MANHATTAN DISTRICT HISTORY

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Chapter 9. Assistance on the Canadian Pile Project.

1. Beginning of the Project. - The early beginning of the Canadian Pile Project is recorded briefly in the document which was issued in Great Britain, a few days after the bombing of Hiroshima, under the title, "Statement by the Department of Scientific and Industrial Research, Issued August 12, 1945". Under the heading: "Joint British-Canadian-American slow neutron project in Canada", this document reads, in part, as follows (Reference: 1, in Appendix to this Chapter):

"Toward the end of 1942 it was decided that the slow neutron research in progress at Cambridge would proceed more quickly and efficiently if it were transferred to a place geographically nearer to Chicago where the corresponding American work was being carried out.

"A proposal was made to the Canadian Government that a joint British-Canadian research establishment should be set up in Canada to work in close touch with the American group. The Canadian Government welcomed the suggestion, with the result that at the beginning of 1943 a large research establishment was set up in Montreal under the general direction of the National Research Council of Canada.

"Practically the whole of the Cambridge group, under Dr. Halban, was moved to Montreal where the research staff was rapidly augmented by many Canadian scientists, several new recruits from the United Kingdom, and a certain number from the United States. The laboratory was at first directed by Dr. Halban. He resigned this position early in 1944 and Prof. J. D. Cockcroft was appointed to suceed him.

"During the spring of 1944 the Americans joined actively in that project which now became a joint British-Canadian-American enterprise. Its scope was enlarged and in 1944 a site was selected on the Ottawa River, near Petawawa, Ontario, for the construction of a pilot scale pile using heavy water supplied by the United States Government as the slowing-down medium".

2. Purpose. - The project contemplated the design, construction and operation of a heavy-water-moderated pile pilot plant, for production of both plutonium and U233, and the able Canadian and British scientists who were engaged in experimental work in Montreal were eager to undertake it, with the necessary assistance from the United States. The group was then headed by Prof. Cockcroft, and some of its members had participated in the early stages of the United States project.

It was an open question whether heavy water might be more suitable than graphite as a pile moderator, but all concerned agreed that the possibility should not be over-looked and that a uranium-heavy water pile of more than experimental size should be built and operated, to extend and supplement the knowledge expected to be gained from the experimental P-9 pile which was then about to reach operation in the Argonne Laboratory. The principal reason why the idea of using heavy water as a moderator had been discarded for the full scale plutonium production plant in Hanford was the difficulty of manufacturing heavy water in sufficient quantity in the time expected to be available; but sound long-term planning dictated that careful exploration should be made of all possibilities of the use of heavy water as a moderator.

An important additional purpose of the project was to insure that the Canadian and British scientists in Canada would have facilities for nuclear physics experimentation, including significant quantities of various fissile materials, as well as the pile itself and all its auxiliaries. These facilities they were naturally very keen to have.

In a later paragraph herein some of the benefits expected to accrue to the United States from this project are enumerated. These serve to amplify the general purpose of the project insofar as the United States is concerned.

3. British-Canadian-American Co-operation. - The active participation of the United States in the project, which began in the spring of 1944, as described in the British statement, was preceded by discussion early in that year between: Major General L. R. Groves, Commanding General of the Manhattan District; Prof. Sir James Chadwick, technical adviser to the United Kingdom members of the Combined Policy Committee; and Dean C. J. MacKenzie, President of the National Research Council of Canada. The Combined Policy Committee, at a meeting on 17 February 1944, had appointed these three men members of a sub-committee "to advise on cost, feasibility and time schedule for construction of a heavy water pile plant under joint American-British-Canadian auspices, to be located in Canada and to use heavy water produced in the United States". A comprehensive report by this sub-committee was accepted and approved by the Combined Policy Committee at its meeting on 19 September 1944. As stated in this report, it was "prepared after technical

discussions as to the possibilities for the construction of heavy water piles with Messrs. A. H. Compton and E. Fermi, and others, at Chicago, and with Messrs. H. Halban, R. E. Newell, and others, at Montreal". (References: 2, 3, 4.)

In May 1944, an agreement was negotiated, whereby the Manhattan District and the Montreal group, under Dr. J. D. Cockcroft, would interchange information essential to the construction of the Canadian pile (References: 5, 6). This agreement was amplified by subsequent additional decisions. Because of security restrictions and because it was essential to avoid delay to any important part of the program then being prosecuted with the utmost speed in the United States, this agreement was limited within prescribed bounds. Information from Los Alamos and Hanford was not to be divulged, and this left the Metallurgical Laboratory and the Clinton Laboratories as the main sources of information for the Canadian group. Without access to information from Hanford, the group was compelled in large measure to develop their own chemical extraction processes. Independent development was necessary in some phases of the project anyway, because of the novel features of the proposed plant, and it is believed this has had further advantages also in tending to increase the general process knowledge to become available.

The agreement, with its later supplements, also provided that certain critical materials, including samples of irradiated metals, would be furnished by the United States (References: 5, 6).

Through decisions reached in meetings of the Combined Policy

Committee's Subcommittee, the United States agreed to ship to Montreal considerable tonnages of heavy water and of Uranium rods for use in the project. On 6 November 1944, General Groves wrote a letter to Sir James Chadwick emphasizing the fact that this material was being furnished on a temporary loan basis and must be handled with utmost care (Reference: 7).

The materials furnished have included over 19 tons of heavy water and 5 tons of pure uranium metal, on loan, and also samples of pure thorium and uranium, dozens of irradiated samples of uranium and thorium metals and salts for development of extraction processes, and samples of fissionable material. Instruments and drawings, and hundreds of reports and other items of pertinent information, as well as the advisory services of experienced United States scientists, have also been furnished. The United States has also sold outright to Canada 10 tons of machined uranium rods for use in the pilot plant, of pure metal not obtainable outside the United States (Reference: 5).

The irradiated samples (or slugs) of uranium and thorium carbonate which were furnished by the United States for the Canadian project came from the pile of the Clinton Laboratories in Oak Ridge, Tenn. Some calibrations and irradiations of samples prepared in Canada have been carried out at the Argonne Laboratory. The heavy water which was furnished was the product of the P-9 project (See Book III). Both the heavy water and the metal which were loaned by the United States are still at the plant and are reported on regular inventories of materials as on loan from the United States project (Reference: 8).

During late May of 1944 Dr. Cockcroft and other senior scientists of the Montreal Group, including Drs. Halban, Newell, Placzek, Volkoff, Ginns and Pontecorvo, visited the Metallurgical Laboratory in Chicago. A comprehensive series of meetings took place, extending from 25 to 27 May 1944. At these and subsequent meetings, many of the problems involved in the contemplated project were discussed. The United States representatives who attended included Drs. Compton, Allison, Watson, Wigner, Hogness, Greninger, Young, Ohlinger, Creutz, Brugeman, and Jacobson, of the Metallurgical Laboratory, and Majors Benbow and Peterson of the Manhattan District. (References: 5, 8, 9, 10, 11.)

Among the specific subjects discussed at these meetings were: film formation, activation of effluent water, general engineering, shielding, health hazards, lattice design, control and stability, boiling disease, light and heavy water cooling, production of U233, canning, water treatment, general organisation of the Montreal group, and liaison with the Manhattan District.

General Groves established a liaison office in Montreal, which was later given the name Evergreen Area, and he assigned Major H. S. Benbow as Liaison Officer, to represent him and to implement the interchange agreement. As his scientific representatives and advisers, and to provide liaison with the Metallurgical Laboratory, General Groves assigned Dr. W. W. Watson, physicist and Dr. John R. Huffman, chemical engineer, to the Montreal office. These senior and experienced scientists worked closely with the Montreal group until November 1945, when they were replaced by Dr. George L. Weil, physicist and veteran pile expert from the United States pile project. In December 1945 Major P. Firmin replaced Major Benbow; Major Firmin was in turn replaced by Colonel A. W. Nielsen in February 1946. (Reference: 5.)

United States assistance continued from May 1944 to August 1946, when enactment of the Atomic Energy Act of 1946 (approved by the President 1 August 1946) suspended all interchange of restricted information and critical materials. Pending determination, at high level, of policies for British-Canadian-American co-operation with respect to agreements made prior to the passage of the Act, this suspension continued, but the United States representatives remained at the project as custodians of U.S. property, as liaison for declassification, and as observers, and the materials loaned by the United States were retained, with status unchanged, by the Canadians (References: 12, Sec. 10).

Under the Canadian Atomic Energy Act of 1946, which was enacted 31 August 1946, full responsibility for the control of atomic energy in Canada was placed upon an Atomic Energy Control Board. (Reference: 13, p. 25.)

With the establishment of the Atomic Energy Research Laboratory at Harwell, Didcot, England, a considerable proportion of the British personnel at the project was called back to England. This loss in personnel was compensated to some extent - at least in manpower if not in experience - by the assignment of other Harwell personnel to the Canadian project for several months of training. When the situation has stabilized, it is anticipated that there will be at the project a group of about 40 on the British pay roll (out of a total of approximately

220 scientists and engineers), but the turnover within this group will probably be appreciable. (Reference: 13, pp. 10, 11.)

4. Description of Plant.

a. General. - The Canadian, or NRX, pile, is termed a heavy-water-moderated pile, or a "polymer" chain-reaching pile, of pilot plant scale. By July 1944, the project, then, as stated in the British announcement, a joint enterprise of England, Canada and the United States, had become tentatively crystallized; a site was selected and from that time on the efforts of the National Research Council Laboratories were concentrated on design and construction.

An excellent description of the plant may be found in "The Canadian Pile Pilot Plant - Interim Report on Design and Construction - Constituting a Final Report by John R. Huffman", written as of 1 December 1945 (Reference: 14). Although construction had not yet been completed at that time and although the design of some parts of the processing equipment had not yet been determined, Dr. Huffman's report and the drawings accompanying it are still essentially accurate insofar as the major features of the pile and of the plant as a whole are concerned (Reference: 8). Engineering changes made since his report was written have been minor ones in the auxiliary, service, and extraction systems. (It may be useful to interpolate here that although construction was substantially completed before 31 December 1946, operation was still several months in the future on that date).

Excellent supplementary information, particularly with respect to the extraction processes, which had not been designed when Dr. Huffman prepared his report, may be found in the "Terminal Report Covering Period Oct. 22, 1945 to Nov. 30, 1946," by Dr. George L. Weil, dated 26 May 1947 (Reference: 13).

It is not necessary nor advisable to repeat here in any detail the description of the plant. A brief outline of the major features will suffice.

b. Site. - The site selected for construction of the plant is on the Ottawa River near Chalk River, Ontario. (The British statement quoted herein above describes the site as near Petawawa, Ontario.) The area occupied by the plant buildings and other facilities comprises, roughly, a rectangle measuring approximately 1500' by 3,000', or about 100 acres. In addition, the project has required the construction of a village for living accommodations and services for the operating and directing personnel. This is described as located on a cove in the Ottawa River seven miles west of Chalk River, Ontario, and about 12 miles by road from the plants. The village has been named Deep River.

c. Design of Pile.

(1) Power Levels, Capacities, and Flux. - The chain-reacting unit is a polymer (heavy water), heterogeneous, normal-water cooled, slow neutron pile, designed for 10,000 kw output, first estimated to require 18.9 tons of heavy water and 10 tons of metal. Originally, in July 1944, an output of 8000 kw, estimated to require 13½ tons of heavy water and 8½ tons of metal, was proposed. As a result of later decisions on some of the design problems, however, influenced by

the availability of critical materials, principally heavy water, the design power level was raised to 10,000 kw. For example, the decision to use normal-water cooled, aluminum-sheathed uranium rods rather than heavy-water cooled, stainless steel-sheathed uranium rods allowed a higher power output for a given quantity of uranium and heavy water, or conversely, allowed lesser quantities of these critical materials for a given power output; also, the decision to use a lattice spacing for least critical volume, to conserve critical materials, made possible a higher power level for a given quantity of heavy water. Then, after the design of the pile was determined, further estimates indicated that about 16.7 tons of heavy water would allow a power output of 10,000 kw, whereas 18.9 tons of heavy water - the maximum which the design would permit - would allow an output of 21,000 kw. A little over 19 short tons of high grade heavy water were finally made available by the United States; therefore, it is anticipated that, within the limits described above, 10,000 to 21,000 kw, the power level for steady operation will be determined by the efficiency of cooling, permissible inferior temperatures, radiation, and decomposition problems. (References: 8, 14.)

The estimated production capacities of the pile are likewise subject to variation, dependent upon the power level at which it will be operated. It is estimated that at an average power level of 10,000 kw the pile would produce 7 grams per day of plutonium and 0.5 grams per day of U233, with sufficient surplus reactivity to produce the tracers estimated as required annually by the United Kingdom and

Canada for medical (both research and therapeutic), industrial, biological, and other laboratory uses (References: 5, 15). As an experimental source of neutrons, it is estimated that a maximum neutron flux of between 10^{13} and 10^{14} square centimeters per second will be available (Reference: 8).

(2) <u>The Pile.</u> (References: 14, 13.) - The pile itself consists principally of an aluminum tank, 8'-9½" O.D. x 10'-6" high, built as a callandria, with 198 aluminum tubes, 2½" I.D. and 1/16" thick, triangularly spaced 6-13/16" center to center. This tank was manufactured to close specifications by the Andale Corp. of Philadelphia. It serves the purpose of providing a container for the heavy water moderator and separated cylinders for the accommodation of the uranium rods, for the production of plutonium. The uranium rods, 176 in number, properly sheathed in aluminum sheaths and each surrounded by a second aluminum tube, to provide a 0.1" cooling water annulus, hang freely in the aluminum tubes of the callandria. Similarly, the remaining 22 of the 198 tubes in the callandria are used for 18 control rods and 4 shut-off rods. All the rods - uranium rods, control rods and shut-off rods - are interchangeable.

The uranium rods, as supplied, are 10'-3" overall in length and 1.360" in diameter. They were fabricated in the United States, by hot rolled process.

Surrounding the cylindrical pile tank, successively, are the following:

(a) an air gap 1½" wide;

(b) a graphite ring 9" thick;

(c) an air gap $2\frac{1}{2}$" wide;

(d) a graphite ring $2\frac{1}{2}$" thick;

(e) an air gap $1\frac{1}{2}$" wide;

(f) the first section of the cast iron side thermal shield 6" thick;

(g) an air gap 2" wide;

(h) the second section of the side thermal shield 6" thick;

(i) an air gap $1\frac{1}{2}$" wide;

(j) the side biological shield, of concrete 8 ft. thick.

The $2\frac{1}{2}$" air gap in the graphite reflector (item (c) between the two graphite rings above), is provided as a space in which to hang rods containing thorium carbonate, for the production of uranium 233. The other air gaps are provided for cooling and for convenience of erection.

The thorium carbonate rods are 1.667" O.D. and are mounted 4" center to center in the gap in the graphite reflector. A total of 92 could be hung in the available space, except that interference with various permanent water or gas pipes and experimental or instrument holes would result; therefore at least 12 thorium carbonate rods cannot be inserted. Occasionally when high intensities are required it will be necessary to lift some 13 more rods out of the reflector; also, certain experimental hole slugs are pierced by rods, which must be removed during experimentation.

Immediately above the pile tank are three vertical sections of a water-iron thermal shield, each section consisting of 2" iron, 6" H_2O and 4" iron, water-cooled and gas-vented; above this thermal shield is a 6 ft. thick concrete biological shield made of four trays each 1½ ft. thick; and this is covered by a top "master plate", of 4" steel. All these sections are accurately keyed together and are pierced by 198 holes accurately aligned with the tubes in the pile tank.

Above the master plate there is a space 5 ft. high for the accommodation of: cooling water manifolds and feeders; shut-off rod controlling mechanisms; and racks and pinions for driving the control rods.

Above this space, for further protection against escape of radiation, an iron-water shield 16" thick is provided, with a circular center section pierced by two holes and so devised that one of these holes can be rotated to accurate alignment over any one of the 198 tube positions.

The pile tank is supported on an aluminum frame with an aluminum side skirt, which in turn rests on a bottom thermal shield, 3'8" thick, water-cooled and gas-vented, in four sections, each section consisting of 2" or 4" iron, 6" H_2O and 2" or 4" iron. Next below comes the bottom master plate, of 4" steel and below that a 6" masonite shield. All these sections below the pile are likewise accurately keyed and pierced by 198 holes accurately aligned with the tubes in the pile tank.

The uranium rod assemblies extend some two to three feet below the bottom master plate and are connected to cooling water exit manifolds in a room below the pile which is completely lined with 3" of lead. The exit manifolds are connected to water mains which join to form a 20" exit main.

The whole structure is about 34' in diameter and stands about 28' above the floor level of the pile building - the bottom of the pile tank is 2' above the floor level. From the floor level of the room below the pile to the top of the topmost shield measures 43'-8".

The experimental facilities of the pile include the following:

3 radial 12" diameter experimental holes;

12 radial 4" diameter experimental holes;

18 radial 3" diameter "self-served" experimental holes, providing for easy insertion of samples;

2 tangential pneumatic holes, 2" diameter at the inside ends and 9" diameter at the outer ends, provided with a pneumatic mechanism for rapid charging and discharging;

2 thermal columns, 5'-9" square, stepped out to 6'-8" square at the outer ends;

2 vertical selection holes, 6" diameter, one at the inner end of each thermal column;

1 central thimble, which is a vertical 5½" I.D. ¼"

tube in the exact center of the aluminum pile tank, providing space for irradiations and experiments at the highest intensity.

In addition there are 12 instrument holes, 7½" in diameter; also some 2½" holes which were intended for instruments but were later decided to be too small, and will be available for experimental purposes.

There are some 756 instruments outside the pile structure proper, for automatically tripping the pile; the largest category of these is 704 pressure switches, located on 176 water tubes. There are also some 41 other instruments associated with the pile which will sound alarms or turn on lights.

(3) Auxiliaries. - An extensive cooling water system has been provided. It was estimated that 4400 Imp. GPM would be necessary for cooling the uranium rods alone if the maximum velocity, 20 ft. per sec., were used in all the annuli. The system includes an 800,000 Imp. gallons reservoir, with high pressure pumps to pump the water therefrom through a 20" main to the header at the top of the pile, and a head tank of 100,000 Imp. gallons capacity, floating on this line, 340 ft. above the water level in the delay tanks hereinafter mentioned. From the pile, the water flows through a 20" main to two 250,000 Imp. gallons delay tanks, which allow an hour each for the decay of activity before the water is discharged to the river. Low pressure pumps are provided for use during shutdowns, and the differences in elevation between the bottom of the main reservoir and the top level in the delay tanks and between this level and the tops of the uranium rod assemblies

in the pile will produce at least a slow flow of cooling water even if all pumps should fail at once and the head tank should be empty; even if a pipe should burst between the main reservoir and the pile, a slight flow backward from the delay tanks would result. Various alarm and tripping circuits for pile shutdown would of course operate in case of water or power failure.

In addition to this water cooling system, the pile auxiliaries include: a heavy-water circulating and cooling system, with a liquid level control; a helium circulating and drying system; a heavy water recombination system to recover decomposing heavy water; and cooling facilities for the graphite reflector, the thermal shielding, the thorium carbonate rods, and the shut-off rods.

Another important and extensive auxiliary of the pile is the equipment provided for the handling and storage of uranium rod and thorium carbonate rod assemblies. This equipment includes: a large vertical lead container, some 35' high and weighing 35 tons; means for transporting the container from the top of the pile to a concrete chimney (with 3' thick walls), located over a water trench; a main-water trench, 4'-0" wide, extending 310 ft. out of the pile building; a horizontal carriage, 35' long (with 2 rods capacity), on rails running the full length of the trench (13' under water), with means for running one end of the carriage up into the chimney and transferring the rods from a vertical position in the container to a horizontally supported position on the carriage; two side water trenches, 12' wide, extending from the main trench to the plutonium and the U233 process buildings; two storage basins, one 33'x39'-3", which could store all the full length rods (176 uranium and about 90 thorium carbonate) in case of emergency, and the other 13'-6"x25', both located adjacent to the main trench.

d. <u>Extraction Processes.</u> (References: 14, 13.) - After the thorium carbonate and uranium rods have been removed from the pile, it will be necessary to process them chemically for extraction of the final products, uranium 233 and plutonium. For both materials solvent extraction processes will be used, differing of course in method and procedure.

(1) <u>Uranium 233 Process.</u> - As first designed, the uranium 233 was to be obtained from the thorium carbonate rods by the so-called manganese dioxide and column extraction method. This process consists, briefly, of: (a) dissolution and removal of aluminum; (b) dissolution of thorium carbonate; (c) removal of 91 Pa 233 (an isotope of protoactinium, referred to by the code number "13") by manganese dioxide (MnO_2) treatment; (d) solvent extraction of U233; (e) decay of protoactinium solutions; and (f) handling of wash solutions.

Late in 1945, after the design for this process had been completed, decision was made to change from the manganese dioxide treatment and column solvent extraction process to the so-called "ethio-carb" batch solvent extraction method which had been under development for some time. This decision was influenced by the fact that supply problems and mechanical handling difficulties militated against the manganese dioxide purification step, the sole purpose of which is to permit subsequent column extraction to be relatively free from beta activity by the removal of most of the isotope "13". Extreme difficulty had been experienced in obtaining MnO_2 of the required purity and in sufficient amount for plant operation. The new process employs batch solvent extraction of U233. In brief, the extraction is as follows: After removal of the aluminum jacket in NaOH, the irradiated $ThCO_3$ is dissolved in HNO_3, and the solution is neutralized with ammonia. The addition of sodium diethyldithiocarbamate forms a complex with the uranium 233. This complex is then extracted by a batch solvent process, using hexone as the solvent. Time saving is an important advantage of this process, as it has been estimated that it will require less than one hour, as compared with 10-15 hours required for the manganese dioxide treatment and column extraction.

A continous column extraction process for U233 has also been developed and is being adapted for eventual full scale use at the Chalk River plant.

The "ethio-carb" process uses the same rod handling and dissolution steps as were previously designed for the manganese dioxide and column extraction method. In fact, most of the services provided for the earlier process remained unchanged; a principal difference is the greater volume of solution to be handled in decay storage, as that solution in the new process will contain the thorium as well as the undecayed isotope "13".

(2) <u>Plutonium Process</u>. - As originally proposed, the plutonium extraction process would parallel the U233 extraction process. The same type of rod handling and dissolution would be used, and similar

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buildings would be required for housing the process. The solution would be delivered as a saturated UNH solution, and two batch extraction processes have been studied, "The Trigley Process" and "The Ether-Trigley Process". Both these processes use triglycoldichloride ("Trigley") and carbon tetrachloride; the latter process uses ether to remove the bulk of the uranium before using the "Trigley", thereby reducing both the number of operations and the volumes of waste solutions.

It is proposed, at least for initial operations, to use the Trigley Process, which may be described, briefly, as follows: The rod is dissolved in HNO_3. The resulting solution is saturated with NH_4NO_3 and the solvent is extracted with "Trigley". This solvent extracts the plutonium, some of the uranium, and some of the fission products. The extract is then passed over saturated NH_4NO_3 solution which removes most of the uranium and fission products, leaving the plutonium in the solvent. Although two methods (bismuth phosphate and ferric acetate) have been developed for the final purification of the plutonium, at the end of December 1946 it was still undecided as to which to install in the plant.

Investigation has shown that the extraction properties of "Trigley" depend upon the presence of "impurities", as yet unidentified, in the solvent. These "impurities" appear after the solvent has "aged", and therefore it seems probable that they are decomposition products of "Trigley". An empirical process for "aging" the "Trigley" has been developed and it is felt that the extraction as planned can be made to work satisfactorily.

Development work has also proceeded on a continuous counter-current, column extraction method; meanwhile, because of the large volume of waste solutions produced by the Trigley Process, waste-storage facilities have been provided and attempts have been continued to develop the so-called Ether-Trigley Processs (which would reduce the volume of the waste solutions, as previously noted.)

e. General Layout. (Reference: 14.) - The plant comprises more than 60 buildings and other facilities, located on the site on the Ottawa River previously described.

Among the more important of the items in the general layout are:

the pile building, and various auxiliaries (the pile building is 145'x111'x85' high; a 25 ton crane, with clear lifting height of 65' from the floor, runs the full length of the building); the various chemistry, physics, and other laboratories;

the dissolving and extracting buildings and various auxiliary facilities;

the power house and substation;

the main work shop and various other shops;

the water treatment plant and various experimental water buildings;

the main reservoir and various tanks;

the sewage disposal plant;

the administration building; the gate house; the medical and biological buildings; the cafeteria, garage, firehouse, and various other service facilities;

the "ZEEP" building (See par. 5, hereinafter).

f. Deep River Village. - The village for the workers at the plant, Deep River (see subparagraph b. above, "Site"), was planned to provide housing for 500 operating workers of Defense Industries Limited and 170 workers of the National Research Council, and their families. Primarily because of an increase in the size of the operating staff (now estimated at about 620) housing facilities are at a premium. There are now well over a thousand permanent inhabitants. There are 50 permanent houses with one-family, two-family, or four-family units in each; also, about 170 "War Time Houses", mostly of four room units, have been moved from other sites in Canada and re-erected at the village; 12 dormitories of a bunk-house type have been provided for payroll personnel. A Staff Hotel provides accommodations for 200 persons, with lounge rooms, recreation rooms and dining hall. The village also contains: a general cafeteria; a shopping center; a garage; a community hall; a grammar school; a library; tennis courts; and other facilities necessary for an independent town (References: 14, 13).

g. Construction and Operating Contractors. - The plant has been constructed by Fraser-Brace Company under subcontract from Defense Industries Limited ("D.I.L"), of Canada; it was originally planned that D.I.L. also operate the plant, in cooperation with the N.R.C., who would perform the experiments, but the Atomic Energy Control Board (which was instituted by the Canadian Atomic Energy Control Act of 1946) assigned the responsibility for operating the plant and research facilities of

Chalk River to the N.R.C. Actually, the Canadian government's construction contract with D.I.L. will be terminated when the chemical plants are esentially completed, while the operating contract will be terminated when the pile and its accessories have passed the initial operating stage (Reference: 13, p. 25). Fraser-Brace Co. started construction in September 1944 and the pile and its equipment were turned over officially to D.I.L. on 15 August 1946 (Reference: 13, p. 3).

5. "Zero Energy Exponential Pile", or "ZEEP". - As the design of the Canadian pile pilot plant proceeded, with continous active assistance from the United States, it soon became evident that it would be impossible to meet the target date which had been set for completion, February 1945, principally because of the complexities of design and the limited size of the staff. The National Research Council accordingly proposed that construction be undertaken of a "Zero Energy Exponential Pile" at Chalk River, to provide much-needed experience and information, before the pilot plant would be in operation. The United States representatives seriously questioned the advisability of this proposal, for the following reasons: it might not be possible to construct the ZEEP much in advance of the larger plant; the ZEEP might interfere with the progress of construction on the larger plant; because of the limited amount of heavy water available it would be necessary to transfer the heavy water from the smaller to the larger pile before the latter could be fully operated, and there would be danger of losses of material in pumping heavy water between the two plants; and the value of the smaller reacting unit in comparison to an exponential experiment was

questionable. General Groves wrote a letter to Sir James Chadwick in November 1944, raising these points (Reference: 16). The proposal was finally agreed to, however, upon the insistence of the Canadian group, but subject to the condition that the construction and operation of the ZEEP would in no way interfere with or delay the design and construction of the pilot plant (Reference: 8).

The delays in completion of the pilot plant, which have unquestionably been long and numerous, cannot be attributed to time spent on the ZEEP; on the other hand, the operation of the ZEEP has certainly been of benefit to those at the project, providing them with a wealth of information and experience, and the United States shares indirectly in these benefits, because of the more efficient and effective operation of the pilot plant which can be anticipated.

Operation of the ZEEP started on 7 September 1945 and it has operated almost continuously since (Reference: 5). It is the first chain reacting pile to be operated outside the United States.

In normal operation the ZEEP uses about 5 tons of heavy water and 3½ tons of uranium metal. It was designed and built to operate at about 1/10 watt power output, and when the chain reaction was established (when the multiplication factor, K, became greater than 1), it was found that the critical volume was exactly that predicted from calculations. Later the shielding was increased and it became possible to operate the pile continuously at 3.5 watts without exceeding the tolerances for an eight hour exposure. For periods of the order of minutes the pile has been flashed to power levels of 30-50 watts (References: 17, 13).

The construction and operation of the ZEEP are briefly described in a publication of the National Research Council of Canada, Division of Atomic Energy, entitled "The Low Energy Pile at Chalk River, P.D. - 207, a Lecture Delivered at the Nuclear Physics Conference, Montreal, 5 September 1946, by B. W. Sargent", dated: Chalk River, Ontario, 23 November 1946 (Reference: 17).

The principal features of the pile may be described as follows:

An aluminum tank, 6'-9" in diameter, 8'-6" high, with dished bottom, is suspended at the top directly, and centrally, from a shallow structural steel box, which is supported high above the floor on four steel posts. The maximum capacity of the tank is about 10 tons of heavy water. The steel box, which is coated with 0.010" stainless steel, is divided into compartments; a square central compartment over the open top of the tank, from which a lattice of uranium rods is suspended; and four narrow compartments at the sides which house the mechanical controls. The lattice of uranium rods is square and the spacing of the rods is capable of variation within certain limits. The individual rods, made up of short rods stacked up to the desired height in aluminum tubes, are suspended vertically by a gimbal arrangement from steel beams which bridge the open top of the tank. The steel beams are plated with copper, nickel and chromium to prevent corrosion.

The central compartment of the steel box is closed with a square lid and gasket after the lattice of uranium rods is suspended from the beams inside. The tank is surrounded by a graphite reflector around its sides and underneath. In a basement under the pile there is a plumbing system for drying the tanks and for pumping and storing the heavy water. The storage tank is of stainless steel. The heavy-water level within the reactor may be raised or lowered by operating a stainless steel gear-type pump, which can be run in either direction.

Other items of equipment include: a "scram value", or large gate value, which may be used to dump the heavy water into the storage tank as a last resort, in case the power runs away; facilities for passing hot air through the closed system and freezing out the moisture in a refrigerating unit; two sets of four shut-off or emergency control rods, of cadmium coated steel tubes, and their operating mechanisms; four operational control plates, of cadmium coated steel, suspended in the gap between the side of the tank and the graphite reflector, and their operating mechanisms; and the main control board.

6. Progress and Costs.

a. Completion Date. - It has been stated in a previous paragraph that the design and construction of the Canadian pile pilot plant was subjected to many delays, principally because of the complexities of the design and the limited size of the staff. The first completion date set, February 1945, proved to be utterly unattainable. The completion date was set forward to January 1946, then to December 1946, and finally to March 1947, which was beyond the termination of the Manhattan District History (Reference: 5). As of 31 December 1946, however, the design and construction were very nearly completed and the start-up of operation appeared to be definitely in sight.

b. Costs. - The total cost of the Canadian pile project has not yet been determined. Prior to 1 December 1945 three successive estimates of the construction cost had been made, increasing progressively from 5 to 11 to 18 million dollars, and Dr. Huffman expressed his personal opinion (as of 1 December 1945) that the total construction cost, exclusive of the cost of the heavy water which has been loaned by the United States, would reach $22,000,000 (Reference: 14).

As of the end of September 1946, the total cash expenditures of the project amounted to $20,448,000, with commitments at that time amounting to $784,000. These figures include expenses allocated to the townsite of Deep River as well as to plant construction, etc.; they do not include the cost of the heavy water. The sum of these figures, $21,232,000, indicates that Dr. Huffman's prediction was not far out of the way, and that it may even be exceeded when the final costs are known. (Reference: 13, p. 28.)

At the same time, the monthly operating costs were estimated as follows:

Plant	$264,972
Townsite	11,692
	$276,664

Allowances for increased labor costs, contingencies, etc., raised the estimated monthly expenditures to $370,000, or an annual total of $4,440,000. (Reference: 13, p. 28.)

7. Benefits to the United States. - The benefits which are expected to accrue to the United States from this project include (Reference: 8):

a. Procurement of fissile material. - For example, under a tentative agreement, the United States will, if desired, receive a substantial portion of the production of U233, one of the two major products expected to be obtained from the pile.

b. Efficient production of some radioactive isotopes. - Some features of the proposed pile, in which it differs from the piles constructed in the United States, particularly in providing, in a thimble at the center, a conveniently accessible space of high flux, may make it possible to obtain more efficient production of some desired isotopes. For example, direct production of P32 sources may be possible, instead of separation from large quantities of irradiated sulphur.

c. High-flux irradiations. - A further advantage of the central high-flux space referred to above would be that it could be used for high-flux irradiations by United States scientists. The National Research Council of Canada has expressed complete willingness to allow such use of its facilities. An important example of use of these high-flux irradiations would be the production of transuranic and possibly other elements by successive neutron captures where the intermediate substances are short-lived. A high flux is obviously necessary.

d. Experimental facilities. - The thermal columns and the various types of experimental holes in the Canadian pile will provide research facilities which may be superior to those in any existing United States pile. It is likely to be two years before similar facilities become available in the United States.

e. General scientific and engineering information. - Much of the operational and experimental information which will be forthcoming from the Canadian pile may be of direct interest and utility to the United States project. Such information may involve, for example: production of U233 in a thorium blanket (breeder and converter piles); chemical extraction of U233; effects of high level irradiation on materials (heavy water and many other substances); biological data to supplement the United States information; supplementary information on the production and use of tracers; and results of pure research in many phases of the atomic energy sciences.

f. Comparative efficiency. - Information will be available to the United States as to the efficiency of the water-cooled, heavy-water-moderated type of reactor compared with other types, as to: construction costs; production of fissile materials; versatility (convertibility from research to production uses); fluxes; plant life; etc. This was one of the major considerations which influenced the original decision to build the Canadian pile.

BOOK I GENERAL - VOL. 4, AUXILIARY ACTIVITIES

Chapter 9, Assistance on the Canadian Pile Project

Appendix - References

1. British Statements Relating to the Atomic Bomb; "Statement by the Department of Scientific and Industrial Research, Issued August 12, 1945"; XII (f). "Joint British-Canadian-American slow neutron project in Canada": Senate Report No. 1211, 79th Congress, 2d Session, pages 69-70, pars. 81-84.

2. Minutes of Meetings of Combined Policy Committee, 17 February 1944 and 19 September 1944: Classified Files of Major General L. R. Groves, Washington, D. C.

3. Report to the Combined Policy Committee from the Sub-Committee on Joint Development of a Heavy Water Pile (presented at meeting of 19 September 1944): Classified Files of Major General L. R. Groves, Washington, D. C.

4. Memorandum from Major Arthur V. Peterson to Files, dated 12 June 1944, Subject "Meeting of 8 June 1944 in Chicago of the Subcommittee of the Combined Policy Committee": Copy in Manhattan District History files, Washington, D. C.

5. "Brief History", on "Assistance on Canadian Pile Project", by Colonel A. W. Nielsen, transmitted by 1st Ind., 6 February 1947, to letter dated 27 January 1947, from Colonel O. G. Haywood Jr., A.E.C., to National Research Council of Canada: Manhattan District History files, Washington, D. C.

6. Agreement of 13 July 1944 between Manhattan District and Montreal group on interchange of information, furnishing materials, etc: Copy in A.E.C. Files, Washington, D. C.

7. Letter from Major General L. R. Groves to Sir James Chadwick, dated 6 November 1944: Copy in classified files of Major General L. R. Groves, Washington, D. C.

8. Letter from Colonel A. W. Nielsen to Colonel O. G. Haywood, Jr., dated 7 March 1947, subject "U.S. Assistance in the Chalk River Pile Project": Manhattan District History Files, Washington, D. C.

9. Letter from Major H. S. Benbow to District Engineer, Oak Ridge, Tenn., Attention Major A. V. Peterson, dated 27 May 1944, Subject "General Meeting Between American, British and Canadian Groups on 27 May 1944 at Chicago": Copy in Manhattan District History files, Washington, D. C.

10. Memorandum from Major A. V. Peterson to Files, dated 30 May 1944. Subject "Visit of Representatives of the Montreal Group to the Metallurgical Laboratory on 25, 26, and 27 May 1944": Copy in Manhattan District History files, Washington, D. C.

11. Memorandum from Major Horace S. Benbow to Files, dated 15 June 1944. Subject "Combined Meeting of the Montreal and American Group on 12 June 1944, at Montreal, Canada": Copy in Manhattan District History files, Washington, D. C.

12. Atomic Energy Act of 1946; Public Law 785 - 79th Congress.

13. "Terminal Report, Covering Period Oct. 22, 1945 to Nov. 30, 1946", by Dr. George L. Weil, U. S. Scientific Representative, Chalk River Laboratory, 26 May 1947: A.E.C. Files, Washington, D. C., E-GLW-110.

14. "The Canadian Pile Pilot Plant - Interim Report on Design and Construction - Constituting a Final Report by John R. Huffman" (written 1 December 1945 - see page 4): Copy No. 2 of 6 (36 pages) in Manhattan District History files, Washington, D. C.

15. Report by Dr. George L. Weil for week ending 11 May 1946: A.E.C. Files, Washington, D. C.

16. Memorandum from Major Horace S. Benbow to Files, dated 7 November 1944, Subject "Meeting 1 November 1944 in Washington, D. C., Between General L. R. Groves, Lt. Col. A. V. Peterson, Dr. W. W. Watson, Dr. John R. Huffman, and Major Horace S. Benbow": Copy in Manhattan District History Files, Washington, D. C.

17. "National Research Council of Canada - Division of Atomic Energy - The Low Energy Pile at Chalk River - P.D.-207 - A Lecture Delivered at the Nuclear Physics Conference, Montreal, 5 September 1946 - by B. W. Sargent - Chalk River, Ontario - 23 November 1946"; printed, unclassified: Manhattan District History files, Washington, D. C.

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MANHATTAN DISTRICT HISTORY

BOOK I, GENERAL - VOLUME 4, AUXILIARY ACTIVITIES

Chapter 10, The Oak Ridge Institute of Nuclear Studies

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MANHATTAN DISTRICT HISTORY

BOOK I, GENERAL - VOLUME 4, AUXILIARY ACTIVITIES

Chapter 10, The Oak Ridge Institute of Nuclear Studies

1. General. - Important factors at Clinton Engineer Works in securing and retaining trained scientific and technical personnel ha been the unique and specialized research equipment and facilities, a the opportunities there for learning new fundamental scientific tech and for working with highly skilled specialists in various fields of nuclear science. While such training has been informal and incident to the primary objectives at Oak Ridge, there was a general feeling that institution of formalized instruction of contractors' scientifi personnel on a graduate level would assist in obtaining scarce techn manpower and be of general overall benefit to project research activ ties. Of the three operating areas at Oak Ridge, Clinton Laboratori has devoted by far the greater part of its efforts to fundamental re search, and consequently it has been inevitable that the operating c tractor, the Monsanto Chemical Company, would be more directly inter ed in such graduate training. In the fall of 1945, therefore, the Monsanto Company and the District arranged for the University of Ten to conduct graduate courses at Clinton Laboratories for the Laborato own scientific personnel. In an effort to make these educational op portunities available to all Clinton Engineer Works in general, and to stimulate closer liaison between Oak Ridge activities and the res programs of neighboring universities, the University of Tennessee ca

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a meeting of southeastern university representatives early in Decem
1945. In addition to providing graduate courses at Oak Ridge, it w
agreed at the meeting that neighboring institutions should be prepa
to participate in and to utilize wherever possible the special rese
facilities available in Oak Ridge, and that faculty members and stu
from these universities should serve as a desirable reservoir of bo
"rotating" and permanent manpower to help staff the District's labo
tories. It was mainly because of its interests in the last-named ob
ive that the District encouraged formation of a definite organizatio
prepared to function as a liaison agency between Oak Ridge and neigh
ing universities. During 1946, with District sponsorship and approv
the group evolved into a corporation called the Oak Ridge Institute
Nuclear Studies, representing a growing number of associated southea
universities, and intended eventually to function under a formal con
tract as an advisory agency, coordinating relations between the Dist
and the various member institutions. At the close of this history,
December 1946, a preliminary contract for these services had been dr
and submitted by the Institute to the District. Further action was
held in abeyance pending review of the entire situation by the Atomi
Energy Commission.

2. Preliminary Conference Sponsored by the University of Tennessee. - On 5 December 1945 the University of Tennessee sponsored a "Conference on Research Opportunities in the Southeastern United States" at Knoxville to consider: (a) the potentialities at the Clin

Engineer Works for academic research graduate training, (b) mutual b
to be derived from cooperation between the Government facilities loc
and neighboring universities, and (c) recommendations for future act
The District Engineer, members of his Research Division staff, execu
from the District's local operating-contractor organizations, numero
scientists from Oak Ridge and members of the faculties of twenty-odd
southeastern universities attended the all-day session. At this tim
an Interim Committee was formed under the chairmanship of Professor
Pollard, University of Tennessee, to draw up a definite program for
action. It was felt that representatives should be appointed from ea
of the cooperating institutions to meet at Oak Ridge as soon as possi
to draft specific proposals for the program. In particular, it was
emphasized that the Oak Ridge research facilities should be utilized
stimulating graduate work in nuclear science under the direction of t
cooperating universities in the region (Reference: 1, in Appendix to
Chapter).

3. The Oak Ridge Institute of Nuclear Studies. - Professor Po
arranged with the District for a conference of the various representa
to be held 27-29 December 1945 at Oak Ridge to formulate a definite
program of action. Some fifty scientists met for this three-day seri
of discussions during which various committees were appointed, confer
and prepared recommendations covering the several objectives desired.
Scientists from the staff of the District Research Division cooperated
with the visiting professors to form committees on Organization, Admin
stration, Immediate Needs, Engineering, Medicine, etc. At the final s

an Executive Committee was elected, with Professor Pollard as Chairm
to effect the recommendations of the several committees. Dr. P. W. McDaniel, Chief of the Research Division's Technical Branch, was cho
Secretary-Treasurer and played an important role during the following months in coordinating the District's relations with the embryonic as sociation. At this time, after considerable discussion, it was unani agreed to call the new organization "The Oak Ridge Institute of Nucle Studies" (Reference: 2).

4. The Institute and the Oak Ridge Programs for Graduate Stud
In general, the Oak Ridge conference had been concerned with two sep and distinct subjects: (a) long-range program for establishing the Institute itself and (b) the immediate problem of providing graduate at Oak Ridge to resident scientific and technical personnel. The se of these two objectives was, and continued to be, of more direct int to the District since it would assist in attracting and holding techn personnel at Clinton Engineer Works. Immediately after the general (Ridge meeting, the newly-appointed Executive Committee convened and a pointed a special committee on Graduate Education, headed by Professo K. L. Hertel of the University of Tennessee, to follow up a positive program for instituting courses at a graduate level at Oak Ridge unde the auspices of the University of Tennessee. It was agreed that the problem would be best handled by this institution because of its pro Scientists from the three Clinton Engineer Works operating areas and of the University of Tennessee faculty comprised the members of the (Education Committee (Reference: 3).

5. <u>Establishment of the Graduate Program</u>. - Earlier, in the : of 1945, the Monsanto Chemical Company, with District support, had arranged to provide graduate instruction for its scientific personne: by the University of Tennessee faculty on Clinton Laboratories' prem: At the 5 January 1946 meeting of the Graduate Education Committee, i: was decided to supplement this program and conduct courses at each o: three Clinton Engineer Works operating areas. Classes were to be sc: for both working and non-working hours, depending on the convenience the various parties concerned. No employees, however, it was felt, : be paid for regular work hours spent in class. These general propos: were approved by the District on 31 January 1946, subject to the ind: approval of the separate contractors. Since they were essentially o: organizations, both the Carbide and Carbon Chemicals Corporation and Tennessee Eastman Corporation found it undesirable to rearrange thei: schedules to permit employees to attend courses in their respective : during regular working hours. The Monsanto Company, however, whose facilities at Clinton Laboratories were essentially for research and ment, cooperated readily in the program. Meanwhile, the University : nessee made arrangements for a schedule of graduate courses to be co: ducted at the Oak Ridge High School in order to serve the needs of a: other interested graduate students in the vicinity. This program op: at Oak Ridge concurrently with the University's regular spring quart: 18 March, with an initial enrollment of 166 students. Graduate cour: continued to be held under this program during the remainder of 1946

The parallel graduate program being conducted for Monsanto employees
Oak Ridge also was continued under University of Tennessee sponsorsh
during the remainder of the year. The inauguration of the Clinton
Laboratories Training Program in the fall of 1946, under the supervi
of Dr. Frederick Seitz, however, has in a large measure supplanted t
need for the University's special program in the Monsanto operating
facilities. By 31 December 1946 most of the Oak Ridge graduate stud
concentrated at the High School (References: 4 and 5).

6. Long-Range Objectives of the Institute of Nuclear Studies
At the time of the establishment of the Executive Committee in Decem
that body was authorized by the university representatives to make a
desirable arrangements with the District and its operating contracto
in the name of the new Institute. Following a series of meetings, t
Executive Committee formally presented to the District, on 3 April 1
a summary of various functions which it was proposed that the Instit
should perform. These were:

a. To serve as a coordinating liaison agency between th
District and the Oak Ridge research laboratories for:

(1) Adequate scientific staffing of the laboratorie

(2) Loan of individual university staff members to
laboratories for special technical problems.

(3) Use of laboratory facilities at Oak Ridge for
academic research sponsored by the universities.

b. To service and expedite requests by participating
universities for Government assistance in the former's own research

program by:

(1) Investigation and recommendation, in an advisor capacity, to the District;

(2) Investigation of existing proposed and possible facilities for such research among the participating universities; a

(3) Encouragement and assistance in negotiation of contracts between these institutions and the Government. (Reference

7. District Approval of Objectives. - The general objectives enumerated in this proposal and the specific procedures outlined by Institute for obtaining them were formally approved by the District 12 April 1946. Under this authorization the Institute was to inform separate regional universities, and such others as might later affil with the group, of the nature of its activities and was also to noti them:

a. That all requests for clearances of scientists for a to classified information and for possible visits to Government labo tories would henceforth be screened through the Institute (except fo cases which clearly did not concern it) for correlation, review and recommendation for appropriate action by the District.

b. All participating universities should furnish the Ins with lists of their qualified scientists who in the future might desi to:

(1) Take leave of absence for full-time employment a Oak Ridge.

(2) Accept continuous employment at Oak Ridge for sh

periods of time to conduct research at the request of the District.

(3) Accept research positions with a Government laboratory at Oak Ridge for the purpose of joining in the fundament research program of the laboratory while continuing as employees of university or universities with which they were affiliated.

(4) Make use of the research facilities at Oak Rid experimental work not directly connected with the District research development program but which could be carried out only at Oak Ridg facilities (Reference: 7).

The general objectives of the Institute and a revie the Executive Committee's activities in pursuing them were contained the "Report of the Executive Committee" circulated 1 June 1946 to th ticipating institutions. The nation at large was formally advised Institute's existence in a statement "A Nuclear Research Institute Oak Ridge" prepared by the Committee and published in the 14 June 19 issue of Science. During the next several months the District arran for the Executive Committee and other members of the Institute to vi the various laboratory facilities at Clinton Engineer Works so that might be familiar with current and potential research programs of wh the installation was capable.

8. Preparation of a Proposal. - In order to function effecti it was felt that the Oak Ridge Institute of Nuclear Studies should formalize its relationship to the Manhattan District by a contract definitely specifying the respective advisory and educational servic which it would perform. Prior to the preparation of such a proposal,

the Executive Committee was reorganized early in August, 1946 to reflect the Institute's primary educational purposes more clearly (Reference: 8). The reorganized committee was composed of Dr. F. P. Graham, President of the University of North Carolina, Chairman, Pro Paul M. Gross, Duke University, Dr. P. W. McDaniel, Manhattan Distri Professor W. D. Funkhouser, University of Kentucky, representing the Conferences of Deans of the Southern Graduate Schools, Professor W. Pollard, University of Tennessee, and Professor F. G. Slack, Vanderb University. The specific functions to be undertaken by the Institut under District contract were presented to the District Engineer on 7 1946 in a "Proposal for an Oak Ridge Institute for Nuclear Studies" mitted by the newly organized Executive Committee. After careful re by the District Research Division, the proposal met with the general of the District Engineer and a meeting was held 18 September 1946, b Executive Committee representatives, Colonel Nichols, and members of staff, to discuss further action. At this time the District agreed subsidize future meetings of the new directing Board of Governors, w was to be created under terms of the Proposal, and also to provide s and office facilities at Oak Ridge for the Institute's Executive sta It was reemphasized at this time that the chief benefit to the Manha District in establishing the Institute would be the assistance the l ter would render in placing scientific personnel from the participat universities with the plants at Clinton Engineer Works. The benefit the participating universities would be the use of the Oak Ridge facilities for training of their graduate students. The general agreement reached at the 18 September meeting was confirmed in a le' from Colonel Nichols to President Graham, the Chairman, on 25 Septe 1946.

9. Incorporation of the Institute. - The August "Proposal"] indicated that the physical form of organization to be assumed by ' Institute as a contracting agency would be as follows:

a. The participating universities would each be repres on a general Council by the respective executive heads of the insti or their authorized representatives. Each representative would ser the official channel between his university and the Institute.

b. The Council would elect a Board of Governors with s members, each to serve a term of five years. The Board's responsib would be to carry out the objectives of the Institute, to approve i budget, program, and the administration of its contractual obligati and its obligations to participating institutions.

c. The Board would elect an Executive Officer as a pers full-time employee to establish headquarters at Oak Ridge and carry the program of the Institute as directed by the Board.

The Executive Committee proceeded with formal organizatic of plans, and a charter of incorporation was granted by the State of Tennessee on 15 October 1946. At the Committee's request, the Distr arranged for an organizational meeting of the Council at Oak Ridge c 17 October. At this time by-laws were adopted and the members of th Institute and their Board of Directors were chosen. Since the work the Executive Committee was now complete, its members resigned from active work at this time. President Graham was elected Chairman of Board of Directors and thereby automatically became President of the Corporation. Other members of the new Board were Dr. Frederick Sei Carnegie Institute of Technology, Dean G. B. Pegram, Columbia Univer Dean Ernest Goodpasture, Vanderbilt Medical School, Dr. P. M. Gross, University, and Dr. W. G. Pollard. No further formal meetings of th Council or its directors were held during the remainder of 1946. Fu activities were dependent upon the negotiations and completion of a tract between the Institute and the District (Reference: 9).

10. Participating Institutions. - The following 14 instituti were participants in the Oak Ridge Institute of Nuclear Studies as o October 1946, the date of the organizational meeting of the Council the last formal meeting prior to the end of 1946:

Alabama Polytechnic Institute, Auburn, Ala.
University of Alabama, Tuscaloosa, Ala.
Catholic University of America, Washington, D. C.
Duke University, Durham, N. C.
Emory University, Atlanta, Ga.
Georgia School of Technology, Atlanta, Ga.
University of Kentucky, Lexington, Ky.
Louisiana State University, Baton Rouge, La.
University of North Carolina, Chapel Hill, N. C.
University of Tennessee, Knoxville, Tenn.
Tulane University, New Orleans, La.
University of Texas, Austin, Tex.

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Vanderbilt University, Nashville, Tenn.

University of Virginia, Charlottesville, Va.

11. Contract Negotiations. - On 31 October 1946, Dr. Pollar representing the Executive Committee, submitted to Colonel Nichols draft of a contract between the District and the Institute, based o original August Proposal as modified by Colonel Nichols' recommenda of 18 September. It was felt that the draft should serve as the ba for further discussion leading to a final contract suitable to both parties. Since the transfer of District activities from the War Dep ment to the Atomic Energy Commission was impending, however, further action on the matter was accordingly postponed until the new civili agency could review the entire program.

REFERENCES

Number	Title	Location
1.	Minutes of Meeting of Southeastern Universities at Knoxville on 5 December 1945, "Research Opportunities in the Southeast."	Research Div
2.	Minutes of the Oak Ridge Conference, Oak Ridge Institute of Nuclear Studies, 27-29 Dec. 1945.	"
3.	Letter from Dr. W. G. Pollard to Col. K. D. Nichols, 14 January 1946.	"
4.	Memorandum from Dr. P. W. McDaniel to files, subject: "Oak Ridge Institute for Nuclear Studies," 6 February 1946.	"
5.	Letter from Dr. W. G. Pollard to Col. E. E. Kirkpatrick, 13 February 1946.	"
6.	Letter from Dr. W. G. Pollard to Col. K. D. Nichols, 3 April 1946.	"
7.	Letter from Lt. Col. A. V. Peterson to Dr. W. G. Pollard, 12 April 1946.	"
8.	Letter from Dr. W. G. Pollard to Col. K. D. Nichols, 7 August 1946.	"
9.	Letter from Dr. W. G. Pollard to Col. K. D. Nichols, 31 October 1946, inclosing draft of proposed contract.	"