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Los Alamos Critical Assemblies Facility

University of California

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LOS ALAMOS CRITICAL ASSEMBLIES FACILITY

by

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ABSTRACT

The Critical Assemblies Facility of the Los Alamos National Laboratory has been in existence for thirty-five years. In that period, many thousands of measurements have been made on assemblies of ^{235}U, ^{233}U, and ^{239}Pu in various configurations, including the nitrate, sulfate, fluoride, carbide, and oxide chemical compositions and the solid, liquid, and gaseous states. The present complex of eleven operating machines is described, and typical applications are presented.

I. INTRODUCTION

The Los Alamos Critical Assemblies Facility consists of three remote-control laboratories, known as Kivas, which are located at some distance from the main laboratory building that houses individual control rooms for each Kiva.

Each Kiva is surrounded by a security fence to keep personnel at a safe distance during remote operations. The Kivas are entered through a manned security station with additional safeguards provided by approved access lists, a strictly imposed "buddy" system, and a controlled key procedure.

Several general-purpose assembly machines occupy each Kiva. However, material and even entire machines can be moved from one Kiva to another. This is probably the only facility in which all fissile species (^{233}U, ^{235}U, and ^{239}Pu) are routinely handled in a multitude of configurations involving all physical forms (solid, liquid, and gaseous). Machines have been run at or near critical, bare (as the 17-kg Jezebel) to massively reflected (as the 19-metric ton Big Ten), with loadings from a few hundred grams to hundreds of kilograms, and at power levels from fractions of a milliwatt to near 100 000 MW (for a few microseconds).

II. KIVA 1

A. Honeycomb

The Honeycomb critical assembly is a universal split-table machine containing a 1.83- by 1.83- by 1.83-m (6-ft) matrix of 76- by 76-mm (3-in.) aluminum tubes (Fig. 1). It is designed as a flexible system to accommodate initial mockup studies for basic critical parameter investigations. Aluminum tubes are used to support components because aluminum is relatively neutral in either fast or thermal neutron systems. Various materials of interest in reactor experiments are available in blocks, bars, plates, and foils, with dimensions commensurate with the Honeycomb matrix. These include large quantities of graphite and beryllium and lesser amounts of iron, aluminum, niobium, molybdenum, tungsten, zirconium, zirconium hydride, and polyethylene. Fuel inventory consists of various fissile species such as 330 kg of 0.05-mm-thick U(93) foils, with widths and lengths appropriate to the aluminum matrix tubes, or extruded/sintered UO_2 rods. Controls and safety rods use sections of the core or reflector materials, and the movable section of the table provides major disassembly.

Many reactor concepts have been mocked up in

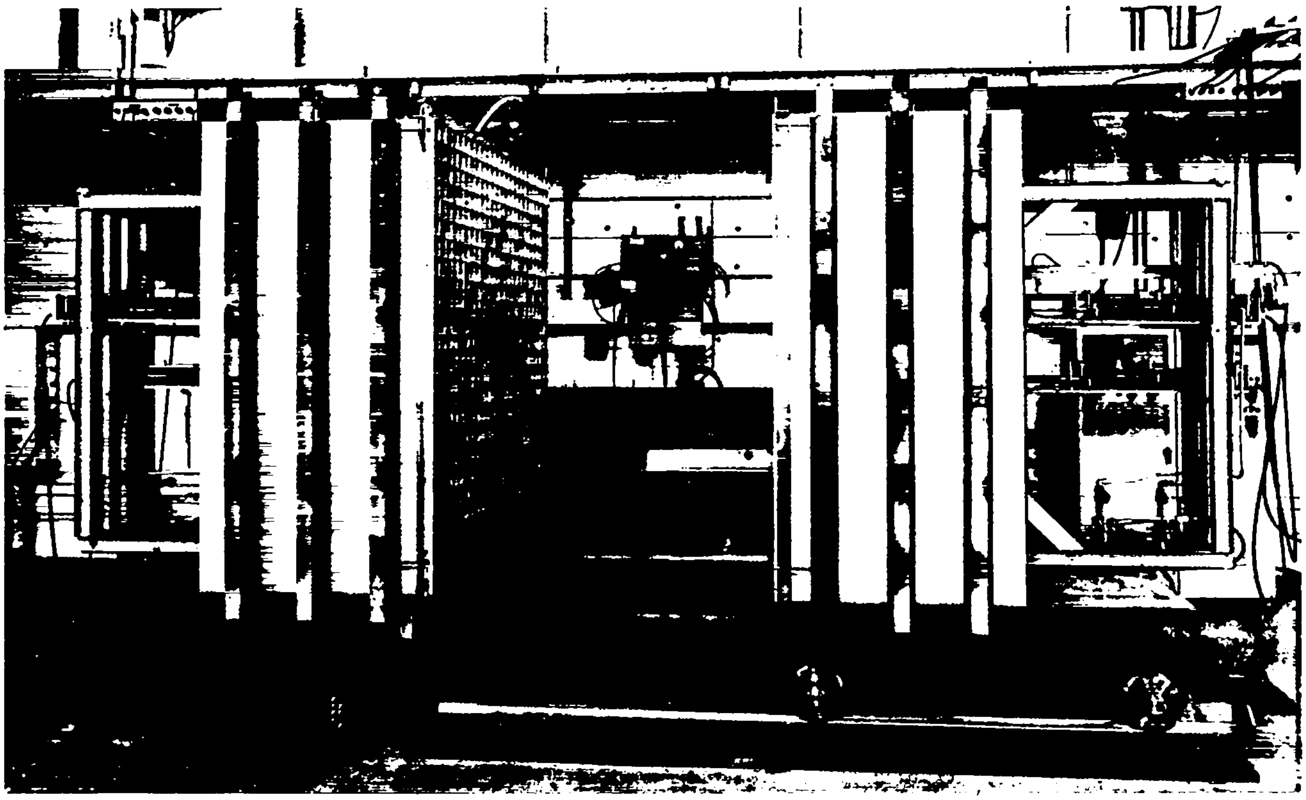

Fig. 1.
Honeycomb is a general-purpose critical assembly machine incorporating a horizontal split table. A cubical mocking-up core, a reflector, and a control system can easily be loaded into the matrix of 76-mm-sq aluminum tubes. The machine is currently loaded with a 65-kg UO_2 core, beryllium-reflected mockup of a space power reactor.

Honeycomb. We have been able to include details much smaller than the 76- by 76-mm matrix tube dimensions by providing fine structure within the tubes. Often we have replaced a section of aluminum tubes with a real reactor section. These options demonstrate the extreme versatility of Honeycomb. Systems that have been studied include the Kiwi, Phoebus, and Dumbo reactors for the Rover Program, the TREAT reactor for Argonne National Laboratory, and several assemblies of more basic interest in the reactor field. The assembly that is just being built up for the space program uses a UO_2/Mo core with a beryllium reflector.

B. Mars

The Plasma Core Assembly (PCA) makes use of our Mars critical assembly machine (Fig. 2), which is basically a heavy-duty stand with a hydraulic cylinder recessed in the floor to provide primary assembly motion. Mars is one of four similar general-purpose assembly machines (Comet, Super Comet, Mars, and Venus). PCA consists of a 1-m-long by 1-m-diam cavity surrounded by a 0.5-m-thick beryllium reflector. Experiments under way are determining critical conditions for a UF_6 gas core.

The beryllium reflector for PCA was assembled from the Rover Program reactor reflector segments. Many of these segments retain residual activation from their high-power operation several years ago. The outer 0.20 m of beryllium is a complete Phoebus 2A reflector. Some adapter pieces of graphite are used to fill voids between beryllium reflector sections. A 1-m-diam by 0.5-m-long beryllium end plug, mounted on a movable cart over the hydraulic piston, supports the core materials. The fueled core and beryllium end plug are inserted by remote control for critical operation.

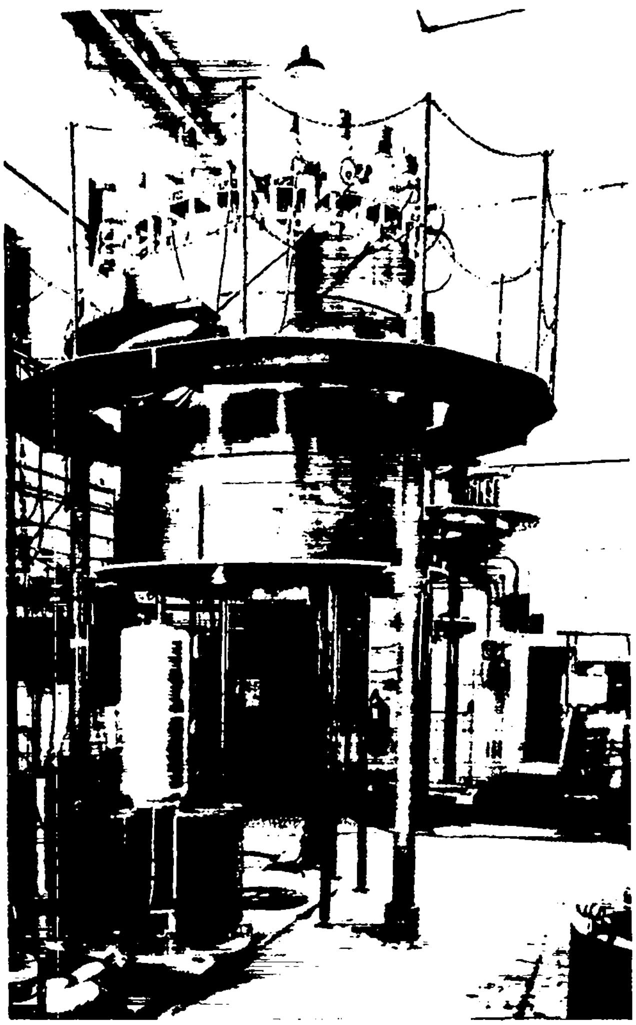

Fig. 2.
The PCA on our Mars critical assembly machine, a heavy-duty stand with a hydraulic cylinder recessed in the floor for primary assembly motion.

Experiments to date have been with small quantities of UF_6, and criticality is achieved by adding a ring of solid uranium-graphite PARKA fuel elements outside the UF_6-containing canister. Recently, PCA was operated at critical with circulating UF_6. In another phase of our plasma core reactor research, we investigated the neutronic properties of a vortex-confined UF_6 gas region in the core of our beryllium-reflected critical assembly. Argon was the confining buffer gas, and helium transported the UF_6 fuel around the system. PCA in its present "clean" configuration is critical with as little as 5 kg of U(93).

Gas core reactors are of interest for space applications, as potential sources of fission-driven laser energy, and as reactor power plants presenting minimum proliferation risk. We recently completed a joint program with United Technology Research Corporation to evaluate the feasibility of gas core reactors. The critical studies with supporting neutronic calculations were conducted at Los Alamos National Laboratory. Initial experiments used a driver section of PARKA fuel elements to effect criticality with small amounts of UF_6 in a central cavity. In continuing experiments, the amount of UF_6 was gradually increased until the behavior of the system with flowing UF_6 fuel could be studied realistically with reference to possible future undriven concepts. A follow-up program will be conducted with the University of Florida (UFLA-UF_6) on a static system with up to 3 kg of UF_6 gas.

C. Venus

The Venus machine is a general-purpose hydraulic ram and support structure to accommodate systems under study. Although unloaded at present, it was most recently used in a bench-mark measurement of a water-reflected U(97) sphere.

III. KIVA 2

A. Big Ten

Big Ten (Fig. 3) is a cylindrical assembly comprising a ^{235}U(10%) core surrounded by a depleted-uranium reflector. Overall, the cylinder is 0.84 m in diameter and 0.96 m long. The reflector has 0.15-m-thick walls and 0.21-m-thick ends. Major disassembly is provided by a movable reflector section 0.39 m long; the stationary section is 0.57 m long.

The fissile core is composed of a central section of homogeneous ^{235}U(10%) surrounded by a region where 3-mm-thick ^{235}U(93%) plates alternate with 27-mm-thick natural uranium plates (making 18 pairs) simulating 10% material. The total ^{235}U inventory in the core is 226 kg.

Twelve movable 88.9-mm-diam rods of depleted uranium are located in the peripheral reflector. Six rods in the movable section and five rods in the stationary section operate in the "in/out" mode with no intermediate positions available and act as safety rods. The

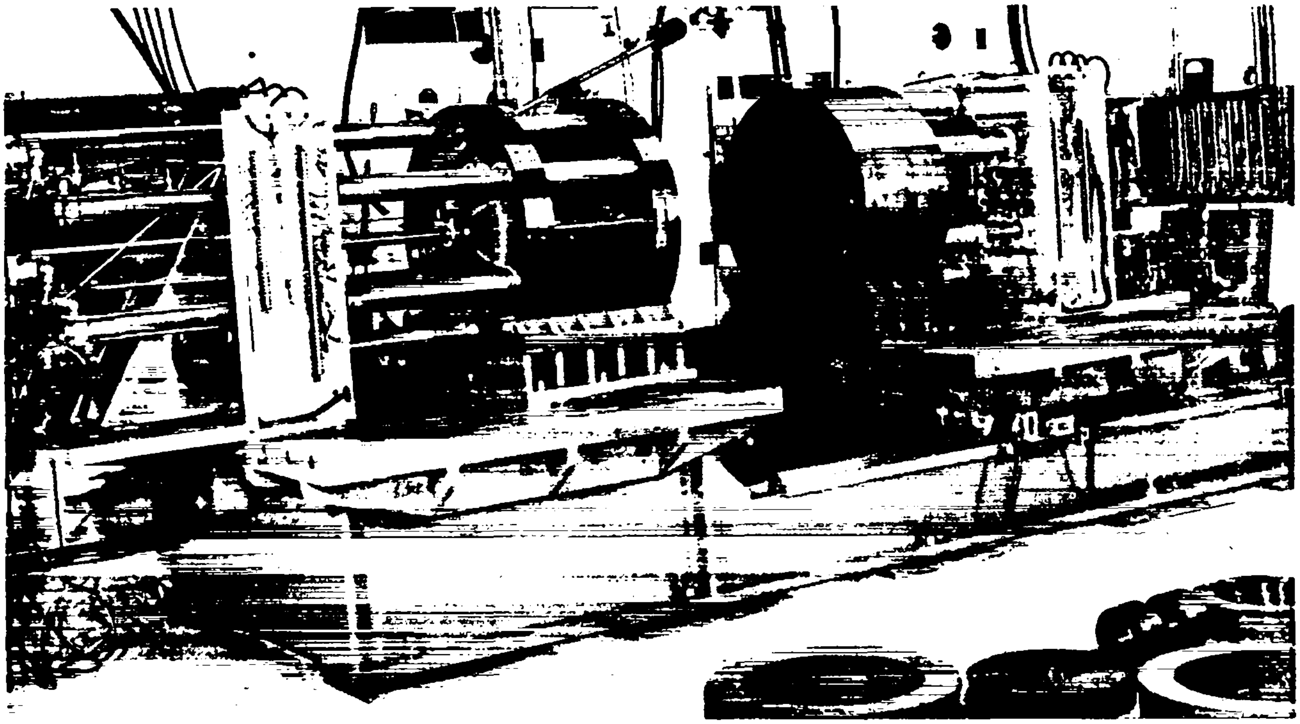

Fig. 3.
Big Ten, a cylindrical assembly with a movable and a stationary section to provide disassembly.

sixth rod in the stationary section and a 38-mm-diam $^{235}U(10\%)$ rod along the axis act as control rods. These rods are continuously adjustable, and their positions are read out accurately in the control room.

The composition of Big Ten was selected to give a neutron spectrum at the center comparable to that in the Liquid Metal Cooled Fast Breeder Reactor (LMFBR) so that verification of cross-section sets in Big Ten would validate those sets for LMFBR calculations as well. The median energy for fission in Big Ten is computed to be ~0.4 MeV.

Measurements of the neutronic properties of Big Ten are being investigated in the same fashion as those of Flattop and Jezebel assemblies. Comparison of calculations with measurements constitutes an unequivocal integral test of input cross sections in the calculations and complements the results for Jezebel, Godiva, and Flattop. Big Ten is presently being used for a series of replacement measurements of transuranic isotopes and for diagnostic irradiations.

B. Comet

The Comet is a general-purpose assembly machine that has been used for many critical determinations and nuclear safety studies (Fig. 4). It is basically a support stand with means for bringing two parts of a configuration together. Secondary vernier motion on top of the table is accomplished by a screw-driven platform powered by a stepping motor, with accurate position read-out in the control room. Various stationary tables are available for the top of the support stand. One of these is a 0.05-cm-thick steel membrane to provide a "massless" supporting plane for a section of the assembly. Often the top support is custom designed for the particular application. Various top support structures are available, including hardware having a vertical actuator and a control rod. Experiments to establish critical conditions are generally subcritical, but some experiments have been operated at critical. Comet provides a flexible facility for conducting many different experiments on short notice.

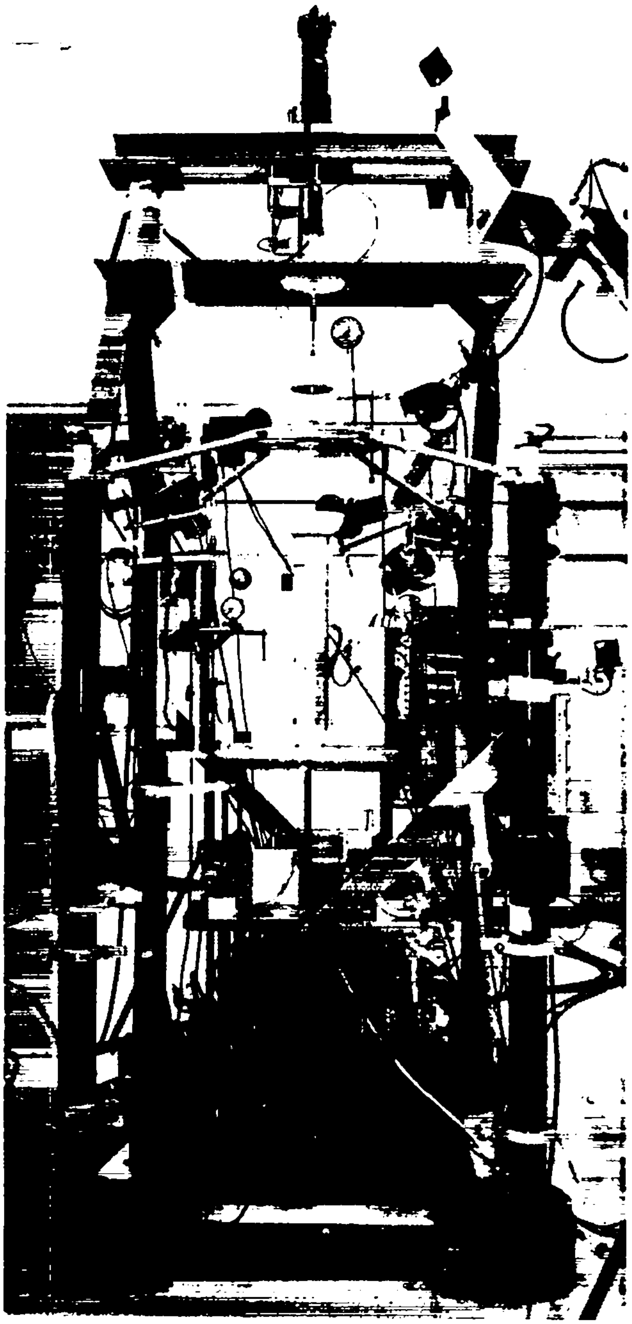

Fig. 4.
Comet, a general-purpose assembly machine used for many critical determinations and nuclear safety studies.

Comet is an assembly machine rather than a critical assembly; generally the configurations on Comet are varied and short-term. Use is made of the Flattop cores, the Thor core, and uranium foil for a variety of criticality safety and critical mass determinations. The Thor core is particularly useful in Comet operations and has come to be associated with the machine.

At present, Comet is set up for a demonstration multiplication measurement and critical determination for a criticality safety class. This basic experiment, with a rectangular array of Lucite plates and uranium foil, is conducted periodically as a graphic hands-on training aid. During 1979, Comet was employed in a series of measurements to evaluate ^{242}Pu cross sections and in various stackings of interest in criticality safety. A recent Comet application was an extensive series of measurements of critical dimensions for spherical systems containing a central 9.8-kg ^{239}Pu-alloy core surrounded by 10-mm-thick shells of various materials and reflected with polyethylene. These data were used to check neutronic cross sections for calculations.

Our Thor assembly, which is of particular current interest, consists of a 9.8 kg ^{239}Pu ball in a thick thorium reflector. Thorium is in the limelight now as breeding material for ^{233}U in place of uranium-plutonium. In that context, another series of Comet experiments is of interest; in these experiments, critical conditions were established for cylinders of plutonium diluted with steel, aluminum, thorium, and depleted uranium, reflected by different thicknesses of uranium and thorium.

Many other experiments have been run on Comet, including tests on the safety of weapons in storage or immersion and additional criticality safety measurements. The lowest critical mass ever measured was determined with the Comet machine. In a polyethylene-uranium core with a thick beryllium reflector, a <300-g quantity of ^{235}U was critical.

C. Flattop

Flattop (Fig. 5) is at the opposite extreme from our unreflected critical assemblies, as it is a thick natural uranium reflector (0.48-m o.d.) around spherical cores of uranium (93.2% ^{235}U and 98.1% ^{233}U) and plutonium (94.9% ^{239}Pu). Different adapter shells of natural uranium allow adjustment of the central reflector cavity to fit cores of various sizes. The two quarter sections of the reflector that are movable serve as scrams. One of these is moved in or out by hydraulic pressure, and the other is motor driven, with position indicated in the control room. Three control rods of natural uranium are inserted from below into the stationary half of the reflector. The fissile core is mounted on a 127-mm-diam

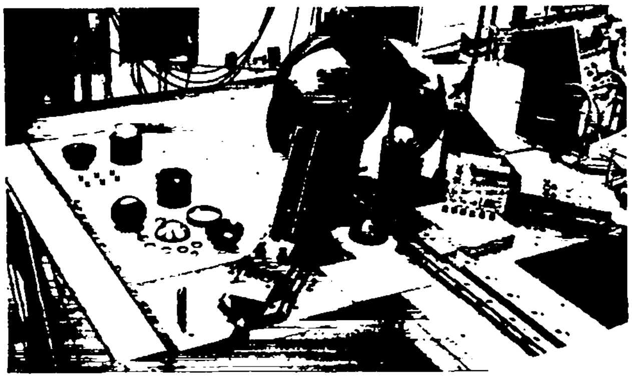

Fig. 5.
Flattop, showing the two movable quarter sections of the reflector, several spherical cores, and the hemispherical cap for the ^{235}U sphere.

natural uranium pedestal that may be moved into its central position by hand cranking a screw. The ^{233}U and ^{239}Pu spheres have 12.7-mm-diam central channels; the ^{235}U sphere has a 25-mm-diam channel. Access to these experimental volumes is through the stationary reflector section. Cylindrical mass adjustment buttons of either reflector or fissile material fit into cavities in the reflector components immediately surrounding the active balls. A thin (2.8-mm) hemispherical shell positioned on the top half of the core between the natural uranium reflector and the fissile material provides additional reactivity adjustment for the ^{235}U sphere. This cap may be of either natural uranium or enriched-uranium pieces. A complete set of data has been obtained for the neutronic characteristics of each of the three core materials. Critical masses are 6.0 kg for the ^{239}Pu (94.9%) ball, 5.7 kg for the ^{233}U (98.1%) ball, and 17.8 kg for the ^{235}U (93.2%) ball after correction to a completely spherical geometry. The ^{233}U sphere for Flattop is in storage and is no longer usable because of its high gamma activity, resulting from daughter products of the ^{232}U impurity in the original material.

Flattop assemblies are characterized by a fast-neutron spectrum at the center of the core and a degraded spectrum in the reflector. An index of the neutron energy is provided by the $^{235}U/^{238}U$ fission detector counting ratio, which is as low as ~6 in the fissile core and increases to ~100 near the outside of the uranium reflector. This varying neutron spectrum characteristic is particularly useful for the activation studies and calibrations conducted by Group CNC-11 for radiochemical diagnostics.

Flattop is one of our bench-mark critical assemblies whose characteristics have been meticulously established over a period of years. Flattop assemblies are used principally in a continuing program of neutron activation and reactivity coefficient measurements, the appropriate neutron energy spectrum being selected by the radial position of the sample. For example, the central reactivity coefficient of ^{237}Np was recently checked in the ^{235}U Flattop core to supplement the same measurement made in Jezebel, which has a different neutron spectrum. Flattop is used also for replacement measurements and service irradiations.

We have determined the neutronic properties of the various Flattop assemblies, thereby establishing precise integral checks for the cross-section verification used by weapons and reactor programs. These include detailed data for ^{233}U, ^{235}U, ^{238}U, and ^{239}Pu, as well as central reactivity coefficients for other fissionable isotopes and many nonfissionable isotopes. The National Bureau of Standards and other agencies have amplified the status of Flattop as a bench mark through fast-neutron dosimetry intercomparison and calibration studies. The services of Flattop will continue to be in demand for dosimetry intercomparisons and for spectrum-sensitive detector calibrations. Because of its generally softer spectrum, Flattop complements Jezebel and Godiva in this regard.

D. Jezebel

The Jezebel assembly (Fig. 6) was established to determine the neutronic behavior of an unreflected critical sphere of delta-phase plutonium. Support and control structures were designed to keep neutron reflection to an absolute minimum. The effects of reflection are small enough to allow confident extrapolations to the unreflected sphere. In that respect, the nickel protective coating on the plutonium metal must be taken into account as a component of extraneous reflection.

Major features of Jezebel, a plutonium sphere clad with 0.13-mm-thick nickel, include a stationary central section, upper and lower movable blocks, and a single plutonium control rod. The central section is actually made up of two separate plutonium pieces clamped together. The reactivity of Jezebel may be adjusted in increments by 12 plutonium filler buttons (12.7-mm diam by 6.3-mm thick) that fit into cavities machined into the top surfaces of the lower block and the central

Fig. 6.
Jezebel, showing the plutonium sphere, stationary central section, upper and lower movable blocks, and plutonium control rod.

section, and by plutonium plugs that fit into the 12.7-mm cylindrical channel passing through the central section. Polar discs of plutonium may be added to the support ends of the upper and lower blocks. For this purpose, the polar surface of these blocks has been machined flat to accommodate the polar mass adjustment discs. Thus, there is significant deviation from sphericity at the poles. In addition, there is a flange machined around the central section that presents another perturbation. Jezebel is mounted on a portable aluminum stand, and extension cables allow operation even outside the building. In fact, measurements have been made with Jezebel supported ~10 m from the ground to avoid neutron room-return effects.

Jezebel measurements supply the same basic information for plutonium that Lady Godiva provided for uranium. Both the weapons and reactor divisions of the Department of Energy (DOE) consider Jezebel a standard for continuous confrontation of neutronics calculations and experiments, and its neutron field is useful for detector development and calibrations. Jezebel also constitutes an invaluable training tool for Los Alamos-sponsored Nuclear Criticality Safety courses.

Early measurements concentrated on establishing a precision value for the critical mass of an unreflected plutonium sphere and on determining various neutronic characteristics such as neutron spectrum, neutron lifetime, and relative fission cross sections for isotopes in the Jezebel neutron spectrum. These still serve to verify computations. Subsequently, central reactivity coefficients were measured for some 40 isotopes, and their absorption cross sections for the Jezebel neutron spectrum were deduced from the resulting data. Results of Jezebel measurements have appeared frequently in the literature.

In the past, the Jezebel machine has also been used to assemble critical unreflected metal spheres of plutonium (20.1% ^{240}Pu) and uranium (98.13% ^{233}U). Detailed neutronics measurements were performed with each critical sphere, the measurements of highest precision being interassembly comparisons. Thus, although the high ^{240}Pu and the ^{233}U spheres have long since been destroyed, our understanding of the neutronics of these assemblies continues to improve as we improve the accurancy of measurements with the present 4.5% ^{240}Pu sphere. The Jezebel components are now being recast and remachined. Jezebel continues as the acknowledged standard for dosimetry calibrations and for spectrum-sensitive detector comparisons.

IV. KIVA 3

A. Godiva IV

Godiva IV is the latest in the line of unreflected enriched uranium critical assemblies. The original spherical Godiva (Lady Godiva) established an accurate value for the critical mass of a ^{235}U unreflected sphere, thereby providing a calculational check for cross-section sets. Such early critical measurements contributed significantly to computations on nuclear weapons. In fact, computational sets must still satisfy Godiva critical conditions. The reactivity self-quenching features of metal critical assemblies were also established with Godiva I. We started the fast-burst reactor evolution by experiments in which we took Godiva past prompt critical and demonstrated the inherent shutdown from expansion as energy is liberated. Godiva I was then used routinely for burst production, primarily for simulating a nuclear weapons radiation environment. Maximum bursts of 2×10^{16} fissions with a half-width of 35 µs were produced, resulting in a peak power greater than 10 000 MW. Subsequent work with Godiva IV gave peak powers of about 100 000 MW.

Because Godiva II was designed specifically for the production of prompt bursts, there was no incentive to preserve the spherical shape. Therefore a cylindrical system was fabricated with emphasis on structural stability and reduced thermal shock. A second model of the Godiva II core was made at Los Alamos for operation in the Sandia Pulse Reactor Facility (designated Godiva III by Los Alamos and SPR-I by Sandia National Laboratories).

Godiva IV (Fig. 7), an improved version of Godiva II, was designed to give maximum pulse yield. The design uses a U-Mo (5%) alloy for increased tensile strength and resistance to deformation and cracking under the operating thermal shock conditions. Godiva IV, which is operating today, had new U-Mo rings installed recently.

Godiva IV bursts are in demand when intense radiation pulses are required, both for weapon- and non-weapon-related experiments. Peak levels approaching 10^{17} fissions per burst are possible. In a recent program, bursts were used to induce nuclear pumping of lasers. Nuclear energy was coupled to the laser gas by fission fragments from the fission reaction or by the n-^{3}He reaction. Typically, a laser tube containing a U(93) foil lining was surrounded by a polyethylene moderator and exposed to the neutron flux from a Godiva IV burst. The moderator slows down the incident fast neutrons, resulting in a high fission rate in the laser foil, several times the rate in Godiva IV itself. A mixture containing UF_6 gas could serve the same purpose as the foil. Enough lasing action has been observed with nuclear pumping to stimulate considerable interest in this direct conversion of nuclear energy into light energy. The obvious application is advanced-concept, high-energy lasers.

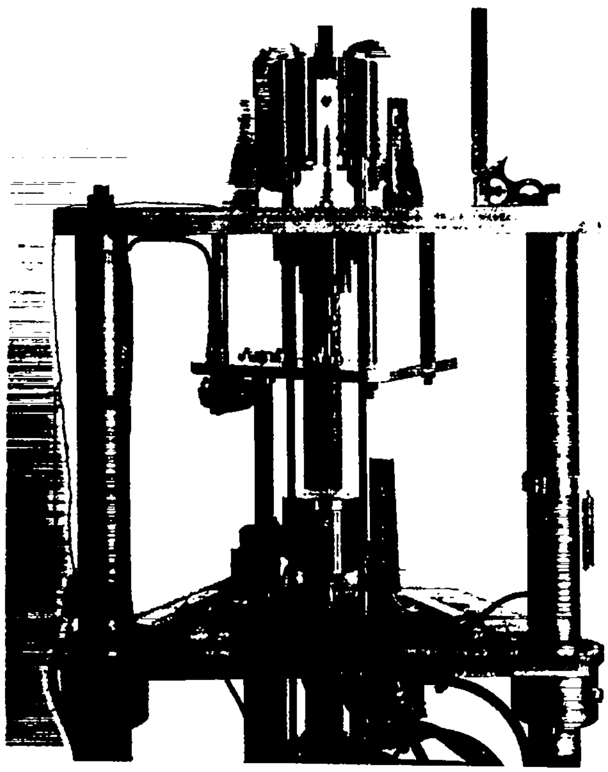

Fig. 7.
Godiva IV, the latest unreflected enriched-uranium critical assembly.

For diagnostic instrumentation development studies, Godiva IV bursts can simulate fast-reactor accident transients by exposing fuel pins in a polyethylene moderator or by inducing a transient in the PARKA critical assembly with a Godiva IV burst. For the latter experiment, a test bundle of fuel pins is located in the central region of PARKA. From these and other tests we hope to specify instrumentation to monitor fuel failure phenomena caused by destructive transients in fast-reactor safety tests.

Other applications of Godiva IV bursts include fluor evaluation for electro-optical imaging systems, coded aperture imaging with neutron and gamma radiation, radiation response of instrumentation, radiation mutations for plant life genetic modifications, and isotope production and analysis using an on-line mass separator.

Godiva IV is a major component in the weapons-supported critical assembly program in Group Q-14. Service is supplied routinely to the Laboratory for various studies. The nuclear-pumped laser program supported by the National Aeronautics and Space Administration is completely dependent on Godiva IV as a source of radiation. Godiva IV is also used extensively in diagnostic instrumentation evaluation for the Safety Test Facility (STF) program. During 1980, Godiva IV provided pulse neutrons as a probe to study fission density distributions on moving geometries.

B. Skua

Skua, a burst-mode critical assembly under construction (Fig. 8), will be an approximate unit-height-to-diameter cylinder of annular U (93) fuel rings, internally moderated by $ZrH_{1.6}$ and externally reflected by copper. The $ZrH_{1.6}$ moderator was chosen over polyethylene because of superior high-temperature qualities.

Skua has an axial moderated-neutron experimental sample volume 51 mm in diameter with clear access from top to bottom. The sample volume diameter is variable, the tradeoff being that the central neutron flux spectrum becomes progressively harder as the moderator is removed to increase the sample volume diameter. Rapid vaporization of uranium to the flux trap is one of the design goals of the system. From the axial sample volume outward, there is a graphite thermal barrier; a $ZrH_{1.6}$ moderator; a cadmium barrier to protect the next region, which is a boral low-energy-neutron barrier, from overheating because of excessive neutron captures; a UC_{100} sleeve; annular U(93) fuel rings; and a 76-mm-thick copper reflector. The copper reflector is 51 mm thick at the top and bottom. The region from the graphite thermal barrier to the UC_{100} sleeve is designed to be packaged as a unit to insure system safety. The fuel rings have a 235-mm i.d. and a 314-mm o.d. Reactor control is by reflector movement. Gross control and shutdown are effected by radial movement of reflector regions, where the reflector worth of ~1 \$/12kg gives a shutdown of >5 \$ reactivity. The fine control and "burst" mechanism will be rotary copper cylinders as shown in Fig. 8.

Fig. 8.
Skua, a burst-mode critical assembly under construction.

The 175 kg of uranium will permit bursts of 2×10^{17} fissions with a mean system temperature rise of ~300°C. With the central "glory hole" at its smallest diameter (51 mm), the "amplification factor" (fission ratio, central to mean core) is 170. This, of course, decreases as the sample diameter increases to its maximum of 234 mm, the fuel inside diameter. For the dimensions given, neutron lifetime is ~0.1 ms and the pulse width is <1 ms.

Skua is designed to provide high thermal fluxes in the central cavity. It is expected that uranium foil can easily be vaporized or fast-reactor fuel pins can be melted. Weapons program applications of Skua are vulnerability studies and spectroscopic measurements of uranium vapor. Fast-reactor safety applications include destructive testing on fuel pins and providing a test bed for fuel motion diagnostic instrumentation. Nuclear pumping of lasers has been demonstrated with Godiva IV for fission fragment excitation of the gas and for excitation by proton and triton particles from the $^3He(n,p)$ reaction. Because nuclear pumping seems to be a threshold phenomena, the order of magnitude increase in excitation that is possible in Skua should open up new areas for investigation.

C. PARKA

PARKA is a Kiwi-type reactor with a special core made up of hexagonal, one-hole, bead-loaded fuel elements (Fig. 9). The core is reflected by 50 mm of

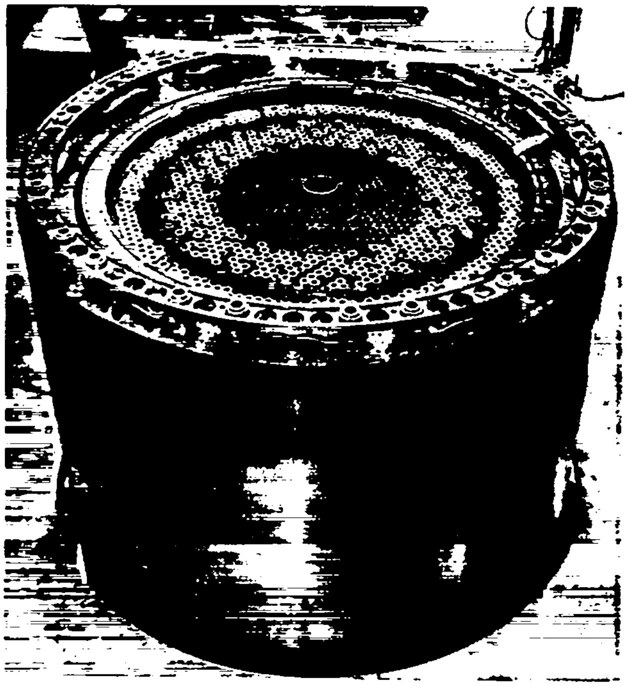

Fig. 9.
PARKA, showing the core of hexagonal, one-hole uranium-graphite fuel elements.

graphite and 114 mm of beryllium; the ends are essentially unreflected. Control is provided by 12 rotating beryllium drums, each with a ^{10}B-Al vane covering 130° of the surface, which also serve as "scram" rods, using springs as the energizing force. The control drums are rotated by stepping motors whose angular position is read out precisely in the control room. All components of PARKA are leftovers from the Rover Program.

PARKA presents a classic example of the payoff of not scrapping a good critical assembly simply because there is no apparent program for it. Until recently, PARKA served as a convenient radiation source, providing gamma and neutron characteristics different from those of our other critical assemblies and thereby being attractive for certain experiments. Measurements to evaluate fuel motion diagnostics were made in PARKA during 1979. More recently, PARKA has been adapted to drive an assembly of fast-reactor-like fuel pins installed in a cavity along its axis. This application gives an accurate representation at low power of conditions in an STF that is being planned by DOE for destructive transient tests of LMFBR core sections. We recently had a Nuclear Regulatory Commission program to explore diagnostic instrumentation for these safety tests. PARKA is the only facility capable of simulating STF because it can serve as an epithermal driver for large arrays of fast-reactor fuel pins, which contain enriched uranium oxide rods to simulate fast-reactor fuel. Currently we are doing experiments with a 37-pin bundle, and calculations show that much larger arrays can be handled. We recently tested a method of operating PARKA in a transient mode, whereby it is driven by a pulse from Godiva. This experiment demonstrated the versatility provided by a multiplicity of critical assemblies. The cost of setting up a system equivalent to PARKA specifically for this reactor safety investigation would be prohibitive.

PARKA experiments necessitated a shielded instrument room to permit observation of conditions in the test fuel pin array without radiation exposure from the PARKA driver. This shield room has been equally useful for experiments with our pulsed Godiva IV assembly on nuclear-pumped lasers. This sharing of facilities (and costs) is a powerful justification for our flexible, multipurpose critical assembly installation. In fact, we anticipate that PARKA will have some application to nuclear-pumped laser studies as well as to the reactor safety program.

PARKA hexagonal fuel elements are made of graphite loaded with pyrolytic-carbon-coated UC beads. They are 19 mm across flats and have a 12-mm central hole. These fuel elements were made for mockup studies of the Phoebus 2 reactor. A fraction of the PARKA fuel elements described here are being used with the PCA.

Some unused Rover ZrC composite elements have been retained for use in PARKA. A small number of these are in the present core, and the rest are being held for potential use.

D. Super Comet

Super Comet is a general-purpose heavy duty stand somewhat larger than Comet. It is presently unloaded and being held in storage.

V. SHEBA

Our new solution assembly, Sheba, which is housed in an extension of Kiva 1, achieved first critical on September 6, 1980, just 4 1/2 months after we received funding approval for the program. Our purpose was to provide a radiation source similar to those in proposed centrifuge processing plants to set a standard for calculations and to evaluate criticality accident alarm detectors and personnel dosimetry. A series of experiments, which included steady-state and ramp operation, was completed for Goodyear Atomic Corporation and Oak Ridge Gaseous Diffusion Plant personnel who were here at Pajarito Site to test their equipment. In addition, seven detector vendors participated in evaluations of their products, and Lawrence Livermore National Laboratory was involved with spectrum and dosimeter measurements.

Sheba (Fig. 10) is a bare assembly fueled with a solution of ~5% enriched uranyl fluoride initially stored in two horizontal 25.4-cm-diam by 1.5-m-long "safe" stainless steel tanks. The solution is transferred to the reactor cavity (a 56-cm-diam by 1.3-m-high stainless steel tank with 0.64-cm-thick walls) by evacuating the cavity while applying helium pressure to the storage tanks. A completely clean geometry is provided in this simple cylindrical system, because reactivity control is effected by varying the solution level. A safety rod may be inserted in a central thimble to provide fast shutdown. The critical solution height is 36.5 cm at 25°C. This corresponds to 85.5 ℓ of solution in the cavity because the specific volume for the system is 2.34 ℓ/cm.

For the just-completed Goodyear Atomic and vendor irradiations, we operated Sheba at powers ranging up to 5 kW. Detectors were positioned at various locations from 2 to 275 m from the assembly. Attenuating shields, used either singly or in combination, included 20-cm concrete, 10-cm Lucite, and steel up to 28 cm thick. Evaluations of the experimental results will be made available to us when they are completed.

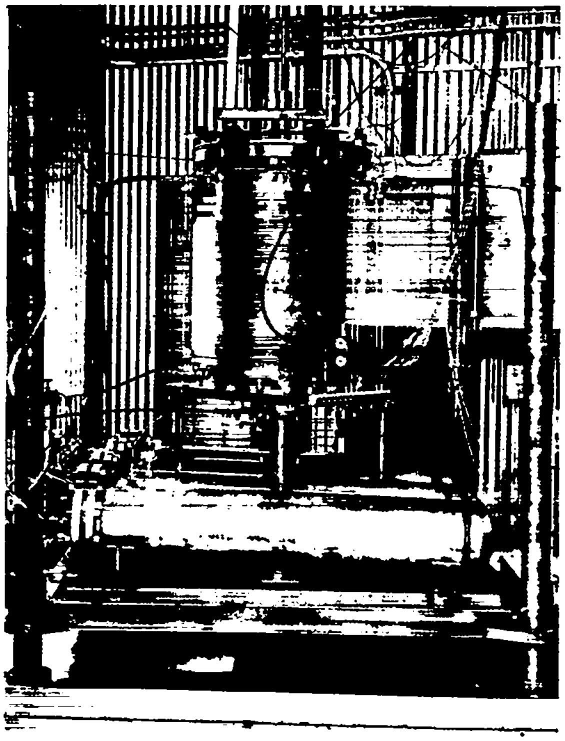

Fig. 10.
Sheba, a bare assembly in which control is provided by varying the solution level.

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