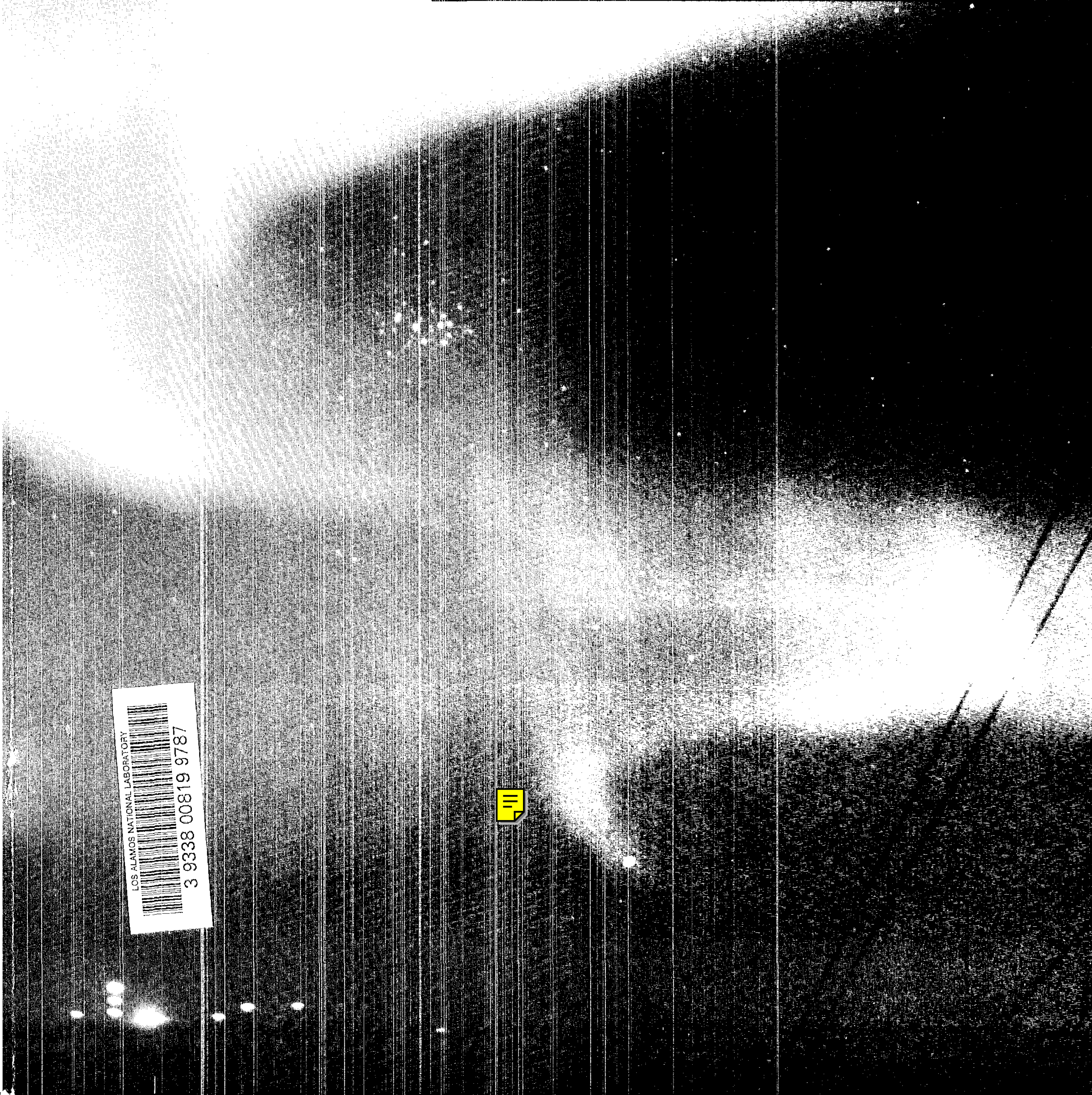
THE ATOM

Los Alamos Scientific Laboratory March, 1965



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ON THE COVER:

An arc and drapery, two of the most common forms of the aurora borealis, above remote Fort Churchill on Hudson Bay in northern Canada. A group of LASL scientists have been at Fort Churchill studying the aurora with rocket-borne instruments. This photograph was taken by PUB's Bill Jack Rodgers. White dots are stars in the northwestern sky. See story beginning on page 4.

Short Subjects

Dr. Kenneth S. Norris, University of California, Los Angeles, will speak about "Recent Advances in Porpoise Research" at a LASL evening lecture scheduled April 22, 8 p.m., in the Administration Building auditorium. Dr. Norris' lecture will include the showing of movies covering the behavior and training of porpoises. It will be open to the public at no charge.

Luanne Schlatterer, 17-year-old Los Alamos High School senior, will represent the state of New Mexico at the national Junior Miss Pageant at Mobile, Alabama, March 13-19. Miss Schlatterer won the titles "Los Alamos' Junior Miss" and "New Mexico's Junior Miss" at Jaycee-sponsored contests in Los Alamos and Santa Fe. Her parents, Mr. and Mrs. Lou Schlatterer, will accompany her to Mobile where she will participate in the week-long activities in connection with the pageant. Final judging, the night of March 19, is expected to be televised nationally.

Testimony in favor of the proposed $55 million meson facility for Los Alamos was presented to the Joint Committee on Atomic Energy in a Washington, D.C. hearing March 4, by Louis Rosen, alternate P division leader and acting project director for the meson work. Rosen was supported in the hearing by LASL Director N. E. Bradbury, and by Senator Clinton P. Anderson and Representative Tom Morris who pointed up the value of the proposal in questions directed to Rosen.

Six LASL employes will present talks, March 13, at the annual meeting of the New Mexico Industrial Photographers Association. The meeting will be held at La Fonda in Santa Fe. LASL speakers and their topics are: Frank May, D-8, "Color Printing at Los Alamos;" Bill Regan, PUB, "Public Relations Photography;" Francis Berry, D-8, "Unusual Autoradiography;" Robert Harper, D-8, "Classic Films and Film Makers;" Robert PerLee, D-8, "Photography in Project Rover," and Juliamarie Langham, "Time Lapse Photography Use in Biology." The program will be attended by professional photographers in a variety of fields from New Mexico, Texas and Colorado.

Four employes of Dow Chemical Company at Rocky Flats have found a way to lick the problem of the forgotten security badge when leaving for work in the morning. The men are members of a car pool and each takes his turn playing security guard when it's his turn to drive. The other three simply don't get into the car without first presenting their badges to the driver.

A complete index to all issues of THE ATOM published during 1964 is available upon request. Copies may be obtained by inter-office mail (phone 7-4506 or 7-4444) or by calling in person at either the Public Relations office in the Administration Building or the Community Relations office in AP Building.

George Cowan

Lawrence Award Winner

Dr. George A. Cowan, LASL J-11 group leader, last month was named a 1965 winner of the Ernest O. Lawrence Memorial Award.

The award by the Atomic Energy Commission is made annually to no more than five scientists for "meritorious contributions in the field of atomic energy."

Dr. Theodore B. Taylor of Washington, D. C., a former LASL staff member, is another recipient.

Cowan was cited for "notable accomplishments and leadership in the application of radiochemistry to weapon diagnostics and for the measurement of fundamental physical quantities using nuclear explosions as neutron sources."

The awards, which consist of a medal, citation and $5,000, will be formally presented in ceremonies April 29 at the National Academy of Science headquarters in Washington, D. C.

Cowan first came to Los Alamos in 1945 and took part in Operation Crossroads, the first Pacific weapons tests, in 1946. He returned to LASL in 1949 after receiving a Sc. D degree in physical chemistry from Carnegie Institute of Technology.

Cowan is an authority in applying radiochemistry techniques to bomb deris for weapon diagnosis. This method gives the most precise values of fission yield and efficiency as well as much information about neutron fluxes and spectra within the exploding devices.

Cowan has been one of the pioneers in using nuclear explosives as a neutron source for scientific experiments. He has developed a unique system based on time-of-flight to measure such quantities as fission cross-sections in the resonance region of the neutron spectrum where application of other methods has not been able to produce results with comparable accuracy.

He has most recently been engaged in experiments in which scientists are attempting to synthesize new elements. These experiments have already yielded isotopes of existing elements that are heavier than ever before achieved.

Cowan, 45, is a native of Worcester, Mass., and received his B.S. in chemistry from Worcester Polytechnic Institute in 1941. He worked at Princeton University in 1941 and 1942 on early cyclotron research with uranium and then spent the war years at the famed Metallurgical Laboratory of the University of Chicago, playing a key role in the atomic bomb project.

Cowan is a member of the American Chemical Society and the American Physical Society. He is married and lives at 721A 42nd Street in Los Alamos.

Taylor, who now is with the Defense Atomic Suport Agency in Washington, was cited for his contributions to the design of nuclear weapons and for nuclear reactor development.

Taylor was a LASL staff member from 1949 to 1956 and served as a consultant until October 1964. He joined DASA last fall after working with General Atomic Corporation in San Diego, California. At Los Alamos, Taylor was responsible for the design of many of the nuclear weapons on which the nation's defense now rests. He was also an early advocate of the use of nuclear explosives for propelling space vehicles, a research project initiated by LASL's Stan Ulam and known as Project Orion.

The Lawrence Awards are regarded as the second highest scientific honor bestowed by the nation. They are named after the late Dr. Ernest Orlando Lawrence of the University of California, who invented the cyclotron and who spent considerable time at Los Alamos during World War II.

Three other LASL staff members have received the Award in the past. Drs. Louis Rosen and James Taub were winners in 1963 and Dr. Conrad Longmire was a recipient in 1961.

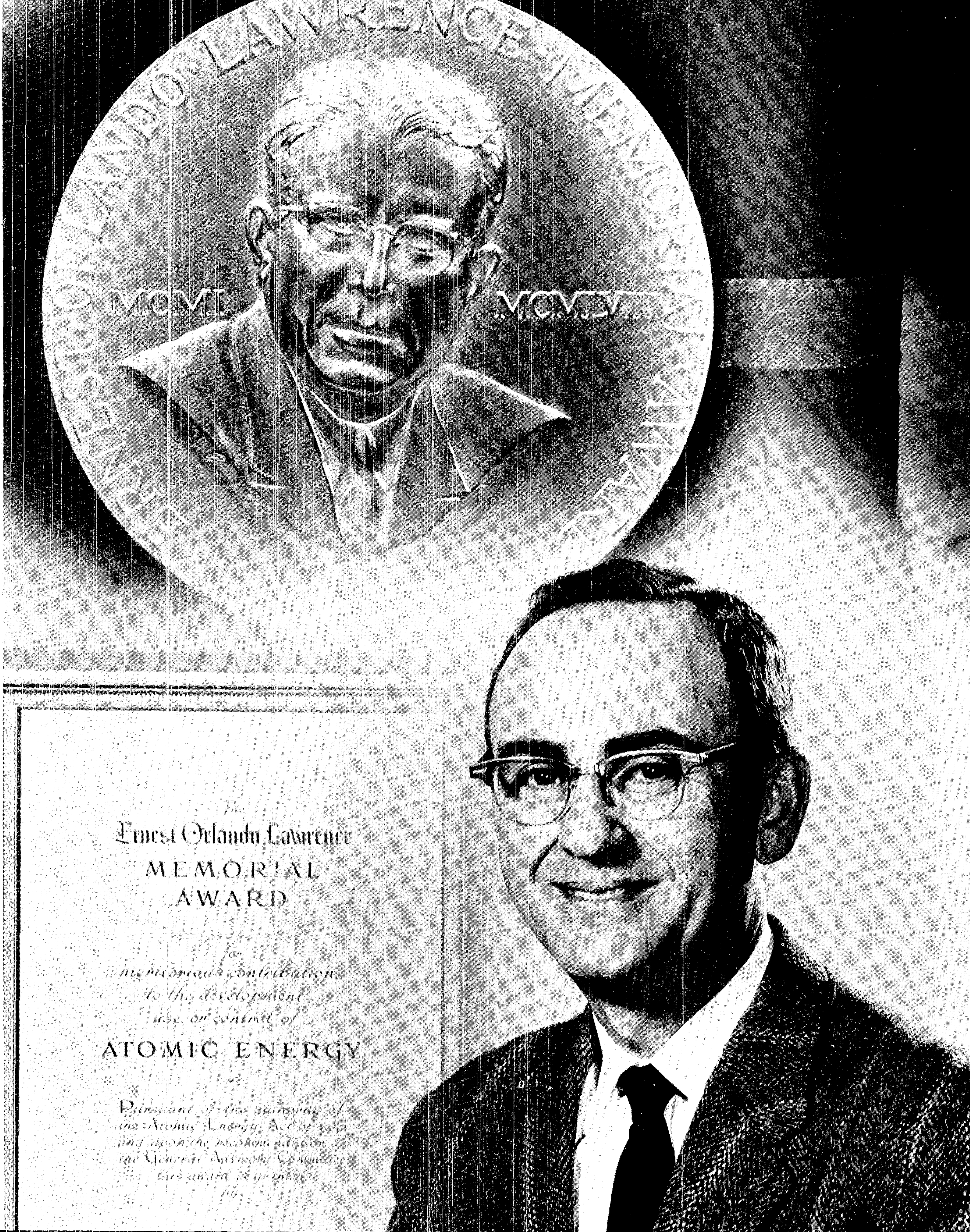
Other winners announced by the AEC:

—Dr. Arthur C. Upton, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

—Mr. Milton C. Edlund, Babcock and Wilcox Company, Lynchburg, Virginia.

—Mr. Floyd L. Culler, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Facing page: Dr. George A. Cowan, his Lawrence award medal, citation.


ERNEST ORLANDO LAWRENCE MEMORIAL AWARD
MCMI
MCMLVIII
The
Ernest Orlando Lawrence
MEMORIAL
AWARD
for
meritorious contributions
to the development,
use, or control of
ATOMIC ENERGY

Exploring the Northern

BY JOHN YOUNG

PHOTOGRAPHS BY BILL JACK RODGERS

Two rockets, bearing specially designed spectrometers, roared into the glowing northern sky beyond remote and frigid Fort Churchill on Canada's Hudson Bay at 11 p.m. February 18.

On the ground, a small group of tense and chilled scientists from Los Alamos, Sandia and Johns Hopkins University clustered about racks of recording instruments.

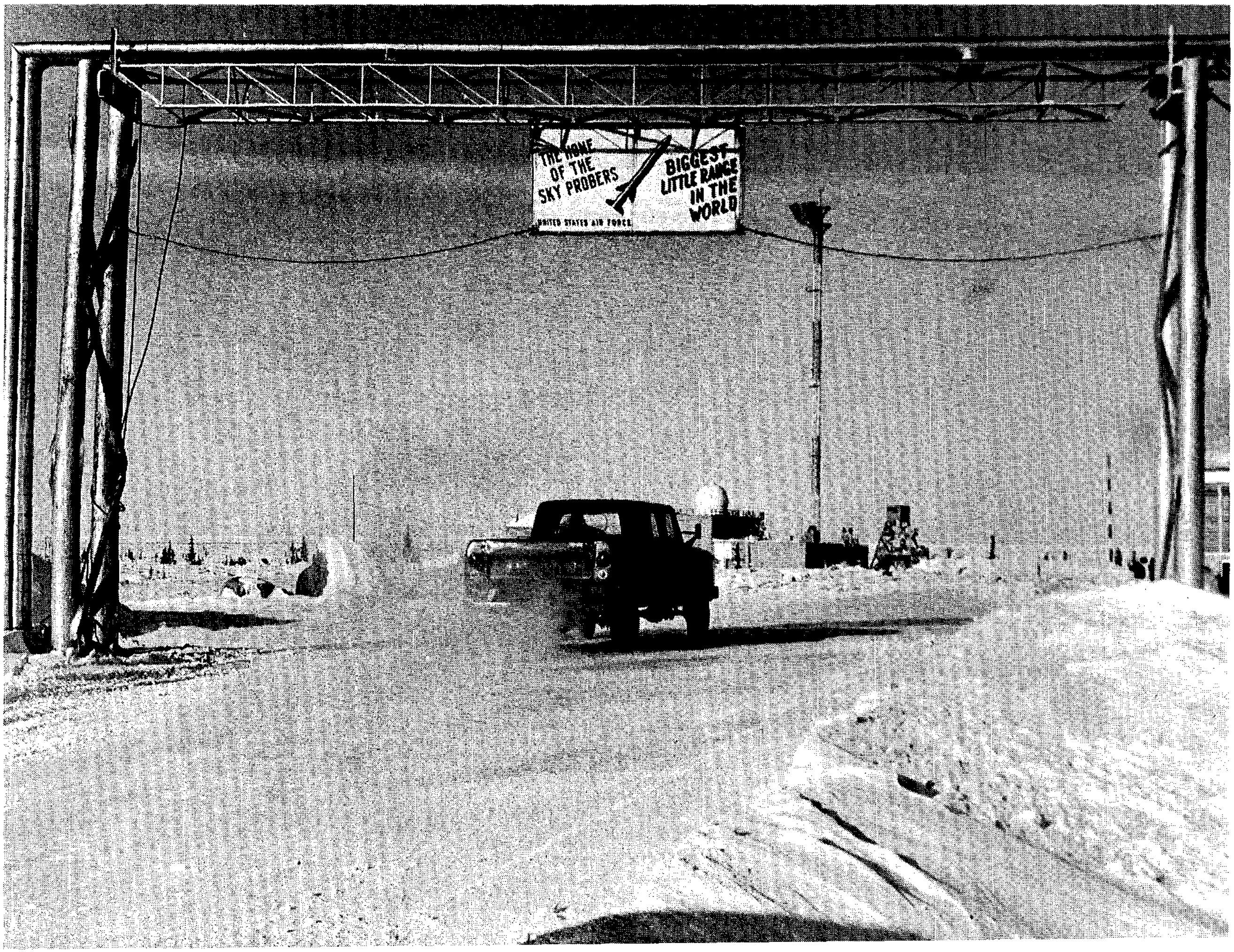
The rocket launches, 42 seconds apart, marked the first two-rocket explorations in history of the fabulous aurora borealis, or "northern lights." The scientific probes capped months of preparation, first at home-base laboratories and then at the northern Manitoba outpost.

The instruments worked perfectly and scientists now are starting the long but exciting data analysis that will almost certainly yield new information concerning what goes on between the earth and the sun.

Of particular interest in this series of experiments is a region of the auroral spectrum which is beyond visible light. This range is known as the vacuum ultra-violet region because it lies just beyond the ultra-violet portion of the spectrum and is detectable only in a vacuum—its energy all being absorbed by air. The vacuum ultra-violet can be produced and observed in the laboratory but can be "seen" in nature only be sending instruments above the atmosphere.

The scientists were at Fort Churchill because that historic installation on Canada's frontier is fully equipped for rocket launching and is almost ideally located

Canada and the U.S. Air Force cooperate to maintain the Fort Churchill station; its facilities are available to members of the North Atlantic Treaty Organization.



becomes possible to predict aurora with considerable accuracy.

However, strangely enough, the velocities of the particles that collide with air are higher than one deduces from their travel time from the sun. This leads to the postulation of the existence of an accelerating mechanism of an unknown nature within the uppermost reaches of the earth's atmosphere, posing one of the most interesting unsolved auroral problems.

To LASL's people, the aurora is a test tube in the sky, a means for upper atmospheric research which cannot even be approached elsewhere on earth. In addition to the widely-shared scientific curiosity about the upper atmosphere—which in one way or another affects all life on earth—Los Alamos has some direct concerns in that region: as in Project Vela, the detection of nuclear ex-

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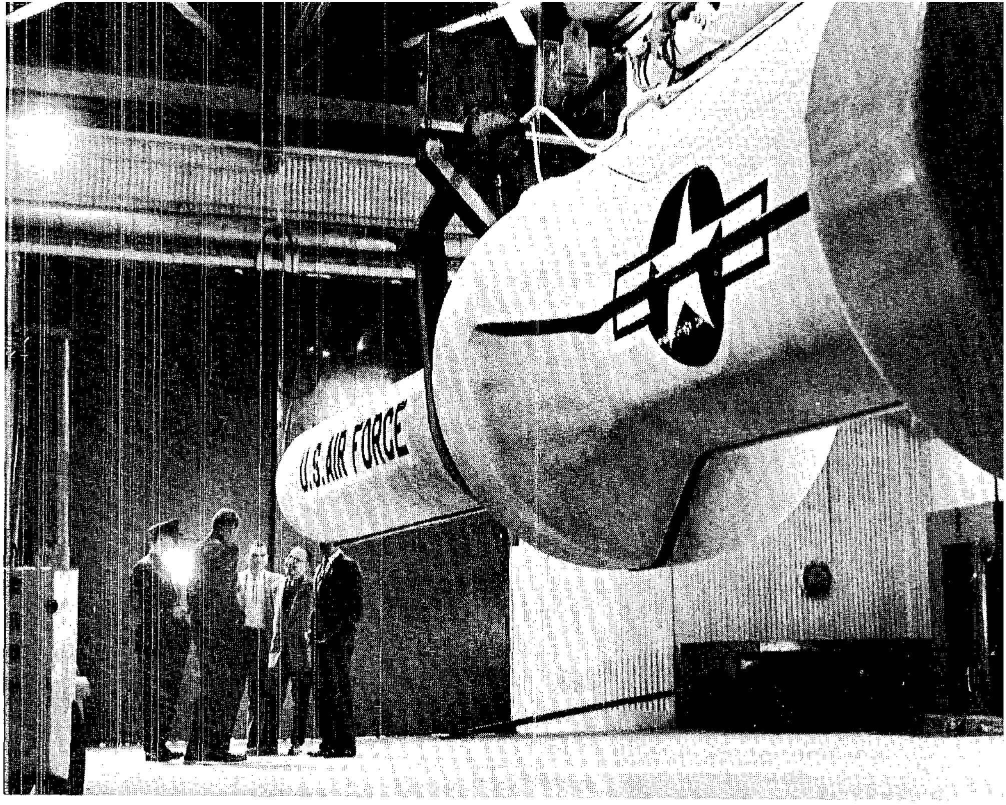
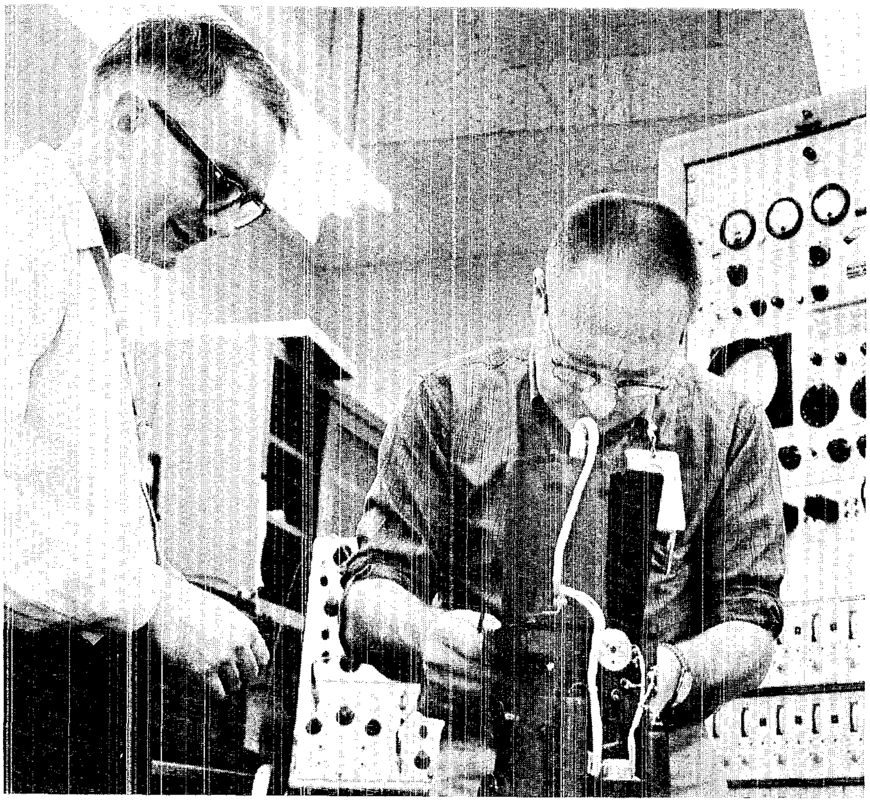
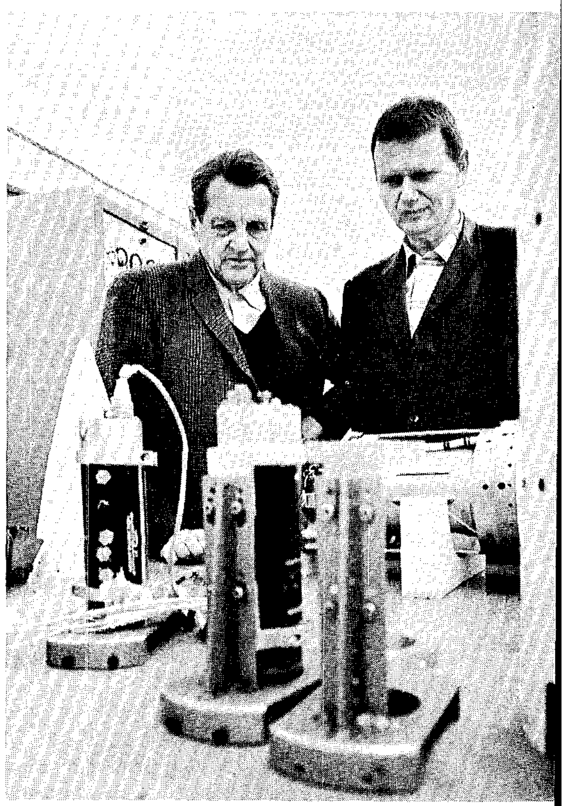


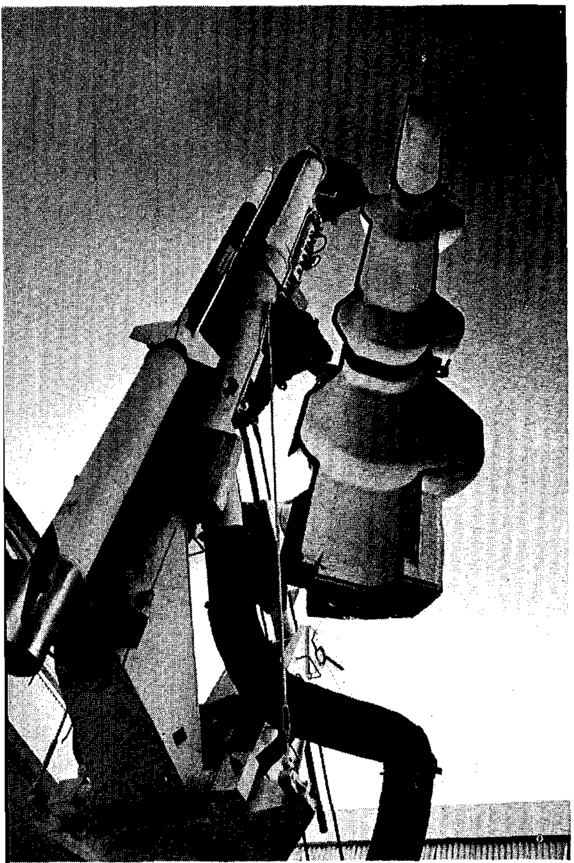
In rocket storage hangar, experimenters discuss launch preparations. Air Force assembly is a heated shield to protect Nike-Tomahawk rocket and payload from the elements before launch.

Sappenfield and Fishine make final adjustments on spectrometer before mounting it in rocket nose cone.



Hoerlin (left) and Peek view some of the diagnostic equipment they used during auroral studies in Canada.





Its shield unfolded, two-stage rocket is ready for launch.

Northern Lights . . .

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plosions; in the comparison of the natural aurora with some laboratory phenomena, and generally in the relationship of air glow and solar radiation.

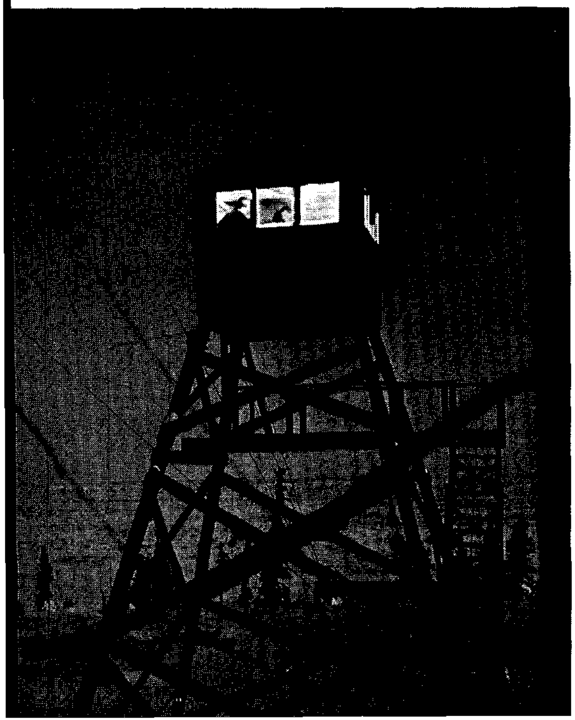
Much of the auroral zone is over water, but Fort Churchill, 600 miles south of the Arctic Circle, is a large and permanent scientific establishment. It is an international auroral research station, open to any member of the North Atlantic Treaty Organization, operated jointly by the U.S. Air Force and the Canadian government. Pan American Airways is the civilian contractor in charge of this amazingly busy place. Nearly 50 rocket launchings were scheduled there in February, including LASL's and Johns Hopkins University's, for a variety of upper atmospheric research projects, including some weather studies.

Situated near the northeastern corner of Manitoba province, the town and base are 560 air miles north of the provincial capital of Winnipeg. In summer the town of Churchill is an important seaport, equipped with skyscraper-size grain elevators and loading facilities from which ships bound for Liverpool carry vast quantities of grain, as well as cattle, flour, lumber and furs. During the icefree season also, Churchill is a fishing port, the principal product being the white whale, or beluga, a member of the dolphin family, prized for its oil and meat. The port is open from late July until late October; then the big freeze seals the bay. In winter, all transportation is by air or train (or dog sled). There are no motor roads to the outside any time of year.

The camp of Fort Churchill is

continued on page 24

Observation tower on the stark and frozen plain near Churchill was used by scientists for the long waiting each night, to see if a satisfactory aurora would appear. Three nights of bone-chilling waiting and watching by Hoerlin, Peek and Fastie preceded launch.



Sleds and dog teams are a last resort but are not uncommon during the bitter winter storms that frequently engulf Churchill. On occasion, scientists were required to travel in vehicle convoy to minimize danger posed by drifting snow. Once, the launch area was evacuated because of a severe blizzard.

"It's about like this," says Stan Whetstone of P-9 as he describes components of new tandem Van de Graaff accelerator for Gallup High School students.

Practicing What Rhodes Preached

Photographs by Bill Regan and Winfred Headdy

BY EARL ZIMMERMAN

When Cecil Rhodes established the famed Oxford scholarships that bear his name, he said:

"Educational relations make the strongest tie."

LASL last month practiced what Cecil Rhodes preached. The Laboratory was host on February 4 and 5 to nearly 80 faculty members and officials of 30 schools from the Rocky Mountains and Great Plains area. One week later it had more than 500 high school science students as guests.

Both occasions were designed to call attention to the great research facilities that exist at Los Alamos

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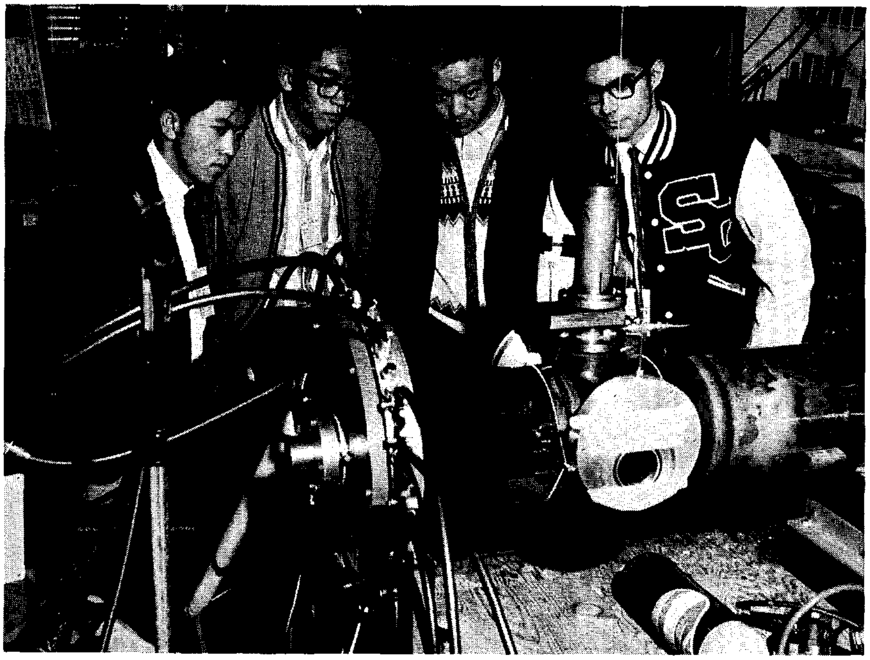


Plasma control device intrigued these science students from Sierra Grande High School of Blanca, Colorado.

Karita Coffey, an Oklahoma Comanche who attends the Institute of American Indian Arts in Santa Fe, disputes with magnetic field of Project Sherwood machine for control of heavy wrench.

Visitors . . .

continued from preceding page

and to emphasize they are available not for the private use of LASL alone. The meetings were, in fact, "to win friends and influence people."

The first visitation was sponsored jointly by LASL and the Associated Rocky Mountain Universities. Purpose, as stated by Director Norris Bradbury, was:

"A step toward increasing cooperation and collaboration with other universities; to find ways the Laboratory and its facilities can participate in graduate education and may be used by university professors on leave for various research projects of mutual interest."

Division leaders spoke to the visiting educators, presenting a survey of facilities and current research programs. In offering its facilities for regional use, Laboratory officials are hopeful of common benefit—provide outstanding research opportunities for graduate students and faculty representatives of cooperating schools and at the same time furnish a constant flow of fresh ideas and young scientists to mingle with the permanent Laboratory staff.

J. M. B. Kellogg, Assistant LASL Director for Scientific Personnel, and A. Ray Chamberlain, Administrative Vice President of Colorado State University, were chairmen.

After two days of tours and synergetic conversations, Chamberlain commented:

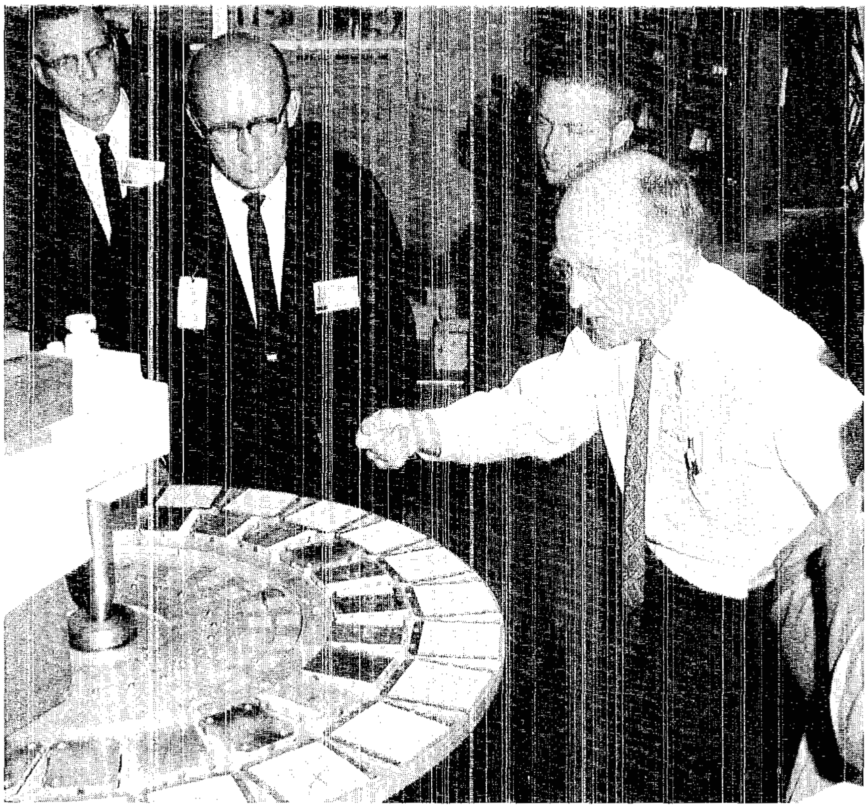
"The past few years have seen a change from the universities asking national laboratories for cooperation. Now, the administrators of the universities may have to push their people to keep pace with the degree of cooperation that is offered."

The Science Youth Days invasion occurred on February 11 and 12. Young people from 21 schools were here for the ninth annual "open house" in memory of Thomas A. Edison, part of a nationwide program to spur interest in science as a career.

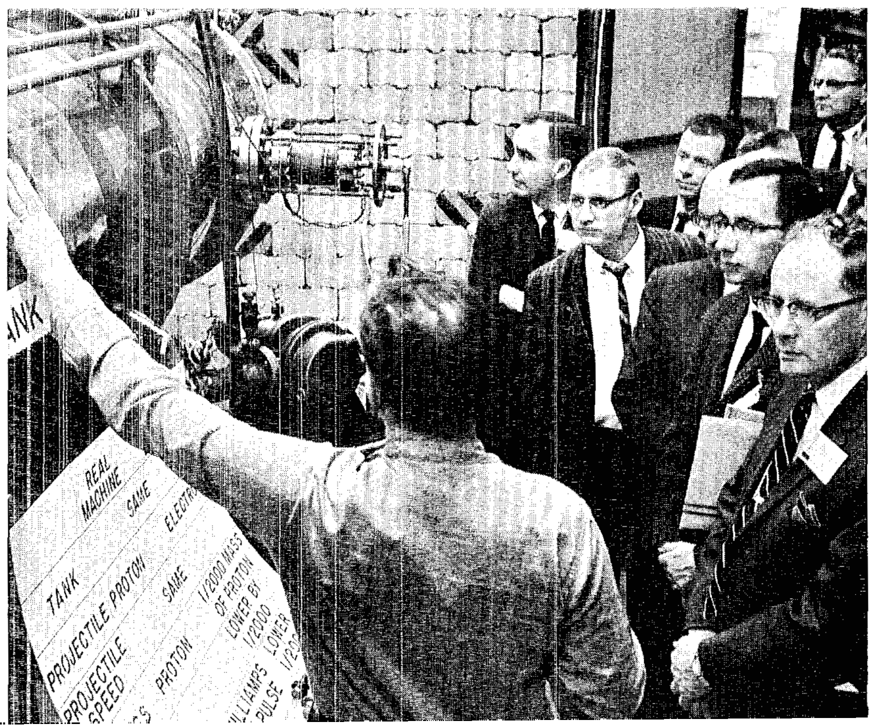
Again Bradbury was on hand to be official greeter. He advised the students to "make science a career if you find it fun. But remember, the hours are long and often lonely. If you find the work tedious, or uninteresting, don't become a scientist. The pay is good, but not that good."

As in the past, the visitors came from Colorado, New Mexico, Texas and California. Tours included the Physics Building and Van de Graaff accelerator, Sherwood facilities and the Health Research Building.

A visitor this year was Ashley Pond IV, whose grandfather founded the Los Alamos Boys Ranch School which was taken over by the Army in 1942 to make way for construction of the Laboratory. The younger Pond is 17 and a student in Taos High School. His father operates a medical clinic in Taos.



Jere Knight (right) of J-11 explains the operation of automatic sample counter developed by John Balagna for use in radiochemistry work at TA-48.

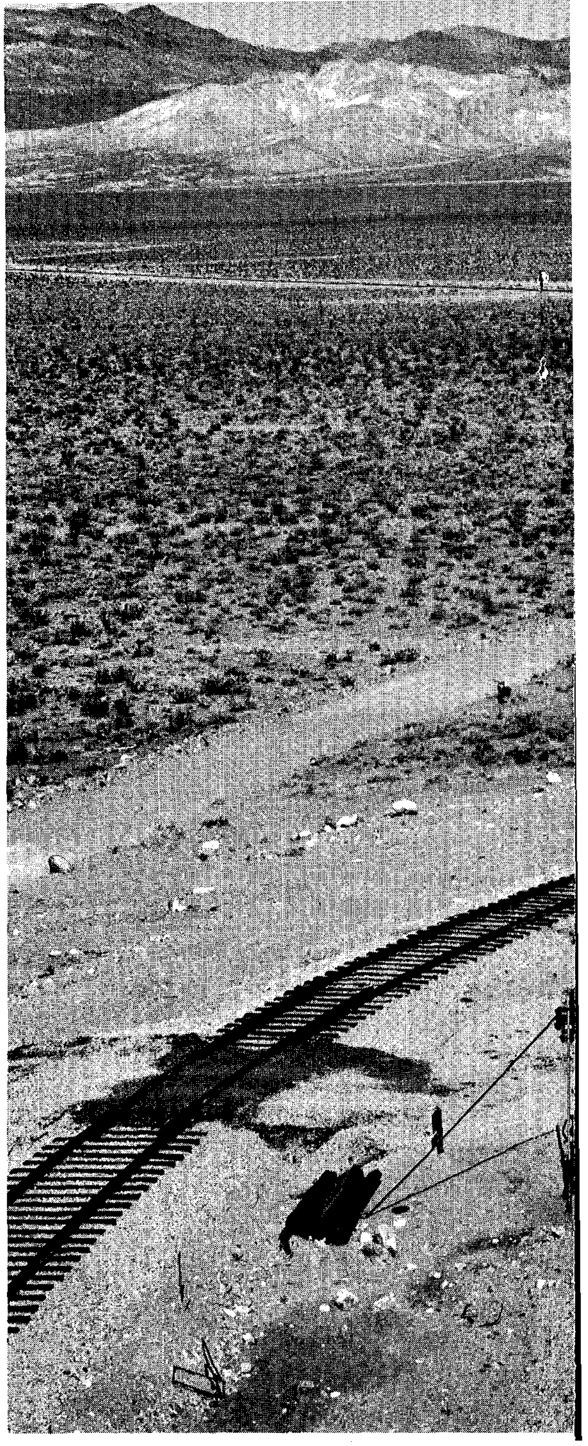


Mockup of portion of proposed meson generator is explained for visiting college officials.

The Jackass & Western

One of the Shortest Short Lines

BY PETER MYGATT



One of the shortest railroad short lines in the United States is located smack in the middle of the Nevada desert.

The line is notable in a number of aspects. It is nameless. It handles no interchange traffic since it connects with no other line. It carries no passengers or crew—not even an engineer. When it highballs down the track it may be doing a whopping one mile an hour. Track maintenance is carried on by Pan American Airways.

The only thing standard about the line is the track gauge.

To those who work with it, the line is affectionately known as the "Jackass Flats Railway" or the "Jackass & Western." The name fits, for it is a major mode of transportation at the Nuclear Rocket Development Station located at Jackass Flats, Nevada. The line's sole purpose is to aid in the testing of Project Rover nuclear rocket reactors. The train moves slowly so reactors will not be jarred during transit.

Original construction of the railway began late in 1957 to transport LASL-developed Kiwi reactors to and from the R-MAD (Reactor-Maintenance, Assembly and Disassembly) building and Test Cell "A." The system has evolved to a total of 8½ miles of track, connecting the following facilities: the R-MAD building, Test Cell "A," Test Cell "C," the new E-MAD (E for Engine) building, Engine Test Stand No. 1 (ETS-1), the R-MAD radioactive hot dump, and the R-MAD decontamination facility.

The line also transports NERVA (Nuclear Engine for Rocket Vehicle Application) reactors developed by the industrial team of Aerojet-General Corp. and Westinghouse Astronuclear Laboratory, and will transport LASL's advanced reactors known as Phoebus, the first of which will be tested during mid-1965.

Nuclear rocket reactors on test cars are moved to the test cells by a remotely-operated, radio-controlled, electric locomotive. After the test series with the reactor has been completed, the locomotive travels to the test cell, picks up the test car with its reactor, returning them to the R-MAD disassembly bay where the reactor undergoes post mortem operations.

The 40-horsepower, four-wheel, battery-powered locomotive, designated L-1, was built for NRDS during 1957-58 by Greensburg Machine Co., Pennsylvania (now merged with National Mine Service Co.).

Later a small former Air Force four-wheel Diesel engine, built by General Electric, was obtained for the Jackass Flats Railway from a Utah supply depot. This engine, carrying the number L-2, is used for switching purposes on the short line. Its speed is somewhat faster than the L-1 engine. A track maintenance motor car is designated L-3.

Other rolling stock includes:

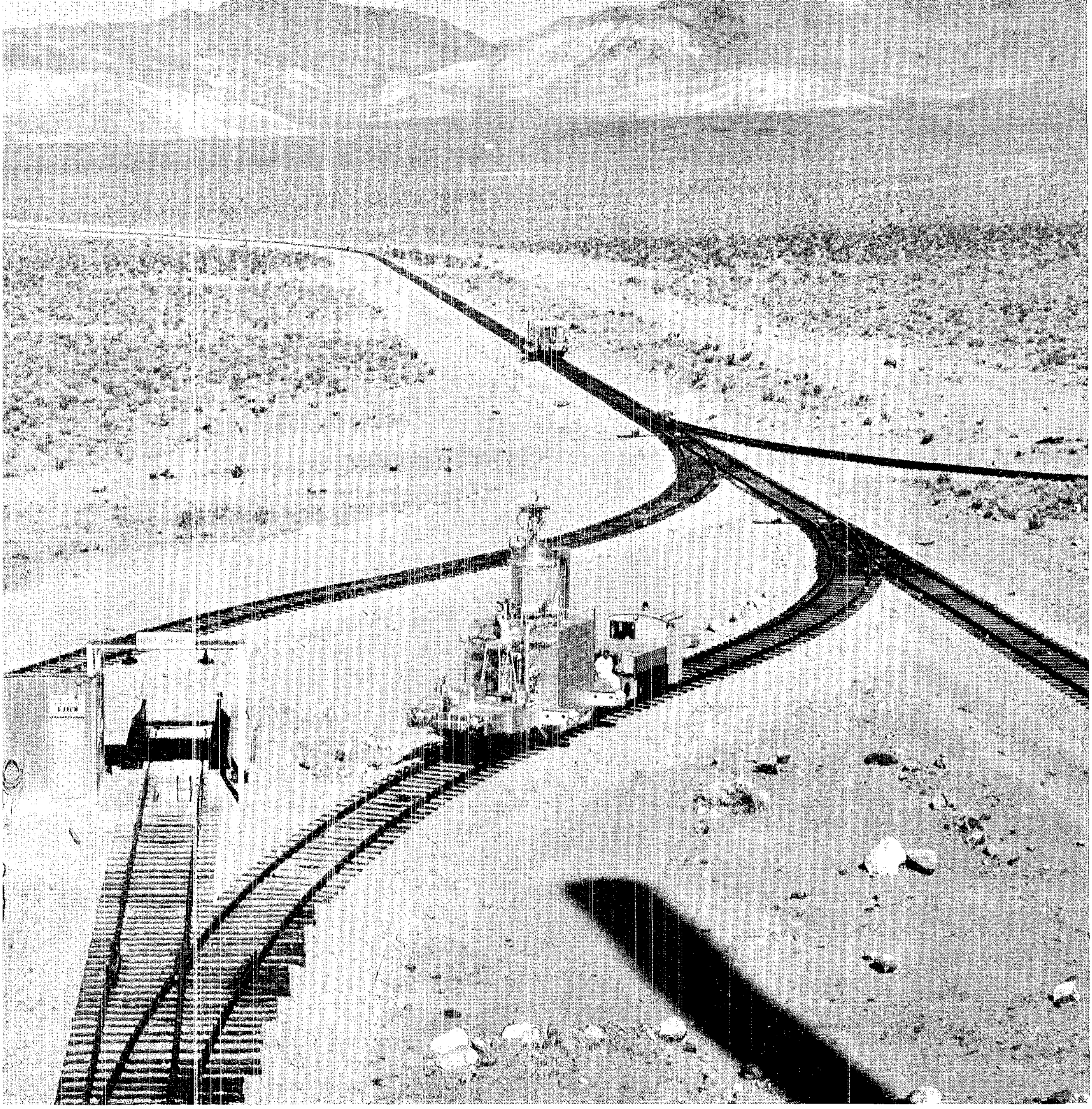
1) A Diesel-powered (not self-propelled) railroad crane with a 25-ton rating which is used to right derailed cars; to move 22-ton lead fuel element shipping casks; and to perform miscellaneous maintenance jobs.

2) Three dump cars.

3) Six flat cars.

4) seven test cars which have hauled all the reactors.

All rolling stock of the Jackass Flats Railway is operated by ACF Industries, Inc.



Tracks traversing Jackass Flats, Nevada, are relatively new to the railroad scene.

Locomotive L-1 can highball at the speed of a full one mile an hour as it transports reactors between the R-MAD Building and the various test cells at the Nuclear Rocket Development Station. Here L-1 has just pushed a test car with the Kiwi-B4-A nuclear rocket reactor to the face of Test Cell "A." Photographs by Mitzie Ulibarri.

A Primer

ON MULTIPLE NEUTRON CAPTURE

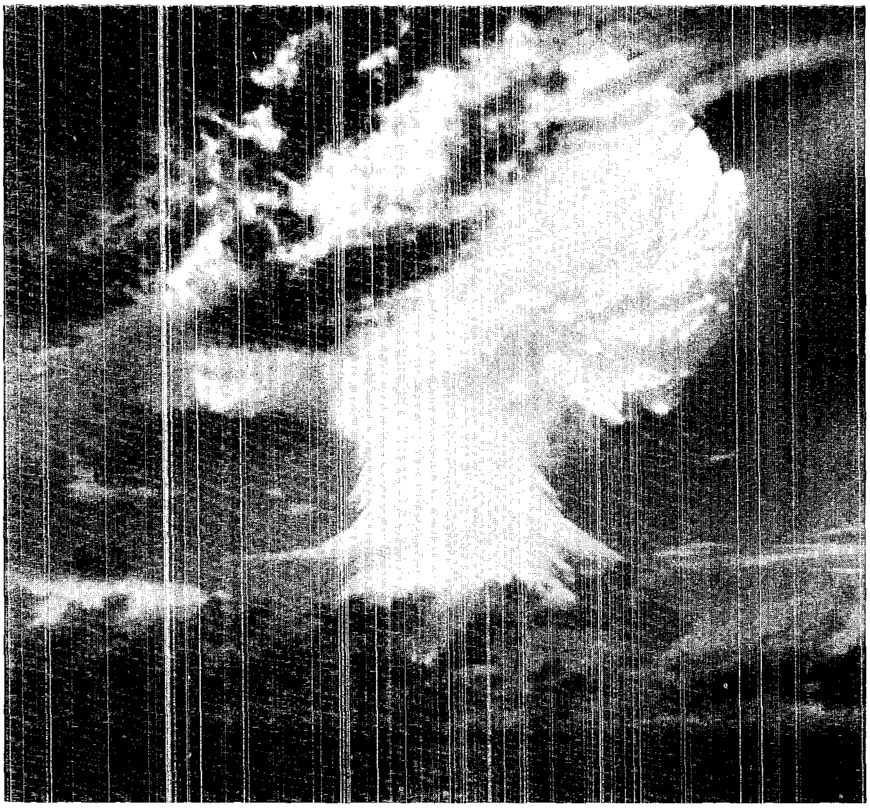
By JOHN SAVAGE

Men have always sought, with unlimited curiosity and a limited set of keys, to unlock the secrets of the universe. Whenever a new research tool is devised—the telescope, the microscope, the cyclotron—additional truths are revealed. Current experiments at the Nevada Test Site are showing that nuclear explosives provide a new and exciting research tool.

Scientists are using nuclear explosions to create new forms of matter. These previously unknown atomic nuclei and the process by which they are made have begun to shed new light on many subjects, including the cosmic origins of all the heavy elements. The new heavy elements are more stable than had been predicted. This unexpected stability has produced new optimism concerning predictions that several super-heavy elements will be synthesized in the next few years.

All natural elements heavier than iron are thought to have originated in exploding stars called supernovae. The development of nuclear weapons has made possible the creation on earth of conditions approaching those believed to exist in such stellar explosions. The results are interesting enough to deserve the attention of all of us who are fascinated by cosmology—the science of the universe and its beginnings.

The current experiments are not difficult to understand. This primer, which will be published in two installments, has been written to provide the necessary background and to describe the experiments conducted so far.



Cloud produced by the "Mike" test, the world's first full-scale thermonuclear detonation, November, 1952. Fourteen new nuclear species were identified for the first time in debris from this explosion.

Every substance in the visible world is made of atoms. The world's simplest atom, that of ordinary hydrogen, consists of one proton and one electron.

Protons are all alike. They are fantastically heavy for their size, but they are very small. In terms of diameter, a proton is about as many times smaller than a pinhead as a pinhead is smaller than the sun. Each proton carries a positive charge of electricity, exactly as strong as the smallest charge ever measured. No smaller charge is known to exist.

When weights and charges are so small, special units are convenient for expressing them. The weight (or, more properly, the mass) of a single proton has been accepted as such a unit. In discussions of nature on the atomic scale, masses may be simply expressed in units equal to the mass of one proton. Similarly, an electric charge equal to that of a single proton is called a unit charge, and all charges on the atomic scale (whether positive or negative) are commonly expressed in multiples of that.

Definition: A proton is a particle having a mass of 1 and a positive charge of 1.

What are protons made of? They are made of the basic stuff of the universe, whatever that means. They are too small to consist of atoms, and therefore have no chemical composition in the usual sense. Perhaps they have no fixed shape. However, many of the *properties* of protons are precisely known. It is customary to think of these properties as belonging to a little ball of essential matter.

Every atom of ordinary hydrogen has such a ball at its center. The proton is the nucleus of the hydrogen atom.

The other part of the hydrogen atom consists of one electron, in orbit around the nucleus.

Electrons are even smaller than protons, and much lighter. It would take 1836 electrons to weight as much as one proton. In terms of electrostatic charge, however, the electron is the proton's equal. It carries a negative charge of 1. This charge exactly balances the positive charge of the nuclear proton, so that the hydrogen atom (like all other atoms) has a net charge of zero.

Definition: An electron is a particle having a mass of 1/1836 and a negative charge of 1.

What are electrons made of? Like protons, they are too small to have any chemical identity. They are tiny particles of essential matter, each carrying one unit of negative charge.

The electron of the hydrogen atom never comes close to the nucleus. It circles the proton at a distance larger, proportionately, than the distance from the earth to the sun. The hydrogen atom, like all other atoms, is mostly empty space.

Simple though it is, an atom made of one proton and one electron has a character of its own. It is hydrogen and nothing else. Two such atoms will always pair up to form a hydrogen molecule. A toy

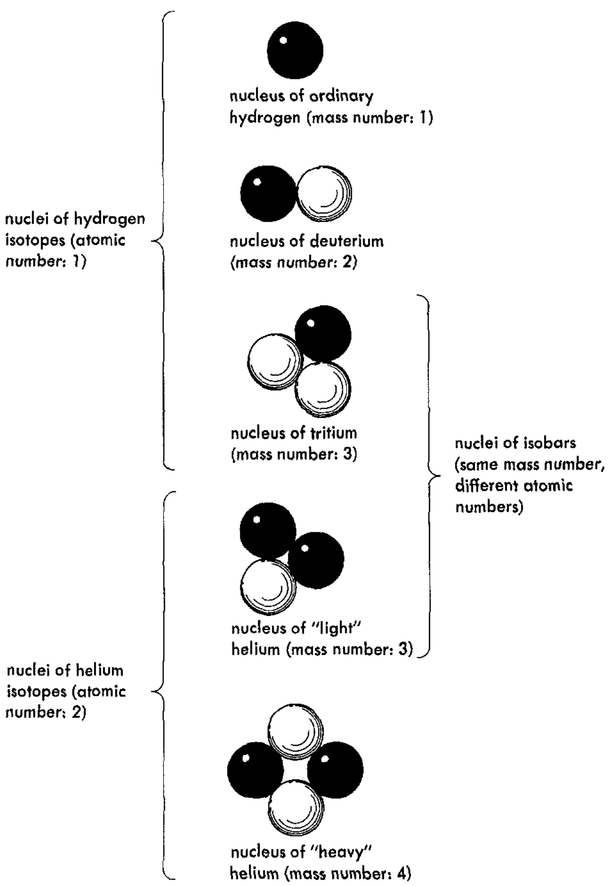
continued on next page

Heavy Elements . . .

Continued from preceding page

balloon full of such molecules will always rise to the end of its string. All the properties of hydrogen are determined by the fact that its atom has exactly one proton and one electron. The "atomic number" of hydrogen is 1, the number of protons in its nucleus.

No other element is quite like hydrogen. Every element has its own atomic number—its characteristic number of protons per nucleus, electrically balanced by an equal number of electrons in orbits. Atoms with 8 protons and 8 electrons are good to breathe. Atoms with 33 protons and 33 electrons will kill you. Atoms with 79 protons and 79 electrons are useful for filling teeth. Atoms with 92 protons and 92 electrons are handy for bombs. The atomic numbers go only a little higher than that.



Schematic drawings of the five simplest atomic nuclei. The black spheres represent protons (mass 1, charge + 1). The white spheres represent neutrons (mass 1, charge 0).

One complication crops up. Most nuclei (all nuclei except that of ordinary hydrogen) contain neutrons as well as protons.

Neutrons are like protons deprived of their electric charge. In fact, when a proton captures and absorbs an electron, the positive and negative charges cancel each other and the proton *becomes* a neutron. Conversely, when a neutron gives off an electron (as neutrons sometimes do) the neutron is left positively charged. It is then no longer a neutron but a proton.

Definition: A neutron is a particle having a mass number of 1 and a charge of zero. (Its actual mass is slightly greater than that of a proton, but the mass *number*, a convenient approximation, is the same.)

All atomic nuclei except that of ordinary hydrogen are combinations of protons and neutrons. For a given element, the number of protons per nucleus, and thus the positive charge per nucleus, is always the same. The number of neutrons is variable. Therefore, for a given element, the total number of "nucleons" (neutrons and protons) is variable.

The presence of neutrons in a nucleus has no effect on the atomic number, since that number refers to protons alone. The neutrons have no effect on the number of electrons around the nucleus, since the neutrons have no charge to be balanced. The neutrons have almost no effect on the chemical behavior of the atom, since such behavior depends almost wholly on the electrons.

In spite of all that, the neutrons in the nucleus have important effects. One of these is that they make the atom heavier. Another is that they influence the stability of the nucleus. Both effects require discussion here.

The atomic number of hydrogen is 1, because hydrogen has one proton. The mass number of ordinary hydrogen is also 1, because it has one nucleon (a proton), and the mass of the orbital electron is negligible. So much for ordinary hydrogen. The reason for calling it "ordinary" is that an extraordinary kind of hydrogen exists. In every 6500 atoms of hydrogen, on the average, 6499 are ordinary. The remaining atom is a different nuclear species called deuterium. Deuterium has a neutron in its nucleus, along with the usual proton. This raises the mass number to 2. Deuterium is still hydrogen, because its atomic number is still 1. It is a different "nuclide" (nuclear species) from ordinary hydrogen, because its nucleus is different. It is an "isotope" of ordinary hydrogen.

Definition: Isotopes are different nuclides of a single element. The difference is always in the number of neutrons in the nucleus. One result of this difference is a difference in mass number.

Ordinary hydrogen is sometimes called H^1, the superscript being the mass number. There are only two naturally occurring hydrogen isotopes, H^1 (ordinary hydrogen) and H^2 (or D, meaning deuterium).

A third hydrogen isotope can be made artificially by the addition of a second neutron to the deuterium nucleus. This third hydrogen isotope is called tritium (H^3 or T).

Tritium is not found in nature. This is because its nucleus (one proton and two neutrons) is an unstable combination. Such combinations frequently occur but, when they do, the forces inside the nucleus have a feasible way of changing the neutron-proton ratio in order to make the relationship more tolerable. Under such conditions, a spontaneous change toward greater stability must be made. The tritium nucleus makes this change in a way to be described in a moment.

Why *should* one *nuclear composition* be more stable than another? Nobody yet claims to have all the answers to that, but three general points can be made with assurance:

1. In the miniature world of the atomic nucleus, unique "binding forces" exist, tending to hold the nucleus together. These forces are neither gravitational nor electrostatic, but are specifically nuclear forces. They are powerful, but operate only at short range.
2. Electrostatic forces also exist in the nucleus. Since like charges repel each other, the protons in a nucleus have a tendency to pull the nucleus apart. Binding forces oppose this tendency. Stability results when binding forces are stronger than disruptive forces.
3. Instability is relative. Even when a nucleus is poorly designed, containing strong disruptive forces, it will be stable unless there is a better design *in sight. In other words, a nucleus will not change* itself spontaneously unless a more stable arrangement of its ingredients is possible and can be achieved without costing more energy than the original nucleus possesses. Conversely, when a nucleus is well designed, containing strong binding forces, it will nevertheless transform itself into something even more stable--provided such a preferable configuration exists, and provided the change is not too costly in energy.

Tritium is an example of the well designed nucleus which nevertheless makes a spontaneous change. The combination of one proton and two neutrons is theoretically tolerable enough, but the tritium nucleus sees something better, a combination of two protons and one neutron. To achieve this preferable state, it throws off a beta particle (another name for an electron).

Two questions arise here: Where does the tritium *nucleus get an electron to throw? How does emitting* an electron change the nucleus toward greater stability?

The only electron in sight is the orbital one, too far out in space from the nucleus to be available. That electron plays no part in the action. Instead, the nucleus makes a new electron out of its own mass (its own mass being equal to that of many thousands of electrons). It ejects the new electron as a beta particle.

The resulting decrease in actual nuclear mass is too small to cause a change in mass number. What changes is the atomic number. The loss of a full unit of negative charge leaves one of the neutrons positively charged--and therefore no long a neutron but a proton. The nucleus has transformed itself, by beta emission, from the relatively unstable combination of one proton and two neutrons to the stable combination of two protons and one neutron. This process has had no effect on the mass number, which remains 3, but it has changed the nuclear charge (the *atomic number, or number of protons*) from 1 to 2. The atom is therefore no longer the heaviest isotope of hydrogen; it has become the lightest isotope of helium. It has changed from H^3 to He^3. H^3 and He^3 have the same mass number but different atomic numbers. They are isobars.

Definition: Isobars are atomic species (nuclides) having different atomic numbers but the same mass number. Some isobars are stable and some are not. In most pairs of isobars, one member is unstable with respect to (*i.e.,* spontaneously transforms itself into) the other.

The definitions are piling up. Here is a short review:

proton: mass number 1, charge +1.
electron: mass very small, charge —1.
neutron: mass number 1, charge 0.
nucleus: the heart of the atom. It consists of one or more protons and (except in H^1) one or more neutrons.
nucleon: a proton or a neutron, considered as a nuclear component.
atomic number: the number of protons in a nucleus (equal to the number of orbital electrons).
mass number: the total number of nucleons (protons and neutrons) in a nucleus.
element: a material composed of atoms all having the same atomic number.
nuclide: a nuclear species (meaning a nucleus having a specified number of protons and a specified number of neutrons).
isotopes: two or more nuclides of the same atomic number, having different mass numbers.
isobars: two or more nuclides of the same mass number, having different atomic numbers.

The earth, with everything and everybody on it, is made of a limited number of nuclides, representing (because many are isotopes) a still more limited number of elements. There are fewer than 300 stable nuclides on earth, ranging up to atomic numbers in the middle eighties and mass numbers a little above 200. The figure on this page shows something very

continued on next page

Heavy Elements . . .

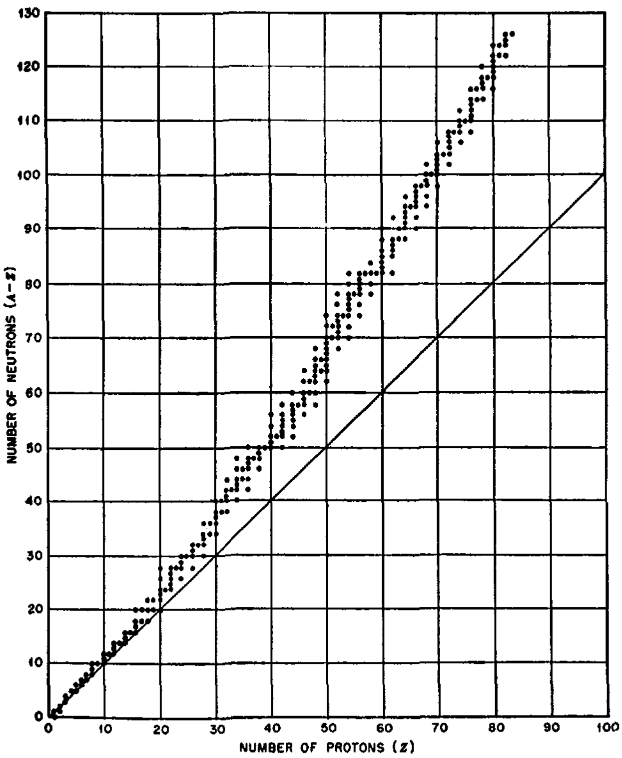
continued from preceding page

striking about the naturally occurring stable nuclides.

The figure is not so complicated as it looks. Each stable nuclide is represented by one dot. The distance of the dot from the bottom of the drawing depends on how many neutrons are present in the nucleus. The distance from the left edge depends on how many protons.

What the figure demonstrates best is that the proportion of neutrons to protons in a nucleus has a great deal to do with stability. It is permissible to speculate that at the creation of the universe there were nuclides of many more kinds, perhaps enough to sprinkle dots over the whole picture. The dots shown in the present drawing may represent the survivors, the successes, the nuclides that are happy where they are.

It is clear that, for each atomic number, stability requires a neutron number that falls within a narrow range. For low atomic numbers, the number of neutrons required for stability is about equal to the atomic number. As the atomic numbers go up, the proportion of neutrons to protons rises, as shown by



Plot of the numbers of neutrons and protons in stable nuclei. See text for discussion. (Based on illustration in Sourcebook on Atomic Energy, by Samuel Glasstone.)

the increasing distance of the dots from the 45-degree line of half-and-half nuclear composition. Thus, the heavier the elements, the more neutrons are needed per proton.

Why do heavy elements need a high proportion of neutrons for stability? Because binding forces operate only at very short range. In a *small* nucleus, protons are close together, and binding forces tend to counteract the repulsion of the like charges. In a *large* nucleus, some of the protons are far apart. Electrostatic repulsion, which is not a short-range force, can still operate between them, while binding forces cannot. For that reason, large nuclei need something that will supply binding energy without adding to the disruptive positive charge. Neutrons fill this need. That is why the "line of stability" around which the dots are clustered veers to the neutron-rich side of the half-and-half line.

The heaviest nuclide shown in the figure is bismuth (mass 209), represented by the dot at 83 protons and 126 neutrons. No heavier nuclide is both stable and of natural occurrence on earth.

Much has been learned by the study of nuclides with mass numbers of 209 or less, but much can also be learned by the study of heavier ones. About 65 heavier nuclides, ranging up to mass 238, are found in the material of our planet. These nuclides are not represented on the drawing because they are unstable. They are in the process of transforming themselves, as evidenced by the fact that they are radioactive. All are "decaying" toward more stable nuclear compositions. Some are decaying by beta emission, some by "alpha" particle emission (two protons plus two neutrons), and some by spontaneous fission (splitting in two), depending on what change each nuclide requires for greater stability and depending on what change each nuclide finds possible. Each nuclide has its own rate of decay, but each of the 65 just mentioned has a decay rate slow enough to permit careful study.

The naturally occurring nuclides, stable and unstable, total more than 340. About three times that number (all unstable, but some with very long lives) have been made artificially.

One makes an artificial nuclide by injecting a proton or neutron, or some combination of these, into a nucleus. Until fairly recently, this could be done only by bombarding target nuclei with particles from nuclear reactors or particle accelerators.

In 1952 a Los Alamos thermonuclear device named "Mike" was detonated on an island in the Pacific. In debris from the Mike explosion, scientists discovered nuclides with mass numbers as high as 255. Nuclear explosions are currently being used to create even heavier nuclides.

How this method works, why its future prospects are so exciting, and what it has accomplished will be discussed in the second half of this primer, to be published in our next issue.

The Technical Side

Colloquium at Brookhaven National Laboratory, Upton, N.Y., Jan. 26:

"Implications of a Meson Facility for Nuclear Physics Research" by Louis Rosen, P-DO.

DASA Conference on Shock-on-Shock Interactions, USAF Flight Dynamics Lab., Wright-Patterson AFB, Ohio, Feb. 2-3: (Classified Conference)

"2-Dimensional Dulerian Shock-on-Shock Calculations" by Richard A. Gentry, T-3.

Surface Seminar, Sandia Corp., Albuquerque, Feb. 4:

"Special Techniques in Optical Microscopy" by W. P. Ellis, CMB-8.

AIChE Symposium on Non-Newtonian Flow, Houston, Texas, Feb. 8:

"Axial, Laminar Flow of a Non-Newtonian Fluid in an Annulus" by Donald W. McEachern, K-4.

Santa Fe-Los Alamos Chapter, New Mexico Society of Professional Engineers, Feb. 25:

"What Are Plastics?" by James S. Church, CMB-6.

Mathematics Conference for Teachers & Administrators, University of New Mexico & Highland High School, Albuquerque, Feb. 13:

"Applications of Number Theory" by Mark B. Wells, T-7.

"Misuses of Statistics" by Roger Moore, T-1.

Presentation at Chemical Engineering Club, New Mexico State University, Feb. 16:

"Coated Particle Fuel Elements for UHTREX" by R. J. Bard, CMB-8.

Meeting on Pulsed Neutron Sources, Washington, D.C., Feb. 18:

"PHERMEX—A High Current LINAC" by H. T. Motz, P-2.

"A Thermal Neutron Facility for LAMPT" by H. T. Motz, P-2.

Spring Convention of Society for Nondestructive Testing, Los Angeles, Calif., Feb. 22-26:

"Non destructive Inspection of Nozzles of Nuclear Rockets" by Paul D. Edwards and Gerold H. Tenney, both GMX-1.

High Temperature Thermometry Meeting, Washington, D.C., Feb. 24-26:

"Thermocouple Development for Project Rover" by J. E. Perry, Jr., N-4.

American Physical Society Meeting, Norman, Oklahoma, Feb. 25-27:

"Fluctuations in the F^{19} (alpha, p)NE^{22} Cross Section" by G. G. Seaman, LASL Post-Doctoral, G. Dearnaley, P-9, W. R. Gibbs, T-DOT, and R. B. Leachman, P-12.

"Thermal Neutron Capture Gamma Rays" by H. T. Motz, P-2. (INVITED PAPER)

"Critical Velocities and Supercritical Flow of Liquid He II in Narrow Channels" by William E. Keller, CMF-9. (INVITED PAPER)

Lectures at University of California, Los Angeles, Feb. 8-11:

"Fundamentals in Metal Forming" by John E. Hockett, CMF-13.

WHAT'S DOING

OUTDOOR ASSOCIATION: No charge; open to the public. Contact leader for information on specific hikes.

Saturday, March 20, Santa Fe Baldy. Leader, Herb Ungnade.

FILM SOCIETY: Civic Auditorium. Films shown 7 and 9 p.m. Admission by season ticket or 90 cents single admission.

Wednesday, March 17, "Bizarre, Bizarre." A fantastic French comedy set in Edwardian, England. 90 minutes.

LITTLE THEATRE: "Invitation to a March," a fantasy-comedy by Arthur Laurents. Tickets, $1.75 adults, 75 cents students, or $5 season tickets available at the door.

Friday, Saturday, March 19 and 20, 8:30 p.m., Civic Auditorium.

LOS ALAMOS HIGH SCHOOL POOL: Schedule for public swimming. Adults 35 cents, students 15 cents.

Saturday	1 p.m. to 5 p.m.
Sunday	1 p.m. to 5 p.m.
Monday	7 p.m. to 9 p.m.
Tuesday	7 p.m. to 9 p.m.

SWIMMING CLASSES: sponsored by Red Cross for members of the Calorie Counters and all pre-natal and post-natal women. Free. Meets every Saturday, noon to 1 p.m., High School pool. Phone 2-4094 for further information.

SWIMMERS CLUB: Meets every Sunday, 7 to 9 p.m., high school pool. Membership open to interested adults.

ART EXHIBIT: Paintings and charcoal drawings by Santa Fe artist Ted Claus. March 15 to April 5, Los Alamos Building and Loan Association. Opportunity to meet the artist and discuss possibility of taking classes from Mr. Claus, Building and Loan office, Sunday, March 21, 2 to 4 p.m.

LASL's Mr. Safety

To help, not hinder, scientific progress is Roy Reider's philosophy.

BY DAVID SUNDBERG

A safety engineer who hates safety posters and believes risks should be minimized but not entirely eliminated. That's Roy Reider, since 1948, LASL's Safety Director.

No, it's not that Reider is fond of risk-taking or dangerous working conditions. But in his professional opinion, as one of the world's leading safety experts in the nuclear field, there is no such thing as absolute safety in a scientific laboratory. To eliminate all risk would be to eliminate any chance of progress, Reider contends.

"Roy Reider is unquestionably our best salesman of the concept that the role of the Safety Office, and the rest of Health Division as well, is to help, rather than hinder, the work of the Laboratory," says his boss, Dr. Thomas Shipman, H Division Leader.

"Unfortunately," says Shipman, "in many places the safety engineer is considered the man who puts hurdles in front of people—the man who simply says 'no.' "

If Reider is not a dissenter, neither does he play nursemaid. LASL has chalked up an excellent safety record during the time Reider has been with the Laboratory. It is due in large measure, says Shipman, "to Roy's insistence, and the subsequent acceptance, of the philosophy that the basic responsibility for safety rests with the individual and his immediate supervisor."

Reider expresses it this way: "Ideally, with proper procedures, good facilities and able supervisors, you ought to be able to line up all the safety engineers and shoot 'em without causing any appreciable change in the Laboratory's routine." If the safety engineers have to do more than five per cent of the safety work, there's something wrong with the system, Reider said.

The safety office, group H-3, encourages group leaders or division leaders to write their own rules, under the general supervision of H-3. "We don't say what the rules should be, but we insist that there be rules and that they be good ones and that they be followed," he said. "Safety SOP, rules, and so forth are entirely too specific for any one office to write them."

On safety slogans and posters: "They are wretched—they make me retch." Reider doesn't use them because "safety is simply too specific and too significant to be left up to the advertising people."

Nearly every division of the laboratory has its own committees on safety. In addition, LASL has a number of Laboratory-wide committees set up by the Director. The Director's committees set up safety standards and procedures to deal with so-called exotic risks, such as nuclear criticality, reactor operations and liquid hydrogen.

Born in Dobbs Ferry, New York, August 13, 1914, Reider graduated from High School when he was 15, took his degree in Chemical Engineering at Rensselaer Polytechnic Institute, Troy, New York, when he was 19. Despite finishing his formal education at such an early age, Reider says he was "not an outstanding student." He got off to an early start by skipping a few grades in elementary school. "You see, I was real smart until I was about 12, then something must have happened."

His career as a safety engineer began in 1936 when, two years out of college, he took such a job with an insurance company. By the time he was 28 he was Safety Superintendent with a major explosives firm in Wisconsin.

Active in community work, Reider has worked at various times in the YMCA, Boy Scouts, American Legion, and is a past president of the Los Alamos Jewish Center and the B'nai Brith Lodge.

Reider takes turns with the other six safety engineers in his group in

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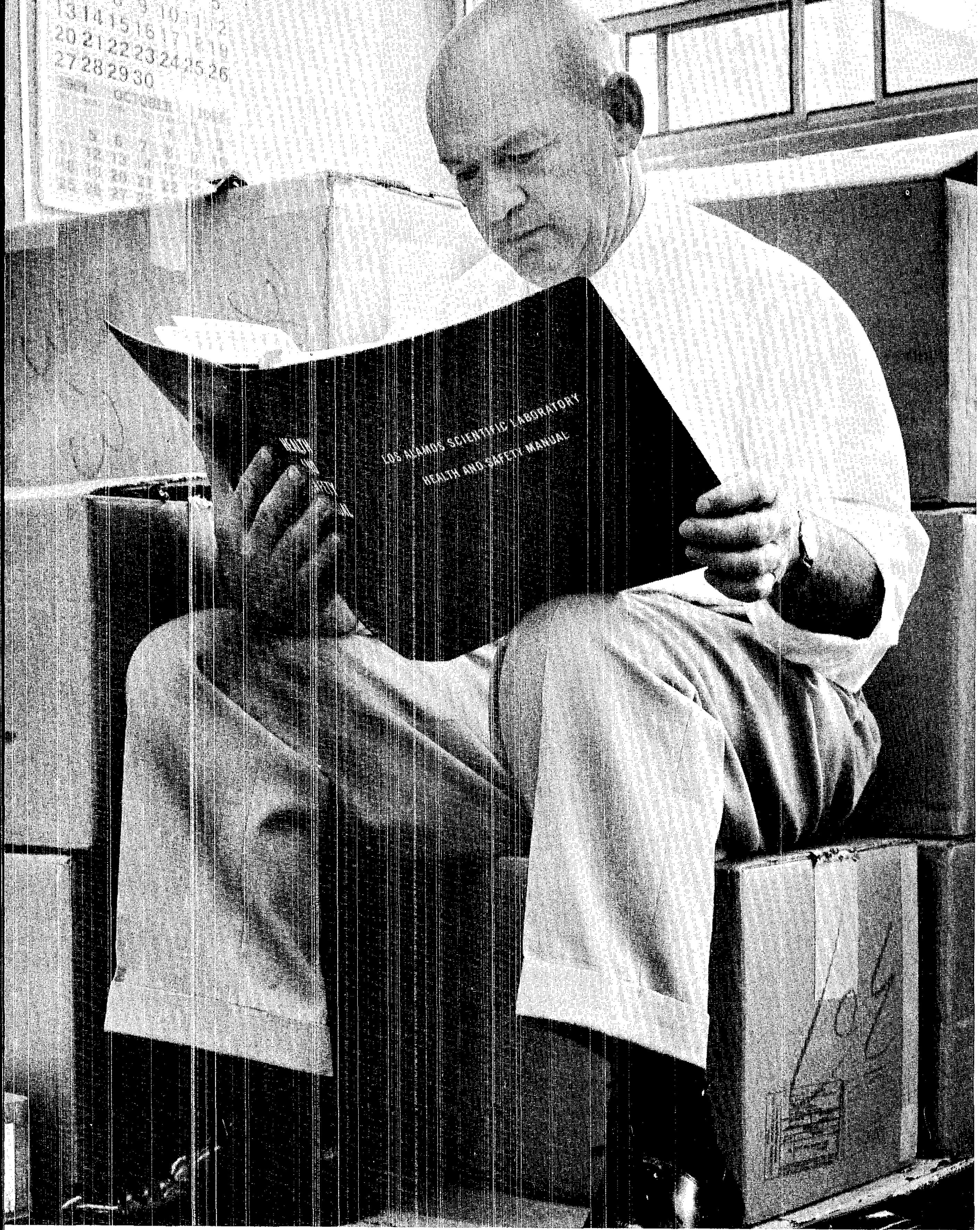
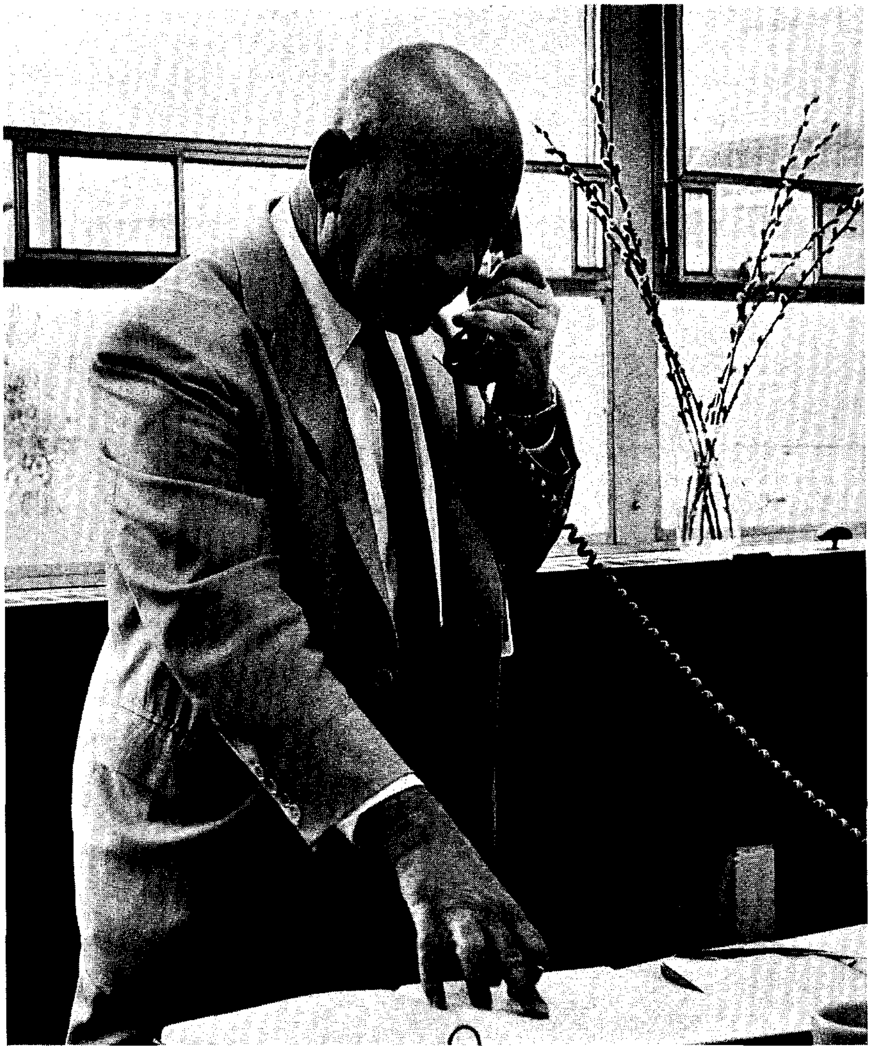


Seated on boxes of safety manuals in his office, Safety Director Roy Reider goes over part of their contents.



Though he "likes to have things in writing," Reider spends a good deal of his working day on the telephone discusssing a variety of safety matters.

continued from page 20

participating in every test of a nuclear weapon or Rover reactor at the Nevada Test Site. But it was during one of the Laboratory's overseas nuclear weapons testing series that Reider performed probably the most unusual safety experiment in his or any one else's career.

The question arose whether the heat given off by an upcoming nuclear detonation might cause minor skin burns to personnel working on a nearby island. Reider said there was no such danger; others disagreed. To resolve the question, Reider decided to expose a portion of his own anatomy to the heat wave. But he had a problem. Having spent several weeks in the Pacific sunshine, Reider had accumulated a dark suntan all over his body—except for the portion of him that had been protected by his Bermuda shorts.

If the test was to be valid, he reasoned, he would have to expose an area of epidermis not already tanned. That way, the slightest burn from the bomb would show up.

So, as the countdown for the explosion began, Reider recalls, "I turned my back, effected my exposure, and just leaned into it." Reider's calculations were correct. He didn't get burned.

"It's Almost Impossibl

While his staff describes him as a man who likes to have everything in writing, Reider has no trouble expressing himself in spoken language. One LASL staff member remarked, "It is almost impossible to misunderstand Reider when he's unhappy about something you've done wrong."

Reider enjoys public speaking and apparently people enjoy hearing him. He gives, on the average, eight to ten talks a month in and out of the Laboratory. He has presented three colloquia lectures at LASL and has twice addressed the National Safety Congress, the annual meeting of the National Safety Council.

But not all his talks deal with safety matters. Once he gave a book review before a meeting of the local chapter of the National Secretaries' Association. On another occasion he spoke to the Kiwanis club on "Profit Margin in Legalized Garmbing," a topic on which he is an authority.

He has made detailed and painstaking studies of the gambler's chances of winning in nearly every form of legal gambling from horse racing to black jack. At the request of some Laboratory group leaders, he has given short talks to LASL employes bound for Nevada, on "How to Lose More Slowly." Reider used to gamble a lot, he confides, during his frequent trips to Nevada. "Very little anymore—I'm no longer interested."

If gambling can be reduced to statistics, can Reider do the same in determining risk in dealing with safety matters? Yes, he answers, but the safety engineer cannot afford to base his decisions concerning safety on statistics alone. "Sure, you can say 'statistics show that if you do such-and-such this way, you can expect only so many accidents in so many thousands of man-hours worked,' but somewhere there has to be a human decision when you're dealing with people's safety. The safety engineer still has to decide: Is this safe enough, or is there a better way of doing it?"

How safe is the nuclear industry of which LASL is a part? Quite safe, says Reider. He feels that a "preoccupation with radiation safety" has "rubbed-off" and made the whole range of work safer. But such a preoccupation with dangers of radiation can be stretched too far, Reider believes, and could tend to curtail the nuclear industry.

Only one-half of one per cent of the disabling injuries in the nuclear industry are due to radiation, Reider says. The bulk of the injuries that do occur can be traced to more ordinary hazards such as strains, falls, tools or fire and accidents with common chemicals.

It's not always the obvious hazards that cause the accidents. One Laboratory group which performs experiments using high explosives went 12 years without a disabling accident. The record was finally broken when one of the group's lady employes slipped on some ice and injured her wrist.

The testing of nuclear weapons is a somewhat risky business, Reider allows, "but not so much because of the bombs." The danger arises mostly out of the transportation involved. There are a lot of people riding in airplanes, cars, trucks, and even boats, during a weapons testing series. Reider calls transportation "the greatest risk of civilization."

Reider's success as a safety director has undoubtedly been enhanced by his ability to keep calm in nearly any kind of situation. N-2 physicist David Smith several years ago shared with Reider the unpleasant experience of disassembling a nuclear device with which something had gone wrong. It was a nerve-wracking thing to have to do, but Smith said "Roy's calming presence" made it easier.

Years later, Reider and his family (he and his wife, Alice, have three daughters) were watching a televison movie in which one of the characters, in a grippingly suspenseful scene was disassembling a "dud" atomic bomb. Roy remarked, "You know, I once helped take an atom bomb apart." His youngest daughter looked up from the screen just long enough to scowl at him and say, "Oh come now, Daddy." Reider didn't say any more about the incident.

In late 1961 Reider suffered a heart attack from which he has made, in his words, "a remarkable recovery." His illness has caused only a few changes in his routine. He's about twenty pounds lighter than before and he gave up smoking after 30 years. He manages to get a lot of exercise, plays five sets of tennis on a weekend afternoon, almost always walks to work from his Western Area home.

That he does a lot of walking may partially account for the fact that he still has the first car he ever owned, a 1949 Mercury he bought to drive to Los Alamos. He also has a newer model automobile but still drives the Merc, though it has "well over 100,000 miles and hasn't had any oil pressure for six years."

An avid reader (he consumes four or five books every week, mostly non-fiction), he has been known to read a book while playing a game of cards. Robert Penland, one of the six safety engineers on Reider's staff and who has played poker with Reider, says, "You've got a chance against him as long as he keeps his head in his book, but if you see him lay the book down, watch out."

Along with his appetite for reading, Reider has an uncanny memory, according to his colleagues. It's a useful ability in the safety business because much of his work is in searching the literature for information. Whether it's a report on a hazardous new chemical or tips on how to avoid shark bite, if Reider has read anything about it, chances are he remembers what he read. At the very least, he remembers where he read it.

"If he tells me to do something," said a member of his staff, "it is possible I will forget. Roy won't."

Reider's ability to remember is valuable in one of his favorite pastimes, bridge. A fellow bridge enthusiast says Reider can play the game for a whole evening, and on the following day recall every card played and who played it for a given hand.

Reider also likes gin rummy. Penland recalls a time some years ago when he and Reider got into a gin game on a Pacific island during a weapons testing operation. It was the day Reider was to return to the U.S. Penland was to drive him to a boat, which in turn would take Reider to another island from which his airplane would depart.

After putting Reider's gear in a jeep, it was still a little early to go to the boat, so the two began a gin game to kill some time. When the hour arrived for his departure, Reider was absorbed in the contest and refused to leave the game unfinished. "I couldn't let him miss the boat," Penland said, "so I got someone else to drive the jeep while Roy and I sat in the back and finished the game."

While he claims to have made no "sweeping changes" in the Laboratory's safety program since his becoming Safety Director, Reider's records show that the Laboratory's accident rate is only about half what it was during the war.

Last November, LASL was presented an Atomic Energy Commission Award of Honor for operating 3,373,000 man-hours without a disabling injury. It was the longest accident-free period in the Laboratory's history.

AURORA STUDIES . . .

continued from page 8

four miles southeast of the town. Built as an Allied overseas military aircraft staging point during World War II, the camp was taken over in 1946 by the Canadian Army as an experimental and training station. Since 1964 it has been under control of the Canadian Federal Department of Public Works. It includes, in addition to the rocket facilities, a general hospital, an airfield, several laboratories and a detachment of the Royal Canadian Mounted Police, and a vocational school for young eskimos.

The weather varies from miserable to impossible. The temperature averages 30 below zero in midwinter, dropping to 50 below on occasion and rarely warming to zero even at mid-day. Elevation of the base is only about 25 feet above sea level, on a water-logged plain of the rocky Hudson Bay shore.

Despite the weather handicap, the rocket launching facilities are extensive. First rockets were fired there by a Canadian Army detachment in 1954. Later, during the International Geophysical Year, Canadian and American scientific groups found the location ideal for their purposes. The base was closed for a time after December 1958, but was re-opened in 1959 under joint Canadian-American sponsorship at the request of scientists from several countries.

Several launch sites, including four launch complexes, are equipped to handle Nike, Aerobee and Black Brant rockets, and one universal launcher for most solid propellant vehicles.

The aurora comes in all colors, from pure white to flaming red. Shades of yellow-green appear most often, but orange, yellow, blue, violet and rainbow shades in between are not uncommon. Auroras may form as bands across the sky from horizon to horizon, or as patches, loops, rays, fans and spirals. In perhaps their most beautiful form, they may appear as enormous draperies, in shimmering, waving folds. Now and then the aurora will put on a fireworks display, appearing in corona-like bursts. But again, they may be no more than a faint glow at the horizon, as if the sun or moon were about to rise in the north. In the lower latitudes, at Los Alamos for instance, about the only form of aurora that is visible, and then only rarely, is a series of long, red pencil-like rays extending toward the zenith.

There are widespread beliefs but no factual evidence that the aurora can be heard. English legends frequently refer to the "sounds of battle" when the aurora appears. In Ireland as late as 1854 scarlet auroras were attributed to the blood of those slain at Balaclava four years earlier. Early writing in Italy, dating from 500 B.C., refers to "flaming spears, clouds on fire, sky glowing in flames." Almost universally their appearance was taken as an omen of disaster, to presage murder and violence. They inspired terror even among civilized people into the 18th century, when scientists began to seek more rational explanations for the phenomena.

Now, with the source of the aurora known and generally understood, experimenters like those from Los Alamos are using the "northern lights" to push the unknown even further into space.

For Reporting Change of Address

Previous Address

If your address has changed please inform THE ATOM by clipping and filling out this coupon. Print or type your name and both your old and new addresses.

Mail to: Mail and Records, *Addressograph*
Los Alamos Scientific Laboratory
Box 1663
Los Alamos, N.M. 87544

name ____________________

address ____________________

city ________ state ________ zip code ________

New Address

address ____________________

city ________ state ________ zip code ________

NEW HIRES

Larry Lee Vaughan, Roswell, N.M., N-1.

Pamela Jeanne Royer, Los Alamos, SP-1.

Donald E. Michael, Las Cruces, N.M. P-15 (Rehire).

Thomas D. Baker, Argonne, Ill., CMF-13.

Edward Clark Snow, Houston, Texas, CMF-5 (Rehire).

Robert G. Sturgess, Mosier, Oregon, CMB-7 (Rehire).

Robert Glen Lawton, Fresno, Calif., N-7.

Lorene L. Sturgess, Los Alamos, N-1 (Rehire).

Fred L. McFall, Jr., Danville, Va., GMX-7.

Ronald Henry Smith, Santa Fe, N.M., SD-DO.

Michael C. C. Haley, Los Alamos, WSD.

Ruth Evelyn Gibson, Los Alamos, SP-1 (Rehire).

Jerome J. Miller, Los Alamos, CMF-9 (Casual).

Kay Jean Fisher, Los Alamos, CMB-1 (Part Time).

Some experts (?) say it was a vapor trail left by a jet plane flown by a drunken pilot. Others say it was the descending trail of a rocket, the zig-zag effect caused by high altitude winds blowing in different directions at various altitudes. Whatever it was, this brilliant pattern against the southwestern sky late in the afternoon of February 12 attracted attention all over northern New Mexico, Los Alamos included. (P.S. The Army reports firing a Pershing rocket from Fort Wingate to White Sands just about that time). Photograph by John Young.

Henry T. Motz
3187 Woodland
Los Alamos, New Mexico