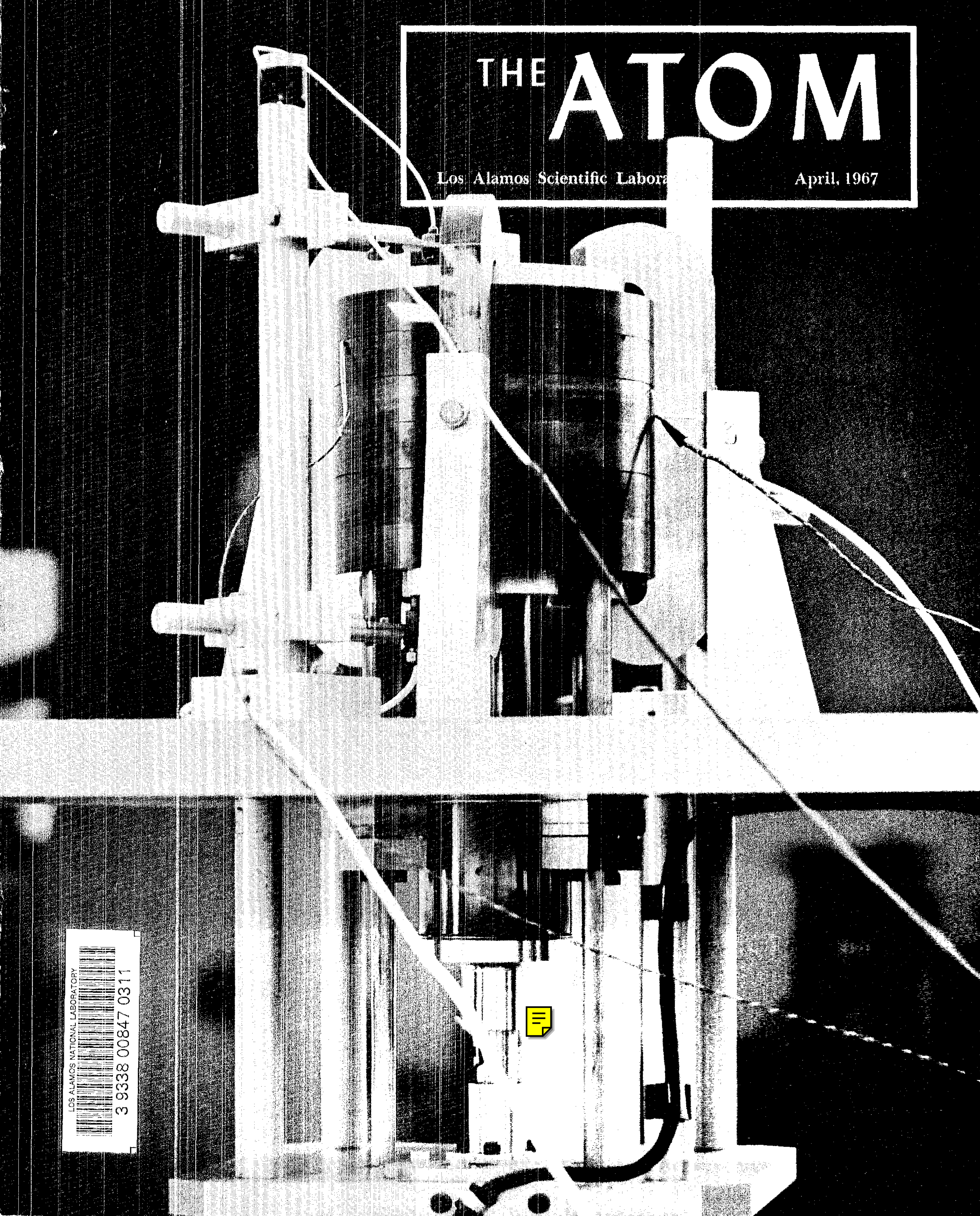
THE ATOM

Los Alamos Scientific Labora

April, 1967



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THE ATOM

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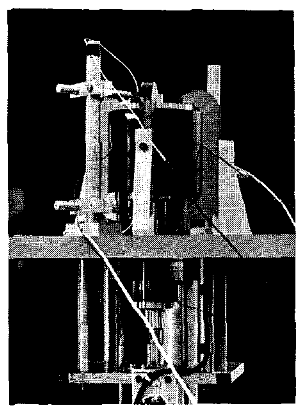


COVER:
Unclad like its namesake, Godiva IV is the latest in the series of LASL fast neutron burst reactors. Story begins on page 8.

short subjects

R. Keith Ziegler, T-1, is on a one-year professional research and teaching leave at the Texas Institute for Rehabilitation and Research of the Texas Medical Center, Houston. During this time, he will consult with the institute's staff on setting up curricula in statistics and biomathematics.

Ziegler has been with the Los Alamos Scientific Laboratory since 1951. He received his B.S. degree from Fort Hayes State College in Kansas, his M.S. from the University of Nevada and his Ph.D. degree from the University of Iowa, all in mathematics.

Ruben G. Rolie, SD-5 machinist, died March 28 in Los Alamos. Rolie had been an employe of LASL since November, 1953. Born in Colgan, N. Dak., March 6, 1910, Rolie attended the State School of Science, Wapheton, N. Dak. Prior to coming to Los Alamos, he was employed by the Simond Saw & Steel Co. of Portland, Ore.

He is survived by three sisters, Mrs. Thora Smith, Mill City, Ore.; Isabel Haagenson, Concord, Calif.; and Capitola Haagenson, Colgan, N. Dak.; and one brother, Jay Rolie, of Williston, N. Dak.

Memorial services were held April 3 at the United Church in Los Alamos.

The Los Alamos sub-section of the Institute of Electrical and Electronics Engineers will serve as co-host to the IEEE Region Six annual conference May 9 through 11. Nearly 1000 IEEE members from 11 western states are expected to attend. Meetings will be held in Albuquerque, with a visit to Los Alamos and tours of parts of the Los Alamos Scientific Laboratory scheduled for Wednesday, May 10.

Four LASL scientists are among the 16 major speakers on the program. **Clarence M. Fowler,** assistant GMX-6 group leader, will speak on "Explosive Electromagnetic Power Generators"; **R. W. Spence,** N division leader, will discuss "Nuclear Rockets: The Rover-Phoebus Program"; **James L. Tuck,** associate P division leader, will give "A Progress Report on Sherwood"; and **David B. Hall,** K division leader, will discuss "Nuclear Reactor Development." **Paul Rudnick,** J-16, is serving as an advisor to the conference committee.

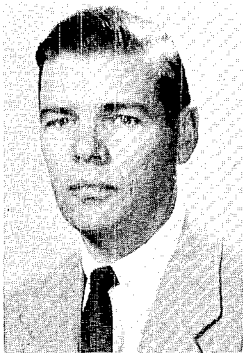
Theme of the conference, which will also be co-hosted by the Albuquerque section of IEEE, is "Frontiers of Energy Conversion."

Robert H. Martin, D-8 photographer and president of the New Mexico Industrial Photographers Association, has been cited by the Professional Photographers of America, Inc., for outstanding service.

This recognition came with the presentation to Martin of the PP of A national award plaque at the April 1 NMIPA annual awards banquet at the Los Alamos Inn. Robert C. Crook, D-8 group leader and New Mexico industrial councilman for the national organization, presented the award, the highest honor that an affiliated organization can bestow on an individual photographer.

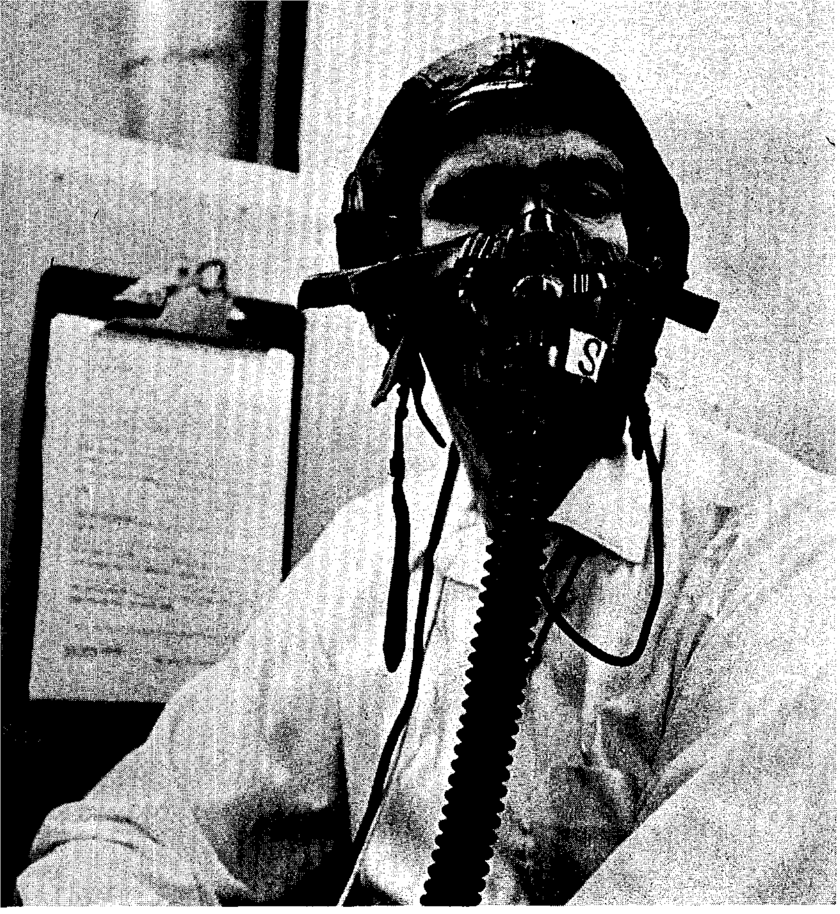
Martin has been an employe of the Los Alamos Scientific Laboratory since 1947. He served the laboratory for a year earlier as a member of the army special engineering detachment.

An additional honor, a first place award for the best color photograph made on the job, was won by Martin. In the same contest, **Bill Jack Rodgers,** Pub-1, earned a first place for the best color photograph taken off the job.



Bergen R. Suydam, T-DO theoretical physicist, is now at the Culham Laboratory, Berkshire, England, working in plasma physics research.

Suydam, who left for the new post last month, will be working under the auspices of a U.S./U.K. exchange program. With Los Alamos Scientific Laboratory since August, 1947, Suydam received his B.S. degree from Pennsylvania State College and his Sc.D. from Massachusetts Institute of Technology, both in physics. His wife, Helene, accompanied him abroad. They will return in June, 1968.



Art Cox, J-15 group leader, recently went through the altitude chamber for refresher training.

Prerequisite For A Plane Ride

By Bill Richmond

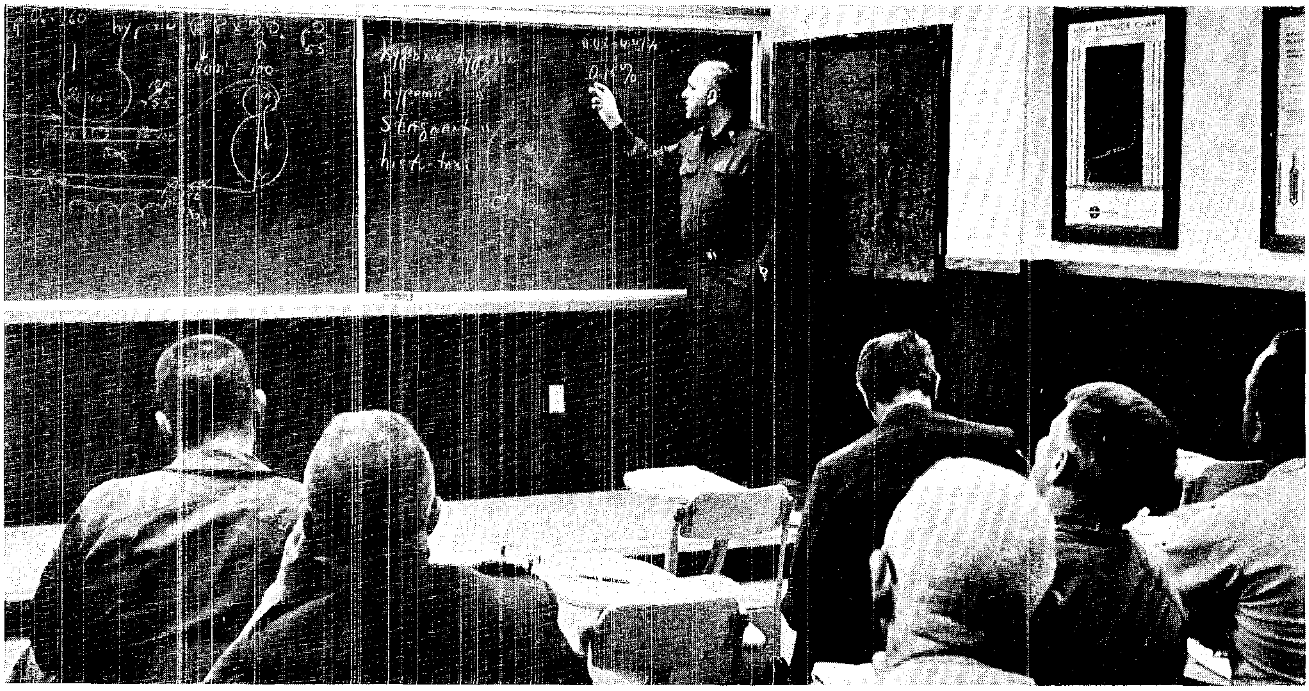
Photos by Bill Regan

In addition to being top-notch scientists, one group of men at the Los Alamos Scientific Laboratory must be physically fit as well. These are the scientists who occasionally conduct studies from LASL's "flying laboratory"—one of three specially equipped NC-135 aircraft which are operated for the Atomic Energy Commission by the U.S. Air Force.

These planes, the military equivalent of the 707 commercial jetliner, fly scientific research missions all over the world from their home base at Kirtland Air Force Base in Albuquerque. One is assigned to LASL, one to the Lawrence Radiation Laboratory and the third to Sandia Laboratory.

Before any of the scientists or technicians are permitted to fly on a scientific mission—such as the recent eclipse and cosmic ray studies—they must successfully complete a physiological training course and a water survival session.

The physiological course is a two-day affair with certification good for three years. Every three years, the scientists must complete a one-day refresher course to remain on flying status. A one-day water survival course must be taken annually and is required by Air Force regulations before making over-the-water flights. Recently, the physiological courses, both basic and refresher, have been taken by LASL personnel at Cannon Air Force Base in Clovis under the supervision of the 832nd Physiological Training



Air Force Capt. J. Devincentis, officer in charge of physiological training at Cannon Air Force Base, gave classroom instruction on a variety of subjects before "students" participated in the chamber flight.

Flight. In past years the course has also been offered at Carswell Air Force Base near Fort Worth. The water survival course is normally conducted at Kirtland and Sandia in Albuquerque, although it has also been held in Los Alamos.

LASL personnel must complete the passenger instruction phase of physiological training. This is required for passengers (i.e., non-crew members—such as Los Alamos scientists) who fly in military jet aircraft at or above 18,000 feet. The course includes, in addition to classroom instruction, an altitude chamber flight to 43,000 feet and a rapid decompression altitude flight.

The classroom instruction covers such subjects as physics of the atmosphere, respiratory and circulatory systems of the body, hypoxia (a deficiency of oxygen reaching the body tissues), hyperventilation and pressure breathing, dysbarisms, cabin pressurization and decompression, oxygen equipment, acceleration and "G" forces, emergency procedures and, finally, a written examination.

Air Force regulations provide that "personnel demonstrating inadequate knowledge in this subject are reported to their unit commanders, and arrangements are made for them to repeat the course of instruction."

Therefore, if the trainee—either civilian or military—does not achieve a passing grade of 70 per cent on the written test, he must repeat the entire course. The test consists of about 60 multiple-choice questions, and those students who snoozed or failed to take notes during the lectures will flunk it.

The Type II chamber flight, which is the highlight of the physiological training and is another means of ascertaining who slept during the lectures, normally occurs on the afternoon of the second day. It is conducted under tightly-controlled conditions with a number of observers, and it instills in the trainee an appreciation for his oxygen equipment. It also underlines in a dramatic way the reasons the physiological training is necessary.

During this training if a student encounters some difficulty or pain, an Air Force instructor is ready to assist. But if the same problem arises on an actual scientific mission, the consequences could be more severe. Thus, the chamber flight offers some means of preparing the trainee for what he may experience in the future.

Before the actual chamber flight, an instructor presents a pre-flight briefing where the entire flight is explained in advance. The primary objectives of this simulated flight to 43,000 feet are:

—To provide practical experience in the use of automatic positive pressure oxygen equipment.

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Physiological Training . . .

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—To acquaint or reacquaint the student with the symptoms of hypoxia.

—To provide experience in the practical use of emergency oxygen equipment.

—To provide instruction in pressure breathing techniques. (In normal breathing at ground level you "work" to get air into your lungs, and relax to exhale. In pressure breathing this is reversed. You relax, and your lungs fill with oxygen. Then you have to "work" to exhale.)

Also, so the trainee will know what it is like to experience a sudden loss of cabin pressure, he undergoes a safe and controlled rapid decompression.

Before entering the chamber, the trainee is issued a leather helmet and an oxygen mask. After entering the chamber and taking his assigned seat, he performs the necessary pre-flight check of his equipment, and the flight is ready to begin.

The first 15 to 20 minutes is spent at ground level —with the chamber door open—on 100 per cent oxygen. This is the denitrogenation period where nitrogen is purged from the blood stream in order to prevent evolved gases from forming bubbles and possibly causing "the bends" at higher altitude.

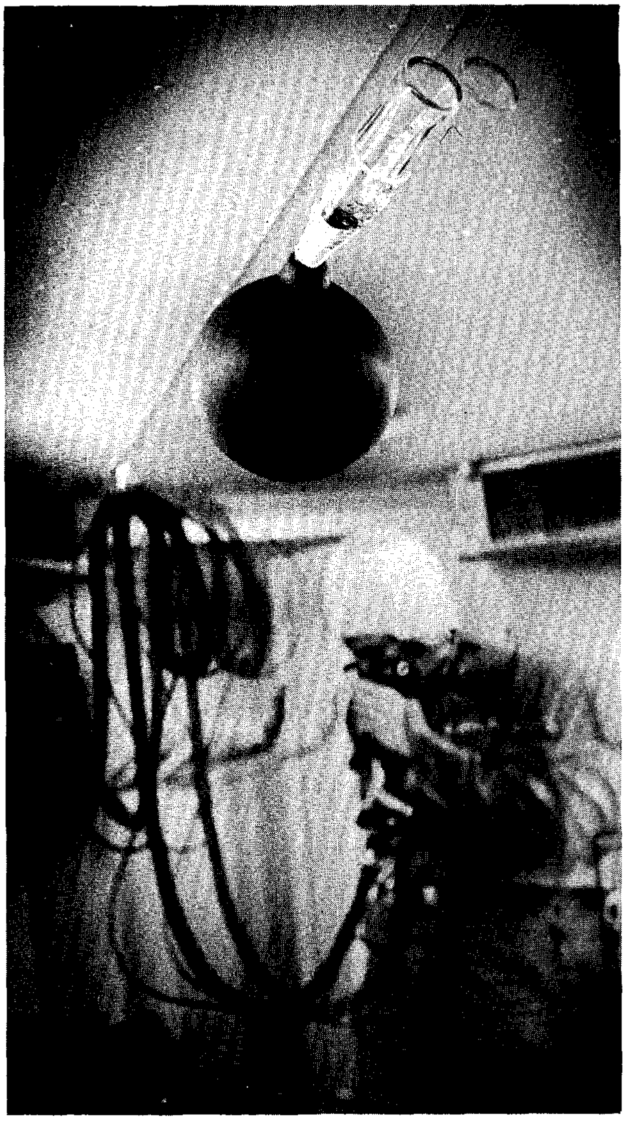
Then the chamber door is closed and the simulated flight begins.

The first part of the flight is a climb to 10,000 feet where the chamber is leveled off and then dropped back to 5,000 feet. The chances are that most ear blocks and sinus trouble caused by the decrease in pressure will show up below 10,000 feet. Thus, by climbing to this altitude and then dropping back, the trainees get chance to clear the passages. After a few minutes the pressure again begins dropping and it's a straight flight upwards to 43,000 feet.

Usually everyone has been able to clear their ears, sinuses and the trapped gases in the stomach. These trapped gases expand in the stomach, until at 43,000 feet the volume is nine times the usual one to two pints at ground level. This results in mild discomfort and occasionally pain which forces a trainee to terminate his flight and leave the chamber.

An unusual problem nowadays, but one which is still possible, is a minute pocket of trapped air between a tooth filling and a nerve ending. This can result in excruciating pain, with the only permanent solution being a new filling.

At 43,000 feet the chamber is leveled off for a few minutes and then a "free fall" to 25,000 feet is simulated. The purpose of this is to acquaint the student with possible bailout practices. In the event an aircraft was operating at this altitude and the occupants were forced to eject, they would not live long at this altitude because of the extreme cold of -67°F coupled with the lack of oxygen. Another reason for a "free



Blurred vision is one of the normal symptoms of hypoxia. The balloon attached to the bottle in the foreground illustrates the pressure decrease in the chamber.

Capt. Devincentis illustrates spatial disorientation for Art Cox.

fall" in an actual emergency is to lessen the opening shock of the parachute. This shock at 43,000 feet would be about 33 "G's", compared to only eight or nine "G's" at 14,000 feet.

The automatic parachutes used by the Air Force are set to open at 14,000 feet. However, for the purposes of the training flight, the free fall is to only 25,000 feet.

To overcome the oxygen problem, a bail-out bottle is provided with each ejection seat or parachute. This bottle is connected to the normal oxygen supply hose and will accompany the pilot and passengers when they leave the aircraft. It contains a 7- to 10-minute oxygen supply, which is ample. In the simulated flight, the trainees fall from 43,000 to 25,000 feet in about a minute--breathing oxygen from the bail-out bottle.

At 25,000 feet the chamber is leveled off for a hypoxia demonstration. During this phase, half of the trainees in the chamber take their oxygen masks off while the others observe the "silent" creeping up of hypoxia. Hypoxia symptoms vary among individuals, but the instructors emphasize that it is paramount for all flying personnel to recognize their own symptoms. Hypoxia occurs when there is a shortage of oxygen, and this can happen when a pressurized cabin slowly loses pressure through a leak, or when an oxygen supply runs out, or if an oxygen hose becomes disconnected.

Since there is usually no pain accompanying hypoxia, it can become extremely difficult to spot in a self-diagnosis. Some of the more common symptoms include impaired vision, dizziness, tingling sensation, fingernails and lips turning blue and so-called "personality changes." A few individuals experience a nauseous state, but this is not common.

The occasional personality changes range from a state of euphoria to one of belligerency, normally accompanied by the feeling of: "I'm fine!!"

While their masks are off, the trainees take a simple written test. This involves adding or subtracting numbers, selecting numbers out of sequence, counting, writing their names and other tasks which are normally accomplished easily. Some people completely forget their multiplication tables. Others refuse to put their oxygen masks back on and have to be forced to do so. The primary objective of this demonstration is to illustrate how hypoxia can slow down or alter the mental processes—a situation which could be fatal at the high altitudes flown today.

After all the trainees have had an opportunity to perform the tasks without oxygen, the simulated flight returns to ground level, and this phase is over.

Next on the training schedule is the rapid decompression flight.

In this phase, a simulated flight at a true altitude of 24,000 feet is set up, with cabin pressurization of

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Physiological Training . . .

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only 8,000 feet. Oxygen masks are not on but are attached to the helmet. This phase is normally conducted with two trainees at a time with one instructor. The trainees are given a warning that the cabin is going to lose pressure, and a few minutes later it does. This consists of a "pop"—which is a loud "bang" on the outside of the chamber—followed by dust and fog in the cabin. The first thing a trainee must do when the cabin loses pressure is to slap his oxygen mask on as soon as posesible. Then the flight returns to ground level, and the chamber flights are completed.

The purpose of the rapid decompression is to emphasize the necessity of having oxygen masks attached to the helmet when the true altitude is above 10,000 feet—even if the cabin is pressurized. A sudden loss of pressure can not be foreseen, and the only cure is oxygen.

After a critique on the examination and the subjects the trainees have covered during the two-day course, a certification card is issued which attests to the fact the individual is qualified to ride as a passenger on Air Force planes.

But, if he will be involved in over-the-water flights —and many LASL personnel are—then the water survival course is also required.

The one-day water survival course includes a morning of lectures and films, with the afternoon set aside for practical use of emergency equipment in the Sandia Base swimming pool.

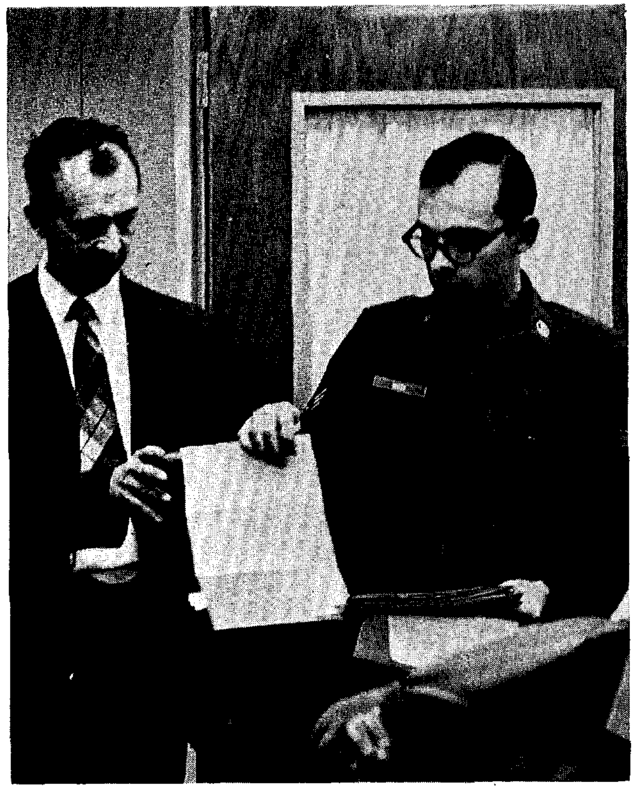
During the lectures, the Air Force instructor explains the make-up of the NC-135 aircraft—including emergency exits and the best way to get out—plus intercom systems, oxygen equipment, takeoff and landing procedures and the emergency equipment carried in the plane and in the life rafts.

The instructor emphasizes that everyone is to grab a first aid kit near the door and take it with him when he goes out the door, because "you never know if it is only a minor alarm or something more serious."

He also warns the students not to grab the end of the rope near the main emergency exit and jump . . . because the rope is longer than the distance to the ground. "You'll break your legs or your neck if you do," he says. Instead, proper procedures call for the rope to be throw out and then the passengers are to clamber down it to the ground.

The afternoon phase consists of putting to practice what was learned during the morning session.

At the swimming pool, the raft is inflated. Each trainee puts on a life jacket and swims out to the raft, where the instructor explains where the various supplies and emergency equipment are stored and what each is for. The trainees also put on "wet suits" —designed to save their lives in waters of the polar regions—and splash around. The new wet suits have an inflatable hood plus booties and gloves which offer further protection against the cold.

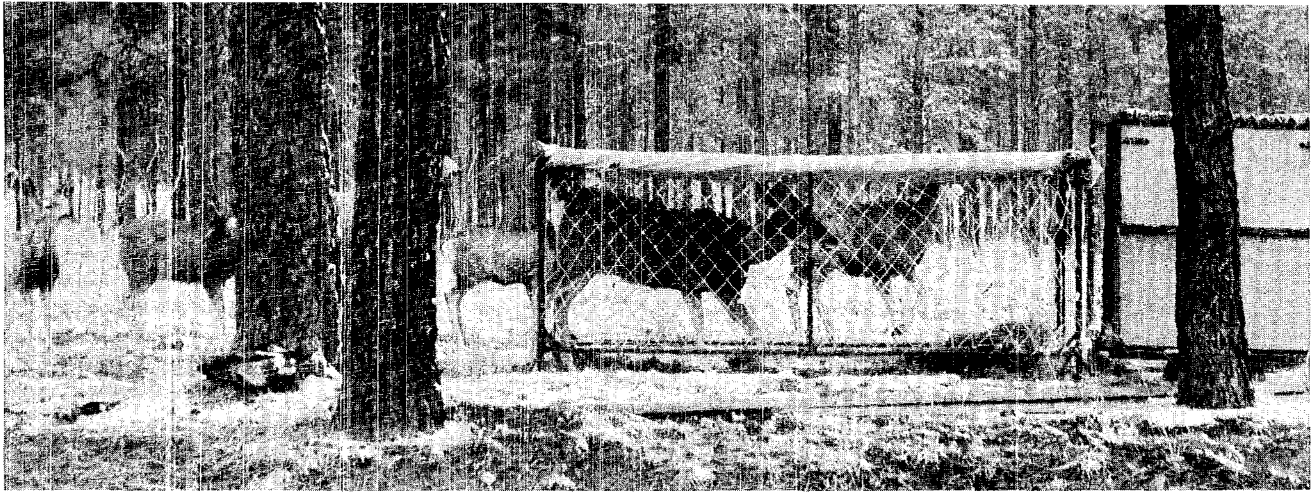


Cox received his "diploma" after completing the refresher course at Cannon Air Force Base.

It is advisable in this course—as in the physiological training—to pay attention to the instructor. Example: The life jacket has cords on the bottom which have to be pulled to inflate the jacket. One trainee didn't listen to the instructor and thought the jacket would automatically inflate by pressure.

So he jumped in the deep end of the pool, settled to the bottom and waited for the jacket to inflate. It didn't. So he decided to swim to the surface and ask how to inflate it. When he was told, the color of his face was a perfect match to the bright orange of the jacket.

Most people who have been through the two courses feel the Air Force has done an excellent job of preparing its passenger scientists for flight and has played a great part in the success of future scientific missions.



Enticed inside by celery and fresh hay, a young deer of the TA-9 family at LASL ventures inside the nylon netting trap set up to allow conservation officer Homer Pickens to trap it, tag it and check its general health as part of his program to study breeding and grazing habits in a fenced area under control conditions. When the trap springs, curtains drop down, darkening the interior and quieting the deer.

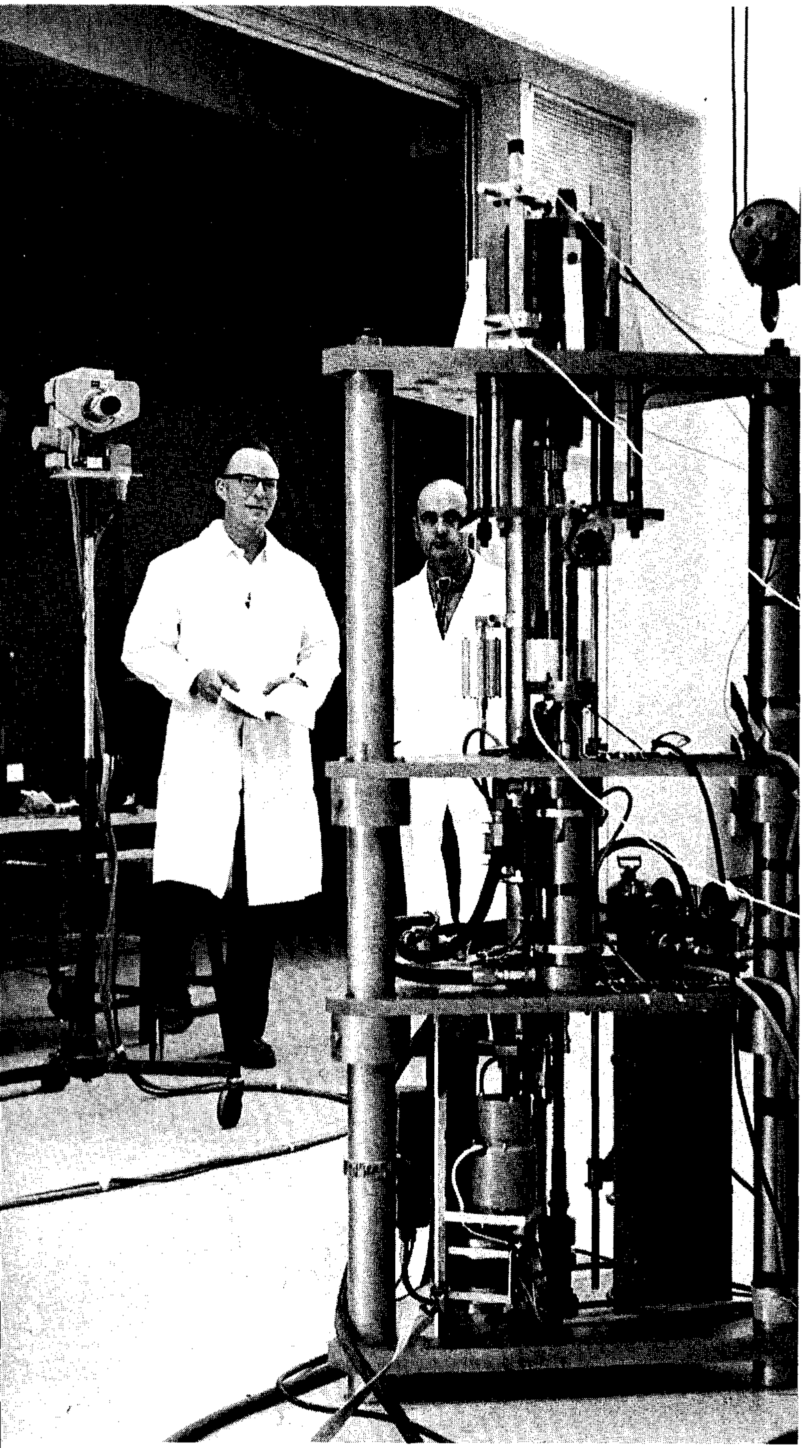
Radio Transmitters Track TA-9 Deer

Privacy in the wilderness is a thing of the past for one herd of Los Alamos deer. The deer of Tech Area 9 are now sporting tiny radio transmitters designed to trace their feeding and breeding habits.

The transmitters were designed by the U.S. Forest Service and have been adapted for use at LASL as a part of a cooperative program between Engineering group 5 and Homer Pickens, Atomic Energy Commission conservation officer for Los Alamos. The transmitter emits a "beep" tone, and a directional loop antenna picks up the signals. The direction a deer travels, his stops and moves can be followed up to a half-mile.

Listening in on the four-point buck as he beeps off into the brush are members of the ENG-5 team which worked on the transmitter, receiver and directional loop antenna. From left are Bobby Hartway, Jack Wilson and Ken Kraker. (ABOVE)

Anesthetized 185-pound, four-point buck is easily handled by veterinarians as collar is put around his neck and transmitter is tested. Jack Wilson, left, radio specialist, locks collar on the buck's neck while L. M. Holland, H-4, and Homer Pickens watch. Deer is half awake but completely docile from tranquilizing drug administered from pointed capsule shot at him with air pistol in Pickens' hand. (LEFT)

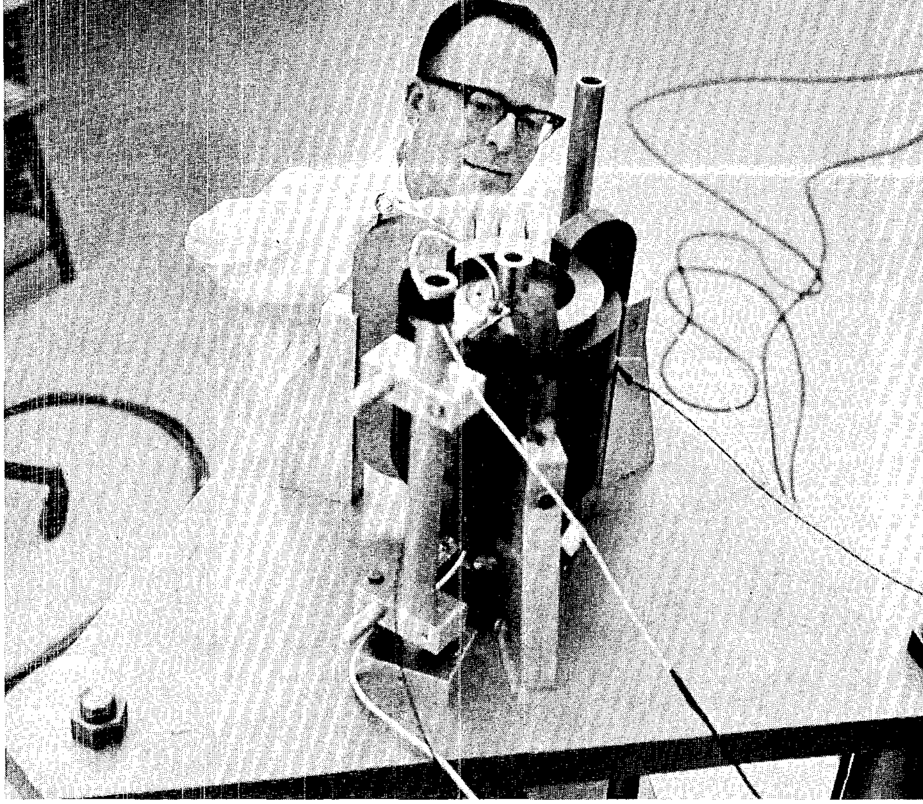


Roger White and Thomas Wimett, both of N-2, inspect Godiva IV in Kiva 2 at Pajarito Site. At left is a closed-circuit television camera which is connected to a TV monitor in the Kiva 2 control room to allow scientists to watch various reactor experiments.

The Unclad Ladies of LASL

The unclad ladies of LASL
Are not famous for twirling a tassle.
But at neutron emission
Resulting from fission
No other machines are more facile.

Roger White makes an adjustment on the Godiva IV assembly. The three large steel C-clamps hold together the six U-235 rings that make up the main body of the reactor.



By Bob Brashear

Lady Godiva probably shivered a little in the Coventry breezes, but her shivers weren't like those of the "ladies" of Los Alamos Scientific Laboratory who carry her name today.

The shivers that ran through the famed lady's unclad frame were no doubt quite gentle. Those that ripple through the unclad Godivas of LASL are more like midget earthquakes.

Godiva IV, the latest in the line, is now undergoing survival tests. Hopefully she will be able to withstand shivers—thermal shock—equaling 100,000 pounds per square inch while producing a burst of power around 100,000 megawatts (in watts, that's 100,000 with six more zeros) in 20 millionths of a second. Add to the shock a rise from room temperature to 500 degrees centigrade, and therein lies our modern Godiva tale.

The Godivas of LASL are fast nuclear reactors. They get their name because there is no protective shielding around the fissionable fuel that is the source of their tremendous energy bursts which are generated in mere millionths of a second.

Back in 1953, when the idea of an unclad, fast burst reactor producing energy rivaling small atom bombs was conceived, the first Lady Godiva was born. Questing scientists wanted their reactor to be dainty of frame, but with the strength that made the original Lady of Coventry a legend. This she was.

The frame was a spidery network of pipes with the sphere of nuclear fuel—uranium 235 metal—suspended between them in pristine isolation. The sphere was designed to separate into three roughly-equal fuel masses. The two outside pieces were mounted on pistons which could push them into contact or rapidly pull them away from the center portion to start and stop the build-up of nuclear fission chains. Two rods of additional uranium could be inserted into the mass to boost the energy release into the so-called "super-critical" range. The burst yield (in scientific language) was 2 x 10^{16} fissions in 35 microseconds (35-millionths of a second.)

The Lady went for one ride too many in the interests of science. She died in a glorious burst of energy with a "shiver" that bent her frame beyond repair. The legacy she left—that incredibly fast reaction and a challenge to engineer even stronger progeny—has resulted in seven fast burst reactors built by LASL and other interested laboratories.

Not all the later models in the family of unclad fast reactors have borne the Godiva name. Godiva II—a true pulsed, fast-burst reactor—came along in 1957 at LASL. Kukla was the name given a reactor of the same type as Lady Godiva by Lawrence Radiation Laboratory scientists around 1961. Also in 1961, LASL and Sandia Corporation got together on a device resembling Godiva II, called SPR I. She was actually Godiva III with a new name.

As interest in the unclad reactors and their energetic feats spread, LRL unveiled Fran, a cylindrical core geometry made up of enriched uranium metal "washers" held together top and bottom by three-

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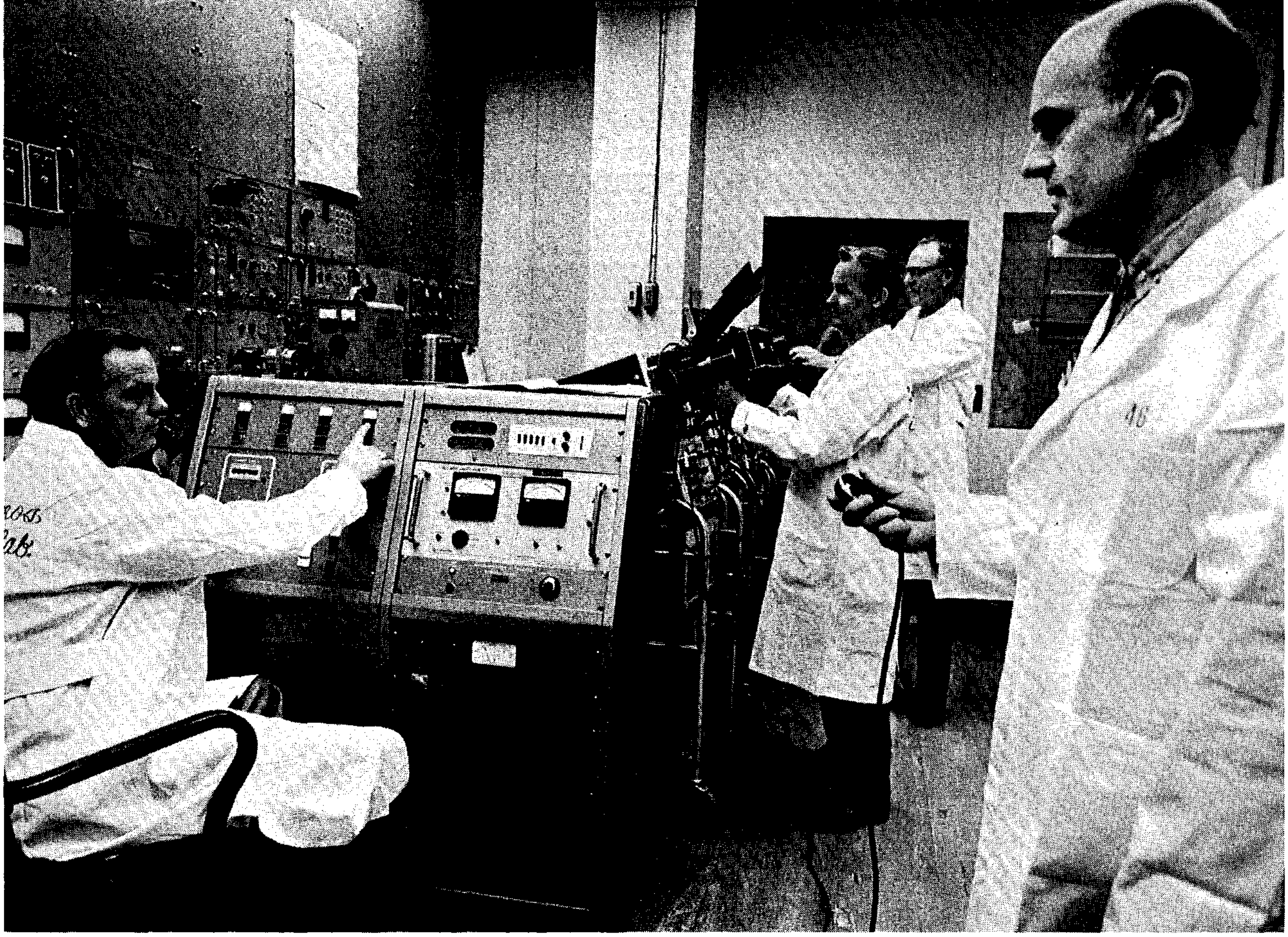

The N-2 team that operates Godiva IV from the Kiva 2 control room includes, from left to right, reactor controls engineer Robert Wagner, seated at the reactor operating console; health physics monitor Ray Pederson; and Roger White and Tom Wimett.

Godiva . . .

Continued from preceding page

quarter-inch steel rings and three-quarter-inch steel bolts. The hole through the center of the washers provided space for insertion of a uranium safety block and a small chamber in which to do irradiation work. The same year, 1962, United Nuclear Corporation came up with the Health Physics Research Reactor and a new idea to offset the break-up and failure of the pure uranium (enriched with 93.5 per cent U-235) by alloying it with 10 per cent by weight of molybdenum. Where the forerunners had ranged between 50 and 59 kilograms, the HPRR was a heavyweight at 115 kilograms—roughly 287.5 pounds. Then came Molly-G, a molybdenum-uranium core worked out at LASL and placed on a framework designed at White Sands Missile Range. The term Molly-G stands for molybdenum alloy Godiva. Molly-G was born in 1964 and weighed in at 97 kilograms (approximately 242.5 pounds). Super Kukla is the name LRL has given a heroic model weighing more than two and a half tons at the core, and still to be heard from in the research department.

Godiva IV was born Feb. 15, 1967. She is a new design with the same old sleek, unclad lines—light but powerful frame—and operating in the ancestral home, Kiva 2 at Pajarito Site. *Her growth and education* are being supervised by mentors of N-2 who set Lady Godiva into her niche in nuclear history. They include Tom Wimett, nuclear physics; Roger White, engineering; Robert Wagner, reactor controls, and Ray Pederson, health physics and monitoring.

Godiva IV's shivers so far have been estimated at more than 15,000 pounds per square inch. Her core exterior expands about four ten-thousandths of an inch as the mass heats 350 degrees C in 36 microseconds. The surge of power is something like 30,000 megawatts (30,000,000,000 watts heat generating rate), four times the electrical generating capacity in the state of California in the same time interval.

When she grows up, it is hoped she will produce 100,000 million watts of power in 20 microseconds, and remain healthy. The shock going through her frame will expand Godiva IV twice over what it has been in preliminary tests, and her temperature will hit 500 degrees C. Although uranium melts at 1100 degrees C, a change in crystal structure takes place around the 600-degree level. This barrier has not yet been passed.

Godiva IV is a mixture of 1.5 per cent by weight molybdenum and enriched uranium. Nobody has tried this alloy before in a prompt burst geometry.

James Taub, CMB-6, said the mixture should show less brittleness and increased ductility while retaining its high tensile strength. The core is actually a cylinder made up of six rings resembling iron washers. It is seven inches in diameter outside and six inches high. A safety block of fuel fits inside the washers to give a total mass of 65 kilograms—about 162.5 pounds. The safety block is held in place by an electromagnet pushed into position by a hydraulic piston. When a burst is generated, the magnet current is cut, and the shock pushes it out of the core.

Three rods are used to bring the nuclear reaction first to a point called delayed critical, and then to push it into the super prompt critical range. They fit into holes bored up into the outer rings of the core. Two are called control rods, and when they are in place the build-up of fission chains in the core is steady—delayed critical. The chain reaction is stopped by dropping the safety block for a short period of time, allowing the mass to cool. The block is re-inserted, and the third rod, called the burst rod, is rammed home quickly to produce the prompt burst of energy.

Three inch-thick C-clamps hold the fuel rings together. They replace the bolts used in earlier models which proved to be unsatisfactory. The clamps are made of a new steel alloy called maraging steel. The makers claim the clamps can withstand a shock pressure of 300,000 pounds per square inch without bending or breaking.

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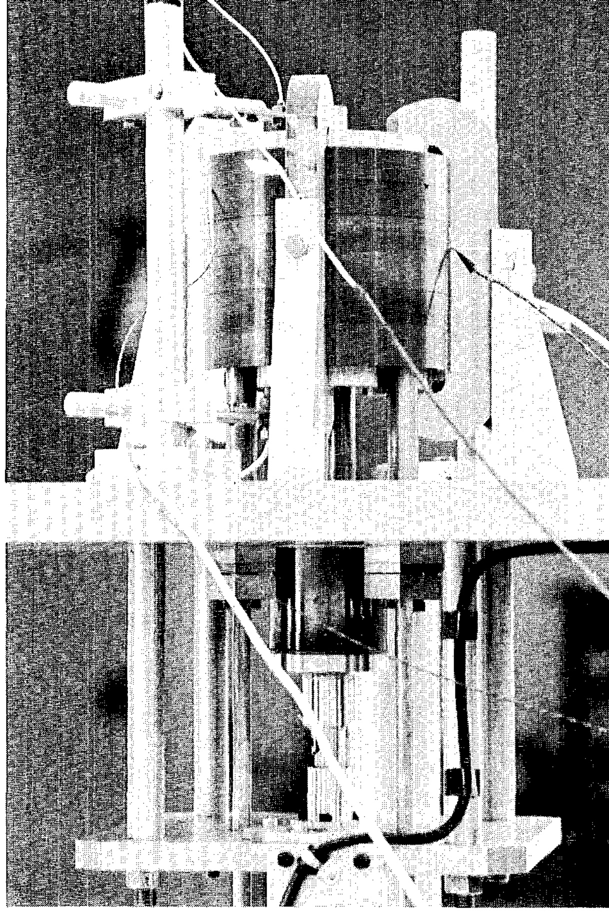
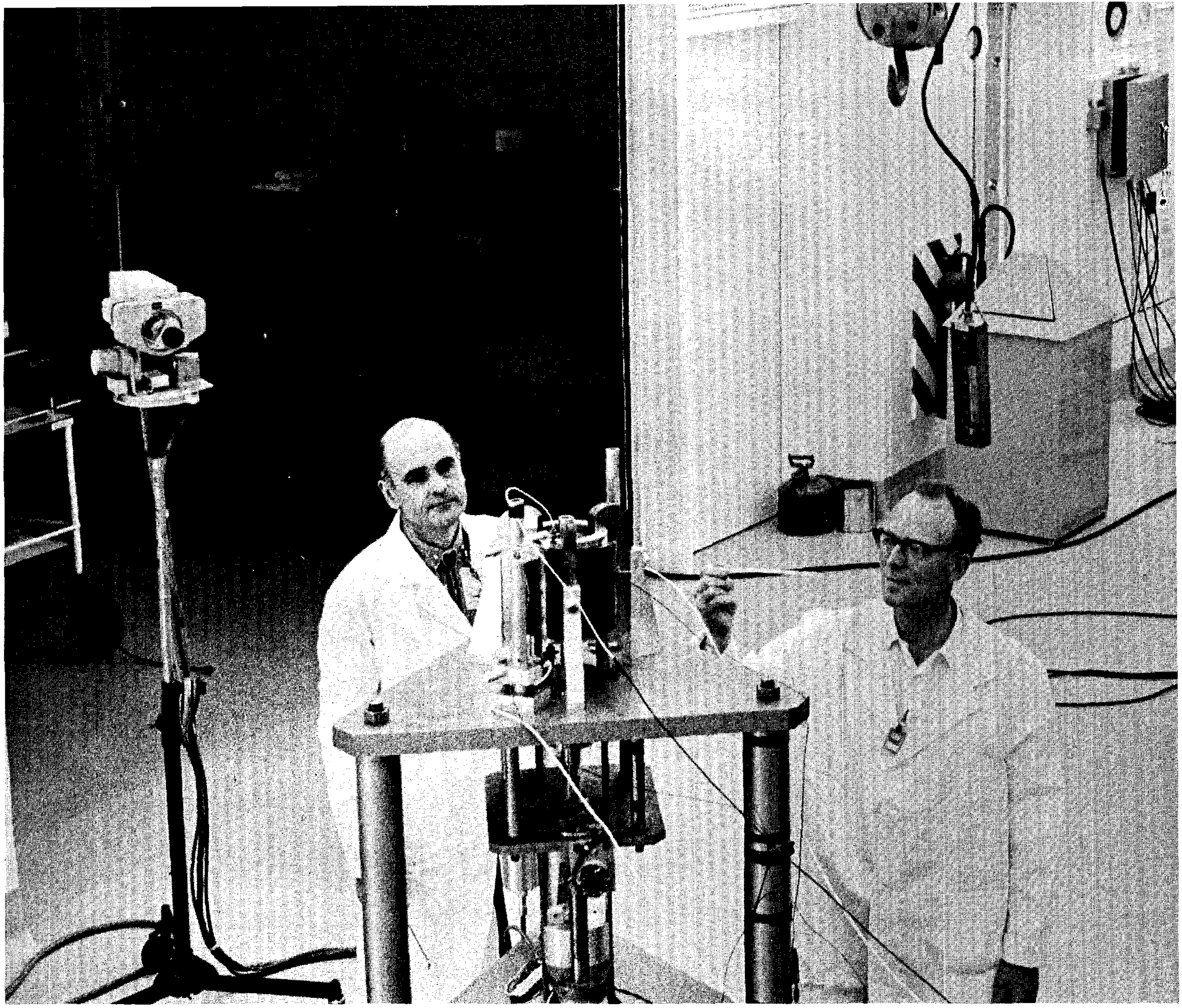


Closeup of Godiva IV shows its main features. On top the platform are the six U-235 "washers" held together by three large C-clamps. Just below the rings are the three U-235 rods which are inserted into the rings to cause the reactor to go prompt critical and produce a very intense and very short burst of neutrons. Below the table is the safety block, a cylinder of U-235, which is raised up into the rings before *the three rods are inserted.* The safety block is held in place by an electromagnet. When a reactor burst is produced, the magnet current is automatically cut off, and the safety block drops out of the core.



Kiva 2 at Pajarito Site is the home of both Godiva IV—left—and the minimum critical mass experiments—right. Tom Wimett and Roger White work on Godiva reactor, while George Jarvis and Carroll Mills check out the minimum critical mass assembly.

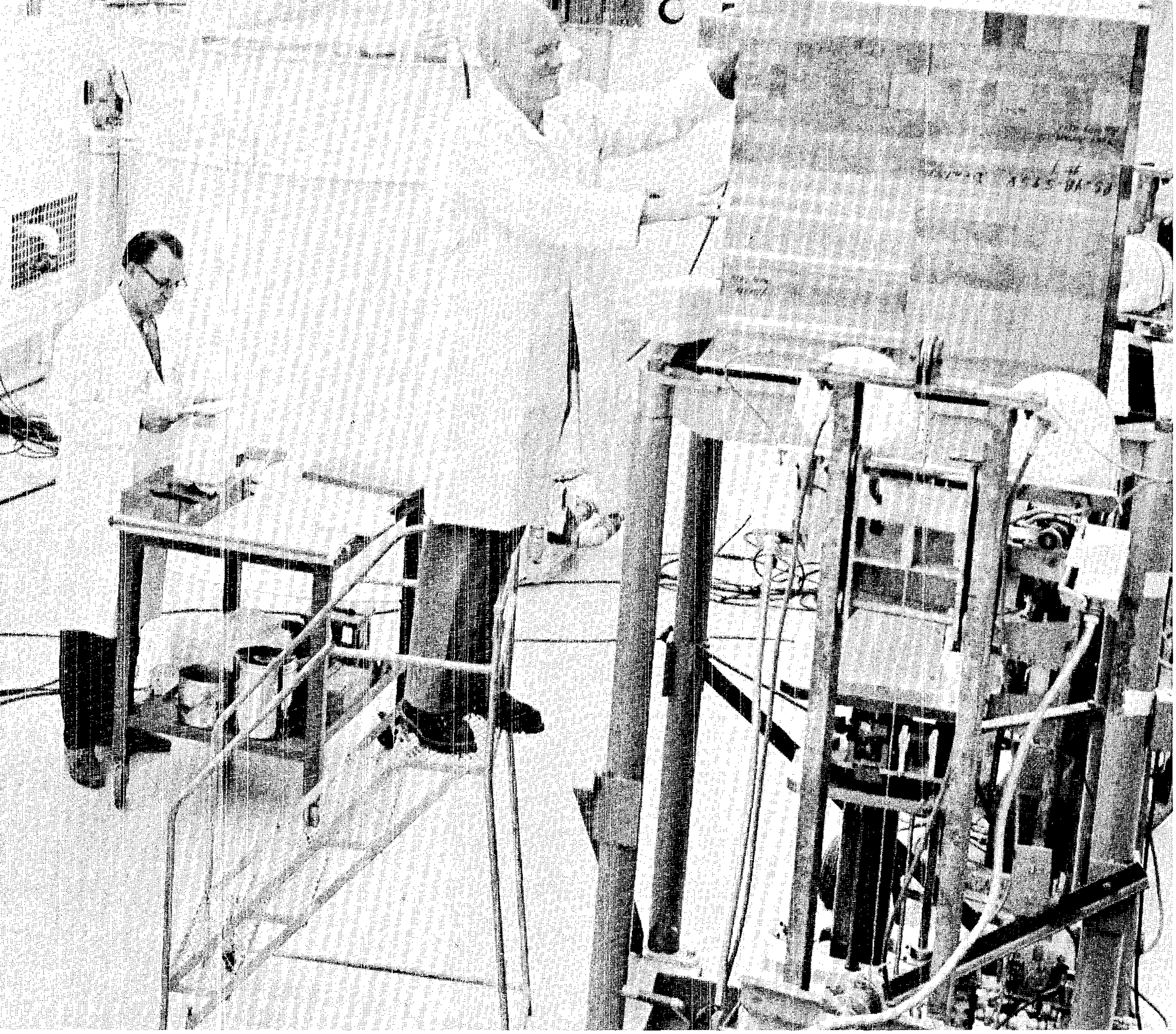
Godiva . . .

Continued from preceding page

"We'll find out if this is true during our test bursts," said Wimett. "After all, there are no other machines in the world which can set up mechanical shocks like these, so the clamps have never been tested." He explained that clamps were used because in earlier models where the fuel rings were bolted together the thermal shock actually stretched the bolts to the breaking point.

The rapid expansion of the fuel tends to slow up and stop the growth of the energy-producing fission chains—a sort of built-in safety valve. The sudden burst or pulse of neutrons from the mass is useful in work on fast neutron spectra provided only by nuclear weapons detonations. These and other data on behavior of reactors are the kinds of information scientists obtain from the Godivas.

The unclad Godivas of LASL are unique in the world for their simplicity, their usefulness and economy, their contribution to basic knowledge of nuclear energy and engineering—a history that bids to make them a legend equal to the unclad Lady of Coventry.



LASL Scientists Construct World's Smallest Reactor

By Robert Masterson

In recent months, much of the attention in the nuclear reactor field has been centered on the ever larger power reactors being built or proposed by the nation's electric power companies in what at times seems like a game of "can you top this".

While these huge reactors, generating as much as one billion watts of electrical power and using tons of uranium fuel, were making headlines, a pair of Los Alamos scien-

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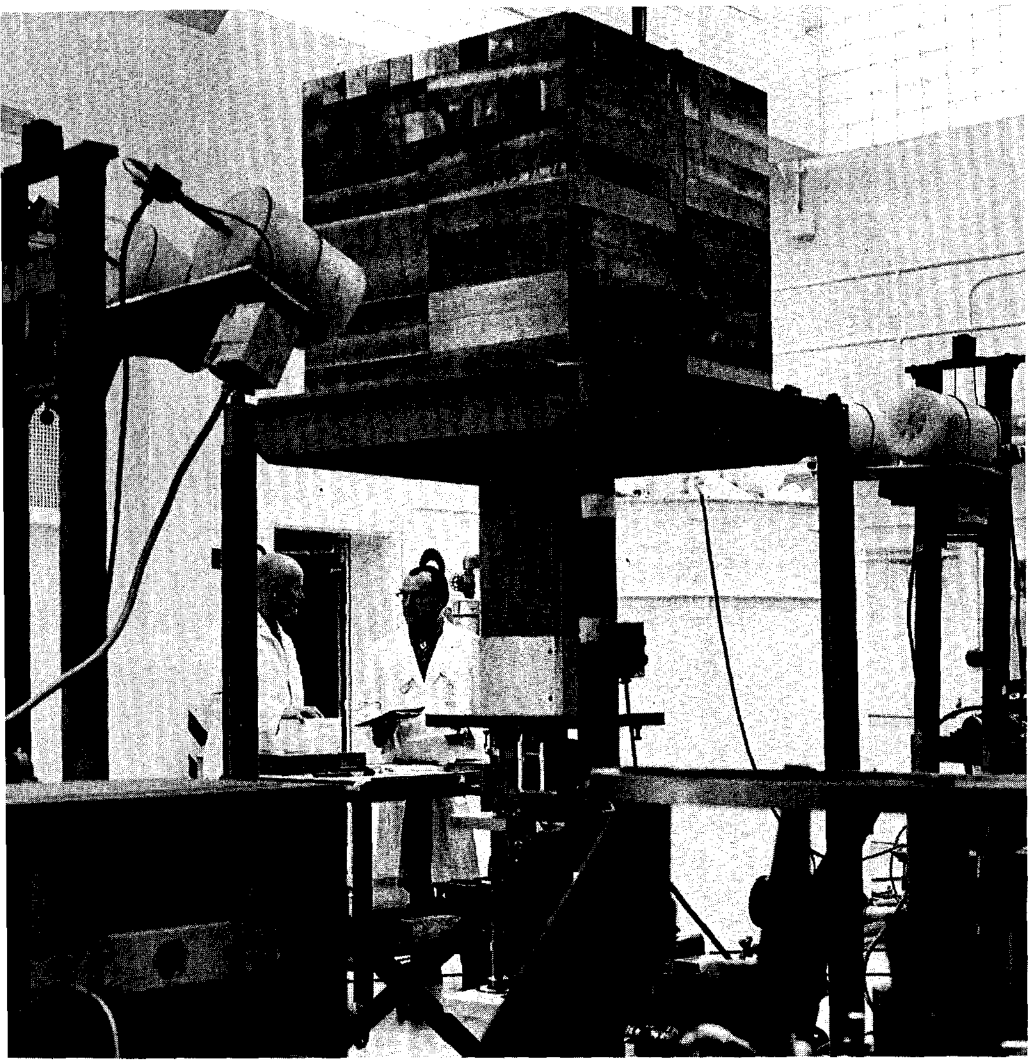

Carroll Mills, left, and George Jarvis check foil and polyethylene sheets used in their uranium 235 minimum critical mass measurements. In the foreground is the critical assembly they used. The large beryllium reflector is on top of the stand, and below is the core assembly which can be raised up into the reflector. The two pairs of large white plastic cylinders are neutron detectors.

Smallest Reactor. . .

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tists were "thinking small" and constructing the world's smallest—in terms of the amount of fuel required—nuclear reactor.

Last fall, Carroll B. Mills, T-DO, and George A. Jarvis, N-2, determined the absolute minimum critical mass of uranium 235 at room temperature and atmospheric pressure—that is, the least amount of U-235 that will go critical and support a nuclear chain reaction. They obtained a value of 242 grams (8.5 ounces).

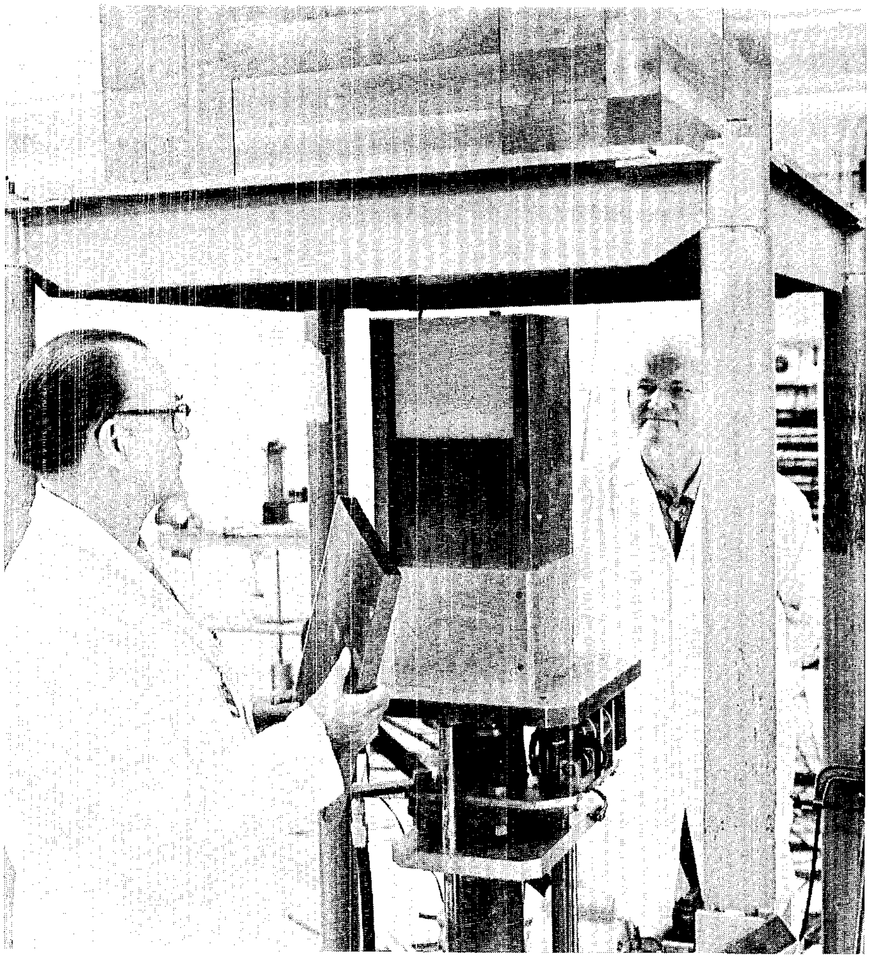
The minimum critical mass (mcm) is an important and sometimes controlling factor in the formulation of practically all the procedures for handling, processing or using a nuclear reactor fuel (an isotope which readily undergoes fission by neutrons) such as U-235.

The value of the mcm is different for each particular combination of fuel, moderator and reflector. The reactor moderator serves to slow down the fast neutrons emitted by the fissioning fuel atoms so they are capable of causing more fissions. The reactor reflector scatters some of the neutrons escaping from the fuel-moderator core back into the core where they can cause fissions. Reactor moderators and reflectors consist of materials which scatter neutrons well without absorbing them. Examples are graphite, heavy water, beryllium and various hydrogeneous materials such as polyethylene and water.

In addition to depending on the particular fuel, moderator and reflector materials used, the value of the critical mass for a reactor system also is affected by the shape and arrangement of these components. Examples range from metallic fuel elements in an unreflected matrix of solid moderator to a homogeneous fuel-moderator mixture, such as a uranium compound in solution in a moderating liquid, surrounded by a thick layer of neutron reflector.

At one extreme is a minimum critical mass of 47 kilograms (103 pounds) for an unreflected, unmoderated sphere of U-235 metal, and

Jarvis, left, and Mills inspect core assembly used to measure the minimum critical mass of uranium 235. Jarvis holds a beryllium plate which has been removed to expose one side of the reactor core consisting of alternate layers of U-235 foil and polyethylene sheets sitting on a thick layer of beryllium. During a measurement, the core assembly is raised into the large beryllium reflector supported by the stand.



the other extreme, until recently, would have been an mcm of 565.5 grams of U-235 for an aqueous solution of uranyl nitrate reflected by a thick layer of beryllium oxide.

This latter value was measured in 1943 by a team at Los Alamos that included L.P.D. King and R. E. Schreiber, following theoretical work by R. F. Christy, in preparation for construction of the Los Alamos Water Boiler Reactor. Since then, values of the mcm for a great number of reactor systems have been measured for a wide range of U-235 fuels with various moderators and reflectors, but the uranyl nitrate solution investigated in 1943 held the record for 23 years as being the smallest reactor system—the one requiring the least fuel—ever assembled.

The LASL Water Boiler value of 565.5 grams remained the champion mcm until last year when Mills became curious and calculated what the optimum moderator and reflector materials and optimum geometry would be for a U-235 reactor. This calculation was part of a cooperative program to develop a powerful new set of computer programs which will allow easy, accurate and fast calculation of the critical parameters of the entire range of nuclear systems.

Key Los Alamos Scientific Laboratory people in this work are Bengt Carlson, T-1, who has been developing fast and flexible computer programs for determining the physical properties of neutron multiplying systems, and Roger Lazarus, T-7, who has been preparing a master computer tape containing all the neutron cross section data for all the elements. In addition, personnel of the N-2 group have been collecting and summarizing a vast amount of data on critical systems and making critical measurements to check the accuracy of the cross sections being assembled by Lazarus.

Mills' calculations suggested that the most reactive U-235 system possible could be approximated using polyethylene (CH_2) as a moderator and beryllium as a reflector. Mills then got together with Jarvis of Hugh Paxton's N-2 group which

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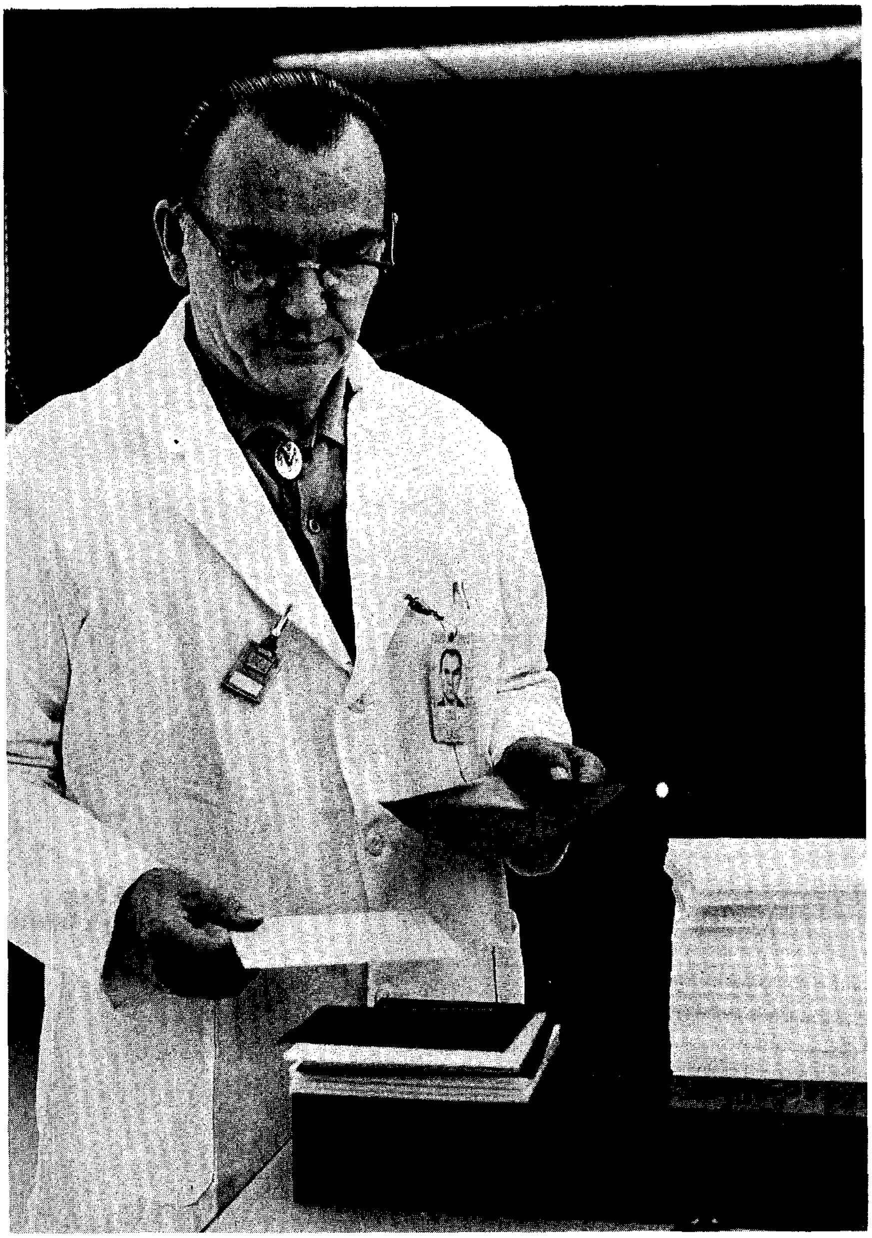

Jarvis stacks U-235 foils and polyethylene sheets to build up core for minimum critical mass measurement.

Smallest Reactor . . .

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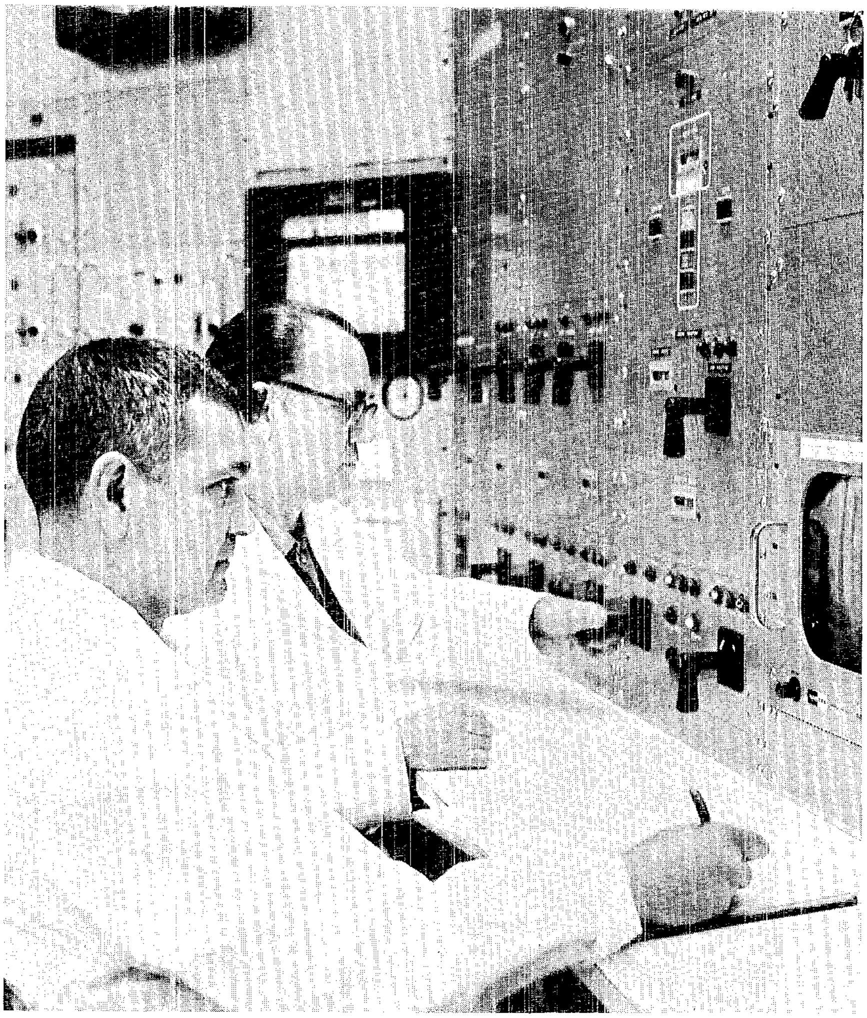
had all the materials necessary to check these calculations.

Using one of the remote control critical assembly facilities, Kiva 2 at Pajarito Site, used by N-2 for many different types of criticality measurements, Jarvis and other N-2 personnel constructed experimental reactor assemblies consisting of cubical cores inside a cubical beryllium reflector with walls 12 inches thick. Cores of three different base sizes (approximately 8 inches, 6.5 inches and 6 inches square) were built by stacking up layers of thin U-235 foil (0.0012 inch thick) and 0.125-inch-thick polyethylene to various heights.

For each measurement, the cubical beryllium reflector with a cubical cavity opening to the bottom was assembled on a stand over a matching hole in the stand. Positioned below this cavity was a small platform on which was placed a U^{325}-CH_2 core assembly resting on a 12-inch layer of beryllium. This core and bottom reflector, which just filled the reflector cavity, was then raised remotely from the Kiva 2 control room into position in the large reflector to see if this particular core and mass of fuel would support a chain reaction.

The scientists repeated this procedure many times with the three different core base sizes, with different core heights and with various thicknesses of U-235 foil and polyethelyne. They found that a minimum critical mass of 250 grams of U-235 is obtained with a core 6 inches square by 4.75 inches high. A further three per cent reduction of the mcm to 242 grams was produced by arranging the fuel with 20 per cent of it at the



Technician Bennie Pena, left, notes data as Jarvis operates Kiva 2 controls for one of the experiments to measure the minimum critical mass of uranium 235.

core boundary—that is, the core was covered on all six sides by a layer of U-235 foil.

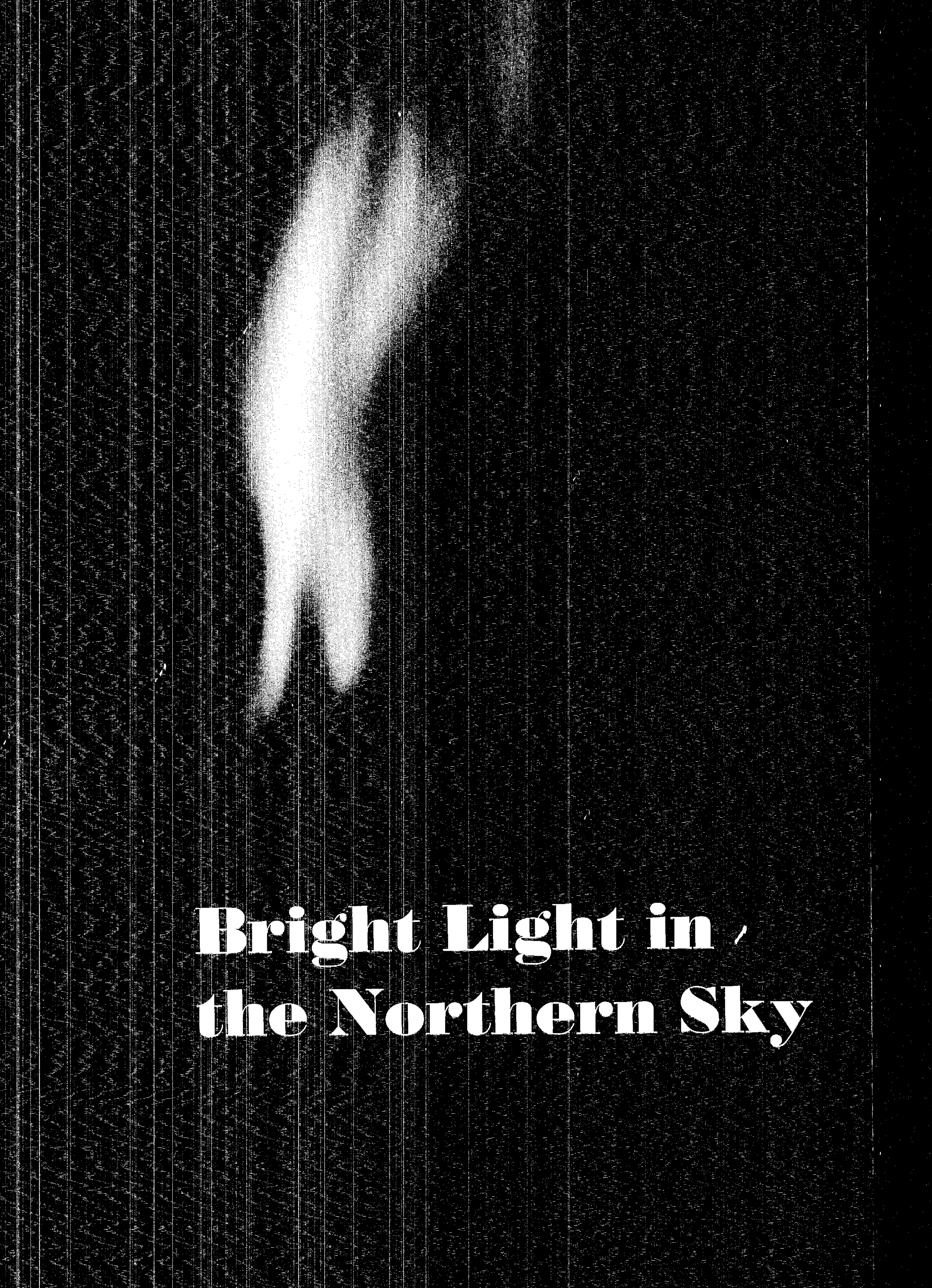
These measurements clearly showed that this value of 242 grams, which, incidentally, is the mass of a uranium ball approximately an inch in diameter, must be close to the absolute minimum mass of U-235 that can be made to support a nuclear chain reaction under any conditions. This result has much significance to the fields of reactor physics, safety and economics.

It is important to reactor physics because it provides a check point in reactor physics calculations, and as an end point—that is, the absolute minimum critical mass of U-235—acts as a kind of boundary condition which may well influence future small reactor design.

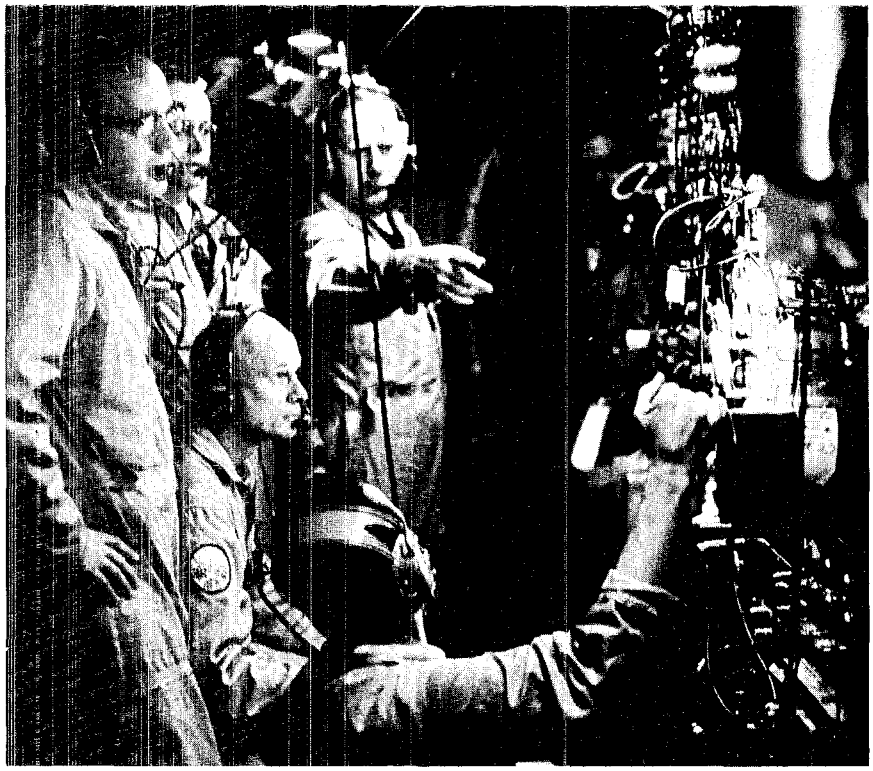
This, in turn, could influence reactor safety and economics since a reduction in the amount of fuel in a reactor tends to reduce the amount of elaborate and usually costly safeguards required to ensure that an accidental chain reaction does not result from distortion or disarrangement of the reactor core or the fuel elements during transportation or storage.

Thus, this data on the smallest amount of nuclear fuel could ultimately have a beneficial effect on the entire nuclear reactor field, including the construction of huge reactors, containing tons of fuel, for electrical power production.

Checker-sized piece of uranium 235 is the equivalent of U-235 used in the form of thin foils in the minimum critical mass experiments.



Bright Light in the Northern Sky



LASL scientists check out instruments during pre-aurora flight. From left, standing, are Dan Stillman, Joe Hollinrake and Dwight Stephenson, all J-8; center, Bob Peterson, J-16; and foreground, Lucien Black, J-16.

The aurora borealis—or "northern lights"—continues to yield its secrets to man. And a pair of studies conducted last month by scientists of the Los Alamos Scientific Laboratory are expected to produce still more data.

A group of about a dozen LASL scientists boarded an instrument-laden NC-135 aircraft in Albuquerque March 5 for a two-week conjugate auroral and cosmic ray study. In addition to LASL, scientists from the Sandia Corporation in Albuquerque, the Lawrence Radiation Laboratory in Livermore, Calif., the University of Alaska and the electronics firm of EG&G, Inc., of Brookline, Mass., participated in the study.

One of the two scientific aircraft flew in the southern latitudes and then traveled around the world near the equator as part of the study. However, LASL's primary mission was in the northern latitudes of Alaska.

The other LASL aurora study—a ground-based one—was conducted the week before the flight missions at Fort Churchill on the west shore of Hudson's Bay in the Canadian province of Manitoba. This involved three LASL scientists and a rocket fired 160 kilometers in the air into the path of the aurora. Although data resulting from the two studies will naturally be compared, one project was not dependent on the other, and each was performed separately.

Scientists feel the NC-135 aircraft represent a unique and valuable potential for investigating many of the relationships and interactions of geomagnetic fields, the atmosphere and solar-induced phenomena.

The observable phenomena range from long-term changes in the earth's magnetic field through the entire electromagnetic frequency spectrum to high energy gamma radiation, and from electron density distributions in the ionosphere to modulation effects on several-billion-volt galactic cosmic rays. These observable effects are interrelated in complicated ways, and their identification, classification and interpretation have been studied intensively. Considerable progress has been made in understanding them, although many questions remain.

A powerful method for the investigation of many of the phenomena is simultaneous conjugate point observation. Scientists searched for similarities or differences in the observed phenomena at the north and south conjugate points on these aerial missions. Conjugate points are places where the magnetic field lines that curve around the earth in a north-south direction meet. By correlating information gathered at identical times and comparable points in the northern and southern hemispheres, the scientists hope to deduce more about the aurora borealis and aurora australis—the "southern lights."

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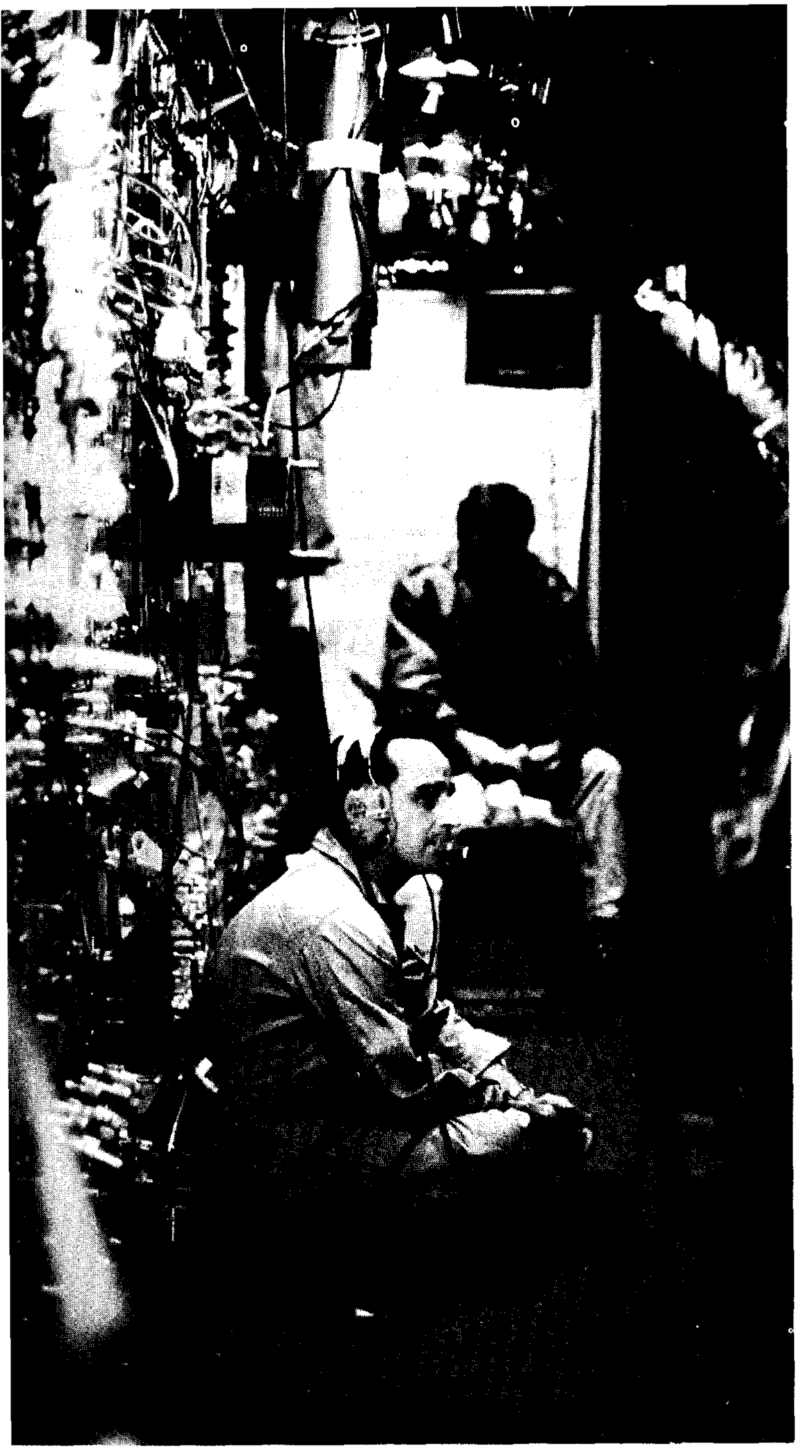

Lucien Black "takes five" after instrument check-out in LASL's NC-135 aircraft.

Aurora . . .

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Scientists find aircraft observations are particularly useful in studying cosmic ray induced effects, magnetic field measurements, very low frequency electromagnetic emissions and aurorae and airglow.

The most appropriate time for such a series of measurements is near an equinox. For the optical measurements it is a requirement, since the equinoxes are the only times of the year in which it is sufficiently dark at the appropriate high latitude conjugate positions at the same time. For other measurements, equinoctial times are still highly desireable since the magnetic field lines and conjugate positions are most nearly symmetrical in the northern and southern hemispheres with respect to solar-induced phenomena.

The aurora flights were performed during the hours of darkness on moonless nights—out of Anchorage, Alaska, for LASL, and Christchurch, New Zealand, for Sandia.

LASL personnel involved in the NC-135 missions included Neel W. Glass, Robert Peterson, Richard Wakefield, Leston Miller, Paul Rudnick, Lucien Black and Leland Sprouse, all J-16; Walt Wolff, Dwight Stephenson, Joe Hollinrake and Dan Stillman, all J-8; and John Cole, J-1. In addition to the flights over Alaska, Wolff joined the other aircraft for the around-the-world flight as LASL's representative.

A practice flight to enable the scientists to check out their equipment prior to the actual aurora mission was conducted during the week immediately preceding the start of the Alaska mission.

This "dry run" practice flight was to Fort Churchill where it was hoped the launching of the instru-

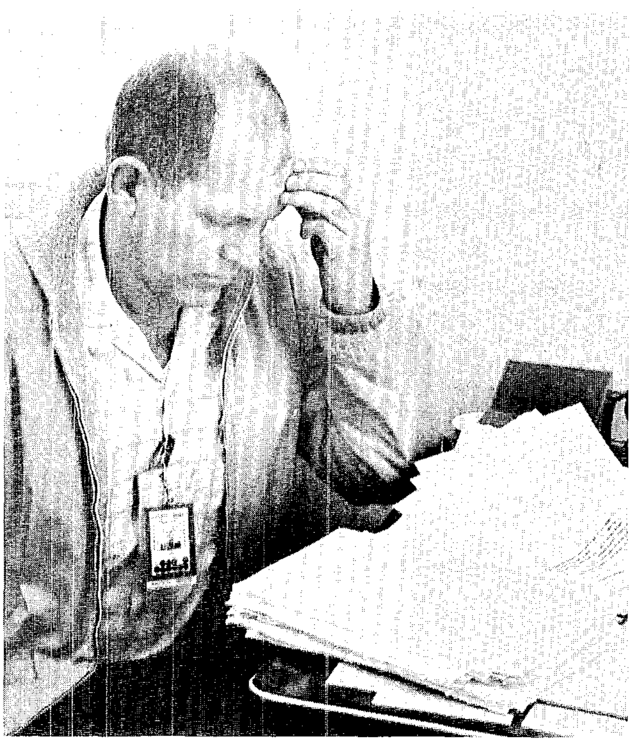
Paul Rudnick, J-16, records data from instruments used to study the aurora borealis.

ment-rocket could be observed from the air. However, the flight arrived over the area about two hours after the missile had been launched.

LASL personnel participating in the missile studies—all from J-10—are Milt Peek, Karl Theobald and Harold Fishbine. Nearly a score of Sandia people also gathered in Fort Churchill for the launch.

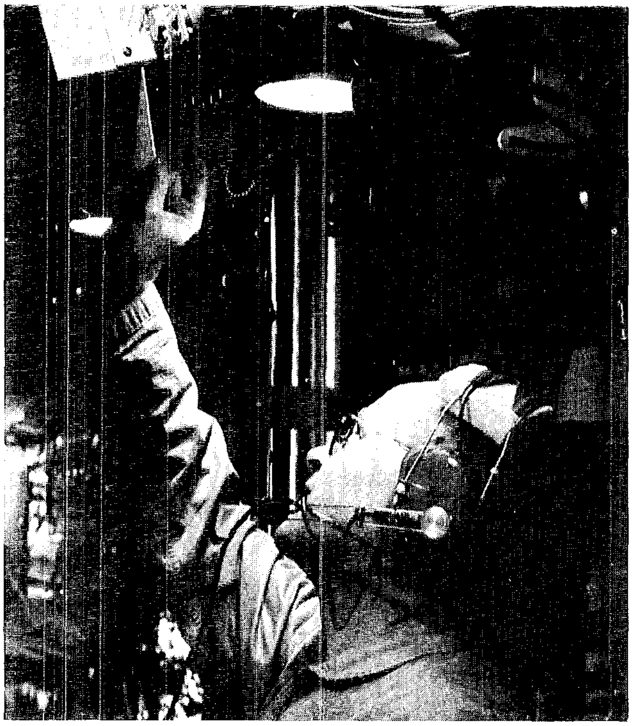
The data-gathering instrumentation, designed and developed by J-10, was installed inside the nose cone of a Nike-Tomahawk missile and launched 112 miles up into the sky. The missile was brought to Fort Churchill by Sandia which was in charge of launching it.

As the missile passed through the path of the aurora it sent back data to a ground-receiving station at Fort Churchill. Theobald said some "very good" data was received. Tentative plans call for another missile-launch program next year.



Neel Glass, J-16, leader for LASL airborne aurora studies in the northern hemisphere, checks teletype message from crew of the NC-135 studying the aurora australis in the southern hemisphere.

Joe Hollinrake regulates instruments on ceiling of plane as scientific crew prepares for aurora studies.



The Technical Side

Presentation at Liquid Metal Instrumentation and Control Symposium, Liquid Metal Fast Breeder Reactor Program Office, Idaho Falls, Idaho, March 1-2:

"High Temperature Neutron Detector Test" by E. O. Swickard and J. L. Bacastow, both K-3.

1967 U.S. National Particle Accelerator Conference, Washington, D.C., March 1-3:

"High Duty Factor RF Sources at 800 MHz" by D. C. Hagerman, MP-2.

"Fast Automatic Phase and Amplitude Control of High-Power RF Systems" by R. A. Jameson and W. J. Hoffert, both MP-2.

"Optimum Generator Characteristics of RF Amplifiers for Heavily Beam-Loaded Accelerators" by T. J. Boyd, Jr., and R. A. Jameson., both MP-2.

"Computer Design of UHF Power Amplifier Tubes" by D. J. Liska, MP-2.

"Crossing High-Voltage Interfaces with Large Bandwidth Signals" by R. P. Severns, MP-2.

"Computer Control of the Los Alamos Linear Accelerator" by H. S. Butler, MP-1. (Invited paper)

"Advances in the Design of Proton Linear Accelerators—Meson Factories and Injectors for Synchrotrons" by D. E. Nagle, MP-4. (Invited paper)

"Data Transmission Across High Voltage Interfaces via Light Links" by E. C. Budge, MP-1.

Sixth International Symposium on High-Speed Testing, Boston, Mass., March 6-7:

"Compressive Stress vs. Strain at Constant Strain Rates" by J. E. Hockett, CMF-13. (Invited paper)

Seminar Presentation at Drexel Institute, Metallurgical Engineering Department, Philadelphia, Pa., March 8:

"Testing With the Los Alamos Scientific Laboratory Cam Plastometer" by J. E. Hockett, CMF-13. (Invited talk)

Talk and Demonstration at the Taos High School, Taos, N.M., March 10:

"Cryogenics" by F. J. Edeskuty, CMF-9.

Presentation at NASA Goddard Space Flight Center, Greenbelt, Md., March 15:

"Vela Satellite Observations of the Solar Wind and Its Thermal Anisotropies" by A. J. Hundhausen, T-12. (Invited talk)

Presentation at Los Alamos Rotary Club, Los Alamos, N.M., March 15:

"Rover" by J. E. Perry, N-4.

Presentation at American Society for Metals Meeting, Albuquerque, N.M., March 16:

"High Energy Rate Forming of Refractory Metals" by D. J. Sandstrom, CMB-6. (Invited talk)

Colloquium at Arizona State University, Tempe, Ariz., March 16:

"The Solar Wind—History and Some Recent Results" by I. B. Strong, P-4.

Presentation at 27th Annual Conference on Physical Electronics, Cambridge, Mass., March 20-22:

"Xenon Pressure Induced Changes in Electron Temperature and Density in a Cesium Plasma Diode" by W. H. Reichelt, N-5. (Invited talk)

Institute of Electrical and Electronic Engineers National Convention, New York, N.Y., March 22:

"NET-2 Circuit Analysis Program" by A. F. Malmberg, T-7. (Invited paper)

Presentations at Nucleon-Nucleon Interaction Conference, Gainesville, Fla., March 23-25:

"Offshell Proton-Proton Scattering in the $^1S_0$ Channel" by J. E. Brolley, P-DOR, and L. K. Morrison, University of Washington.

"Calculations of Proton-Proton Bremsstrahlung" by Marvin Rich and Leon Heller, Both T-9.

"Interaction of Two Nucleons at Low Energies. $I = 1$" by Leon Heller, T-9. (Invited paper)

"Low Energy Neutron-Proton Polarization Experiments" by J. E. Simmons, P-DOR. (Invited paper)

American Physical Society, Chicago, Ill., March 27-30:

"Temperature-Dependent Isomer Shift of the Sn^{119} Mössbauer Resonance in Nb_3Sn" by J. S. Shier and R. D. Taylor, both CMF-9.

Colloquium on Biochemical Evolution—Properties and Structure of Homologous Enzymes, Paris, France, March 28-30:

"Evolution of Enzyme Locational Specificity: Models in Microbial Genetics" by K. D. Munkres, H-4. (Invited talk)

Vibrations Conference, American Society of Mechanical Engineers, Boston, Mass., March 29-31:

"The Avoidance of Thermal-Acoustic Oscillations Induced by Forced Convection Film Boiling in Tubes" by R. S. Thurston, CMF-9.

Presentation at Chemistry Colloquium, Arizona State University, Tempe, Ariz., March 31:

"The Energy Metabolism of Cultured Mammalian Cells" by C. T. Gregg, H-4. (Invited talk)

Presentation at Biochemistry Seminar, Arizona State University, Tempe, Ariz., March 31:

"Glyoxals as Cell Growth Regulators" by C. T. Gregg, H-4. (Invited talk)

new hires

Director's Office
Mary E. Thomas, Los Alamos, TANDT

GMX Division
Betty M. Smith, Espanola,N.M., GMX-7
Frederick A. Schmidlapp, Columbus, Ohio, GMX-11

H Division
Elvira Bain, Norman, Okla., H-4 (Rehire)

J Division
Paul D. Simenstad, Phoenix, Ariz., J-8
Nedra M. Barnes, Los Alamos, J-10 (Casual)

K Division
George C. Hopkins, West Lafayette, Ind., K-1

MP Division
Gustaf A. Ekeroth, Jr., Norwood, Mass., MP-1
Edward J. Baran, Santa Barbara, Calif., MP-2
Jerry L. Davis, Columbus, Ohio, MP-2
Theodore F. Roller, Albuquerque, MP-2
Herbert F. Vogel, Argonne, Ill., MP-4
David L. Garcia, Espanola, MP-5

Mail & Records
Porfirio F. Valdez, Espanola, M/R-1

P Division
Donald E. Bartram, Alexandria, Va., P-16

Personnel Department
Glenna Newman, Los Alamos, PER-7

Shops Department
Linda G. West, Los Alamos, SD-O
Billie F. Wright, Los Alamos, SD-DO
William R. Achurch, Steelville, Mo., SD-1
Edwin A. Kelley, Washington, Pa., SD-1
Cayetano Leyba, Santa Fe, SD-1
David Trujillo, Colorado Springs, Colo., SD-1 (Rehire)
Seferino F. Vigil, Albuquerque, SD-1
Anthony J. Padilla, Santa Cruz, N.M., SD-5
Ramundo A. Romero, Santa Fe, SD-5
David Naranjo, Santa Fe, SD-6

Supply & Property
Marilynn J. Halliday, Los Alamos, SP-12

T Division
Jack M. Ross, Los Alamos, T-7 (Rehire—Casual)

W Division
James M. Bunch, Lincoln, Neb., W-3

Myra Van Vleet, a secretary in Supply & Property group 11, has acquired quite a following as an artist among employes in the SP-Personnel Building. She has recently started to work with oils at home, but her specialty has been seasonal scenes on office chalkboards. Though she never took an art lesson, Myra whips out her colored chalk drawings in 15 or 20 minutes, and before major holidays, her lunch hours are busy filling requests for chalkboard art. So popular are her drawings that her Christmas sketches stayed on most boards until Easter, when she replaced Santas with Easter bunnies and snow drifts with flowers. Another favorite of co-workers is her whimsical roadrunner, above. (Photos by Bill Regan).

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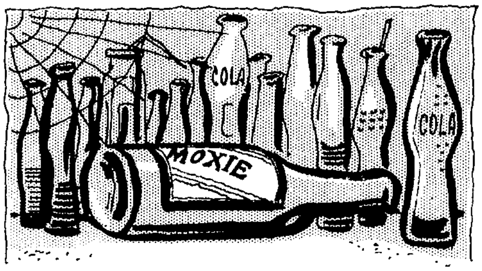


years ago in los alamos

Culled from the files of The Los Alamos Times, April, 1947, by Robert Y. Porton

AEC Chiefs Visit Project

Los Alamos was host this week to a group of men high in the councils of the Atomic Energy Commission. The party of Atomic scientists and advisors included Dr. J. R. Oppenheimer, former director of the Los Alamos Laboratory, now chairman of the Presidential Advisory Committee to the AEC; Dr. James B. Conant, president of Harvard University; Brig. Gen. James McCormack, director of the AEC's Division of Military Application; Dr. John H. Manley, acting executive secretary of the Advisory Committee; Dr. Roger Warner, special assistant to the AEC manager; and Dr. I. I. Rabi, member of the Advisory Committee's sub-committee on Weapons.

Site Elects New Council

Eight candidates received a clear majority in the election of the new town council of Los Alamos this week. Included are Charles R. Canfield, who received the most votes; Don P. MacMillan, and Fredrick C. Sander. The new council held a first informal meeting in the Lodge, at which Robert J. Van Gemert, chairman of the retiring council, was a guest.

Architect Recalls Problems in Lodge Construction

The building of Fuller Lodge was an experiment in the architectural uses of materials indigenous to this region, according to John Gaw Meem, who designed the Lodge. Santa Fean Meem, told Mesa Club members this week that the Lodge was built 19 years ago. He said the Los Alamos Ranch School for Boys which occupied this site before the Manhattan Engineering District took over, obtained special permission from the U.S. Department of the Interior to fell logs for the building. Los Alamos is a part of the Santa Fe National Forest.

Each log was picked for size according to the exact position it would have in the structure. The wood was dried for a year before construction started.

Bottle Shortage Threatens Thirst for Soft Drinkers

Los Alamos faces the possibility of an unquenched thirst for soft drinks, unless Site imbibers of such beverages make a more faithful return of bottles in the future. Notice has been received by the Engineer Exchange that the sale of certain drinks will be discontinued because of extreme bottle losses which have been incurred.

"The future soft drink supply is entirely dependent upon our efforts to return the bottles to the vendors for refilling," said Major Carl G. Nottrott, Exchange Officer.

what's doing

FILM SOCIETY: Civic Auditorium. Admission by single ticket, 90 cents, or season ticket, $4.
- Wednesday, April 19, 7 and 9:15 p.m., "Kwaidan," Japanese ghost stories.
- Wednesday, May 17, 7 and 9:15 p.m., "Seduced and Abandoned," Italian comedy-drama.

AN EVENING OF DANCE DRAMA by the Institute of American Indian Arts of Santa Fe, Saturday, April 22, 8:15 p.m., Civic Auditorium. Sponsored by the Los Alamos Arts & Crafts Association. Adults, $1.50; students, 75 cents. For tickets, call Mrs. W. K. Brown, 2-3978.

OUTDOOR ASSOCIATION: No charge, open to the public. Contact leader for information about specific hikes.
- Sunday, April 23, Cerro Pedernal, Mike Williams, leader, 2-3616.
- Thursday, April 27, Meeting—election, annual business at the home of Dibbon Hagar, 3710 Gold Street, Apt. 6, 2-6209.
- Saturday, April 29, Jemez Falls-Battleship Rock, Marlene McKee, leader, 2-4988.

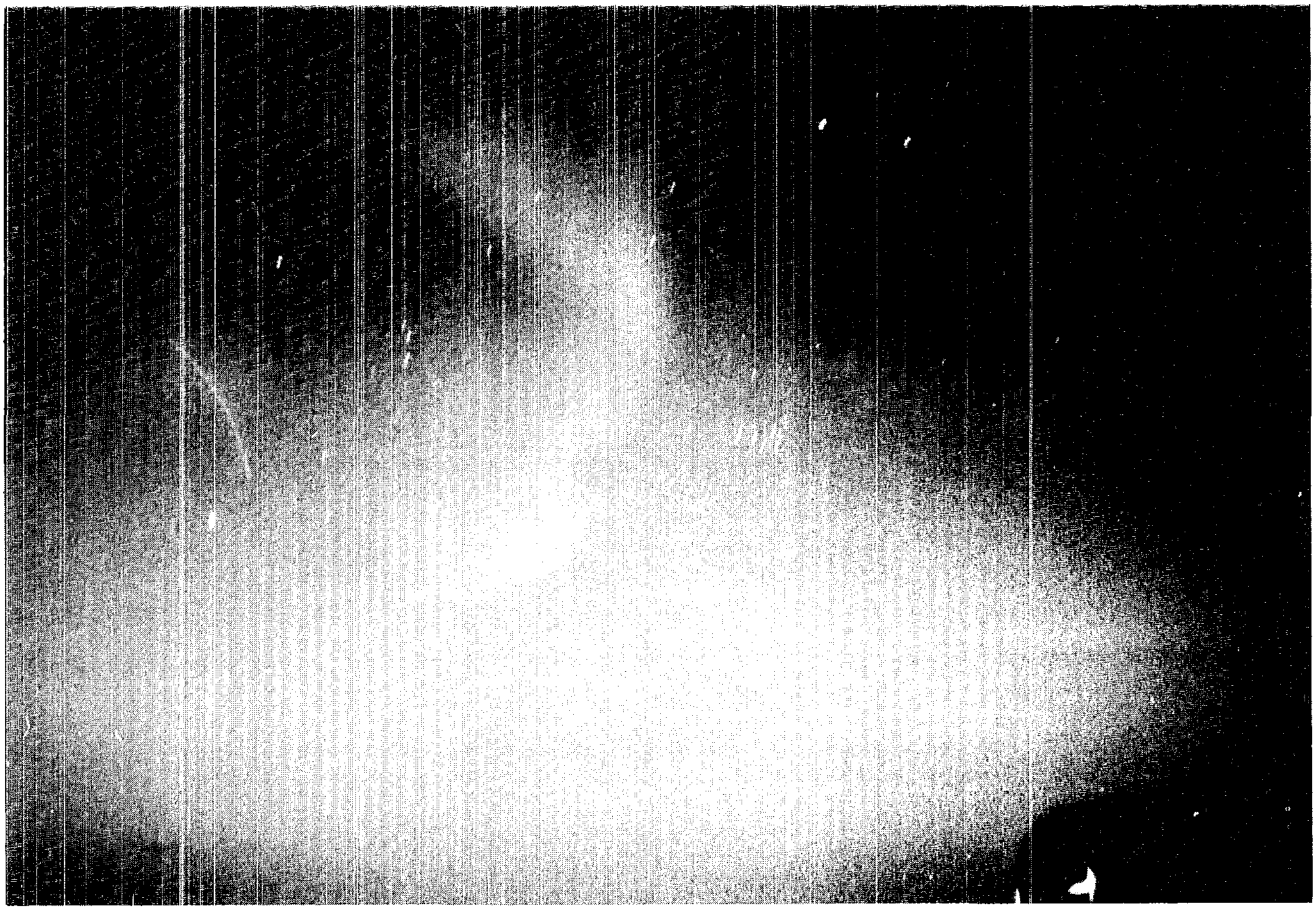
SWIM & TRIM: Free Red Cross recreational swimming class open to all women, Saturdays noon to 1 p.m., Los Alamos High School Pool. Telephone Mrs. L. K. Neher, 2-4094, for more information.

PUBLIC SWIMMING, Los Alamos High School Pool. Adults 25 cents, children 15 cents. Saturday and Sunday, 1 to 6 p.m.; Monday through Friday 7:30 to 9:30 p.m. Adults only Sunday, 7 to 9 p.m. (Swimmers Club of Los Alamos).

MOUNTAIN CLIMBING SCHOOL: Wednesdays, 8 p.m., through May 14, Fire Station at Arkansas and 41st. Sponsored by Los Alamos Mountaineers. For more information, contact E. C. Anderson, 2-3510.

ST. JOHN'S COLLEGE LECTURE-CONCERT SCHEDULE: The Great Hall, St. John's College, Santa Fe, 8 p.m. Open to the public. Admission free.
- Friday, April 21, Beaux Arts Quartet Concert.
- Friday, April 28, Francis Fergusson, Department of Comparative Literature, Rutgers University, New Jersey, "On Dante."

MUSEUM OF NEW MEXICO: Buildings in Santa Fe open 9 a.m. to 5 p.m. Tuesday through Saturday; 2 to 5 p.m. Sundays and holidays. Closed Mondays.
- Museum of International Folk Art:
  - "Fabric for Living—year-long exhibit, opened April 2.
- Fine Arts Building:
  - "The Indian View of the Newcomer" —exhibit through April.
  - "To Save from Oblivion" or "The Changing Image of the Indian"—opens April 16. Slide lecture by James Taylor Forrest, April 21, 8 p.m., in St. Francis auditorium of the Fine Arts Building. Admission free.



Aurora borealis in a star-filled sky is a spectacular view from LASL's NC-135 aircraft high above Hudson's Bay. Story on LASL's aurora mission begins on page 18. (Photo by Bill Jack Rodgers).

BACK COVER:

Robert Y. Porton, PUB-2 group leader, spent several days at Trinity Site last month gathering pieces of "trinitite" for the LASL Science Hall and Museum. Trinitite is the glass-like substance formed when the intense heat of the world's first atomic bomb--built by Los Alamos scientists and tested July 16, 1945—fused the sand around ground zero.

Henry T. Motz
3187 Woodland
Los Alamos, New Mexico 87544