THE ATOM

Los Alamos Scientific Laboratory Sept.-Oct. 1974

Mimicking Cancer's Clockwork

Volume 11 Number 5
September-October 1974

THE ATOM

Published bimonthly by the University of California, Los Alamos Scientific Laboratory, Office of Public Information, TA-3, West Jemez Road, Los Alamos, New Mexico 87544. Address mail to P.O. Box 1663, Los Alamos, New Mexico 87544. Second Class Postage Paid at Los Alamos, N.M.

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Office: D-442-B Administration Building. Telephone: 667-6102. Printed by the University of New Mexico Printing Plant, Albuquerque.

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COVER

The ATOM cover features a colony of human cervical carcinoma cells growing in monolayers in an artificial culture medium and photographed in the last stage of mitosis. These particular cells are well known among biomedical researchers, being one of many colonies grown from cervical cancer cells removed from a patient given the pseudonym Helen Lane. Such colonies are called "HeLa" cells as a contraction of the patient's pseudonym.

Cells progress through a typical growth cycle. By understanding and manipulating the clockwork of cancer cells, LASL scientists have devised an ingenious system to test new anti-cancer drugs as more fully described in the story beginning on page 6.

SUPER FILM FOR SUPERCONDUCTORS?

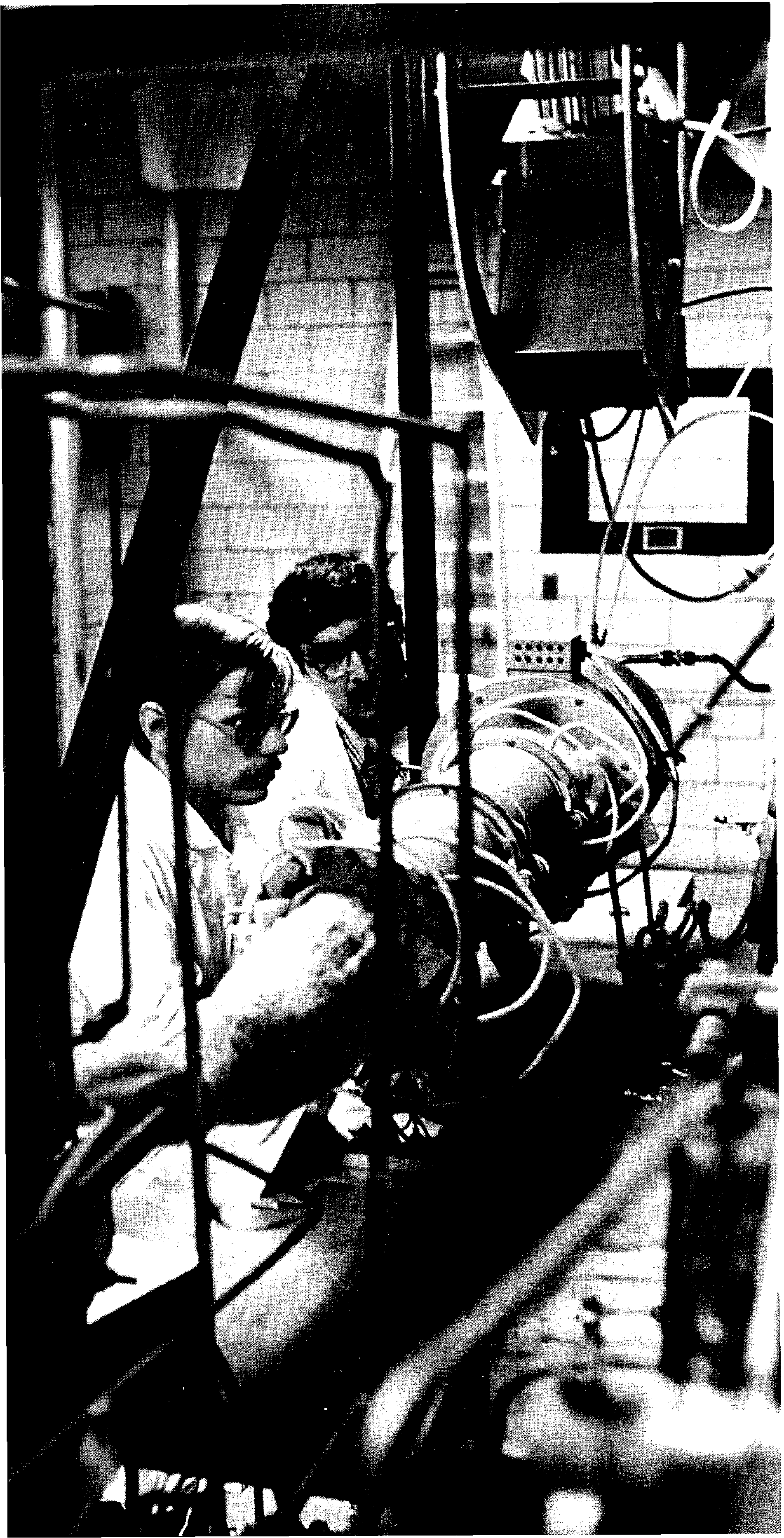
A handful of Los Alamos Scientific Laboratory chemists conducting vapor deposition experiments with equipment partly assembled from surplus may have scored a scientific advance that will profoundly alter the path of superconducting transmission research.

The achievement: demonstrations that a compound of niobium and germanium in films thicker than heretofore deposited can carry very large currents with no resistive losses at temperatures significantly higher than have been achieved with other materials.

The significance: a potentially more economical and scientifically attractive approach to superconducting transmission that could advance by years the widespread introduction of practical superconducting transmission lines into the nation's power system.

And, as a by-product, it leads to speculations that the superconducting transmission line of the future could do more than deliver electrical power in massive amounts. It could also deliver another form of energy that may become increasingly important as petroleum resources dwindle: hydrogen.

For what has been demonstrated at LASL is this: the new thick films of niobium germanide become



superconducting at temperatures that can be achieved by cooling with hydrogen slush. Previously, most superconducting schemes were based on cooling by fluid helium in order to conduct electrical current in meaningful amounts.

Helium is expensive, scarce, and nonrenewable. Hydrogen is relatively cheap and is limitless in supply, being rather easily extracted from water. Thus, the nation's power industry would find the use of hydrogen slush as a coolant for superconducting transmission lines of interest for its cost savings alone.

But the power industry may also find another economic advantage in adopting such a superconducting transmission line. The hydrogen slush pumped into one end of a superconducting transmission line could be withdrawn at the other end—and sold as storable, transportable, and nonpolluting fuel for industries and even for automobiles of the future.

Finally, hydrogen slush—a mix of liquid and solid hydrogen—offers some scientific niceties leading to neater, simpler engineering. With fluid helium, engineers would have to allow for a temperature gradient because the fluid helium would absorb heat and gradually warm up as it is pumped along the superconducting transmission line. Its temperature at the terminus would be higher than at the point of origin. The amount of current that a superconducting transmission line could carry would be limited by the higher temperature at the terminus.

Not so with hydrogen slush. The temperature would remain constant along the transmission line so long as some solid hydrogen remained

Larry Newkirk, left, and Flavio Valencia, both CMB-3, operate the vapor deposition device constructed, in part, with components from the defunct Rover program at DP-East. Vapor deposition is typically conducted at about 900° Celsius, but temperatures may be varied to produce different superconducting characteristics.

in the mix. The principle is the same as for a pitcher of ice and water. The ice may melt, but so long as some ice remains in the mix the temperature of the water remains at a constant 0° Celsius. The heat absorption is accounted for in the energy required to melt the ice and does not cause a temperature rise.

Thus, hydrogen slush would allow the entire superconducting transmission line to be designed to a constant temperature.

These are the possibilities that have "turned on" the imaginations of normally conservative scientists. Among the ideas being bandied about, and not altogether lightly, is one that visualizes giant energy complexes by the side of the sea where water would be processed for multiple uses. One facility might extract deuterium, the hydrogen isotope essential as fuel for fusion power plants. Another might convert the remaining hydrogen into hydrogen slush for superconducting power lines leading out of the complex. So long as water were being processed, it might be profitable to extract various minerals from the sea at the same time. And finally, if natural fresh water were in critical supply, it might prove economically and technologically advantageous to incorporate a desalinization plant into the complex.

If such complexes or something like them should ever come to pass, historians of the future may well trace their origin to the short lengths of copper tubing within which LASL scientists succeeded in depositing a thick film of whitish material during the summer of '74.

A Joint Effort

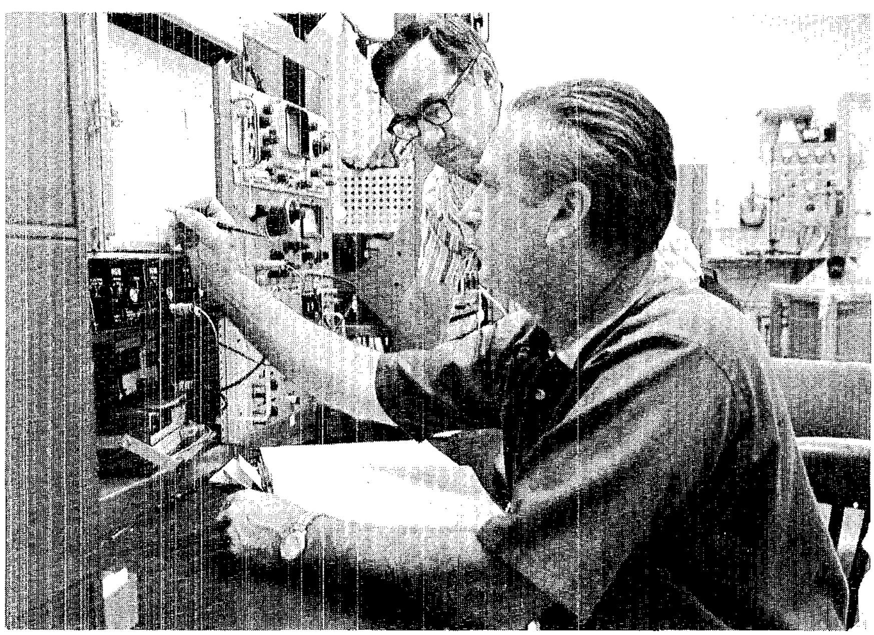
The development of vapor deposition experiments leading to the successful demonstrations of the niobium germanide film's superconducting characteristics is an example of LASL interactive scientific research at its best. And it's an example of how the free exchange of information with other research institutions can lead to sudden and rapid advances.

LASL had long been a leader in low-temperature physics and cryoengineering research as a necessary adjunct to weapons, nuclear rocket power, and Controlled Thermonuclear Research programs. In 1945, a cryogenics group (now Q-26) was formed to specialize in this type of research. Today, the group numbers about 35 and conducts experiments with an impressive array of laboratory equipment including a 20-meter test bed for testing various configurations of superconducting transmission lines under study.

Various compounds consisting of niobium and other elements, primarily tin, had been tested with encouraging results. Then announcements from 2 major research institutions prompted LASL researchers to investigate compounds of niobium and germanium.

In 1973, Westinghouse Research Laboratories and Bell Telephone Laboratories announced that they had demonstrated that a compound of niobium and germanium—Nb_3Ge—has the highest known transition temperature—above 22K.

The Westinghouse and Bell Laboratories work was done, however, using small sections of an extremely thin film of Nb_3Ge deposited by sputtering. The film was so thin (less than 0.1 micron) that it was impossible to make vital measurements of the current the Nb_3Ge could carry at various temperatures. And there was some doubt as to whether the same effect would be exhibited in thick films.



Angelo Giorgi, foreground, and Eugene Szklarz, both CMB-3, determine the transition temperature of a specimen by noting the changes in inductance of a coil surrounding the specimen at various temperatures from 4 to 22K. A pronounced change in inductance occurs at transition temperatures.

LASL scientists decided to investigate further, drawing on a vast fund of knowledge gained during experiments for the Rover program, since terminated, for developing nuclear powered rocket engines for space. A considerable amount of research had been accomplished in vapor deposition techniques for depositing exotic materials on carbon to protect various components from erosion by extremely hot radioactive gases.

Personnel at CMB-Division retrieved various components of the vacuum deposition equipment used in the Rover program and, with the addition of other components "scrounged" here and there, assembled a vacuum deposition device in a warehousing section of the DP-East building.

"The purpose of chemical vapor deposition is to react gaseous materials to form a sold compound on a surface," explains Larry Newkirk, CMB-3 and a principal investigator. "It allows the buildup of suitable thick films, typically of 50 microns, of uniform characteristics. By varying temperature, pressure, and flow rates, we can alter the stoichiometries, or composition, of the substance, and thus alter the lattice parameters and the superconducting characteristics."

The lattice parameters of a given substance is the arrangement of atoms in crystalline structure. The distances between atoms may be somewhat altered from that of their normal crystalline form through the vapor deposition technique. To date, some 120 samples of Nb_3Ge with differing transition and load-carrying capabilities have been produced at CMB-3.

Other principal CMB investigators are CMB-Division Alternate Leader Melvin Bowman, Flavio Valencia, Angelo Giorgi, Eugene Szklarz, Terry Wallace, and John Farr, all of CMB-3. Participating in the work was Bernd Matthias of the University of California at San Diego and the Bell Telephone Laboratories who is also a LASL Fellow.

After vapor deposition has been accomplished in a length of copper tubing of 2.5 centimeters (1 inch) inside diameter and about 60 cm (2 feet) long, the tube is cut longitudinally for testing by CMB-3. One instrument, an x-ray diffractometer, employs a collimated x-ray beam directed against the sample: scattering gives measurements of the lattice parameters for that sample. Another instrument, which measures electrical resistance as a function of temperature, indicates the transition temperature. The more promising samples are sent over to Q-26 for further testing.

In one of Group Q-26's laboratories the sample is tested under cryogenic conditions, principally by Roger Bartlett and Henry Laquer. The sample is immersed in a cavity within a dewar cooled by liquid hydrogen and current measurements are taken at various temperatures below transition.

As William Keller, Q-26 group leader, explains, "We have measured transition temperatures as high as 22.2K in a recent sample, which is above liquid hydrogen's normal boiling temperature of 20K. By altering the pressure on the hydrogen coolant, we can lower its temperature to that of hydrogen slush, which is in the vicinity of 14K.

"While the transition temperature is an important measurement, in practical application it would not have a great deal of meaning because only a small volume of current can be carried near the transition temperature before quench is encountered. (Quench is the sudden loss of superconductivity caused by the induced magnetic field generated by the passage of the current through the superconductor itself.)

"More meaningful are the current increases obtained for each degree the sample is lowered in temperature. For instance, the sample with a transition temperature of 22.2K will carry only a nominal current at that temperature, but will carry 30,000 amperes per square centimeter at 19K. Further lowering the temperature to the vicinity of 14K would, if our extrapolations prove out, allow current on the order of 1,000,000 amperes per square centimeter to be carried."

Bartlett added that such large-current tests at the lower temperatures have not yet been conducted because the current available in the laboratory is limited to 500 amperes.

If such capability becomes a reality, then a medium-size city could receive its entire electrical supply through a pair of superconducting wires each no larger in diameter than a pencil, surrounded by coolant conduit and insulation in a cable that could be buried in a right-of-way considerably less than required for overhead lines of comparable capacity.

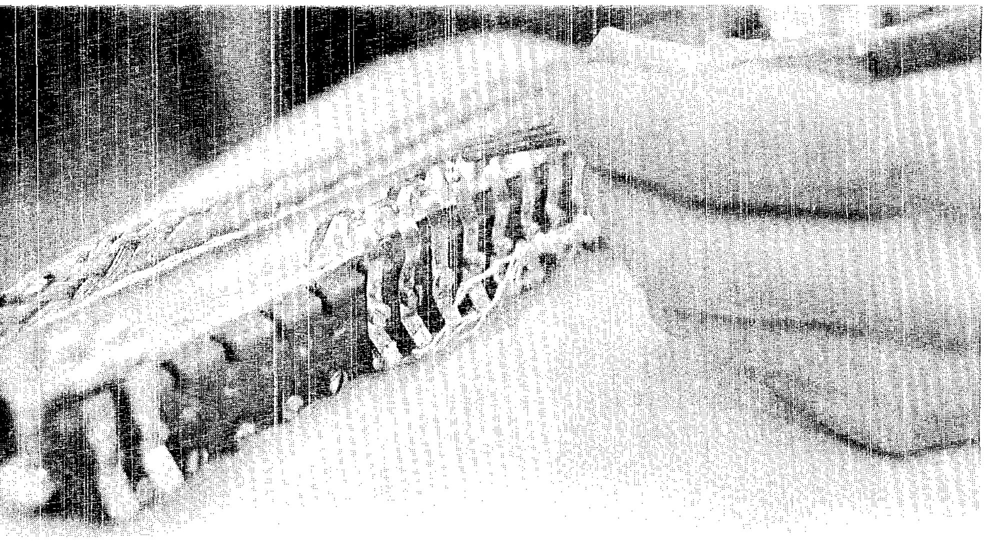
And because superconducting transmission lines would carry power at no resistance loss, the energy saved in transmission projected to 1990 would be the equivalent of all the energy the Alaska Pipeline could deliver.

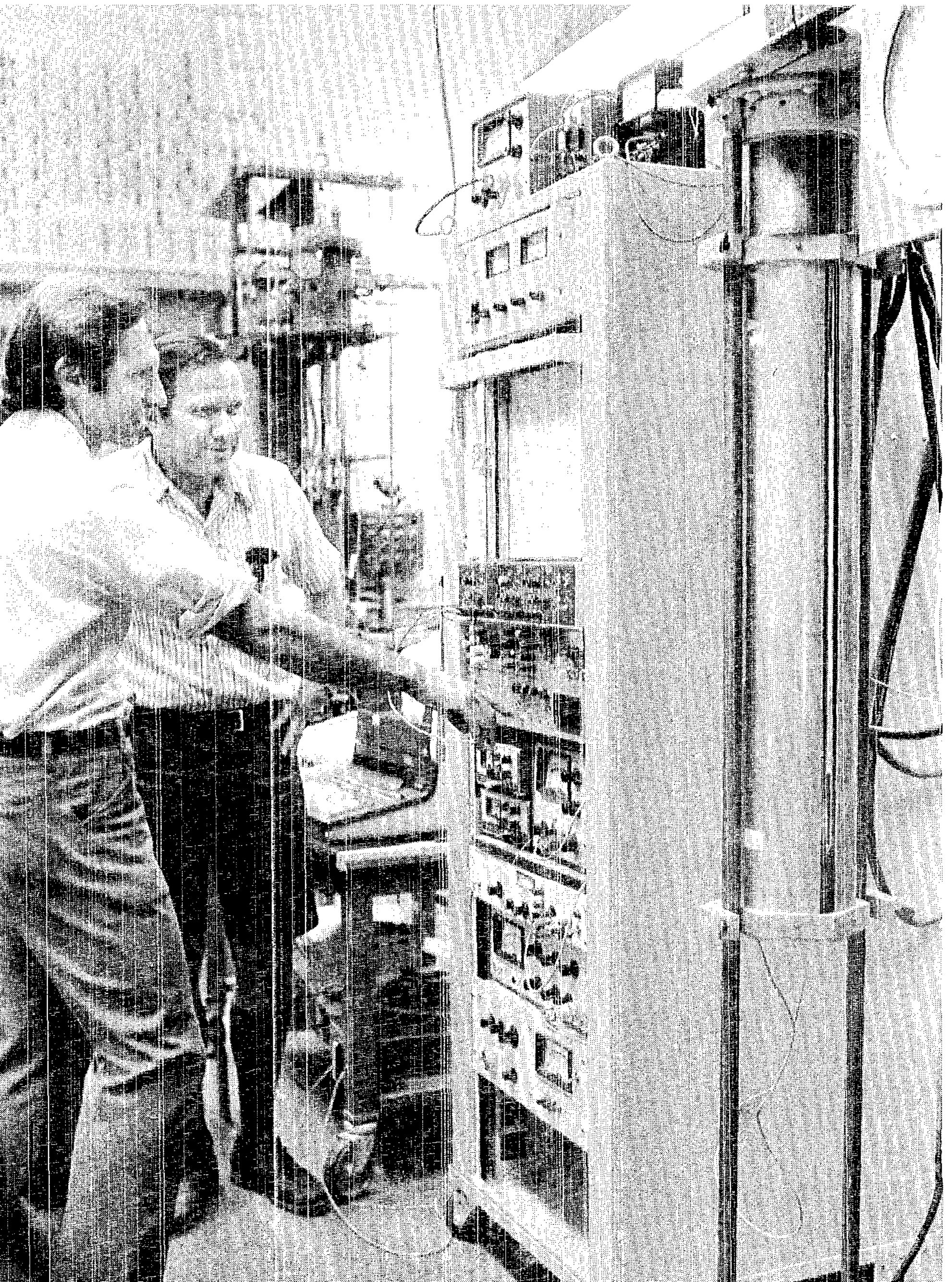
The Future

According to Bowman, LASL scientists visualize current basic research as only the beginning. As every scientist knows, the research road is often lined with unpleasant surprises lying in ambush. A host of technological problems remain to be solved, even after the superconducting capabilities of the final sample are proven to satisfaction. Among them is the problem of differing coefficients of expansion of the various materials that would be used in a superconducting transmission line. At the near absolute zero temperatures to which the materials would be subjected, the differences in contraction might be measured by meters per kilometer, leading to severe separation and other problems.

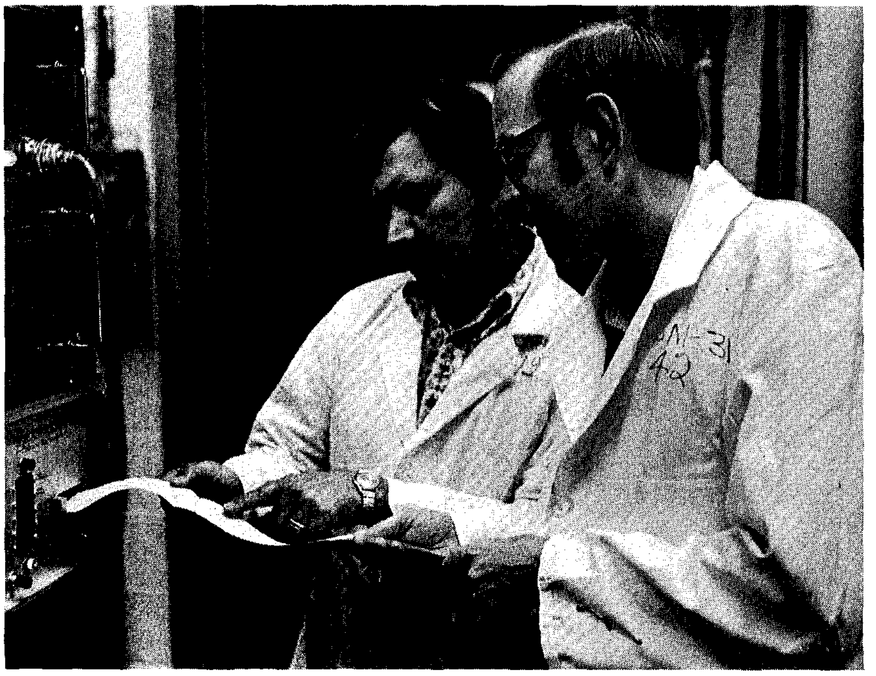
Thus, nobody is ready to label the advance by that much abused term, "breakthrough," yet. An investment in land by the side of the sea as a speculation against the day when those "blue sky" energy complexes might be built would be premature at this time.

Or would it?





Potential probes are attached at one-centimeter intervals along a sample of niobium germanide deposited on a copper-tube substrate. The sample is then inserted in the hydrogen-cooled dewar to the right in the photo (left) for testing in the 13.8-21K range by Roger Bartlett and Henry Laquer, both Q-26.



Principal investigators for a National Cancer Institute program to develop a fast, inexpensive means of testing new drugs are Robert Tobey, H-9, and Harry Crissman, H-10, here reading a printout tape from the flow microfluorometer developed by H-10. The instrument records differing DNA content as an index of a cell's position in the cell cycle. Readings give distribution of surviving cells at various phases in the cycle.

Mimicking Cancer's Clockwork

by

Barb Mulkin

Los Alamos Scientific Laboratory researchers probing the secrets of cell structure, growth, and synthesis have devised a novel system for testing new anti-cancer drugs. By mimicking the clockwork of a cancer cell's growth, they can determine which drugs are most effective at a given point in the cell's cycle.

The system is unique in that it can obtain results using cultured animal tumor cells which mimic the response of human cancer cells, accounting for all cells in the initial population faster and more economically than the standard animal model testing system now widely used.

Cancer cells divide in essentially the same way as normal cells, but differ in that they stop responding to the body's mechanisms for the regulation of growth. In a typical cell cycle, a cell initially divides during mitosis (the M stage), then enters stage G-1 in which preparation for DNA replication occurs. In the synthesis stage (S), DNA is replicated and the cell prepares for its next division during stage G-2. The cell then enters the M, or dividing, stage to begin the cycle anew.

Tumors consist of both inactive (nondividing) cells at various stages and active (dividing) cells. However, inactive cells often survive drug treatment that kills active cells. These inactive cells may later divide following treatment, causing a recurrence of the tumor.

The new system is designed to help researchers learn why the inactive cells survive and to test drugs that may prove effective against them.

Because Chinese hamster cells normally divide in only 16 hours as compared with the 24 hours required by human cells, and because they can be manipulated to mimic human cancer cells, they were chosen by Group H-9 for use in the system. As Robert Tobey, H-9, explains, withdrawing an essential ingredient, such as isoleucine (an amino acid), from the nutrient medium in which the cells are grown stops the cell's clockwork, thus mimicking the dangerous inactive cells of a tumor in humans. This happens because the cells need amino acid for their growth and, being unable to synthesize the material themselves, they become dormant.

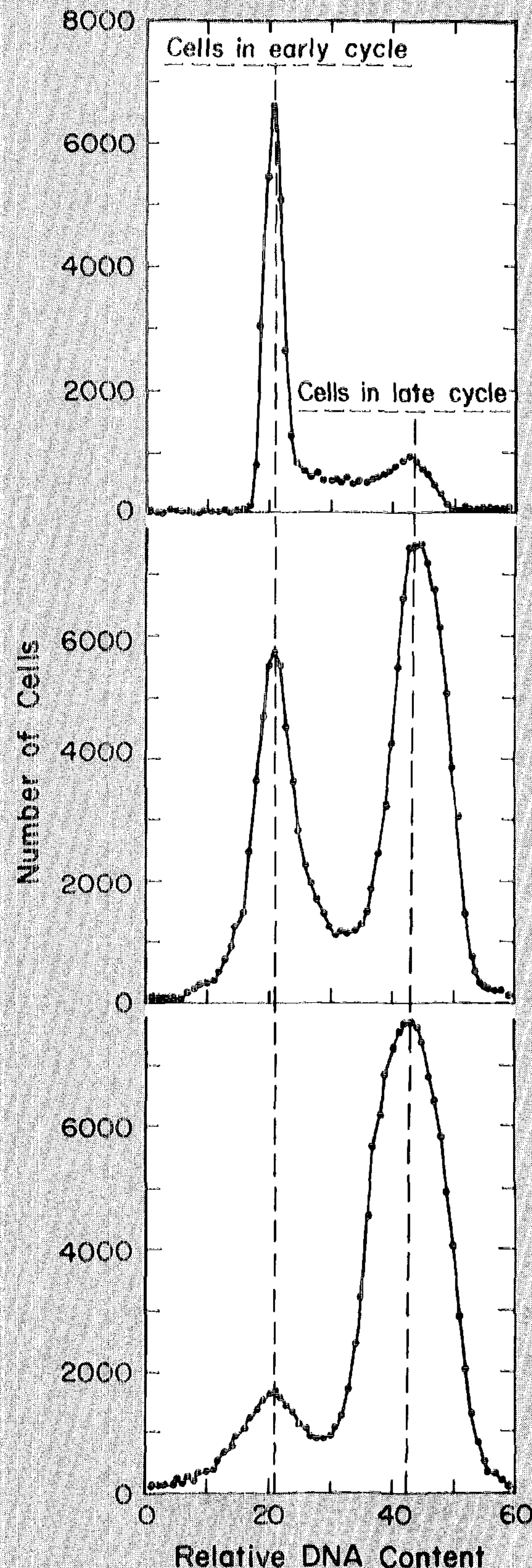
A specific drug may then be administered while the cells are in the inactive state and its effects observed. Isoleucine may then be reintroduced into the nutrient medium to restart the clockwork. Further observations may also be made to determine effects, if any, the drug may have had on cell behavior further along in the cycle.

Determining a given cell's position in the cell cycle is the key to the whole technique. This may be accomplished by measuring the cell's DNA content. DNA is replicated midway in the cell cycle, and cells in later stages of the cycle have twice as much DNA as in the earlier stages.

In application, a fluorescent stain is bound specifically and in direct proportion to the amount of DNA initially present in the cell. The relative fluorescence of large numbers of cells can then be measured using a flow microfluorometer (FMF) developed by Group H-10. Thus, the effectiveness of a drug, or drugs, can be measured by the number of cells present in various stages of the cell cycle as shown by the presence of fluorescent stain.

Because the program appears to afford a new capability for the fast, inexpensive testing of new drugs, it is being funded by the National Cancer Institute through an interagency agreement with the U.S. Atomic Energy Commission. Principal investigators are Tobey, assisted by Phyllis Sanders and Priscilla Jose, both H-9, and Harry Crissman, assisted by Mel Oka and Elvira Bain, all of H-10.

"There are quite a few drugs which are known for their kill capacity," Tobey explains, "and we also know that some drugs are most effective at specific stages of typical cell growth cycle. What we are after is information which will tell the clinician the expected behavior



How cells in a division cycle are redistributed by treatment with chlorozotocin is shown in these graphs. Prior to treatment, most of the cells were in the early cycle (top). Cells were then exposed to the drug for 2 hours, followed by growth for 30 hours in a drug-free medium. FMF analysis showed that most cells treated with a low concentration (middle) and a high concentration (bottom) had relocated in the late cycle. *Maximum cell kill could then be accomplished by administering a second drug that is effective in the late cycle.*

"This is what we are after: an increase in survival rates in all types of cancer such as we are seeing in acute leukemia..."

of the surviving cells and will provide a basis for selection of additional therapeutic drugs."

Typical animal experiments, which are the accepted way of testing anti-cancer compounds, use laboratory animals such as mice or rats. Cancerous cells are introduced into the rodents, and, as they develop tumors, some are kept for control, while others are given drugs which have a known or believed capacity for killing malignant cells. The tumors are excised, measured, and the cell count is recorded.

Tobey says that although the LASL system, which works with cells outside a living body, is much cheaper—a typical drug can be analyzed for as little as $20 compared with several thousand dollars for an animal experiment—it is not designed to replace animal model systems, but to add to the information derived from them.

A grant recently awarded H-10 by the National Cancer Institute, will be used to initiate an animal model system at LASL, Tobey reports, and H-9's simple analysis system will then be used in conjunction with animal experiments to perfect the clinical information which is passed on to the NCI for dissemination to cancer clinicians.

Meanwhile, Tobey believes the FMF analysis does have an advantage that is lacking in other analytical systems. It has the ability to detect certain abnormalities in cell division which are frequently associated with tumor production. These include unequal cell division and cells which advance through multiple rounds of DNA replication without dividing, a process which leads to formation of giant, potentially dangerous polyploid cells.

"We hope, ultimately, to routinely classify anti-cancer agents on the basis of the type of tumor against which they are most effective," Tobey says, "and certainly, we hope to provide guidelines indicating the kinetic response of tumors to specific agents."

Tobey explains that a drug which is effective against cancer in an organ such as the human liver, may be totally ineffective in another part of the body.

"Various organs 'break down' a drug in different ways and the yield is composed of metabolic products or compounds, some of which are toxic for cancer cells," Tobey points out. "The trick is to find the intermediate compounds and relate them to the organs in which they will produce maximum cell kill."

Cancer is actually a collection of over 100 diseases, and thus responds to no single "cure" or agent. Standard weapons to combat cancer are radiation therapy, surgery, and chemotherapy, where chemical compounds are used to attack the malignancy.

Tobey claims chemotherapy has made slow but significant progress in cancer treatment in the past 2 decades, and is, in fact, producing normal life expectancies in patients suffering from at least 10 types of cancer. It may be the only answer to some types of the disease, such as acute leukemia, where surgery and radiation are not applicable.

Today, Tobey says, there are a substantial number of long-term survivors with well-documented evidence of acute leukemia, even though there has been but a conservative use of chemotherapy.

One report he pointed to in the Cancer Yearbook of 1972 documents patients with acute leukemia who have survived more than 5 years from the time of diagnosis through chemotherapeutic methods. Sixty per cent of this group showed no sign of disease 8 to 20 years after a diagnosis was confirmed.

Other reports from the same source include one of a 50 per cent remission incidence in patients receiving combination chemotherapy for Hodgkin's Disease, a virulent form of cancer which affects the lymph glands, spleen, and liver. A six-fold increase in induction of remissions of adults suffering from acute myelocytic leukemia is noted for the period from 1960-1968. Chemotherapy is also credited with raising survival rates for women suffering from cancer of the breast and ovaries.

"This is what we are after," Tobey says. "An increase in survival rates for all types of cancer such as we are seeing in acute leukemia, where systematic chemotherapy has become the mainstay of successful treatment."

Though Tobey is enthusiastic about the LASL analysis system, he cautions against viewing it or animal model systems as "the answer to drug testing per se."

"For instance, one drug, cis-diamminedichloroplatinum, which appeared tremendously successful when used against cancer cells in animals, had a bad side effect, of which we were unaware until it was used on human patients. It caused deafness."

Tobey said another drug tested at Los Alamos, streptozotocin, which was found effective in treating cancer of the pancreas, caused a mild form of diabetes in human beings. However, a newly developed derivative of streptozotocin, chlorozotocin, appears promising in the attack on pancreatic cancer, and no unusual side effects have appeared so far.

Some of the drugs sent to LASL by the National Cancer Institute have already proven effective in combating some forms of cancer, and they have been used to calibrate the LASL simple analysis system. Results so far have been excellent, Tobey says.

Other drugs Laboratory analysts have scanned are untested in humans. One such compound, fluorothymidine, was sent to Tobey by an East German scientist, Dr. Paul Langen of the German Academy of Sciences, Berlin.

"I described our system at a conference in Moscow to which I was invited by the Soviet Academy of Sciences," Tobey relates. "I met Dr. Langen and he asked if we would test 3'-deoxy-3'-fluorothymidine. We got the necessary clearance, and the drug looks promising—we'll be sending him our results soon."

Such international cooperation

Priscilla Jose and Phyllis Sanders, both H-9, examine colonies of cells. Each colony consists of several hundred cells, all derived from a single cell. Drugs are administered and cells are then allowed to incubate for a period of time, typically a week. Only the surviving cells reproduce, forming the colonies shown above.

is where the real hope of meaningful advances in cancer treatment lies, Tobey believes.

"The worldwide push to develop new and improved treatment means scientists in all countries are building upon each other's published work, sharing knowledge, and, eventually, the grinding hard work will pay off."

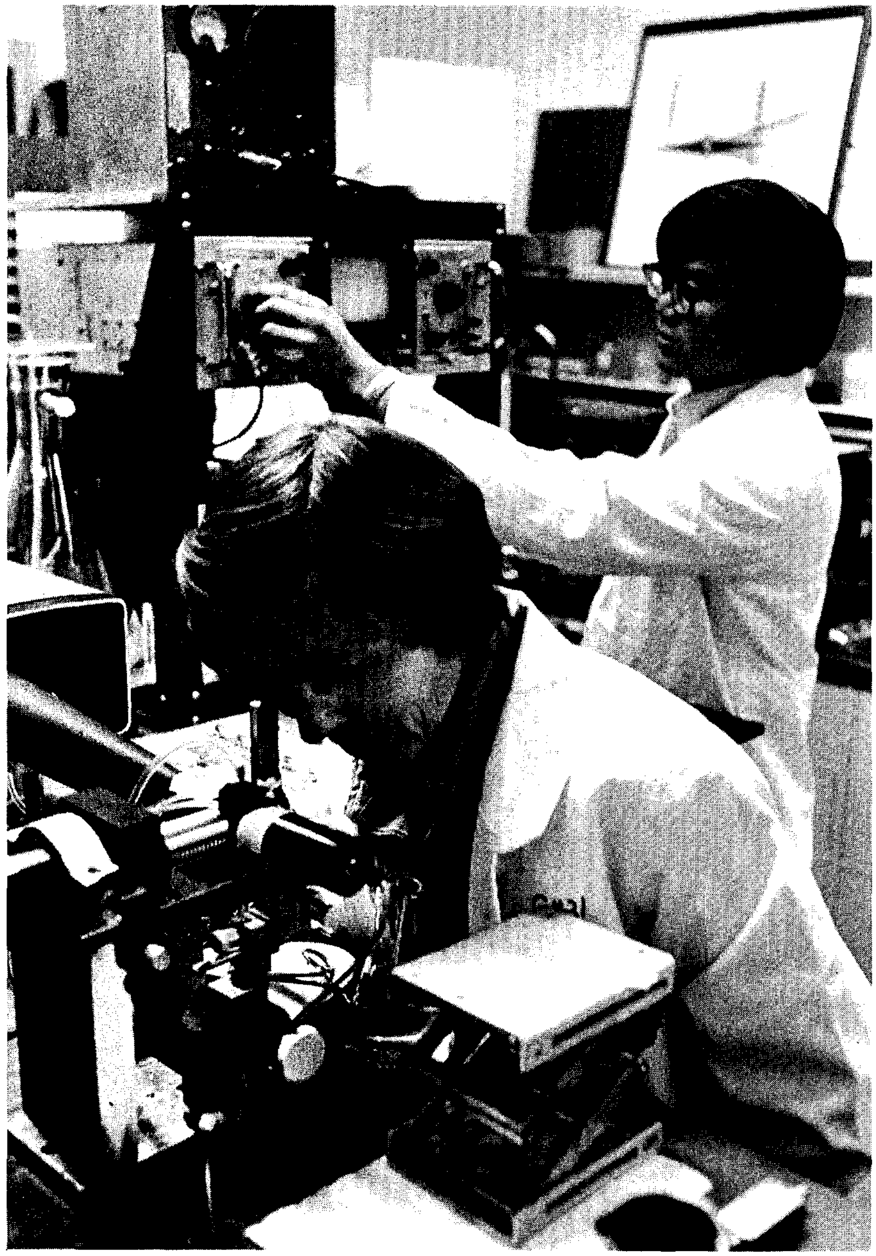
Word of "imminent breakthroughs" in cancer treatment headlined in the popular press leave Tobey angry and frustrated.

"Cancer research is based upon an enormous outlay of talent, time, and money, and significant progress is being made," he claims. "But these imminent breakthroughs reported in the press are tragic. They are usually issued by publicity-seeking individuals who dupe the press into running headlines which raise false hope for cancer victims and their families."

Tobey dismisses such people as "professional charlatans" and says because cancer is such a highly complex disease, there are no simple answers to the problem. However, he is optimistic.

"In 1948, medical students were taught that acute leukemia was an inevitably and usually rapidly fatal disease whose etiology was unknown. Shortly thereafter, it was reported that aminopterin and several other folic acid antagonists would cause remissions in about 30 per cent of the children suffering from this form of cancer. Although it was found such remissions were temporary, the discovery was built upon, and an earnest search for other chemotherapeutic agents was begun. So we are progressing," he says.

It is this solid and often unheralded research, rather than "breakthroughs," that is the best hope for thousands of cancer victims, Tobey believes. Although chemotherapy is still a relatively new modality of cancer therapy, dating back only to the 1940's, the demonstrated success of some drugs used in cancer therapy spurs researchers on in the all-out war against the disease.



Elvira Bain and Mel Oka, both H-10, operate the group's flow microfluorometer. Cells from a drug test, stained to indicate DNA content, are in a solution which is passed through a laser beam. Laser light causes the stain to fluoresce with an intensity in relation to the cell's DNA content, allowing measurements of cells at various points in the cycle that have survived drug treatment.

"We're not asking anyone to give to the United Fund but are asking everyone to invest in the area in which they live because the returns are all so real."

So says Sherman Rabideau, CNC-2, chairman of the annual Los Alamos United Fund Campaign as he and his volunteers begin a fund drive to support 19 agencies which provide vital services to the community.

Los Alamos' goal this year is $145,000, of which $10,000 will be kept in an emergency reserve fund. The rest will support participating agencies.

It is more than likely that you, your family, or someone you know will benefit directly in time of need. For instance:

- Did you know that arthritis hits 1 of 4 families in Los Alamos? Your contribution supports education, research, training, and expert patient treatment that may assist 100,000 arthritics in New Mexico.
- Did you know that 3,662 Los Alamos-area women received free Pap smears for the detection of cervical cancer last year? The Los Alamos Cancer Clinic provides free consultation, maintains tumor and cancer records, and has only 1 paid employee.

UNITED FUND: *swinging into action*

- Did you know that 6 Los Alamos children are now receiving vital aid from the UF-supported Cystic Fibrosis Center in Albuquerque? One of these is Wesley Brewer, son of Gordon Ray Brewer, CMB-14. Wesley is New Mexico's CF poster child for 1974, and is pictured here with UF President Lore Watt and UF Campaign Chairman Sherman Rabideau.
- Did you know that alcoholism ranks with cancer, mental illness, and heart disease as a major national health problem? The Los Alamos Alcoholism Council is a source of help for the estimated 800 alcoholics in the county.
- Did you know that Jemez House, which cares for boys from disadvantaged backgrounds, might not secure 3-to-1 matching state funds essential to its operation without adequate United Fund contributions?

And examples could go on and on—for the Family Council, the Chaparral Home, the Sheltered Workshop, the Visiting Nurse Service, to name a few. Your child may be enjoying benefits now as a Boy Scout or Girl Scout.

To put every donated dime directly to work, the Los Alamos United Fund Campaign relies solely on volunteer workers. Less than 1 per cent of contributions are applied to campaign expenses.

Many LASL employees are giving generously of their time and effort for this year's United Fund Campaign. Back them up with your gifts of dollars.

As their slogan says, "It's working—thanks to you."

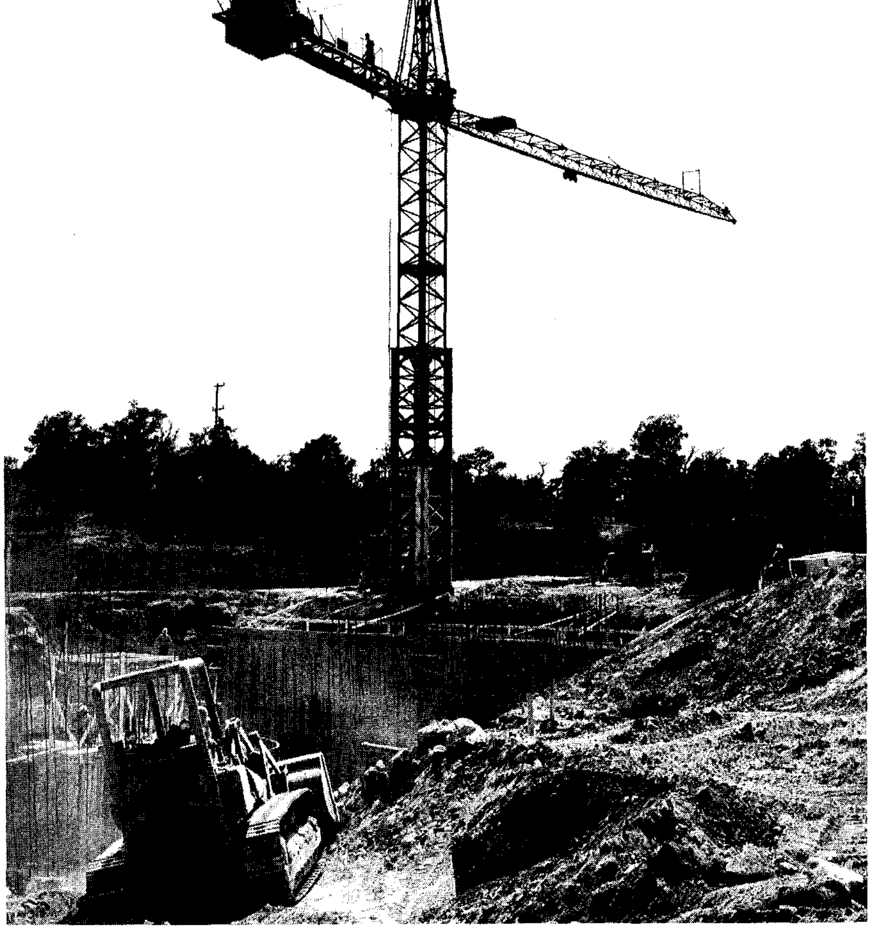
LASL United Fund Volunteers

Lore Watt, ISD-4 casual, president; Paul McConnell, ENG-DO, vice president; June Gage, T-9, secretary; Robert Kriz, AO-5, treasurer; Ivan Bergstein, AO-2, financial secretary; Michael Coburn, WX-2, trustee; William McCreary, CMB-6, trustee; Carroll Thomas, H-4, trustee; Jerry Wackerle, WX-7, trustee; Sherman Rabideau, CNC-2, campaign chairman; Otis Farmer, T-3, team leader; and Lawry Mann, CTR-6, team leader. (Many LASL employees will serve as team members.)

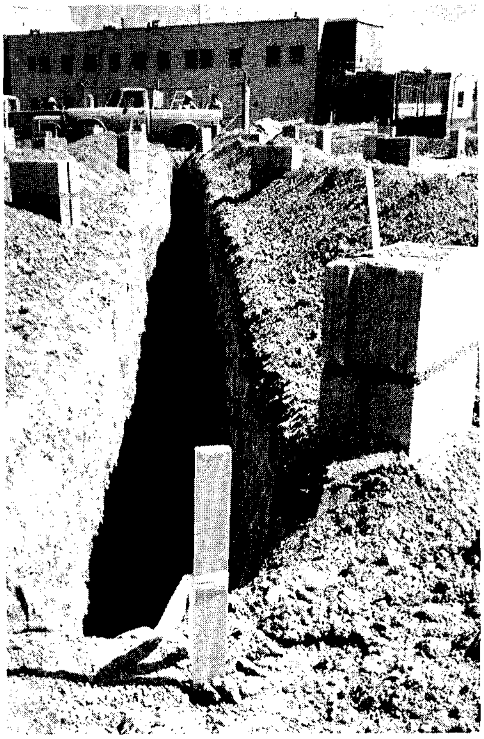
Participating Agencies and Goals

Alcoholism Council, $6,350; Arthritis Foundation, $2,000; Boy Scouts, $10,000; Cancer Clinic, $8,500; Chaparral Home $1,500; Cystic Fibrosis, $3,950; Family Council, $24,500; Girl Scouts, $10,000; Heart Association, $4,900; Jemez House, $25,000; National Council on Crime and Delinquency (NCCD), $800; Red Cross, $7,000; Retarded Children, $5,500; Salvation Army, $7,600; Sheltered Workshop, $3,500; United Services Organization, $850; Visiting Nurse Service, $4,650; Family YMCA, $8,000; Baseball Congress, designated funds only.

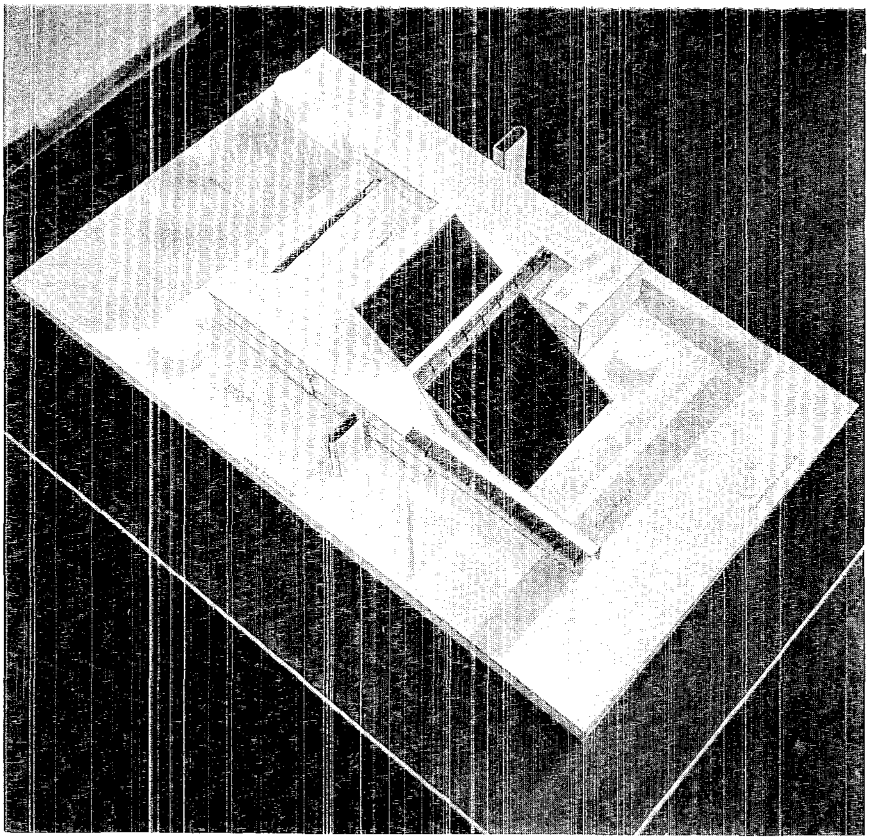
Photo Shorts



Construction of the Weapons Neutron Research facility in the vicinity of LAMPF is well under way. Construction workers poured 720 cubic yards *in one working day,* which, *if not a* record for Los Alamos, is a very substantial amount. The WNR will utilize a portion of the LAMPF beam "piped" underground to the new facility.



That ditch on the left—was it dug by the bio-subterrene on the right? No, the gopher, *somewhat miffed,* was merely ousted from his home by trenching in preparation for the now completed installation of transportable offices for CTR-Division on a site west of SM-102 on Pajarito Road. The gopher was removed to an area where he has by now established a new home.



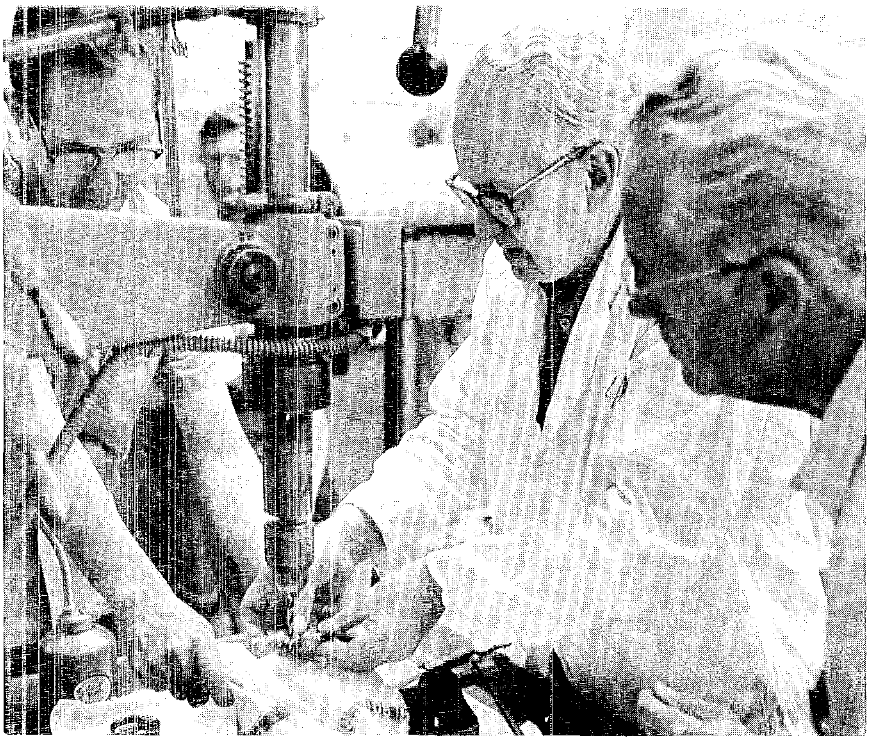
On August 28-29 at the AEC's Los Alamos Area Office, Charles Luckman and Associates, architecture and engineering firm, presented recommendations and a scale model of the National Security and Resources Study Center, construction of which is scheduled to begin in 1975. The Center will occupy a portion of the parking area north of the east wing of the Administration Building.

An unusual feature of the Center will be incorporation of a solar heating and cooling system, as indicated by the black panels in the scale model. Interior windows will allow visitors to view the system in operation.

The basement will house classified and unclassified reports and the solar laboratory. The first floor will provide library services and the second floor will be used for conferences, audio-visual presentations, exhibitions, and offices.

The AEC and affected LASL groups are reviewing the proposals. The ATOM will present a more detailed report on this important addition to the Laboratory in a future issue.

LASL became involved in the great buried-treasure story of 1974 when, in late July, a group claiming rights to purported treasure at the White Sands Missile Range presented a one-pound gold bar to Governor King for inspection. King sent the bar to LASL for assay. Bill Powell, CMB-6, and Don Silver, SD-5, drill the bar for shavings as Raemer Schreiber, deputy director, watches. Following LASL's report, state officials appeared unimpressed with the antiquity of the sample and the group has not been permitted to conduct a search.



ANOTHER FIRST FOR LAMPF

On July 30, 1974, a small bottle was shipped from the Los Alamos Scientific Laboratory to the nuclear medicine section of the Veterans Administration Hospital in Denver, Colorado. The significance of the event went unnoticed except by a small group of scientists in LASL's nuclear chemistry group (CNC-11) and those working in the Clinton P. Anderson Los Alamos Meson Physics Facility (LAMPF).

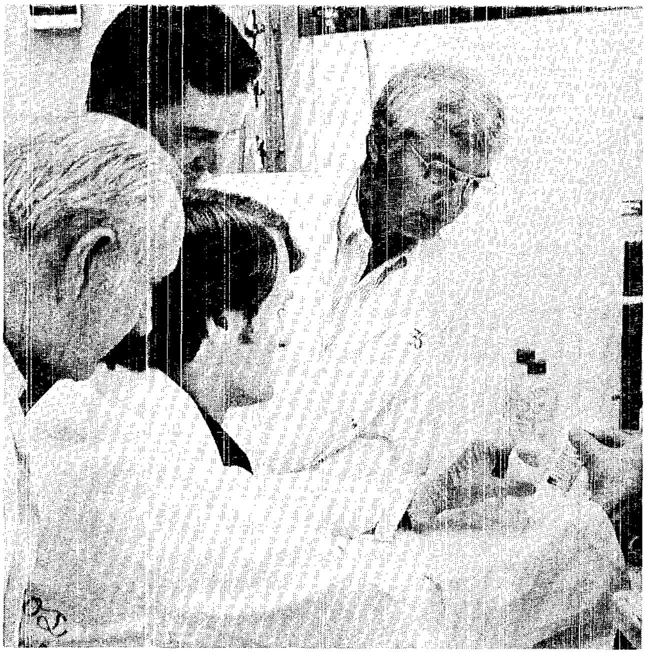
For these few, a milestone was recorded, for the bottle contained the first shipment of a radioactive isotope produced at LAMPF for medical research. The delivery marked the culmination of many months of development work, principally by Pat Grant and Allen Ogard of CNC-11 and Milton Kahn, professor of chemistry at the University of New Mexico and visiting LASL staff member. This shipment represents the beginning of a continuing program to provide radioisotopes made at LAMPF to medical facilities throughout the world for the purpose of evaluating their usefulness in medicine.

The isotope delivered to Denver, strontium-82, is one of many radioisotopes used in the rapidly expanding field of nuclear medicine for a variety of diagnostic and therapeutic purposes.

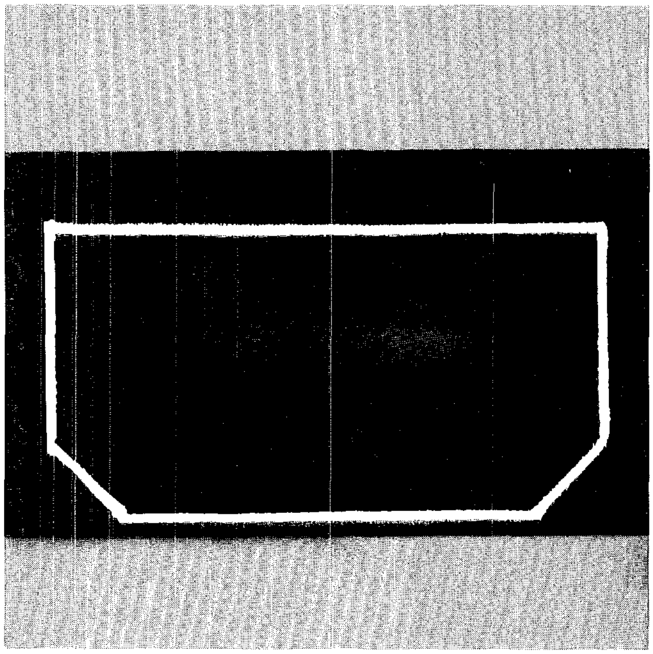
Hal O'Brien, associate group leader of CNC-11 and principal investigator of the Medical Radioisotope Research Program, said strontium-82 may prove to be important in rapid diagnostic testing of some forms of heart disease.

Strontium-82 has a half-life of 25 days, while its decay product, rubidium-82, has a half-life of only 75 seconds. The ionic form of rubidium is readily soluble in the blood stream and, thus, rubidium-82 may be used repeatedly in rapid dynamic studies such as are needed in coronary occlusion, for measuring cardiac output, or for arteriography (tracing the flow of blood through the arterial system). Far less radiation dose will be administered to the patient than that resulting from the use of other radioisotopes. Rubidium-82 decays to stable, harmless krypton-82 within the patient's body in a very short period.

A molybdenum target was irradiated under test conditions in a temporary irradiation facility in the LAMPF Line X beam stop in late May to prepare the strontium-82. The activated target was transported from LAMPF in a shielded cask to the hot cell operations area of CNC-11. Under the direction of Jack Barnes, Dorsey Dunagan of CNC-11 and visiting staff member Harry Houtz (chairman of the mathematics department of Santa Fe Senior High School) carried out the chemical separation of the strontium fraction from the molybdenum target using procedures developed principally by Grant and Kahn. Although the initial test of



Milton Kahn looks over the shoulder of Pat Grant as Grant prepares to package the first shipment of LAMPF-produced radioisotopes for delivery to the Veterans Administration Hospital, Denver, Colorado. Watching (left to right) are Allen Ogard and Hal O'Brien. All are CNC-11 members.



An autoradiograph of an aluminum monitor foil attached to a target shows the area of the target irradiated by the proton beam. An autoradiograph is made by laying the foil on Polaroid film. Radiation then makes the exposure. White outline shows the size of the target.

the separation was successful, Barnes said his group plans to study several processing improvements suggested from this initial test.

Although insufficient for patient usage, the 120 microcuries of strontium-82 shipped to the Denver hospital is adequate for preliminary testing in preparation for later clinical studies. A new strontium-rubidium generator, an apparatus for the periodic separation of rubidium-82 from strontium-82 developed by Pat Grant, is being evaluated by the Denver group for clinical study.

O'Brien said Allen Ogard has developed procedures for the recovery of 2 other isotopes (iodine-123 and xenon-127) produced at LAMPF, in addition to the strontium-82; but only the latter has been produced under test conditions in sufficient quantities to warrant shipment to a medical facility.

Experiments are being conducted with the isotope iodine-123, which is useful as a diagnostic agent in disorders of the lung, thyroid, liver, and kidney. Iodine-123 offers greatly reduced radiation doses to patients compared with the widely-used iodine-131, delivering less than 3 per cent of the radiation dose as that from the latter.

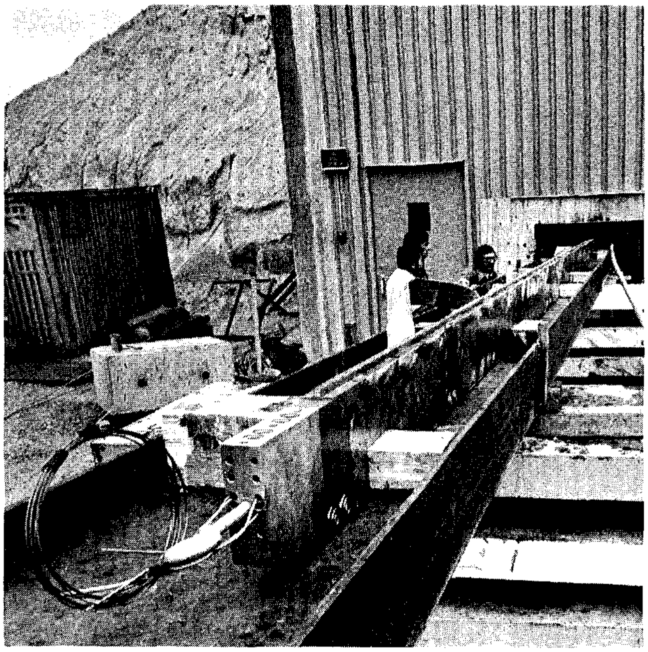
Xenon-127 has also been separated from LAMPF-irradiated targets. This radionuclide possesses nuclear decay properties that, for diagnostic applications, are superior to those of the currently used xenon-133, which is employed in regional lung ventilation and perfusion studies.

At least 8 other isotopes are under investigation by CNC-11.

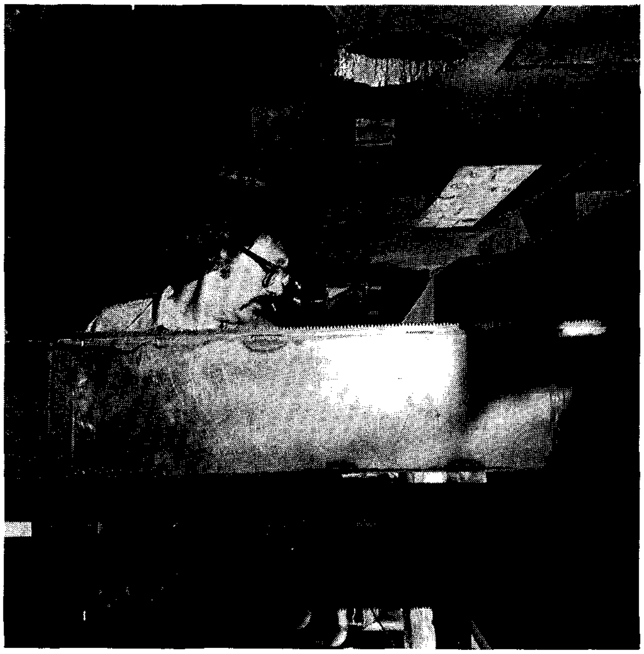
One major stumbling block to the preparation of larger quantities of these isotopes, O'Brien pointed out, is the completion of installation and testing of the first 4 target-insertion devices (TID's) in the Isotope Production Facility at the LAMPF beam stop. The testing of the drive mechanism of one of the TID's is scheduled early this fall, while all 4 should be completed by July. The facility is designed for future expansion to accommodate 12 TID's.

Each TID will accommodate a target roughly 15 centimeters in diameter by 3.8 centimeters thick. The target will be placed in a chamber that is attached to the end of the TID with remote tooling, and the TID can then be driven through a slot in the shielding to a point where the target intercepts the proton beam. Water cooling is provided to each target to remove the heat deposited by the proton beam during irradiation.

It is the combination of proton energy and beam intensity which makes the LAMPF beam unique for isotope production, O'Brien said. With the 800-MeV protons available at LAMPF, radioisotopes relatively far from the line of stability have a greater probability of being made. This, coupled with the very



The target insertion device is essentially a 26-foot long steel box-beam 2 inches wide by 8 inches high. A target is placed at the opposite end and inserted into the beam stop. The TID weighs 1 ton because of the addition of lead shielding.



Daniel McDonnell, CNC-11, descends into the target pit at the Isotope Production Facility to align the TID. After the Facility is placed in full operation, radiation will prevent further human entrance into the pit while the LAMPF beam is on.

large number of protons in the beam (1 mA= 6.25×10^{15} protons per second), yields these difficult-to-obtain isotopes in quantities sufficient for large-scale distribution to distant medical facilities.

Also, the high-energy protons will penetrate several layers of target material, permitting the simultaneous irradiation of a number of different targets. (The full-scale development of the Isotope Production Facility will allow for the irradiation of any combination of targets up to a total of 45.7 centimeters thick.)

The isotope production program is a small, but practical and important, part of the overall LAMPF program. The LAMPF facility is designed to accommodate 12 or more simultaneous experiments. Although the Isotope Production Facility is located at the very end of the accelerator, from 30 to 50 per cent of the initial beam intensity is expected to reach it. Thus, it is the "waste" or by-product beam which will be used to produce isotopes for medicine (on a noninterference basis with regard to other LAMPF experiments).

The major objectives of the Medical Radioisotope Research Program are to investigate medium-energy proton-induced spallation processes as a means of providing a new source of radioactive isotopes of demonstrated or potential value in the health sciences, and to support research and application studies using these spallation-produced radioisotopes in biomedicine through a cooperative radioisotope research program.

In cases where radioisotopes produced at LAMPF gain widespread acceptance among the nuclear medicine community, large-scale production of the isotopes will be warranted. Hopefully, a major national benefit will result from the distribution of these radioisotopes by commercial pharmaceutical firms. Already representatives from a number of pharmaceutical companies have visited Los Alamos to be briefed on the status of this program. These firms include Abbott Laboratories of Chicago, New England Nuclear of Boston, Dainabot Radioisotope Laboratory, Ltd. of Tokyo, Amersham-Searle of Chicago, Union Carbide Nuclear Company of New York, and Mallinckrodt Pharmaceuticals of St. Louis.

O'Brien said that the progress achieved in this program, as with many programs throughout the Laboratory, was made only through the cooperation and contributions of many individuals in a number of different groups.

Dr. Louis Rosen
MP Division Director
Los Alamos, N. M. 87544

Dear Louis:

I am certain that this, again, is a great step for the benefit of all mankind. Please inform your colleagues how pleased we were to learn of this result so soon after LAMPF became operational. Keep up the fine effort.

Sincerely,
CHET HOLIFIELD
Member of Congress

short subjects

Honors: **Keith Boyer,** L-Division leader, has been named to receive the Atomic Energy Commission Citation for 1974 at the annual American Industrial Forum-American Nuclear Society meeting to be held in Washington, D.C., October 28-30. **Darrel Douglas,** H-5, was elected vice chairman of the American Conference of Governmental Industrial Hygienists during the group's recent annual conference in Miami Beach, Fla.

WASH-1400, popularly known as the Rasmussen report, has been received at the LASL library and by a number of LASL groups with an interest in nuclear power plant safety. The two-year, $3 million study sponsored by the AEC compares risks of nuclear power plant accidents with those of various natural and other man-made origins. Material includes a popular level summary, the draft report, and appendices. The latter publications are also available in microfiche.

An international meeting on Dry Hot Rock Geothermal Energy was held at the Los Alamos Scientific Laboratory September 17-19.

The meeting was sponsored by LASL and the North Atlantic Treaty Organization's Committee on Challenges of Modern Society. Approximately 100 persons attended the conference with about a third of these from foreign countries.

The first day's sessions began with a welcome by **Harold Agnew,** Director. A series of discussions on various geothermal energy projects was held on Tuesday and Wednesday and on Thursday the group visited LASL's geothermal operations at Fenton Hill in the Jemez Mountains.

The First National Topical Meeting on Nuclear Process Heat Applications is being held October 1-3 in Los Alamos. The meeting is sponsored by the Trinity and San Diego sections of the American Nuclear Society with **Bob Duffield,** Q-Division leader, serving as general chairman. Assisting in administration are **Dick Malenfant,** Q-DOT, **Doug Balcomb,** assistant Q-Division leader, and **David R. Smith,** P-5.

From the AEC: **Kenneth R. Braziel** was named manager of the Los Alamos Area Office, effective August 18. Braziel had been deputy area manager of LAAO since October, 1970, and acting area manager since April, 1974, following the transfer of former Area Manager **H. Jack Blackwell** to AEC headquarters in Washington, D.C. Braziel joined the AEC in 1952.

W. Randy Cooper joined the Albuquerque Operations Office as assistant manager for plans and budgets, succeeding **David B. Anthony,** who has retired. Cooper was previously assistant manager for plans, engineering, and budgets at the Nevada Operations Office.

The annual meeting of AEC contractor plant facilities managers was held in Los Alamos and Santa Fe, September 9-12. More than 90 AEC officials and facilities managers attended programs featuring speakers such as AEC Commissioner **William Anders, H. C. Donnelly,** manager of the Albuquerque Operations Office, and LASL Director **Harold Agnew.**

Records: The Norris E. Bradbury Science Hall and Museum was visited by the largest number of monthly visitors since its inception. During July, 15,384 visitors were recorded, including a throng of 587 visitors during one hectic afternoon.

Fans in the Chemistry and Metallurgy Research Building's ventilating system are being operated at reduced speeds as a temporary measure to reduce objectionable noise. An outside consultant has studied the problem with LASL engineers and recommendations for a permanent solution are expected in the near future. Implementation depends upon the magnitude of the work involved and availability of funds.

Retirements: **Gayle Patterson,** H-1 health physics surveyor; **James Coulter,** SD-1 developmental machinist; and **Arno Roensch,** SD-3 group leader. Deaths: **Helen Ketola,** ISD-4 librarian; and **Joseph B. Bourne,** WX-3, staff member and section leader.

A LAST LOOK at the WATER BOILER

On Wednesday, July 31, a 30-year era ended quietly when the historic Water Boiler at Omega Site was deactivated.

On Friday, August 2, the era came back to life briefly, but so vividly that fascinated bystanders could almost feel that they, too, had been there that tense night in September 1944 when Lopo, the first version of the Water Boiler, went critical.

The deactivation on Wednesday was a coolly methodical procedure as 12.65 liters (about 3 gallons) of radioactive liquid fuel were pumped into 6 containers for shipment to the U.S. Atomic Energy Commission's Operations Office at Idaho Falls, Idaho, for reprocessing.

A totally different spirit prevailed on Friday morning when 4 of the men who had helped design, build, and operate the first Water Boiler met at Omega Site to bid farewell to the venerable reactor. One reminiscence led to another until the stark concrete room was filled with talk and laughter.

The 4: Raemer Schreiber, deputy director; L. D. P. King, retired in Santa Fe but still very active with the Laboratory as a consultant; John Starner, P-2; and James Bridge, MP-7.

Among the bystanders: Merle Bunker, P-2 alternate group leader and Water Boiler chairman. A "newcomer," he had been associated with the Water Boiler "only" since 1950. But if he had not been present at its birth, he had directed its operation for a large portion of its life and presided at its demise.

The Birth of the Boiler

In the urgent wartime period of the Manhattan Engineer District, normal procurement procedures were ruled out. Existing research equipment at various universities was hurriedly commandeered, including a cyclotron from Harvard University, 2 electrostatic accelerators from the University of Wisconsin, and a Cockcroft-Walton accelerator from the University of Illinois.

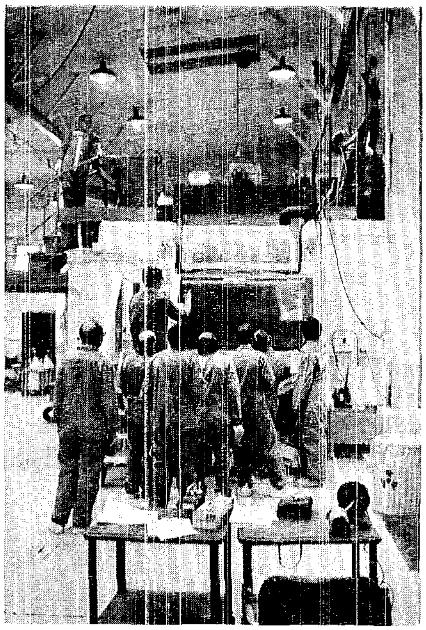
But more equipment was needed, including an intense neutron source for critical mass measurements, for determining cross sections of fissionable materials and the effectiveness of tampers and reflectors, for measurements of neutron capture and scattering, and for other data vital to the design of the atomic bomb.

Enrico Fermi advocated design and construction of what was to become the world's first homogeneous liquid-fuel reactor and the first built for research purposes. It was also the first reactor to use uranium enriched in uranium-235. In all, 3 versions were built, all using the same basic concept.

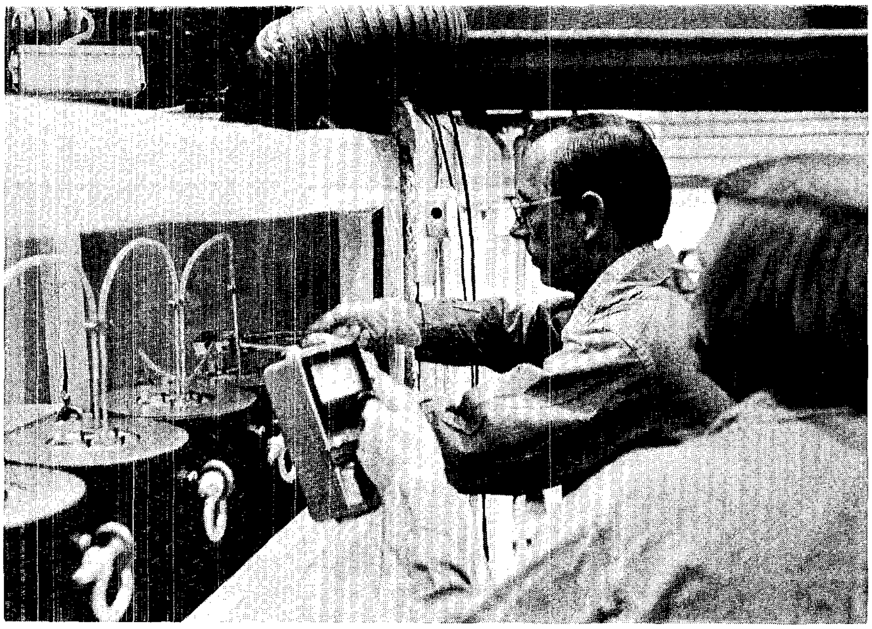
The first Water Boiler experiment was started late in 1943 with a group of 6 staff members and 6 technicians assigned to the job. The core consisted of a spherical stainless steel container 30 centimeters (1 foot) in diameter surrounded by neutron-reflecting blocks of beryllium oxide on a graphite base. Neutron-absorbing safety and control rods were built into the reflector and a piping and gas pressure system permitted the enriched uranyl sulphate solution, soon to become known as "soup," to be pumped from a conical storage basin into the sphere. Since the reactor was intended for low-power operation, there was no provision for cooling or shielding.

The reactor was named the Water Boiler as a code name for security purposes. The name was appropriate because, in later versions, the soup appeared to boil due to the formation of radiolytic gas bubbles.

The initial version was called Lopo (for "low power") because it



The withdrawal of "soup" starts Wednesday morning, marking the beginning of the end for the Water Boiler.



Withdrawal of soup is now complete. Merle Bunker, Water Boiler chairman, cuts and crimps tubes as Glenn Neely, H-1, monitors.

operated at virtually zero power. This allowed design and construction simplicity and eliminated the need for shielding.

Lopo worked, serving the purposes for which it had been intended: determining the critical mass of the soup and as a test of the design principles themselves. Hastily, a new version of the reactor was built to operate at power levels to 5.5 kilowatts, thus providing the source of neutrons the Laboratory needed. Cooling coils within the sphere and a "Glory Hole" through it (allowing samples to be placed in or passed through the area of most intense neutron flux) were added. The soup was changed to one of uranyl nitrate and concrete shielding was added. The reactor became operative in December and was named Hypo because of its higher power.

It was with Hypo that most of the key measurements were made that contributed to the design of the atomic bomb.

In 1950, further modifications were made permitting operation at power levels up to 45 KW, producing neutron fluxes above 10^{12} n/cm^2 sec. This version was named Supo, for "super power," and it operated continually until its deactivation.

The Death of the Boiler

Removing the Water Boiler's fuel was in principle simple, in practice painstaking. Bunker had prepared a 42-page procedure for deactivation and he supervised the operation assisted by John Schulte, CMB-14 group leader. Operating the pumps, transfer valves, and the control console were P-2 members Bill Starner, Stan Bodenstein, and Tom Brunton. Elapsed time records were kept by summer graduate student Kevin Crosthwaite. Concerned with safety, especially the major hazards of spills and leaks, were Carl Buckland, Glenn Neely, Don Gibbons, and Dale Hankins, all H-1.

All went like clockwork and 6 lead pigs were successfully loaded with the golden liquid and placed within "Paper Tiger" steel drums for shipment to Idaho.

Dismantling the reactor itself awaits future funding. "It's ironic that the initial cost of the Water Boiler was probably about $75,000, but its dismantling may cost several times that amount," Bunker comments. "Nevertheless, it was inevitable that the Water Boiler be deactivated. Other neutron sources are available at the Laboratory, and one cannot keep adding new equipment indefinitely without disposing of some of the old."

But Bunker could not dismiss the Water Boiler without a few kind words. "It was, after all, a superb research instrument—simple, easy to control in a very reproducible manner, and it could be turned on or off in 2 minutes. You could run 50 experiments a day on it if you wished.

"And it was very economical. That soup had been in the reactor since 1950 and we had burned out only about 18 grams of uranium-235."

The Boilermakers

The Water Boiler's importance was underscored in different ways by the 4 men who bade it farewell Friday morning. At the time, the world's only separated uranium-235 had been consigned to the Water Boiler. "We had 2 machine gun posts not more than 100 yards from here in the canyon guarding it," remarked "Perc" King.

"It's a wonder Joan Hinton

"As we heard the counter clicking faster, we began to get uneasy. . ."

"Some of them were heading for the door—right behind me!"

"Fermi wouldn't stop. But finally he said, 'Wow, that ought to be enough!' and eased it back."

never was shot coming to work," Schreiber added. "She used to walk along the mesa, then take a path down here through the woods. Strictly nonregulation."

(Joan Hinton was a physicist who after the War defected to Communist China. In the tense Cold War period, this caused considerable alarm. However, Schreiber remarked that she had never had access to weapons research and he doubted that she could have revealed much information of value.)

Talk inevitably turned toward the illustrious scientists, some retired, some still active elsewhere, who had been associated with the Water Boiler during its construction and early operation: Robert Christy, Charles Baker, Richard Feynman, Bruno Rossi, Freddy de Hoffman, Marshall Holloway, Donald Kerst, Gerhart Friedlander, Lindsay Helmholz, Herbert Anderson, Darragh Nagle. And, of course, the late Enrico Fermi.

"The Water Boiler was Fermi's plaything," Schreiber recalled. "He would work on weapon physics problems in the morning and then would spend his afternoons down at the Water Boiler. He would come in and say: 'Well, what will we do this afternoon?' We knew better than to answer that question since he already knew what we would do. He would work right along with us and always analyzed the data as it was being collected. He was very insistent on this point and would stop our experiment if he did not feel that the results made sense. He was a wonderful man to work with."

Bunker brought out a chart, yellowing with age, upon which many of the men involved with the Water Boiler had predicted points at which Lopo would go critical. Feynman's prediction was closest.

Criticality experiments were started in early 1944 with more and more enriched uranium being added as it became available. Eventually the neutron multiplication curves indicated that one final addition would achieve criticality and Fermi took over the controls to bring the reactor alive.

"Remember that night?" Starner asked. "There must have been 20 people in this room, and I bet 6 or 7 of them were Nobel prize winners."

"And I'm sure some of them were heading toward the door—right behind me!" added Schreiber. "Fermi was at the controls and as we heard the counter clicking faster and faster, we began to get uneasy. Fermi wouldn't stop. But finally he said, 'Wow, that ought to be enough!' and eased it back. He knew what he was doing."

Knowing what one was doing was essential in those days, and as a result, know-how was drafted with the same urgency as equipment. Universities were "raided" for groups of scientists actively engaged in relevant research. These groups were frequently kept intact for specific projects. In the case of the Water Boiler, 4 came from a related project at Purdue University: Schreiber, King, Holloway, and Baker. Holloway and Baker had earlier been drafted from Cornell to work on the project at Purdue.

"I never thought of it until now," King said, "But most of the scientists associated with the Water Boiler were 'Boilermakers' from Purdue. Apppropriate, isn't it?"

Bridge observed that putting equipment together was often a catch - as - catch - can proposition. Bridge and Starner were then Army technicians assigned to the project. Hypo's first radioactive gas exhaust vent was nothing more than a tygon tube led outside and tied up in a pine tree, he remembered.

Because of the "there's a war on" psychology, it was thought that the slight release of radioactivity might be tolerated temporarily. But when appreciable radioactivity was detected in the canyon, a tall stack was constructed.

That called to mind another incident. Fermi and Schreiber had been exposed to minor radioactivity. "I guess I was one of the world's first fallout victims, and I was worried," Schreiber remembered. "But Fermi reassured me. 'It's just beta,' he said." Schreiber paused, then added with a laugh, "Just beta!"

And more reminiscences followed. Because round-the-clock surveillance was required, Baker was "elected" to sleep there. "He was the only bachelor," Starner explained.

The group strolled from the Water Boiler to a point some 50 feet away where, at the moment, stood the sealed "Paper Tiger" steel drums. "This is where Lopo stood," Bridge explained, pausing by one of them. "They added on to the building and moved the Water Boiler to where it is now when we went to Hypo."

"And over there," said Schreiber, pointing to a corner some 20 feet away, "is where the accident took place."

The mood changed to one of seriousness as details were recalled. In 1945, Harry Daghlian was performing a critical assembly. As Schreiber reminded, he shouldn't have been performing it at all that night, but motivated by the gung-ho spirit of the time, did it anyway. He was alone in the room, manipulating small quantities of fissile material—harmless when separated, deadly when joined—when something went wrong. The material glowed instantly in a bluish light. Daghlian separated the material with his hands but received lethal radiation in the process. He died 3 weeks later.

Starner had been in the adjoining control room and was spared. "Harry surely saved the Laboratory from a far more serious accident," he commented. The others nodded silently.

Critical assembly was transferred to Pajarito Site and, of course, critical assembly by hand, a wartime exigency, has long since been discontinued, replaced by remote methods that accomplish critical assembly in safety.

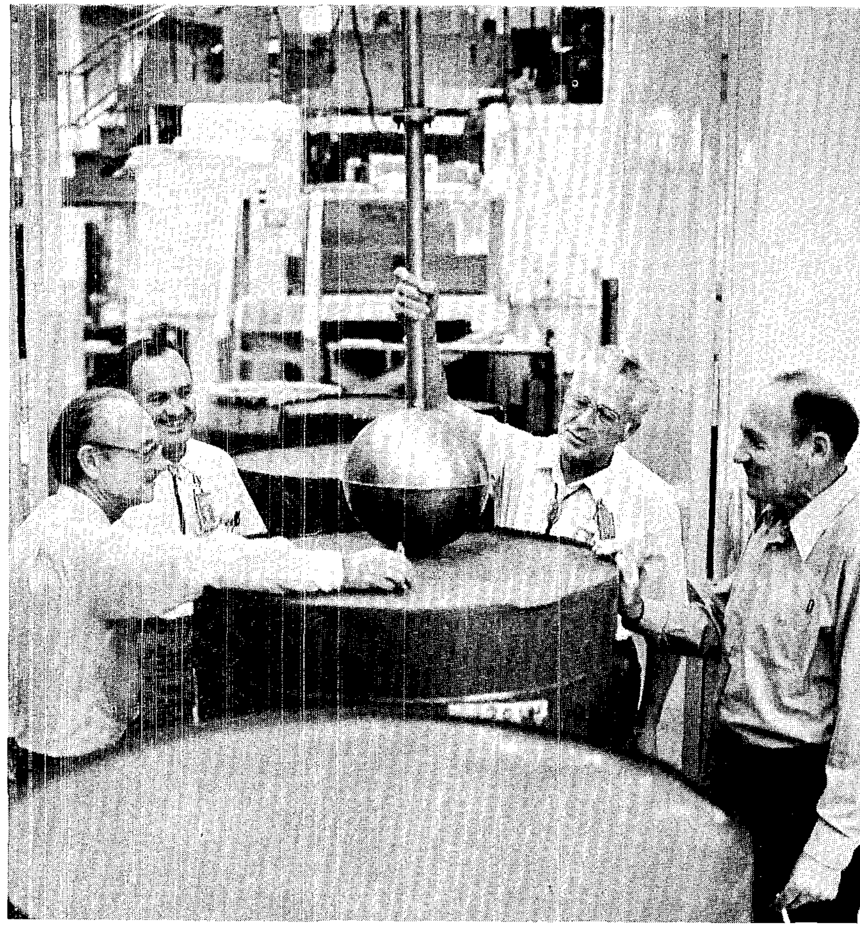
Now the group strolled back past the Water Boiler and around the corner to the control panel that King had helped design some 30 years ago and that had been used right up to the final hour.

Nearby was a replica of the core and the group remembered how Al Romero, SD-1, had performed miracles of welding stainless steel in assembling the spherical cores.

Moving outside, the men recalled how just getting to the site was an adventure in itself. The stream had to be forded 5 times, and even jeeps and tracked vehicles would often bog down.

At last the seemingly endless fund of anecodotes began to dwindle. The men glanced at their watches. There was work to be done in the present world.

Without a backward glance, they got in their cars and drove off.



"Perc" King, James Bridge, Raemer Schreiber, and John Starner stand with a replica of the stainless steel core at the spot where Lopo stood 30 years ago. Drums contain "soup" ready for shipment.

Dr. Harold M. Agnew, Director
Los Alamos Scientific Laboratory
Los Alamos, New Mexico 87544

Dear Harold:

On the occasion of the final removal of the fuel from the Los Alamos Water Boiler Reactor, I send congratulations to the members of the Laboratory on the very fruitful and safe operation of this pioneering research facility. It was the first of its type, and the last in operation, and you certainly must be proud of all that was achieved over three decades.

Please convey my appreciation to all concerned for a job well done.

Sincerely,
ERNEST GRAVES
Major General, USA
Assistant General Manager
for Military Application

PROBING EARTH'S INNER FIRES

by Barb Mulkin

Volcanoes are mountains gone mad. Mighty upheavals which afford man rare glimpses of the inner fires of the earth. Enigmas whose eruptions are still largely unpredictable, quite often disastrous, difficult to study, and among the most intriguing of natural phenomena.

Though volcanoes are classified as active or extinct solely on the basis of their activity during historic time, mighty eruptions such as Vesuvius in A. D. 79, and destructive eruptions in Alaska in 1912, New Guinea in 1951, and Russia in 1956, all in supposedly extinct volcanoes, testify to the discrepancy between the enormity of geologic time and man's brief period of observation.

In the context of geological time, few volcanoes may be considered extinct, including the one which formed the Jemez Caldera on whose eastern lava slope the city of Los Alamos was founded 30 years ago. Relatively recent, the Jemez explosive ash eruptions occurred 1.4 and 1.1 million years ago, and the youngest of the rhyolite domes surrounding the caldera was formed less than 40,000 years ago. The caldera provides a ready-made volcano laboratory for a new group, Q-21, formed last April in the Los Alamos Scientific Laboratory's Energy (Q) Division.

Essentially, Group Q-21 will support geothermal and subterrene research at LASL as well as engaging in basic volcanology including working toward a practical goal: eruption prediction. A probe into the roots of the Jemez volcano is planned, an attempt will be made to assess the seismic hazard in the Los Alamos area, and evaluations of the earthquake magnitude generated by natural events and bomb tests will be made. Q-21 personnel, in cooperation with existing seismological efforts in J-9, will monitor both LASL and private industry's geothermal exploratory drilling, and study stresses in the earth's crust.

Tom McGetchin, Q-21 group leader, said the basic study of volcanoes has gone beyond cause and effect. "There are applied areas of volcanology which promise to be important factors in our nation's ability to respond to a growing number of pressing needs."

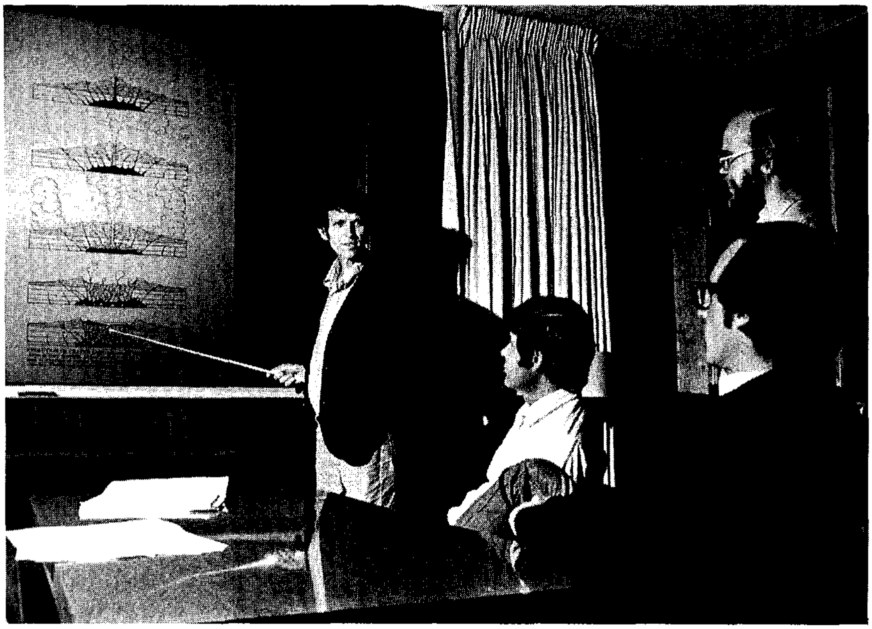
McGetchin cited the possibility of tapping volcanoes as direct sources of energy.

"There is increasing discussion about drilling into the magma chamber of a volcano and inserting a heat exchanger for extraction of geothermal energy," he explains, declaring the concept, "possibly an idea whose time has come" and visualizing a consortium of universities, corporations, and government agencies involved in a broad-ranging volcano-geothermal program.

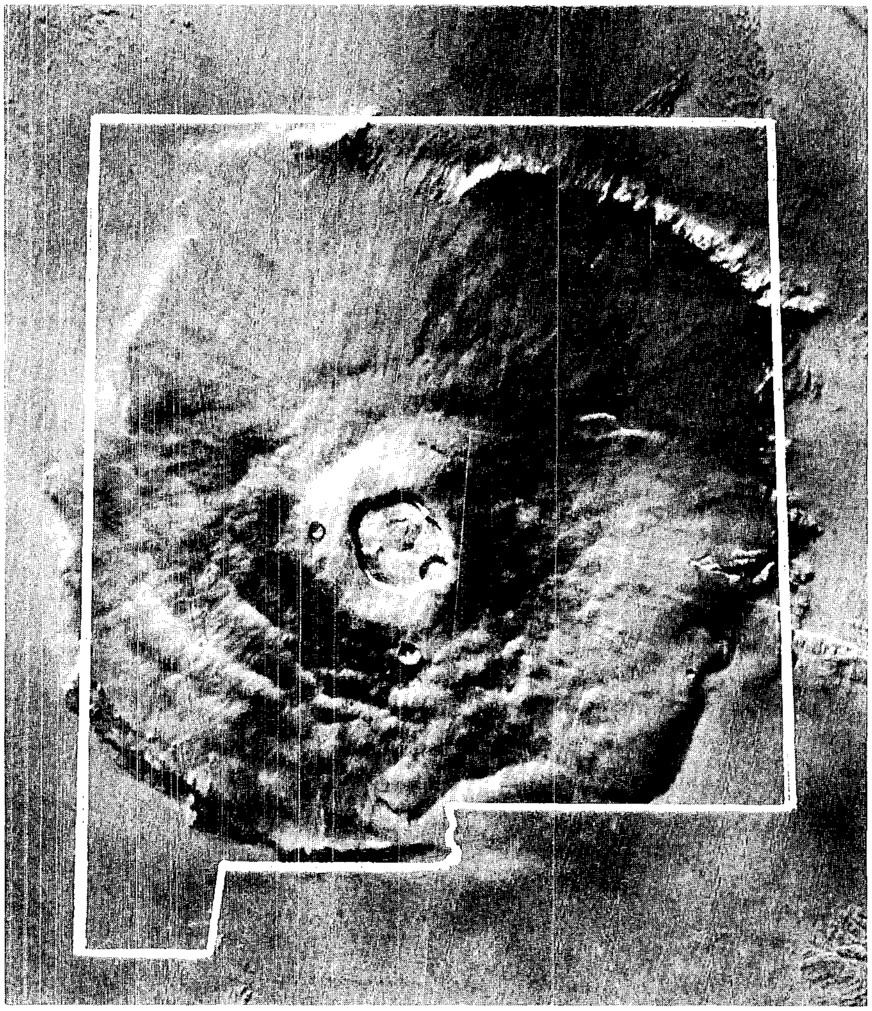
LASL studies in the Jemez Caldera may include expansion of a seismic network operated for several years by J-9 to focus on the existence, location, and properties of the volcano's magma chamber.

"Seismic readings received here from other areas of the world could help us pinpoint the magma chamber," he declares.

National need for critical re-



Discussing a diagram of the formation of a caldera are members of the new Q-21 group, formed to support geothermal research and a number of Laboratory programs as well as to conduct original volcanological studies. Left to right: Tom McGetchin, group leader; Ron Gooley and John Eichelberger (standing), both Q-21; and Scott Baldridge, summer graduate student from the California Institute of Technology.



A stupendous volcano on Mars, Mons Olympus, is 600 kilometers in diameter and 24 kilometers in elevation—three times higher than Mount Everest. Its cone would occupy most of New Mexico. LASL's Q-21 group hopes to participate in studies of volcanoes on Mars and other planets as well as on Earth. This mosaic photo was created by the U. S. Geological Survey for the National Aeronautics and Space Administration.

sources such as uranium and other metals may dictate an extensive program of mineral and ore exploration and extraction, McGetchin believes. Remote sensing and a continental drilling program will play a large part in any such effort and volcano study will form an integral part of any future program because of the known association of ore deposits with volcanic rock.

LASL's Q-21 hopes to be involved in at least 2 long-range NASA programs including remote sensing from space to monitor volcanoes and to detect ore deposits, and planetology (volcanism and the thermal evolution of the planets).

"The Mariner missions provided valuable information on Mars, including some views of Mons Olympus, the largest volcano discovered to date in the solar system," McGetchin points out. "Two soft landings are planned for Mars in 1975-76, and in the post-Viking period, perhaps by 1980, NASA may be undertaking further investigations of Mars using unmanned probes, possibly to the Martian volcanoes. We hope to be involved."

LASL's expertise in monitoring field events gives it a unique capability which could be applied to volcanology. Such problems as sample collection, high-speed photography, *in situ* chemical studies, spectroscopy, surveying, and aerial photography, if applied to the study of volcanoes, would yield a valuable array of data bearing on how volcanoes work.

McGetchin said several universities and governmental agencies and the Smithsonian Institution are attempting, with some success, to use imaginative techniques to study eruptions worldwide, including satellite-based communications from seismometers for realtime monitoring of potentially hazardous volcanoes.

"This particular system could serve as an 'alarm bell' for deployment of scientific field teams, including one from LASL," McGetchin says.

Meanwhile, members of Q-21 have made reconnaissance trips to volcanic sites in the Southern Cascade Mountains of California, Chile, Ecuador, and Hawaii in addition to local sites in New Mexico, Arizona, and Utah. Hopefully, LASL teams will establish stations in some of these areas and coordinate observations of volcanic geology, petrology, chemistry, and geophysics.

A permanent logistical base for detailed observatory mode investigation of an island arc volcano is a possibility at the former AEC weapons test site on Amchitka in the Aleutian Islands.

The andesite cones associated with island arc volcanoes are among the most interesting in the world, according to McGetchin, and they constitute a significant volcanic hazard because eruptions are fairly frequent in the geologic time scale, and they come without reliable warning, often producing vast amounts of ash and lahars (large mud flows).

"As in studies in the Jemez Mountains, results from such an observatory would serve programmatic needs. These volcanoes may one day serve as a source of geothermal power," McGetchin concludes.

"We have developed a mode of operation which attacks volcanism in several ways," McGetchin says. "We employ geologic mapping, petrologic investigation of lava and xenoliths, physical measurements, and theoretical modeling. Our approach always begins with detailed field observations, and the lab work proceeds 1 of 2 ways—towards petrological studies, or toward eruption mechanism and related processes."

Q-21's functions have been organized into 2 broad categories: geology and geochemistry, and geophysics and rock mechanics. The first will include geological, petrological, and chemical studies; the second, seismology and heat flow, and experimental and theoretical studies in rock mechanics. Activities in both areas will include field, laboratory, and theoretical studies.

A broad outline of projected programs through 1980, according to McGetchin, will encompass geothermal and magma chamber studies; seismic monitoring; resource exploration and ore deposit investigation; seismic magnitude studies related to weapons testing; monitoring of the Jemez Caldera and establishment of a volcano observatory in the southern Cascades and possibly later in the Aleutians; eruptions expeditions; and participation in the Mars missions.

10 years ago in los alamos

Culled from the September and October, 1964, files of The Atom and the Los Alamos Monitor by Robert Y. Porton

LASL Represented At Geneva

Eight LASL staff members are authors or coauthors of papers prepared for the Third International Conference on Peaceful Uses of Atomic Energy in Geneva, Switzerland. Nuclear specialists from 37 countries and 5 international organizations were participants in the conference. In addition to papers, 2 displays from the Laboratory's nondestructive testing group were included in the technical exposition staged by the United States.

The Diagnostic Air Force

Nearly 40 LASL staff members and technicians are taking part in test readiness exercises, without nuclear explosions, scheduled in October, in the vicinity of Johnston Island in the Pacific. The exercises are to check out one of the safeguards outlined to the Senate by the Atomic Energy Commission and the Department of Defense when a limited nuclear test ban treaty was approved in 1963.

Computers

Laboratory Research Advisor Stanislaw Ulam is the author of an article titled "Computers" appearing in the September issue of **Scientific American.** Eleven pages in the magazine are devoted to the article which traces the evolution of electronic computers, explains how they work, and how they promise to play a role in the progress of mathematics itself.

Demos Lose Buttons

Whoever broke into local Democratic Headquarters last week must have a pocketful of political buttons and a tummy full of candy. It was reported to police that all that was missing after the break-in was a supply of candy and campaign buttons supporting either Lyndon B. Johnson for President or Jack Campbell for Governor. About $6 in cash was not touched. Police are casting a wary eye at anyone these days who is wearing more than 2 Johnson or Campbell buttons at one time.

Crowds Visit Camp May

The Los Alamos County Planning Department estimated that over 2,500 people visited the new facilities at Camp May Community Park this past weekend. Many families took advantage of the new picnic facilities.

Among Our Guests . . .

Internationally known physicist and Nobel Laureate I. I. Rabi spoke on "Oppenheimer, the Scientist" at a LASL colloquium August 9, later explored the question, "Can Mankind Survive Its Powers?" at the Los Alamos Civic Auditorium.

Members of the Atomic Energy Commission's General Advisory Committee, meeting in Los Alamos July 29-31, were briefed by LASL Director Harold Agnew (standing left) on the Laboratory's programs.

In a talk laced with subtle wit and perceptive insights, Alistair Cooke spoke of his experiences filming the TV documentary series, "America" to a standing-room-only audience at a colloquium on July 30. Cooke later visited LAMPF accompanied by Louis Rosen, MP-Division leader (background).

Some 20 members of the American Cancer Society visited LASL on August 16 to review various cancer research programs. Here several members, including Justin Stein, president of the Society (far right), are being shown the treatment room at LAMPF's Radiobiology and Therapy Research Facility by Tom Lane, MP-3 (left).

Back Cover

A model, approximately 30 centimeters (12 inches) in diameter, of a derivative of a vitamin B_{12} molecule forms an intriguing abstract pattern for ISD-7 photographer Henry Ortega. For Phillip Vergamini, CNC-4, and Richard Fuentes, graduate student from the University of Texas at Austin, it was a product of painstaking work this summer. The model was built to help Harry Hogenkamp, professor of the department of biochemistry at the University of Iowa, Iowa City, and Nick Matwiyoff, CNC-4 alternate group leader, conduct studies of the enzymatic mechanisms of derivatives of vitamin B_{12}. In the photo, hydrogen (white), carbon (black), and oxygen (gray with slots) atoms surround a cobalt atom (not visible).