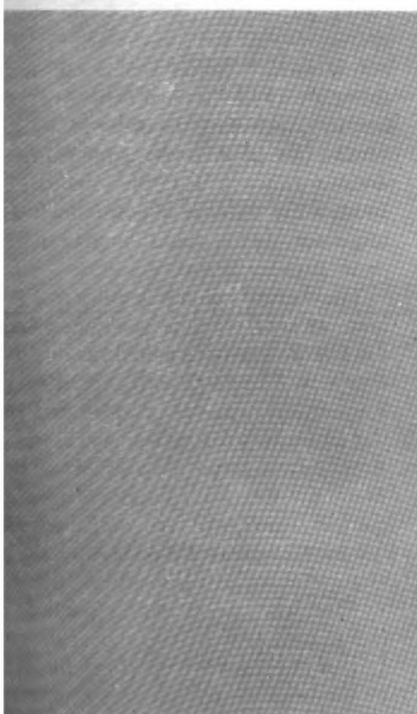
by RUSSEL B. MESLER, Ph.D.
Assistant Professor of Nuclear Engineering
Department of Chemical and Metallurgical Engineering

oon to be on North Campus . . .

THE FORD NUCLEAR REACTOR



University of Michigan's North Campus with the Phoenix Memorial Laboratory and the Ford Reactor shown in the foreground.

With the completion of the Ford Nuclear Reactor a vast new frontier will be opened at the University of Michigan. Not only will this machine provide unique experimental facilities at the University but it will also provide students and staff with first hand experience with the problems of operating and using a nuclear reactor. A course is already being offered which will give students experience in operating the reactor and using its experimental facilities.

The Ford Nuclear Reactor is a one megawatt reactor which together with its building cost one million dollars. It is a swimming pool type reactor with the core of the reactor clearly visible through twenty feet of high purity water. The core of the reactor contains approximately 23 fuel elements each 3″ x 3″ x 24″ long. The U-235 fuel in these elements is contained in 18 plates. The plates are sandwiches with the fuel on the inside and 23 aluminum on the outside. The fuel elements set in an 8 x 10 position matrix plate with graphite reflector elements surrounding the fuel elements.

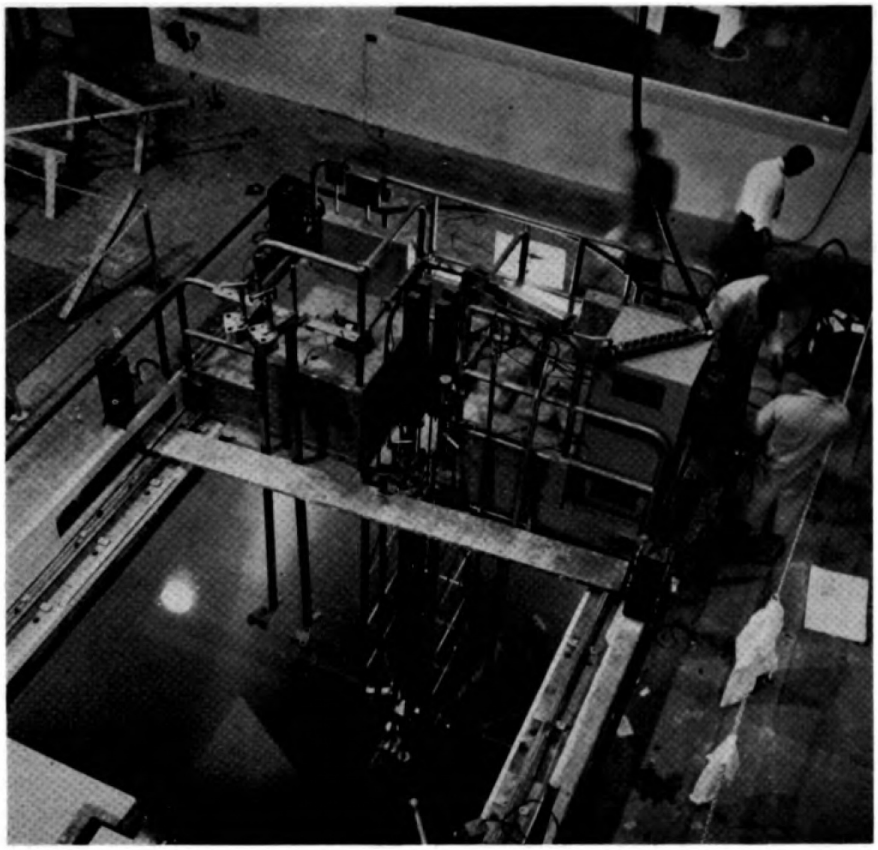
There are at least three distinct endeavors which will be advanced by the presence of the reactor. First, the reactor will make it possible to train students in reactor technology. It will provide not only the opportunity for students to work with an operating reactor and its experimental facilities but the reactor will also attract students and staff to the University. Second, those people active in reactor technology can now design experiments using the reactor which will give them some of the badly needed data with which more efficient and economical reactors will be built. Third, uses of the reactor radiation for purposes other than its degradation into heat can be studied. Here lie some of the interesting possibilities such as direct conversion of the nuclear energy into chemical or electrical energy.

Although the reactor is not alone responsible for growth of a nuclear engineering program at the University, it is one of the principal factors. The first masters degree in nuclear engineering was granted in 1954. Last year there were 9 masters degrees awarded and a Ph.D. program was inaugurated. There are now 75 graduate students in the masters degree and Ph.D. degree programs.

The reactor will be used as an intense source of neutrons and gamma rays. The heat that is generated is removed at temperatures of less than 100° F. and is not used.

The Ford Nuclear Reactor is designed to operate at the power of one megawatt. It is the highest power reactor located on a university campus. There are several reactors with higher power levels, but these are at Atomic Energy Commission installations.

Special provisions have been made to build such a high power reactor in the middle of a campus. The primary hazard



The "swimming pool" of the Universi
Ford Nuclear Reactor.

is the radio activity contained within the reactor. Heretofore, such a reactor has always been located inside a large fenced-in area. Instead of this, the University has located the reactor in a windowless building of monolithic construction so as to contain any radioactivity which might be released inside.

A factor which greatly enhances the use of the reactor is its location. Not only is it easily accessible to those wishing to use it, but also it is adjacent to the facilities of the Phoenix Memorial laboratory equipped to handle all levels of radioactivity up to the equivalent of 10,000 curies or Co-60. These facilities make the installation unique for any university campus.

The reactor is operated by the Michigan Memorial-Phoenix Project. The Phoenix Project was established to pursue all phases of the peaceful uses of nuclear energy. It is the policy of the Phoenix Project to make the reactor available on a equal basis to workers in engineering, science, medicine and other fields of endeavor. The reactor is to be used first to train students, second, to provide experimental facilities for faculty and student research and third, to provide experimental facilities for industry. The reactor will be operated initially on a forty hour week although it is expected that the demand will be such that more shifts will be added.

Although security and classification are often obstacles in nuclear energy work, there is nothing about the reactor that is classified. Furthermore, experimental work with the reactor will be unclassified.

Special Experimental Facilities

To utilize effectively the radiation from the reactor several special experimental facilities have been incorporated. The facilities include beam ports, a thermal column, a pneumatic tube system and an underwater pass-through connecting the reactor pool with a hot cell.

The beam ports serve two functions. They permit a horizontal beam of neutrons to be taken from the reactor through 4 feet of water and 6½ feet of high density concrete. Once outside this shield the collimated neutrons can be used for a variety of uses. The beam ports also permit experiments to be placed next to the reactor at the end of the ports.

There are 14 beam ports in all. Twelve of these have 6 inch inside diameters and two 8 inch. Neutron beams taken the ports will be ordinarily of smaller dimensions, the order of ¼ ir square. One of the reasons for using density concrete for the shield i shorten the distance a beam must t to get outside the shield. Shorter dist mean stronger beams.

The thermal column is a 6 x 6 x 8 long stack of graphite positioned so the reactor can be centered on one 6 foot face. The graphite is especially The usefulness of a thermal column li the fact that carbon does not absorb trons nearly as readily as does w Thus, the thermal column provides gion in which there are well therma neutrons distributed more uniformly a larger volume than in the water.

There are two operating positior the reactor. One of them is at the end of the pool where there are t of the beam ports. The second ope position is in the middle of the pool the thermal column on one side an beam ports on the other side.

A pneumatic tube system permits exposure of small samples to reactor r tion. The system is similar to that us department stores except that the tu and carriers are much smaller. The tubes are $1\frac{1}{2}''$ O.D. and the carrier can carry samples up to 20 grams. One end of the system terminates in the pool along side the reactor. The laboratory terminals are located in laboratory hoods.

The underwater pass-through connecting the pool with a hot cell is a section of 12" pipe with a valve on each end. The valve in the hot cell is air operated for remote control manipulation.

Reactor Laboratory Course

The reactor laboratory under Professor Ernest Klema has already offered students an opportunity to participate in the effort of getting the reactor into operation. Their first effort was to fill the pool for the first time with high purity water. The water used to fill the pool is purified with two mixed-bed demineralizers. These demineralizers each purify 1000 gal per hour but can remain on stream with Ann Arbor city water for only 6 to 8 hours. At the end of this time the demineralizer must be regenerated with muratic acid and caustic. The students had first hand experience in the operation and regeneration of the demineralizers.

Another project of the course was a complete check of the control circuits for the reactor. A systematic checking procedure was worked out which would guarantee each switch, motor, relay and relay contact was functioning correctly. The procedure was then used to perform the check.

Experiments which will be performed in the course are all intimately connected with the reactor. Each is designed to demonstrate either a use of the reactor or a technique used in reactor operation.

One of the experiments will be the determination of the mass of U-235 required to attain criticality. The object is to add increments of fuel in such a way that there is no possibility of adding too much. Too much fuel presents the possibility of the power of the reactor rising at such a rate as to be not easily controlled.

The purpose of the control and safety rods in the reactor is to provide a means of controlling the power of the reactor. The effect or worth of each rod must be determined experimentally. This can be measured by adjusting the rods to give a just critical reactor. Then the rod to be evaluated is withdrawn a small amount. The rate of rise of reactor power is then measured which is a measure of the change of worth in moving the rod. This experiment is repeated with various initial rod positions until the rod is completely evaluated.

Another experiment involves measurement of reactor power and power distribution using foils which become radioactive in proportion to the reactor power.

Initial Reactor Experiments

Before the reactor can be used as a source of radiation a large number of experiments must be performed on the reactor itself. The experiments are necessary to characterize the reactor so that safety of operation can be assured. During this time the reactor will be operated at power levels of less than one watt. At power levels below this the fuel elements do not become too radioactive to be handled. It is expected that this low power level will be necessary for three months.

During this initial period operating procedure will be checked for workability and safety. Instrument behavior will be watched particularly for reliability and troubles.

The first experiment will be used to determine the masses of U-235 required to make the reactor critical under various conditions. These will be followed by experiments to evaluate the worth of the control and safety rods. The effect of the beam ports and thermal column on the reactivity of the reactor will be determined also.

A measurement must be made to establish the power level of the reactor. At such low powers it is not practical to determine the power by a calorimetric method. Instead the neutron flux will be measured and converted to power information. With this the sensing power of the ionization chambers will be calibrated.

Water temperature has an effect on the reactivity of the reactor and this must be measured. Also a complete flux mapping of various core configurations must be performed.

Initial Experiments

Many uses of the reactor are being considered and are developed to varying degrees. Many of the plans are still in the embryonic stages. Among the experiments

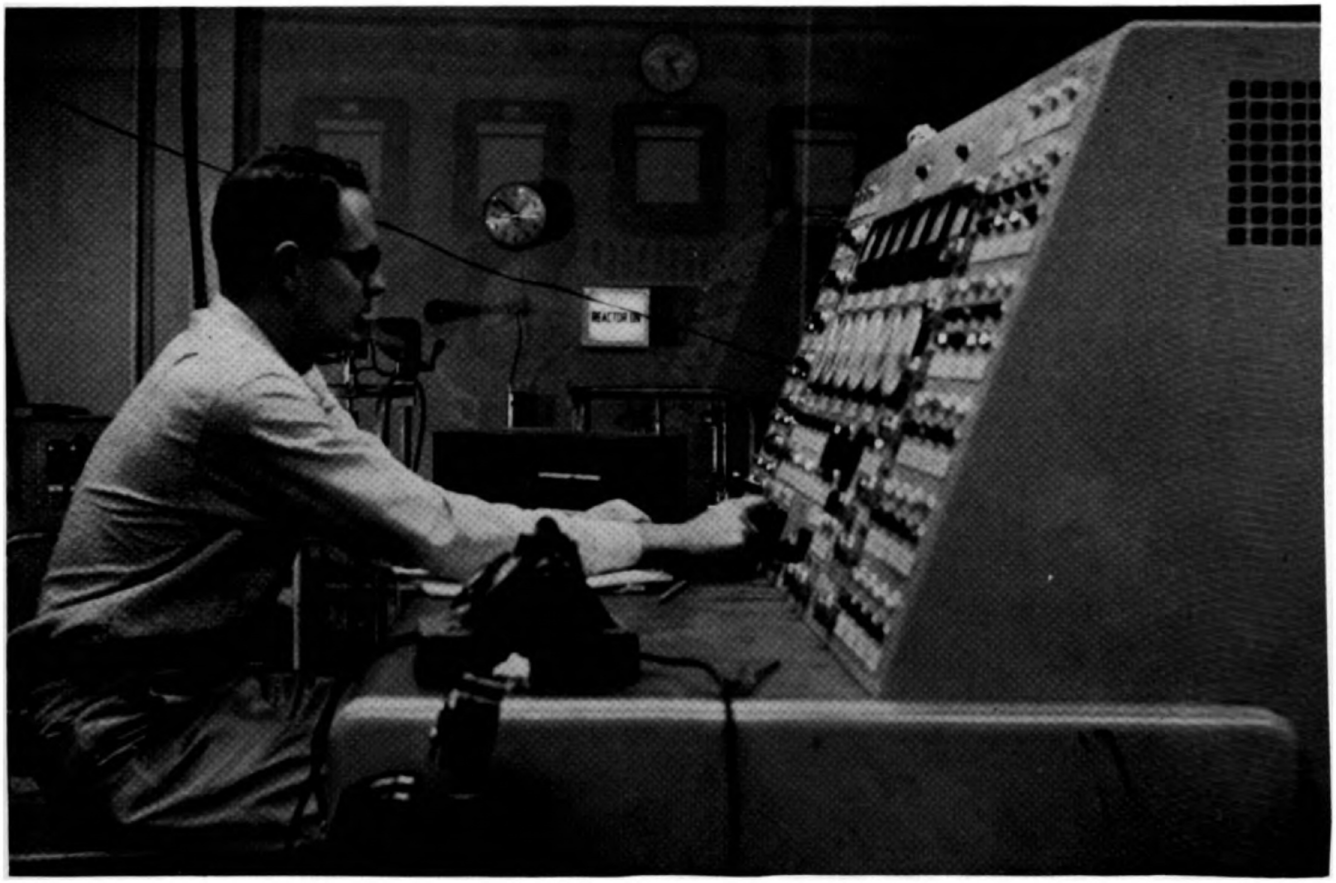
(Continued on page 28)

Russell Mesler, Professor of Nuclear Engineering in the Department of Chemical and Metallurgical Engineering, is the author of "The Ford Nuclear Reactor." He has been with the reactor on North Campus since its beginning and has been project engineer since February 1955. He also has studied at the Oakridge School of Reactor Technology in Oakridge, Tennessee.

Professor Mesler was born in Kansas City, Missouri. He attained his Bachelor of Science from the University of Kansas in 1949, but he attained his Master of Science in 1953 and his Doctor of Philosophy in 1956 from the University of Michigan. He has been teaching at the University of Michigan for two years.

THE FORD NUCLEAR REACTOR

(Continued from page 17)



Control panel—the "nerve center" of the reactor.

for which plans have progressed the furthest are studies of neutron diffraction, the effect of radiation on chemical reactions, the corrosion of graphite by liquid metals under irradiation, and activation analysis. Uses which are in earlier stages of planning are general radiation damage studies, wear studies using parts irradiated in the reactor, testing of standard electron components under irradiation, brain tumor treatment and production of very short-life isotopes for medicine.

Experiments using neutron diffraction are based on the wave behavior of neutrons. Information on molecular structure can be obtained using this technique. X-ray diffraction is similar except that x-ray diffraction techniques are unable to supply information on hydrogen atoms.

Gamma radiation is known to have an accelerating effect on some chemical reactions. The reactor is a much more intense source of gamma rays than the Co-60 sources on campus that are now used in such studies. To take advantage of this a continuous flow, chemical reactor is being designed which will operate in a beam port.

An interesting type of reactor is the liquid metal fueled reactor. Graphite is being considered as a container for the bismuth-uranium fuel. However, before such a reactor can be designed data must be obtained on the corrosion of graphite by the liquid fuel in the presence of radiation.

Activation analysis is a very sensitive method of analyzing for some elements, sodium for example. The method makes a sample radioactive with neutrons. The resulting radio-activity is measured and the decay of the radioactivity is followed to determine the presence of those elements for which the method is most sensitive. Activation studies are now in progress using a much weaker source. The pneumatic system will lend itself particularly well to activation analysis.