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ANNUAL REPORT OF THE HEALTH SERVICES LABORATORY

NATIONAL REACTOR TESTING STATION

IDAHO OPERATIONS OFFICE
U. S. ATOMIC ENERGY COMMISSION

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1970
ANNUAL REPORT
OF THE
HEALTH SERVICES LABORATORY

Donald I. Walker
Director

UNITED STATES ATOMIC ENERGY COMMISSION

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PREFACE

The 1970 Annual Report of the Health Services Laboratory is published herewith in order to continue the documentation of the efforts and highlights of the Laboratory's activities during the past year. While many of the specific achievements of our personnel have been exhibited through various publication media and through presentations at scientific meetings, the report does permit the majority of the Laboratory's activities, primarily associated with the National Reactor Testing Station, to be gathered into one encompassing document, to be made available to friends and colleagues who share our interests in these endeavors.

With the increased emphasis, both nationally and locally, on environmental questions and issues, the Laboratory finds itself even more oriented toward such programs than before. New and revised air and water quality standards, promulgated by both Federal and state agencies, have required in 1970 and will continue to require in the future even greater efforts in our environmental programs for the NRTS. The ever-increasing demands for lower standards, greater sensitivities, and smaller emissions are reflected in our Laboratory work.

In mid-1970, the former Director of the Laboratory, George L. Voelz, M.D., accepted the position of Health Division Leader for Los Alamos Scientific Laboratory. As his successor, I join the entire staff of the Laboratory in expressing appreciation to Dr. Voelz for his leadership and guidance of the Health Services Laboratory programs during the previous three years. Also as his successor, it is my privilege to offer you, with pride, our 1970 report. Again, we solicit your comments and inquiries concerning our activities and programs; and we welcome exchange of information on these topics.

Donald I. Walker, Director
Health Services Laboratory

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1970 ANNUAL REPORT OF THE HEALTH SERVICES LABORATORY

I. INTRODUCTION

The Health Services Laboratory (HSL) is composed of five branches: Analytical Chemistry, Dosimetry, Environmental, Instrumentation, and Medical. Additionally, the U.S. Geological Survey (USGS) and the Air Resources Laboratories Field Research Office of the National Oceanic and Atmospheric Administration (NOAA) maintain technical staffs at the National Reactor Testing Station for which the HSL provides programmatic direction for their NRTS activities. The Organizational Chart for the Laboratory, effective December 31, 1970, is included as an appendix to this report.

There were no major organizational changes during 1970, though the Waste Management Section responsibilities for the compilation and maintenance of NRTS waste records were unified in ID's Nuclear Technology Division in Idaho Falls and the Section Chief was transferred to that Division. As of December 31, the staff totaled 74, a decrease of 2 from the end of the previous year. The number of professional personnel had changed from 49 a year ago to 48 at the end of this year. The number of technicians remained at 19 and the number of clerical personnel changed from 8 to 7. At year end, the USGS employed a staff of 5 and the NOAA a staff of 10.

The first responsibility of the Laboratory is to the National Reactor Testing Station, supplying services to the contractors in various fields including industrial medicine, personnel dosimetry, portable instrumentation, chemical and radiochemical analyses, as well as providing all environmental monitoring on and off the NRTS for air, water, soils, vegetation, and other selected types of samples such as milk and food grains. While a large share of the Laboratory's efforts is devoted to the routine work, considerable research and development work is performed, not only for the NRTS, but also for the AEC's Divisions of Biology and Medicine and of Reactor Development and Technology, both of which fund a portion of our efforts. A considerable part of the Laboratory's time and efforts is presently devoted to the AEC's Regulatory Program, providing environmental and chemical services to the Division of Compliance in its efforts to determine independently the conditions within, and in the environment of, various licensed facilities around the country. These have included boiling- and pressurized-water power reactors, fuel fabricating facilities, uranium mills, and materials handling facilities.

A volume such as this cannot, of course, include the complete details of the Laboratory's work, but it can serve to highlight the more important aspects of activities, from the viewpoint of both the operational work and the research and development programs, which we feel will be of greatest interest to our peers.

II. ANALYTICAL CHEMISTRY BRANCH

(C. W. Sill)

1. 1970 ANALYTICAL CHEMISTRY BRANCH ACTIVITIES

1.1 Routine Analytical Chemistry Activities

The Analytical Chemistry Branch of the Health Services Laboratory maintains the capability of providing chemical or radiochemical analyses for virtually all chemical elements and radionuclides in a wide variety of environmental and biological samples. The primary responsibility is to provide analytical services in support of operations at the NRTS, including work generated by NRTS contractors and the operational problems of the Health Services Laboratory. The other major source of routine analytical work comes from the Office of Regulation. This includes analyses of environmental samples obtained during routine surveillance of the licensees under each of the regional offices of the Division of Compliance, as well as similar samples resulting from the Independent Measurements Program recently inaugurated. This latter program involves an independent verification of the types and quantities of radioactive materials actually released to the environment by licensees operating nuclear power reactors and other nuclear facilities located throughout the entire United States.

During the past year, over 21,500 analyses were made on some 12,000 samples of many different types, and 684 direct in vivo measurements on humans were made. The analyses, most of which were made at extremely low levels, included most fission products, the transuranium elements, and the heavy element daughters of the naturally occurring series.

1.2 Independent Measurements Program (R. L. Kirchmeier, G. E. Grothaus)

The purpose of the Independent Measurements Program is to determine the quantities and types of radioactive materials actually being released to the environment by various licensed facilities in the United States. During the past year, the program has been expanded to include a fifth major nuclear facility in the environmental sampling program. The five facilities include a nuclear fuels chemical reprocessing plant, a scrap recovery-fuel fabrication plant, a commercial radioisotope production facility, a boiling water power reactor, and a pressurized water power reactor. In addition, even through certain gross analyses are still performed routinely on the more than 2,000 environmental samples received, there has been a marked shift in emphasis from gross analyses to specific quantitative isotopic determinations. Of approximately 6,500 analyses performed during the year, more than 150 were quantitative specific isotopic analyses in which over 30 specific isotopes were identified.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Calibration of Ge(Li) Detector (D. G. Olson)

Because NaI(Tl) detectors have known volumes and mass absorption coefficients, they are by definition detection standards. This is not true with Ge(Li) detectors because of an unknown drift depth and configuration. Therefore, a newly acquired detector was calibrated for many types and configurations of samples. Six nuclides were used with gamma energies covering the range from 0.1 to 1.4 MeV. The activity was counted as point sources 1, 3, 5, 8, and 10 cm from the face of the detector; as a liquid with the volume varying between 10 to 400 ml; and in 10 to 100 g of soil. The data for each configuration were plotted by a least-squares fitting technique and a tabulated readout was obtained. By using these tables the efficiency of any gamma ray in any of the counting configurations used can be readily selected.

2.2 Intercomparison of Gamma Detectors (D. G. Olson)

An intercomparison of three different gamma detectors using a ^{137}Cs source 1 cm from the detector and counted for one minute is listed in Table I and shown in Figure 1. The relative widths of the photopeaks at half-height show clearly the superior resolution of the Ge(Li) detector. The figure also shows that more counts will be in the peak channel of the Ge(Li) spectrum from the same source at the same distance from each detector. Therefore, the lower detection limit is obtained from the Ge(Li) detector. The final advantage of the Ge(Li) detector is the low Compton continuum, which means less interference to lower energy peaks.

TABLE I

INTERCOMPARISON OF THREE GAMMA DETECTORS

Detector	Size	Count at Peak	Peak Integral	Resolution FWHM, keV	Peak/ Valley	Peak/ Compton
Ge(Li)	65 cc	13755	1.89×10^4	2.3	393	49
NaI(Tl)	3 in. x 3 in.	2240	5.70×10^4	54	42	9
NaI(Tl)	8 in. x 4 in.	4200	1.38×10^5	66	30	12.4

2.3 Combined Computer Analyzer System (D. G. Olson)

Programs were developed so that the following techniques can be used. The alpha or gamma spectrum is searched for peaks with selected shapes and amplitudes. When a peak is located, the area is integrated. The background is determined by smoothing a 30-channel portion of the spectrum surrounding the peak and averaging the six channels having the fewest counts. Appropriate efficiency and yield corrections are made and the events-per-minute and the fraction of the total spectrum found in that peak are printed. Each peak in

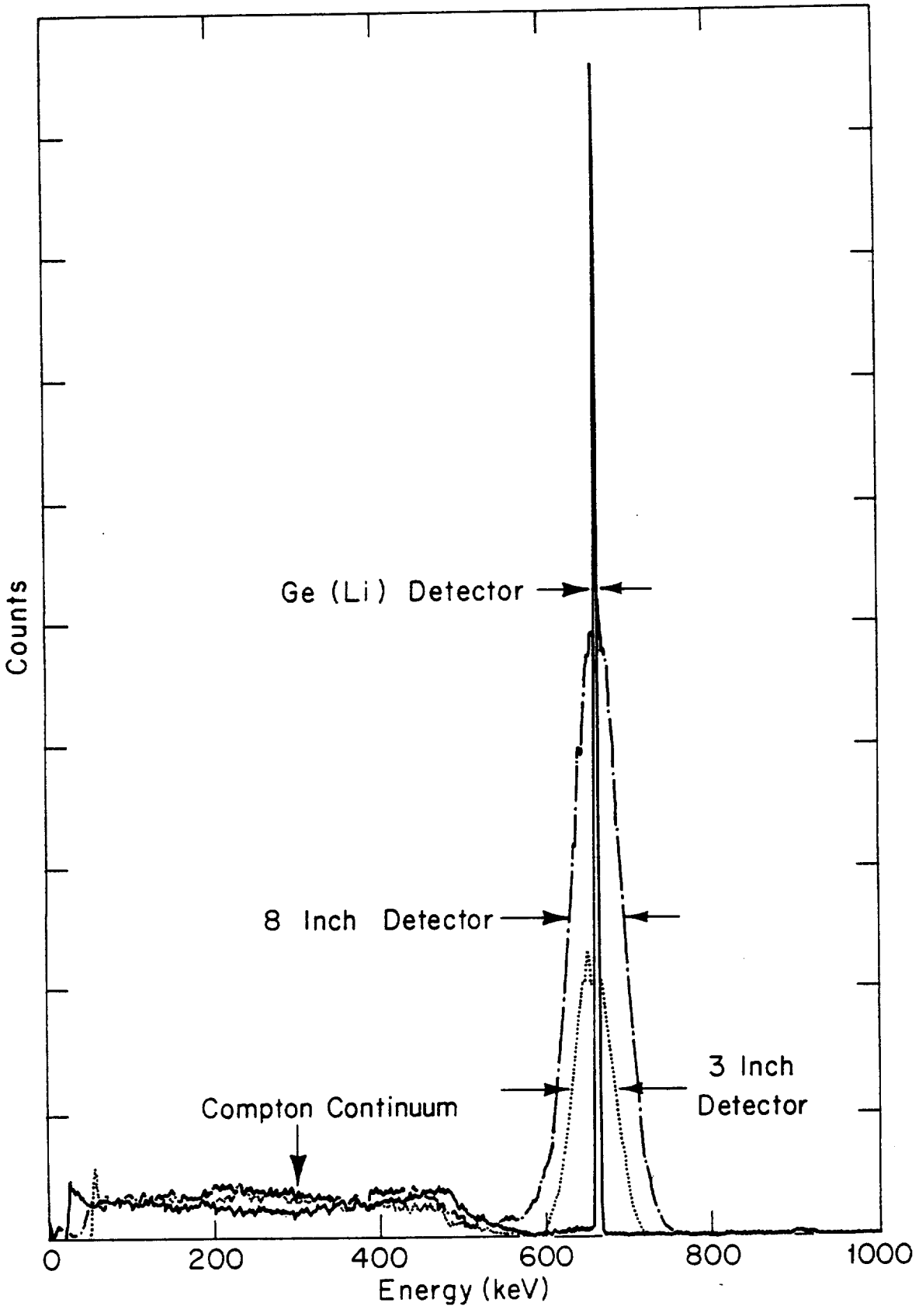


FIG. 1 GAMMA-RAY SPECTRA OBTAINED FROM COUNTING THE SAME SOURCE 1 CM FROM A 65 CC Ge(Li), A 3- BY 3-INCH NaI(Tl), AND AN 8- BY 4-INCH NaI(Tl) DETECTOR.

the spectrum is located and recorded in a similar way so that the data readout shows all the peaks which are found, along with their energies, emission rates, and the total events in the entire spectrum. At the operator's option, the process can be made automatic so that the analyzer is erased, another preset count collected, and resolved. Thus, the system is adaptable for use with automatic sample changers. The program also starts, stops, and erases the analyzer, provides digital printout, data smoothing, data transfer, seven linear plot scales, three semilog plot scales, and point plotting.

2.4 Direct Gamma Spectral Analysis for Thorium in Background Level Soils (B. B. Barnett)

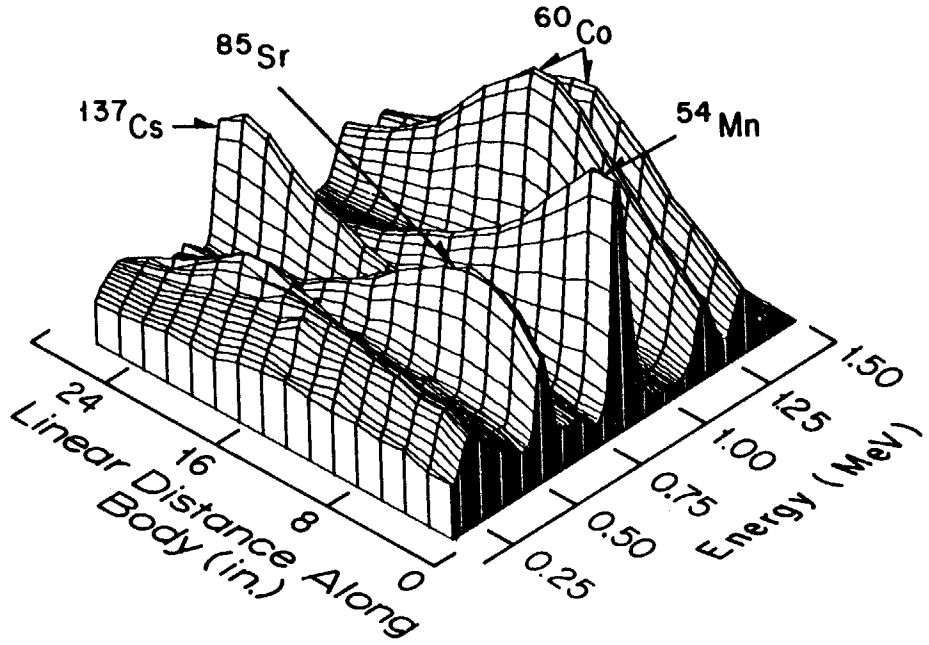
A procedure has been developed for the direct gamma spectral analysis of background level soils for thorium. The advantages of this procedure are: there are no chemical manipulations of the sample; the aliquot size is large, thus minimizing errors due to sample inhomogeneity; and other low-level gamma emitters may be determined with the same count. The determination is made using from 100 to 125 grams of soil; the count time is 1,000 minutes (overnight); and the detection limit is 0.16 mg of thorium, which is equivalent to $1.6 \times 10^{-4}\%$ thorium by weight.

2.5 Whole-Body Counting and Gamma Spectrometry (J. I. Anderson)

Special counting techniques and computer programs have been developed to trace the movement of radionuclides in the human body. Distributions of radioactive elements in the body are determined by helical scanning. Computer-produced isometric plots of multiple gamma-ray spectra define the positions of the radionuclides in the body.

Figure 2 shows a typical computer-produced isometric plot from a helical scan of a phantom containing sources of ^{54}Mn, ^{85}Sr, ^{60}Co, and ^{137}Cs. One spectrum was accumulated for each of 16 different revolutions of the detector around the body while it moved 24 inches parallel to the central axis of the body. Therefore, each spectrum represents gamma activity for one of 16 different cross-sectional areas of the body. The order of the four different sources along the body is readily discernible from the plot. The 0.84-MeV peak of ^{54}Mn appears on the distance axis maximally at zero inches, the 0.51-MeV peak of ^{85}Sr at 8 inches, the 1.17- and 1.33-MeV peaks of ^{60}Co at 16 inches, and the 0.66-MeV peak of ^{137}Cs at 24 inches. One of 17 sets of numerical values for the spectra is shown underneath the plot. Relative quantities of the different nuclides in different cross-sectional areas are shown in the seventh column under area.

Figure 3 shows results from a scan of an individual with 1.5 μCi each of ^{137}Cs and ^{60}Co in the GI tract. The two different isometric plots are from the same data. Only the angle of viewing the spectra differs. The ^{60}Co with its 1.17- and 1.33-MeV peaks had been ingested about 1.5 hours prior to the scan. The ^{137}Cs was held in the mouth while the counting data were accumulated. The plots show the 0.66-MeV peak for ^{137}Cs at zero or the starting position of the detector which was over the mouth. The centroid of the ^{60}Co peaks which was in the stomach is at about 16 inches down the body from this reference point. The variation in the distribution of the radioactive elements can be determined if large numbers of these plots are obtained in sequential order



FIRST CHANNEL	LAST CHANNEL		HEIGHT	CHANNEL	WIDTH	AREA	QUALITY OF FIT	IDENT.
46	55	PARAMETERS→ ERRORS →	7667.6 152.3	50.2054 0.0574	6.779 0.155	55326. 992	7.55	^{85}Sr
60	70	PARAMETERS→ ERRORS →	6940.0 119.9	64.4383 0.0580	7.713 0.158	56978. 906	6.13	^{137}Cs
77	86	PARAMETERS→ ERRORS →	9970.2 67.3	81.2476 0.0229	7.755 0.068	82301 539	1.39	^{54}Mn
109	118	PARAMETERS→ ERRORS →	13574.1 58.8	113.5453 0.0195	9.580 0.072	138429. 748.	0.38	^{60}Co
125	134	PARAMETERS→ ERRORS →	11497.8 86.6	128.7027 0.0410	9.895 0.140	121104. 1283.	2.67	^{60}Co

FIG. 2 COMPUTER-PRODUCED PLOT AND NUMERICAL DATA OF A HELICAL SCAN.

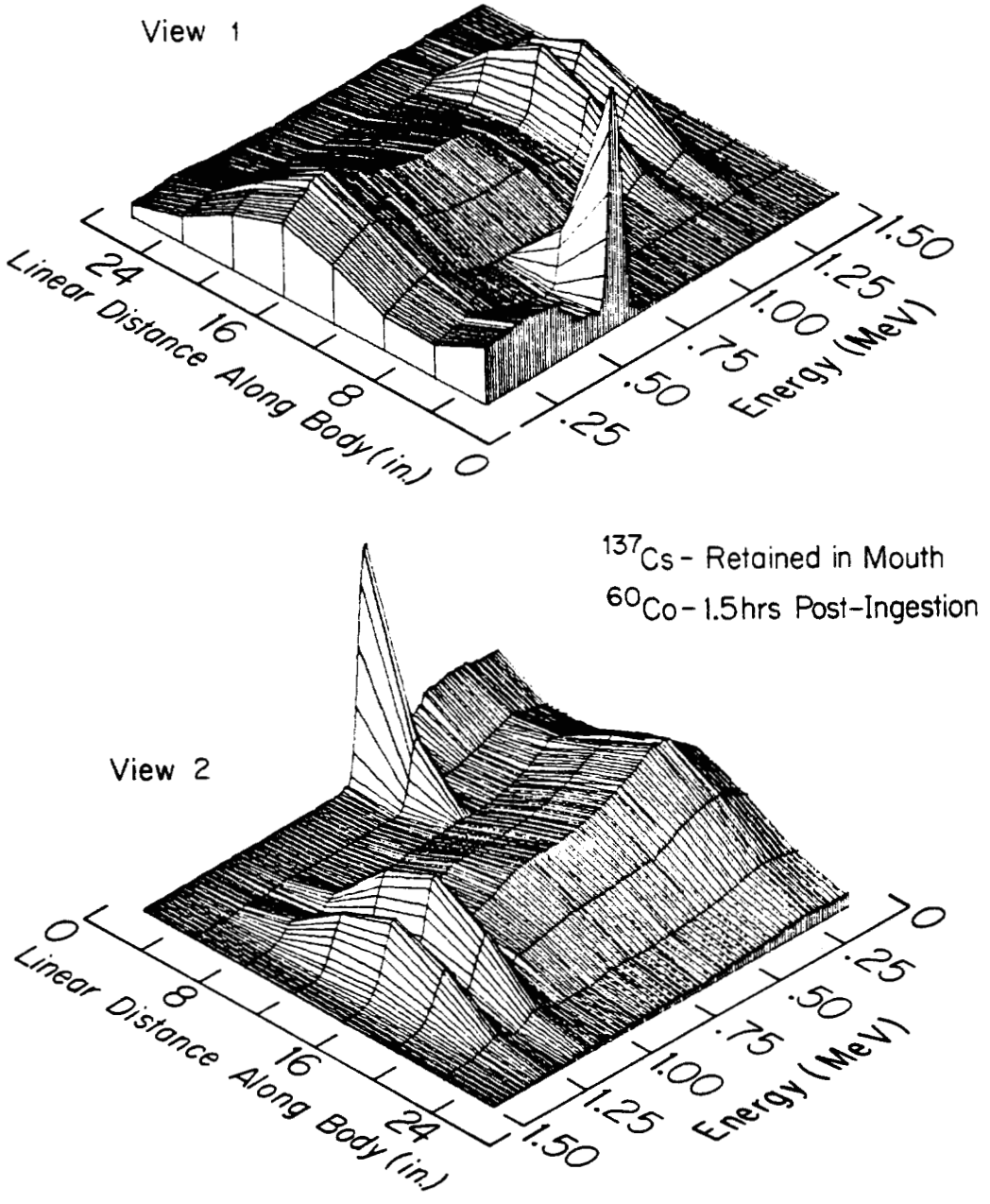


FIG. 3 COMPUTER-PRODUCED PLOTS OF A HELICAL SCAN OF A HUMAN SUBJECT WITH 1.5 μCi EACH OF ^{137}Cs AND ^{60}Co.

by repeated helical scans. Changes in the position of photopeaks of the plots reflect changes in the distribution of the radioactive elements in the body. Plots that are produced directly from the original counting data and plots produced by linear extrapolation between original data sets are recorded sequentially on 16 mm movie film. A dynamic display of the plots is shown when the film is projected as a motion picture. Movement of the different photopeaks in the gamma-ray spectra depict movement of specific radionuclides in the body. Coordinates of the plots define the nuclide and its position.

Our computer capability for reducing the data from gamma-ray spectra has been improved by the incorporation of a "peak search" subroutine into the program. The program was written for the large IBM 360 computer. The new subroutine locates the peaks in a spectrum and fits them to a modified gaussian function by the method of least squares. Accurate values are calculated for the position, height, width, and area of each peak in the spectrum. The program is versatile, so it is applicable to alpha and gamma-ray spectra from different types of detectors. It has been used successfully to reduce spectra from whole-body counts and spectra from Ge(Li) detectors. The program has been used to analyze large numbers of soil and water samples from the NRTS burial ground.

2.6 Freeze Dryer (J. I. Anderson)

Preliminary work has been done to develop a capability to study trace elements in tissues of humans and animals. Freeze drying is an accepted method used to remove water from tissue samples before neutron activation. Laboratory-built equipment is now operational in our laboratory for freeze drying large and small volumes of tissue and tissue homogenates. Twenty-four small tissue sections can be dried simultaneously in small polyethylene bags. After the drying is completed, the bags are sealed and inserted into plastic rabbits to be activated in the reactor.

2.7 Vacuum Operated Sample Changer (J. I. Anderson)

To prepare for automatic analysis of activation samples, a laboratory-built sample changer has been interfaced to the ND 4096 analyzer. The simple vacuum-operated system shown in Figure 4 was designed for use with a Ge(Li) detector to count small biological samples that have been activated in the reactor. Samples to be counted are held in the vertical section of the vacuum line. In order to simplify the electrical control system, signals that operate the analyzer and the readout indicator lamps on the multichannel analyzer were used to trigger the sample control solenoids. In the analyzer mode of operation, the solenoid that allows a sample to move to a position over the detector is triggered. The readout mode triggers one solenoid to release the sample to the sample storage container and a second solenoid to allow another sample to move to a precount position between the two sample control pins in the vertical part of the vacuum line. After readout is complete so that the data are recorded on magnetic tape, the cycle is repeated. Counting data for each sample are recorded automatically on magnetic tape. The quantitative results are calculated by the IBM 360 computer by using the "peak search" routine previously described.

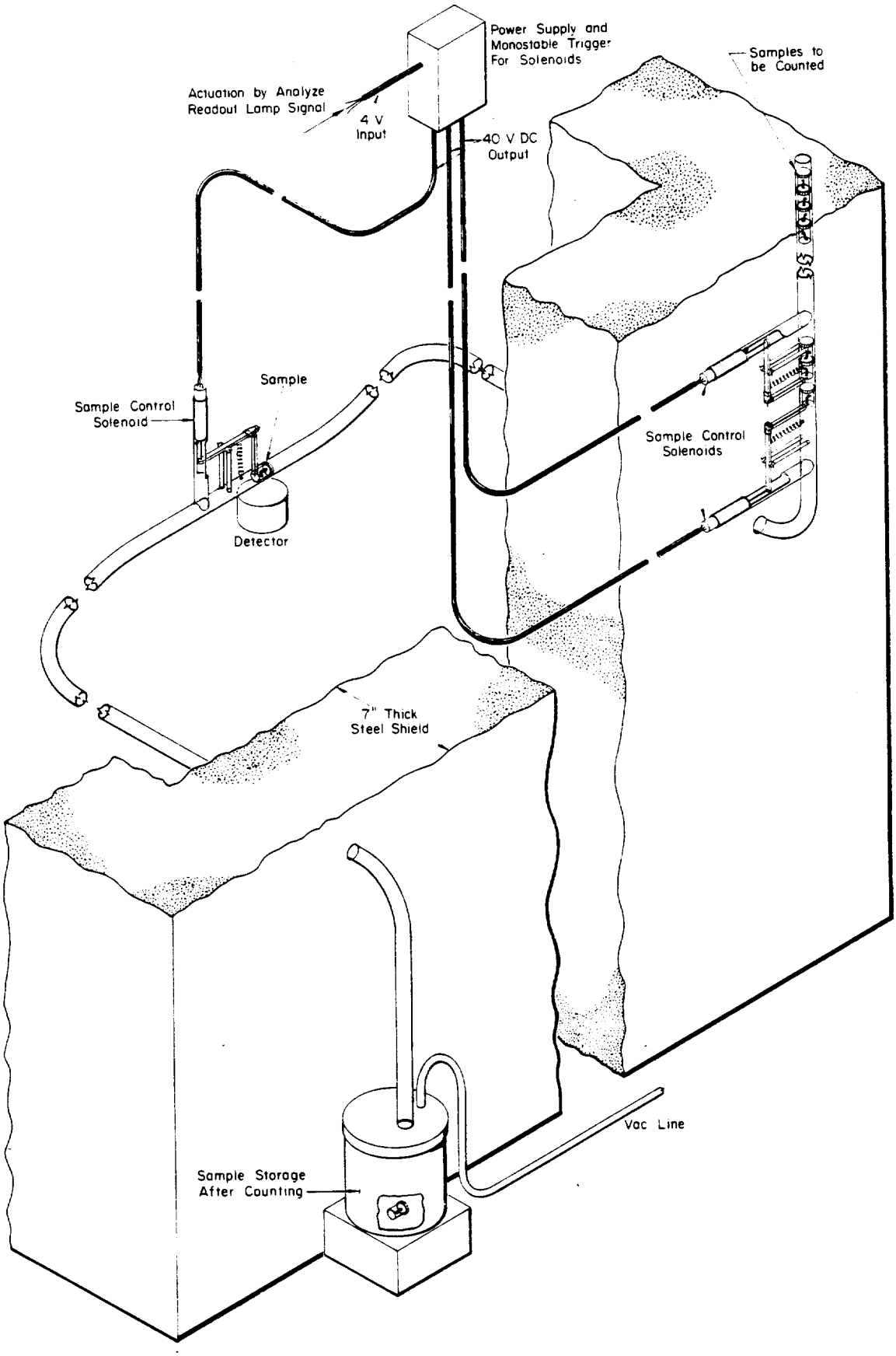


FIG. 4 VACUUM-OPERATED SAMPLE CHANGER.

2.8 Electrodeposition Procedure for High Resolution Alpha Spectroscopy (K. W. Puphal, D. R. Olsen)

The present electrodeposition procedure was modified to include 100 mg of $NaHSO_4$ in the electrolyte to prevent the formation of refractory and, subsequently, undepositable forms of the alpha-emitting actinides. Additional work includes an extensive and comprehensive study of interference of cations in the deposition of ^{230}Th, ^{233}U, ^{239}Pu, and ^{241}Am. The interference of certain cations such as aluminum and iron that form fluoride complexes was reduced markedly by the presence of fluoride.

2.9 Gross Alpha Research (K. W. Puphal, D. R. Olsen, F. D. Hindman)

A method was developed for the analysis of all actinides in 10 g of soil. After precipitation of the actinides on $BaSO_4$, the $BaSO_4$ is dissolved in molten $Al(NO_3)_3 \cdot 9H_2O$. The aluminum nitrate is adjusted to 2.5M and the actinides in all their valences are extracted into a quaternary amine. Selective back

corrosive effects of direct contact with the sample. Disadvantages are: (a) the direct fusion method requires a flux to sample ratio of 6 to 1 as opposed to the 3 to 1 ratio required for pretreated samples, and (b) subsequent transposition of the potassium fluoride cake with sulfuric acid is incomplete when the sample contains more than about 5% iron. The method appears to be generally useful for soil samples up to 5 g but is not recommended for any quantity of ores and solid process wastes.

2.13 Determination of ^{210}Po in Soils (R. P. Bernabee)

A procedure has been developed for the determination of ^{210}Po in as much as 10 g of soil. The method utilizes total sample decomposition via fluoride and pyrosulfate fusion in the presence of strong oxidizing agents to prevent ^{210}Po from volatilizing or plating on the platinum vessel. The ^{210}Po is then extracted with tri-n-laurylamine from an HCl solution and stripped with 4N perchloric acid. The determination of ^{210}Po can then be made either by spontaneous deposition on silver or by precipitation with tellurium. Overall recovery is 99%.

2.14 Elimination of ^{210}Po from Platinum (R. P. Bernabee)

Under certain conditions, ^{210}Po will deposit on platinum and is highly resistant to removal by acids. The problem is compounded by the fact that ^{210}Po will deposit on platinum from concentrated HNO_3. Decontamination factors of 200 have been obtained on platinum electrodes using a cleaning bath of H_2SO_4, Ce(IV), and Na_2SO_4.

2.15 Instability of ^{210}Po Tracer in Acids (R. P. Bernabee)

Observations of ^{210}Po tracer solutions (over a period of time) prompted a study of such solutions. Polonium-210 does not appear to be stable in 1 m HNO_3 over a period of 30 days. A solution of HNO_3 and H_2O_2 stablizes the ^{210}Po over the length of time studied. Various combinations and acids are presently under investigation as to their stability.

2.16 Determinations of ^{90}Sr (L. E. Thompson)

A new procedure for ^{90}Sr in soils is being developed to shorten the time required for analysis and to eliminate the use of a hazardous chemical, fuming nitric acid. The procedure involves a solvent extraction of the yttrium daughter from aluminum nitrate. Preliminary studies indicate the feasibility of separating strontium phosphate from all other radionuclides at pH 4.0 to 4.5. The procedure might be developed into a rapid method of high yield for ^{90}Sr determination in water.

2.17 Measurement of Gross Activity in Environmental Samples (R. L. Kirchmeier)

It has been observed that, because of variations in the atomic number, density, particle energy, and particle size and distribution in raw environmental samples, the accurate determination of gross activity present in a sample prior to any chemical treatment is extremely difficult. Therefore, several correction curves have been derived under controlled conditions on specific environmental samples of known composition in order to determine the effect of each variable

mentioned above. The variation in atomic number, density, gross particle energy, and particle distribution has been shown to cause up to 100% error in the determination of the amount of activity present. The effect of particle size is yet to be studied. A mathematical description of several of the correction curves has been developed.

2.18 Determination of ^{14}C in Environmental Samples (R. B. Randolph)

The previous procedure for determination of ^{14}C in environmental samples by liquid scintillation was improved and extended to include vegetation and air samples. A faster and more complete degradation of vegetation samples was accomplished by a wet combustion procedure using a mixture of perchloric and nitric acids in a ratio of 20 to 1. The $^{14}CO_2$ from the samples is collected in large bubblers containing saturated $Ba(OH)_2$ with nearly 100% efficiency. The $Ba^{14}CO_3$ precipitate is suspended in a scintillation gel and counted.

2.19 Determination of ^{90}Sr and ^{89}Sr Simultaneously by Liquid Scintillation (R. B. Randolph)

A method is being developed to determine both ^{90}Sr and ^{89}Sr in environmental samples by liquid scintillation beta spectrometry. This method would have obvious advantages over the usual methods used for determination of ^{90}Sr in that it would eliminate the need for beta counting the chemically separated ^{90}Y daughter after ingrowth of several days. The method involves elimination of the ^{90}Y as the hydroxide and subsequent dissolution of the strontium salt in a homogeneous liquid scintillation system. A dual isotope technique is then used to determine the ^{90}Sr and ^{89}Sr simultaneously.

2.20 Automatic Sample Changer (C. P. Willis)

An automatic sample changer for gamma spectral analysis of both solid and liquid samples has been placed in operation. The data are read out of a TMC 400 channel analyzer on paper tape which can be fed into a computer for data reduction.

2.21 The Fluorometric Determination of Zirconium (T. D. Filer)

A fluorometric method for zirconium using 3,4',7-trihydroxyflavone in a sulfuric acid solution has a detection limit of 0.05 μg, a precision of about 1% on 5 μg, and excellent tolerance to most common elements.

2.22 The Fluorometric Determination of Antimony (T. D. Filer)

A fluorometric procedure for the determination of antimony using 3,4', 7-trihydroxyflavone has been developed that is 50 times more sensitive than any other method. The fluorescence of the antimony (III) complex is measured in a perchloric acid solution using phosphate as a masking agent. The method has a detection limit of 0.04 μg, a precision of about 2% on 5 μg, and excellent tolerance to many common elements. After decomposition of the sample by pyrosulfate fusion, the antimony is extracted as the triiodide into methyl isobutyl ketone from a sulfuric acid solution.

2.23 The Fluorometric Determination of Tin (T. D. Filer)

A fluorometric method for the determination of tin is being developed using 3,4', 7-trihydroxyflavone. The method is more sensitive than any previously known procedure, having a detection limit of 0.007 μg and a precision of about 2% of 1 μg of tin.

2.24 Determination of ^{125}I and ^{131}I in Bovine Thyroids (L. E. Howard)

In the Controlled Environmental Release Tests (CERT) 28 and 29, ^{125}I and ^{131}I were administered to six cows. After the radioactive iodine was fixed in the thyroid, it was found that the effective half-life could be reduced 30% by feeding 10 g of stable potassium iodide daily. These data agree with the results obtained in 1969.

2.25 Whole-Body Counting (L. E. Howard)

Two separate studies of interest were performed on employees from the NRTS. One individual received a lung burden of 0.5 μCi of a mixture of ^{182}Ta, ^{175}Hf, and ^{181}Hf. The effective half-life of each isotope was determined. The second study was on a puncture wound in the finger of an employee in which ^{60}Co, ^{95}Zr-^{95}Nb, and ^{181}Hf were identified at levels below 0.02 μCi.

2.26 High Resolution Alpha Spectrometry of Environmental Samples (R. L. Williams)

A method has been developed for high resolution alpha spectrometry on samples up to 100 ml of water and 0.5 g of soil. The alpha activity is co-precipitated on barium sulfate, dissolved in EDTA, and reprecipitated on 0.2 mg of cerium (IV) hydroxide. Overall recovery is better than 95% of all alpha emitters from thorium to californium except uranium. A uniform deposit of the cerium hydroxide on a two-inch plate produces a spectral resolution of better than 35 keV for ^{241}Am.

2.27 Determination of All Alpha Emitters on Samples of Up to 0.5 g of Soil (R. L. Williams)

Samples of up to 0.5 g of soil can be co-precipitated on 20 mg of $BaSO_4$ with an efficiency of better than 97% for the worst case. Calcium is kept in solution with HCl and uranium is reduced with titanium trichloride. Other potential interferences are eliminated by keeping the sample size below 0.5 g.

2.28 Reduction of Pu and Oxidation of U with Iron (R. L. Williams)

The use of a mixture of ferrous and ferric iron as a reductant for plutonium and oxidant for uranium was studied and found to be satisfactory for both requirements. When iron was added, only 0.008% of the plutonium remained in the oxidized state and only 0.3% of the uranium remained in the reduced state. Iron and sodium sulfate are used to replace H_2O_2 to prevent the catalytic oxidation that occurs with peroxide in the presence of iron.

3. PUBLICATIONS

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L. E. Howard, Jr., J. H. Spickard, M. Wilhelmsen, "A Human Radioactivity Counter and Medical Van", Health Physics (in press).

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III. DOSIMETRY BRANCH

(F. V. Cipperley)

The Dosimetry Branch of the Health Services Laboratory provides routine personnel dosimetry service for everyone employed at the National Reactor Testing Station and for all visitors who enter radiation areas. The Branch also is involved in applied research projects in dosimetry, has a sizable record-keeping function, and provides a variety of special services in the field of dosimetry such as consulting and support service to contractors regarding dosimetry problems.

1. OPERATIONAL DOSIMETRY ACTIVITIES

1.1 Summary of External Radiation Exposure Statistics

The Dosimetry Branch provided personnel dosimetry coverage for 7,934 regularly assigned persons and 10,211 visitors to the NRTS during 1970. This involved the processing of 47,321 permanently assigned beta-gamma dosimeters, and 10,211 temporary dosimeters for transient personnel. The Branch also provided special processing of 1,199 permanently assigned dosimeters at the request of the contractors' health physicists, and processed 56,615 other nonroutine items. Personnel dosimetry coverage was also provided for approximately 4,300 persons at four offsite AEC-connected facilities involving some 5,000 dosimeters. A total of 115,346 dosimeters of all types were processed during the year.

Approximately 7,800 persons, or 98% of the monitored personnel, received an annual accumulated exposure of less than 3.0 rem; while 95 persons, or a little less than 2.0%, received between 3.0 and 5.0 rem. No one received more than 3.0 rem in any quarter nor 5.0 rem for the year, the recommended radiation protection guides for occupational exposure.

The total recorded accumulated whole-body radiation exposure for NRTS personnel in 1970 was 1,655 rem. The average annual accumulated exposure of 234 mrem per person compares favorably with the current 10-year average of 308 mrem per year.

1.2 Summary of Internal Radiation Exposure Statistics

Results obtained by the Analytical Chemistry and Medical Branches on 954 urinalyses and 1,394 in vivo whole-body counting measurements on humans were recorded and tabulated. Although some statistically significant activities were detected, no significant exposures were found.

1.3 Offsite Coverage

The Dosimetry Branch provides dosimetry service for several offsite AEC-connected groups. This is in line with Atomic Energy Commission policy on Intra-Agency assistance to increase efficiency and lower costs.

Personnel dosimetry coverage for some 500 regular employees and 1,000 visitors at the Nuclear Rocket Development Station (NRDS) in Nevada was provided. A personnel dosimetry Record and Report system was developed by Pan Am personnel which greatly simplified reporting of personnel exposures at the NRDS. No potentially dangerous exposure situations were encountered during the year.

Provision of dosimetric services to Sandia Laboratories at Livermore, California, was begun in June. Coverage for approximately 800 regular employees and 2,000 visitors is presently being provided. All of the regular employees are covered on an annual basis except 30 which are monitored monthly.

Personnel dosimetry coverage for personnel of the Compliance Division, Region IV, at Denver, Colorado, and for members of the Radiological Assistance Team at AEC Headquarters was continued during 1970.

1.4 Program Improvements

The thermoluminescence analysis equipment utilized in the Independent Measurements Program has been improved in order to obtain greater accuracy and reliability of radiation measurements in the environment at very low dose levels. A new photomultiplier tube has been installed that has a signal-to-noise ratio of over 10,000 to 1. An electronic gating mechanism has been installed to activate the phototube when the thermoluminescent dosimeter (TLD) planchet has reached a predetermined temperature and to deactivate the tube upon completion of the glow curve. This technique allows a 50 to 60% reduction in apparent dark current which includes the infrared component produced by the heated planchet. The computer program to analyze the data has been thoroughly reviewed with respect to data handling and the statistics applied to perform the exposure calculations; a revision is in progress.

In order to provide reliably uniform and reproducible radiation measurements, the thermoluminescence analyzers (TLA) must be calibrated on a continuing basis. An NBS certified picoampere source has been obtained for calibrating the TLA electronics. Also a precision surface temperature thermocouple measuring probe with associated electronics has been obtained to calibrate the heater circuits in the TLAs. The environmental chamber has been completely calibrated to provide programmed temperature and humidity cycles in order to study environmental effects on thermoluminescent dosimeters.

Early in 1970 the calibration facility was transferred from CF-634 to CF-638. The transfer provided greater convenience in the use of the existing radiation sources and allowed the establishment of a high-level calibration capability. At present the facility is divided into four sections, a radiation-free control area, a low-level calibration room for the automatic ^{226}Ra calibrator, a medium-level room for generating filtered X-rays or K-fluorescent monoenergetic X-rays, and a high-level calibration room utilizing a ^{60}Co gamma ray camera. A closed-circuit TV system and remote control equipment have been installed in the low-level calibration room to monitor and control the ^{60}Co camera in the high-level calibration room. Through the use of this facility the Dosimetry Branch now has the capability to perform radiation calibrations in the energy range of a few keV through ^{60}Co, with dose rates ranging from 0.5 mR/hr through more than 10 kR/hr. Good accuracy is assured

through the use of free-air ionization chambers, NBS calibrated intercomparison standards, and condenser R meters.

The computer program to evaluate data generated from Nuclear Accident Dosimeters and Personnel Neutron Threshold Detectors has been updated. The program has been combined and simplified to shorten the emergency neutron dosimetry procedures. The sequence of events necessary for analysis is now more efficient and logically arranged.

2. SPECIAL PROBLEM DOSIMETRY

The Dosimetry Branch has developed methods, devices, and application of materials that enable accurate gamma exposure measurements from 0.5 mR through 10^6R and neutron dose calculations at five energy levels. Various thermoluminescent and radiophotoluminescent (RPL) materials, as well as activation foils, radiochromic dyes, and dosimetric films, are utilized to support the AEC contractors in the performance of special problem dosimetry.

2.1 Uranium Mine Radiation Measurements (J. P. Cusimano)

The Western Area Occupational Health Laboratory of the Public Health Service requested that the Dosimetry Branch utilize its skill and knowledge of thermoluminescence dosimetry to determine the effect of plate-out of the radon progeny at various working levels to determine the gamma dose-rate from the uranium concentration in mine walls. These gamma measurements would determine whether uranium miners should be badged in order to assess total whole-body exposure above normal background. The measurements were performed in the Public Health Service Uranium Research Mine in the Ambrosia Lake district near Grants, New Mexico.

2.2 High-Level Gamma Measurements (J. P. Cusimano)

In order to facilitate the design of a large diameter loop in the ATR, gamma heat measurements were requested by Bettis Laboratory to be performed in the ETRC loop mock-up, positioned in one of the flux traps of the ATRC. Calcium fluoride: manganese (CaF_2:Mn) TLD material encapsulated in 1 x 6 mm glass rods was used for the radiation measurements. Similar gamma heat measurements utilizing the CaF_2:Mn microrods were performed in the ETRC. The use of the TLD microrod dosimeters allows in-core measurements to be made without appreciable perturbation of the flux patterns.

3. RESEARCH AND DEVELOPMENT PROJECTS IN DOSIMETRY

3.1 Radiation Damage Studies (J. P. Cusimano)

Experiments are planned at the Naval Reactor Facilities to determine radiation damage to various components. A feasibility study was performed to determine the types of TLD materials, RPL materials, and various other

dosimetric materials that could be utilized in ranges from 10^7 through 10^{10} rad with a good degree of accuracy and reproducibility. The measurements are to be performed over periods of time ranging from 3 to 6 months with varying dose rates to the component under study; therefore accuracy is of prime importance. The study has revealed that two dosimetric materials, bismuth borate glass and triphenylmethane dye cyanides, can be utilized for measurements of high doses in the megarad region. The response of these materials is determined by the spectrometric change of optical absorption in the visible region. Experiments are under way to determine the reliability, reproducibility, energy dependence, and temperature effects of the dosimetric materials.

3.2 Phosphor Evaluation (J. P. Cusimano)

Many of the NRTS contractors request measurements of gamma-ray dose in mixed neutron gamma-ray fields. These are often performed with lithium fluoride thermoluminescent phosphor. It has been observed that the apparent gamma-ray dose measured by this method can be as much as 5 to 10 times greater than the true gamma-ray dose, depending on the radiation, the batch, and history of the dosimetric material. The apparent enhancement of response can be explained in terms of ^6Li content of the phosphor. The thermal neutron cross section of ^7Li is negligible in comparison with the 945-barn cross section for the (n, α) reaction in ^6Li. Therefore, a study was begun to determine the percentage of ^6Li contamination in a variety of batches of ^7Li thermoluminescent phosphor to determine if a correction can be applied for the neutron response with respect to the percentage of ^6Li contamination. This study is still in progress.

3.3 CaF_2:Dy Fade Study (J. C. Culley)

A computer program to evaluate the fade rates of TLD materials and mathematically describe a TL "glow-curve" has been developed. Equations were developed that will predict and describe the fade characteristics of CaF_2:Dy TL dosimeters. The process involves reducing a TL "glow-curve" by a spectrum strip and enhancement technique into a set of five probability distributions representing five TL temperature zones. The ratio of the TL trap temperature to the standard deviation of the normal curve representing the TL "glow-peak" (T/σ) is a constant. It has been observed that the value of the constant is the same regardless of the "glow-peak" being analyzed. The computer program has been designated the ROCINANTE method.

3.4 Electronic Data Processing (V. D. Watkins, G. McDaniel)

The Mark IV programming system is a software system developed by Informatics Inc. for use in IBM 360 computers. This is a file management system which provides a fast and simple means of creating data files and producing reports from data files. Use of this system should provide a significant reduction in Branch programmer costs in the future.

During the year several programs for the IBM 360 were developed. One program was written to produce badge reports, ordered by a special code, such that work groups and work types can be arranged together. This report has been very useful in controlling exposure levels of specific groups of people.

Another program creates reports in alphabetical order, grouped together by contractor or for all active NRTS personnel. This report is used for control of individual exposures without requiring knowledge of the workers' dosimetry badge numbers.

Work was begun on a program to generate the Monthly Termination Report required by AEC Manual Chapter 0525. This has been a difficult program to design because both the report tape and master tape files must be searched to obtain the required information.

3.5 Commercial Equipment Evaluation (J. P. Cusimano, M. R. Guffey)

A commercial semi-automatic personnel TL dosimeter analyzer and a number of TL dosimeter packets were evaluated. The test program determined the overall reliability, reproducibility and long-term usability of the system and the TL dosimeters. This was performed to obtain adequate information for a possible backup system for the ATLAS development.

Two other commercial thermoluminescent analyzer systems were also evaluated to determine their potential applicability to the operational dosimetry program.

3.6 Automatic Thermoluminescence Analyzer System (ATLAS) (J. C. Culley)

As stated in the 1969 Annual Report, the Branch is involved in the design and construction of an automatic thermoluminescence dosimetry system to replace the photographic dosimetry system at the NRTS.

During 1970 two prototypes of an automatic analyzer for the system were constructed by the Instrumentation Branch. The second of these performed reasonably well in spite of some temperature control problems and difficulties with the dosimeter identification system. Several usable graphs were obtained proving that unique luminescence curves could be produced for each different energy level of radiation.

The dosimeter used in this system is a homogeneous mixture of TL phosphor and a synthetic organic polymer 1.7 x 1.2 x 0.015 inch thick with 0.125-inch radiused corners. It is rugged, easily handled, self-identifying, and can be used in any dosimetry badge presently using film packets. The dosimeter (see Figure 5) is identified by imprinting the identification information on the nonreading edge of the dosimeter itself, with a BCD system printer.

Up to 500 dosimeters are stacked in the reading magazine. A sliding dosimeter transport mechanism transports the dosimeter by means of a pulsed stepping motor under a predetermined constant-temperature heating block. The stepping method of heating the dosimeter allows the luminescence emitted by each filter zone on the dosimeter as measured by the photomultiplier tube, located below the heating block, to be utilized as a series of digital values or integrated in any desired array. The identification information is then read off the dosimeter using a BCD system reader. In this model (see Figure 6) the output of the photomultiplier is used to drive an X-Y recorder and, through use of a digital voltage-to-current converter, to provide digital input to a PDP-8/S computer. Various circuitry changes can also provide a digital display or a printed readout.

Work is presently progressing on what is hoped to be the operational model. It is planned to initiate the new thermoluminescence dosimetry system in 1971.

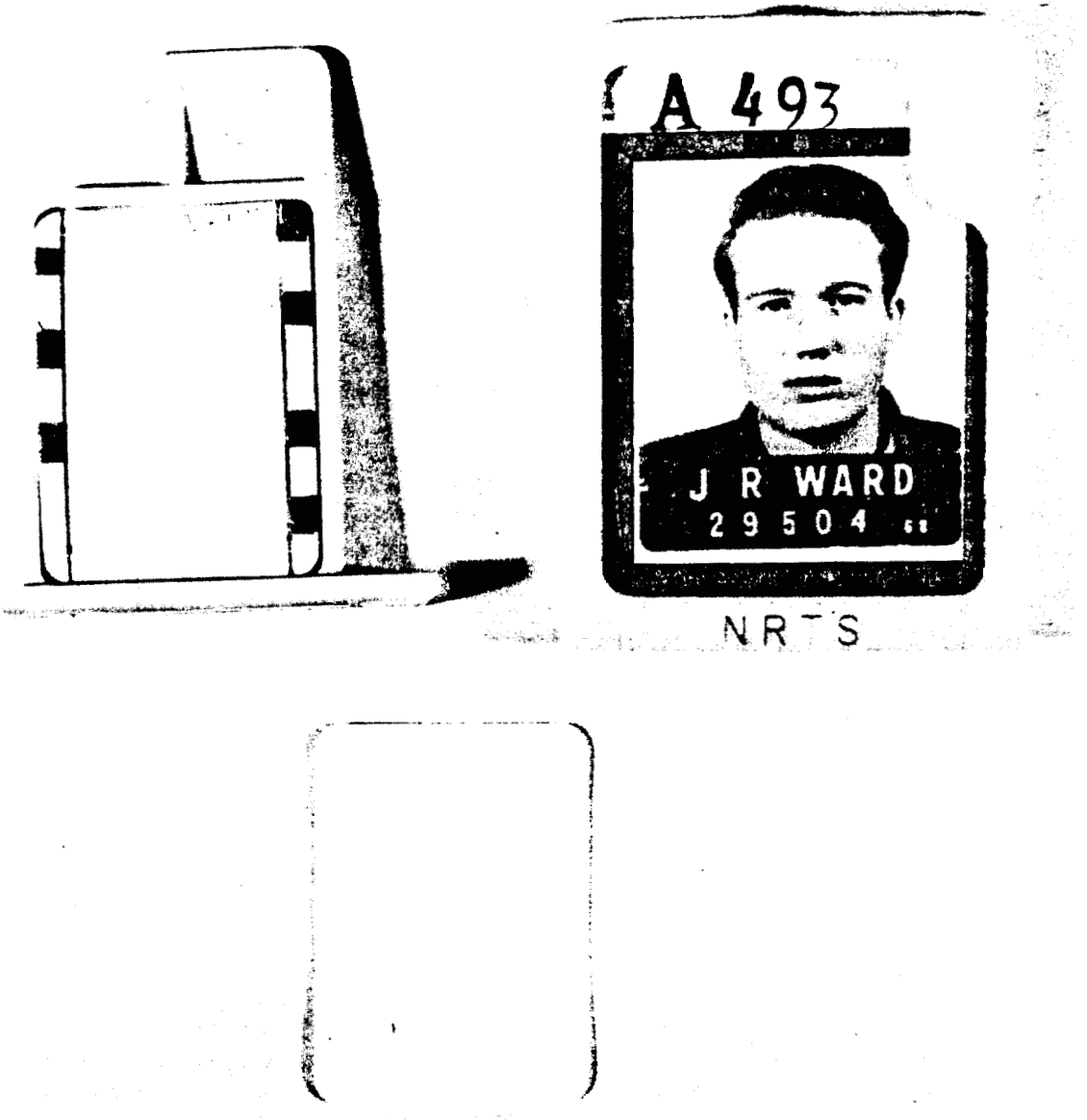

FIG. 5 NEW NRTS TL DOSIMETER AND BADGE.

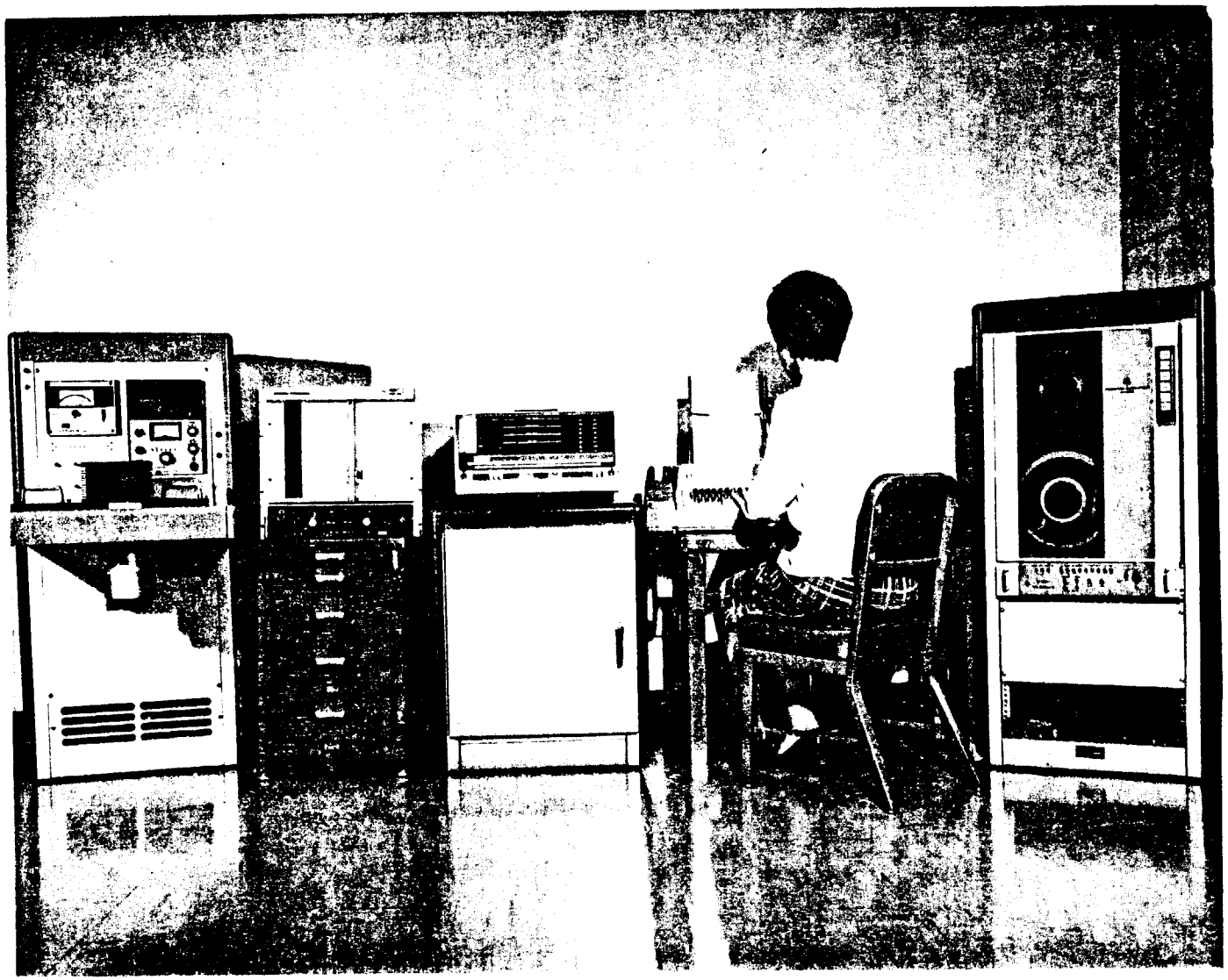

FIG. 6 AUTOMATIC THERMOLUMINESCENCE ANALYZER SYSTEM.

IV. INSTRUMENTATION BRANCH

(M. Wilhelmsen)

1. ROUTINE INSTRUMENTATION ACTIVITIES

1.1 Field Instrument Maintenance

During 1970, 2,348 individual repairs and calibrations were performed on instruments in the radiation instrument pool. A contractor request for an audible safety backup detector for all portable detection instruments ranging above 200 mR/hr necessitated the addition of a new series of small detector instruments. Special holding brackets will be fastened to all instruments of this type so that this backup detector can be clipped on and used as needed. This small packaged detector has a detection threshold of 200 mR/hr with an audio tone of increasing frequency as the dose rate increases.

1.2 Laboratory Instrumentation Maintenance

The maintenance of the Health Services Laboratory instruments continues to be one of the major efforts of the Instrumentation Branch. Complexity of the instrumentation involved ranges from simple single circuit devices to complex computerized data-acquisition systems employing multiple peripheral instruments and interfaces. Generally, two methods of maintenance are employed. The first is in-house maintenance performed by HSL personnel after breakdown or failure has occurred. Most of the in-house service is of the demand type although an attempt is made to perform preventative maintenance on those instruments having histories of repetitive failures. The second general method of maintenance employs field-service engineers representing manufacturers of complex and specialized equipment to service such equipment either on a periodic

2.2 Binary Counting Circuits for Cloud-Dose Study (D. Johnson)

Forty counting circuit boards (10 for each of 4 counting systems) were designed and fabricated for counting pulses from the GM detectors used by the Environmental Branch in cloud-dose studies.

2.3 Incremental Magnetic Tape Recording (K. H. McGary, D. Johnson)

In order to better support the Rotational Whole-Body Counting Program of the Analytical Chemistry Branch, a new "Kennedy" incremental magnetic tape reader/recorder was interfaced to the counting system for recording the experimental data being generated.

2.4 X-Y Plotter Control (D. Johnson)

An X-Y plotter control was designed and constructed for the Personnel Dosimetry Branch to enable an operator to plot a temperature ramp and a glow curve at the same time. The operator has a choice of pens and combinations of operating procedures.

2.5 Special Circuitry Development (K. H. McGary)

The following list of special electronic circuitry was designed and constructed in support of the various programs indicated below. Typical circuit boards are shown in Figure 7.

Level Changer for Alpha Sample Changer

Nine circuits and 48 components on one board to change the various positive and negative input and output levels of associated equipment so that the signals are compatible to transistor logic. (Analytical Chemistry Branch -- ACB)

Relay Drives for Alpha Sample Changer

Six circuits and 25 components including six reed relays on one board. Used to drive relays from transistor-transistor logic. (ACB)

Level Changer for Radon Sample Changer

Six circuits and 30 components on one board to change the levels of signals from associated equipment so that the signals are compatible with transistor-transistor logic. (ACB)

Level Changer and Clock for 4096 Channel Analyzer to Kennedy Tape Deck Interface

Nineteen level changers to change the 4096 output signals to levels compatible with transistor-transistor logic. One clock to sequence the information from the 4096 to the tape deck -- 128 components. (ACB)

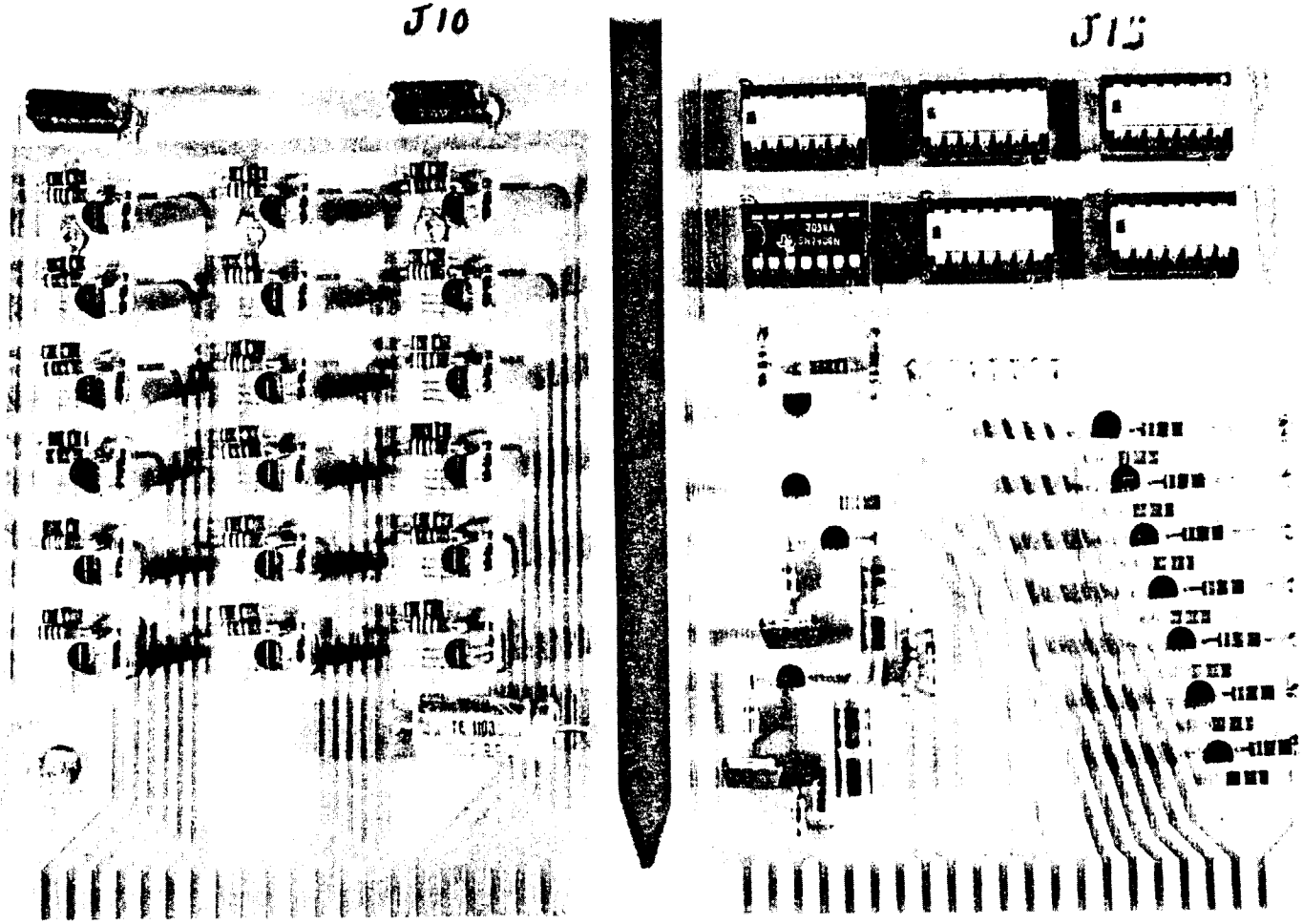

FIG. 7 TYPICAL CIRCUIT BOARDS.

Constant Current Regulator for Electrodeposition Equipment

Ten boards with two circuits and 27 components on each board. Used to keep the current at a constant level during the electrodeposition of plutonium. (ACB)

ATLAS Position Detectors and Lamp Drivers

Two boards with four circuits and 16 components including six ICs per board. Used to detect the slide position and turn on lamps indicating the position. (Dosimetry Branch -- DB)

ATLAS Level Changers

Two boards with 18 circuits and 75 components on each board. One board to change signals from the PDP-8/S computer to levels compatible with transistor-transistor logic. One board to change signals from transistor-transistor logic to levels compatible with the PDP-8/S. (DB)

ATLAS Clock and Startup Reset

One board with five circuits and 66 components including one IC. The startup reset sets the electronics and mechanical equipment to the beginning position approximately three seconds after applying power. The clock supplies pulses to control motor speeds and readout timing. (DB)

ATLAS Heater Solenoid and Lamp Control

One board with four circuits and 28 components including two ICs. Controls the turning on and off of the heater solenoid and the badge number reading lamp. Also has inverters and level changers for signals to the slide drive motor. (DB)

2.6 Ion Chamber Detection Systems (D. G. Hill, L. M. Talbot)

Twenty-eight special low-energy ion chamber detection systems which did not operate satisfactorily upon receipt by the Environmental Branch were modified and calibrated. Unstable operation due to voltage fluctuations from undersized batteries was one of the major problems.

2.7 Aerial Monitoring System (D. G. Hill, L. M. Talbot)

Modification of the Aerial Monitoring System is in progress to incorporate the NOAA radar unit. Radiation levels at the aircraft during aerial monitoring will be transmitted to the radar unit on the East Butte, combined with aircraft location data, and telemetered to CF-690 where all data are recorded on magnetic tape. The tape will subsequently be used with a modified NOAA tetroon computer program for plotting aircraft location and radiation levels on NRTS site plots.

2.8 Routine Telemetry System (D. G. Hill)

A preliminary design and equipment investigation to upgrade and replace the old telemetry system has been completed. Specifications were written and

a contract let for the manufacture of a computer controlled base station with two remote stations. This system will be installed and tested and, if satisfactory, additional remote stations will be procured to replace the present obsolete equipment. This new system will also accommodate the NOAA weather telemetry requirements.

3. INSTRUMENTATION RESEARCH AND DEVELOPMENT PROJECTS

3.1 In Vivo Lung Monitoring For ^{239}Pu (D. Parker, K. H. McGary)

An in vivo ^{239}Pu detecting system is under development with most components of the system performing satisfactorily. Needed yet is a proportional detector of improved design with the capacity, resolution, and efficiency necessary to meet the exacting conditions of in vivo detection of 17 keV X-rays at the low activity levels anticipated. Specifications for such a detector have been written and several manufacturers have indicated an interest in supplying one. Plans are under way for obtaining the detector.

3.2 Automatic Thermoluminescence Analyzer System (D. Parker, K. H. McGary, P. R. Boren)

An automatic thermoluminescence analyzer system (ATLAS) for reading and recording exposure and identification data from film-size TLDs is being designed and constructed. A simple prototype was built which demonstrated the feasibility of the proposed reader. An improved model of the analyzer is shown in Figure 8.

3.3 High Speed Telemetry System (D. G. Hill, L. M. Talbot)

Fabrication and assembly of a three-station high-speed telemetry system for data transmission from Grid III to CFA is nearing completion. This system is capable of transmitting 14 analog signals simultaneously from each station to the central receiver which under computer control sequentially reads the data from each station through an analog to digital converter, processes it in the computer, and stores it on magnetic tape. Average readout speed is 0.05 second per data point.

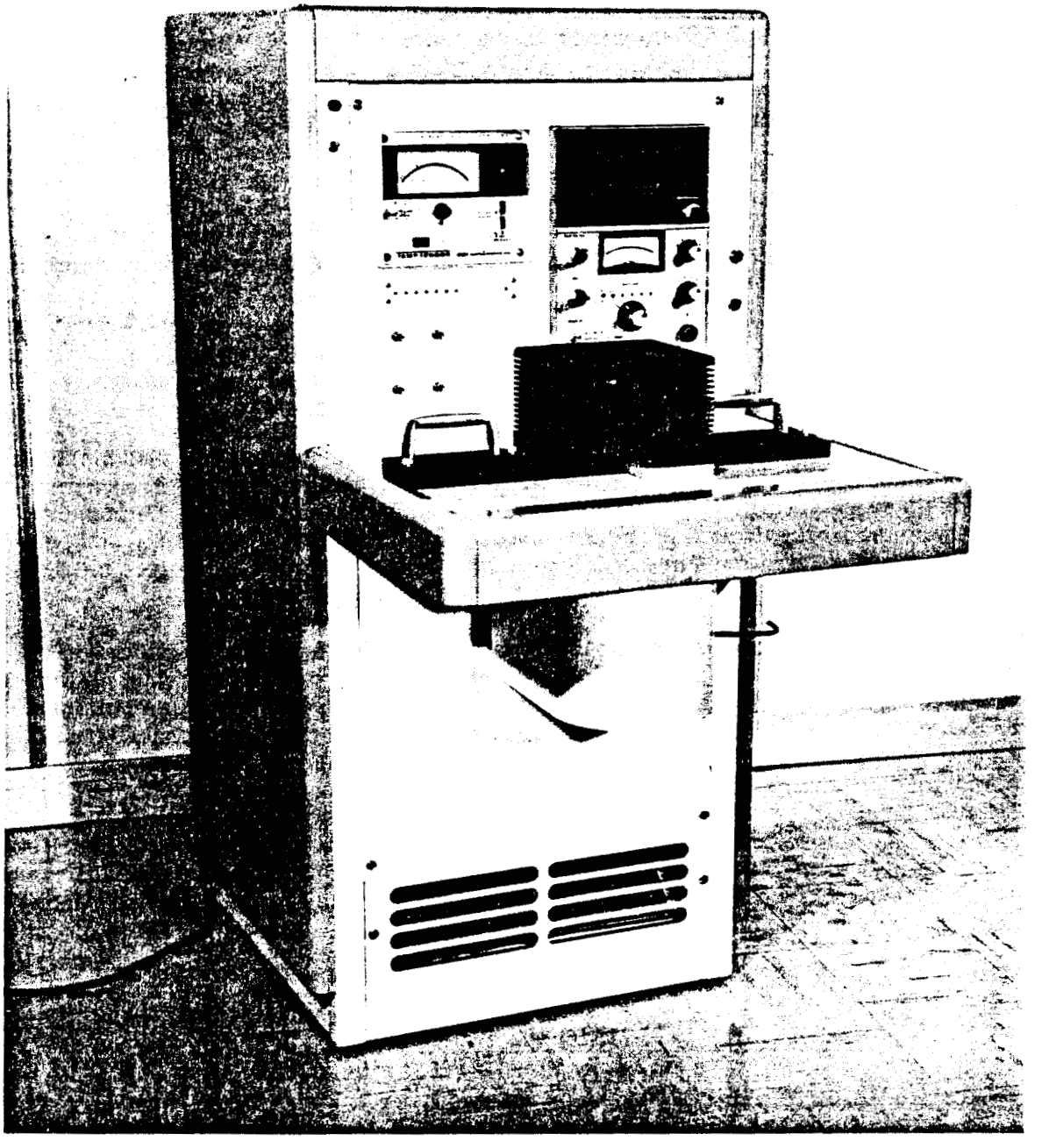

FIG. 8 AUTOMATIC THERMOLUMINESCENCE ANALYZER DESIGNED AND CONSTRUCTED BY PERSONNEL OF THE INSTRUMENTATION BRANCH.

V. MEDICAL BRANCH

(J. H. Spickard, M. D.)

Occupational medical services at the NRTS are provided through an organizational system which is unique to U. S. Atomic Energy Commission medical programs. The AEC Medical Branch is responsible for the planning, operation, and direction of this program for NRTS contractors and AEC personnel. This medical system is complicated by the fact that several different companies serve under Operations Offices other than the Idaho Operations Office. An effective program is maintained because of the rapport established between parent company medical departments and the AEC Medical Branch plus the acceptance of this program by the local contractor managements. The AEC Medical Branch serves as the company medical department for Idaho Nuclear Corporation (INC).

1. ROUTINE MEDICAL ACTIVITIES

The Medical Branch provides an occupational medical service that includes physical examinations (preplacement, periodic, termination, and special), diagnosis and treatment of occupational illnesses and injuries, emergency or short-term treatment of nonoccupational illnesses and injuries, and consultation with contractors and employees on health problems. Complete medical records are kept of all patient visits at the NRTS dispensaries.

The preplacement questionnaire, which has been in use for four years, has been of benefit in determinining employability and predicting restrictions for prospective employees. The use of addressograph plates continues to be an efficient method for identifying medical records and request slips and for reproducing recurrent reports. Microfilming of inactive charts is performed annually and a duplicate record is stored as a protection against loss or fire. Scheduling of patients for physical and periodic laboratory examinations is simplified by the use of computerized monthly reports that list individuals due for examination. Computer compilation of data on ID-13 industrial accident reports continues to be a satisfactory method of retaining and reproducing accident and injury data.

2. SUMMARY OF 1970 MEDICAL BRANCH WORK STATISTICS

2.1 NRTS Work Population

A decline in the work force from 5,888 in January of 1970 to 5,614 in December resulted primarily from a reduction of 244 INC employees. As anticipated the medical activity work statistics reflect this decline. Fewer preemployment and more termination exams were performed, compared to the prior year.

At the end of 1970, construction on the Loss-of-Fluid Test Facility (LOFT) had progressed to a point where employment of a construction nurse was no longer warranted. In addition, personnel formerly stationed at Test Area

North (TAN) were transferred to Idaho Falls. As a result the TAN nurse (INC) now covers part time at the Chemical Processing Plant (CPP) dispensary. The INC nurse at CFA will make periodic visits to first aid stations at SPERT and at the Computer Center and Rogers Building in Idaho Falls.

By December, 789 employees were stationed in Idaho Falls compared to 604 in January. The increase in staffing in town may result in a need for a full-time nurse at the Headquarters dispensary.

2.2 Patient Visits to AEC Dispensaries

Total treatment visits at AEC Central Facilities (CF) and Idaho Falls (HQ) dispensaries decreased from 8,223 in 1969 to 8,074 in 1970. There was a drop of 3% in the CF dispensary visits in 1970 (see Figure 9) while there was an increase of 1% in the HQ dispensary visits. Although 25% of AEC dispensary treatment visits were made at the HQ dispensary, only 2.6% of them were for occupational injuries. In contrast, 20% of the treatment visits to the CF dispensary were occupational. Total visits for all purposes decreased from 11,618 to 11,272.

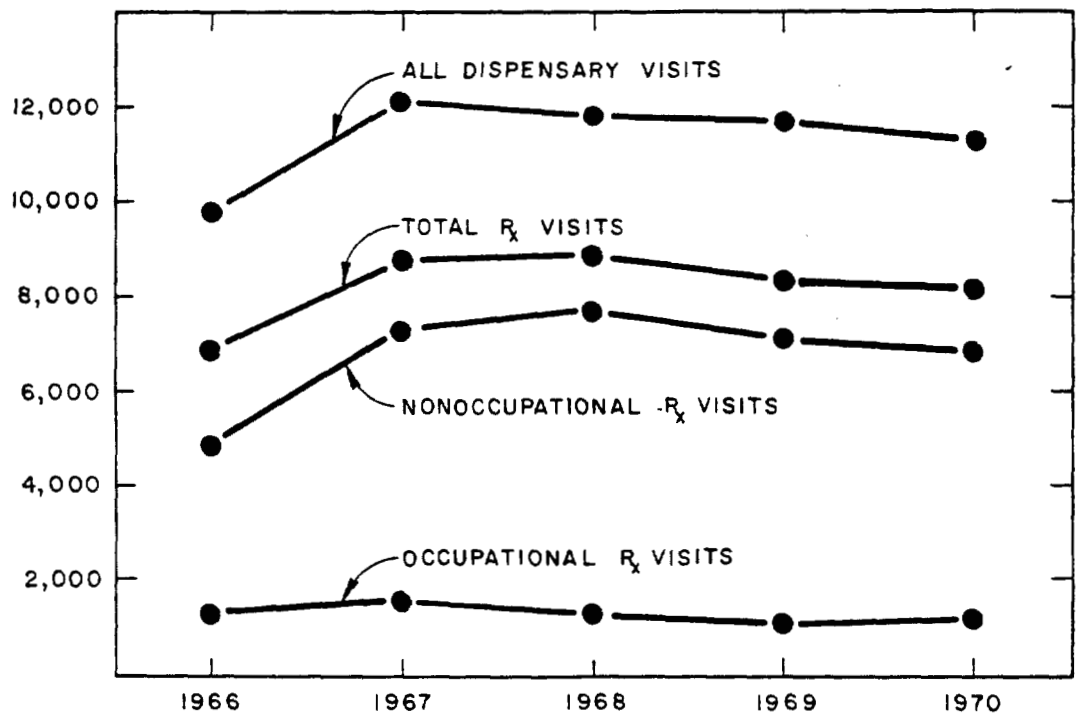

FIG. 9 CENTRAL FACILITIES AND AEC HEADQUARTERS DISPENSARY VISITS.

Treatment visits at AEC dispensaries during 1970 were distributed as follows:

(1) Idaho Nuclear Corporation	56%
(2) Atomic Energy Commission	22%
(3) Westinghouse Electric Corporation	9%
(4) Argonne National Laboratory	6%
(5) Construction Contractors	4%
(6) Other Federal Agencies	2%
(7) Other	1%

2.3 Patient Visits to all NRTS Dispensaries and First Aid Stations

There was a slight increase in the total NRTS dispensary visits from 35,476 in 1969 to 35,891 in 1970 (Table II). Only 15% of the treatment visits were for occupational injuries or illness.

Percentages of total treatment visits to area dispensaries for occupational injuries were quite uniform (range 11 to 12%) with the exception of HQ (2.6%) and first aid (38%). After excluding CF dispensary visits the average number of treatment visits per employee for 1970 was four, the same as for 1969. A comparison of the treatment visits at the CF dispensary with the other dispensaries is not practical since many patients are referred from plant dispensaries for physician evaluation or for the more extensive examination and treatment facilities at the CF dispensary.

2.4 Physical Examination Programs

The moderate decrease in the number of preemployment and periodic physicals was partially offset by the slight increase in the number of termination physicals performed (see Figure 10). Total examinations decreased from 2,248 in 1969 to 2,125 in 1970. Only half as many physical examinations were performed at the HQ dispensary during 1970 because of the significant reduction in preplacement examinations.

2.5 Laboratory and X-Ray

The 37,404 laboratory procedures recorded in 1970 again displayed a marked increase over the 1968 value (19,000). This is a result of the continuation of the blood profile procedure adopted in May 1969. Although the blood was collected and prepared by the Medical Branch, the tests (805 included a complete blood count and 14 "chemical analyses" and 360 included 12 "chemical analyses" each sample) were performed by two contract laboratories. There were 1,165 such examinations representing approximately 23,000 procedures in excess of what might have been run by our own medical laboratory.

X-ray examinations increased slightly in 1970, while whole-body counting procedures decreased (Figure 11). Approximately 12% of the X-ray examinations were performed in the medical van and 4% at the Navy dispensary in Idaho Falls.

TABLE II

1970 NRTS DISPENSARY VISITS

Dispensary	Occupational Treatment Visits	Other[a]	Percent	Nonoccupational Treatment Visits	Percent	Total
Central Facilities & Headquarters	1,185	3,198	38	6,889	62	11,272
Chemical Processing Plant	142	0	12	1,041	88	1,183
Argonne National Laboratory	272	36	11	2,595	89	2,903
Test Reactor Area	203	0	12	1,488	88	1,691
Naval Reactor Facility	1,743	2,697	30	10,281	70	14,721
Test Area North	167	1	11	1,304	89	1,472
First Aid	1,007	0	38	1,642	62	2,649
Total	4,719	5,932	30	25,240	70	35,891

[a] Other includes physical examinations, X-rays, clinical laboratory visits, urine samples for radiological analysis, and immunizations.

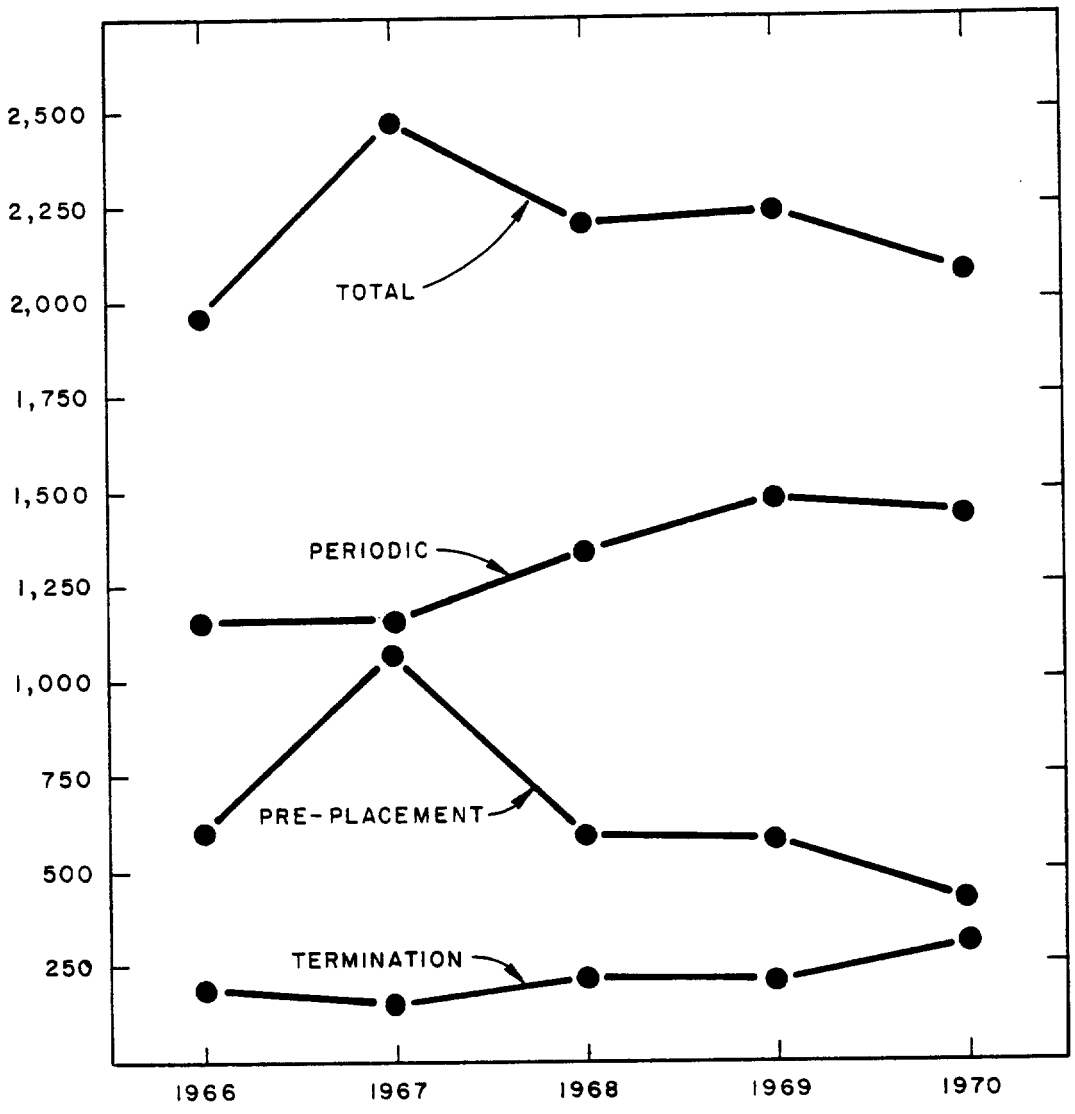

FIG. 10 PHYSICAL EXAMINATIONS PERFORMED AT NRTS.

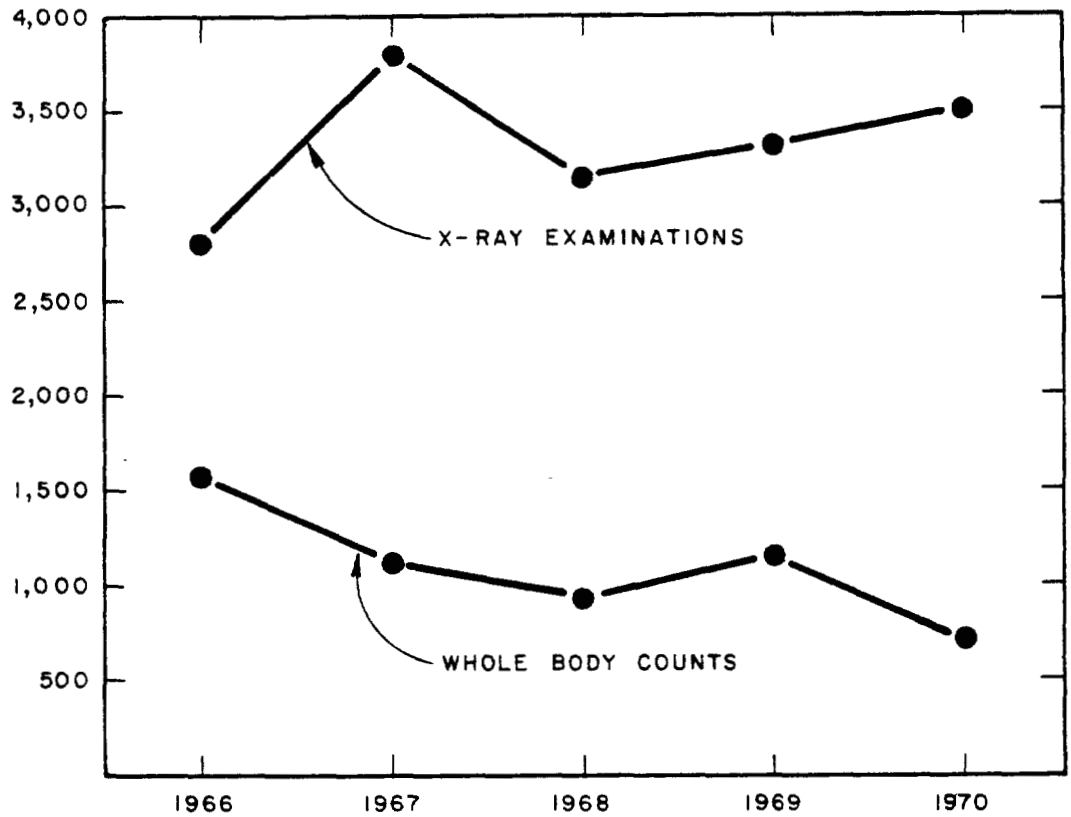

FIG. 11 X-RAY AND VAN WHOLE-BODY COUNTS.

3. REVIEW OF SPECIAL PROJECTS

3.1 Blood Chemistry Profiles

During 1970, blood chemistry testing was transferred from the United Medical Laboratory (UML) in Portland to the Eastern Idaho Clinical Pathology Laboratory in Pocatello. Testing is now done on an SMA 12/60 rather than on the Swedish autoanalyzer used by the Portland Laboratory. The change was made to the local laboratory because of the lower price, convenience, and the availability of consultation from area pathologists. Currently, Dr. Thomas Mitchell, the pathologist at LDS Hospital of Idaho Falls reviews all abnormal results periodically and recommends followup procedures. The UML profile consisted of a complete blood count and 14 blood chemistries which included creatinine, total lipids, and a computation of globulin and the albumin/globulin ratio (tests not done on the SMA 12/60). The SMA 12/60 profiles consist of 12 chemistries (including calcium and phosphorous determinations which are not available on the UML profile) and will eventually include triglycerides, a more specific test than "total lipids" as a predictor of cardiovascular disease.

Table III summarizes the abnormal chemistry values in the 1,165 profiles (805 UML, 360 SMA) conducted in 1970.

TABLE III

ABNORMAL BLOOD CHEMISTRIES IN 1,165 PROFILES

Test	UML	SMA	Totals
Alkaline Phosphatase	100	6	106
Cholesterol	124	19	143
Total Bilirubin	9	16	25
Total Protein	6	1	7
Albumin	0	27	27
Globulin	3	---	3
A/G Ratio	3	---	3
Total Lipids	231	---	231
SGO-T	68	13	81
LDH	18	10	28
Glucose	34	14	48
BUN	14	24	38
Uric Acid	38	27	65
Inorganic Phosphate	---	11	11
Calcium	---	3	3
	648	171	819

Many of the "abnormal" values are determined not to be significant by the examining physician and no followup is indicated. Where abnormal values persist the patient is referred to his own physician. Health counseling, including dietary advice, and repeat laboratory evaluation is available for individuals with a "high" cholesterol.

3.2 Medical Van

In 1970, 720 whole-body counts were performed in the medical van. The decrease in procedures from the 1,159 performed in 1969 was due to lack of "special" requests at Argonne and Westinghouse.

Internal radioisotope contamination was identified in 30 individuals (compared to 33 in 1,159 exams during 1969) with ^{60}Co identified in 18 persons, ^{137}Cs in 13 (two had both isotopes) and ^{110m}Ag in 1. No levels exceeding 0.1μCi were found.

Late in 1970, the van was scheduled at the Headquarters dispensary to take chest X-rays on personnel stationed in Idaho Falls. With an increase in the number of contractor personnel now working in town, chest X-rays can be performed more efficiently in the van than through the Navy dispensary.

3.3 Physical Examination Program

The general schedule for physical examinations was revised during 1970 so that most employees would be examined at the same age. Prior to this, different schedules were applied for radiation and nonradiation areas. Experience has shown that with the level of radiation exposure at the NRTS no increased incidence of medical problems is encountered in "radiation" workers. With the new schedule an employee may anticipate examination at time of hire, at ages 25, 30, 34, 37, 40, every two years until age 62, and then annually. Reactor operators, drivers, and some other work categories are still examined on special schedules.

Annual blood counts and urinalyses on employees working in radiation areas were discontinued as a routine procedure since no specific abnormal patterns have developed in this group over several years. In a similar vein, slit lamp examinations are no longer done as a routine procedure for evaluating some categories of radiation workers because of several years of "negative" findings. Special eye examinations have been added for personnel working with lasers. An initial examination is performed by an ophthamologist, with special evaluation for any retinal abnormalities (retinal photographs are not taken). Annual followup exams will be done by an AEC physician.

Tonometry testing for glaucoma was started during the year as part of the routine physical examination on people over age 40. Lateral chest X-rays have been added to the routine PA every three years.

A complete periodic physical examination at this time, in addition to the "routine" physical and history, would include: chest X-ray; laboratory work -- complete blood count, urinalysis, and blood (chemistry) profile; pulmonary function testing; stool occult blood; PAP smear (optional); EKG and testing of visual and auditory acuity. Counseling and referral to private physicians follow in the event that abnormalities are identified.

3.4 Emergency Planning

Hospital plans for management of contaminated casualties were reviewed and updated in 1970. A guide book for handling patients at the NRTS was prepared with specific sections for physicians, nurses, firemen, and health physics

personnel. Training of Fire Department personnel on use of the decontamination room has started and will continue under the guidance of Dr. W. S. Brainard. Initial contacts have been made to utilize the University of Utah Medical Center as a referral institution for the treatment of radiation accident patients.

3.5 Safety Film

Under sponsorship of the Medical Branch, a film, "Emergency First Aid and Rescue", was prepared by Idaho Nuclear Corporation Health and Safety and the AEC Fire Department on uses of various types of first aid and rescue equipment for vehicular accidents.

3.6 Industrial Hygiene

Rapport has been excellent between the Medical Branch and the Idaho Nuclear Corporation's Industrial Hygiene group. Industrial hygiene investigation of a number of medical cases was requested and medical opinion and support was provided for several industrial hygiene studies. A number of studies during the year included evaluations of: welding shops; glass blowers shop; lasers; microwave oven; pesticides; noise problems; black widow spider infestation of "imported" wastes; cafeterias; water supplies; exposures to carbon monoxide, nickel carbonyl, cadmium, bus exhausts, and skin sensitizers and irritants. The hearing conservation program included some lectures by AEC physicians to various shop groups.

3.7 Industrial Accident Data

The ID-13 form for medical reporting and classification of industrial accidents is used for ID and AEC contractor personnel. Data from these forms are coded for computer data acquisition and retrieval, and printouts are made quarterly and annually. Information identifies the contractor, nature of injury, and whether work restrictions or lost time occurred. Nature of injury may be described either as to body part involved and source of injury, or by source and accident type (agent).

1970 INDUSTRIAL ACCIDENTS

Contractor	Number	Work Restrictions	Lost Time
AEC	45	0	0
ANL	144	13	1
INC	649	19	4
Other	675	54	3

Westinghouse and GE KAPL are generally not included in the ID-13 statistics.

4. LONG RANGE PLANNING

4.1 Audiometric Training

Initial preparations have been made to establish a training course for audiometric technicians through the Department of Speech and Audiology at Idaho State University. Michael A. Nerbonne, Ph.D., will provide this training for NRTS nurses on a two or three day program.

4.2 Industrial Psychologist

Consideration is being given to hiring an industrial psychologist to assist in the development and maintenance of numerous programs relating to mental health including alcoholism, counseling on diet and smoking, mental health and interpersonal relations, and drug abuse. Initial guidance and staffing may be sought from the Eastern Idaho Mental Health Clinic.

4.3 Computer Records

Methods are being investigated for accumulation of morbidity and mortality data on NRTS employees. If a practical system can be established, information on sickness will be coordinated with absenteeism data. An attempt is now being made to identify all site employees over an extended time period. Once identified, this list can probably be compared with the cancer registry to attempt to develop more complete cancer incidence statistics.

4.4 Residency Training

No residents in occupational medicine have taken advantage of the approved residency at the National Reactor Testing Station. Because of the limited number of applicants encountered in this specialized field, modified training or preceptor programs may be preferable. Dr. David Discher of the University of Washington has expressed interest in establishing this type of program and would like to consider the NRTS for a portion of this training.

VI. ENVIRONMENTAL BRANCH

(C. A. Pelletier)

1. ROUTINE ACTIVITIES

1.1 Environmental Monitoring (R. L. Bangart, D. L. Newcomb, W. L. Polzer)

The concentrations of radioactive materials in air are monitored continuously by drawing air through particulate and charcoal filters at eight onsite and eight offsite locations. These filters are changed weekly and counted for long-lived alpha and beta radioactivity. In addition, a network of 18 telemetry stations (6 onsite and 12 offsite), designed primarily for emergency situations, is operated on a continuous basis. Filterable airborne radioactivity and the external gamma exposure rate are monitored continuously at each station. All stations are interrogated hourly and the data are telemetered to the Labora-

1.2 Independent Measurements Program (R. L. Bangart, D. L. Newcomb)

The Branch assists in the Division of Compliance program of environmental monitoring in the vicinity of nuclear facilities. This involves coordination of the sampling procedures at the facilities and the analyses of the samples performed by the Health Services Laboratory, interpretation of data, and preparation of reports. Routine environmental monitoring programs are currently under way around a nuclear fuels reprocessing plant, a boiling water power reactor, a pressurized water power reactor, a scrap recovery and fuel fabrication plant, and a radiochemical supply laboratory. In addition, direct radiation levels in the vicinity of two other operating nuclear power plants are measured. Development of a computer program for handling the data from all surveys was completed and the program is being debugged.

1.3 Particle Sizing and Counting (B. W. Mortensen)

The Branch provides a particle sizing and counting service for NRTS contractors. Air samples from Naval Reactor Facility work areas were counted for asbestos particles, and samples from boiler stack exhaust air were sized and counted for Idaho Nuclear Corporation.

1.4 Emergency Response and Preparedness

The Branch is responsible for evaluating hazards to on- and offsite personnel resulting from planned and unplanned releases of radioactivity to the environment, and for acting to minimize personnel exposure in the event of a radiological emergency. A group of trailers (Trailer City) is maintained in a state of readiness for response to an emergency at any NRTS area. Branch personnel are available to operate Trailer City and to assist contractor personnel when the need arises. The Branch is also responsible for maintenance of the emergency kits of equipment used by ID Radiological Assistance Teams.

Development of a set of Dose Action Levels for accidental radiation exposure of the general public was begun. The dose limits will provide a basis for the derivation of other Action Levels on which decisions to take remedial actions following an uncontrolled release will be based.

1.5 Health Physics (C. A. Pelletier, B. W. Mortensen)

The Branch is responsible for the protection of Laboratory and other ID personnel from unwarranted radiation exposure. Routine contamination and direct radiation surveys of AEC facilities at the NRTS are performed, and radioactive shipments to and from the Laboratory are monitored. Disposal of radioactive waste from the Laboratory is arranged as required. Measurements of face velocities of fume hoods in the Laboratory and Dispensary are made periodically.

The responsibility for evaluation of internal exposures to radionuclides was assigned to the Branch during 1970. No accidental inhalations or ingestions of radioactivity requiring detailed dosimetric calculations occurred. Theoretical analyses of potential inhalation exposures were continued.

1.6 Geochemical and Waste Studies

The Branch is responsible for making recommendations relating to problems arising from waste disposal and accidental release to the soil/water environment in cooperation with the Waste Management Branch of the Nuclear Technology Division (NT). As part of the procedure for making recommendations, both laboratory and field studies, in addition to the regular programs, are conducted for proper evaluation of the problems. Proposals and documents concerning waste disposal and its management are reviewed.

1.7 Reporting of Radioactive Waste Disposal

Development of a data format for utilization of the MARK IV File Management System for NRTS radioactive gaseous and liquid waste data was initiated and partially completed. The Waste Management Branch, NT, is completing this task.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Controlled Environmental Release Test (CERT) Program

The objectives of the CERT program are to (a) define variables which affect the transfer of radionuclides from the point of release to the atmosphere to a human receptor, (b) perform controlled experiments to measure the variables influencing the observed transfer phenomena, and (c) develop and test predictive models of the processes involved. Investigations into the behavior of radioactive particles and of radioactive gases other than ^{131}I have been started and will become the dominant aspect of this program.

(1) Effect of Stomatal Opening on Transfer of $^{131}I_2$ to Grass (D. R. Adams, P. G. Voillequé)

The results of a series of laboratory experiments to evaluate the effect of stomatal opening on $^{131}I_2$ to Manchar Bromegrass were summarized in a paper which has been accepted for publication.

(2) Environmental Chamber (C. A. Pelletier, P. G. Voillequé)

The velocity profile generator for the chamber was assembled and installed. Preliminary measurements of wind speeds and turbulence spectra were made with hot-wire anemometers. Hot-wire data processing techniques were established with the assistance of personnel of the Instrumentation Branch and the Air Resources Laboratory Field Research Office (ARLFRO), National Oceanic and Atmospheric Administration (NOAA). A carbon dioxide analyzer was purchased for use in monitoring and controlling CO_2 concentrations during extended studies of retention of radionuclides by growing plants. Additional lighting capability and a radiogas distribution system were installed in the chamber.

(3) Field Release Tests (P. G. Voillequé, J. B. Echo, D. R. Adams)

Six field tests were conducted in which aerosols were produced by atomizing sodium or potassium carbonate solutions labeled with ^{24}Na or ^{42}K. Activity median aerodynamic diameters and deposition velocities were determined.

(4) Bovine Metabolism of Radioiodine (C. A. Pelletier, D. R. Adams, P. G. Voillequé

Two single metabolism experiments were performed in cooperation with B. R. Moss of Montana State University to evaluate the effect on iodine metabolism of feeding Sudangrass to lactating Holstein cows. Feeding Sudangrass decreased the radioiodine milk/plasma ratio and the percentage of radioiodine secreted per kg of milk.

2.2 Experimental Cloud Exposure Study (C. A. Pelletier, P. G. Voillequé, B. D. Johnson)

Five elevated releases of ^{24}Na aerosols were conducted at Test Grid III. Direct radiation from material deposited on sagebrush and instruments was found to be a significant problem. Laboratory evaluation of an air curtain device for preventing detector contamination has shown it to be feasible. Development of modifications to the aerosol generator to reduce the size of released particles was begun. Twenty-eight additional detectors were obtained; a data collection system for the detectors was designed.

2.3 Movement of Radionuclides in Soil (J. B. Echo, W. L. Polzer)

Core samples from the bottom of the Test Reactor Area (TRA) 1964 Pond were taken and analyzed for the distribution of radionuclides with depth and distribution between the alluvium and the pond water in contact with the alluvium. The results of the above studies will be included in a report on the distribution of radionuclides in the soil/water environment as a result of waste disposal being prepared by B. L. Schmalz, Waste Management Branch, NT, in cooperation with the Laboratory.

A theoretical study on the solubility of plutonium in soil/water environments was made in order to obtain some insight into the behavior of dissolved plutonium in the environment. This work was summarized in a paper prepared for presentation at the April 1971 Symposium on Safety in Plutonium Handling Facilities at Rocky Flats. A research proposal was prepared for a cooperative laboratory study of plutonium behavior in the soil/water environment by W. L. Polzer and F. J. Miner of the Rocky Flats Division, Dow Chemical Company.

2.4 TRA Pond Studies (J. B. Echo, W. L. Polzer)

The infiltration of liquid waste decreased to the extent that the 1964 pond was not capable of holding the discharged liquid. The pond was drained and kept dry for several months' duration. Observations suggested that algae and calcium carbonate precipitate could have affected the infiltration rate. A laboratory study showed that both algae and calcium carbonate significantly

affected the infiltration of pond water into test columns of alluvium. The effects on infiltration of drying the columns is still being investigated. Copper sulfate was shown to have no effect on the distribution of nuclides in test columns of alluvium. The addition of copper sulfate to the pond water in order to eliminate algae growth was recommended.

2.5 Tritium Studies (J. H. Osloond, J. B. Echo, W. L. Polzer, B. D. Johnson)

A sampling method and an analytical technique have been developed for measuring air concentrations of tritiated water. Tritium concentrations of 2×10^{-11} μCi/cc are detectable in a sample of one cubic meter of prefiltered air collected over a period of 168 hours at a temperature of 25°C and a relative humidity of 10%. Atmospheric moisture is collected on silica gel and a 5-g aliquot of gel is counted for 20 minutes in a liquid scintillation detector. The counting efficiency for directly analyzing tritiated water absorbed on silica gel is within 3% of that for liquid tritium samples. Moisture collection efficiency of silica gel, for air flow rates from 6 to 8 liters per hour, is greater than 95% over a temperature range of 0 to 27°C and relative humidity between 10 and 100%. The tritium sampling equipment can be added to existing sampling systems for a cost of under $50.

The study of the question of selective absorption of tritiated water by precipitated minerals and by silica gel is being continued.

3. PUBLICATIONS AND PRESENTATIONS

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VII. U.S. GEOLOGICAL SURVEY

(J. T. Barraclough)

1. HYDROLOGIC INVESTIGATIONS AT NRTS

The U. S. Geological Survey investigates and describes the water resources and geology at the NRTS and adjacent areas. The studies determine the influence of disposal of liquid low-level radioactive and chemical wastes to the subsurface at the NRTS. A continuing program of investigation serves to determine natural changes in the geohydrology and changes brought about by activities at the station. The USGS also serves as geohydrologic consultants to the AEC.

Study of the groundwater hydrology at the NRTS was continued during 1970. A total of 700 measurements of the water level in about 100 different wells were made to denote changes in water storage in the Snake River Plain aquifer and in perched groundwater bodies. About 300 groundwater samples were collected to evaluate water quality changes. Over 800 chemical and radiochemical analyses were performed on these samples. Fourteen wells and ponds were equipped with continuous water-level recorders. Three continuous discharge stations were operated on the Big Lost River and 10 direct stream discharge measurements were made. Thirty-two wells were logged with geophysical and radiation probes to evaluate water and rock properties.

The flow of the Big Lost River at the NRTS Diversion during 1970 was about 87,000 acre-feet. This is about one-third of the record high flow of 1969. The effects of this water on the Snake River Plain aquifer and the dilution of the nearby radioactivity in the aquifier is being studied. Recharge from the record flow last year caused the water in many wells to rise to record high levels in 1970.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Investigations of the Influence of Underground Waste Disposal

The geohydrologic study of the influence of long-term waste disposal to ponds and wells continued. The long-term volumes, compositions, and locations of waste discharges were compiled. The quantities of chemical wastes released to the subsurface were computed. Materials balance analyses for waste salts, tritium, strontium-90, and temperature were computed. Most of the strontium-90 has been adsorbed in the subsurface but very little tritium or chloride has been adsorbed.

Waste products discharged to the Snake River Plain aquifer spread out with a dispersion angle of about 90 degrees. This very wide angle causes considerable dilution of the wastes and the concentrations are rapidly reduced. The waste products can be traced about five miles southward (downgradient) from disposal and cover about 15 square miles. Dilution and radioactive decay then reduce the concentrations to about the background level.

Revised chemical data were used to prepare contour maps illustrating the geochemical properties of the Snake River Plain aquifer prior to NRTS. Specialized analyses of water samples collected from hot springs on the edges of the Snake River Plain show heterogeneous compositions. These water compositions reflect the complex deep subsurface geology.

A detailed review of the geology, sufficient to understand the geochemistry, was completed. The geologic review provides support for the hypothesis that fault-block mountain structures of Paleozoic rocks lie beneath the Snake River Plain.

The permeability decreased in a large radioactive waste pond at the Test Reactor Area. The water level rose two feet and threatened to overflow. Waste diversion to another pond allowed the pond to dry for two months. Dessication cracks formed, algae and other plants died, and infiltration tests indicated that the permeability was restored. The pond is now operating satisfactorily.

Two production wells at the Idaho Chemical Processing Plant contained waste products and the amount of perched water under the plant increased. A 600-foot deep disposal well corroded and collapsed which diverted the waste water into the perched water zone. The disposal well was cleaned and cased and is now disposing of the waste fluids.

2.2 Study of Possible Waste Migration from NRTS Burial Ground

A project headed by Coyd Yost, Jr., was initiated to determine the influence of hydrogeologic factors on the possible migration of waste radionuclides at the solid waste burial ground. Test drilling and coring will be used to determine the subsurface conditions at the burial ground, to detect migration of radionuclides, and to collect rock and water samples. The drilling specifications have been prepared.

2.3 Big Lost River Floods at NRTS

A system analysis of flood routing of the Big Lost River at the NRTS has been developed by P. H. Carrigan, Jr., Washington, D.C. A digital computer model routs flows through various river sections and predicts the magnitudes of rare catastrophic floods and their effects on the NRTS. A wider channel at the NRTS diversion would offer increased flood protection.

2.4 Seismic Investigations at NRTS

A study and report was completed by H. E. Malde, Denver, Colorado, to determine the potential for faulting and earthquakes at or near the NRTS. Surface linear features were excavated and are not a result of faulting. Two fault scarps, one north of Arco and another north of Howe, were excavated which revealed faulting at both locations. Six temporary seismometers were installed and no seismic activity could be detected at the NRTS. Future seismology studies at the NRTS are warranted to better evaluate the seismicity of the area.

3. PUBLICATIONS

J. B. Robertson, Vertical Molecular Diffusion of Xenon-133 Gas after Injection Underground: U. S. Geological Survey Professional Paper 700-D (1970).

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P. H. Carrigan, Jr., Probabilities of Flows Exceeding Capacity of Flood Control System at the National Reactor Testing Station: (in review).

J. B. Robertson, R. Schoen, J. T. Barraclough, The Influence of Liquid Waste Disposal on Geochemistry of Water at the National Reactor Testing Station, Idaho: 1949-1970: (in preparation).

VIII. AIR RESOURCES LABORATORIES FIELD RESEARCH OFFICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

(C. R. Dickson)

1. RESEARCH AND DEVELOPMENT PROJECTS

1.1 Mesoscale Transport Studies

An operational version of the computer program, which produced microfilm plots of objective wind field analyses from the 21 wind stations over the upper Snake River Plain, was used to produce a wind field plot for every sixth hour of the year 1969. Examination of these plots revealed a high percentage of conformity of the wind flow, over the upper plain, to a fishhook shaped depression in the topography. This depression proceeds northeastward from the American Falls reservoir for about 55 miles then turns northwestward for about 30 miles then southwestward over the NRTS for about 45 miles. The flow pattern over the plain appeared to be highly correlated with this depression during some portion of a day for more than 200 days of the year. The large circular eddy, which was observed previously in random samplings of the data, was seen to be a manifestation of this topographic feature. It was observed to occur during some portion of about 12% of the days. The various features of the flow patterns, which were observed in the wind field plots, illustrated that the expanded point of view provided by a display of a network of wind observations can be a valuable tool in studying mesoscale flow phenomena.

The objective analyses of the wind data were used to obtain a summary of potential transport pattern types over the upper Snake River Plain for the year 1969. A computer simulation was conducted in which hypothetical "particles" were released once each hour during the entire year from the Power Burst Facility (PBF) location in the south-central portion of the NRTS. The path of each "particle" was computed from the winds which were recorded at the wind stations. Microfilm plots, each containing 12 "particle" trajectories, were used to determine the frequency of occurrence of recognizable types of transport patterns. The most predominant single type, in all seasons except summer, is the one in which the material released during a 12-hour period moves directly to the southwest and off the computational grid. Other predominant types indicated changes in the wind direction and speed, in space as well as in time. These types emphasized the importance of a knowledge of the wind over the entire area of concern, instead of simply at the source of the release.

To demonstrate more clearly the importance of wind measurements over an area, pairs of trajectory plots were produced for several 12-hour periods. One plot of each pair depicted the trajectories constructed using the wind at the source, as if it applied over the whole area. The second plot of each pair showed the trajectories constructed from the flow defined by all 21 wind stations. The contrasts in the trajectory patterns were quite striking. It was very evident that for distances of more than a few miles estimates of effluent transport obtained from the source wind can be somewhat misleading.

An investigation was begun to determine how well trajectories, constructed from the network of fixed stations, would represent actual trajectories in the atmosphere. The atmospheric trajectories were obtained by radar tracking constant density tetrahedonal-shaped balloons (tetroons). Trajectories constructed from the wind station data for the corresponding time periods were then compared with the tetroon trajectories. The comparisons for the small sample available showed that the technique of constructing trajectories from the wind network was feasible and would produce reasonable results for the layer in which the tower winds were representative.

1.2 Computer Graphics and Animation

The computer program that produced the trajectory plots was used to develop a program which depicted the wind field derived transport in animated form on 16 mm film. The "particles" were represented by consecutive upper case letters which appeared at the source, one per hour, and moved away as they were carried by the wind. As the letters left the grid they changed to dots which remained at the exit points. Motion pictures were produced for two different release points for up to 72 hours of release time. This type of presentation is more dynamic and easier to interpret than a single plot containing the trajectories of several "particles".

1.3 Tetroon Drag Coefficient Study

A series of 230 controlled ascents and descents of one cubic meter tetroons were filmed to obtain tetroon time motion analyses. The study was conducted inside the Minidome on the Idaho State University campus in Pocatello to allow greater control over atmospheric conditions. The primary objective of the measurements was to provide a set of data for evaluating the coefficient of drag over a sufficient range of Reynolds numbers. From such a knowledge of drag coefficients, the response characteristics of the tetroon, and thus the suitability of the tetroon system for sensing various scales of atmospheric motions, can be evaluated.

1.4 Diffusion and Deposition Comparisons

A set of paired diffusion tests over 30-minute time periods was conducted to directly determine whether significant differences exist in the diffusion and deposition characteristics of uranine dye and molecular iodine gas. Each of these tracers was released simultaneously with methyl iodide gas. Thirty-minute mean plume center-line concentrations, crosswind-integrated concentrations, standard deviations of lateral plume spread, and limited amounts of vertical sampling all reflected the effect of different rates of effluent deposition. Lateral plume spreading was least sensitive to the rates of deposition involved. Peak center-line concentrations and crosswind-integrated concentrations were highly sensitive to the different removal rates. For weak temperature lapse conditions during these tests, uranine dye concentration values underestimated molecular iodine gas concentrations by about 2-1/2 times, and methyl iodide gas concentrations by about 4-1/2 times. The general finding of this test set comparison is that real caution must be exercised if the diffusion climatology of one tracer is to be used to describe the concentrations of another effluent.

1.5 Aircraft Wake Turbulence Studies

The research supported in this study was part of a joint government and industry accelerated evaluation of the operational impact of the wake turbulence produced by large jet aircraft. Data were collected through low altitude aircraft flybys near instrumented towers. Aircraft induced air circulations were measured by hot film/hot wire anemometry. Smoke visualized vortex circulations were filmed by FAA personnel to supplement these measurements. Eight different jet aircraft types were evaluated. The first portion of this study was the measurement of aircraft effects from nine series of aircraft flybys during February of the 200-foot Grid III tower at the NRTS. The second portion of this work was a series of 150 flybys at Atlantic City, N. J. during May and June. From these data approximate vortex characteristics such as size, basic shape, tangential speed versus radial distance, core diameter, age, speed of horizontal transport, separation of vortex pair centers, and supplemental measurements of atmospheric winds and temperatures were obtained. Some new graphics techniques were developed which will be useful in future data presentations and report preparations.

1.6 Wind Forecasting

The primary emphasis has been on a statistical prediction of winds 18 to 36 hours after forecast time. A variation of Multiple Linear Regression, (MLR) called Regression Estimation of Event Probabilities (REEP), is used to predict the probability of a wind direction class; e.g., the directions 200 to 260 degrees inclusive constituted one of the classes. The wind speed is predicted by the MLR equation that applies to the wind direction class of highest probability according to the REEP part of the forecast. The total reduction of variance was significantly increased by stratifying the data sample according to basic types of upper air flow patterns and deriving a set of forecast equations to go with each type. Equations were derived to predict the maximum hourly-averaged speed on winter afternoons about 30 hours after forecast time. A sample of 280 independent cases of 30 hour forecasts was then evaluated with the result that the statistical predictions were significantly better than the man-made forecasts verifying at the same time. For forecasts of six hours the man-made predictions were far better than the statistical predictions.

Man-made predictions are greatly enhanced by a thorough knowledge of the local terrain effects upon the large scale wind fields and the diurnal characteristics of the wind. Knowledge of the diurnal wind character was refined when wind roses for each hour of the day for each of six two-month periods were constructed and the times of significant wind shifts recorded.

An altogether different approach to wind forecasting is to use the "analog" technique. From an historical file of weather maps an attempt is made to find one which looks very nearly identical to the current weather map. The winds and weather associated with the historical map would presumably be a good forecast of wind and weather conditions associated with the current map. With respect to winds the results show a great deal of scatter within samples of identical historical maps. Further work is needed to determine if this scatter can be explained systematically by looking at other meteorological variables.

1.7 Receptor Climatology

A climatology of transport from a given site to surrounding areas was simulated on the computer in each of three experiments in which particles were transported (a) by a wind field determined from many wind stations, (b) a wind field determined by one wind station, and (c) in a steady direction with frequency of different directions determined from a wind rose. The climatologies were each significantly different from one another. The multi-station wind field very nearly represents the true transport field. The two experiments using winds from only one wind station were performed to determine the relative value of transport climatologies determined from a single wind record. The identical experiments were performed upon two sets of data, two years from the NRTS and one month from Los Angeles. The wind flow patterns in the Los Angeles area are more complex than over the NRTS, and the difference between the multi-station and single station transport climatologies was greater than at the NRTS. The tentative conclusion is that the more complex the local wind flow patterns, the greater the need for many wind stations to have any dependability in determining a climatology of transport.

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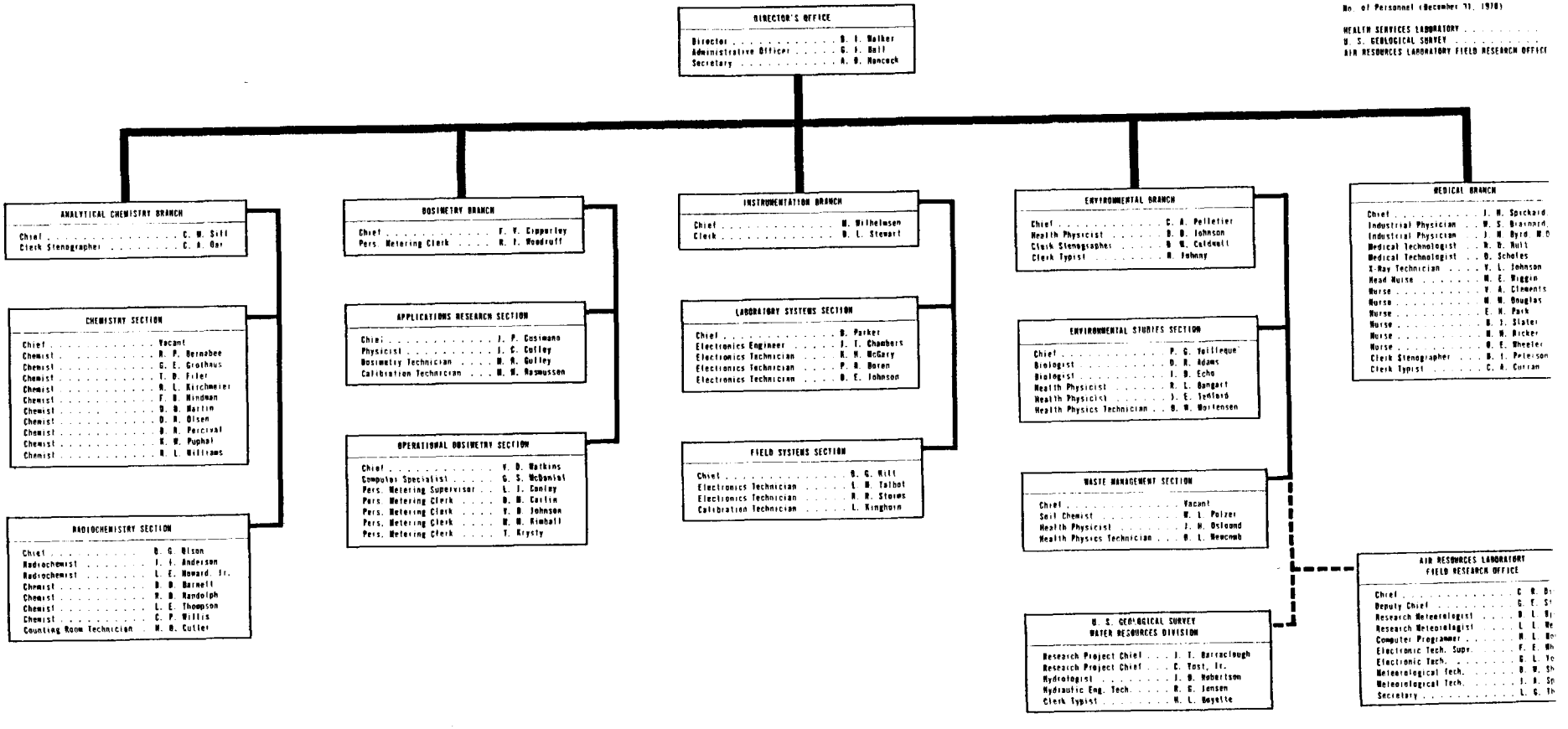
APPENDIX - - ORGANIZATIONAL CHART OF THE HEALTH SERVICES LABORATORY

HEALTH SERVICES LABORATORY



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