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THE FAST CRITICAL ASSEMBLY

by

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SUMMARY

The fast zero power reactor experiment (ZPR-III) is planned to obtain neutron physics information necessary for the design of fast power breeder reactors.

The systems to be studied are blanketed cores having a range of compositions in which the volume fractions of U^{235} , U^{238} , Fe, and Na (simulated by reduced density Al) are varied.

This is accomplished by assembly of small pieces in drawers which are placed in an array of square tubes mounted on two carriages so that two half-critical sections initially separated may be brought together in a carefully controlled manner.

The reaction is controlled by inserting or removing drawers from the back of each half of the reactor with drives which are continually activated for scram under air pressure. Five of these safety-control drawers are provided in each half and may operate either in the core or blanket.

The build up of the first critical assembly was begun October 18, 1955, and the assembly went critical two days later, October 20.

INTRODUCTION

As a part of the program to establish the feasibility of a sodium-cooled, unmoderated, "fast power breeder" reactor for the production of economic power, Argonne National Laboratory has constructed a fast critical assembly facility, located at the National Reactor Testing Station. This facility has been designed and constructed in such a manner as to permit investigations over a wide range of fast power reactors. The first phase will see experiments on reactors fueled with U^{235} , having a maximum critical mass of 250 kilograms of fissionable material. However, later experiments, using larger amounts of fissionable material, including Pu^{239} , are contemplated.

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A review of the fast reactor's potential has been presented by Zinn¹ while a detailed description of the proposed prototype, Experimental Breeder Reactor II, has been given by Barnes, et al.² The EBR-II, as presently conceived, consists of an annular core of approximately 60 liters volume in the form of a right cylinder. The center of the annulus is to be filled with blanket material, and the core is to be fully blanketed, both radially and axially. Control is to be accomplished by the movement of fuel elements.

Typical dimensions and volume composition fractions for EBR-II are listed in Table I.

Table I

GEOMETRY AND COMPOSITION IN PER CENT BY VOLUME OF EBR-II

Region	Outer Radius, cm	Length, cm	Meat $U^{235} + U^{238}$	Fertile Material (Depleted U)	Structure (Steel)	Coolant (Na)
Control blanket	8	36	--	55	13	32
Core	24	36	32	--	17	51
Blanket above and below core	24	66	--	37	17	46
Inner radial blanket	35	168	--	55	13	32
Outer radial blanket	78	168	--	80	8	12

It is planned that early in the fast critical assembly program a detailed mockup of EBR-II be made to provide the physics data directly pertinent to its design. However, it is also planned to do a wide range of fundamental experiments in simple geometries in order to provide a firm experimental basis for fast reactor physics calculations.

¹W. H. Zinn, "Review of Fast Power Reactors," Geneva Conference Paper No. 814.

²A. H. Barnes, L. J. Koch, H. O. Monson, and F. A. Smith, "The Engineering Design of EBR-II, A Prototype Fast Neutron Reactor Power Plant," Geneva Conference Paper No. 501.

A survey of the present status of fast reactor physics at Argonne National Laboratory has been presented by Okrent, et al.³ This paper summarizes most of the presently available experimental information and makes clear the complete lack of data on assemblies similar to EBR-II, or even larger assemblies. A fundamental characteristic of unmoderated dilute reactors is the wide range of neutron energies over which those reactions important to the maintenance of the neutron chain take place. Hence, the variation of neutron cross sections with energy makes it important to know accurately, not only the cross sections as a function of neutron energy, but the energy spectrum of neutrons (itself a function of cross section) existing in the assembly. Present knowledge of cross sections in the energy range of interest, a few kilovolts to a few megavolts, is inadequate to assure prediction, by calculation, of the nuclear characteristics of such fast neutron assemblies.

The program for the critical assembly is thus aimed at establishing, primarily by integral experiments, the effective cross sections and neutron energy spectrum existing in the assembly, as well as the effects of geometry on nuclear performance.

³D. Okrent, R. Avery, and H. H. Hummel, "A Survey of the Theoretical and Experimental Aspects of Fast Reactor Physics," Geneva Conference Paper No. 609.

I. THE ASSEMBLY

A. Reactor

A photograph of the reactor is shown in Figure 1. The assembly machine is basically a platform on which two tables or carriages are mounted, one of which is movable. Half of the reactor is built up on each carriage by inserting drawers containing the reactor materials into a matrix structure consisting of square (2.18 in. x 2.18 in.) cross section stainless steel and/or aluminum tubing stacked in a square array (67 in. x 67 in.) and constrained in position by means of clamps which are fastened to the carriage.

The movable carriage allows the assembly to be split in half as a safety measure and is also convenient in loading and unloading operations.

Each half of the assembly contains five safety-control rods. These rods are fuel-removal type rods consisting of stainless steel fuel drawers fastened to the drive mechanism. Four of the rods in each half function as safeties, and the fifth is used as a control rod. By changing wiring connections, any one of the rods may be used as the control rod. Phone jacks are provided on the control panel to accomplish the wiring change to convert a safety to a control rod. On a scram, all the rods will act as safeties, being driven out of the reactor by compressed air.

Each half of the assembly contains a polonium-beryllium source which is driven in or out of the assembly by means of a motor drive.

A hinged platform, that may be swung into place between the separated halves to stand on for loading and unloading operations, is provided. An interlock insures that the platform is out before the carriage can move.

Electrical connections to the control console are by conduit through the shield wall.

1. Carriage Assembly

The assembly machine consists of two wide flange beams mounted parallel to each other with welded cross members forming a bed on which two carriages are mounted. One of the carriages is a stationary unit mounted at one end of the bed. The other carriage is movable, sliding on machined ways which insure accurate alignment of the movable carriage as the halves are brought together. Position-indicating devices are provided to check the position and alignment of the carriages as they approach each other. The carriage assembly bed is twelve feet long to provide sufficient travel of the movable carriage to separate the halves of the assembly by a distance of five feet in the open position. The carriages form a platform 67 in. x 100 in. on which to mount the assembly and controls.

Figure 1
Critical Assembly Machine

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The movable carriage is driven by a lead screw, which is connected through a slip clutch and speed reducer to three gear head motors mounted at the end of the bed. Each motor is provided with a magnetic clutch wired so that only one motor may be connected to the main speed reducer at one time. The motors provide three speeds for the carriage as the reactor halves are brought together.

The slip clutch is provided between the lead screw and speed reducer for two purposes. If any obstruction should be left between the carriages, the clutch will slip before any damage is done to the assembly. Also, when the carriages are driven together, the clutch allows them to be driven to an exactly reproducible position not dependent upon a limit switch. This is accomplished by setting the torque of the clutch somewhat higher than required to drive the carriage, and driving the carriage until the mating surfaces are in contact, causing the clutch to slip. This slipping is indicated on the control panel by a light connected by means of a commutator, so that slipping of the clutch causes this light to go on and off.

Limit switches at various positions along the travel determine the speed at which the halves may be assembled as follows:

- a. With a separation of 3 in. or less - low speed only, $1/2$ in. per minute ($3/4$ -HP drive motor)
- b. With a separation of 18 in. to 3 in. - intermediate speed only, 6 in. per minute ($3/4$ -HP drive motor)
- c. With a separation of 60 in. to 18 in. - high speed only, 30 in. per minute (3-HP drive motor)

On a scram, the carriage is driven out at a rate of 30 in. per minute for the entire travel by the 3-HP drive motor.

The movable carriage has the following position-indicating devices on the control panel:

- a. A linear dial showing position of the carriage for the full travel. This is graduated to 0.1 in.
- b. A linear dial, graduated to 0.050 in., indicating carriage position for the last 10 in. of travel.
- c. A linear dial, graduated to 0.005 in., indicating carriage position for the last $2-1/2$ in. of travel.

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- d. A circular dial, graduated to 0.001 in., indicating any misalignment of the carriages as they come together. This is driven by a differential selsyn operating between two selsyns, one located on each side of the carriage.

All these indicators are selsyn driven devices utilizing appropriate gearing.

2. Matrix Assembly

The matrix assembly is constructed of stacked tubes as described earlier. Each tube is 2.18 in. square and 33 in. long, with a wall thickness of 0.040 in. The aluminum tubes are 3003 F alloy, and stainless steel tubes are type 304. The first assembly is made entirely with the stainless steel tubes.

The core section of the matrix contains aluminum drawers with 0.032 in. wall thickness into which the reactor materials are placed for convenience of loading. The drawers are loaded in a separate work room, then brought into the assembly room and placed in position in the reactor.

The drawers are provided with lugs which engage in notches in the matrix tubes, so that they are accurately positioned and provide a flat interface between the assembly halves.

In the blanket section of the assembly, the slugs are loaded directly into the matrix tubes.

The slugs provided for loading the assembly are of various sizes to provide the desired flexibility of reactor arrangement in all sections of the reactor. Figure 2 shows the various sizes and kinds of slugs used. They can best be described by breaking the reactor down into sections. There is a cylindrical core section at the center of the reactor large enough in diameter and long enough to accommodate all anticipated cores to be built. A cylindrical end blanket section of the same diameter as the core section extends to the ends of the matrix tubes from the core section. An annular intermediate blanket section surrounds the core and end blanket sections for the length of the reactor to allow a fine structure at core blanket interface. An annular outer blanket section surrounds the intermediate blanket section the length of the reactor.

In the core sections, where the greatest flexibility of arrangement is desired, 15 in. long drawers are loaded with 2 in. x 1/8 in. slugs 1/2 in., 1 in., 2 in., and 3 in. long. These slug sizes are provided in U²³⁵, depleted uranium, stainless steel, and aluminum perforated to give apparent densities of 45% and 63%. Enough slugs of each material are provided to allow a large variety of core loadings to be assembled. The drawers are loaded by stacking the slugs on edge in the drawer to permit easy visual

Figure 2
Building Blocks

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inspection of the drawer loading. The aluminum slugs are color anodized to distinguish each density for this visual inspection. The U^{235} slugs are also coated with a 1-mil Teflon coating, colored to distinguish them from the depleted slugs. Thus each constituent of a drawer is easily distinguished on visual inspection of a loaded drawer.

Seventeen-inch long drawers in the end blanket section are loaded with 1 in. x 1 in. slugs 2 in., 3 in., and 5 in. long, since the required flexibility of arrangement is not as great in this section. These slug sizes are provided in depleted uranium, stainless steel, and special aluminum perforated to give an apparent aluminum density of 56%.

Fifteen-inch and seventeen-inch drawers in the intermediate blanket section are loaded with 1 in. x 1 in. slugs 2 in., 3 in., and 5 in. long and with 2 in. x 1/8 in. slugs 1/2 in., 1 in., 2 in., and 3 in. long. These slug sizes are provided in depleted uranium, stainless steel, and aluminum of 45%, 56%, and 63% apparent densities.

All the drawers in the core section are provided with special leaf springs which are inserted at the back of the drawer. The springs hold the slugs against the front of the drawer.

The outer blanket slugs are loaded directly into the matrix tubes in the assembly. The depleted uranium slugs are all 2 in. x 2 in. x 2 in., and the stainless steel and solid aluminum slugs are 2 in. x 2 in. x 1/4 in. The various density aluminum slugs are provided to allow the aluminum concentration to be changed in the reactor.

Figure 3 shows a typical loaded core and blanket drawer.

Thimbles are provided for experimental purposes at a number of points in the assembly, in both the vertical and horizontal directions. Thimble holes are located on both the vertical and horizontal center lines. These are located approximately every three inches in each half of the assembly.

Counter drives are provided that may be operated from the control panel to accurately position a counter in these thimbles. Travel of the drive is sufficient to move a counter completely across the assembly.

3. Safety-Control Rods

All the rods are dual purpose rods in that each can be operated as a control rod, yet all rods act as safeties in that they are driven from the reactor in the event of a scram.

Figure 3
Typical Drawer Loadings

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Each rod drive consists of a 1/4-HP reversible gear head motor, equipped with brake, driving a pinion through a magnetic clutch. The pinion drives a rack, connected on one end to a 2 in. air cylinder and on the other to a stainless steel fuel drawer. The drives are mounted on a support plate located at the end of the carriage so that the fuel drawer will slide in a matrix tube. The fuel drawer is chrome-plated to minimize the danger of galling and sticking of the rod.

One hundred forty psi air pressure is applied to one end of the air cylinder at all times, exerting a 440-pound force tending to pull the fuel drawer out of the reactor. The other side of the air cylinder is open to the atmosphere through a 150-psi relief valve, which acts as a dash pot to decelerate the rod on a scram. To scram the mechanism, the magnetic clutch is de-energized, thereby releasing the pinion, and the air cylinder pulls the rod out of the reactor. Regardless of position of any rod, it will be driven out of the reactor on a scram. An interlock will also scram all rods if the supply air pressure drops below 100 psi.

The torque on the magnetic clutch is adjusted sufficiently high to just overcome the load from the air cylinder and fuel drawer. Thus, the clutch would slip, if a drawer should bind, before any damage could be done to the drawer or matrix tube.

Setting the torque on the clutch to a minimum also shortens the time required to release the clutch in the event of a scram. Figure 4 gives the performance of the rod drive.

Full travel of the safety-control rods is 10 in.; appropriate limit switches control travel and operate indicator lights on the control panel. Control drive speed is 2 in. per minute. This speed may be changed, depending on the worth of a control drawer. Rate of reactivity change will be the controlling factor. The safety-control rods have selsyn driven circular dials on the control panel which indicate rod position to 0.005 in. Since the selsyn generator on the rod cannot follow the scram speed of the rod, it is driven by a counterweight-loaded rack which disengages from the rod on scram, the counterweight returning the rack slowly to the zero position. A lug on the end of the selsyn rack engages with a matching lug on the rod, as the rod moves forward, providing a positive drive for forward movement of the rod. The counterweight return on the selsyn rack keeps the lugs engaged for outward movement of the rod at control speed. Figure 5 is a photograph of a drive mechanism and its associated fuel drawer.

4. Source Assembly

Two polonium-beryllium sources are used, one being used for each half of the assembly. In each case the source is mounted on the end of a flexible shaft and is driven from its coffin, at the side of the assembly,

FIGURE 4
SAFETY ROD
PERFORMANCE CURVE.

Figure 5

Control-Safety Drive Mechanism and Control Drawer

through a thimble to a point adjacent to the core on one side of the assembly. Appropriate limit switches control the travel and indicate position on the control panel. Since the source is either completely in or out of the reactor, indicator lights are sufficient for indication of position. Since these sources present somewhat of a physiological hazard when working around the reactor, they are placed in the coffins when removed from the reactor. The sources are so interlocked that when the halves are drawn apart, they must be replaced in the reactor before the reactor can be reassembled.

5. Reactor Instrumentation

The reactor is equipped with the following instruments for start up and operation:

- a. Two vibrating reed electrometers with recorders.
- b. Three trip level safety circuits with recorders.
- c. Two logarithmic amplifiers and period meters with recorders.
- d. One γ -ray monitor - logarithmic amplifier and recorder.
- e. Two proportional counter channels.

A block diagram of this instrumentation is given on Figure 6.

The vibrating reed electrometers are used for both start up and operation at all anticipated power levels. These are used to measure the current from uncompensated boron-coated chambers and cover a range of six decades by the use of appropriate resistor and shunt changes. These instruments have been found to be very reliable in operation, being free of instabilities and drift in the electronic circuits.

The trip level safety circuits are DC amplifiers used to shut down the reactor in case the reactor power goes above the preset level. They are connected to ion chambers located adjacent to the assembly. These are of the type commonly used on other reactors for this purpose. Of the three supplied, two will be in use at all times during operation.

The period meter consists of an ion chamber, logarithmic amplifier, and differentiating circuit of the type presently in use with other reactors. The output of the log amplifier, as well as the output of the differentiating circuit, is brought out to a recorder. This provides a single scale record of power level over the entire operating range without changing of scale factors.

The γ -ray monitor provides a check on the general γ -ray level in the assembly room.

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Figure 6
ZPR III Instrumentation

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The proportional counter channels are audible from the operator's position and are used for start up.

6. Operation

The operation can best be described by starting with the loading of the assembly. Master loading charts are made out to establish the loading for each drawer in the assembly. These charts are then used to load and check the drawers, which are numbered to correspond with their location in the reactor. Complete records are kept of the loading of the reactor at all times. After a loading has been completed and inspected, the reactor is ready to operate.

A daily check-off list to insure that all controls and safety mechanisms are operating properly, assembly is inspected, etc., must be filled out. In addition, there is a weekly interlock check to insure proper operation of interlock circuits. Jack-type interlock jumpers and warning lights are provided on the front of the control panel, in full view of the operator, so that interlocks may be jumpered out for the weekly check or for experimental purposes.

The full list of interlocks on the reactor is as follows:

- a. Scram Interlocks - The following occurrences cause scram:
 - (1) Source leaves assembly.
 - (2) Carriage retracts from closed position after having reached that position.
 - (3) Airlock door opens.
 - (4) High power level (three circuits).
 - (5) Short period (two circuits).
 - (6) Low safety rod drive air pressure.
 - (7) Air pressure becomes positive (gauge) in assembly room.
- b. Start Up Interlocks - The reactor refuses to start up under the following conditions:
 - (1) Carriage is not fully retracted.
 - (2) Source is not in assembly.

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- (3) Neutron level meter is not indicating.
- (4) Working platform is not out.
- (5) Eight safety rods are not in.
- (6) Control rods are not out.
- (7) Air pressure in assembly room is not negative (gauge).

To insure safe and proper start up, a sequence circuit establishes the order of operation of the various components of the assembly. Before the carriage can be started, the following conditions must be met:

- a. Both sources must be in the reactor.
- b. The safety-control rods in use as safeties must be in the farthest in position.
- c. The safety-control rods in use as controls must be in the farthest out position.
- d. Supply of air pressure for "b" and "c" must be above one hundred psi.
- e. The neutron detection instrument must be above its "source out" position.
- f. The doors to the assembly room must be closed.
- g. A device for counting the number of people in the assembly room must indicate zero.
- h. All safety circuits must be operating and reset.
- i. The loading platform must be out.
- j. Air pressure in assembly room must be negative ($-1\frac{1}{2}$ in. water).

When all the above requirements are met, the movable carriage may be started in at its highest speed (30 in. per minute) until the halves are separated by 18 in. At this point a limit switch drops out the high speed drive and automatically starts the intermediate speed drive (6 in. per minute) which drives the carriage until the halves are 3 in. apart. A limit switch then drops the intermediate speed drive out. The assembly is brought to this point automatically when the operator throws the proper switches. Beyond this point he must hold a switch in the closed position in order to bring the halves together.

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After the halves are brought together, the two control rods may be driven in to bring the reactor to critical.

B. Building

The floor plan for the ZPR building is shown in Figure 7. The building consists of a high bay assembly room section of reinforced concrete, and a one story section containing the control room, work room, vault, laboratory rooms, offices, service rooms, etc. This latter section is of concrete block exterior construction with the exception of the vault, which has reinforced concrete walls and ceiling. The whole building has a concrete slab floor. Interior partitions are stud and dry wall with the exception of the vault, mentioned above, and the boiler room with concrete block walls.

This building is designed in accordance with the standards for Earthquake Zone II in which the Testing Station is located.

The dimensions of the assembly room itself are 45-1/2 ft long by 42 ft wide by 29-1/2 ft high. The total enclosed volume associated with the assembly room, including the passageway and ventilating equipment mezzanine but excluding the airlock, is 75,000 cubic ft.

The shielding walls of the assembly room are made of reinforced concrete. The shielding wall between the assembly room and the control room is 5 ft thick up to 12 ft above the floor and 3 ft thick the remainder of the distance to the roof. The north wall is 2 ft thick; the east and south walls are 1 ft thick. The partial wall between the assembly room and the passageway and ventilation equipment mezzanine is 4 ft thick up to 12 ft high and 2 ft thick the remainder of the distance to the roof. The roof is supported by long span trusses and has 6 in. of concrete poured on top of a corrugated steel deck.

The shielding wall between the assembly room and the control room is penetrated by 24 2-in. "S" shaped conduits for wiring. In addition, there are 20 stepped holes with steel plugs through this wall for experimental purposes.

In order to contain radioactivity within the assembly room, the room and its openings have been built for minimum leakage.

Access to the assembly room is normally through the airlock. As shown in Figure 8, the airlock consists of a concrete cell with two gasketed motor-operated sliding doors. These doors are interlocked so that they may operate in sequence only and may not be opened simultaneously. In case of power failure counterweights will close both doors. The leading edge of each door will operate a safety switch to cause the door to open in case anyone is caught between the door and the jamb. The airlock doors are interlocked with the reactor scram circuit so that the reactor will not start up until the doors are closed, and a scram will occur if the doors are opened during operation.

ZPR BUILDING FLOOR PLAN

Figure 7

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Figure 8

Airlock Entrance to Assembly Room

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There is also a motor-operated, gasketed freight door in the south wall which closes on power failure, and a manually operated, gasketed escape door in the east wall. The escape door has a lever and cam arrangement to assist in opening the door against the positive outside pressure of 1-1/2 in. of water.

The conduits through the shield wall are sealed after the wires are run. The stepped holes through the shield are sealed with expansible rubber plugs and shielding plugs.

The ventilation system is designed to maintain a negative pressure of 1-1/2 in. of water in the assembly room under normal conditions. The supply system takes outside air through an emergency manually operated intake damper, a 2-in. thick fiber glass filter, 2 finned steam heating coils in series, and a 12,000 cfm blower with 2-speed motor. The exhaust system takes air from the ceiling of the assembly room and passes it through a 2-in. thick fiber glass prefilter and a 11-1/2-in. thick Chemical Warfare Service absolute filter. The exhaust fan is rated at 13,000 cfm at 5 in. of water. Flow of air through the exhaust fan is controlled by an inlet vane damper. The air passes through a manual emergency exhaust damper and is exhausted up a stack 25 ft above the roof of the assembly room.

The negative pressure in the assembly room is controlled by a differential pressure indicator controller located in the control room. Under normal conditions the controller will maintain a negative pressure of 1-1/2 in. of water on the assembly room by proportioning the air flow through the inlet vane damper to the exhaust fan. The range of the controller is from zero to -4 in. of water. The controller is interlocked with the reactor scram circuits so that when the assembly room pressure rises above a certain point, the reactor will not start up or will scram.

Upon loss of power, or by manually cutting the power, the emergency intake and exhaust dampers will close and seal off the ventilating system.

The assembly room is furnished with both 110-volt AC and 440-volt AC outlets. It is lighted by both mercury vapor and incandescent lamps.

There is no water supply line or outlet in the assembly room.

Steam is supplied only to the heating coils in the mechanical equipment room on the mezzanine over the passageway.

There are no floor drains in the assembly room. One roof drain runs along the east wall from the roof through the floor.

Crane service in the assembly room itself is furnished by a 5-ton capacity bridge crane having a vertical lift of 24 ft. The crane is controlled by pendant push buttons and has five operating speeds.

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A 5-ton capacity monorail hoist with a motor-driven trolley operates between the loading platform, through the freight door, across the passageway and into the assembly room. This hoist has a 13-ft lift and a variable speed control operated by pendant push buttons.

All reactor control equipment is located in the control room, and the reactor is operated from this point. In addition, some special experimental equipment is mounted in this room.

Motor starting relays, DC power supply, switch gear, fuse boxes, transformers, etc., are located on the walls of this room. Figure 9 is a photograph of the control console. From left to right on the photograph: the first cabinet is the terminal cabinet; the second contains the gamma monitor chassis and recorder; the third contains the safety circuit chassis. The left wing of the main console contains the jacks for changing control rods to safety rods, three safety circuit recorders, a vibrating reed and recorder, and four safety rod position indicators for the moving half of the critical assembly. The upper center panel contains the interlock jumper jacks, the three linear carriage position indicators, position indicator dials for the two control rods, differential carriage alignment indicator dial, a period timer, and a recorder which may be switched to either vibrating reed circuit. The lower slanting center panel contains all of the reactor operating controls consisting of the two key switches, the control power reset switch, the safety drive clutch switches, the control drive motor switches, the source drive switches, the carriage drive switches, a reactor "off" switch, and a scram switch. The right hand panel contains the four position indicator dials for the safety rods on the fixed half, a vibrating reed chassis, and a two-pen recorder for period and log power. The two right-hand cabinets contain two period chassis, two period timers, and two proportional counter scaler-counters.

To the right of the permanent console are located the portable relay racks for experimental equipment.

The vault is a room 29 ft long by 26 ft wide by 11-1/2 ft high, with walls and roof of reinforced concrete 9 in. thick. This is equipped with the requisite vault and day doors.

The sole use of the vault is for storing fissionable material. The fuel slugs will be stored on racks in special "birdcage" type containers which limit the storage density to two kilograms per cubic foot.

Ventilation to the vault consists of air supplied through a grill from a supply blower, filter, convector unit located in the boiler room, and an exhaust system consisting of a prefilter of fiber glass, a C.W.S. absolute filter, and a 3000-cfm fan and a 25-ft stack mounted on the roof.

Figure 9
Control Console

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Immediately outside the vault is the work room. This room is used for loading, checking, and unloading drawers, and for material accounting. Storage bins, drawers, and shelves are provided in this room for the aluminum, steel, and depleted slugs and for drawers, springs, etc.

Large red warning lights which blink when the reactor is operating are located in the control room over the airlock door and on the east wall of the assembly room where it can be seen both from the assembly room and the passageway. Exterior warning lights are mounted on the northeast and southeast corners of the building and on periphery fence light poles to the north of the building and southeast of the building. These exterior lights are to warn the patrolling guards and others to avoid the vicinity of the assembly room during reactor operation.

There are two horns which emit a ten-second warning blast when the carriage starts moving. One of these is located in the assembly room and the other on the exterior of the building on the southeast corner.

There are two manual scram buttons in the building, one on the control console and one on the partial wall in the assembly room next to the exit.

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II. THE FIRST EXPERIMENT

The buildup of the first critical assembly was begun October 18, 1955, and the assembly became critical two days later, October 20. For this assembly, an average core composition similar to that anticipated for EBR-II was placed within a high density, depleted uranium blanket. The machine was initially loaded with blanket material throughout, and the core was gradually built out from the center, keeping the two halves symmetrical.

The geometry and composition of the critical assembly were as follows:

The core was a rectangular parallelepiped, 30.68 cm deep, 45.41 cm wide, and 38.71 cm high. Its average composition in atoms per cm^3 was as follows:

U ²³⁵	0.006758×10^{24}
U ²³⁸	0.007690×10^{24}
Al	0.01899×10^{24}
Stainless Steel	0.01048×10^{24}

The critical mass was 142.4 kg of U²³⁵. This core was located within a blanket of right-cylindrical shape. The blanket was 76.4 cm deep, providing 22.86 cm of material at each end of the core. The average radius of its roughly circular outline was 58.5 cm. The configuration of core and blanket is sketched in Figure 10.

The blanket was uniformly constituted, containing 83.5% depleted uranium, 7.3% stainless steel, and 2.3% Al, by volume, with a small amount of void.

This assembly is believed to have contained the largest mass of highly enriched fuel yet assembled in an unmoderated chain-reacting system. The drawers on the core perimeter were later reloaded to provide a cylindrical assembly of identical composition and length. The result was an effective core radius of 23.27 cm, corresponding to a critical mass of 137.8 kg of U²³⁵.

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FIGURE 10
CORE AND BLANKET CONFIGURATION FOR FIRST ASSEMBLY