use of the telephone is exceedingly important. Question the caller carefully in order to obtain all information desired.

   b. Upon receiving the Personnel Statistics weekly report, all name changes, terminations, and additions are entered on the Daily Service Log. Note that these entries are made whether badge film meter service is indicated or not.

2. Get name and telephone number of caller.

3. Get confirmation.

   NOTE: Sometimes the telephone call is a duplication. To avoid unnecessary work, it is well to check the Kardex file and/or cross-file reference system before making any definite meter assignments or changes in the record.

4. Place your initials in proper space, thereby identifying person who takes the call in case of future questions.

Daily Service Log - Instructions for Use

10.1 Description and Definitions (See Appendix, P. 102)

A. The upper part of the Daily Service Log is used to enter the various transactions which change or add to the record. The lower part of the Log is used as a check list, the chief function of which is to note progress on action taken in case the initial job is not completed.

B. Across the top of the form are the following headings under which appropriate notations can be made:

1. New Index Number: The number of the slot in the distribution alley by which the meter user finds his meter. This is the number assigned for current use. In alley transfers, the old index number is noted under "Remarks".

2. Name: "Given" name, initial, and employee's last name.

3. PI Number: Personnel identification number (preceded by an "M" when the number is assigned by Health Physics).

4. Division: Name and code number of the division to which the employee is assigned.

5. Supervisor: Usually the Division Director or Superintendent.

6. Alley: Designated alley in which meter is assigned or terminated. No entry is made here on transfers from one alley to another.

7. Check accordingly:

   T - Termination. Employee is removed from payroll.
   NMS - Termination with no meter service.
   R - Replacement of meter which is out of service.
   A - Additional meter service.
   W - Withdrawal of meter service. Employee remains on payroll.

8. Alley Transfers: Designate alleys involved in transfer by noting numbers in proper columns.

9. Remarks: Use this column for any statement that will further clarify the record.

10. By: Person who makes entry and supervisor who approves the entry place initials here.

10.2 Check Lists

A. Terminations and Withdrawals:

Check off jobs as they are completed as follows:

1. Film in laboratory: When meter has been recovered and film prepared for processing.

2. Work Sheet: When "Personnel Exposure Questionnaire" (See Appendix, P. 105) form has been completed.

3. Processed Film: When film has been developed and read on densitometer.

4. Recorded on Kardex: When results have been properly entered on Kardex.

5. Change list: When a number has been removed from the list, thus bringing it up to date.

B. Additions and Replacements

1. Confirmed: When a proposed transaction has been investigated to confirm its validity.

   a. An employee requests meter service who already has such service.

   b. An employee requests a replacement when meter is temporarily misplaced.

2. Badge assembled: When badge meter has been fabricated, loaded with new film, and is ready for service.

3. Cards in file: When three 3 x 5 cross-file cards are in the file.

4. Meter in alley: When the meter has been placed in the distribution alley.

5. Adjust Kardex file: When a new Kardex card has been filed properly.

6. Change list: When a number has been added to the list, thus bringing it up to date.

10.3 Using the Check List

Numbers across the top of the check list correspond to the numbered lines on the Daily Service Log. Each line provides sufficient space to give all information necessary for an exact amendment of the records. As successive steps are completed in the transaction, shift letter is placed (X, Y, Z) in the box under the number which matches the proper line.

Use of Daily Service Log in Conjunction with Cross-File System and Kardex Card

11.1 Introduction

A. Any action taken on entries in the Daily Service Log alters the status of the cross-file and Kardex cards. This is true since cross-file cards serve to give a complete identification of meter users and as such, constitute an up-to-date file for all persons assigned to the Laboratory.

B. Any change in name or PI number will necessitate re-making the badge meter front. In this case the film in the old meter is assembled in the new badge unit.

C. Following is a list of transactions with which technicians should be thoroughly familiar:

1. Name changes.

2. Payroll number changes, as necessitated by departmental transfers.

3. PI number changes.

4. Transfer of badge film meter from one distribution alley to another.

5. Addition or discontinuance of neutron film service.

11.2 Procedures

A. Name Change

1. Enter the following information under proper headings:

a. Index number.

b. Name before change (Example: Jean T. Doe).

c. PI number.

d. Division name and code number.

e. Division director or superintendent.

f. Alley.

2. Under "Remarks" write:

a. Name changed to Jean Doe Smith.

3. Change name on all three cross-file cards.

4. Change name on both sides of Kardex card.

5. Obtain new or temporary badge front.

6. Enter shift letter opposite "Confirmed", "Badge Assembled", "Meter in Alley", and "Adjusted File".

B. Payroll Number Change

Appropriate same procedure as for "Name Change", with suitable comment under "Remarks" and no change in the face of the film meter.

C. Reassignment of Badge Film Meter to Another Index Number

1. Enter the following information under proper headings:

   a. New index number.

      NOTE: This is the index number which is assigned for the new location of the badge film meter. It is considered the index number in current use. Never enter an old index number in this column.

   b. Name.

   c. PI number.

   d. Division

   e. Division director or superintendent.

      NOTE: Make no entry under "Alley".

2. Under "Alley Transfer" designate distribution alley numbers involved.

3. Under "Remarks" enter old index number.

4. Change index number on all three cross-file cards, and put date to the left of new index number.

5. Relocate 3 x 5 card filed by index number. Substitute blue card showing index number is available for reissue.

6. Change index number on both sides of Kardex card.

7. Relocate Kardex card by new index number.

8. Reassemble badge meter using back, showing newly assigned index number.

9. Prepare "Meter Number Change Notice" according to the following example:

> Effective at once you have been reassigned meter # 766
>
> which is located in Alley B at the West portal.

Attach notice to badge clip, and return to old index number slot.

10. Enter shift letter, opposite "Confirmed", "Badge Assembled", "Meter in Alley", and "Adjusted File".

11. Make index number correction on change list (when prepared) and put shift letter opposite same on Daily Service Log.

D. Addition or Discontinuance of Neutron Film Service

1. Enter the following information under proper headings:

   a. Index number.

   b. Name.

   c. PI number.

   d. Division name and code number.

   e. Division Director or Superintendent.

   f. Alley.

2. Under "Remarks" write appropriate comment.

3. Add or delete "NFS" from 3 x 5 cross-file cards and date.

4. Enter NFS (neutron film service) or NOS (neutron film out of service) on Kardex card under proper date.

5. Enter shift letter opposite "confirmed" and "Adjusted File".

NOTE: a. Neutron film technicians will adjust neutron records using the transcript of the Daily Service Log as a source of information.

b. It is especially important to record: (1) change in index number when a badge film meter is transferred from one alley to another; (2) change in PI number when a person with a number in the "M" series (arbitrarily assigned PI numbers) is assigned a regular X-10 PI number.

E. PI Number Change

Great care is required in entering on the Daily Service Log transactions involving discontinuance of a PI number in the "M" series and concurrent issuance of an X-10 PI number, as when a person (with meter service) formerly on loan to the Laboratory is subsequently added to the X-10 payroll. The following procedure applies in such a case:

Enter on Daily Service Log:

1. Termination of the "M" number.

2. Addition of new X-10 PI number on same Daily Service Log Sheet.

3. Issue new Kardex card (showing transition).

   a. Show old PI ("M") number on new card, above meter service date.

   b. Show new PI number on Kardex card which is put in termination file.

4. Make new 3 x 5 cards.

Use of Daily Service Log Involving Additions and Terminations of Badge Film Meter Service

12.1 Introduction

A. The Daily Service Log is a record of all transactions which result in additional badge film meters being put into service and in termination of badge film meters when they are no longer needed. When an employee leaves the Laboratory his film meter service is terminated. When an employee no longer requires meter service, but remains on the payroll, his film meter service is withdrawn. When a badge film meter is lost, it is replaced upon the request of authorized personnel. The Daily Service Log is used to record these transactions including information concerning new employees who do not require meter service and terminees who had no meter service.

B. These transactions, unlike those preceding, require the handling of film, in some cases, as well as the adjustment of the cross-file and Kardex file. It is the purpose here to show the relationship between the Daily Service Log, the cross-file and Kardex file, and to outline how the film is dispensed.

12.2 Termination of Badge Film Meter Service

A. Procedure

1. Making Entries on Daily Service Log

a. Enter the following information under proper headings:

(1) Index number

(2) Name

(3) PI number

(4) Division name and code number

(5) Division director or superintendent

(6) Distribution Alley

b. Check "T" (Termination)

2. Handling the Film

a. Get badge film meter from distribution alley or from person to whom assigned.

b. X-ray PI number on film and disassemble meter.

c. Initiate "Personnel Questionnaire Information" form.

d. Attach film to form and give to darkroom technician.

3. Adjusting the Files (See Procedure #8 for significance of card colors.)

a. Remove white, pink, and yellow cards from cross-file and destroy. (See Procedure #8.5,B.)

b. CAUTION: For security reasons these cards are sometimes burned.

c. Place a blue card in the file which is arranged numerically by index number. This card is stamped with the terminated index number only.

d. Stamp "terminated" on Kardex card under effective date and send it to Records Clerk.

e. Check "Film in Laboratory", "Work Sheet", "Stamped Cards", and "Change List", if affected.

12.3 Withdrawal of Badge Film Meter Service

A. Procedure

1. Making Entries on Daily Service Log

a. Same as 12.2,A,1,a.

b. Check "W" (Withdrawal)

2. Handling the Film

a. Same as 12.2,a,2

3. Adjusting the Files

a. Stamp or write "withdrawal" on yellow and pink cards and date.

(1) Mark through index number on yellow card, but leave it in the files.

b. Remove pink and white cards and destroy.

c. Same as 12.2,A,3,c

d. Enter the symbol MOS (meter out of service) on Kardex card under effective date and send card to Records Clerk.

e. Same as 12.2,A,3,e

12.4 Termination with No Badge Film Meter Service

A. Procedure

1. Making Entries on Daily Service Log

a. Same, except for 6 as 12.2,A,1,a

b. Same, with additional check under "NMS", no meter service.

2. Adjusting the Files

a. Initiate "Personnel Questionnaire Information" form.

b. Remove all three cross-file cards from inactive file.

c. Stamp them "terminated - no meter service", and date.

d. Destroy pink card.

e. Destroy white and yellow cards.

f. Stamp "terminated - no meter service" on effective date on Kardex card.

g. File with "terminations", alphabetically.

h. Check "stamped cards" on Daily Service Log.

12.5 Addition of Badge Film Meter Service

A. Procedure

1. Making Entries on Daily Service Log

a. Same as 12.2,A,1,a

NOTE: (1) The index number for a new meter assignee is found by inspecting the cross_file. Pink cards inserted in this file indicate index numbers which can be issued.

(2) A separate file for available index numbers can be used.

b. Check "A" (addition).

2. Handling the Film and Badge Components

a. Fabricate meter (See Procedure #13).

b. Insert dated film and place in distribution alley.

3. Adjusting the Files

a. Activate three cross-file cards.

b. Activate Kardex card.

(1) Enter "MSD" symbol on effective date.

c. Check "confirmed", "Badge Assembled", "Cards in File", "Meter in Alley", "Kardex Card", and "Change Sheet", if affected.

NOTE: The "Change Sheet" or "Pick-up" sheets (See Appendix, page 106) are routinely prepared at the end of the week. Transactions occurring at the beginning of the week usually do not require checking off "Change Sheets" on the Daily Service Log.

12.6 Addition with No Badge Film Meter Service

A. Procedure

1. Making Entries on Daily Service Log

a. Same as 12.2,A,1,a, except no index number is assigned.

b. Same as 12.2,A,1,b. Check also "NMS".

2. Adjusting the Files

a. Place three cross-file cards in inactive file.

b. Kardex card remains inactive.

c. Check "Confirmed", "Cards in file".

12.7 Replacement of Badge Film Meter

A. Procedure

1. Making Entries on Daily Service Log

(a) Same as 12.2,A,1,a.

(2) Check "R" (Replacement).

2. Handling the Badge Film Meter

   a. Same as for "Additions".

3. Adjusting the Files

   a. Enter replacement date on cross-file cards and label "replacement".

   b. Enter symbol "FMR" (film meter re-issued) under proper date on Kardex card.

   c. Check "confirmed", "badge assembled", "meter in alley", "adjusted file", "change list", if indicated.

Badge Film Meter Assembly and Loading Procedures

13.1 Description

A. The ORNL badge film meter is constructed of stainless steel. It is equipped with a single jaw alligator clip for attaching it to the clothes of the wearer. Two cadmium filters, each approximately 1 mm thick, are placed in such a manner as to cover both sides of one end of the film pack. The lower part of the meter contains an "open window" approximately 1/2" x 3/4" which permits the entry of "soft" radiation.

B. The badge consists of two sections. The front section consists of a stainless steel frame in which reposes an identification insert which may be a photograph. A cadmium filter, perforated with the PI number of the wearer, is inserted behind the identification insert. A stainless steel retainer plate completes the front section and serves to hold the various components in place. The back section of the badge consists of a stainless steel frame on which is attached the alligator clip and the back cadmium filter. This filter lies directly behind the perforated one with the film pack between them when the meter is assembled. The index number is engraved on the back section of the assembly.

13.2 The Film Pack

A. Film packs are manufactured by the E. I. duPont de Nemours Company and sold commercially as Type 552.

B. A pack contains two films designated as "sensitive" and "insensitive". Sensitive films have a practical usable range of 30 to 10,000 mr based on radium gamma calibrations. Insensitive films have a practical usable range of 500 to 20,000 mr based on the same calibration factor.

C. Film packs are characterized by a green flap which facilitates stripping away the jacket enveloping the film. The green flap is also useful as a guide in properly positioning the film in the meter.

13.3 Apparatus and Equipment

A. Badge Meter Components (Fig. 6a)

B. Badge Meter Assembly Machine (Fig. 6b)

C. Cummins Perforator (Fig. 6c)

UNCLASSIFIED
DWG. C-10028A

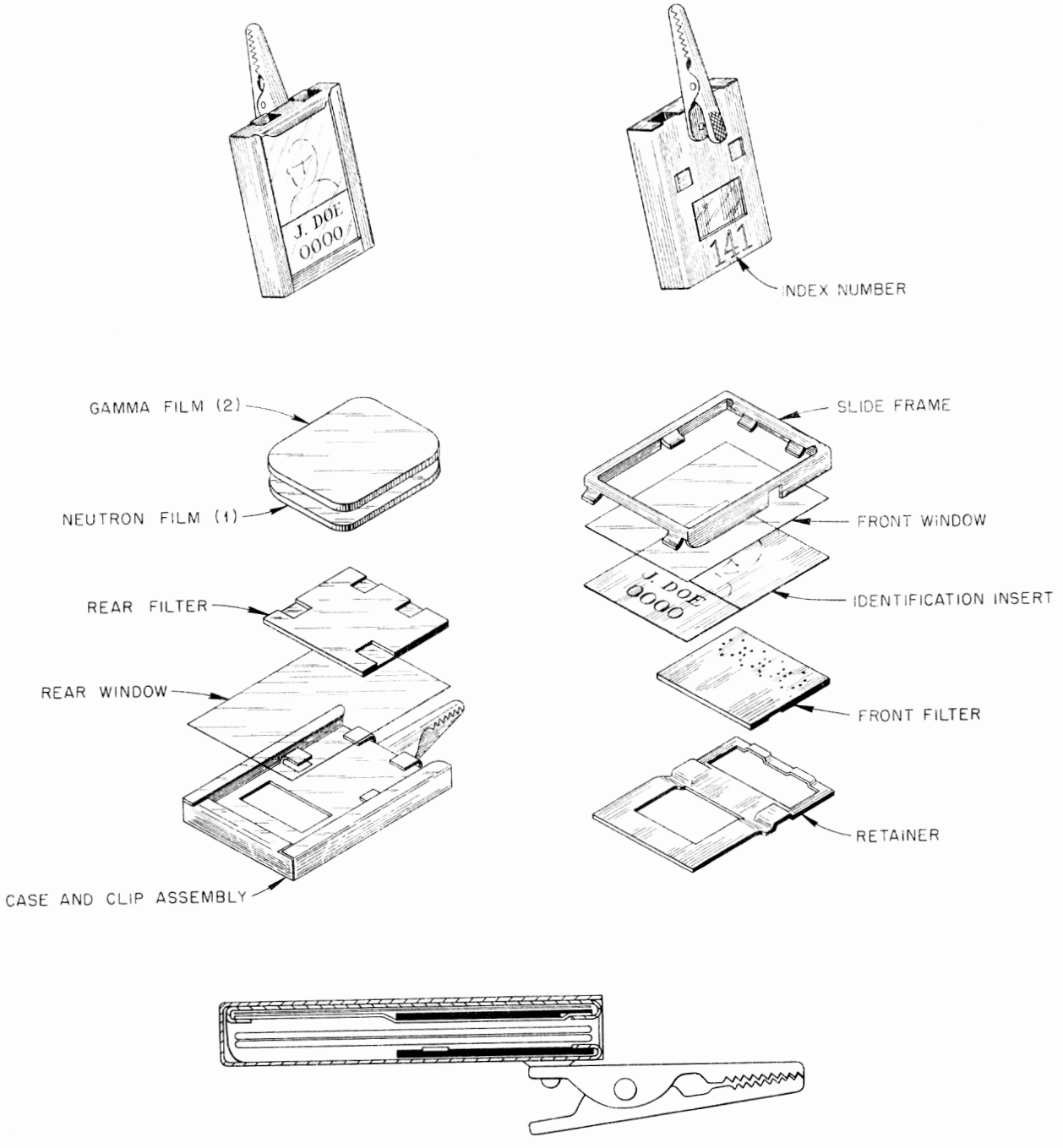


Fig. 6-A. Details of ORNL Badge Film Meter.

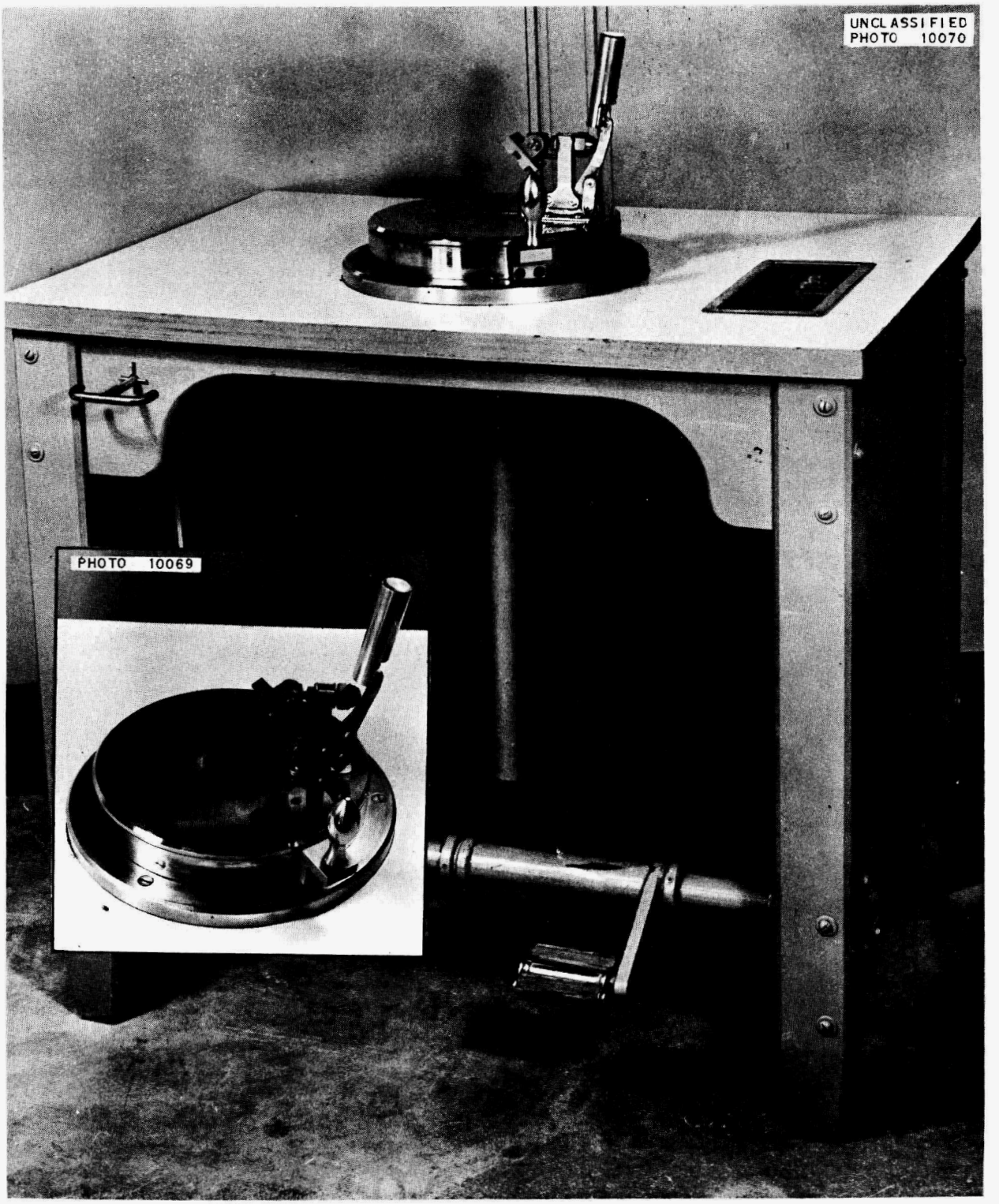


Fig. 6B. Badge Meter Assembly Machine Designed and Fabricated at ORNL. Insert shows assembly head.

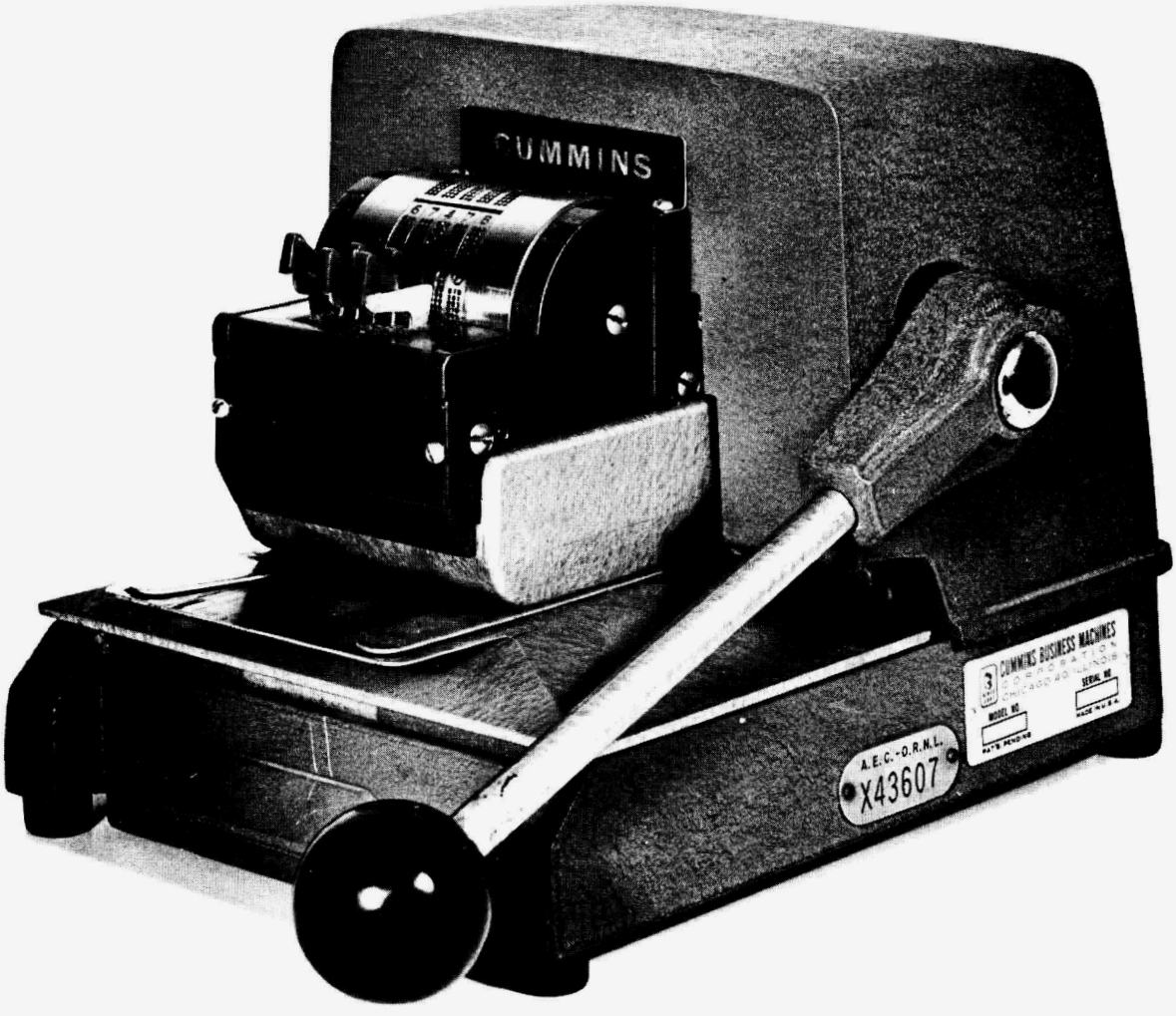


Fig. 6-C. A Cummins Perforator Used for Punching PI Numbers in the Cadmium Filters.

13.4 Procedure

A. Identification Insert

Where a photograph is used, simply trim edges to fit front frame. In the absence of a photograph, a temporary numbered front is used.

NOTE: Use Daily Service Log as source of information.

B. Affixing the PI Number to the Cadmium Filter

1. Insert cadmium filter in perforator using the positioning "jig".

2. Rotate numbers until the ones desired "click" into position.

CAUTION: Listen for "click" to avoid bending punches.

3. Pull handle of perforator downward and release.

C. Assembling the Meter

1. Insert cellulose cover in meter front.

2. Insert identification insert.

3. Insert perforated filter (inverted with number in reverse order).

4. Insert retainer plate.

5. Move lever of assembling machine to right.

6. Place meter front in receptacle.

7. Depress arm to hold front firmly in place.

8. Move lever of assembling machine to left.

9. Press pedal with foot.

D. Loading the Badge

1. Put sliding front on table with cadmium shield exposed and lying to the left.

2. Place dated film pack in meter front with green flap visible and pointing downward. The pack is positioned in this manner so that the sensitive film lies next to the "open window". (Neutron films are dated and stamped to show position of shield and open window. Place neutron film on top of regular film with rough side up and open window showing through opening.)

3. Close the meter by sliding the front and back sections together. CAUTION: Do not tear or damage the film pack, as this will admit light and ruin the film for monitoring purposes.

X-ray Assembly for Marking Films

14.1 General

A. The X-ray unit itself consists essentially of a transformer, X-ray tube on a pedestal for tube alignment, manually operated timing device, and a control panel.

B. The tube is assembled on a pedestal at the base of a box-type housing which is shielded with lead to prevent the release of stray X rays during marking operations. An opening at the top front of the housing, also shielded when closed, permits insertion of trays bearing films to be marked. The box housing has the following dimensions:

1. Inside dimension - 20" x 20" x 50" h.

2. Wood - 3/4".

3. Lead lining - 1/8" sealed at all joints.

4. Distance of tube to brass plate - 30".

C. Trays, constructed of brass, 16" x 16" x $\frac{1}{4}$", have been fabricated in such a manner as to allow 54 badge film meters to be placed face downward side by side six rows deep and nine rows wide. An opening 5/8" x 1-1/4" located immediately under the cadmium filter bears identification perforations which permit the X rays to pass through the films - thus effecting the marking phase.

D. The X-ray unit is a General Electric Model F, type 4, portable machine which operates on 110 - 125 volts. Marking is done at 30 - 40 KV with an amperage of 4 - 6 milliamperes and an exposure time of three seconds.

14.2 Equipment

A. Badge meter marking trays (Fig. 7).

B. Week and batch marking trays (Fig. 8).

C. X-ray unit and housing (Fig. 9).

14.3 Procedure

A. Insert loaded brass tray in opening at top front of X-ray unit housing.

CAUTION: Perform this operation with care to avoid spilling contents of plate onto X-ray tube.

UNCLASSIFIED
PHOTO 10259

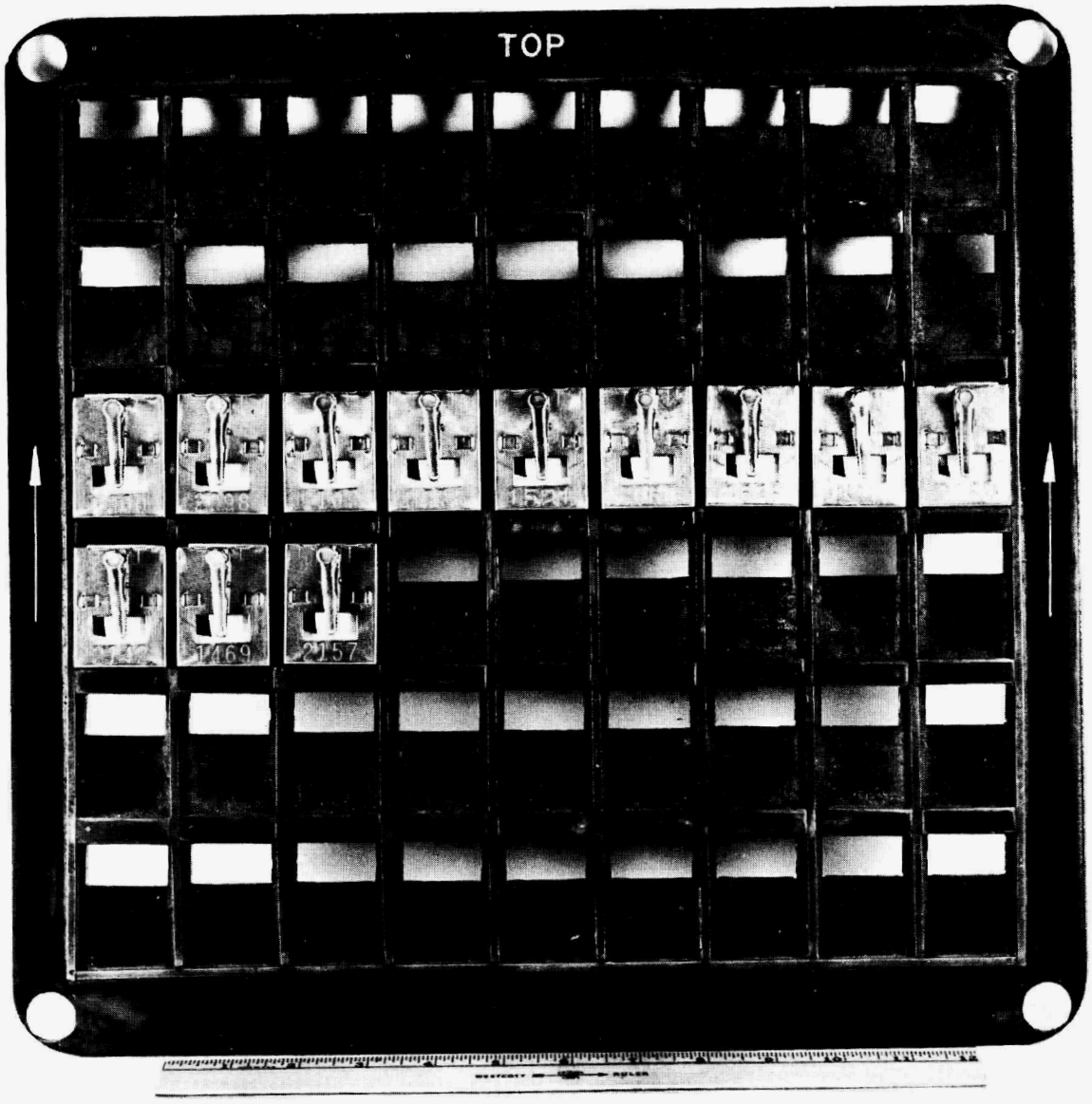


Fig. 7. Badge Meter Marking Trays.

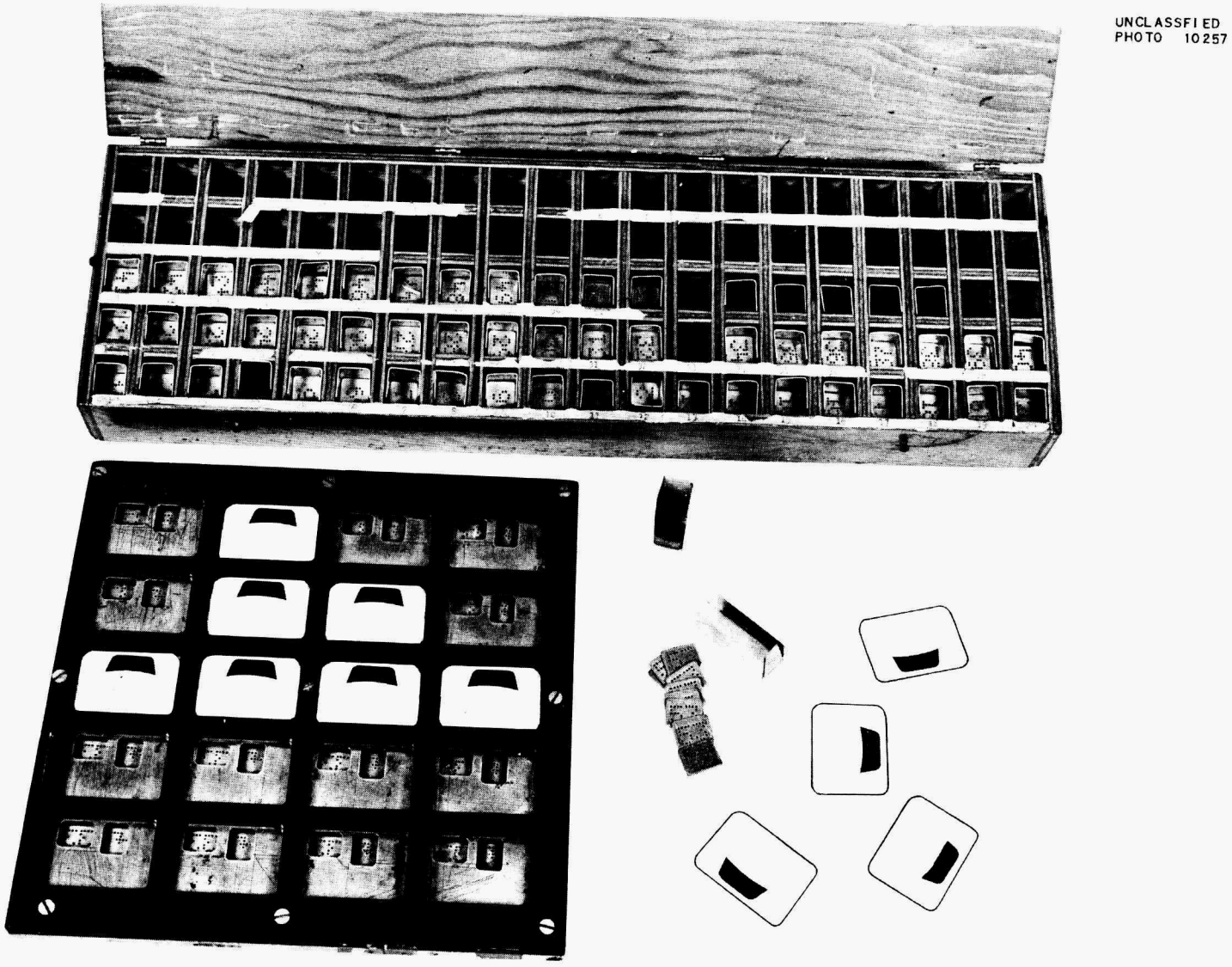


Fig. 8. Week and Batch Number Marking Equipment Showing Box of Prepared Stencils (perforated cadmium slugs) and Marking Tray with Stencils and Film Packs in Place for X-raying.

Fig. 9. Photograph of X-Ray Facilities Used for Marking Films.

B. Close opening, making sure that all doors are shut securely to prevent X-ray leaks.

C. Snap switch on control panel to "on" position. Red warning light at top of control panel is now on.

D. Turn timer clockwise and set at 3 seconds.

E. Press timer button on right, firmly and steadily, while timing pointer travels to zero position and "click" is heard.

F. Snap switch on control panel to "off" position. Red warning light is now off.

14.6 Special Requirements

A. While depressing the timer button, technicians are required to see that the milliamperage indicator always points to 4 - 6 milliamps for the duration of the exposure.

B. Care should also be taken to note that the red light always comes on when the control panel switch is in the "on" position. Red light should always be off until time for the next exposure.

Routine Film Marking

15.1 Purpose

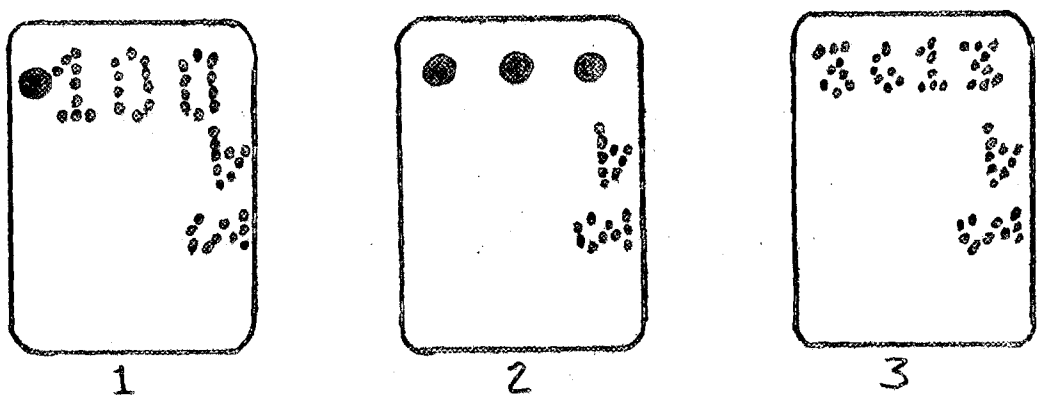
A. The filing system for cataloging the finished film requires that films be permanently marked by X rays with a PI number, batch number, and week number.

B. Films are filed in numerical order by PI number.

C. A set of calibration films is developed with each batch of monitoring films regardless of the number of films in the batch; it is necessary to X-ray the same week and batch numbers on both the calibration and monitoring films to make batch-wise comparison of densities possible.

D. Week numbers are necessary for locating at some future date a specific film for comparison with the set of calibrations developed with it.

E. Fig. 10 shows how X-ray markings appear on the finished film.



1. 100 mr calibration. Identified with one black dot. (Note: 1000 mr is identified with one black dot on each side of the numeral "1".)

2. Tray blanks and/or calibration blank. Identified with three black dots.

3. Regular monitoring film. "3613" is the PI number. The figure "4" in all figures is the batch number; the figure "3" in all figures is the week number.

Fig. 10 - How X-ray Markings Appear on The Finished Film

15.2 Health Physics Day and Week

Week number 1 begins with the calendar week which includes the first day of January. The Health Physics day begins at 4:01 P.M. The Health Physics week begins on Saturday.

15.3 Equipment

A. Brass trays for marking badge meter films (See Fig. 7, P. 49).

B. Brass "week and batch number" tray, 9" x 9", with interchangeable cadmium stencils, made with 20 insets to receive films after removal from badges (See Fig. 8, P. 50).

15.4 Procedure

A. Preliminary to X-raying PI Number

1. Place brass badge meter tray on work table.

2. Arrange badge film meters, face downward, with shielded portion of meter superimposed over openings on plate. CAUTION: Operators must be absolutely certain that the cadmium filters are directly over the openings in the brass tray - otherwise the readings on the films will be altered.

B. Preliminary to X-raying Week and Batch Number

1. Place brass "week and batch number" tray with openings toward upper part of plate and stencils toward table.

2. Place films on plate with green flaps up and pointing toward upper part of plate.

a. Arrange calibrations on plate in order according to gradations of densities and separated as to beta and gamma.

b. Stack 3 or less films in each plate slot.

c. Calibrations and six tray blanks are X-rayed first. Calibration densities have been previously marked.

d. Arrows painted on plate will indicate correct direction of green flaps.

3. Remove calibrations and tray blanks from plate, keeping green flaps in same direction to facilitate opening the pack later.

a. Check order of calibrations. They should be arranged so that when standard procedures are followed the first film opened in the darkroom is the 100 mrep level.

b. Wrap rubber band around calibrations and tray blanks. Tray blanks are usually secured to the side of the bundle.

4. Remove films from plate, 18 to a bundle, and wrap with rubber band.

NOTE: This facilitates dark room handling. If 3 films have been placed in each plate inset, removing films from 6 insets and bundling them together is standard practice. This enables a quick count of 3 bundles of 18 films each in the dark room to avoid loss.

C. Changing Week and Batch Numbers

1. Change "batch" stencils after each batch. This is the duty of the technician who X-rays a batch. Tray should always be left ready to use for the next batch and so labelled.

2. Change "week" stencils at end of Health Physics week.

a. Turn tray to opposite side (from right to left).

b. Put "week" stencils in slots on right (in reading position).

c. Place "batch" stencils with top of numbers toward "week" stencils.

d. Slots are labelled "W" (Week) and "B" (Batch) to guide technicians. (Positioning stencils to correspond to position of these letters painted on tray accomplishes the same result as following the steps outlined above and standardizes the marking of films.)

General Considerations for The Care and Maintenance of The Dark Room

16.1 General

Chemicals used in darkroom routine are generally obtained from commercial stock. Either crystals or liquid mix may be supplied. Final mixing in the tanks is done by the darkroom technician.

16.2 Processing Tank, Its Equipment, and Water Supply

A. ORNL uses a commercial Buck Thermo Tank, Model 30-30. The solution containers are suspended in the tank into a temperature controlled circulating water bath. The solutions are arranged from left to right in the following operating sequence: (1) developer, (2) acid stop bath, and (3) fixer. Rinsing is performed in the circulating water bath.

B. Temperature changes are considered critical; therefore, elaborate steps have been taken to maintain 68°F ± 2° throughout the entire processing effort.

1. Room temperature is controlled by an auxiliary air conditioning unit.

2. Temperature of solutions is maintained by mixing hot and cold water controlled by a mixing valve which ensures that water of proper temperature surrounds the solution containers. This regulated water flows continuously from the mixer through a "cut off" valve, thence into the large tank and out through an overflow pipe. A 5-ton refrigeration unit supplies cooling features when the tap water gets too warm for this purpose.

3. Temperature of rinse is likewise controlled since the circulating water bath is used for rinsing purposes.

C. Under normal conditions, the temperature is maintained adequately by adjusting the mixing valve control to 68°F and leaving it in that position. This single control utilizes the hot and cold water adjustments, both of which remain in a set position.

D. Solutions are changed on the day shift, Friday, and the 4-12 shift, Sunday. Adherence to this schedule is important, so that fresh solutions are always in the tanks just before and after the weekly routine film servicing.

NOTE: Less frequent changing of solutions will depend upon the number of films processed. At ORNL, changes are made when approximately 4000 sq. in. of film surface per 5 gallon mix has been processed. This technique, along with strict temperature control, has practically eliminated fogged film resulting from the processing technique.

16.3 Apparatus and Equipment at ORNL

A. Buck Thermo Tank (See Fig. 11)

1. Developer, acid stop bath, and fixer container of five gallon capacity each.

2. Rinse tank, 47 gallon capacity with a 141 gallon/hour change-rate.

B. Developer (duPont concentrated X-ray developer - liquid mix)

1. Five bottles (1 qt. each) mixed with water to make five gallons of solution.

C. Fixer (duPont concentrated X-ray fixer - liquid mix)

1. Five bottles (1 qt. each) mixed with water to make five gallons of solution.

2. Five bottles (4 ounces each) of hardening solution.

D. Glacial acetic acid (8 oz. to 5 gals. of water) from chemical stock.

E. Bakelite mixing paddle.

F. Glass bottle (1 gallon capacity).

G. Stiff scrubbing brush.

H. Beaker (5 liter capacity).

I. Floating Fahrenheit thermometer.

16.4 Procedure

In general, the preparation of dark room solutions is simply a matter of following the manufacturer's directions which appear on the bottle or can. The following precise directions are presented here for the purpose of demonstrating the empirical method used at ORNL.

A. Preparing Tank for New Solutions

1. Cut off water supply by closing valve above solutions tank.

2. Open drain valve underneath tank.

3. Remove plugs located at bottom right of all three solution containers.

Fig. 11. Model 30-30 Buckite Thermo Tank with Cascade Partition.

4. Connect rubber hose to water faucet located just under mixing valve, and using a stiff brush, wash down all three containers to remove crystal traces and other undesirable substances.

5. Turn off faucet and replace plugs in containers.

B. Preparing Developer

1. Using water from the HOT-COLD mixing faucet set at 68°F, fill developer container (left) 1/2 full of water. (Filling the container half full in this stage facilitates stirring.)

2. Add five quarts of developer.

3. Stir well. Developer crystals require diligent stirring to effect adequate dissolving.

4. Fill remainder of the container with 68°F water to the inside ledge.

C. Preparing Replacement Developer

1. Add three quarts of 68°F water from mixing faucet to a five liter beaker.

2. Add one quart of developer.

3. Stir thoroughly.

4. Transfer the mixture to a one gallon bottle.

5. Fix the bottle stopper or cap firmly in place to prevent evaporation and oxidation. Store on shelf. The replacement developer is now ready for use as the developer in the tank is diminished through use.

NOTE: This is usually a Sunday, 4-12, procedure as one gallon of replacement developer will last a week.

D. Preparing Acid Stop Bath

1. Fill acid bath container (center) 1/2 full of 68°F water.

2. Add eight oz. Glacial Acetic Acid.

3. Stir.

4. Fill remainder of container with 68°F water to the inside ledge.

E. Preparing Fixer

1. Fill fixer container (right) 1/2 full of 68°F water.

2. Add five quarts of fixer.

3. Add five bottles (4 oz.) of hardener.

4. Stir well.

5. Fill remainder of container with 68°F water to inside ledge.

16.5 General Notes

A. A short time may be necessary for the temperature to adjust itself after solutions are changed before films can be processed. However, in changing solutions it is not necessary to move the mixing valve control and the temperature will adjust itself.

B. Under usual circumstances no fixer replacement is needed, as the solution level remains fairly well constant although it weakens slightly. Continued use of solutions tends to weaken them. In addition, age, oxidation, and evaporation are factors. Replacement solutions in this sense are not to be confused with "replenisher" solutions. "Replenishers" are intended to maintain solutions at a certain concentration. With the large volume of films being processed at ORNL, along with fogging considerations, it has been found advisable to keep new fresh solutions in stock.

C. Distilled water is often recommended but ORNL tap water has proven adequate.

Developing Technique

17.1 Purpose

A. The developed latent image on a film used for monitoring represents a quantity of radiation exposure. The primary purpose in processing film is to effect development of the latent image so that the film density becomes a fixed value resulting in a permanent record of exposure.

B. The effectiveness of the film metering program depends on controlled darkroom techniques to an extent where the resultant density represents radiation exposure only. For this reason it is highly important to control carefully those variables associated with developing technique.

17.2 General

A. Insofar as is possible, white light must be kept from the darkroom since a minute quantity will affect the density of the film. Under normal working conditions the provided "safe" light can be left on during the whole process without damage to the film. The same "safe" light is used for both NTA and Type 552 films.

B. Following are three primary variables which have an effect on the density of the finished film:

1. Temperature - The 68° F $\pm 2^{\circ}$ level should be maintained. Exceeding this level will increase relative density. Falling below this level will result in a decrease.

2. Time

   a. Developing is done for an arbitrary time of 3 minutes. Exceeding this limit will increase darkening. Falling short of this limit will decrease darkening.

   b. Acid stop bath requires approximately one minute. The function of the acid is to stop the chemical action of the developer.

   c. Fixing is arbitrarily set at 10 minutes. Failure to allow adequate time for fixing will tend to discolor the film. Excessive fixing will sometimes produce cloudiness and cause the surface of the film to become brittle.

3. Solution Strength - Special effort should be made by the darkroom technician to maintain the strength or concentration of the solutions. Long exposures to air will cause oxidation, thus rendering them less potent. Continued processing of film will also lower the concentration. As the concentration weakens, blackening on the film becomes proportionately less.

C. Although the variables of temperature, time, and concentration will each, when taken alone, affect the relative density of the finished film, one, in practice, controls this feature by adjusting one variable against the other. For example: if the temperature is up the time of development can be reduced. As a "rule of thumb" for each elevated degree above 68°F, the time can be reduced by 15 seconds. Some manufacturers include tables of values from which this can be estimated.

D. ORNL has developed special developing trays, or film holders, for developing mass quantities of dental type (size 1-1/4" x 1-3/4") films.

17.3 Apparatus and Equipment

A. Darkroom facilities.

B. Timers (2).

C. Floating thermometer (Fahrenheit).

D. Film holders

1. Commercial film hangers (Fig. 12).

2. Film tray assembly (Fig. 14, P. 68).

17.4 Procedure

A. Turn on master light switch. Toggle switch is located outside at entrance to darkroom.

NOTE: The light circuits are wired so that the "white" lights go off when the "safe" lights are turned on. Indicating lights are located on the master panel switch outside to indicate which darkroom lights are burning. CAUTION: If the red indicating light is glowing, never throw the master switch or enter the darkroom without obtaining permission from the darkroom attendant.

B. Enter and close sliding doors.

C. Obtain film to be developed and arrange in working position under "safe" light.

D. Lay out frames, trays, and/or racks.

E. Check temperatures and make adjustments as required.

F. Turn off "white" light.

UNCLASSIFIED
PHOTO 10256

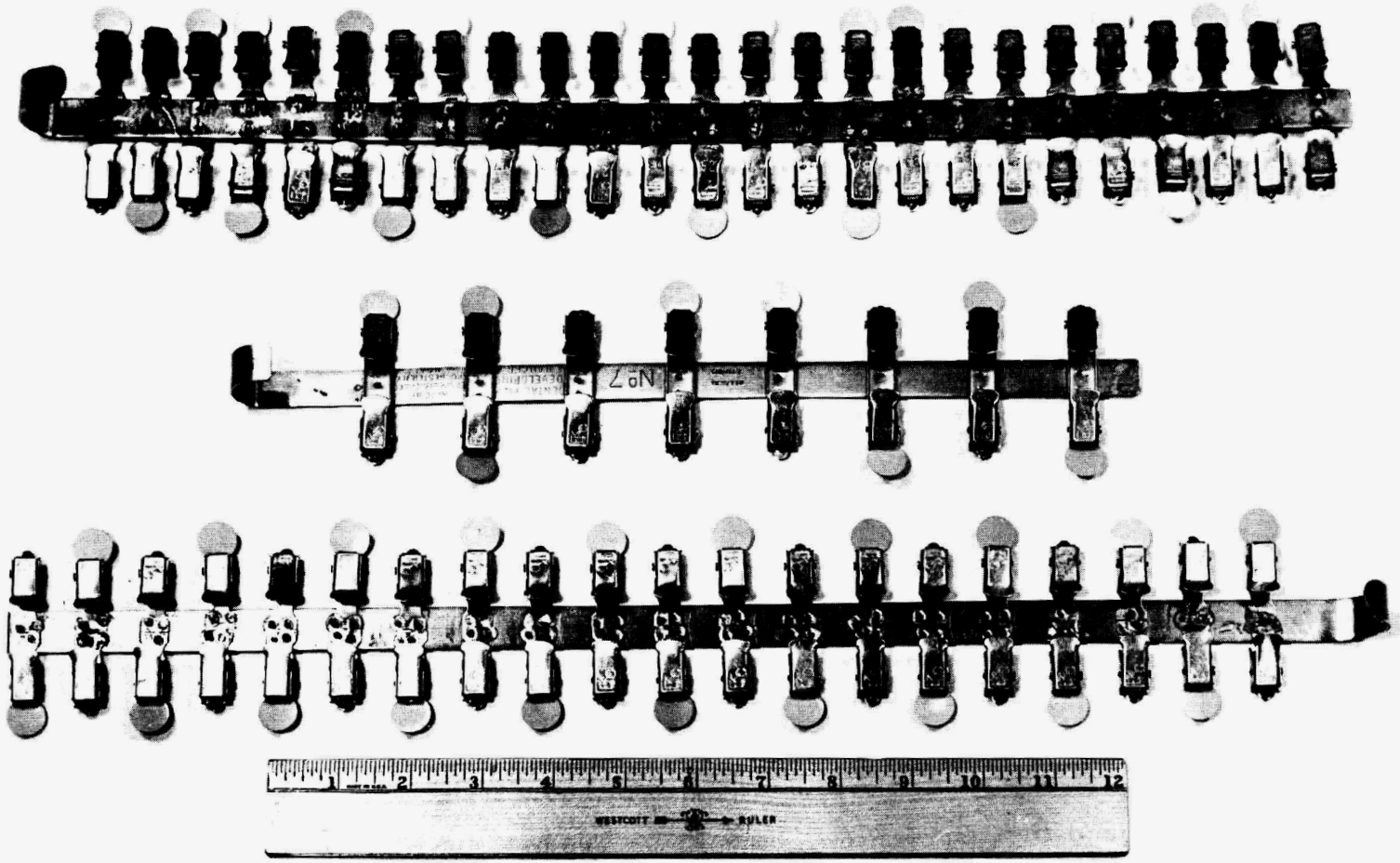


Fig. 12. Commercial Film Hangers. The two long units have extra clips added.

G. Make general inspection to be sure the room is properly darkened.

H. Open film, if packed, handling all films by their edges to avoid finger marks.

CAUTION: Make certain that the hands are dry and free of all traces of developer and fixer.

I. Arrange films in holders, as required.

J. Start the "developer" timer.

NOTE: Timers are operated simply by pressing the button on top. They are set for the proper time with allowance for a few seconds to submerge film. They reset automatically. It is only necessary for technicians to press the button on right to turn off the alarm. Then the timer is ready for the next batch.

K. Submerge the film holder laden with films in the developer.

L. Agitate the films through development process.

M. Remove holder, after prescribed time interval, submerge in acid stop bath, and agitate.

N. Remove holder, after prescribed time interval, submerge in fixer.

O. Start the "fixer" timer. (See note above.)

P. Agitate through fixing process.

Q. Remove holder, after prescribed time interval, and submerge in quick rinse.

R. Agitate for one minute.

S. Remove holder and submerge in final rinse.

T. Allow films to rinse for 20 minutes.

U. Place holders in dryer after allowing suitable time for water drainage.

17.5 The Film Dryer

A. The film dryer (Fig. 13) is constructed so that the doors can be opened from inside or outside the darkroom. However, when one door is ajar, the opposite door cannot be opened. Door handles are placed in a vertical position when the door is not in use so that the door on the opposite side can be opened. When the door handle is in a horizontal position, the opposite door cannot be opened.

UNCLASSIFIED
PHOTO 10266

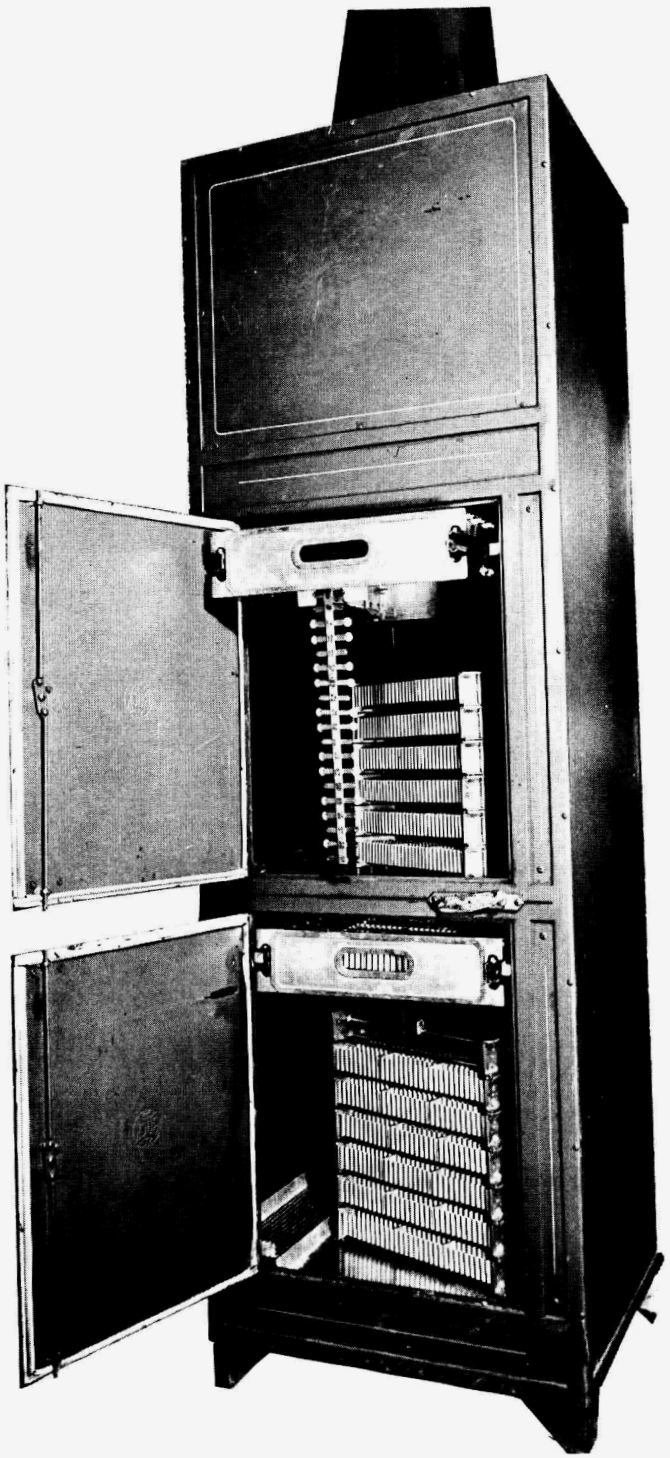


Fig. 13. Buck Film Dryer.

B. The dryer requires a warming up period of approximately 15 minutes before it will function at maximum efficiency.

C. Two toggle switches, one for the blower and the other for the heating unit, are located on the panel outside the darkroom. Both switches should always be turned off when the dryer is not in use.

17.6 Operating Note

A. The "white" light can be turned on after film has been in the fixer for five minutes.

B. Going in and out of the darkroom while the "safe" light is on is a practice which should be held to a minimum.

Badge Film Processing

18.1 Introduction - The Batch

A. In this procedure "badge films" are specified as those duPont Type 552 films which are used in the ORNL picture type badge film meter. (See Fig. 6 for details of this meter.)

B. Badge films are processed in stainless steel multiple trays designed to hold films securely in orderly position while they are being submerged in solutions. When six developing trays are locked together, one on top of the other, they easily hold 216 regular packs, plus 18 calibrated packs and blanks. This constitutes a standard batch.

C. When processing films in mass, as on Saturday, technicians are instructed to use the standard number of 216 packs per batch. This consists of four badge meter marking trays having a capacity of 54 packs each. When six or less developing trays are used, it is possible to vary the size of a batch from a maximum of 235 packs, plus 18 calibrations and blanks, to a minimum of one pack plus 18 calibrations and blanks.

D. If there are not more than 235 packs in the last collection on Saturday morning, it is sometimes expedient to put them all in one batch. However, if the number collected exceeds 235, the standard batch is used and the remainder are X-rayed with the next batch number. The day shift processes the residue collection if it comprises 1/2 batch; otherwise, the batch is left for the 4-12 shift to complete.

E. Grouping films in batches together with calibrations and blanks facilitates their isolation for special treatment, if such consideration is indicated. The batch is also useful as a means of enumerating films to avoid losses.

F. The top developing tray in each batch contains the calibration set. A blank film is placed in each tray.

18.2 Apparatus and Equipment

A. Darkroom facilities.

B. Badge film developing tray and assembly unit (Fig. 14).

C. Calibrated film sets.

D. Tray blanks.

UNCLASSIFIED
PHOTO 10253

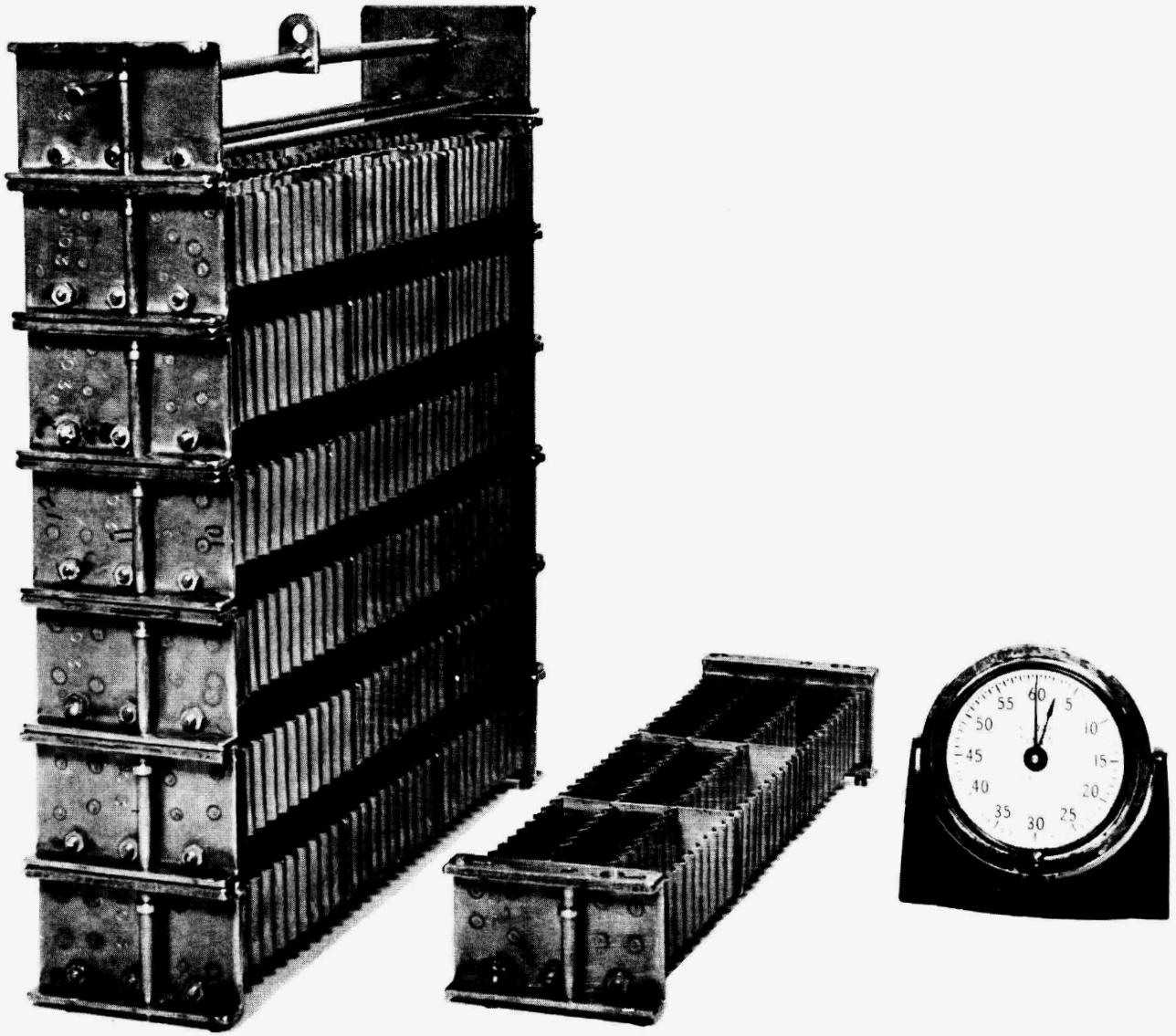


Fig. 14. Badge Film Meter Developing Trays Designed and Fabricated at ORNL.

18.3 General

A. Procedure #17 outlines the broad procedure of darkroom processing of films. In general, the procedure indicated can be followed here, there being no difference in such steps as setting the darkroom in order, inspection, and operation of lights and doors, timing, temperature, and drying the film. Procedure #18 is necessary because it shows specifically how to handle the tray assembly, how to open the film packet correctly, and how to place films in the tray assemblies in proper sequence. These items apply to the duPont 552 film packet only.

18.4 Disassembling the Multiple Tray Unit

A. There are four circular locks on the bottom of each tray and four openings on top. These are situated in each corner. The openings are large enough at one end to receive the locks and small enough at the other end to hold the locks in place when the flanges of lock and opening are engaged. In this position, the trays can be slid apart.

B. When two trays are in exact locking position, metal pegs which move vertically fit into receptacles in the tray below thus preventing any sliding motion. With the pegs engaged, the two trays cannot be separated.

C. At the top of the assembly is a handle which locks to the top tray in the same manner described above.

1. Put assembled tray on work table.

2. Lift the two metal pegs upward and slide the two trays apart.

NOTE: Trays are assembled as sets and numbered. Trays of the same number should be kept together as a unit.

18.5 Opening duPont 552 Film Packet

A. Hold packet in left hand with forefinger and thumb at upper left of packet with the green tab toward the operator.

B. Grasping green tab with thumb and forefinger of right hand, break flap to first fold.

C. Inserting left thumb inside wrapper, grasp film at top between left thumb and forefinger and pull packet completely open with the thumb and forefinger of the right hand.

D. Take free film in right hand, holding at sides so that fingers do not touch surface.

E. Discard packet.

NOTE: Packets are kept until it is determined conclusively that none of them contain undeveloped film.

F. Separate sensitive film and insensitive film in left hand.

NOTE: Both films are green when removed in "white" light. Under the "safe" light the sensitive is darker, the insensitive being almost white by comparison. The insensitive film is a trifle more flexible. These characteristics enable the alert technician to distinguish between the two.

G. Put sensitive film in tray first with right hand.

H. Then put insensitive film in tray.

18.6 Placing Films in Trays

A. Calibrations

1. Arrange six trays, disassembled, on work table lengthwise.

2. Insert film in following order, starting at left end of the top tray:

a. Beta blank - sensitive, insensitive.

b. Beta sensitive, starting with the lowest exposure unit (100 mrep), then the insensitive of the same exposure.

c. Remainder of beta, in numerical order by exposure unit.

d. Gamma blank - sensitive, insensitive. (Follow same procedure for gamma as for beta.)

e. Beta should be first in the tray, as it is first read by the densitometer technician. Beta is also on top of bundle as it comes from the X-ray technician (See Procedure #15).

B. Monitoring Film

1. Preliminary: Count film in bundle to avoid losses. (Described in Routine Film Marking, Procedure #14.)

a. Insert monitoring film, sensitive first, then insensitive.

b. Insert a tray blank in the center row at one end of each tray.

c. Push loaded tray to back of table and place another in loading position.

d. Lock trays together when a batch has been loaded.

e. Process the batch and put in dryer. (See Developing Technique Procedure #17.)

f. Deposit empty packets in containers until film file has been checked and all film accounted for.

The Densitometer and Its Operation

19.1 Purpose

The densitometer is used for determining relative densities on films for subsequent comparison with densities caused by known quantities of radiation. These densities are later converted to some exposure unit. Figures 15A and 15B picture two types in use at ORNL.

19.2 Description and Operation

A. The densitometer described for use here is a converted Ansco, Model 12, manufactured by the Ansco Corporation, Binghamton, N.Y. This instrument has a linear scale with a density range from 0.0 to 6.0 graduated in increments of .02. It has a movable arm which pulls down over an aperture through which light passes when the instrument is in operation. The instrument case houses circuitry for regulating the power supply.

B. A photoelectric cell is installed in the measuring arm. The cell is activated by a filament type light from a 6-8 volt lamp of 32 candlepower.

C. Since all determination of densities for monitoring purposes is accomplished with black and white densitometry, the color filters have been replaced with filters of varying densities which are used as check points in establishing the calibration.

D. A phenomenon occurring in the photocell causes a deflection of the meter pointer toward the right of zero position as blackening on the film increases and transmission of light decreases. When a developed "blank", or unexposed, film is placed over the aperture plate, the needle will deflect indicating a reduction in transmitted light. This is "background" density and occurs proportionally on all films of a given type and batch. For convenience in interpreting densities above "background", it has been found practical to "zero" the densitometer with a "blank" film before reading the monitoring films. The instrument is made ready for use by allowing the light to pass through a "blank" film placed over the aperture in reading position and increasing the light until the pointer comes to rest at "zero". When a monitoring film is being read, any normal decrease in transmitted light is assumed to be blackening above background and is considered to represent an exposure to radiation.

E. With use, blackening develops on the surface of the light bulb and decreases the amount of transmitted light. When this progresses to a point where it is not possible to "zero" the instrument, the voltage should be adjusted or the lamp replaced.

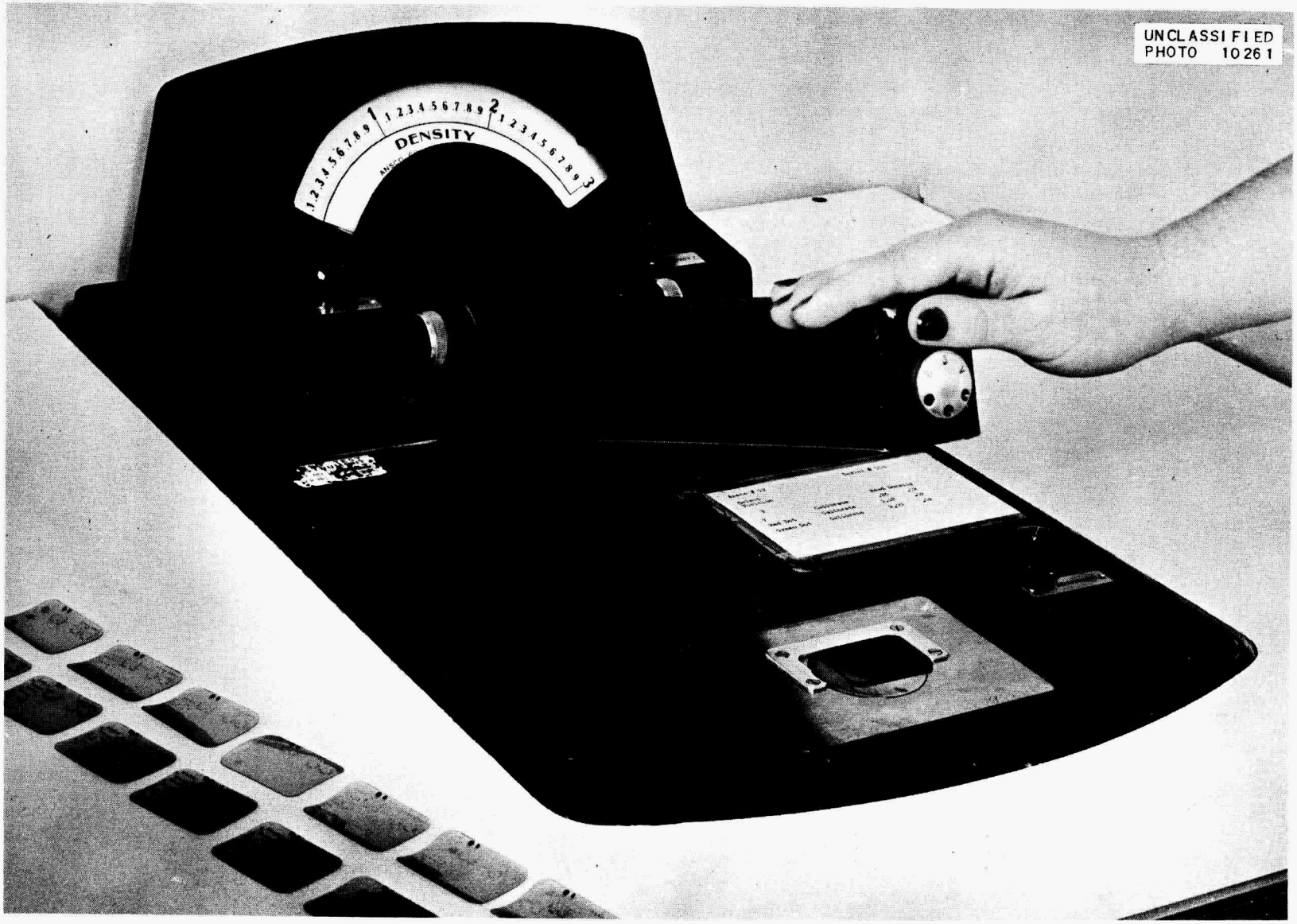


Fig. 15-A. Modified Ansco Densitometer.

UNCLASSIFIED
PHOTO 10254

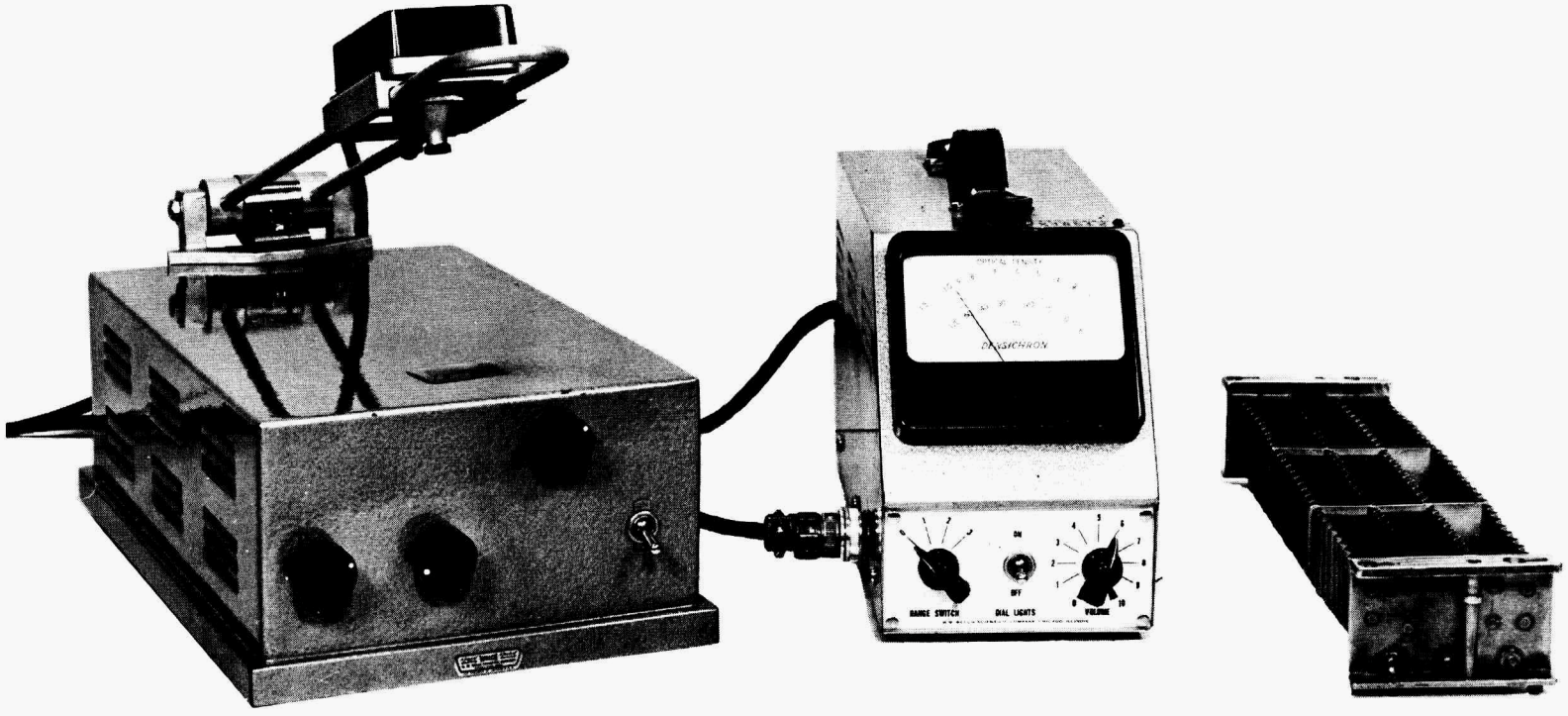


Fig. 15-B. Welch Densichron.

19.3 "Zero" and Sensitivity Settings

A. The instrument will not reach thermal equilibrium immediately. A "zero" drift will occur during the first few minutes of operation. It is therefore advisable to check the zero at intervals to assure more accurate readings. Allow at least 5 minutes for the tubes to heat before using the instrument.

B. In order to check the calibration of the instrument a reference wedge is used. The wedge has different gradations of blackening with assigned values. To calibrate the instrument, the sensitivity control must be adjusted until the meter readings are in agreement with these values.

C. Instructions placed on the top of the densitometer are to be followed for calibration of the instrument. These instructions vary from one densitometer to another.

19.4 Procedure for Preparing the Densitometer to Read Absolute Densities

A. Turn instrument on by rotating the On-Off switch clockwise to the "on" position and allow five minutes for warm-up.

B. Set the filter selector control on "3". The filter selector control knob is located at the front end of the measuring arm. Normally the selector will remain in this position, which enables the technician to read densities up to a density of 3.

C. Bring measuring arm down so that it fits snugly against the uncovered (no film in place) aperture plate. This should be a precise technique in that if too much or not enough pressure is applied, readings will vary at the upper end of the scale.

D. Rotate the zero adjustment knob (so labelled) until the meter pointer rests at zero.

E. Bring the measuring arm up and down against the aperture plate two or more times in order to make sure that the pointer stays at the zero point.

F. Set filter selector to a specified check point and adjust sensitivity to the reading prescribed on the instruction chart located on the top of the densitometer unit. This is the calibration check. The instrument is now ready for use to read absolute densities up to a density of 3.

G. The measured density of the material placed between the light source and the photo cell is the reading indicated by the meter.

19.5 Reading Absolute Densities from 3 to 6

A. After suitable warm-up time, rotate the zero adjustment counter-clockwise so that a minimum of light is passing through the aperture plate.

B. Set the filter selector on "6" and bring the measuring arm to a snug position over the aperture plate.

C. Rotate the zero adjustment knob until the pointer rests at zero.

D. Set the filter selector control to a specified check point and adjust sensitivity to the reading prescribed on the instruction chart located on the top of the densitometer unit. This is the calibration check. The instrument is now ready for use in reading absolute densities from 3 to 6.

CAUTION: The No. "6" position on the control knob leaves the ultra-sensitive photo tube completely exposed. It is important to protect the tube by shielding it from bright light. This can be done by holding the thumb over the aperture immediately under the photo cell or by placing an opaque material over the aperture plate.

E. The measured density of the material placed between the light source and the photo cell is the reading indicated by the meter plus 3.

19.6 Procedures for Obtaining Relative Densities

Allow suitable warm-up time. Place the correct "blank" film under the aperture plate, and proceed as in Section 19.4 and/or 19.5, whichever case applies.

19.7 Commentary

There are several acceptable densitometer units available. ORNL Personnel Monitoring, in general, has standardized with the Ansco type since it is rugged, reliable, and has a large linear scale. In general, the above procedures will be applied with most densitometer units with slight modifications. As a rule, special instructions will be followed for each unit being used. The calibration of the instrument is important and must be performed with care. At ORNL this is done under the direct supervision of the person in charge of densitometry. The use of a standard photographic wedge is imperative. However, since most provided wedges are calibrated film, the values change readily with use and wear. For this reason, the so-called "standard" wedge is used infrequently and in its place "secondary" wedges are substituted. With the Ansco densitometer, these "substitute" wedges are conveniently located in the place of color filters.

Using the Densitometer

20.1 Introduction

A. The purpose of this section is to standardize the technique of removing film from tray assemblies and reading them so as to gain maximum efficiency with minimum lost motion. This system becomes increasingly important when films are read in mass, as it is necessary to do on the Saturday routine servicing.

B. Film calibrations are previously arranged in standard order at the X-ray table and subsequently inserted in the tray assemblies in the same order to avoid sorting while densitometry is in progress. (See X-ray and Darkroom Procedures #14, #16, and #17.)

C. A metal frame, fastened to the top of the aperture plate, enables the densitometer operator to place films so that they are read in a standard position. The orderly arrangement of films in trays and the ease with which they can be positioned correctly on the aperture plate greatly facilitates the work of the operator.

20.2 Materials and Equipment

A. Densitometer (Fig. 15A, P. 73a).

B. Tray assemblies containing:

1. Calibrations and blanks.

2. Badge films.

20.3 Procedure

A. Disassemble trays placing top tray along right side of densitometer. Insensitive film is closest to operator.

B. Prepare proper headings on calibration data form.

C. Prepare densitometer. (See Densitometer and Its Operation, Procedure #19.)

D. Remove beta blank from tray with right hand.

CAUTION: Hold finger tips between sensitive and insensitive films to prevent scratching.

NOTE: When trays are loaded according to standard procedures, beta is first followed by gamma. The tray is turned so that beta is closest to the operator. The remainder of films in tray are removed in sequence with no skips.

E. Hold insensitive film in left hand and position sensitive film with right hand.

F. Depress arm with left hand.

G. Use adjustment to "zero" blank.

H. Remove beta (100 mrep) from tray and position.

I. Note reading on meter and record on calibration data form.

J. Proceed to next calibration in tray.

K. Proceed to badge film.

NOTE: The blank is the first film used in each tray.

20.4 Operational Notes

A. In standard position, the open window portion of the film is always read first. The film is then moved to the left of the frame which brings the shielded portion into reading position.

B. Distinction is made between "zeroing absolute" (See Densitometer and Its Operation) and "zeroing the blank". "Zeroing absolute" is done when the meter range is being checked for operating efficiency. This operation is performed at the beginning of each batch. "Zeroing the blank" is done to reduce "background" density to zero. This operation is performed at the beginning of each tray.

Film Calibrations and Charting

21.1 Purpose

In order to determine the amount of exposure indicated on films used for radiation monitoring, a film of the same emulsion is given prior exposure to standard sources of radiation. A set of calibrations is developed with every batch of film. This practice largely eliminates variable factors encountered in the developing process.

21.2 General

A. Lot Number

1. All monitoring films plus calibrations are developed from the same lot. It is sometimes necessary to budget films as a "lot" approaches depletion in order to avoid using different emulsions in the same batch. Moreover, all old "lot" numbers are taken out of service when there are no films left for calibrations.

2. Films are stored in a cool place. If the entire lot consignment is not received on the same day, boxes are dated to aid technicians in using the oldest emulsion first. The Calibration Unit takes films from this supply and delivers 30 sets of exposed films to the Personnel Monitoring Laboratory on Friday of each week.

B. Calibration Sources

The gamma calibration is achieved with a 100 mg Ra source placed at a distance of approximately 30 cm from the films which are arranged in a circle with the source located in its center. Plates of U_X metal placed in direct contact with a film loaded badge meter are used as a beta source. The films are identified after processing by X rays in the customary manner.

C. Calibration Sets

There are 19 packs in a complete calibration "set", as follows: 8 betas plus 1 blank, and 9 gammas plus 1 blank. Exposures are made at the following levels:

Beta (mrep)	Gamma (mr)
100	100
250	250
500	500
750	750
1000	1000
2000	2000
5000	5000
10000	10000
	20000

D. The Low Range Calibration Chart

1. The calibration chart (or graph) is a reference from which relative film densities are translated into mr(ep) units.

2. The chart is prepared by plotting relative density on the vertical axis versus the mr(ep) value on the horizontal axis. The vertical axis has a density range of 0.0 to 1.5 which extends the curves to 2000 mrep.

3. Linear graph paper is used and four curves are drawn as follows:

   a. Beta, open window, sensitive.

   b. Gamma, shield, sensitive.

   c. Gamma, open window, sensitive.

   d. Gamma, shield, insensitive.

4. Routine interpretation is done from the sensitive film using beta open window, and gamma shield. The insensitive film is interpreted when the sensitive film cannot be read.

E. The High Range Calibration Chart

The high range chart is similar to the low range chart except that it is drawn so as to extend the curves to saturation densities.

F. Plotting

1. Materials and Equipment

   a. Calibration charts. (See Appendix, PP 107 and 108.)

   b. Blue and red ink.

   c. Ink pens.

   d. Calibration data sheet. (See Appendix, P 110.)

   e. Flexible drawing curve.

21.3 Procedure

A. General Instructions

1. Use the following symbols and colors to plot points:

o	Blue	(Gamma, open window, sensitive)
x	Blue	(Gamma, shield, sensitive)
o	Red	(Beta, open window, sensitive)
*	Blue	(Gamma, shield, insensitive)

2. Prepare heading on calibration chart.

3. Plot beta points.

4. Plot gamma points.

   a. Shield, sensitive.

   b. Open window, sensitive.

   c. Shield, insensitive.

5. Draw beta curve.

6. Draw gamma curves.

21.4 Commentary

A. Technicians are required to develop a technique in plotting points and drawing curves. Precise interpretation depends largely upon accuracy, neatness, and experience in this operation.

B. Normally, only the Low Range Charts are plotted. When monitoring film densities fall beyond the range of the plots on the Low Range Chart, plots are then made on the High Range Chart.

Interpreting Film Densities Which Approach Saturation

22.1 Introduction

A. Normally, gamma interpretations are given on duPont 552 sensitive film up to 10,000 mr. Similarly, insensitive film is interpreted up to 20,000 mr. However, in both cases, high exposures can be interpreted by special techniques. (Beta exposures can be determined at considerably higher levels than gamma exposure.)

B. Special techniques noted above are applied only where advance information regarding a "high" exposure is available. The technique requires (1) high calibrations, and (2) special developing techniques. These developing techniques are well known and are not reproduced here for the sake of brevity.

22.2 Reporting High Readings Under Normal Conditions

A. Sensitive Film

When the sensitive film is blacked out, or density has reached saturation, readings should then be taken from the insensitive film and so indicated in all reports. If the insensitive film is not available, the sensitive film should be reported as follows:

OW Beta	OW Gamma	S Gamma	Remarks
>10,000 mrep	>10,000 mr	>10,000 mr	Blacked out

B. Insensitive Film

When the insensitive film is being used and it is found through densitometry that the density is saturated, report as follows:

OW Gamma	S Gamma	Remarks
>20,000 mr	>20,000 mr	Blacked out

NOTE: When the sensitive film shows a discrepancy, the PTR (probable total reading) should be quoted from the insensitive film with appropriate comment.

22.3 Reporting High Readings Where Special Techniques are Applied

In general, the calibration films will be given exposures up through 200r if duPont 552 film is being used. Special developing techniques must be utilized. This will include developer and fixer solutions of a particular mix with temperature and time of development and concentration being specified. In this instance, the calibration curves are extended to the point where they begin to level off and readings quoted accordingly. In all cases, a complete report describing techniques, methods, etc., must accompany readings so interpreted. Special techniques are permitted only on the prior approval of the department head.

Weekly Routine Badge Film Meter Servicing

23.1 Introduction

A. This procedure is an account of the weekly routine badge film service, also a summary of the detailed sections preceding it. Additional steps and notes are introduced where needed to integrate all badge film procedures into a single unit.

B. On Saturday of each week, all permanently issued badge film meters are serviced. Servicing includes:

1. Collection.
2. Reloading with new film.
3. Checking for contamination.
4. X-ray marking.
5. Redistribution.
6. Darkroom processing.
7. Densitometry.
8. Interpretation and evaluation.
9. Recording.
10. Filing.

C. Every available badge film meter is processed on Saturday morning. Normally, the only meters not processed on the initial servicing are those being used by the 8-4 shift. These are processed on the 4-12 shift or when they become available. They are not processed again until the following week except by special request. This schedule conforms with the Health Physics Week which begins at 4:01 P.M. on Saturday.

23.2 Procedure

A. Badge film meters are arranged in the alleys in numerical order by index number. Prior to Saturday, "change sheets" (see Appendix, P 106) are prepared listing all badges to correspond to the alley arrangements.

B. Collecting Badge Film Meters

1. Remove meters in numerical sequence by index number, starting in the first alley.

2. Check (✓) each meter under "PU" (picked up) on change sheets.

   a. Use black pencil on 8-4 shift; use red pencil on 4-12 shift.

   b. Note the index number on the meter. Do not depend upon the numbered slot.

3. Load meters on brass badge meter marking tray (Fig. 7, P 49).

4. Check placement of film in badge.

   a. All irregularities, including improper placement of film in badge, are noted on "batch" card (see Appendix, P 109) with PI number and index number of affected meter.

   b. Check neutron film in badges (asterisked on change sheets) and mark (✓) "batch" card.

5. Write alley and tray numbers on "batch" card.

6. Place meter laden tray in X-ray port.

   CAUTION: Make sure green light is burning indicating that X-ray port is ready to receive tray.

C. X-raying PI Numbers and Reloading Badges

1. X-ray PI numbers.

2. Check (✓) "X-rayed" on batch card.

3. Transfer X-rayed meters on tray to "change" table.

4. Pull badge partially open so as to permit the film packet to come out. (A brass track, placed lengthwise along the front side of the work table is used for this operation. On one end of the track is a ledge over which the face of the badge is hooked to facilitate pulling it apart. At this point, neutron film is put aside and handled separately. Badges requiring neutron film are reloaded with a previously stamped neutron film pack.)

5. Slide the partially opened empty badge to the left along track slowly. As the badge moves along it is checked above and below for contamination by G-M tubes permanently installed. Contaminated badges are replaced.

6. Insert new beta-gamma film in badge. Film is dated prior to the Saturday servicing. There is a gross of film in each box. Enough film is stamped to change all meters serviced by the 8-4 and 4-12 shifts.

7. Slide the two sections of the badge together and place in its designated position in the brass marking tray.

8. Check "loaded" on batch card.

NOTE: Also note PI and index number of meters not returned for redistribution.

9. Send batch card and tray to alley for meters to be redistributed.

D. X-raying Batch and Week Numbers on Beta-Gamma Film (See Routine Film Marking, Procedure #15)

1. Load batch marking tray (Fig. 8, P 50) with beta-gamma calibrated films and X-ray.

2. Load batch marking tray with films and X-ray.

3. Send films by batches to darkroom indicating the number of the batch and the number of films in the batch.

E. Redistributing Meters

1. Reinsert the badge film meters in numbered slots in numerical order by index number.

NOTE: Since meters are collected in this order and returned in the same order, this operation is simplified.

2. Keep batch cards for future reference.

3. Check (✓) each meter under "PB" (put back) on change sheets using a blue pencil.

4. Check for presence of neutron film in meters identified by an asterisk on change sheets.

CAUTION: This is the final check on neutron films before racking the meters. Neutron films which may have been overlooked are replaced.

F. Developing the Films (See Badge Film Processing, Procedure #18)

1. Load films in tray assemblies.

CAUTION: Count 18 films in each bundle to avoid losses.

2. Develop, fix, and rinse.

3. Place film in dryer.

NOTE: Disassembling the trays facilitates drying.

G. Reading the Films (See Using the Densitometer, Procedure #20)

1. Remove films from dryer.

2. Place on densitometry work table.

3. Read calibrations.

NOTE: Calibrations, including blanks, are packaged, in order, by exposure value and filed. Beta and gamma are separated.

4. Write calibration data on form provided.

5. Read monitoring films.

6. Write positive readings (densities only) by PI number on "Positive Reading Sheet" (see Appendix, P 103). Irregularities such as contamination, fogging, exposure to light, weathering, pressure marks, etc., are entered on form whether the film has a positive reading or not.

7. Place sensitive film with its insensitive counterpart in an envelope provided for this purpose.

a. As sensitive film lies on aperture plate at this stage of procedure, drop insensitive film on top of it, pick up both together and place in envelope.

b. PI numbers of both sensitive and insensitive films are in exact superposition and visible as one number when the films are properly placed.

8. Films with positive readings are set aside in their envelopes beside the densitometer until checked against the positive reading sheet.

9. Zero reading films are immediately filed.

H. Maintaining the Records

1. Prepare calibration chart from the calibration data.

2. Using the calibration chart and the positive reading sheet, convert the density readings to the required "mr" or "mrep" value.

NOTE: Draw diagonal line over density and show the converted unit above it as follows:

$\frac{120}{.12}$ which means a density of .12 is interpreted as 120 mr(ep).

3. Transcribe positive readings to change sheet.

NOTE: Both the Pi and index numbers are noted on the change sheet. This enables clerk to transfer without going to the cross-file.

4. Initiate Personnel Exposure Questionnaire Information Form (See Appendix, P 101.)

5. Transfer monitoring results to the Kardex cards.

6. Tabulate Kardex card. (See Procedure #6.)

7. List all meters <u>not serviced</u>.

NOTES: a. Meters indicated on change sheets as not picked up comprise the list.

b. Steps 6 and 7 above are Sunday routine and include records on meters collected at 11:30 Saturday night.

c. Check all questionnaire work sheets (high reading sheets) against Kardex cards to include pocket meter readings recorded on Saturday.

8. Films packaged in envelopes are filed in numerical order by PI number. Cardboard boxes (2" x 19", capacity 300), are used for this purpose.

9. Check films in file against PI number file (3 x 5, pink).

a. All files must be in strict numerical order.

b. All cards must have corresponding film in file.

c. Cards are up-ended in drawer to designate film <u>not yet in file</u>.

23.3 <u>Special Note</u>

Badges free from contamination and in acceptable repair are reloaded with film before redistribution.

Hand Exposure Meter

24.1 Introduction

A. The hand exposure meter is a film loaded modified plastic finger ring and is used as a beta-gamma monitoring device by personnel whose work involves potential exposure to the hands. It can be pinned to the clothing for monitoring particular areas of the body.

B. It is mamufactured of black opaque plastic. The small size and an opening in the ring band for expansion permits a universal fit so that the meter is adaptable to one or more fingers of most individuals.

24.2 Meter Assembly (Fig. 16)

A. There are cadmium filters, or "washers", on both sides of the film each 1 mm thick and 9/16 inch in diameter. An "open window", 3/16 inch in diameter, is located directly in the center of the filter which, to all appearances, resembles a simple metal "washer".

B. Film discs are punched from the duPont Type 552 film pack out of the 502 emulsions (sensitive) for use in the meter. One thickness of the "green" paper wrapper is left surrounding the film prior to punching. The film disc is thereby covered on both sides by a thickness of paper when placed in the meter.

C. The meter cavity is loaded with (1) cadmium washer, (2) protecting paper, (3) film, (4) protecting paper, and (5) cadmium washer in that order. The light seal is made by fixing a screw type cap of 0.02" thickness to the body of the meter. The open window of the assembled meter is taken to be an absorber of about 70 mg/cm^2.

24.3 Equipment and Materials

A. Numbering Machine (Fig 17): A device used for engraving numbers on the underside of the meter. The device is a modified arbor press. Metal stencils are pressed into the soft plastic body of the meter leaving the impression of the numbers. The press is hinged on a wooden base enabling the operator to lay the press flat while inserting the metal stencils which are braced by two adjustable screws. An anvil has been attached to the base adapted to hold the meter while it is being numbered.

B. Film Punch (Fig. 18): A device used for cutting out film discs from the 502 emulsion. It is constructed of metal and consists of a wheel which turns a horizontal shaft fitted with an eccentric. A circular cutting edge, riding the eccentric by spring action, moves up and down as the wheal is turned. A movable track feeds the meters into loading position one at a time and a film with paper protectors is dropped into the meter cavity.

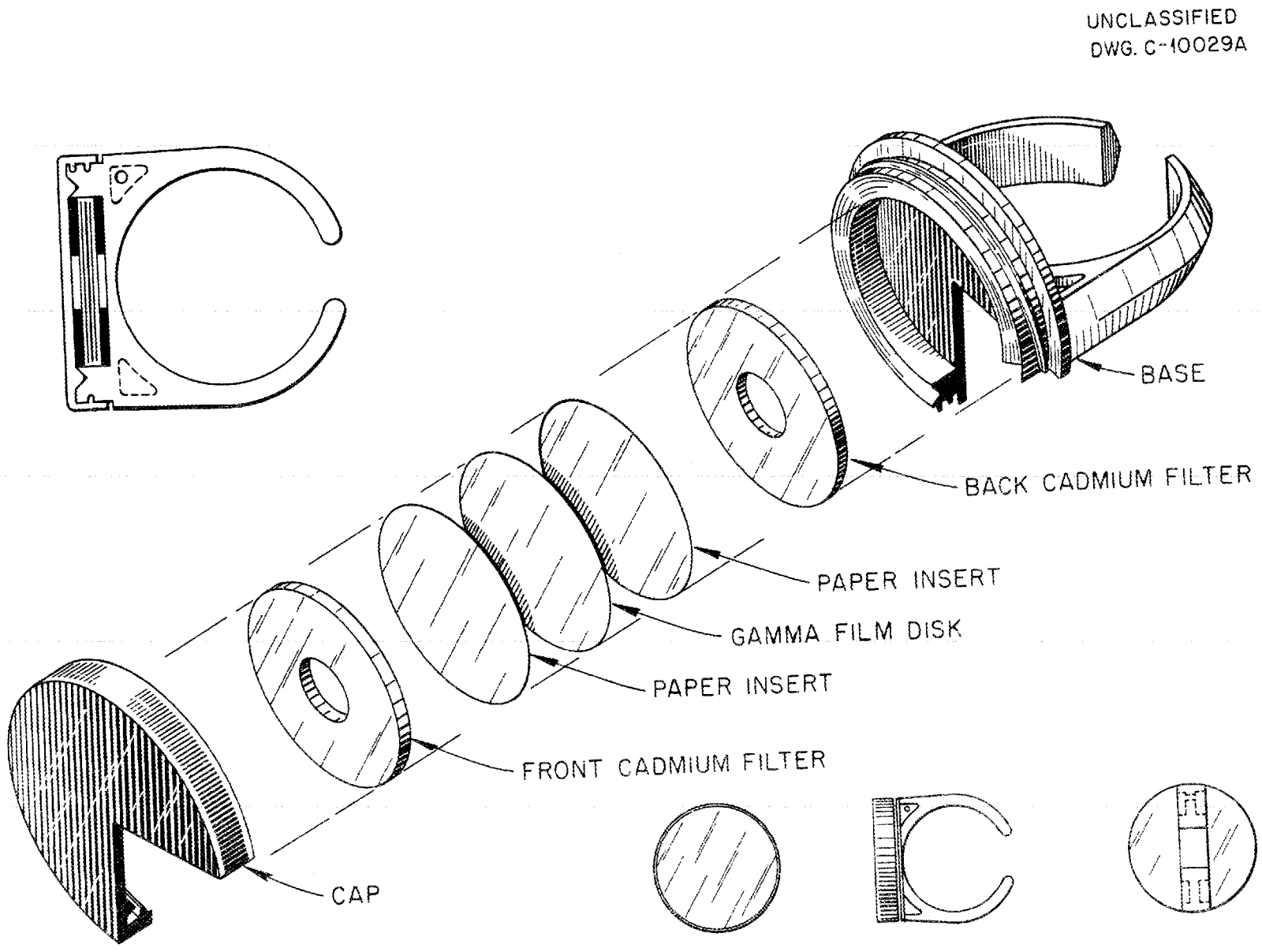


Fig. 16. Details of the ORNL Hand Exposure Meter.

UNCLASSIFIED
PHOTO 10258

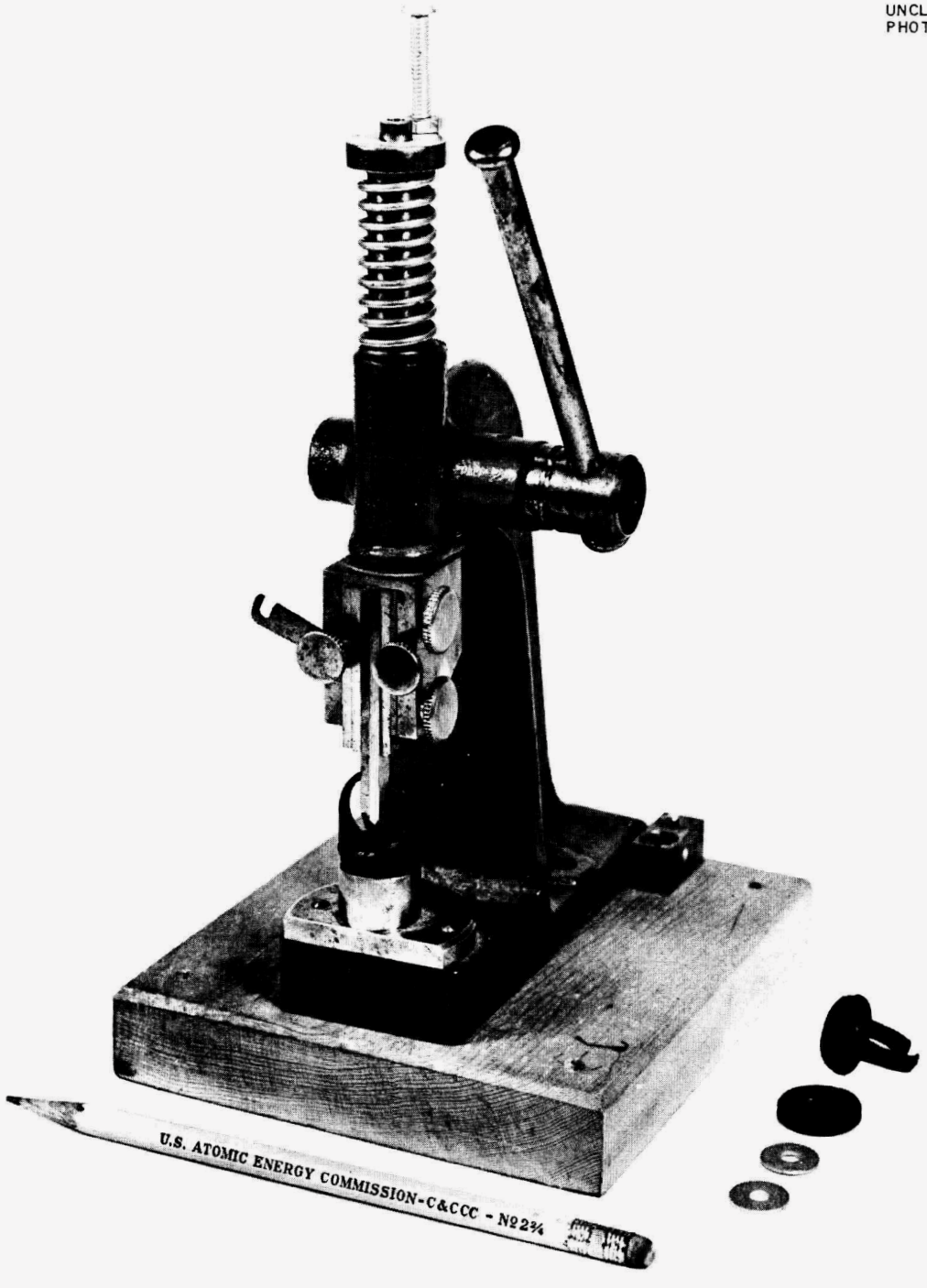


Fig. 17. Shop-made Machine Used for Affixing an Identification Number on the ORNL Hand Exposure Meter.

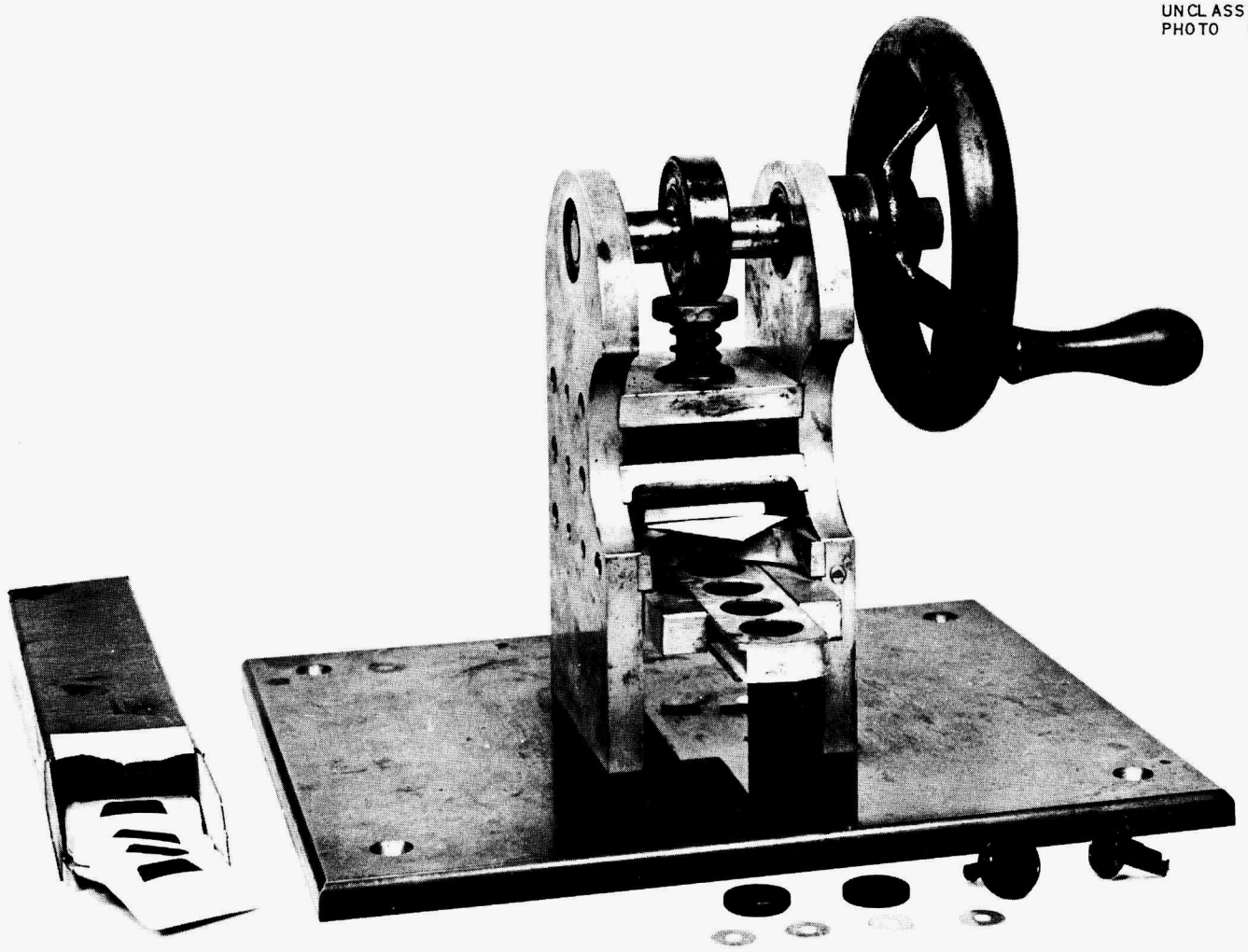


Fig. 18. Film Punch. A device used for cutting out film discs for use in the ORNL Hand Exposure Meter.

C. X-ray Numbering Plate (Fig. 19): A device used for marking film discs with an identification number. (Capacity - 25 film packets from which 100 discs are fabricated.)

D. duPont 552 Film Pack

E. Cadmium filters or washers

24.4 Procedure

A. Numbering the Meter

1. Fit meter snugly over anvil of numbering press with the band up.

2. Depress lever and release.

3. Deposit meter in numbered bins.

B. X-raying The Film with Identification Number

1. Put plate on table with number 1 away from operator.

NOTE: Four consecutive numbers are X-rayed on each film in the pack, one number in each corner.

2. Place film packets on plate with green flaps away from operator.

3. Write numbers on packet, as follows: left to right, top, 1, 4; left to right, bottom, 2, 3,; etc. This enables technicians to punch out discs in sequence, if jackets are disarranged in darkroom.

C. Loading the Meters

1. Insert meters, bands down, in movable track arranging in sequence with No. 1 first, then 2, etc.

2. Add cadmium washer to empty meter cavity.

3. Engage grooves of punch and track from front and slide No. 1 meter into loading position.

CAUTION: Carefully align notches on punch and track and listen for click.

4. Turn on "safe" light. (The "white" light is turned off automatically.)

5. Hold film pack with green flap up and toward the left.

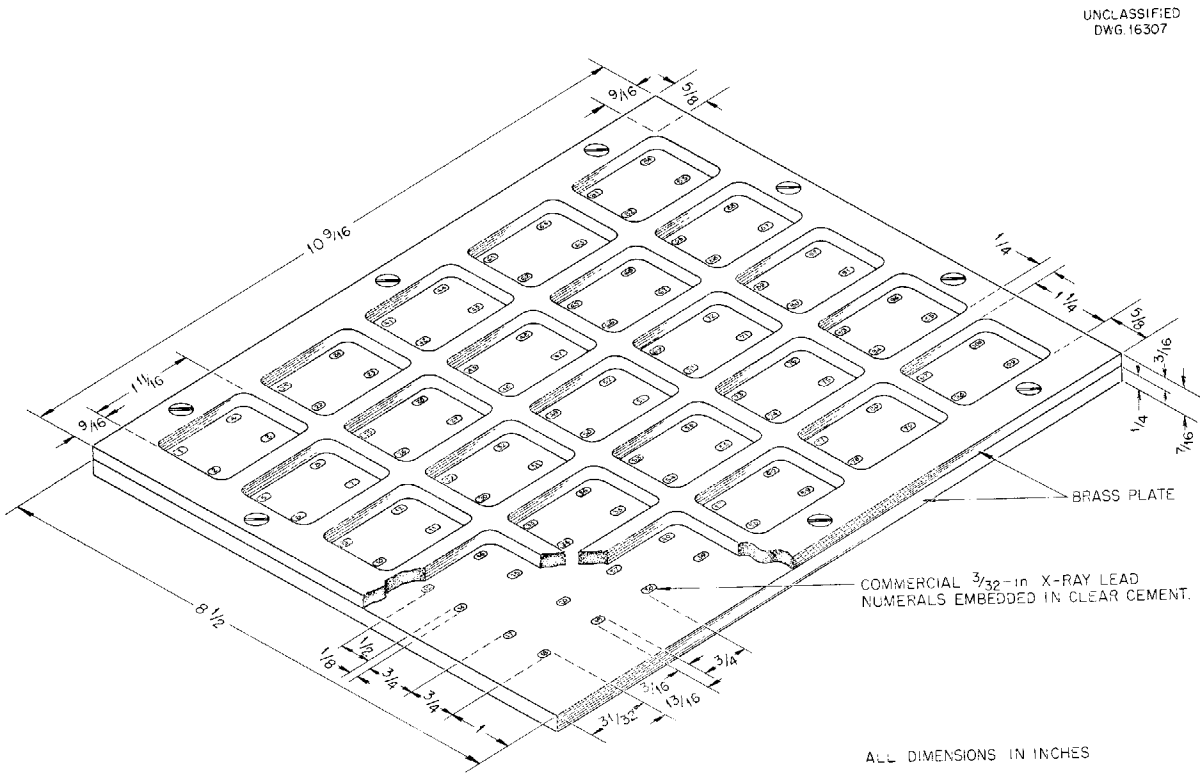


Fig. 19. X-Ray Numbering Plate Used To Affix Identification Numbers On Hand Exposure Meter Films.

6. Grasp green flap with right hand and strip wrapper back.

7. Remove white paper leaving only the green paper and films.

8. Remove insensitive film which is above the sensitive film - the sensitive film lying on that portion of the green wrapper which includes the flap.

9. Tear off flap portion of green wrapper.

10. Turn film and insert in punch, bringing No. 1 into cutting position.

NOTE: a. No. 1 is now directly away from the operator.

b. Insert film diagonally as far as it will go.

11. Make one complete turn of operating wheel. This cuts out the No. 1 disc which, along with green paper protectors, drops into No. 1 meter.

12. Push No. 2 meter, No. 3, etc., in position and repeat operation, always turning film clockwise to next corner.

13. Add second cadmium washer.

NOTE: According to standard procedures, hand exposure meter films are shielded on both sides the same as badge meter film.

D. Sealing the Meters

1. Remove track from the rear of punch.

2. Remove meters from track.

3. Place screw cap snugly on each meter.

4. Turn on white light.

5. Store loaded meters in a cool place pending distribution.

Neutron Measurements Using NTA Film

25.1 General

A. Personnel Monitoring provides a fine grain particle track film for persons who work where a significant exposure to neutrons is considered possible. This special film is placed in the badge meter behind the beta-gamma packet.

B. The films used are commercially listed by Eastman Kodak as NTA Nuclear Fine Grain Particle Emulsion.

C. Thermal neutrons produce protons by the (n,p) reaction after capture by nitrogen in the gelatin of the emulsion. These protons in turn activate the silver halide grains in the emulsion leaving "tracks" on development. These tracks appear on the open window portion of the film, since the cadmium shield (see Fig. 6a, P. 46a) absorbs essentially all thermal neutrons.

D. Fast neutrons produce recoil protons in interaction with the hydrogen of the emulsion, likewise producing tracks. These occur throughout the film, as the cadmium shield has negligible absorption for fast neutrons.

E. The tracks are counted by means of a microscope at approximately 950 magnification, using an oil immersion objective and dark field illumination. The number of tracks per field is proportional to the neutron exposure - the "shield" reading being a measure of fast neutron dose, and the difference between "open window" and "shield" readings being a measure of thermal neutron dose.

F. The total area observed at one microscope setting is known as a "field". A "track" is defined as three or more developed grains in a row. Several tracks converging toward a common center are called "stars" and may be due to cosmic radiation or a series of alpha disintegrations from a uranium atom.

25.2 The Microscope (viewed from base to top)

A. Illuminating Unit: Beam from microscope lamp is centered on adjustable plane mirror at base of microscope.

B. Condenser: A substage bracket holds the dark-field condenser. This bracket is vertically adjustable by a rack-and-pinion arrangement.

C. Mechanical Stage: The mechanical stage comprises a bracket which holds a glass slide on the microscope stage, and racks and pinions for back and forth and transverse motions.

D. Objectives on Revolving Nosepiece

1. Low power (10X), for centering light, and focusing to plane of emulsion.

2. High power (95X), for viewing tracks. This is an "oil immersion" objective with built-in iris diaphragm.

E. Adjustments

1. Coarse, for locating plane of emulsion.

2. Fine, for focusing during examination.

F. Eye Pieces (binocular): Transversely adjustable to eye spacing.

25.3 Microscopy Equipment (Fig. 20, P. 96, shows a typical set-up)

A. Microscope

B. Illuminating Unit

C. Developed neutron film

D. Data form

E. Immersion oil

F. Glass slides

G. Lens paper

H. Kleenex

I. Xylene

25.4 Procedure

A. Developing Neutron Films

1. Under the "safe" light hold packet with rough side toward operator and strip off wrapper.

NOTE: Neutron film has emulsion on one side only. Emulsion is next to rough side of wrapper.

2. Bend film slightly concave toward emulsion side and insert in tray assembly.

3. Develop film according to Procedure #17. CAUTION: The time of development may vary from one batch to another. The correct developing time will be established by supervision for each new batch.

Fig. 20. Typical set-up showing technician preparing to read neutron films. The counter in left hand is used for keeping a record of tracks observed.

B. Adjusting the Microscope

1. Direct light from illuminating unit on microscope mirror.

2. Drop oil on dark field condenser.

   NOTE: Apply more oil for every 5 films.

3. Position glass slide.

4. Drop oil on top of glass slide, directly over condenser.

   NOTE: Apply more oil on glass slide for each new film.

5. Place film on oil with emulsion side up and the PI number to the right. The "open window" is in the reading position. (The PI number is reversed as seen from the emulsion side of the film.)

6. Raise condenser by turning rack and pinion adjustment until oil touches glass slide. Position low power objective by rotating nosepieces.

7. Adjust plane mirror until light appears in center of field.

8. Set low power objective immediately over slide. Using coarse adjustment, raise until tiny grains appear in field as seen through eye pieces.

9. Use stage and bracketed slide adjustments to center a representative field.

10. Raise low power objective.

11. Drop oil on top of film, directly over condenser.

12. Position "oil immersion" objective by rotating nosepiece.

13. Lower "oil immersion" objective with coarse adjustment until it touches oil on film.

14. Use fine adjustment until grains appear plainly as seen through eye pieces.

15. Use coarse, fine, and condenser adjustments until object is clearly focused.

C. Reading Neutron Films

1. Count tracks in first field ("open window").

2. Shift film to new field by using transverse adjustment of bracketed slide.

   NOTE: A grain in extreme left of field is shifted until it disappears to right.

3. Record readings on Kardex card.

4. File film with duPont 552 in numerical order by PI number.

25.6 Commentary

A. The accuracy and ease of reading can be improved by keeping the microscope free of dust, grease, and lint. Lens paper only is used to clean the objectives and eye pieces. Excess oil from the stage, and the oil from each film after reading, is removed by xylene applied with Kleenex.

B. The condenser is never removed except for cleaning purposes.

APPENDIX

Minometer Work Sheet

Personnel Exposure Questionnaire Information Form

Daily Service Log

Positive Reading Sheet

3 x 5 Card

Personnel Exposure Questionnaire

Change Sheet

Calibration Chart LOW

Calibration Chart HIGH

Batch Cards

Calibration Data Sheet

MINOMETER WORK SHEET

Minometer No. _____ Date _____

Technician _____ Personnel Monitoring Shift Worked (8-4) (4-12)
"Z" Check ( )

A. Personnel

1. List data for persons on the (day) (night) shift(s) with pocket meter pairs as follows:

(a) Insignificant
(b) Significant low of 50 mr or more

Name	Pay-roll #	Division	Signif. Entry		Insignificant Entry			TSR
			50-95	100-300	OS-OS	Non-Read.	Comb.	

B. Statistical

1. Tabulate single meter data.

(a) Off Scale
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 _____

(b) Non-readables
Lost 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 _____
Damaged 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 _____
Total

(c) Meters distributed _____ Pairs x 2 = _____

(d) Meters read _____ b = _____ c = _____

Date _____

PERSONNEL EXPOSURE QUESTIONNAIRE INFORMATION

Name of Employee _____ Badge Number _____ Index Number _____

Division _____ Supv. in Charge _____

Reason for Questionnaire:

( ) A reportable pocket meter total of _____

( ) P.T.R. of 300 mr(ep) or more

( ) _____

Film total covers period extending from _____ through _____

Processing Date	Week Number
Dark Room Technician	Batch Number
Remarks:	

FILM RESULTS

SENSITIVE FILM

Open Window		Shield	
Dens	mrep	Dens	mr

INSENSITIVE FILM

Open Window		Shield	
Dens	mr	Dens	mr

EXPOSURE RESUME

	METERS	Sun	Mon	Tues	Wed	Thur	Fri	Sat	Totals	PME
Last Week	Pocket Meters									
	Badge Meters	W S	W S	W S	W S	W S	W S	W S	W S	
	PTR									
This Week	Pocket Meters									
	Badge Meters	W S	W S	W S	W S	W S	W S	W S	W S	
	PTR									

REMARKS:

Approved _____
Supervisor

DAILY SERVICE LOG
DATE _____
ending at 4 PM

T-Terminations NMS-No Meter Service
R-Replacement W-Withdrawal A-Addition

	New Index No.	Name	Badge No.	Dept.	Supv.	CHECK Alley	T	NMS	R	A	W	ALLEY TRANSFER From	To	Remarks	By
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															

Terminations and Withdrawals

1	2	3	4	5	6	7	8	9	10	11	12	13

Film in laboratory
Work Sheet (PM-4)
Stamped Cards
Processed Film
Recorded on IBM
Change List (Fri.)

Confirmed
Badge Assembled
Cards in File (3)
Meter in Alley
Adjust IBM File
Change List (Fri.)

Additions and Replacements

1	2	3	4	5	6	7	8	9	10	11	12	13

POSITIVE FILM EXPOSURES

Photometer No. _____ Week No. _____

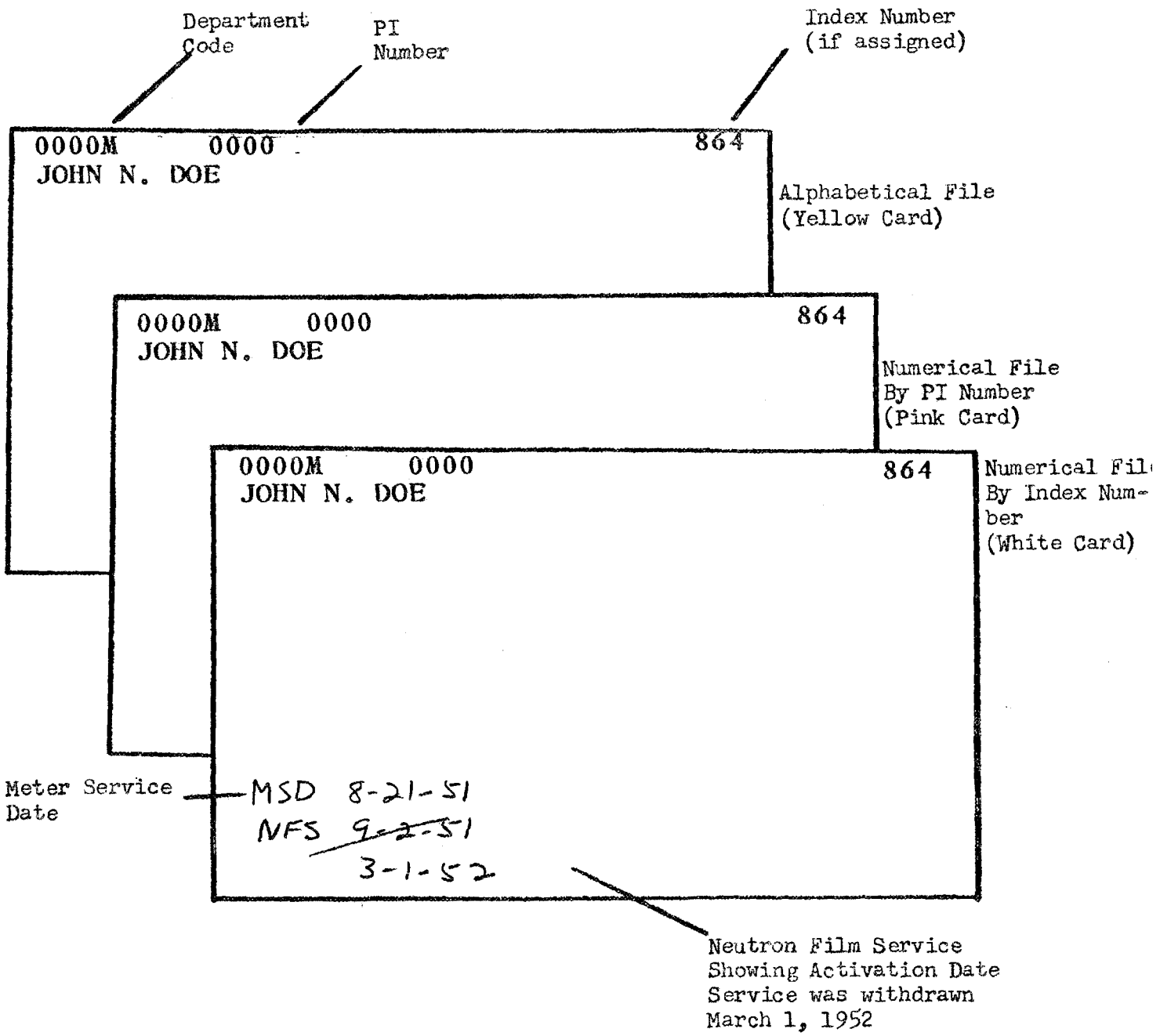
By _____ Date _____

Batch _____

Payroll No.	Sensitive		Insensitive		Remarks
	OW	S	OW	S	

Charted by _____ Interpreted by _____ Recorded by _____

Approved: _____ Supv.


Department Code
PI Number
Index Number (if assigned)
0000M 0000 864
JOHN N. DOE
Alphabetical File (Yellow Card)
0000M 0000 864
JOHN N. DOE
Numerical File By PI Number (Pink Card)
0000M 0000 864
JOHN N. DOE
Numerical File By Index Number (White Card)
Meter Service Date
MSD 8-21-51
NFS 9-2-51
3-1-52
Neutron Film Service Showing Activation Date Service was withdrawn March 1, 1952

Health Physics
Personnel Exposure Questionnaire

A

Name of Employee _____ Payroll No. _____ Date _____

Dept. or Division _____ Supv. in Charge _____

B

PERSONNEL MONITORING REPORT

Coincident with the above date the items checked and noted below indicate a possible exposure or an incomplete record concerning the above named employee:

☐ 1. Pocket and/or Film Meter Record

	METERS	SUN.	MON.	TUE.	WED.	THUR.	FRI.	SAT.	TOTALS	REMARKS
LAST WEEK	Pocket Meters									
	Film Meters									
THIS WEEK	Pocket Meters									
	Film Meters									

☐ 2. _____

By _____ Noted by _____
Supv. Personnel Monitoring

C

RECORD OF SURVEYOR'S INVESTIGATION

3. Statement of Health Physics surveyor relative to probable cause of above report.

_____

_____

4. Health Physics surveyor's recommendation

_____

_____

_____

Investigated By _____ Date _____ Noted by _____
Health Physics Surveyor Employee's Supv.

D

FURTHER ACTION (IF ANY) BY SURVEY HEADQUARTERS

_____

_____

Noted: _____ Date _____

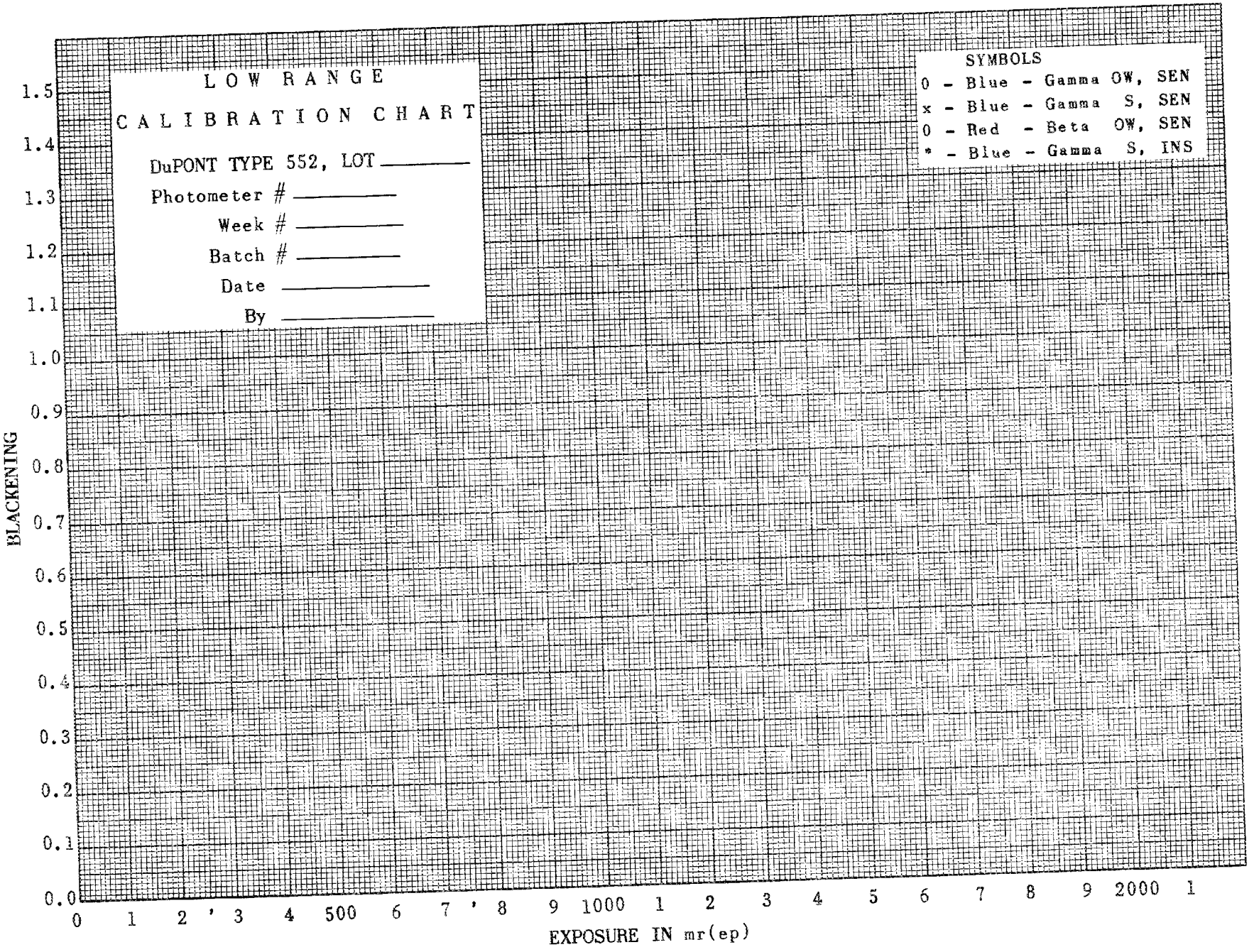
PERSONAL AND CONFIDENTIAL

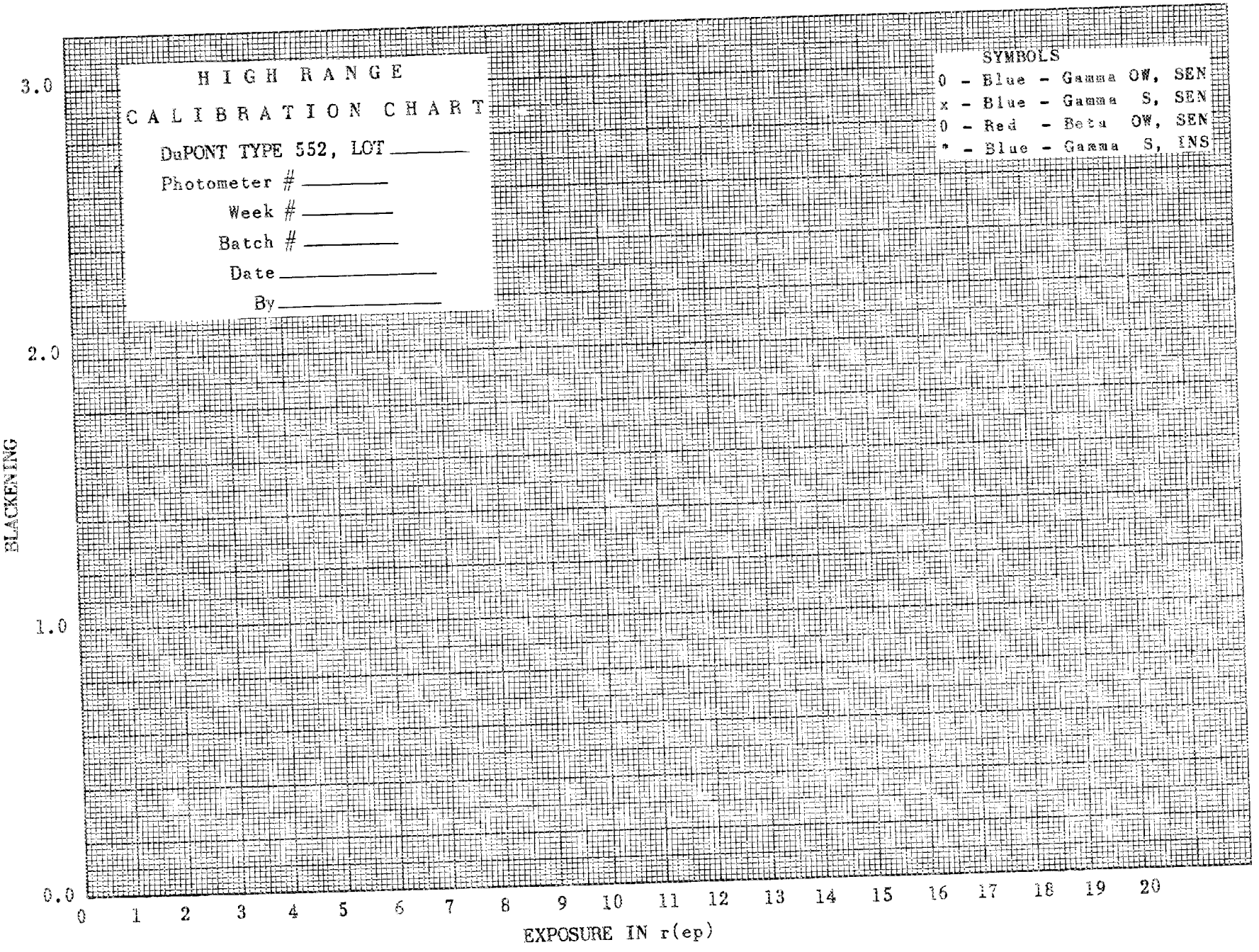
FILM METER RECORDING SHEET

Week No. 195 Clock Alley(s) _____

PU	PB	Badge Number	Sen		Ins	
			OW	S	OW	S
		00				
		01				
		02				
		03				
		04				
		05				
		06				
		07				
		08				
		09				
		10				
		11				
		12				
		13				
		14				
		15				
		16				
		17				
		18				
		19				
		20				
		21				
		22				
		23				
		24				

PU	PB	Badge Number	Sen		Ins	
			OW	S	OW	S
		25				
		26				
		27				
		28				
		29				
		30				
		31				
		32				
		33				
		34				
		35				
		36				
		37				
		38				
		39				
		40				
		41				
		42				
		43				
		44				
		45				
		46				
		47				
		48				
		49				


LOW RANGE
CALIBRATION CHART
DuPONT TYPE 552, LOT _____
Photometer # _____
Week # _____
Batch # _____
Date _____
By _____
SYMBOLS
0 - Blue - Gamma OW, SEN
x - Blue - Gamma S, SEN
0 - Red - Beta OW, SEN
* - Blue - Gamma S, INS
BLACKENING
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 1 2 3 4 500 6 7 8 9 1000 1 2 3 4 5 6 7 8 9 2000 1
EXPOSURE IN mr(ep)


HIGH RANGE
CALIBRATION CHART
DuPONT TYPE 552, LOT _____
Photometer # _____
Week # _____
Batch # _____
Date _____
By _____
SYMBOLS
0 - Blue - Gamma OW, SEN
x - Blue - Gamma S, SEN
0 - Red - Beta OW, SEN
* - Blue - Gamma S, INS
BLACKENING
3.0
2.0
1.0
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
EXPOSURE IN r(ep)

WEEK #_____ DATE _____

FILM REPLACEMENT IN BADGE	BADGE CONTAMINATED	BATCH # _____
Badge # _____	_____	ALLEY # _____
Index # _____	_____	PLATE # _____
Badge # _____	_____	X-RAYED _____
Index # _____	_____	LOADED _____

NEUTRON _____

C A L I B R A T I O N D A T A

Dev. Temp. _____ °F

Film Meters ( )

Week or Process No. _____

Dev. Time _____

Batch or Series No. _____

Dark Room Technician _____

Misc. Film ( )

Date _____

	Sensitive Film Density			Insensitive Density		
Exposure in mr(ep)	Beta OW	Gamma OW	Gamma S	Gamma OW	Gamma S	Remarks
100						
250						
500						
750						
1,000						
2,000						
5,000						
10,000						
20,000						

Photometer No. _____

By _____

INDEX

INDEX

F

G

H

I

K

L

M

N

O

P

R

S

T

W

X

Z