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# THE OAK RIDGE NATIONAL LABORATORY RESEARCH REACTOR (ORR)

## A GENERAL DESCRIPTION

T. E. Cole
J. P. Gill



OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
A Division of Union Carbide and Carbon Corporation

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Printed in USA. Price 40 cents. Available from the

Office of Technical Services
U. S. Department of Commerce
Washington 25, D. C.

ORNL-2240

Contract No. W-7405-eng26

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## A GENERAL DESCRIPTION

Research Reactor Design Group

T. E. Cole
J. P. Gill

DATE ISSUED

JAN 21 1957

OAK RIDGE NATIONAL LABORATORY
Operated by
UNION CARBIDE NUCLEAR COMPANY
A Division of Union Carbide and Carbon Corporation
Post Office Box X
Oak Ridge, Tennessee

ORNL-LR-DWG.-4538
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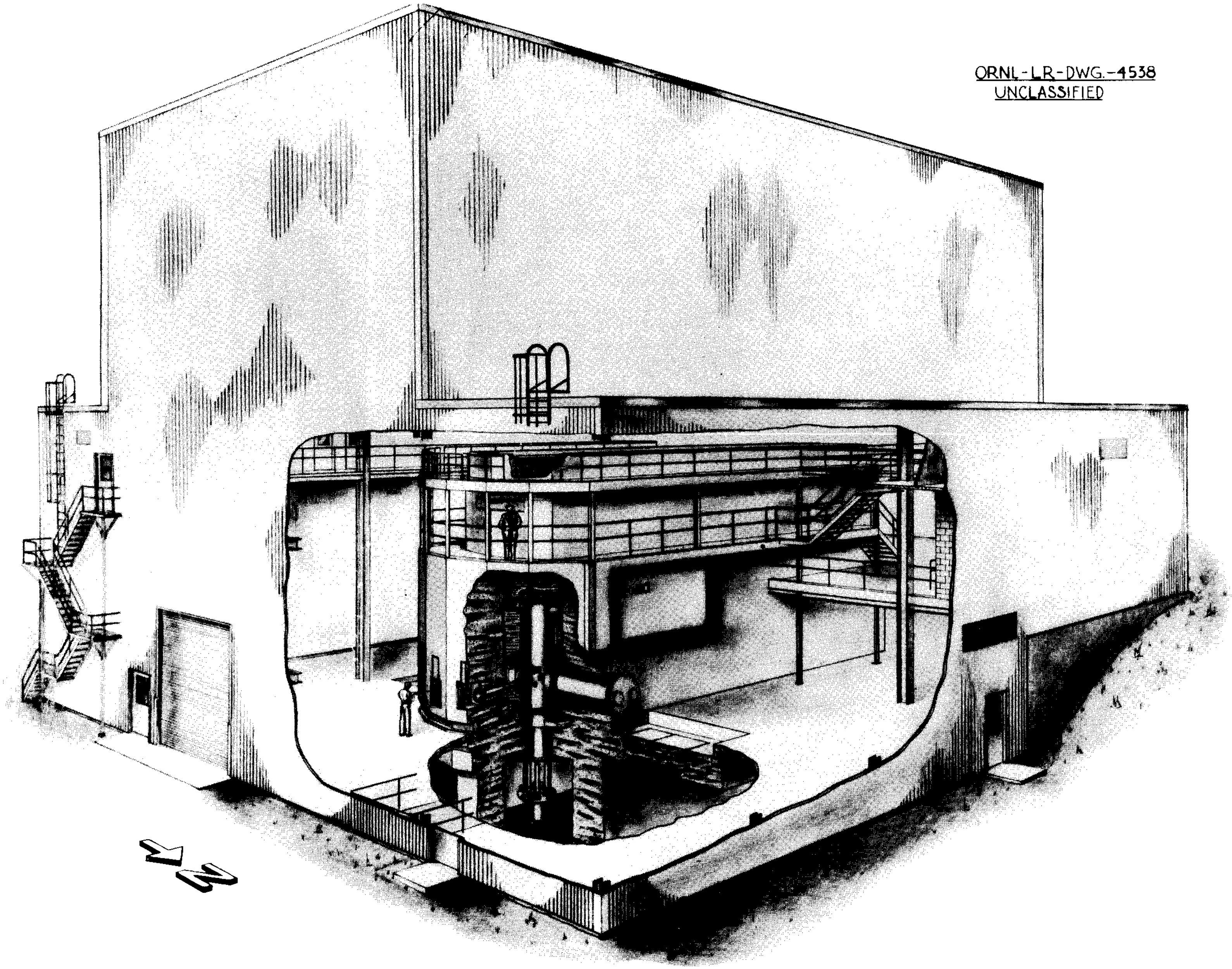

O.R.N.L. RESEARCH REACTOR PROJECT

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## ACKNOWLEDGMENT

This report was prepared through the cooperative efforts of the Oak Ridge National Laboratory Research Reactor Design Group. Other Laboratory organizations shared responsibility in their special fields.

# FOREWORD

This report is issued primarily to make available a general description of the Oak Ridge Research Reactor (ORR) in its present 20 Mw form.

## I. ABSTRACT

The proposed ORNL Research Reactor is designed to serve as a general purpose research tool delivering an average thermal neutron flux of $1.3 \times 10^{14}$ n/cm$^2$-sec at the initial power level of twenty megawatts. Operation at power levels up to thirty megawatts is proposed for such times as sufficient cooling capacity is available to handle the increased heat load.

The reactor will use MTR type fuel elements and beryllium reflector pieces in a 7 x 9 grid with moderation and cooling provided by forced circulation of demineralized water. The reactor tank is submerged in a pool filled with water with walls and bottom of barytes concrete which serves as a biological shield. Experimental facilities include two "Engineering Test Facilities" approximately 19" x 25" and six 6" diameter beam holes. In addition, access to the core is available through the water of the pool.

## II. INTRODUCTION

The history of the ORR (ORNL Research Reactor) Project began in the early part of 1950 when it was determined that a permanent reactor facility was required at the Oak Ridge National Laboratory in order to carry out successfully the various research programs then being undertaken. The reactor selected was a simplified version of the MTR (Materials Testing Reactor), to operate at a power level of five megawatts, which would require a minimum of design and development. Preliminary design work on the ORR was supported by the Atomic Energy Commission. During the initial phase the proposed design changed considerably as required by the shift in emphasis on the experimental programs. With the operating experience of the MTR and other reactors as a guide and the additional data now available in the field of reactor technology a number of improvements have been made in the basic design.

The need for improved facilities for experiments requiring neutron beams, expanded facilities for isotope production, and the necessity for an irradiation facility to permit engineering tests of the materials and components of liquid fuel reactors has become increasingly urgent. Construction and operation of the ORR in conjunction with existing facilities will help meet the requirements for neutron irradiation space of both the basic and applied research programs of the Laboratory and will help meet the expanding requirements for radioisotope production at this location.

A preliminary Proposal[(1)] which outlined the basic features of the reactor was submitted to the Atomic Energy Commission in March, 1954. This proposal was approved, and a directive was issued permitting the use of funds to secure the services of an Architect Engineer for the purpose of preparing a design on the basis of five megawatt operation. A contract, calling for the definitive design of the building, reactor shielding structure, and cooling system was executed, on July 21, 1954, with The McPherson Company of Greenville, S. C. On August 25, 1954 a modification of this directive was issued authorizing design and procurement of the reactor and controls by the Oak Ridge National Laboratory. A subsequent modification was issued early in 1955 providing funds to allow design and installation of equipment necessary for initial operation at twenty megawatts. Construction of the building, reactor shielding structure, and cooling system is being performed by Blount Brothers Construction Company of Montgomery, Alabama, a contractor who was selected on a competitive "lump-sum" bid basis. It is estimated that the reactor will be placed in service in the summer of 1957.

Copies of the Preliminary Proposal were sent to members of the Advisory Committee on Reactor Safeguards. A further description of the facility was given at a meeting of this Committee held at Cincinnati, Ohio on April 21, 1954.

On December 15, 1954 a review was made of the status of the ORR Project coupled with a review of the requirements for irradiation space by the ANP and HRP. One result of this review was the decision that sufficient justification existed to warrant an increase from 5 - 10 MW initial power level to 20 MW. This increase in initial power level was discussed with members of the Advisory Committe on Reactor Safeguards and in March, 1955, the following modifications were agreed to constitute adequate safeguard measures considering the design of the reactor, the location and the proposed use:

a) Containment is to be provided to the extent that an accident releasing the volatile fission product gases from the reactor core will not constitute a widespread hazard.

b) Available excess reactivity is to be minimized in so far as practical.

c) That the experimental installation in the engineering test facilities be restricted so that upon failure or malfunction of the installation no more than 1.4% reactivity will be added to the reactor.

## III. DESCRIPTION OF FACILITY

### A. General Description of the Reactor

The Oak Ridge National Laboratory has proposed (1) that a research reactor of intermediate power be built and operated in support of its basic and applied research programs. It is now proposed that this system be operated at a power level of twenty megawatts corresponding to an estimated average thermal neutron flux of $1.3 \times 10^{14}$ neutrons/cm.$^2$ sec. It is further proposed that at such times as adequate cooling is available the system be operated at power levels up to thirty megawatts.

The design of the ORR incorporates a heterogeneous core which utilizes enriched uranium fuel with ordinary water as coolant and moderator. The reflector will be a relatively thin layer (3 to 6 inches) of beryllium metal, backed by a thick layer (approximately 4') of water. A plan view of the core is shown in Fig. 1.

The core arrangement, fuel elements, and methods of shim and control are similar to those used in the MTR(2). The reactor core is housed near the bottom of an aluminum tank approximately fifteen feet in overall height,

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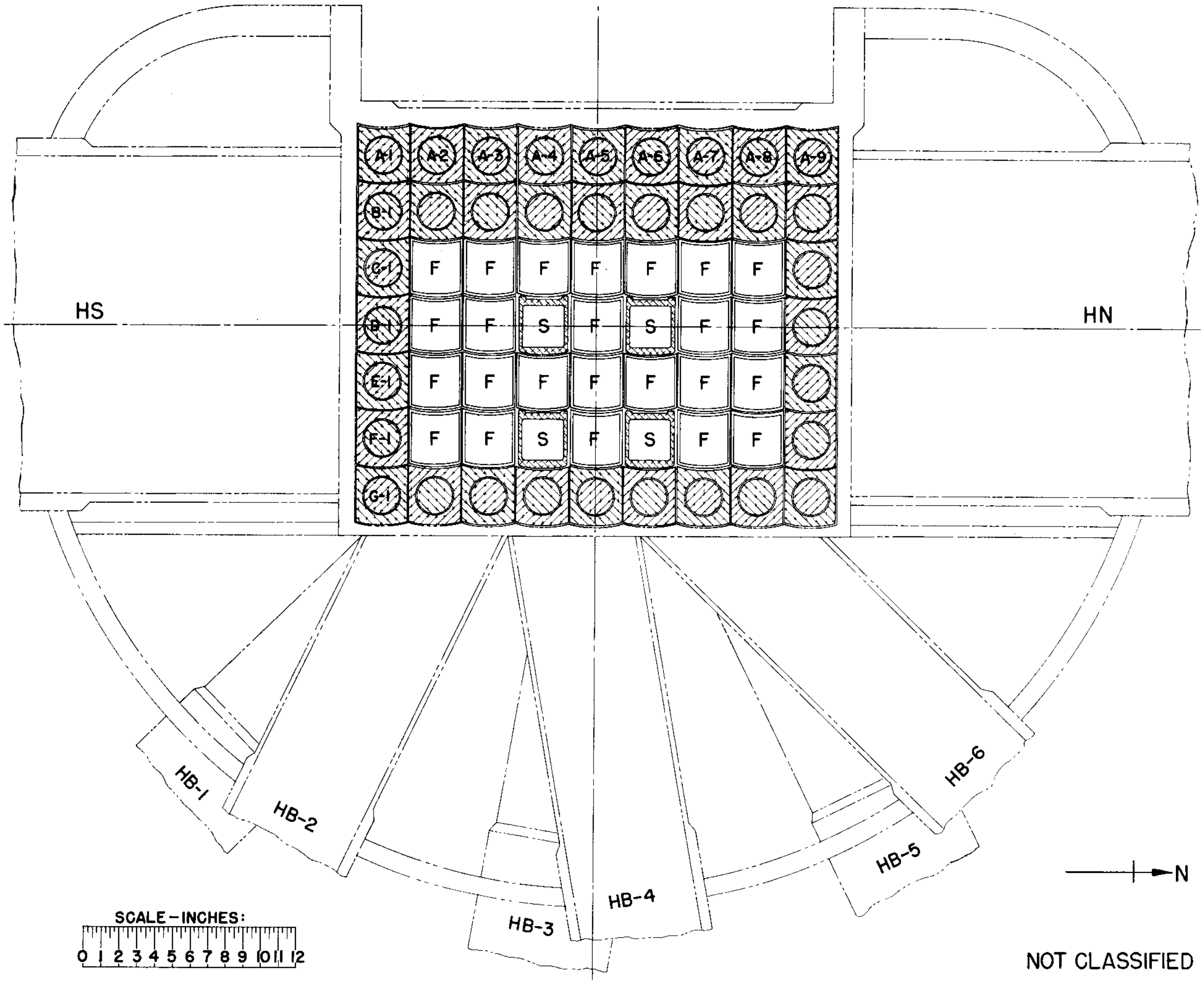


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LATTICE PATTERN: F-FUEL. S-SHIM ROD. OTHERS-REFLECTORS.
EXPERIMENTAL FACILITIES: HN & HS-LARGE FACILITIES. HB-BEAM HOLES.

ORNL RESEARCH REACTOR

HORIZONTAL SECTION THRU REACTOR ℄

**Figure 1**

and approximately five feet in diameter as shown in Fig. 2. Control drives are operated from below the reactor through a large shielding plug as illustrated in Fig. 3. This assembly, together with a top cover plate, constitutes the reactor unit which may be completely removed (with considerable effort) should the occasion arise, see Fig. 4. The design of this reactor unit incorporates many features which have already been tested or which are now being used in other installations[(2),(3),(4),(5)].

The reactor unit is located in a pool of demineralized water which is approximately twenty-one feet long, ten feet wide, and twenty-eight feet-eight inches deep, as illustrated in Figs. 3, 5 and 6. The twenty-four feet of water above the core centerline provides the main shielding above the reactor during operation and also provides the shielding required for the transfer of fuel elements, control rods, and vertical experiments from the reactor to the storage areas of the pool. These storage areas are adjacent to the reactor pool itself and are separated from it by removable aluminum gates. The entire series of pools are to be lined with ¼" welded aluminum plate in order to help maintain high water purity and to insure against leakage through the pool walls and floor.

Although the pool water is normally independent of the reactor cooling system, provision is made for circulation of this large volume of water through the reactor core should such a procedure be necessary under emergency conditions.

The structure above the sub-pile room ceiling and the adjacent storage pools is designed to meet biological shielding requirements during reactor operation and also to permit safe transfer of fuel and experimental equipment between

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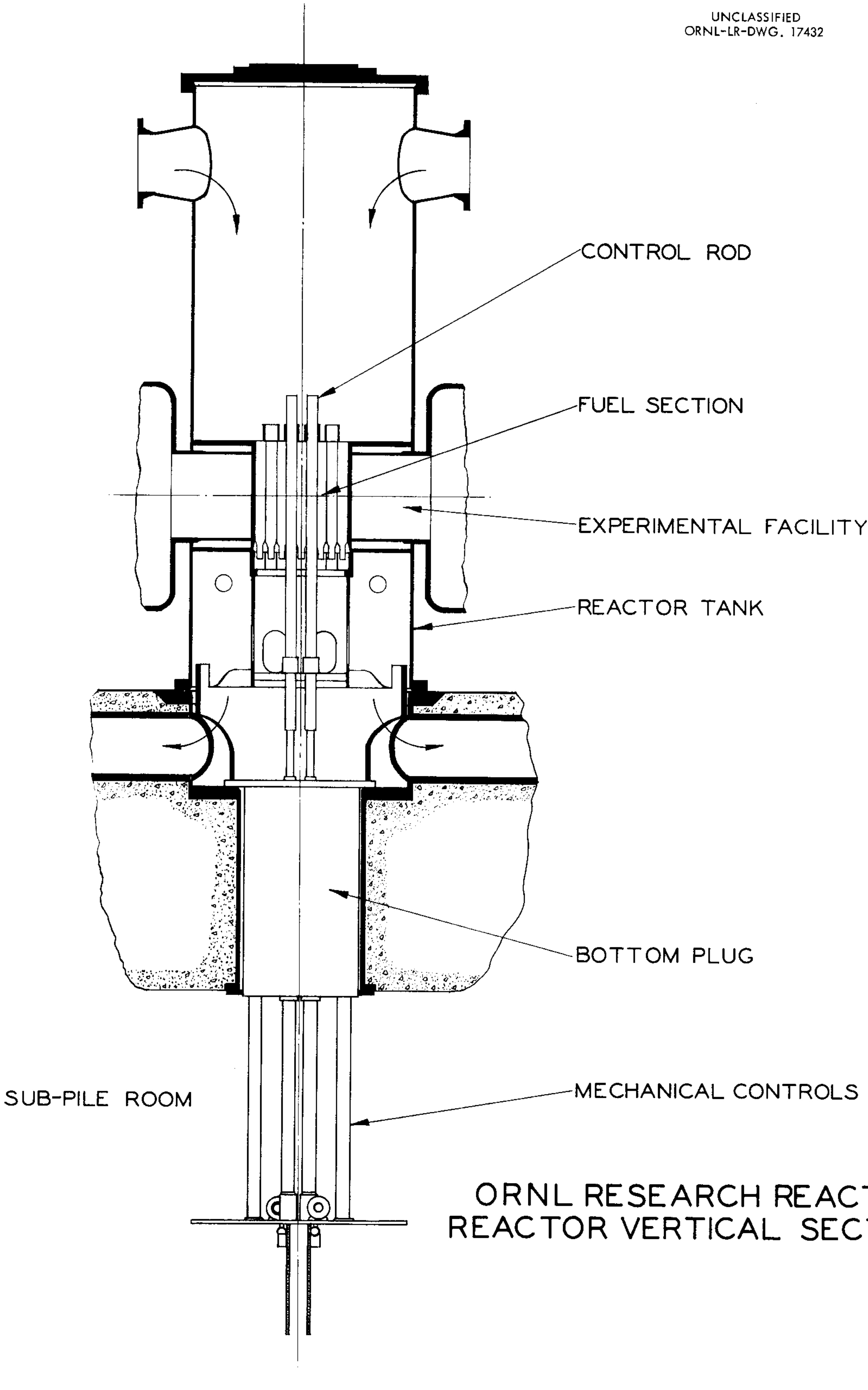
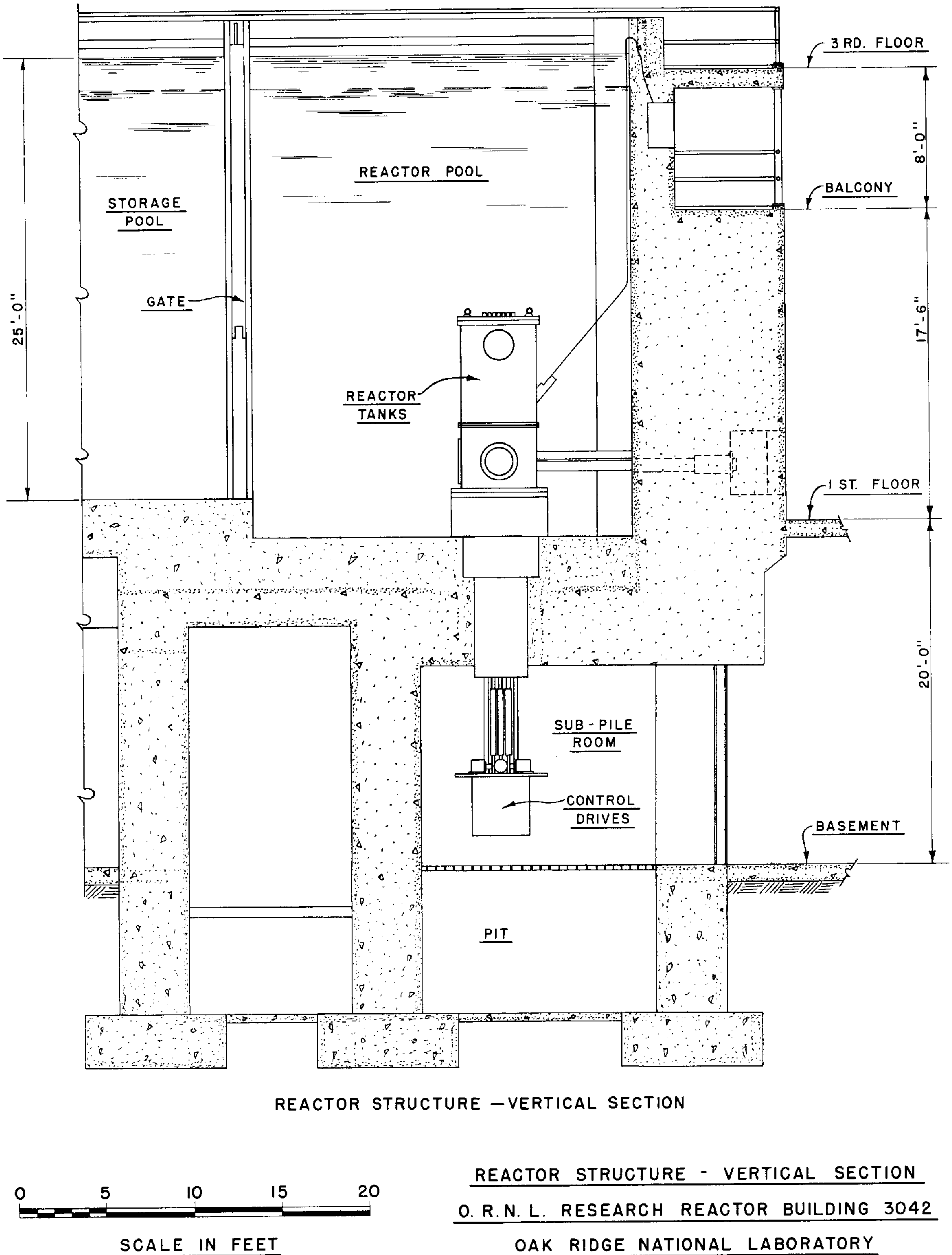



ORNL RESEARCH REACTOR
REACTOR VERTICAL SECTION

Figure 2




REACTOR STRUCTURE —VERTICAL SECTION

REACTOR STRUCTURE - VERTICAL SECTION

O. R. N. L. RESEARCH REACTOR BUILDING 3042

OAK RIDGE NATIONAL LABORATORY

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Figure 3

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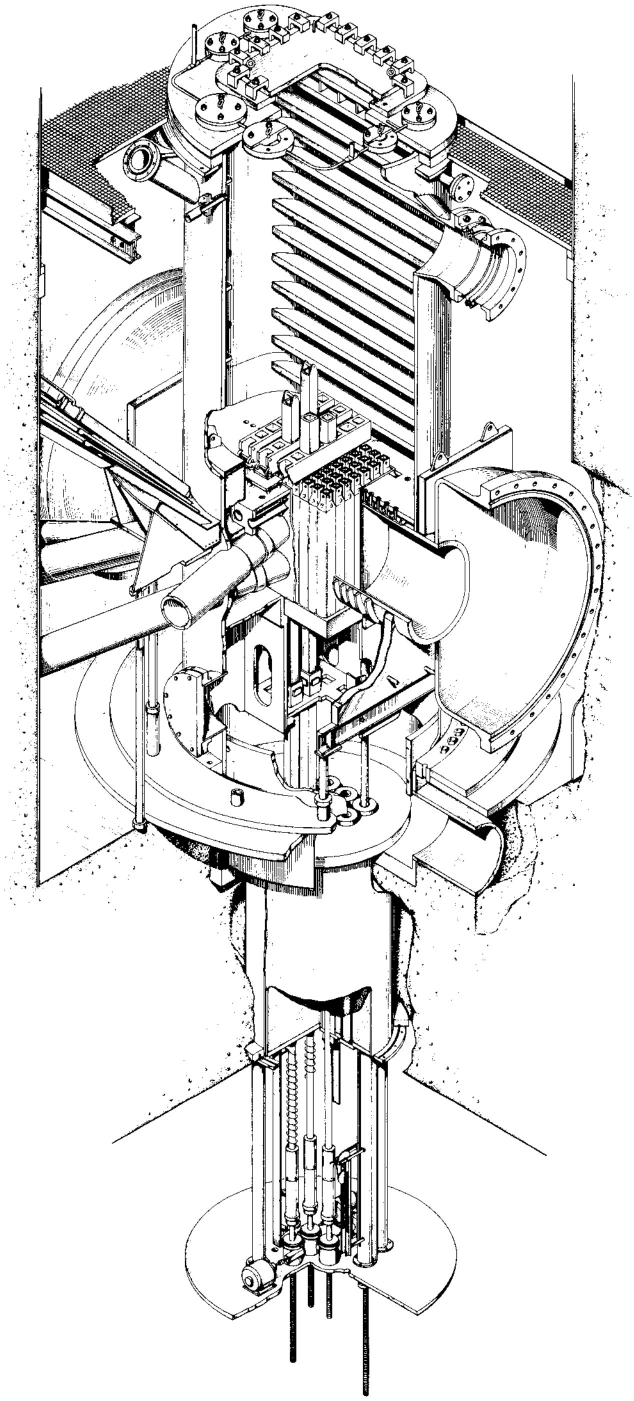
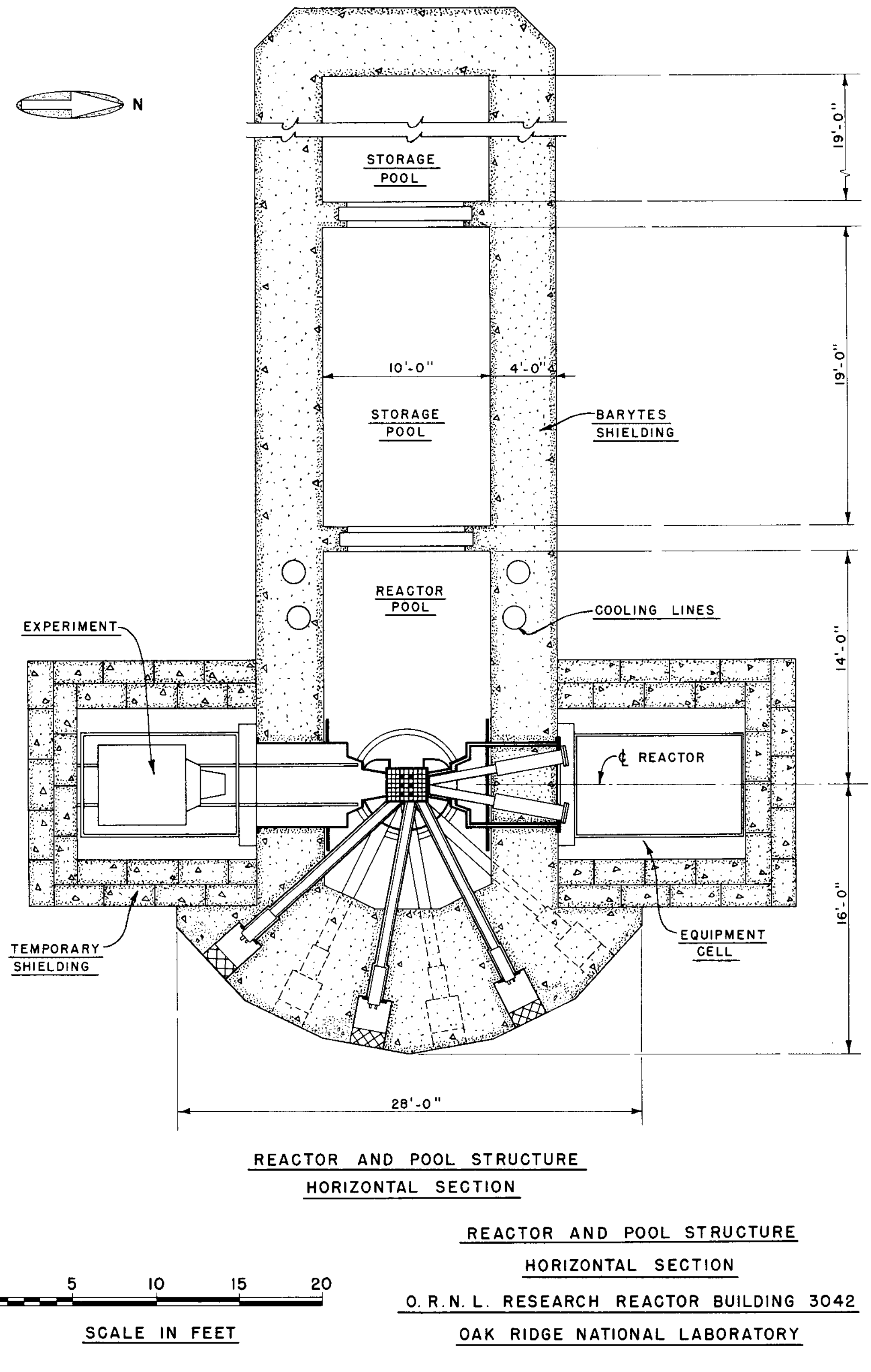


# OAK RIDGE RESEARCH REACTOR

OAK RIDGE NATIONAL LABORATORY

Figure 4




REACTOR AND POOL STRUCTURE
HORIZONTAL SECTION
O. R. N. L. RESEARCH REACTOR BUILDING 3042
OAK RIDGE NATIONAL LABORATORY

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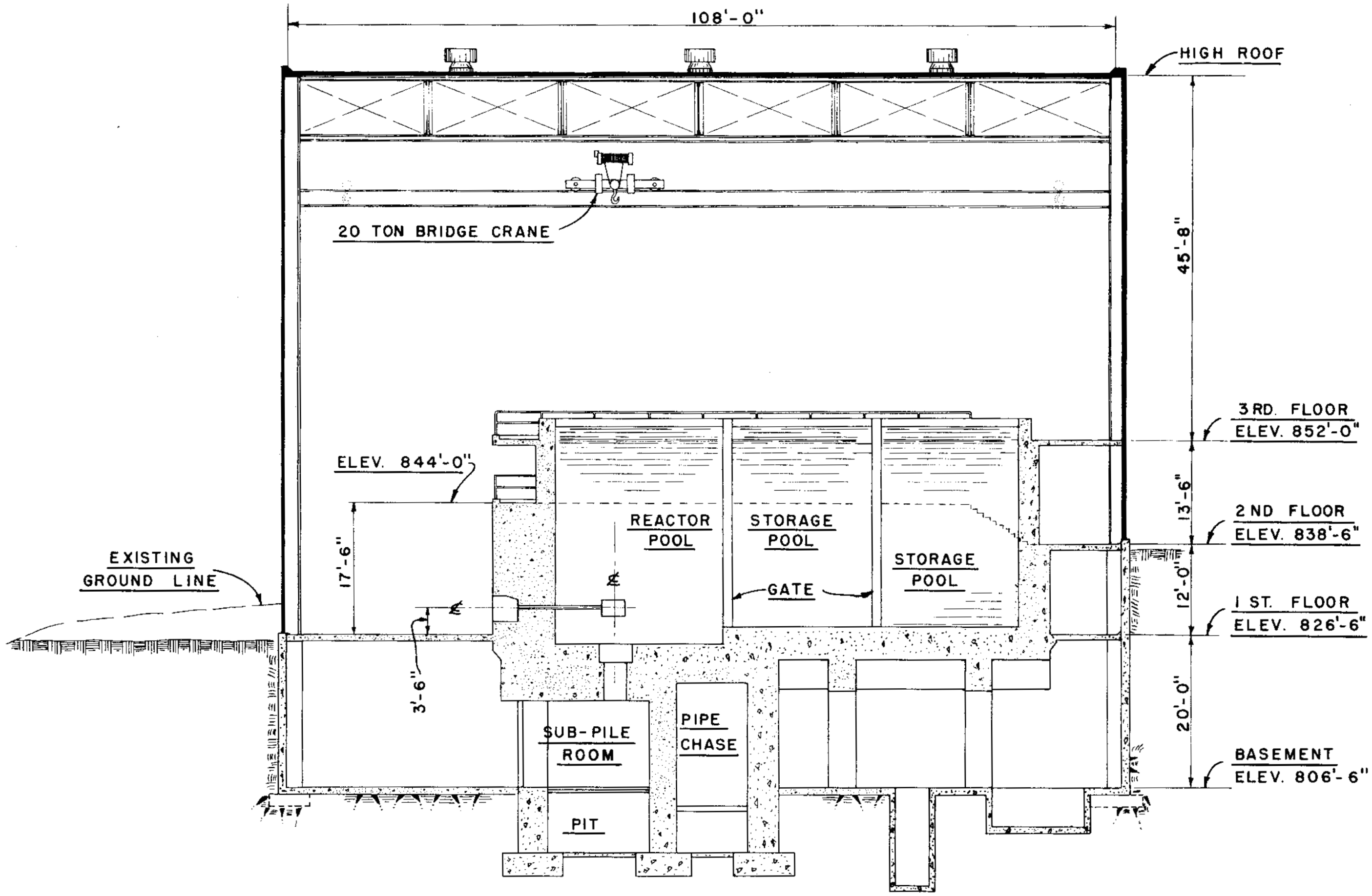
Figure 5




SECTION "B - B"

O. R. N. L. RESEARCH REACTOR – BUILDING 3042

OAK RIDGE NATIONAL LABORATORY

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0 10 20 30 40 50

SCALE IN FEET

Figure 6

pool sections. The pool walls are to be constructed of high density barytes concrete. The barytes concrete shielding will be a minimum of four feet thick in the vicinity of the reactor core. Immediately adjacent to the six beam holes, the shield is nine feet thick.

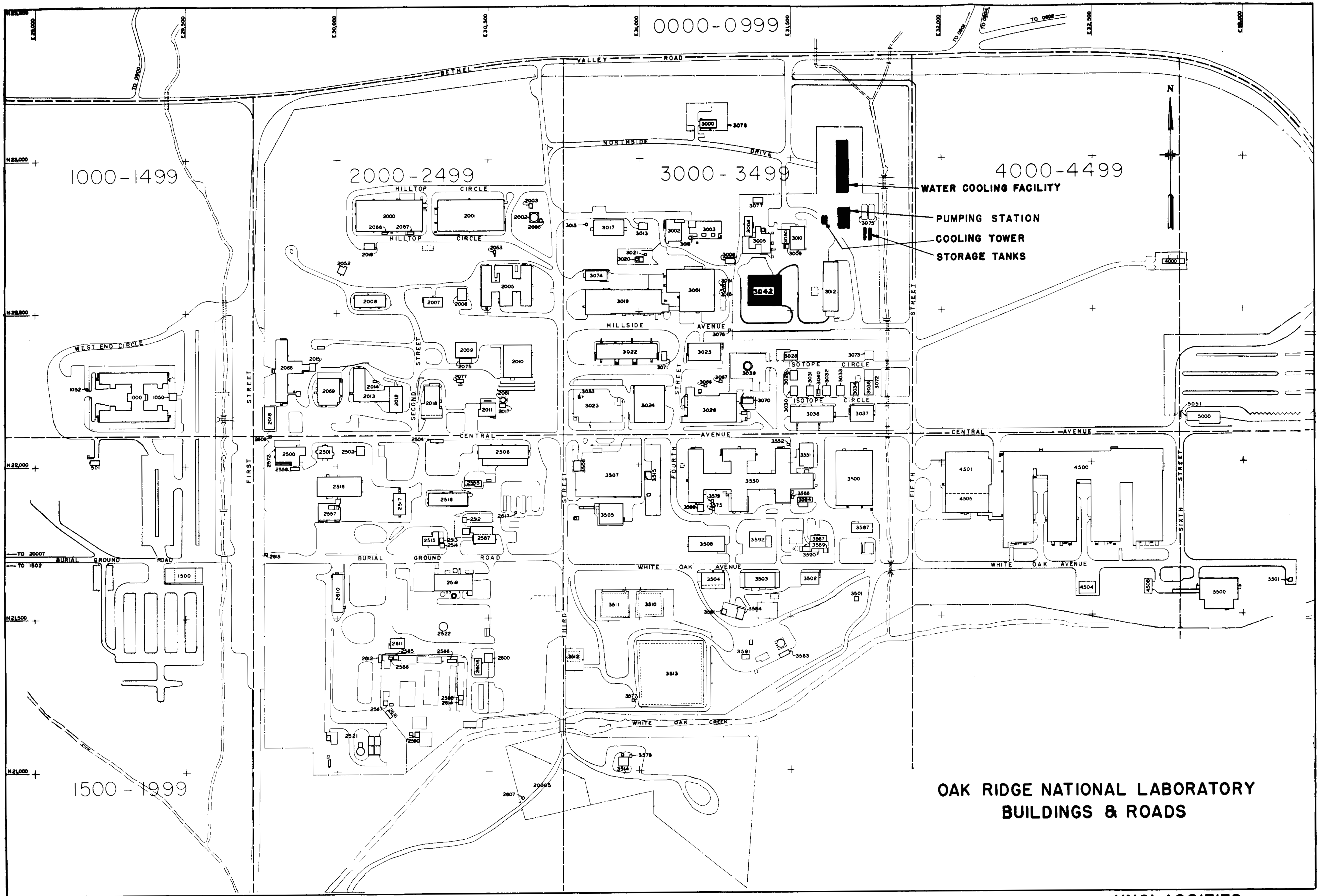
Each of the three pool sections is approximately the same size (see Fig. 6) with a total capacity of 150,000 gallons. The sections are separated by removable aluminum gates and can be filled and drained independently. There is sufficient water provided between the reactor and the walls in most cases to prevent serious activation of the concrete. The concrete closest to the reactor will be protected by thermal shields to prevent excessive heating.

B. Reactor Site

The construction site for the ORR is located in the north central portion of the Oak Ridge National Laboratory as indicated in Fig. 7. This location is approximately 650 feet south of the nearest periphery fence. Other buildings in the general vicinity (see Fig. 8) are as follows:

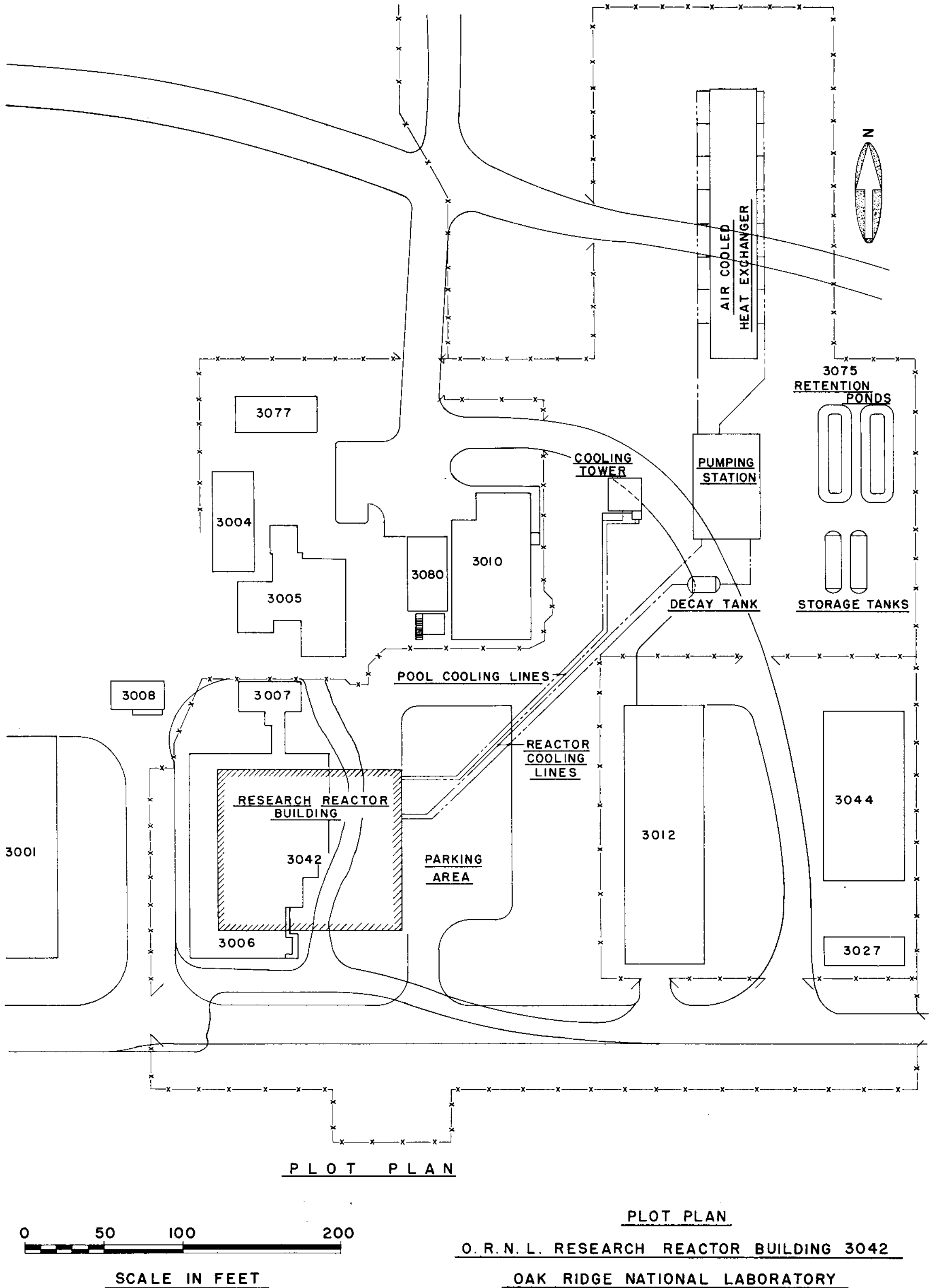
| Building | Location |
|---|---|
| Bulk Shielding Facility (3010) | 80' NE |
| X-10 Graphite Reactor (3001) | 110' W |
| LITR (3005) | 80' N |
| Rolling Mill (3012) | 125' E |

The building housing the ORR is to be located on the side of a hill which slopes in an easterly direction from elevation 835' to a small creek at elevation 800', approximately 350' east of the reactor site. This particular location was chosen because of the availability of services already in the area, integration of operations with currently existing similar facilities, and the availability of space for future expansion and for conducting neutron experiments at some distance from the neutron source. The cooling system




OAK RIDGE NATIONAL LABORATORY
BUILDINGS & ROADS

Figure 7




PLOT PLAN

O. R. N. L. RESEARCH REACTOR BUILDING 3042

OAK RIDGE NATIONAL LABORATORY

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Figure 8

for the pool water is located east of Building 3010, the Bulk Shielding Facility, and the cooling system for the core is located approximately 300' northeast of the reactor building as shown in Fig. 8.

C. Reactor Controls

The reactor control and safety system resembles the system installed on the MTR.[(2), (6)] However, experience with control systems on similar reactors, particularly the LITR and the Geneva Conference Reactor, has given sufficient confidence in the instruments to permit an instrument-controlled startup, leaving the operator free to concern himself with things not amenable to reactor controls, such as the cooling system, the experiments, and any unusual or abnormal conditions that might occur. Actions of the operator and of the automatic controls are monitored continuously by instruments independent of the safety system. The automatic start is terminated at about 300 kw; at powers above this level the operator must take into account the requirements of the experiments and the condition of the cooling system before proceeding. The automatic start is not used above 300 kw.

The Level Safety System is counted on to shut the reactor down in case of malfunction of operator or controls, but considerable effort is made to forestall a scram caused by an operating error or a false signal by equipping the control system with less drastic modes of corrective action, which can correct many potentially dangerous situations before a scram becomes necessary.

The control of the reactor is effected by the accurate vertical positioning of four or more removable elements within the reactor core. These elements are approximately twice the length of the reactor core, the lower half of the element consisting of fuel of the same shape and essential composition as the fixed fuel elements of the core and the upper half consisting of a poison section. When any rod is raised more fuel and less poison is in the core resulting in a rise in reactivity. When any control rod is lowered fuel is removed and poison is introduced in the core resulting in a lowering of the reactivity of the core.

For normal control of the reactor the movement of these control elements takes place in small vertical increments, requiring precise positioning by either manual or automatic means. This movement is effected by driving a lead screw, to which the guide tube is attached, by a reversible electric motor. At times it is necessary to reduce the core reactivity rapidly. For this operation the control rod should be dropped; thus removing fuel and inserting poison as rapidly as possible. This is accomplished by disengaging the control rod from the drive mechanism and allowing it to fall under the action of gravity to its lowest position. Near the lower extremity of the travel the rod is decelerated to prevent shock damage to the rod or its lower stop, see Fig. 9.

Since it is possible to conceive that a rod may tend to stick and not fall entirely to the lowest position when released from the drive mechanism it is necessary to provide a power drive follow up which will pull the rod down slowly if this sticking should occur.

At the lowest extremity of rod travel it is necessary to provide positive indication that, when dropped, the rod indeed falls to the bottom of its travel. Such indication is provided by the seat switch. The control assembly then consists of four identical and interchangeable units comprising the following major components for each unit.

1. A fuel-poison control rod guided by two spring loaded bearings which permit free vertical travel of the rod in the reactor core.

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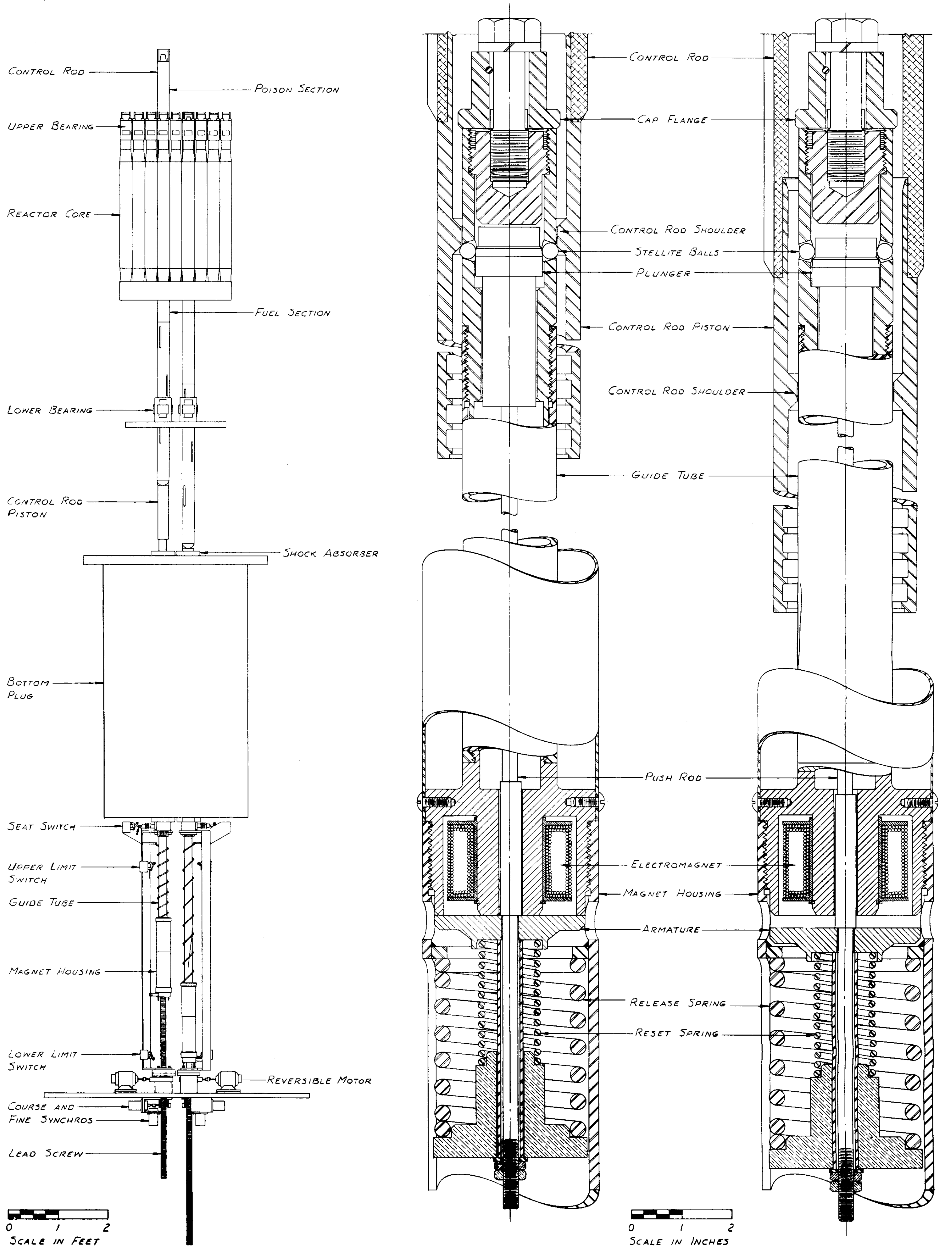


ORNL RESEARCH REACTOR MECHANICAL CONTROLS

Figure 9

2. A reversible drive mechanism for vertical positioning of the rod along with position indication of the rod.

3. A method of connecting and disconnecting the drive mechanism to or from the control rod.

Very near the top of the guide tube there is an assembly comprising eight stellite balls which occupy one of two positions 1) either extended from the guide tube wall by approximately .075" or 2) withdrawn just below the surface of the guide tube. When the balls are extended they engage a shoulder on the inside of the control rod and when the drive mechanism is raised the balls bear the weight of the rod. When the drive mechanism is lowered, the rods follow the drive mechanism down under the force of gravity. Assuming that the rod could stick in the bearings, the balls would pull away from the control rod when the drive is lowered. To prevent this happening a cap flange is provided above the balls that engages the top side of the control rod shoulder and pulls the control rod down to the safety position.

At any time that the balls are withdrawn there is no support for the control rod and it will normally fall to the bottom of its travel.

The actuation of the eight balls is extremely critical since upon this mechanism depends the quick release of the control rod which in turn effects a quick shutdown or "scram" of the reactor.

Operation of this ball release is effected by cam action of a plunger with a tapered shoulder forcing the balls into tapered holes when the plunger is raised by the push rod. When the push rod is not raised it is held in the down position by a heavy coil spring. In this "down" position the balls, under the action of gravity, fall or roll in their respective tapered holes to the lowest position. The balls can be extended only at the lower position of the drive when the tension of the heavy coil spring is removed, thereby allowing a small compression spring to raise the push rod driving the balls into their extended position. This occurs only at the bottom of the rod drive travel when the balls must be below the shoulder of the control rod.

In this reset operation the drive mechanism compresses the heavy coil spring allowing the small compression spring to raise the push rod and the magnet keeper, thereby extending the balls. The lower end of the push rod extends thru the core of an electromagnet, the armature of which in the form of a disc is attached to the push rod. When the push rod is raised this armature comes in contact with the face of the electromagnet and is held there by the magnetic field when the coil of the magnet is energized. This force holds the push rod in this "cocked" position as the drive mechanism is raised. Thus the large coil spring is now compressed and exerts a force downward on the push rod. When the magnet is de-energized this spring pulls down on the push rod allowing the balls to retract thus releasing the control rod which drops.

When the control rod enters the shock absorber it displaces water from the shock absorber unit. This water has to pass through restricted passages formed by annular grooves in the bottom of the control rod. Such action provides a hydraulic shock absorber cushioning the impact of the rod on its seat. When seated, the rod depresses a 3/16" diameter push rod which transfers this displacement through a bellows seal at the bottom of the shielding plug flange to a micro switch thereby giving indication that the control rod has seated in the shock absorber.

The cap piece which bolts on the guide tube above the ball release mechanism serves to allow the drive mechanism to exert a downward pull on a stuck control rod. It further insures against any force, such as reversed water flow from moving the control rod upward off the drive mechanism more than a short distance.

This cap must be attached after the guide tube is inserted thru the "Palmetto" seals and must be removed before subsequent withdrawal of this guide tube through these seals. A means must be provided for passing the shoulder of the control rod over this cap and maintaining this engagement until it is desired to remove the control rod or drive assembly. In order to effect this the shoulder in the control rod has four slots at $90^{\circ}$ spacing and the cap on the guide rod has four ears of proper dimension to pass through these slots when the two are in juxtaposition.

After the control rod has been slipped over the locking cap it is necessary to rotate the entire drive mechanism $45^{\circ}$ with respect to the acme thread lead screw, so as to engage the control rod with the locking cap. The mechanism is now ready to operate and may be "cocked" by driving down to the lowest position. If the drive assembly is not rotated $45^{\circ}$ after slipping on the control rod, the ball release mechanism will not "cock" when the drive mechanism reaches the lowest limit of travel.

The release mechanism magnet is connected to the reactor safety system as in the LITR and MTR[6]. Rod motion, other than scram insertion, proceeds from a drive motor operated from the a-c line. Alternating current motors have been specified in order to minimize the possibility of greater than normal speeds. Single phase power will be used throughout to avoid potential troubles encountered by opening one wire of a polyphase line.

Four limit switches are provided on each shim-safety rod as follows:

(1) Upper limit on drive mechanism.
(2) Lower limit on drive mechanism.
(3) Clutch switch showing aspect of release mechanism.
(4) Seat switch showing whether or not the rod is actually seated.

In addition to these limit switches, a double synchro pair is provided for each rod, the coarse synchro to rotate $270^{\circ}$ for the full rod travel of 30";

the fine synchro to rotate $360^\circ$ for each inch of travel. It will be possible to indicate the position of the rod drive mechanism to the nearest 0.01 inch and still avoid any ambiguity as to rod position.

The four rods control a $\delta k/k$ of about 30 % in a 5 x 5 or 3 x 9 lattice[7]. The average rate of addition of reactivity is 0.1% per second and occurs when the rods are simultaneously withdrawn at their maximum speed of five inches per minute.

Nuclear information is transmitted to the operator and to the control and safety systems from several channels as follows, see Fig. 10.

(1) Level Safety. Three PCP chambers supply current to three Level Safety Channels[6].

(2) Period. One compensated chamber supplies current to a Period Channel[6].

(3) Linear. One compensated chamber supplies current to a Leeds and Northrup Micromicroammeter.

(4) Counting Rate. One fission chamber supplies pulses to a Linear Amplifier, Pulse Height Selector, Scaler and Log Count Rate Meter.

The three types of chambers designated above are to be of the same type as those currently in use on other ORNL reactors. Both the PCP and compensated chambers will be installed in a manner similar to those used on the Tower Shielding Facility, and the Geneva Conference Reactor, that is, "sealed" chambers which do not require a flow of gas. The fission chamber will be of the Westinghouse sealed type as used on the Geneva Conference Reactor and TSF.

Control of the cooling system is accomplished through the use of conventional instrumentation as regards parameters such as flows, temperatures and pressures. Radiation detectors are provided to give warning of contaminated water (see Fig. 11).

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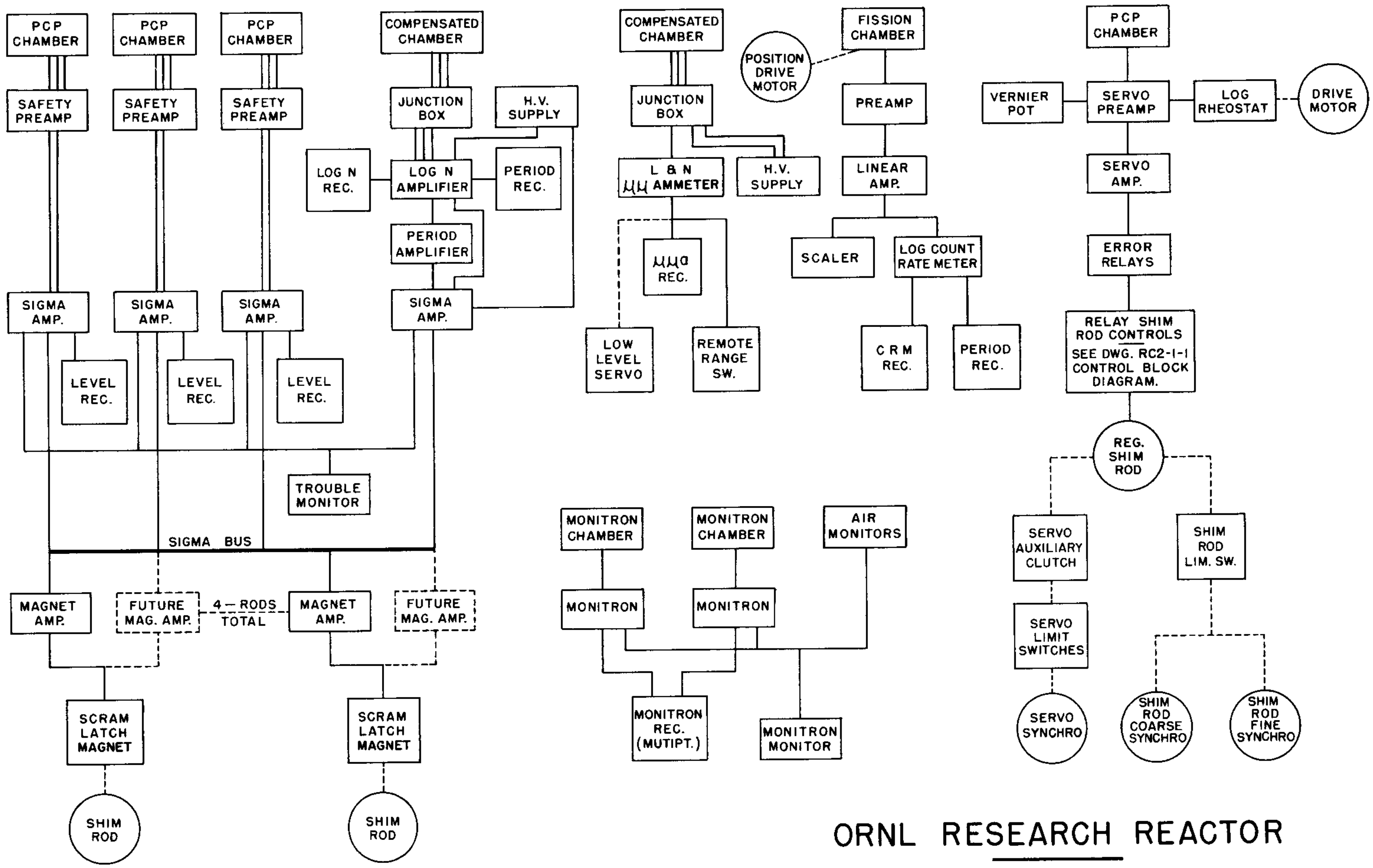


ORNL RESEARCH REACTOR
NUCLEAR INSTRUMENTATION
BLOCK DIAGRAM

Figure 10

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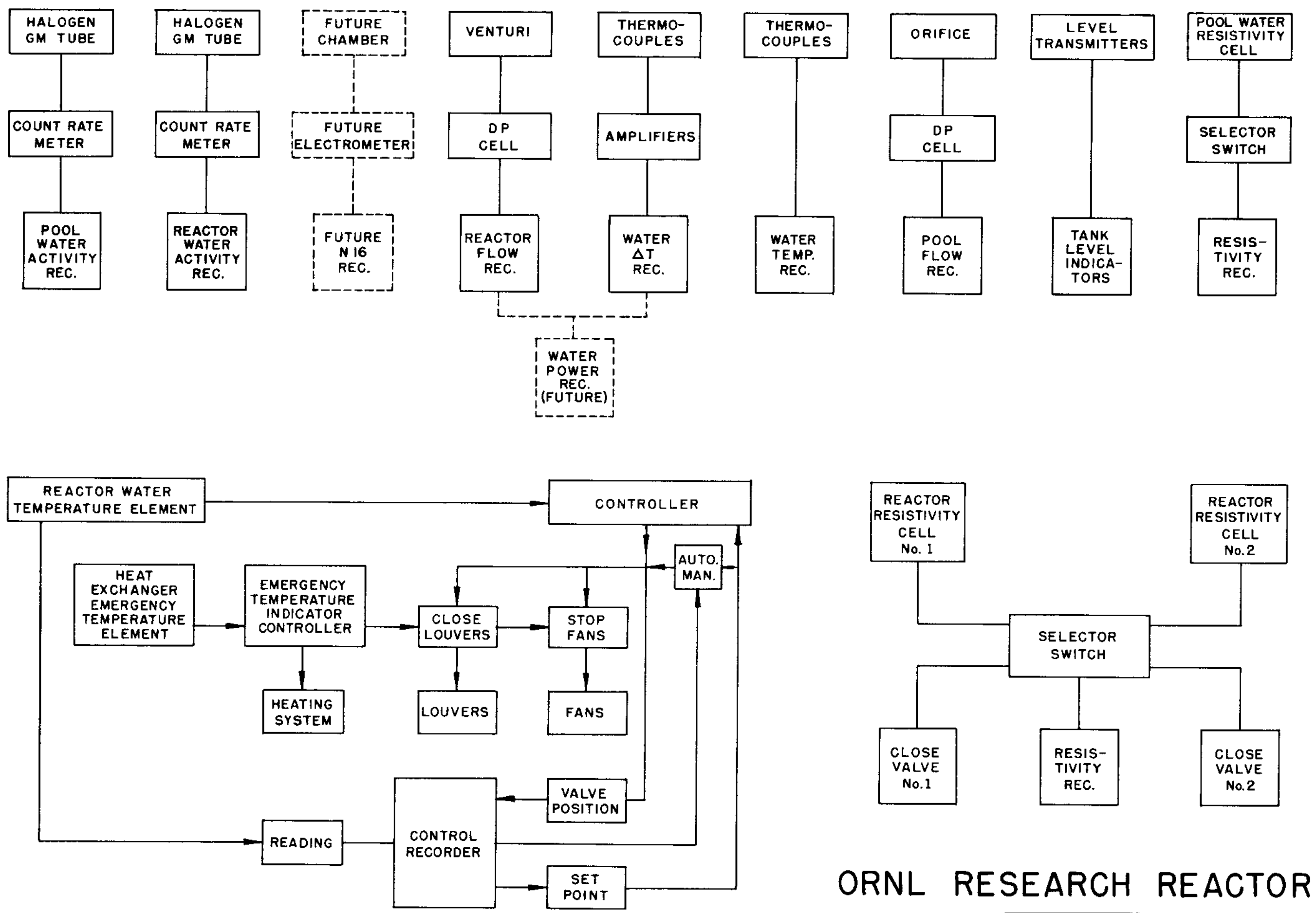


ORNL RESEARCH REACTOR
PROCESS INSTRUMENTATION
BLOCK DIAGRAM

Figure 11

It is planned to provide a servo system to maintain the neutron flux at constant level, and to change level in an orderly manner. The control element will be one of the shim rods. The servo-controlled rod may be any one of the shim rods; however mechanical connections must be made up and therefore the selection cannot be changed during a run. The rate of rod motion initially will be identical with that available to the shim control, although it may be desirable to change the maximum rate for the servo-controlled rod by a factor of as much as two in one direction or the other. A maximum rate of about 0.05% $\delta k/k$ per second is the highest now contemplated. Since the servo-controlled rod moves at shim-rod speed, the reactivity turned over to the servo is limited only by electrical interlocks. Additional limit switches are provided however, to make shimming more orderly, and to help the operator keep the servo-controlled rod in a region of useful sensitivity. If in the future it become desirable to turn over to the servo additional amounts of reactivity, to compensate for depletion, xenon, etc., this additional reactivity will be carefully limited and made available in predetermined amounts by way of fixed limitations built into the control system.

D. Experimental Facilities

Figure 5 is a section through the reactor structure showing the arrangement of the major experimental facilities. Six nominally 6" diameter holes penetrate the biological shield to one face of the lattice and will be used mainly for the semi-permanent type beam experiments, in which the length of the beam hole is not a major consideration and where the bulk of the equipment can be mounted on the floor area, the cubicle, or the face of the shield. Examples of such experiments are: neutron or gamma ray spectrometers, neutron velocity selectors, neutron diffraction, nuclear alignment studies, etc.

Shielding in this region consists of a minimum of six feet of water and nine feet of barytes concrete. The region around the 6 horizontal beam holes will be hydraulically separated from the reactor tank in order to make provision for a future $D_2O$ blanket for the purpose of increasing the neutron flux in this region. Such a blanket will require an auxiliary cooling system not described in this report. This system will be conventional in all details and will present no unusual problems except for safeguarding the $D_2O$. Whether or not the $D_2O$ blanket is used is contingent upon the requirements of the experimenters. In any case the reactor will first be put into operation with light water in this region.

The two large penetrations to the reactor lattice are designated as "Engineering Test Facilities" and are designed for a number of anticipated installations. Two large water tight bulkheads approximately five and one half feet in diameter pierce the shield to a point just outside the reactor tank opposite the lattice, where a transition section of obround shape approximately 19" x 25" penetrates the tank. Initially these holes will house water-tight dummy plugs which will duplicate the main shielding in this vicinity. These facilities are being designed specifically to meet the needs of the type experiment now required for the fluid fuel reactor loop programs, where it is desirable to have the plug diameter as large as possible and the length of the plug as short as possible.

The cell immediately outside of the engineering test facilities will be erected as required for the shielding of the auxiliary equipment required for the experiment and will have provisions for service connections from the basement area and for instrumentation and control connections at the balcony level. Space is provided for the construction of disassembly cells to be located either on the main floor or the basement floor. Sufficient permanent shielding is to be provided so that the equipment cells can be entered during shutdown periods, provided the type of experiment is such as to allow entry.

Removal of the large plug from either side of the reactor will allow for the insertion of what may be termed "major engineering experiments", in which all the primary components for the test such as the fuel loop, pumps, heat exchangers, etc., are to be exposed to the high flux region of the reactor. In this proposal, the reactor would be completely unloaded, the original plug placed in a storage cell and the experiment inserted as a package. It is believed that with the proper selection of construction and shielding materials, primarily aluminum and chemically pure lead, in both the reactor and facility design, and with fuel and reflector removed to a storage pool, insertion of these experiments can be accomplished with a minimum of remote handling equipment.

By locating the control rod drive mechanism below the reactor, it is possible to consider insertions into any of the sixty-three possible fuel or reflector spaces, depending upon the lattice arrangement. Small experiments which require outside connections can be inserted in tubes and guided into the reactor through sleeves located in the top plug. Storage of these tubes on the side walls of the pool during refueling operations can be accomplished without breaking the external instrument or service connections. Larger experiments such as small fuel loops can be inserted in such a manner that they can remain in the reactor during the refueling operation. The connections here are to be made through flanges on the top cover plate.

The fourth face of the reactor lattice provides a major facility for the installation of experiments from the pool side, for shielding studies a thermal column, engineering type tests, etc.

The top region of the reactor tank is designed with sufficient access openings to accommodate several rabbit hole type facilities. No specific design of such facilities are being made at present.

E. Water System

1. Main Reactor Cooling Loop:

For 20 Mw operation approximately 12,000 gpm will be pumped from the exit header of the reactor tank through two 18" O.D. lines; these lines join into one 24" O.D. line which expands to a 36" O.D. line outside of the building. The 36" O.D. line leads to a decay tank of approximately 10,000 gallon capacity immediately preceding the main circulating pumps. A 24" O.D. line from the decay tank will serve as a pump header. Three main circulating pumps will be installed. Each will be a 6,000 gpm pump operating at approximately 70 feet head and requiring a 250 h.p. motor. A 24" O.D. line will connect the air-cooled heat exchanger to the pumps. In the 24" O.D. line leading from the air-cooled heat exchanger there will be a flow measuring device and a strainer. The 24" O.D. reactor return line will divide into two 18" O.D. lines which return to the upper reactor tank (see Fig. 12).

A 12" IPS line will connect the two 24" O.D. lines leading to and from the air-cooled heat exchanger. This by-pass line will contain a globe valve which will control the flow. As much as 6,000 gpm may be by-passed at this point in order to reduce the total pressure drop in the main reactor cooling loop. Thus, quantities of water in excess of the designed flow rate of 12,000 gpm may be pumped through the reactor tank with the proposed pump head.

During operation at low ambient air temperature, it may be desirable to take one or two of the cells of the air-cooled heat exchanger off-stream

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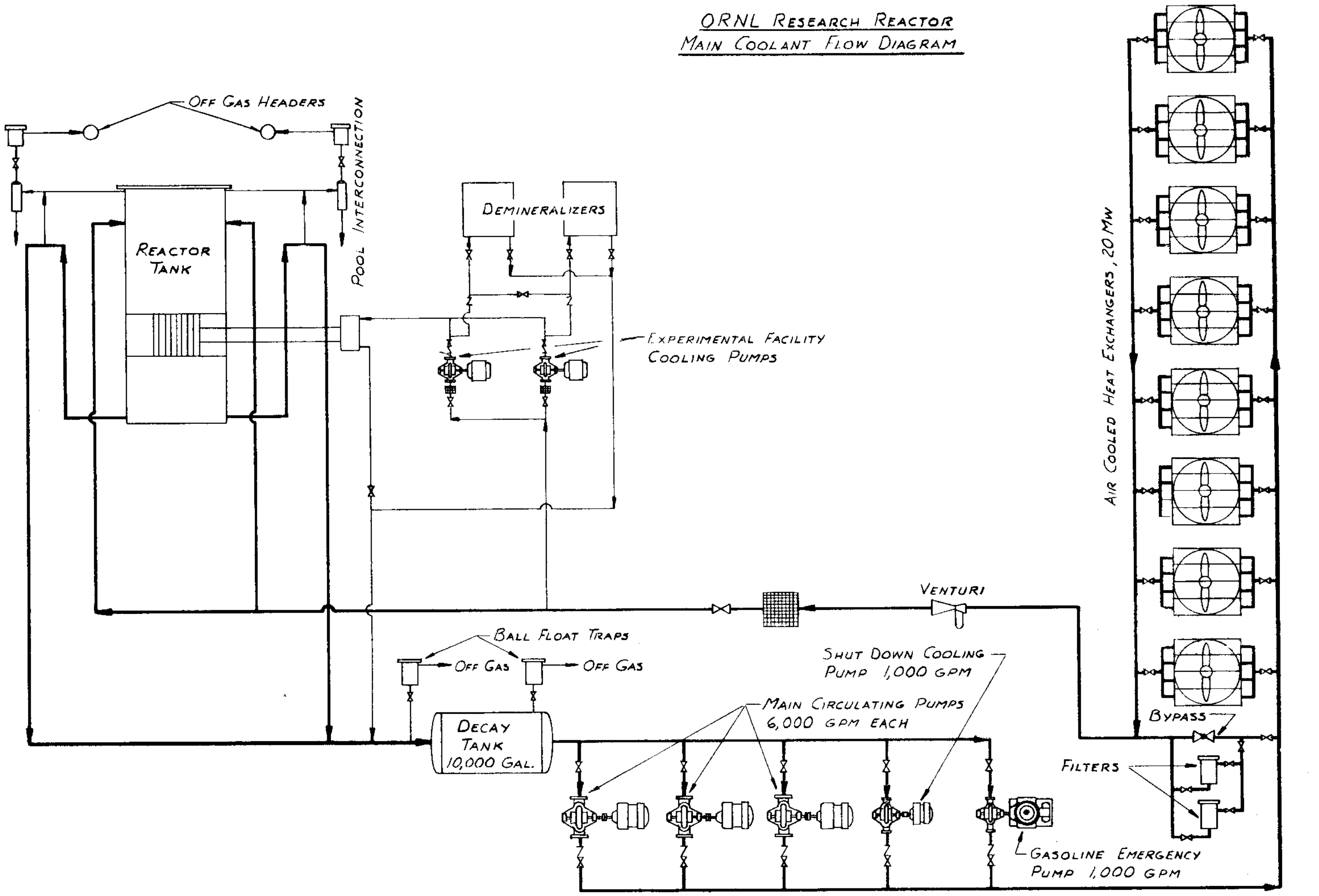


Figure 12

for maintenance purposes. In this event the water ordinarily flowing in these units will be by-passed; thereby maintaining the design pressure drop across the air-cooled heat exchanger.

Two 100 gpm filters will be placed in parallel across the by-pass control valve. Piping for these filter units will be 3" IPS. The filters will be used to remove suspended solids from the main reactor cooling loop water.

Two 3" IPS lines will connect the main reactor cooling loop to the reactor pool. This interconnection will allow for the expansion and contraction of water in the main reactor cooling loop during start-up and shut-down. In heating the reactor cooling loop system from 60 to 120°F, approximately 600 gallons will flow through these lines. Flow through these lines from the pool will also replenish any leakage from the main reactor cooling loop system.

In the event that the level of radioactivity in the reactor cooling loop makes the introduction of this water to the pool undesirable, several alternatives are possible. Small mixed bed demineralizer units containing about 2 cubic feet of resin could be submerged in the pool and connected to the flanged ends of the two 3" IPS overflow lines. Flow either in or out of the reactor cooling system would pass through the beds thereby removing radioactive ions. The beds would be removed for regeneration.

A second alternative would be to drain water from the reactor cooling loop during the period that the water was increasing in temperature. This could be done easily by placing a remote control valve in the line draining water to the retention ponds or in the line draining water to the storage tanks.

The reactor tank and the two invert loops in the exit lines will be vented continuously to the off-gas system through two ball-float traps.

The 10,000-gallon decay tank and the 36" section of reactor cooling loop piping will also be vented through ball-float traps. Gas from these sources will go into the plant off-gas system. All other high points of the reactor cooling loop will be vented to the surrounding air through locally operated valves.

A 1,000-gpm pump is provided to circulate water in the reactor tank and main cooling loop for cooling purposes after the reactor has been shut-down.

2. **Emergency Reactor Cooling:**

Provision has been made to insure cooling in case of emergency shutdown conditions. The electric 1,000 gpm shutdown pump is fed from a separate feeder than the main pumps and some small measure of protection is afforded thereby. In addition an emergency generating plant is now being designed to supply electric power for the reactor and experiments in the case of failure of outside power; relative merits of steam turbine and diesel drives are now being evaluated. The electric 1,000 gpm pump will be arranged for automatic transfer to this system in case of failure of the secondary feeders. As further insurance a 1,000 gpm gasoline driven pump will be automatically started on failure of electric power. As a backup for the previously outlined systems the water in the reactor pool can be used under gravity head to provide a flow sufficient for shutdown cooling. To accomplish this a valve in the drain line from the reactor cooling loop to the retention pond may be opened in the event of an emergency, and water will drain from the reactor cooling loop thereby drawing the water from the reactor pool through the lattice. A flow of from 600 to 900 gpm may be provided through the lattice in this manner. The capacity of the pool is such that cooling may be continued until such a time that danger of damage to the reactor due to shut-down heating has passed. This last feature will be incorporated if determined necessary during the testing period.

The second emergency involves a major catastrophe resulting in the loss of water from all or part of the reactor cooling loop system. Loops in the reactor exit lines are provided to prevent the drainage of water by gravity from the reactor tank. Suction breaks are provided from the top of these loops to the top of the reactor tank to prevent the syphoning of the water from the reactor tank. In the event that these measures fail to keep a head of water over the reactor lattice, a 2" line is provided to spray plant process water over the reactor lattice. This line is operated by a valve placed near the north wall of the reactor building just below the first floor elevation. An extension handle on this valve permits operation of the valve from the first floor or from the exterior of the building at this approximate location.

3. Heating System and Air-Cooled Heat Exchangers:

In order to prevent internal freezing in the heat exchanger units during shut-down in cold weather, each unit will be provided with a set of remotely operated louvers and a steam supply. The louvers in the closed position will prevent the escape of air through the top of the units, and steam-heated finned-pipe sections will provide heat below the tubes. During long shut-down periods the units will be vented and drained.

4. The Experimental Facility Cooling Loop:

Approximately 400 gallons per minute will be pumped from the reactor cooling loop line. Approximately 80 gallons per minute will be diverted to go to either of the two reactor system demineralizer units; the remainder of the flow will go to the headers leading to the experimental facility cubicles. This water will flow through the experimental facilities providing cooling and will then be collected in the experimental facility exit headers to return to the reactor exit line.

5. The Reactor System Demineralizer Unit:

The head provided by the two experimental facility cooling pumps will provide a flow of approximately 80 gallons per minute to either of the two reactor system demineralizers.

The reactor system demineralizer is composed of two identical units either of which will provide the necessary flow for standard operation. Use of alternate units allows the inoperative unit to be regenerated without interruption of demineralizer service. When it is desirable both units may be used concurrently to provide a maximum flow of approximately 160 gpm.

6. Pool and Circulating Loop:

It has been estimated that approximately 1½ Mw of heat will be transferred to the reactor pool by gamma radiation from the reactor and convection from the reactor tank.[8] This heat will be removed by pumping approximately 900 gpm of the reactor pool water through the tube section of a U-tube, shell and tube heat exchanger. This water will be cooled by a flow of 900 gpm of plant process water circulated through the shell of the heat exchanger and through an induced-draft cooling tower. The design temperatures have been selected as approximately 101°F for the reactor pool water and 90°F as the return temperature, (see Fig. 13).

One of the major problems envisioned at present and yet not subject to refined calculations is the radiation due to nitrogen-16 formed in the pool.[8] A major source of this isotope will be at the surface of the indented side of the reactor tank. Provisions have been made to place a "chimney"

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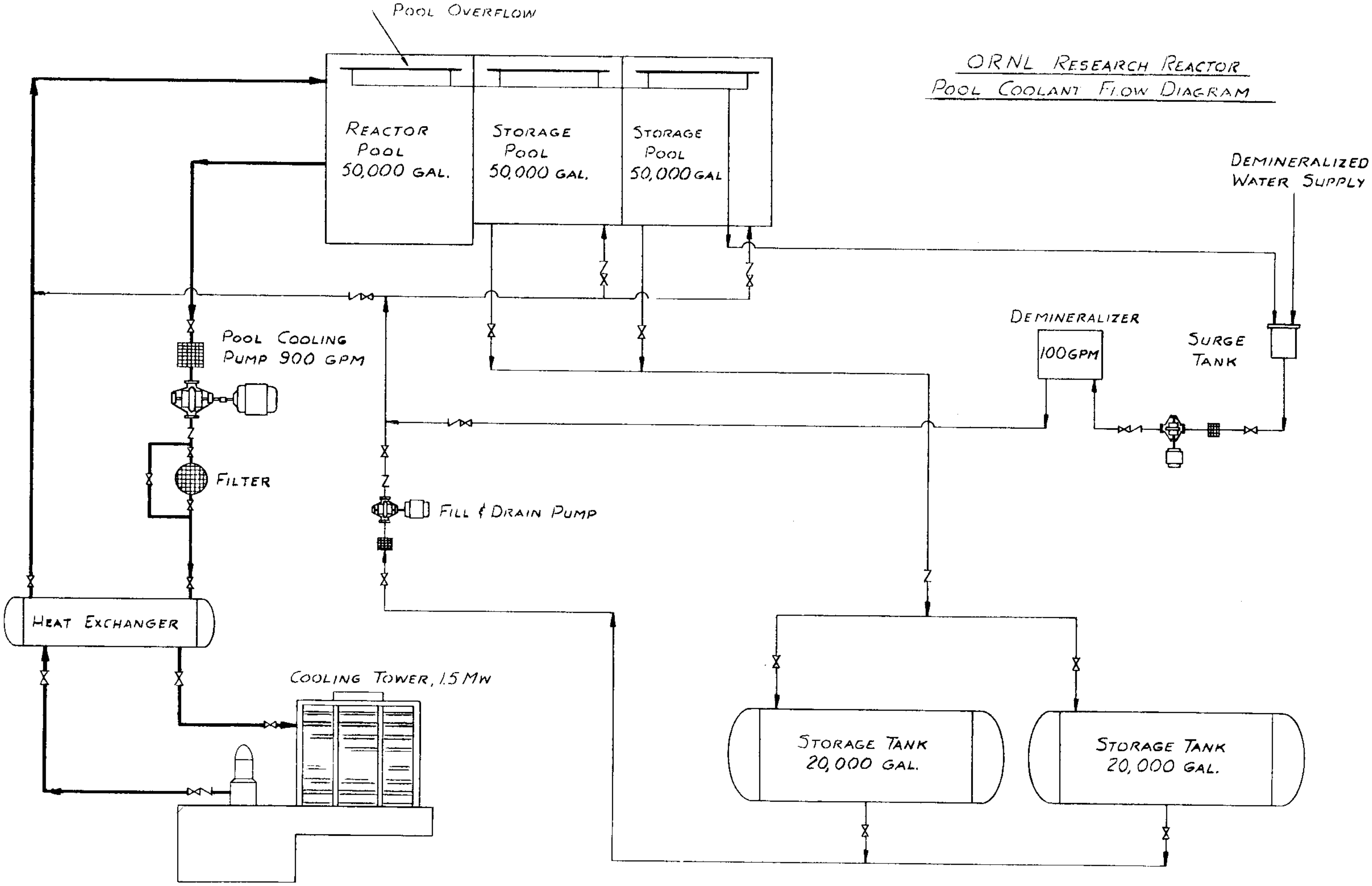



Figure 13

at this point through which this highly radioactive water may be removed. The "spare" lines may be used to take this water to a decay tank and then to the pool demineralizer, or to any alternate disposal system.

F. Building and Services

The facility will be housed in a structural steel framed, insulated metal panel sided, mill-type building 108 feet long, consisting of a central crane bay area 60' wide with a service wing on each side 20' wide. The height of the mill-type structure, measured from the first floor, (see Fig. 14) is about 36' for the service wings and about 71' for the crane bay. The area grade contour is such that a truck entrance to the building at street level has been provided at the second floor level on the west side of the building, and a second street-level truck entrance on the east side of the building at the first floor level. All construction below grade level will be reinforced concrete. The basement floor is 20' below the first floor level. Approximately 30' of shale and earth below the existing grade will be excavated to place the structure on a rock foundation.

The reactor pool structure will be of barytes concrete with walls of various thickness. Thick walls of reinforced concrete enclosing the basement sub-pile room and pipe chase support the reactor pool, and concrete columns support the storage pools.

The building will be divided into four working levels as follows:
(1) A full basement of 11,400 square feet (see Fig. 15) which will include a fan and filter room, the sub-pile room, shielded demineralizer rooms, reactor sub-structure, electrical load center, and future cell areas.
(2) A first floor of 9,500 square feet (see Fig. 16) which will contain the reactor beam hole areas, general experimental area, and truck access.

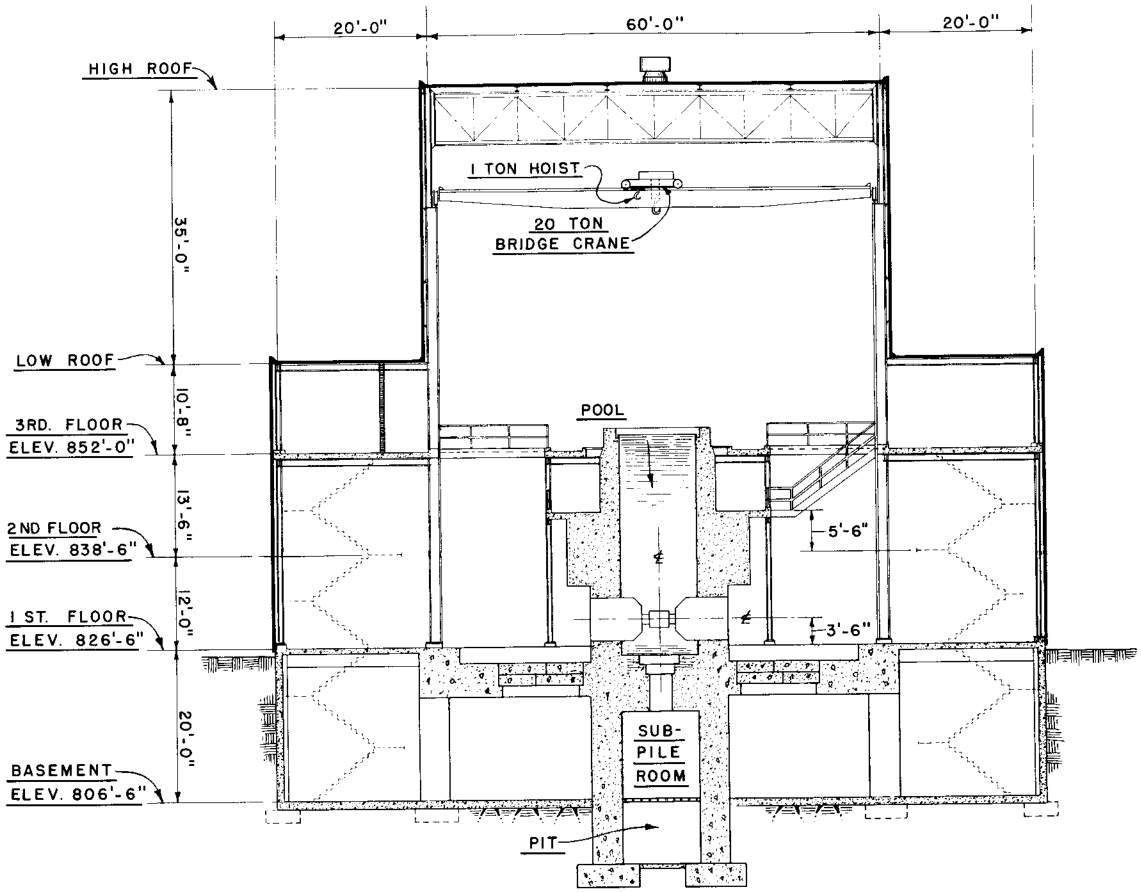
(3) A second floor of 3,000 square feet (see Fig. 17) which will contain truck access to the building, office, rest rooms, and balcony access around the reactor pool at an intermediate level 5' -6" above the second floor. (4) A third floor of 6,800 square feet (see Fig. 18) which will contain four offices, six laboratories, control room, equipment and instrument repair shop, access around the pool, and a future hot cell to be located over the west end of the pool.

The total floor area is 30,700 square feet and the gross building volume is 831,000 cubic feet.

A twenty-ton bridge crane with auxiliary one-ton hook will be provided as illustrated in Fig. 14.

Heating and ventilating will be provided by forced draft units having steam heating coils, and power roof exhausters[9]. Auxiliary summer ventilation will be provided by forced draft from the fan and filter room, located in the basement. As a fire prevention measure, the basement is sealed off from the floors above by hatch covers and fire walls around the stair wells. Air in the basement will be exhausted from the building through a vertical tunnel. Air conditioning will initially be limited to the third floor control room, offices, and equipment and instrument repair rooms.

Services provided to the reactor include plant process water, demineralized water, compressed air, "hot" off-gas exhaust which connects with the existing "3039" 250' stack[10], "hot" drains which connect with the existing ORNL waste disposal plant[11], and process drains. These services are provided to convenient locations on the third floor walkway around the pool,




SECTION "A - A"

O. R. N. L. RESEARCH REACTOR – BUILDING 3042

OAK RIDGE NATIONAL LABORATORY

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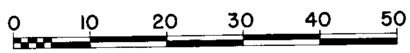
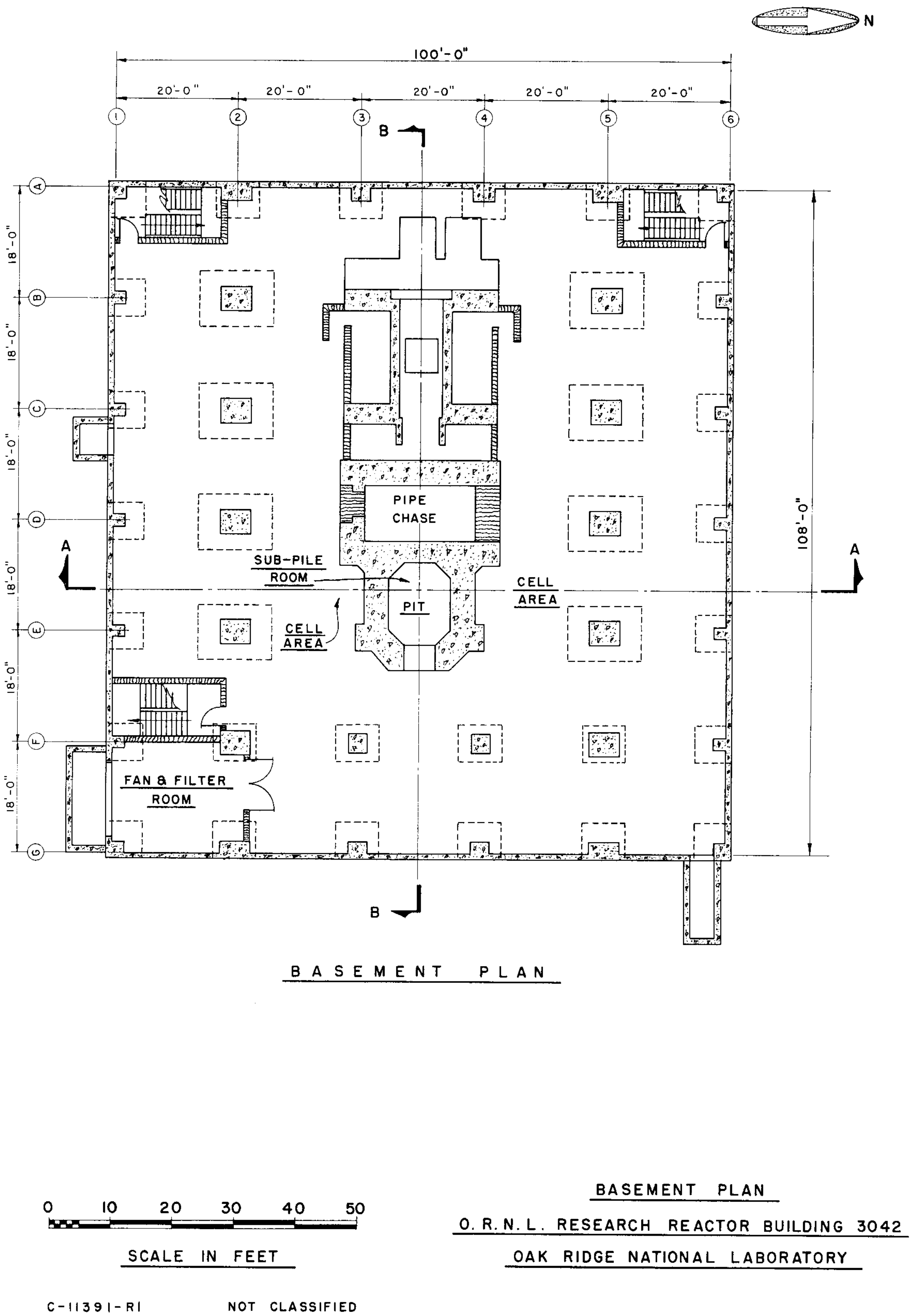



SCALE IN FEET

Figure 14


N
100'-0"
20'-0"
20'-0"
20'-0"
20'-0"
20'-0"
1
2
3
4
5
6
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D
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F
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18'-0"
18'-0"
18'-0"
18'-0"
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18'-0"
108'-0"
B
B
A
A
PIPE
CHASE
SUB-PILE
ROOM
PIT
CELL
AREA
CELL
AREA
FAN & FILTER
ROOM
BASEMENT PLAN
0 10 20 30 40 50
SCALE IN FEET
BASEMENT PLAN
O. R. N. L. RESEARCH REACTOR BUILDING 3042
OAK RIDGE NATIONAL LABORATORY
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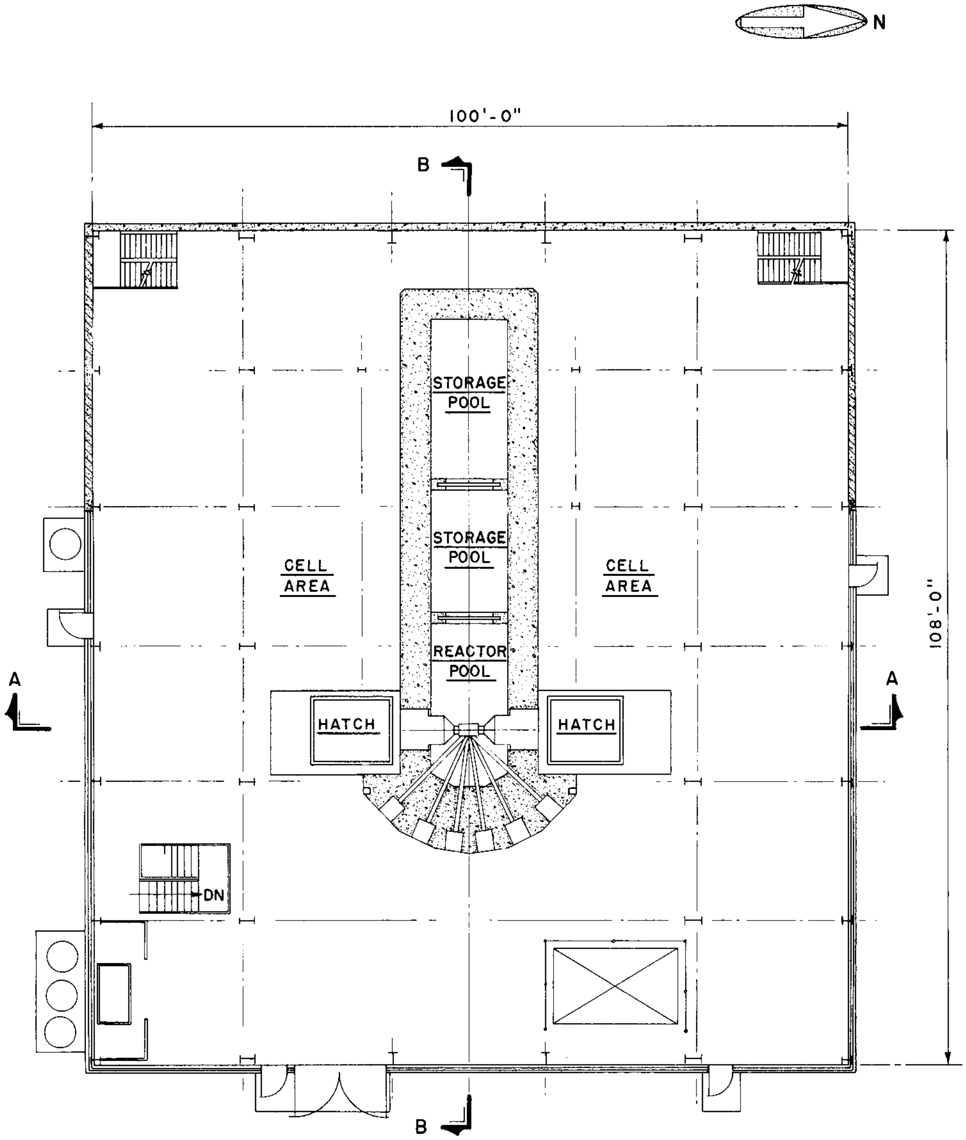
Figure 15




FIRST FLOOR PLAN

0 10 20 30 40 50

SCALE IN FEET

FIRST FLOOR PLAN

O. R. N. L. RESEARCH REACTOR BUILDING 3042

OAK RIDGE NATIONAL LABORATORY

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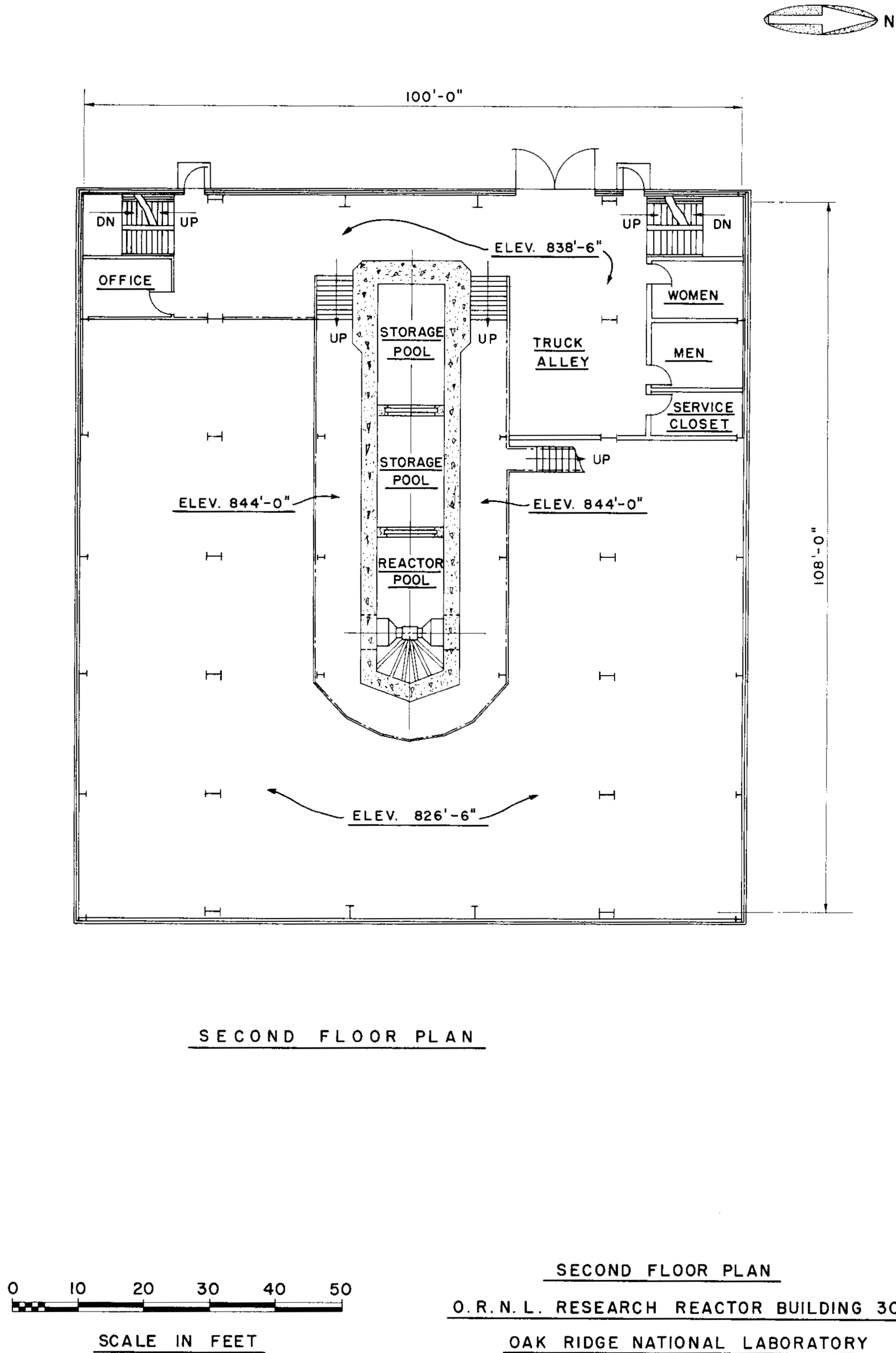
Figure 16




SECOND FLOOR PLAN

O. R. N. L. RESEARCH REACTOR BUILDING 3042

OAK RIDGE NATIONAL LABORATORY

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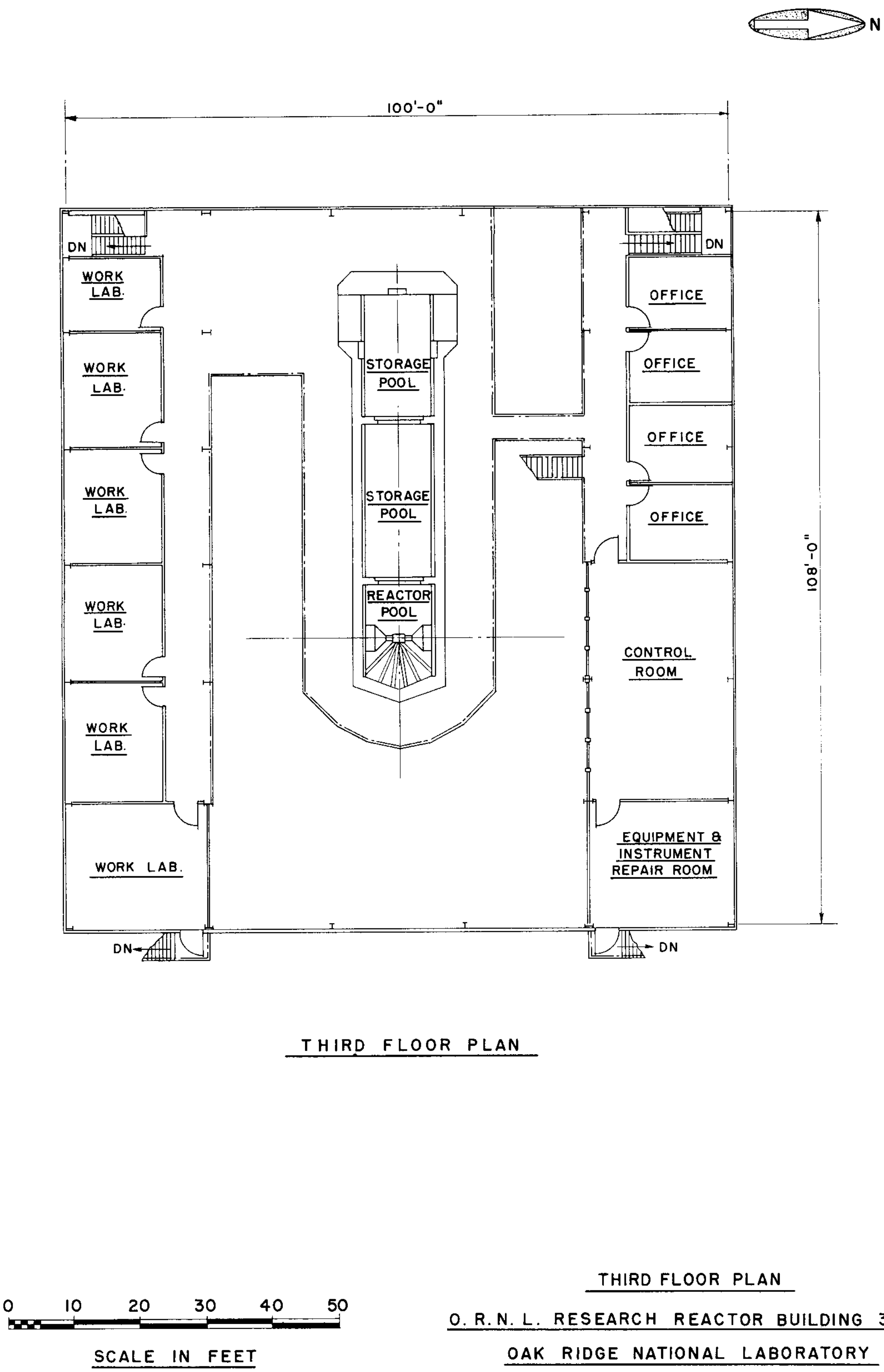
Figure 17




THIRD FLOOR PLAN

O. R. N. L. RESEARCH REACTOR BUILDING 3042

OAK RIDGE NATIONAL LABORATORY

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Figure 18

on the second floor at the back of the pool convenient to the "rabbit" stations, and to all the experimental stations around the face of the reactor structure at the first floor level. Supply and return lines from the main reactor cooling circuit are provided to the first floor experimental stations for cooling purposes. These lines are imbedded in the pool wall in order to provide adequate shielding from $N^{16}$ activity. Both 440 volt and 120/208 volt convenience outlets are provided around the reactor structure. In addition, ten 50 amp. distribution boxes on the 115/230 volt special service line are provided to the experimental areas for instruments. All services in the experimental areas are arranged to provide a high degree of flexibility. Numerous sleeves, pipe chases, and empty conduits are provided.

Initially, services to the six third floor laboratories will include plant water, compressed air, special and normal electrical services and process drains.

## IV. OPERATING PROCEDURE

It is anticipated that the ORR will be operated on a basic 24 hour day probably with a scheduled shut-down one day per week. It will be necessary to modify this schedule in accordance with the requirements of the experimental program.

Operation of the reactor will be the responsibility of the Reactor Operations Department of the Oak Ridge National Laboratory Operations Division. This department is currently responsible for operation of both the LITR and the X-10 Graphite Reactor. Operating personnel will be chosen from this organization, which has gained several years experience in operating a reactor of similar design, the LITR, and will report through their supervisor to the department superintendent.

At least two persons will be present at all times during operation; an operator to perform the required manual tasks, including manipulation of the control mechanisms, observation of instruments, recording of operational data, etc.; an experienced reactor foreman will be available to oversee the reactor operations and give instruction in the event of some atypical behavior of the machine. Since the Reactor Operations Department maintains a crew of four or five on all shifts, assistance is available for the performance of operations requiring additional personnel.

Initial operation of the ORR will be accomplised by the Reactor Operations Department with the assistance of experienced members of the Laboratory staff and in accordance with official procedures. Major changes in operating procedure, modifications or fuel loading, etc., will be reviewed by the Reactor Operations Review Committee which consists of five senior members of the Laboratory staff.

It is not contemplated to change an entire loading at any one time. A tentative fueling plan, similar to that used in the LITR, calls for the shifting of the elements, at intervals of about two weeks, in such a way as to achieve uniform burnout. At the time this shifting is done those elements, having a calculated burnout such that the minimum excess reactivity required will be unavailable before the next scheduled shutdown, will be replaced.

Elements having a burnout equal to the maximum determined to be permissible will be placed in racks in one of the storage pools for a time sufficient to permit cooling to a level which will allow their safe transfer in shielded shipping containers to the processing plant at the National Reactor Testing Station at Arco, Idaho.

## V. EXPERIMENTAL PROGRAM

### A. Types of Experiments

The ORR is to be constructed to serve as a permanent general purpose irradiation facility for use in the experimental and production programs at the Oak Ridge National Laboratory. The experiments anticipated, therefore, may be expected to be quite varied, including the conventional "in-pile" irradiation of small samples as well as complicated circulating fuel loops which release large amounts of energy during irradiation.

The following types of experiments are expected to form a large part of the operational load of the ORR:

1. Dynamic loop tests to determine the effect on fluid fuels, and on the engineering equipment associated with them.
2. The irradiation of fluid fuels in quantities large enough to permit chemical studies of continuous fuel processing systems.
3. "Conventional" neutron experiments in which the reactor is utilized as a source of neutrons.
4. Radio-isotope production.
5. Solid-State physics and metallurgy investigations of the effects of radiation on engineering materials and basic studies of the properties of metals, alloys and ceramics.

B. Limitations to be Placed on Experiments

Generalization of the limitations to be placed on experiments would serve little purpose here. It is obvious, however, that in addition to the specific problems directly concerned with the safety of the experimental apparatus, any effect that the experiments may have on the reactor must be governed by the same basic safety considerations as govern operation of the reactor itself. The reactor control and safety system will be provided with means whereby information concerning the experiments can be introduced. All experiments will be carefully reviewed in order to avoid violation of basic safety criteria. Experiments to be installed in the engineering test facilities will be designed so that any mishap in the experiment cannot introduce a reactivity change of more than 1.4% as set forth by the Advisory Committee on Reactor Safeguards. In addition the experiments must be treated individually and collectively with respect to their effect on the overall operation of the facility.

In order to insure the safety of the reactor and personnel, all proposed experiments will be reviewed by the Oak Ridge National Laboratory Experiment Review Committee, a permanent committee which consists of five senior members of the Laboratory Staff.

## VI. DESCRIPTION OF THE SAFETY MECHANISMS

### A. Nuclear Safety

The primary nuclear safety device is the Level Safety System[6]. Three ionization chambers supply current to amplifiers whose outputs form an auctioneer circuit: The largest signal governs the response of the system. When the neutron flux at any chamber exceeds a preset level (usually 1.5 times full power; much lower during critical experiments), the Sigma Bus voltage (output of the auctioneer) will vary so as to cause a decrease in the curent in the rod release magnets which in turn will release the rods.

Following Newson[12], one calculates the shortest period occurring during a startup accident wherein the rods are simultaneously withdrawn. The Period is found to be approximately 60 milliseconds. The rod release solenoids and mechanisms introduce a delay of less than 21 milliseconds[13], between the time the level reaches 1.5 times full power, and the time the rods actually begin to move. If one assumes a downward rod acceleration of 1 g, the power excursion to be expected from this situation will have a maximum value of 3.5 times full power.

The start-up accident described above uses a built-in potentially dangerous mechanism--shim rod withdrawal--and the installed safety system prevents ill effects. Other nuclear accidents may be postulated which add various amounts of reactivity at various rates, due to, for example, sudden changes in installed experiments. The insertion of experiments or proposed changes in the reactor must be controlled by administrative action consisting in review of all proposed changes in operating procedure by the Operations Review Committee, and review of all proposed experiments by the Experiment Review Committee and strong Operating Department Control on proposed experiments. The possible interaction between experiments and the reactor is investigated by these committees, and particular attention is given to making sure that no credible accident can introduce reactivity in amounts or at rates exceeding those which can be adequately handled by the safety system.

During startups, or at low power, a period shorter than one second will result in a scram. This is done so that malfunction of equipment or maloperation at low levels need not raise the power above rated full power before a scram results.

Less drastic means are provided for correcting a potentially dangerous situation before it requires a scram. In order of decreasing severity they are:

1. Reverse - Motor-driven insertion of all rods.
2. Setback - Automatic decrease for requested flux level on servo system.
3. Alarm - This requests the operator to initiate manual corrective action.

These corrections may be applied in echelon, such that an increasing dangerous condition calls for an increasingly drastic cure, culminating in a scram if necessary. The level safeties are independent of other corrective actions.

B. Non-Nculear Safety Considerations

The reactor and the people associated with its operation must be protected against harm which could result from malfunction or misuse of non-nuclear equipment.

Health physics instrumentation is provided to warn personnel of contamination or high radiation. These will include the following.

1. One hand-and-foot counter, - personnel contamination

2. Two constant-air-monitors, - particulate air-borne contamination (Five may be installed eventually)

3. Six monitrons, - neutron and gamma ray intensity. (Thirteen may be installed eventually)

4. Beta-gamma survey instruments of various types, - for operation and maintenance work in potentially dangerous areas

Many experiments interact with the reactor in such a way that difficulty with the experiment could ruin the experimental device, cause an increase in reactivity, or even endager the reactor structure. Detection of such conditions must be made to call for appropriate remedial action by the experimental device and by the reactor control system. Provision is made for interconnecting the experiment instrumentation with the reactor controls, so that more or less drastic corrective action may be taken as required. Depending on the nature of the experiment this may consist of simply an alarm to the reactor operator, or circumstances may require a full array of scrams, setbacks and alarms.

The integrity of the reactor may be jeopardized by the failure of the cooling system. It is therefore provided with appropriate safety devices, as follows:

a. If the level of the water in the reactor pool or in either of the storage pools is lowered by an unsafe amount, an alarm will sound to warn personnel of the condition.

b. If for some reason all water is lost from the reactor cooling loop and also from the pool, plant process water may be sprayed onto the lattice in order to dissipate afterheat. Valves for this purpose will be provided on the first floor and also outside the building.

c. The activity of the reactor cooling water and of the reactor pool water will be monitored continuously; excessive activity will sound an alarm in the control room.

d. The cooling system instrumentation will be interconnected with the reactor controls in such a way that, at power levels where cooling is needed, cooling failure will initiate a reactor shutdown. In particular, low flow or high reactor outlet temperature will initiate a shutdown.

Other interlocks will supervise the operation of the cooling system to minimize the effects of its malfunction or misoperation on reactor operation.

## VII. REACTOR HAZARDS

### A. Natural Hazards: Fire, Windstorm, Flood, Earthquake

Fire cannot directly damage the reactor since it will be completely surrounded by a large volume of water. The possibility of fire damage to the pool structure is remote since it is not constructed of combustible materials. Care will be taken to see that all combustible material utilized in experiments is properly safeguarded against dangerous increases in temperature.

Even though most of the equipment in the building will be noncombustible, certain combustible items will be present. Immediate fire protection will be available in the form of 1½" standpipes and hose racks together with $CO_2$ extinguishers located at strategic points throughout the building. In addition to this the Laboratory Fire Department is available at all times and may be summoned by call boxes located in the building.

A severe windstorm could possibly result in damage to the ORR building; however, there would be no radiation hazard from the reactor. Damage to the cooling system by windstorm is unlikely, but could possibly result in local contamination of the area in the vicinity of the coolers with small quantities of $Na^{24}$.

The location of the ORR at elevation 835' effectively precludes danger to the reactor itself by flood conditions. Damage to the cooling system under such circumstances is conceivable but not likely.

The eastern portion of Tennessee, including the Oak Ridge area, does not have a history of any major earthquakes or of frequent minor ones. Shocks of moderate intensity (5-6 on the Rossi-Forel scale) which did not cause any significant damage, were recorded in Knoxville (1877, 1913), Chattanooga (1902), Sweetwater (1914) and Lenoir City (1918). The comparative freedom from seismic shock of the Valley of East Tennessee, in which Oak Ridge is located, is due to the general stability of the earth's crust in this area(14). In the unlikely event that an earthquake severe enough to rupture the pool walls occurred, it is not believed that other than local damage would be encountered.

B. Hazards During Normal Operation

The potential hazards which exist during the normal operation of the reactor, but against which no automatic devices other than alarms are provided for the protection of the reactor and its operating personnel are:

1. Cracking of the shield due to thermal stress.
2. High radiation intensities due to inadequate shielding.
3. High radiation intensities due to contamination of the pool water.
4. High radiation intensities due to contamination of the reactor cooling loop.
5. Leakage from one or both water systems.

The steps taken to minimize these hazards follow:

A radial temperature gradient will be created in the shield, particularly at a plane passing horizontally through the core center, due to the deposition of energy by the attenuation of gamma rays. It has been estimated[15] that the maximum temperature reached in the main shield will, at thirty megawatts operation, be insufficient to cause excessive stresses in the concrete. Since the temperature in the interior of the shield is a very sensitive function both of the conductivity of the shield and of the heat transfer coefficient at the inner wall, thermocouples will be installed in the shield in order to determine the actual temperature distribution and to insure against excessive heating. Should measurements indicate that excessive temperatures will develop, additional thermal shielding will be installed.

Estimates indicate that with the exception of the demineralizer cells no regions of high radiation intensity (several R/hr.) are available to personnel. Access to the demineralizer cells will be prevented by means of locked doors or security gates. It will not be necessary to approach this equipment during operation. Lower level activity (~ 30-200 mr/hr) may be encountered in the pump house, near the main heat exchanger, the sub-pile room and the facility cooling pumps. These areas will be restricted access regions and local shielding will be provided as necessary.

Radiation intensity above the pool may be caused by the upward convection of $N^{16}$ produced near the surfaces of the reactor core tank. Should undesirable intensities actually occur, provision has been made to install baffling in order to prevent the direct upward flow of the $N^{16}$ bearing water from the vicinity of the core and thus eliminate the hazard.

c. Contamination in the pool water is expected to be largely due to its use as a storage facility for contaminated or activated material. The amount of induced activity will be small since the thermal flux available outside of the core tanks will be quite low. The control of activity in the pool is therefore largely an operational problem. It is anticipated that the system will be operated in such a manner as to restrict the maximum radiation intensity at the edge of the pool to less than the tolerance level. Because of the short half life of $N^{16}$ it is believed that essentially none of this material will leave the reactor pool except through the shielded reactor exit water lines.

In addition to these sources of radiation there is a minor interchange of water between the cooling system of the reactor and the pool system. This, too, is expected to be negligible compared to contamination from stored materials.

Adequate instrumentation will be provided to give warning of increases in activity of the pool water.

C. Reactor Hazard Protection

The building design is such that the accidental release within the building of gaseous fission products will not present an undue hazard due to ingested material to personnel in other areas near to the Reactor Building[16].

Practical containment within the building is accomplished by evacuating air from the building at a sufficient pumping rate to insure that any air leakage through the building shell will be inward rather than outward. The conclusion from a study made of the contaminated gas disposal problem was that the exhausted air from the building could be filtered, scrubbed free of the iodine nuclides and be discharged through a near by stack without undue hazard to personnel at ground level. The building has a separate 10,000 cfm capacity duct system intended only for the emergency air evacuating of the building, discharging as described above.

Design provisions for maximum building air-tightness include taped and caulked joints in the insulated metal siding panels, gaskets around door jambs, and spring closers actuated by electro-penumatic switches on all dampers in the building ventilation openings, both intake and exhaust. The two large truck doors have pneumatic motors for emergency closure. All building ventilation units, the truck doors, and the emergency building exhaust system can be operated from a push-button station in the reactor control room.

The addition of an appreciable amount of fission products to the cooling system would result in higher than normal intensities in the pump house and at the heat exchangers. The cooling loop will be provided with adequate instrumentation to detect abnormal rises in activity. In addition, such increases would be quickly detected by an increase in activity on the ion exchange beds of the demineralizer.

D. Cooling System Failure

It has been shown by E. T. Jurney[17] that a sudden removal of all coolant concurrent with shut down of a reactor of the ORR type operating at five megawatts would not result in melting of the fuel elements in less than 13 minutes. Extrapolation of this calculation to thirty megawatts indicates that about two or three minutes would be required to supply sufficient afterheat to melt the core even if no heat transfer from the core were permitted.

In order to protect against a possible loss of cooling water, seal legs are provided on the exit water lines and provision is made to permit water from the pool to enter the reactor tank. In addition to this, water may be added directly to the core from the plant process system.

In view of these precautions it would appear that only a major catastrophe resulting not only in loss of water to the core cooling loop, but also rupturing the pool itself and at the same time disrupting the process water supply would be likely to result in melting of the core.

E. Loss of Shielding Due to Loss of Pool Water

Since the top shielding and to a lesser extent the side shielding of the ORR depend upon the fact that the core tanks are immersed in the pool, it is clear that any situation in which the level of the water in the pool is not maintained is dangerous.

In order to prevent accidental draining of the reactor section of the pool no provision has been made to drain this section below the top of the reactor tank. All connections, both inlet and outlet, are above this level. Temporary piping would have to be installed in the event this section is to be drained.

The remaining two pool sections have inlet and outlet lines located in the floor of the pool, however the gates between these pools and the reactor pool will normally be in place during operation. The inlet lines to the storage pools are 4" diameter and are protected from inadvertent draining by check valves immediately below the pool floor. The outlet lines are 2" diameter and approximately 3½ hours is required to drain the storage pools. This should be sufficiently long to detect and correct an operating error. An alarm system will be provided to warn when the level of any of the pool sections drops below the safe minimum.

F. Accumulation of Large Volumes of Contaminated Water

While the pool and cooling loop demineralizers are considered adequate to handle contamination in excess of the levels expected, there does exist the possibility that, due to malfunction of the system, it may become necessary to dispose of large quantities of contaminated water.

The two water systems contain a total of approximately 150,000 gallons. There are available at the Oak Ridge National Laboratory several methods of handling this water. The water could be sent directly to one or both of two 20,000 gallon retention ponds and then bled slowly into the Clinch River by way of White Oak Creek as is done with other "warm waste". In case additional capacity were needed temporary lines could be installed to either or both of two other retention ponds which have a total capacity of 400,000 gallons. The water could be impounded here for a time sufficient to allow for decay of the shorter lived components and then handled through the regular "warm waste" system.

Should the activity of the water be too great to handle by either of the above methods, temporary piping from the reactor building could be installed conveying the water to the ORNL tank farm (a distance of approximately 400') whence it could be led through existing piping to either of two 500,000 gallon lagoons where its volume would be dissipated by solar evaporation and the concentrate impounded indefinitely. This procedure is in current use for the disposal of large volumes of radioactive chemical waste from other processes at the Laboratory.

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