CONFIDENTIAL
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# A NUCLEAR REACTOR

# AT THE

# UNIVERSITY OF MICHIGAN

Proposal Submitted

to the

United States Atomic Energy Commission

June 4, 1952

Prepared by the University Committee
for a Nuclear Reactor

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UNIVERSITY OF MICHIGAN
ANN ARBOR

OFFICE OF THE PRESIDENT

June 4, 1952

Honorable Gordon Dean, Chairman
U. S. Atomic Energy Commission
Washington 25, D. C.

Dear Mr. Dean:

Thank you for the opportunity granted a few weeks ago to discuss the research reactor for the University of Michigan. At this time I have the pleasure of submitting the Proposal prepared by the special committee of the faculty appointed for this purpose. The University of Michigan incorporates a large and exceptionally capable group of diverse scientists and engineers who are actively cooperating in nuclear education, research and development at this time. The scope of the unique Michigan Memorial Phoenix Project which embraces the legal, social and economic aspects of atomic energy as well as the problems of physical science and engineering, indicates the wide range of active interests of the faculty and students.

We are thoroughly aroused to the importance of nuclear energy in the future lives of our students. The nuclear reactor is the prime source of this energy for peace time uses and therefore a most essential device in the educational and research program of the University. Long range research of a fundamental and exploratory nature always flourishes best in the creative atmosphere of a well-equipped University where there is active enthusiasm and a willingness of men in different fields to work together.

The Detroit Edison and Dow Chemical Companies have indicated that the availability of such a reactor at the University of Michigan will help support their program of study of atomic energy for power.

Particularly the University requests:

1) the permission of the Commission to construct the reactor as described in the attached Proposal.
2) the loan of the required fissionable material.
3) the granting of a budget of $615,570 for the construction of this reactor.

The University will provide suitable housing for this reactor and will operate it at least to the extent necessary and desired in its program of education and research.

Sincerely,

Harlan Hatcher

Harlan Hatcher

UNIVERSITY OF MICHIGAN
MICHIGAN MEMORIAL-PHOENIX PROJECT
ANN ARBOR

OFFICE OF THE DIRECTOR

3 June 1952

Honorable Gordon Dean
Atomic Energy Commission
Washington 25, D. C.

Dear Mr. Dean:

On behalf of the Executive Committee of the Michigan Memorial-Phoenix Project I wish to assure the Atomic Energy Commission of the great interest of the Michigan Memorial-Phoenix Project in the proposal to place a nuclear reactor at the University of Michigan, and of the intention of the Phoenix Project to assist in the support of this reactor. Plans are now being drawn for a Laboratory Building for the Michigan Memorial-Phoenix Project in which it is intended to house the University of Michigan's synchrotron and cyclotron, as well as other research requiring high radiation flux. The University of Michigan plans to provide the housing for the nuclear reactor, and this reactor will be placed either adjacent to the Phoenix Laboratory or in an extension of the Laboratory, so that the reactor group can use the shop and other common facilities of the Laboratory. These various activities then will form an integrated whole. The Phoenix Project is assisting in the design work of the reactor and expects to provide part of the funds for operation of the reactor.

The Phoenix Project funds are being used to assist and strengthen the broad program of research in nuclear physics and in the applications of nuclear research to all fields of study and research in the University. We believe that a reactor is an extremely desirable feature of this research program, and will help to provide the University with a very broad and well-rounded program in this field. It seems to us that the research program of the University and the industrial interest in Michigan in the development of power from nuclear reactors make the University a strategic place for the location of a reactor.

Sincerely yours,

Ralph A. Sawyer
Ralph A. Sawyer
Director

## SUMMARY

A survey under a contract between the United States Atomic Energy Commission and the University of Michigan (AT(11-1)-224) has been made of the reactors available for installation at the University of Michigan. A design was made to provide the features desirable for combined teaching and research. A heterogeneous reactor with light water for moderation, shielding and cooling was chosen. In essence the design combines features of the Bulk Shielding Facility and the Low-Intensity Training Reactors in operation at the Oak Ridge National Laboratory.

A flux of $10^{13}$ neutrons per square centimeter per second is provided. This requires a power level of 1000 kw and forced water cooling. The fuel requirement is 3.67 kg of uranium-235 which allows for 10 per cent burn-up, poisoning, and operation with six neutron beam holes in use.

Full consideration has been given to the safety problems involved in the installation of the reactor on the newly developed North Campus of the University. The existing Radiation Safety Organization of the University will be expanded to provide proper supervision of the Reactor Laboratory.

The returns to be expected, both in research and education, from the installation of a reactor at the University are discussed. In brief it will permit the University to assume a leading role in the training of engineers and scientists for work in nuclear energy. New ideas may be expected to flow from independent investigation by scientists in the diverse fields represented at a large University.

A budget developed from cost quotations and consultation with experienced Atomic Energy Commission reactor personnel is presented for the reactor installation and auxiliaries. The amount requested from the Atomic Energy Commission is $615,570, of which $450,370 is for the reactor installation and $165,200 is for auxiliary equipment. The reactor will be housed in the Michigan Memorial-Phoenix Project Building at a total cost to the University of $1,200,000. Thus the request from the Commission comprises one-third of the total investment planned for new high-level radiation facilities at the University.

# PROPOSAL FOR A NUCLEAR REACTOR AT THE UNIVERSITY OF MICHIGAN

Ann Arbor, Michigan
January 22, 1952

# PROPOSAL FOR A NUCLEAR REACTOR
# AT THE UNIVERSITY OF MICHIGAN

## INTRODUCTION

The University of Michigan has always advocated pioneering research in all fields of human endeavour. In recognition of the tremendous new problems created by the advent of atomic energy, the Phoenix Project was created at the University "to explore the ways and means by which the potentialities of atomic energy may become a beneficent influence in the life of man." The utilization of the energy available from the atomic nucleus has reached its greatest development, up to the present time, in the nuclear reactor.

That the University may participate fully in the research and development of this new field of energy, it is becoming evident that a research reactor should be available to the faculty for research and instruction.

Just as the availability of radioactive tracer material led rapidly to a very broad research program, in which all scientific branches of the University are participating, so too it is believed that the advent of a nuclear reactor with adequate auxiliary facilities will bring forth a broad program of basic and applied research.

In addition, the University educational program in nuclear physics, engineering, chemistry and cognate fields can be given a basic nature only obtained by direct experimentation with a nuclear reactor.

This neutron flux can be maintained over a significant volume despite the presence of several test specimen.

The proposed design will utilize both the technique of inserting experimental assemblies adjacent to the reactor elements and under sufficient water to provide shielding and cooling, and also direct neutron beam exposure through suitable ports in the tank wall. At least two or three such ports will be designed into the reactor assembly.

It is further proposed that coils through which solutions can be circulated will be installed in high neutron intensity positions within the reactor, so that processing studies may be made in a continuous manner under operating conditions without interfering with the functioning of the reactor.

The fuel elements are similar to those now in use at Oak Ridge and Idaho and for which fabrication and reprocessing facilities are available. By encasing the fuel elements in an inert metal sheath, loss of fission products and contamination is avoided. It is anticipated that at average rates of operation, the life of the fuel elements will be about 2 to 3 years. The design of the reactor permits removal of individual elements and storage under water until the radioactivity has subsided to a level which permits easy shipment to the Atomic Energy Commission to exchange for new fuel elements.

From previous construction experience and a preliminary cost analysis of the modifications necessary to provide water circulation and easily accessible neutron ports, it is estimated been tested in A.E.C. installations and the performance can be guaranteed.

An alternate design, known as the "Water Boiler" and which is a lower cost device is being studied. According to the information released from North Carolina State College, where such a unit is being built, the proposed reactor will reach $10^{13}$ neutron flux operating at a power level of about 30 kw. However, we have been led to believe, through discussions with the responsible directing personnel of the Oak Ridge Reactor group, that this flux density may not be achieved, especially when practical size specimens are inserted in high neutron flux positions. It is felt, therefore, that it would be unwise to commit ourselves to this design as opposed to a larger, somewhat more costly, system whose performance can be assured. From our study to date, it would appear that the extra cost of the 1000 kw unit over that of the 30 kw size is more than warranted by extended usefulness of the larger capacity unit.

It is acknowledged that Uranium is at all times the property of the Atomic Energy Commission and the cost of Uranium is not included in our estimate.

SITE FOR REACTOR AND BUILDING

The University has already undertaken the development of a new auxiliary campus of 265 acres located approximately two miles northeast of the center of the present campus. The

UNIVERSITY PROGRAM

As an indication of the scope of activity now existing at the University and which will supply the basis for the research program to be built around the reactor, Table I. has been prepared giving a partial list of research studies now being carried out under the direction of University faculty members.

On the basis of conferences held with persons actively engaged in research, a tentative program for utilizing the reactor facility was prepared and is presented in Table II. Specific items as follows have been selected for further discussion.

In the field of physics, the techniques of X-ray and electron diffraction have already been strongly developed and great masses of basic data on atomic, molecular and crystal structure have been obtained thereby. Some early work has now been done using the De Broglie wave length of neutrons as the basis for diffraction studies in the solid state. This is a field which has just come into being and which has great promise particularly since light nuclei will interact strongly in this new type of diffraction system.

Nuclear energy level studies still provide a large field for systematic exploration in order that a consistent and adequate nuclear model may be developed. In addition, if a sufficiently strong source of fast neutrons is available, further work on neutron deficient nuclei, a relatively unexplored field, can provide a long and profitable program.

Of the engineering problems listed, two which are particularly vital are those of the effect of neutrons on structural materials and the problems of removing and recovering in pure form, materials produced by neutron capture and by fission. Techniques of ion exchange, liquid-liquid extraction and other transfer operations should provide significant results when applied in this field.

While we are aware of the special efforts being made to test materials under intense radiation conditions, we feel that a more general University type program would provide ample problems in which the pile neutron flux would be essential for solution. Further, special studies of the simultaneous effects of neutrons and high temperature would be of special interest and could well be carried out.

In Chemistry, analysis through the studies of neutron induced activity have provided a very sensitive and promising new technique. Many studies in both organic and inorganic systems can be set up for this type of work. For research purposes both in chemistry and in applied fields, short half life isotopes can be freely used since they would be readily available. We now fly palladium in from Chalk River for studies of the effect of ionizing radiation on flame propagation rate

Many problems in biology have arisen as a result of neutron irradiation. A group now working on the campus on biological effects of radiation has already indicated interest

## SECURITY AND SAFETY PROBLEMS

The necessity for proper security in matters involving atomic energy is recognized. However, research incentive and the creation of new ideas require a minimum of restriction. We would consider it most desirable if the proposed reactor design could be unclassified. However, if this cannot be done, then at least the face of the reactor in which neutron ports have been provided for general research must be freely accessible. Likewise, in the field of education, students must have free access to observe control panel operation and other technical details of pile systematics.

On the other hand, it is recognized that specific research problems must be conducted on a classified basis, entailing the restriction of specific areas to authorized personnel. The University has long operated in research problems of this nature and can handle the administrative details involved.

The installation of a reactor in any area automatically raises problems of safety. The reactor design selected has inherent safety features which will prevent catastrophic failure even under earthquake conditions. For control and protection of personnel, a University Radiation Safety Committee is now functioning, a Radiation safety officer with an adequate staff is working on a routine basis and health examinations have been made mandatory for all personnel requiring film badges.

This organization can easily be expanded to service the reactor installation.

# TABLE I.

## Partial List of Research Programs in Progress at Ann Arbor of Direct Interest to A.E.C.

1. Physics - High Energy Accelerator Research - Crane A.E.C. Assistance
   Nuclear Energy Levels - Wiedenbeck A.E.C. Assistance
   Cork A.E.C. "
   Dislocation in Solid State - E. Katz
   Molecular Structure - Infra red - Sutherland -
   Biophysics - virus genetics - Levinthal -
   Cosmic Rays - Hazen -

2. Engineering
   a. Development of High Magnification Radiation Microscope (Gomberg - Kerr) A.E.C. Contract
   b. Effect of Radiation (γ) on Jet Flame Propogation (Vincent - Brownell) Partial A.E.C. Support
   c. Food Preservation by Radiation (Brownell) } M.M.P.P.
   d. Pharmaceutical Sterilization by Radiation (Brownell) } Support
   e. Chemical Reaction Catalysis - Martin ✓ Partial A.E.C. Support
   f. Solid State Structure Analysis using Tracers and Activation Techniques (Gomberg)
   g. Heat Transfer and flow problem analysis (A.D. Moore) ✓
   h. Servo Mechanisms Research (Rauch - Aero.) (MacNee - Elec.) ✓
   i. New Autoradiographic Systems (Gomberg) A.E.C. Contract ✓
   j. Characteristics of Metals at High Temperature (Freeman) ✓
   k. Ion Exchange Techniques (R. R. White) ✓
   l. Solid State Analysis - X-ray (Thomassen) ✓
   m. Gas Turbine Studies (Schwartz)
   n. High Pressure gas diffusion (Martin) ✓
   o. Reactors shielding (Bobrowsky and Chenea)
   p. Properties of metal under neutron bombardment (Chenea)

3. Chemistry
   a. Fission product analysis (Meinke)
   b. Thermodynamic property changes caused by bombardment with neutrons (Westrum)
   c. Fission Product Distribution - Stable and Radioactive (Rulf - Meinke)
   d. Very Low Temperature Thermodynamics (Westrum) A.E.C. Support
   e. Electron Diffraction Studies in Solid State (Brockway)

TABLE II.

Tentative Research Programs Involving Use of Research Reactor

A. Pure Research

1. Physics:

- Capture and Scatter Cross Sections to thermal and (Depending on pile design) fast neutrons
- Neutron Diffraction studies of solid state
- Neutron Diffraction study of molecular structure
- Knock-on (solid state structure) experiments
- Neutrino measurements
- Nuclear Energy levels

2. Engineering:

- Pile instrumentation and control
- Structural materials analysis under radiation and high temperature
- Use of radiation for catalyzing reaction on an industrial basis
- Use of radiation for sterilization
- Fission product recovery methods - ion exchange
- Fuel refining methods
- Power generation methods
- Investigation of direct energy recovery possibilities

3. Chemistry:

- Neutron spectroscopy for analysis
- Activation analysis
- Short half life isotope preparation
- Fission oroduct characterization
- Radiation chemistry

4. Biology:

- Effects of radiation as direct cause of damage
- Use of induced mutations for creation of new types for industrial microbiology work