

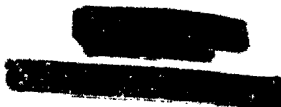


Dec 03 1946

MANHATTAN DISTRICT HISTORY  
BOOK I - GENERAL  
VOLUME 7 - MEDICAL PROGRAM

Department of Energy Document Review	
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FOREWORD


This volume presents a non-technical record of the history of the Medical Program of the Manhattan District. The history covers the period from the inception of the Manhattan District to 1 July 1946. The data was obtained from the files of the Medical Section, and from those individuals who were associated with the Medical Program during its organization and development.

Included in the volume is a resume of all activities of the Medical Section except those which concern Area Y. The Medical Program at Area Y, although under the supervision of Colonel Stafford L. Warren, Chief of the Medical Section, is described in Book VIII of the Manhattan District History.

11 March 1947

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SUMMARY

1. Introduction. - It was the purpose of the Manhattan District Medical Section to supervise and advise on the numerous unique problems arising from the processes used in the District and to facilitate progress of the Project by safeguarding the health of the employees. The Medical Program covered: research on the effect of absorbed uranium, plutonium, fission products, etc., on the human organism; industrial hygiene, with appropriate programs instituted in the various plants and laboratories; and clinical and public health programs, the purpose of which was to supply adequate facilities for the personal health of the communities. The authorizations for the construction and operation of the Medical Facilities of the Manhattan District were provided in general by Public Law No. 703, Public Law No. 354, Public Law No. 580, and Executive Order No. 9001. Specific authorizations were provided in a Report of 17 June 1942 to the President of the United States by Dr. V. Bush and Dr. J. B. Conant, by delegations of authority under Executive Order No. 9001, and in a memorandum dated 23 September 1942 signed by the General Policy Group designated by the President of the United States. The problems facing the Medical Section were intensified by the urgency of the need for their solution since many of the materials to be studied were already in use at least on a laboratory scale, and in some instances on a plant scale. The necessity of maintaining security was also a major factor affecting the District's medical program. As a result, there was some difficulty in preventing

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duplication of effort, since interchange of information between related projects was restricted to the minimum required for intelligent conduct of the individual operations. To insure cooperation and to maintain security regulations, special arrangements had to be made with other agencies, such as the local Medical and Dental societies, the Procurement and Assignment Service, State Boards of Dental Examiners, and State Boards of Medical Examiners.

2. Hazards of Operations. - Normal industrial hazards such as are noted in large construction programs and in chemical plants were to be expected in the operations of the Manhattan District. One of the major problems was the hazards of radioactivity, which were known in a general manner by the results published on the radium dial painting industry. The radioactive emanations which were encountered were: alpha particles, or electrically charged nuclei of helium atoms; beta particles, which are free electrons; gamma rays and x-rays, which are not particulate but are electromagnetic waves; and neutrons, or particles which have no electric charge. Radioactive substances from which any or all of these emanations might be expected are: radium, on which considerable data has been accumulated; radon, a gas produced when the radium atom disintegrates; polonium, a decay product of radium; plutonium, a product of neutron bombardment of uranium which is the basic material on which the District operates; and fission products, which consist of a series of radioactive substances produced in the "pile" process. A second major problem was the chemical hazards, some of which were due to entirely

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new substances while others were well known industrially. Of the gases used or produced, considerable care was exercised with fluorine and hydrogenfluoride, two very corrosive materials; and with phosgene, a by-product in the production of uranium tetrachloride. The liquids which were produced or used were the fluorocarbons, which are entirely new compounds, industrially, and are moderately toxic; and such solvent materials as trichlorethylene. Metals other than the radioactive type, which were employed in sufficient quantities to warrant notice as hazards, were: beryllium, cadmium, and nickel. Because of the number and varied types of materials and the great quantities involved, it was necessary to set tolerance values for the various hazards. Definite values for the maximum allowable exposures to the various materials, both radioactive and chemical, had to be established to facilitate efficient over-all operation. Beta radiation, neutron radiation, combined gamma and fast neutron radiation and x-ray or gamma radiation tolerance levels, stated in terms of total body radiation, and alpha radiation tolerance levels, based upon the amount in the body tissue, were established by the District Medical Section. Tolerance concentrations for radioactive substances in air, such as radon, polonium, plutonium, fission products and uranium and its compounds were studied and established with factors of safety as high as practicable. Since practically all of the materials used could be absorbed into the body, tolerance levels of radioactive material in body tissues were established for radium, polonium, plutonium and fission products. It was impossible to analyze human tissues for radioactive materials, so an indirect method was

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employed which consisted of analyzing the urine for such materials. This indirect method necessitated the establishing of tolerance levels of radioactive substances in urine. In the case of the non-radioactive materials it was necessary to establish tolerance levels in air for chemical hazards. In order that the various tolerance levels would not be exceeded it was necessary to institute methods and instruments for estimating hazards and, as a result of intensive research, such methods and instruments were developed and constructed. For the measurement of radioactive emanations, counter instruments, electrostatic indicators and the vacuum tube electrometer were adapted or developed. Monitoring methods which were developed to maintain supervision over the various hazards included the use of mechanical devices such as: film badges, pencil chambers, and finger rings containing x-ray film inserts. Physio-biological methods for monitoring, such as finger printing to note destructive changes in the print ridges, and blood counts to note deleterious changes in the peripheral blood, were also used rather extensively. In radioactive dust monitoring a device designed by Mine Safety Appliance Company called an "electrostatic dust precipitator" was used to determine the amount of radioactive dust in the air. Urine and breath samples were used to monitor the amount of exposure experienced by the various employees. Instruments and methods for chemical hazard monitoring were developed where necessary, the most important being those for fluorine detection, phosgene

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Fluorine and the fluorocarbons in general were industrially new products and processes, and studies of their hazards and medical control had to be considered. Protective measures included physical examination of workers and the use of adequate ventilation and fire protection systems. Boron production, with its attending hazards and medical control, was also one of the problems of the industrial Medical Division. Since those processes normally were conducted in closed systems, exposures were unusual. Protective measures consisted in control of dust and fume concentrations, good housekeeping and physical examinations, on the limited numbers of people employed. Process research was performed by universities or industrial laboratories selected to do research on various problems. Research on the diffusion process had a wide scope covering all phases of the development of the process. Contractors on the developmental research included the Kellogg Corporation, S. A. M. Laboratories and the Linde Research Laboratory. The hazards encountered were those associated with uranium hexafluoride and the fluorocarbons but these hazards were carefully supervised by medical control. Developmental research, on fluorocarbons, radium extraction, and methods of manufacture of uranium compounds, was carried out in various universities and these installations were inspected and supervised in respect to medical hazards by the Industrial Medical Section. Analytical research on methods of ore analysis, and the analysis of various uranium compounds were carried out at National Bureau of Standards, Princeton University and Massachusetts Institute of Technology. The development and production of process material in general presented, with few exceptions, no hazards requiring medical supervision. Barrier production presented

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a hazard of nickel dermatitis, while the manufacture and testing of pumps for the diffusion process produced the hazards of handling uranium hexafluoride, fluorine and the fluorocarbons. These last mentioned hazards were also noted in production of the unit assemblies for the diffusion process.

The gas diffusion and thermal diffusion processes were located in Oak Ridge, Tennessee. These processes and their hazards were of prime importance to the Industrial Medical Division. The hazards of the gas diffusion process and the hazards of the thermal diffusion process were primarily due to uranium hexafluoride and its hydrolysis product, uranium oxyfluoride, although numerous other hazards were also present. The medical control of hazards for both gas and thermal diffusion was in general based on an industrial hygiene program developed around the Carbide and Carbon Chemicals Company medical organization. Two types of routine medical examinations were performed: a pre-employment examination to determine the physical condition of the prospective employee, and interval and termination examinations to determine whether any deleterious effects had been produced by the employee's type of work. In order that a close check on hazards could be kept, a program of monitoring was instituted, including air contamination and radiation surveys, which were made at frequent intervals. General industrial hygiene was also a problem of major importance in the processes. About 15,000 patient visits per month was average when the processes were in full production. Occupational and non-occupational medical care were divided in a ratio of 35% occupational 65% non-occupational. In its relationship to the Safety Departments, the

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Medical Department followed the Safe Practice Recommendations of the New York Safety Committee. Other Activities included: local public health work, and a catastrophe program to provide for the protection and treatment of plant personnel in case of any major emergency. The organization of the Carbide and Carbon Chemicals Corporation medical staff was under the supervision of Dr. Adolph Kammer. The Ford, Bacon and Davis Company operated a separate medical department until February 1945 at which time Dr. Kammer assumed full responsibility. The medical program of the Percleve Corporation was also under the supervision of Dr. Kammer. The construction and operating costs for the various companies' medical programs, covering all medical work for both gas and thermal diffusion processes, totalled approximately \$660,845.58 as of 30 June 1946.

The electromagnetic process, like the gas and thermal diffusion processes, was located in Oak Ridge, Tennessee. The principal hazards of this process were phosgene and dusts containing uranium, but numerous other hazards were also present. The medical control of the hazards in general was under the supervision of the industrial hygiene service maintained by the Medical Division of Tennessee Eastman Corporation. Pre-employment physical examinations, interim examinations, and termination examinations were made as a routine procedure to protect both the employees' and company's interests. A monitoring program was established to maintain a close check on: uranium-containing dust in the plant air; phosgene, a poisonous by-product; and radiation of all types produced in the process. The problem of general

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industrial hygiene was of definite importance, especially in keeping the employees on their jobs. A general indication of the amount of service offered is the fact that when the process was in full production an average of 35,000 patient visits per month was recorded. An average of 150 cases of occupational injury or illness and an average of 400 cases of non-occupational injury or disease were seen every 24 hours. The Tennessee Eastman Corporation Division also supervised the local plant sanitation and public health. The organization of the Medical Division was under the direction of Dr. James<sup>H.</sup> Sterner while the District Medical Section liaison was carried out by officers from the District Industrial Medical Division. The total cost of this medical program was \$994,000 as of 1 July 1946, not including the cost of certain facilities in Knoxville.

The pile process was developed for the production of plutonium from uranium. The process consists in general of the neutron bombardment of canned slugs of uranium placed in the pile in a pre-arranged manner. Metal processing and shaping in preparation for coating and canning the uranium slugs is done at Hanford. Experimental work on all phases of plutonium production was conducted at both Clinton Laboratories and the Metallurgical Laboratory. The hazards of metal shaping and processing were primarily due to the possibility of breathing uranium-containing dust while the hazards noted in the operation of the pile were principally due to the enormous amount of radiation

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produced. In the plutonium extraction and concentration processes the intense radioactivity of the activated uranium slugs, the radioactivity of the gases liberated in dissolving the metal and the toxicity of plutonium and the fission products were of primary interest as major hazards. The hazards of the experimental work were roughly the same as those of the plant processes, with some additional hazards. Hazard control was in general divided into two problems: monitoring and protective procedures. Monitoring of personnel necessitated the careful check of all employees, who were required to wear two pocket ionization meters and a film badge. Plant areas, atmospheres surrounding the plant, and the large quantities of water used in the process were also very carefully monitored. Maintenance work in any of the hazardous areas was always preceded by monitoring surveys and a job analysis. Miscellaneous special surveys for radioactive contamination were made periodically in the cafeterias, laundry, office buildings, etc. Protective procedures consisted of: use of floor and table covering to guard against contamination of work benches, etc.; protective clothing, apparatus and equipment, which included coveralls, gloves, hats, shoes, etc.; and the rotation of employees from places of high radiation intensities <sup>to</sup> places of low radiation intensities at frequent intervals. Medical examinations, consisting of pre-employment physical examinations, interval examinations and termination examinations, were performed on all employees. In an evaluation of hazard control it can be stated that the foregoing methods provided complete protection to the individuals working on various phases of the pile process. In the general

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industrial hygiene work at the Hanford Engineer Works the major objective was the protection of the employees and the public from over-exposure to radiation. The Industrial Medical Section was responsible for all occupational and non-occupational medical care at Hanford. Statistics showing the extent of activities are presented in the body of this report. A Special Hazard Committee coordinated the activities of the industrial medical division with operations. A catastrophe program for area evacuation was devised and revised periodically to meet changing conditions. The industrial medical organization was under the supervision of Dr. W. D. Norwood. Space and facilities for the principal headquarters of the Industrial Medical Division were in Kadlec Hospital. Records of the Industrial Medical Division were kept separate from all other hospital and clinical charts. The cost of the Industrial Medical Division, exclusive of facilities, was \$2,581,158.85 to 30 June 1946.

At Clinton Laboratories all occupational and non-occupational care was conducted in the medical dispensary on the Laboratory area. A definite relationship to the Safety Department of the Clinton Laboratories was established through the Chief of the Medical Division who was a member of the Central Safety Committee. A catastrophe program was organized in two phases, one to correlate with the general Oak Ridge Program and one for Clinton Laboratories area alone and, in addition, the medical division had other activities related to local plant public health problems. The organization and facilities of the Clinton Laboratories medical division were under the supervision of

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Dr. R. S. Stone and Dr. S. Cantril. The cost of providing the industrial medical service at Clinton Laboratories was estimated at \$368,000 from the time of its inception until 1 July 1946. At the Metallurgical Laboratory in Chicago all of the occupational and non-occupational medical care was handled by project physicians. As at Hanford and Clinton Laboratories there was a direct relationship to the Safety Department of Metallurgical Laboratory. A catastrophe program was never organized, as the University of Chicago considered it unnecessary because of the many safety features incorporated in the operations. A number of physicians at the Metallurgical Laboratory had other activities, mainly along the lines of clinical research. The organization of the medical division, which employed some 90 persons at the peak of its activities, was under the supervision of Dr. R. S. Stone. At first the dispensary facilities of Billings Hospital were used but after July 1944 Drexal House was used for this purpose. No breakdown of the cost of operating this service is available.

Polonium was produced at the Monsanto Chemical Company's units 3 and 4, located at Dayton, Ohio. The process used at this installation is primarily physio-chemical in nature. The hazards of polonium production are primarily those of radiation since practically all of the materials handled are radioactive. The medical control of hazards was handled in general through the Industrial Medical Division of the Manhattan District Medical Section. The three routine types of medical examinations performed at Dayton were: pre-employment, interval and termination, all of which were in accordance with usual industrial

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practice. Monitoring of the atmosphere in the working areas for radio-activity was performed daily. To facilitate job procedures and prevent excessive radiation hazards to employees, detailed monitoring of routine operations was done at frequent intervals. Personnel were also carefully checked at frequent intervals by means of urine, blood, and feces analysis, as well as by the use of film badges, pencil chambers and wrist films. The general industrial hygiene problems were handled in the small dispensary by a registered nurse. More than minor injuries and illnesses were referred to a physician in part-time employment of the company. The organization was under the direction of Captain B. S. Wolf and consisted of 27 employees. The cost of this medical program from October 1943 to 30 June 1946 was approximately \$243,000.

4. Clinical Medicine and Dentistry. - The provision of medical and dental care and related services for both the Clinton and Hanford Engineer Works presented numerous difficult and unusual problems. Clinical medicine and dentistry at Oak Ridge consisted of a medical program attuned to the community needs. Service was planned at first for an estimated population of 8-10,000; but, as the project grew it was necessary to adjust the planned service for estimated populations of 15,000 to 50,000 and finally for estimated population of 72,000. The policy concerning fees, personnel and service necessarily had to be revised from time to time with the increasing demand. The type of medical service rendered was limited at first to first-aid and emergency medical care but was finally expanded into a full hospital and clinic service with the associated medical specialties.

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A pre-payment plan for medical care under the name of the Oak Ridge Health Association was instituted since it was felt that such a plan would insure better medical care, reduce absenteeism, decrease bookkeeping and be an inducement in recruiting workmen. The plan operated under a contract between the Association and the hospital. The objectives of the plan were to give hospitalization and medical coverage in as broad a sense as was economically feasible. Membership was limited to government employees and the personnel of the operating companies, the charge for a family membership being \$4.00 per month. The services covered were: hospital service, diagnostic service and physicians' services. There were certain services not covered, such as: alcoholism, self-inflicted injuries, special nursing care, etc. which are not covered in the usual medical pre-payment plans. The administration of the plan was first under the direction of Mr. Henry Vaughn and later under Mr. J. H. Stallings. In an evaluation of the Oak Ridge Hospital Association it can be said that this plan offers more benefits to the subscriber than any existing plan. The financial status is best shown by the fact that in approximately two years of operation reserves amount to about \$80,000.00; but the probable future of the plan is unpredictable. An emergency disaster program was established by the medical staff for use in case of a major disaster which might require medical participation. The organization of the clinical medical program at Oak Ridge was first undertaken by the University of Rochester under authorization by the Manhattan District. Later the organization

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was taken over by the Roane-Anderson Company. Statistics on operations show an increase from 8 doctors and 1,890 patients in July 1943 to 52 doctors and over 20,000 patients in July 1945. Following V-J Day the total population of the area gradually decreased to approximately 42,000 in July 1946; during this period Army Medical Corps Physicians were gradually replaced by civilian physicians according to the needs of the community. A dental program was instituted in conjunction with the medical program and was continually adjusted to the community dental needs. The policy was to use civilian dentists since procurement of dentists was less critical and dentists would have no contact with classified material. The dental facilities were increased from accommodations for two dentists at first to accommodations for 29 dentists in March 1945 and 25 thereafter. The organization was at first under the direction of Dr. Don Clawson but was later placed under the direction of Dr. William Squires. The statistics on operations show an increase from 28 patients in July 1943, to 4233 patients in March 1945 and 3609 in July 1945. On 1 February 1946 the dental clinic ceased to be operated by Roane-Anderson Co.; thereafter dentist care was provided on a private practice basis. A public health program under the direction of Captain Bernard Blum was organized in January 1944, and a veterinary service was organized under the direction of Captain Lloyd Jameson in August 1943. On 18 December 1945 Captain Blum terminated his Army Service and was succeeded by Mr. Leon S. Blankenship as public Health officer; Captain Lloyd Jameson was succeeded by Dr. James Kile as Area Veterinarian on 1 January 1946. The net cost of all of these services to 1 July

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1946 amounts to \$2,829,349.

Clinical medicine and dentistry at Hanford Engineer Works was divided into two phases, one existing during the construction period and the other during the operations period. The construction phase medical program was instituted to meet the community needs of a temporary community of construction workers, the policy concerning personnel, facilities and charges being directed by the contractor, E. I. du Pont de Nemours and Company, Inc. The type of medical service rendered began as first-aid and emergency medical work but rather quickly developed into full hospital and clinic service, including an industrial medical relations section as a part of the Medical Division. An interesting feature of the program was a plan adopted to utilize all available manpower by the use of handicapped workmen. The organization of the Medical Division was under the supervision of Dr. J. M. Wetherhold who in turn was responsible to the contractor. The operating statistics show a maximum in personnel and also in patients seen during the months of May through September and June and July of 1944. A dental program and a public health service were also in operation during the construction phase. A breakdown of the cost of operations during the construction phase shows a deficit of \$1,724,000. The operations phase medical program, in contradistinction to the construction phase, was instituted to meet the community needs of a permanent type of community of a higher type of worker. The policy, as in the case of the construction phase, was under the direction of the contractor, E. I. du Pont de Nemours and Co. The type of medical service rendered was that of a regular hospital

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with attached clinics having all specialties available. The organization of the medical service at Richland was under the direction of Dr. W. D. Norwood, who in turn was responsible to the Assistant Plant Manager. Operating statistics show an increase in doctors in general relation to the total population. A dental program was established in close association with the medical program and was available in August 1944. In January of 1945, the public health program entailed a transfer of the Public Health Section from Hanford to Richland. An emergency disaster program was established in conjunction with the industrial medical group for operation in case of a major disaster. A breakdown of the cost of operations during the operations phase shows a total net medical cost of \$2,581,158 to July 1 1946.

5. Biologic and Health Physics Research. - The research section came as a natural development of the rapid progress of physical research. The purpose of the research program was to investigate the potential damaging effects of uranium and other radioactive compounds used, as well as certain special materials which had had no previous industrial use. Radiation research was first realized to be necessary by the University of Chicago group because of their work on the pile process. X-ray and gamma radiation as well as neutron radiation, beta radiation, alpha radiation and mixed radiations were studied thoroughly in both acute and chronic doses. Projects covering instrument research were in general interested in the development of new instruments in order to cope successfully with the radiation problems. Institutions chosen to work on the instrument problem



as well as on radiation research were: the University of Chicago, Clinton Laboratories and the University of Rochester. Hazard research on radioactive substances was a problem of major importance. In general this work was concerned with the possible damaging effects of radioactive substances when inhaled, ingested or placed in contact with the skin; and the substances studied were: radium, polonium, plutonium, fission products and uranium. Substances of potential chemical toxicity such as the fluorocarbons, elemental fluorine, etc., were also studied to prevent possible hazards. Industrial research concerned itself in general with the new medical aspects, such as: monitoring, protective measures and statistical studies. This type of work was performed at the University of Chicago, Clinton Laboratories and the University of Rochester. Records of research activities in the various laboratories and universities were maintained through the medium of progress reports, copies of which are on file in the office of the District Medical Section. The organization of the Biologic and Health Physics Research Division is divided into various subgroups responsible to the Manhattan District. The subgroups are the University of Chicago, Clinton Laboratories, the University of Rochester, the University of California, the National Cancer Institute, Columbia University, the Biochemical Research Foundation and the University of Washington. Costs for these programs are not available since they were lumped with costs of other types of research at the same institutions.

6. Organization. - With the transfer of all OSRD contracts pertaining to the development of atomic power to the Manhattan

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District it became essential that a well qualified physician be procured to act in a staff capacity to the District Engineer. Dr. Stafford L. Warren was appointed in the capacity in March 1943. The original table of organization for officer personnel for the Medical Section of the Manhattan District, with subsequent semi-annual revisions, is presented in this report. Qualifications of all officers appointed to the Medical Section were carefully considered in every case. In order to commission certain civilian medical personnel and to make available material procurement facilities, assistance from the Surgeon General's Office was necessary and arrangements for such assistance were completed in September 1943. These have functioned remarkably and appreciation for this service is extended to that office.

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MANHATTAN DISTRICT HISTORY

BOOK I - GENERAL

VOLUME 7 - MEDICAL PROGRAM

SECTION 1 - INTRODUCTION

1-1. General. - The primary objective of the Manhattan District was to develop and operate processes which would make possible the utilization of the tremendous energy available from the splitting of uranium. Numerous unusual medical problems were encountered as a result of the unique nature of these operations. These difficulties developed, primarily, as a result of the fact that the basic materials were radioactive and little or no toxicity data concerning them were available.

1-2. The Objectives. - The objectives of the Manhattan District Medical Program were to facilitate the progress of the Project by safeguarding the health of the employees, not only from the hazards inherent in the peculiar nature of the District's operations, but also from the usual industrial medical hazards, and to provide the usual clinical and public health services required for the communities established at the plant sites (See App. A1).

1-3. Scope.

a. Research. - Investigation was required to determine what effect absorbed uranium and plutonium compounds would have on the human body; what effect absorbed<sup>b</sup> products of uranium (fission products from the pile process) and radioactive products produced in the actual explosion of the uranium and plutonium bombs would have; and what hazards might be encountered from absorption of other materials developed for use by the District. In addition, although the dangers of work with radium were

fairly well known, it was discovered that the knowledge concerning the maximum safe exposures to various radiations was not well-founded, and that considerable research would be required to establish safe levels with certainty. A natural corollary to these investigations, was research designed to establish early signs of toxic effects from these materials or from radiation, and to develop specific measures which would be useful for treating over-exposures.

b. Industrial Hygiene. - Appropriate programs of industrial hygiene had to be instituted in the plants and laboratories working with these unusual materials. Plant medical staffs had to be provided with the information necessary to the intelligent performance of their duties, without compromising the security of the project. Research was required to devise means of estimating the degree of hazard and exposure to which the employees were subjected.

c. Clinical and Public Health Programs. - In addition, at Oak Ridge and Hanford, the locations selected for the major operations, medical and dental facilities were either unavailable or already overloaded with patients. In consequence, it was necessary to provide the facilities and staff required to render adequate war-time medical and dental care, to fulfill essential public health functions and the minimum veterinary service needed in the area.

1-4. Authorizations. - Authority to construct and operate the Medical facilities of the Manhattan District is provided by the following:

a. General. -

(1). Public Law No. 703. - 76th Congress, 3rd Session, approved 2 July 1940, which authorizes the Secretary of War to provide

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for the necessary construction, rehabilitation, conversion, installation and operation of plant and buildings for development, manufacture, and storage of military equipment and supplies, and for shelter.

(2). Public Law No. 354. - ("First War Powers Act") 77th Congress, 1st Session, approved 18 December 1941, which empowered the President with certain broad wartime authorities (See Book I, Vol. 1).

(3). Public Law No. 580. - 77th Congress, 2nd Session, approved 5 June 1942 which provided amendments to Public Law No. 703 above (See Book I, Vol. 1).

(4). Executive Order No. 9001. - dated 27 December 1941, which delegated to the War Department authority to enter into contracts under the "First War Powers Act" (See Book I, Vol. 1)

b. Specific.

(1). Report of 17 June 1942 to the President of the United States by Dr. V. Bush, Director of the Office of Scientific Research and Development and Dr. J. B. Conant, Chairman of the National Defense Research Committee. This report presents the results of a study made to determine the advisability of carrying on what later became the Manhattan District Project, the consequences involved, and the results attained (See Book I, Vol. 1).

(2). Delegation of Authority under Executive Order No. 9001. A memorandum dated 30 December 1941 from the Secretary of War to the Under Secretary of War, whereby the Under Secretary is delegated the powers previously delegated to the War Department by Executive Order No. 9001 (See Book I, Vol. 1).

(3). Delegation of Authority by the Under Secretary of War to Major General L. R. Groves. - A memorandum dated 17 April 1944, signed

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by the Under Secretary of War, empowered Major General L. R. Groves to exercise contractual powers under Executive Order No. 9001, effective 1 September 1942 (See Book I, Vol. 1).

(4). Further Delegation of Authority Under Executive Order No. 9001. In a memorandum dated 10 June 1944, Major General L. R. Groves delegated to the District Engineer, Manhattan District, authority to enter into contracts for the Manhattan District (See Book I, Vol. 1).

(5). Memorandum Dated 23 September 1942. - The General Policy Group designated by the President of the United States to determine general policies of the project, in a conference on 23 September 1942 appointed a Military Policy Committee to consider and plan military policy relating to the project and named Major General (then Brig. Gen.) L. R. Groves to sit with the Committee as Executive Officer to carry out the policies that may be determined (See Book I, Vol. 1).

1-5. Urgency. - The problems facing the Medical Section were intensified by the immediate need for their solution. When the medical research programs were started, the materials to be studied were already in use at least on a laboratory scale, and, in some instances, on a plant scale. Similarly, throughout the course of Manhattan District operations, the Medical research programs were pressed to keep up with operations. Likewise, the Industrial Medical Division at its inception/ was confronted with plants and laboratories in operation on unfamiliar materials, and data concerning their toxicity were almost non-existent. Finally, in the sites at which it was necessary to provide medical and dental care, staffs had to be procured and services instituted on very short notice. There was not time to experiment or shift personnel. Medical services had to

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be inaugurated with the knowledge that the quality of professional care was excellent and that its availability was adequate.

1-6. Effects of Security. - The necessity of maintaining the security of the Project/ was a major factor affecting the District's medical program. Interchange of information between related projects was restricted to the minimum required for intelligent conduct of the individual operations. This fact alone was responsible for great difficulty in preventing duplication of effort. Likewise, in the dissemination of data from medical research to contractors, great care was required to determine that the information reached only those individuals entitled to receive it. The physicians procured for medical service at Oak Ridge were commissioned in the Army primarily in the interests of security, since it was planned originally for them to serve the plants as well as the rest of the community. Army medical officers were selected also to insure that capable individuals were procured and kept on the job.

1-7. Special Arrangements with Other Agencies. - Certain special arrangements had to be made to insure the cooperation of other agencies and to maintain security.

a. Local Medical and Dental Societies. - The local medical and dental societies at both Hanford and Oak Ridge were consulted and their approval obtained on the types of medical and dental service being offered. In addition, fee schedules were drawn up in conformity with the prevailing rates of the communities.

b. Procurement and Assignment Service. - Numerous negotiations were conducted with the Procurement and Assignment Service for Physicians, Dentists and Veterinarians. It was necessary that the national office and

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certain local offices of this organization be advised of the importance and urgency of the Manhattan District operations in order that procurement of physicians and dentists from civilian practice could be facilitated, and that retention of men in essential civilian activities of the District could be insured. The Procurement and Assignment Service was found to be most cooperative and helpful in the problems with which it was concerned (See App. B7).

c. State Boards of Dental Examiners. - It was impossible to procure a sufficient number of dentists licensed in Tennessee and Washington to fulfill the needs of the communities. In addition, licenses to practice dentistry in both Tennessee and Washington are granted only by examination and there is no provision in the law for temporary licensure. Therefore, arrangements were made with the State Boards of Dental Examiners in these states to permit dentists to work on the project until such time as they could be spared to take the examination for licensure.

d. State Boards of Medical Examiners. - The arrangement made with the State Boards of Medical Examiners in Tennessee and Washington required that civilian physicians obtain licenses by examination or reciprocity with the least possible delay after reporting for work.

e. Universities, Medical Schools, Biologic Institutes. - Negotiations were continually carried on with these organizations to aid in procurement of personnel and to make available special services and equipment.

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SECTION 2 - HAZARDS OF OPERATION

2-1. Normal Industrial Hazards. - Medical hazards identical with those in large construction programs, with those incurred in chemical plants, and with those involved in the use of high voltage electrical equipment, were present in the operations of the Manhattan District. Since these activities were exceedingly varied and were carried on in a large number of different plants, the degree and type of hazard varied greatly from place to place, and from time to time. These risks did not cause any special concern. The contractors' medical staffs were well qualified and equipped to deal with problems of the toxicity of well known chemicals, and to handle industrial accidents. The Safety Section of the Manhattan District aided materially the contractors' safety groups in accident prevention, and in establishing safe-handling practices (See Book I, Vol. 11 - "Safety Program").

2-2. Hazards of Radioactivity.

a. General. - The chief problem confronting the Medical Section was the proper evaluation of the radioactivity of the basic materials as industrial hazards. The importance of proper evaluation of these hazards was given impetus by the memory of the dire consequences of improper precautions in the radium dial painting industry as evidenced by the cases of radium poisoning which occurred after the last war. The memory of this tragedy was very vivid in the minds of people, and the thoughts of potential dangers of working in areas where radiation hazards existed were intensified because the deleterious effects of radiation could not be seen or felt and the results of over-exposure might not become apparent for long periods after such exposure. It was necessary, therefore, to

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obtain accurate positive information for the use of contractors' medical staffs on the toxic effects of radiation and radioactive materials, to provide methods for estimating hazards, and, whenever possible, to recommend prophylactic measures against over-exposure.

b. Radioactivity. - First, let us consider the radioactive elements which are encountered in the operations of the Manhattan District. These elements emit alpha and beta particles and gamma rays. Neutrons should also be considered but they are produced only under special conditions.

(1). Alpha particles are electrically charged nuclei of helium atoms. They are projected from certain radioactive substances with great energy but travel only a relatively short distance in air and are stopped by extremely thin layers of solids. When alpha particles strike human skin they are stopped in the outer dead layer of cells, and therefore are incapable of causing damage.

(2). Beta particles are electrons which are projected by certain radioactive substances with greater velocity than alpha particles, and these particles are more penetrating than alpha particles. They are capable of injuring human skin because they penetrate to the vital growing layers. However, the skin has marked recuperative power and a certain amount of beta radiation may be received daily, year after year, without damage occurring. Since beta particles are stopped in the skin, they are incapable of directly producing systemic effects so long as the particles arise from an external source (outside the body).

(3). Gamma rays may arise from radium and other radioactive substances and are electro-magnetic waves which have great pen-

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etrating power. Gamma rays can pass completely through a human body. They can be stopped by lead and other elements of high atomic number. Since gamma rays and x-rays can pass completely through the body, over-exposures affect primarily the most sensitive tissues. Continued over-exposure results in damage to the blood forming organs (principally the bone marrow) and the reproductive cells (testes and ovaries). In the case of gamma and x-rays, as with beta particles, a certain amount of exposure may be incurred day after day and year after year without harmful effect.

(4). Neutrons are particles which have no electric charge. They arise from the nuclei of atoms under proper conditions. The instrument most commonly used heretofore to produce neutrons is the cyclotron. Neutrons like gamma rays can penetrate the entire body, and the effects of over-exposure are identical with those of gamma rays. However, the biological effects resulting from ionisation by fast neutrons are approximately three times as great as those produced by the same amount of gamma rays.

c. Radioactive Substances. - Secondly, work with radioactive substances presents certain problems in addition to the external radiation which was discussed above. These radioactive substances may be inadvertently introduced into the body by inhalation and ingestion and skin absorption and thus deposited in the body tissues. Once deposited, alpha, beta, or gamma radiation may produce untoward effects on the tissues. Also, concentrations of some of these substances which have a relatively low radioactivity may produce toxic effects on the body from a chemical standpoint. The important toxic radioactive elements are:

(1). Radium. - The toxic effects of absorbed radium were well known. Only a fraction (perhaps 10 per cent) of the absorbed material is deposited, but the bulk of that fraction enters the bone. When an excessive amount is deposited, the unfortunate individual, after a number of years, may cease to produce blood cells (aplastic anemia) and succumb. In some instances, necrosis (rotting of the bone) also has occurred. In a few cases bone cancers and a condition known as leukemia (an over-production of white blood cells), also a fatal process, have occurred.

Fortunately, sufficient data have been accumulated on radium to establish the maximum allowable dosage which produces no significant biological effect. In addition, relatively easy, accurate methods are available for determining the amount of radium in the body, providing a positive control for workmen exposed to the substance. (One method measures the radon gas formed from radium, which is excreted in the breath; the other method depends upon the radioactivity in an individual's body as a result of the radium deposited.)

The fact that these data were available on radium was exceedingly useful to the Medical Section, for by comparing the relative energies of other substances with radium, it was possible to estimate "maximum allowable storage" which could be permitted without danger to the individual.

(2). Radon. - This substance is a gas and is produced when a radium atom breaks up with the ejection of an alpha particle. Radon, like its parent element radium<sup>m</sup>, is radioactive and is capable of emitting alpha particles. The daughter products of radon emit beta particles and gamma rays, so that all three types of radiation are present, since

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there are usually daughter elements in equilibrium with radon. If this gas is inhaled in a sufficient concentration and for a sufficiently long period, the lungs may be damaged by the alpha radiation.

(3). Polonium. - It is known that radium spontaneously disintegrates and new substances are formed which in turn decay until the final stable residue of lead is reached. Polonium is a decay product of radium and is one of the substances which emit alpha particles and yet have no radioactive decay products. It has been shown that when polonium is injected into rats, it is deposited in the greatest quantity in the kidneys and in smaller quantities in the spleen, in the testes (reproductive organs) and in the bones. If enough polonium is injected, death will ensue due to toxic damage of these vital tissues.

(4). Plutonium. - The "Pile Process" transforms Uranium 238 into plutonium, which has an atomic weight of 239 and an atomic number of 94. This transformation is accomplished by bombarding U-238 with neutrons in a manner described later in this report (See Par. 3-12, b). The potential hazard involved in the handling of plutonium is probably quite similar to radium. This substance, like radium, shows a predilection for deposition in the bony tissues with the attendant effects outlined under radium. There are, however, some important differences. Plutonium is approximately one-tenth as toxic as radium when it is permanently stored in the bone. The rate of elimination of absorbed plutonium is less rapid than that of radium, and, therefore, a larger proportion of absorbed plutonium tends to become permanently stored than in the case of radium.

(5). Fission Products. - In the industrial production of plutonium and in the atomic disintegration of plutonium or U235 many

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radioactive substances are produced. These substances are known as fission products and intensive research work on animals has revealed that these fission products are potentially toxic agents because of their radioactivity.

(6). Uranium. - In addition to its radioactive properties, uranium has been known for many years to be a substance capable of producing damage to the kidneys, and has been used frequently to produce a type of experimental nephritis in animals similar to that produced by mercury. Studies on such uranium nephritis in dogs have proved invaluable in the control and treatment of the later stages of human nephritis in which large amounts of protein are lost in the urine. Industrially, uranium compounds have been produced on a limited scale as coloring matter for the ceramics industry; and also have been encountered as a by-product in the refining of pitch-blende ore to produce radium. Conferences with physicians who had medical supervision over persons working with uranium, indicated that toxic effects had not been observed by them (See App. B2). However, the Manhattan District operations involving uranium were on a far larger scale than any previously carried on, and water soluble compounds (which might be absorbed much more readily) were used. Consequently, it was considered possible for workmen to develop irritation of the kidneys if excessive exposures to uranium were encountered, and also, although considerably more remote, to store sufficient uranium to have toxic effects from the radioactivity of the material.

2-3. Chemical Hazards. - There were a number of chemical substances used in the industrial operations of the Manhattan District which were not of a radioactive nature. Some of these substances were well known industrially; others were entirely new. Some of the well known chemicals, however,

were used on a much larger scale than ever before. Some of the more important substances will be commented upon briefly.

a. Gases.

(1). Fluorine and Hydrogen Fluoride. Hydrogen fluoride or hydrofluoric acid has been widely used industrially. Fluorine, on the other hand, was a laboratory curiosity. Both were used by the Manhattan District on a large scale in the preparation of special compounds of uranium and in the preparation of a series of special lubricant compounds, known as the fluorocarbons, which will be discussed later (See Par 2-3, b (1)). The hazard from fluorine is primarily that of a chemical burn, which can produce death with sufficient exposure. The hazard from hydrogen fluoride is the marked corrosive effect the acid has on body tissues. This is particularly insidious because there is a latent period before there is perception of pain. It is stated that 50 parts of hydrogen fluoride per million parts of air will be extremely dangerous if inhaled for an extended period of time.

(2). Phosgene. - This is a well known poison gas which was used during World War I, and in the Manhattan District industrial operations occurs as a side-product in the preparation of special uranium tetrachloride. Phosgene produces a devastating effect on lung tissue if inhaled in toxic concentrations. It is estimated that if a person should be placed in an atmosphere which contains one part of phosgene in 10,000 parts of air for two minutes, death would ensue.

(3). Carbon Monoxide. - This industrial hazard occurs to a very limited extent in some of the processes. However, control of other toxic elements by ventilation accomplishes control of this gas as well.

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Hence as a special specific hazard no control measures are directed toward it.

b. Liquids.

(1). Fluorocarbons. - These compounds are composed of fluorine and carbon and are primarily used as lubricants and coolants by the Manhattan District. These compounds ( $C_7F_{16}$ ,  $C_8F_{16}$ ,  $C_{21}F_{44}$ ) were found to be moderately toxic to animals upon inhalation, but some of the intermediate products formed in the production of these compounds were found to be toxic to animals in concentrations varying from 70-500 parts per million parts of air. The animals exposed to toxic concentrations of these intermediate products of the fluorocarbons died apparently as a result of respiratory failure.

(2). Trichlorethylene. - This substance is primarily used as a grease solvent in the Manhattan District. Trichlorethylene is classified as a narcotic poison and chronic intoxication supposedly produces a damaging effect upon the central nervous system.

c. Solids.

(1). Metallic Beryllium. - This substance has been used in industry and is capable of producing marked damage to lung tissue if inhaled as a dust. Enough information about the causes and prevention of beryllium poisoning was available so that no research work was carried out with this substance.

(2). Metallic Cadmium. - This substance is used by the Manhattan District because of its efficiency as a neutron absorber. A few fatalities as a result of over-exposure to cadmium, in industrial operations other than Manhattan District, have been reported previously. Safety pro-

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cedures were set by the Manhattan District so that the hazard from cadmium was only of a very minor nature.

(3). Metallic Nickel. - This substance is known as a hazard in industry primarily because of its potentiality as a skin irritant. With this substance also, safety procedures were so set up by the Manhattan District that the hazard from nickel was only of a very minor nature.

2-4. Tolerance Levels for Various Hazardous Materials.

a. General. - The materials discussed above were used on a vast industrial scale by the Manhattan District and many people were engaged in this work. It was obviously imperative, therefore, to learn about the degree and nature of the toxicity of these substances so that a definite industrial hazard policy could be established which would insure a maximum factor of safety to the people working with these substances. Definite values for the maximum allowable exposures or tolerance to these materials had to be established to facilitate efficient over-all operation. (The terms "maximum allowable exposure or concentration" or "tolerance" will be used interchangeably in this discussion and the term "tolerance" in this case will not refer to the definition proposed in pharmacological texts.) The radioactivity of these potentially toxic substances was therefore thoroughly investigated, their chemical properties were studied and the effects of these various toxic agents were evaluated in carefully controlled animal experiments. It was as a result of this orientation program that the degree of toxicity of these substances for the various animal species was arrived at. Toxicity in man was estimated from such data and from previously established toxicological information, and arbitrary tolerance values were introduced which would offer a maximum factor

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of safety to the employees of the Manhattan District engaged in industrial operation and research work.

The following is a brief outline of the arbitrary tolerance values which were established. These values, especially those pertaining to the radioactive materials for which meagre background data were available, were subject to constant checks and revisions as more information was gathered through research and experience.

b. Tolerance Levels for Various Types of Radiation.

(1). Total Body Irradiation. - The probable safe level for exposure to radiation for a person employed over an indefinite period was set at 0.1 roentgen units of gamma or beta particle radiation in any twenty-four hour period. This value was established by the U. S. Bureau of Standards in 1937 and was adopted by the Manhattan District (See App. B1). (The roentgen is used as a measure of radiation and is defined as a quantity of x-ray or gamma radiation such that the associated corpuscular emission, for one cubic centimeter (0.001293 grams) of air, produces in that air ions carrying one electrostatic unit of electricity of either sign.)

(2). Alpha Radiation. - The tolerance value for alpha particle radiation from an alpha emitting substance capable of being deposited in body tissue was established as 0.025 roentgens (physical equivalent) per twenty-four hour day.

(3). Beta Radiation. - The safe limit of beta radiation for the body as a whole has been set at 0.1 roentgen per twenty-four hour day, and the figure set for beta radiation on the hands only has been established at 0.5 roentgen units per twenty-four hour day.

(4). Neutron Radiation. - The biological effects resulting

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from fast neutrons has been shown by experiments to be from two or ten times as great as that of the same amount of radiation produced by x-ray. For ionization in body tissue, a factor of  $3\frac{or}{4}$  is probably ample as measured in roentgen equivalent physical, and 0.025 roentgens (physical equivalent) per twenty-four hours might be taken as a tolerance dose.

(5). X-rays or Gamma Rays. - The National Bureau of Standards, acting upon the advice of the Advisory Committee on X-ray and Radium Protection, has established the tolerance dose for x or gamma rays of 0.1 roentgens per twenty-four hours. The committee recommended the tolerance dose of 0.1 roentgen per day as provisional, and it is advisable to apply generous safety factors to prevent exposure even at this level. For this reason, it has been deemed advisable to build in protective measures in fixed installations so as to have the intensity such that the operating personnel working on 8 hour day get no more than 0.1 roentgen in any twenty-four hour day, giving a safety factor of 3 in this case.

c. Tolerance Concentrations for Radioactive Substances in Air.

(1). Radon. - The tolerance level of radon in air has been established as  $10^{-10}$  curies per liter of air. (curie is a unit of radium emanation from, or the amount of radon equivalent to, one gram of radium.) This value was based on the New York State Code for Radium Dial Painters established in 1939. This limit represents one-tenth of the exposure that was thought to have produced harmful effects on people working in the mines of Czechoslovakia (See App. B1).

(2). Polonium. - The maximum allowable concentration of this material has not been definitely established but a provisional level of  $5 \times 10^{-4}$  micrograms per cubic meter in air has been set. This figure was arrived at after extensive animal experimentation.

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(3). Plutonium. - A tolerance limit of  $3.5 \times 10^{-5}$  curies of Plutonium per liter of air was used for the Manhattan District. This figure was based on extensive computation and comparison with radium and other substances which emit alpha particles. The maximum allowable air concentration has not been clearly established

(4). Fission Products. - It is very difficult to establish tolerance values for these substances, but an arbitrary value for the mixed fission products has been set at one to ten microcuries per cubic meter of air. (One microcurie is equal to one millionth of a curie.)

(5). Uranium. - The tolerance value for uranium which was accepted for the Manhattan District industrial operations has been set at 150 micrograms per cubic meter of air. This is also the tolerance value arbitrarily established for lead by the United States Public Health Service. No conclusive data was available on the toxicity of uranium prior to the start of the Manhattan District, and the above mentioned tolerance level was, on the best authority, applied to uranium pending the procurement of further data through research and experience.

d. Tolerance Levels of Radioactive Material in Body Tissues. -

It is obvious that people working with these radioactive substances would inadvertently ingest and inhale these substances to some degree. It was necessary, therefore, as an additional precautionary measure, to monitor the personnel to make certain that they had not accumulated more than the maximum allowable concentration of these substances in their body tissues. Tolerance levels for absorbed quantities of these radioactive materials were therefore derived from animal experimentation and extrapolation from these values to man and also from previously reported .

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experimental work found in the literature. The tolerance levels established for these substances are:

(1). Radium. - A tolerance limit of 0.1 microgram of radium stored in the body as established by the U. S. Public Health Service in 1941 was adopted by the Manhattan District (See App. B 1).

(2). Polonium. - A tolerance limit of .15 micrograms of polonium stored in the body was established as a result of animal experimentation and a comparison of the radioactive energy of this compound with radium.

(3). Plutonium. - The tolerance value for plutonium (1.0 micrograms stored) was derived in a manner similar to that of polonium. It is established that plutonium is about 1/10 as toxic as radium when deposited in the body.

(4). Fission Products. - Tolerance levels for fission products deposited in tissue have not been established experimentally, but it is possible to calculate the maximum allowable concentration by converting available data on x-rays, gamma rays, and alpha radiation from radium into comparable energy limits taking into consideration the distribution of the individual fission products after absorption.

e. Tolerance Levels of Radioactive Substances in Urine. -

Since it is obviously impossible to analyze human tissues for the amount of radioactive substances present, indirect methods had to be employed to estimate the probable amounts of these substances which were present in body tissue. It is known that radioactive materials are excreted in the urine. A tolerance value for urinary excretion has been established only in the case of polonium. The urinary excretion tolerance value for the other radioactive materials are still under investigation, and no definite

figures have been established. The tolerance value for urinary excretion of polonium has been set at 5,000 disintegrations per minute in the total urine excreted per day. (The use of disintegrations per unit of time is a method for determining very small amounts of radioactive substances. Each disintegration is due to the radioactive disruption of an atom and the number of disintegrations per unit of time is a relative measure of the amount of total radioactive material present.)

f. Tolerance Levels in Air for Chemical Hazards. - There are a number of substances which are important as industrial hazards in the operation of the Manhattan District, but their potential danger is in the form of chemical toxicity. The tolerance values for these substances will be mentioned briefly.

(1). Gases:

(a). Fluorine

Maximum Allowable Concentration  
1 part per million parts of air, as established by application of data gained on exposure of animals to controlled atmospheres of this gas.

(b). Hydrogen Fluoride

3 parts per million parts of air, the level set by the American Standards Association and adopted by the Manhattan District.

(c). Phosgene

1 part per million parts of air, the level set by the Chemical Warfare Service as a safe concentration for troops.

(2). Liquids:

(a). Fluorocarbons: The tolerance levels for these sub-

stances ( $C_7F_{16}$ ,  $C_8F_{18}$ ,  $C_{21}F_{44}$ ) were established after a series of animal experiments. The term forerun is used to designate the fraction of a substance on which fractional distillation passes through the column first (low boiling point) prior to the collection of the desired material. Crude refers to the material after chemical preparation but before distillation

has taken place. Some of the available tolerance values established are listed below:

$C_8F_{16}$ -1	250 parts per million parts of air
$C_8F_{16}$ -2 Foreshot	70 parts per million parts of air
$C_8F_{16}$ -2	300 " " " " " "
$C_8F_{16}$ Crude	50 " " " " " "
$C_7F_{16}$ Foreshot	100 " " " " " "

(b). Trichlorethylene. - The maximum allowable concentration for this substance has been established by the State of Massachusetts as 200 parts per million parts of air, and this figure has been adopted by the Manhattan District.

(c). Chloroform and Carbon Tetrachloride. - The maximum allowable concentrations of these substances <sup>have</sup> ~~has~~ been set at 300 parts per million parts of air. This figure has been adopted by the Manhattan District.

(3). Metals.

(a). Beryllium. - No tolerance value has been set for this substance, but the existing information on the causes and prevention of poisoning in the manufacture of beryllium is quite adequate from a practical standpoint. Beryllium is controlled by the prevention of inhalation exposure to fumes during processing. Should exposure occur with the appearance of an initial shortness of breath, removal of the individual for a period of several months will effect complete cure.

(b). Cadmium. - The tolerance level for this material has been set as 1 mgm. of cadmium per ten cubic meters of air. This is the

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concentration on cadmium as set by the American Standards Association and adopted by the District.

2-5. Methods and Instruments for Estimating Hazards. -

a. General. - it was obviously imperative to have methods and proper instruments to evaluate the degree of hazard involved in working with these potentially toxic materials. As a result of intensive research, such methods and instruments were developed and constructed.

b. Radioactivity. - First, the methods and instruments developed for the evaluation of radioactivity such as alpha, beta, gamma, or x-ray, and neutron radiation will be considered. Three general types of instruments are used in survey and monitoring work with radioactive emanations. These are:

(1). Counter Instruments. These instruments count individual particles emitted by a radioactive element (See App. C 1).

(2). Electrostatic Indicators. - This type of instrument does not respond to the individual radioactive particles but averages or integrates the effects of the total number of particles by the charge produced by ionizing a fixed volume of air (See App. C 2).

(3). Vacuum Tube Electrometer. - This type of instrument is similar to the Electrostatic Indicators but the current produced by ionization in a fixed volume of air is amplified and indicated on a meter. (See App. C 3).

c. Monitoring Methods. - Five special monitoring methods which measure the degree of radiation received by each individual should be mentioned. The first three methods are mechanical devices which measure the total degree of radiation to which a person is exposed. These are:

(1). Film Badges. - For determining the amount of radia-

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tion received by a person in a given period of time, a special badge containing x-ray film is worn. These films are developed, and by measurement of calibration curves the total radiation received over a given period is determined (See App. C 4).

(2). Pencil Chambers. - These instruments are small pocket meters in the form of a pencil or pen and are worn in a pocket and measure the degree of radiation received by a person over a given period of time (See App. C 5). Prior to use, the quartz fibre enclosed in the chamber is given a calibrated electrical charge which it retains indefinitely. However, on exposure to gamma and x-rays the ionization so inducted causes a discharge of this charge on the fibre directly proportional to the amount of radiation received, and can be measured in a variety of technical manners.

(3). Finger Rings. - To determine the amount of radiation received by the hands of the employees in specific operations involving possible exposure to beta rays, finger rings with x-ray film inserts are used. These films are developed and calibrated to indicate radiation received in a given period of time (See App. C 6).

The other two methods utilize early changes in the human body when there has been exposure to radioactive materials. These are:

(4). Fingerprints. - Through research activity, it was determined that one of the earliest indications of damage to the hands of persons handling radioactive materials was a noticeable change in the finger-print ridges. In order to take advantage of this early sign of radiation damage, a program of securing periodic wax impressions of exposed employees' fingers was established (See App. C 7).

(5). Blood Counts. - It has been definitely established that blood-forming organs (bone marrow) are sensitive to radiation, and their function is easily deranged by over-exposure to radioactive material. This is reflected when the blood cells in the peripheral blood are counted and examined. Frequent periodic blood counts were therefore taken on all employees engaged in work with radioactive materials. This procedure served as a valuable early means of warning when any person might be getting more than the maximum allowable exposure to radioactive materials.

d. Radioactive Dust Monitoring. - It was essential, also, to establish monitoring methods for radioactive dust measurements on uranium, plutonium, and polonium. The amount of radioactive dust in the air is determined by a Mine Safety Appliance Company Standard Electrostatic Precipitator or a device of similar design. A volume of air is drawn through the precipitator and the dust is electrically precipitated on a metal foil. The activity of the precipitate is then determined by a Derschen electrometer or other radiation measuring device (App. C 8).

e. Urine and Breath Samples. - As was pointed out previously, the people engaged in work with the radioactive materials will inadvertently ingest and inhale these substances in spite of all careful precautions. It was therefore essential to keep careful surveillance at periodic intervals of the people engaged in this work. This was accomplished in the following manner:

(1). Urine. - It is well known that the radioactive materials such as uranium, plutonium, and polonium, are excreted in the urine, and by measuring the radioactivity of the urine and by special calcula-

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tions, a rough approximation of the amount of radioactive material absorbed and stored in the body tissues can be derived. It should also be pointed out that early chemical toxicity of uranium can be detected by periodic examinations of the urine. As was shown previously, uranium and its compounds are a potential nephrotoxic (kidney damaging) agent, and the damage done to the kidneys will be reflected in the urine excreted. Likewise fluorine is excreted in excessive amounts after exposure to the gas or to fluorine compounds. The periodic urine examinations of all persons exposed to uranium and its compounds as well as fluorine and its compounds was therefore incorporated as part of the Manhattan District safety program.

(2). Breath Samples. - The exhaled air of workmen engaged in work with radium will contain a portion of this radioactive material as the gas, radon. Samples of this exhaled air are collected in evacuated containers. By measuring the radioactivity of these air samples the approximate amount of radium deposited in the body may be calculated.

2-6. Instruments and Methods for Chemical Hazard Monitoring. - Lastly, the methods and instruments used for estimating the hazards due to substances which are dangerous because of their potential chemical toxicity should be mentioned.

a. Fluorine Detection. - To ascertain the presence of fluorine and hydrogen fluoride in air which is breathed, a "Fluoride Detector" is used (App. C 9). This instrument consists of a vacuum pump equipped with dye-impregnated filter paper. As air is pulled through the filter, a quantitative indication of fluorine content is given by change in color of the filter paper.

b. Phosgene Detection. - The human sense of smell is the best

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method for phosgene detection but the M-9, the Standard Chemical Warfare Kit for Detection of Toxic Cases, is employed in all operations where there is a possibility of hazardous phosgene concentrations (App. C 10). The principle of the kit is similar to that method for fluorine detection described above. In place of filter paper used above, a colloidal gel is employed which changes color if phosgene is present in the air.

c. Solvent Detection. - The Halide Lamp is used for the detection of hazardous concentrations of such agents as trichlorethylene and such materials as fluorine, chlorine, and bromine (App. C 11).

2-7. Conclusion. - It was through a thorough and complete understanding of the hazards of operations with the materials discussed, the possession of proper instruments, and estimation of the degree of hazard that the Manhattan District was able to provide a maximum factor of safety to its employees.

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SECTION 3 - INDUSTRIAL MEDICINE

3-1. General. - The Division of Industrial Medicine of the Medical Section was formed to aid Manhattan District contractors in establishing programs of industrial hygiene appropriate for the peculiar hazards encountered. This Division, acting in a staff capacity through the Area Engineers, recommended schedules of physical and laboratory examinations of employees, recommended measures to determine the amount of toxic substances and radiation present in plant operations, and reviewed the results of these procedures to ascertain whether or not changes in the process or work routine would be required to protect the workmen. In addition, the Division was responsible for transmitting useful information from the medical research programs to the contractors, and for making the needs of the industrial concerns known to the research groups.

3-2. Scope of Activities. - The medical programs recommended were varied in scope depending upon the type of hazard present. Extent of supervision varied from occasional cursory inspection, to full-time assignment of a medical officer to the operation. In general, close supervision was extended to those projects in which the Government was financially responsible for all costs of the operation. Those contractors who were performing their usual work received regularly only casual supervision, but the complete facilities of the Division were available on request.

3-3. Industrial Hygiene Laboratory. - A laboratory, equipped to perform the special and unusual analyses necessary to control the

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occupational hazards of District operations, was instituted at the University of Rochester and supervised by the Division of Industrial Medicine (See Par. 5-8 d). Included in its activities were dust counts for radioactive material, air analyses for radon, film monitoring (use of x-ray film to measure radiation), analyses of urine for uranium and fluorine, and radiation measurements by instruments.

3-4. Relationship to Other Health-Physics Groups. - The Division of Industrial Medicine was responsible for medical supervision of all District contractors operating on cost-plus-fixed-fee contracts. However, all of the concerns listed below were under the immediate supervision of Dr. Robert S. Stone and his associates in the health program of the Metallurgical Laboratory. The Chief of the Medical Section personally determined that the activities of this group were appropriate. The concerns listed are:

- a. Metallurgical Laboratory, University of Chicago
- b. Clinton Laboratories (University of Chicago)
- c. Hanford Engineer Works (du Pont)
- d. Other subcontractors of the University of Chicago and of du Pont doing work related to Hanford Engineer Works.

3-5. New York Safety Committee. - A committee was formed by engineers of the Kellogg Corporation, assisted by a medical officer from the Industrial Division, to write a series of bulletins containing approved safe-handling methods and first-aid procedures for work with fluorine, uranium hexafluoride, hydrofluoric acid, trichlorethylene, and other agents used in cleaning procedures (See App. B 3). These manuals were written originally for the use of

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employees of Kellogg and its subcontractors, but in time became standard reference works for District operations using these substances.

3-6. Organization. - The functions of this Division were originally carried on by Lt. Col. H. L. Friedell. The responsibilities were delegated to Major John L. Ferry during May 1943. Major Ferry was assisted by Lt. R. A. Tybout, who supervised the industrial hygiene laboratory; by Captain Joe W. Howland, who supervised the contracts of the Madison Square and New York Areas, from 1 July 1944 to 15 March 1945, and was replaced 15 March 1945 by Captain Burtis J. Kears; by Captain Fred Bryan who became Assistant Division Head 15 March 1945; by Captain B. S. Wolf, liaison officer and roentgenologist for the electromagnetic process (1 August 1944 to 1 April 1945), who later was operations medical consultant to the polonium production plant; by Captain B. M. Brundage, liaison officer for the gas and thermal diffusion processes; and by Captain L. Jaffe and Lt. E. D. Frank, liaison officer and roentgenologist respectively at the electromagnetic process plant, following reassignment of Captain Wolf (App. C 12). During the first six months of 1946, there were many changes in personnel of the Industrial Medical Section. This resulted from both army discharges and Operation Crossroads. By June 30, 1946, Capt. B. S. Wolf was in charge of Industrial Medicine for the Dayton and New York Areas and Capt. William R. Clarkson, reassigned from the Oak Ridge Hospital Staff, to supervise industrial Medicine in Oak Ridge.

3-7. Uranium Processing and Special Chemicals.

a. General. - As physical research on the various methods of separation of uranium 235 progressed, it became necessary to expand the program of procurement of ore and processing materials at an exceedingly rapid rate. No longer could the small, limited supply organizations engaged in manufacture of the various salts and oxides produce adequate amounts of material to meet even the most limited scientific needs. Hence the establishment of a procurement facility was imperative, to coordinate and anticipate the needs of the experimental laboratories; to extend various types of processing research; and to construct improved processing and pilot plants of various types for specific phases of the work, in addition to supplying standard materials for use of the District. The Madison Square Area was established to serve such a purpose. Its operations are described in Book VII - Feed Materials.

Medical work carried out in this phase of the program concerned itself only with the hazards which might be incurred because of exposure to uranium and its various compounds, from crude ore to the finished product, plus the new special materials such as fluorine and the fluorocarbons which were to be used in various steps of the processes. Medical programs were initiated in all areas, the scope and extent of such programs depending on the type of hazard present. In many plants where the operations involved constituted those with which the management was familiar from long experience, only cursory supervision was extended. The Medical Section did not interfere with the normal industrial hygiene programs of such installations but served in an advisory capacity only. Because of the need for security



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in all operations the Medical and Safety Departments of the various plants could not be sufficiently well informed on the special hazards due to these compounds. Hence constant liaison between Medical and Safety Sections was encouraged. Their coordinated efforts resulted in efficient protection of the workers with the least possible interference with the plant production.

b. Uranium Processing and its Hazards.

(1) The Crude Ore.

(a) Process. - Uranium exists in its natural state in the chemical form of the black oxide ( $U_3O_8$ ), combined with a variety of other substances such as silicon and the like. The concentration of this oxide varies from fifty to eighty per cent in the very rich ores (for example, African pitchblende) to only trace amounts found in earths almost universally. However, the ores used by the District in processing were of the highest uranium content available and ranged from about two per cent to approximately eighty per cent in content. When uranium exists in its natural state it is always accompanied by its daughter in the radioactive series, radium. Therefore, in addition to the hazard present from the uranium, handling of ore subjects the worker to radium as well.

(b) Contractors. - Uranium ore was handled in the following installations in the United States: (Not included was the El Dorado site in Canada)

(1) U. S. Vanadium, Vanadium Corporation of America, Uravan, Durango, Naturita and Grand Junction, Colorado.

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- (2) Middlesex Warehouse, Middlesex, New Jersey.
- (3) Vitro Manufacturing Co., Canonsburg, Pennsylvania.
- (4) Linde Ceramics Plant, Tonawanda, New York.

(c) Hazards. - The hazards related to uranium and its daughter, radium, are of two general types; those caused by radiation of various types from these metals, and those related to direct toxic or poisonous action of a chemical nature on certain organs or tissues of the body. For a more detailed survey of these hazards reference should be made to Section 2 dealing with physiological effects.

(2) Preparation of Black Oxide. (U<sub>3</sub>O<sub>8</sub>)

(a) Process. - After solution of ore in sulfuric acid and differential precipitation of the radium, lead, vanadium and other impurities, the uranium is precipitated as the sodium salt, reconverted to the ammonium salt in an acid solution and finally calcined (or burned) to pure black oxide U<sub>3</sub>O<sub>8</sub> in a hot furnace which drives off the previously combined ammonia. This process is essentially similar in all of the three contracting companies using it, with the exception that the source material may be ore, uranium carbonate and waste liquors or sludges containing amounts of uranium feasible for recovery purposes.

(b) Contractors. - This process was carried out at the Linde Air Products Company and the Vitro Manufacturing Co., Canonsburg, Pennsylvania, by almost identical methods. E. I. du Pont de Nemours and Company, Inc., at Wilmington, Delaware, carried out a

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similar recovery process on sludges and low grade materials in their "recovery" plant. Black Oxide refining contractors mentioned in Book VII are Vitro Manufacturing Co., and Linde Air Products Co. Mallinckrodt Chemical Co. processed Brown Oxide  $UC_2$ .

(c) Hazards. - Hazards in this process are related to the possible absorption and the breathing of radium and radon of the soluble sodium and ammonium uranium salts.

(3) Preparation of Brown Oxide.

(a) Process. - In several installations the black oxide is dissolved in nitric acid and washed several times with differential ether and water washes to remove the impurities. The nitrous oxide of the formed uranium nitrate is driven off by heating and the resultant orange oxide ( $UC_3$ ) converted into brown oxide ( $UC_2$ ) by heating in a hydrogen furnace.

(b) Contractors. - This process was carried out at the du Pont de Nemours Company in the above mentioned plant, at the Mallinckrodt Chemical Company, and formerly at the Linde Air Products Plant.

(c) Hazards. - Hazards in this process arise from possible exposure to the soluble uranium nitrate which has been shown by laboratory experiment to be one of the most toxic of these compounds. However, for the most part, this substance is handled as a wet solution or paste, and only in the heating step (transfer by hand to the ovens) does much exposure occur.

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(Par. 3-7b)

(4) Preparation of Green Salt (UF<sub>4</sub>).

(a) Process. - The process of conversion of the brown oxide (UO<sub>2</sub>) to the green salt (UF<sub>4</sub>) is by reaction, in inclosed chambers, of the brown oxide with anhydrous hydrofluoric acid, at a high temperature. After passage of the anhydrous hydrofluoric acid over the oxide for a specified number of hours, it is removed in the dry state by hand and routed to plants for the production of either the hexafluoride (UF<sub>6</sub>) or the pure metal (U).

(b) Contractors. - This process for the preparation of the tetrafluoride was carried out in the Linde Air Products Company, the Mallinckrodt Chemical Company and the Marshaw Chemical Company of Cleveland, Chic. The green salt prepared in the first two installations named was used for reduction to metal; that in the last, for the production of the hexafluoride.

(c) Hazards. - Hazards in this operation are for the most part due to exposure to anhydrous hydrofluoric acid and the tetrafluoride and its small content of the oxyfluoride (UOF<sub>2</sub>). This latter is scluble and moderately toxic.

(5) Preparation of Hexafluoride. (UF<sub>6</sub>)

(a) Process. - The hexafluoride is prepared by the direction of a stream of pure elemental fluorine (F<sub>2</sub>) over inclosed trays of the green salt UF<sub>4</sub>. The hexafluoride so formed is volatile at the temperature encountered and passes off through ducts and is collected in cooled tanks. It is then purified by driving off excess impurities by redistillation, collected in nickel containers and shipped to the main processing plant, where it is used as the base

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material for the diffusion purification process for the separation of uranium 235.

(b) Contractors. - This process was carried out by the Harshaw Chemical Company of Cleveland, Ohio. At one time the du Pont Company maintained a similar installation of smaller size.

(c) Hazards. - Hazards encountered in this process are related to inhalation and absorption of the soluble hexafluoride, the possible exposure and hazard due to burning or corrosiveness of elemental fluorine, and the danger related to the possible absorption of uranium oxyfluoride remaining in the reactor trays after the hexafluoride is driven off. In addition to the oxyfluoride, most of the disintegration products of the uranium used in the original charge are left behind in the residue. These uranium  $X_1$  and uranium  $X_2$ , the natural daughters of radioactive decay of uranium, account for most of the radioactivity possessed by uranium. When  $UX_1$  and  $UX_2$  are concentrated, as in this process, they form a potent source of beta radiation. Suitable protective measures are required, such as gloves, shields, and radiation exposure monitoring.

(6) Preparation of Uranium Metal.

(a) Process. - In the preparation of uranium metal the green salt ( $UF_4$ ) is thoroughly mixed with magnesium powder, placed in a dolomite-lined steel container, and heated until the reaction starts. The reaction maintains itself without further heat, much in the manner of thermite. This reaction reduces the tetrafluoride to uranium metal, forming a biscuit which falls to the

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bottom of the container. This biscuit is remelted in a vacuum furnace, chipped, labelled, and shipped to the ultimate destination, where it is reworked into ingots for use in the pile process.

(b) Contractors. - This process was carried out at the Mallinckrodt Chemical Company, the Electro Metallurgical Company at Niagara Falls, and at the Iowa State College, Department of Chemistry, at Ames. Related procedures were done by Metal Hydrides, Beverly, Massachusetts, Brush Laboratories, Cleveland, and Westinghouse Manufacturing Company, Bloomfield, New Jersey.

(c) Hazards. - Hazards are the minimal one of exposure to black oxide formed by oxidative reactions on the surface of the metal, and radiation from the surface of the metal.

(7) Medical Control of Hazards of Uranium Processing.

Methods of medical control of the hazards involved in uranium processing were instituted in the following fashion. Periodic inspections of each facility were made to see that hazard control measures were followed and to examine for possible new sources of trouble. Workers were given complete physical examinations, plus examinations of the blood and urine, for abnormalities. Chest x-rays were taken; blood serology recorded. Examinations of the urine at monthly intervals and of the blood at tri-monthly intervals were made. Any abnormalities were a cause for complete review of the case and correction if possible. Repeat examinations (physical) were made at annual or semi-annual intervals depending on the individual circumstances. Protective devices such as special clothing, dust masks, gloves and

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the like were recommended where necessary, and if no suitable methods of protection were available, developmental procedures were instituted. General overall monitoring of the hazards existing in the individual plant was carried out. Individuals exposed to possible excesses of radiation were required to wear film badges, which determined the total amount of exposure received during the day or week. Dust samples were collected and analyzed so that plant conditions could be controlled by suitable reduction in exposure. If necessary, it was recommended that ventilation be increased, housekeeping of the plant be improved, or chemical or engineering procedure be altered, to reduce exposure. Analysis of plant atmosphere for radon content was made whenever exposures to high radium-containing ores were encountered.

Such careful inspection and analysis of plant conditions enabled the Medical Section to enforce tolerance concentrations of hazardous materials in the individual plant, and thus protect the workers from possible radiation or chemical injury.

(8) Metal Shaping and Engineering.

(a) Process. - The processing of the metal consisted of the forming, coating, and canning of uranium rods in suitable form for use in the pile process.

(b) Contractors. - Following are listed the industrial concerns which set up experimentation on, and development of processing methods, and performed various phases of the program of metal shaping and engineering:

- (1) Copper Weld Steel Company, Warren, Ohio.

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- (2) Baker Brothers, Inc., Toledo, Ohio.
- (3) Herring, Hall, Marvin Safe Company,  
Hamilton, Ohio.
- (4) B & T Metals Company, Columbus, Ohio.
- (5) Revere Copper & Brass Company, Detroit,  
Michigan.
- (6) Joslyn Manufacturing & Supply Company,  
Ft. Wayne, Indiana.
- (7) Battelle Memorial Institute, Columbus, Ohio.
- (8) Carborundum Company, Niagara Falls, New York.
- (9) Andrew C. Campbell Division of American  
Chain and Cable Co., Bridgeport, Connecticut  
and Wilkes Barre, Penna.
- (10) William E. Fratt Manufacturing Company.
- (11) C. H. Schuman & Co., Sprugate, Penna.
- (12) McKinney Tool Manufacturing Company,  
Cleveland, Ohio.
- (13) Quality Hardware & Machine Corporation,  
Chicago, Illinois.
- (14) Grasselli Chemical Company, Cleveland,  
Ohio.
- (15) Aluminum Company of America, New Kensington,  
Pennsylvania.

(c) Hazards. - These procedures subjected workmen only to contact with the metal and the oxide ( $U_3O_8$ ) found on its surface. In most instances the experimental production was continued for only a

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few months, and the hazard to workmen was considered negligible.

(d) Medical Control. - The program of medical supervision was less elaborate for these contractors than that listed above (paragraph 3-7 b(7)). Occasional air analyses for uranium content were made, and the employees underwent periodic routine examinations.

c. Fluorine and Fluorocarbons.

(1) General. - Prior to the existence of the District, elemental fluorine was a laboratory curiosity. However, quantity production of this element was required for use in treating metal surfaces to make them less reactive with uranium hexafluoride; and for the production of uranium hexafluoride and various fluorocarbons (the fluorocarbons were selected for their properties as coolants, lubricants and plastics which would not react with uranium hexafluorides).

(2) Fluorine.

(a) Process. - This element was produced by electrolysis of anhydrous hydrofluoric acid in the presence of potassium and fluoride.

(b) Contractors. - Fluorine was produced at Johns Hopkins University, Baltimore, Maryland; by E. I. du Pont de Nemours, Wilmington, Delaware; by Hooker Electrochemical Company at Niagara Falls, New York, and Oak Ridge, Tennessee; and by the Harshaw Chemical Company, Cleveland, Ohio.

(c) Hazards. - Fluorine is an exceedingly

irritating substance, and, depending upon its concentration, can cause skin rashes and burns and irritation of the respiratory passages and lungs.

(d) Medical Control: - Workmen had periodic physical examinations and examinations of the urine and blood. Since the hazard of chronic effects was negligible, examinations were made annually or semi-annually, and the results were used as controls for persons exposed to uranium. Spot-checks were made on the urinary fluoride excretion to guard against excessive fluoride absorption. Inspections were made, and adequate ventilation and fire protection required. Suitable masks and protective clothing were recommended after thorough testing.

(3) Fluorocarbons:

(a) Process: - The lubricant and coolant fluorocarbons are produced by reacting hexafluoroxylene or special oils with cobalt and silver fluoride catalysts. The catalysts are renewed by reaction with fluorine. A plastic fluorocarbon is produced by polymerization of monochlorotrifluoroethane in chloroform, and treatment with cobalt trifluoride.

(b) Contractors: - Chemical processes in the production of lubricants and coolants were performed by Johns Hopkins University, Hooker Electrochemical Company, and E. I. du Pont de Nemours and Company. The plastic was produced by Linde Air Products Company, Tonawanda, New York.

(c) Hazards: - Severe pulmonary and skin irritation may be encountered from fluorine and the catalysts used in

the process. Intermediate products in the process cause moderate irritation, and the end-products are slightly irritating. In addition, the well-known hazards of work with chloroform and carbon tetrachloride are present. These consist primarily in anesthetic effects with possible brain and nerve damage, liver damage and kidney damage.

(d) Medical Control. - Physical and laboratory examinations similar to those used in fluorine control were instituted for these workers as well. Suitable protective equipment was recommended, and engineering procedures were instituted which minimized contact with toxic materials.

d. Boron Production.

(1) Process. - Boron trifluoride was reacted with dimethyl ether and distilled. This substance was converted to boron trichloride, which was passed in an atmosphere of hydrogen across a hot tantalum wire, with the collection of metallic boron on the wire.

(2) Contractors. - The following contractors were concerned with the various steps in the boron production process:

- (a) Harshaw Chemical Co., Cleveland, Ohio
- (b) Standard Oil of Indiana, Whitins, Indiana.
- (c) American Cyanamid Co., Stamford, Connecticut.

(3) Hazards. - Boron trifluoride, boron trichloride, dimethyl ether, and boron trifluoride dimethyl ether complex are all low-grade pulmonary irritants. Dimethyl ether also has anesthetic properties, and is highly inflammable. The metal deposition process is hazardous only from the possibility of explosion of hydrogen.

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(4) Medical Control. - Employees on these projects received the routine examinations ordinarily made in the plants listed. The chemicals were handled in closed systems and exposures were unusual. A few spot-checks of fluoride excretions were made on Harshaw employees. These indicated that the workmen were absorbing fluoride in greater than normal, but not dangerous, amounts.

3-8. Process Research.

a. General. - A number of universities were given contracts to do research on various problems in chemistry and physics related to District operations. These projects varied in size from a few to more than a thousand persons. Likewise the hazard and medical supervision required varied considerably in the different operations.

b. Research on the Diffusion Process.

(1) Scope. - Extensive research was carried out on all phases of the development of the diffusion process, including the pumps, barriers, cooling devices, seals and instruments required for the mechanical separation of U<sub>235</sub>. Equipment design and pilot plant operation were part of the research.

(2) Contractors. - The fundamental research in the program listed above was performed by the S.A.K. Laboratories of Columbia University. The Kellogg Corporation, a subsidiary of M. W. Kellogg Company, did the engineering design and operated a small pilot plant. The Linde Research Laboratory, Tonawanda, New York, tested motors, operation drives and seals. The Bell Telephone Laboratories of Summit, New Jersey, and Princeton University, Princeton, New Jersey, did certain research on the corrosion and the effect on

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porosity of metals produced by fluorine and uranium hexafluoride.

(3) Hazards. - These activities were accompanied by the hazards associated with the use of uranium hexafluoride, fluorine and the fluorocarbons, and, in addition, those chemicals usually encountered in chemical research. In general, the work was not considered to be especially hazardous.

(4) Medical Control. - Employees engaged in these activities received careful periodic physical and laboratory examinations according to the schedule outlined in paragraph 3-7 b (7). Careful statistical studies of the data obtained revealed no significant difference in the findings of the exposed and non-exposed groups. Checks also were made of the atmospheric content of noxious substances, and periodic spot-checks were made of urinary excretion of uranium and fluoride.

c. Developmental Research.

(1) Fluorocarbons. - Chemical research on methods of producing fluorocarbons was done at Johns Hopkins University. Hazards were those listed in paragraph 3-7 c, but no formal medical program was instituted other than specific instructions in treatment of acute exposures to the materials.

(2) Radium Extraction. - Research was performed at Yale University to develop a simple method of extracting both uranium and radium from ore. Hazards involved were small because the work was done entirely on a laboratory scale. Radiation measurements were made by both instruments and film badges. Air samples for radon content of room air were made and found to be well below

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tolerance limits. Workmen were checked by breath samples to determine the amount of absorbed radium. These tests likewise indicated no excessive exposure.

(3) Methods of Manufacture of Uranium Compounds.

Fundamental research on methods of manufacture of uranium compounds was done at Purdue University, *d.* Lafayette, Indiana; the National Bureau of Standards, Washington, D. C.; and at Brown University, Providence, Rhode Island. All of these projects were inspected and found to have negligible hazards. Consequently, no formal medical program was instituted.

d. Analytical Research. - Research on analytical methods and analyses of ore, and various uranium compounds was carried out at the National Bureau of Standards, Washington, D. C.; Princeton University, Princeton, New Jersey; and at Massachusetts Institute of Technology. Inspections were made of these projects; dust counts and radiation measurements were taken but, because of the negligible hazard, no formal medical program was instituted.

3-9. Process Equipment.

a. General. - In the majority of instances the contractors supplying process equipment were performing their usual operations, and no special medical supervision was required. The few exceptions are noted below.

b. Barrier Production. - The barriers for the diffusion process are especially-formed nickel tubes. They were produced by the Houdaille-Hershey Company of Decatur, Illinois, and Linde Air Products Company, Tonawanda, New York. The only hazards were those

of nickel dermatitis in susceptible persons and from use of trichlorethylene. Proper engineering reduced contact with these substances, and persons sensitive to nickel were gradually eliminated from employment. The schedule and extent of examinations were those usual with the individual companies for their employees.

c. Pumps for Diffusion Process. - In the manufacture and testing of pumps, a limited amount of uranium hexafluoride was used by the Allis-Chalmers Company of Milwaukee, Wisconsin. The operation was inspected. Instructions were given for acute exposures, and employees were examined regularly as outlined in paragraph 3-7 b(7).

d. Unit Assemblies for Diffusion Process. - These units were manufactured by the Chrysler Corporation, Detroit, Michigan. The only special hazard involved was that of the use of elemental fluorine for preliminary conditioning of the equipment. Inspections were made, and appropriate directions for treating acute exposures were provided. The program of physical examinations was that used for other Chrysler employees in similar jobs.

3-10. Gas Diffusion and Thermal Diffusion Processes.

a. Processes and Hazards.

(1) Gas Diffusion Process. - The gas diffusion process separates the rare uranium 235 from the more abundant uranium 238. This separation process consists of passing uranium hexafluoride, which exists at temperatures above 130 degrees F., in the gaseous state, through long porous tubes or barriers located in an enclosed system. The process, which is completely described in

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Book II of this history, effects the diffusion of the lighter uranium 235 through the fine pores of the tubes or barriers, leaving the heavier uranium 238 atoms still in the central system. This uranium 235 is passed through numerous stages of concentration up to approximately 30 per cent in the final stage, instead of the 0.7 per cent contained in the original metal or its hexafluoride. In the product rooms, by means of a cooling system, the enriched uranium hexafluoride (containing higher percentage of U<sub>235</sub>) is removed for shipment to another installation at which further concentration is made. The "depleted" uranium hexafluoride which still contains considerable amounts of 235, is then piped to a tails accumulator building for storage until it can be either re-introduced into the cascade or disposed of in some other way. Before any uranium hexafluoride can be processed, it is necessary that all metal parts of systems be made inactive to this substance to prevent reaction and breakdown to a non-gaseous form. A "conditioning process" is used for this purpose, consisting of treatment with fluorine, forming on all metal surfaces a film of metal fluoride which does not react with the hexafluoride. Prior to this treatment with fluorine the metals are washed with trichlorethylene, sulfuric acid, sodium hydroxide and thoroughly dried with hot air.

(2) Hazards of Gas Diffusion Process. - The hazards in various steps of this process are those from exposure to fluorine in the gaseous state in the "conditioning process" and exposure to uranium hexafluoride and its breakdown products in the remainder of the process. Fluorine, as previously described (see paragraph

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3-7 c(2)) may cause painful burns. In addition, in high concentrations it (s) extremely irritating to the upper respiratory tract, trachea and lungs. No severe systemic toxicity from it has been noted. Uranium hexafluoride in the gaseous form is also quite irritating and is easily absorbed from the lungs. Apparently, however it is possible to absorb appreciable quantities in any acute exposure without severe or prolonged damage resulting. The breakdown products of uranium hexafluoride are chiefly uranium oxyfluoride in the form of a soluble dust produced when uranium hexafluoride reacts with moist air and hydrofluoric acid. Uranium oxyfluoride in moderate concentration is also toxic and capable of causing kidney injury. To date, exposures to uranium hexafluoride have been well controlled and no serious effects have been encountered. There are other hazards present, but these are identical with those usually found in chemical plants and include trichlorethylene and other solvents. The potential hazards from radiation are small because of the extremely long half-life of the uranium metal and lack of concentration of the uranium X<sub>1</sub> and X<sub>2</sub> breakdown products. Again, inasmuch as the system is entirely closed, the alpha and beta radiation present will not penetrate the metal walls to a hazardous extent. The fluorinated hydrocarbons used in cooling and lubricating the above machinery are also in an enclosed system, and human exposure to them in high concentration occurs only in case of a breakdown. In such instances adequate protection was provided by the use of army assault masks to avoid lung irritation, the major damage.

(3) Thermal Diffusion Process. - This process separates uranium 235 from the more abundant uranium 238 by a process

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of thermal diffusion. (A complete description of this process is given in Book VI of the history). The uranium hexafluoride feed material is first placed in the transfer room, weighed, and then piped to the columns where the thermal diffusion action takes place. The "enriched"  $UF_6$  is removed from the top of the column and the "depleted" material is either drawn off the bottom or recirculated from the bottom to the transfer room and returned to the column. The "enriched" material is drawn from the top of the column into metal capsules, which are then taken to an area in the conditioning shop outside the main building for transfer into larger containers. About 1 June 1945 an additional apparatus was constructed for the transfer from these larger containers to large shipping tanks. For operational reasons, the thermal diffusion process was abandoned in August 1945 and placed in a standby condition.

(4) Hazards of the Thermal Diffusion Process. - The transfer procedures for uranium hexafluoride constitute the major hazard in this process (excluding rupture of a high pressure tank or steam line). Before a container is attached, the line containing  $UF_6$  is frozen off with dry ice. Then the container is connected and the line is opened by thawing the solid uranium hexafluoride with heat from a Bunsen burner flame. The process is repeated to remove the container. The danger of breathing  $UF_6$  and of being burned by it in this operation is considerable. In this process, as in the gas diffusion method, metal parts coming in contact with uranium hexafluoride must be pre-conditioned with trichlorethylene and fluorine. This procedure is done in a conditioning shop outside

the process building. The major hazards in this area are those of burns of the hands from fluorine and to a lesser extent from uranium hexafluoride. Dusts and fumes from hydrolysis of UF<sub>6</sub> are occasionally present although exposure is variable. Burns arising from the high pressure steam in the lines (900 to 1200 pounds per square inch) are also found.

b. Medical Control of Hazards.

(1) General. - The industrial hygiene program for control of occupational hazards of both the thermal and gas diffusion processes was developed around the Carbide & Carbon Chemicals Company medical organization. The physicians and nurses and dispensary facilities were used for both operations. Special services were provided by the chemistry and physics laboratories of C&CCC on the request of the Medical Department of this installation.

(2) Medical Examinations.

(a) Pre-Employment. - Pre-employment physical examinations were instituted for all employees to insure maximum use of available manpower in job situations most favorable to their health. The physical examinations included a brief medical history, a physical examination by a competent physician, laboratory examinations of the blood and urine, x-ray of the chest and blood serology for syphilis. Examinations of this type are considered more than adequate according to the general standards of most companies employing large groups of people. The average rate of examinations in July 1944 was 10-15 per day; in March of 1945 a peak of 110-120 examinations daily was reached; in July of 1945 the number had decreased

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to 80-85 per day. In August 1945 the number was raised to 100/day and then a sharp drop occurred. In June 1946 the number had dropped to 8-9/day.

(b) Interval and Termination. - Interval examinations at both installations were brief and consisted of cursory physical examination, blood count and urinalysis, x-ray of the chest and special examinations as indicated. If there was a history of exposure to hazardous materials, special attention was directed toward the determination of signs of bodily damage. There was no specific interval for these examinations. Termination physical examinations included a complete physical examination, blood count and urinalysis and x-ray of the chest. Beginning in January 1945 urinalyses for uranium content were started on persons exposed to uranium hexafluoride. Tests were made on all persons exposed to high concentrations of uranium compounds, and also in the periodic health examinations. These tests were made a part of the routine industrial health examinations, starting early in 1945. The program was designed to provide, at intervals of six to seven weeks, a check of the general health of all persons employed and to evaluate absence because of illness, weight loss, changes in blood pressure, and other abnormalities. These tests were instituted to detect early signs of toxic effects from work with uranium compounds, and correct the condition before injury is incurred.

(3) Monitoring.

(a) Air Contamination. - Beginning in December of 1944, the chemical laboratory made air analyses for fluorine and uranium hexafluoride content. These analyses were made at weekly

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intervals at various points in both the gas diffusion and thermal processes and reported to the Medical Department for interpretation.

(b) Radiation. - Because of the possibility of exposure to radiation, routine surveys were begun by the physics laboratory personnel in March of 1945. Corporal Wendell Miller and assistants were assigned to carry out measurements of alpha, beta and gamma radiation. Selected areas in both gas diffusion and thermal process plants were surveyed at weekly intervals with special recording apparatus. Data from these surveys were reported weekly to the Medical Department for interpretation and recommendations.

c. General Industrial Hygiene.

(1) General. - An indication of the amount of service which was provided by the Medical Department may be demonstrated by the increase in patient visits per month from the start of operations.

July 1944	1000 patient visits
September 1944	2,550 patient visits
January 1945	6,300 patient visits
March 1945	11,050 patient visits
June 1945	15,500 patient visits
August 1945	20,400 patient visits
October 1945	11,700 patient visits
February 1946	9,600 patient visits
June 1946	10,000 patient visits

(These figures include all occupational disease and accident cases, initial visits for non-occupational

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illness or disease, special examinations for groups in potentially hazardous areas, and pre-employment examinations.)

(2) Occupational and Non-Occupational Medical

Care. - An average of 170 occupational cases were seen daily in the dispensary (approximately 35% of total work-load of the treatment section). These included injuries from special hazardous materials as well as the type of occupational injury occurring in any manufacturing plant. The remaining 65% consisted of the treatment of non-occupational illnesses which interfered with the efficiency of the worker. Treatment of non-occupational illness or injury was limited to one or two visits. The K-25 Dispensary, a branch of Oak Ridge Hospital, provided medical care similar to that rendered in a physician's office for non-occupational conditions occurring among employees or residents of K-25 Area. In September 1945, following a reduction in population of the K-25 Area, the dispensary was closed. Cooperation was maintained between the medical department and the worker's personal physician to insure efficient medical service.

(3) Relationship to the Safety Departments. - The

Medical Department, in its liaison with the Safety Departments responsible for the prevention of accidents and injuries not due to hazardous special material, followed the Safe Practices Recommendations of the New York Safety Committee (See par. 3-5). The supervisor of the Medical Department was a member of the Special Hazards Committee, which met at monthly intervals to study hazards arising from special materials and to make suitable recommendations for their control. All minor injuries were investigated by the Safety Depart-

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ments. Submajor accidents involving removal from work and major accidents involving hospitalization, required a combined investigation of both the Medical and Safety Departments. All injuries involving uranium compounds were especially investigated.

(4) Catastrophe Program. - A complete program was organized to provide for the protection and treatment of plant personnel in case of any major emergency. This program was divided into two parts, one established for the Medical and affiliated departments of K-25 Area, and the other, a disaster program which included all medical groups on the Area, and was directed by the staff of the Oak Ridge Hospital. Commitments were made under both plans for the evacuation of the plants and areas and for the treatment of injured personnel.

(5) Other Activities. - The Medical Department also supervised general sanitation, waste, and garbage removal and related activities. It also maintained a visiting nurse service for the home care and medical control of those patients who did not require hospitalization.

d. Organization.

(1) Carbide & Carbon Chemicals Corporation.

(a) Staff. - The organization of the medical department of the Carbide and Carbon Chemicals Corporation was started in April of 1944, when the services of Dr. Adolph Kammer, formerly Medical Director of Inland Steel Company, were secured on a full time basis. Dr. Bernard Zussman and Dr. Raymond Cooper were hired in February of 1944 but no departmental operations were started

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until Dr. Kammer's arrival. Prior to April of 1944, pre-employment examinations for this organization and its subsidiaries were carried out at the Medical Service Building by the Oak Ridge Hospital medical staff. From April 1944 to July 1944 the pre-employment examinations were carried out in one office and three examining rooms in the Carbide and Carbon Corporation Administration Building. Actual operation of the main dispensary of the medical department began in July of 1944. The dispensary was designed to handle 5000 operating employees. The prime functions of the Medical Department were: the selection of adequate personnel through pre-employment examinations, the treatment of occupational injuries and disease, the preliminary treatment of non-occupational, or welfare, injuries and diseases, and the industrial hygiene control of occupational disease hazards. The staff at the time of opening of the Dispensary consisted of three doctors and six nurses. Dr. Martin Costello was added to the staff in August of 1944 and in the following January he was made assistant supervisor of the Medical Department, thus freeing Dr. Kammer for executive duties. In September of 1944 the staff consisted of five doctors, nine nurses, eight technicians and eight clerks. By 1 July 1945 the staff had increased to a total of 14 physicians, 28 nurses, 14 technicians, and 23 clerks and stenographers. In December 1945, the staff had decreased in the number of physicians to a total of 10 physicians, 30 nurses, 14 technicians, and 28 clerks and stenographers. In June 1946, the staff had decreased to 8 physicians, 24 nurses, 12 technicians, and 19 clerks and stenographers.

(b) Facilities. - The Dispensary (See App. C 13)

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consisted of a frame U-shaped building of a semi-permanent type containing two six-bed wards, four four-bed wards, two treatment rooms with cubicles, doctors' offices, x-ray room and darkroom, laboratory, and an emergency room. Since the original estimate of the number of employees was too low, it became necessary to acquire additional facilities. Because the employees of the Ford, Bacon and Davis Co., a contractor, and those of the <sup>H. K.</sup> Ferguson Company (Fercleve) were also to be handled by the single medical department, additional first-aid stations or infirmaries were opened or taken over in their plant areas. Because of the increasing demand for x-ray examinations for diagnostic purposes, it was considered necessary to include x-ray equipment in the Carbide dispensary building. Diagnostic x-ray service was provided in October of 1944 and a photo-roentgen unit was added in April of 1945.

(2) Ford, Bacon and Davis Company. - In March of 1944, the Ford, Bacon and Davis Company began operating a field hospital, under the direction of Dr. J. B. Rogers, for construction workers. Later an infirmary was opened and operated in the present conditioning building, under the supervision of Dr. Harris Sklaire, from September 1944 to February of 1945. At this time the responsibility was shifted to Dr. Kanner and his associates. Ford, Bacon and Davis continued to employ their own nurses. In May of 1945 this Company turned over all operations to the Carbide Corporation, and the infirmary became first-aid unit of the Carbide medical department.

(3) Fercleve Corporation. - The Fercleve Corporation

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(H. K. Ferguson Company of Cleveland) began its medical program in October of 1944 with pre-employment and termination examinations, which were carried out at the Carbide dispensary. First-aid work was done in the beginning in a temporary structure on the plant site. On 1 February 1945 a semi-permanent building (See App. C14) was opened. The new first-aid unit contained two treatment cubicles, an eye treatment room, an office and space for the Safety Department. For operational reasons, the Ferroleve Corporation's unit was closed and held in standby condition in August 1945.

e. The Cost.

(1) Carbide & Carbon Chemicals Corporation. - The cost of constructing the dispensary exclusive of equipment was \$181,823.75. The approximate cost of operating the facility from its opening to 30 June 1946 was \$479,021.83 of which the following amounts were chargeable to other contractors.

(a) Ferroleve Corp.	\$53,299.77
(b) Kellex	1,645.22
(c) Hooker	16.68
(d) U.S.E.D.	108.55
(e) F.B.&D. (Oper.)	5,183.28

(2) Ferroleve Corporation. - The first-aid station built for Ferroleve cost \$16,411.53. Total cost of medical service including the facility amounted to \$62,095.72.

(3) Ford, Bacon and Davis Company. - The cost of equipping the Ford, Bacon & Davis first-aid unit was \$3,878.50. The additional cost of operating the medical service prior to trans-

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fer to C&CCO amounted to \$26,127.05.

3-11. Electromagnetic Process.

a. Process and Hazards.

(1) The Process. - The electromagnetic process accomplishes separation of the rare uranium 235 from the more abundant uranium 238 by passing uranium tetrachloride in a gaseous, ionized state through a magnetic field which tends to deflect the lighter atoms ( $U_{235}$ ) from the normal path of the gas. (A detailed description of this process is given in Book V of this history.) The process feed material, uranium tetrachloride, was prepared, until 28 May 1945, by reacting uranium trioxide with carbon tetrachloride under pressure. This operation produced large amounts of phosgene as a by-product. After 28 May 1945, a vapor phase method of chlorination was used, which operated at much lower pressures and produced less phosgene. The uranium trioxide ( $UO_3$ ) was obtained from other Manhattan District contractors at the start of operations. This was supplemented by material returned from the separation operation for reprocessing. Early in 1945, an increasing amount of "enriched" uranium hexafluoride (material in which the  $U_{235}$  content had been increased) was received from the gas and thermal diffusion processes for conversion to uranium tetrachloride. Following purification, the uranium tetrachloride is bottled and processed in the electromagnetic plant (See Book V, Vol. 6). Part of the uranium tetrachloride introduced into the bottle remains unprocessed. This material is returned to a recovery plant and is reconverted to uranium tetrachloride and the sequence of operations is repeated.

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(2) Hazards. - Phosgene and dusts containing uranium are the principal hazards of the electromagnetic process but there are numerous other hazards present in some degree. These include alpha, beta, and gamma radiations; carbon dust; trichlorethylene; carbon tetrachloride, ordinary chemicals such as nitric acid, hydrochloric acid, etc.; and the dangers attending the use of high voltage sources of electricity.

b. Medical Control of Hazards.

(1) General. - For the control of occupational hazards, a complete industrial hygiene service was maintained by the Medical Division of Tennessee Eastman Corporation. Personnel and facilities were provided for evaluating the potentially harmful environment factors, such as the concentration of toxic dusts, gases, and vapors, and physical conditions such as lighting, humidity, temperature, etc. A clinical section performed a variety of laboratory tests for the detection of possible injury from materials encountered in the operation of the electromagnetic process. For the control of radiation hazards, a Special Instruments Laboratory was maintained in conjunction with the Process Improvement Division.

(2) Pre-employment Physical Examinations. - In order to insure the maximum utilization of available manpower and that persons employed would be placed in jobs appropriate for their physical status, a system of pre-employment physical examinations was started, on Tennessee Eastman Corporation applicants for employment, on 1 July 1943. The pre-employment physical examination included a brief medical history, a physical examination by a competent physician,

laboratory examination of the urine, a Wasserman Test on the blood, and an x-ray of the chest. This type of examination is considered adequate by the general standards of most large industrial concerns engaging in work on a similar scale.

(3) Interim Examinations. - Shortly after the opening of the new medical dispensary in July 1944, the staff of doctors was large enough to allow one physician to work part time on special examinations of employees in potentially hazardous areas. Those workers employed in the Liquid Phase process, where phosgene was a major potential hazard, and those handling uranium compounds (for example: the chemical recovery employees and bulk treatment employees) were given frequent physical check-ups, including blood counts, urinalysis and, in some cases, blood non-protein nitrogen indicating kidney damage and icteric index determinations for liver damage. The employees having the greatest potential hazard were examined three times a year, while those where the hazard was least were examined at least once a year. If any abnormal findings were noted in these examinations, the employee was referred to the Medical Liaison Officer for further study as to the cause of the abnormality.

(4) Termination Examinations. - On termination of employment the employee was referred to the medical division for a short interview to determine whether or not he felt he had been injured in any way by his work. If any complaint was made and considered worthy of investigation, the employee received a complete physical examination to evaluate the validity of his claim.

(5) Monitoring.

(a) Dust. - On 10 April 1945, following several preliminary surveys, a routine of dust monitoring was set up. In locations with the highest potential dust hazard, dust measurements were made at least once each month, while at other places where the dust hazard was not so high, the measurements were made at least once every two months.

(b) Phosgene. - The monitoring of phosgene, the other principal hazard, was particularly difficult because there were no efficient and sufficiently accurate methods of measuring this gas at low concentrations. The human sense of smell is probably the most accurate detector of the gas at concentrations of about one part per million. Because of this fact, it was felt that the workmen themselves, when trained to recognize the odor of phosgene rather than rely on the use of questionably accurate chemical detectors, could more effectively apply the necessary safety precautions. Consultation with the Division of Chemical Warfare revealed that this principle of depending on the sense of smell has been used by them in the manufacture of phosgene at Edgewood Arsenal. Since the vapor phase method of making uranium tetrachloride has been in use, the potential phosgene hazard has practically disappeared.

(c) Radiation. - Because of the possibility of exposures to radiation, the Special Instruments Laboratory began to survey the electromagnetic process from beginning to end in the fall of 1943. Surveys on alpha, beta, and gamma radiation were carried out. Dr. William Bale, a physicist attached to the District

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Medical Section in the Rochester area, was called in as consultant and visited the Tennessee Eastman Corporation plant in February 1944, and again in July 1944. During his visits he made thorough surveys with portable testing meters and found that there were no areas which had harmful amounts of radiation (See App. B 9). Dr. Bale suggested, however, that the "cubicles" which contain the large kenotron rectifying tubes, the tube testing rooms and the cable testing rooms, be surveyed periodically. After a thorough preliminary survey to determine the most probable sources of radiation in these areas, a system of routine monitoring was instituted in February 1945. The selected areas were monitored by placing x-ray film in light-tight containers at fixed points in the rooms to be checked. The degree of blackening of this film gives a measurement of the amount of radiation. This type of monitoring was carried out twice weekly until the first of July 1945, and the radiation was found to be far below the tolerance level.

c. General Industrial Hygiene.

(1) General. - An indication of the amount of service rendered by the Tennessee Eastman Corporation Medical Division is demonstrated by the increase in patient visits per month as shown in the following table.

<u>Month</u>	<u>Patient Visits</u>
September 1943	81
January 1944	4,365
July 1944	17,459
January 1945	22,386

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June 1945	25,579
September 1945	19,740
October 1945	12,960
March 1946	8,539
June 1946	9,299

These figures include occupational disease and accident cases, non-occupational disease cases, special examinations on groups employed in potentially hazardous areas, and pre-employment examinations. In addition, advice on health problems was given by individual consultation, by articles in the Tennessee Eastman Corporation Bulletin, and as a part of the Supervisory Training and Induction Training Programs.

(2) Occupational Injuries and Illness. - The medical division at the Tennessee Eastman Corporation plant was responsible for the medical procedures necessary to treat occupational accidents and diseases. An average of 150 occupational cases, varying greatly in severity, were seen every twenty-four hours in the dispensary. All cases of phosgene exposure, no matter how minor, were seen and thoroughly checked at the dispensary. Oxygen breathing equipment was ready and available for treatment of all phosgene cases. All cases of severe injury requiring prolonged treatment and cases requiring operative procedures or the services of a specialist were referred to the Oak Ridge Hospital for care. The compensation forms required by Tennessee state law, such as the Employer's First Report and the Physician's First Report, were filled out by the dispensary staff and forwarded, through

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the District, to the insurance carrier.

(3) Non-Occupational Injuries and Diseases. -

limited medical service for non-occupational illness or injury was available for employees while at work. This service was designed to keep the employee on the job by avoiding loss of time for care of minor illness. Persons requiring more than simple diagnostic and therapeutic procedures were referred to their family physicians for treatment. Approximately 400 of such cases were seen in the dispensary every twenty-four hours.

(4) Sanitation and Public Health. - To insure

adequate sanitation in the handling and supplying of food in the plant site cafeterias, a frequent inspection and bacteriological testing program was carried on by the Medical Division, which also supervised mosquito and vermin control.

d. Organization.

(1) Medical Division, Tennessee Eastman Corporation. -

The organization of the Medical Division of Tennessee Eastman Corporation was started in February 1943 when the services of Dr. James H. Sterner, of Eastman Kodak Company, were secured on a part-time consultant basis. He was joined, on 1 July, by Dr. A. N. Streeter, who was appointed temporary Medical Director and began to assemble the dispensary staff. The actual operation of the Medical Division began in September 1943, in a dispensary designed to handle approximately 7,000 operating employees. The staff, at this time, consisted of 1 doctor and 2 nurses. The dispensary was a hollow-tile, permanent type of building, containing a six-bed ward, treatment cubicles and

doctors' offices, as well as space for the clinical and industrial hygiene laboratories. As plant operations approached full capacity, it was found that the original estimate of the number of employees was too low, and it became necessary to enlarge the medical facilities. In the early part of 1944, consideration was given to an expansion of the existing dispensary, but, because of its off-center location and the necessity for the complete remodeling of the building, it was decided to construct a new dispensary (See App. C 15) centrally located within the operations area. The new dispensary was designed to handle 13,500 employees. Provided in the building were dispensaries for emergency ambulatory care, six doctors' offices, x-ray rooms, treatment cubicles, space for twenty beds, an emergency receiving room, an emergency operating room, a large laboratory to house both the clinical and industrial hygiene sections, and a special instrument laboratory. The number of beds was increased from six to twenty in the new building, since it had been determined that even minor cases of phosgene exposure should be observed for at least twenty-four hours, utilizing more beds than were originally thought necessary. Because of the increasing demand for x-ray examinations for diagnostic purposes, permanent x-ray equipment was installed in this new dispensary, to avoid transporting employees to Oak Ridge Hospital. The dispensary was completed and occupied during July 1944. The original dispensary building was converted to an office unit for the Chemistry Department.

On 1 November 1943, Dr. James Sterner was free to assume the duties of director of the Medical Division, on a part-time basis, with Dr. A. E. Streeter acting as Assistant Director. At this time,

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the staff consisted of two doctors and six nurses. On 1 March, 1945, Dr. Christopher Leggo was obtained from the United States Public Health Service, to become Director of the Medical Division, with Dr. James Sterner acting as part-time consultant in Industrial Hygiene Control. The staff, on 1 July 1945, consisted of seven doctors, thirty nurses, nineteen technicians, and twenty-seven clerks and stenographers. By 30 June 1946, the staff had undergone a moderate decrease to six physicians, 25 nurses, 21 clerks and secretaries and 8 technicians. The Industrial Hygiene Laboratory was located in the original medical dispensary building from January 1944 until July 1944, at which time the laboratory was transferred to the allotted space in the new dispensary. This change to larger quarters was necessitated by the increase in laboratory personnel. This control section was under the supervision of Dr. James H. Sterner from its inception early in the summer of 1943.

(2) District Medical Section Liaison. - On 3 August 1944, Lt. Bernard Wolf was cleared to work in the restricted areas of the electromagnetic process, as liaison officer for the Manhattan District Medical Section and as radiologist. Prior to Lt. Wolf's arrival, all x-rays taken at the Dispensary were transported to the Oak Ridge Hospital for final reading. On 20 April 1945, Lt. Wolf was replaced by Captain L. Jaffe as Liaison officer, the latter remaining in this post until his army discharge in March 1946. The roentgenologist at Oak Ridge Hospital reassumed, temporarily, the responsibility of interpreting the Dispensary's x-rays. On 11 June 1945, Lt. Edward D. Frank was cleared to work at the Dispensary, and as-

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sumed the duties of radiologist. Upon Captain Edward Frank's release from active duty in May 1946, the x-rays were once again sent to the Oak Ridge Hospital for interpretation.

e. The Cost. - An estimate of the cost of the medical service, from its inception to 1 July 1946, is given in the following figures. These figures do not include the first small dispensary used nor do they include the rental cost of the space used in Knoxville as a pre-employment examining center, since these costs are included with the personnel and safety budget and are not available as separate items.

Cost of Construction of Dispensary		\$268,632
Equipment		45,073
Operating Costs		
(a) Supplies, Maintenance and Miscellaneous	\$246,950	
(b) Salaries	<u>433,345</u>	<u>680,295</u>
Total Cost		<u>\$994,000</u>

3-12. The Pile Process.

a. General. - The pile process was developed for plutonium production from uranium (See Book IV of this history). The fundamental physical and chemical research on this process was done at the Metallurgical Laboratory of the University of Chicago, and small experimental piles were built and operated by the University at the Metallurgical Laboratory and at Argonne. Two installations were designed and constructed. One of these was a pilot plant, called Clinton Laboratories, at Oak Ridge, Tennessee, built for the study of production methods, and the other was the final production plant at Hanford, Washington. The general principles, on which these

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plants were based, were developed at the University of Chicago. The engineering design was made by E. I. du Pont de Nemours and Company, of Wilmington, Delaware, submitted to the scientists of the University of Chicago for approval or revision, and then constructed by the Du Pont Company. The Clinton Laboratories were operated by the University of Chicago, until July 1945, at which time the Monsanto Chemical Company of St. Louis assumed responsibility for its operations. The Hanford Plant was operated by the du Pont Company with the advice of the University of Chicago. The three installations were closely interrelated. Key medical and operating personnel for both Clinton Laboratories and Hanford Engineer Works were, in a large part, either recruited from or trained at the Metallurgical Laboratory. Because experimentation had indicated that an operation of this type might be hazardous, elaborate precautionary medical programs were instituted to determine the source and type of hazards which might be incurred, to protect operating personnel against these hazards, to recommend the measures necessary in design for safe operation, and, in addition, to provide routine occupational care.

b. The Process.

(1) General. - Canned slugs of uranium are placed in the pile in a pre-arranged manner, which subjects them to neutron bombardment. The neutrons are produced continuously by uranium fission, which occurs at a controlled rate in the pile. The effect of the bombardment is to convert uranium 238 into plutonium, and to produce certain other breakdown products of uranium known as "fission products." After a pre-determined period of time, the

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activated uranium slugs are removed by remote control from the pile to temporary storage under water. They are loaded under water into lead containers and transported to a separate water storage area. After a period of storage sufficient to reduce the radioactivity of the material (by decay of the fission products having relatively short half-lives), the slugs are removed in lead containers and transported to other areas in which extraction and concentration of plutonium is made. In these areas the uranium slugs are dissolved and the plutonium is purified and concentrated, in chemical procedures carried on by remote control behind concrete shielding. The final solution from this process is removed to special isolation units in which the final extraction is made. Waste uranium and by-products of the extraction process are stored for the most part in underground tanks. Bulky, less active wastes are delivered to settling ponds. Plutonium isolated at Hanford is stored in special underground storage vaults.

(2) Metal Processing and Shaping. - At Hanford billets of uranium metal are received from other District contractors and are extruded into rods. The rods are straightened, cut-gassed, cut into suitable lengths, machined, coated and canned in a manner appropriate for use in the pile process. Prior to the completion of these facilities at Hanford, the Metallurgical Laboratory machined slugs of uranium metal and did experiments in coating and canning of slugs, and experimental pouring of uranium metal.

(3) Experimental Work. - Chemical and physical research on all phases of plutonium production were conducted at

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both Clinton Laboratories and the Metallurgical Laboratory. New methods of operation were first investigated on laboratory scale prior to inauguration of regular production procedures. In addition, particularly at Clinton Laboratories, considerable effort was expended in study of methods of isolation and on the physical and chemical properties of the radioactive fission products from the pile reaction. As in plutonium production, "hot" uranium slugs were passed through the water canal, and taken in shielded containers to special "hot" laboratories in which separation and research on fission products were conducted. This work was confined to laboratory scale.

c. Hazards.

(1) General. - The principal hazard of the pile process results from the enormous amount of radioactivity produced in the operation. In addition, the plutonium and the fission products are radioactive materials capable of causing serious damage if absorbed in sufficient quantities (See par. 2-2 c(4) and 2-2 c(5)). Consequently, the most important factor in safe operation of the plant was engineering design, which protected against radiation and minimized contact with the materials.

(2) Metal Shaping and Processing. - The primary hazard of the various preparatory procedures is that of breathing uranium dust. However, as indicated previously (See par. 3-7 b (6)(c)) the dust is the black oxide ( $U_3O_8$ ) and is essentially non-toxic. In addition, there is exposure of the hands to the relatively weak radiation from uranium metal. Under ordinary con-

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ditions of handling, this constitutes a negligible hazard. Finally, in cleaning the uranium slugs, acids and degreasing agents (trichlorethylene and carbon tetrachloride) were used. It seems likely that the use of carbon tetrachloride constitutes the greatest danger in this operation.

(3) Operation of the Pile. - The hazardous components of the radiation produced in the pile are neutrons and gamma rays and, to a lesser extent, beta rays (See Sect. 2-2 b). A tremendous amount of cooling water is required by the process, and in passing through the pile this water and the air it contains become radioactive and require special handling. The uranium slugs, and even the materials of construction of the pile, become intensely radioactive. Consequently, removal of the slugs and any repair work done on the pile require intricate protective procedures.

(4) Plutonium Extraction and Concentration. - The principal hazards of these procedures result from the intense radioactivity of the activated uranium slugs, from the radioactive gases liberated in dissolving the metal, and from the toxicity of plutonium and the fission products (See par. 2-2 c(4) and 2-2 c(5)). The toxicity of these materials becomes important only in the final separation of plutonium or in case of accident. Sampling procedures throughout the process introduce the additional danger of spills of active material. Finally, waste solutions from the process, containing uranium and fission products, are hazardous because of the radioactivity present and the toxicity of the materials contained.

(5) Experimental Work. - The research work on plu-

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onium production and on isolation and purification of various other radioactive isotopes was accompanied by all the hazards encountered in the pile process production plant. In some instances the hazards were greater in the laboratory than in the plant because of makeshift shielding and equipment. Then, too, safe practices for experimental work could be developed in a general way only. Final formulation of specific rules had to await information obtained from the research work. In certain instances, also, familiarity of the scientists with radioactive materials made them less cautious than they might have been.

d. Hazard Control.

(1) General. - Hazard control was divided into the following parts: monitoring, which included methods of checking personnel, plant areas, atmosphere, and wastes; and protective procedures which concerned floor and table coverings, protective clothing and equipment, and methods of rotating employees in hazardous areas. Automatic controls were installed to stop the apparatus when over-tolerance levels of radiation were reached.

(2) Monitoring.

(a) Personnel. - All individuals working on the pile process, at all three locations, were carefully checked to insure that harmful amounts of radiation were not received. All persons admitted to areas at Clinton and Hanford which could possibly have significant amounts of radiation were required to wear two pocket ionization meters and a film badge (See par. 2-5 c). This routine was the usual practice at Chicago, but was not compul-

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sory. The pocket meters were read daily and the film badges at intervals of one or two weeks. If the pocket meters indicated that exposures above the tolerance level of 0.1 roentgen of beta or gamma radiation were received, an immediate check of the type of exposure was made, and corrective measures were instituted to prevent recurrence. Individuals who received more than tolerance amounts (a rare occurrence) were observed closely for a period of time to insure that no bodily damage was incurred. Radiation of the hands was checked by the use of ring film meters or wrist-badges (See par. 2-5 c). In addition, finger ridge impressions were taken at 3 month intervals of all employees handling radioactive materials (See par. 2-5 c(4)). Change~~f~~ in the fingerprints of any individual was sufficient excuse to effect an immediate investigation. At Chicago, as a further check, studies of the capillaries of the hands were also made, and at the end of every shift the gloves, hats, shoes, respirators and protective clothing of employees working in radioactively contaminated areas were tested. Clothing contaminated with radioactive material was sent to a special laundry for decontamination. If evidence of over-tolerance activity still existed in this clothing after laundry procedures were carried out, it was either discarded or stored until such excess activity diminished by natural radioactive decay. Hand counters were used to determine excessive hand contamination, and, if contaminated, the hands were cleaned by scrubbing or chemical methods.

(b) Plant Areas. - All hazardous working areas in the plants were monitored, by continuously recording instru-

ments, equipped with automatic alarm devices, which were set off as soon as the tolerance level of radioactivity was reached (See App. C 23). Biological monitoring was also carried out at Clinton Laboratories, by placing rabbits and rats in strategic locations, to determine whether long continued exposure would have any significant effect on them. A specially trained staff of workers examined all work areas, apparatus, equipment, tables and hoods at regular frequent intervals to determine the presence of harmful levels of radioactive substances. Analyses were made of the air to determine the concentration of radioactive dusts or gases.

(c) Atmosphere. - All gases and fumes emitted by the pile and by the chemical separation process exhaust stacks were examined carefully in order to prevent any hazard to the plant areas and to the surrounding region. Continuous checks were made for the presence and amount of radioactive gases by the use of recording analysers and film packs. This equipment was in strategic locations in the immediate vicinity of the three installations, with other units at distances up to several miles from the stacks. No hazardous concentrations were found at any time. Some biological monitoring was carried out at Clinton Laboratories by introducing animals directly into stack gases and examining them at intervals to determine whether injury had occurred. To date no injury has been demonstrated (See App. B 4).

(d) Water. - Large quantities of water are used in the separation and decontamination procedures. Continuous monitoring of this waste for radioactivity was carried out, in order

to prevent radioactive products from being discharged into the streams in the vicinity. All the water after use was drained into holding ponds where it was allowed to remain until its activity was reduced by precipitation and radioactive disintegration. In addition to the check on the water, additional studies have been carried out on the mud of the stream bed, the plant life and algae and the fish population at optimum locations (See App. B 5).

(e) Maintenance Work. - Maintenance work in any of the hazardous areas was preceded by monitoring surveys and a job analysis. After careful evaluation, special protective equipment such as clothing, respirators, goggles, and gloves might be required. The monitoring was continued during the entire period of work. Upon completion, special examinations were made of instruments, tools and clothing to detect any unusual amount of radioactivity. Pocket meters and film badges were read and every possible precaution was taken to prevent over-exposure.

(f) Miscellaneous. - Special surveys for radioactive contamination were made periodically in the cafeterias, laundry, office buildings, and other locations within the plant areas, to detect the deposition of minute quantities of radioactive material. Checks were made on the atmospheric content of lead in the lead shop where the lead shields for protective units were fabricated.

(3) Protective Procedures. - Special protective apparatus and procedures were found necessary to eliminate those hazards which could not be controlled by engineering design and processing methods. As previously stated, these include the use of floor

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and table coverings, protective apparatus and equipment, and regular rotation of employees away from high exposure areas.

(a) Floor and Table Coverings. - To guard against high radioactivity in the concentration and isolation processes where the concentrations of plutonium and other substances of this type were comparatively high, work benches, tables and floors were covered with paper which in turn was destroyed and replaced at regular intervals. In some laboratories glass tops were found to be preferable.

(b) Protective Clothing, Apparatus and Equipment. - Periodic changes of protective work clothing for all employees working in plant areas was required. This included coveralls, gloves, hats and shoes. The periods of time between changes were determined by the type of work performed, possibility of exposure, and actual contamination as determined by the monitoring for radioactive materials. In certain hazardous areas clean clothing was regularly issued daily. Special gloves were worn in carrying out those operations which necessitated exposure of the hands to radiation or contamination. Respirators, previously tested for efficiency, were worn in all maintenance work involving exposures to the radioactive dusts of fission products and plutonium. Goggles were issued to all employees engaged in operations in which a possibility of the contamination of the eyes existed.

(c) Rotation of Employees. - If it became necessary for certain employees to receive radiation in excess of tolerance for a limited period of time, those workers were then removed

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from the hazardous work and reassigned to other radiation-free areas for the time required to determine that no damage had been incurred. There were very few of these cases, the actual number not being available.

(4) Medical Examinations. - The medical control of the health status of plant employees was exercised by the following examinations. All employees received a pre-employment examination before being hired to work in the plant area. Interval examinations were carried out at specified times, for general health control and to determine whether any damage, due to exposure to radioactive materials, had been incurred. A termination examination was carried out at the time of discharge, to determine whether any changes had occurred which might be related to exposures to radioactive hazards in the plants. The pre-employment examination included a complete physical examination, chest x-ray, complete blood count, urinalysis, and a serological test for syphilis. Physical examinations were repeated at intervals of 6 to 12 months. Laboratory examinations varied in frequency, depending on the degree of hazard, and usually consisted of blood counts and urinalyses, repeated at intervals of no more than one month for persons in hazardous areas. Termination examinations were similar to the pre-employment examinations. Special attention was directed toward the detection of changes due to radiation. The transfer examination on employees moving to other areas was identical with the termination examination. All plant personnel working elsewhere in the areas received these examinations at intervals of three to six months. Occasional blood and urinary examinations for lead were carried out

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of individuals who had exposure to lead.

(5) Evaluation of Hazard Control. - The methods indicated above provided complete protection of the individuals working on the various phases of the pile process. To maintain such high standards of protection necessitated a very considerable expenditure of energy, and the number of persons required exceeded by far the number usually assigned to this type of work. As an additional protective measure in these operations, a very conservative view was taken of the dosages of radiation and of radioactive substances considered safe for long-continued exposure, and additional factors of safety were introduced in most instances. The fact that no evidence has developed to indicate that any individual has been injured in any way by the special hazards of this process, is considered to be ample justification for the efforts expended.

e. - e. General Industrial Hygiene.

(1) Hanford Engineer Works.

(a) Objective. - The Industrial Section of the Medical Department at Hanford was responsible for: determining the physical status of applicants for work in the pile process plant, in order to utilize most effectively the manpower available; the protection of the employees and the public from over-exposure to radiation and radioactive substances, by appropriate examinations of the plant environment and of the plant personnel; the care of occupational illnesses and injuries; and the minor medical care necessary to reduce absenteeism.

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(b) Occupational and Non-Occupational Medical Care. - The Industrial Section was responsible for the treatment of all occupational illnesses and injuries. Minor cases were cared for at the first-aid stations. Patients requiring hospitalization were treated in Kadlec Hospital at Richland, Washington. Close liaison was maintained between the physicians of the Industrial Section and the staff of the hospital. As a matter of policy, treatment was provided by the Industrial Section also for minor non-occupational illnesses and injuries, in order that workmen could receive treatment with the least possible loss of time from work.

(c) Relation of Industrial Medical Division to Operations. - A Special Hazard Committee was established in November 1944, as a subcommittee of the Central-Safety Committee, to act as the liaison group between the Industrial Medical Section of the Medical Department and the Operations Supervisors. The Committee reviewed various radiation hazards and issued special bulletins outlining the control procedures to be used by plant personnel. Responsibility for radiation safety was primarily charged to the department concerned with any particular operation. The Health Department Instrument Group of the Industrial Medical Division were required to keep the departments informed of the existence of unsafe working conditions or operating practices. The Health Instrument Group also provided an educational program for supervisors on radiation hazards and protection.

(d) Catastrophe Program. - An area evacuation plan was devised, and revised periodically with changing conditions.

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The first-aid units were instructed, if evacuation of the area was ordered, to answer emergency calls, and, after completion of these duties, to pick up their personnel and establish field headquarters in a location designated by the Health Instrument Section.

(e) Organization. - E. I. du Pont de Nemours and Company, the prime contractor, accepted the responsibility for all medical care required in the operations phase, both the industrial and community medical care. Dr. W. D. Norwood was chosen in February 1943 to be Director of the Medical Department. He was especially qualified for this position as holder of a degree of Master of Science in Electrical Engineering, in addition to long experience as an industrial physician. Doctor Norwood received indoctrination in the special hazards of the Project at the Metallurgical Laboratory of the University of Chicago and began full-time work in Richland, Washington, during March of 1944. He was joined in September 1944 by Dr. S. T. Cantril, a specialist in radiology from Seattle, and by Dr. H. L. Parker, a specialist in radium dosimetry. Doctor Cantril and Dr. Parker had both had considerable previous training at the Metallurgical Laboratory, and had been active in the direction of the Medical Department of Clinton Laboratories. They became the heads of Industrial Medicine and Health Physics respectively. Additional physicians, nurses, technicians, and other helpers were added as the needs of the Section increased, until a total of 81 persons were directly employed by the Industrial Medical Division and there were 145 in the Health Physics Group.

(f) Facilities. - The principal headquarters

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of the Industrial Medical Division was in Kadlec Hospital (See App. C 16). Space and facilities were available for pre-employment physical and laboratory examinations, and for the administrative offices of the Health Physics Group. In addition, first-aid stations were established in each plant area (seven in all), to care for minor illnesses and injuries and to conduct periodic physical and laboratory examinations. All of these stations were open on a 24-hour basis except the one in the 300 area. The work schedule in this area was only one shift per day and the first-aid station was operated accordingly. The first-aid station in Kadlec Hospital was used for patients requiring specialized care not available in the areas. After 1 February 1945 this station also served as the Village emergency medical center from 4:00 p.m. to 8:00 a.m.

(g) Records. - The records of the Industrial Medical Department are kept separate from all other hospital and clinical charts since they comprise part of the employee's employment record. These medical records are made in duplicate, the original being kept in the central record room of Kadlec Hospital and the duplicate going to the area first-aid station. If an employee is transferred from Hanford to another Manhattan District project, a photostatic copy of the record is forwarded. The supervisor of industrial medical records is also in charge of company accident and health insurance claims, the clerical work relative to medical leaves and absences, and the necessary contacts with the employment and security departments to insure that prior medical approval is received before employees and visitors are permitted in restricted

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areas.

(h) The Cost. - The net expense of the Industrial Medical Division from its inception through 30 June 1946, exclusive of facilities, was \$2,561,156.85.

(2) Clinton Laboratories.

(a) Occupational and Non-occupational Care. -

The care of all injuries received while working at Clinton Laboratories was conducted in the medical dispensary. This type of service formed approximately 25 per cent of the activity of the first-aid and treatment section. The remaining 75 per cent of the work consisted of care of non-occupational minor illnesses. Close liaison was maintained between the dispensary physicians and the worker's personal physician. Any patient requiring hospital care for either occupational or non-occupational illness was closely followed.

(b) Relationship to the Safety Department of the Clinton Laboratories. - The Chief of the Medical Division was a member of the Central Safety Committee of the Clinton Laboratories, which met at monthly intervals, to set down measures for the control of the hazards occurring at this installation. For the control of special medical hazards, a Subcommittee on Activity Hazards was formed. This group, which met usually at monthly intervals, formulated an extensive manual on the detection and control of hazards from radiation. In this publication measures were established for effective control of the radiation hazards of each area. All sub-major and major accidents required a combined investigation of both the Safety and the Medical Departments. Minor injuries were investi-

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gated by the Safety Department only. All injuries were investigated with particular care if there was a chance of contamination by radioactive material. Reports were made to the Safety Section of such findings, and control measures were set up by the combined effort of both the Safety and the Medical organizations.

(c) Catastrophe Program. - Two catastrophe programs were organized to provide for the protection and treatment of plant personnel in the case of a major emergency. One program was established for the Clinton laboratories alone, and the other was organized as a part of a group enterprise under the control of the Oak Ridge Hospital. Provisions were made under both plans for the evacuation of the plant and area, and the treatment of all injured personnel.

(d) Other Activities. - The medical division also supervised general sanitation, water purification, waste and garbage removal, and the like. A visiting nurse service was also maintained for the home visits and care of certain patients not sufficiently ill to require hospitalization.

(e) Organization and Facilities. - Since the major hazards of the pile operation were well defined before construction was started at Clinton laboratories, it was possible to procure the medical personnel before the facilities were completed. The selection of individuals familiar with hazards which would be encountered was made by Dr. R. S. Stone. Under his direction the general policies of hazard control for the pile process were developed. Experience was gained at the Argonne experimental pile and

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the University of Chicago Metallurgical Laboratory. In September of 1943 Dr. S. T. Cantril was transferred from the Metallurgical Laboratory to Clinton Laboratories and placed in charge of the Medical Division. In July 1944 Dr. John E. Wirth was appointed to the medical staff, and in September of that year he succeeded Dr. Cantril, who was transferred to the Hanford Engineer Works. A medical dispensary was planned and constructed to provide for routine examinations and necessary first-aid and emergency treatment of an estimated 1200 employees. It provided a first-aid and emergency treatment room, a four-bed ward for care of casualties, a minor surgery room, a clinical laboratory, and six combination offices and treatment rooms. Construction of this building was started in April of 1943, and in August of 1943 the first pre-employment physical examinations were carried out. Additional space was later provided for the health-physics (monitoring) and instrument laboratories in the new Health-Physics building. The medical facility at present is staffed by the chief medical officer, Dr. Wirth, and three assistant physicians. Six to seven nurses have been sufficient to permit the dispensary to be open for the complete 24 hour shift. Approximately six pre-employment and five to six termination or transfer examinations have been carried out daily since the project started. The working population has remained within the extremes of 1100 to 1800 at all times. Approximately 90 to 130 patients are seen daily for first-aid and emergency treatment. Routine and special examinations for persons in hazardous areas are also carried out.

(f) The Cost. - The expense entailed in providing

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industrial medical service at Clinton Laboratories from the start of operations until 1 July 1946 is estimated at \$368,000. This amount includes an expenditure of ~~\$103,000~~ <sup>\$128,000</sup> for facilities, and ~~\$151,000~~ <sup>\$240,000</sup> for operations.

(3) Metallurgical Laboratory.

(a) Occupational and Non-occupational Medical Care. - All out-patient occupational and non-occupational medical care of employees of the Metallurgical Laboratory was performed by project physicians. Dispensary facilities for this service were maintained in Billings Hospital of the University of Chicago from June 1942 until 1 July 1944, and since that time service has been rendered at Lazel House, the health center of this University. Persons requiring hospitalization for occupational illness or injury were placed in Billings Hospital under the care of a member of the regular attending staff. Employees were furnished out-patient care, without charge, for non-occupational illnesses and accidents. This service was provided to minimize the time lost by reason of minor illness, and also to ascertain that the illnesses were non-occupational. Hospitalization and physicians fees for non-occupational illnesses and injuries were not provided. However, project physicians maintained close liaison with the physicians caring for hospitalized personnel. Staff physicians from Billings Hospital provided consulting service when consultation was necessary.

(b) Relationship to the Safety Department of Metallurgical Laboratory. - The Safety Department accepted the responsibility for ordinary safety and fire prevention. The Section of

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Clinical Medicine was responsible for all radiation hazards, for safe-handling of radioactive materials and chemicals. When a situation involved both departments, conferences were held and the lines of responsibility were determined.

(c) Catastrophe Program. - Because of the many safety features incorporated in the operations at Metallurgical Laboratory, no catastrophe program was considered necessary by the University of Chicago, and none was organized.

(d) Other Activities. - A number of the physicians employed by the Metallurgical Laboratory for this Section devoted their time to clinical research. This work was directed primarily toward tests which would indicate early damage from, or provide means of measuring, absorption and excretion of the materials in use.

(e) Organization. - Dr. Robert S. Stone, Associate Director for Health of the Metallurgical Project joined the project in July 1942. He was assisted by Dr. Leon Jacobson, who was consultant to the project beginning in January 1942; he started giving half-time in November 1942, and became a full-time staff member in July 1943. Dr. S. T. Cantrell was added to the staff in August 1942. (He became Director of the Medical Department of Clinton Laboratories in September 1943, and in September 1944 he was transferred to Hanford Engineer Works to head the Industrial Medical Program under Dr. W. D. Norwood.) Dr. J. J. Nickson and Dr. Margaret Nickson were employed in September 1942 and May 1943 respectively. The following doctors were added on the date indi-

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cated; Dr. S. Schwartz, November 1943; Dr. E. S. G. Barron, November 1943; Dr. C. J. Watson, November 1943; Dr. E. Clay, 15 March 1944; and Dr. J. G. Allen, July 1944.

Dr. Robert S. Stone has been director since coming on the project. His first assistant, from August 1942 to August 1943, was Dr. S. T. Cantril, and, since May 1944, has been Dr. Leon Jacobson, Dr. Jacobson has been in charge of the blood laboratory since coming on the project, and since July 1943, he has been in charge of clinical medicine (medical care of occupational and non-occupational illnesses and injuries) and of clinical investigation (special laboratory procedures to detect injury by, or measure excretion of, chemicals). In this work he has been aided by Dr. S. Schwartz, in charge of biochemistry, Dr. E. S. G. Barron, in charge of Enzyme studies, and Dr. Margaret Nickson, in charge of skin studies. The clinical medicine at the start was done by Drs. Cantril, Jacobson, M. Nickson, and J. J. Nickson. It was delegated 15 March 1944 to Dr. E. Clay who continued until 21 July 1944. Since that time the clinical work has been done by Dr. J. G. Allen; Dr. C. J. Watson has acted as consultant to this Section and also the Biological Research Section. Dr. M. Nickson has acted as a consultant, only, since November 1944.

When Dr. Jacobson was made Associate Division Director in May 1944, the Industrial Hazards Division, previously included in his Section, was removed, and Dr. J. J. Nickson was made Section Chief.

Approximately 19 persons worked in the clinical



medical section, about 50 in clinical investigation, and an average of 38 in the Industrial Hazards Section. Approximately 90 persons were attached to the Medical Division at the peak of employment (2500). At this level, there was a turnover of about 200 persons per month, and the number of examinations, including pre-employment, interval termination, occupational and non-occupational types, totalled approximately 1,000 per month. The rather large medical staff was necessitated by the hazardous, laboratory-scale experiments, and the considerable turnover of personnel.

(f) Facilities. - From the start of operations until July 1944, dispensary facilities of Billings Hospital were used by the physicians of the Metallurgical Project. Since that date facilities in Drexel House have been used for a dispensary. This installation provides out-patient facilities, similar to the average physician's office, suitable for treating minor illnesses and injuries and for making physical examinations. In addition, a small laboratory was provided for making emergency laboratory examinations. Routine urine and blood examinations were done in a laboratory located in Billings Hospital.

(g) The Cost. - No breakdown of the cost of operating this service is available. It is included in the expense of the Health Program of the Metallurgical Laboratory at Chicago.

3-13. Polonium Production.

The need for polonium (or Radium F) as a neutron source for use elsewhere in the District was foreseen in early 1944, and accordingly a processing program was instituted at the Monsanto

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Chemical Company.

a. Process. - Units #3 and #4 of the Monsanto Chemical Company at Dayton, Ohio, were set up for the extraction and purification of polonium. From November 1944 to January 1945 a small amount of polonium was extracted from radioactive lead ores, but during January 1945 this process was abandoned. Concurrently with the extraction from radioactive lead ores and continuing up to the present, a second method for preparation of polonium has been in use, which produces a much larger amount of polonium than can be extracted from lead ore. The polonium is artificially produced in a pile by the neutron bombardment of bismuth. The polonium is then chemically extracted, from the unchanged bismuth remaining, and further purified by physico-chemical procedures. A detailed explanation of the process can be found in the volume concerning the Los Alamos Project.

b. Hazards of Polonium Production. - In addition to the hazards of chemicals in general use such as acids, alkalis, etc., there were two special chemical hazards noted only in the process using the radioactive lead ores. These hazards were exposure to lead and tellurium. The major hazards were due to alpha radiation from polonium; beta and gamma radiation from the precursor of polonium (Radium F); and beta and gamma radiation from activated impurities such as silver and iron (See par. 2-2 b). There was also a hazard from the toxicity of polonium per se (See par. 2-2 c(3)).

c. Medical Control of Hazards.

(1) General. - The industrial hygiene program for control of occupational hazards at Dayton was under the direction of

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the Industrial Medical Division of the Manhattan District Medical Section.

(2) Medical Examinations.

(a) Pre-employment. - Pre-employment physical examinations were mandatory on all incoming employees. These examinations served as a base line for subsequent examinations and also insured the maximum use of available manpower in job situations suitable to the employee's best interests. The examination included a brief medical history, a physical examination and ~~an~~-ray of the chest. Laboratory examinations of the blood and urine were performed and blood serology was done as a check for syphilis.

(b) Interval Examinations. - Periodic physical examinations were performed on the exposed employees every six months while the unexposed personnel were examined once a year. Routine complete blood counts were done on the exposed group monthly while the unexposed group were checked every three months. Urine analyses were done on the exposed group weekly and on the unexposed group monthly. These examinations were designed to detect early signs of toxic effects from work with polonium.

(c) Termination Examinations. - When an employee was terminated, he was given an examination much like the pre-employment examination, to determine whether he had received any deleterious effects from his employment. This procedure was of benefit to both the terminated employee and the employer.

(3) Monitoring.

(a) atmosphere. - all recirculated air was

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monitored daily for radioactivity and the circulating ducts and precipitron were cleaned and decontaminated on the basis of the readings obtained. The atmosphere of all "hot" laboratories was also monitored daily.

(b) Radiation. - Because of the large amounts of radioactive material present it was necessary to make daily counts of all working surfaces, including the hoods in all laboratories handling active material. To facilitate job procedures and prevent excessive radiation of employees, detailed monitoring of routine operations was done on frequent occasions. Special or occasional operations were carefully monitored to prevent accidents and to supply data for future reference. All containers of active material were monitored before shipping.

(c) Personnel. - Employees exposed to polonium had urinalyses for this element weekly while the unexposed employees were checked monthly. Analyses of blood and feces for radioactivity were made when indicated. Routine beta and gamma radiation monitoring was done on all personnel by the use of wrist films and pencil chambers. Twice a day routine hand counts were done on all personnel, and all clothing entering the laundry was monitored before and after laundering. All exposed personnel were fingerprinted (See par. 2-5 c (4)) every three months as an added precaution.

d. General Industrial Hygiene. - The care of occupational and non-occupational illnesses and accidents offered at this installation was limited to that which could be handled by the registered nurse in attendance at the dispensary. Illnesses and accidents of

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more than minor nature were referred to Dr. Lynn Baker, who was a physician in the part-time employ of the company.

e. Organization. - From the time of its inception until April 1945 the Health and Safety Section was under the direction of L. L. E. Silverman. In April 1945 Captain (then Lieutenant) B. S. Wolf was assigned by the District Medical Section to take charge of the Health Program. Mr. J. T. Faust was assigned by the District Safety Section to take over the Safety Program. After Lt. Wolf's arrival, new personnel were rapidly added, in order to keep the Health Program abreast of the new problems created by expanding production. By 30 June 1945, the organization consisted of 27 people, most of whom were assigned to the Health Physics Department. Captain B. S. Wolf was reassigned to New York City in May 1946 and was not replaced.

f. The Cost. - The estimated cost of the Health Program from October 1943 to 30 June 1946 was \$243,000. The bulk of the cost was for salaries. The cost of special monitoring equipment is not included in this figure, as it was obtained from the Metallurgical Project and the Clinton Laboratories and is included in their program.

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SECTION 4 - CLINICAL MEDICINE AND DENTISTRY

4-1. General. - Provision of medical and dental care and related services, for both the Clinton and Hanford Engineer Works, presented numerous difficult and unusual problems. Existing facilities and personnel were grossly inadequate to care for the influx of construction and operations employees. It was necessary, therefore, to accept the responsibility of providing essential medical services in both areas. The contractor at Hanford accepted complete responsibility for this service, and the Medical Section of the Manhattan District was required only to determine for the District Engineer that proper hospital and medical services were provided. On the other hand, at Oak Ridge, the Medical Section was required to organize the complete program of medical care and to operate the facilities established. In this instance, because of the urgency of the program and the security involved, Army Medical Department officers were used, and the policies were determined by the Administrative Division of the Medical Section.

4-2. Clinical Medicine and Dentistry at Oak Ridge.

a. The Medical Program.

(1) Community Needs:

(a) Estimated Population - 8-10,000. - The original plans for establishing medical service at Oak Ridge were developed to provide essential care for a community population of 8,000 to 10,000. It was not anticipated at first that any patients would be hospitalized on the area. Rather, medical care would be limited to office calls, home visits, and the first-aid and emergency medical care.

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ordinarily provided by employers in large industrial operations. It was planned that persons for whom hospital care was required would be sent to hospitals in the surrounding area. An investigation of hospital facilities available in the vicinity of Oak Ridge caused this plan to be abandoned. It was discovered that the facilities were inadequate to take on the additional load this increase in population would occasion. In Knoxville there were only 615 hospital beds, or 3 per thousand of population. Knox County and eight surrounding counties had only 755 beds, or approximately 2 per thousand. The accommodations were already overcrowded by the increase in population from other war industries, and the physicians and dentists in Knoxville and environs were physically unable to accept the added responsibility of caring for the residents of Oak Ridge. To fulfill the needs of the community, a medical service building (See App. C17) and a 50-bed hospital were planned. Construction of the Medical Service Building, similar to a hospital out-patient department, was started in March 1943 and completed in June 1943. This building was to supplement the first aid station established by the construction contractors and was designed and equipped for pre-employment examinations, emergency surgery, ordinary medical out-care, emergency dental care, and essential public health functions. The hospital of 50 beds would provide between 5 and 6.2 beds per thousand population, well above the national average of 3.4 beds per thousand. The decision to build a hospital of this size was reached after consideration of the fact that a large percentage of employees were to be housed in dormitories, and consequently, would have to be hospitalized for

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contagious diseases and any other illness which made it impossible to leave the dormitory for food. In addition, the large construction program would require adequate facilities to care for industrial accidents. Accordingly, a 50-bed hospital was authorized, construction was started in June 1943, and completed in November 1943. In addition, a nurses' home to house 29 nurses was constructed near the hospital.

(b) Estimated Population - 15,000 - It became evident before the Medical Service Building was completed that the original estimates of the population would be exceeded, and that a minimum of 10,000 to 15,000 individuals would be living on the reservation. It was considered advisable at this time to attempt to provide essential services without any increase in facilities, since with a population of 15,000 the hospital bed ratio to population would be 3.3 per thousand, essentially the same as the national average. (See App. A7).

(c) Estimated Population - 50,000 - Before the hospital was completed it became apparent that even the new estimates of the onsite population were inadequate and that the number of residents would reach at least 50,000. Because of the unusual community requirements, additional hospital facilities were planned to provide 5 hospital beds per thousand. Two 100-bed units, and a complete out-patient department were authorized. The first 100-bed addition was started in March 1944 and completed in July 1944. This unit contained obstetrical, pediatric, and contagion units. The Out-patient Department and second 100-bed addition were started in April 1944 and completed in July 1944, respectively. (See App. A15). This expansion of hospital facilities required additional quarters for nurses and technicians.



Consequently, construction of a dormitory large enough to accommodate 140 persons was begun in April and finished in June 1944 (See Bk I Vol 12 App. C6).

(d) Population - 72,000. - By March 1945 the area population exceeded 72,000. The hospital facilities were dangerously overloaded, and many patients were being cared for in the corridors of the hospital. Consequently, beginning in March 1945 (See App. C6) an annex of 60 beds was built west of the D Wing, increasing the total capacity to 310 beds, or 4.3 beds per thousand. During the spring of 1945 the hospital continued to be dangerously overcrowded, because of the high incidence of severe upper-respiratory infections. No further additions to the hospital were planned, because the seasonal decrease in illness was expected to, and did, relieve the immediate shortage of beds.

(e) Estimated Population 40-45,000 - In August, 1945 the peak of the area population was reached. During this month, the highest number of hospital admissions and hospital "patient days" was recorded. Following the cessation of hostilities (V-J Day), the total population began to gradually decline. This reduced the overcrowded condition of the hospital, and, in January 1946, it was possible to discontinue use of E Wing of the hospital, thereby reducing the total capacity to 250 beds. E Wing was placed in a stand-by condition and served as an emergency reserve for use if hospital facilities were taxed by an epidemic or unforeseen catastrophe.

(2) <sup>Policy</sup> (a) Policy Prior to V-J Day - As indicated the plans for medical service were revised with changing conditions from emergency type care to a comprehensive complete program. The

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medical service was rendered by Army officers and two civilian psychiatrists. The schedule of fees was based on the fee schedule of the Knox County Medical Society. The fees went to the University of Rochester and, later, to Roane-Anderson Company (and, in turn, to the Government). The hospital was operated with a "closed staff" (only those doctors regularly assigned to the hospital were permitted to care for patients in the hospital). The industrial physicians who referred cases to the hospital were extended "courtesy privileges", and acted as consulting physicians in the case of their patients. A prepayment plan (See Par. 4-2a(4)), the Oak Ridge Health Association, was offered to employees of the Government and the operating contractors. Medical and dental service was furnished to military personnel in accordance with Army regulations.

(b) Policy After V-J Day - Following the reduction in area population, plans were formulated to convert the medical staff of the Oak Ridge Hospital to a civilian status. These plans were carried out during the ensuing six months period.

Civilian physicians were selected and admitted to practice according to their qualifications and medical necessities of the community. Where possible, specialists, so designated by Medical Specialty Boards, were selected to insure a high grade of medical care. Army Medical Corps physicians were released according to policies of the Surgeon General's Office. During the transition period, civilian physicians were retained on salary by the Roane-Anderson Company; 60 per cent of the fees received for their professional services in providing emergency medical care were credited to the physicians. On 1 March 1946, the hospital terminated

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its contract arrangements with the civilian physicians, coincident with the appointment of Dr. Lucius A. Salisbury as director of the Oak Ridge Hospital, the Oak Ridge Dental Clinic, the Oak Ridge Medical Service Center and the Veterinary Facilities.

(3) Type of Medical Service Rendered. - Limited first-aid and emergency medical care (other than that provided by construction contractors for occupational injuries) were first available to area employees and residents 1 July 1943. Although ~~construction of the~~ <sup>was not yet fully in operation</sup> Medical Service Building ~~had not been completed~~ at that time, pre-employment physical examinations were performed, inoculations against typhoid fever and smallpox were given, and the emergency room was operated on a 24-hour basis. During this period also, necessary house calls were made, and sanitary inspections of the cafeterias and dormitories were initiated. Since the Oak Ridge Hospital had not been completed, critically ill patients were referred to the care of physicians who were staff members of the hospitals nearby. After the hospital was completed in November 1943, complete medical service was offered to employees and residents of the area. The medical staff was organized by specialties for both in-patient and out-patient service. As the staff grew in size, new specialties were offered until the hospital had Departments of: Surgery; Medicine; Obstetrics and Gynecology; Eye, Ear, Nose and Throat; Pediatrics; Psychiatry; Proctology; Neurology; Urology; Orthopedics; and Dermatology. The head of each section was a physician who had postgraduate training in the specialty. In most instances, the other department members also had special training in the field of medicine to which they were assigned. Ade-

quate laboratory and x-ray facilities were provided for both the in-patient and out-patient services.

(4) Prepayment Plan for Medical Care. (The Oak Ridge Health Association) (See App. A 2).

(a) General. - It was considered desirable to institute a prepayment plan to cover medical and hospital expenses for persons employed at Oak Ridge, and for the families of employees if they were residing on the area. It was felt that such a plan would be an inducement in recruiting workmen, would insure better medical care, and, consequently, reduce absenteeism; and, finally, would appreciably decrease the bookkeeping and collection problems of the hospital. However, the security requirements of the project made it impossible to utilize the services of existing insurance programs, because it was not permissible to disclose the number of patients, the job classifications of subscribers, etc. Therefore, it was decided that an area prepayment insurance plan should be devised and instituted, controlled by staff physicians and members of the different operating companies, under the direction of the District Engineer. To that end, the services of a consultant, Dr. Nathan Sinai, were obtained. Dr. Sinai was associated with the School of Public Health at the University of Michigan and is one of the country's outstanding authorities on prepayment insurance plans. The proposed plan was presented to officers of the Knox County Medical Society and no objection was raised to its inauguration.

(b) Objectives. - The Oak Ridge Health Association started operating in November 1943, under a grant of authority from the District Engineer. Its objectives were the following:

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(1) The contract was to provide not only hospitalization but also medical coverage, and that coverage should be as broad as economically feasible.

(2) The association should be self-supporting.

(3) The doctors should have a 50% voting power on the Board of Directors and on the Executive Committee.

(c) Membership and Fees. - Membership in the association was offered to Government employees and the personnel of all contractors with the exception of construction companies. The turnover of workers in the construction companies was considered to be too great for the financial safety of the organization. Seventy-five per cent of the personnel of a company had to subscribe for membership before the group was accepted. The charge was \$4.00 for a family membership, which allowed the subscriber and his family to have hospital care, but restricted office visits to the subscriber. For individual subscribers, the membership fee was \$2.00 per month and entitled the subscriber to both in-patient and out-patient care. Most of the companies had payroll deductions for the monthly dues.

(d) Services Covered. - The following was offered to the employee subscriber:

(1) Hospital Services.

(a) Up to 30 days of hospital care each year at the Oak Ridge Hospital on authorization of a staff physician, plus a 50% discount of hospital costs for an additional 90 days. Hospital care included:

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Bed and Board	Casts and Splints
Operating Room	Transfusions
General Nursing	Oxygen
Anesthetic	Serums
Laboratory Service	Drugs

Ambulance within the Area

(b) If, in case of emergency, the member had to enter another hospital, the association would pay to that hospital up to \$5.00 per day for the first 30 days and up to \$2.50 per day for the next 90 days, and in addition, would pay the attending physician the maximum fee allowed by the Oak Ridge fee schedule for similar service.

(2) Diagnostic Services. - All medical, surgical, and other services, including diagnostic x-rays, electrocardiograms, and basal metabolism tests, rendered to a member who was a bed patient in the Oak Ridge Hospital.

(3) Physicians' Services. - All services (exclusive of medications) rendered by physicians in their offices in the Oak Ridge Hospital, including laboratory and x-ray examinations.

(e) Services Not Covered. - The following services were not covered by this plan: home calls, obstetrical care during the first ten months of enrollment, dental care, nervous, mental, and tuberculosis cases after diagnosis, drug addiction and alcoholism, plastic operations for beautifying or cosmetic purposes, intentional self-inflicted injuries, special nursing, appliances other than casts and splints, radiation therapy, physical therapy, workmen's

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compensation cases, office calls except for subscriber.

(f) Contract of the Association With the

Hospital. - The Oak Ridge Health Association made a contract with the Oak Ridge Hospital (See App. B8) by which the hospital received \$5.10 per day for each in-patient eligible for association benefits. This sum covered all services to which in-patients were entitled under the subscriber's contract except x-ray services and other professional services. The association paid the hospital for x-ray services on in-patients at the rate charged private patients. In addition, the hospital received \$3.00 per day per in-patient as the professional fee for the care of medical patients. The hospital received the minimum fee of the Oak Ridge Hospital schedule of fees for each surgical in-patient. The hospital received a \$2.00 fee for each out-patient visit of association subscribers, which included all services rendered (exclusive of medications).

(g) Administration. - The first director of

the plan was Mr. Henry Vaughn, Department of Public Health, University of Michigan. On 29 August 1944 he was succeeded by Mr. J. H. Stallings.

(h) Evaluation of the Oak Ridge Hospital Associ-

ation.

(1) Benefits. - This plan was eminently

satisfactory to the subscriber. The rates were moderate and the benefits received were generous. The medical care was rendered primarily by specialists, was readily available and excellent in quality.

(2) Financial Status. - The association was

able to discharge the obligations of its contracts with the subscribers

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and the hospital, and accumulate a surplus of about \$80,000 in almost two years. This was appreciably less than the reserve of \$10 per subscriber which had been recommended as necessary as insurance against an epidemic or other unforeseen catastrophe. The rates to the Oak Ridge Health Association were set somewhat lower than the cost of similar services for private patients. There was a tendency for members of the association to use the hospital services more frequently than nonmembers, and to receive more service per visit, which increased materially the difference between the amount paid by the association and the cash value of the service rendered.

(3) Modifications in Plan

a. Diagnostic and Professional Services - On 1 March 1946, an agreement was made with the Oak Ridge Hospital for the Oak Ridge Health Association to pay \$1.25 for each out-patient attended by a civilian physician; this sum was paid for all laboratory and x-ray services provided by the Oak Ridge Hospital. A fee of \$2.00 was paid to the civilian physician for each out-patient visit. For each out-patient treated by a military physician, the Oak Ridge Health Association continued to pay the Oak Ridge Hospital \$2.00; this fee provided for the physician's services and all x-ray and laboratory charges.

b. Hospital and Out-Patient Benefits - On 1 May 1946, the agreement between the Oak Ridge Health Association and the Oak Ridge Hospital was terminated, and the following changes occurred:

(1) The Oak Ridge Health Association paid to the subscriber \$5.00 for each hospital day. For miscellaneous hospital services, including operating room, anaesthesia, delivery room, lab-

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oratory tests, ordinary drugs and medicines, casts, splints, x-ray photographs and fluoroscopy, except for teeth, and oxygen therapy if not used during an operation, the total amount payable for all such services was not to exceed \$25.00 for each separate hospital admission.

(2) The \$3.00 per day fee paid to civilian physicians for in-patients was discontinued. Hospital patients became responsible to their physician for their own medical fee; this obviated any tendency for physicians to hold patients in the hospital in order to secure payment of the medical fee by the Oak Ridge Health Association.

(3) The subscriber became entitled to reimbursement of expenses in an amount not exceeding three-fourths (3/4) of the sums allowable to the subscriber for services rendered to members of the subscribers family as bed patients.

(4) Reimbursement for out-patient x-ray and laboratory charges as well as all fees for professional services rendered to out-patients were discontinued.

(4) Probable Future of the Plan - The reduction in total membership to approximately 4,000 members on 1 July 1946, from the previous total of 22,000 members in July 1945 and a reduction in the reserve fund to \$12,000. as of 1 July 1946, makes operation of the plan under the present program inadvisable. It is expected that on 1 August 1946 the present association will be dissolved and thereafter the pre-payment for medical care program will be handled by the Provident Life Insurance Company of Chattanooga, Tennessee.

The Oak Ridge Health Association will continue to operate as a non-profit organization, acting as agent for the Provident Life

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Insurance Co. The present reserve fund will be used to cover current and future claims, and will be disposed of in accordance with the grant of authority from the District Engineer. (See App. A 2)

(5) Emergency Disaster Program. - A medical emergency disaster program was established by the medical staff, for use in case of a major disaster which required medical participation. Field units were established, consisting of two doctors and one nurse, and were completely equipped with first-aid supplies, emergency medical equipment, and transportation. Definite emergency assignments were established in the hospitals and first-aid stations, operated by the medical organizations of the operating contractors, which were to assist in their respective areas.

(6) Organization. - In April 1943, the University of Rochester was authorized by the Manhattan District to procure the medical and dental personnel necessary to render the medical service planned (later Lt.Col.) for Oak Ridge. In May 1943, Dr. C. E. Rea was chosen to head the staff and agreed to procure 10 additional physicians and 2 dentists as members of the staff. The late Dr. William B. Holt of Chicago, Illinois, was hired as Hospital Director and was authorized to procure the necessary nurses, technicians, and administrative staff. The original medical staff members were chosen for their specialized professional abilities, and separate departments of surgery, medicine, pediatrics, obstetrics and gynecology, eye, ear, nose and throat, roentgenology, laboratory, and public health were planned. By 1 September 1943, 11 doctors and 7 nurses had reported for work. Subsequent additions to the staff were made according to the demand for the services of the various special-

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(Par. 4-2a(6))

ties. The ratio of physicians to population was maintained at approximately 1 to 1,500 (the average throughout the country during the war). The contract for administration of the medical and dental facilities was transferred, 23 September 1944, from the University of Rochester to the Roane-Anderson Company, but the policies regarding medical care remained under the general supervision of the Manhattan District Medical Section. Also, in accordance with arrangements previously made, the entire medical staff, with the exception of Dr. Holt, was commissioned in the Army Medical Corps during November and December 1943, in order to safeguard the security of the project and to insure the retention of men with outstanding professional abilities. After December 1943, additions to the staff were procured through the Surgeon General's Office. The number of physicians increased to a total of 52 in July 1946, stabilizing at this level during the months of July, August and September. Medical Corps officers were separated from the Manhattan District as they became eligible for discharge from Army service and were replaced by civilian physicians. On 1 March 1946, the by-laws of the medical staff of the Oak Ridge Hospital were amended to conform with the recommendations of the American College of Surgeons for Hospitals housing over 150 beds. (See App. A 5)

(7) Statistics. - From July 1943, the medical operating statistics were as follows:

<u>Period</u>	<u>Doctors</u>	<u>Nurses</u>	<u>Attendants</u>	<u>Orderlies</u>	<u>Out-Pat. Treatments</u>	<u>Hospital Pat. Days</u>
<u>1943</u>						
July	8	4	0	2	1,890	-
August	8	4	0	2	3,653	-

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<u>Period</u>	<u>Doctors</u>	<u>Nurses</u>	<u>Attendants</u>	<u>Orderlies</u>	<u>Out-Pat. Treatments</u>	<u>Hospital Pat. Days</u>
<u>1943</u>						
September	8	5	6	4	6,235	-
October	10	7	10	5	7,283	-
November	11	25	11	5	6,705	55
December	11	28	11	6	4,772	1,017
<u>1944</u>						
January	12	41	18	6	7,801	1,705
February	14	45	18	5	7,833	1,928
March	14	45	16	6	9,581	2,137
April	16	51	25	7	10,643	2,472
May	20	60	30	6	12,788	2,293
June	23	72	37	7	12,934	3,024
July	25	72	37	6	10,403	4,046
August	26	85	46	9	12,186	4,433
September	26	91	47	12	11,861	4,837
October	28	112	42	11	12,915	5,910
November	27	131	41	12	12,985	6,397
December	36	136	43	12	13,042	7,783
<u>1945</u>						
January	35	137	36	14	16,719	7,262
February	34	136	44	16	15,605	8,195
March	34	145	47	17	18,715	8,843
April	38	141	54	16	16,873	8,025
May	42	144	51	20	18,507	8,713
June	47	143	50	20	18,337	8,616

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<u>Period</u>	<u>Doctors</u>			<u>Nurses</u>	<u>Attendants</u>	<u>Orderlies</u>	<u>Out-Pat. Treatments</u>	<u>Hospital Pat. Days</u>
<u>1945</u>	<u>M. C. T.**</u>							
July	50	2	52	144	49	20	19,599	9,050
August	50	2	52	136	48	22	21,570	9,376
September	50	2	52	132	41	25	17,343	8,138
October	40	2	42	144	54	25	18,275	8,730
November	40	6	46	139	47	25	16,893	8,849
December	42	7	49	146	46	22	13,335	8,694
<u>1946</u>								
January	36	16	52	133	44	22	15,816	6,885
February	28	16	44	130	38	23	13,803	6,605
March	26	19	45	125	36	18	7,061*	7,147
April	19	23	42	129	33	20	4,770*	7,382
May	10	24	34	124	36	20	3,752*	6,629
June	9	29	38	129	39	20	3,023*	5,775

NOTE: \* Represents only patients attended by Army Medical Corps physicians.

\*\* M -- Military  
C -- Civilian  
T -- Total

b. The Dental Program.

(1) Community Dental Needs. - As indicated in Par. 4-2a(1)(a), it was planned originally to provide only emergency dental care at Oak Ridge. However, with the rapid increase in population it became evident that the dentists of surrounding communities, already overloaded with patients, could not provide adequate care for the residents of Oak Ridge. Accordingly, the dental service assumed the responsibility of providing adequate wartime dental care for all residents

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(Par. 4-2b(1))

of the area.

(2) Policy. - It was considered preferable to have dental care provided by civilian dentists, since procurement of dentists was less critical than that of physicians and since the dentists would have no contact with classified information. It was decided, further, that the dentists should be employed on a straight monthly salary, in order to insure high professional standards and to keep fees at a moderate level. The fee schedule was derived from that in use in Knoxville and the surrounding communities. Fees were collected by the University of Rochester, and later Roane-Anderson Company, and, in turn, reverted to the Government. Each dentist originally was permitted to conduct his practice according to his training, ability, and judgment. As the clinic grew in size, specialists were procured and new patients were, after diagnosis, assigned to the dentist best fitted to do the work required.

(3) Facilities. - Accommodations for 2 dentists were included in the Medical Service Building when it was designed. By September 1943, the space devoted to dentistry was increased to allow 4 dental operators to work simultaneously. In the spring of 1944, the Dental Clinic was again enlarged and a total of 8 dental chairs was installed. One of these was equipped with an x-ray unit and was used both for ordinary operative dentistry and for dental radiography. By May 1944, it was necessary to start a night schedule of appointments, in order to provide essential service with the facilities available. To keep pace with the growing dental requirements of the rapidly increasing population, a separate building, the Dental Health Center, was designed.

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and construction was completed July 1944 (See App. C19). The new clinic was used exclusively for adult patients and the old was remodeled to care for children.

(4) Organization. - The first dentist, Dr. Harold Nelson, started work 15 July 1943. He was joined by Dr. Harry Pitluck in September 1943, and together they operated the clinic until the first Dental Director, Dr. Don Clawson, came 1 August 1944, on leave of absence from Meharry Dental School, Nashville, Tennessee. It became necessary for him to return to Meharry on 1 February 1945 and he was succeeded by Dr. William Squires, a retired Colonel of the Army Dental Corps, who continued in the capacity until 1 August 1945. Colonel Squires was succeeded by Dr. Ewell Neil, who acted as Director until 1 February 1946, at which time the Dental Clinic ceased to be operated by Roane-Anderson Company; thereafter, dental care was provided on a private practice basis. On 1 February 1946, there were 9 full time and 2 part time dentists. Two additional full time dentists were admitted to practice during the ensuing 3 months. The growth of the organization in personnel and the services rendered are indicated in the statistical section (Par. 4-2<sup>b</sup>(5)).

(5) Statistics. - Following is a table which illustrates the growth of the Dental Clinic in technical personnel and volume of work performed, from July 1943:

<u>Period</u>	<u>Dentists</u>	<u>Dental Assts.</u>	<u>Hygienists</u> <u>X-ray Techn.</u> <u>Anesthetists</u>	<u>Patients</u> <u>Treated</u>
<u>1943</u>				
July	2	1	1	28
August	2	1	1	80

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(Par. 4-2b(5))

<u>Period</u>	<u>Dentists</u>	<u>Dental Assts.</u>	<u>Hygienists</u> <u>X-ray Techn.</u> <u>Anesthetists</u>	<u>Patients</u> <u>Treated</u>
<u>1943</u>				
September	2	1	1	200
October	2	1	2	300
November	4	2	2	315
December	3	2	1	400
<u>1944</u>				
January	3	2	2	650
February	3	2	2	930
March	5	2	2	1,090
April	5	4	1	1,265
May	5	5	1	1,195
June	7	5	1	1,027
July	9	3	6	1,436
August	15	5	6	1,794
September	16	3	9	2,303
October	25	17	10	3,003
November	24	22	9	3,298
December	25	25	9	3,200
<u>1945</u>				
January	26	28	11	4,096
February	27	24	10	4,408
March	29	23	13	4,233
April	25	21	10	3,898
May	25	22	9	4,207
June	25	25	8	3,533
July	25	27	9	3,609

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<u>Period</u>	<u>Dentists</u>	<u>Dental Assts.</u>	<u>Hygienists X-ray Techn. Anesthetists</u>	<u>Patients Treated</u>
<u>1945</u>				
August	26	18	20	3,671
September	24	21	14	3,883
October	24	22	15	3,535
November	24	21	15	2,992
December	25	23	14	2,005
<u>1946</u>				
January	21	18	13	1,916

c. Public Health Program. - A formal public health program was organized in January 1944, under the direction of Captain Bernard Blum. Prior to this time, physical examinations had been made of food handlers, and periodic inspections of eating places and dormitories had been instituted. Captain Blum was charged with the responsibility of procuring personnel and organizing a public health program, adequate to protect the health of area residents, employees, and visitors. A milk control program was established, and, in cooperation with Knoxville Health Department, farms and processing plants supplying milk to Oak Ridge were periodically inspected. The U. S. Public Health Service Milk Ordinance and Code were adopted 7 September 1945, and un-pasteurized milk was barred from the area. The effectiveness of these measures was demonstrated by a progressive decrease in the bacteria count of the milk, and in the number of properly pasteurized specimens received by the Milk Control Laboratory. Area water supplies were inspected and samples were analyzed at regular intervals. A venereal disease control program was organized and included a treatment clinic,

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<u>Period</u>	<u>Doctors</u>	<u>Nurses</u>	<u>Pre- Employment</u>	<u>First Aid</u>	<u>Out-Pat. Treatments</u>	<u>Hospital Pat. Days</u>
<u>1944</u> December	21	101	848	9,896	1,909	4,184
<u>1945</u> January	19	74	420	8,811	1,646	3,714
February	11	2	-	2,593	183	973

(2) The Dental Program. - A dental clinic was established in connection with the hospital. Two dentists were available throughout the construction phase. This limited number was considered sufficient, as only emergency work was performed. The clinic operated in a manner similar to the Medical Clinic.

(3) Public Health Service. - As the physical well-being of each individual on the reservation was of vital importance to the successful completion of the construction project, public health and sanitary inspection units were established. On 31 March 1944, a public health physician was employed and was then appointed, by the State of Washington Department of Health, as Deputy State Health Officer for the Hanford Engineer Works. This arrangement gave legal sanction to the Hanford Public Health Program and tied the program into that of the state, but permitted security restrictions to be maintained, by special arrangements with the State Health Department. Mess halls and cafeterias were inspected daily, and milk, water, and food inspections were made periodically. Trailer camps were inspected weekly, and periodic inspections were made of barracks, dormitories, schools, and stores in both Hanford and Richland. In order that the load on the medical staff could be decreased, by relieving them of unnecessary house calls and clinic visits, the Public Health Service instituted a home nursing

educational activities, and investigation of venereal disease contacts. A public health nursing service was established, which included: immunization and communicable disease program; maternity service; infant, pre-school, and school hygiene; and service for crippled children. Health education was high-lighted by a food-handlers' school which had a total attendance (at three classes) of 3,619 persons. In addition, the public has received instruction in disease prevention by films displayed in local theaters, by articles in the Oak Ridge Journal, and by means of a poster contest on respiratory diseases. The program of general sanitation involved inspections of sewage treatment plants, the swimming pool, trailer camps, grocery stores, drug stores, barber shops, and eating houses. An active rodent and insect control program was followed. The handling of food was supervised and food handlers were required to receive periodic physical examinations. Outbreaks of gastroenteritis were investigated, as well as complaints relating to general sanitation. The Public Health Department was first located in the Medical Service Building but in time outgrew its quarters. Consequently, the Stone and Webster Field Hospital on Scarboro Road was remodeled and the department was transferred there 15 May 1945 (See App. C 20). Captain Blum, on 18 December 1945, terminated his Army service and was succeeded by Mr. Leon S. Blankenship, who is the present Public Health Officer.

d. Veterinary Service. - In August 1943, veterinary service, under the direction of an Army Veterinary Officer, Captain Lloyd Jameson, was established, primarily to care for Government-owned livestock and to assist the Public Health Department in milk and meat in-

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spections. Compulsory rabies inoculations for all dogs brought into the reservation was required. A dog pound and small animal hospital were constructed and operated by Roane-Anderson Company. Dr. James Kile succeeded Capt. Lloyd Jameson in the capacity of area veterinarian on 1 January 1946. A small animal hospital, which in September 1944 has been leased on a concession, continued in operation.

e. The Cost. - The expense entailed in construction and operation of the medical and allied facilities at Oak Ridge to 1 July 1946 is indicated below:

Medicine:

Cost of construction of hospital	\$ 984,564
Cost of construction of out-patient	184,111
Additional construction costs	<u>126,701</u>
Total construction costs	1,295,376
Operating expenses	3,929,014
Operating revenue	<u>2,954,930</u>
Operating deficit	974,084
Total expense for medicine	\$2,269,460

Dentistry

Cost of construction of dental clinic	94,656
Operating expenses	554,726
Operating revenue	<u>371,999</u>
Operating deficit	182,727
Total expense for dentistry	277,383

Public Health

Cost of construction of quarters	50,545
Operating expenses	<u>190,311</u>
Operating deficit	240,856
Total expense for Public Health	240,856

Veterinary Service

Cost of construction	16,111
Operating expenses	31,130
Operating revenues	<u>5,591</u>
Operating deficit	25,539

Total expense for veterinary service 41,650

Total net cost of Clinical Medicine, Dentistry,  
Public Health and Veterinary Service at Oak  
Ridge \$2,829,349

4-3. Clinical Medicine and Dentistry at Hanford Engineer Works.

a. Construction Phase.

(1) The Medical Program

(a) Community Needs. - In March 1943 construction was begun on the Hanford plant for plutonium production, and in May 1943 on the Richland Village thirty miles away, in which 15,000 people directly or indirectly connected with the plant were to be housed (See Book IV, Vol. 5). The plant and village had to be completed at the earliest possible date. Workmen could be attracted to the isolated site only with special inducements. One of these inducements was the provision of facilities for laborers to live with their families in privately-owned trailers. Another was the provision of complete, high-quality medical care for workmen and their families. On ordinary construction projects, medical facilities are provided only for industrial medical care of employees during working hours. At Hanford, however, the provision of these unusual facilities, among a number of others, increased the morale of workers and lowered the labor turnover. There were other reasons for providing complete medical fa-

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(Par. 4-3a(1)(a))

cilities at Hanford. The most important one was that extreme secrecy was mandatory. This necessitated all medical facilities being under Government control and, as far as possible, that medical care for persons located on the plant site be performed at the plant rather than at other population centers, to prevent leaks in information as to the size and nature of the project. To centralize Government control, it was decided that the prime contractor would be responsible for all medical care on the area. The extremely isolated spot at which the plant was located limited to almost nothing the medical care which could be made available through normal channels. The medical facilities of Pasco, Washington, already had been overtaxed by the 600 to 700 people who were added to the town population at the beginning of the project. Yakima and Walla Walla, each about 80 miles from Hanford, were at almost the limit of medical load prior to the project, because of war industries located in their areas. The facilities became completely inadequate when the population was increased by the families of Hanford workers who lived in these areas and chose to commute to the job rather than live in Hanford. At one time, St. Elizabeth's Hospital in Yakima was so crowded that Government funds were being sought from Hanford Engineer Works to build additional wings to supply the need for hospital beds. The original plans, on which the medical program was based, called for a labor force of 10,000 men to be housed in barracks and fed in mess halls. It very quickly became apparent that a labor force of that size was far too small. The addition of family units to the construction camp brought additional large numbers of people for whom no medical plans had been made. Facilities for housing single workers, and

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new trailer sections, had to be increased month by month as the construction difficulties became more apparent. At the peak, in order to meet construction schedules, it was necessary to have a population at Hanford of 51,000 people and to process through pre-employment examinations a total of more than 91,000 applicants. The expansion of medical facilities, to care for this constantly and unpredictably growing population, was the greatest problem faced by the medical administrator during construction days.

(b) Policy. - The medical program was started by the construction contractor, E. I. du Pont de Nemours & Company, Inc., in March of 1943. Definite requirements were stipulated for the professional members of the staff. Doctors were required to have credentials necessary to enable them to secure temporary license to practice in the state of Washington. Permanent license to practice in the state of Washington was contingent upon the passing of basic science examinations and, in some cases, reciprocity examinations. The Washington State License Bureau offered cooperation in making proper exceptions to the Medical Practice Act during the emergency. Nurses were required to be registered graduates of a school for nurses and to be licensed in the state of Washington. The operation of the Hanford Hospital followed closely that of a municipal hospital in a normal city of comparable size. Admission to the hospital, in accordance with usual hospital practices, was by order of the attending physician, and the case remained in the assigned physician's care during the patient's stay in the hospital. Rooms were assigned on the basis of availability and the physical condition of the patient. Fees for hospital care,

doctors' services, drugs and medication were based on the lowest prevailing rates in the surrounding territory. In order to gain the cooperation of patients and in the interest of the general project welfare, no charge was made for services in the Health Center (Public Health Service), Contagious Disease Unit, or Psychiatric Unit of the Infirmary. To facilitate the payment of medical fees by the contractor's employees, a wage deduction plan was adopted whereby any employee could have proportionate amounts deducted from his wage check each pay period until the fee was discharged.

(c) Type of Medical Service Rendered. - In April 1943, a first-aid station was established at the site of construction, and by June facilities and staff were available for first aid and 10 bed cases. Regular hospital facilities were first available to employees and their families in July 1943. At this time the capacity of the hospital was 38 adult beds, 4 pediatric beds, and 8 cribs. By June 1944, the capacity of the hospital had been increased to 116 beds. In September 1943, an out-patient clinic was opened in conjunction with the hospital for treatment of patients not requiring hospitalization. Patients visited the clinic voluntarily and selected their favorite doctors within the limits of their availability. In November 1943, a temporary sick bay was established in three barracks, as hospital facilities were inadequate to care for the large numbers of cases which required confinement. Because of an increase in the number of contagious and infectious diseases, a special isolation unit was established in a barracks building in December 1943. In January 1944, an additional barracks was added to the isolation unit. As the population continued



to increase, it became apparent that the temporary barracks facilities for sick bay and isolation were inadequate, and the construction of an infirmary and public health building was begun. This building, providing space for 224 beds and quarters for the Public Health Service, was occupied in June 1944. As these isolation, sick bay and psychiatric units were established, the temporary barracks which had been used for these services were returned to housing. Since the medical service was maintained by the contractor, all pre-employment and termination physical examinations were made by the medical staff. Adequate laboratory and x-ray facilities were provided for both in-patient and out-patient services (See App C 21).

(d) Industrial Medical Relations. - An industrial medical relations section was established as part of the Medical Division. This section performed the necessary functions in handling accident and health insurance, disability wage payments, and wage compensation. Medical reports, concerning the eligibility of applicants for the above benefits, were submitted from this section. One senior clerk, one assistant, three stenographers and one messenger were assigned to duty in this section.

(e) Use of Handicapped Workmen. - As a means of utilizing all available manpower, a plan was adopted whereby persons with major physical defects could be hired, with the understanding that job placement would be made in accordance with the nature of the defect. These defects were those which were existent at the time of application for employment. If, however, an employee sustained an occupational injury by which he was incapacitated to some degree but retained

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(Par. 4-3a(1))

a high percentage of his working ability, the Medical Division recommended that he be placed on "guided work". Any employee who was given guided work was allowed to work nine hours a day for five days a week, with Saturday and Sunday as specified rest periods. The work given the employee was dependent upon the severity of the injury. The guided work policy was another means of conserving manpower, and acted as an incentive to the employee to recover his total ability to return to his regular job.

(f) Organization. - The Medical Division was organized on 21 March 1943, under the direction and control of the prime contractor, E. I. du Pont de Nemours & Company, Inc. Under the supervision of Dr. J. M. Wetherhold, an office was established in the Gray Building in Pasco, Washington. The staff comprised two doctors and a nurse. No x-ray or laboratory work could be performed at this office and, consequently, these procedures were carried out in the Lady of Lourdes Hospital in Pasco. With the shift of the medical facilities to the construction site at Hanford, the medical staff expanded to keep pace with the increasing demand, until, in June 1944, ~~the staff had developed~~ developed into a force of 372 people (29 supervisors and assistant supervisors, 31 physicians, 165 nurses, 10 technicians, 4 dieticians and 133 aides and orderlies). The peak demand on medical service during the construction phase occurred during the summer of 1944, near the end of the construction work. Following this period, the major medical facilities were shifted to Richland. On 10 February 1945 the Out-patient Clinic was closed, and, on 15 February 1945, the last patients in the hospital were transferred to Richland.

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(g) Statistics. - From March 1943 until the

close of the construction phase, the medical operating statistics were as follows:

<u>Period</u>	<u>Doctors</u>	<u>Nurses</u>	<u>Pre-Employment</u>	<u>First Aid</u>	<u>Out-Pat. Treatments</u>	<u>Hospital Pat. Days</u>
<u>1943</u>						
March	1	0	108	-	-	-
April	3	2	1,070	560	-	-
May	4	6	1,661	2,983	-	-
June	5	10	1,961	4,329	-	-
July	7	15	3,124	6,933	-	-
August	9	22	3,303	7,147	-	-
September	13	30	2,720	6,812	1,388	630
October	14	47	3,594	7,916	1,824	940
November	16	53	5,585	12,465	1,838	1,606
December	18	79	6,732	15,145	2,326	3,732
<u>1944</u>						
January	21	95	5,591	19,869	2,802	7,113
February	21	105	5,247	18,775	2,861	6,078
March	21	111	7,280	22,688	3,213	5,591
April	24	117	6,716	22,017	2,911	7,309
May	27	130	9,489	27,759	3,450	7,178
June	35	150	8,182	31,224	3,427	5,875
July	38	160	6,189	30,753	3,339	6,057
August	35	157	4,536	30,621	3,740	5,128
September	34	159	3,938	25,685	3,201	5,017
October	32	143	2,319	21,707	3,756	5,687
November	27	122	855	14,320	2,602	4,736

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service. This unit handled requests for medical service at barracks or trailers. Upon receipt of such requests a nurse was dispatched to the patient. It was the duty of this nurse to determine whether the patient required hospitalization, the services of a physician, or first-aid treatment by the nurse.

(4) The Cost. - The expense entailed in constructing and operating medical facilities at Hanford during the construction phase is indicated below.

(a) Cost of Hospital Buildings

1. <u>Hospital</u>	\$ 434,000	
2. <u>Convalescent &amp; Isolation Ward &amp; Public Health</u>	512,700	\$ 946,700

(b) Cost of Hospital Equipment 237,000

(c) Operating Cost - Medical Facilities

1. <u>Labor</u>	\$1,734,000	
2. <u>Material</u>	310,000	<u>2,044,000</u>
	Total	\$3,227,700

Operating Deficit

Operating Cost	\$2,044,000	
Less revenue	258,000	
Less expendable supplies transferred out	<u>62,000</u>	\$1,724,000

b. Operations Phase.

(1) The Medical Program.

(a) Community Needs. - In the establishment of the medical program for the village of Richland, it was determined

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that it would be necessary to provide facilities for complete medical care of all residents of Richland who were dependent on the Hanford Engineer Works either directly or indirectly, for both occupational and non-occupational illnesses and injuries. The isolation of the project, from centers of population with established medical facilities of sufficient capacity to render the required medical service, was the determining factor in this decision as it was at Hanford. It was also decided that the medical facilities provided at Hanford for construction personnel should not be used after the start of operations, as the plant hazards, as determined by the pilot plant, indicated that this construction village should be completely evacuated. To provide the required medical facilities for an estimated population of 15,000 persons, the construction of a 75-bed hospital was authorized. This was located at Richland, 30 miles from the boundry of the operating area. The ratio of 5 beds per thousand population, although higher than the national average, was necessary because of the isolation of the village and the high percentage of dormitory-housed workers, and because normal hospital patient population ratios cannot be applied safely to a population as small as 15,000. Shortly after the hospital was placed in operation, it became evident that even though the capacity was adequate for general needs, the estimate was low for obstetrical cases and also for out-patient facilities. To provide additional facilities, a wing was added to the Obstetrical Section and a separate building was constructed to house the Dental Section and the Out-patient Department. Two housing units were provided to be used as isolation wards for the care of contagious diseases.

(b) Policy. - The operations medical organization was made up of two major divisions, one concerned with village health and the other with industrial medical care. This latter division is discussed under Par. 3-12e(1). It was felt that the specialties, including obstetrics, pediatrics, surgery, internal medicine, eye, ear, nose and throat, should be maintained as such and that specialists in these fields should be procured to head each specialty. In this way better service could be offered than if a type of general practice was instituted. Definite requirements were stipulated for the professional members of the staff. All employees of the Medical Department, including physicians, were remunerated for their services entirely by salary. The policy of free choice of physician by the patient was maintained in so far as the physician's time permitted. Fees and charges were, in general, based upon Washington State compensation fees. However, the usual charges in the neighboring villages and communities also were considered in reaching an approved fee schedule for Richland. Fees charged for medical care were somewhat lower than those usually charged for the specialized services offered, because it was agreed that good medical care at low expense was an inducement in procuring personnel and in reducing labor turnover. A medical prepayment plan was given consideration but discarded in favor of a wage deduction postpayment system for contractor's employees. Military personnel were furnished medical and dental care in accordance with Army regulations.

(c) Type of Medical Service Rendered. - For a short period, from March 1944 until 20 May 1944, the medical care of

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the residents of Richland was provided by physicians from the Construction Section. Non-industrial patients were charged a regular fee for service, with the physicians being given the privilege of retaining the fees collected. On 20 May 1944, however, because of the unsatisfactory condition of medical care due largely to the attention of the physicians to the pay patients, and because of the dissatisfaction arising from the reimbursement of physicians on a part salary and part fee-for-service basis, it was decided to take over the medical care of the village residents at this time rather than wait until the previously planned date of 1 August 1944. Because of this sudden change in plan, medical routines and procedures were informal and were modified as necessary to carry the load. Because of the excessive work load at this time, practically all medical care was on an emergency basis. To avoid confusion, a policy was adopted that plant injuries only, or very minor personal illnesses or injuries, would be treated without charge by the first-aid station. All other patients were referred to the clinic and were charged for medical care. Gradually procedures were developed by which the patient came to the clinic only with a prior appointment, except in case of emergency. In November 1944 the out-patient facilities became over-crowded and a separate building was constructed. This building housed the Medical and Dental Out-patient Departments and was ready for use in January 1945. After full operation of the village hospital was realized, specialty services such as surgery, pediatrics, obstetrics, internal medicine, eye, ear, nose and throat were a regular part of the medical service offered to patients both in the hospital and in the out-patient clinics.

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Adequate laboratory and x-ray facilities were available for both in-patient and out-patient clinics.

(d) Organization. - The medical service at Richland was administered by the Medical Department of the contractor, E. I. du Pont de Nemours & Company, Inc. The Medical Department was under the direction of the Medical Superintendent, Dr. W. D. Norwood, who in turn was responsible to the Assistant Plant Manager. The staff, on the opening of the village medical service in late May 1944, consisted of 2 doctors and 12 nurses. As the construction phase declined, physicians were shifted from Hanford to Richland. Formal offers to applicants and processing of personnel for the staff were performed as a routine procedure of the company Employment Department. Selection of prospective members of the Professional staff was made by medical personnel of the Hanford Engineer Works, with approval by the Medical Superintendent. In some instances, the Wilmington Office of E. I. du Pont de Nemours & Company, Inc., directed the employment or transfer of individuals for the medical staff. By July 1945, the medical service had developed into a staff of 366 employees, consisting of 14 physicians, 78 nurses, and 274 other employees such as orderlies, aides, janitors, etc.

(e) Statistics. - From June 1944 until June 1946, the medical operating statistics were as follows:

<u>Period</u>	<u>Doctors</u>	<u>Nurses</u>	<u>Orderlies, Aides, etc.</u>	<u>Out-Pat. Treatment</u>	<u>Hospital Pat. Days</u>	<u>Total Population</u>
<u>1944</u>						
June	2	14	31	1,000	79	4,462
July	7	24	41	1,516	419	5,692

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<u>Period</u>	<u>Doctors</u>	<u>Nurses</u>	<u>Orderlies, Aides, etc.</u>	<u>Out-Pat. Treatment</u>	<u>Hospital Pat. Days</u>	<u>Total Population</u>
<u>1944</u>						
August	8	34	-	1,623	686	7,050
September	9	50	-	2,170	1,267	9,096
October	10	69	218	2,597	1,434	10,360
November	11	68	226	3,057	1,655	11,270
December	12	61	226	3,282	1,731	11,760
<u>1945</u>						
January	12	75	272	3,470	2,185	----
February	15	83	272	3,525	2,215	15,147
March	15	81	276	3,373	2,270	15,401
April	14	78	278	3,363	2,595	15,355
May	14	77	280	3,304	1,948	15,266
June	14	78	274	3,044	1,761	14,403
* July	12	51	31	3,746	1,996	14,167
* August	12	47	29	3,772	2,169	13,616
* September	11	51	33	3,596	2,119	13,218
October	11	47	36	2,815	1,871	13,098
November	11	49	37	3,439	1,863	13,113
December	11	51	40	3,278	1,546	13,126
<u>1946</u>						
January	11	53	37	3,852	2,038	13,178
February	11	53	36	3,882	2,301	13,234
March	11	54	36	3,675	1,641	13,194
April	11	57	33	4,095	1,918	13,113

\* As of end of month  
Balance as of midnight 25th of month

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<u>Period</u>	<u>Doctors</u>	<u>Nurses</u>	<u>Orderlies Aides etc.</u>	<u>Out-Pat. Treatment</u>	<u>Hospital Patient Days</u>	<u>Total Population</u>
<u>1946</u>						
May	11	54	35	3,895	1,917	13,021
June	11	53	34	3,660	1,859	12,761

(2) Dental Program. - The dental program at Richland was established in close association with the medical program. The first dentist arrived in June 1944 and provisions for emergency dental care were instituted. During June and July, emergency treatment was provided for approximately 250 persons. Regular dental service was first available in August 1944, with the arrival of additional personnel. Dental patients were free to choose their favorite dentists within the limits of their availability. The fees charged were comparable to those of the surrounding area. A daily record of work completed and income earned was maintained by each dentist for administrative purposes. However, no percentage or bonus was given for income earned in excess of his normal yearly salary. Operations of general practice were not standardized, each dentist being allowed to conduct his practice according to his ability, training, and judgment. The following table indicates the dental work load from June 1944 to June 1946.

<u>Period</u>	<u>Dentists</u>	<u>Number of Dental Patients</u>
<u>1944</u>		
June	1	(Approx. 250 cases
July	1	seen in this period)
August	2	384
September	2	525
October	3	844

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<u>Period</u>	<u>Dentists</u>	<u>Number of Dental Patients</u>
<u>1944</u>		
November	3	1,038
December	3	1,072
<u>1945</u>		
January	3	1,222
February	3	1,221
March	5	1,749
April	5	1,772
May	5	2,032
June	5	2,033
* July	7	2,007
* August	7	1,886
* September	7	1,674
October	6	1,855
November	5	1,382
December	4	1,222
<u>1946</u>		
January	6	1,218
February	7	1,646
March	8	1,766
April	8	1,864
May	8	1,669
June	7	1,610

\* As of end of month  
Balance as of midnight 25th of month

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(3) Public Health Program. - The Public Health Section of the Construction Medical Department had gradually shifted personnel to Richland on a loan basis, as the need for such service shifted from Hanford to Richland. On 15 January 1945, this unit was completely transferred to the Operations Medical Department. The personnel transferred included a supervisor of public health, a nursing supervisor, seven public health nurses, one health educator, three sanitarians, and two clerical assistants. The functions of this unit were comparable to those of the Public Health Department of a city of similar size. Tuberculosis, venereal disease, and maternity clinics were maintained for the protection of the project personnel. Periodic sanitary inspections were made of all cafeterias, canteens, cafes, dormitories, barracks, and food stores. A public health nursing service, including infant and pre-school, school, adult, and industrial hygiene, and morbidity and crippled childrens' services, was established. Milk, water, and food inspections were made periodically. The Sanitary Section maintained supervision of sewage disposal, malaria and pest control and water analysis. No charges were made for services rendered by the Public Health Department, as these services were primarily for the benefit and protection of the project as a whole.

(4) Emergency Disaster Program. - A medical preparedness program was established, in conjunction with the industrial medical groups, for operation in cases of a major disaster which required medical participation. The overall direction of this program was assumed by Mr. Newton Stapleton. However, definite emergency assignments were given all medical personnel and emergency field units were organized.

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Special provisions were made to evacuate the plant areas and Richland Village if an emergency arose requiring these drastic procedures.

(5) The Cost. - Following is an estimate of the cost of providing medical and related facilities and care for Richland Village thru June 1946.

(a) Permanent Medical Facilities

1. Hospital building \$615,000

2. Professional Building 110,000

Total \$ 725,000

(b) Operating Cost thru June 1946 3,394,758

Total Medical Cost 4,119,758

(c) Revenue 813,599

Total Net Medical Cost 3,306,159

(d) Breakdown of Operating Medical Costs and

Revenue.

	<u>Gross Expense</u>	<u>Non Industrial Revenue</u>	<u>Net Expense</u>
Dental Dept.	\$ 137,478.90	\$130,474.94	\$ 7,003.96
Pharmacy	64,648.22	62,529.85	2,118.37
Utilities (water, fire, elect, etc)	84,186.43		84,186.43
Public Health	1,857,362.93		1,857,362.93
Industrial			
Medical and Hospital Expense	1,251,081.47	620,594.31	630,487.16
<b>TOTAL</b>	<b>\$3,394,757.95</b>	<b>\$813,599.10</b>	<b>\$2,581,158.85</b>

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SECTION 5 - BIOLOGIC AND HEALTH PHYSICS RESEARCH

5-1 General. The origin and growth of the research section came as a natural development of the rapid progress of physical research. Before the responsibilities of the project were assumed by the Office of Scientific Research and Development, research carried out in isolated physical experiments concerning isolation and utilization of uranium 235 was on a very small scale and, in reality, constituted no medical hazard. However, as the physical phases developed, it became apparent that hazards due to radiation, from the parent substance, uranium, and its natural and artificial disintegration products, including radium and the fission products, could be extremely injurious to the human body. Experience had previously accumulated to show that long-lasting detrimental effects, and occasional fatalities, could occur, following indiscreet use of radium or x-rays, through either ignorance or neglect. This concept was apparent to the directors of the individual projects and, with the grouping of the small units under OSRD, caused them sufficient concern to allocate a portion of the funds of the Chicago project to biological research, and development of methods of protection for both research and production employees. The cooperation between the medical and physical research sections, even at this early date, resulted in the accumulation of much valuable data. With the continuing success of physical and chemical research, the general scope of the project expanded rapidly. The responsibility for overall supervision of the project was assumed by the Manhattan District in 1942. With this consolidation of all facilities, it became necessary to organize a medical section to supervise the medical research and health protection for the entire project.

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5-2 Purpose of Research Program. - The hazard problems, which accompanied the growth and development of the Manhattan District into a gigantic industrial enterprise, have been reviewed in Section 2 of this Volume. The primary concern of the research section was to investigate the potential damaging effects of the uranium and other radioactive compounds used, from radiation or chemical toxicity or both, and to establish firmly the maximum doses of the various radiations which could be received safely by project employees. In addition, the toxicity of certain special materials, which had had no previous industrial use, had to be determined. This knowledge was sought in order that effective protective measures might be incorporated in the design and operating practices of the plants. It was necessary, also, to attempt to develop effective methods of treating toxic reactions which might be encountered in persons working with these materials.

5-3. Radiation Research.

a. General. - The need for medical research on the hazards of the Manhattan District program was first realized by the University of Chicago group, whose research was on the pile process, for the transformation and isolation of the transuranic element, plutonium (239). (See Par. 3-12). The pile reaction produces a tremendous discharge of particles or energies of all types of radiation (alpha, beta particles and gamma rays, and fast and slow neutron radiation). All of these radiations cause reaction on entering living tissue. Consequently, it was important to study biological effects of all types of radiation to determine the allowable exposures to radiation arising both from an external source and from material taken into the body.

b. X-ray and Gamma Radiation.

(1) Knowledge Available. - There were considerable data on the biological effects of x-ray and gamma rays existing prior to the Manhattan District operation. However, most of this information concerned lethal or sublethal doses and, although "tolerance" levels had been set, the information on which these levels were based was quite sketchy.

(2) Research Required. - It was determined, therefore, that a program should be instituted to establish firmly the "tolerance" or "maximal allowable dose" for chronic exposures. In addition, it was considered advisable to establish beyond question the comparative effectiveness of gamma rays and x-rays (known to be quite similar) and of x-rays of different voltages.

(3) Research Program Instituted. - The research instituted to investigate these points consisted primarily of daily exposure of groups of animals of various species to gamma rays and to x-rays of different voltages, each group of animals receiving a different level of exposure. In addition, exposures to single larger doses of these radiations were made, to study the acute effects produced. The animals in all of these experiments were carefully and regularly examined, using their growth and general appearance as a guide to the state of health. Special tests were also performed, including blood counts, urinalyses, chemical examinations of the blood and certain other tests in selected cases. All experiments were carefully controlled. At death or at the end of the experiment post-mortem examinations were made. To determine the effect of these radiations on genetics, special experiments were initiated to study the occurrence of mutations in fruit flies, and the effects of radiation on the breeding of mice. Other experi-



ments were carried out to determine the biological effect of certain doses of x-ray on fish of various sizes from the egg stage through the various developmental stages to adult fish (App. B5). Attempts have been made also to find better tests of radiation damage and to devise effective methods of treatment.

(4) Institutions. - The Metallurgical Laboratory of the University of Chicago performed some of the acute radiation exposure and delegated to the National Cancer Institute at Bethesda, Md., a comparative study of exposures of animals to x-rays and gamma rays from radium, at different dosage levels, given daily over an <sup>8</sup> hour period and continuing for specified periods of time. Another program, designed to study the effects of exposure to x-rays from voltage sources of 250,000 and 1,000,000 volts, at various dosage levels, given in a period of a few minutes each day, was instituted at the University of Rochester (See Par. 5-7). The genetics study on fruit flies and the mouse breeding experiments also were done there. The fish study was delegated to the University of Washington, Seattle, Washington. Tests for damage and treatment methods have been investigated at both the University of Rochester and the University of Chicago.

(5) Results. - During the year <sup>July</sup> 1945 to June 1946 enough data has been accumulated <sup>to confirm</sup> which ~~again confirmed~~ the advisability of the tolerance level selected. The various institutions are in the process of preparing monograms dealing with their experimental work.

c. Neutron Radiation.

(1) Knowledge Available. - Before the Manhattan District

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project was initiated, sketchy information had been accumulated on the biological effect of fast neutrons, largely from the treatment of a few cancer patients with this type of radiation.

(2) Research Required. - However, very little data was available concerning the effect of neutrons on the health of individuals or concerning the comparative effectiveness of neutrons and x-ray or gamma radiation.

(3) Research Program Instituted. - Programs which paralleled the x-ray and gamma radiation research were set up also for neutron exposures. These investigations were planned and conducted in such a way that comparison could be made with the x-ray and gamma radiation research. Careful studies of the animals were carried on as in the x-ray and gamma ray experiments.

(4) Institutions. - The Cancer Research Laboratory of Columbia University did a series of experiments in which groups of mice were exposed to a daily dose of fast neutrons, each group receiving a different dosage level. A similar set of experiments, using dogs instead of mice, was carried on at the Biological Foundation of the Franklin Institute, Newark, Delaware. Additional experiments on the metabolic effects of neutron exposures were carried out at Clinton Laboratories, Oak Ridge, Tenn.

(5) Results. - Although all of these experiments are continuing, it has been established that neutron radiation produces essentially the same effect as x-ray and gamma radiation (See App. B6). Further, it has been demonstrated that when neutrons are measured by instruments used for measuring x-rays and gamma rays, a given unit of neutron radiation is about 7-8



subject was performed at the University of Rochester.

(5) Results. - This research is continuing, but has demonstrated already that the maximum allowable tolerance figures for beta radiation to the skin are conservative and unquestionably safe (See App. B4 & B6). It has been proved also that the lethal dose of beta radiation delivered externally is far greater than the lethal dose of x-ray or gamma radiation (See App. B4 & B6). The experimental results during the 1945-1946 period were again strongly confirmative of the above statements.

e. Alpha Radiation. - When alpha radiation arises from a source outside the body, it has such limited penetrating power that it is unable to produce either systemic or skin effects. Consequently, no investigation of this type was undertaken.

f. Mixed Radiation. - In the operation of the pile process, there exists the possibility of individuals being exposed to more than one type of radiation. Experiments were instituted at Clinton Laboratories whereby animals were kept in various parts of the operating areas in which they would be exposed primarily to neutron and beta radiation. These animals were carefully observed to detect harmful effects. None was found in spite of the fact that the animals lived 24 hours per day, for as long as more than a year, in the more hazardous locations of the plant, areas in which workmen did not spend more than a few minutes per day (See App. B4 & B6).

g. Instrument Research.

(1) General. - New instruments had to be developed in order to cope successfully with the radiation problems that arose in the course of Manhattan District operations. Certain instruments were required for use

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in the separation processes; others were needed for health protection. The latter (as indicated in Section 2) were based on well known principles of radiation physics, and the chief contributions of the Instrument Research group were in developing appropriate ranges of sensitivity, designing portable models, and making other modifications which adapted the instruments to the specific needs of the operations. In addition, special instruments were developed for measuring the content of various radioactive substances in air.

(2) Institutions.

(a) University of Chicago. - The Instrument Section of the University of Chicago group designed delicate electronic indicators for various types of radiation, and adapted such apparatus to the conditions necessary for either analytical work or monitoring. This Section also produced a large number of instruments for other areas, and designed and constructed instruments for determining the content of radioactive substances in air (See App. B4).

(b) Clinton Laboratories. - The Clinton Laboratories organized a separate instrument section for the construction of instruments especially designed to meet the needs of the Clinton installation.

(c) University of Rochester. - The Rochester University group also assigned a group of men who devoted their time to instrument research and development. Standard alpha meters and all purpose meters for measuring alpha and beta particles and gamma rays were designed and constructed for other areas with hazard problems from radiation (See App. B6).

(d) Other Instrument Sections. - Both Columbia University and Hanford Engineer Works had Instrument Development Groups at

work on the design of instruments especially adapted to the specific problems of their respective operations.

5-4. Radioactive Substances - Hazard Research.

a. General. - During the year 1945 - 1946 metabolism experiments on polonium, plutonium and radium, using dosages expressed as micro curies per Kg., the short term lethal dose studies indicate that polonium is three times as toxic as plutonium and that plutonium is at least thirty times as toxic as radium. On the basis of relative energies of the alpha particles of these three substances, it is apparent that for radium and its daughters and plutonium, the energies per micro-curie are approximately equal. The reason for this is that the amount of radium lost from excretion is compensated by the retention of its daughter products. On the same basis, the polonium/plutonium comparison indicates that the former is approximately twice as toxic per unit of alpha ray energy dissipated in the body for 10 days, five times at 20 days and as high as ten times at the 30 day period. Biological explanation for these differences may be explained<sup>based</sup> on the distribution of these elements, the radium burying itself deep in the bone, the plutonium in the endosteal layers near the marrow and the polonium in the hematopoietic and lymphatic tissues themselves. The 6-8 months studies of the comparative lethal dose tend to corroborate the above findings. Pathological findings indicate that radium shows an affinity for the hematopoietic system, vascular system, liver, kidney, bowel, bone, and testes with damage proportional to dose and time. Polonium shows an affinity for the hematopoietic system, bowel, and testes only with damage again probably proportional. Plutonium shows its affinity for the hematopoietic system,

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( liver, kidney, bowel, bone and testes. The changes observed with radium, although more widely distributed, are not <sup>so</sup> ~~as~~ severe as those noted with polonium. An usual finding with radium is the development of far advanced arteriosclerosis of the aorta and larger arteries including the coronaries. Studies are being conducted on the injection of non-toxic amounts of plutonium, polonium, radium, uranium and possibly lead into human subjects in order to determine the excretion rates in the urine and feces of these substances. These studies are not ready to report at the present time. The information gained from such studies will be used in determining accurately the allowable doses as judged by excretions of these substances in the careful monitoring of plant personnel working with them. The urinary quotient will indicate the amount of harmful material present in the body at that unit time.

( b. Radium. - Although processing of this material was not a major activity of the Manhattan District, it was necessary to conduct animal studies with radium, to use this substance as a base line of comparison with the other comparatively new radioactive substances. The experimental work was undertaken at both the University of Rochester and the University of Chicago (See Par. 5-7).

c. Polonium. - Polonium (Radium F) was being produced in relatively large amounts (See Par 3-13) for the Manhattan District. A careful survey of the medical literature revealed that the information on its toxicity was very sketchy and of doubtful accuracy. Accordingly, a program was established at the University of Rochester to provide the information required. These experiments followed the plan indicated in Par. 5-4, a., and from them it was possible to arrive at a "tolerance value"

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for both deposition and urinary excretion (See Par. 2-4, d and e). These findings, plus a fairly simple quantitative method of measuring urinary polonium, resulted in an effective, relatively simple means of monitoring personnel. The injury produced by large doses of this material is primarily to the kidneys and the blood-forming organs. Investigations are continuing and have served to corroborate the preliminary estimates of "tolerance" for urinary excretion. "Tolerance" figures have also been calculated for polonium in air, but are of considerably less value, because the amount of absorption through the lung has to be estimated.

d. Plutonium. - The University of Chicago carried out most of the research on the metabolism of plutonium (239) and its toxic effects on the animal organism. It was suspected that this material might behave in some fashion similar to radium and, therefore, parallel studies were made on radium for purposes of comparison. The Crocker Radiation Laboratory of the University of California was enlisted to carry out part of the experimental work on plutonium. Plutonium (239) was made in the cyclotron at the University of California in trace amounts and used in metabolic experiments (See App. B4). The relative effects of plutonium alone or in combination with other substances were compared. The results of these experiments with tracer amounts of plutonium were used as pilot experiments, for establishing the type of experimental work to be done by the Biological Section of the Chicago group, when larger amounts of plutonium became available. The work at the Crocker Radiation Laboratory also included work carried out on soils of various geologic types which were artificially contaminated with plutonium (239) (See App. B4). Tests were made to determine the effect of the contamination on grow-



ing plants and to estimate the efficacy of various methods of decontamination in removing such materials from the soil. Another phase included work on methods of removal of absorbed plutonium from the animal body (See App. B4). In addition, certain chemical experiments were carried out by this group in developing new methods useful in their work (See App. B4).

Results to date would indicate that plutonium after absorption may be one tenth or one fiftieth as dangerous as radium. "Tolerance" figures for body deposition, air content, etc. have been developed by taking the most conservative assumptions, with the result that in this work great effort was expended to keep contact down to extremely small amounts. Recent work on a method of measuring urinary excretion is promising and it appears likely that it soon may have practical application.

e. Fission Products. - The experimental work on these radioactive products was carried out by the University of Chicago group of investigators and by the Crocker Radiation Laboratory of the University of California. In the pile process, a number of radioactive breakdown products of uranium are formed, and in the chemical separation of plutonium these substances could be hazardous. These fission products are formed by actual splitting of uranium or plutonium atoms into two portions of unequal size. Since they are radioactive, there is the double problem of acute toxicity and the chronic effect of the radiation produced by material deposited in the body. These problems also required investigation, and experiments were planned to carry them out. At first, none of the calculated fission products was available and they were made for the project by the group working with the 60-inch cyclotron at the Crocker Radiation Laboratory. The scope of the work on fission products

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included: determination of poisonous or toxic levels on various species of animals; study of acute and chronic poisoning after exposure to fission products by feeding, breathing, and introduction of the substance mechanically into the blood stream or tissue spaces of the body; the effects on the various organs of the body after each type of exposure; and the rates of elimination of substances from the body. Methods for removal of these substances from the body were investigated (See App. B 4). The Crocker Radiation Laboratory of the University of California also carried out work on fission products (See App. B 4). The metabolism of the fission products in animals was studied, and the effect of artificial contamination of soils of various geologic types with fission products was investigated. Tests were made on plants grown on such soils, and methods of decontamination to remove such materials from the soil were studied. Another phase of the problem dealt with methods of increasing the elimination of these substances from the animal body. The University of Washington also carried out some work to determine the effect of stream pollution by water from the pile, on fish native to the Columbia River. Fish were raised in tanks fed by various concentrations of the effluent from the piles (which contained minute amounts of fission products) and observations were made. Insufficient time has elapsed to form any conclusions from this study. During the period of 1945-1946 the fish program has continued and the results are being compiled for a comprehensive report. The plan of work is as follows: 1.) follow-up of the present experiments extending thru 1948; 2.) continuation of the exposures to chemical materials and also observations of possible effect in the Columbia River; 3.) completion of the histological studies already in

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progress on fishes damaged by the variety of x-ray dosages.

f. Uranium. - During the period of July 1945 to June 1946 a variety of animal species were exposed to the dusts of five uranium compounds,  $UF_6$ ,  $UO_2$ ,  $UCl_4$ ,  $UF_4$  and  $UO_2(NO_3)_2$ . These compounds were selected because the greatest number of employees were exposed to these substances.  $UO_2(NO_3)_2$  was included in the above list because of the necessity of a base line of comparison with data available in the scientific literature. (Most of the animal experimental work done prior to the Manhattan Project was done with  $UO_2(NO_3)_2$ .) Two concentrations of dusts were used in the experimental chambers. One dust level was selected because it was thought that it would produce no toxic effects, and the other level (approximately ten times <sup>as great</sup> ~~greater~~) was chosen because it would probably cause minimal toxic effects. In this manner, the probable maximum safe level of dust concentration would be established. The experimental results thus far indicate that the established tolerance level allows a maximum factor of safety to the people who work with these compounds. Additional important work consisted in the development of accurate methods for the measurement of the particle size of uranium compounds in the air. These techniques are used in the control of the concentrations of the uranium compounds in the experimental inhalation chambers, and in the monitoring of the concentrations of such compounds in industrial areas where humans are exposed. Techniques for the fractionation of the particles of uranium compounds into lots of uniform size have been developed. In this way exposure of experimental animals to particles of known size can be determined. Preliminary data indicates that the small particles are most toxic.

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5-5. Substances of Potential Chemical Toxicity. - The special materials which were developed for use in the processing of uranium compounds constituted potential medical hazards, since, like uranium, very little was known concerning their toxicity for the human body. The most important of these substances were elemental fluorine and various compounds manufactured by reacting fluorine with hydrocarbons (fluorocarbons -  $C_7F_{16}$ ,  $C_8F_{16}$ ,  $C_{21}F_{44}$ ). The toxicity of these substances was tested by an experimental program similar to that used by the Toxicology Division of the U. S. Public Health Laboratories. Protective devices were tested and recommended for installations requiring their use (See App. B 6). The work on these special substances was carried out by the Pharmacology Division of the University of Rochester. No additional substances in this category were tested in the year 1945-46.

5-6. Industrial Research.

a. General. - The industrial application of results of the research program is described elsewhere in this volume (Section 3 Industrial Medicine). In conducting the Industrial Medical activities it was necessary to do certain non-medical research primarily concerned with hazard control.

(1) University of Chicago. - The Chicago group studied methods of monitoring and developed methods of using x-ray film and ionization chambers to determine the amount of radiation existing around working areas. Ventilation systems were studied and working areas were designed to offer the maximum protection. By use of the data developed by the workers in this research group and the animal research group, measures were instituted to cover all likely possibilities of exposure and

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to safeguard the workers in all cases.

(2) Clinton Laboratories. - The Clinton group had an industrial research section similar to the one at Chicago. This group assumed responsibility for the medical supervision and protection of all workers at Clinton Laboratories, both by monitoring the plant and making physical and laboratory studies of the workers at frequent regular intervals.

(3) The University of Rochester. - The University of Rochester also had an industrial research section. Film and instrument monitoring methods and protective devices were developed, for the protection of the workers exposed to uranium and other special materials (See App. B 6). Actual monitoring of the plant areas, under the supervision of the District Medical Section, was done to detect dangerous amounts of radioactive substances. Consultant service was provided, for the determination of the extent of the radioactive hazard in the individual industry.

5-7. Reports on Research Activities. - The various research sections kept in close contact with the Office of the Medical Section through the medium of progress reports. The Chicago, Clinton Laboratories, University of California, and National Cancer Institute reports are filed with the District and are designated as the CR and CN reports. The University of Rochester and Biological Foundation reports are also filed in the Office of the Medical Section and are designated as M reports. The reports from the University of Washington are filed in the same office and are designated as Fish Program Reports and Charts.

5-8. Organization.

a. Manhattan District Personnel. - The District Engineer was required to approve all contracts of the Manhattan District, including

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(Par. 5-8(a))

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those for medical research. The Chief of the Medical Section, Colonel Stafford L. Warren, acted in a staff capacity to the District Engineer, to provide information on the District requirements for biological research and to report the progress of the program. Colonel Warren organized, supervised, and integrated the medical research program. In this task he was aided by Lt. Col. H. L. Friedell. In March 1945, Lt. Col. Friedell was appointed Head of the Division of Biological and Health Physics Research of the Medical Section. Capt. J. W. Howland was selected as Assistant Division Head, and, with Capt. David Goldring, acted as liaison officer to the research organizations. The relationship of the Division of Biological and Health Physics Research to the civilian research agencies is illustrated in the attached chart (See App. C 22).

b. University of Chicago. - The Health Program of the Metallurgical Laboratory of the University of Chicago was directed by Dr. Robert S. Stone, formerly professor of radiology at the Medical School of the University of California. Dr. Stone joined the Metallurgical Project as Associate Project Director for Health, in June 1942. He was charged with the responsibility of protecting the health of all of the individuals engaged in the pile process. To discharge this obligation he was required to procure the necessary personnel, to set up safety standards and safe-operating procedures for the pile process, and to plan and supervise the research necessary to insure intelligent formulation of the standards of health protection. Dr. Leon Jacobson, a member of the staff of the University of Chicago Clinics, had been assigned previously the task of clinical care of project employees, first as a consultant in January 1942 and later as an assistant (November 1942) in that capacity with

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Dr. Stone. Dr. Simeon T. Cantril, previously Director of the Radiological Department of Swedish Hospital, Seattle, Washington, became Dr. Stone's assistant in August 1942, and, with Dr. H. M. Parker, an expert in radiation dosimetry, instituted the industrial hazards section, charged specifically with the responsibility of instituting safe-operating practices for radiation and radioactive substances (Both Dr. Cantril and Dr. Parker were transferred to Clinton Laboratories in August 1943, to head the Health Program and Instrument Section respectively). Dr. E. W. Wollan, Assistant Professor of Physics, University of Chicago, aided in the development of monitoring instruments and in the design of the shielding required by operation of the pile. After Dr. Cantril left the staff, Dr. L. O. Jacobson became assistant to Dr. Stone. The activities of the organization were divided into the following groups, headed by the persons listed:

- 1) Clinical Medicine - Dr. L. O. Jacobson
- 2) Biological Research - Dr. K. S. Cole
- 3) Industrial Hazards - Dr. J. J. Nickson

Dr. Cole had been Associate Professor of Physiology, College of Physicians and Surgeons, Columbia University, and performed experiments on toxicology of radioactive substances. He was assisted in this work by Dr. R. E. Zirkle, Professor of Botany, University of Indiana, Dr. C. L. Prosser, Assistant Professor of Zoology, University of Illinois, and Dr. A. M. Brues, Associate Physician, Huntington Memorial Hospital, Boston, Mass. Dr. Albert Tannenbaum, of the research staff of Michael Reese Hospital, Chicago, Illinois, performed the feeding experiments to determine the toxicity of uranium compounds for mice. The Industrial Hazards Section, after Dr. Cantril's departure, was headed by Dr. J. J. Nickson (serving directly

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(Par. 5-8(b))

under Dr. Jacobson) who was assisted by Mr. John E. Rose. Assisting in the Section on Clinton Medicine were Dr. Samuel Schwartz, who was in charge of biochemistry, and Dr. E. S. G. Barron, Associate Professor of Medicine, University of Chicago, who directed studies of enzyme Chemistry. The Pathology Section was headed by Dr. William Bloom, Professor and chairman of the Department of Anatomy, at the University of Chicago. Dr. Bloom was assisted by Dr. Herman Lesco. Dr. G. Failla, Professor of Radiology and Director of the Radiological Research Laboratory, College of Physicians and Surgeons, Columbia University, Dr. W. H. Talliaferro, Dean, Division of Biological Sciences, University of Chicago, and Dr. J. Watson, Professor and Head of the Department of Medicine, University of Minnesota, acted as consultants to the project. The organization grew in size as the research program expanded, until approximately 215 persons were employed at the period of greatest activity. This does not include the 90 people employed in the clinical group. Not included in this total are persons in the Instrument Section who worked full or part time on the development and maintenance of instruments required by the Health Program.

c. Clinton Laboratories. - The health program at Clinton Laboratories, under the supervision of Dr. R.S. Stone, was directed by Dr. Simeon Cantril, from its inception in July 1943 to September 1944. He was replaced at this time by <sup>Dr.</sup> John Wirth, who had been previously at the National Cancer Institute. Dr. Wirth, in addition to his duties as director, supervised the clinical medicine section of Clinton Laboratories. Dr. H. J. Curtis, formerly Assistant Professor of Physiology, College Physicians and Surgeons, of Columbia University, was in charge of biological research. Dr. K. Z. Morgan, previously a research physicist

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(Par. 5-8(c))

at the University of Chicago, was in charge of the instrument section. At the peak of employment, a total of approximately 100 persons were employed by the Clinton Laboratories Health program.

d. The University of Rochester. - The Biological and Health Physics Research project of the University of Rochester was inaugurated in April 1943, with Dr. Stafford L. Warren, Chairman of the Department of Radiology, in charge. He organized and supervised the project, which was divided into the following major sections, headed by the individuals listed:

- 1) Radiology - Dr. Andrew H. Dowdy.
- 2) Pharmacology - Dr. Harold Hodge.
- 3) Instruments and Special Problems - Dr. William F. Bale.

All of these men were members of the staff of the University of Rochester at the start of the project. Dr. Dowdy was associate professor of radiology, Dr. Hodge was associate professor of biochemistry and pharmacology, and Dr. Bale was associate in radiology. As Dr. Warren became more and more concerned with activities of the Manhattan District, Dr. Dowdy became assistant director and, in November 1943, was appointed director. He continued to supervise the radiology section, until Dr. Robert Boche (Research Fellow University of Pennsylvania Medical School) was added to the staff, in the spring of 1944, to head the department. Dr. Dowdy was assisted in the administration of the project by Mr. Maury Wantman, who also was in charge of the statistics section. Other individuals who supervised research groups included:

(a) Dr. George Boyd - - Head of Cyclotron and Nuclear Research Department, Biochemical Research Foundation, Newark, Del., in charge of

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special studies of the toxicity of certain radioactive substances.

(b) Capt. Fred Bryan - - Formerly instructor in the School of Medicine and Dentistry, University of Rochester, in charge of hematology (subsequently replaced by Dr. George Suter, also instructor in Medicine, at the University of Rochester).

(c) Dr. Alexander Dounce - - Instructor in Biochemistry at the University of Rochester, who was responsible for enzyme chemistry.

(d) Dr. Francis Haven - - Associate in Biochemistry at the University of Rochester, who was in charge of the mechanism group.

(e) Capt. Roger Metcalf - - Who was responsible for the pathology of the experimental work.

(f) Dr. L. T. Steadman - - Associate in Radiology at the University of Rochester, in charge of spectrochemistry.

(g) Dr. Herbert E. Stokinger - - Immunochemist, University of Rochester, who was responsible for supervision of inhalation experiments.

(h) Mr. David Tiedemann - - Who replaced Mr. Wantman as head of the statistical section.

(i) Capt. Paul Rekers - - Conducted special hematological research in radiation exposures.

(j) Capt. William Valentine - - Conducted similar hematological research in radiation exposures as Capt. Paul Rekers.

(k) Dr. Carl Voegtlin - - Retired Chief of the National Cancer Institute, an authority on toxicology, served as full time consultant to the pharmacology section.

Other part-time consultants to this section included:

(l) Dr. H. H. Schrenk - - Associate Toxicologist of the Bureau

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of mines.

(m) Dr. J. F. Treon - - Instructor in Toxicology, Kettering Laboratory of Applied Physiology, Cincinnati, Ohio.

As the research program expanded, especially trained individuals were added to the staff until a peak of approximately 380 persons was reached.

e. University of California. - The medical research program at Berkeley was under the direction of Dr. Joseph G. Hamilton, Assistant Professor of Medicine and Radiology, Radiation Laboratory, University of California. Dr. Hamilton was assisted by Dr. Louis Jacobson, Dr. Ray Overstreet and Dr. Kenneth S. Scott. The program was closely correlated with that of the University of Chicago. Approximately 16 persons were employed at the peak of operations.

f. National Cancer Institute. - The work at National Cancer Institute was under the direction of Dr. R. R. Spencer, Chief of the National Cancer Institute of the U. S. Public Health Service. He was assisted by Drs. E. Lorenz, A. B. Eschenbrenner, M. Deringer, W. E. Heston, and approximately 6 others.

g. Columbia University. - The research performed at Columbia University was integrated with the radiation program of the University of Rochester and was under the direction of Dr. G. Failla, Professor of Radiology and Director of Radiologic Research Laboratory, College of Physicians and Surgeons, Columbia University. He was assisted by Dr. T. C. Evans. Approximately 6 additional persons were employed on this project.

h. Biochemical Research Foundation. - The program of research at the Biochemical Research Foundation, Franklin Institute, Newark,

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(Par. 5-8(h))

Del., was directed by Dr. Ellice McDonald, Director of the Foundation. He was assisted in this work by Dr. Harold M. Terrell. Approximately 14 other persons were employed in the program.

i. University of Washington. - The fish program conducted by the University of Washington was headed by Dr. Lauren Donaldson, assisted by Mr. Richard Foster. Approximately 4 other individuals were employed in the performance of this experimental work. Mr. Hanford Thayer acted as CSRD consultant to the project.

j. The Cost. - In most cases the research projects in the foregoing paragraphs were carried out in areas where types of research other than medical were being performed. Because of this fact, costs for the medical research alone are not available, since all costs have been lumped into one sum for each project.

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SECTION 6 - ORGANIZATION

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8:00

6-1. General. - On 1 May 1943, all OSRD contracts pertaining to the development of atomic power, including associated biologic and health physics research programs, were transferred to the Manhattan District, and, to insure proper coordination and to avoid duplication, all research programs were made subject to the approval of the District Engineer. It was essential, therefore, that a well-qualified physician be procured to act in a staff capacity to the District Engineer. A survey of the leading medical authorities familiar with the special medical problems encountered in project operations revealed that Dr. Stafford L. Warren, Professor of the Department of Radiology, University of Rochester, Rochester, New York, was the best qualified physician available for the position. Accordingly, in March 1943, Dr. Warren was appointed consultant to the District Engineer and began the development of the organization required to discharge the responsibilities delegated to the Section (App. A1).

6-2. Officer Personnel. - The Medical Section of the Manhattan District. - The first medical officer attached to the District was Lt. Colonel, (then Captain) Hymer L. Friedell who was assigned as liaison officer to the Metallurgical Laboratory of the University of Chicago in August 1942. With the appointment of Dr. Warren as Consultant to the District Engineer, Lt. Colonel Friedell became his executive officer. In May 1943, Major (then Captain) John L. Ferry was added to the staff and was given the responsibility of supervising the industrial medical programs of District contractors and of acting as liaison officer to the research program at the University of Rochester. During the summer of

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1943, Charles E. Rea, M. D. (now Lt. Col.), Harry Pitluck, D. D. S., and the late William B. Holt, M. D., were procured from civil life to provide care for the community of Oak Ridge. Dr. Rea was appointed Chief of Clinical Services for the Area, Dr. Pitluck, Director of Dental Service, and Dr. Holt, Director of Medical Service. On 5 November 1943, Dr. Warren was commissioned a Colonel in the Army Medical Corps, A. U. S., and designated Chief of the Medical Section. His organization grew in size as operations of the District increased, until, on 1 July 1945, there were 72 medical, 3 dental, 3 medical administrative, 1 veterinary, and 1 sanitary corps officer assigned. There are charts to indicate, at intervals of six months, the growth of the organization, and the individual assignments within it (See App. C12). The activities of the Section were divided largely into three groups coordinated by the Section Chief and his Executive Officer:

- a. Biologic and Health Physics Research.
- b. Clinical Medicine and Dentistry.
- c. Industrial Medicine.

6-3. Qualifications. - The qualifications of officers assigned to the District are indicated on "personal history statements" (See App. B10).

6-4. Contractors' Medical Organizations. - The Section Heads of the major contractors medical organizations are indicated in Section 3 of this volume which describes the activities of those organizations.

6-5. Assistance from the Surgeon General's Office. - Arrangements were made, in September 1943, with the Surgeon General's Office (App. A4), to commission certain civilian medical personnel employed by the District, to obtain the additional medical department personnel required by the

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(Par. 6-5)

District, to make available the material procurement facilities of the Surgeon General's Office, and to use funds available to the Surgeon General for the medical and dental care of military personnel stationed at Manhattan District Projects at which there were facilities for providing medical and dental care. In the interests of security, Colonel Arthur B. Welsh was appointed by the Surgeon General as his liaison officer with the authority to approve requests from the Manhattan District. Further, the District Engineer and the medical officers under his control were not required to submit to the Surgeon General any reports which would reveal the nature, scope, or military importance of the project. (All of the reports of the work of the Manhattan District which ordinarily would have been forwarded to the Surgeon General were prepared and retained in the files of the Medical Section.) Finally, medical department personnel assigned, attached, or allotted to the Manhattan District would not be transferred to or from the control of the District Engineer without his prior approval. This measure was considered necessary to control the security of classified information and to maintain especially qualified personnel at their assigned tasks. The relationship with the Surgeon General functioned efficiently from its inception, and is continuing at the time this history is written. Lt. Col. Carl B. Sox replaced Colonel Welsh as Liaison Officer during the spring of 1945, but otherwise the relationship has continued unchanged.

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MANHATTAN DISTRICT HISTORY

BOOK I - GENERAL

VOLUME 7 - MEDICAL PROGRAM

APPENDIX A - DOCUMENTS

- | <u>No.</u> | <u>Title</u>  |
|------------|---|
| 1          | Responsibilities of the Medical Section. A letter from Colonel K. D. Nichols to Colonel S. L. Warren dated 10 August 1943.                            |
| 2          | Grant of Authority for the Oak Ridge Health Association.  |
| 3          | Hospital and Medical Facilities for Oak Ridge. A letter from Colonel S. L. Warren to Colonel K.D. Nichols dated 15 February 1944.                     |
| 4          | Medical Facilities, Manhattan District. A letter from Major Gen. L. R. Groves to The Commanding General, Army Service Forces dated 21 September 1943. |
| 5          | By-Laws of the Oak Ridge Hospital   |

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WAR DEPARTMENT  
UNITED STATES ENGINEER OFFICE  
MANHATTAN DISTRICT  
P. O. BOX 42  
STATION F  
NEW YORK, N. Y.

LT

AS

D-22-b

10 August 1943

IN REPLY  
REFER TO

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~~SECURITY INFORMATION~~

Subject: Responsibilities of the Medical Section

To: Dr. Stafford L. Warren, Chief, Medical Section

Reference is made to your communication of June 17 and subsequent conferences on the basic subject.

The functions and responsibilities of the Medical Section include the following:

1. To carry on or arrange for and to supervise or maintain liaison with such research work as is deemed necessary for carrying out the functions of the Medical Section. In this regard, however, all existing research agencies working on the health problems of the project should be utilized to their capacity and every effort should be made to have them do additional research work when required and to avoid duplication of effort.
2. To determine what health hazards are present in any of the operations of the Manhattan District.
3. To determine what protective measures should be taken to eliminate or protect against any specific health hazard of a serious nature.
4. To keep the various contractors and Area Engineers informed in regard to approved measures to be taken for the safeguarding of health.
5. To organize and operate a hospital, medical service, and dental service at the Clinton Engineer Works.
6. To confer with and to advise the Area Engineer and contractor at the Hanford Engineer Works and to determine that proper Hospital and Medical Services are established there.

It will be the responsibility of the Area Engineers involved to see that the approved or recommended protective health measures are put into effect by the contractors although the Medical Section will be expected to give assistance and cooperation in this matter by making periodic inspections to check on the working out in actual practice of the protective measures devised.

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~~SECURITY INFORMATION~~

AI

Dr. Stafford L. Warren

-2-

10 August 1943

The organization of the Medical Section and the personnel assignments are noted. The Section itself will be administered by:

Dr. Stafford L. Warren, Chief, Medical Section  
Dr. H. L. Friedell, Executive Officer, Medical Section

The assignment of Captain John Ferry to the Medical Section, Special Products, has been approved in a communication dated 8 August 1943.

The assignments of Dr. Charles Rea as Clinical Supervisor, Clinton Engineer Works, and Dr. William B. Holt as Chief, Hospital Service, Clinton Engineer Works, are hereby approved.

For the District Engineer:

*K. D. Nichols*

K. D. NICHOLS  
Colonel, Corps of Engineers  
Deputy District Engineer

cc: Area Engr., Hanford Engr. Wks., Pasco, Wash.  
Dep. Distr. Engr., Knoxville, Tenn.  
Area Engr., Chicago Area  
Area Engr., Wilmington Area  
Area Engr., California Area  
Area Engr., Columbia Area  
Area Engr., Murray Hill Area  
Area Engr., New York Area

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~~SECURITY INFORMATION~~

ARMY SERVICE FORCES  
UNITED STATES ENGINEER OFFICE  
Manhattan District  
Oak Ridge, Tennessee

In reply  
refer to EIDLE

13 October 1946

Subject: Grant of authority for the Oak Ridge Health Association

To: All Government and Operating Contractor Personnel

For the furtherance of its successful operation, an instrument of authority of the Clinton Engineer Works, to be known as the Oak Ridge Health Association, is hereby created and, subject to the conditions hereinafter set forth, it is authorized to establish, maintain, and operate a voluntary medical and hospital plan whereby medical and hospital services will be furnished to members and paid for by assessment. The plan is to promote the health of members by making it possible to secure prompt and early treatment of illness; and to promote, assist, and conduct scientific education and other activities for the benefit of the physical welfare of its membership. The Association shall be organized and operated subject to the following general conditions:

1. Membership shall be restricted to Government and operating contractors personnel at the Clinton Engineer Works and members of their immediate families (spouse and children under nineteen years of age) who reside at Oak Ridge, Tennessee. Membership shall be on a group basis, each group to consist of one of the aforementioned agencies, and each group shall be eligible for admission upon the subscription of at least seventy-five percent (75%) of its total personnel. The Association shall be operated on a non-profit basis and its subscription charges shall be used only to defray the operative and administrative expenses of the Association, including the establishment and maintenance of a reserve fund reasonably sufficient to provide for unforeseeable emergencies and for the liquidation of the obligations of the Association upon its dissolution, provided, however, that the amount of such reserve fund shall not be less than a sum equivalent to the aggregate of three dollars (\$3.00) per member in accordance with the total membership. The total surplus funds including the reserve fund may fluctuate between an aggregate of ten dollars (\$10.00) and three dollars (\$3.00) per member. If the surplus, including the reserve fund, should exceed the aggregate of ten dollars (\$10.00) per member, action shall be taken to readjust the membership fees or benefits.

2. The Association shall be organized and managed by a Board of Directors of not less than twelve (12) members representative of the District Engineer and of the subscriber and physician groups as follows:

**Grant of Authority for the Oak Ridge Health Association.**

- a. Employee subscriber groups -- one member from each group
- b. Physicians' group -- one physician member for each non-physician member
- c. District Engineer -- two members

Initial members of categories b. and c. representatives will be selected by the District Engineer or his authorized representative. The members of categories a. will be initially selected by the subscriber groups. All members shall serve for a term of (1) year from the date of their respective election or appointment. All vacancies on the board of category a. members shall be filled by the respective subscriber groups. The members of categories b. and c. will serve indefinitely at the pleasure of the District Engineer. All vacancies on the board of category b. members will be filled by the District Engineer on the recommendation of the physicians' group. All vacancies in category c. will be filled by the District Engineer.

a. The Board of Directors shall select from its membership a president, vice-president, secretary, and treasurer of the Association and it may employ a business manager and such other employees as may be necessary for the execution of the Association's work. The board shall make all decisions and do all things necessary to carry out the Association's objectives. It shall adopt a set of by-laws stating the duties of its officers and key employees and prescribing its rules of procedure and operation. A certified copy of the by-laws and of all amendments thereto shall be promptly furnished the District Engineer. The District Engineer shall have the power of veto in whole or in part thereof.

b. The treasurer or his successor shall be the custodian of the Association's funds and shall be solely responsible to the Association and to the District Engineer for their collection, safeguarding, disbursement and accountability. The treasurer shall promptly deposit or cause to have deposited all Association funds in a selected bank which shall be a member of the Federal Reserve System to the credit of the Oak Ridge Health Association. The depository of the funds, in whole or in part, shall not be removed to any other bank or place.

(1) All disbursements made from the funds of the Association shall be by check signed, "The Oak Ridge Health Association, by \_\_\_\_\_, Treasurer," provided that the treasurer or his successor may, on his own responsibility, set up with adequate safeguards and accountability such petty cash account as may be necessary but not to exceed fifty dollars (\$50.00) total, and payment therefrom shall exceed twenty-five dollars (\$25.00) amount.

(2) The treasurer is authorized during periods of his absence in excess of two days from Oak Ridge, Tennessee, to appoint a deputy Treasurer to perform his duties. In the event absence

Subject: Grant of Authority for the Oak Ridge Health Association

of the treasurer from Oak Ridge shall exceed thirty (30) consecutive days, the Board of Directors shall appoint a new treasurer.

c. The secretary of the board shall keep accurate minutes of all meetings of the Board of Directors and Executive Committee, as well as perform other duties as may be assigned by the board. A copy of all minutes shall be promptly furnished to the District Engineer.

d. The Board of Directors shall meet as often as necessary to properly supervise the activities of the Association. Regular meetings shall be held at least quarterly.

e. The president shall preside over all meetings of the Association and of the Board of Directors.

f. The Board of Directors shall elect from its membership an Executive Committee composed of six members, three of whom shall be physicians, headed by a chairman who will be the same individual as the president of the Board of Directors. The board will also elect from its membership a Budget Committee and an Audit Committee of three members each, and such other committees as shall be considered necessary by the board. The primary function of the Executive Committee shall be to supervise the operation of the association as directed by the Board of Directors. The Budget Committee shall keep itself fully informed as to the financial status of the Association and shall study all budget matters submitted by the business manager and make recommendations to the board as to the course to follow in the matter of budgeting funds. The primary function of the Budget Committee shall be to keep the board informed of the financial status of the Association and make recommendations for corrective action when necessary to insure that the financial status of the Association is sound at all times. The Audit Committee's primary responsibility shall be to insure that an adequate bookkeeping and accounting system is maintained at all times; that all disbursements are for authorized purposes and within budgetary limits; and that all property and funds are properly accounted for.

4. Officers of the Association and members of the Board of Directors shall serve without compensation. Employees shall be compensated at rates not in excess of those paid locally for similar services and as approved by a majority of the Board of Directors. Officers or employees of the Association charged with the handling of its funds shall be adequately bonded.

**Subject: Grant of Authority for the Oak Ridge Health Association.**

5. Hospital services at the Oak Ridge Hospital will be procured by contract with the Roane-Anderson Company or its successor at charges which may be subject to periodic adjustment on the basis of hospital costs or otherwise as may be approved by the District Engineer. Medical fees will be comparable to those charged in the surrounding territory.

6. Office space and equipment will be made available by the District Engineer with or without rental for the Association's use. All such facilities will remain the property of the Government and shall be held accountable as such. Adequate measures will be adopted for their care and maintenance.

7. A financial and membership statement shall be prepared monthly and copies thereof shall be furnished each member of the Board of Directors. A copy thereof, signed by the president and the treasurer shall be promptly delivered to the District Engineer. Adequate records shall be maintained of the Association's activities and competent safeguards, bookkeeping, and accounting procedures equal to AR 210-50 and AF Form 15 shall be inaugurated and maintained for the protection and accountability of all property and funds for which the Association is custodian. The District Engineer shall have the privilege of auditing or inspecting the accounts, books, and affairs of the Association at any time or to require additional reports relative to the Association's operations.

8. The association may be dissolved at the discretion of the District Engineer with or without the recommendation of the Board of Directors. In the event thereof, the Board of Directors will proceed to liquidate all outstanding obligations within a year immediately following the receipt of notice to dissolve and will thereupon dispose of all assets and surplus funds and all property in its custody. The disposal of assets and surplus funds of the Association shall be with the concurrence of or at the direction of the District Engineer as follows: (1) By donation to the American Red Cross, the National War Fund, and/or the Salvation Army; (2) by transfer to a successor organization; or (3) by such other donations or transfers as desired except that in no instance and under no circumstances shall any of the assets or surplus funds be distributed to any officer or member of the Association. Disposition of Government property in the custody of the Association will be with the concurrence of or at the direction of the District Engineer.

9. The members of the Board of Directors and officers of the Association shall not be held personally responsible for any losses or any liabilities of the Association, except individually as shall be caused by the fraud or bad faith of any such member or officer.

10. This grant of authority shall be retroactive in effect as of the first day of August 1943, and shall remain continuously in effect until revoked by the District Engineer.

/s/ K. D. Nichols  
K. D. NICHOLS,  
Col., Corps of Engineers,  
District Engineer.

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THIS DOCUMENT CONSISTS OF 2 PAGE(S)

WAR DEPARTMENT / OF 5 COPIES. SERIES A

UNITED STATES ENGINEER OFFICE

MANHATTAN DISTRICT

~~XXXXXXXXXXXXXXXXXXXX~~  
P. O. Box 1111, Knoxville, Tenn.

IN REPLY  
REFER TO

EIDM-a

MD-700 Gen.

15 February 1944

Subject: Hospital and Medical Facilities for Oak Ridge

MEMORANDUM TO District Engineer, Manhattan District  
(Attention Lt. Col. T. T. Crenshaw)

1. Reference is made to memo EIDM-11, 29 January 1944, indicating that a minimum of 45,000 "permanent" residents will be housed at Oak Ridge with a possible peak of 50,000 by July 1944. Other information indicates that between July and December, an additional 25,000 construction workers will also be housed on this area.

2. Adequate minimum requirements should be made available for both constant bed occupancy for expected illnesses in this area, and a certain amount of excess capacity, usually 20%, for sudden epidemics. There are no data from which to determine directly the requirements of the somewhat abnormal community at Oak Ridge. However, there are certain assumptions which may be made from current experience.

3. The ratio of beds to population in the U. S. for 1939 was 3.4/1000, with 60% occupancy. For 1943, the ratio is not available, but the occupancy was nearly 95%, which is dangerously high. This sudden increase in bed occupancy may be directly the result of several factors:

a. The smaller number of physicians available, which makes it impossible for sick patients to be cared for in their homes, as was the custom previously.

b. More members of the family working, with no one at home to care for the patient.

c. An influx of single "war" workers into communities where they have to be hospitalized when ill.

d. Patients earning more money demand the better care and lower risk which hospital facilities provide.

All of these factors are present at Oak Ridge. Approximately 1/5 of the population are single workers. The majority of the operating personnel belongs to the white-collar class who are accustomed to the best medical care.

4. In the city of Rochester, New York, from which come many of the operating personnel, the ratio is 5.1 beds/1000, and the ratio of beds to population has changed from 1/750 to 1/1200, within the past year. Since the ratio of physicians to population

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Subject: Hospital and Medical Facilities for Oak Ridge

15 February 1944

in Oak Ridge has been fixed at 1/2000, because of the difficulty of obtaining physicians, it is imperative that the proposed beds to population ratio be maintained at a high level.

5. After studying the advice of consultants and surveying the local situation, it is recommended that hospital facilities, including out-patient service, be based on the ratio of 8 beds /1000, or 250 beds. N

6. It is recommended that these facilities be constructed immediately so that the entire hospital unit is available for use by 1 July, 1944.

*Stafford L. Warren*

STAFFORD L. WARREN  
Colonel, Medical Corps  
Chief of Medical Section

*What is it in Washington DC.?*

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ADDRESSES APPLY TO  
CHIEF OF ENGINEERS, U. S. ARMY  
WASHINGTON, D. C.

WAR DEPARTMENT

OFFICE OF THE CHIEF OF ENGINEERS  
WASHINGTON

REFER TO FILE NO. \_\_\_\_\_

~~SECRET~~

SECURITY INFORMATION

21 September 1943

Subject: Medical Facilities, Manhattan District

To: The Commanding General, Army Service Forces,  
Washington, D. C.

*Handwritten:*  
JKS  
JAS  
21 Sept 43

1. Due to the unique occupational hazards which will be encountered in the operation of the projects under the control of the Manhattan District of the Corps of Engineers, it has been necessary to provide on-site hospital and medical facilities for the personnel employed thereon and such of their families as are required to live on the projects. It has also been found necessary to contract with certain institutions for the furnishing of medical facilities and especially qualified personnel.

2. At one project, hospital facilities are nearing completion. The medical staff, provided by the contractor in charge of a part of the medical research pertaining to the project, has necessarily come into possession of considerable secret information. For this reason and primarily in order to insure the retention on the project of their outstanding professional qualifications, and to insure continuity of research and medical treatment, it has been determined to be essential that a certain portion of this medical staff be in the military establishment.

3. It is therefore recommended:

a. That <sup>certain of</sup> the medical personnel be commissioned in the Medical Department, and that a procurement objective and allotment of personnel be made available to the Surgeon General for that specific purpose in the numbers and grades indicated on the inclosure, and that the District Engineer, Manhattan District, be authorized to correspond directly with the Surgeon General in order to expedite the militarization of this medical staff.

b. That the Surgeon General be asked to give the fullest consideration to recommendations of the District Engineer as to the grades in which the members of that staff are to be appointed.

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SECURITY INFORMATION

Subject: Medical Facilities, Manhattan District

21 Sept. 43

and to requests for any necessary waivers of physical disabilities of those persons, provided that such disabilities will not prevent them from performing their assigned contemplated duties.

c. That existing Medical Department personnel and materiel procurement facilities be made available to the Manhattan District, where it is advantageous to the Government.

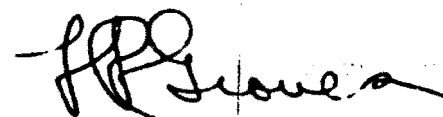
d. That those persons named in paragraph 2, AR 40-505, and stationed at those Manhattan District projects at which there are located medical facilities, be authorized to receive medical care at those facilities, and the expenses incurred thereby be reimbursed to the Manhattan District by the Surgeon General from funds available to him, the manner of reimbursement to be mutually agreed upon between the Surgeon General and the District Engineer.

e. That, for security reasons, a liaison officer be appointed by the Surgeon General with station at the Office of the Surgeon General, with full authority and freedom of action to approve, in the name of the Surgeon General, requisitions accomplished by the District Engineer, Manhattan District, for such Medical Department personnel and materiel as are necessary, and to expedite the filling of such requisitions. This officer will be provided by the Manhattan District with the information (for his personal use) necessary for him to act intelligently.

f. That the District Engineer and the medical officers under his control be not required to submit to the Surgeon General or his representatives any reports which in the opinion of the District Engineer will reveal the nature, scope, or military importance of the work being performed by the Manhattan District.

g. That the Medical Department personnel assigned, attached, or allotted to the Manhattan District be not transferred to or from the control of the District Engineer without his prior approval. This measure is necessary in order to control the security of classified information and in order to insure that the especially selected medical personnel will be retained on their presently assigned tasks.

For the Chief of Engineers:



L. R. GROVES  
Brigadier General, C.E.

Incl.:  
Organization Chart

## BY-LAWS OF THE OAK RIDGE HOSPITAL

### PREAMBLE

Recognizing that the best interests of the patient are protected by concerted effort, the physicians practicing in the Oak Ridge Hospital hereby organize themselves in conformity with the by-laws, rules, and regulations hereinafter stated.

For the purpose of these by-laws the word medical staff shall be interpreted to include all physicians who are privileged to attend patients in the Oak Ridge Hospital.

Whenever the term governing board appears, it shall be interpreted to refer to the controlling group.

### ARTICLE I. NAME

The name of this organization shall be the "Medical Staff of Oak Ridge Hospital."

### ARTICLE II. PURPOSE

The purpose of the organization shall be:

1. To insure that all patients admitted to the hospital or treated in the out-patient department receive the best possible care.
2. To provide a means whereby problems of a medico-administrative nature may be discussed by the medical staff with the governing board and the administration.
3. To initiate and maintain self-government.
4. To provide education and to maintain educational standards.

### ARTICLE III. MEMBERSHIP

#### Section 1. Qualifications

The applicant for membership on the medical staff shall be a graduate of an approved medical school, legally licensed to practice in the state of Tennessee, qualified for membership in the local medical society, and practicing the community or within reasonable distance of the hospital.

#### Section 2. Ethics and Ethical Relationships

The code of ethics as adopted by the American Medical Association and the "Principles of Financial Relations in the Professional Care of the Patient" of the American College of Surgeons shall govern the professional conduct of the members of the medical staff. Specifically, all members of the medical staff shall pledge themselves that they will not receive from or pay to another physician, either directly or indirectly, any part of a fee received for professional services. On the contrary it shall be agreed that all fees shall be collected and retained by the individual physician in accordance with the value of services rendered.

### Section 3. Application for Membership

Application for membership on the medical staff shall be presented in writing on the prescribed form, which shall state the qualifications and references of the applicant, and shall also signify his agreement to abide by the by-laws, rules, and regulations of the medical staff.

### Section 4. Terms of Appointment

a. Appointments to the medical staff shall be made by the governing board of the hospital and shall be for the period of one calendar year. At the end of the year the governing board of the hospital may reappoint all members of the medical staff for a further period of one year, provided the medical staff has not recommended that any specific appointment shall not be renewed. In such case all other reappointments may be made.

b. Should the governing board wish to take the initiative in refusing to make reappointment of any member, it shall so advise the medical staff, stating reasons and asking for recommendations as to further action.

c. In no case shall the governing board take action on an application, refuse to renew an appointment, or cancel an appointment previously made without conference with the medical staff, but regardless of the recommendations of the medical staff, final responsibility for appointment or cancellation of an appointment must rest with the governing board.

d. Appointment to the medical staff shall confer on the appointee only such privileges as may be hereinafter provided.

### Section 5. Procedure for Appointment

a. The application for membership on the medical staff shall be presented to the director of the hospital and by him referred to the secretary of the medical staff.

b. At the first regular meeting thereafter, the secretary shall present the application to the medical staff, at which time it shall be either recommended for rejection or referred to the credentials committee.

c. The credentials committee shall investigate the character, qualifications, and standing of the applicant and shall submit a report of findings at the next regular meeting of the medical staff, or as soon thereafter as possible, recommending that the application be accepted, deferred, or rejected. In no case shall this report be delayed for more than three months.

d. When determining qualifications, the credentials committee shall also assign privileges as provided in Article VI, Sections 1 and 2 of these by-laws.

e. On receipt of the report of the credentials committee, the medical staff shall immediately recommend to the governing board that the application be accepted, deferred, or rejected.

f. The recommendation of the medical staff shall be transmitted to the governing board through the director of the hospital.

g. The governing board shall either accept the recommendation of the medical staff or shall refer it back for further consideration. In the latter case the governing board shall instruct its secretary to state to the medical staff the reasons for such action.

h. When final action has been taken by the governing board, the director of the hospital shall be authorized to transmit this decision to the candidate for membership, and if he is accepted to secure his signature to these by-laws, rules, and regulations. Such signature shall constitute his agreement to be governed by the said by-laws, rules, and regulations.

#### Section 6. Emergency and Temporary privileges

a. In case of emergency the physician attending the patient shall be expected to do all in his power to save the life of the patient, including the calling of such consultation as may be quickly available. For the purpose of this section, an emergency is defined as a condition in which the life of the patient is in immediate danger and in which any delay in administering treatment would add to that danger.

b. The director of the hospital shall have the authority to grant temporary privileges to a physician who is a member of the local medical society and desires to attend an occasional patient in the hospital but who is not a member of the medical staff. Such temporary privileges shall be granted after conference with the chief of staff or the medical director to determine an authoritative opinion as to the competence and ethical standing of the physician who desires such temporary privileges, and in the exercise of such privileges he shall be under direct supervision of the chief of staff. Temporary privileges may not be granted to attend more than four patients in any one year, after which the physician to whom the temporary privileges have been granted shall be required to become a member of the medical staff before being allowed to attend additional patients.

### ARTICLE IV. DIVISIONS OF THE MEDICAL STAFF

#### Section 1. The Medical Staff

The medical staff shall be divided into honorary, consulting, active, associate, and courtesy groups.

#### Section 2. The Honorary Medical Staff

The honorary medical staff shall consist of physicians who are not active in the hospital and who are honored by emeritus positions. These may be physicians who have retired from active hospital service or physicians who are of outstanding reputation, not necessarily resident in the community.

The honorary medical staff shall be appointed by the governing board on recommendation of the active medical staff and shall have no assigned duties or responsibilities. Their privileges shall be determined by the credentials committee as provided in article VI of these by-laws.

### Section 3. The Consulting Medical Staff

a. The consulting medical staff shall consist of recognized specialists who are active in the hospital or who have signified willingness to accept such appointment. These may be Fellows of the American College of Surgeons or the American College of Physicians, diplomates of one of the national boards of medical specialties, members of the national society representing the specialty, or others whom the credentials committee may consider to be worthy of being appointed as members of the consulting medical staff. Membership on the consulting medical staff shall not render the member ineligible for membership on the active medical staff.

b. Appointment shall be made by the governing board on recommendation of the active medical staff. Credentials shall not be required for such appointments and the proposed member may be invited to accept appointment.

c. The duties of the members of the consulting medical staff shall be to give their services without charge in the care of free patients on request of any member of the active medical staff, and also in any case in which consultation is required by the rules of the hospital.

d. In so far as their specialty is concerned, members of the consulting medical staff shall have unrestricted privileges, but in cases not falling within their specialty they shall have such privileges as may be determined by the credentials committee as provided in Article VI of these by-laws.

### Section 4. The Active Medical Staff

a. The active medical staff shall consist of physicians who have been selected to attend free patients in the hospital and to whom all such patients shall be assigned. Members of the active medical staff shall not be required to be exclusive specialists, but it is to be expected that they will be well-skilled in the particular branch of medicine to which they are assigned, and that the major part of their private practice will fall within that specialty.

b. Appointments shall be made annually by the governing board on recommendation of the active medical staff from the former members of the active medical staff, and, in so far as it is possible, vacancies shall be filled by promotion of members of the associate medical staff who have signified a desire to become more active in the work of the hospital.

c. The duties of the active medical staff shall be to attend all free patients and, in so far as free work is concerned, they shall attend only such patients as are admitted to their services. All business of the medical staff shall be transacted by the active medical staff and only members of the active medical staff shall be eligible to vote and hold office.

d. In so far as free cases are concerned, members of the active medical staff shall treat patients in both the in-patient and out-patient departments as assigned to the service and in the treatment of these they shall have unrestricted privileges and shall treat the patient to a conclusion, whether such treatment is given in the in- or the out-patient department or both. In so far as private patients are concerned, they shall have unrestricted privileges in the treatment of patients falling within the

specialty to which they are appointed, but in the others they shall have only such privileges as may be determined by the credentials committee in conformity with Article VI of these by-laws.

#### Section 5. The Associate Medical Staff

a. The associate medical staff shall consist of junior and less experienced members or of physicians who have not been actively interested in the work of the hospital but have but have expressed a wish to become active as vacancies occur.

b. They shall be appointed and assigned to services in the same manner as provided for the active medical staff and each shall be associated as junior with a member of the active medical staff.

c. The duties of the members of the associate medical staff shall be to attend free patients in accordance with assignment by the senior with whom they are associated. They may be required also to act on all committees except the executive committee and the credentials committee.

d. In so far as free cases are concerned, the members of the associate medical staff shall be limited to the treatment of cases falling within the service to which they are appointed and in accordance with assignment by the member of the active medical staff with whom they are associated. In so far as private patients are concerned, they shall have such privileges as provided by the credentials committee in Article VI of these by-laws.

#### Section 6. The Courtesy Medical Staff

The courtesy medical staff shall consist of those members of the medical profession, eligible as herein provided for medical staff membership, who wish to attend private patients in the hospital, but who do not wish to become members of the active medical staff or who, by reason of residence, are not eligible for such appointment. They shall be appointed in the same manner as other members of the medical staff and they shall have such privileges as may be determined by the credentials committee in conformity with Article VI of these by-laws, but they shall not be eligible to vote or hold office.

### ARTICLE V. CLINICAL DEPARTMENTS

#### Section 1. Services

Divisions or services of the medical staff shall be as follows: Medicine to include cardiology, communicable diseases, dermatology and syphilology, diseases of the lungs, diseases of metabolism, endocrinology, gastrointestinal diseases, neuropsychiatry, pediatrics; surgery to include malignant tumor surgery, neurological surgery, orthopedics, plastic surgery, proctology, thoracic surgery, traumatic surgery, urology; and other services related to the specialties of radiology; pathology; anesthesia.

#### Section 2. Specialization

While the members of the active and associate services shall not be required to be exclusive specialists, it is to be expected that they will be well skilled in the specialty to which they are assigned and that not less than fifty per cent of their private work in the hospital shall be in that

specialty. The chief of each service shall be a recognized specialist.

### Section 3. Assignment to Services

Assignment to the service shall be made at the first meeting of the active medical staff after its members have been appointed by the governing board, and members so assigned shall remain on service for one year or until a successor has been appointed. Appointments shall be made after a careful analysis of the efficiency of the candidate as shown by a record of his work in the hospital.

### Section 4. Organization of Services

a. At the annual meeting there shall be elected a chief of the medical staff who shall be a member of the active medical staff. He shall be responsible for the functioning of the clinical organization of the hospital and shall keep or cause to be kept a careful supervision over the clinical work in all divisions and services. He may, if desired, also be elected as president of the medical staff.

b. Each service shall be organized as a division of the medical staff and shall have as its head a chief of service, who shall be responsible to the chief of the medical staff for the functioning of his service and shall have general supervision over the clinical work falling within his service whether it be free or private.

c. Immediately after appointment, the members of the active medical staff in each service shall meet and each shall designate the member or members of the associate medical staff whom they wish to have as their assistants.

d. The members of each service division shall meet during the first two weeks after they are appointed for the purposes of electing a chief of service and a secretary, and of perfecting such organization and arranging such a schedule of duties for their term of office as may seem advisable to promote the best interests of the patients.

e. In the medical and surgical services there shall be elected also an assistant chief for each service who shall perform such duties as may be assigned by the chief of service. The members of the services shall be responsible to the chiefs of services and through them to the chief of the medical staff.

f. Each service may meet separately, but such meetings shall not release the members from their obligation to attend the general meetings of the medical staff.

g. In so far as free cases are concerned, members of the active medical staff shall treat patients in both the in-and out-patient departments as assigned to the service and in the treatment of these, they shall have unrestricted privileges and shall treat the patient to a conclusion, whether such treatment is given in the in-or out-patient department or both. In so far as private patients are concerned they shall have unrestricted privileges in the treatment of patients falling within the specialty to which they are appointed, but in others they shall have only such privileges as may be provided by the credentials committee in Article VI.



## ARTICLE VI. DETERMINATION OF QUALIFICATIONS AND PRIVILEGES

### Section 1. Classification of Privileges

Privileges extended to physicians who have been appointed to the medical staff shall be divided into major, intermediate, and minor, and shall be determined by the credentials committee. The following shall serve as a guide in differentiating the three types of privileges:

a. Major privileges in any service will allow the physician to treat patients when, for any cause, such treatment involves a serious hazard to the life of the patient.

b. Intermediate privileges in any service will allow the physician to treat patients when, for any cause, such treatment does not involve a serious hazard to the life of the patient but does involve a danger of disability.

c. Minor privileges in any service will allow the physician to treat patients when, for any cause, the treatment does not involve either a serious hazard to the life of the patient or a danger of disability.

### Section 2. Newly Appointed Medical Staff Members

All members of the staff when newly appointed shall be granted only minor privileges until such time as the credentials committee may determine what further privileges may be granted with safety to the patient, such extension of privileges being based, as far as possible, on records of performance as provided in Sections 3 and 4 of this article. The committee may grant major privileges to a newly appointed member. (Amendment May 6, 1946)

### Section 3. Direct Observation

Every member of the consulting or active medical staff, at the conclusion of any case in which he has been associated with a member of the associate or courtesy medical staff, shall transmit to the medical records librarian a memorandum stating whether, from his observation of competence in so far as the particular case is concerned, the member of the associate or courtesy medical staff may be granted further privileges as specified in Section 1 of this article. Such expression of opinion shall be kept as absolutely confidential by the medical records librarian and shall be accessible only to the credentials committee when making recommendations for promotion, appointment to service, or granting of increased privileges.

### Section 4. Recommendations for Promotion or Appointment to Services

When making recommendations for promotion, appointment to services, or the granting of privileges, the credentials committee shall base its judgment on the consensus as determined under Section 4 of this article, together with the opinion of the chief of service concerned, on the record of performance as provided in Section 3 of this article, and on the further qualifications of the member of the staff as shown in his filed credentials.

## ARTICLE VII. OFFICERS AND COMMITTEES

### Section 1. Officers

The officers of the medical staff shall be the president, the vice president, and the secretary. These shall be elected at the annual meeting of the medical staff, and shall hold office until the next annual meeting or until a successor is elected.

The President shall call and preside at all meetings and he shall be a member EX OFFICIO of all committees. He may if it is so desired, also be elected as chief of the medical staff.

The Vice President in the absence of the president shall assume all his duties and have all his authority. He shall also be expected to perform such duties of supervision as may be assigned to him by the president.

The Secretary shall keep accurate and complete minutes of all meetings, call meetings on order of the president, attend to all correspondence, and perform such other duties as ordinarily pertain to his office. If there are funds to be accounted for, he shall also act as treasurer.

### Section 2. Committees

Committees shall be standing and special. All committees other than the executive shall be appointed by the president.

The Executive Committee shall consist of the president and secretary of the medical staff and of three other members of the active medical staff to be elected at the time of the annual meeting. The duties of the executive committee shall be to consider carefully and act on all matters which are not of a clinical nature and it is to be expected that all such business of the medical staff shall be transacted by the executive committee in order that the time of the regular meetings of the medical staff may be devoted to matters pertaining to the professional care of patients. The executive committee shall present, at each meeting of the medical staff, a report of any action that it may have taken since the last meeting. The executive committee shall act as a liaison group between the medical staff and the administration of the hospital. At the discretion of the president of the staff, the executive committee will function as the credentials committee. (Amendment May 6, 1946)

The Medical Records Committee shall consist of three members of the medical staff and shall meet weekly for the purpose of reviewing the medical records of all patients discharged during the week. The committee shall report to the medical staff the names of any members who are persistently delinquent in the completion of their records. This committee shall be held responsible for notifying the program committee of any cases that should be presented before the medical staff.

The Program Committee shall consist of three members of the medical staff and shall be responsible for the preparation and presentation of the programs of all meetings.

The Credentials Committee shall consist of seven members of the consulting or active staff, so selected as to insure representation of the

of the major specialties. Its duties shall be to investigate the credentials of all applicants for membership and to make recommendations in conformity with Article III, Section 5c, of these by-laws, to investigate any breach of ethics that may be reported; to review any records that may be referred by the medical director and to arrive at a decision regarding the performance of the staff member, or to refer the case to the full active medical staff if this is considered desirable; to review all information available regarding the competence of staff members and as a result of such reviews to make recommendations for the granting of privileges and the appointment of members to the various services and departments as provided in Article VI of these by-laws.

The Intern Committee shall consist of three members of the medical staff. Its duties shall be to act as an advisory committee in the selection of interns, to outline courses of instruction for the resident medical staff and to see that they are carried out, and to assist the administration in matters of government and discipline of the resident medical staff. The Therapeutic and Pharmacy Committee shall consist of 5 members. Its duties shall be to decide upon drugs and preparations to be stocked by the pharmacy; and to report to the medical staff on new drugs. (Amendment May 6, 1946)

Special committees shall be appointed from time to time as may be required to carry out properly the duties of the medical staff. Such committees shall confine their work to the purposes for which they were appointed and shall report to the full medical staff. They shall not have power of action unless such is specifically granted by the motion which created the committee.

## ARTICLE VIII. MEETINGS

### Section 1. The Annual Meeting

The annual meeting of the medical staff shall be the last meeting before the end of the fiscal year of the hospital. At this meeting the retiring officers and committees shall make such reports as may be desirable, officers for the ensuing year shall be elected, and recommendations for appointment to the active medical staff shall be made.

### Section 2. Regular Meetings

Regular meetings of the medical staff shall be held at least monthly at a time and place to be provided in the rules and regulations for the government of the medical staff.

### Section 3. Special Meetings

Special meetings of the medical staff may be called at any time by the president and shall be called at the request of the governing board, the executive committee, or any five members of the active medical staff. At any special meeting no business shall be transacted except that stated in the notice calling the meeting. Sufficient notice of any meeting shall be posted on the bulletin board in the staff room at least 48 hours before the time set for the meeting.

#### Section 4. Attendance at Meetings

a. All members of the active medical staff shall be required to attend all meetings. Absence from three consecutive meetings or from one-third of the regular meetings for the year, without acceptable excuse, shall be considered as resignation from the active medical staff, and shall automatically place the absentee on the associate or courtesy medical staff of the hospital.

b. All members of the associate medical staff shall be expected to attend meetings with the same regularity as members of the active medical staff. Absence from three consecutive meetings or from one-third of the meetings for the year, without acceptable excuse, shall be considered as resignation from the associate medical staff and shall automatically place the absentee on the courtesy medical staff.

c. Reinstatement of members of the active and associate medical staffs to positions rendered vacant because of absence from meetings may be made on application, the procedure being the same as in the case of original appointment.

d. Members of the honorary, consulting, and courtesy divisions of the medical staff shall not be required to attend meetings, but it is expected that they will attend and participate in these meetings unless they are unavoidably prevented from doing so.

e. Any member of any division of the staff who has attended a case that is to be presented for discussion at any meeting shall be notified and shall be required to be present. Failure to attend on receipt of such notice shall involve the penalty, in the case of a member of the consulting or active medical staff, of reverting to the associate medical staff and, in the case of a member of the courtesy medical staff, of forfeiting his medical staff membership.

f. Should a member of the staff be absent from any meeting at which a case that he has attended is to be discussed, it shall nevertheless be discussed unless the member is unavoidably absent and has requested that discussion be postponed. In no case shall postponement be granted for a period longer than that which will elapse until the next regular staff meeting.

#### Section 5. Quorum

Fifty per cent of the total membership of the active medical staff shall constitute a quorum.

#### Section 6. Agenda

The agenda at any regular meeting shall be:

##### A. Business

1. Call to order.
2. Reading of the minutes of the last regular and of all special meetings.
3. Unfinished business.
4. Communications.
5. Reports of standing and of special business committees.
6. New business.

**B. Medical**

- 7. Review of patients in the hospital with special reference to diagnoses, treatment, and delayed recovery; selected cases discharged since the last conference with special consideration of selected deaths, unimproved cases, infections, complications, errors in diagnoses, and results of treatment; and analysis of clinical reports from the various departments.
- 8. Reports of standing and of special medical committees.
- 9. Discussion and recommendations for improvement of the professional work of the hospital.
- 10. Adjournment.

The agenda at special meetings shall be:

- 1. Reading of the notice calling the meeting.
- 2. Discussion of the business for which the meeting was called.
- 3. Adjournment.

**ARTICLE IX. RULES AND REGULATIONS**

The medical staff shall adopt such rules and regulations as may be necessary for the proper conduct of its work. Such rules and regulations shall be a part of these by-laws, except that they may be amended at any regular meeting without previous notice by a two-thirds vote of the total membership of the active medical staff. Such amendments shall become effective when approved by the governing board.

**ARTICLE X. AMENDMENTS**

These by-laws may be amended after notice given at any regular meeting of the medical staff. Such notice shall be referred to a special committee which shall report at the next regular meeting and shall require a two-thirds majority of those present for adoption. Amendments so made shall be effective when approved by the governing board.

**ARTICLE XI. ADOPTION**

These by-laws together with the appended rules and regulations shall be adopted at any regular meeting of the active medical staff, shall replace any previous by-laws, rules, and regulations, and shall become effective when approved by the governing board of the hospital. They shall, when adopted and approved, be equally binding on the governing board and the medical staff.

Adopted by the active medical staff of Oak Ridge Hospital

\_\_\_\_\_  
President of Medical Staff

\_\_\_\_\_  
Secretary of Medical Staff

Date.....

Approved by the governing board of the Oak Ridge Hospital.

\_\_\_\_\_  
Secretary of the Governing Board

Date.....

## RULES AND REGULATIONS

1. The monthly meeting of the medical staff shall be held the first Monday of each month at 7:00 P.M.
2. Except in emergency, no patient shall be admitted to the hospital until after a provisional diagnosis has been stated and the consent of the director secured. In case of emergency the provisional diagnosis shall be stated as soon after admission as possible.
3. Physicians admitting private patients shall be held responsible for giving such information as may be necessary to assure the protection of other patients from those who are a source of danger from any cause whatsoever.
4. All free patients shall be attended by members of the active medical staff, and shall be assigned to the service concerned in the treatment of the disease which necessitated admission. The members of the active medical staff must assign a reasonable number of cases to the juniors who are associated with them and the member of the associate medical staff to whom the case is assigned shall carry on the treatment under supervision of the senior. No physician shall receive compensation for attendance in the case of any patient who is admitted free by the hospital, but in the case of patients from whom the hospital is receiving partial compensation the attending physician may charge a fee proportionate to that received by the hospital. Pay patients shall be attended by their own private physicians. In the case of a pay patient applying for admission who has no attending physician, he shall be assigned to the members of the active medical staff on duty in the service to which the illness of the patient indicates assignment.
5. Laboratories shall be provided in the hospital so that all types of laboratory examinations may be done.
6. Standing orders shall be formulated by conference between the medical staff and the director. They may be changed only by the director after conference with the medical staff. These orders shall be followed in so far as proper treatment of the patient will allow, and when specific orders are not written by the attending physician they shall constitute the orders for treatment. Standing orders shall not, however, replace or cancel those written for the specific patient.
7. All orders for treatment shall be in writing. Verbal orders shall not be accepted or carried out. An order shall be considered to be in writing if dictated to a senior nurse or other authorized person and signed by the attending physician. Orders dictated over the telephone shall be signed by the person to whom dictated with the name of the physician per his or her own name. At his next visit the attending physician shall sign such orders, and neglect to do so shall be considered as acknowledgment of their correctness.
8. As far as possible the use of proprietary remedies shall be avoided. When such are ordered for private patients by the attending physician, they will be secured and a special charge made to the patient.

9. The attending physician shall be held responsible for the preparation of a complete medical record for each patient. This record shall include identification date; complaint; personal history; family history; history of present illness; physical examination; special reports such as consultations, clinical laboratory, X-ray, and others; provisional diagnosis; medical or surgical treatment; pathological findings; progress notes; final diagnosis; condition on discharge; follow-up; and autopsy report when available. No medical record shall be filed until it is complete, except on order of the medical records committee.

10. A complete history and physical examination shall in all cases be written within 24 hours after admission to the hospital.

11. When such history and physical examination are not recorded before the time stated for operation, the operation shall be cancelled, unless the attending surgeon states in writing that such delay would be detrimental to the patient.

12. All records are the property of the hospital and shall not be taken away without permission. In case of readmission of a patient all previous records shall be available for the use of the attending physician. This shall apply whether the patient be free or pay, and whether he be attended by the same physician or by another.

13. Except in cases of emergency, patients for operation shall be admitted not later than four o'clock the day previous to operation.

14. All operations performed shall be fully described by the attending surgeon. All tissues removed at operation shall be sent to the hospital pathologist who shall make such examination as he may consider necessary to arrive at a pathological diagnosis.

15. In all cases where a patient is admitted in a condition of abortion, she or her representative shall sign a statement certifying that neither any employee of the hospital nor the attending physician was directly or indirectly responsible for its production.

16. Except in emergency, consultation with a member of the consulting or of the active medical staff shall be required in all major cases in which the patient is not a good risk and in all curetages or other operations which may interrupt a known, suspected, or possible pregnancy. The consultant shall make and sign a record of his findings and recommendations in every such case. In all cases where a rule of the hospital requires consultation and in the case of free patients, the consultants shall give his services without charge.

17. Each member of the courtesy medical staff, not resident in the city, or immediate vicinity, shall name a member of the medical staff who is resident in the city, who may be called to attend his patients in emergency. In case of failure to name such associate, the director of the hospital shall have authority to call any member of the staff should he consider it necessary.

18. Patients shall be discharged only on written order of the attending physician. At the time of discharge the attending physician shall see that the record is complete, state his final diagnosis, and sign the record.

19. At the monthly meeting of the medical staff the medical records librarian shall submit a report of the professional work of the hospital for the previous month. This shall show patients discharged and the results, deaths (the cause being stated as given by the attending physician), autopsies, consultations, and infections of all kinds. The discussion at the meeting shall be based on this report and at no meeting shall abstract discussion of scientific medical subjects be permitted. After each meeting the secretary of the medical staff shall transmit to the director of the hospital such reports and recommendations as the medical staff may wish to make to him or through him to the governing board.

20. Every member of the medical staff shall be actively interested in securing autopsies whenever possible. No autopsy shall be performed without written consent of a responsible relative or friend. All autopsies shall be performed by the hospital pathologist or by a physician to whom he may delegate the duty.

21. The hospital shall admit patients suffering from all types of disease. Patients may be treated only by physicians who have submitted proper credentials and have been duly appointed to membership on the medical staff.

22. Surgeons must be in the operating room and ready to commence operation at the time scheduled, and in no case will the operating room be held longer than fifteen minutes after the time scheduled.

Adopted at a regular meeting of the active medical staff

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President of Medical Staff

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Secretary of Medical Staff

Date.....

Approved by the governing board

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Secretary of the Governing Board

Date.....



~~SECURITY INFORMATION~~

MANHATTAN DISTRICT HISTORY

BOOK I - GENERAL

VOLUME 7 - MEDICAL PROGRAM

APPENDIX B

REFERENCES

<u>No.</u>	<u>Description</u>	<u>Location</u>
1	Protection of Radium Dial Workers and Radiologists From Injury by Radium. Robley D. Evans, The Journal of Ind. Hygiene and Toxicology. Sept. 1943 Volume 25, No. 7 p 253.	Medical Section Files G-4C
2	The Toxicology of U Compounds. Albert Taumenbaum and H. Silverstone. Metallurgical Project Report CH2146.	Medical Section Files CH2146
3	New York (Kelllex) Safety Committee Bulletins.	Medical Section Files.
4	University of Chicago Health Reports.	Medical Section Files.
5	Fish Program Reports and Charts.	Medical Section Files.
6	University of Rochester Progress and Special Reports.	Medical Section Files.
7	Correspondence on Procurement of Personnel.	Medical Section Files.
8	Contract of Oak Ridge Health Association with the Oak Ridge Hospital.	Medical Section Files.
9	Two Reports from Dr. <sup>W.</sup> Hale to Col S.L. Warren on Radiation Measurements at Tennessee Eastman Corporation. Dated 9 February 1944 & 17 May 1944.	Medical Section Files.
10	Manhattan District Medical Officers Experience and Qualifications.	Medical Section Files.

~~SECURITY INFORMATION~~

~~SECURITY INFORMATION~~

MANHATTAN DISTRICT HISTORY

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VOLUME 7 - MEDICAL PROGRAM

APPENDIX C - PHOTOGRAPHS

1. Counter instrument for measuring alpha radiation.
2. Electrostatic type of electrometer for measuring radiation.
3. Vacuum tube type of electrometer for measuring radiation (Rochester Ion Meter)
4. Film badge.
5. Pencil chambers.
6. Special finger-ring.
7. Finger print impressions.
8. Electrostatic precipitator for measuring dust in the air.
9. Chrysler pump for measuring concentration of fluorine and hydrofluoric acid in air.
10. Standard Chemical Warfare kit.
11. Halide lamp.
12. Organization Charts - Manhattan District Medical Section
  - a. 1 May 1943 to 31 October 1943
  - b. 1 November 1943 to 30 April 1944
  - c. 1 May 1944 to 31 October 1944
  - d. 1 November 1944 to 30 April 1945
  - e. 1 May 1945 to 31 July 1945
  - f. Chart dated 31 July 1946
13. Dispensary - Carbide & Carbon Chemicals Corporation, Oak Ridge, Tennessee.
14. Dispensary and First Aid Station, Percleve Corporation, Oak Ridge, Tennessee.
15. Dispensary - Tennessee Eastman Corporation, Oak Ridge, Tennessee.

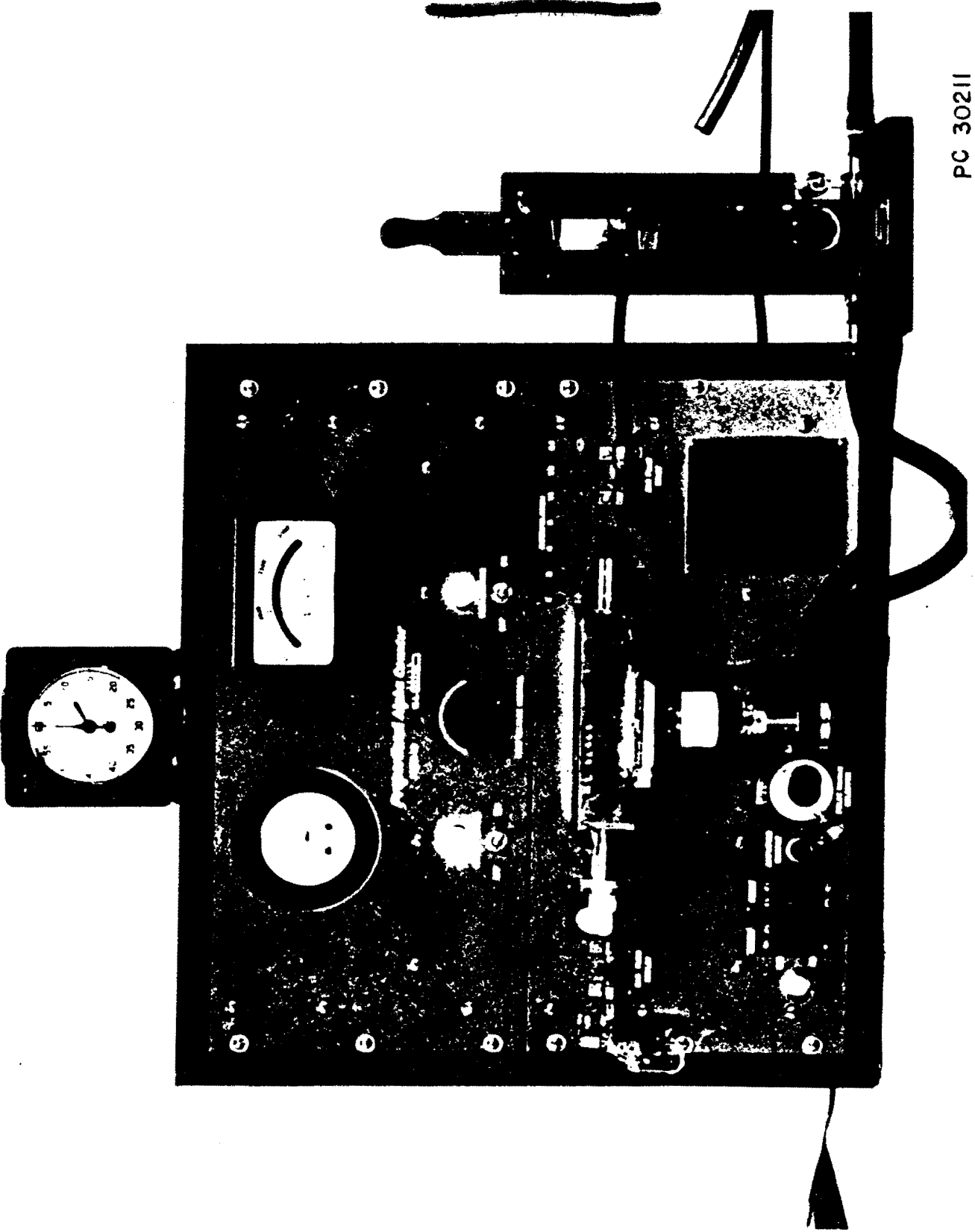
~~SECURITY INFORMATION~~

~~SECRETARY INFORMATION~~

16. Kadlec Hospital - Richland, Washington.
17. Roane-Anderson Medical Service Building, Oak Ridge, Tennessee.
18. Oak Ridge Hospital
  - a. Front entrance
  - b. Rear
19. Oak Ridge Dental Health Center.
20. Oak Ridge Department of Health Buildings.
21. Hospital and first-aid units at Hanford Engineer Works
  - a. Hospital Unit No. 1
  - b. Hospital Unit No. 2
  - c. First medical building and first and second first-aid buildings, Hanford, Washington
  - d. Third first-aid building at Hanford and first-aid station at Richland, Washington.
22. Chart showing relation of District research division to civilian research agencies.
23. Automatic recording and alarm system for monitoring, Hanford Engineer Works.

~~SECRETARY INFORMATION~~

C1 - A COUNTER TYPE INSTRUMENT FOR MEASURING ALPHA RADIATION

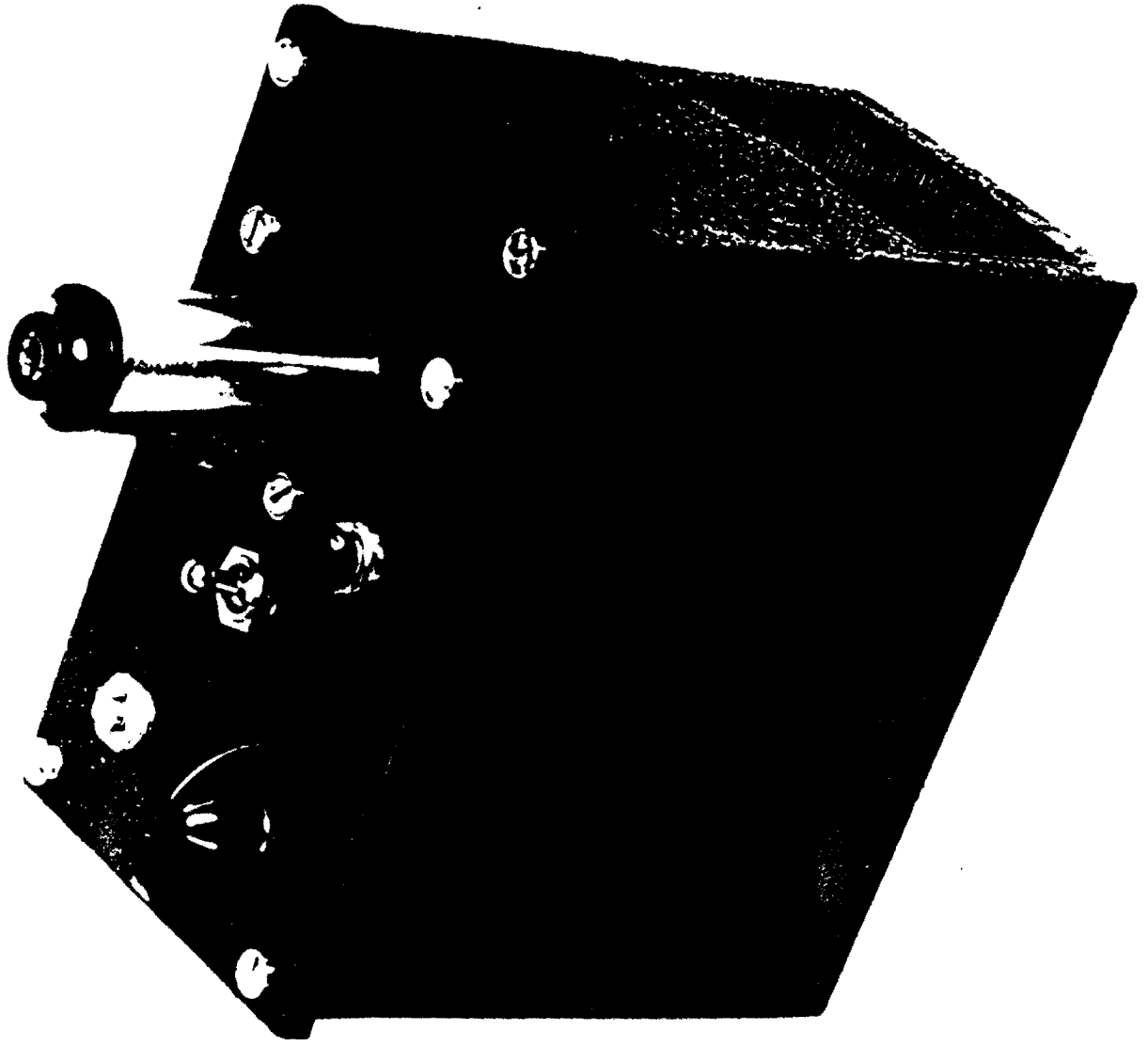


PC 302II

**C2 - AN ELECTROSTATIC TYPE OF ELECTROMETER FOR MEASURING RADIATION**

SE

Figure 2

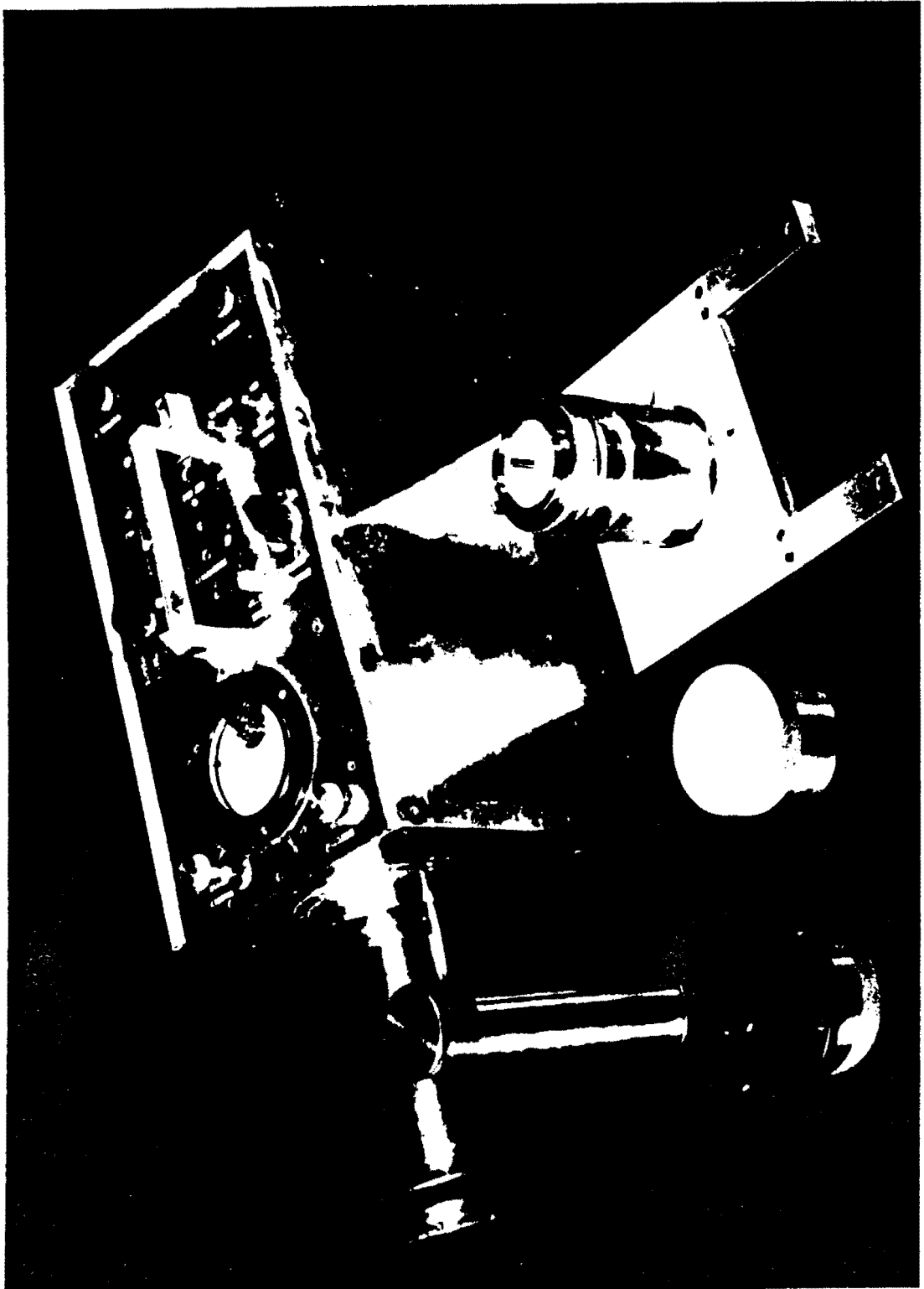


SE

C3 - A VACUUM TUBE TYPE OF ELECTROMETER USED IN MEASURING RADIATION.  
THIS INSTRUMENT IS KNOWN AS THE ROCHESTER ION METER.

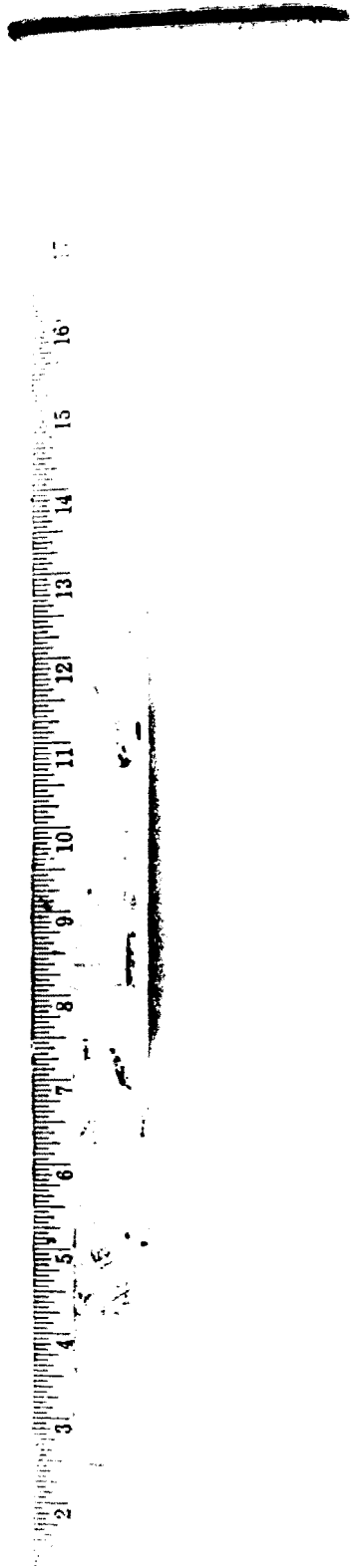
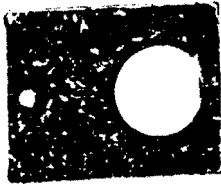


~~CONFIDENTIAL~~



~~CONFIDENTIAL~~

C4 - THE MANHATTAN DISTRICT FILM BADGE FOR MONITORING PERSONNEL  
EXPOSED TO RADIATION. BOTH THE ASSEMBLED BADGE AND THE  
COMPONENT PARTS ARE SHOWN.

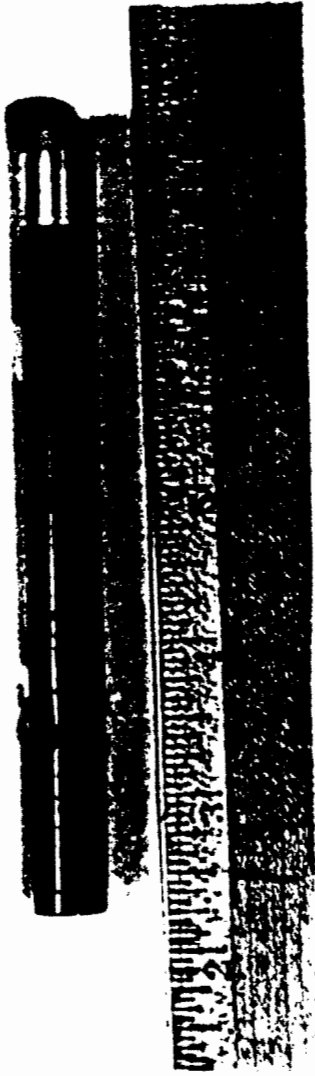


C5 - TWO TYPES OF PENCIL CHAMBERS FOR MEASURING RADIATION, IN  
USE BY THE MANHATTAN DISTRICT.

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**C6 - A SPECIAL ALL-SILVER FINGER RING USED IN MONITORING  
PERSONNEL EXPOSED TO RADIATION. A SMALL DISK OF DENTAL  
X-RAY FILM IS PLACED IN THE CAP SHOWN ON THE RIGHT.**

~~SECRET~~



~~SECRET~~ INFORMATION

C7 - A. AN ENLARGED PHOTOGRAPH OF A NORMAL FINGER PRINT RECORDED  
IN A WAXLIKE IMPRESSION COMPOUND.

B. AN IMPRESSION OF A RIGHT INDEX FINGER SHOWING EARLY  
FLATTENING OF THE RIDGES AND SOME LOCALIZED ATROPHY.  
THIS IS MOST NOTICEABLE IN THE UPPER RIGHT OF THE PICTURE  
FROM RIGHT EDGE OF BOOK.

THIS IMPRESSION IS FROM A RADIOLOGIST WHO HAD WORKED  
5 YEARS WITH X-RAY AND RADIUM.





A

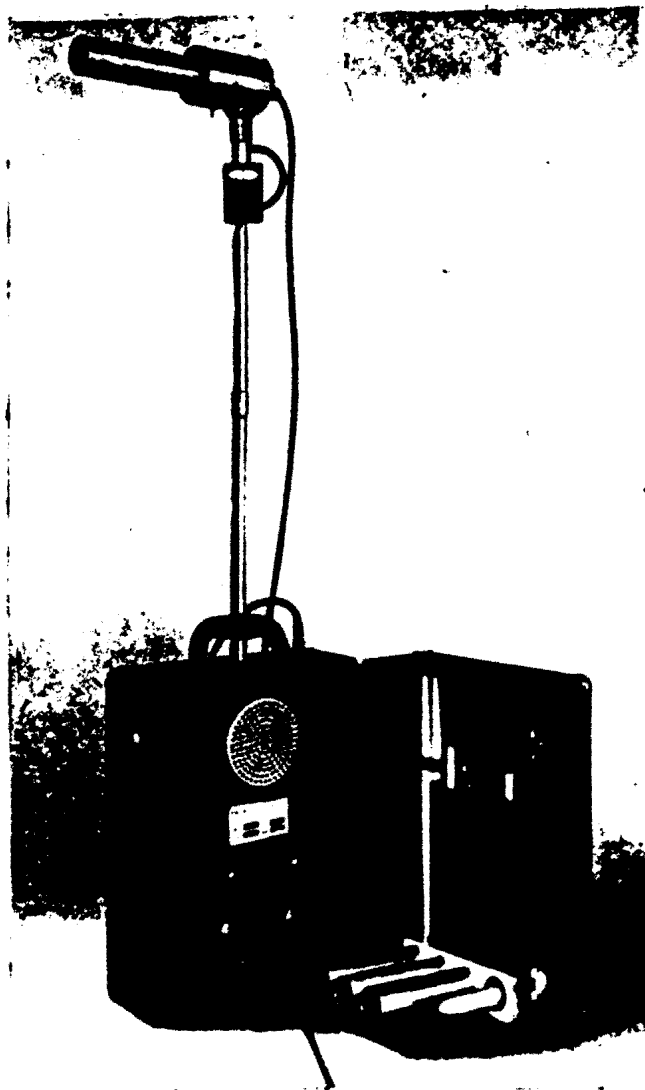


B

**C 8 - AN ELECTROSTATIC PRECIPITATOR USED FOR MEASURING THE AMOUNT  
OF DUST IN THE AIR.**

~~SECURITY INFORMATION~~

~~SECRET~~

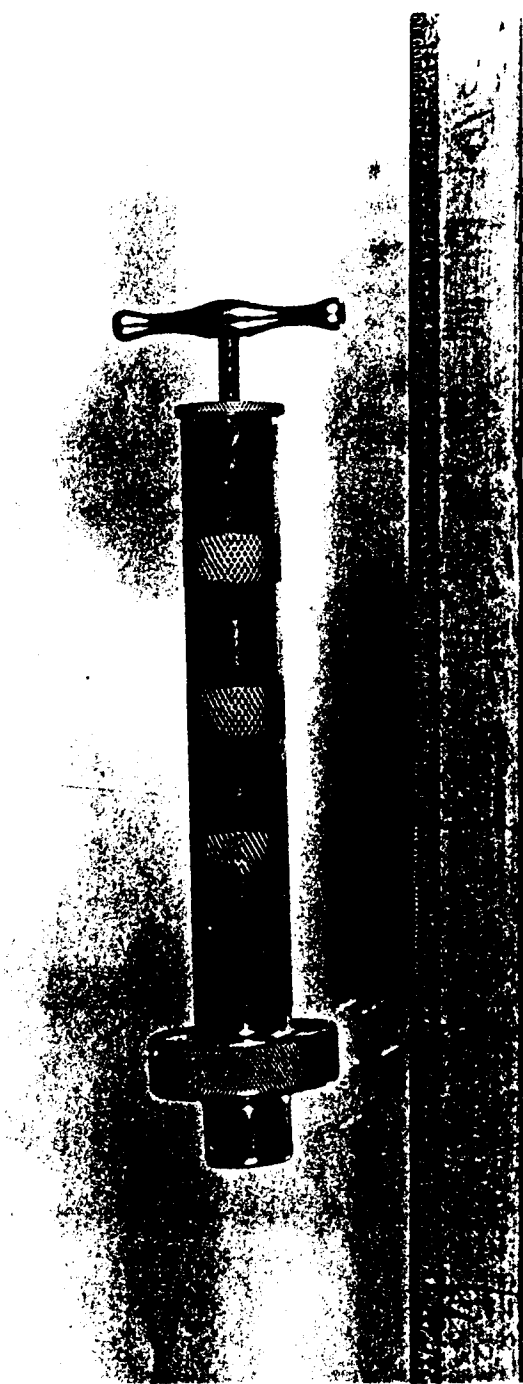


~~SECRET~~

~~SECURITY INFORMATION~~

C9 - THE CHRYSLER PUMP. AN INSTRUMENT FOR MEASURING THE CONCENTRATION OF FLUORINE AND HYDROFLUORIC ACID IN AIR.

~~SECURITY INFORMATION~~



~~SECURITY INFORMATION~~

C10 - THE STANDARD CHEMICAL WARFARE KIT FOR DETECTION OF TOXIC GASES. THIS KIT WAS USED PRIMARILY FOR THE DETECTION OF PHOSGENE PRODUCED AS A BY-PRODUCT IN THE ELECTROMAGNETIC PROCESS.

~~SECURITY INFORMATION~~



~~SECURITY INFORMATION~~

C10

**GL1 - AN HALIDE LAMP USED FOR MEASURING THE CONCENTRATION OF  
VOLATILE CHLORIDES AND FLUORIDES IN AIR.**



~~SECURITY INFORMATION~~

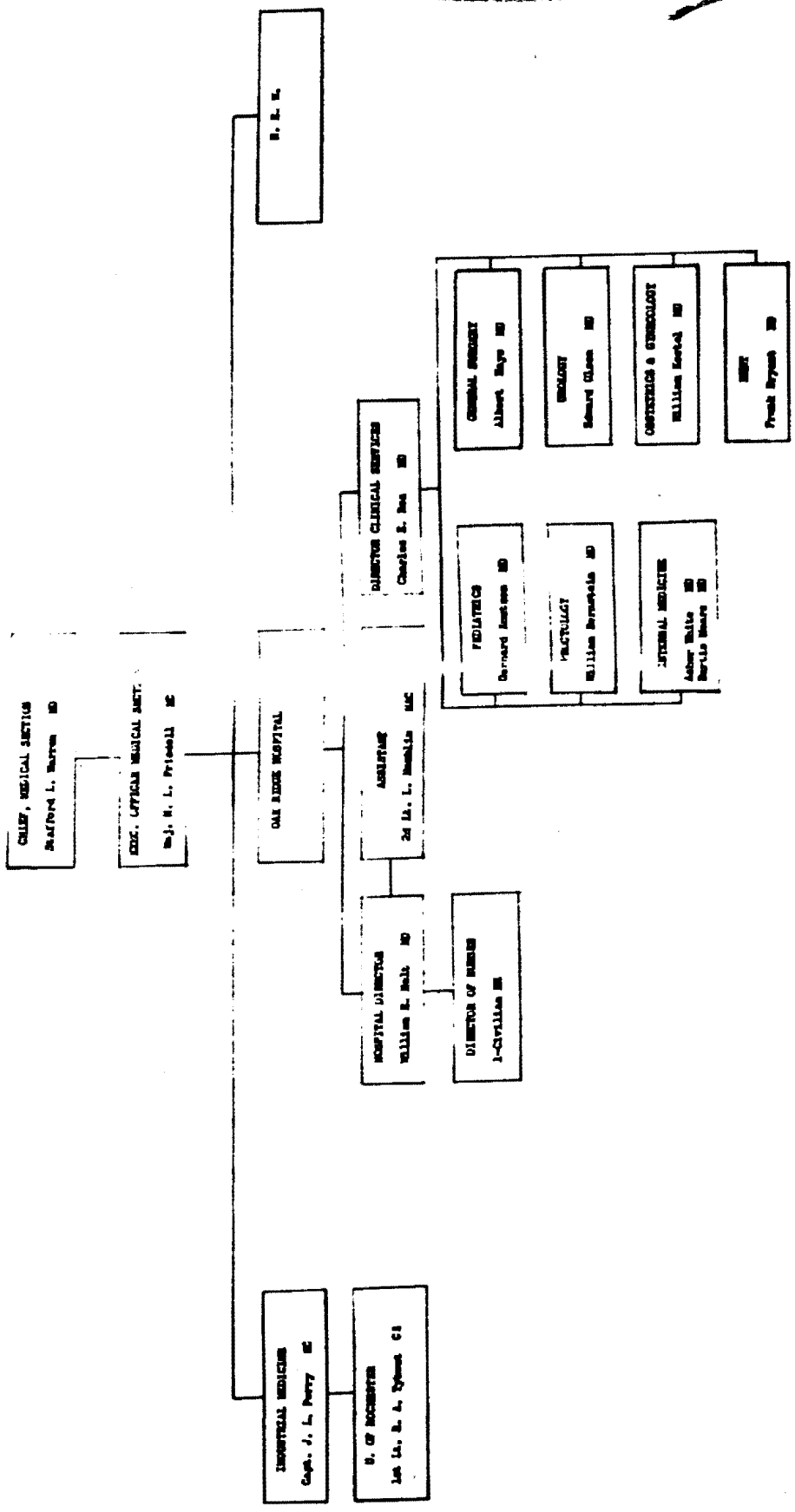


~~SECURITY INFORMATION~~

C-12

RECEIVED BY THE DIRECTOR OF THE FBI ON 11/11/61  
FROM THE SAC, NEW YORK (100-100000) 1P  
RE NEW YORK TELETYPE TO BUREAU 11/10/61

MEDICAL SERVICE  
1 May to 31 October 1943



W. E. W.

CHIEF, MEDICAL SERVICE  
MAJ GEN L. MURPHY MC

CHIEF, LYTTON MEDICAL INST.  
MAJ GEN L. FRIEDELL MC

OAK RIDGE HOSPITAL

HOSPITAL DIRECTOR  
WILLIAM E. HALL MD

DIRECTOR OF NURSING  
J-CIVILIAN MC

ASSISTANT  
2d LT L. MUMFORD MAC

DIRECTOR CLINICAL SERVICES  
CHARLES S. BOE MD

OBSTETRICS  
DORRARD JONES MD

OBSTETRICS & GYNECOLOGY  
WILLIAM MORTON MD

INTERNAL MEDICINE  
ARTHUR WATTS MD  
BERTIE HENRY MD

OBSTETRICS & GYNECOLOGY  
ALBERT RAY MD

OBSTETRICS & GYNECOLOGY  
WILLIAM MORTON MD

OBSTETRICS & GYNECOLOGY  
FRANK RYAN MD

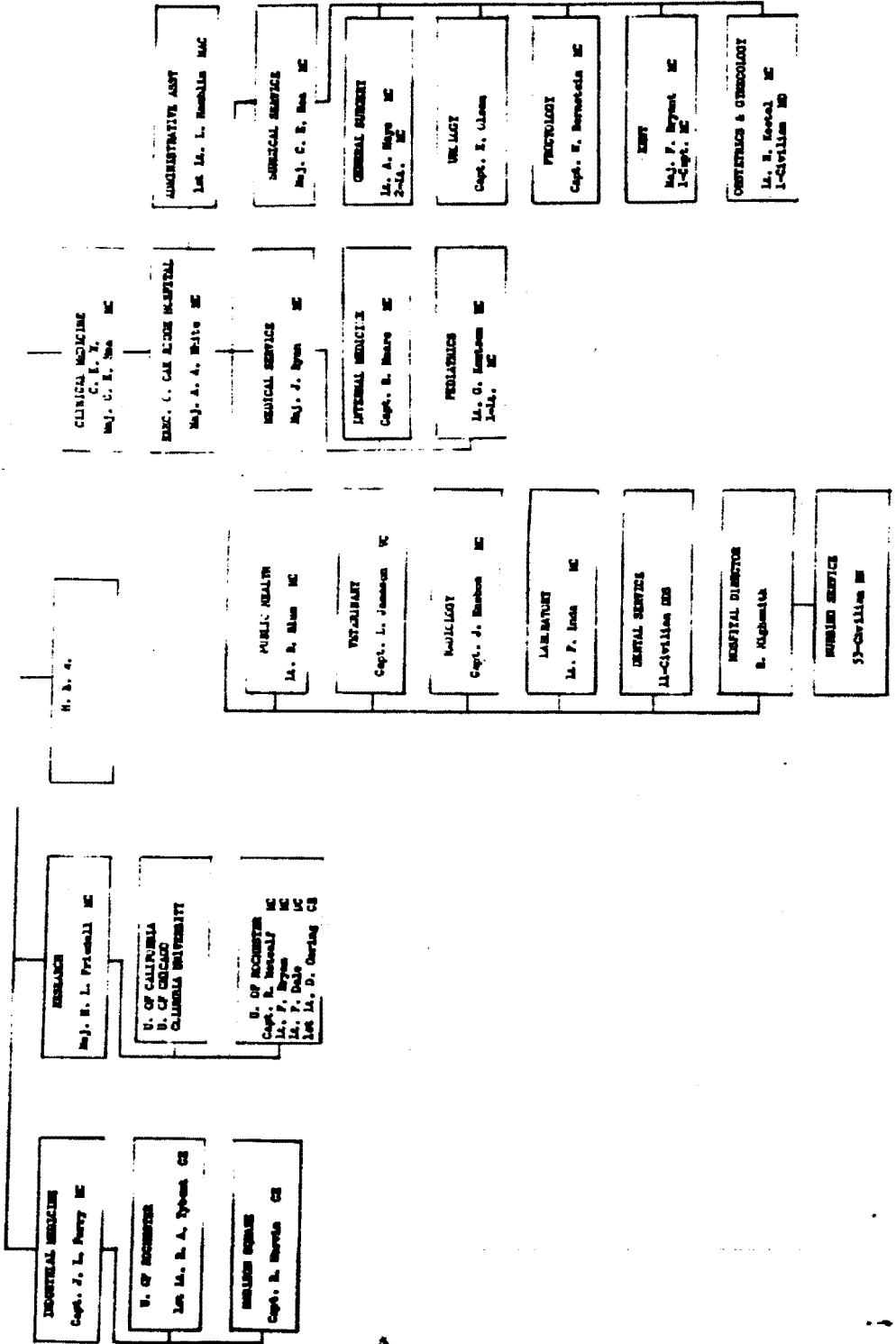
HOSPITAL MEDICINE  
CAPT J. L. PERRY MC

W. OF RECEIVING  
2d LT L. A. TYSONS CI

1 November 1953 to 30 April 1954

CHIEF, MEDICAL DIVISION  
Maj. G. R. Searles MC

DEPUTY CHIEF, MEDICAL DIVISION  
Maj. R. L. Frenschel MC



C12767







PERSON

OFFICERS	29
ENL.	1
P.	1
SP.	3
CAP.	3
SGS.	1
BISEL.	1
VAC.	
TOTAL	53

**MEDICAL Division**

Medical Branch is advisory body to Dist. Mgr. for general health and welfare of Man. Dist. personnel. Charged with providing med. care, reviewing and determining seriousness for ind. health hazards, conducting biological and health physics research necessitated by these health hazards.

Col. W. D. Fleming, Chief  
Capt. E. E. Brumbaugh, Exec. O.

**IA.**

**INDUSTRIAL MEDICINE SECTION**

Determines health hygiene and necessary health measures, advises plant physicians and examines manufacturing operations.

Capt. E. R. Clarkson, Chief  
Capt. F. J. Jernan, Asst Chief  
Capt. B. S. Wolf

**IB.**

**MEDICAL RESEARCH SECTION**

Biological and health physics research. Supervises liaison with research programs and recommends modification or additions to the established research programs.

Capt. J. E. Penland, Chief  
Capt. J. E. Vallentine, Asst Chief  
Capt. F. E. Roberts  
Capt. F. A. Ioda

**IC.**

**CLINICAL MEDICINE SECTION**

Determines the number and type of ind. med. wt. and public health facilities to be provided. Operates these facilities in accordance with the policies of the chief of medical section.

Capt. F. E. Deming, Chief  
Dr. I. A. Salisbury, Clin Med Adv  
Capt. J. J. Clark, MEd Dir Hosp  
Capt. R. C. Dahlstrom  
Capt. J. D. DePercia  
Capt. J. D. Gilbert  
Capt. R. A. Johnson  
Capt. J. T. Purdy  
Capt. E. A. O'Connor  
Capt. C. J. Nagam  
Capt. L. F. Proctor  
Capt. B. G. Tucker  
Capt. J. H. Allen, Jr.  
Capt. G. Bellie  
Capt. J. E. Brooks  
Capt. C. S. Proctor, Sr.  
Capt. E. L. Bayler

**ID.**

**ADMINISTRATIVE SECTION**

Administrative assistant to the chief of medical branch. Supervises office management, office personnel, medical supplies and reports.

1st Lt. E. J. Higgins, Chief  
Capt. J. E. Falkenberg, Asst Insp  
1st Lt. E. E. Rosenbaum  
G. Jones, Gln. CAP-6  
E. Chancy, Gln. Steno. CAP-4  
D. Stevens, Gln. Steno. CAP-4  
Cpl. L. B. Sawyer Steno.

**ORGANIZATION CHART**  
MANHATTAN DISTRICT

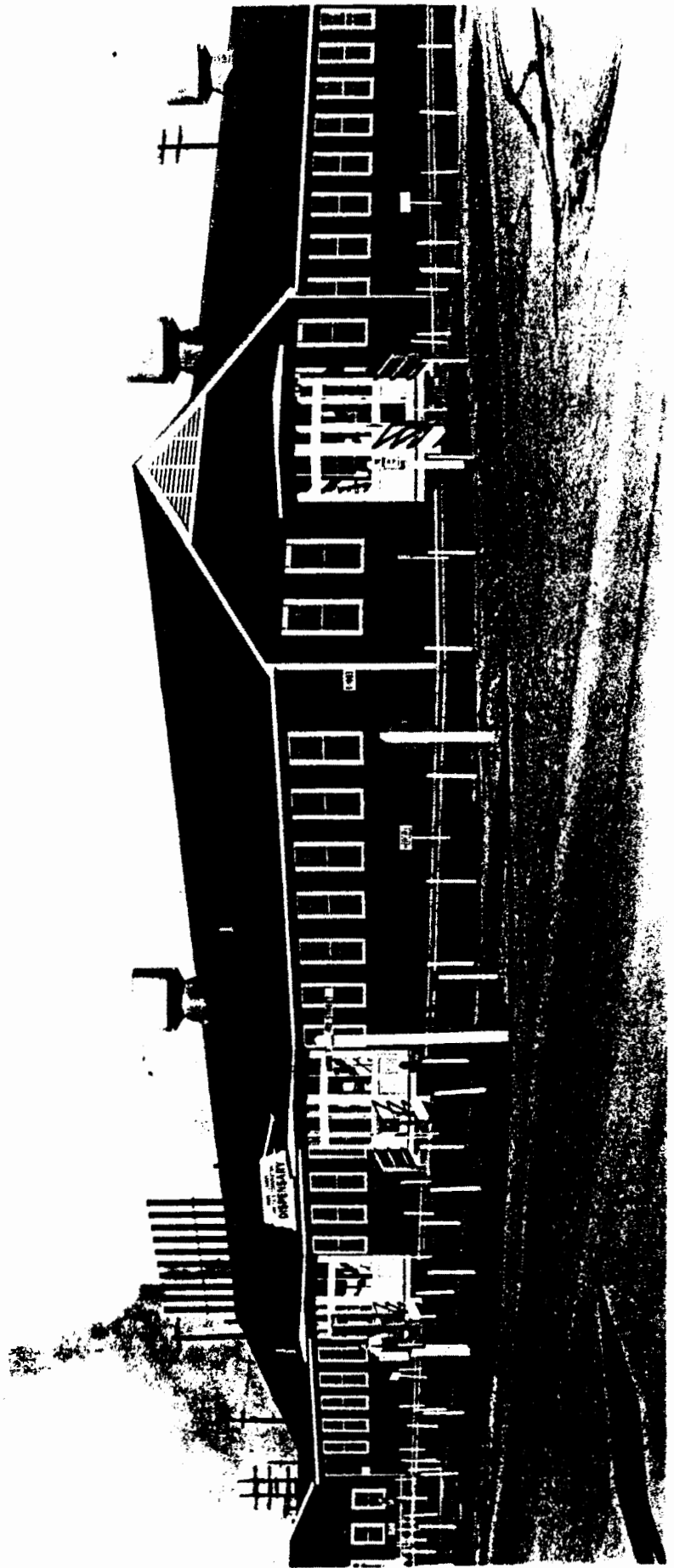
UNIT MEDICAL BRANCH INDUSTRIAL BRANCH  
SUBMITTER: [Signature]  
RECOMMENDED: [Signature]  
APPROVED: [Signature] DATE: 10/14/44

~~SECRET~~

C12(f)







61A - FRONT VIEW OF THE DISPENSARY AND FIRST AID STATION LOCATED  
AT THE FERGLEVE CORPORATION PLANT AT OAK RIDGE, TENNESSEE.

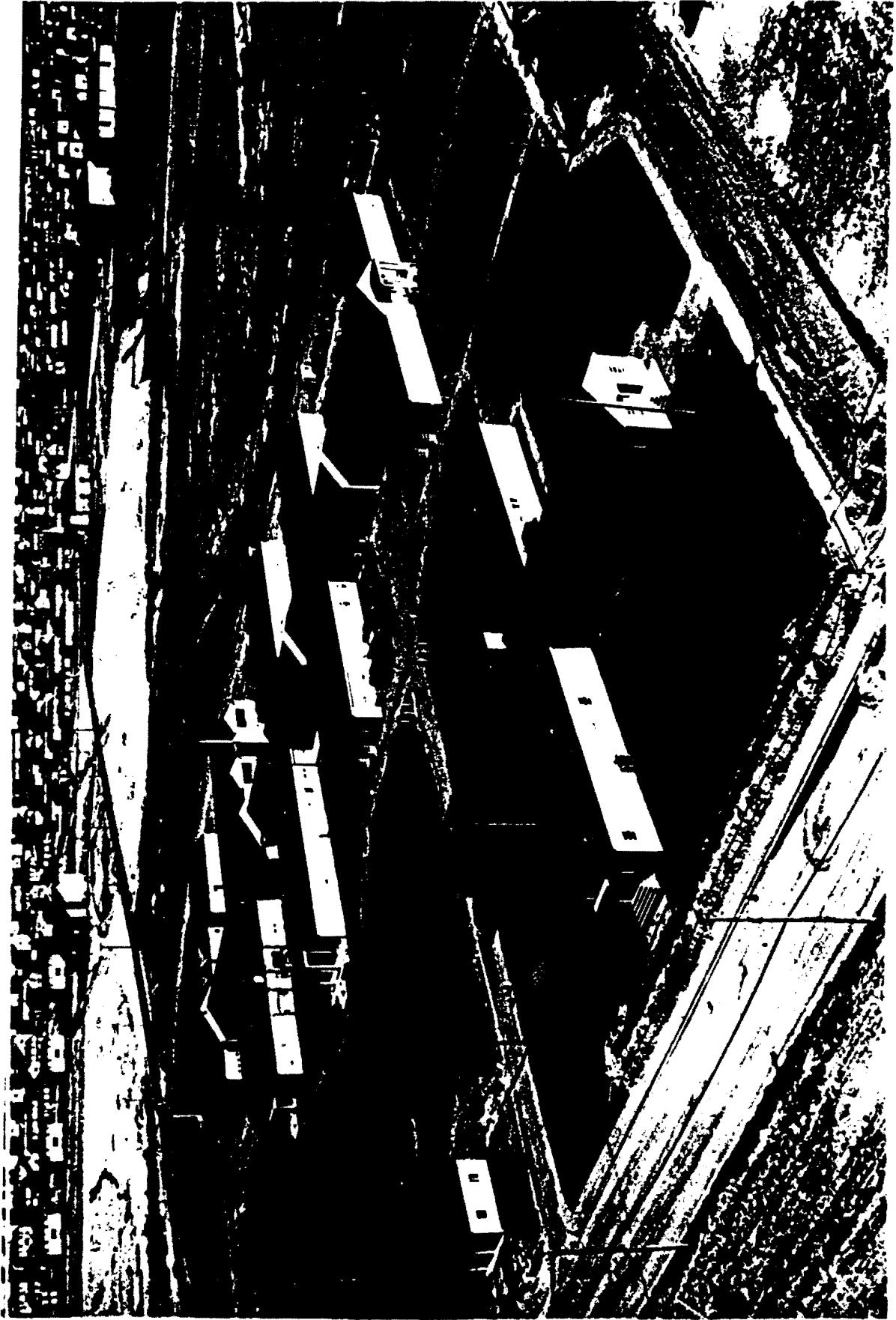


ION

**015 - FRONT VIEW OF THE MEDICAL DISPENSARY AT THE TENNESSEE  
EASTMAN CORPORATION PLANT AT OAK RIDGE, TENNESSEE.**



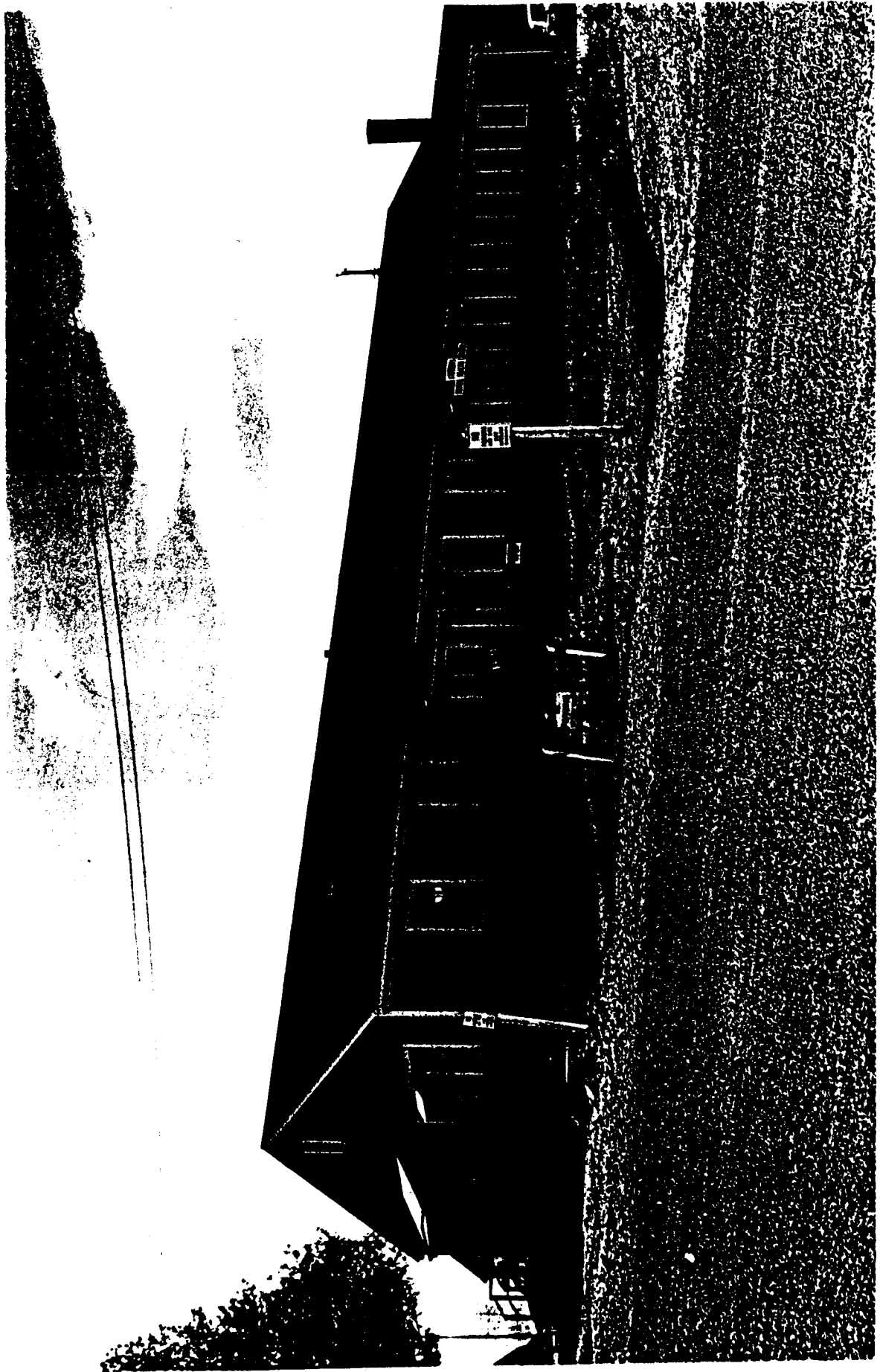
016 - VIEW OF KADLEC HOSPITAL AT RICHLAND, WASHINGTON



NOTICE

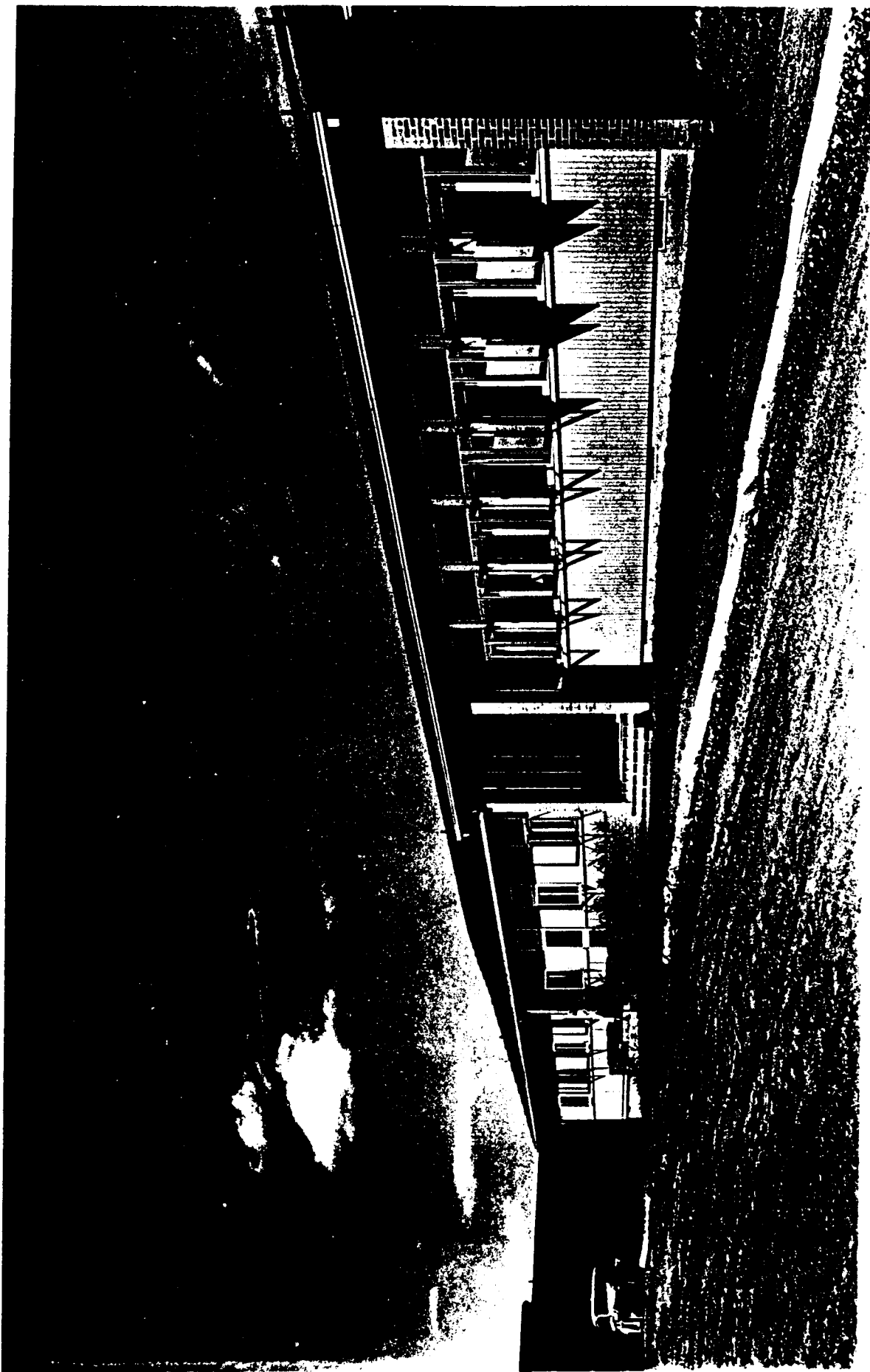


017 - VIEW OF ROAME-ANDERSON MEDICAL SERVICE BUILDING AT OAK  
RIDGE, TENNESSEE.



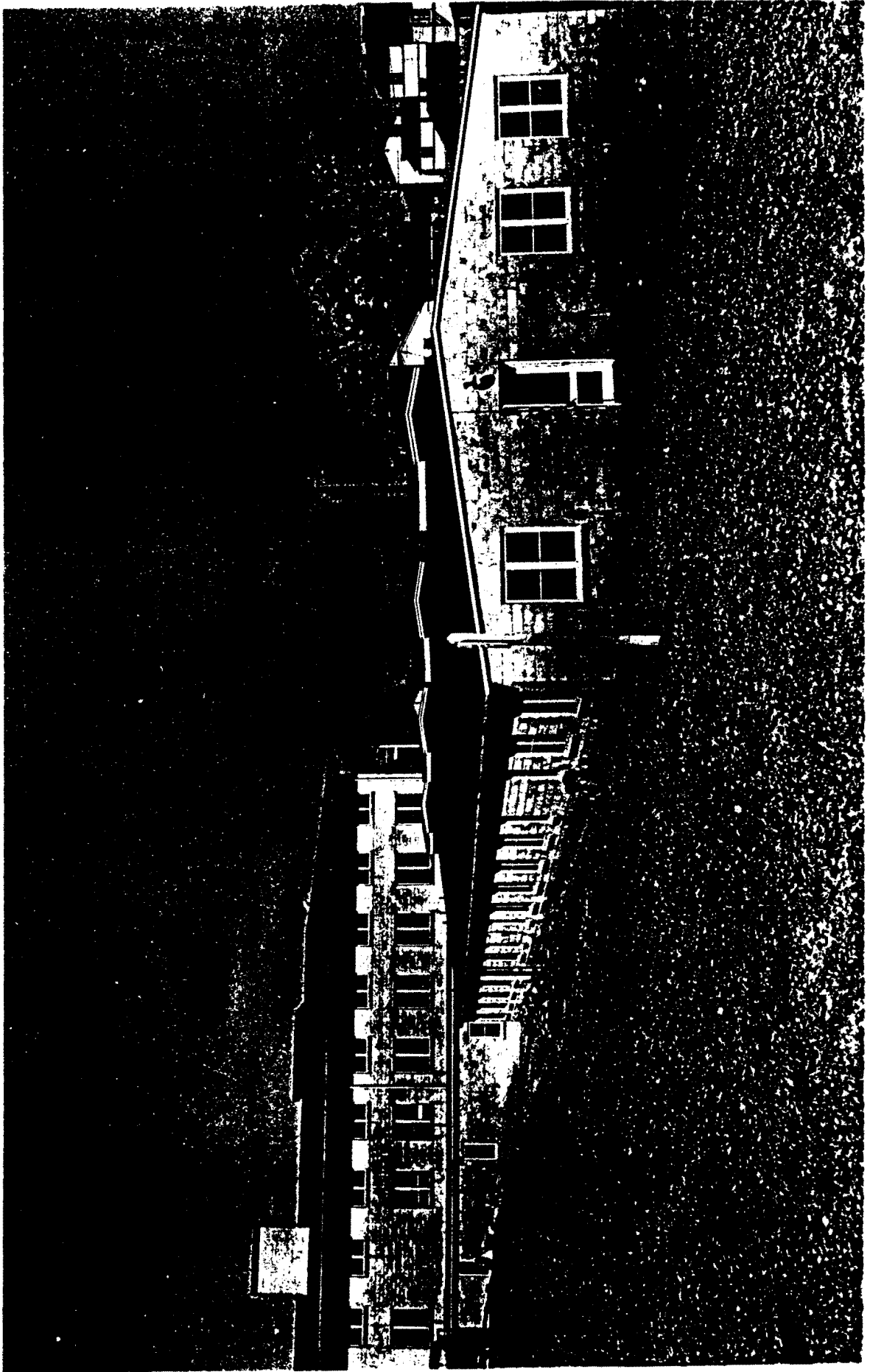
SECURITY INFORMATION

**CL8 - TWO VIEWS OF OAK RIDGE HOSPITAL SHOWING FRONT ENTRANCE  
AND REAR OF HOSPITAL.**



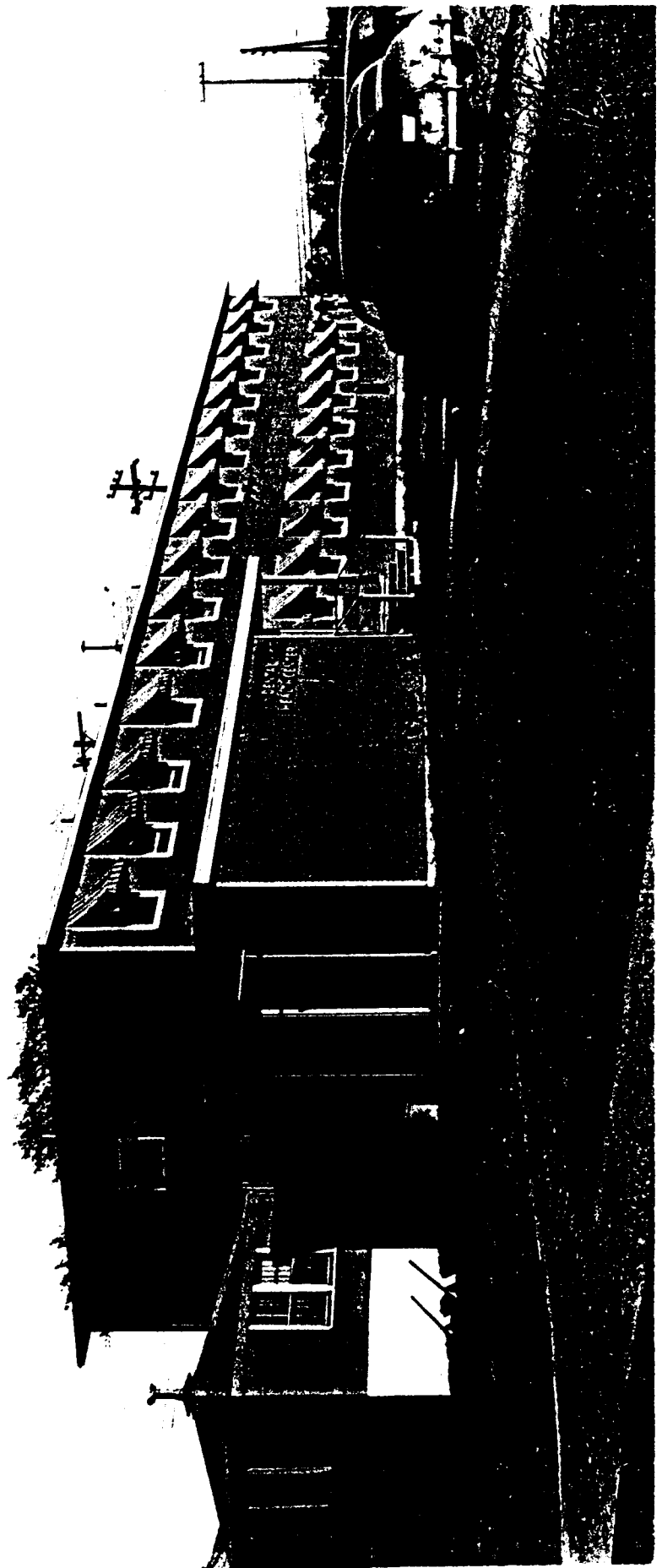
100-100000-100000

C18(a)



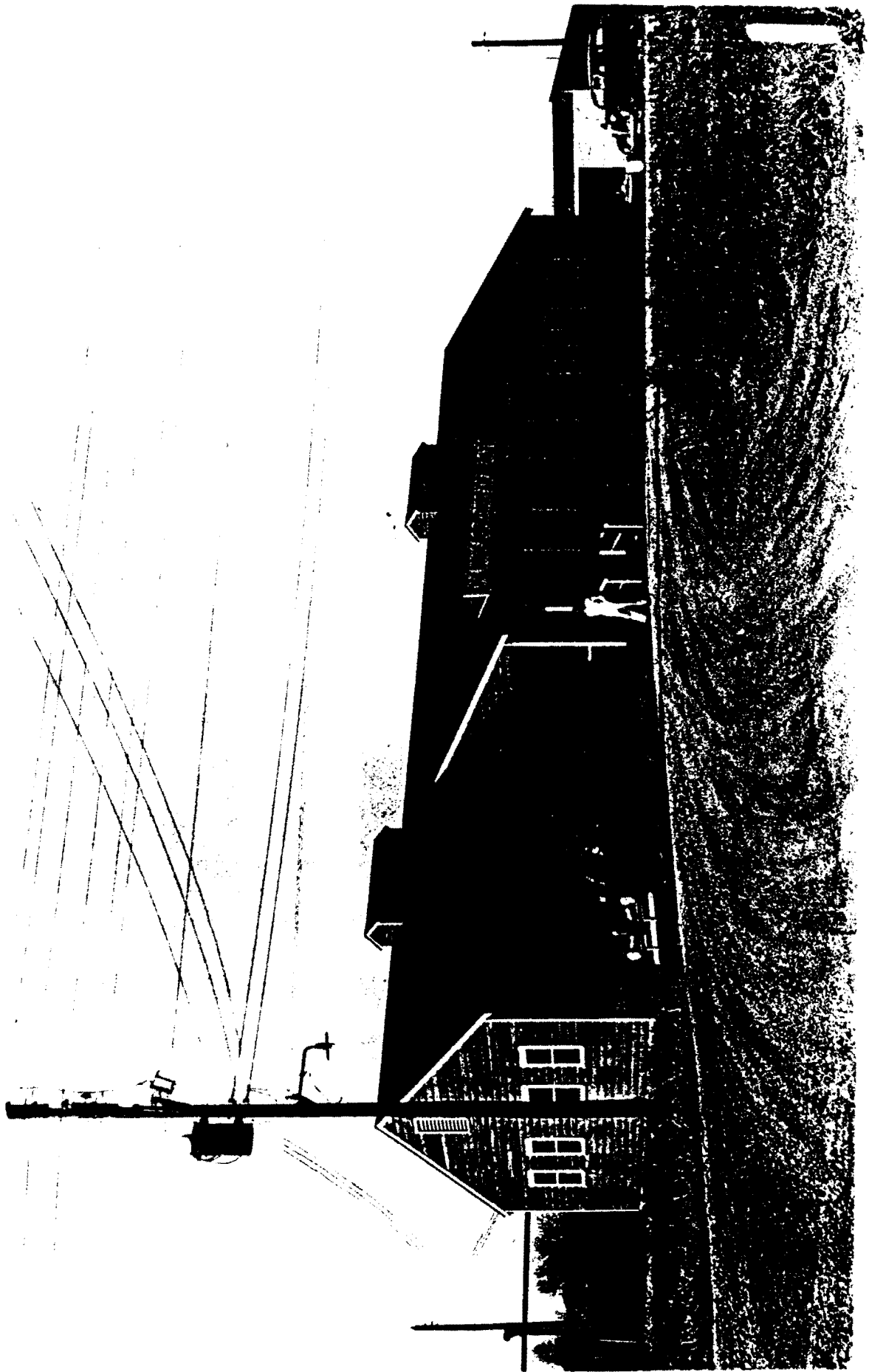
SECRET

C19 - FRONT VIEW OF THE OAK RIDGE DENTAL HEALTH CENTER. THE  
ADULT POPULATION WAS TREATED IN THIS BUILDING. THE  
CHILDREN'S DENTAL CLINIC IS IN THE ROANE-ANDERSON MEDICAL  
SERVICE BUILDING PICTURED IN C17.



G20 - FRONT VIEW OF THE BUILDING HOUSING THE OAK RIDGE DEPARTMENT  
OF HEALTH, OAK RIDGE, TENNESSEE.





STREETS

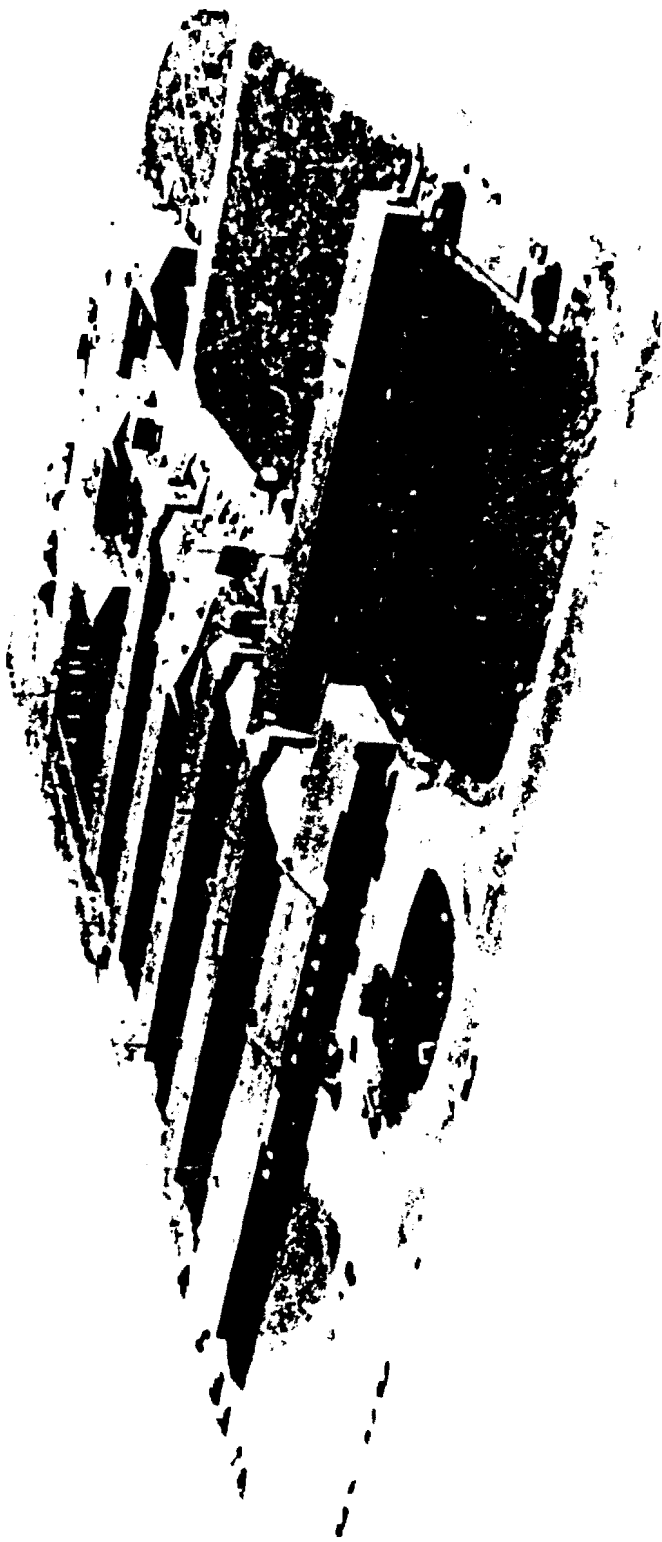
C21

THE UNITED STATES OF AMERICA  
DEPARTMENT OF JUSTICE  
FEDERAL BUREAU OF INVESTIGATION  
WASHINGTON, D. C. 20535

1

HOSPITAL UNIT NUMBER 1





HOSPITAL UNIT NUMBER 2

SECURITY INFORMATION

C21(b)



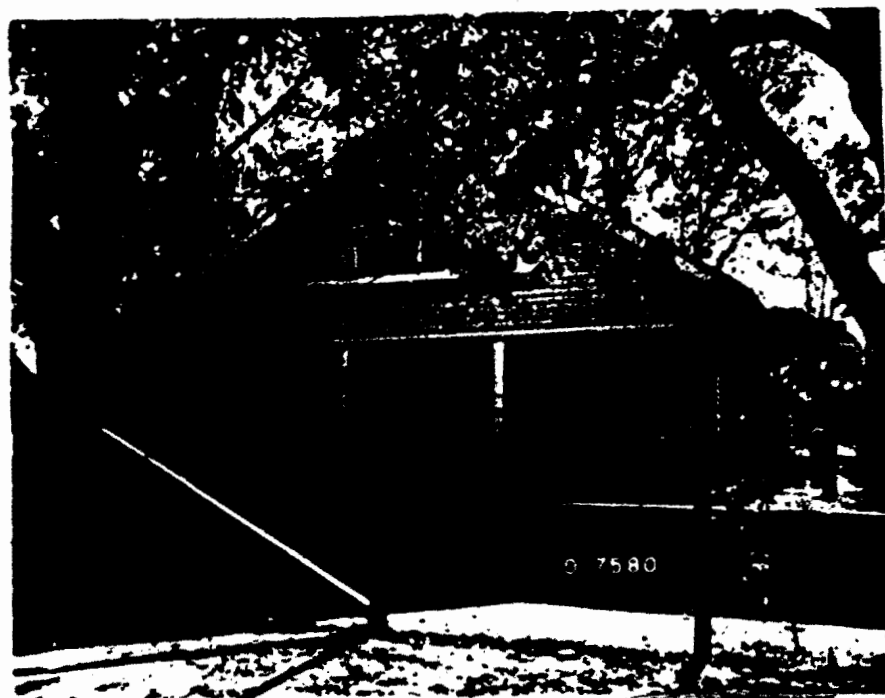
(UPPER)

FIRST  
MEDICAL BLDG.  
in Hanford

Used during latter  
part of April and  
during May of 1943.  
Contained 20 cot  
beds - staffed by  
nurse and orderly.

(CENTER)  
SECOND  
FIRST AID BUILDING  
in Hanford

Used from April 12, 1943  
to June 1, 1943 - staffed  
by 5 nurses and 2 doctors



(LOWER)

FIRST  
FIRST AID BLDG.  
in Hanford

A remounted farm  
house - used from  
April 4, 1943, to  
April 12, 1943 -  
staffed by 2 nurses

C21(c)

MEDICAL DIVISION ORGANIZATION  
as of June 1, 1943

Medical Supervisor	1	Nurses	5
Physicians	4	Stenographers	1
Supervisor of Nurses	1	Clerks	3



THIRD FIRST AID BUILDING IN HANFORD

This type of First Aid Building was used from June 1, 1943 to July 23, 1943 --- staffed by two doctors and 5 nurses. This building contained doctors' offices and 10 beds in addition to First Aid. Similar buildings were later used as sick bays for males, females, and isolation cases.



FIRST AID STATION IN RICHLAND

Typical early First Aid Station in Richland. Used prior to erection of Radco Hospital. There were at different times, 3 First Aid Stations in Richland.

50

C21(d)

53

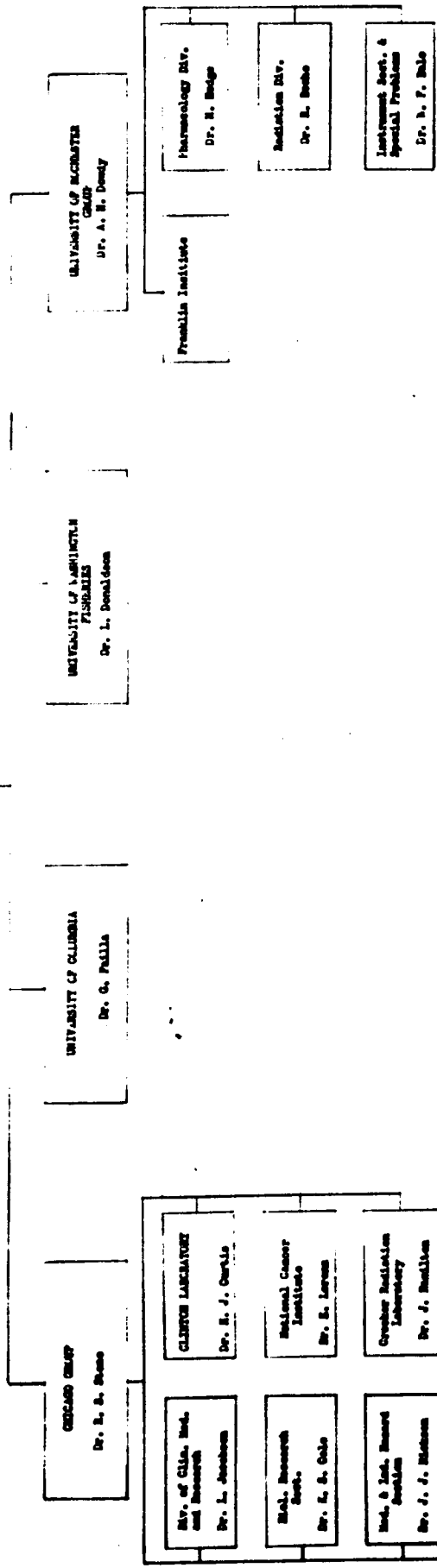
C22

RECEIVED THE OFFICE OF THE ATTORNEY GENERAL  
STATE OF TEXAS  
AT DALLAS

DISTRICT ENGINEER

MEMBER INSTITUTIONS

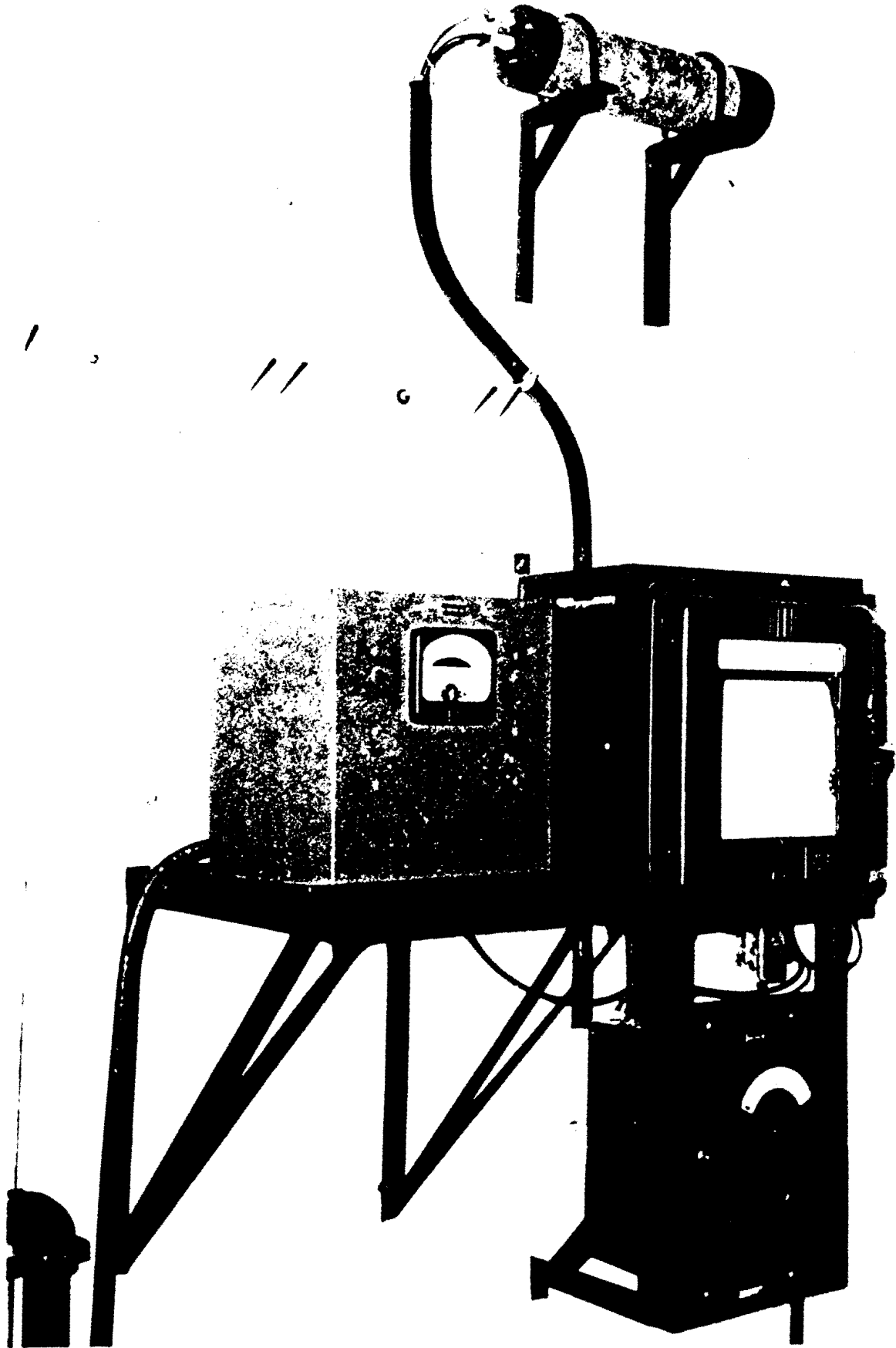
- Col. S. L. Warren MC
- Lt. Col. H. L. Friedell MC
- Capt. J. A. Merrill MC
- Capt. D. Colvard MC





C 23 - VIEW OF AUTOMATIC RECORDING AND ALARM SYSTEM FOR RADIATION  
MONITORING IN USE AT HANFORD ENGINEER WORKS.

~~SECURITY INFORMATION~~



~~SECURITY INFORMATION~~

Mr. Hadden  
CPI

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