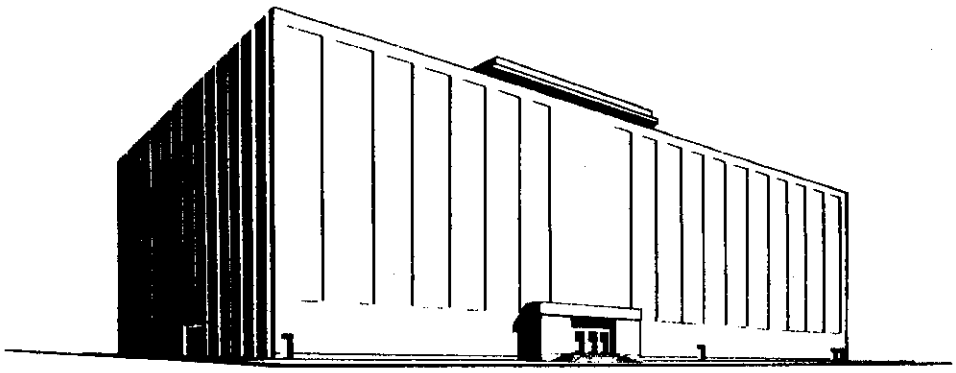


History of U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

for the year 1965

S A N F R A N C I S C O C A L I F O R N I A

CHAPTER I -- PROGRESS AND COOPERATION

10TH ANNIVERSARY

September 1965 marked the 10th anniversary of NRDL as an independent command. Prior to that the Laboratory was a subsidiary organization of the San Francisco Naval Shipyard. NRDL's tenancy remains unchanged even though SFNS was redesignated Hunters Point Division, San Francisco Bay Naval Shipyard on 11 May 1965, reporting to the Commander, San Francisco Bay Naval Shipyard at Vallejo.

SHIFT IN MANAGEMENT CONTROL

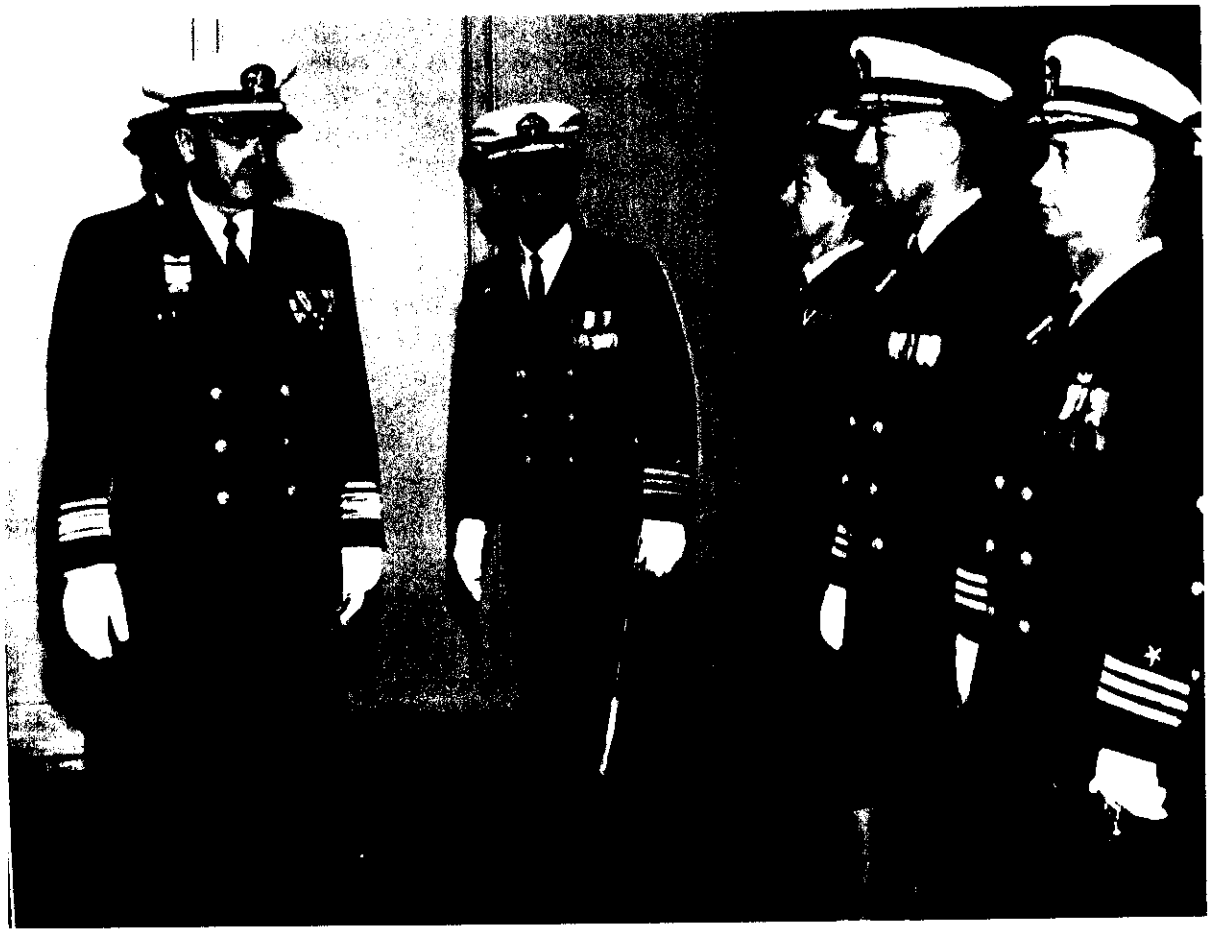
However, Navy control of NRDL was changed on 1 January 1965. The Chief of Naval Material was assigned Command and the Bureau of Ships was assigned support responsibilities. These replace military command by COMTWELVE and management control by BUSHIPS. COMTWELVE now exercises area coordination functions. These changes have not significantly influenced operations at NRDL.

REPORTING SUPERSTRUCTURE CHANGES

During the year a number of important changes were noted in NRDL's reporting superstructure: In September RADM John A. Clark, USN, succeeded RADM John McNay Taylor, USN, as COMTWELVE, and CAPT Harry C. Mason, USN, relieved CAPT Warfield C. Bennett, Jr., USN, as Assistant Chief of BUSHIPS (R&D). NRDL's first Director, RADM John J. Fee, USN, became Deputy Director of the Bureau of Ships on 1 December, replacing RADM Charles Curtze, USN, who retired. RADM Edward J. Fahy, USN, Commander, SFBNS, was appointed Chief of the Bureau of Ships to replace RADM William Brockett, USN, when he retires on 1 February 1966; and RADM John H. McQuilkin, USN (C.O. & Director at NRDL 1957-60) was named to replace Admiral Fahy.

"EXCELLENT", INSPECTORS REPORT

An over-all rating of "Excellent" was assigned to NRDL by both the 12ND military inspectors who visited the Laboratory on 11 February and the Bureau of Ships Inspector General's group following their comprehensive command and inspection held here 20-23 July.



12ND INSPECTION--RADM John McNay Taylor, Commandant, Twelfth Naval District, conducts inspection of military personnel. On completion of the inspection, the Admiral commented that - "Even though this is a unique and primarily non-military activity unlike the average ship or station, you certainly know how to turn out a smart looking inspection." He also commented upon the good impression NRDL makes for the U.S. on the frequent foreign visitors to the Laboratory.

"Even though NRDL is a unique and primarily non-military activity, unlike the average ship or station," said the 12ND Commandant, RADM Taylor, when he conducted a full dress inspection of the Laboratory's military personnel on 12 February, "you certainly know how to turn out a smart looking inspection." He also mentioned the good impression that NRDL makes for the United States on the frequent foreign visitors to this Laboratory.

The BUSHIPS' inspection report specifically commended enlisted training, civilian career development, and forms and paperwork management. The "personnel action" tickler system for military personnel was cited as being outstanding. The Laboratory's equal employment program was also commended.

AFFIRMATIVE ACTION

The C.O. & Director, CAPT D. C. Campbell, was a member of the "Affirmative Action Panel" at a 12ND Area Conference on Equal Employment Opportunity held at Treasure Island on 22 October.

NRDL hired five youths between the ages of 16 and 21 during the summer in cooperation with President Johnson's Youth Opportunity Campaign aimed at providing extra work and training opportunities for at least half a million young people throughout the country. Hired, also, as a working boss was Eric Partch, a junior at Harvey Mudd College, Claremont, California.

IN MEMORY OF A GREAT MAN

It is with sadness that the death of Dr. Robert Reid Newell, 73, must be noted in 1965. He passed away at his home in San Francisco on 27 August after a long illness. NRDL had the privilege of having Dr. Newell on its staff for 6½ years as a Medical Consultant after he retired from Stanford University School of Medicine after 37 years there. Not only was Dr. Newell one of the world's most renowned radiologists, but he was also an extremely outgoing person who provided invaluable counsel and guidance to hundreds of young scientists and medics.

DR. COOPER RETURNED FROM LONDON

The Scientific Director, Dr. E. P. Cooper, returned to NRDL on 9 August after a one year stay in England, where he worked out of the Office of Naval Research in London. Dr. E. R. Tompkins, who assumed Dr. Cooper's

YOUTH OPPORTUNITY GROUP -- These five youths and their boss, Eric Partch (third from left), were hired as part of the Youth Opportunity Campaign.

duties during his absence, resumed full time duties as Associate Scientific Director.

During his year abroad, Dr. Cooper visited most of the European Laboratories doing work of interest to NRDL, attended international conferences, and wrote reports.

NRDL-OCD CONTRACT MILESTONE

First research study to be completed under the NRDL (Navy) OCD contract monitoring arrangement made in 1964 was reported early in April. Factory Mutual Research Corporation completed an investigation of fire safety upgrading for fallout shelters in buildings. Evaluation of shelter shielding against nuclear radiation and a guide for determining fire hazard to shelter occupants was included. Methods, mainly untried, for upgrading on an emergency basis the fire safety of existing fallout shelter buildings were suggested. These included thermal barriers for window openings, automatic smoke detectors with manual response by fire-fighting shelter personnel, and environmental seals for shelter areas.

PROGRAM REVIEW TERMINATED

The weekly series of Program Review Seminars initiated in September 1964 continued until November 1965 when it was discontinued. The technical program of one branch was reviewed each week. By March 1965 the entire branch structure plus special projects and the Core program had received one review. This was followed by a second set of reviews all of which proved exceptionally productive.

COST REDUCTION GOAL UPPED

In September 1965 the Cost Reduction Committee was reconstituted with new membership. Mr. Paul E. Zigman was named chairman and Mr. J. E. Carroll continued as coordinator. In accordance with ALNAV 32 of 22 September 1965, cost reduction suggestions were accelerated during the "Open Season" period 27 September through 26 November. Reported savings in FY65 amounted to $147,000 and a strong effort is being made to meet the FY66 goal of $213,000.

PAY RAISE FOR ALL NRDLERS IN 1965

A military pay raise was signed by President Johnson on 21 August

and became effective on 1 September -- an increase of 6% of base pay for officers and 11% increase for the enlisted men. Classified employees received a 3.6% increase retroactive to 1 October; and on 5 December, blue-collar employees received a raise, also averaging about 3.6%.

INTERVIEW PROGRAM

On 22-24 March an interviewing study was conducted by a group of four psychologists from the Naval Personnel Research Activity, San Diego, California. This group consisted of Dr. Calvin W. Taylor, Dr. William H. Githens, Dr. Warren S. Blumenfeld, and Mr. Irving E. Kaplan. They conducted interviews of about one hour each with 34 members of the Nucleonics Division. The interviews were designed to determine what were considered by the interviewees to be favorable and unfavorable working conditions. The responses were coded to make them anonymous. The data obtained in this study were analyzed by Dr. Taylor's group and compared with that obtained from previous studies at other laboratories. The type of responses will be studied as functions of organizational level, education or training, and previous experience as obtained from personnel records. Professor Taylor is particularly interested in the relations between creativity and productivity and other environmental factors. The results of this study were made available to NRDL management in written and oral form.

MAJOR PERSONNEL CHANGES

CIVILIAN

There were no major permanent civilian personnel changes during 1965. On a temporary basis, however: (1) Dr. D. J. Kimeldorf, Head, Physiology-Psychology Branch, was appointed Acting Head of the Biological and Medical Sciences Division during the one-year absence of the Head of the Division, Dr. E. L. Alpen. From 1 July 1965-1 July 1966, Dr. Alpen will be at the Institute Gustav Roussy near Paris (see page 48). (2) Dr. W. E. Kreger, Head, Nucleonics Division, was designated as Cyclotron Project Director when the Cyclotron Project Office was established (see page 7). Dr. Kreger was given authority to recruit and assign to his group any person in the Laboratory needed in the early completion of the Project. Dr. Kreger continues as Head, Accelerator Branch. However, for

SCIENTIFIC DEPARTMENT LEADERS

Dr. Richard Cole
Chem Tech Div.

Dr. William Kreger
Nucleonics Div.

Mr. Robert C. Lilly
Asst. Scientific Director

Mr. Samuel C. Rainey
Military Evaluations Div.

Mr. Charles Ksanda
Operational Requirements Office

Dr. Edward Alpen
Bio Med Div.

Mr. Paul Zigman
Technical Mgmt Office

Dr. Edward Tompkins
Associate Scientific Director

Not shown is the Scientific Director, Dr. Eugene P. Cooper, who was on a year's tour of duty with ONR Branch Office, London, when this picture was taken.

ENGLISH INFLUENCE -- Dr. Eugene P. Cooper, Scientific Director, reported back to the Laboratory in high English style complete with umbrella and derby hat following a year's leave of absence for an ONR-NRDL collaborative duty working out of the Office of Naval Research Office in London. Dr. Cooper visited virtually all of the major laboratories in Europe involved in nuclear or radiological research and compiled in monthly segments an exhaustive report on his study of their work and facilities.

DR. DONALD J. KIMELDORF
Acting Head, Bio Med Division

LCDR M. I. VARON, USN
Radiological Medical Director

the duration of the Cyclotron Project, Dr. C. Sharp Cook, Physics Consultant, Code 903, was temporarily relieved of those responsibilities and was assigned as Head of the Nucleonics Division.

The Head of the Wage and Classification Staff, Donald Woll, returned to NRDL in July after an absence of two years in London, England, as Assistant Personnel Officer of the Navy Consolidated Industrial Relations Office....Lt. Col. Gerald Gibson, USMC (Ret), NRDL Marine Liaison Officer from 1957-60, retired and returned as a civilian Operations Research Analyst in the Military Evaluations Division....a former Wave stationed at NRDL from 1956-58, Marjorie "Wilkins" Jones, returned in November as a civilian Biological Technician.

MILITARY

Key officer changes included the following: (1) The Medical Director, CAPT Paul F. Dickens, Jr., MC, USN, went to Washington, D. C. in February as Medical Officer at the Naval Station with additional duty as Staff Medical Officer of the Washington Naval District. He was replaced by LT F. G. McKnight, MC, USNR, who went out of the Navy in July. Until LCDR Myron I. Varon, MC, USN, reported aboard in August as the new Medical Director, the billet was filled by LT J. S. Hege, MC, USNR, a Medical Investigator in the Experimental Pathology Branch. (2) After an absence of eight years, CDR Mildred J. Gehle, USNR, returned to NRDL in July and was assigned to the C. O. and Director's staff as Head of Central Scheduling, a new Code 105. (See page 7). While here from 1954-57, CDR Gehle was Assistant to the Administrative Director. (3) When the Administrative Division Officer, LCDR Kenton Hypes, Jr., MSC, USN, was transferred to the Far East in October, he was replaced by LT J. A. Zimmeht, MSC, USN. (4) LCDR A. G. Opitz, USN, retired in January. He was replaced as the C. O. and Director's Representative at Camp Parks by a civilian, R. R. Soule, who is also Head of the Technical Developments Branch. As Officer-in-Charge of the NAVRADCON Team, LCDR Opitz was replaced by LCDR B. T. Sansom, USN, Technical and Administrative Services Director. LTJG M. A. Chase was appointed Assistant Representative at Camp Parks.

CONSULTANTS UNDER CONTRACT NOW TOTAL 11

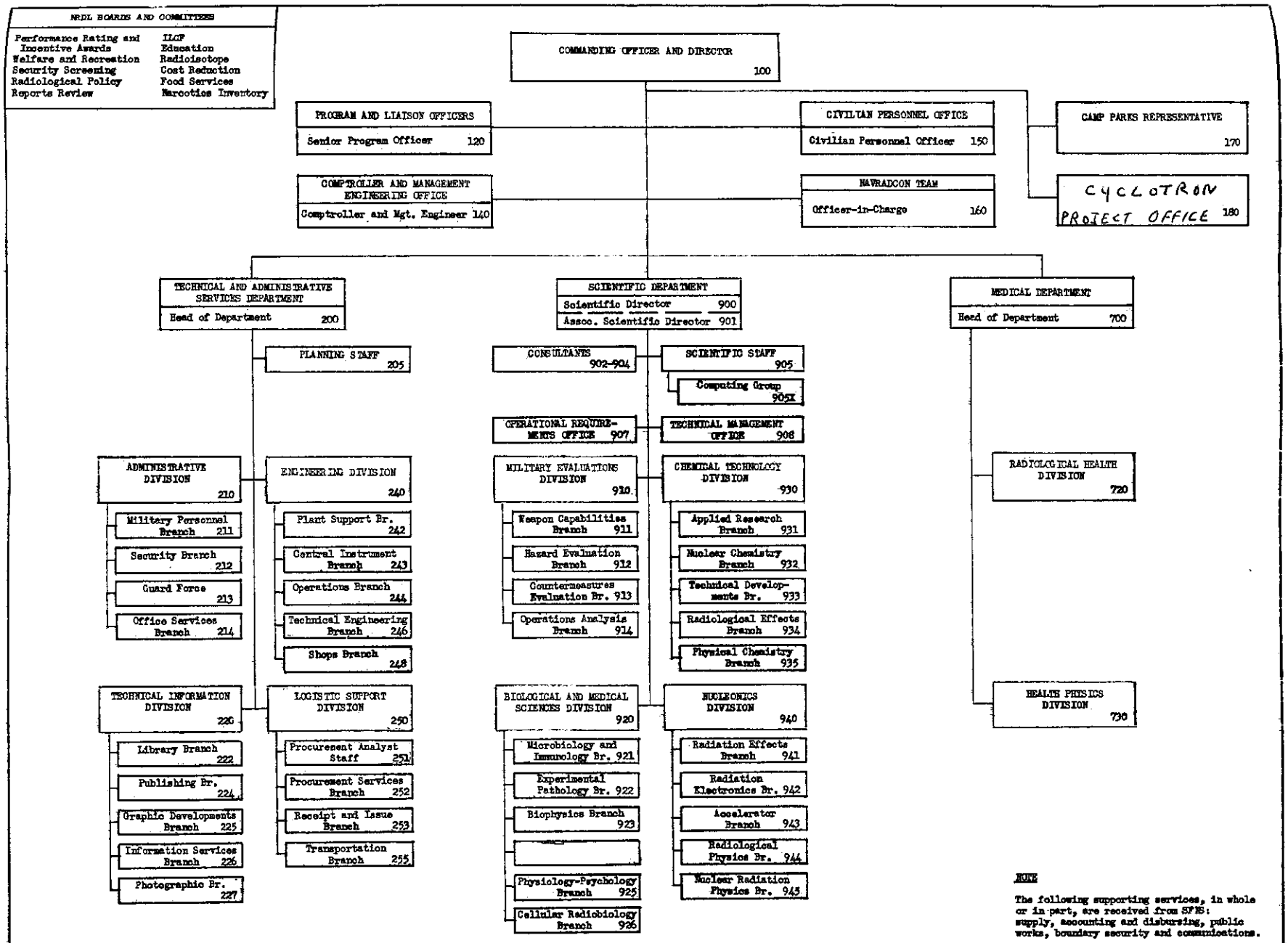
There were 11 distinguished scientists under contract during 1965 to consult periodically with members of the NRDL permanent staff. Con-

tinuing in this capacity from the previous year were (and their area of interests): (1) DR. ABRAHAM BROIDO, Head, Fire Chemistry Group, Pacific Southwest Forest and Range Experimental Station, U. S. Dept. of Agriculture, Berkeley (Thermal Radiation effects; mechanisms of ignition and pyrolysis). (2) DR. CECIL ENTENMAN, Director, Institute for Lipid Research, Berkeley (Effects of ionizing radiation on intermediary metabolism and nutrition). (3) DR. ROBLEY D. EVANS, Professor of Physics, Massachusetts Institute of Technology (Biophysical problems pertaining to radiation effects and hazards; general integration of NRDL research program). (4) DR. HARRY Y. HECKMAN, Research Physicist, Lawrence Radiation Laboratory, Berkeley (Identity of particle charge and rate of energy loss of primary cosmic rays in tissue). (5) DR. MAURICE HOLT, Professor of Aeronautical Sciences, U. C. Berkeley (Hydrodynamics of underwater explosions). (6) DR. BERNARD D. KERN, Professor of Physics, University of Kentucky, Lexington (Stabilization of the 2 MeV Van de Graaff accelerator positive ion beam current to reduce periodic oscillations and random shifts of beam). (7) DR. VICTOR J. ROSEN, Chief of Pathology, Veterans Administration, Los Angeles (Pathology of acute and late effects of ionizing radiations). (8) Professor VIRGIL E. SCHROCK, Associate Professor of Nuclear Engineering, U. C. Berkeley (Kinetics of reactor systems, heat transfer problems, radiological hazard evaluation). The three new consultants added during the year were DR. GERALD E. HANKS, Assistant Professor of Radiobiology, Stanford University (Relation of endotoxin protection of hematopoietic nodule formation in spleen of irradiated mice); DR. THEODORE L. PHILLIPS, Assistant Professor of Radiology, U. C. Medical Center (Applications and techniques of electron microscopy; analysis of electron micrographs of tissues from irradiated animals); and DR. GORDON L. BROWNELL, Associate Professor, Massachusetts Institute of Technology (Radiation hazard analysis, radiation physics, and radiation dosimetry).

ORGANIZATIONAL CHANGES

The chart on next page shows graphically the organization of NRDL as of 31 December 1965. During the year the following changes were made:

On 4 January the Pharmacology Branch (Code 924) within the Biological and Medical Sciences Division was disestablished. Functions of the Branch were reassigned to the Physiology-Psychology Branch (Code 925), to the Cellular Radiobiology Branch (Code 926), and to a unit within the Divisional Office, Code 920.


NRDL BOARDS AND COMMITTEES
Performance Rating and Incentive Awards
Welfare and Recreation
Security Screening
Radiological Policy
Reports Review
ILGF
Education
Radioisotope
Cost Reduction
Food Services
Narcotics Inventory
COMMANDING OFFICER AND DIRECTOR 100
PROGRAM AND LIAISON OFFICERS
Senior Program Officer 120
CIVILIAN PERSONNEL OFFICE
Civilian Personnel Officer 150
CAMP PARKS REPRESENTATIVE 170
COMPTROLLER AND MANAGEMENT ENGINEERING OFFICE
Comptroller and Mgt. Engineer 140
NAVRADCON TEAM
Officer-in-Charge 160
CYCLOTRON PROJECT OFFICE 180
TECHNICAL AND ADMINISTRATIVE SERVICES DEPARTMENT
Head of Department 200
PLANNING STAFF 205
ADMINISTRATIVE DIVISION 210
Military Personnel Branch 211
Security Branch 212
Guard Force 213
Office Services Branch 214
ENGINEERING DIVISION 240
Plant Support Br. 242
Central Instrument Branch 243
Operations Branch 244
Technical Engineering Branch 246
Shops Branch 248
TECHNICAL INFORMATION DIVISION 220
Library Branch 222
Publishing Br. 224
Graphic Developments Branch 225
Information Services Branch 226
Photographic Br. 227
LOGISTIC SUPPORT DIVISION 250
Procurement Analyst Staff 251
Procurement Services Branch 252
Receipt and Issue Branch 253
Transportation Branch 255
SCIENTIFIC DEPARTMENT
Scientific Director 900
Assoc. Scientific Director 901
CONSULTANTS 902-904
SCIENTIFIC STAFF 905
Computing Group 905X
OPERATIONAL REQUIREMENTS OFFICE 907
TECHNICAL MANAGEMENT OFFICE 908
MILITARY EVALUATIONS DIVISION 910
Weapon Capabilities Branch 911
Hazard Evaluation Branch 912
Countermeasures Evaluation Br. 913
Operations Analysis Branch 914
CHEMICAL TECHNOLOGY DIVISION 930
Applied Research Branch 931
Nuclear Chemistry Branch 932
Technical Developments Br. 933
Radiological Effects Branch 934
Physical Chemistry Branch 935
BIOLOGICAL AND MEDICAL SCIENCES DIVISION 920
Microbiology and Immunology Br. 921
Experimental Pathology Br. 922
Biophysics Branch 923
Physiology-Psychology Branch 925
Cellular Radiobiology Branch 926
NUCLEONICS DIVISION 940
Radiation Effects Branch 941
Radiation Electronics Br. 942
Accelerator Branch 943
Radiological Physics Br. 944
Nuclear Radiation Physics Br. 945
MEDICAL DEPARTMENT
Head of Department 700
RADIOLOGICAL HEALTH DIVISION 720
HEALTH PHYSICS DIVISION 730
NOTE
The following supporting services, in whole or in part, are received from SFNS: supply, accounting and disbursing, public works, boundary security and communications.
APPROVED
CAPT, USN, COMMANDING OFFICER & DIRECTOR
U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
BUREAU OF SHIPS
BASIC STRUCTURAL ORGANIZATION
CHART NO.
NRDL INST 5450.3A

Special duties as Code 105 on the staff of the C. O. & Director were added when CDR Gehle reported aboard (page 5). Code 105, representing a Central Scheduling function, is concerned with central maintenance, in graphic form, of program schedules and progress.

On 1 November the Cyclotron Project Office (Code 180) was established, superseding the former offices of Cyclotron Coordinator and Cyclotron Installation. (See page 4).

FACILITIES

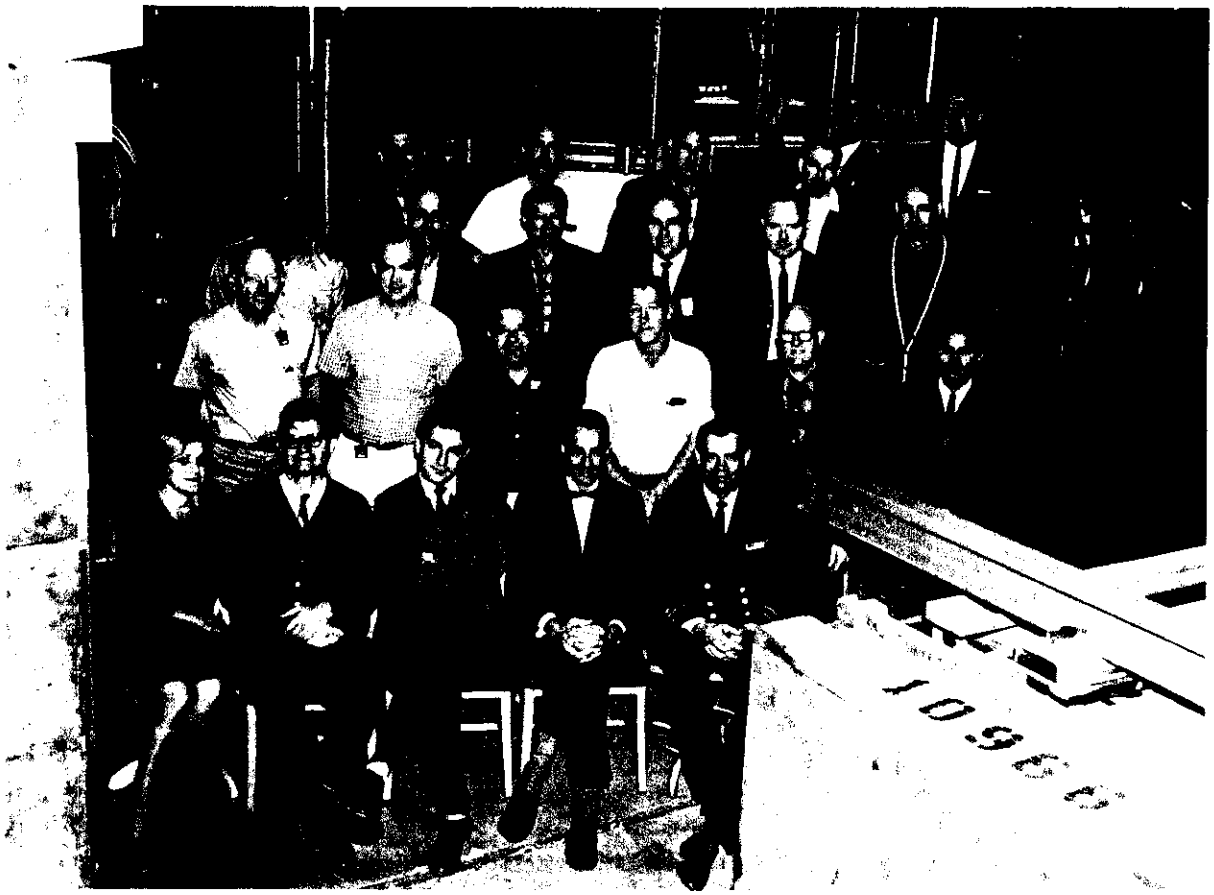
ANIMAL FACILITY CONSTRUCTION SET FOR 1966

Construction is set to start in January 1966 on the new $793,000 NRDL Research Animal Facility approved late in the year by Congress and the President under a MILCON Project. It will take about one year to complete the two buildings - the 16,000 sq. ft. main one story building to house pathogen free colonies, holding rooms, and sterilizing rooms, and the 8,000 sq. ft. dog kennel. This facility will be located across the tracks from the main building and slightly west, including part of the present "B" parking lot.

CYCLOTRON PROGRESS REPORT

Completion of the first major phase in construction of the 70" cyclotron was achieved on 11 February when power to the main coils was successfully applied. All preliminary tests indicated that the subsystems were all performing well within design specifications. A total current of 1340 amperes was passed through the coils satisfactorily. The operation of the cooling system and all interlocks were indicative of adequate design. Only minimum adjustments were required in the main power supply to achieve full power of the system. Detailed magnetic measurements to determine the general nature of the main magnetic field were being conducted on a continuing basis as the remaining installation of the other assembly items continued.

A machine shop was installed in Building 820 to furnish the necessary fabrication support for construction, installation and operation of the cyclotron and its varied components. One trained mechanic was assigned there at all times, but on a rotating basis.



CYCLOTRON PROJECT STAFF - Pictured in front of the 70" NRDL cyclotron now under construction is the staff behind the project. Dr. W.E. Kreger, Head of the Cyclotron Project Office, is seated second from right. Others are (left to right) front row: Miss R. Smith, Secretary; Dr. H.A. Howe, Physics Design; Dr. D.J. Horen, Physicist; Dr. Kreger; LCDR E.L.St.Ville, USN, Proj. Liaison Officer. Second row: H. Merritt, Model Maker, K. Hofeling, Machinist; J. Ascorra, Model Maker; M. Brownell, Leadingman Model Maker; S. Williams, Elex. Tech.; J. Ricafort, Draftsman. Third row: L. Jenkins, Electrician; F. Watson, Elex. Tech.; J. Hall, Elex. Tech.; O. Fredriksson, Proj. Eng. (W.M. Brobeck & Assoc.); J. Flynn,Mech. Eng.; F. Lyles, Eng. Tech. Fourth row: G. Hibbs, Electr.; W. Chinn, Elex. Tech.; J. Deach, Elex. Tech.; W. Mallet, Physicist. Back row: R. L. Anderson, Eng. Tech.; M. L. Tasem, Planner & Estimator. Personnel not pictured: LTJG D. Luck, USNR, Math.; L. Shaw, Physicist; J. Walters, Math.

To attempt to recoup time losses due to fabrication delays, the construction schedule for the NRDL cyclotron was considerably revised. A new PERT logic diagram was formulated to reflect this revision and to add non-MILCON activities. A completion date of 22 November 1966 was projected, even though there was a 2-month additional delay in the fabrication of pole magnet tips, the critical path item. Also, a longer magnet measurement activity was absorbed in the schedule to obtain needed information regarding the magnetic field of the 70" magnet, including pole tips, holsters and hill shims.

The magnet core, coils and power supply were tested and shown to be satisfactory. The fore vacuum system was installed and tested as satisfactory. Shielding for the neutron physics and shielding research cave and the charged particle physics cave was virtually completed. Low energy extraction peeler and regenerator, extraction iron, extraction coil and yoke bending magnet design were essentially completed and fabrication started.

Start-up period began on 26 October. Four target stations are being developed: two inside the main cave and two external physics areas. Approximately one year will be required to bring the beam up to full power required by the technical program.

ANIMAL FACILITIES RELOCATED

In 1951 the Laboratory acquired the old SFNS brig and modified it into a laboratory lined with sound dampening material to provide a constant environment in which could be studied the changes of psychological performance of irradiated small animals, specifically rats. In 1953 a gamma radiation source was added. This "laboratory" had never really been satisfactory because it was in an old concrete block building difficult and expensive to maintain, ventilate and heat, as well as being located in a barracks area used by the Shipyard. This program was moved into the former hot cell, Building 364, which was renovated to provide a much more adequate work space for the program, permitting better use of space available. Added advantages over the former brig are that it is located more conveniently to the main Laboratory building and is not in the vicinity of any SFNS quarters. The new facility provides a shielded area with a zincbromide viewing window which had not been possible in the former building. The scientific program to be conducted in the new facility now can be expanded in its logical development to include studies of irradiated primates.

X-RAY EQUIPMENT

Construction started directly east of Building 815 in 1964 for a shield to house the 1 MeV X-ray machine. It was completed during 1965 and the X-ray machine was moved in.

The Bio-Med Division obtained a surplus Westinghouse X-ray machine and it was installed in Room 597 of Building 815, in the same room as the G. E. X-ray machine.

COMPUTER

NRDL's old computer seemed to be reaching the "end of the line" and was beset by increasing operating difficulties which resulted in delays to a number of research problems.

The computer operation was faced with the problem of increasing demand because of the more theoretical and analytical programs being undertaken. In this same period equipment failures increased to the point where over-all computer lost-time was running approximately 49% with most of the failures attributed directly to faulty tape drives. In spite of concerted effort by Lab electronics personnel and company engineers from all over the Bay Area there was no noticeable improvement in performance. The equipment is so old that it is very difficult to obtain replacement tape units or to find engineers who are familiar with its maintenance.

This computer record was cited to the Bureau as a further indication of NRDL's urgent need for a new and therefore more reliable equipment. Heavy emphasis in current programs is on applied mathematics, operations research and theory. This work depends so heavily on fast and reliable machine computation that without it the most capable investigators cannot operate effectively. In surveying recent developments in the computer field, the Laboratory has been greatly impressed by the capabilities, relatively low cost and potentially high reliability and low maintenance of the newly developed systems. From all indications, the early purchase of such equipment can provide NRDL with increased computing capability sufficient to satisfy the foreseeable demands of the longer-range programs.

Impressed with the potential of centralized computers operated from a number of remote stations, early in May Lab management observed a demonstration by a major concern on a time sharing system in which a teletype station in Sunnyvale is one of several remote stations connected to a computer in Phoenix, Arizona.

CAMP PARKS

The NRDL field facility at Camp Parks, was the scene of considerable activity during the year. NRDL is now at Camp Parks on its second 5-year permit and has consolidated its functions into a contiguous area. The Office of Economic Opportunity, operating through its contractor, Litton Industries, set up a training center at the Camp and acquired certain Laboratory facilities for training purposes including the transportation building complex, the target complex and the gymnasium part of the building holding NRDL's large fallout dispersers. NRDL negotiated with Litton to pay for relocating these facilities to a consolidated area in order to release the desired space. Litton erected a chain link boundary fence for its training center area and activated over 60 buildings.

On 30 June the Sixth Army relinquished responsibility for support of Camp Parks and at that time the responsibility was assumed by the District Engineer of the Army Corps of Engineers in Sacramento.

A team of AEC specialists made a brief inspection on 5 November of Parks and a site near Folsom, Calif. as possible locations for the world's biggest atom-smasher. The team, headed by Dr. Spofford English, Assistant General Manager, AEC, is visiting a number of proposed sites throughout the United States.

The accelerator has been recommended by the White House, but has not yet been approved by Congress. Initial estimates have the cost at nearly $300 million to build and $56 million a year to operate.

FIRE RESEARCH FACILITIES

NRDL concluded arrangements with the Pacific Southwest Forest and Range Experiment Station, U. S. Forest Service, for cooperative use of fire research facilities at the University of California Field Station in Richmond, California. NRDL personnel involved in DASA fire vulnerability studies, by using these existing facilities on a courtesy basis, avoided delays and costs attendant upon Navy construction. It is expected also that experience gained will be of great value in the possible later design of permanent fire research facilities.

LIBRARY EXPANDED

Improvements in the Library completed in October included additions to space and facilities plus streamlining of the document collec-

tion and changes in location. Service to the Science Department is expected to be appreciably enhanced by the addition of two reading rooms and a microfiche microfilm reading facility located in an area out of the main stream of Library traffic. These quiet and convenient facilities, next to the literature sources, will provide scientists making literature surveys for technical report preparation more efficient locales than the improvised nooks in their office or laboratory areas. The rearrangement of documents involves the separation of the classified from the unclassified technical reports, and the separation of reports from books and reference material into separate sections of the Library. This will realize long-range savings in vault space, assist Library users by clearer identity of the location of reports, as opposed to books, and will provide an assist to operations efficiency of the Library staff.

"NIGHT WATCH" EQUIPMENT INSTALLED

"Night watchman" telephone equipment was installed to make it easier for personnel working after-hours to receive calls. MI-8-6900 calls go to the Guard Station. The guard contacts a called party and gives him a code number. After insuring a dial tone, the called party dials the code number from any NRDL phone and is automatically connected to the outside line.

CHAPTER II -- TECHNICAL PROGRESS AND ACCOMPLISHMENTS

Technical progress and accomplishments at NRDL during 1965 are reviewed in this chapter as in the 1964 History on a cross-sectional basis. Beginning with overall military applications studies reflecting research conducted by the various Scientific Department Divisions, this Chapter also covers highlights of research in various other disciplines including nuclear physics, radio-chemistry, electronics, engineering and biology-medicine.

PROTECTION AGAINST NUCLEAR WEAPONS AND RADIATION

Thermal Radiation Predictions for Naval Shipyards

As part of the Target Vulnerability Studies applicable to naval shipyards, a method was designed to make an approximate prediction of the damage to shipyards from thermal radiation and subsequent fire. A research project contracted to United Research Services Corporation, yielded a method designed to approximately predict the damage to naval shipyards from the thermal radiation and subsequent fire ignition and spread; provide preliminary procedures and data required for these procedures, as well as data specifically applicable to the Pearl Harbor Naval Shipyard. Fire-spread through the shipyard from the directly ignited structures is considered and specific procedures are given for estimating the extent of this spread.

NBC Defense Bill for USS THOMAS - 'STOPS' Project

NRDL's STOPS Task Group prepared a N/W, B/W and C/W defense bill for the USS Herbert Thomas, DD-883, for use during the operational tests of the STOPS (Shipboard Toxicological Protective System). The experimental installation aboard this ship is designed to furnish a FRAM 1 destroyer the additional capability of operating in a toxic (NBC) environment for extended periods of time. Revision of certain bills and instructions in the ship's organization and battle control manuals was essential in order for the ship to take full advantage of the STOPS capability.

The Laboratory also compiled and submitted a list specifying the modifications made to the THOMAS during its FRAM-1 conversion which involved installation of the STOPS. The modifications were described in such a way as to acquaint personnel already familiar with more conventional FRAM-1 destroyers with the involved features of the THOMAS, particularly areas in which differences in shipboard equipment require changes in operating procedures. This information is expected to be useful to personnel such as those of the FTG who will be required to provide training and assess the performance of the ship and its crew.

Nuclear Warfare Doctrine Enhanced

Nuclear warfare doctrine was enhanced by fallout-models and predictions made by Ian O. Huebsch, a mathematician at NRDL. (In recognition of these contributions, a Gold Medal for Scientific Achievement was presented to Mr. Huebsch on 27 May 1965 at the Laboratory's fourth annual Gold/Silver Awards ceremony by the Acting Scientific Director, Dr. E. R. Tompkins. (See page 47). Until Mr. Huebsch created his original development, applying hydrodynamic and thermodynamic theory to cloud use and expansion, no fallout model was available for water-surface nuclear explosion bursts. Heretofore, fallout predictions for water-surface-bursts have essentially used land-surface-burst fallout models, yet land-surface and sea-water-surface nuclear explosions produce different kinds of fallout. Precise calculations of transit dose and dose rates can now be made because of Mr. Huebsch's perceptive extensions of models approximating base-surge phenomena.

Weapon Effects Damage-Casualty Estimating

Criteria for estimating structural damage and personnel casualties from the immediate effects of a single-surface or above-surface burst of a nuclear weapon in the 1-1000 MT range have been developed in a NRDL study completed in July. Effects taken into account include air blast, ground shock, thermal radiation and initial nuclear-radiation. The non-immediate effect, namely, fallout nuclear radiation, is also included. In connection with air blast, the concept of "damage-equivalent peak overpressure" is introduced, defined and used. A new treatment of the problem of the atmospheric transmission of thermal radiation is given and the questions of overlap of initial-radiation fatalities with blast and thermal effects fatalities and of overlap of thermal-effects fatalities with blast fatalities plus corresponding questions of overlap of non-fatal casualties are considered. General objectives of the project are the development of means for defining more clearly short and long-term biological and environmental consequences of nuclear warfare together with rapid quantitative estimating of these consequences.

Weapons Burst Analysis

The second in a series of compilations and analysis of initial gamma data from nuclear weapon bursts at varying heights was completed. This study for BUSHIPS presented a compilation of initial gamma free-field film badge data from surface-intersecting bursts and a preliminary empirical analysis of these data. A surface-intersecting burst is defined as a burst above the surface but at a height less than one fireball radius or $193W^{0.35}$, where W is expressed in KT and the radius is in feet. Data were available from Operations SANDSTONE, TUMBLER-SNAPPER, IVY, UPSHOT-KNOTHOLE, TEAPOT, and PLUMBBOB.

Primary Nuclear Weapon Ignition Ranges

NRDL thermal radiation specialists assembled the currently best available information pertinent to the thermal-effects capability of nuclear weapons in a form which will permit the rapid and convenient prediction of the extent of primary ignitions in urban, rural and forested areas following the detonation of a nuclear weapon for a variety of atmospheric and environmental conditions. Finding that the problem lends itself well to machine computation, a preliminary computer program was devised which calculates radiant exposure contours and ranges of primary ignitions in a variety of kindling fuels for a very broad range of weapon yields and environmental conditions.

State of the Art in Fire Research

The Office of Civil Defense sponsored a study of the state of the art in fire research in general and of research efforts in the nuclear weapon effects thermal and fire problem in particular. Background information was compiled on fire research efforts in the United States and elsewhere, particularly in Japan and the United Kingdom. The contributions of fire research efforts sponsored by the OCD to the solution of the nuclear weapon effects thermal and fire problems were evaluated and recommendations made having to do with organization aspects of fire research efforts in the USA.

Water-Surface-Burst Fallout Evaluation

Development of "first order" procedures for umpiring effects on naval ships of fallout from one or several water-surface nuclear bursts were announced during the year. Also completed was a procedure for evaluating resulting hazard to an aircraft carrier and to its screenships, assuming washdown, deep-shelter and manual decontamination countermeasures

can be implemented. Use of the procedure for estimating combat ineffectives among ships crews and for comparison of water-surface vs land-surface bursts for short distances from ground zero involves reference to fallout-dose predictions by the NRDL D-model and to tables of radiological-countermeasure effectiveness and radiation transmission for various ship types.

Times of Arrival vs. Cessation of Fallout

Fallout arrival and cessation times at points on the ground have been determined and related by starting with the concept of a cylindrical radioactive-cloud source model. For any fallout prediction system that is to be used in nuclear-attack vulnerability studies, the results show that a minimum of two effective fallout winds are needed if the dynamics of fallout arrival and the distribution of particle-sizes on the ground are to be adequately reproduced.

SNAP (System for Nuclear Auxiliary Power) Program

NRDL was assigned technical management responsibility for AEC's program concerned with radiological safety in the use of SNAP sources. Part of this program consisted of laboratory corrosion studies of fuel sources and fuel encapsulants. It was planned to extend the Laboratory corrosion investigations to include studies in an actual ocean environment and as part of an effort to locate an appropriate ocean site for the extended studies, a visit was made to San Clemente Island on 25 October. Available locations were inspected and discussions relative to field support were held with military and civilian personnel on the island. Preliminary estimates on the costs involved in mooring a surface platform for the work and in providing power to the platform were obtained from Public Works personnel.

Tracing Plutonium in Seawater

Accidents which would expose the plutonium fuel used in SNAP generators to seawater could occur in deployment of these generators. The radiological hazard which would exist following such accidents could depend on the dissolution behavior of the exposed radionuclide fuel. NRDL scientists came up with a rapid and accurate method for determining trace quantities of the plutonium in seawater after the evaluation of all pertinent parameters. The method is capable of determining the trace quantities without any chemical separation.

Radiation Exposure Criteria for Nuclear Rockets

In the analysis of the potential hazards from radioactive debris resulting from accidental or operational fragmentation of nuclear reactors used in rocket propulsion, a need exists for the presentation of established dose criteria as well as for discussions and summaries of the expected effects of beta and gamma radiation from small discrete particle sources and large gamma-emitting sources. First phase was completed of a search for such presentations and summaries and NRDL investigators devised tables of variously established radiation dose criteria of importance to the safety evaluations of nuclear propulsion rocket flights. Brief summaries have also been spotlighted of experiences involving skin burns from X rays, cathode rays and beta radiation. A discussion of the lung pathology due to deposited radioactive material was developed and a summary presented of radiation effects as they apply to analysis of effects of exposure of the gastro-intestinal tract to insoluble beta emitters.

Decomposition of Rocket Fuel

Tests were made to determine whether it is possible to suppress the generation of non-condensable gases when monomethylhydrazine (MMH) rocket fuel is subjected to ionizing radiation, since gas generated in rocket fuel tanks by solar cosmic, Van Allen, and nuclear rocket radiations might develop excessive pressure and require venting. It has been found that MMH produces more than twice its volume of gas (measured at $25^{o}C$ and 1 atm.) consisting of hydrogen, nitrogen and methane when irradiated to nearly 10^{7} rads with gamma rays.

Contamination from Non-Nuclear Destruct

The radiological environments which may result from the non-nuclear destruction of Nike-Zeus nuclear warheads at a specific location were predicted in laboratory studies. Wind criteria are recommended in this study for the launching of a nuclear-armed Nike-Zeus missile to limit the extent of plutonium contamination from a warhead destruct and a plan was developed for the radiological reclamation of areas and facilities contaminated with plutonium.

Population Characteristics for Nuclear Attack Situation

In an AEC-sponsored project, wrapped up during April, a data card file was constructed of selected population characteristics for the

9.4 million residents of ten Southern California counties. These data were prepared for studies of long-range recovery from nuclear attack. In the case of such an attack, estimated casualty and damage are generally known for populations and places as a function of time after attack and distance from the burst point. This file can be used to help determine the location and characteristics of the population remaining after any catastrophe effects of which are known as a function of time and distance and whose interactions with such environmental factors as structure type, structure vulnerability to blast or fire, weather conditions, etc. could be assumed.

In addition to and supplementing the above study, one of the most comprehensive studies of its kind yet made by Laboratory operations research specialists was completed on the subject of demographic response to nuclear attack in the State of California. In this study an analysis was made of the response to nuclear attack with high yield weapons against selected aiming points in Southern California, utilizing a methodology developed at NRDL. Comparison was made of fallout calculations with the NRDL "D" Model and the Rand Quickcount Model, when utilized as sub-routines of the general methodology, to show the sensitivity of target response to the type of fallout model used. Some sociological aspects of the demographic response in Santa Barbara County were presented, such as changes in population distribution by age, sex and occupation as a result of an attack.

Fallout Shelter Study Wind-up

In a concluding fallout shelter study for OCD on the problem of fallout carried into shelters via ventilation systems, experimental results did not check out too closely with several pre-test assumptions. For instance, while it was assumed that fallout particles penetrating the ventilation intakes would be deposited in the shelter living area, experimental evidence indicated that as little as 50% of the penetrating fallout may reach the living area with the remainder being deposited on the steps and landing of the entrance. Maximum estimated ingress dose was 11.8r at 167 miles downwind from a 100 to 100,000 KT detonation. A relation between mass per unit area deposited outside the shelter and the mass penetrating the ventilation intakes was determined as a function of particle size. Also, particle penetration by the largest size range (500 to 700 μ) appeared to be due principally to "bounce-in" rather than entrainment by the air stream.

RAD Recovery Manual

At the request of the U. S. Army Engineering School at Ft. Belvoir, NRDL submitted a review of the draft of the proposed TM 5-225: "Radiological and Disaster Recovery of Fixed Military Installations." Principal observation and comment from the Laboratory was the apparent Civil Defense orientation of the manual vs. an orientation toward the assigned post-attack mission of a military installation. As previously reported to the Army Engineer School, NRDL, under Bureau of Yards and Docks' support, undertook preparation of another version of the manual.

FIELD OPERATIONS

NRDL at CHASE III

NRDL participated in the joint ONR-BUWEPS CHASE III experiment built around the scuttling of a 300-foot hulk loaded with 700 tons of over-age ordnance, and the detonation of that ordnance 1000 ft. below the surface in 5000 ft. of water off of Cape Charles, Va. Laboratory participation consisted of minimal surface photography and flyovers of the water pool created by the blast with airborne infrared scanning equipment. Infrared gear, aircraft, crew and technical assistance were furnished by NADC, Johnsville. Preliminary results indicated this to have been an excellent opportunity for the gathering of seismic data and other technical information regarding deep underwater explosions.

Costa Rica Research Team

A research team from NRDL was in the field near San Jose, Costa Rica. The Costa Rica joint NRDL-SRI project involved additional studies of fallout from the volcano, Irazu, which appeared to be petering out after having erupted over a period of over a year. NRDL interests covered the natural arrival and deposition of the volcanic 'fallout' particles, the retention of particles by individuals in the open, the ingress of particles in the buildings as a function of meteorological conditions, the effectiveness of removal of fallout by organized cleaning operations, and the mass transportation of fallout in rough gutter storm drains and sewers by run-off waters.

'SILVER LANCE' Participation

A number of NRDLers participated in this major fleet exercise held between 23 February and 12 March and involving more than 80 ships and 70,000 Navy-Marine Corps personnel of the U. S. Pacific Fleet. Three NRDLers served as official observer-umpires aboard the carrier Midway and the Radiological Health Officer served as medical doctor for the Marine Force during the exercise conducted at sea off Southern California.

Barge for Ocean Studies

Since late 1964 the Environmental Radioactivity Program has been involved in two studies to further evaluate the distribution of radioactivity and dissolved gases in the North Pacific Ocean. As a result of working in the marine environment, certain capabilities have evolved which, although specifically planned for the present program, are potentially useful for future oceanographic research.

A 110 by 34 foot YFN (see next page) has been adapted to serve as a sampling platform on which equipment and living quarters are permanently located. This barge is assigned to NRDL and its use is limited only by tug availability and weather. With sufficient notice, tug availability is no problem. For the two barge trips so far completed, the USS Cahokia has been available through arrangements made with 12ND to hold the barge at sampling site 15 miles west of the Farallon Islands. Although sea conditions imposed a limitation to sampling, the 'shakedown' cruise tested the seaworthiness of the barge and indicated that it can remain on station in fairly severe weather. Fifteen foot waves, accompanied by 50 to 60 knot winds, were encountered, yet no damage to equipment or vessel resulted. During the second cruise, the mixed layer was successfully sampled and continuous operations proved possible in a sea state as high as 4. Both sea water and dissolved gases were stored and returned to the Laboratory.

This system, with and without modifications, suggests possibilities for further oceanographic research, especially chemical and biological. The existing hose length will reach to the average depth of the oxygen minimum zone, which includes the mixed layer and much of the thermocline. Any level may be sampled in as great a volume as desired for both chemical constituents and microbiological content. The deck area forward of the hose reel can be used for any specialized equipment required for the particular operation. Other equipment mounted on the barge includes a bathythermograph winch, which provides a temperature profile to 900 feet, a crane capable of placing buoys and unmanned sampling platforms, a power supply plant consisting of a 75 kw and a 60 kw generator, and a portable oceanographic unit. A standard hydrographic winch, living quarters for

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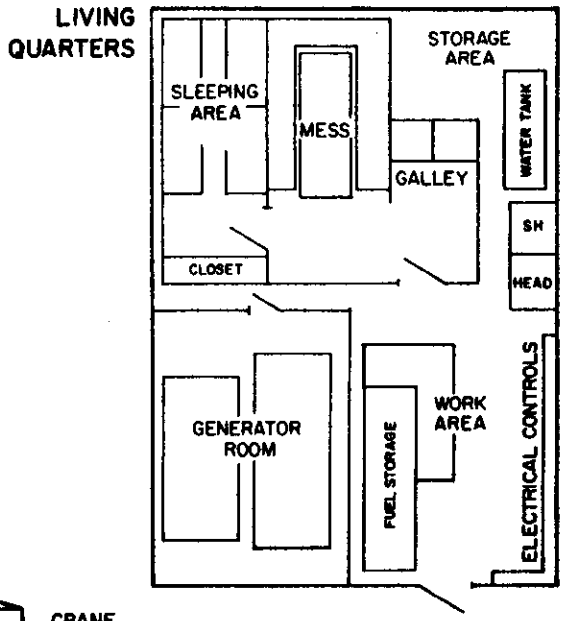
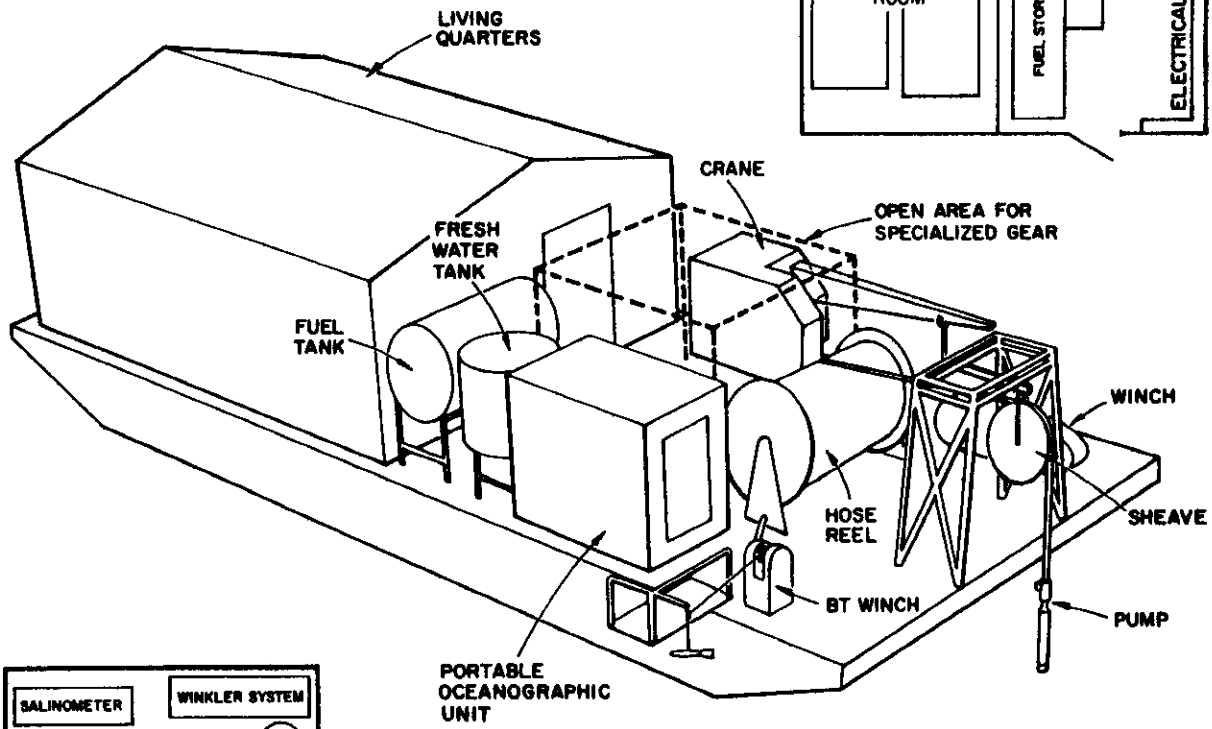
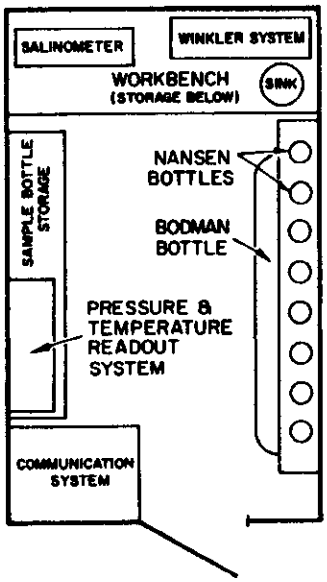






NRDL YFN BARGE FOR OCEAN STUDIES

eight providing sleeping and mess areas, a galley, shower and toilet, and a small workshop are also provided. The portable oceanographic sampling unit consists of an aluminum radar shack converted into a combination wet and dry laboratory and a readout system for the pressure transducer and thermistor is mounted in the radar shack, as well as a two-way radio for communication with the tug and NRDL.

SAILOR HAT Weapons Test Instrumentation Check Out

Two members of the research staff of NRDL participated in the SAILOR HAT high-explosive underwater shock tests conducted by the Defense Atomic Support Agency off Kahoolawe in the Hawaiian Islands during late March and early April. The NRDL participation in this event was for the purpose of testing the performance of a prototype floating instrument platform designed for use in the collection of information on nuclear radiation fields and for sampling of "fallout" from underwater nuclear detonations. The test provided valuable information for use in bringing equipment designs to a readiness-to-test status.

Cold Weather Washdown Tests

Results of the cold weather tests conducted by NRDL investigators of a ship washdown system aboard the USS POWER (DD 839) at U. S. Naval Station, Argentia, Newfoundland, tallied as follows: Three 20-minute washdown tests were conducted at dockside during ambient temperatures of 28,25 and 10°F. Icing during the 28 and 25° tests was limited primarily to rails, lines and other fixtures away from the heated decks and bulkheads. Icing during the 10° test was more severe with small amounts forming on bulkheads and about 1/2 to 1 inches of slush ice forming on most exposed decks. The water-slush-ice mixture could be easily swept overboard immediately after securing the washdown but refroze into solid patches if allowed to remain long on decks. Twenty knot winds (crosswind during 10° test, 50 to 60° off bow during others) caused many large bulkhead areas of the ship to fail to be covered by the washdown spray. A greater number of tests had been planned but could not be run due to insufficient cold weather at Argentia and use of the ship being on a non-interference basis with another research project. These tests indicated that operation of a washdown system may be feasible at temperatures as low as 10°F.

Physiological Program for SEALAB II

One of the four SEALAB II physiological programs was conducted by

NRDL's Dr. R. W. Brauer, Bio-Med Division. He was concerned with red blood cell formation of the men who lived for a period of two weeks at a depth of 210 feet beneath the sea off the La Jolla, California, coast. Assisted by Dr. H. S. Winchell of Donner Laboratory, Dr. Brauer administered radioactive iron (Fe^{59}) to four of the SEALAB II participants prior to their descent, and determined the rates of disappearance of the iron. During the actual SEALAB II test, Dr. Brauer depended upon the physician-in-charge to repeat the same test.

Project ARKOSE Aerial Survey

Under NRDL technical management, early in September a team composed of personnel from NRDL, NAS, Miramar, and ITEK Corporation successfully conducted an operational aerial on-site inspection as part of a continuing ARPA research project. An inspection zone near Blanding, Utah, was used on the Project ARKOSE Operation as part of a field evaluation program of on-site inspection using an integrated team concept. This concept stresses the application of combined air and ground search procedures to the on-site inspection (detection of underground nuclear explosions) problem.

Mono Lake Test Burn Observation

The Laboratory did not actively participate, but did have two observers aboard for Operation FLAMBEAU, a major test burn, thermal effects research project conducted in the vicinity of Mono Lake, California. The NRDL scientists reported that it appeared that financial, programmatic, and weather circumstances dictating the timing of the event probably accounted for such problems as insufficient instrumentation in some areas and over-instrumentation (e.g. gas sampling) in others. It was surmised that much valuable information, especially on the impressive fire whorl and the noxious gas problems, could be obtained at nominal cost, if NRDL researchers participate more actively in the next test burn in February.

Drone Boat Instrumentation for Early Time Investigation

An instrument that can be dropped from a drone boat has been developed which records information on fission product gamma radiation and measures depth of a radioactive waterpool. The total system incorporates low cost recorders and standard Geiger-Mueller tubes to provide a self-contained instrument which can be dropped into a contaminated pool and recovered at some later time.

Space Nuclear Power Plant Studies

Two planned destruct tests of nuclear power plants for space propulsion offered sources of realistic debris particles for study in connection with NRDL nuclear accident studies for the Space Nuclear Propulsion Office. The first of these tests, designated KIWI-TNT, was carried out at the Nevada Test Station in January; the second, APG-3, was conducted at the Aberdeen Proving Grounds in June. From the nuclear destruct test, KIWI-TNT, NRDL investigators obtained samples of debris for the study of physical characteristics which are important in connection with hazard evaluations. At the APG-3 destruction of a reactor mock-up by high explosives, a NRDL team participated to place an array of sample collectors in the "fallout" zone. This collection provided size and distribution data as well as a good set of samples for physical analysis. Samples of debris were also obtained for study from the PHOEBUS excursion which occurred at the Nevada Test Station in June.

Oceanic Sampling

In another of several valuable assists given the NRDL studies of radioactivity in the oceans, the U. S. Coast Guard provided an opportunity for the collection of ocean water samples at a remote weather station in the Eastern Pacific Ocean. Through the cooperation of the Coast Guard, an NRDL oceanographer went aboard the Coast Guard Cutter Bering Strait at Honolulu and remained aboard to collect a series of deep ocean water samples during the on-station period at weather station Victor. The collection was a highly successful one, providing an excellent set of samples for analysis and establishing a check point at a location which would otherwise have been inaccessible to the Laboratory.

CHEMISTRY, RADIO-CHEMISTRY, AND NUCLEAR PROCESSES

Decontamination of Ships' Painted Surfaces

A close-out report on studies of the behavior of fission product elements in seawater fallout on ship surfaces described work done using an ionic-colloidal simulant. This simulant was designed in accordance with the observations and measurements of fallout from field tests of nuclear detonations in seawater. It consists of inert fission product carrier elements and a single-tracer isotope in natural seawater con-

centrated to the saturation point of NaCl. Ba, La, Zr, and Nb comprise the first group of fission product elements investigated. Ease of removal was studied as both a function of their contamination parameters and decontamination parameters using fresh water wash methods. It was found that La and Nb are harder to remove than Ba and Zr. Also, adding complexing agents to fresh water spray during decontamination can decrease residual activity by as much as a factor of 10, if their concentration is greater than 0.2 weight-%. Detergents added during fresh water spray decontamination do not aid removal of these elements from painted surfaces. Also, removal is greatly enhanced if the fallout dries quickly and remains dry on the painted surface. Spray time, temperature, and pressure (over the ranges investigated) have little effect on the amount of removal. Appreciable differences in the removal of La in three separate tests were caused by variation in the total simulant salt concentration, partitioning of the fission product elements by the salts precipitated during simulant preparation, and the atmospheric conditions during which the contaminant dried on the painted samples.

Rocket-Borne Radiation Samplers

A recapitulation or summary analysis on an airborne nuclear radiation intensity measuring system, evolving from the HYDRA II tests held off San Clemente Isle, was completed. A rocket-borne radiation transducer and telemetry system was developed for making of beta and gamma measurements with respect to time and location. The system developed represents a satisfactory compromise between the factor of cost and of design simplicity and operational dependability. For a specific set of operating conditions the ranges or even types of transducers can be pointed to suit those conditions and the same is true for site and target geometries different from those tested. The flight tests yielded sufficient information to allow the calculation of trajectories for the SPARROW I Sustainer and SPARROW III rocket motors, as well as the HBR which would extend the range from the present 9,000 ft. to 16,000 ft.

Design Criteria for Roof Washdown Systems

Final report on a series of tests designed to study the basic principles involved in transport of particulate matter by water films was completed early in the year. This study covered the relationship of slope to transport on an ideal surface. It was found that on a near-horizontal surface no transport occurs when the water flow rate is insufficient to produce turbulent flow. The slightest slope causes particles to be transported at low water flow rates in laminar flow. Surface waves which are present at all slopes under most flow conditions increase

transport rate. An empirical equation was developed for the computation of the transport velocity of both spherical and irregular shaped particles, together with the maximum amount of particulate matter that can be transported.

Radioactivity Release from Aero-Space Reactor Fuels

Acciental seawater immersion of a NERVA reactor core could result in a criticality excursion, releasing fission product radionuclides to the environment. In order to simulate the excursion situation and to study the resulting radionuclide release, NRDL chemists irradiated specimens of NERVA/ROVER fuel in a TRIGA reactor operating in a pulsing mode to produce a high-flux, short duration exposure. In the first phase of a long-range, AEC sponsored project, with fuel irradiations restricted to a dry environment, measurements were completed of fission gas release, fuel material changes and maximum temperature, neutron flux exposure, fuel fissions and reactor neutronic characteristics and radiological considerations of experimental manipulations. These measurements will provide the foundation for extending the simulation to more severe and realistic conditions.

Reactor Beta Decay Hazards

In order to permit an evaluation of the possible hazard due to beta decay under various conditions of nuclear reactor operation and/or destruction, the energy spectra of the various beta emitters were required. Computing from the Fermi theory using experimental and high energies and probabilities, NRDL investigators prepared plots of the spectra vs. energy. Presentations will follow on the beta spectra due to mixture of fission products at various times, from a few minutes to many hours, after fission.

Tritium Adsorbtion Findings

Another milestone was reached in understanding the radiological hazards involved when tritium is released in a confined area occupied or later entered by personnel. Research on total tritium activity adsorbed on the surface of various metals as a function of exposure concentrations and exposure time revealed the following: at a one-hour exposure in a tritium-air atmosphere the total activity of tritium adsorbed on surfaces of structural steel, galvanized steel, brass and aluminum is less than 10 uc/cm^2 of surface up to an exposure concentration of 0.23_{mc} T_2/cm^3. The tritium activity adsorbed on carbon steel under these conditions was

much greater than on the other metals, apparently due to the texture of the surface of carbon steel. No significant increase in the total tritium activity adsorbed was observed as the exposure time was increased from 15 min. up to 4 hours, using a constant exposure concentration of 0.11_{mc} T_2/cm^3.

Rapid Rare Earth Determination

A rapid procedure was devised for the quantitative recovery of the individual rare earth elements and yttrium from a synthetic mixture of carrier-free yttrium, terbium, gadolinium, europium, samarium, promethium, neodymium, praseodymium, cerium and lanthanum radionuclides. The separations can be accomplished in 14 hours by elution from a Dowex 50W-X4 resin column with -hydroxyisobutyrate solutions at room temperature.

High Temperature Isopiestic Technique

A modification of the isopiestic method of determining chemical activities in solutions was developed for use with liquid metallic oxides at high temperatures. This method was tested by measuring the uptake of vaporized rubidium and molybdenum oxides by a number of simple oxides and binary oxide systems. The experimental results were used to investigate the interactions and the formation of structural groups among the components of liquid oxide solutions. This modified method was devised as a partial solution to the persistent experimental difficulties of working with chemically reactive substances and high temperature in oxidizing atmospheres. It can be used to obtain quantitative thermodynamic data relating to the reactions to the components in liquid oxide systems at temperatures in the 1000-1800 C^o range.

Pulse Height Distribution

Investigation having to do with scintillation spectrometers dealt with the matter of pulse height distribution as an instrumental distortion of the gamma ray spectrum for which it is a measure. By calibrating the detector with radioactive sources of known strength and gamma energy, a representation of this distortion may be embodied in a detector response matrix. A series of computer programs was developed and presented which aids in forming this matrix and in using it to effect a mathematical transformation from the measured pulse height distribution to the desired gamma ray spectrum.

Analysis of Radionuclide Mixtures

In a nuclear chemistry investigation, a shift correction technique was devised in using computer methods for the analysis of radio-nuclide mixtures from gamma ray scintillation spectrometer data. Evaluation study of use of the shift correction technique on known radio-nuclide mixtures showed that the method improves the precision of determination of the constituents of such mixtures. In addition, the method provides the basis of a quality control procedure by which it should be possible to reproduce exact conditions of measurement over months or years. Such reproducibility would be of great value in maintaining the validity of calibration data collection which usually requires a large amount of time and effort.

Specific Nuclei Predictions

Chemistry investigations yielded a new model or method for predicting the yields of specific nuclei from thermal neutron fission yield. Atomic number, weight, fragment excitation energies and kinetic energies are predicted by the model which has been found to give good agreement with experiment where data are available for comparison.

Indium Isotope Formation

As part of an overall look at the distribution of nuclear charge in uranium fission, information on formation of indium isotope (mass-121) was required. This has led to development by NRDL chemists of a rapid radiochemical separation method to confirm the isotope formation. Evidence for the existence of precursors has bee found also.

Weather Influence on Sodium-Containing Aerosols Above Beaches

In the course of calculating the hazard due to neutron-induced radioactivity produced where nuclear attack occurs in coastal areas, it is necessary to determine the atmospheric content of sodium above seashores using a sampling method of short duration. It is also necessary to apply this method to the study of wind and wave activity in the production of aerosols and in terms of these data to determine the exchangeable sodium content of a beach in terms of distance from high tide. Lab investigators have developed an instrument which satisfies the above conditions and also the results of the study of wind, sea and multi-seismic action on the content of sodium. An average profile of exchangeable sodium in a beach can be determined and factors are suggested for computing the effect of weathering on this profile.

Changing Fallout Spectrum and Ground Roughness

An examination of fallout samples from several past field operations verified that the energy spectrum of the gamma ray radiation field varied due to the following: neutron-induced activity in the soil and weapon material, location and position of the weapon, weapon type, fallout particle size and decay of the fallout field. One sample was chosen and analyzed into its component gamma rays over a period of 616 hours. The results have been used in a calculation to find out how the effective ground roughness would be expected to vary as the energy spectrum varied. It was concluded that the effect of multiplying the build-up factor and attenuation together produced a constant that varied only slightly over the recorded time that the data were taken.

Gamma Radiation Characteristics of Desert Terrain Fallout Field

The problem of measuring the gamma radiation existing over the fallout field in rough desert terrain has been dealt with in a study originally based on experiments conducted in conjunction with the DOMINIC II SUNBEAM test in Nevada. Measurements were made of the gamma ray spectra as a function of angle of incidence and included characteristics of the fallout field, comparisons with other data of a similar nature, and provision of spectral data for calculating dose penetration into compartmented steel structures. Pulse-height measurements showed that there were only small differences in gamma ray intensities from the different azimuthal directions. The minimum and maximum intensity pulse height distributions differed by about 10% and the vertical-angle pulse height distributions varied in an expected manner. These incident angles from below the horizon gave several photo peaks and those from above the horizon had only the smooth, scattered radiation distribution. Several direct radiation peak intensities were plotted vs. vertical angle and compared with a calculation of how an infinite plane source would be attenuated by a series of overlying, absorber, mean-free-path patterns.

Fission Track Detection in Fission Foil/Glass Combinations avoids most of the disadvantages of the conventional methods (nuclear track evaluations and activation foils) for integrating neutron measurements. These systems are insensitive to gamma radiation, temperature, climatic and chemical disturbances, are easy to evaluate, have no directional dependence and have an extended dose and energy range plus superior accuracy. This improved method has been investigated, using different dosimeter glasses, edging conditions, fissionable materials and neutron energies by the thermal and 14 MeV. The fission track detection efficiency has been found to be 100%, and the sensitivity for fissionable metals thicker

than ca. 5 μ is 1.3×10^{-5} tracks/neutrons/barn. Simple evaluation tracks and practical applications, mainly for fast neutron personnel dosimetry, have been developed.

Thermal Radiation of Cellulose

Despite the advanced state of knowledge of ignition behavior of cellulosic materials, almost nothing is known about chemical mechanisms responsible for the ignition event. An experiment to measure pyrolysis products of cellulose exposed to intense thermal radiations revealed that: (a) spontaneous flaming ignition alone is accompanied by a distinct change in volatile pyrolysis products, (b) pre-ignition exposures generate mostly H_2O, CO_2, CO and tar, (c) hydrogen, methane, ethane and ethylene, undetected initially, appear and increase rapidly at about the time when ignition would occur in air, and (d) these elements are important components in long exposures. It is suggested also that cellulose decomposes in the main by two competitive modes: tar forming and char forming reactions. Together these reactions destroy the cellulose before it ever attains temperature as high as those (at the surface) accompanying ignition. Therefore, the hydrogen and hydro-carbons do not appear to derive from the cellulose per se.

Steady State Method

A steady state method for studying the kinetics of thermal degradation in solid materials, with application to alpha cellulose, has evolved from one of the more basic Laboratory research programs. In order to understand and/or control the ignition phenomena of cellulosic materials it is necessary to first understand the mechanisms of thermal degradation. NRDL researchers have noted a crying need for a fresh approach, capable of providing well-designed, quantitative data for individual reactions, especially those of the solid-solid type and have come up with the conception and application of a new technique. That is, a method utilizing the measured temperature profile and a power balance obtained during steady-state ablation has been conceived and applied to α-cellulose with and without 2% $KHCO_3$ (by weight) added as a controlled impurity. The rate of generation of chemical heat was determined as a function of temperature, and the heat required to pyrolyze 1 gm. of cellulose was estimated.

Theory of Deformed Nuclei

Dr. John Davidson, Scientist in Residence from Rensselaer Polytechnic Institute, expanded his work on the theory of the structure of

deformed nuclei. He developed the theory to the point where the parameters which characterize the collective motion of any given nuclide can be calculated directly from the available experimental data, making optimum use of the available data. This model was applied to the rare-earth nuclides, finding some unexpected trends followed by certain of the collective parameters with variation of proton or neutron number. A particularly significant part of this work was the prediction of electric monopole transition probabilities on the framework of the collective model. This new development has been used successfully to predict the decay properties of excited levels in platinum isotopes, for which experimental data was only recently obtained.

Space Radiations Handbook Data

A survey of data appropriate for a much needed handbook on space radiations, to be used for design testing and pre-flight and in-flight calibration of interplanetary environment radiation probes, was completed on a contract to Stanford Research Institute. Derived from an extensive literature survey, the data for the proposed handbook provides information required so that allowance can be made for such factors as the effects of irradiation on the electronics and sensors and of micrometeorites on the vulnerable portions of the probe. Electromagnetic radiation, corpuscular radiation and meteorites information is included.

Analysis of Xenon

Nuclear physics interest (BUSHIPS CORE Program sponsored) in one instance during the year took the form of an analysis of the xenon content of the Richardton meteorite and of earth's atmosphere interpreted to show that certain nuclear events occurred following the formation of the meteorite. This analysis stems from the question: Can the difference in both chemical content and physical structure from individual to individual of the various chondrites that have been recovered be used to formulate a sequence of events occurring during formation of the solar system?

INSTRUMENTATION

Mobile Radiac Repair Facility

In view of the efficient and effective utilization of the AN/MDM-1, Mobile Radiac Repair Facility, by INDMANSIX, the Laboratory completed an investigation of the AN/MDM-1's suitability for use in the field by the Marine Corps Force Service Regiments. It was determined that, with minor modification, the Marine Corps could provide AN/MDM-1 type facilities with existing Marine Corps equipments that would enable the Force Service Regiments to accomplish calibration, repair and maintenance of field radiacs. More efficient use of available radiac instruments in the field will be in prospect. This will, in turn, further reduce maintenance and calibration costs. It was further determined that all necessary equipment, facilities and tools from the standard AN/MDM-1 can be suitably installed in a modified Marine Corps S-280( )/G shelter. This shelter is transportable on the standard Marine Corps 2-1/2 ton truck, thereby providing a facility with excellent off-road operating capabilities.

Another special radiac project for HQMC had as its objective the development and verification of improved calibration procedures for the Marine Corps' IM-174/PD Radiacmeters. Results indicated that a tentative calibration procedure developed during earlier work at NRDL will, with minor modifications, be a significant improvement over the presently used procedure. In addition, a special technique was developed which will allow field repair facilities to electrically calibrate the IM-174 if the instrument is needed and no isotopic or X-ray source is readily available for calibration.

Space Applications Seen in Thin-Film Transistor Tests

Limited studies and tests of nuclear dose effects on insulated-gate thin film transistors indicated that the threshold of ionizing radiation dose for significant semi-permanent surface effects in the IGTFT is considerably above that of operational interest in nuclear weapon environments. However, these effects may prove important in some space applications. One qualification to this conclusion was that measurements in the transistor tests were made during relatively long exposures and effects resulting from fast surface states could not be observed. (There was some evidence that these states will affect recovery following exposures of a microsecond). A second limitation to the conclusion was that all units tested were evacuated or potted and in the presence of an easily ionized medium (gas), observed effects could be enhanced.

Dosimetry for Large Animal Experiments

A systematic study of the depth of distribution in large animals was made at the Camp Parks Radiation Facility and compared with similar exposures made at other radiation sources. A quadrilateral configuration of four movable uncollimated Co^{60} sources with a total activity of 9000 curies was used to obtain exposure measurements in air and depth doses in a masonite phantom for radiation experiments involving sheep. The depth dose distribution in the phantom in the four source exposure was compared to distributions obtained using a single collimated Co^{60} source four times in succession to simulate the four source array and exposure geometry and 1 mvp X-rays in a bilateral exposure. Distributions of the quadrilateral gamma and X-ray exposures differed quantitatively by no more than 5% throughout the phantom thickness.

Bias Influence on Transistors

An investigation for BUSHIPS to determine influence of bias on radiation induced surface effects in transistors turned up the following principal result. Radiation induced surface effects, causing increases in leakage current (I_{CBO}) and changes in beta and input impedance, were clearly enhanced by the continuous presence of collector-base voltage in the type 2N526 geranium transistor. However, no similar correlation was found in the type 2N329A Si transistor at the exposure level used in the tests. It was felt that exposures at higher levels in the latter instance will show a bias influence. The major response of I_{CBO} in the Si2N329A was due to junction photo current and gas ionization in the transistor can.

New X-Ray Detector Accessory Successful

With conventional alpha radiacs, the detector must be placed within a very small distance of the surface being monitored (about 1/16 of an inch), because of the very short range of alpha particles in air. As a result, the detector "sees" only an area directly under the probe. If the surface being monitored is not remarkably smooth and flat, metering becomes a slow and tedious process and since the detector must have a very thin window to admit the alpha particles, it can be damaged easily in a field operation. In addition, any contamination buried under thin layers of dust or moisture cannot be detected. NRDL instruments experts have come up with a new Model DT-302 (XN-1) X-ray accessory designed to detect X-rays associated with the alpha decay. Because of their relatively low frequency of occurrence, X-ray detection is relatively insensitive compared to direct alpha detection; but since the mean path links of these X-rays are about 4 to 10 mm. in air and 4 to 10 mm. in water, the

advantages of alpha rate detection in the situations described above are apparent. For example, an X-ray device can be used at a distance of about a foot.

Two-Parameter Gamma Pulse Height Analyzer

A transistorized two-parameter gamma pulse height analyzer system was obtained, installed and put into operation. This system, manufactured to meet performance specifications established by NRDL, represents a significant advance in gamma-ray spectrometry and extends the Laboratory's capabilities for original research in nuclear chemistry. The increase in number of channels and data storage capacity and the computer compatible output which this system provides not only makes a greater volume of measurements possible but also allows nuclear identifications and measurements in areas which were previously beyond the reach of available equipment. This equipment provides a tool which enables the nuclear scientists of the Laboratory to continue to gain the benefits of many years of experience in the development and application of gamma spectrometric methods for the identification and measurement of nuclear properties.

High Precision Measurements Apparatus

In the course of investigating for a BUSHIPS sub-project the effects of nuclear radiation on the thermo-electric properties of a number of compound semiconductors, an apparatus was designed, built and tested with gratifying results. Precision tests, where samples were removed from and remounted in the apparatus between measurements, showed variations not larger than $\pm 5\%$ in remeasuring Seebeck coefficient and electrical resistivity for eleven materials. Also, the variation in remeasuring Hall coefficient for a sample of single-crystal bismuth telluride was found to be not larger than $\pm 2\%$.

Gamma-Ray Measurement Improvement

An improvement in sensitivity of several orders of magnitude has been achieved in a Laboratory designed instrument for measuring the gamma-ray dose albedos of concrete, aluminum and steel. A platic scintillator, optically coupled to a photomultiplier tube, as the detector, and an analog-to-digital converter and its register as the measuring device, produced the sensitivity gain. Differential dose for gamma rays with energies up to 700 kev, and dose rates as low as 0.2 mr/hr, have been measured with this new instrument to better than ± 11 per cent. This device could be used aboard ship or at a land installation where highly sensitive, directional, gamma-ray dose measurements might be required.

Field Radiometer and Calorimeter Improvements

To increase the sensitivity and reliability of NRDL field radiometers and to improve the methods of calibrating these instruments, two prototype instruments have been constructed and evaluated. These include a vacuum calorimeter and a new calibrating source consisting of banks of tungsten-iodine lamps. New devices were required for the equations relating the physical and thermal parameters of the instruments and a considerable body of information was accumulated about existing instruments and sources in the process of design and evaluation of such instruments. Also, this led to a considerable number of modifications made in the radiometers to increase their reliability and ruggedness.

Nuclear Emulsion Track Analysis Instrumentation

NRDL experts working on analysis of thick, nuclear research emulsions came up with a listing and analysis of current microscope equipment, related equipments and custom fabrications most used or applicable to this field. Performance evaluation and suggested refinements of commercially available and other equipment are included along with background data, detailed descriptions and a summary of overall effectiveness of five major microscope assemblies. A report on this NASA-sponsored effort is expected to draw considerable interest from DOD and AEC scientists.

Parks Range Now 10,650 Curies

In the course of obtaining calibrations of the Camp Parks Radiation Range for use by the Bio-Med Division, investigators planning long range experiments with animals, dose distributions of five high-intensity Co^{60} sources at the Camp Parks Radiation Range were measured for precribed distances and their configurations. Inverse square fall-off of dose was found to apply in a limited region where scattering and attenuation do not modify the results substantially. Because of extensive scattering the gamma field cannot be met categorically without dosimetry done locally. Four of the sources yielded equivalent curie ratings of about 2400 at time of measurement, while tower sources measured only 1050 curies.

Tungsten Iodine Lamps as Thermal Sources

For some years this Laboratory has used carbon arc image furnaces to simulate the thermal radiant energy from a nuclear detonation. The spectral distribution of the radiation from the carbon arcs is very

similar to that from the detonation and thermal radiant power as high as 100 Cal Con-2 sec-1 may be obtained with fused optical systems. These furnaces are really bulky, however, they require a DC power supply to illuminate a relatively small area, and are subject to unavoidable variation of several per cent. Extensive experimentation has demonstrated that close simulation of the spectral distribution of the energy radiation from the detonation is unnecessary for some problems. For these problems a high radiant tungsten filament source is now more suitable than a carbon arc furnace, but is also more flexible, illuminates a larger area and is considerably easier to use. Because of its advantages for these certain purposes, a source using the tungsten iodine cycle lamps has been built, tested and put into operation at the Laboratory.

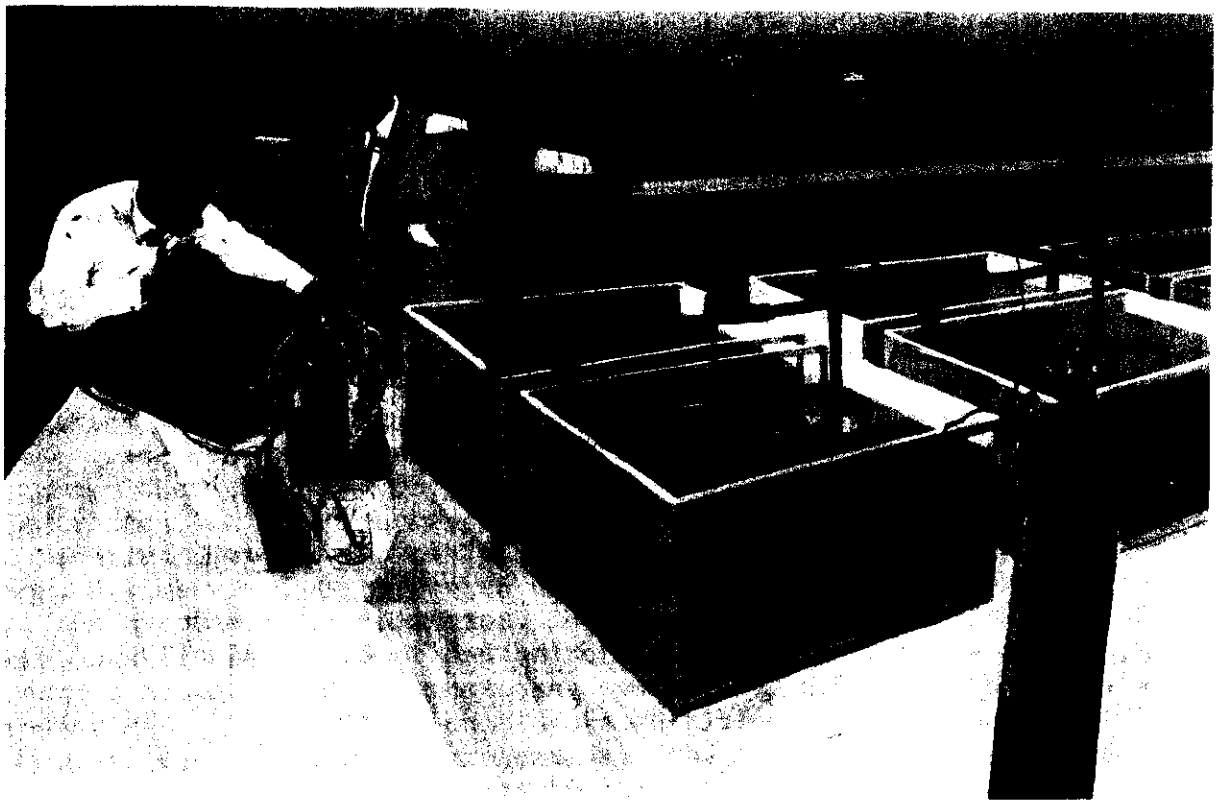
Detector Efficiencies Calculated

An important consideration in the study of nuclear structure is that of gamma ray intensities in a particular decay scheme. In order to determine these intensities, careful measurements must be made with a detector, the detection efficiency of which vs. energy is known. Thus, to correct experimental data from a Ge(li) semi-conductor detector at NRDL, a computer calculation of total detection efficiencies was completed.

BIO-MEDICAL RESEARCH

Biospheric Contamination Project

The experimental phase of the most significant biomedical investigations launched under the NRDL in-house independent research CORE Program for the Bureau of Ships, on biospheric contamination, got underway early in 1965. The project entered the first phase of an overall objective to establish the nature of the underlying complex biophysical mechanisms for radioelement uptake, rates of movement and turnover and mechanisms of transfer in living systems. Long range objective is to provide a rational basis for development of biological monitoring, decontamination approaches, and preventive measures against contamination by radioelements entering the biosphere as a consequence of reactor or weapons developments. Current work is being focused mainly on growth and maintenance of multi-cellular marine algae, as needed to insure a ready supply of test material. Ion transport studies have been implemented in *Ulva lactuca* and attempts will be made to assess irradiation effects on oxidative photophosphorylation in these phytoplankton. (See next page).



RADIOELEMENT UPTAKE IN SEA PLANTS -- Above is illustration of a new laboratory research set-up unique in NRDL annals. The picture shows scientists making preliminary observations of radioactive tracer uptake in marine algae cultures in aquaria. Long rage objective of this program is provision of a rational basis for development of biological monitoring, decontamination approaches, and preventive measures against contamination by radio-elements entering the biosphere as a consequence of reactor or weapons developments. Project equipment includes a rapid-flow, salt water culture system wherein salt water is pumped through a plastic pipe system at a rate of 25 ± 5 gal/min. Sterilization and total filtration of free-swimming contaminating species is provided.

Immunological Mechanism

For the past several years, one of the major biological research efforts at NRDL has been directed towards the understanding and control of the immunological mechanism and process, present in all mammalian systems, by which genetically foreign tissue or cell transplants are rejected. Experimental studies in this area include questions on tissue antigenicity, restoration of lethally irradiated animals by means of bone marrow transplants, immunological tolerance, recovery of the immune system after irradiation, the role of humoral antibodies, and the involvement of the thymus in tissue homograft rejection and retention. These areas of research have been and are the focus of intensive research throughout the world; the competition is keen, and new developments and insights occur in rapid succession. In a series of several brilliant NRDL Technical Reports and published papers, of which he was the senior author, Dr. Marvin Tyan presented new and original observations, techniques, and hypotheses in this area. His studies demonstrated three important new findings in what can be termed the field of radiation-transplantation immunology: (1) That the system responsible for the normal "throwing-off", i.e., rejection of foreign tissue grafts by adult animals (such as mice) is in fact heterogeneous; that is, qualitatively different cell "lines" or populations within the same organism are "called up" to respond to the more "foreign" tissue grafts than those which respond to foreign tissue grafts from genetically more closely related donors. (2) That the very early mouse embryo--perhaps as early as a one-day old fetus --already possesses the tissue antigens able to evoke transplantation reactions. Therefore, the normal material tolerance for the embryo is accounted for by the existence of an "inert barrier" between the mother and fetus. (3) New findings on the ontogeny, i.e., development of the immune system in mammals, showing that the cells destined to become competent to reject foreign tissue grafts are first present in the early mouse embryo liver and thymus.

At the present time, the benefits from this research are intangible. These are related to the extension of new knowledge in the fields of transplantation immunology and radiation biology. New insights and concepts about the mechanisms by which the body rejects genetically foreign skin grafts and hemopoietic and lymphoid cell grafts are forthcoming from these findings. The extent to which they may now be specifically applied to problems in treatment of radiation casualties and in surgery of "spare parts" in humans is not yet known. However, for the time being, the results of these studies constitute significant additions to the "scientific capital" in this field, which is aimed toward eventual human application.

Liver Research Advance

Dr. Raymond Schofield, NRDL's 10th Scientist-in-Residence, from the Christie Hospital and Holt Radium Institute in Manchester, England, in collaboration with Mr. Leonard Cole, Head, Experimental Pathology Branch, made important strides in research on the function of the spleen in haemotopoiesis and radiation recovery. The spleen has for many years been implicated as an important organ in protection from lethal doses of radiation. It is involved in some way with the haemotopoietic recovery but no completely essential role has ever been ascribed to it nor is much of its function understood. It is known that when heavily irradiated mice are protected by injection of bone marrow cells, nodules consisting of these cells appeared in the spleen shortly after. Dr. J. H. L. Playfair, a former Scientist-in-Residence, and Mr. Cole, observed that if the cells from these nodules were injected in the attempt to protect mice from otherwise lethal irradiation, only those mice which had intact spleens were restored while mice which had been splenectomized became very anaemic and died.

Mr. Schofield investigated this phenomenon more thoroughly and was able to show: (1) That the splenectomized mice, irradiated and injected with "spleen nodule cells" may survive but do develop a profound, slowly recovering anaemia which persists for two to three months. Similarly tested mice which were sham-splenectomized do not become very anaemic and recover quickly; (2) that the function of the spleen does not appear to be simply hormonal but the anaemia may be modified and somewhat improved if the spleen is surgically removed after irradiation, and (3) that using radioiron techniques, it appears that the injected "spleen nodule cells" do not act as a functional "graft" in bone marrow cavity, as was assumed, and this is true whether the animal has a spleen or not. Protection by these cells must be by some other mechanism, but haemotopoietic recovery under these conditions is apparently due to spontaneous recovery of surviving bone marrow stem cells. However, the presence or absence of the spleen determines whether or not the animal will remain anaemic and there is evidence that the life span of the red blood cells produced is determined, under these conditions, by the spleen.

Effects of Radiation on Bone Growth

Results from previous experiments have indicated that growth retardation resulting from exposure to ionizing radiation may involve factors in addition to local damage of the tissue in question. In a study on retardation in bone growth subject to radiation, NRDL scientists found that approximately one-half of the growth reduction occurring in the hind limb bones of rats after total-body irradiation (450 R) was

attributed to the direct effect of radiation damage on the limb. The remaining one-half was the result of indirect effects from radiation effects on the remainder of the body. Various regions of the body were irradiated and yielded results which indicated that the indirect effects were more dependent upon the body region exposed than upon the amount of tissue irradiated. The results suggest the possibility that the indirect effects of irradiation on bone growth may reflect radiation-induced alterations in endocrine and metabolic functions.

New Approach to Study of Antibody Formation

A new experimental approach to the study of antibody formation *in vivo* as a clonal phenomenon was announced by Scientist-in-Residence from the British Isles, Dr. John Playfair, who had been working with a fellow biomedical specialist, B. W. Papermaster of the University of California, Berkeley. In this approach, normal (non-immunized) lymphoid cells from spleen were injected into lethally-irradiated syngeneic mice and then induced to make a primary hemolysin from 2 mm. to a few cms. in diameter. 89% were histologically identified as epithelial cysts enclosing a mass of laminated, cornified material. The remainder were either true sebaceous cysts (6%) of cysts of sweat gland origin (5%). It was found that the overall incidence of animals with cysts was significantly increased by both doses of X rays and by a higher dose of neutrons. For the four irradiated groups, cysts appeared earlier than in the controls. In the control animals the age-specific cyst rate began to arise appreciably at 18 months of age, while for irradiated groups, it began to rise 5 - 6 months earlier. Since these findings are generally similar to the effects of radiation with respect to tumor formation, it appears that skin cysts should be categorized with the benign tumors of the skin rather than as a separate entity.

Decreased Radiation Mortality through Typhoid-Paratyphoid Vaccine

Only a limited number of radiation protectants are known to be effective in animals other than laboratory rodents. In a study to determine if T-PT vaccine would increase survival in an (anesthetized) mid-lethally irradiated dog, the vaccine given 24 hours before 1 Mvp X-irradiation significantly increased survival. No protective effect was produced by the vaccine treatment one hour after radiation. Either pre- or post-irradiation administration of the vaccine produced marked changes during the second week in the number of circulating granulocytes. The number of platelets was also increased during the second week in animals given the vaccine 24 hours before a sub-lethal exposure of 195 r. Effects on the granulocyte levels coincides temporarily with the abortive

recovery or rise in granulocytes which has been reported to occur spontaneously in several species, including man.

Radiation Damage During Primary Antibody Response

Ionizing radiation is known to impair the ability of an animal to respond to anti-genetic stimulation. Bio-Med personnel conducted a study to determine the nature of radiation damage during the initial period of the primary antibody response. It was found that monocytes which have been incubated with a soluble antigen (bovine gamma globulin) and lymph node cells are both necessary to effect an antibody response in an irradiated rabbit (450 r total body X irradiation). Also, it was noted that unirradiated rabbits are able to produce antibody in response to injection of antigen alone or of monocytes incubated with antigen.

Mortality and Recovery Studies on Sheep

Estimates of the LD_{50} for small experimental animals usually ranges from 600 to 900 r. In general, similar estimates for most large experimental animals and for man are below 500 r. These differences in LD_{50} may indicate that radiation data obtained from large, domestic animals may more closely approximate the radio-sensitivity and perhaps the systematic recovery potential of man. 1965 Laboratory experiments designed to establish the LD_{50} and to evaluate the systematic recovery in sheep, using the split-dose technique, showed that the $LD_{50/60s}$ for sheep irradiated with Cobalt 60 gamma or 1 Mvp X rays are 237 r and 252 r, respectively. These midline, air doses increase to midline tissue doses of approximately 145 rads. Systematic recovery studies showed that 30 days after an acutely administered two thirds $LD_{50/30}$ dose there was recovery of 50-70% of the initial radiation injury. At least 10% of radiation deaths in the sheep occurred after 30 days. This indicated that the $LD_{50/60}$ is a more satisfactory end-point than the $LD_{50/30}$ for evaluating the acute mortality response of the domestic sheep.

Rad Effects on Peritoneal Cavity Cells

It is well established that whole body exposure to ionizing radiation causes severe damage to the bone marrow and lymphoid tissue. As a result, the number of leucocytes in the blood is greatly diminished. NRDL Bio-Med investigators completed a study of whether the cells present in the peritoneal cavity, some of which originate in the lymphoid tissue and others presumably in the bone marrow, are similarly affected. It was also important to determine the number and kind of leucocytes normally

present in the peritoneal cavity in the mouse and to study the effect of total body X-irradiation on this cell population. Results showed that at least 95% of the cells in the peritoneal cavity of normal LAF_1 mice were mononuclear; of these about 70% were lymphocytes and 30% were macrophages. One day after exposure to midlethal doses of X-irradiation and for three weeks thereafter both the total number of cells and the percentage of lymphocytes were greatly reduced. The number of macrophages in the peritoneal cavity declined only slightly and very gradually between 1 and 21 days post-irradiation. Normal cell counts were again found in approximately three months after exposure.

Radiation-Induced Motivation, Humoral Factor

The motivational effect of irradiation exhibited in various conditioned avoidance responses has been shown to have general characteristics whereby it can be differentiated from the prompt stimulatory effects of irradiation. Prompt stimulation resulting from high rates of exposure (that is 3 r/min and more) may contribute to the motivation effect. Nevertheless, motivation can be produced independently of initial neutral effects. In one experiment, it was found that in rats, temporarily deeply anesthetized during X-irradiation with 90 r at 60 r/min., a conditioned aversion to saccharin-flavored fluid could be produced by providing a saccharin taste experience in the postanesthesia-postexposure period. The preliminary findings in another study still in progress indicate that in rat-pairs, joined by non-neural vascular anastomosis, a saccharin aversion can be conditioned in the sham-irradiated member following the exposure of its partner to 360 r of X-rays (24 r/min). This constitutes positive evidence for a systemic humoral factor which can mediate radiation-induced motivation.

Leukemic Cells Growth/Competence Control

Laboratory investigators "zeroed in" on a new approach for therapy of experimental leukemia in mice, involving the combined use of X-radiation and "immunotherapy". It was concluded that *in vivo* growth and competence of isogenic transplanted leukemic cells in mice can be significantly altered and controlled by combined therapy, employing sublethal whole-body X irradiation, together with transplantation of normal, immunologically competent lymphoid cells obtained from spleens of allogeneic donors, i.e., mice of a different inbred strain than that of the recipients.

Immunological Reactivity/Distinct Cell Populations

Recent research observations have suggested that isohemagglutinin

Application of a new method to study the effects of ionizing radiation:

A special kind of surgical preparation was used to study the biological effects of ionizing radiation. In the procedure, two young rats are joined together surgically through a bridge of skin containing a large number of blood vessels. Thus, the pair of animals share a common circulation. The joined pair live together without difficulty, eating and drinking at the same time and sharing their experiences. A pair is illustrated in the photograph; they were joined together several months previously. The pair provides a powerful tool for studying radiation effects since it is possible to irradiate one animal of a pair and study the effects in the non-exposed (shielded) animal. The effects of radiation which can be observed in the non-exposed animal are presumed to be the results of materials transmitted through the circulation system from its irradiated partner. This technique was developed to study the extent to which agents transmitted in the blood may produce the effects of radiation in several systems of the body. It is expected that isolation and identification of transmitted agents may ultimately lead to a means of preventing many of the symptoms of radiation induced sickness.

production and homograft rejection may be the manifestations of immunologic responses in separate cell populations. A laboratory experiment to check this was conducted wherein sublethally irradiated mice previously sensitized by several methods were grafted 30 to 61 days following irradiation. In all groups the homograft response was significantly impaired 30 and 61 days after irradiation. However, in two different groups normal secondary hemagglutinin responses were noted. This asynchronous recovery of the hemagglutinin and homograft responses suggested that distinct cell populations were responsible for these two manifestations of immunologic reactivity.

Radiation Effects on Renal Enlargement

Conflicting reports exist in the literature regarding the degree of renal enlargement occurring after either total body or local irradiation, and it seems possible that total body irradiation could exert an indirect effect on the initiation and the degree of hypertrophy. The direct effect of radiation on the enlarging kidney is of general interest and is of particular importance in children undergoing radiotherapy after removal of one kidney for nephroblastoma. In a NRDL experiment conducted on mice, it was found that the radiation in the dose ranges of 500 - 600 r and at 1350 r did not exert a direct inhibitory effect on renal weight increase, but it limited body weight gain which influences kidney weight. The poor nutrition and general condition of the animals equally inhibits both the renal and body weight gain so that the ratio remains constant.

X-Ray Response Traced to Olfactory Brain Region

Research on radiation-induced, neural activation in animals indicated that lesions of the olfactory bulbs almost abolish the response to X-rays. This indicates a critical role for this principal region in the process of sleeping rats being awakened upon exposure to radiation. Exposure to 100 Kvp X-rays produced electroencephlographic activation in rats without brain lesions or with lesions of the cerebral cortex, while 35 Kvp X-rays were much less effective. Therefore, it appears that peripheral, sensory stimulation is not essential to the reaction.

Stimulation of DNA Synthesis

In the present stage of transplantation immunology, the development of a valid objective *in vitro* method for histocompatability matching of prospective tissue donors and recipients would be of great practical significance for tissue transplantation and should be an effective tool

in the study of the mechanisms of the primary immune response. In an experiment dealing with the developmental phases and tests of such a method, successfully adapted to certain in vitro cultures of mixed suspensions of spleen cells derived from xenogeneic strains of rodents, a marked stimulation of DNA synthesis occurred when spleen cells from LAF_1 mice and a pool of spleen cells derived from three noninbred rats were mixed and cultured. No such response occurred in the mouse spleen cultures either (a) in the absence of rat spleen cells or (b) in the presence of disrupted (frozen-thawed) rat spleen cells. A similar stimulation of DNA synthesis occurred when spleen cells from one rat were mixed and cultured either (c) with C57BL10J (or DBA/2J) mouse spleen cells, or (to a less marked extent), (d) with spleen cells from a second unrelated noninbred rat. The data suggests that this mixed lymphocyte culture (MLC) test is dependent on certain genetic differences inherent in the two cell populations.

Enzyme Activity Changes

Increased enzyme activity post-irradiation is associated with large and medium-size thymic cells, rather than the small thymocytes, research disclosed, adding to the very little information available on cellular encyme activities associated with radiation-induced atrophy and subsequent regeneration of the thymus. Following whole-body exposure of 2-month old female LAF_1 mice to a single sublethal dose of X rays (600 rad), cell suspensions were prepared from the thymus at various time intervals post-irradiation. Portions of the cell suspensions were analyzed for cell size distribution with the Coulter counter and others were assayed fluorimetrically for enzyme activities: alkaline phosphatase, alanyl amidase, and leucyl amidase. For all enzymes, activities expressed on a per cell basis showed an increase on the first day post-irradiation reaching a maximum at 5-7 days, and returning to control levels by Day 11. Alkaline phosphatase activity was established histochemically on irradiated thymus sections. An increase in the number of enzyme-positive cells and capillaries (which reached a peak on Day 5, returned to normal levels by Day 11 post-irradiation) was observed. The findings suggest that the observed changes in enzyme activities in thymus after X irradiation may be the biochemical expression of differentiation of the thymus cell populations under these conditions.

How Peritoneal Cells of Mice Respond

Investigation to determine the number and kinds of leucocytes normally present in the peritoneal cavity of the mouse reveals that at least 95% of the cells of normal LAF_1 mice were mononuclear; of these

about 70% were lymphocytes, 30% were macrophages. One day after exposure to midlethal doses of X-irradiation and for 3 weeks thereafter, both the total number of cells and the percentage of lymphocytes were greatly reduced. Normal cell counts were again found approximately 3 months after exposure.

Homograft Response and Hemagglutinin Production in Mice Experiment

Recent observations have suggested that at least partial recovery of the immune mechanism is possible after a potentially lethal dose of X radiation in the absence of the thymus. New experiments were performed in an effort to further delineate the thymus-dependent components of the immune mechanism of the adult mouse recovering from the effects of whole-body X irradiation. The results indicated that although hemagglutinin production and the homgraft response were intitially greatly impaired by thymectomy and lethal irradiation, repeated antigenic challenge resulted in the return of the specific homograft response to near normal reactivity. At the same time antibody production became progressively more impaired. The results suggest that (1) antibody production and homograft sensitivity are manifestations of immunologic responses by associated but distinct cell populations, (2) antibody production is more thymus-dependent than is the homograft response, and (3) the method of sensitization employed determines both the relative and absolute number of "sensitized cells" produced within each cell population.

Protein Component Study

Fundamental to the study of radiation or other forms of tissue injury is the problem of isolating the differential processes occurring to a vast number of cell proteins of unknown function and of assigning identifying characteristics to them. Findings in this area showed that a sex-associated protein component, previously thought to exist normally only in the male rat liver, was present in the female rat but thirty-two times less concentrated than in the male. Experimentally, the adrenal glands do not seem too directly involved in this sex phenomenon. There is additional evidence that the protein is a sex-hormone-dependent component, responding to a direct acting antagonism between the sex hormones.

Radioactive Tracers in Cholera Treatment

The clinical phase of a fairly long range study by a NRDL-NAMRU research team neared completion and the study of fluid compartment changes in the body, induced by a cholera outbreak in the Philippines in 1961 was

completed. Using radioactive tracers intra-cellular fluid shifts were measured during rehydration therapy and during controlled periods of diarrheal dehydration. Better understanding of physiological processes was achieved using the tracer techniques to pin down such findings as the following: (1) that some degree of sodium loading occurs when fecal and estimated insensible losses are replaced by equivalent volumes of isotonic saline at a plasma specific gravity of 1.024. For otherwise normal patients, this would be within reasonable range of renal compensation; (2) that at high fecal outputs, the tracer sodium initially excreted into the gut appeared not to be reabsorbed, and it is delayed several hours in appearing as stool; (3) that cholera dehydration causes marked depletion of extracellular water with comparatively small losses from intracellular water.

LOOKING AHEAD

The statement of NRDL's mission was not changed during the past year and essentially covers fundamental studies concerned with nuclear weapon defense. However, solution to many radiological defense problems is in sight and a broader field of effort is indicated. Studies, far from complete, in conjunction with the parent Bureau indicate a trend, based on whole Navy need, toward a broader mission of scientific research and development in the physical and biological sciences and related fields directed toward new and improved materials, equipment, techniques and systems, in special warfare areas.

Records of annals of the past 10 years show that NRDL has done a thorough job in many of the areas of nuclear defense research. This posed a problem to program planners this year in insuring work for the next decade which will be as useful to sponsors as that of the past 10 years span.

When the cyclotron becomes operational NRDL hopes to increase participation in space radiation programs and proposes to continue with an effort to evaluate the threat to the Navy from BW/CW agents. From this operational analysis program, a determination may be made on whether or not additional BW/CW experimental programs are required to meet the Navy's needs.

Research in some areas will be phased out or considerably reduced over a period of 2-4 years. However, considerably more information is

needed in some areas of research such as shielding against high energy neutrons and protons and on mechanisms of the interactions of these particles with matter.

A Proposed Technical Program for FY66-70 was forwarded to BUSHIPS along with five year forecasts by the seven other BUSHIPS labs late in the year. The technical work proposed has been arranged under nine program areas, as follows: (1) Operational Requirements; (2) Naval and Amphibious Warfare; (3) Damage and Casualty Assessment and Countermeasures; (4) Surveillance and Reconnaissance; (5) Weapon and Weapon Phenomonology; (6) Bacteriological and Chemical Warfare; (7) Materials Research; (8) Environmental Studies, and (9) Fundamental Studies. The proposal represents a gradual broadening of the mission of NRDL and trend from research in nuclear defense to a more applied research.

THE CHANGED FACE OF NRDL

Front of building is shown with new section doubling the width of the sidewalk. Gone is the grass plot which has been replaced with crushed rock, shrubs and trees.

CHAPTER III -- PUBLICATIONS

REPORTS AND MEMORANDA

Throughout 1965 there was an impressive steady increase in the flow from the Scientific Department of NRDL's foremost end product - technical reports and other research publications. A new high was achieved with a total of 291 technical reports of one type of another as opposed to 213 in 1964 and 144 in 1963.

The breakdown for 1965 is as follows:

U. S. Naval Radiological Defense Laboratory Report (Formal)	15
Technical Reports (USNRDL-TR)	128
Reviews and Lectures	17
Progress Reports	27
Technical Memorandums	2
Technical Notes	2
Technical Manuals	3
Letter Reports	74
Evaluation Reports	7
Total	275

Also, a series started in 1964 that are published externally:

Technical Papers published externally (TPX)	10
Technical Reports " " (TRX)	2
Technical Memoranda " " (TMX)	1

And, the addition in 1965 of a TRC series, whereby research being done on contract for NRDL is prepared as a technical report and published externally | 3

Total	16
Grand total	291

PUBLICATIONS IN THE OPEN LITERATURE

Here, too, an increase was shown over recent years. Fifty articles by NRDL authors appeared in 26 journals.

OTHER PUBLICATIONS

An Informational Guide to NRDL, used for visitors and as a recruitment brochure, was updated.

PATENT ACTIONS DURING 1965

Five patents were issued: (1) K. F. Sinclair, "Backscatter Flaw Detection System," Patent No. 3,197,638. (2) D. Y. Lee and R. L. Hopton, "Intermittent Digital Readout," Patent No. 3,175,211. (3) W. J. Parker, C. P. Butler, G. L. Abbott and R. J. Jenkins, "Determination of Thermal Properties of Materials," Patent No. 3,165,915. (4) H. A. Zagorites, L. A. Perrine and M. I. Lipanovich, "Recording and Reproducing System," Patent No. 3,167,777. (5) C. F. Ramstedt, "A Torpedo Autopilot Servo," Patent No. 3,167,048 issued 26 January 1965, but patent filed at NOTS, China Lake.

There were 14 patent applications pending and 12 patent disclosures under development.