NRC Form 313 I
(12-81)
10 CFR 30

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR BYPRODUCT MATERIAL LICENSE
INDUSTRIAL

See attached instructions for details.

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

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

	a. NEW LICENSE
	b. AMENDMENT TO: LICENSE NUMBER
x	c. RENEWAL OF: LICENSE NUMBER 45-15923-01

2. APPLICANT'S NAME *(Institution, firm, person, etc.)*
U.S. Dept of the Interior,
Geological Survey
TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION
(703) 860-7662 (FTS) 928-7662

3. NAME AND TITLE OF PERSON TO BE CONTACTED REGARDING THIS APPLICATION
Allan B. Tanner
TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION
(703) 860-7662 (FTS) 928-7662

4. APPLICANT'S MAILING ADDRESS *(Include Zip Code)* *(Address to which NRC correspondence, notices, bulletins, etc., should be sent.)*
U.S. Geological Survey
National Center, STOP 990
Reston, VA 22092

5. STREET ADDRESS WHERE LICENSED MATERIAL WILL BE USED *(Include Zip Code)* Physics Building, Lot "O" off South Lakes Drive, and National Ctr, 12201 Sunrise Valley Drive, Reston, VA 22092 (See supplementary sheet)

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

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

	FULL NAME	TITLE
a.	See attachment	
b.		
c.		

7. RADIATION PROTECTION OFFICER
Allan B. Tanner

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

8. LICENSED MATERIAL

LINE NO.	ELEMENT AND MASS NUMBER A	CHEMICAL AND/OR PHYSICAL FORM B	NAME OF MANUFACTURER AND MODEL NUMBER *(If Sealed Source)* C	MAXIMUM NUMBER OF MILLICURIES AND/OR SEALED SOURCES AND MAXIMUM ACTIVITY PER SOURCE WHICH WILL BE POSSESSED AT ANY ONE TIME D
(1)	See separate sheet			
(2)				
(3)				
(4)				

DESCRIBE USE OF LICENSED MATERIAL
E

(1)	See separate sheet
(2)	
(3)	
(4)	

9. STORAGE OF SEALED SOURCES

LINE NO.	CONTAINER AND/OR DEVICE IN WHICH EACH SEALED SOURCE WILL BE STORED OR USED. A.	NAME OF MANUFACTURER B.	MODEL NUMBER C.
(1)	See separate sheet		
(2)			
(3)			
(4)			

10. RADIATION DETECTION INSTRUMENTS

LINE NO.	TYPE OF INSTRUMENT A	MANUFACTURER'S NAME B	MODEL NUMBER C	NUMBER AVAILABLE D	RADIATION DETECTED *(alpha, beta, gamma, neutron)* E	SENSITIVITY RANGE *(milliroentgens/hour or counts/minute)* F
(1)	See separate sheet					
(2)						
(3)						
(4)						

11. CALIBRATION OF INSTRUMENTS LISTED IN ITEM 10

☒ a. CALIBRATED BY SERVICE COMPANY (α, β, γ, X-)

NAME, ADDRESS, AND FREQUENCY Annually, by Health Physics Services, Potomac, MD or Radiation Service Organization, Laurel, MD

☒ b. CALIBRATED BY APPLICANT (neutron)

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

12. PERSONNEL MONITORING DEVICES

TYPE *(Check and/or complete as appropriate.)* A	SUPPLIER *(Service Company)* B	EXCHANGE FREQUENCY C
☒ (1) FILM BADGE (X, beta-gamma) + albedo neutron track-etch	Siemens Gammasonics, Inc. Customer No. 14736	☒ MONTHLY
☐ (2) THERMOLUMINESCENCE DOSIMETER *(TLD)*		☐ QUARTERLY
☒ (3) OTHER *(Specify)*: Government-owned Bendix 884 fast neutron and gamma dosimeters are used in addition to fast neutron and gamma film badges by Physics Building personnel.		☐ OTHER *(Specify)*:

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

☒ a. LABORATORY FACILITIES, PLANT FACILITIES, FUME HOODS *(Include filtration, if any)*, ETC.

☒ b. STORAGE FACILITIES, CONTAINERS, SPECIAL SHIELDING *(fixed and/or temporary)*, ETC.

☒ c. REMOTE HANDLING TOOLS OR EQUIPMENT, ETC.

☐ d. RESPIRATORY PROTECTIVE EQUIPMENT, ETC.

14. WASTE DISPOSAL

a. NAME OF COMMERCIAL WASTE DISPOSAL SERVICE EMPLOYED

U.S. Army, Rock Island, IL, Agreement W52H09-80212-003

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

INFORMATION REQUIRED FOR ITEMS 15, 16 AND 17

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

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

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

    a. Principles and practices of radiation protection.

    b. Radioactivity measurement standardization and monitoring techniques and instruments.

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

    d. Biological effects of radiation.

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

18. CERTIFICATE

(This item must be completed by applicant)

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

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

a. LICENSE FEE REQUIRED *(See Section 170.31, 10 CFR 170)* Government Agency; Exempt per 10CFR 170.11(5)	b. CERTIFYING OFFICIAL *(Signature)* Doyle G. Frederick c. NAME *(Type or print)* Doyle G. Frederick
(1) LICENSE FEE CATEGORY: N.A.	d. TITLE Associate Director
(2) LICENSE FEE ENCLOSED: $ N.A.	e. DATE March 7, 1984

FEE EXEMPT

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5. STREET ADDRESS WHERE LICENSED MATERIAL WILL BE USED (cont'd)

Licensed materials (4), (5), (11), (15), and (16) may be used at temporary job sites of the applicant in the 48 contiguous states.

6. INDIVIDUALS WHO WILL USE OR DIRECTLY SUPERVISE THE USE OF LICENSED MATERIAL (*Precedes names of those currently licensed.) Resumes follow item 17.

Full Name	Title
* Allan B. Tanner	Geophysicist; Radiation Protection Officer
* Frank E. Senftle	Physicist, Project Chief
* Jon L. Mikesell	Physicist
* Danny W. Dotson	Electronic Technician
* Philip A. Baedecker	Research Chemist; Chief, Branch Analyt. Chemistry
* John W. Morgan	Research Chemist; Chief Chemist
Curtis A. Palmer	Chemist; Project Chief
* Louis J. Schwarz	Chemist
Gregory A. Wandless	Chemist
* John F. Sutter	Geologist
* Michael J. Kunk	Geologist
* David J. Shultz	Hydrologist

7. RADIATION PROTECTION OFFICER

The Radiation Protection Officer is Allan B. Tanner, who has acted in such capacity since 1967. With the move of Geological Survey facilities to Reston, Virginia, in 1974, he was given collateral responsibility for supervision of all NRC-licensed activities at the National Center. His training and experience are detailed on a form referenced to items 16 and 17.

8 A-D. LICENSED MATERIAL

Line	A. Element & Mass	B. Form	C. Manufacturer & Model	D. Maximum Quantity
(1)	Hydrogen-3	Titanium tritide foils and contaminated neutron generator equipment	U.S. Radium LAB 508-1	30 curies total
(2)	Hydrogen-3	Target in sealed tube for Kaman A-702 neutron generator	Kaman A-3042-DT	1.5 curies
(3)	Hydrogen-3	Gas adsorbed on getter and target of sealed tube	Kaman A-520	5 curies
(4)	Hydrogen-3	Gas and occlusion in target of sealed tube	Kaman "Zetatron"	8 curies per tube (3 tubes)
(5)	Cobalt-60	Sealed sources	New England Nuclear (2) NES-142T (1) NES-134S	3 sources not to exceed 16 microcuries total
(6)	Cobalt-60	Liquid	N.A.	500 microcuries
(7)	Nickel-63	Plated sources	Amersham-Searle NBC-3	1 source not to exceed 10 millicuries
(8)	Nickel-63	Plated source	Hewlett-Packard 18803-60520 EC detector	1 source not to exceed 15 millicuries
(9)	Nickel-63	Plated source	Hewlett-Packard 18713A EC detector	1 source not to exceed 15 millicuries
(10)	Barium-133	Liquid	N.A.	500 microcuries
(11)	Cesium-137	Sealed sources	New England Nuclear NES-139T	3 sources not to exceed 20 microcuries total
(12)	Thulium-170	Sealed source	In-house custom source	1 source not to exceed 60 millicuries
(13)	Protactinium-231	Any	ORNL	10 microcuries
(14)	Neptunium-237	Any	ORNL	10 microcuries

(continued)

8 A-D. LICENSED MATERIAL (continued)

(15) Californium-252	Sealed sources (special form)	Savannah River Labs doubly-encapsulated sources;zircaloy outer capsule, ref. dwg. SRL:SK-184-PM (0.081" wall)w/welded plug;platinum-ruthenium inner capsule, ref. dwg. SRL:SK-183-PM(0.044" wall) w/welded plug	1 source of 60 millicuries; 1 source of 13 millicuries; 1 source of 4 millicuries; 1 source of 1 millicurie
(16) Californium-252	Sealed sources (special form)	Savannah River Labs doubly-encapsulated sources ("Medical Afterloading Cells") per dwg. 1-62-AE, dated 11-9-67	2 sources of 0.6 millicurie each
(17) Any byproduct material	Any	Activated samples	530 millicuries total
(18) Americium-241	Any	N.A.	500 microcuries total
(19) Americium-241	Sealed sources	Custom sources	2 sources not to exceed 40 millicuries total

8E. USE OF LICENSED MATERIAL (cont'd)

(15, 16) Californium-252 sources are to be used in development of neutron-activation methods of in situ and other field analyses for mineral exploration and environmental pollution. Sources of a wide activity range are desirable to determine optimum activity for delayed-gamma and capture-gamma methods.

(17) a. Small quantities of byproduct materials are the result of exposure of natural materials to neutron sources. The longest-lived detectable activity produced is usually 15-hr Na-24.

b. The analytical services program of the Geological Survey requires a large number of neutron activation analyses. These are usually of mineral samples that have been ground, put in polyethylene vials, and irradiated in reactors at Denver (USGS), Gaithersburg, MD (NBS), or Lemont, IL (Argonne National Lab).

c. Small mineral samples are to be irradiated for radioactive age dating, as more fully described in our letter of October 7, 1980.

8E. USE OF LICENSED MATERIAL

(1) Use of the neutron generator is not anticipated in the near future, but the reasonable possibility of need for it makes it desirable that we be licensed to maintain the target foils in storage. We intend to dispose of a 3-target set from the Technical Measurements Corp. Model 211 Activatron neutron generator (more fully described in application dated May 23, 1966, for license 8-861-7.) A replacement set of 3 targets is unused; we intend to keep the set stored in a sealed can in the storage location (see block 13). No use will be made of the targets without approval of a supplementary license application.

(2) As in paragraph (1), above, we do not anticipate use of the Kaman A-702 neutron generator in the near future, but the desire to have it available for contingencies (such as withdrawal of our californium-252 sources) leads us to request permission to maintain the sealed generator tube in storage in one of the large cans in the storage location (see block 13). No use will be made of the neutron-generator tube without approval of a supplementary license application.

(3) The Kaman A-520 neutron generator is to be used in the Physics Building "Accelerator Pit" or borehole to study neutron energy and density populations in test samples.

(4) The Kaman "Zetatron" neutron generator tubes are to be used to study neutron energy and density populations in test samples, to determine timing of gamma rays resulting from the several neutron interactions with geologic materials, to provide calibration information, and to perform field analyses in boreholes by (n, n'γ), (n, γ), and decay gamma radiation.

(5, 11) Sources to be used for energy and intensity calibration, resolution-testing, and efficiency evaluation of high-resolution X-ray and gamma-ray semiconductor detectors. The relatively poor efficiency of these detectors makes use of generally-licensed spectrometer sources too time-consuming in practice.

(6, 10, 13, 14, 18) Material is to be used for tracers to give yield determination in neutron activation analyses. It is intended to add about 0.0001 microcurie of the selected tracer to each sample requiring the tracer.

(7, 8, 9) Electron-capture sources for detector cells in gas chromatographs to be used for analysis of natural materials.

(12, 19) Sources to be used in research toward methods of field analysis by X-ray fluorescence techniques. Our research has been published in two papers and two AEC progress reports, demonstrating the need for sources of a geometry not available in standard commercial designs; hence the need for custom sources. To be stored in various commercial or AEC cylinders having lead walls and doors of 2.5cm or greater thickness. In use, 1-cm-thick lead glass will be used to minimize exposure to persons.

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9. STORAGE OF SEALED SOURCES (Indexed to line number of licensed material, Item 8)

Line	A. Container	B. Manufacturer	C. Model No.
(2)	Neutron generator tube	Kaman Sciences Corp.	A-3042-DT
(3)	Neutron generator tube	Kaman Sciences Corp.	A520
(4)	Neutron generator tube	Kaman Sciences Corp.	"Zetatron"
(5)	None required	N.A.	N.A.
(7)	Gas chromatograph	Packard Instrument Co.	Model 419-8088
(8)	Gas chromatograph	Packard Instrument Co.	Model 419-8088
(9)	Gas chromatograph	Hewlett-Packard Co.	Model 5731A
(11)	None required	N.A.	N. A.
(12)	Vertical lead shield	Atomic Instrument Co.	Model 800B
(15)	Underwater mine casing (see figure 1)	U.S. Navy	MK6 Mod 0, custom modified
	Laboratory shield (see figure 2)	Unknown; modified in-house	N.A.
	Shipping/storage cask (see figure 3)	Atkinson Steel Co., Austin, TX	Unknown
	"B of E" cask (see figure 4)	Westinghouse (?) modified in-house	Unknown
(16)	Refrigerant container (see figure 5)	Unknown; modified in-house	N.A.
(17)	Various lead pigs of at least 2.5-cm wall thickness are used for transport and storage of activated samples.	N.A.	N.A.
(19)	2-inch steel pipe nipple w/end caps	ORNL (?)	N.A.

10. RADIATION DETECTION INSTRUMENTS

Line No.	Type of Instrument	Manufacturer	Model No.	No. Available	Radiation Detected	Sensitivity Range
I. Physics Building						
(1)	Windowless gas flow proportional counter	Nuclear Measurements	PCC-10	1	α,β	0-6000 c/m
(2)	Alpha scintillator probe	Ludlum Measurements	43-5	1	α	N.A.
(3)	Pancake G-M probe	do	44-9	1	β,γ	N.A.
(4)	Thin wall G-M probe	do	44-6	2	β,γ	N.A.
(5)	1 mm NaI scintillator probe	do	44-3	1	X,γ	N.A.
(6)	2 mm NaI scintillator probe	do	44-3S	1	X,γ	N.A.
(7)	High-energy NaI gamma probe	do	44-2	1	γ	N.A.
(8)	Fast neutron scintillation detector	do	42-2	1	n (fast)	N.A.
(9)	10" polyethylene sphere neutron detector	do	42-4	2	n (all)	N.A.
(10)	Geiger counter (for any probe 2 through 9)	do	3	1	N.A.	$5\text{-}3\times10^5$ c/m
(11)	Single-channel analyzer (for any probe 2-9)	do	16	1	N.A.	$5\text{-}5\times10^5$ c/m
(12)	Alarm rate meter (for any probe 2-9)	do	28	3	N.A.	$5\text{-}5\times10^5$ c/m
(13)	Alarm rate meter (for any probe 2-9)	do	177	1	N.A.	$5\text{-}5\times10^5$ c/m

10. RADIATION DETECTION INSTRUMENTS (cont'd)

Line No.	Type of Instrument	Manufacturer	Model No.	No. Available	Radiation Detected	Sensitivity Range
I. Physics Building (cont'd)						
(14)	Area monitor (for any probe 2-9)	do	300S	1	N.A.	50-50K c/m
(15)	Area monitor	do	300	1	γ,X	0.02-20 mR/hr
(16)	Micro R meter	do	12S	1	γ	0-5 mR/hr
(17)	Multiplying ion chamber survey meter	Health Physics Instruments	1010	1	γ	0.001-1000 mR/hr
(18)	Fast-slow neutron counter	Eberline Instruments	PNC-4	1	n (all)	50-500K c/m
(19)	Fast neutron scintillation counter	Eberline Instruments	PN-14	1	n (fast)	0-3000 n/cm^2-m
(20)	High-resolution research detectors	Princeton Gamma-Tech	N.A.	4	γ	N.A.
(21)	Spectrometer systems	Tracor-Northern	NS-660, TN-1700	2	N.A.	0-600kc/m
		LeCroy	3500	1	N.A.	0-100kc/s
(22)	Low-level radon counter	Johnston Labs, Inc.	LLRC-2	1	Rn-222	0-600kc/m
II. Radiochemistry Project						
(23)	Wide & low beta (G-M) counter	Beckman	N.A.	2	β	0.5-50k (est.)c/m
(24)	G-M counter	Baird-Atomic	BA-420S	1	β,γ	0.5-50 mR/hr
(24a)	Area monitor	Ludlum	300	2	γ,X	0.02-20 mR/hr

10. RADIATION DETECTION INSTRUMENTS (cont'd)

Line No.	Type of Instrument	Manufacturer	Model No.	No. Available	Radiation Detected	Sensitivity Range
II. Radiochemistry Project (cont'd)						
(25)	G-M meter	Nuclear-Chicago	2650	2	β,γ	0.01-100 mR/hr
(26)	High-resolution spectrometer systems	Various	N.A.	9	γ	N.A.
III. Water Resources Division Gas Chromatography						
No survey instruments are possessed by the project. Wipes are to performed on instrument (1).						
IV. Radioactive Dating Project						
(27)	Geigor counter	Ludlum Inst.	3+ 44-6	1	β,γ	5-5x10^5 c/m (0-350mR/hr

11. CALIBRATION OF INSTRUMENTS LISTED IN ITEM 10.

Line No.	Calibration Frequency and Procedure
(1)	Background run with each set of measurements; 2 π geometry assumed; plateau run annually
(2)	Plateau run annually against U-238 foil
(3-7) (15-17) (24-25) (27)	Calibrated annually by contract with Health Physics Services, Inc., Potomac, MD, or Radiation Service Organization, Laurel, MD.
(24-25)	Checked quarterly against spectrometer source
(8-9, 18-19)	Calibrated annually with bare Cf-252 source in air
(10-14)	Calibrated with precision pulser
(17)	Calibrated annually with bare Cf-252 source in air or Ra-226 standards
(20-21, 26)	N.A.
(22)	Literature calibration assumed
(23)	N.A.

ITEM 13. FACILITIES AND EQUIPMENT

I. Solid-State Physics Building (Licensed Material Lines 1-5; 11-12; 15-17, 19)

Plans of the Solid-State Physics Building and its surrounding security area are figures 6 and 7. A larger-scale plan of the Geophysical Field Operations Room is figure 8. During off-hours, the security-fence gates will be under surveillance by roving guards from the guard station at the main National Center Building, about 300 yards away; all entrances to the Solid-State Physics Building itself will be equipped with door switches that will cause an alarm at the main guard station. Certain of the exterior door switches and other interior door switches, as indicated in figure 6, will be wired also to a panel in Room 110, adjacent to the Operations Room to provide alarm during operations involving exposed Cf-252 sources of 50 mCi or more. The entire building is under control of the neutron-activation project personnel. Custodial services, if any, performed in the Operations Room will be done under escort. Custodial services elsewhere are performed during working hours.

All storage and handling of byproduct materials enumerated above will be in the Physics Building. All storage and handling of Cf-252 sources will be in the Geophysical Field Operations Room which is served throughout its area by a 2-ton capacity walking crane capable of handling any of the shields. Storage of other sources in active use will be in locked lead shields which will reduce external radiation levels to 0.1 mR/hr or less, and rooms containing such materials will be marked per 10 CFR 20.203. About 12 standard AEC or commercial shields are available. Storage of sources not in active use will be in the Operations Room, either (1) in lead shields, (2) in one of the long tubes in the "accelerator pit," or (3) in one of the large cans in the "accelerator pit" (see figure 8). Several 500- to 900-pound lead shields, about 60 lead bricks, 600 concrete blocks, 100 paraffin-filled cartons, 50 water-filled cartons, 3 extra paraffin-filled shields, and numerous lead slabs are available for construction of gamma and/or neutron shielding as required for experiments.

The Operations Room has been designed to permit simulation of field conditions insofar as it is possible (see figure 8). Because a substantial amount of our research is directed toward quantitative analysis in boreholes, a 40-ft deep hole has been drilled in the floor and has been fitted with a closed-bottom, 4-in inside-diameter, ABS plastic tube, about which there is space for 33-in diameter annular wooden barrels containing ore or background materials. Core from the drilling operation has been analyzed. The hole has been so placed that the instrument van can be properly placed without requiring either roll-up door to be open.

To simulate ocean-bottom or estuary-bottom conditions, a plastic-lined, 15-ft diameter by 40-in deep swimming pool will be placed on the main floor, as in figure 8. The pool water will be filtered continuously.

The remote control cables of both the crane and the source-rod raising and lowering device will permit operation from any location within the operations room. Bare-source measurements with the largest Cf-252 source could be accomplished with the experimenter at a distance of 15 metres with an exposure dose equivalent rate of about 2 mrem/h. (Basis: Savannah River certification of 138 μg (73.4 mCi) source SF-CF-1872: "The radiation intensity at three meters from a source in air at standard atmospheric conditions and without contributions from scattering media is no greater than 400 mrem/hr neutrons plus 30 mR/hr γ for each milligram of ^{252}Cf in the capsule." Specific activity = 532 mCi/mg. Inverse-square reduction factor, $(3/15)^2 = 0.04$.)

A 4- to 5-ton capacity fork lift truck will be available in the building for unloading shipping casks from closed trucks.

The "Hot-Rock Shed", a 12-ft square masonry storage building,was constructed in 1981 within the fenced compound of the Physics Building. It is naturally ventilated, locked, and posted with a "radioactive materials" sign. Although constructed for storage of radioactive ore samples, it has sealed, below-ground tubes available for material storage and space available for radioactive waste awaiting disposal.

II. Radiochemistry Project (Licensed Material Lines 6, 10, 13, 14, 17, 18)

The laboratory facilities at the Geological Survey National Center to be used for activation analysis consist of: (1) Two counting rooms (3C233 and 3C235) where low-level sources will be beta or gamma counted on NaI(Tℓ) or Ge(Li) detectors; and (2) two chemical laboratories (3D237 and 3D239) each equipped with four radiochemical fume hoods with high efficiency filters.

We expect to remove the activities above to the Physics Building gradually over the next two years. Until submission and approval of the relevant amendment of this license, the move will be limited to (1) transfer of the low-level beta and gamma counters from rooms 3C233 and 3C235 to Physics Building rooms 209 and 210 (see figure 7), (2) removal of the inner vials of irradiated mineral samples from the outer vials in the hood in room 204, and (3) storage of radioactive waste and contaminated materials awaiting disposal in the "Hot Rock Shed" (figure 6).

The facilities are equipped with lead storage containers, lead bricks for shielding, dry waste containers with disposable plastic liners and containers with absorbent material for liquid waste. Gloves, lab coats, trays and absorbent paper will be provided.

III. Gas Chromatography in Branch of Analytical Chemistry (Licensed Material Lines 7-8)

The Packard Instrument Co. gas chromatograph originally used in the Water Resources Division, Room 5B331, and transferred to the Branch of Analytical Chemistry (see letter dated July 1, 1983), does not currently require use of the nickel-63 detector cells. Its associated cells will be held in storage in the "Accelerator Pit" of the Physics Building until a qualified operator is found and an appropriate amendment is approved.

IV. Water Resources Division Gas Chromatography (Licensed Material Line 9)

The Hewlett-Packard gas chromatograph will be located in National Center Room 5B135 (see figure 9). The source will be mounted within the device.

V. Field Operations with Neutron Sources at Temporary Job Sites

The sources are to be used for development of mineral exploration and in situ analysis in boreholes, in continuation of field work conducted under the present license and under license 8-861-9. Sources of different activities are needed to determine optimum activity for delayed-gamma and capture-gamma methods. The sources individually and collectively qualify as Type A quantities (special form, < 2Ci) and will be transported in water-extended-polyester or paraffin-filled, locked, sealed shields meeting DOT specification 7A.

Sondes containing neutron generator tubes will be kept on cushioning material and secured either in a fitted box or tube or in a permanent-type retainer in the logging truck.

Field operations with the Californium-252 sources will employ the following equipment:

A. A 2 1/2-ton stake-body truck equipped with a crane capable of handling the shields;

B. (Figure 11) High-density polyethylene source-holding screws and a manipulator for handling them at a distance of 1.5 metres or more;

C. (Figures 1, 3, 5) Storage and transport shield;

D. (Figure 10) A handling shield;

E. (Figure 12) A heavy-duty polyethylene tank, used filled with water for shielding during insertion of source-holding screws into borehole apparatus; and

F. (Figure 13) A borehole sonde employing a high-resolution semiconductor detector, electronics, detector shielding, and a source-holder section.

VI. Radioactive Dating Project

The facilities to be used are described in our letter dated October 7, 1980.

15. RADIATION PROTECTION PROGRAM

The Radiation Protection Officer is responsible for overall supervision the radiation protection program for NRC-licensed activities at Geological Survey facilities at Reston, Virginia. He exercises day-to-day supervision of radiation protection at the Physics Building and usually accompanies the field activities based there. He inspects other licensed activities at approximately one-year intervals and counts leak-test wipes from the gas chromatograph sources. He consults and conducts surveys in the National Center Building on demand where exposure to radioactive materials is suspected. Day-to-day radiation protection is provided the several licensed activities as follows:

I. Physics Building (Licensed Materials 1, 2, 3, 4, 5, 7, 8, 11, 12, 15, 16, 19)

History: Gamma sources of the intensities covered and Cf-252 sources up to 173 mCi have been used under license 8-861-9 and 45-15923-01 for a total of about 14 years. Film monitoring has been conducted during the entire period and has yielded no exposure greater than 0.164 rem during either a calendar month or calendar quarter; during the period of the present license no whole body monthly exposure has exceed 0.060 rem. Fast-neutron and gamma tissue-equivalent dosimeters have also been in use more than 12 years, have been consistent with film monitors and surveys, and have indicated average exposures ranging from 0.0015 to 0.005 rem per week.

Site survey: Before radioactive material was brought to the site, the grounds were surveyed outside on a grid with 25-ft centers and the building was surveyed at at least 4 locations in each major room and on 2-metre centers in the operations room. A passive γ-ray log was made of the experimental borehole.

Monitoring: Gamma-ray and neutron monitors will be operated
(1) inside the Operations Room at the inside roll-up door;
(2) at the wall outside the Operations Room in the entrance foyer, and
(3) opposite the "accelerator pit."

Alarm: An audible alarm will be set to sound if the gamma radiation level in the Operations Room exceeds 1 mR/hr, as measured at monitor (1) above. During any experiment or transfer where an unshielded neutron source of greater than 50 millicuries is to be exposed more than momentarily, the operations room and the adjacent outside area will be cleared; and the door-switch circuits will be set to sound an alarm if any of the entrances marked by a red-circled "D" on figure 6 are opened. The monitors at location (2) above will be observed; if the dose rate equivalent exceeds 2 mrem/hr, non-participating personnel and any visitors will be moved to areas of the building in which the dose rate equivalent is less than 2 mrem/hr. It is expected that the 2-ft thick solid concrete walls between the Operations Room and other personnel areas will prevent exposure rates from reaching 2 mrem/hr under any realistic conditions. Operations with bare Cf-252 sources above the floor and with neutron generators in the "Accelerator Pit" have been nearly undetectable outside the Operations Room.

Operating area: Operations involving other than momentary exposure of an unshielded source will be conducted either (1) in such areas of the Operations Room that the dose equivalent rate in the ore storage shed nowhere exceeds 2 mrem/hr or (2) with that area of the shed in which 2 mrem/hr may be exceeded roped off with yellow rope and stands bearing the standard "Radiation Area" sign.

Control malfunctions: In the event of malfunction of the remote control for raising a source rod into a shield, the crane that will necessarily be attached will be used to move the source and shield over the swimming pool, the source will be lowered into the pool, and repairs will be effected while the source is shielded by at least 2 ft of water.

Neutron source handling practice: (1) In normal operations with a neutron source a "handling shield (figure 10) will be positioned immediately over the storage shield, and the source will be drawn up into the handling shield by remote control. The crane will then move to the operation point and lower the handling shield to the floor or shielded experimental setup. (2) If the operation point is the borehole, the borehole handling shield (figure 10) will first be situated over the borehole. The source will be lowered into the borehole handling shield: the other handling shield will be raised to permit insertion of a locking pin in the source holder and disconnection of the remote-control cable; the appropriate borehole attachments will be screwed into the source holder; the borehole cable will be slipped into a snatch block attached to the remote control cable; and the locking pin will be withdrawn. After the experiment the source will be secured by the reverse procedure.

Leak test: Will be performed by the radiation protection officer as required by conditions of the license. (1) For sealed gamma sources, a swab will be made of the source surface or of the inner surface of its container; the swab will be examined by a sensitive, thin-window NaI(Tℓ) detector (instrument 5) or by a windowless gas-flow proportional counter (instrument 1). Leak tests will not normally be performed on sources in storage. (2) For Cf-252 sources, the source will be wiped under water in the swimming pool with a commercial smear circle and counted in a gas-flow proportional counter (instrument 1).

Swimming pool operations: Gamma-ray measurements will be made quarterly at the pool filter pump to see whether any activity is building up. Upon evidence of any significant increase in activity at the filter, any sources in the pool will be withdrawn and leak tested, and a sample of at least 10 liters of pool water will be evaporated to dryness and examined in the proportional counter. If any significant activity of half-life greater than 5 days is found, the pool will be drained through demineralizer columns and the contaminated columns will be kept in the radioactive waste location until the contamination has decayed to exempt levels. The columns will be monitored by an electrical conductivity meter while in use. We calculate that continuous exposure of the pool water to a 173-mCi Cf-252 source would generate, as the only significant activation product, an activity of 0.02×10^{-3} μ Ci/ml of Na-24, compared with 6×10^{-3} μ Ci/ml maximum permissible average concentration in effluent per 10CFR 20.303(b1) and Appendix B, Table 1, Col. 2.

Handling of Cf-252 capsules and afterloading cells: The experimental conditions and logging sondes vary sufficiently that it is not feasible to specify a particular design of source-holding device during actual operations. The source holding and handling devices will be exemplified by the source-holding screws and manipulator shown in figure 11. All source holders will feature threads to receive the Cf-252 capsule (or so that it cannot fall out during sonde disassembly. Manipulators appropriate to the source-holder designs will avoid having to handle the Cf-252 sources at close range and will enable transfer of sources among holders with shielding of at least 50 cm of water in the swimming pool or in the portable tank (figure 12).

Repair of leaking sources: Any source found leaking will be placed in a tight polyethylene container and heat-sealed in an outer polyethylene envelope. The outer envelope will be wipe-tested for contamination and decontaminated if necessary. The package will then be encased in a container meeting requirements of the applicable 10CFR71 or 49CFR170-189 and returned to the source manufacturer.

Operations with neutron generators: Only one neutron generator will be operated at a given time. Referring to figure 8, the neutron generator in use will be operated in (1) the "SWIMMING POOL", (2) the "BOREHOLE", or (3) the "ACCELERATOR PIT". Before operation, it will be verified that the adjacent outside compound is unoccupied and locked.

The swimming pool is a 4-ft deep, 15-ft diameter, water-filled pool. The neutron generator will be operated at mid-level and near the pool's center, so that the fast neutrons output will be heavily moderated by the water. The interlock described below will be used.

The borehole is a 10-cm inside diameter, ABS plastic tube that penetrates the ground to a depth of 11 m. The first 3.6 m is surrounded by an 80-cm diameter recess that will be filled with material in order to simulate a given geologic formation around the borehole. In operation the target plane of the neutron generator will be not less than 1 meter below the surface of the concrete floor of the Field Operations Room; personnel will be evacuated from the room; and the interlock system, descibed below, will be used.

The accelerator pit is a 2.6-m deep, 3-m square pit in the floor of the Field Operations Room. A neutron generator will be operated on its side with the target not more than 60 cm from the bottom, not more than 90 cm from the north wall (left on Figure 8), and not more than 2 m from the west wall of the accelerator pit. Such positioning will provide a distance of 5 meters with 3.6 meters of concrete and moist ground shielding to the nearest occupied space on the first floor and a distance of 7.6 meters with 2.4 meters of concrete shielding to the nearest occupied space on the second floor. By comparison, the Sandia Laboratories find that personnel exposure is within regulatory

limits with a similar neutron generator operated (for calibration purposes) in open air at a distance of 15 meters from the van containing operating personnel (W. A. Stephenson, "PFN Field Logging," Sandia National Laboratories Preprint, 1981).

The neutron generators will be operated from the "Alarm Panel" in Room 110. During neutron-generator operation in either the borehole or the accelerator pit, personnel will be excluded from the Field Operations Room and from the area within the security fence adjacent to the room. Operation of the neutron generator will be announced one minute beforehand over the building public address system. A continuity circuit passing through the 5 door switches marked in red on Figure 8 will be interlocked with the controls of the neutron generator so that opening any of the five doors or the gate to the adjacent area will immediately halt output of neutrons from the generator until the area is checked and the interlock is manually reset.

At the first operation of a neutron generator in either location, a radiation survey will be made along the security fence and along interior walls on both floors adjacent to the Field Operations Room. The survey instruments used will be calibrated for fast and thermal neutrons and for photon radiation, and the photon meter will be sensitive to photons of 30 keV and greater. Any locations at which radiation levels exceed 2 mrem/hr will be placed off limits by locking of that room or by cordoning off the area with yellow and magenta rope and stands bearing "Caution-Radiation Area" signs. Alternatively, above-floor paraffin or concrete shielding will be added until the radiation levels in all occupied areas do not exceed 2 mrem/hr.

II. Field Operations with Neutron Sources at Temporary Job Sites (Licensed Materials 4, 15, 16): Except for field operations, the material will be covered by the Physics Building program I, above.

Leak test: If periodic leak tests might become due during field operations, the leak tests will be performed before departure from the home facility. Field operations spanning more than two months are very unlikely.

Field operating procedure: Procedures for handling and use of Californium-252 sources in borehole (drill hole) operations were developed in a laboratory borehole and in boreholes in the field under license 8-861-09, amendments 06 and 07, during 1969-1973. No sources leaked or were damaged or lost. The maximum dose equivalent received by any individual was 0.099 rem in one month, including natural background, and the average monthly dose equivalent for individuals in the field was 0.025 rem, including natural background. The source-holding screws and manipulator were developed and tested in connection with work described in application dated June 20, 1974; the maximum dose equivalent received by any individual during the eight working days was 0.021 rem, including natural background, and the average was about 0.010 rem.

The Californium-252 source capsules will be inserted into the source-holding screws at the home facility, underwater in the pool, or if unavailable, in the water-filled polyethylene tank (figure 12) using tongs and a manipulator (e.g., figure 11). The source-holding screws will be screwed into special inserts in the storage shield (figure 11); the inserts were found to work well during the investigations described in the application dated June 20, 1974, and permit stacking of the three source-holding screws in the bore of the storage and transport shield. With the sources in the shield the radiation level was found to be a maximum of 40 mrem/hr at the surface of the shield and a maximum of 5.0 mrem/hr at 30 in from the surface of the shield. During transport and periods of non-operation, the shield will be locked and sealed.

For borehole operations it will be necessary to extract the source-holding screws and to insert the screw with the appropriate source into the bottom of the shield section of the borehole sonde. The storage shield will be lifted by crane and placed on the ground next to the source carrying truck and next to the polyethylene tank, filled with water. Source-holding screws will be removed with the manipulator from the storage shield and plunged into the water in the tank. The source-holding screws not immediately needed will be screwed either into threaded holes in the central boss in the tank or left in the storage shield. The source-holding screw to be used will be screwed into the bottom of the shield section of the borehole sonde and the manipulator will be disengaged. The protective bottom cap will be attached to the shield section, and the section will be inverted. The handling shield (figure 10) will be positioned coaxially over the tank. The remainder of the borehole sonde will be lowered through the handling shield and attached to the shield section. The handling shield will be lowered to rest on the tank. The sonde will be drawn up into the handling shield so that the source is at its center, and a pin will be run through the sonde to secure it while the handling shield is moved into place by crane over the borehole to be examined. The sonde (weight about 40 lb) will be lowered by its suspension and electrical cable (breaking strength, 2900 lb) into the borehole either by the instrument truck winch or by hand. Retrieval of the borehole sonde and removal and storage of the sources will be by the reverse procedure.

An alternative procedure is as follows:

The largest source will be mounted in a source-holding screw (figure 11) and the screw will be inserted in the bottom shield section (figure 1) and covered with a protective end cone at the home facility under water. The bottom shield section and spacers will be stored and transported in the spherical shield, avoiding the need to manipulate the largest source-holding screws in the field.

On the 2-1/2 ton stake-body transport vehicle, the spherical shield will be tied down by wire rope or chain to the truck bed in a wooden cradle. At the field site, one of two procedures will be used, depending on the configuration of the borehole platforms:

(1) The seal, lock, and upper locking pin will be withdrawn from the spherical shield. The handling shield (figure 10) will be positioned by crane just above the spherical shield. A cord or cable passing through the bore of the handling shield will be attached to the eye of the source-and-spacer assembly. The assembly will be drawn up into the handling shield, and secured by a locking pin through the holes in the shield and assembly. The shield will then be positioned over the borehole.

(2) Alternatively, the wire ropes or chain will be unclamped, the lower locking pin will be removed, and the shield will be lifted from the cradle and positioned over the borehole either on a platform of paraffin blocks or directly on the borehole casing, as appropriate. The remainder of the borehole sonde (or a suspension cable, if activation and measurement are to be done in separate passes) will be attached before the upper locking pin is removed. Upon conclusion of measurements, the source-and-spacer assembly will be secured and locked by the upper locking pin before removal of the suspension cable.

Logging with neutron generators: Only the "Zetatron" neutron generators are contemplated for field use. The tube is contained in a stainless steel, hermetically sealed sonde supported by a standard logging cablehead assembly and by a double-armored logging cable of 2900-lb breaking strength. Generation of neutrons by the sonde requires supply of power and application of trigger pulses from the logging truck. Next to the control panel inside the truck and outside the truck next to the winch are (1) a 3-inch yellow light that goes on when power is applied, (2) a 3-inch red light that flashes when trigger pulses are being transmitted, and (3) a shut-down button that cuts off power to the sonde. In addition, while trigger pulses are being transmitted, a very audible alarm beeps at 1-second intervals. The logging winch has an accurate depth control and indicator. The sonde will not be operated when the target plane is less than one metre below ground surface.

III. Neutron Activation Analysis Projects (Licensed Materials 6, 10, 13, 14, 17, 18)

The project supervisor of the Radiochemistry Project (Curtis A. Palmer) will be responsible for on-site radiological safety for the operation and personnel of his project. The designated Radiation Protection Officer for the U.S.G.S. National Center at Reston (Item 7) will be responsible for overall radiation safety and will assure that all personnel follow lawful, accepted, safe procedures and maintain the required records.

Signs will be posted at all rooms containing radioactive materials and entry will be limited to authorized personnel. Rooms containing radioactive materials will be locked during non-duty hours. All personnel using the facilities will wear film badges, dosimeters or other personnel monitoring as necessary. All radioactive materials will be stored in lead shielding to protect personnel from exposure.

Regular surveys will be made and recorded for all areas where isotopes are handled, processed or stored. At conclusion of experiments or an analytical sequence, areas will be cleaned, monitored and wipes taken for counting. Spills of α-active material will be surveyed by the Radiation Protection Officer on his designee with instrument (2).

Samples irradiated at the N.B.S. Reactor at Gaithersburg, Maryland; the U.S.G.S. Reactor in Denver, Colorado; or the Argonne National Laboratory will be transported to Reston, Virginia in lead shielded containers in accordance with D.O.T. regulations. Samples will be monitored (a) upon receipt, (b) when processed radiochemically, and (c) before disposal, and the required records of radioactivity will be maintained.

IV. Gas Chromatography in Branch of Analytical Chemistry (Licensed Material 7 and 8)

The detector cells will be kept in storage in the Accelerator Pit until approval of a future amendment.

V. Water Resources Division Gas Chromatography (Licensed Material 9)

The detector cell will be mounted within the gas chromatograph and will be touched only by the Radiation Protection Officer to accomplish wipe testing. Wipes will be counted in instrument (1) using 0.96% isobutane-in-helium counting gas for beta-gamma counting. The gas chromatograph will be operated to a maximum temperature of 350°C.

VI. Radioactive Dating Project (Licensed Material 17, 30 millicuries)

The radiation protection program for this project was described in our letter dated October 7, 1980.

ITEM 16, FORMAL TRAINING IN RADIATION SAFETY

and

ITEM 17, EXPERIENCE

Resumes of the radiation protection officer and all other persons listed in item 6 follow this sheet.

On-The-Job-Training Relevant to Above:

Employer	**Type of Work**	**Time Applicable To (a)**	**(b)**	**(c)**	**(d)**
Canada Dept. Mines & Tech. Svcs.	Radioactive assays	2 yr	2 yr	2 yr	2 mo
MIT (included 3-week program monitoring fallout, etc. at Nevada Test Site)	Research in Isotope Appl.	2 yr	2 yr	2 yr	2 mo
USGS (member of radiological defense team several years)	Applied Nuclear Phys.	32 yr	32yr	32yr	3yr

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
Zn-65	1 mCi	MIT	3 mo	Tracer adsorption
Ag-110	1 mCi	"	3 mo	"
Pb-210	1 mCi	"	3 mo	"
Ca-45	1 mCi	"	3 mo	"
Na-22	1 mCi	"	3 mo	
Am-241	100 mCi	USGS	1 mo	Neutron activation
I-125	8 mCi	"	1 yr	X-ray fluorescence
Gd-153	30 mCi	"	1 mo	"
Co-57	10 mCi	"	1 yr	"
Pm-147	1 mCi	"	3 mo	"
H-3	30 Ci	"	3 yr	Neutron generator research
Cf-252	173 mCi	"	15 yr	Neutron activation

Name: Frank E. Senftle **Title:** Physicist

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Univ. Toronto	1938-1942	BA	Science
Univ. Toronto	1942-1944	MA	Physics, Geology
Univ. Toronto	1944-1947	PhD	Physics, Geology
Mass. Inst. Tech.	1948-1951	Post-Doc	Neutron Activation

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Physics, Math, Chemistry	Univ. Toronto	7 yr	x	x	x	
Civil Defense	MIT	3 da	x	x	x	x
Radiation Safety	USGS	6 hr	x	x	x	x
Radwaste Disposal	USGS	1 hr	x	x		x
DOT Regulations	USGS	1 hr	x	x		

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)
Howard University	Nuclear Spectroscopy	1 yr	2 yr		
USGS	Neutron Activation	6 yr	6 yr	6 yr	1 yr

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
X-Rays		Howard University	7 years	Crystallography
Co-60	1mCi	" "	"	"
Co-57	1mCi	" "	"	"
Cs-137	1mCi	" "	"	"
Na-22	5mCi	" "	"	"
Cf-252	100mCi	USGS	6 years	Neutron Activation
Co-57	.5mCi	"	"	Calibration

Name: Jon L. Mikesell   Title: Physicist

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
MIT Cambridge, MA	1962-1966	S.B.	Nuclear Physics
Howard University Washington, D.C.	1971-1976	M.S.	Solid State Physics
Howard University Washington, D.C.	1976-1978		Nuclear Physics

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Nuclear Physics	MIT	2 years		x		
Nuclear Physics	Howard Univ.	1 year		x		
Modern Physics	MIT	2 years		x		
Quantum Mechanics	Howard	1 year		x		
Modern Physics Lab	MIT	1 year		x		
Graduate Lab	Howard	1 year		x		
Calculus		4 years			x	
Mathematical Physics		3 years			x	
Radiation Safety	USGS	4 hours	x	x	x	x
Rad Waste Disposal	USGS	1 hour	x			x
DOT Regulations	USGS	1 hour	x	x		x

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)
U.S. Navy	Radiological Control Monitor	3 yr ⟶			
Wyle Laboratories	Radiation Instrumentation Repair & Calibration	18 mos ⟶			
VEPCO	Nuclear Instrumentation/Radiation Control	1 yr	4 yr	1 yr	1 yr
U.S. Geological Survey	Neutron Activation Analysis	1 yr	6 yr	2 yr	1 yr

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
Cs- 137	Multiple Ci	Holy Loch Scotland	3 yrs	Calibration
Pb- 210	100 μCi	Holy Loch Scotland	3 yrs	"
Pu-Be	Multiple Ci	Holy Loch Scotland	3 yrs	"
Co-60	1 Ci	Surry Power Station	7 yrs	"
I-131	Multiple Ci	Surry Power Station	7 yrs	"
Am-241	70 sources at 100 μCi	Wyle Laboratories	18 mos	Research
Sr-90	100 μCi	Holy Loch Scotland	3 yrs	Calibration
Fission Products Liquid Waste Gaeous Waste	Multiple Ci	VEPCO	7 yrs	Reactor Waste & By Products
Cf-252	100 mCi	U.S. Geological Survey	4 yrs	Research
H-3 (n gen.)	8 Ci	U.S. Geological Survey	2 yrs	"

Name: Danny W. Dotson Title: Electronics Technician

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Hampton High School	1961-1964	Diploma	Science
Christopher Newport College, Newport News, VA	1965-1965	--	Chemistry
U.S. Navy ETA School	1966-1966	Graduated	Electronics

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Radiac Instrumentation	Tresure Island Calif.	6 wks	x	x	x	x
Radiological Control	Dunoon, Scotland	6 mos	x	x	x	x
Health Physics	Surry Nuclear Power Station, Surry, VA	2 wks (Per yr for 7 yrs)	x	x	x	x
Nuclear Data 812 Computer	Chicago, IL	2 wks		x	x	
Nuclear Data 6620 Computer	Chicago, IL	2 wks		x		

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)
Univ. California-Los Angeles	Neutron Activation	5yr	5yr	5yr	2mo
Mass. Inst. Technology	Neutron Activation	2yr	2yr	2yr	1 mo
U. S. Geological Survey	Neutron Activation	7yr	7yr	7yr	1yr

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
Z=3 to 83	1 Ci	Univ. Kentucky	5 yr	Neut. Act.
		Mass. Inst. Tech.	2 yr	"
		Univ. California-L.A.	5 yr	"

Name: Philip A. Baedecker **Title:** Research Chemist

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Ohio University		BS	Chemistry
University of Kentucky		PhD	"
Massachusetts Institute Tech.	2 yr	Post-Doc	Neutron Activation
Univ. California-Los Angeles	5 yr	Post-Doc	"

Formal Courses Relevant To:
- (a) Principles and practices of radiation protection.
- (b) Radioactivity measurement standardization and monitoring techniques and instruments.
- (c) Math calculations basic to use and measurement of radioactivity.
- (d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Chemistry, math	Ohio, Kentucky	7 yr	x	x	x	x
Radiation Safety	USGS	6 hr	x	x	x	x
Radwaste disposal	USGS	1 hr	x	x		x
DOT Regulations	USGS	1 hr	x	x		

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)
Atomic Energy Research Establishment, Harwell, England	1948-1952: Making and testing radiation detectors for β, γ, n	1y	2y	3mo	1mo
" "	1955-1956: Neutron activation analysis	1y		1y	
" "	1956-1959: Mass spectrometry using radioactive (Pu-U) and stable isotopes	1y			
Australian Atomic Energy Commission (AAEC), Sydney, Australia	1959-1961: Standardization of radioactivity. Identification of activity in reactor circuits.	1y	2y		
" "	1966-1968: In charge of low level Radiochemistry Lab responsible for environmental monitoring.	0.5y	0.5y	0.5y	0.5y
University of Kentucky (UK) Lexington, KY	1968-1970: 14 MeV neutron activation analysis of lunar samples	1y	0.5y	0.5y	
University of Chicago (UC) Chicago, Ill	1970-1976: Radiochemical neutron activation of lunar, meteoritic and terrestrial rocks	2y	2y	2y	
University of Texas at San Antonio	1967-1977: University Radiation Protection Officer	1mo			1mo
U.S. Geological Survey (USGS), Reston, VA	1977-present: Instrumental and radiochemical neutron activation	3y	3y	3y	

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
^{3}H	10mCi	AAEC	1m	standardization
^{7}Be	"	"	2y	tracer
^{10}Be	<1μCi	"	0.5y	environment
^{14}C	<1μCi	ANU	1m	dating and biological

Name: John W. Morgan Title: Research Chemist

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Queen Mary's Grammar School Walsall, England	1943 - 1948	School Cert	Science
Oxford School of Technology Oxford, England	1948- 1951	Inter B.Sc	Science
Birmingham University	1952-1955	B. Sc (Pure Science)	Chemistry
Australian National University Canberra A.C.T. Australia	1961-1966	Ph. D.	Geochemistry

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Calculus	Grammar School	1 yr			x	
Physics	" "	5 yr	x	x		
Chemistry	" "	5 yr	x			
Math	Oxford Tech	2 yr			x	
Physics	" "	2 yr	x	x		
Chemistry	" "	2 yr	x			
Physics	Birmingham U	1 yr	x	x	x	
Chemistry	"	3 yr	x			x
Engineering	"	1 yr	x			
Neutron Activation Research	A. N. U.	5 yr			x	
Statistics	"	3 months			x	

Note also, I have taught courses in: Nuclear Chemistry & Physics
Chemistry of Urban Waste Management
Radiochemistry of Radioactive Waste Disposal

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
^{115}Cd-^{115m}In	10μCi	UC; USGS	5y	RNAA
^{114m}In	10μCi	UC	5y	RNAA
^{122}Sb				
^{124}Sb	10μCi	UC	5y	RNAA
^{123m}Te	<1μCi	UC; USGS	1y	RNAA
^{132}Te	10μCi	UC; USGS	1y	RNAA
^{131}I	10μCi	AAEC	3m	fission product studies
^{131}Cs	10μCi	AAEC	3m	activity identification
^{134}Cs	10μCi	UC; USGS	2y	RNAA
^{137}Cs	1mCI	AAEC	3m	fission product studies
	10μCi	UC; USGS	2y	tracer for RNAA
^{131}Ba	10μCi	AAEC	3m	activity identification
		UC; USGS	3m	RNAA
^{139}Ba	10μCi	USGS	1m	RNAA
^{140}Ba-^{140}La	10μCi	ANU	3m	RNAA
		USGS	1m	RNAA
^{140}La	10μCi	USGS	9m	RNAA; INAA
^{141}Ce	10μCi	USGS	9m	RNAA; INAA
^{144}Ce	10μCi	AAEC	3m	fission studies
^{147}Nd	10μCi	USGS	9m	RNAA; INAA
^{153}Sm	10μCi	USGS	9m	RNAA; INAA
^{152m}Eu	10μCi	USGS	9m	INAA
^{152}Eu	10μCi	USGS	9m	RNAA; INAA
^{153}Gd	10μCi	USGS	9m	RNAA; INAA
^{159}Gd	10μCi	USGS	9m	RNAA; INAA
^{160}Tb	10μCi	USGS	9m	RNAA; INAA
^{166}Ho	10μCi	USGS	9m	RNAA; INAA
^{171}Er	10μCi	USGS	9m	RNAA; INAA
^{170}Tm	10μCi	USGS	9m	RNAA; INAA
^{175}Yb	10μCi	USGS	9m	RNAA; INAA
^{177}Lu	10μCi	USGS	9m	RNAA; INAA
^{186}Re	100μCi	ANU; UC; USGS	15y	RNAA; INAA
^{188}Re	10μCi	USGS	9m	INAA
^{185}Os	1μCi	ANU	1y	RNAA
^{191}Os	10μCi	ANU; UC; USGS	15y	RNAA
^{188}Ir	1μCi	ANU	1m	proton activity
^{192}Ir	1mCi	UK; UC;USGS	8y	RNAA; INAA
^{197}Pr	1μCi	USGS	1m	RNAA
^{198}An	1mCi	UC; USGS	5y	RNAA; INAA
^{199}Au	10mCi	UC	3m	RNAA
^{204}Tl	1μCi	UC	5y	RNAA
^{210}Pb	<1μCi	AAEC	6m	U disequilibrium

John W. Morgan, cont'd

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
^{16}N	10μCi	U. K.	1y	14 MeV NAA
^{22}Na	10μCi	AAEC	1m	tracer
^{24}Na	1Ci	AERE;AAEC;U.C.; USGS	10y	INAA; RNAA
^{28}Al	10μCi	U. K.	2y	14 MeV NAA
^{31}Si	10μCi	AAEC	3m	reactor spectrum
^{32}P	10μCi	"	1m	RNAA
^{35}S	1μCi	"	1m	RNAA
^{42}K	10μCi	ANU; USGS	6m	RNAA
^{45}Ca	10μCi	AAEC	3m	RNAA
^{46}Sc	10μCi	USGS	3m	RNAA
^{51}Cr	1mCi	ANU	1y	RNAA
^{56}Mn	1mCi	USGS	1m	INAA
^{59}Fe	1mCi	USGS; UC	1m	INAA
^{58}Co	1mCi	AAEC	1m	reactor spectrum
		U.C.	1y	RNAA
		U.K.	6m	coincidence
^{60}Co	6×10 Ci	all	10y	many
^{59}Ni	<1μCi	U.C.; USGS	1y	RNAA
^{63}Ni	<1μCi	AAEC	6m	monitoring
^{65}Ni	100μCi	USGS	1m	INAA
^{64}Cu	10μCi	USGS	1m	INAA
^{65}Zn	1mCi	U.C.	5y	RNAA
		AAEC	3m	monitoring
^{72}Ga	10μCi	U.C.	3m	RNAA
		USGS	1m	INAA
^{76}As	10μCi	AERE	3m	RNAA
		USGS	1m	INAA
^{75}Se	100μCi	U.C.; USGS	5y	RNAA
^{82}Br	100μCi	U.C.; USGS	2y	RNAA
^{86}Rb	10μCi	U.C.; USGS	2y	RNAA
^{85}Sr	10μCi	AERE; AAEC	2y	RNAA
		U.C.; USGS		
^{87m}Sr	10μCi	AERE; USGS 6m	6m	RNAA
^{89}Sr	10μCi	AERE	6m	RNAA
^{90}Sr-^{90}Y	<1μCi	AAEC	2y m	monitoring
^{95}Zr-^{95}Nb	100μCi	AAEC	3m	fission measurement
^{106}Rn	100μCi	AAEC	3m	" "
^{104}Rh	<1μCi	USGS	1m	INAA
^{014m}Rh	"	"	"	"
^{103}Pd	"	"	"	RNAA
^{109}Pd	"	"	"	"
^{110m}Ag	10mCi	AAEC	1m	monitoring

John W. Morgan, cont'd

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
^{210}Bi	1μCi	UC	5y	RNAA
^{210}Po	1μCi	AAEC	6m	U disequilibrium
^{222}Rn	<1μCi	AAEC	2y	Ra determination
^{226}Ra	<1μCi	AAEC	2y	monitoring
^{230}Th	<1μCi	AAEC	6m	U disequilibrium
^{232}Th	<1μCi	AAEC	6m	electrodeposition
^{231}Pa	<1μCi	AAEC	6m	"
		ANU	5y	RNAA tracer
^{233}Pa	1μCi	ANU	5y	RNAA
^{232}U	<1μCi	AAEC	6m	isotope dilution
^{233}U	1mCi	AERE	3m	mass spectrometry
^{235}U	10μCi	AERE	1y	"
^{238}U	<1μCi	AAEC	6m	electrodeposition
^{237}Np	10μCi	ANU	5y	RNAA tracer
^{239}Np	10μCi	ANU	5y	RNAA
^{239}Pu	1mCi	AERE	3m	mass spectrometry
^{240}Pu	1mCi	AERE	3m	mass spectrometry

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)
Oregon State University	Research Assistant	2 yr.		2 yr.	
Washington State University	Lab Tech.	5 yr.	1yr.	5 yr.	1 yr.
U.S. Geological Survey	Research Chemist (Radiochemistry)	3 yr.		3 yr.	

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
^{24}Na	0.5mCi	Oregon State University Washington State University U.S. Geological Survey	3 5 3	Neutron Activation Radiochemistry
^{59}Fe	0.5mCi	"		
^{60}Co	0.5mCi	"		
^{46}Sc	1 mCi	"		
^{137}Cs	~10 μCi	"		
Other Activatable Isotopes	0.1mCi	"		

Name: Dr. Curtis Palmer   Title: Project Chief

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Principia College Elsah, Illinois	9/67 - 6/71	B.S.	Chemistry
Oregon State University Corvallis, Oregon	9/71 - 10/74	M.S.	Nuclear Chemistry
Washington State University Pullman, Washington	2/75 - 4/83	Ph.D.	Analytical Chemistry Geology Minor

Formal Courses Relevant To:
- (a) Principles and practices of radiation protection.
- (b) Radioactivity measurement standardization and monitoring techniques and instruments.
- (c) Math calculations basic to use and measurement of radioactivity.
- (d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Nuclear Chemistry	Oregon State Univ.	6 quarter hrs.	✓	✓	✓	
Neutron Activation	Oregon State Univ.	6 quarter hrs.	✓		✓	
Radiation Safety Sem.	Oregon State Univ.	3 hrs.	✓	✓		✓
Radiation Safety Sem.	Washington State Univ.	6 hrs.	✓	✓		✓
Safety Seminar	U.S. Geol. Survey	3 hrs.	✓	✓		✓
Reactor Users Training	National Bureau of Standards	4 hrs.	✓	✓	✓	✓
Physics	Principia College	25 quarter hrs.			✓	

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)
Illinois Inst. Tech.	Radiochemistry	1 yr	1 yr	1 yr	1 yr
University of Maryland	"	1 yr	1 yr	1 yr	1 yr
Argonne National Lab	"	2 mo	2 mo	2 mo	2 mo
U. S. Geological Survey	Activation Analysis	14yr	14yr	14yr	1 yr

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
Z=3 to 83	500 mCi	U.S. Geological Survey	14 yr	Activation analysis

Name: Louis J. Schwarz **Title:** Chemist

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Gallaudet College		BA	Chemistry

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Gallaudet College Chemistry	Gallaudet College	2 yr	x	x	x	
Radiation Safety	USGS	6 hr	x	x	x	x
Radwaste Disposal	USGS	1 hr	x	x		x
DOT Regulations	USGS	1 hr	x	x		

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)
U.S.G.S.	Instrumental and Radiochemical Neutron Activation Analysis	6yr.	4yr.	6yr.	2yr.

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
Na^{24}	.5mCi	U.S.G.S.	6 yrs.	Activation Analysis
Sc^{46}	1.0mCi	|	|	|
Fe^{59}	0.5mCi	|	|	|
Co^{60}	0.5mCi	|	|	|
Cs^{137}	10 μCi	|	|	|
other activated products	0.5mCi		|	|

Name: Gregory Wandless **Title:** Chemist

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
George Mason Univ. Fairfax, VA	1973 - 1977	B.S.	Chemistry

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Radiation Safety	U.S.G.S.	6 hrs.	✓	✓		✓
Physics	George Mason Univ.	2 yrs.	✓	✓	✓	

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)
Rice Univ. 1965 ↓ 1969	Operation of:				
	alpha counter	✓	✓	✓	
	gamma-ray spectrometer	✓	✓	✓	
	x-ray flourescence spectrometer	✓	✓	✓	
	x-ray diffractometer	✓	✓	✓	
	mass-spectrometer	✓	✓	✓	
NASA, Johnson Space Center 1969-1970	Chemical separations using radioactive tracer	✓	✓	✓	
State University of New York at Stony Brook (SUNYSB) 1970-1971	Neutron irradiation of various materials, including rock and mineral samples, at the High-FLUX Beam reactor at Brookhaven National Lab and Mass spectrometric analysis of rare gases samples from irradiated at SUNYSB.	✓	✓	✓	
	Taught seminar in geochemistry	✓	✓	✓	

(continued on page 3)

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
^{32}P ^{33}P ^{35}S ^{45}Ca $^{49}Ca/^{49}Sc$ ^{51}Cr ^{55}Fe ^{54}Mn ^{59}Fe ^{86}Rb ^{46}Sc ^{47}Sc ^{58}Co ^{60}Co	100 mCi	State University of NY at Stony Brook (Dept. of Earth and Space Sciences)/High Flux Beam Reactor, Brookhaven National Lab, Brookhaven, NY	Oct 70 - Oct 71	Mass spectrometric analysis of rare gases produced by neutron irradiation of rock & mineral samples.
		Dept. of Geology and Mineralogy, Ohio State Univ./ Geological Survey TRIGA Reactor, Denver, Colorado and Phoenix Memorial Lab., Univ. of Michigan, Ann Arbor, Mich.	Oct 71 - Sept. 80	Mass spectrometric analysis of rare gases produced by neutron irradiation of rock & mineral samples.

Name: JOHN F. SUTTER Title: GEOLOGIST

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Capital University Columbus, Ohio	1961-1965	B.S.	Geology
Rice University Houston, Texas	1965-1968	M.A.	Geology
Rice University Houston, Texas	1968-1970	PHD	Geology

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Math	Capital U.	1½ yr.			✓	
Chem	Capital U.	3 yr.	✓	✓		
Biology	Capital U.	1 yr.				✓
Physics	Capital U.	1 yr.	✓	✓	✓	
Geochemistry	Rice U.	1 yr.	✓	✓	✓	✓
Radiogeology	Rice U.	½ yr.	✓	✓	✓	✓
Thermodynamics	Rice U.	½ yr.			✓	
Seminar in Nuclear Geochemistry	Rice U.	½ yr.	✓	✓	✓	✓

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)	
Doctors Hospital	Medical lab tech.	x	x	x	x	3 mos.
The Ohio State Univ.	Research Asst.	x	x	x	x	2 yrs.
U.S. Geological Survey	Geologist	x	x	x		2 yrs.

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
^{99}Tc	Minimal	Doctors Hospital	3 months	Medical
^{131}I	Minimal	Doctors Hospital	3 months	Medical
^{39}Ar	<3mCi	O.S.U. & USGS	3 yrs	Research
^{31}Si	3mCi	"	"	"
^{28}Al		"	"	"
^{55}Fe		"	"	"
^{59}Fe		"	"	"
^{54}Mn		"	"	"
^{56}Mn		"	"	"
^{42}K		"	"	"
^{45}Ca		"	"	"
^{49}Ca		"	"	"
^{64}Cu		"	"	"
^{32}P		"	"	"
^{41}Ar	<3mCi	O.S.U. & USGS	3 yrs	Research
^{37}Ar	5.4mCi	O.S.U. & USGS	3 yrs	Research

Name: Kunk, Michael J. Title: Geologist

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
The Ohio State University	9/68 - 12/79	B. S.	Geology
The Ohio State University	1/80 - 3/82	M. S.	Geology

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Radiation Safety	OSU	4 hrs	x	x		
Math 150	OSU	5 qtr hrs			x	
Math 151	OSU	5 qtr hrs			x	
Math 152	OSU	5 qtr hrs			x	
Geology 620	OSU	5 qtr hrs		x	x	
Geology 999	OSU	22 qtr hrs	x	x	x	
Geology 693	OSU	4 qtr hrs	x	x	x	
Biology 100	OSU	5 qtr hrs				x
Biology 101	OSu	5 qtr hrs				x

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)	
USGS	Safety Officer (Bureau Safety Management Award) (1974-1977)	x				(3-yrs)
USGS	Research used low levels <100 μCi-^{14}C in tracer studies June-Sept. 1981	x	x	x	x	(4-mos)

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
^{14}C	<100 μCi	(USGS) Reston, VA	3-mos	Tracer Studies

Name: David J. Shultz **Title:** Hydrologist

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Capital Univ. Columbus, OH	1963-1967	B.S.	Chemistry
Univ. of Texas Austin, TX	1968-1970	M.S.	Marine Chemistry
Florida State Tallahassee, FL	1970-1974	Ph.D.	Chemical Oceanography

Formal Courses Relevant To:
- (a) Principles and practices of radiation protection.
- (b) Radioactivity measurement standardization and monitoring techniques and instruments.
- (c) Math calculations basic to use and measurement of radioactivity.
- (d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
CBR Unit U.S. Army Reserves	Tallahassee, FL	1970-1973	x	x		x
Isotope Geology	Univ of Texas Austin, TX	1 semester			x	
Radiation Safety	USGS	2 hr	x	x	x	x

On-The-Job-Training Relevant to Above:

Employer	Type of Work	Time Applicable To (a)	(b)	(c)	(d)	
MIT(student)	Thoron alpha counting		x	x		(4 mos.)
U.S. Geol Survey:	Meas. radioactivity of natural gas	x	x	x		10 mos.
	Meas. radon in soil gas, mine air, drill holes, natural waters, & petroleum	x	x	x		6 yrs.
	Developed X-ray fluorescence meth.		x	x		3 yrs.
	Developed γ-ray spectrometric meth.	x	x	x		12 yrs.
	Developed neutron activation meth.	x	x	x	x	12 yrs.
	Radiation protection officer	x	x	x	x	16 yrs.
Advised National Cancer Institute on radon meas.		x	x	x	x	4 mos.
Participant with National Council on Radiation Protection and Measurements (Committee work & annual meetings)		x			x	3 mos.
Invited participant at Symposium of Areas of High Natural Radioactivity (Epidemiology), Poços de Caldas, Brazil, 1975		x			x	1 wk

Experience with Radiation:

Isotope	Maximum Amount	Where Experience Was Gained	Duration	Type of Use
Th-232 + drs.	155pCi	MIT	4 mo	Standardization
Ra-226	2μCi	USGS	14 yr	"
Ra-226	0.5mCi	"	16 yr	Calibration
Rn-222	2μCi	"	14 yr	Calibration; measurement
Co-57	30mCi	"	2 yr	XRF research
Gd-153	30mCi	"	1 mo	"
I-125	8mCi	"	1 yr	"
Tm-170	40mCi	"	2 yr	"
Fe-55	1.5mCi	"	6 mo	"
U-235	10nCi	"	12 yr (intermittently)	Calibration
Cf-252	173mCi	"	13 yr	Neutron Activation
H-3	61.5Ci	"	2 mo	"
Na-22	0.1mCi	"	1 mo	Calibration
Th-232	2.5mCi	"	13 yr	Gamma-ray Spectrometry
U-238	1.3mCi	"	13 yr	"
Am-241	29mCi	"	1 wk	Calibration, testing
Co-60	14uCi	"	6 yr	
Ra-226(+Be)	30 mCi	"	2 wk	"

Name: Allan B. Tanner **Title:** Geophysicist (Radiation Protection Officer)

Formal Education:

Institution and Location (City & State)	Dates of Attendance	Degree	Field
Massachusetts Institute of Technology Cambridge, MA	9/1948-6/1952	S.B.	Geology
University of Utah	9/1956-1/1959	-	Geophysics, Nuclear Physics

Formal Courses Relevant To:
(a) Principles and practices of radiation protection.
(b) Radioactivity measurement standardization and monitoring techniques and instruments.
(c) Math calculations basic to use and measurement of radioactivity.
(d) Biological effects of radiation.

Course	Where?	How Long?	Relevant to (Check) (a)	(b)	(c)	(d)
Radioactivity	MIT	2 semester hours	x	x	x	x
Thesis: Thoron measurements	MIT	4 semester hours		x	x	
Chem. Bact. Radiol. Warfare	U.S. Army	8 hours	x			x
Modern Physics	Univ. Utah	3 quarter hours		x	x	
Nuclear Physics	Univ. Utah	9 quarter hours		x	x	
Radiation Seminar	U.S.G.S.	2 hours	x			x

Teach courses in Radiation Safety, Radwaste Disposal, and D.O.T. Regulations at USGS

17137

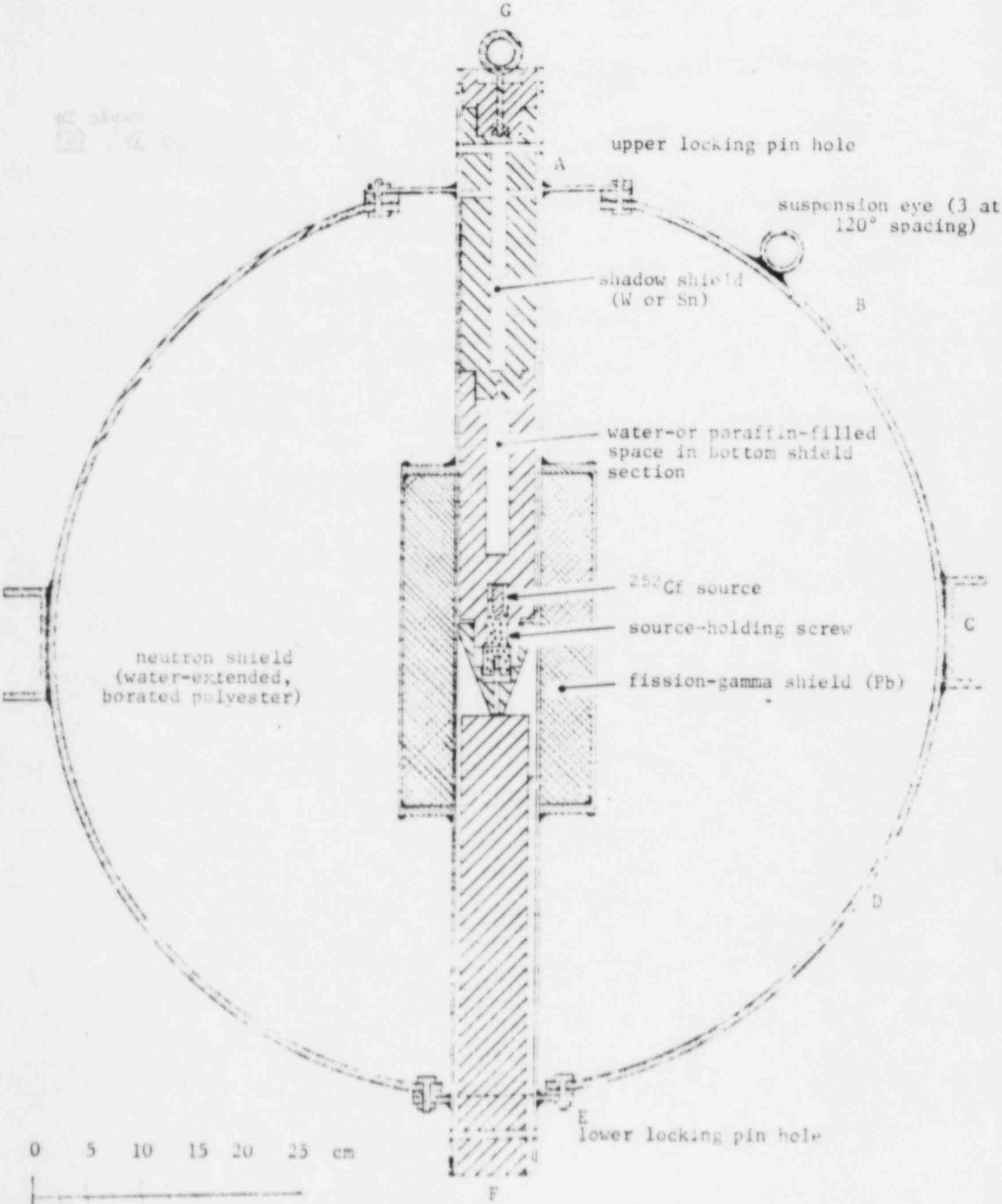


Figure 1. Spherical shield for ^{252}Cf source. Letters indicate locations of radiation survey, attached. Shield weight is 400 kg (880 pounds).

Attachment to Figure 1: Radiation survey of 96-mCi ^{252}Cf source in spherical shield.

Instruments used: for neutrons, Ludlum Measurements Model 28 ratemeter with Model 42-4 LiI(Eu) detector in polyethylene ball; for gamma, Health Physics Instruments Model 1010 Multiplying Ion Chamber Survey Meter (tissue equivalent)

Location	Neutrons (biological equiv.) (counts/min)	(mrem/hr)	Gamma (tissue equiv.) (mrad/hr)	Total DE (mrem/hr)
--Results as close to surface as detector would permit (several azimuths)--				
A	2700	35.1	14	49
B	1600	20.8	5.5	26
C	1000	13.0	4.5	18
D	1300	16.9	4.5	21
E	1400	18.2	6.0	24
F	1900	24.7	6.6	31
G	2200	28.6	13	42
--Results with detector center 3 ft from surface, radially outward--				
A	400	5.2	1.0	6.2
B	300	3.9	0.7	4.6
C	200	2.6	0.5	3.1
D	230	3.0	0.5	3.5
E	260	3.4	0.7	4.1
F	550	7.2	0.9	8.1*
G	440	5.7	1.0	6.7

*Transport index

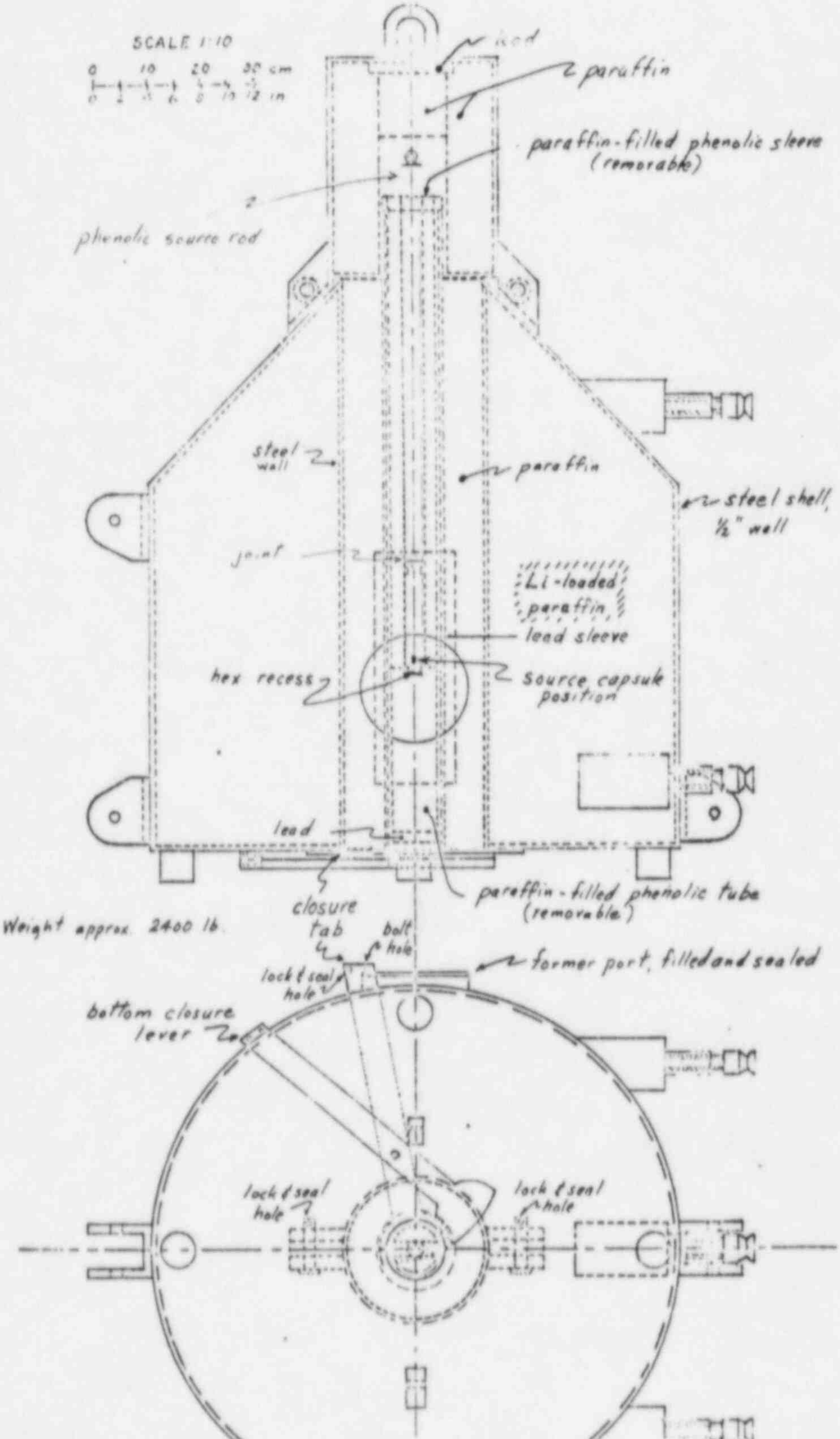


Figure 2 Storage shield for 173-mCi Cf-252 source. A survey of the shield without either removable central sleeve or the top cap was made using a 48.9-mCi source. Extrapolating to 173 mCi, the maximum exposure dose equivalent at an accessible surface would be 16.6 mrem/hr fast neutrons + 14.2 mR/hr gamma = 30.8 mrem/hr; at 30 inches, 5.3 mrem/hr; at 1 metre, 5.3 mrem/hr (averages lower at 1m)

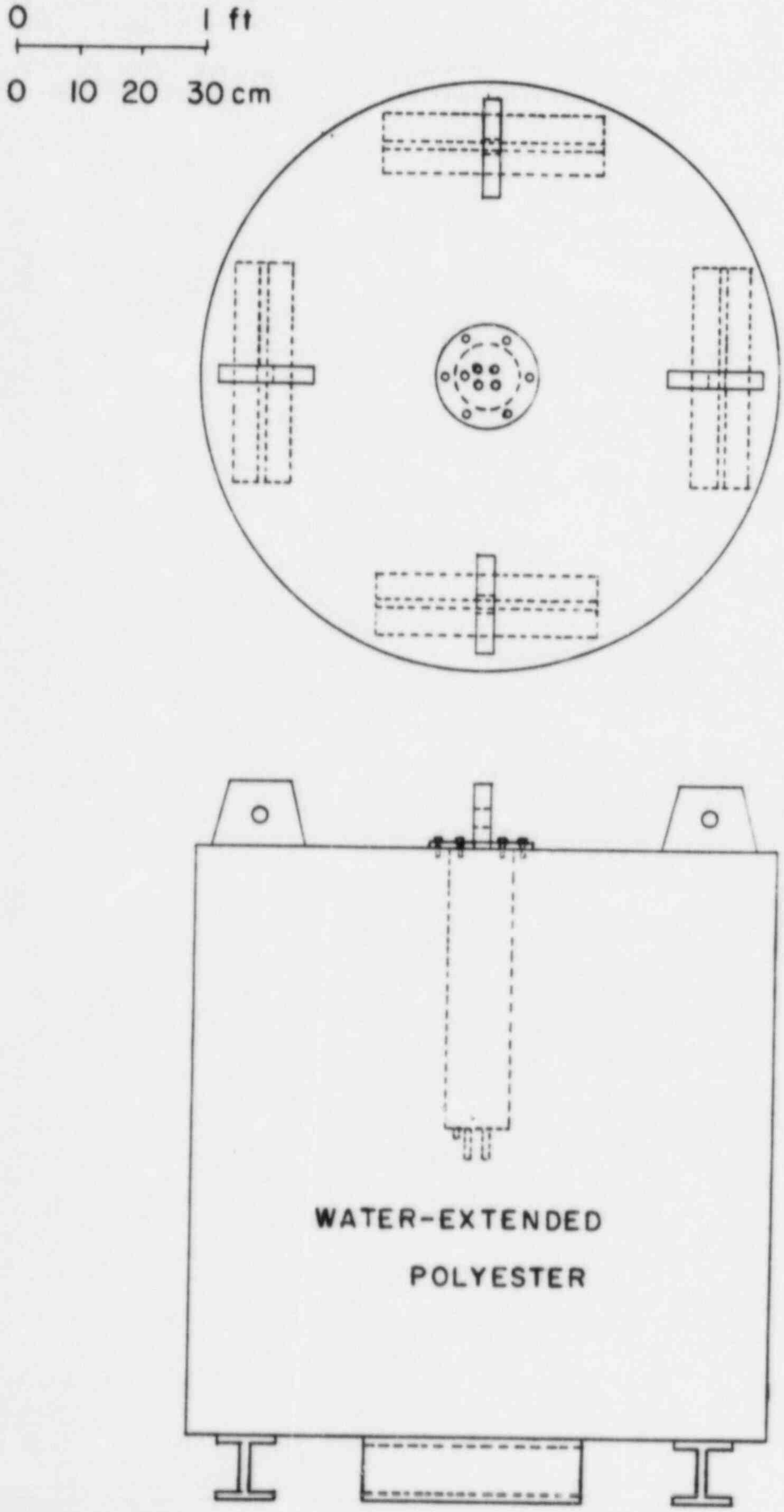


Figure 3. Shipping and storage cask for Cf-252 sources. Manufacturer; Atkinson Steel Co., Austin, TX. S/N 249, 1850 lb. DOT Specification 7A.

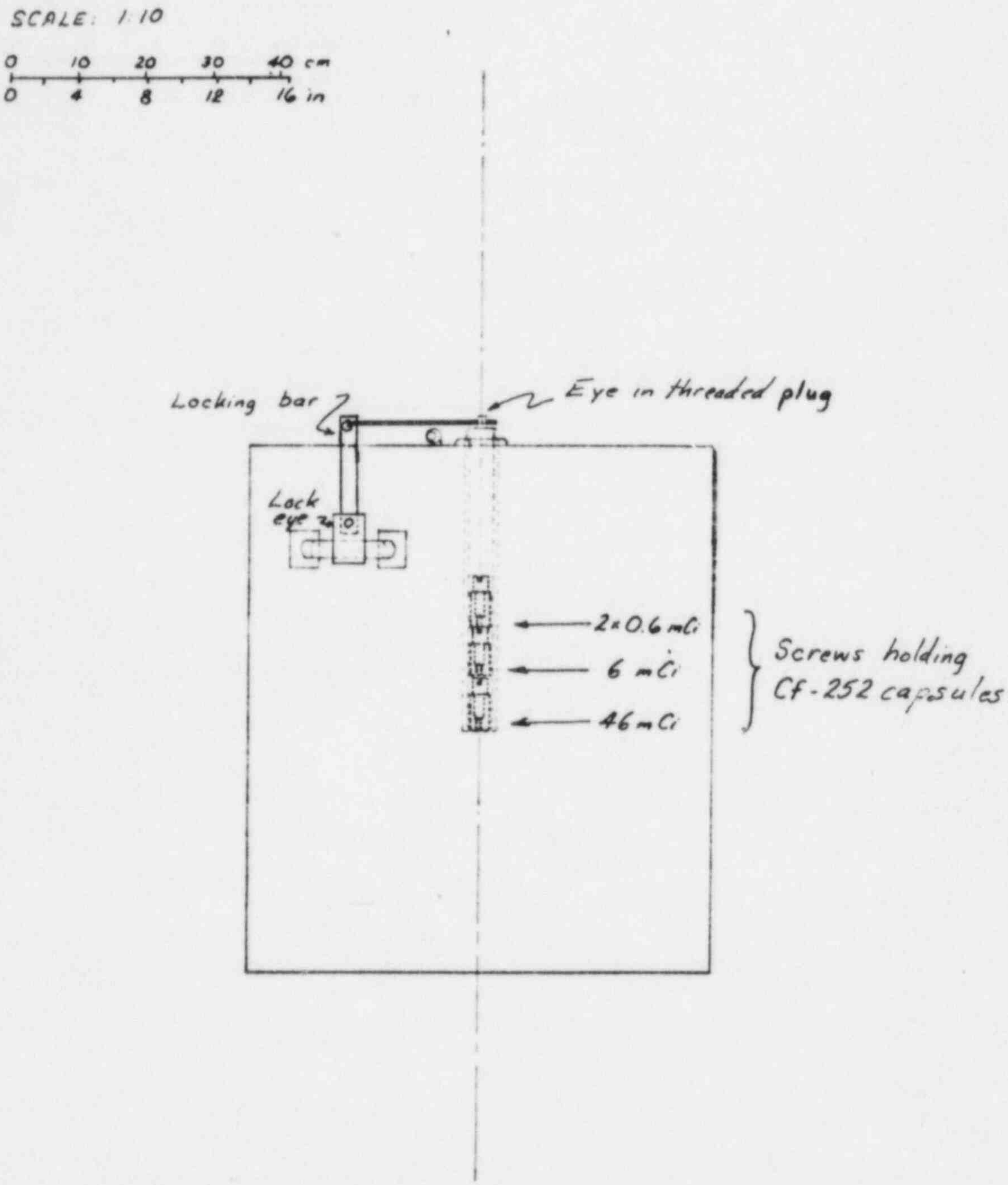


Figure 4 Storage and transport shield for californium-252 sources. The shield is a paraffin-filled steel barrel and bears B of E Permit stamp no. 181. The maximum dose equivalent rate with sources of 40, 6, 0.2, and 0.2 millicuries loaded together as shown was measured at 40 mrem/hr at the shield surface and 5.0 mrem/hr at 30 inches from the surface.

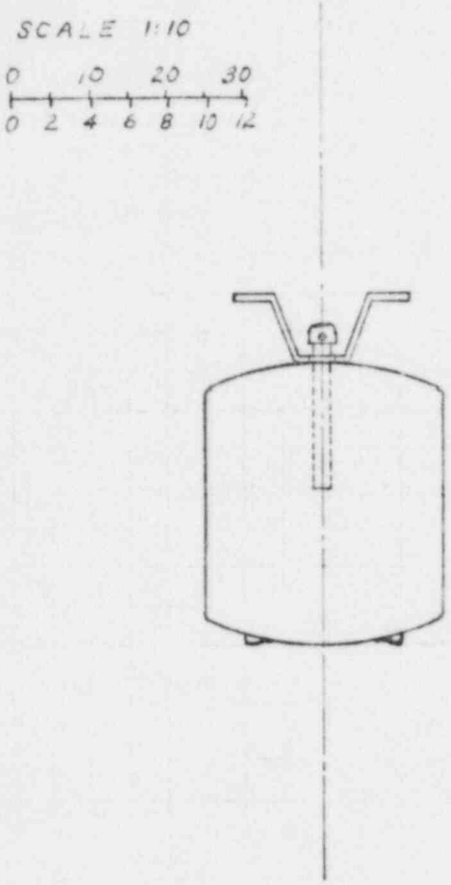


Fig. 5 Storage shield for two 0.6 mCi Cf-252 sources. The shield is a paraffin-filled refrigerant container (steel). A survey of the shield with one 0.31 mCi source showed a maximum dose rate equivalent of 3.9 mrem/hr at surface and 0.6 mrem/hr at 30 in. (15 mrem/hr and 2.3 mrem/hr for two 0.6 mCi sources)

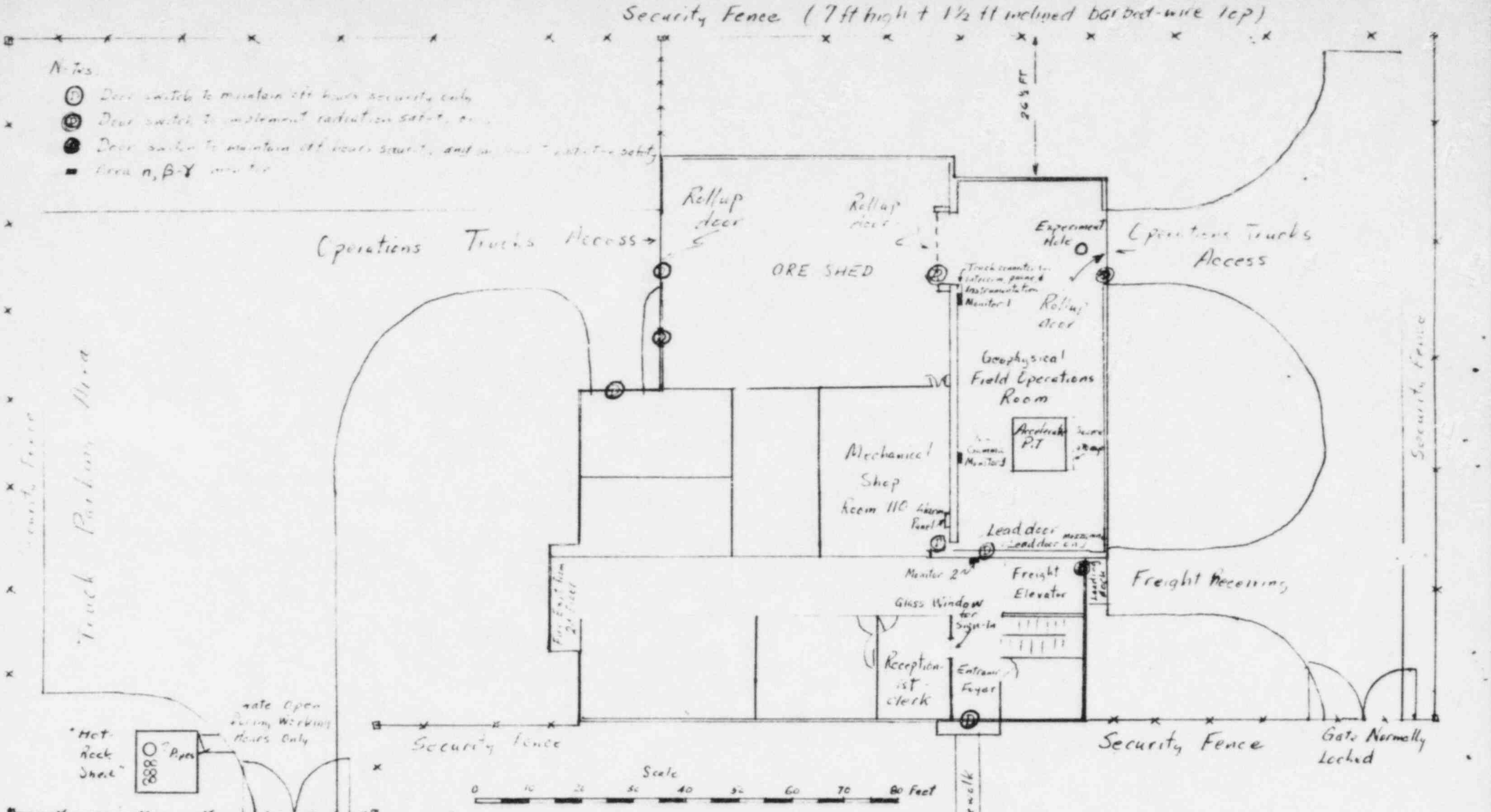


Figure 6 Solid State Physics Bldg and Security Area

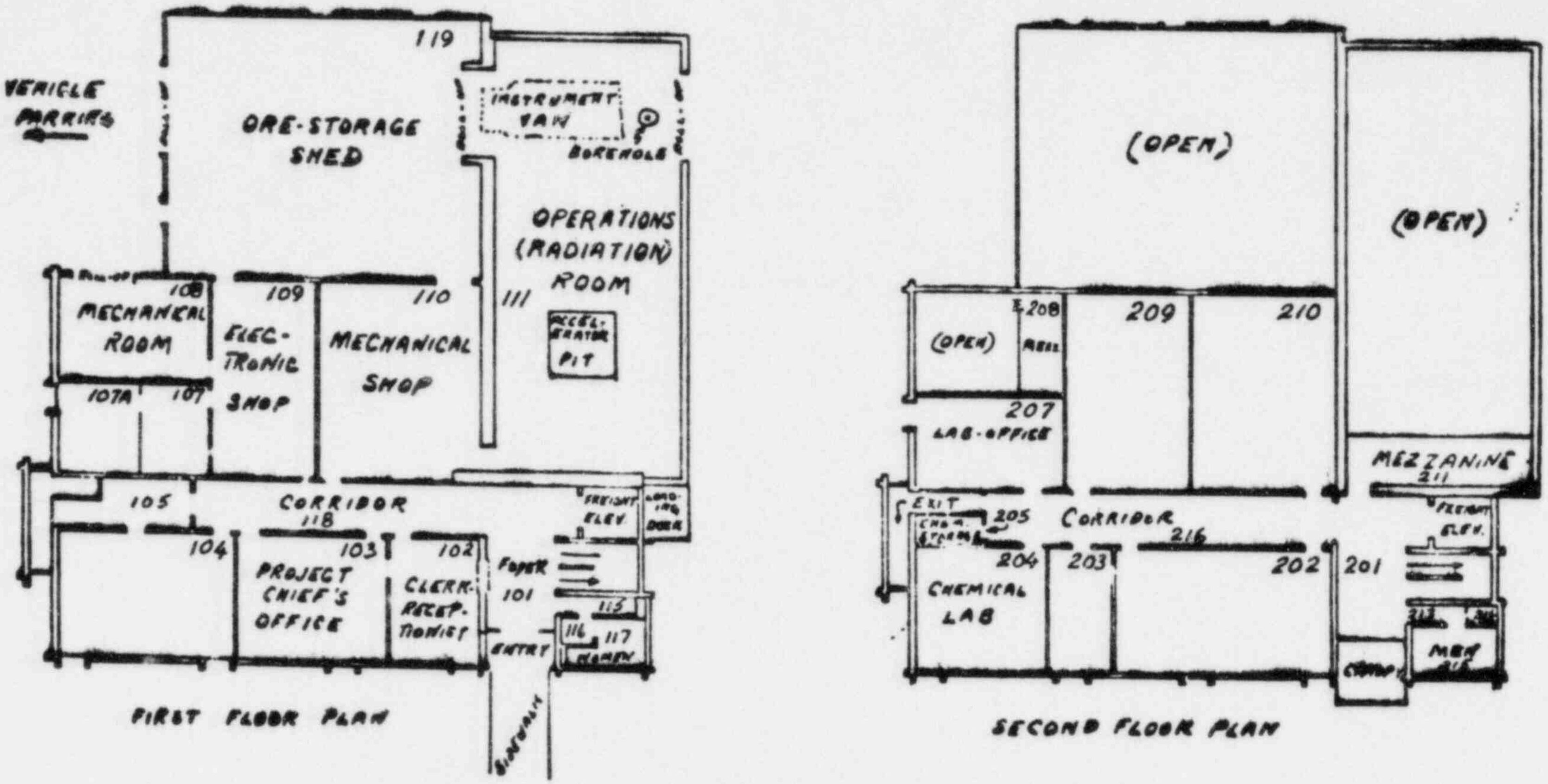


FIGURE 7

US GEOLOGICAL SURVEY

PHYSICS BUILDING

RESTON, VIRGINIA

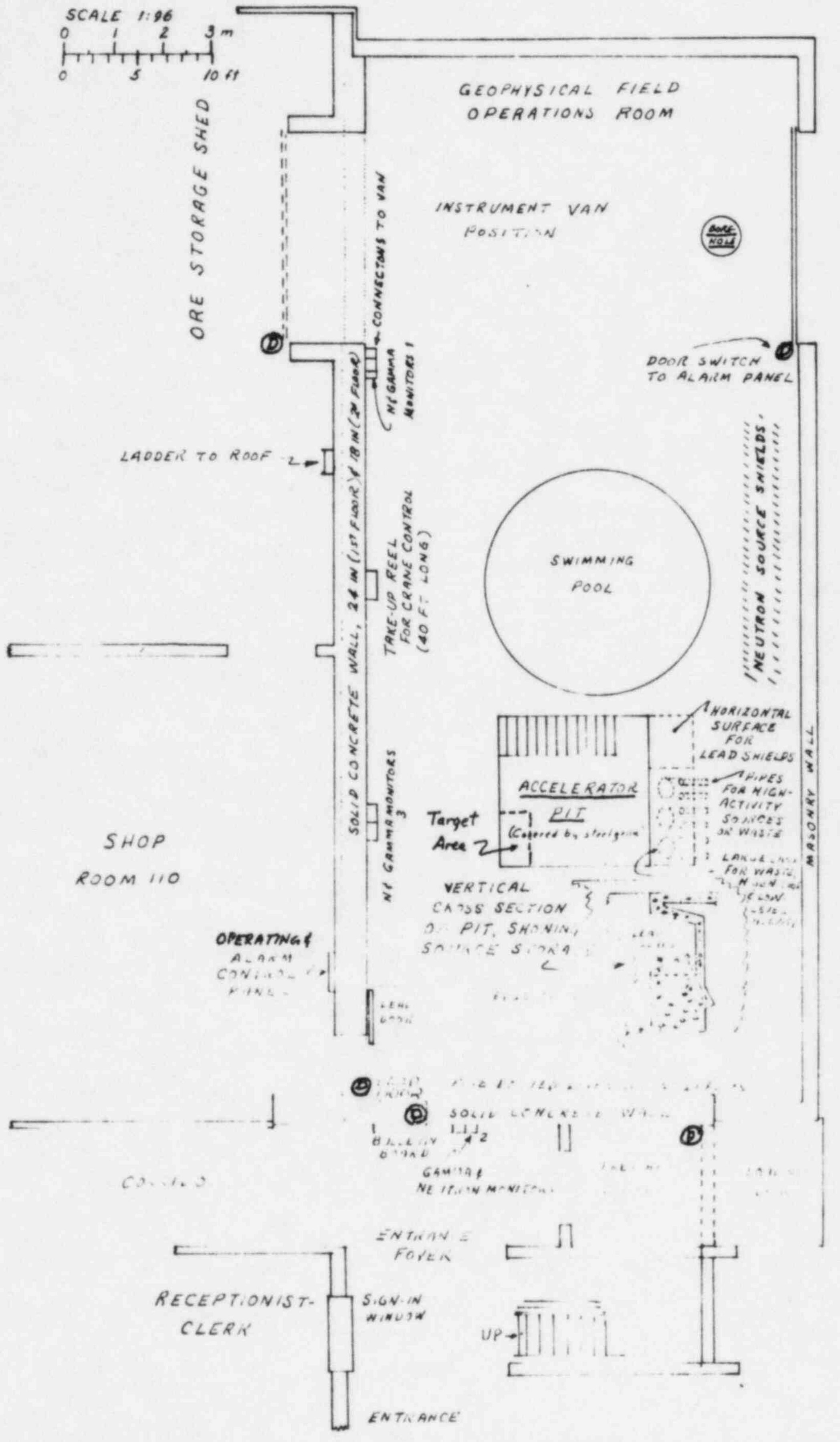
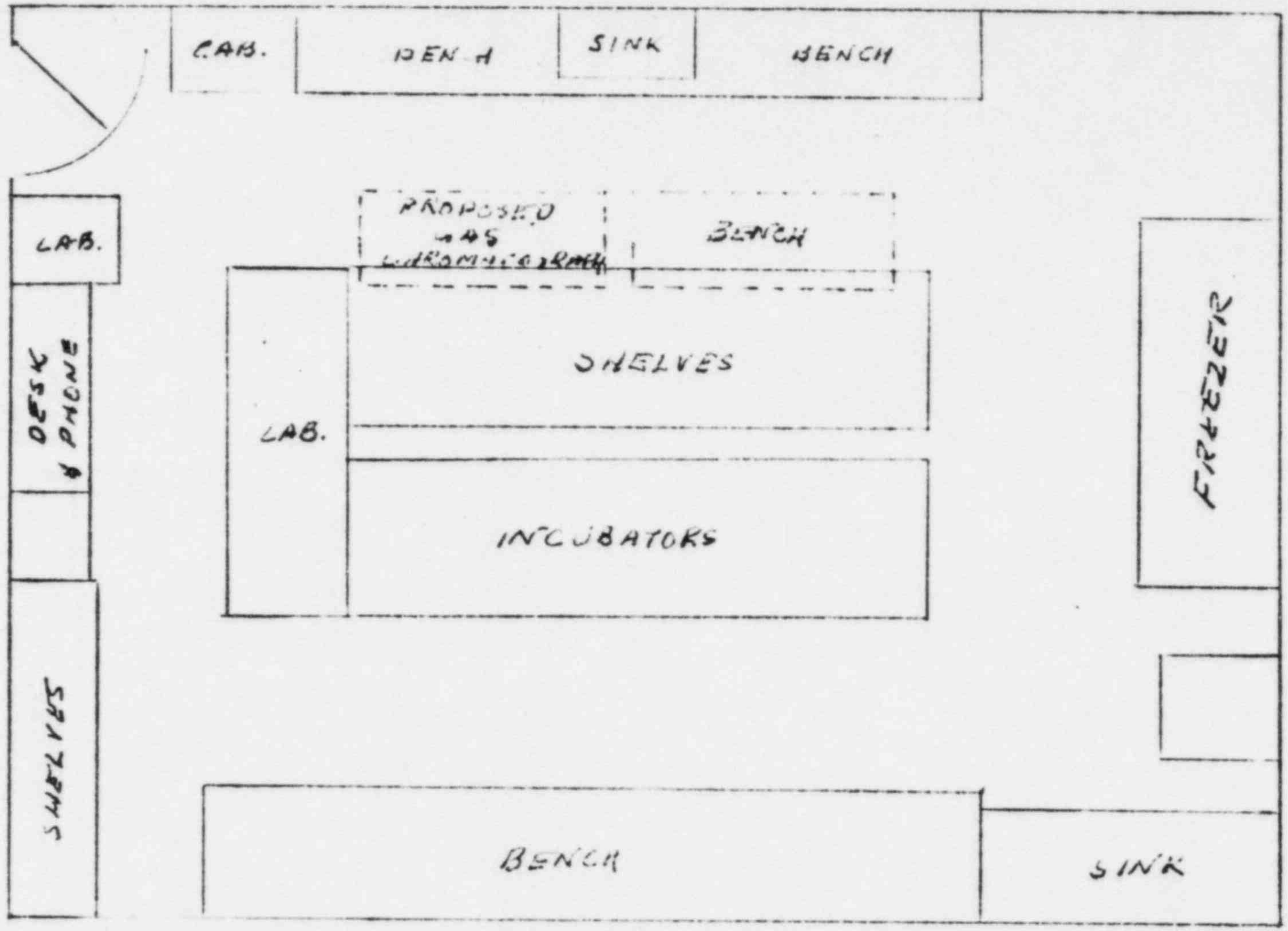


Figure 8 Plan of Geophysical Field Operations Room and adjacent areas. A fine dotted line shows differences between second and first floors. (The Operations Room is open to the ceiling, except for a second-floor mezzanine).

FIG. 9 SKETCH OF USGS NATIONAL CENTER ROOM 5B135, SHOWING FACILITIES AND LOCATION FOR PROPOSED GAS CHROMATOGRAPH



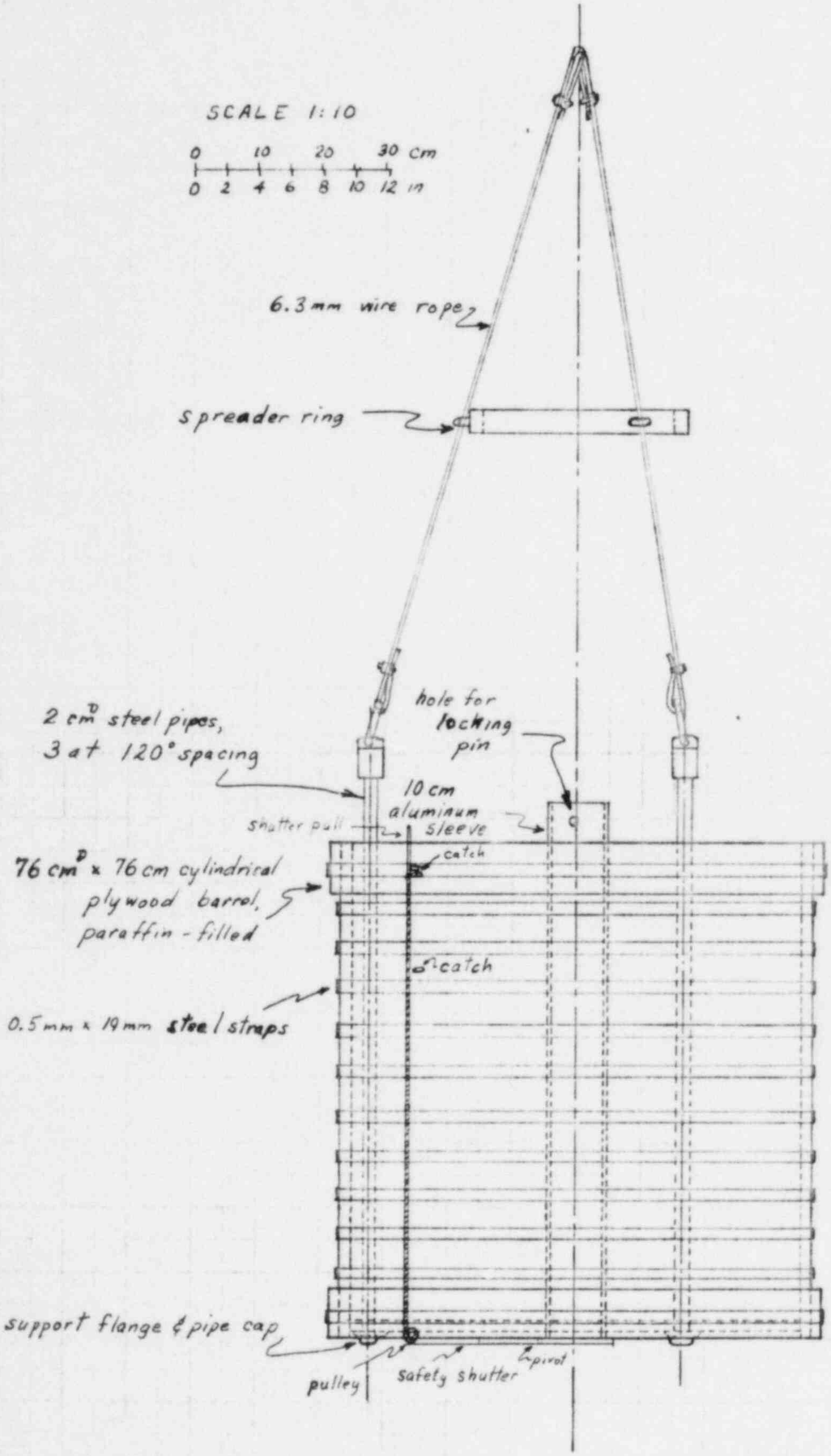


Figure 10 Borehole handling shield for Cf-252 sources. Minimum path length in paraffin is 29.6 cm (11.6 in). Measured maximum dose rate equivalent with 69.7 mCi source was 45 mrem/hr at surface, 5.1 mrem/hr at 30 in.

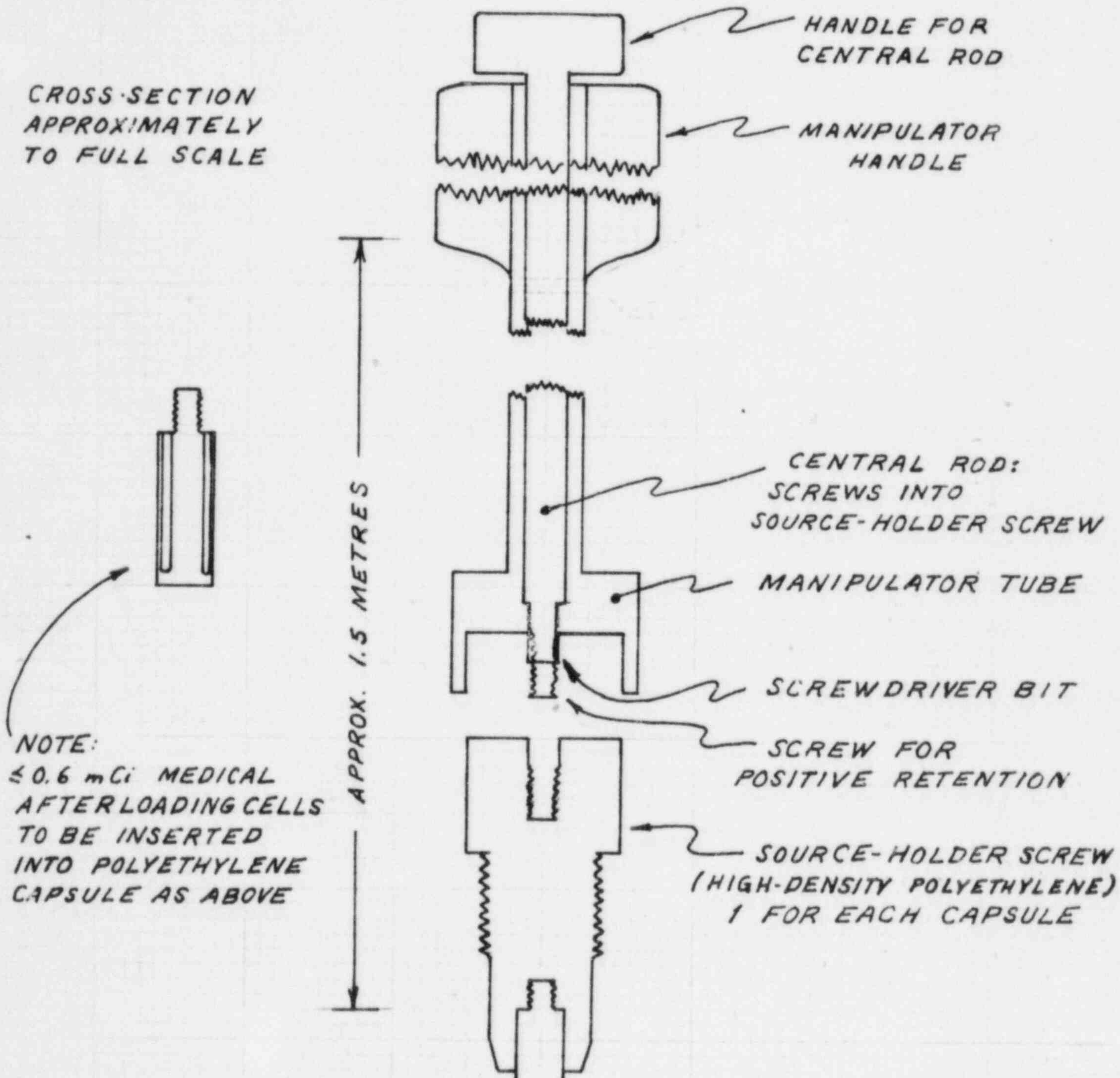


FIGURE 11. SOURCE-HOLDER SCREWS AND MANIPULATOR

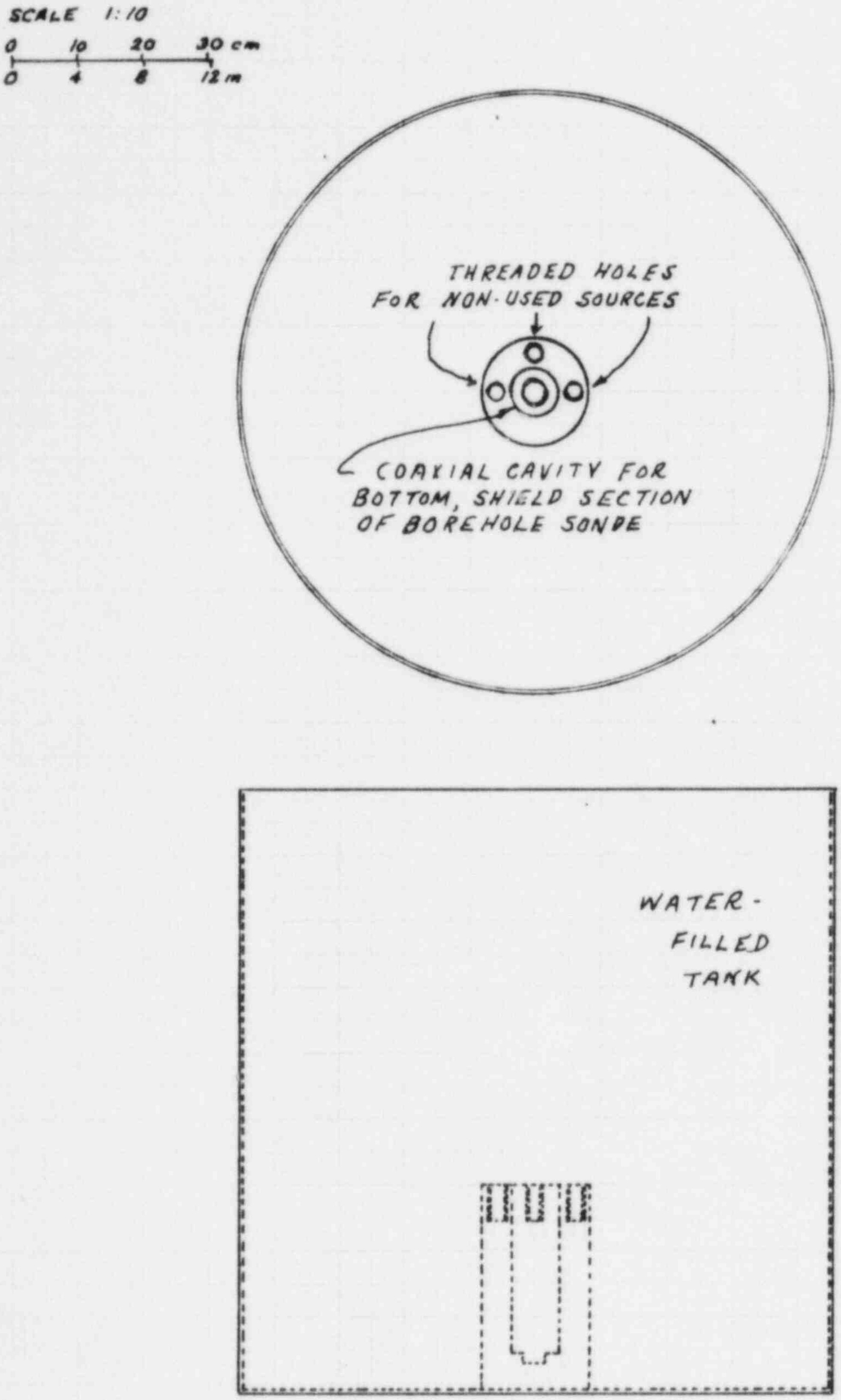


Figure 12 Heavy-duty polyethylene tank to be filled with water at job sites and used for personnel shielding during transfer of source-holding screws between the storage shield and the borehole sonde. Threaded holes are for temporary holding of sources located above the one to be used in the storage shield.

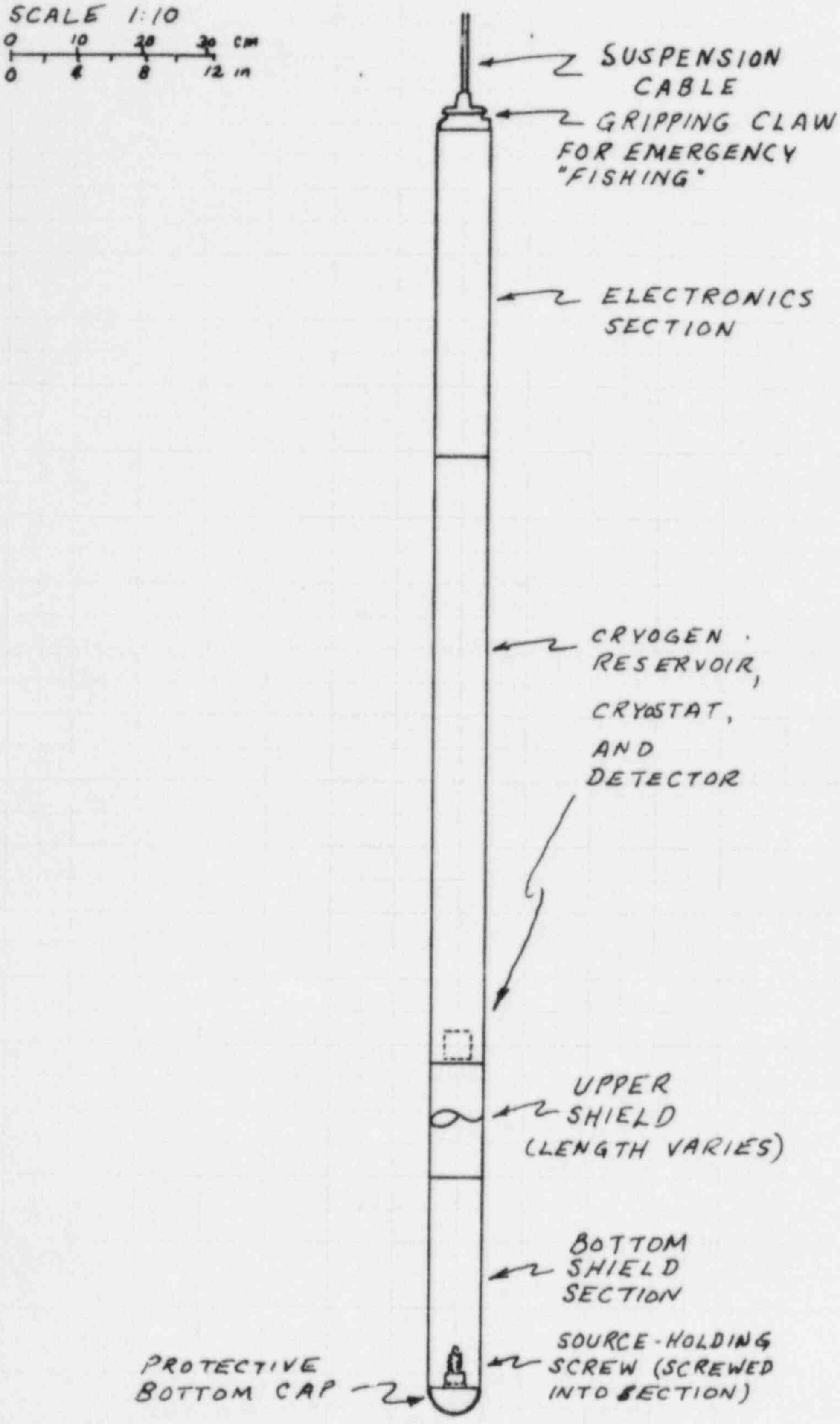


Figure 13 Outline-sketch of borehole sonde. The positions of the Ge detector and the Cf-252 source-holding screw are shown by dotted line.