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MATERIALS TESTING REACTOR PROJECT
PROGRESS REPORT
FOR THE PERIOD ENDING MAY 30,1950

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CLASSIFICATION CHANGED TO: DECLASSIFIED
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BY: R. Morrison 7/10/57

MATERIALS TESTING REACTOR PROJECT
PROGRESS REPORT
for the Period Ending May 30, 1950

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Edited by

H. J. McDuffie, Jr.

DATE ISSUED: JUL 26 1950

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SUMMARY

Analysis. The complete hydraulic picture of the MTR, based on an overall pressure drop of 40 psi, a flow of 30 ft/sec through all 0.118 in. cooling channels, and a total process water flow of 20,000 gpm, appears to be quite satisfactory.

Air cooling of the graphite reactor has been reviewed and complete design calculations have been reported.

The decision to specify barytes aggregate concrete as the principal material in the reactor shield has resulted in the elimination of all iron aggregate concrete from the design. Moreover, only a small amount of supplemental steel and/or lead will be required to restore the attenuation characteristics of the shield in the neighborhood of interruptions in the concrete.

Estimation of temperatures in the side thermal shield in the zone of maximum heat production has been completed. Temperatures and temperature differences in the hottest plate appeared greater than desired upon initial inspection. However, subsequent calculations of the resulting thermal stresses by Blaw-Knox have indicated that these stresses are not excessive.

An experimental plug for use in the insertion of an MTR fuel assembly into the Chalk River Reactor for radiation damage studies has been designed and is under construction. A six-months period of exposure is scheduled to begin July 1.

Design. Major efforts of the group have been directed toward completion of design details and placing on order the reactor parts which are to be furnished by ORNL. It is certain that this work will be finished before the reactor structure engineering design drawings (requiring ORNL check and approval) begin arriving from Blaw-Knox in appreciable numbers.

An improved combination of flanges and gaskets for the mechanical joints of the reactor tank has been designed. A mock-up of these joints, for use in full scale testing, has been placed on order.

Experimental.

a. Mock-up: During the past quarter the MTR Mock-up system has been brought to critical nearly two hundred times, and much experience in operation

[redacted]

and control has thereby been gained. The mock-up has been operated successfully as a reactor at power levels up to approximately 250 watts. No significant deviation from anticipated operation has been found necessary, and no design deficiency of any consequence has been observed.

b. *Instrumentation:* Circuits for the MTR safety system and the period meter have been given to the Instrument Division for the construction of prototypes. Detail drawings of the shim rod control plans are being made by Blaw-Knox. Other circuits have been carried beyond the experimental stage.

c. *Corrosion:* Additional corrosion studies of hot-pressed and extruded beryllium have indicated that the kind of surface finish and the amount of cold working influence the initial corrosion resistance; however, the calculated penetration rates, in all instances, were low. In general, ground surfaces were more corrosion resistant than milled surfaces. Accelerated corrosion tests at high temperatures (250°C) have revealed no severe corrosion damage.

Metallurgy and Fabrication. Control of blister formation in fuel plates containing natural uranium proved satisfactory, and production of plates containing enriched uranium was resumed. An average yield of 96% blister-free plates was obtained using the preferred process, while the overall yield from 11 different runs was 85.5% (201 blister-free plates out of 235).

Eleven enriched fuel assembly units were produced for use in the MTR critical experiment. A simplified fuel assembly process being developed promises to eliminate several steps previously required.

Deep hole drilling of hot-pressed MTR beryllium reflector sections has been accomplished with considerably better accuracy and precision than had been anticipated.

Studies of lead creep under various combinations of stress and temperature are being carried out in order to predict the probable behavior of the MTR neutron window.

ANALYSIS

WATER FLOW IN THE ACTIVE LATTICE AND THE BERYLLIUM

The hydraulic picture of the MTR has been completed except for final checking. Listed below are the water flows and pressure drops (based upon an overall pressure drop of 40 psi) required to give a flow of 30 ft/sec through all 0.118 in. cooling channels.

LOCATION	PRESSURE DROP	FLOW
Upper Support Casting	3 psi	13050 gpm
Upper Assembly Grid		
a. Top and side openings	9	1830
b. Opening above reflector	12	770
Fuel Assemblies (23)	37	11,190
Beryllium Assemblies (14)	37	31
Interstices	18	2600
Beryllium Reflector	30	2920
Lower Grid Support	10	2920
Lower Assembly Grid	10	2600
Shim Rods		
a. Cadmium (8)	40	3380
b. Thorium (8)	40	2900
Total Flow		
a. With 8 cadmium rods	40	20,120
b. With 8 thorium rods	40	19,640

In normal operation fewer than eight shim rods will be used so the proposed total process water flow of 20,000 gpm should be adequate.

AIR COOLING OF THE GRAPHITE REFLECTOR

(Ref: ORNL CF 50-3-102)

Design calculations involved in specifying the cooling for the graphite reflector have been completed and reported. Maximum temperatures of 500°F in the permanent graphite and 570°F in the pebble bed for 45,000 kw operation and heat production data reported in ORNL 167[1] formed the basis for the calculations.

The total air requirement of the reactor was found to be 28.3 lb/sec or 27,000 ft^3/min at 75°F and 25.5 in. Hg abs. It was estimated that the total heat produced in the reflector and thermal shield will be 825 kw for 45,000 kw operation resulting in an exit air temperature of 185°F. Under those conditions the pressure drop through the reflector will be 26 to 29 in. of water. The cooling hole pattern for the graphite reflector is shown in Fig. 1-1.

MTR SHIELDING SURVEY

The most significant result of the shielding survey is the decision to specify barytes aggregate concrete of density 3.5 gm/cm^3 as the principal material in the reactor shield. Also, a basis for the analysis of the shield has been developed which is consistent with the experimental data from the MTR Mock-up and the results from lid tank experiments. Finally, a variety of specific shielding problems have been analyzed and appropriate structural changes, if needed, have been proposed.

The fiducial specification of the biological shield in MonT-433[2] called for 9 ft of ordinary concrete outside the thermal shield. Many deviations from this were introduced into the design with the expectation that moderate amounts of special supplemental shielding would suffice to restore the attenuation characteristics of the shield. When the initial shield survey indicated that excessive amounts of special shielding would be required to supplement the ordinary concrete, it was decided to specify barytes concrete as described in ORNL 667[3] as the principal shield material. This change has resulted in the elimination of all iron aggregate concrete from the design and requires only a small amount of supplemental steel and/or lead.

(1) Martin, A. B. and Mann, M. M., *Critical Experiments for the High Flux Reactor*, ORNL 167 (Oct. 22, 1948).

(2) Huffman, J. R., Leverett, M. C., Newson, H. W., and Weinberg, A. M., *Feasibility Report of Clinton High Flux Pile*, MonT-433 (Dec. 1, 1947).

(3) Tirpak, Edward G., *Report on the Use of Barytes Aggregates in Concrete for Shielding Purposes*, ORNL 667 (Apr. 13, 1950).

[redacted]

DWG. 8605

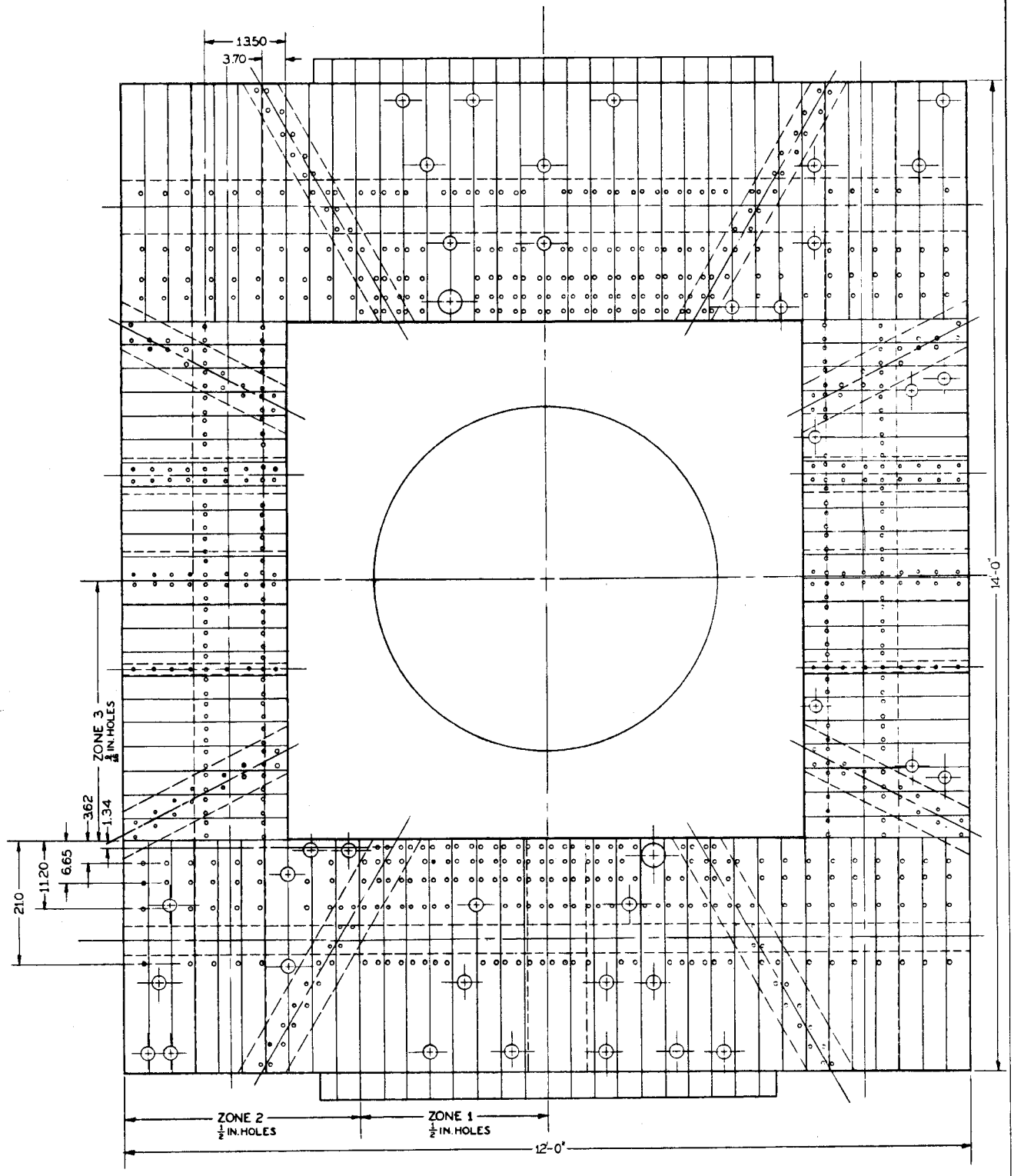

FIG 1-1

HOLE PATTERN FOR THE GRAPHITE REFLECTOR

Although no bulk shielding tests have been made on barytes concrete, some indication of its probable neutron performance can be obtained by comparing its macroscopic total cross section with that of ordinary concrete. Such calculations indicate that use of a neutron relaxation length of 8 cm is conservative. The extrapolation of the γ-ray performance of ordinary concrete on the basis of relative densities yields a relaxation length of 10 cm for design purposes.

Some physical properties of barytes have been reported by Tirpak in ORNL 667.[4] Further tests on strength, shrinkage and thermal properties are under way by the shielding materials group at ORNL.

The current basis for the shielding survey employs the following fluxes and cadmium ratios incident on the steel thermal shield to determine shielding requirements at various locations around the reactor:

LOCATION	THERMAL FLUX (30,000 kw)	Cd RATIO
Bottom	3×10^{11}	100
Cubicle sides	4×10^{11}	200
Far sides (thermal column)	2×10^{11}	200
Top	2×10^{11}	200
Vertical edges	1×10^{11}	400
Top horizontal edges	1×10^{11}	400
Corners	5×10^{10}	500

Because of the 8 in. steel thermal shield, the shield design is found to be dominated by the secondary γ-rays generated by neutron degradation and capture in the concrete. Details will be presented in the forthcoming report on the MTR shield survey. This report will also include a discussion of various particular problems encountered in the survey.

HEAT PRODUCTION AND TEMPERATURE DISTRIBUTION IN THERMAL SHIELDS

(Ref: ORNL CF 50-3-43)

Estimation of the temperatures in the side thermal shield in the zone of maximum heat production has been completed. The calculations were published

(4) Tirpak, E. G., *op. cit.*, ORNL 667.

and submitted to Blaw-Knox for use in evaluating the stresses and deflections.

The maximum and minimum temperatures in the plate adjacent to the graphite were found to be 292°F and 101°F respectively for 60,000 kw operation and 75°F cooling air. Corresponding temperatures in the plate adjacent to the concrete were 134°F and 82°F. The temperature and temperature differences in the hottest plate appeared greater than desired; however, calculations of thermal stresses made by the Blaw-Knox engineers indicated that these stresses were within safe limits.

CHALK RIVER EXPERIMENT

Detail design of an experimental plug for insertion of an MTR fuel assembly and three Argonne fuel assemblies into the Chalk River Reactor for radiation damage studies was started in April and completed in May by the Engineering Division. Drawing E-7542 was approved for construction, and fabrication of the plug was started on May 19; scheduled completion date is June 15, when the plug will be sent to Argonne for insertion of their specimens. The plug is scheduled to be introduced into the Chalk River Reactor on July 1 for a six month irradiation period.

Design of a carrier for returning the irradiated MTR specimen and instrumentation for detecting radiation damage are well under way by the Engineering Division of ORNL.

DESIGN

SUMMARY

During the past quarter, the efforts of the Design Group have been directed mainly toward completion of design details and placing on order the reactor parts which are to be furnished by ORNL. It is now certain that this work will be substantially finished, except for the follow-up and inspection in vendors' plants, before the reactor structure drawings requiring ORNL check and approval are received from Blaw-Knox in appreciable numbers. An improved combination of flanges and gaskets for the mechanical joints of the reactor tank has been designed. A mock-up of these joints, for use in full scale testing, has been placed on order. Liaison with Blaw-Knox on the reactor structure continues as required.

REACTOR STRUCTURE

Design studies on the reactor structure have continued in conjunction with Blaw-Knox. While there have been relatively few changes in the structure itself, it was decided, as is mentioned elsewhere, to pour the entire biological shield of barytes concrete. In connection with the shielding analysis leading to this decision, there have been minor changes in the locations of the inlet air ducts to insure adequate protection at the balcony level. All previously specified MO type concrete is eliminated and is to be replaced by barytes. In addition to these changes, the shutdown overflow line has been eliminated and the auxiliary water line moved to the north side of the structure in its place.

Although it was previously planned to provide an access to the basement for shielded lines at each end of the HT facility, this was changed slightly to provide access for shielded lines at the north end only. At the south end, an access is provided to the basement with no special provisions for shielding within the structure itself.

It has been decided to adopt the roll-away type steel balconies as proposed originally and further to provide a stairway from the first floor level to the top of the structure at the northeast corner. The lower section of the stairway is to be removable to prevent interference with the HG-5 facility.

EXPERIMENTAL FACILITIES

It was decided in early March to eliminate the built-in neutron crystal spectrometer planned earlier. Investigation of the problem indicated that the inherent complexities and cost of the unit were not consistent with efforts to economize throughout the project. It was found, however, that with the existing cubicles at the horizontal angular beam holes, installation of a spectrometer at a later date would be feasible.

In a further attempt to reduce the initial cost of the reactor, it was decided to modify the shielding facility. Blaw-Knox is now instructed to provide only a 7 ft opening in the west side of the structure and to specify that it be filled with barytes brick for the reactor start-up. A steel liner is to be provided for the opening and the barytes blocks are to be protected at the inner end with 1/4 in. Boral plate. It is thus planned that at some future date, should the necessity arise, either a second thermal column or a shielding facility can be installed in the opening. The deep well storage extending into the basement is to be maintained as planned; however, all other facilities set forth in the shielding facility report are eliminated. Provisions are to be made for installation of a neutron curtain as on the east side, but neither the curtain nor the drive is to be installed in the structure as built. All previously specified MQ concrete is to be replaced with barytes mix.

As was disclosed in the previous progress report, recesses were provided at the ends of the HT-1 facility for a recirculating experiment through the reactor tank, returning via the HG-2 facility in the graphite, thence to a hot cubicle in the basement. This basic arrangement is still incorporated though it has been modified by re-location of the basement access hole on the north side so that the lines are shielded within the inside face of the cubicle. Previously these lines were recessed into the floor for runs to the basement access opening. The access is now located so that the lines do not enter the cubicle floor area. In recirculation of fissionable fluids through the facility, the amount of shielding required outside the structure in the vicinity of the cubicle will thus be reduced considerably. At the south end of the facility an unshielded basement access is provided in the cubicle floor area. It is believed that a shielded access is required on one end only, and that a straight basement access is sufficient on the opposite end. The latter

access would be used only for direct accessibility to the basement area from the south cubicle or conceivably for a return line to the north end of the facility via a cold conduit through the reactor structure outside the thermal shield.

Details of experimental facility start-up plugs other than those with radiation doors are now the responsibility of ORNL. Basic information for detail design of these plugs is to be furnished Blaw-Knox at an early date. This is to include also the concrete closure plugs to be used in conjunction with the VG holes.

SERVICE FACILITIES

The auxiliary services to be provided at the various experimental facilities have been reviewed in an effort to bring them up to date with the latest thinking on experiments likely to be performed. These services have now been firmly established and have been added to the Blaw-Knox structure studies. Figure 2-1 is a condensed version of the "Flow Diagram" now in preparation by Blaw-Knox, showing the various auxiliaries which will be required, or simply available, at the various openings in the face of the reactor structure.

In explanation of the liquid supply system as shown in Fig. 2-1, it should be mentioned that it is now planned to cool plugs with process water rather than demineralized water unless a particular experiment dictates an exception. Water discharged from the various water-cooled plugs is to be returned to the process water coolant stream as was previously planned. The decision to adopt process water cooling allowed a significant reduction in the capacity of the demineralizer unit as originally proposed.

CONTROL ELEMENTS

Drawings and parts lists for the regulating rod and shim-safety rod drives are completed and checked. It is expected that these will be in the vendor's shop in early June and that the parts will be delivered in December of this year. All major components with the exception of the shim-safety rod magnetic couplings and the active portions of the elements now either are on order or have been requisitioned.

Dwg. 9128

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SERVICE FACILITIES

LEGEND:
R..REQUIRED AT THE EXPERIMENTAL FACILITY SERVES THAT FACILITY ALONE.
A..AVAILABLE TO FACILITY MAY ALSO SERVE OTHER FACILITIES.

	LIQUID SUPPLY						GASES & VAPORS					ELECTRICAL A.C.& D.C.						LIQUID	
SERVICE → / EXP. FACILITY DESIGNATION ↓	DEMINERALIZED WATER	AUXILIARY (FILTERED) COOLING WATER	HIGH PRESSURE DEMIN. WATER 100 PSI	PROCESS WATER	PROCESS WATER RETURN	COMPRESSED AIR	1/2" SPARE LINE	1/2" SPARE LINE	STEAM	HOT GAS EXHAUST	110V A.C.	110V A.C. (FOR REG.V. ONLY)	220V A.C.	1 1/2" SPARE CONDUIT	CONDUITS FOR 200A-300V D.C.	SPARE CONDUIT FOR 1000A-D.C.	INTERCOM. OR TELEPHONE	WARM LIQUID DRAIN	SPARE LIQUID SUPPLY
HB-1	R	A		R	R	R	A		A	R	R	R	R	R	A	A	A	R	R
HB-2	R	A		R	R	R	A		A	R	R	R	R	R	A	A	A	R	R
HB-3	R	A		R	R	R	A		A	R	R	R	R	R	A		A	R	R
HB-4	R	A		R	R	R	A		A	R	R	R	R	R	A		A	R	R
HB-5	R	A		R	R	R	A		A	R	R	R	R	R	A		A	R	R
HB-6	R	A		R	R	R	A		A	R	R	R	R	R	A		A	R	R
DB-1	R	A			R	A	A		A	R	R	R	R	R	A		A	A	R
DB-2	R	A			R	A	A		A	R	R	R	R	R	A		A	A	R
DB-3	R	A			R	A	A		A	R	R	R	R	R	A		A	A	R
DB-4	R	A			R	A	A		A	R	R	R	R	R	A		A	A	R
DB-5	R	A			R	A	A		A	R	R	R	R	R	A	A	A	A	R
DB-6	R	A			R	A	A		A	R	R	R	R	R	A	A	A	A	R
VH-1			R								A	A	A				A		
VH-2			R								A	A	A				A		
VH-3			R								A	A	A				A		
VH-4			R								A	A	A				A		
HR-1						R	A			R	A	R	A	A			A		
HR-2						R	A			R	A	R	A	A			A		
HR-3	R				R	R	A			R	R	R	A	A			A	A	
HR-4	R				R	R	A			R	R	R	A	A			A	A	
HT-1	R	A		R	R	R	A		A		A	A	A	A	A		A	R	
HI-2						A	R	R			R	R	A	A	A		A		
HI-3						A	R	R			R	R	A	A	A		A		
HG-1	R	A			R	A	A			A	R	R	A	R	A		A	A	
HG-2	R	A			A	A	A			A	R	R	A	R	A		A	A	
HG-3	R	A			R	A	A			A	R	R	A	R	A		A	A	
HG-4	R	A			A	A	A			A	R	R	A	R	A		A	A	
HG-5	R	A			R	R	A			R	R	R	R	R	A		A	A	
HG-6	R	A			R	R	A			R	R	R	R	R	A		A	A	
GT-1						A	A			A	R	R					A		
GT-2						A	A			A	R	R					A		
T-2*	R	R			R	R	R			R	R	R	R	R	A		A	R	
T-2H-1	A	A				A	A				R	R	R	R	A		A	A	
T-2H-2	A	A				A	A				R	R	R	R	A		A	A	
T-2V-1	R	R				R	A				R	R	A	A			A	A	
T-2V-2	A	A				A	A				A	A	A	A			A	A	
VN-1						A	R	R			A	A		R			A		
VN-2						A	R	R			A	A		R			A		
VN-3						A	R	R			A	A		R			A		
VN-4						A	R	R			A	A		R			A		
VN-5						A	R	R			A	A		R			A		
VN-6						A	R	R			A	A		R			A		
VG-1	A	A				A	A				A	A	A	A			A	A	
VG-2	A	A				A	A				A	A	A	A			A	A	
VG-3	A	A				A	A				A	A	A	A			A	A	
VG-4	A	A				A	A				A	A	A	A			A	A	
VG-5	A	A				A	A				A	A	A	A			A	A	
VG-6	A	A				A	A				A	A	A	A			A	A	
VG-9	R	A			R	A	A				R	R	R	R			A	R	R
VG-7 AND THRU 26						A	A				A	A	A	A			A	A	
VG-29 THRU 62						A	A				A	A	A	A			A	A	

FIG. 2-1

* FACILITIES SERVING T-2 MUST BE ADEQUATE FOR HG-9, T2H3, 4, 5, 6, 7, 8.

Roller type bearings have been installed in the MTR Mock-up regulating rod. These bearings have operated satisfactorily and it is planned that they be incorporated in the MTR.

The mechanical coupling on the regulating rod has been redesigned for the MTR. Instead of the screw type coupling as used in the mock-up, a ball-in-groove type coupling has been patterned after commercial quick-disconnect couplings used on fluid hoses. Adoption of the joint promises a simplified disengagment operation at the top plug platform.

The previously designed slip-joint in the shim-safety rod has been redesigned and incorporated in the top of the rod itself, just beneath the magnetic coupling armature. The difficulty arising from the magnet power leads being cut in the slip joint is therefore eliminated.

A simplified "down position" indicator has been adopted for use in the lower shock-absorber of the shim-safety rod. Previously, a transmitter rod and a micro-switch were used to indicate the down position of the rod. It is now planned to bleed water into the shock-absorber and use the bleed line pressure as an indicator.

BERYLLIUM REFLECTOR

The program for design and procurement of the beryllium shapes for the MTR is proceeding according to the accelerated schedule which calls for completion of the reflector in early 1951. Brush Beryllium Company has been supplied approved drawings of the rough machined shapes as they are to be delivered to Y-12 for final machining. Delivery of billets is to begin in June and to continue through October when the MTR requirements should be fulfilled. Meanwhile, detailed drawings for final machining are in the checking stage and will be finished and approved about June 15. Machining is to be started upon arrival of the first billets and will probably continue until January, 1951.

At a meeting held April 20, at the Brush Beryllium Company, minor changes in the specifications for chemical purity of the metal and in the testing and inspection procedures were made. These changes are not expected to delay the program, but rather are designed to accelerate the procurement of beryllium by modifying unnecessarily stringent specifications and clearing up misunderstandings and misinterpretations of the inspection and testing procedures.

PERMANENT REFLECTOR

On the basis of the permanent graphite design report and the addenda thereto, the overall philosophy of fabricating the reflector has been established. In cooperation with Blaw-Knox personnel, graphite requirements have been worked out in detail and the material has been requested by ORNL through the Oak Ridge AEC. Machining is to be done in the Y-12 graphite shops, including production of the pebbles. Conferences have been held among ORNL, Blaw-Knox, and Y-12 personnel in which machining and assembly techniques have been discussed, and a tentative machining schedule has been prepared by Blaw-Knox. Machining will be initiated upon receipt of materials and proper approval by Oak Ridge AEC.

Graphite for the fabrication of graphite plugs has been requisitioned through ANL and Chicago AEC. Machining of these components is likewise to be done in Y-12 under an arrangement similar to that on the permanent graphite.

REACTOR TANK AND COMPONENTS

Detail design of the reactor tank and its contents is nearing completion. Critical materials have been placed on order and it is expected that all major parts except for the reactor tank will be in vendors' shops not later than July 1. Although detailing is completed on the reactor tank, its fabrication is to be held up pending completion of the flange mock-up test described elsewhere. Work orders for fabrication of the top and bottom plugs have been placed in the Y-12 shops and the materials have been ordered. Tank sections *B* (expansion joint) and *C* are on order for use in the flange mock-up test and will later be used in the MTR itself.

MTR PARTS PROCUREMENT

The Oak Ridge Office of AEC has approved (Letter, Sapirie to Center, March 23, 1950) the proposal of the Idaho Office and the Steering Committee whereby ORNL is to procure the reactor components to be installed at the site. A transfer of funds from the Idaho office is being made in the amount of $311,100 for purchase and check-out testing.

Procurement requisitions were initiated in early April on the critical materials with long delivery schedules. As design details are completed and checked on the various components, purchase requisitions are placed for issuance of purchase orders. As of May 31, all major components were either on requisition or on order, with the exceptions noted elsewhere. Many of the small parts have yet to be ordered but in these cases a short delivery is anticipated.

The major components are being supplied by the vendors listed below:

Aluminum reactor tank sections	Stacey Bros. Gas Constr. Co., Cincinnati, Ohio
Reactor tank expansion joint	Cook Electric Co., Chicago, Illinois
Control element drives	Modern Die and Tool Co., Los Angeles, California
Top and bottom plugs	Carbide and Carbon Y-12 shops
Reactor tank castings	Aluminum Co. of America, Los Angeles, California Modern Die and Tool Co., Los Angeles, California (machining only)
Regulating-rod motors	U. S. Navy, Crane, Indiana Ammun. Depot

MTR FLANGE MOCK-UP

Based on experience in the MTR Mock-up with the mechanical joints of the reactor tank, it was decided to investigate the sealing problem more closely with the objective of improving the existing joints. As has been reported earlier, these joints have not been altogether satisfactory for two reasons: (a) the design of the flanges themselves resulted in a softer and weaker flange than predicted; (b) the manufacture of the flange faces was defective.

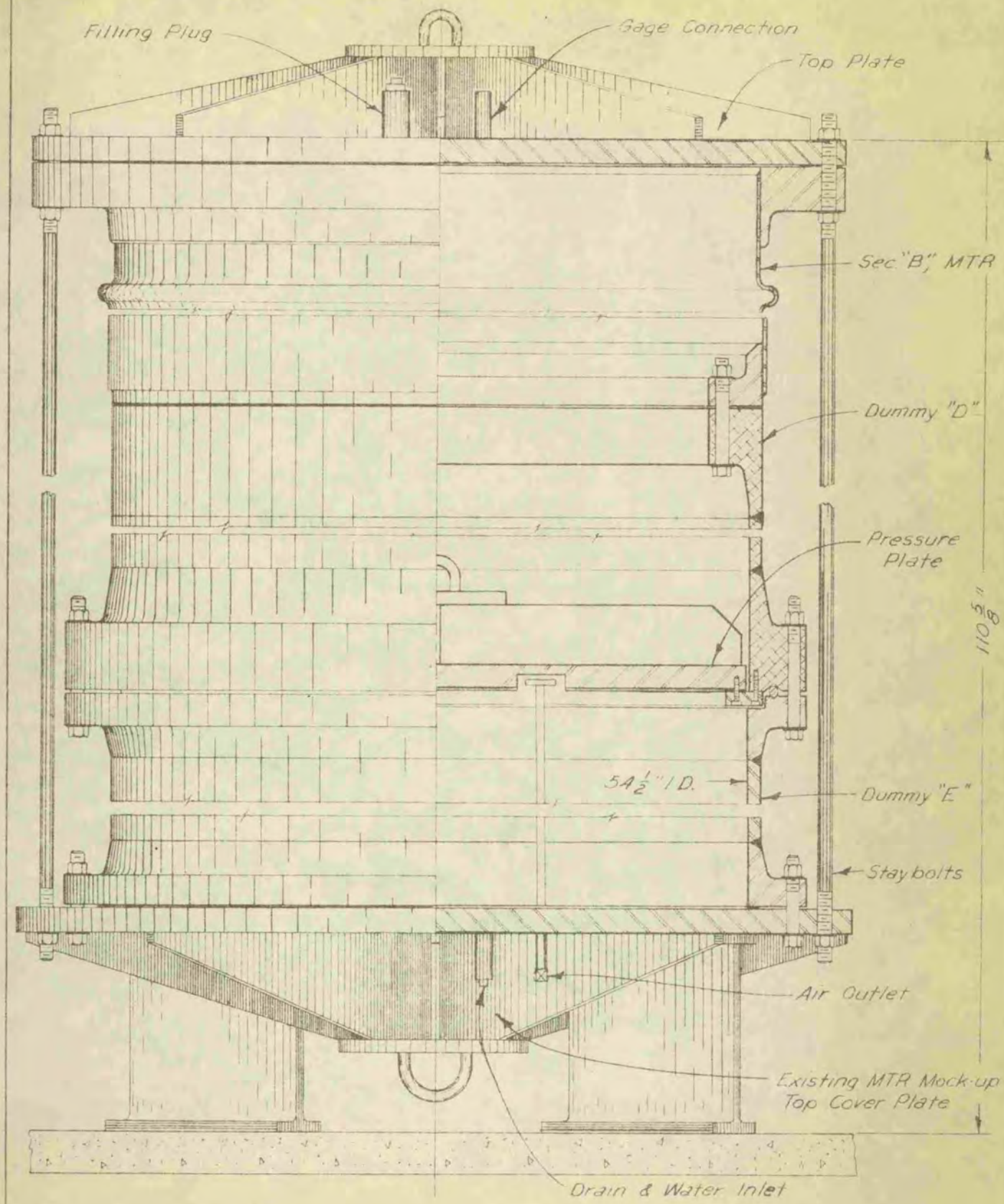
In cooperation with the Taylor Forge Company, a different type of flanged joint has been proposed, based primarily on the extensive experience of the Taylor Company with metal gaskets. Notwithstanding, the data available on

joints of the size and materials required in the MTR is meager. It was consequently decided to test the full size joints not only to prove the sealing of the joint, but also to determine the bolting torques required to seal, seal heavily, and eventually leak under simulated reactor conditions. Coincidentally, the fabrication of the required aluminum vessels will afford excellent conditions for qualification of welders in the vendors' shops on the shell and flange materials to be used in the MTR.

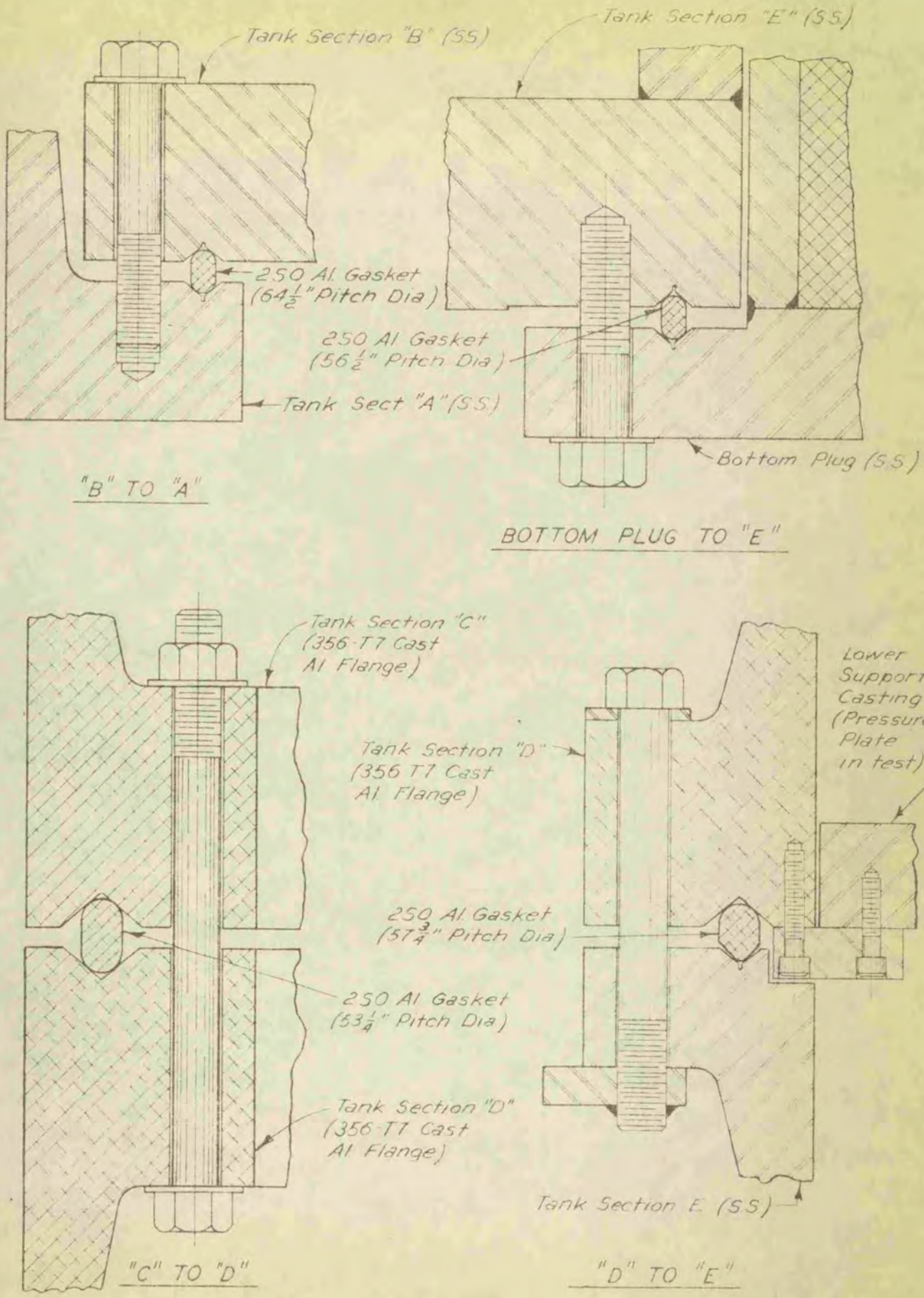
Figure 2-2 is a schematic representation of the test vessel made up of three separate sections. Figure 2-3 shows the actual joint designs proposed for the MTR which will be proven in the proposed test. With the section as shown, and with one additional aluminum vessel, it will be possible to test each type of joint in the MTR under precisely the same hydraulic conditions as will be experienced in the reactor. The pressure plate shown at the lower flange of section *D* will impart the same load on the flange as will the hydraulic load of the pressure drop across the MTR reflector. In order to prove the aluminum-to-aluminum joint, tank section *E* as shown will be replaced by *D*, and a second aluminum section *C* will be inserted over *D* in its new position. It is planned to test the joints over a range of pressures from 75 to 125 psi with various differentials across the pressure plate so that the sealing characteristics of each type joint can be accurately determined prior to installation at the site.

To minimize the cost of the testing equipment, the design has been developed so that the tank sections *B* (expansion joint) and *C* can be transferred directly to the MTR. Further to minimize the cost, the existing top cover plate of the MTR Mock-up is being adapted as one of the required pressure heads in the test. It is expected that the parts now on order shall have been delivered and the test completed by September 1.

Dwg. 9127
Not Classified



MTR FLANGE MOCK-UP
FIGURE 2-2



MTR REACTOR TANK - TYPICAL GASKET DETAILS

FIGURE 2-3

Scale 3/8" = 1"

EXPERIMENTAL

MTR MOCK-UP

Summary. The details of the construction of the Materials Testing Reactor Mock-up and the results of a series of non-nuclear experiments have been included in previous interim reports. More recently it has been reported[1] that fuel elements containing approximately two kilograms of U^{235} have been placed in the mock-up and the reactor has been made critical. In the interim covered by the present report, the system has been brought to critical nearly 200 times, and much experience in operation and control has been gained by the experimental group. The mock-up has been successfully operated as a reactor at power levels up to approximately 250 watts. No significant deviation from anticipated operation has been found necessary, and no design deficiency of any consequence has been observed.

A description of the mock-up and its operation, including instrumentation, and the results of most of the experiments have been reported recently.[2] A resumé of the data and information which have been obtained will be presented in the following paragraphs.

Neutron Flux and Heat Production Measurements. Neutron flux and heat production measurements have been made in one quadrant of the graphite reflector of the MTR Critical Experiment for use in evaluating the designs for the thermal shield and the graphite reflector. Measurements of neutron fluxes have been made in the active lattice for estimating the operating power of the critical experiment and providing data regarding relative heat production within the lattice.

It has been determined that the heat production in the graphite reflector of the MTR was overestimated by a factor between 1.5 and 4, depending upon position, and that the heat production in the thermal shield was overestimated by a factor of 1.5 to 2. The ratio of maximum to center thermal flux (and heat production) in the lattice is ~1.2 which is less than the design figure of 1.45.

(1) Mann, M. M. and Lane, J. A., *Materials Testing Reactor Project Progress Report for the Period Ending February 28, 1950*, ORNL-628 (Apr. 10, 1950).

(2) Beall, S. E., *Interim Report of Neutron and Gamma Experiments on the MTR Mock-Up*, CF 50-5-140 (May 11, 1950).

The layout of the reactor components and the locations of the test holes are shown in Fig. 3-1. The core contains thirteen fuel assemblies and two shim rods, ~2 kg of fuel, located in the northwest corner of the lattice opening. There is a 15 cm beryllium reflector backed by water on the south and east sides of the core and a full loading of beryllium between the aluminum tank wall and the lattice on the north and west sides. The boundaries of the pebble bed and the graphite reflector are such that the northwest quadrant has dimensions similar to the actual MTR, and enough reflector is provided in the northeast and southwest quadrants to minimize disturbances in the flux and heat production patterns in the northwest quadrant. A concrete block shield begins about 18 to 30 in. from the outer boundary of the graphite. There is no steel thermal shield, but bricks were stacked at one location to provide a four foot square shield used for estimating the effect of the steel upon neutron flux and heat production in the graphite.

Neutron flux measurements in the lattice were made with gold foils in the midplane and near the top and bottom planes. Results of the midplane and top plane measurements are presented in Figs. 3-2 and 3-3. Fluxes in the top and bottom planes were about the same so the fewer measurements made in the bottom plane are not reported here.

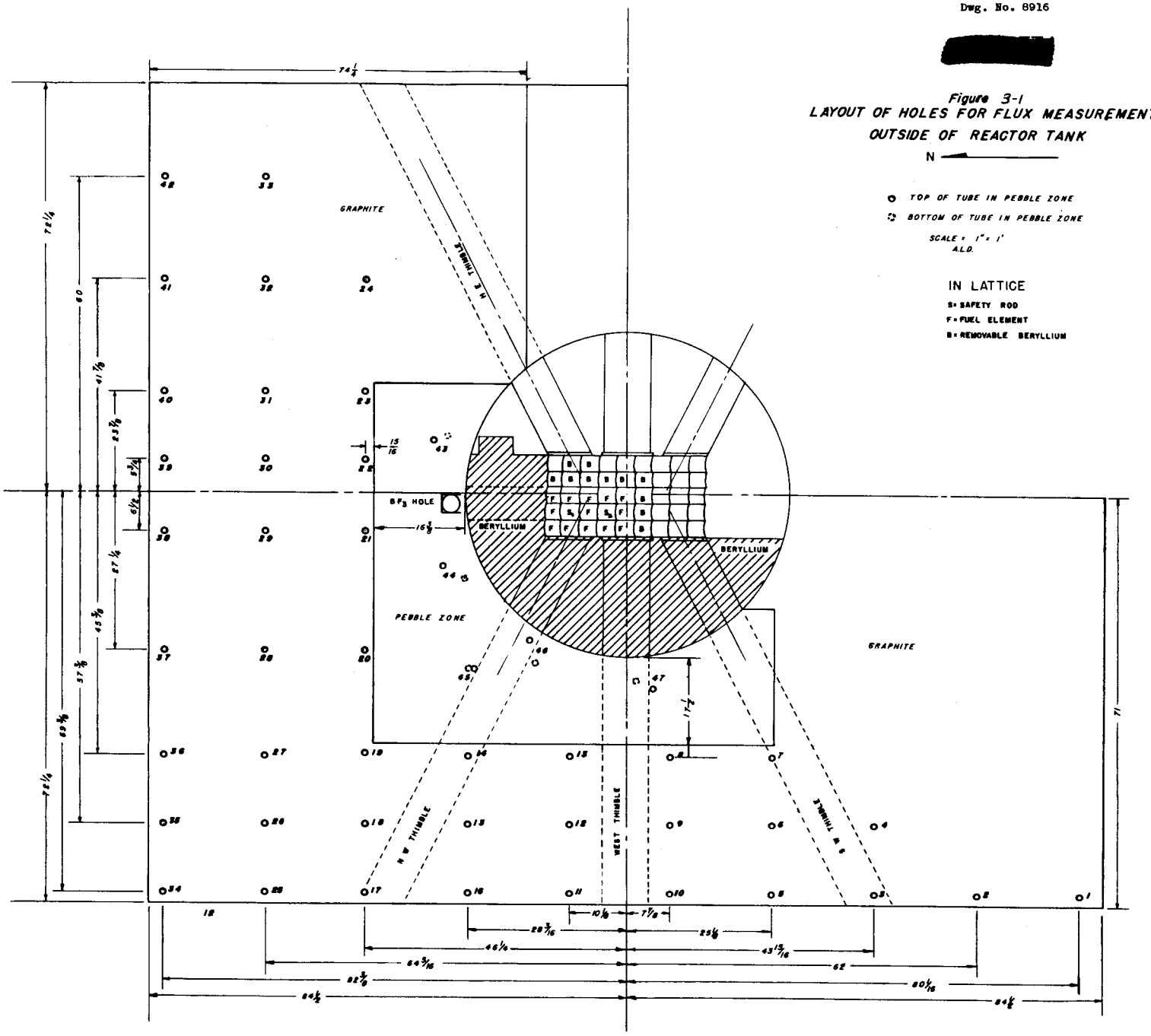
Data from Fig. 3-2 show the thermal neutron flux in the midplane to be reasonably uniform with a maximum to center ratio of ~1.2. This is less than the value, 1.45, used in recent design calculations. The flux was found to vary by a factor of ~2 between the midplane and the top and bottom planes. The average of several measurements resulted in a cadmium ratio, corrected for the absorption of resonance neutrons, of 2.7 at the center of the lattice. There was a significant difference between the measured midplane fluxes along the east and west faces of the lattice. This is attributed to the larger water gap, 3/8 in. vs. 1/16 in. along the west face and the nearness to the northwest thimble which was open during the measurements.

Neutron fluxes in the reflector were measured with indium foils and heat production data were obtained with graphite ionization chambers. Measurements were made in the horizontal midplane in most of the holes shown in Fig. 3-1 with the northwest beam hole empty and filled with beryllium. In all experiments the west center hole was totally or partially filled with beryllium. Horizontal traverses were made near the top and bottom of the graphite, and some information was obtained regarding the difference in fluxes with and without a steel thermal shield. Complete vertical traverses were made in several of the holes.

Dwg. No. 8916

[redacted]

Figure 3-1
LAYOUT OF HOLES FOR FLUX MEASUREMENTS OUTSIDE OF REACTOR TANK



[redacted]

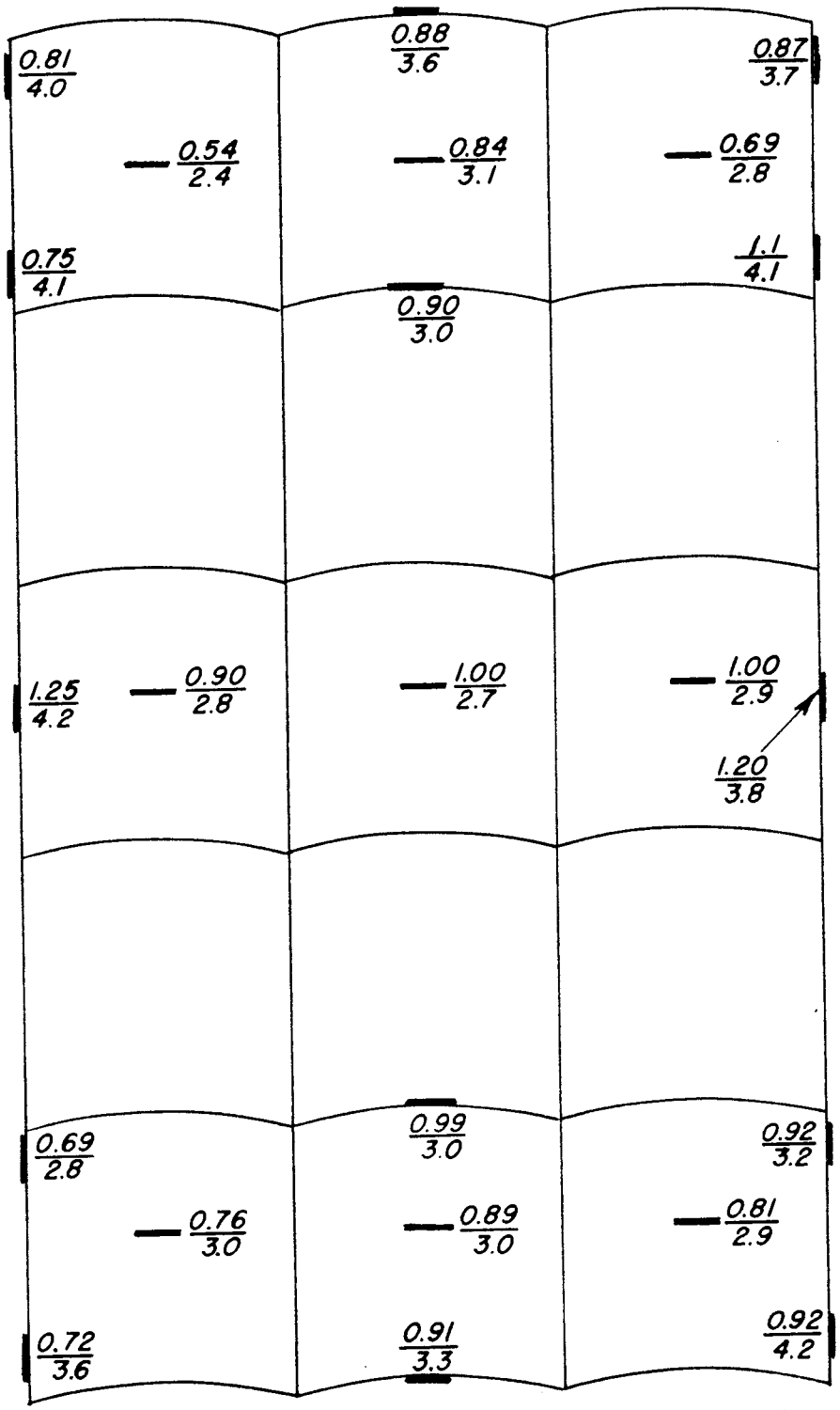


Fig. 3-2 — Neutron Flux in Midplane of Active Lattice

[redacted]

Numerator is NV_{th} Relative to NV_{th} at Center of Lattice
Denominator is Cadmium Ratio ÷ 1.1

Dwg. No. 8920

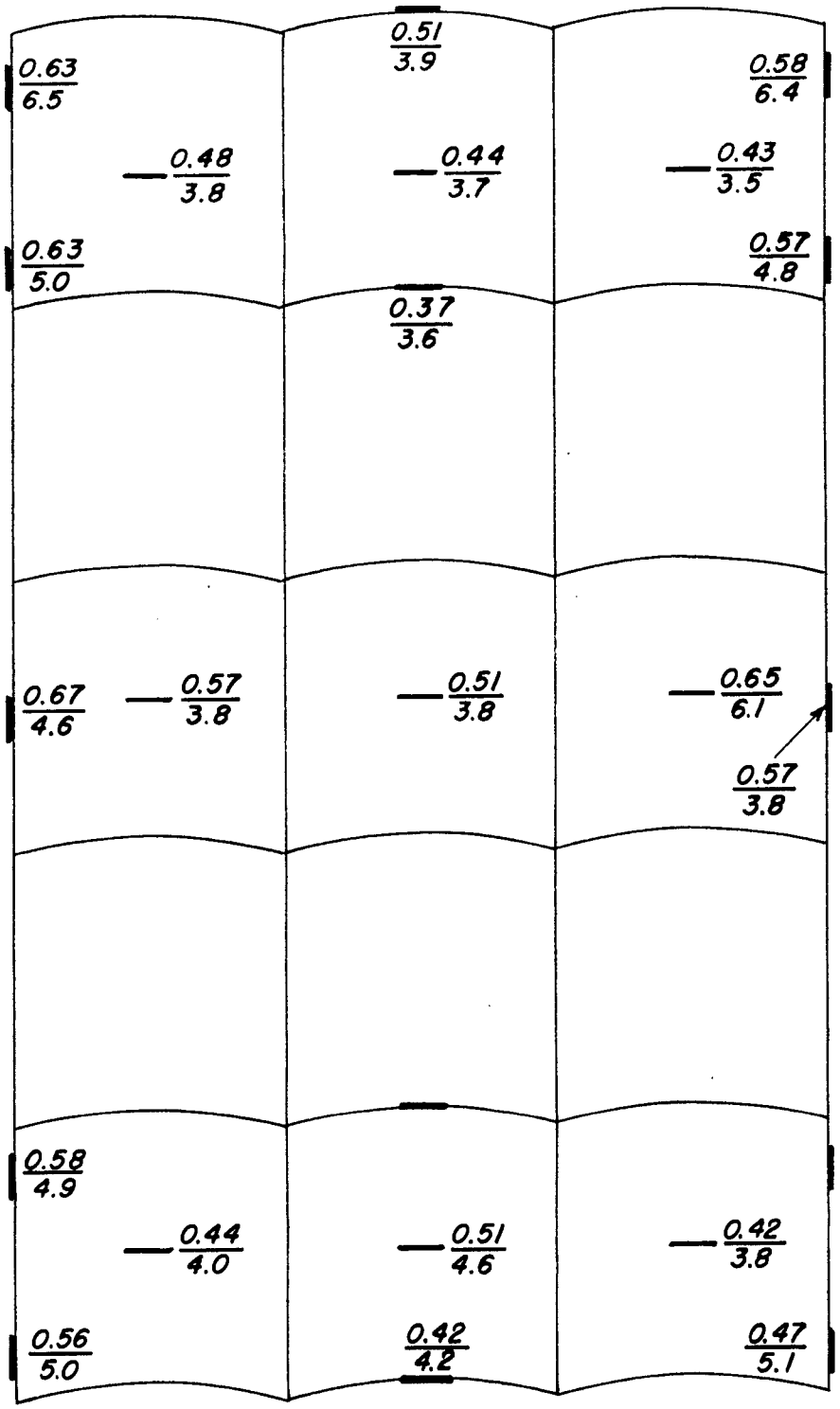


Fig. 3-3 - Neutron Flux in Top Plane of Active Lattice

[redacted]

Numerator is NV_{th} Relative to NV_{th} at Center of Lattice

Denominator is Cadmium Ratio ÷ 1.1

[redacted]

The results, measured at thermal neutron fluxes between 2×10^9 and 4×10^9, and normalized to a flux of 1.0 neutrons/cm^2 sec at the center of the lattice, are presented in Tables 3-1 through 3-5. Corresponding values used in designing the cooling for the graphite reflector and the thermal shield are also given for references. In comparing the measured and the design values, the measured values were multiplied by a factor of 1.5 to correct for the lower power but greater reactivity of the small lattice. Upon this basis the neutron fluxes in most of the graphite are less than predicted by about 50 percent. In the vicinity of the HG 9 hole and the open northwest thimble the measured neutron flux exceeds the calculated flux by about 25 percent. On the top and bottom surfaces of the graphite the calculated flux is greater than the measured flux by factors of 1.4 to 5.

The situation from the standpoint of thermal shield design is not so favorable at the outer surface in the midplane. The ratio, design/1.5 measured, varies between 0.77 and 1.7 along the west side and between 0.98 and 0.53 along the north side. However, the thermal shield does not extend into the region of high neutron flux on the north side so no problem exists there. Only operation with completely open beam holes would result in fluxes along the west side appreciably greater than design. These conclusions are based upon data obtained without a steel thermal shield. Measurements made between a four foot square steel shield and the surface of the graphite near the northwest thimble indicate that the introduction of steel may result in 10 to 20 percent lower fluxes in the corners and 10 to 15 percent greater fluxes near the center of the sides of the graphite reflector.

The data indicate that the predicted heat production in most of the graphite was overestimated by a factor of 2 to 4. Near the top surface of the graphite the measured gamma radiation heat is less than the design values by factors of 3 to 6 and near the bottom surface it is less by factors of 1.4 to 8. Near the outer surface in the midplane the ratio, design/1.5 measured, varies between 6 and 11 with the thimbles filled with beryllium and between 1.5 and 5 with the northwest thimble empty. Since the design of the thermal shields was based upon the absorption of capture gammas from the steel and the absorption of pile and reflector gammas producing equal quantities of heat, it appears that the design heat production rates will not be exceeded in any critical zone and that they are conservative by a factor of 1.5 to 2 in most critical places. The total heat produced in the thermal shield with 60,000 kw operation should be nearer 50 kw than the calculated 100 kw.

TABLE 3-1

Neutron Flux in Midplane of Graphite Reflector

HOLE NO.	NW THIMBLE BERYLLIUM FILLED		NW THIMBLE OPEN		DESIGN	RATIO: DESIGN/1.5 MEASURED	
	nv_{th}* ($\times 10^{-3}$)	Cd RATIO**	nv_{th}* ($\times 10^{-3}$)	Cd RATIO**	nv_{th}* ($\times 10^{-3}$)	THIMBLE FILLED	THIMBLE OPEN
44	120.				150.	0.83	
45	60.	63			90	1.0	
46	70.	53			150	1.4	
13	23		27	90	65	1.9	1.6
19	12		16		25	1.6	1.2
20	28				50	1.2	
21	52				60	0.77	
12	8.6	530			30	2.3	
15	7.9		18	40	15	1.3	0.77
18	5.0				12	1.6	
26	2.1				5.4	1.7	
27	3.2				9.5	2.0	
28	8.6				14	1.1	
29	12.				26	1.4	
11	2.6				6.0	1.5	
16	1.8				5.0	1.8	
17	1.2				3.0	1.7	
25	0.54				1.7	2.1	
34	0.23	1100	0.30	210	0.50	1.5	1.1
35	0.48				1.0	1.4	
36	0.88				2.0	1.5	
37	1.5				2.5	1.1	
38	1.9				3.0	1.1	
11***	1.1		0.92		1.6	0.97	1.2
16	0.55		1.1		1.2	1.5	0.72
17	0.37				0.95	1.7	
25	0.23				0.45	1.1	
34	0.19		0.24		0.22	0.77	
35	0.19				0.28	0.98	
36	0.29				0.39	0.90	
37	0.65		0.65		0.56	0.58	
38	0.86		0.45		0.68	0.53	1.2

* Normalized to 1 n/cm^2 sec @ center of core.
** Corrected for absorption of resonance neutrons.
*** Outer surface of graphite behind hole.

TABLE 3-2

Gamma Heat in Midplane of Graphite Reflector

(Heat Production - watts/cm^3*)

HOLE NO.	DESIGN ($\times 10^{-18}$)	MEASURED		RATIO: DESIGN/1.5 MEASURED	
		THIMBLE Be FILLED ($\times 10^{-18}$)	THIMBLE OPEN ($\times 10^{-18}$)	THIMBLE FILLED	THIMBLE OPEN
44	1600	450	470	2.4	2.3
45	680	150	250	4.2	1.7
46	1100	400	560	1.9	1.3
13	240	37	44	4.3	3.6
19	110	8.4	14	8.7	5.3
20	230	32	44	4.8	3.5
21	440	74	82	4.0	3.6
12		8.2	8.5		
15		6.1			
18		3.4	7.1		
26		1.1	1.6		
27		2.3			
28		5.0			
29		7.6			
11	23	2.3	3.2	6.6	4.8
16	18	1.5	4.1	8.0	5.2
17	11	0.7	4.7	10.5	1.5
25	6.4	0.4	0.9	10.7	4.8
34	3.0	0.2	0.4	10.0	4.3
35	4.0	0.3		8.8	
36	6.0	0.5		8.0	
37	8.0	0.9		6.0	
38	10.0	1.1		6.1	

* Normalized to nv_{th} = 1.0 n/cm^2 sec at center of core.

TABLE 3-3

Neutron Flux in Top and Bottom Planes* of Graphite Reflector

	POSITION (in. from tank)	NORMAL ** nv_{th} ($\times 10^{-3}$)	Cd*** RATIO	DESIGN nv_{th} ($\times 10^{-3}$)	DESIGN / 1.5 MEASURED
BOTTOM PLANE	6	0.46	~ 100	2.1	3.0
	18	0.67	~ 200	1.7	1.7
	24	0.71		1.5	1.4
	30	0.43		1.1	1.7
	47	0.10	~ 500	0.44	2.9
	59	0.049		0.30	4.1
	62	0.043		0.20	3.1
TOP PLANE	6	0.13	~ 700	0.97	5.0
	18	0.21	~1100	0.85	2.7
	24	0.20		0.80	2.7
	30	0.23		0.57	1.7
	47	0.070	~ 800	0.25	2.4
	59	0.048		0.15	2.1
	62	0.046		0.10	1.5

* Measured at surface of graphite along intersection of vertical plane through holes 17 and 46.

** Normalized to $nv_{th} = 1.0\ n/cm^2$ sec at center of core.

*** Corrected for absorption of resonance neutrons.

TABLE 3-4

Gamma Heat in Top Plane* of Graphite Reflector

(Heat Production - watts/cm^3 **)

HOLE NO.	DESIGN (x 10^{-18})	MEASURED (x 10^{-18})	DESIGN / 1.5 MEASURED
44	16	1.9	5.6
45	13	2.6	3.3
46	15	1.6	6.3
13			
19	6.5	0.79	5.5
20	9.4	1.2	5.2
21	12	1.4	5.7
12	5.8	1.0	3.9
15	5.1	0.74	4.6
18	3.3	1.2	1.4
26	3.2	0.32	4.6
27	2.9	0.29	6.7
28	3.6	0.47	5.1
29	4.7	0.37	8.5
11	3.3	0.50	4.4
16	2.9	0.32	6.0
17	2.2	0.26	5.6
25	1.5	0.21	4.8
34	0.7	0.16	2.9
35	1.0	0.23	4.3
36	1.3	0.16	5.4
37	1.8	0.16	7.5
38	2.2	0.22	6.7

* Measured in graphite 6 in. below top plane.

** Normalized to nv_{th} = 1.0 n/cm^2 sec at center of core.

TABLE 3-5

Gamma Heat in Bottom Plane* of Graphite Reflector

(Heat Production - watts/cm^3 **)

HOLE NO.	DESIGN (x 10^{-18})	MEASURED (x 10^{-18})	DESIGN / 1.5 MEASURED
44	32	15	1.4
45	26	12	1.4
46	30	9.5	1.9
13			
19	13	2.6	3.3
20	19	4.7	2.7
21	24	8.7	1.8
12	12	1.4	5.7
15	10	1.5	4.4
18	6.6	0.95	4.6
26	4.4	0.37	8.0
27	5.8	0.79	4.9
28	7.2	1.1	4.3
29	9.4	1.4	5.7
11	6.6	0.63	7.0
16	5.8	0.68	7.8
17	4.4	0.40	7.3
25	3.0	0.18	11.
34	1.4	0.16	5.8
35	2.0	0.26	5.1
36	2.6	0.22	7.8
37	3.6	0.37	6.5
38	4.4	0.42	7.0

* Measured in graphite 6 in. above bottom plane.

** Normalized to nv_{th} = 1.0 n/cm^2 sec at center of core.

Servo Control Mechanism for Regulating Rod. An automatic neutron level control mechanism has been installed in the Mock-up. In this installation the neutron flux is monitored by a 3 in. multiple plate ionization chamber so arranged that any deviation from a predetermined level activates the regulating rod drive in a manner appropriate for correcting the deviation. For convenience this sensory and controlling device is referred to as the "servo." It is apparent, from preliminary observations, that the operating power level is held quite constant and the servo response is fast. The neutron level, as recorded by other ionization chamber signals, is constant to well within a percent when the reactor is not manually disturbed. Large changes in shim rod positions cause some change in apparent neutron level chiefly because of shading, since the level ion chambers and the servo ion chamber are located on opposite sides of the reactor. When the mock-up is operated at approximately 250 watts, a current of 30 microamperes flows through the servo ion chamber. When the power is reduced to seven watts, the servo ion current is about one microampere and the background noise is sufficient to cause the regulating rod to vibrate considerably, even with no water flow. Investigations are now being made of the use of filters and their effect on response times.

The servo demand level, which determines the reactor operating level, is controlled by means of a logarithmic potentiometer in the ion chamber load; two decades, from 2.5 to 250 watts, are covered in 100 steps or approximately 4% per step. A step change in demand level of 4% is followed by a corresponding change in neutron level, the new neutron level being attained in less than 0.2 seconds.

The reactor operating level can be increased at either fast or slow speed and reduced at slow speed by action of the servo mechanism alone. An attempt to lower the power level rapidly with the servo results in a simultaneous insertion of the shim-safety rods.

Calibration of Regulating Rod. It was necessary to evaluate the change in reactivity of the mock-up as the regulating rod is completely withdrawn. This was of particular interest prior to automatic regulation with the servo. It would be undesirable for an increase in reactivity (of sufficient magnitude to make the reactor prompt critical) to be accidentally imposed by a failure of the control mechanism resulting in the sudden withdrawal of the regulating

rod. For safety, therefore, it was necessary to know the regulating rod sensitivity to be less than about 0.7% in $\Delta k/k$ where Δk is the change in reactivity produced by the regulating rod withdrawal.

In a series of experiments, the regulating rod was withdrawn manually by small increments when the reactor was critical and the change in reactivity determined from measurements of the resulting period. A summation of these incremental reactivity changes over the entire regulating rod length has shown it to be equal to about 0.6% in $\Delta k/k$.

Effect of Water Flow Through Reactor. Some preliminary observations have been made of the stability and control of the reactor when critical with the design flow of water through it. A steady flow of approximately 15,000 gal/min of water was maintained through the reactor corresponding to a linear velocity of approximately 30 ft/sec between the plates in the fuel elements. The recirculating water was not completely free of bubbles. The fuel elements were not rigidly mounted in the lattice and were subject to horizontal displacements of ± 1/16 in. due to the turbulence of the flow. With manual operation there was no inordinately large fluctuation in the neutron level during steady flow or when the flow was started or stopped.

When the reactor was operating on automatic control some instability was evidenced by the continually reversing motion of the regulating rod. It has not yet been determined if the neutron level fluctuation is due to air bubbles or to mechanical instability of the fuel elements.

INSTRUMENTATION

Summary. Instrumentation development for the MTR has been a part of the experimental program of the mock-up, and its progress has been included in the mock-up reports. A number of the circuits have been carried beyond the experimental stage and their progress toward fabrication for the MTR is recorded here.

The circuits for the MTR safety system and the period meter have been given to the Instrument Division for construction of prototypes. The circuits of the period amplifier, counting rate meter and high voltage supply for the differential chambers are now available for construction of additional units.

The shim rod control diagram is being brought up to date. The general layout of the console has been decided upon and detail drawings are being made by Blaw-Knox.

Instrumentation for the water monitoring room has been given consideration, and it has been decided that water activity will be measured after a 90 second hold-up by three twelve-point fission product monitors and a Brown electrometer. Provision for by-passing the hold-up coils will be made so that the N^{16} activity can be measured if desired. Water temperature will be measured in each channel by connecting thermocouples to three twelve-point recorders with individual high temperature alarms. Water flow will be monitored continuously in each channel and a scram signal initiated when the flow in any channel becomes less than that in a nearby channel. The total water flow will be measured and will cause a scram if it falls below 80% of normal while the reactor is operating at greater than 1/30 full power.

CORROSION

Summary. Corrosion tests of approximately two months duration have been completed on production samples of hot-pressed and extruded beryllium exposed to distilled water at 85°C. The solution was 0.005 *M* in H_2O_2 and a *p*H of of 5.5 to 6.5 was maintained. The hot-pressed samples were machined and/or ground in different ways so that the effect of surface finish and cold working on corrosion resistance could be studied.

It was found that the kind of surface finish and the amount of cold working influence the initial corrosion resistance of beryllium; however, the calculated penetration rates, in all instances, were low. In general, ground surfaces were more corrosion resistant than milled surfaces. Calculated penetration rates for QM-V, QRM, and QPT beryllium averaged 0.008, 0.014, and 0.006 mils/mo., respectively. These rates are based on Radiac surfaces which were ground smooth. Radiac surfaces ground by cuts of 0.005, 0.010, and 0.020 in. exhibited no significant difference in corrosion resistance. The corrosion rate for milled surfaces generally increased as the depth of cut was increased from 0.020 in. to 1/2 in., although the maximum rates obtained were comparatively low. The corrosion resistance of milled surfaces was enhanced by grinding.

The most noticeable corrosion damage on the hot-pressed metal was caused by shallow pits which were more prevalent on the QRM samples. The maximum pit depth was 13.8 mils. Since pitting is believed to be caused by impurities in the metal, an effort is being made to determine which constituents act as pit nuclei.

Corrosion rates for vacuum-cast extruded beryllium averaged 0.011 mils/mo. Pitting was mild; the maximum depth was 3.5 mils.

Accelerated tests on beryllium exposed to distilled water at 250°C have revealed no severe corrosion damage. A few small blistered areas have occurred on hot-pressed metal after 96 hours of exposure. These blisters exhibited little tendency to expand during longer exposure periods. Rough-machined surfaces appear satisfactory for short-term autoclave tests.

An accelerated test on three rough-machined Class A pieces of QM-V beryllium revealed no defects.

Static Corrosion of Hot-Pressed Beryllium Exposed to Distilled Water at 85°C. Corrosion tests of approximately 60 days duration were run to determine the relative corrosion resistance of QRM, QM-V, and QPT hot-pressed beryllium exposed to distilled water at 85°C. The solution was 0.005 *M* in H_2O_2 and a *p*H range of 5.5 to 6.5 was maintained. All three types of beryllium samples were machined and/or ground in different ways so that the effect of surface finish and cold working on the corrosion resistance could be studied.

The samples were machined by the Brush Beryllium Company from block Nos. Y-4460BP QRM, Y-4483BP QPT, and Y-4478BP QM-V. The general procedure used for machining the samples was as follows: After rough-machining the blocks, slabs 1 in. in thickness were cut on a Peerless saw. These slabs were cut into 1 in. cross sections on a shaper and were then ground to size. The ground 1 in. cross-section bars were used to make the 1 in. × 1 in. × 1/4 in. test pieces by the following procedures:

A: 1. First 1 in. × 1 in. × 1/4 in. thick pieces were cut off with a Radiac

2. Then ground on a surface grinder to remove Radiac wheel marks.

B: 1. First 1 in. × 1 in. × 1/4 in. thick pieces were cut off with a Radiac

2. Then 0.005 in. grind at one cut was taken on each of both faces.

C: 1. First 1 in. × 1 in. × 0.270 in. thick pieces were cut off with a Radiac

2. Then 0.010 in. grind at one cut was taken on each of both faces.

D: 1. First 1 in. × 1 in. × 0.290 in. thick pieces were cut off with a Radiac

2. Then 0.020 in. grind at one cut was taken on each of both faces.

E: 1. First 1 in. × 1 in. × 0.290 in. thick pieces were cut off with a Radiac

2. Then 0.020 in. single milling machine cut was taken on each of both faces.

F: 1. First 1 in. × 1 in. × 0.290 in. thick pieces were cut off with a Radiac

2. Then 0.020 in. single milling machine cut was taken on each of both faces

3. Then both faces were ground smooth.

G: 1. First 1 in. × 1 in. × 1/2 in. thick pieces were cut off with a Radiac

2. Then 1/8 in. single milling cut was taken on each of both faces

3. Then both faces were ground smooth.

H: 1. First 1 in. × 1 in. × 3/4 in. thick pieces were cut off with a Radiac

2. Then 1/4 in. single milling machine cut was taken on each of both faces

3. Then both faces were ground smooth.

I: 1. First 1 in. × 1 in. × 3/4 in. thick pieces were cut off with a Radiac

2. Then 1/4 in. single milling cut was taken on each of both faces.

J: 1. First 1 in. × 1 in. × 1-1/4 in. thick pieces were cut off with a Radiac

2. Then 1/2 in. single milling cut was taken on each of both faces

3. Then both faces were ground smooth.

K: 1. First 1 in. × 1 in. × 1-1/4 in. thick pieces were cut off with a Radiac

2. Then 1/2 in. single milling machine cut was taken on each of both faces.

All milling machine cuts were made with a 6 in. carbide-tipped end mill-HA grade, 135 rpm speed, and 1.180 in. feed per minute. Coolant used was synthetic turpentine. All grinding was done on a No. 5 Brown and Sharpe surface grinder using a crystalline wheel No. 32A60-H8YBE, 10 in. × 1/2 in. × 3 in. hole. Table feed was 20 ft per minute. Wheel rotates at approximately 2300 rpm. Radiac cutting wheel used was type C-90 LRE-23, 10 in. dia. × 1/32 in. thick.

Twelve samples of each type, machined by procedure A, were tested to determine the relative corrosion resistance of the three types. These samples were selected so that they were machined from several different locations in the starting blocks. The calculated penetration rates for the QM-V, QRM, and QPT beryllium were 0.008, 0.014, and 0.006 mils/mo., respectively. Corrosion data are given in Tables 3-6, 3-7, and 3-8. The most noticeable corrosion damage was shallow pits which were more prevalent on the QRM samples. The cause of the more severe pitting attack on the QRM beryllium is not evident from an examination of the reported chemical analysis. In an effort to determine the cause of this pitting, corrosion tests are to be run on samples in which the impurity areas have been mapped by metallographic methods.

An examination of the corrosion data for the samples machined and/or ground in different ways indicates that surface finish and cold working influence the initial corrosion resistance of beryllium. These data are given in Tables 3-6, 3-7, and 3-8. In general, ground surfaces were the most corrosion resistant. Radiac surfaces ground smooth by cuts of 0.005, 0.010, and 0.020 in. exhibited about the same corrosion resistance. The high penetration rate caused by numerous small pits for the QRM samples, machined by Procedure C, is not believed to have been caused by machining procedure. The pits on these specimens were distributed uniformly over all the exposed surfaces. The sides of all the specimens tested were machined by the same procedure, yet no pitting comparable to that which occurred on these samples was observed. Surfaces produced by milling machine cuts varying from 0.020 in. to 1/2 in. exhibited an increase in corrosion rate. The corrosion resistance of these milled surfaces was enhanced by grinding. Surfaces produced by grinding cuts immediately following heavy milling machine cuts (greater than 1/8 in.) were not as corrosion resistant as those obtained by light milling cuts followed by grinding. This corrosion behavior probably indicates that the corrosion resistance is influenced by the kind of surface finish as well as the amount

TABLE 3-6

Static Corrosion of QM-V Beryllium Exposed to Distilled H_2O

(Temperature 85°C, *p*H Range 5.5-6.5, 0.005 *M* H_2O_2, Test Period 59 Days)

MACHINING PROCEDURE	PIT COUNT PER CM^2	MAXIMUM PIT DEPTH (Mils)	AVERAGE PIT DEPTH (Mils)	MAXIMUM PIT DIAMETER (Mils)	DEFILMED WEIGHT LOSS (mg/Decim.^{2})	PENETRATION RATE (Mils/mo)
A	0.8	0.7	0.6	8	7.4	0.008
A	2.0	3.2	0.5	8	7.4	0.008
A	0.9	2.1	0.7	8	7.9	0.009
A	0.5	1.3	0.6	8	12.6	0.014
A	0.3	3.5	0.6	8	5.8	0.006
A	0.5	2.1	0.6	4	4.7	0.005
A	2.9	2.4	0.6	12	7.4	0.008
A	1.3	0.9	0.6	4	9.0	0.010
A	2.4	2.0	0.8	12	8.4	0.009
A	3.7	0.9	0.4	16	5.8	0.006
A	0.6	7.1	0.8	8	6.3	0.007
A	1.7	1.0	0.6	4	10.0	0.011
B	1.7	4.7	1.8	40	8.4	0.010
B	0.7	7.2	3.5	60	17.9	0.022
C	0.9	4.7	2.0	40	13.7	0.017
C	0.5	5.1	2.8	60	12.6	0.015
D	4.7	5.5	1.4	20	13.	0.017
D	3.7	5.0	1.7	28	16.3	0.020
E	5.3	7.1	0.8	40	21.6	0.026
E	3.7	5.0	3.5	60	23.6	0.029
G	3.2	5.1	1.2	40	10.0	0.012
G	3.2	4.5	1.4	60	13.7	0.017
H	2.0	5.0	0.9	40	14.7	0.018
H	1.6	6.5	1.6	80	20.5	0.025
I	2.0	5.9	3.3	80	26.8	0.032
I	4.4	4.9	3.1	100	34.2	0.041
J	0.3	4.0	2.6	60	15.8	0.019
J	0.8	4.8	3.9	60	13.7	0.017
K	3.9	5.9	3.5	100	45.7	0.056
K	3.7	4.7	3.5	60	36.3	0.044

TABLE 3-7

Static Corrosion of QRM Beryllium Exposed to Distilled H_2O

(Temperature 85°C, *p*H Range 5.5-6.5, 0.005 *M* H_2O_2, Test Period 61 Days)

MACHINING PROCEDURE	PIT COUNT PER CM^2	MAXIMUM PIT DEPTH (Mils)	AVERAGE PIT DEPTH (Mils)	MAXIMUM PIT DIAMETER (Mils)	DEFILMED WEIGHT LOSS (mg/Decim.^{2})	PENETRATION RATE (Mils/mo)
A	3.9	9.9	2.4	20	9.5	0.010
A	3.7	12.2	1.3	12	12.6	0.013
A	4.9	4.7	1.1	28	13.1	0.014
A	3.2	6.3	1.2	60	14.7	0.015
A	6.0	4.7	1.3	20	13.1	0.014
A	4.5	2.8	1.2	10	12.1	0.013
A	4.7	2.8	0.5	20	13.1	0.014
A	6.7	3.9	1.2	10	18.9	0.020
A	5.7	4.7	1.3	40	8.4	0.009
A	3.1	3.5	0.9	12	11.6	0.012
A	3.9	10.6	1.1	30	13.3	0.014
A	4.9	2.8	1.2	28	9.5	0.010
B	3.8	9.9	0.9	20	16.8	0.018
B	2.1	4.1	1.7	39	12.1	0.013
C	Numerous	8.3	0.6	20	33.1	0.036
C	Numerous	3.9	0.5	20	31.0	0.034
D	4.0	2.9	1.7	39	13.7	0.015
D	4.1	5.1	1.7	20	12.1	0.013
F	4.5	9.4	2.4	20	16.8	0.018
F	6.3	6.7	1.6	39	15.8	0.017
G	5.7	13.8	2.1	20	13.2	0.014
G	2.7	6.3	1.6	60	10.5	0.011
H	2.9	4.3	1.8	39	20.5	0.022
H	5.8	5.1	1.4	60	22.1	0.024
J	3.7	7.1	1.2	79	18.9	0.021
J	3.8	4.5	2.4	60	21.6	0.024
J	4.3	4.3	2.9	39	22.6	0.025
J	5.1	5.5	2.6	69	22.1	0.024

TABLE 3-8

Static Corrosion of QPT Beryllium Exposed to Distilled H_2O

(Temperature 85°C, *p*H Range 5.5-6.5, 0.005 *M* H_2O_2, Test Period 69 Days)

MACHINING PROCEDURE	PIT COUNT PER CM^2	MAXIMUM PIT DEPTH (Mils)	AVERAGE PIT DEPTH (Mils)	MAXIMUM PIT DIAMETER (Mils)	DEFILMED WEIGHT LOSS (mg/Decim.^{2})	PENETRATION RATE (Mils/mo)
A	1.8	1.8	0.7	20	3.7	0.004
A	2.0	2.0	0.6	8	6.3	0.007
A	2.2	2.3	0.8	8	6.8	0.007
A	1.6	0.9	0.6	10	3.7	0.004
A	2.7	1.2	0.7	12	6.3	0.007
A	2.2	1.0	0.6	8	7.4	0.008
A	1.3	1.0	0.7	12	6.3	0.007
A	2.0	1.1	0.6	12	4.7	0.005
A	3.2	1.1	0.6	8	6.8	0.007
A	2.9	1.3	0.7	20	5.8	0.006
A	2.7	1.0	0.8	20	5.8	0.006
A	3.8	1.9	0.9	12	5.3	0.005
B	9.9	5.9	3.5	60	18.9	0.018
B	9.2	4.3	1.4	99	21.6	0.020
C	2.3	4.5	1.7	60	25.2	0.023
C	5.2	4.2	1.9	39	27.4	0.025
D	2.1	5.1	3.2	39	22.1	0.021
D	1.3	5.1	3.0	40	20.3	0.019
E	2.4	4.3	3.2	50	20.3	0.019
E	2.4	5.5	3.5	40	19.4	0.018
G	4.2	4.3	3.1	40	20.3	0.019
G	4.9	4.9	2.8	39	15.3	0.014
H	1.6	3.7	2.2	99	20.0	0.019
H	3.4	4.7	2.6	60	20.3	0.019
I	2.8	6.2	4.6	50	28.9	0.027
I	2.7	4.7	3.2	39	27.4	0.025
J	2.0	4.7	0.8	39	24.8	0.023
J	0.2	7.3	3.1	39	16.3	0.015
K	3.4	4.3	3.5	39	23.4	0.026
K	2.9	4.3	3.1	79	28.4	0.026

of cold working. However, no severe damage occurred on any of the samples as evidenced by the low calculated penetration rates.

It is emphasized that the above-mentioned effects of surface finish and cold working are based on the results of short-term tests. A better evaluation of the corrosion resistance can be made from the results of long-term tests now in progress.

Static Corrosion of Extruded Beryllium Exposed to Distilled Water at 85°C. Twelve specimens of vacuum-cast extruded beryllium (Heat No. 164) were exposed for 59 days to static distilled water at 85°C. The water was 0.005 *M* in H_2O_2, and a *p*H of 5.5—6.5 was maintained. The samples were rough-machined by lathe cuts up to 1/8 in. deep. Then they were machined to size (1 in. diameter × 1/4 in. thick) by lathe cuts of 0.005 to 0.010 in. The faces of six of the samples tested were ground smooth on No. 80 followed by No. 180 emery paper.

The corrosion data are given for these extruded samples in Table 3-9. The calculated penetration rate was 0.011 mils/mo. A few shallow pits were observed on most of the samples. No significant difference in corrosion resistance was observed for the ground and unground surfaces.

Accelerated Corrosion Testing of Hot-Pressed and Extruded Beryllium. Samples of various types of beryllium were exposed to distilled water at 250°C in an attempt to determine if accelerated corrosion tests are reliable in detecting chemical and metallurgical defects which would appear in long-term low temperature tests. Data for these tests are given in Table 3-10. A few shallow pits (2 mils maximum depth) appeared on all the samples at the end of the first 48-hour exposure. During the next 48 hours, small blistered areas formed on the old extruded samples and on one of the QRM samples. At the end of 264 hours of testing, small blistered areas had formed on two other QRM samples and one QPT sample. Blistered areas formed during the second 48-hour test exhibited little tendency to grow during the succeeding 168-hour test. The old extruded beryllium tested had previously shown poor corrosion resistance in low temperature tests. No blistering occurred on the hot-pressed or extruded beryllium (Heat No. 164) during the 60-day low temperature tests; however, this type of corrosion damage may develop during longer exposure periods.

An accelerated test of 96 hours duration was run on QRM and QM-V samples machined and/or ground in various ways. No significant difference in corrosion

TABLE 3-9

Static Corrosion of Extruded Beryllium (Heat No. 164) Exposed to Distilled H_2O

(Temperature 85°C, *p*H Range 5.5-6.5, 0.005 *M* H_2O_2, Test Period 59 Days)

MACHINING PROCEDURE	PIT COUNT PER CM^2	MAXIMUM PIT DEPTH (Mils)	AVERAGE PIT DEPTH (Mils)	MAXIMUM PIT DIAMETER (Mils)	DEFILMED WEIGHT LOSS (mg/Decim.^{2})	PENETRATION RATE (Mils/mo)
L*	None	-	-	-	9.3	0.010
L	None	-	-	-	10.6	0.012
L	0.2	2.8	0.5	20	8.0	0.009
L	None	-	-	-	8.0	0.009
L	0.5	2.4	2.0	20	8.6	0.009
L	0.3	0.8	0.4	8	10.6	0.012
M	1.1	3.2	2.0	40	14.0	0.015
M	0.4	2.4	0.6	20	8.0	0.009
M	0.3	1.4	1.4	20	10.6	0.012
M	None	-	-	-	12.6	0.014
M	0.3	2.4	0.8	24	9.3	0.010
M	0.7	3.5	0.8	20	10.6	0.012

* L - Rough-machined on a lathe, then machined to size by lathe cuts of 0.005 to 0.010 in., then both faces ground on No. 80 followed by 180 emery paper.

M - Rough-machined on a lathe, then machined to size by lathe cuts of 0.005 to 0.010 in. (no grinding done).

TABLE 3-10

Static Corrosion of Hot-Pressed and Extruded Beryllium Exposed to Distilled H_2O at 250°C

MATERIAL	SPECIMEN WEIGHT CHANGE Mg/Decim^2				SURFACE CONDITION*
	FIRST 48 HRS	NEXT 48 HRS	NEXT 168 HRS	TOTAL 264 HRS	
Ext. Be-Heat No. 164	4.7	11.3	6.0	22.0	
Ext. Be-Heat No. 164	4.0	10.0	4.0	18.0	
Ext. Be-Heat No. 164	5.3	7.3	4.0	16.6	
Ext. Be-Heat No. 164	3.3	8.6	6.7	18.6	
QRM Be-Y4460BP	1.6	11.6	21.0	34.2	3 blistered areas formed during 168-hr test.
QRM Be-Y4460BP	7.9	1.6	2.1	8.4	
QRM Be-Y4460BP	8.4	3.7	1.6	13.7	2 blistered areas formed during 2nd 48 hrs, 5 observed at end of 264 hrs.
QRM Be-Y4460BP	7.4	0.0	2.6	10.0	1 blistered area formed during the 168-hr test
QMV Be-Y4478BP	3.7	1.6	3.2	8.5	
QMV Be-Y4478BP	7.9	0.0	0.5	8.4	
	5.8	0.5	0.5	6.8	
	7.9	1.1	1.6	10.6	
QPT Be-Y4483BP	9.5	0.0	0.5	10.0	
QPT Be-Y4483BP	8.4	2.1	2.1	12.6	
QPT Be-Y4483BP	2.1	7.4	2.1	11.6	
QPT Be-Y4483BP	7.9	0.5	3.1	11.5	
QPT Be-Y4431	4.4	3.8	13.4	21.6	1 blistered area formed during the 168-hr test.
QPT Be-Y4431	2.5	4.1	4.4	11.0	
Ext. Be**	3.0	18.5	13.0	34.5	Numerous blistered areas formed during 2nd 48 hrs.
Ext. Be**	4.2	25.8	18.5	48.5	3 blistered areas formed during 2nd 48 hrs.

* A few shallow pits (2 mil maximum depth) were present on all the samples at the end of the first 48 hr test.

** Old extruded material that showed poor corrosion resistance in long-term tests.

behavior attributable to machining effects occurred during the short test period. The corrosion data are given in Table 3-11.

Accelerated Corrosion Testing of MTR Reflector Beryllium. Seven rough-machined Class A pieces of QM-V beryllium (Lot No. Y-4520) have been received from the Brush Beryllium Company. An accelerated test of 104 hours duration on three of the pieces, designated A-7, A-10, and A-11, revealed no chemical or metallurgical defects. Distilled water at 250°C was the corrosion medium.

TABLE 3-11

Corrosion Data For Hot-Pressed Beryllium Exposed to Distilled Water at 250°C

(Exposure Time - 96 Hours)

MATERIAL	MACHINING PROCEDURE	SPECIMEN WEIGHT CHANGE ($mg/Decim^2$)	SURFACE CONDITION*
QRM-Y4460BP	B	3.7	
QRM-Y4460BP	C	2.6	
QRM-Y4460BP	D	2.6	
QRM-Y4460BP	F	2.1	
QRM-Y4460BP	G	9.0	
QRM-Y4460BP	H	28.4	1 blistered area on side of specimen 1/4 in. × 1/4 in.
QRM-Y4460BP	J	1.9	2 small blisters on 1 side of specimen-Each 1/8 in. diameter
QMV-Y4478BP	B	17.3	1 blistered area on side of specimen 1/4 in.× 1/4 in.
QMV-Y4478BP	C	3.7	
QMV-Y4478BP	D	2.6	
QMV-Y4478BP	E	4.7	
QMV-Y4478BP	G	3.7	
QMV-Y4478BP	H	3.2	
QMV-Y4478BP	I	20.0	1 blistered area on side of specimen 1/4 in. × 1/8 in.
QMV-Y4478BP	J	7.4	
QMV-Y4478BP	K	4.2	

* A few shallow pits were present on all of the samples.

METALLURGY AND FABRICATION

MTR MOCK-UP FUEL PLATES

Blistering. Two additional natural uranium runs (N25, N26) gave high yields (90%) of blister-free plates after treatment with aluminum brazing flux (Eutectic No. 190) at 1100°F. Accordingly, production of plates containing enriched uranium was resumed.

Critical Experiment Production. Production of enriched uranium plates was resumed with a modified procedure incorporating an extra step, that of heating the clad plate to 1100°F while coated with a slurry of brazing flux. Yields were much improved over those obtained previously. Of 235 plates rolled, 201 did not blister. A listing of individual yields for each run is shown in Table 4-1. During the last five runs, the amount of flux applied to the plates was varied; in the cases of runs N31, N33, N35, a very heavy coating was applied. A thin coating was brushed on the plates from runs N32 and N34. As can be seen from Table 4-1, the former treatment seems to be best. An average yield of 96% was obtained from runs N31, N33, N35, while only a 69% yield was realized with runs N32, N34.

TABLE 4-1

Yields of Blister-Free Plates

HEAT No.	TOTAL PLATES	BLISTERED PLATES	YIELD OF UNBLISTERED PLATES (Percent)
N25	20	4	80
N26	21	4	81
N27	22	2	91
N28	22	2	91
N29	22	3	86
N30	20	3	85
N31	22	0	100
N32	20	6	70
N33	22	2	91
N34	22	7	68
N35	22	1	97
	235	34	Average 85.5

Analysis. Melt samples from runs CE20, CE34, and CE36 were submitted to the Y-12 analytical laboratory for mass analysis. Calculated values and actual values as determined at Y-12 are listed below. Since approximately 40% of the charge to any one heat was scrap from previous heat, these values are a good check on the U^{235} enrichment of all heats.

RUN	U WEIGHT		U^{235} WEIGHT	
	CALCULATED	ACTUAL	CALCULATED	ACTUAL
CE20	0.400 gm	0.400 gm	0.378 gm	0.379 gm
CE34	0.483	0.483	0.460	0.460
CE36	0.687	0.687	0.647	0.650

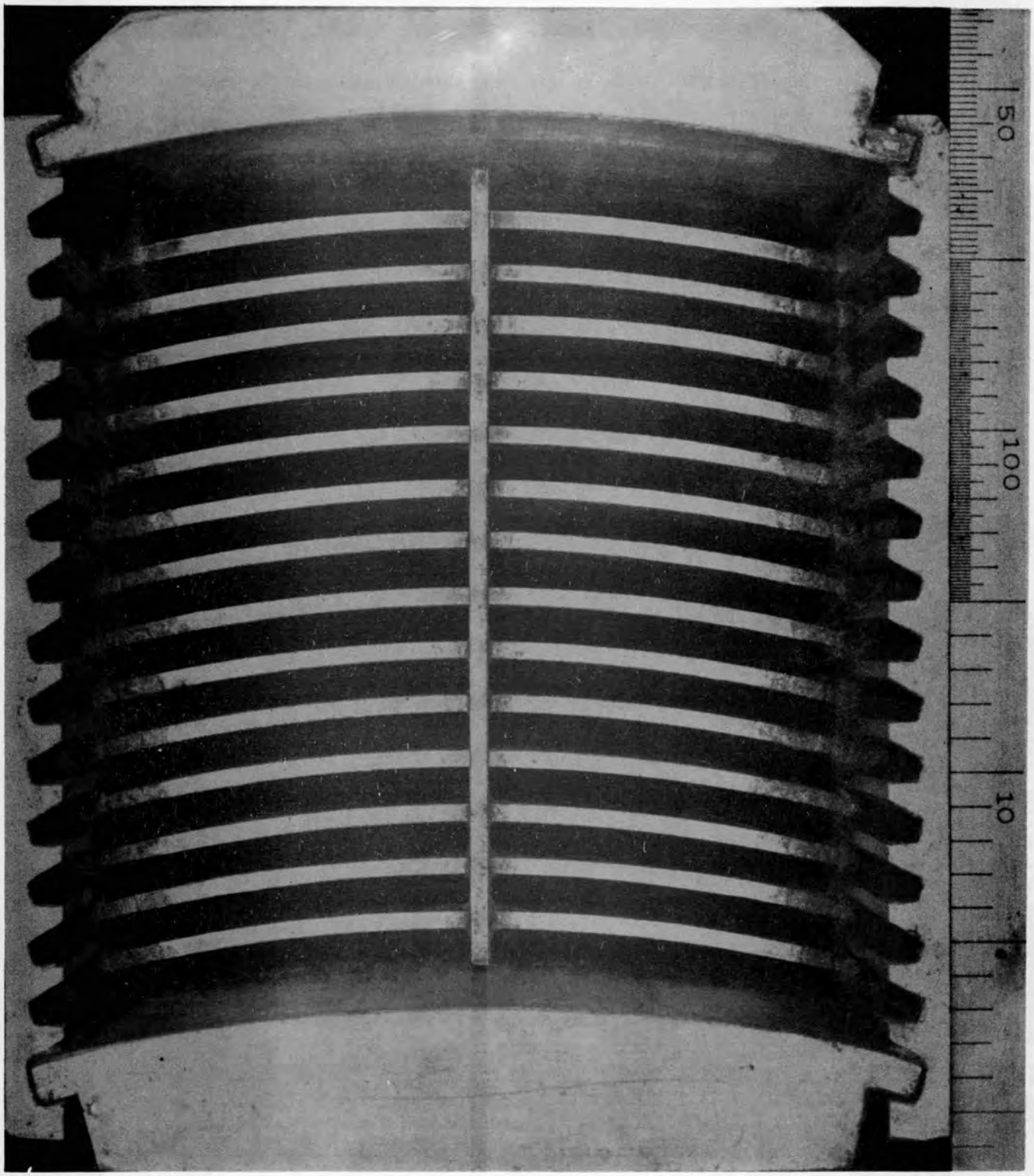
MOCK-UP CRITICAL EXPERIMENT FUEL ASSEMBLIES

Production. Eleven enriched fuel assembly units were produced, completing the commitment of fuel fabrication for the Materials Testing Reactor critical experiment. An additional fuel section was prepared for use in a shim safety rod for the experiment. A production technique, described below, was adopted which would insure preparation of such units with a minimum of rejection because of exposed uranium alloy. The uranium section, after brazing, is shown in Fig. 4-1. In addition to a heavy top and bottom plate of aluminum, the assembly differs from standard fuel sections in width. These units are smaller in width than the latter sections; therefore, the component plates are also smaller. After fabrication of active plates for standard fuel it was found feasible to select those plates most nearly centered for use in control-rod sections. With the aid of suitable templates and fluoroscopic examination, sufficient of these were set aside for further machining operations. It was found that all plates thus selected could be milled to proper dimensions satisfactorily.

Inspection. The previous MTR Quarterly Report[1] tabulates the results obtained for 25 enriched fuel assembly units. The key dimensions (Fig. 4-2) obtained on all 25 units are plotted in Fig. 4-3. The range of values obtained has been plotted against its frequency, thus, if one assembly shows a range of but 0.003 in. in sagitta, this point is shown as 4%, 0.003 in. (sagitta). Since no assembly shows a range greater than 0.026 in. for this dimension, the point 100%, 0.026 in. corresponds to the extremity of this curve.

(1) Mann, M. M. and Lane, J. A., *Materials Testing Reactor Project Progress Report for the Period Ending February 28, 1950*, ORNL 628 (Apr. 10, 1950).

PHOTO Y-1407



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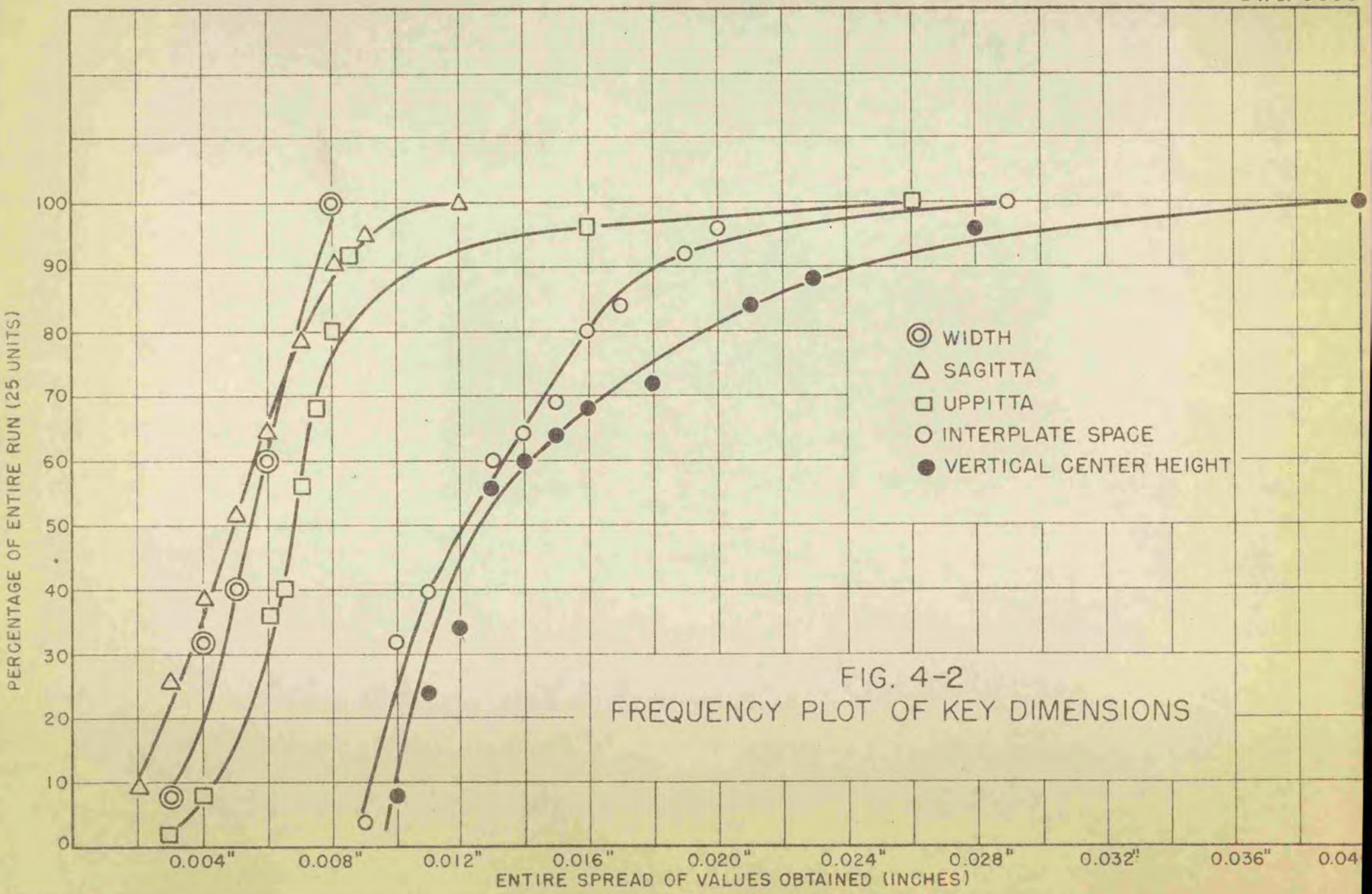

FIG. 4-2
FREQUENCY PLOT OF KEY DIMENSIONS

[redacted]

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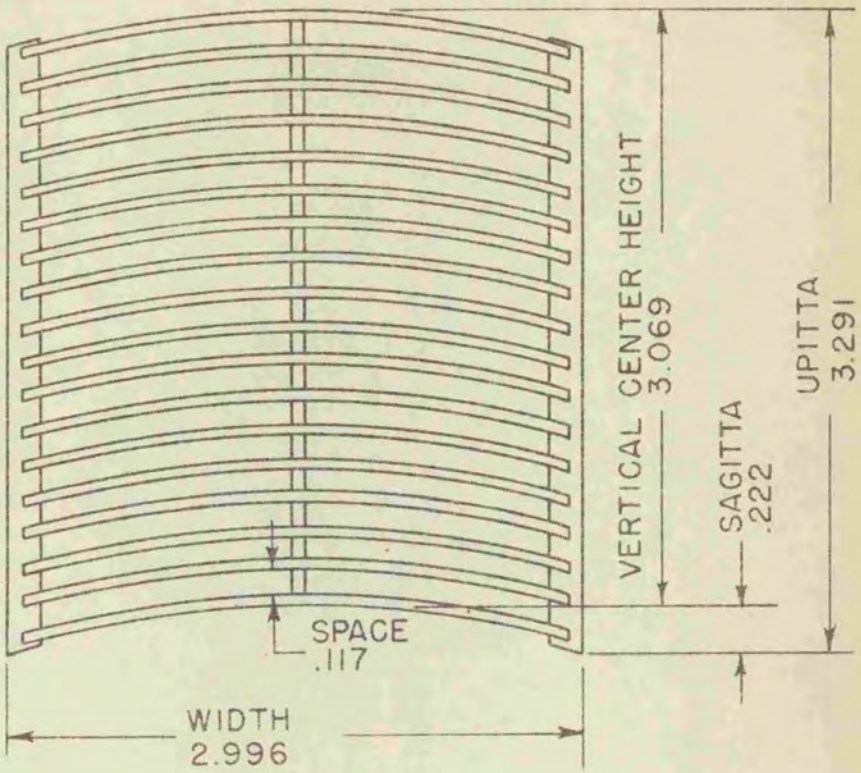

FIG. 4-3
FUEL ASSEMBLY DIMENSIONS

Storage. Cadmium foil was used as a shield-wrapper for the first enriched fuel assemblies produced. Some thought was given to the question of the possibility of cadmium pickup during handling and to ckeck this a series of filter paper smear tests was made. Although the cadmium pickup by the assemblies was found to be low, it was considered possible that large amounts could conceivably be picked up since cadmium is a ~~soft metal~~. As a precaution, subsequent assemblies were wrapped first in paper to avoid direct metal contact. The above work is covered in memorandum CF 50-2-48.[2]

FUEL ASSEMBLY—MISCELLANEOUS

Brazing. Experiments were made to study the feasibility of eliminating the drying and/or preheating steps in fuel assembly fabrication. Details are as follows:

OPERATION	DRYING		PREHEATING		BRAZING	
TYPE OF JIG	STAINLESS STEEL		CERAMIC		CERAMIC	
ASSEMBLY \ TIME TEMPERATURE	TIME MIN.	TEMP. °F	TIME MIN.	TEMP. °F	TIME MIN.	TEMP. °F
Standard procedure	120	302	50	850	38	1110
1	120	302	-	-	45	1100
2	120	302	-	-	55	1110
3	-	-	-	-	65	1110
4	-	-	-	-	75	1110
5,7	-	-	-	-	70	1110

In the first case there was insufficient flow of braze metal. In the second trial, braze joints were uniform and good. This established that the preheat part of the cycle may not be necessary. Assembly 3 was insufficiently brazed, while Assembly 4 had some run-through of braze alloy. Assemblies 5 and 7 had good brazed joints indicating that the time cycle was correct. However, dimensions such as plate spacing, width and vertical center height

(2) Drosten, F. W., *Cadmium Pick-up During Handling of MTR Fuel Assemblies*, CF 50-2-48 (Feb. 13, 1950).

were far out of tolerance. In the case of Assembly 7, the ceramic jig cracked badly during brazing. The poor dimensional results and the cracked jig are an indication that there was not enough clearance for expansion. Possibly this was due to flux in the grooves. These results were very encouraging and definitely established the feasibility of eliminating the preheating operation. Further development of this simplified fuel assembly process is being carried out.

Assembly for Irradiation Test at Chalk River. An insufficient number (14) of plates remained from the MTR Critical Experiment run to fabricate this assembly. Consequently another ingot was cast and rolled, and from it 22 additional plates were fabricated. All were blister-free when annealed at 1100°F. These have been machined. The assembly was brazed during the week of May 22 and has been shipped for testing.

Machining and Castings. In continuing the long term efforts of this section in setting up for reactor fuel production, an estimate has been obtained for the outside contracting of required machined aluminum parts. Precision Shapes Incorporated have submitted a proposal for the preparation of assembly side plates. The Research Shops superintendent has been informed of this proposal and suggests that a detailed study of costs be made.

In addition to these machined parts, end box castings must be procured. Several vendors of permanent mold and die castings are to be contacted for production proposals. The initial stock of sand castings has been depleted during the critical experiment fabrication run. Since the design of the units has been established, mass production operations can be utilized in supplying the necessary components.

Segregation in Ingots. To ascertain the relative distribution of uranium in cores and punching scrap, two ingots (N30, N31) were cast and rolled to 0.300 in. Twenty cores were punched from each slab. Then, in each case, the cores were melted in one batch and the scrap in another. Samples for assay were taken from each melt prior to pouring. Results in Table 4-2 show no significant difference.

TABLE 4-2

Segregation - Cores vs. Scrap

HEAT NO.	ANALYSES, PERCENT U		
	MELT	CORES	SCRAP
N30	13.41	13.34	13.30
N31	13.43	13.37	13.36

Alternate Site for Fabrication. At the request of the AEC, a survey was made of possible alternate sites for MTR Fuel Rod Fabrication. A memorandum covering this topic was issued.[3]

MTR BERYLLIUM

Specifications. The specifications for the beryllium for the MTR reflector were drawn up and transmitted to the Steering Committee for inclusion in the material request. They include chemical and metallurgical specifications for both hot-pressed and extruded metal.

Drilling. During the past quarter, six hot-pressed Materials Testing Reactor (MTR) reflector sections were deep-hole drilled in the Research Shops at ORNL. These full length (40 in.) sections were cut from the first large slab produced in the new horizontal sintering furnace recently installed at Brush Beryllium Company of Cleveland, Ohio. Results were most encouraging and indicated that hot-pressed metal could be drilled equally as well as extruded metal by the gun barrel drilling technique. Accuracies obtained in drilling the long, straight, 3/16 in. diameter cooling holes were greater than expected.

Practically all earlier drilling work was conducted on extruded stock, and there existed some doubt as to the direct applicability of this technique to the hot-pressed metal. In fact, comparison tests with high-speed drills at High Standard Manufacturing Company last summer showed that the hot-pressed metal entailed more frequent resharpening than did the extruded metal. This excessive tool wear was presumably due to the additional amount of beryllium oxide present in the hot-pressed metal. This difficulty was remedied with the use of the wolfram carbide tipped tools.

Below are given the pertinent data used in deep hole drilling and fabrication of the six sections into standard *A* type reflector units:

Drill diameter	0.184 in.
Angular speed of work piece (counterclockwise)	146 rpm
Angular speed of drill (clockwise)	1476 rpm
Angular speed of drill with respect to work piece	1622 rpm
Drill feed	0.392 in. per min
Coolant	Mixture 50-50 sulphurized oil-Varsol, plus 2-5% by volume Oil Dag
Coolant pressure	15-20 psi

(3) Smith, C. D., *Alternate Facilities for Fabrication of MTR*, CF 50-3-23 (Mar. 7, 1950).

MATERIAL IDENTIFICATION	HOLE DIAMETER (in.)		NO. OF DRILLS USED	END DIFFERENCE BETWEEN AXES OF DRILL AND WORK (in.)	MAX. VARIATION BETWEEN HOLES AND SIDES AFTER MACHINING (in.)	
	LOWER END	UPPER END			UPPER END	LOWER END
Y4460 BPQRM-1	0.1885	0.1880	4	<0.030	0.005	0.004
-2	0.1870	0.1875	2	0.016	0.004	0.002
-3	0.1875	0.1870	2	>0.005	0.001	0.002
-4	0.1870	0.1870	2	>0.005	0.000	0.002
-5	0.1880	0.1890	2	<0.005	0.001	0.002
-6	0.1870	0.1875	2	0.000	0.001	0.001

Four drill tools, stepped in convenient lengths (16, 28, 40 and 56 in.) to cover the forty-inch range adequately, were used in drilling the first unit. Shorter length drills are required in the beginning to minimize whipping of the tool shaft. Use of too many tools, however, increases the hole run out from straightness; therefore, only two tools were used in drilling the last five units and this appears to be the optimum number.

The drill tool uses its own prime mover and rotates on an axis independent of the workpiece. "End difference" refers to the maximum runout on the final end resulting from the drill rotating on one axis and the workpiece on another. After drilling, the unit is aligned on the hole axis and the sides are machined parallel to the hole axis. The last two columns in the table indicate the accuracy to which the lateral sides can be finished machined with respect to the water cooling channel.

NEUTRON WINDOW

The lead creep tests mentioned in the last MTR Quarterly Report[4] were discontinued and new ones were started to check the results obtained. In the new tests the deformation is being measured with SR-4 strain gauges. Chemical lead and lead calcium alloys are being held at 150°C under stresses of 30 and 60 psi.

(4) Mann, M. M. and Lane, J. A., op. cit., ORNL 628.

[redacted]

The specimens under the 60 pound stress have been stressed about 1000 hours and are elongating along smooth curves. The loading is not exactly axial so the two sides of the specimen are following different curves; however, they do seem to be approaching the same rate. The differences were in the first stage of the creep. The calcium-containing alloys are elongating more rapidly than those of chemical lead. This is not what was expected and work is being started to see if this is a true effect caused by the low stresses at high temperature or if it resulted from poor heat treatment. At present the average creep rate for the chemical lead is about 0.1 microinches per hour or about 0.1% per year. The average rate for the calcium lead is about 0.2% per year.

The specimens under a stress of 30 pounds have not yet (ca. 1000 hours) elongated enough to produce definite results.

Since the exact temperature of the window is not yet available and the results for 30 psi are doubtful it is desirable to obtain some curves from which the desired values can be extrapolated. To obtain such curves for both temperature and stress new tests are being set up. These tests include temperatures of 100°C, 150°C and stresses of 30, 45, 60, and 90 psi.

Consideration was given to the possible use of cast litharge as a neutron window.[5]

BORAL SHIELDING

A meeting was held with members of the Shielding Group in order to discuss the rolling and cladding of large ingots of Boral.[6]

Additional experimental rolling of small Boral ingots (4 in. × 4 in. × 1 in.) showed that compositions up to 50% B_4C by volume could be hot-rolled at temperatures as low as 700°F without reheating. Total rolling time per ingot was 3-1/2 minutes.

(5) Kerze, F., *Cast Litharge as a Neutron Window*, CF 50-5-114 (May 19, 1950).

(6) Smith, C. D., *Rolling and Cladding of Large Ingots of Boral*, CF 49-12-71 (Dec. 15, 1949).

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