the Atom

Los Alamos Scientific Laboratory
September-October 1975

A Cow by Committee?

Volume 12 Number 5
September-October 1975

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Published bimonthly by the University of California, Los Alamos Scientific Laboratory, Office of Public Information, TA-3, West Jemez Road, Los Alamos, New Mexico 87545. Address mail to P.O. Box 1663, Los Alamos, New Mexico 87545. 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.

COVER

A cow by committee? In a way, yes. The men on the cover either designed it, made it, or are using it now for testing the electronics for a livestock identification system described in the article beginning page. 20.

From left to right on the cover: Al Koelle, E-3, Ron Bobbett, E-3, Paul Martinez, E-2, who helped build the "cow cart," Gerald Martinez, E-2, who drew the design, Jeremy Landt, E-DOR, Dale Holm, H-6, and Paul Salazar, E-2, who cut the styrofoam. Recording the cow and the committee for the cover was Johnnie Martinez, ISD-1.

MANNA

Then the Lord said unto Moses, Behold, I will rain bread from heaven for you; and the people shall go out and gather a certain rate every day, that I may prove them, whether they will walk in my law, or no . . .

And when the dew that lay was gone up, behold, upon the face of the wilderness there lay a small round thing, as small as the hoar frost on the ground.

And when the children of Israel saw it, they said to one another, It is manna; for they wist not what it was. And Moses said unto them, This is the bread which the Lord hath given you to eat.

from Exodus, Chapter 16

Since this dramatic episode, which may have occurred about 1200 BC and is believed to have been first recorded in writing some 300 years later, scholars have been intrigued by manna. Some believe manna might have been coriander seeds, others a type of lichen common in African and Arabian deserts.

However, what manna may have been is not so important as what the Pentateuchal account represents: man's age-old dream of a miraculously provided food so perfect that it would satisfy all human needs.

If the yearning for manna was strong 3 millenia ago, it is even stronger today. The spectre of starvation stalks millions of the world's mounting population. The high hopes placed on the Green Revolution, which seemed so promising in the '60's, are fading as mounting costs of petroleum, the basis of modern fertilizers essential to the Green Revolution, threaten to make fertilizers unavailable to poorer nations.

Man needs a modern manna. The call for science to respond was aptly put this year by James Kendrick, Jr., University of California vice president for agricultural sciences, as he spoke during the 100th anniversary celebration of the University's Agricultural Experiment Station at Berkeley:

One hundred years ago, greater agricultural production was a pressing need for our rapidly growing society, and farmers needed the help of science to achieve it. Now, as we face the next 100 years, we have that same pressing need for production . . . and the help of science is needed more than it was before . . .

Major limits to production growth for the rest of this century will not be physical, but man's ability to discover new knowledge . . .

The time has come for more resources to go into nutrition research, new food technology, and ways to increase productivity per acre. We need to explore ways of capitalizing on photosynthesis and making better use of the sun's energy. . .

Answering this appeal in a variety of innovative ways is an interdisciplinary group of scientists and technicians at the Los Alamos Scientific Laboratory who have made significant advances in this area and are confident they will soon demonstrate that their solution is a viable one in the field. They believe they have touched on modern manna. Interestingly, it would turn out to be one of earth's oldest, most primitive yet most efficient life forms: algae.

Ubiquitous Photosynthesizers

Algae exist everywhere in thousands of varieties. While resembling bacteria, some of which can photosynthesize, algae have cell walls and are far more efficient photosynthesizing organisms. Some algae grow in colonies, resembling plants. Best known of these are the sea kelps, some of which can attain lengths of several hundred feet. However, algae such as these differ from true plants in not having root, circulatory, and other complex transport systems. Each cell is self-sufficient; break a piece of sea kelp off and it will retain its viability.

Algae are generally, if not entirely satisfactorily, classified by color: green, blue-green, red, and brown. However, regardless of camouflaging pigmentation, all contain green chlorophyll for photosynthesis.

Algae may be found wherever there is water, or even moisture: in the ocean (where they are a major constituent of plankton), lakes, rivers, streams, ponds, hot springs with a high mineral content, and short-lived rain puddles. They may be found living on the ground or beneath the earth's surfaces, on the bark of trees, on rocks, and even within the bodies of higher plants and animals.

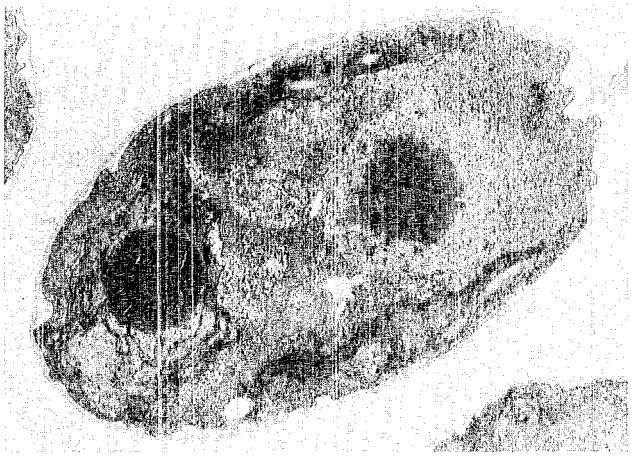
Primitive as algae may seem, most are highly efficient photosynthesizers (more so than plants), utilizing light energy (greater than 10% conversion efficiency), carbon dioxide from the air, and hydrogen from water to synthesize proteins, carbohydrates (starches and sugars), and lipids (fats). A few strains, of special interest to researchers, rapidly metabolize molecular nitrogen from the air to proteins and other nitrogen-containing biomolecules. In addition to nitrogen, algae require inorganic phosphorus (usually from phosphates) and micro quantities of certain metals to grow. The trace metals appear in the algae along with essential vitamins necessary for balanced human nutrition.

And algae grow rapidly. A few cells in a pond, under optimum conditions, can reproduce to cover the pond with thick scum in but a few hours. Exceptionally fast growing varieties have cell-generation times of from 2 to 3 hours; a single cell splitting at this rate could produce algae covering the earth within a very short time. Obviously, there are limiting factors.

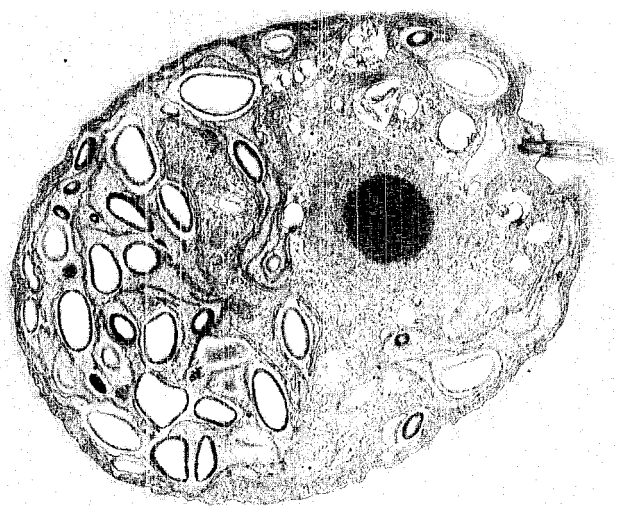
Some types of algae have been used as a food source for centuries. A few primitive tribes have gathered algae for food. In the Orient, sea kelp is today used in a few areas, and, in the Western world, dried and powdered sea kelp is sometimes used as a dietary supplement. One form of algae, when mixed and seasoned with other foods, is considered an exotic delicacy in isolated Asian areas. A species of blue-green algae, dried and powdered, is available now in health stores, but in small amounts at high prices. Some survival manuals contain instructions for making pond-scum into an edible broth.

But except in these minor ways, the immense nutritional potential of algae has not been utilized as a primary food source by humans. Why it has not can be readily surmised. Some species are toxic, some (but far from all) merely are difficult to digest or just plain taste bad. Algae is simply not in the cultural eating patterns of most of the human race.

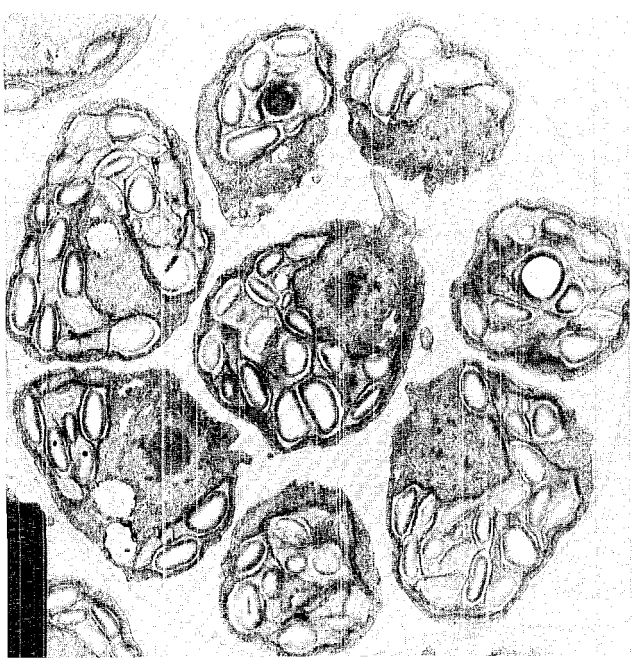
This being so, there has been no incentive for farmers to grow algae, especially during a fast-receding era when traditional foods were abundant and cheap.



Dawn. During the night, photosynthesis and growth stopped. The cell survived by consuming food it had produced and stored during the day. Note the paucity and small size of white carbohydrate globules compared to those shown in photos taken later in the day.



Midmorning. After several hours of photosynthesizing, the cell becomes "ripe" with the food it has generated. Note the abundance and larger size of white carbohydrate globules. The cell itself has also considerably increased in volume.



A Day in the Life of an Alga Cell

Understanding the life cycle of algae helps scientists determine optimum times for harvesting, among other things. Algae harvested before dawn, for instance, would be deficient in certain nutrients. Following a quiescent period at night, algae start their growth and reproduction cycles together; time when preponderance of cells will be at the same stage can be predicted and the algae can be harvested accordingly for highest content of desired nutriments.

The negatives for these photos were made with an electron microscope at 3,400 to 4,700 magnification by Relf Price, visiting staff member from Utah State University, while investigating cell cycles and other algal cell characteristics at Group H-11.

Several times during the day. Daughter cells have now formed and are separating within the parent cell. As many as 16 new cells may form. Following the dissolution of the cell wall, visible as a faint line surrounding the cluster, the new cells will become separate entities.

After sunset, photosynthesizing and reproduction stops and the cell begins to draw on its food reserve. Although algae do not require a rest period as do many higher forms of life, providing artificial light at night to maintain the cycle does not presently appear cost effective.

But with the impending world food crisis, all this may change.

A Problem in Credibility

Among those who believe that things not just may, but will change is Victor Kollman, H-11 (Organic and Biochemical Synthesis), one of the principal investigators in an interdisciplinary group conducting photosynthesis research and developing technology for the viable production of algae as food.

According to Kollman, the most quantitatively productive food crop grown today is sugar cane, which can produce about 4 tons of usable material per acre of arable land per year with modern intensive methods. Based on repeated laboratory results at the Los Alamos Scientific Laboratory with certain green and blue-green algae, an acre of land, not necessarily suitable for conventional agriculture, but dedicated to growing algae in tanks of water—the technology is called aquaculture—might produce over 700 tons of food (dry weight) per year, under optimum conditions. In theory, an area the size of Rhode Island could feed many times the world's present population.

Protein, the "building blocks" of the body, is a key index of nutritional value in foods. Animal protein is the most expensive of nutriments, being derived at the end of complex food chains in livestock, poultry, and dairy products. High-quality green-plant protein is found in small to moderate amounts in many grains, in larger amounts in some common varieties of beans, and in a relatively high amount (about 30 per cent) in soybeans. Production of plant protein is less complex and more cost effective.

Green and blue-green strains of algae of interest can produce a higher percentage of protein than any of these sources: 55-60 per cent, or about 3 times the protein content of beef, almost twice that of soybeans. An acre used to grow algae might produce the protein equivalent to 2,000 tons of beef or 1,000 tons of soybeans..

Kollman estimates that an efficient aquaculture facility, based on the technology applied at LASL, could produce algae at 3 to 15 cents per pound for energy, materials, and labor. To this, economists would add amounts for overhead and profit. Even if the end production cost turned out to be 2 or 3 times the basic cost, and then middleman costs were added, algae would remain a low-cost source of high-quality protein.

The growing of algae by aquaculture is environmentally attractive, sunlight being the prime energy source. A closed-environment technology would conserve heat as well as admit light for the photosynthetic process. One scheme calls for utilizing otherwise wasted stack gasses from nearby power plants; these would provide carbon dioxide, a portion of the oxides of nitrogen for protein, and heat. If certain nitrogen-fixing strains were grown, no petroleum-based fertilizers would be necessary for rapid growth.

Algae can be grown anywhere under controlled conditions, but since growth is dependent upon sunlight and heat, the growing of algae would be especially attractive to tropic and subtropic areas with abundant sunlight. These, in general, are areas most in need of both improved food sources and new industry.

Clean water is no necessity; algae can be grown in salt, mineral-laden, or polluted water and, in fact, these substances can contribute to growth.

Although protein is the nutriment of greatest interest, algae are more than protein providers, containing carbohydrates, lipids, and vitamins and minerals of importance. Further, genetic and environmental manipulation has been used by LASL scientists to alter the proportions of these constituents considerably.

Algae's first widespread application in the United States is likely to be as a feed for livestock, where it would free acreage now devoted to growing grain for animals to producing food for humans. Tilapia, fish which consume algae as their major nutritional source, are more efficient than mammals in converting feed to food and could be raised in large "fish farms" rather than harvested in their natural habitat.

As if algae's potential as a food were not enough, algae can—and in some cases are—being used for water purification in sewage disposal systems (it might conceivably be employed to remove minerals from whole bodies of water such as the Colorado River), as a soil fertilizer and conditioner, and in some specialized industrial uses. Most intriguing is the possibilty of using algae as an energy source. Some strains, cultured under anaerobic (oxygen-deficient) conditions, can produce hydrogen.

The production levels possible with the mass culture of algae are incomprehensible to the lay person in the same way that the distance of a light year and the hundreds of billions of dollars in a federal budget are. The Utopian science-fiction overtones to it all makes it difficult for many to accept and support the idea. What is needed is a physical facility actually growing algae so that people can get a feel for it firsthand.

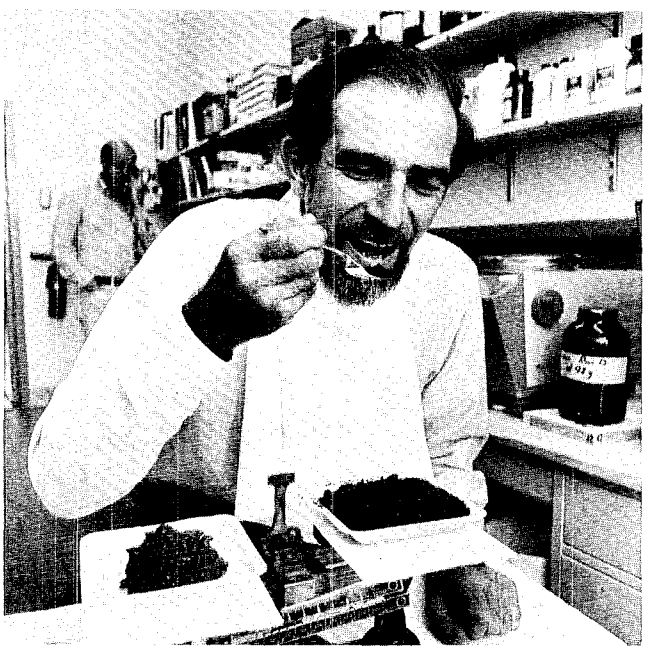
From Science Fiction to Reality

Fortunately, the members of the Four Corners Regional Commission (FCRC) did not find the concept mind-boggling, but rather worth developing as a new industry for the states of the Four Corners—New Mexico, Arizona, Utah, and Colorado. Construction of a pilot plant is now in progress at Los Lunas, New Mexico—the first such facility in the United States. Completion is anticipated in late December.

The plant is being built as a collaborative effort between the State of New Mexico, LASL staff, and private enterprise, with funding by the FCRC. The building contractor is TA/CO Industries, headed by former Los Alamos teacher, Leon Cooper. Taking an active interest in the project and involved in its planning and administration are Leo Murphy, personal representative of New Mexico Governor Jerry Apodaca to the Four Corners Regional

(Continued on page 6)

Algae: a Nutritional Bargain



You would get the same amount of protein from the 114 grams (¼ pound) of hamburger at the left on the scales in the photo above as you would from the 37 grams (1/12 pound) of green algae being measured out on the right by Victor Kollman, H-11. The hamburger contains about 18 per cent protein while the algae contains 55 per cent protein. A housewife would have to buy only ⅓ as much algae for an equal amount of protein. If hamburger and algae were to cost the same per pound, she would save ⅔ of her meat-protein budget.

While the weight of the green algae, for an equal amount of protein, is ⅔ less than for hamburger, the bulk of the algae is substantially greater because in this form it is dried, flaky, and somewhat fluffy, whereas hamburger is moist and compacted.

A Daring Taste Test

After the above photography was completed, ATOM Editor Jack Nelson, ISD-1, posed for the "dining on algae" photo above right. After the shot was taken, Nelson screwed up his courage and actually ate the algae on his fork.

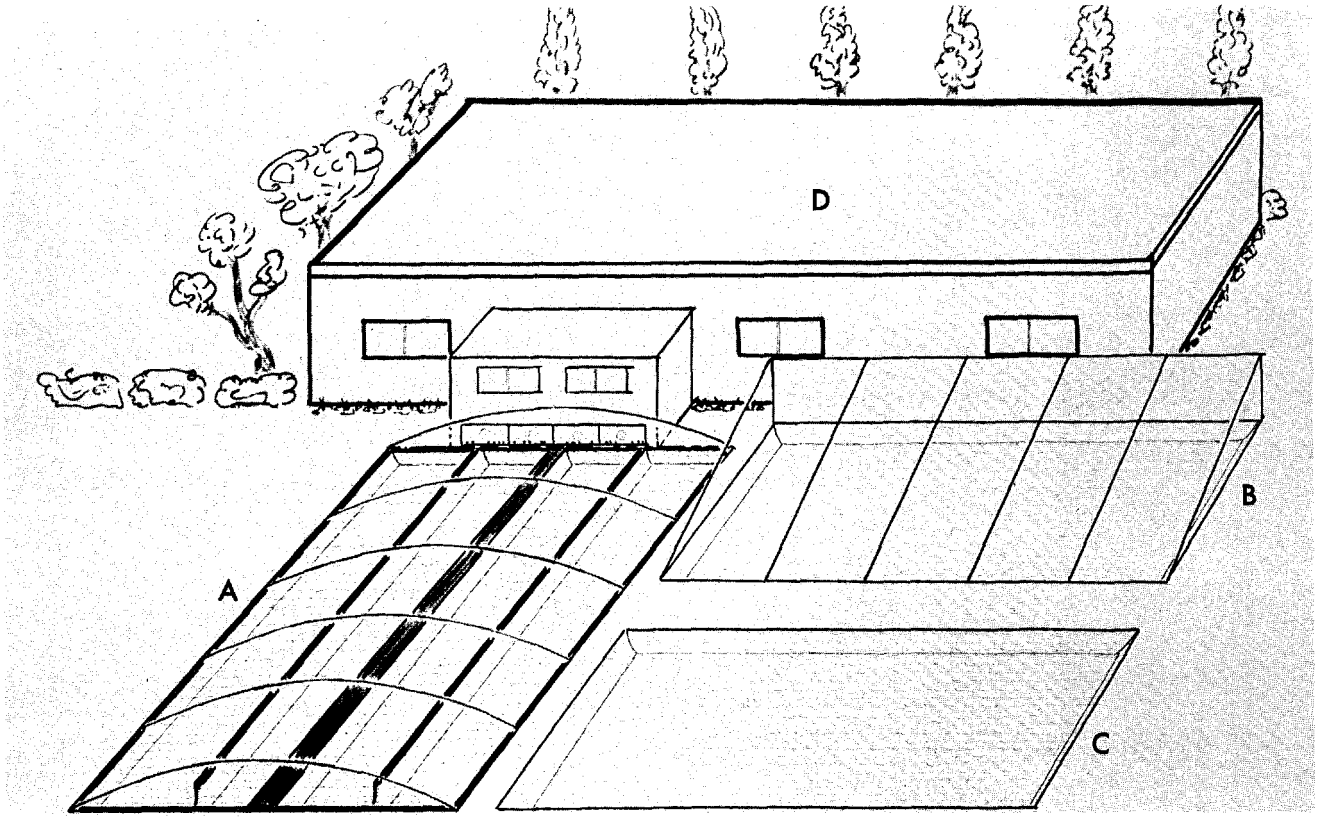
"My first impression was that I had eaten a mouthful of fluff and that algae has no taste at all," Nelson reports. "As it moistened and compacted, the algae became a slightly sticky, chewy lump and began to taste a little like mild American cheese. Some seconds later, it began to taste faintly bitter. As I learned later, this was because enzymes in my saliva had begun the digestive process.

"I wouldn't say I'd rush out to buy a batch of algae to feast on, but at no time did I find the taste unpleasant. I think I could even grow to like the stuff when mixed with other foods and with a little seasoning. Vic (Kollman) says that the food-processing industry can easily alter the flavor to just about anything desired, or to no flavor at all.

"Some minutes after swallowing it, I experienced a little heartburn. Vic explained this was because my digestive system was unaccustomed to handling the chlorophyll and cellulose in the raw algae. Cooking would have eliminated the problem.

"He then added that I had just eaten about $1000 worth of algae (my most expensive meal yet) and that really escalated my heartburn. Of course, Vic's costs were based on all the research investment behind it. Algae like it would probably cost less than 15 cents a pound to produce on a commercial basis.

"I decided that if the General Accounting Office questions me about the missing algae, I'll ask them to wait and I'll replace the algae later rather than reimburse them in cash now."



The algae pilot plant at Los Lunas, as shown by this preliminary sketch, will have plastic-covered growing tanks (A), solar heating collectors (B), solar cooling pond (C), and laboratory (D). An atmosphere rich in carbon dioxide will be circulated through vents at the base of the laboratory wall.

Commission, Herman Grace, director of the Division of Human Resources, Office of the Governor, and Dwight Walker, project coordinator. The Los Lunas site is in proximity to the New Mexico State University Agricultural Experiment station, which will provide technical assistance. Waste gas from the burning of natural gas in a steam generator at the station will be scrubbed and tested as a carbon dioxide source.

The pilot plant itself will be one-fourth acre in size, enclosed with ultraviolet, radiation-resistant, double-wall polyethylene, solar heated and cooled to maintain an optimum growing temperature of 95°-100°F, and equipped with devices to monitor and control the growing medium.

To utilize as much of the sun's energy as possible for maximum growth rates, tanks will be lined with aluminized polyethylene to reflect much of the sunlight back into the growing medium.

Because of algae's potential as an inexpensive, abundant animal feed, "recipes" ranging from mixes with conventional feed containing very little algae to pure algae feed will be tested.

Collaborating in the project are various laboratories and institutions. Algae will be shipped to Iowa State University at Ames for human nutritional studies and to New Mexico State University at Las Cruces for poultry and livestock nutritional studies. Soil fertility and conditioning studies will be conducted by the Argonne National Laboratory, Argonne, Illinois. The New Mexico Department of Game and Fish will conduct nutritional studies with fish. And the pilot plant will make algae available to other institutions with a research interest in algae.

With a diversity of institutions involved, and with a number of aspects of algae as human or animal food being investigated, progress can be rapid towards understanding and utilizing algae as an important nutritional source. While a number of institutions concentrate on research pertaining to usage, the pilot plant will allow the development of practical production methods and cost studies. From time to time, new strains and new technologies will be tested.

Creating "Super Algae"

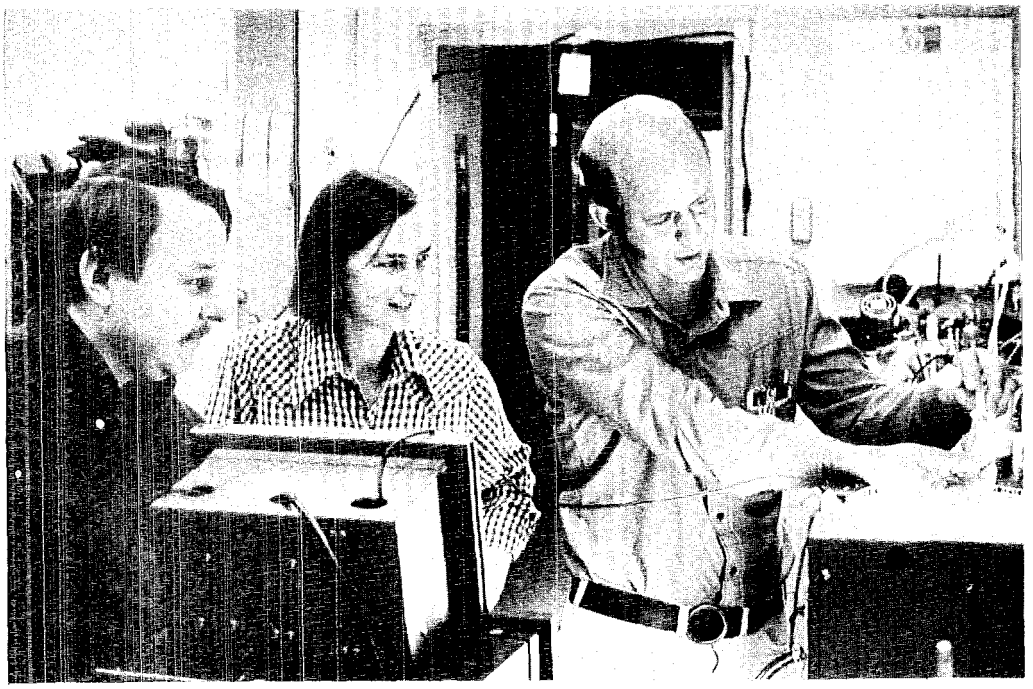
If growing algae were simply a matter of putting water in a tank, adding a few algae cells, and watching them grow, algae "farming" would exist today, regardless of the fact that it probably would not have enjoyed much of a U.S. market. But intensive algae "energy farms" require a precise balance of temperature, nutrient levels, and light energy for maximum yields. Increased carbon dioxide levels are

necessary to sustain the rapid growth. It is essential that rate-limiting factors be minimized.

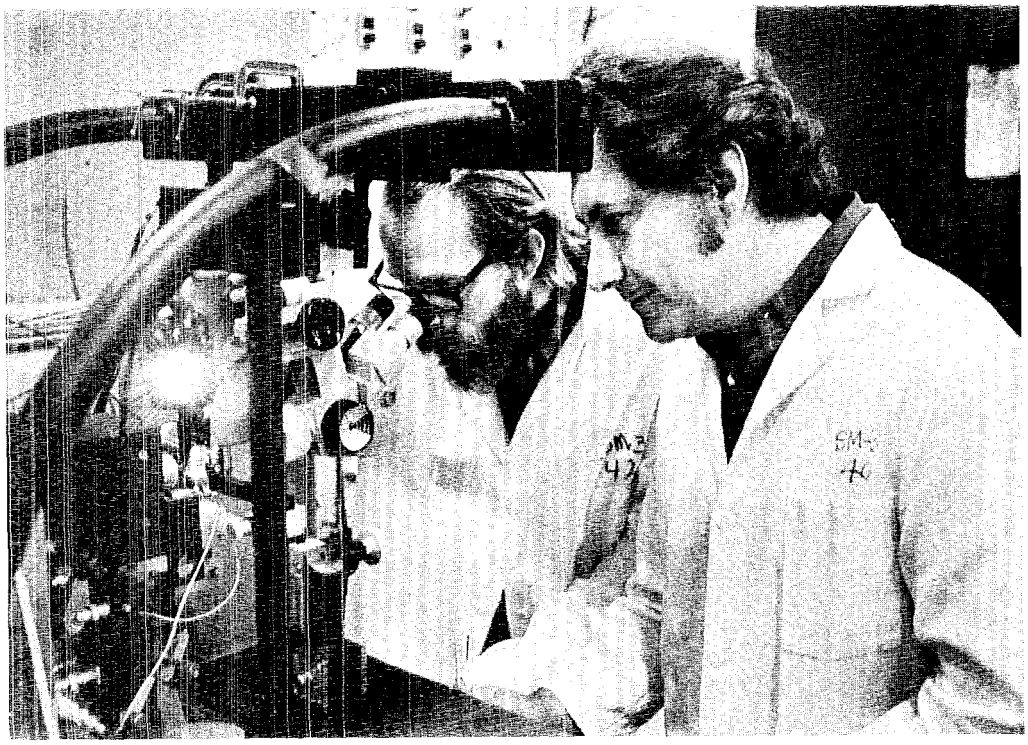
To produce the kind of algae useful to man at a production rate making the concept economically practical has required a sophisticated research program attacking the problems in two broad categories: genetic alteration and nutrient manipulation. Collaborating with investigators at LASL on genetic alteration has been visiting staff member Catherine Stevens, Pennsylvania State University. Taking promising species of blue-green algae, she has introduced chemical mutagens to affect organism changes. A painstaking process, Stevens' method involved culturing the mutant algae and isolating several likely pigment mutants. Of the pure mutant strains, one has proven promising. It has a growth rate of 1.6 times that of the parent strain.

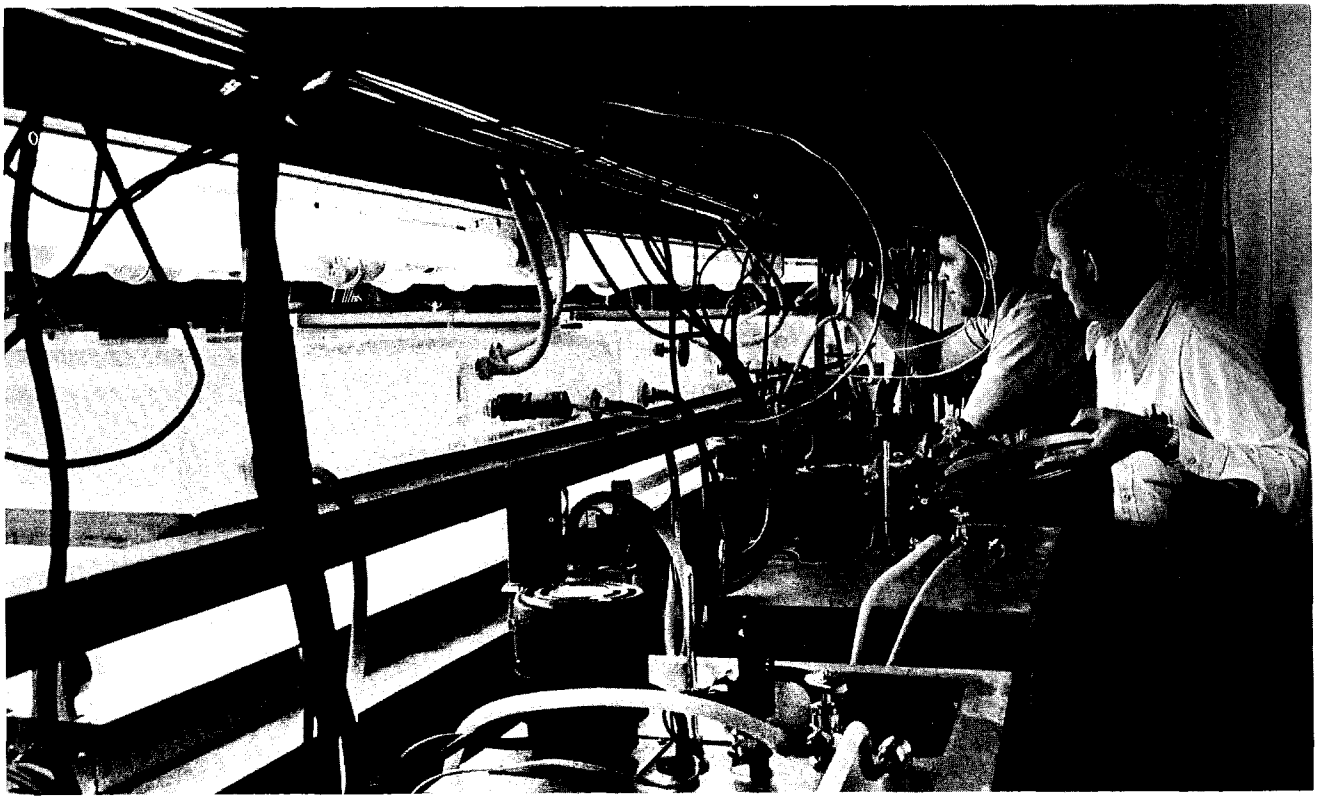
At the heart of this genetic manipulation is alteration of pigmentation in the mutant strain to enhance the photosynthetic efficiency. Thus, a key phase of this research has been understanding better the photosynthetic process itself. In collaboration with Stanley Shapiro and Tony Campillo, both L-2, research into the photon energy transfer process of photosynthesis, a reaction occurring in trillionths of a second, was made using lasers and streak cameras (The Atom, May-June 1975). The new insights gained represent an advance in basic research.

The genetic development of "super algae" is not achieved without paying a price. The mutant strain, after a number of generations, may revert to its original parent strain, and growth rates decline. To monitor this, a rapid-flow analysis system technique has been developed by Harry Crissman and John Martin, both H-10, and Kollman. Laser light is focused on a small, fast-flowing stream containing algae cells. The cells fluoresce, and a counter records characteristics of this fluorescence as a series of events. From this data, which is computer processed, investigators can measure the algae's DNA and



S. Edwards and Catherine Stevens, visiting consultants from Pennsylvania State University, and Kollman examine a sample of a mutant strain of algae taken from a growth chamber, above. Below, John Martin and Harry Crissman, both H-10, set up equipment which they developed for the simultaneous analysis of chlorophyll and DNA content in algae cells. A beam of laser light, focused on a small, fast-flowing stream containing cells, causes the cells to fluoresce. Counting these events electronically provides the data.





Algae growth chambers located in the Health Research Laboratory are checked by John Hanners, H-9, and Kollman. Lighting is provided by very-high-output fluorescent lights above and below the transparent polycarbonate chambers. Constant agitation of the growing medium is necessary to provide adequate mixing of the culture and to achieve optimum growth.

chlorophyll content as well as measuring cell volume. These relate directly to cell growth rates and are a "tipoff" to cell deviation. In the pilot plant, when reversion occurs, production will be stopped, a new inoculum of the genetically altered strain added, and production will begin anew with the pure strain.

The developers of the analysis system see additional uses for this sophisticated instrument. Since polluted water usually contains algae, and the type of algae varies with the kind of pollution, analysis of the algae in water samples could provide a fast "reading" of the type and extent of pollution present in water.

Collaborating with Robert London, CNC-4, in the characterization of the photosynthetic unit through the use of stable isotopes, such as carbon-13, is S. Edwards Stevens, visiting staff member from Pennsylvania State University. Their work will provide additional insights into the structural characteristics of the photo-apparatus.

Manipulating the environment for algae product control has been the primary area of investigation for Kollman, John Hanners, H-9, and Henry Adame, H-11. Aside from the obvious, that the inorganic nutrients provided to the algae largely determine the biochemicals the algae will contain, the metabolism and thus the growth of the algae can be profoundly altered by the control of certain chemicals in the waters in which algae are grown.

Determining the proper combination of temperature, carbon dioxide and other gases in the algae's closed atmosphere, and nutrients and control chemicals in the water solution, can lead to an almost infinite number of combinations in environmental control.

Among the factors to be dealt with is the decline in growth rates as algae "saturate" the water solution, blocking out some of the light essential to uniform growth. Determining the proper point for "harvesting" algae by removal of a portion of the "crop," allowing the portion remaining to continue growing, is fundamental to the process. Systems have been designed to monitor the chemical characteristics of the water solution and for the replenishment of chemicals to maintain optimum growth conditions. Application of these laboratory-developed techniques in the pilot plant at Los Lunas is expected to lead to further refinements and improvements for production of algae on a commercial scale.

At a site in New Mexico, about 100 miles from Trinity Site where the atomic age was introduced in a blinding flash of light, another type of revolution, albeit less spectacular, may be in the making. If this turns out to be the case, as at Trinity 30 years ago, Los Alamos scientists will have played a vital role in its birth.

Visiting physical therapist Ann McGirt lends a helping hand to Mrs. Agnes Schaming.

That Certain Glow

Supporting United Way All the Way

Lore Watt (wife of Bob Watt, L-2), president • Michael Coburn, WX-2, vice president • Carroll Thomas, H-4, secretary • Robert Krix, AO-5, treasurer • Jerry Wackerle, WX-7, financial secretary • Louis Bunch, The Zia Company; William Keller, Q-26; Jean Elder (wife of John Elder, H-4); Dr. Carolyn Linnebur (wife of Eldon Linnebur, TD-1); Vivian Malik (wife of John Malik, J-DO); William McCreary, CMB-6; all directors • Martha Wells, LASL Employees Credit Union, campaign chairman • Paul "Lum" Edwards, DIR-FMO, and Lawry Mann, CTR-6, LASL team leaders • Robert Brashear and Sue Wooten, both ISD-2, speakers' bureau cochairmen

United Way Participating Agencies and Campaign Goals

Los Alamos Council on Alcoholism ($7,500) • The Arthritis Foundation, New Mexico Chapter ($2,000) • Boy Scouts, Kit Carson Council ($11,000) • Los Alamos Cancer Clinic ($11,000) • Chaparral Home and Adoption Services ($1,500) • Cystic Fibrosis Foundation, New Mexico Chapter ($4,400) • Los Alamos Family Council ($25,000) • Girl Scouts, Sangre de Cristo Council ($12,000). • Los Alamos Heart Association ($6,000) • Jemez House ($27,820). • New Mexico Council on Crime and Delinquency ($1,000) • American National Red Cross, Los Alamos Chapter ($8,000) • Los Alamos Association for Retarded Citizens ($6,100) • Salvation Army, Los Alamos Unit ($5,600) • Los Alamos Sheltered Workshop ($5,000) • U.S.O. ($875) • Los Alamos Visiting Nurse Service ($13,285) • Los Alamos Family Y.M.C.A. ($10,000)

The trouble with modern giving is that it seems so businesslike and impersonal—at least to those of us blessed with trouble-free lives. An amount is rather painlessly extracted from your paycheck and by some anonymous process, a few cents are distributed here, a few cents there. You may never meet someone who has received help. It's all a little too cool for producing the glow that comes from giving.

But talk to some of the people in participating Los Alamos Area United Way agencies—so many of them unpaid volunteers—and you begin to share in theirs.

Like the counsellors of the Los Alamos Family Council who ease the anguish of a troubled family whose teenage daughter is into drugs, or one whose frightened children suffer helplessly as a marriage falls apart. The Council helped 800 family members like these last year.

Like the visiting nurse who comforts an elderly bedridden patient as much by a smile and a touch of the hand as by the medication she brings. The registered nurses of the Los Alamos Visiting Nurse Service made over 1500 such calls last year and therapists made almost 600 visits of their own.

And so it goes for the people of each of the 18 participating United Way agencies—people helping people who need help.

Every one of the agencies participating last year received their full quota of funds. However, the campaign did not raise the full amount of emergency funds desired.

Lore Watt, Los Alamos Area United Way president, points out that just a little more support from employees living in Espanola, Santa Fe, and communities other than Los Alamos and White Rock could make the difference in reaching this year's goal of $175,000. "Almost every agency, including those based in Los Alamos County, offers services to all persons working in Los Alamos and their families, regardless of where they live," she says.

You may not get that glow from giving of yourself directly. But you'll certainly help give it to others.

"That Cat," held affectionately by its mistress, Dorothy Brown, Albuquerque, shows no signs of the inoperable squamous-cell tumor that once involved an area from the right nostril to the right eye. The pet was 1 of 5 cats treated by LCF hyperthermia for this type of tumor. All showed regressions.

Putting the Heat on Cancer

An implacable and wily foe, cancer comes in at least 100 guises to confound those mounting a scientific offensive against it. Almost every form of cancer can present special problems to the therapist. Depending on its type, size, location, and other factors, it may require different weapons, or various combinations of weapons, to attack it with hope of success.

Thus, researchers and physicians have long held that no single type of therapy, frequent "cancer-cure" headlines in the popular press to the contrary, is likely to emerge as an ultimate, all-purpose weapon. Victory over cancer is more likely to be achieved, they say, in a broad-front assault using an arsenal of weapons, singly or in combination according to the situation.

The 3 weapons most often associated with cancer therapy are surgery, chemotherapy (LASL is conducting extensive research in cell-growth cycles and effects of various drugs), and radiotherapy (such as the pion-radiation technology being developed at LAMPF). Progress in the latter 2 types of therapy at LASL and other laboratories has been impressive, accounting for widespread attention by the press and the public.

Yet, there is another form of therapy, lesser known, that holds bright promise of its own. It utilizes a form of energy that was among the first to be used by man, and whose therapeutic efficacy has been known for years: heat.

Since the 19th century, physicians have observed that many cancer patients with fevers (from other causes) showed a definite, sometimes permanent, regression of their tumors following the period of high fever.

This suggested the deliberate application of heat as cancer therapy. Whole-body heating at about 42°C (107°F) has proven effective in some cases. Several hours of treatment are required at this temperature, posing problems in the ability of the whole body to withstand sustained heat equivalent to that of a very high fever, especially if the patient is in a weakened condition.

For shorter treatments, of half an hour or less, a higher temperature of 44-45°C (111-113°F) is required for effective cancer kill rates. However, this is a temperature in excess of the highest whole-body fever a human can endure. If heat at these temperatures could be applied mainly to cancerous cells, while whole-body temperatures remained at normal levels, then an effective form of hyperthermia, or intense heat therapy, could be developed.

Several methods for the applica-

tion of localized heat have been tried, and 2 techniques, microwave and ultrasound diathermy, are capable of heating to depths of several centimeters. While both techniques appear to hold promise, there are at present some limitations in precise localization and heating in depth with microwave diathermy. With ultrasound diathermy, there are some questions concerning nonthermal effects. Work in progress at several institutions may yield solutions to these problems.

Now, a major advance in the realm of heat therapy may be in the offing as the result of investigations and developments by Danny Doss and Bill McCabe, both MP-3, at the Clinton P. Anderson Los Alamos Meson Physics Facility (LAMPF). They call their technique "Localized Current Fields" (LCF) and it provides a way of localizing heat application in tissue through the use of electric currents.

Spot Heating

The principle is simplicity itself: place suitable electrodes around the treatment area, direct a current between sets of electrodes, and the electrical resistance of tissue to the current will result in heat generation within the tissue.

However, not every kind of current will do. Direct current, such as from a battery, will depolarize nerves and muscle fiber, resulting in pain and muscle contractions. Ordinary 60-cycle (or 60 Hz) alternating house current will, too, as anyone who has experienced electrical shock in the home can attest. Boost the frequency to about 100,000 cycles, or 100 kilohertz (kHz) where it is called a radio-frequency (rf) current, and these effects disappear. The only sensation to the patient is one of localized heat.

On the other hand, too high a frequency presents technical difficulties, including some inaccuracies from heat measurements. The optimum range appears to be between 100 kHz and 10 million cycles, or 10 megahertz (10 MHz).

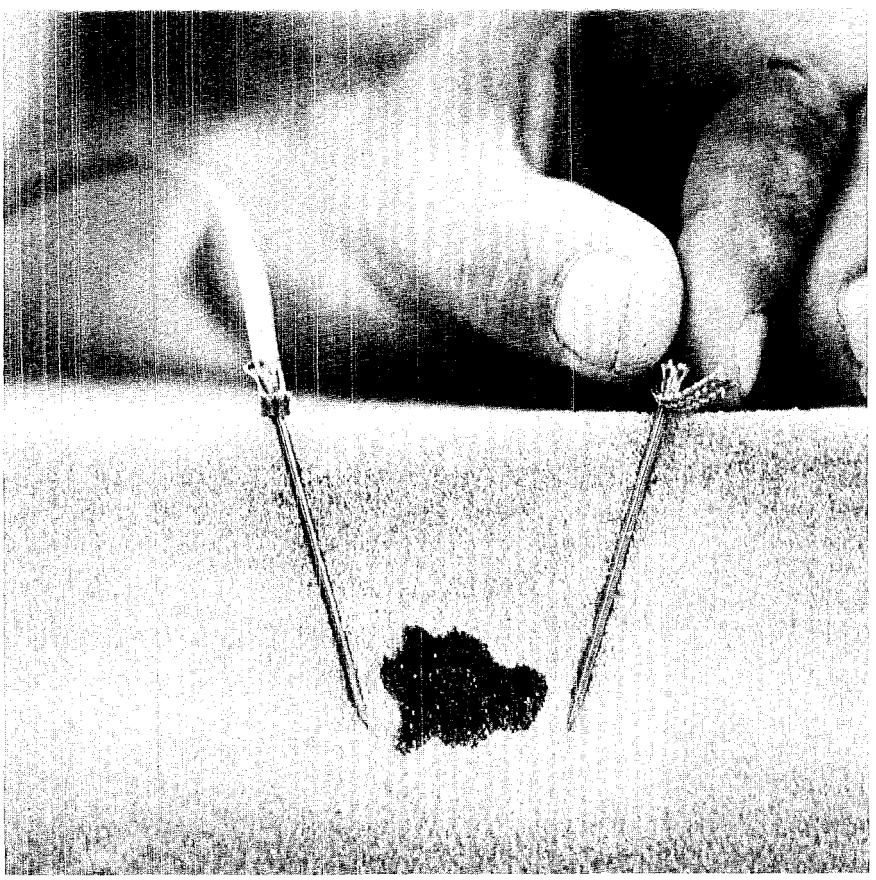
Doss dismisses the electronic circuitry involved in the LCF technique as "trivial," and, indeed, to an electronics expert it may be. Yet, its very simplicity is a virtue, allowing these units to be manufactured at what Doss guesses to be a cost of only $5,000 each, a bargain in terms of today's prices for modern clinical equipment. Doss speculates that eventually the units could be attractive for treatment of certain types of tumors in underdeveloped countries which cannot afford the far more expensive and elaborate apparatus required for some other forms of therapy.

The essential electronic components of the unit are a generator to convert 60-cycle house current to the desired frequency, a temperature controller (linked to a thermistor implanted in the tumor), and a modulator to regulate the rf current input by varying the duty factor, i.e., the percentage of time the current is on. It may be varied from 0 to 100 per cent; for a 60 per cent duty factor, the rf current would be on for 6 milliseconds (thousandths of a second) and off for 4 milliseconds.

In another configuration, the amplitude of a continuous-wave, rf current would be varied to control power delivered to the tumor. With either method, temperature control is fast and precise; the characteristics of the feedback control circuit provide virtually instantaneous control within a temperature range of less than one tenth of a degree Celsius.

Provision is also made for plac-

Two pins and a block of styrofoam provide a simplified illustration of one technique for electrode placement. Current flows between the pins; the resistance of tissue to the current results in heat generation. More current flows between the points because they are closer together, thus more heat is generated in the vicinity of the "tumor" drawn in black. Less heat, tolerable to human cells, is generated in the healthy tissue toward the surface.



ing additional thermistors within the tumor or in surrounding tissue for additional monitoring.

Pinpointing Heat

Both the practicality and the versatility of LCF is most evident in the electrodes. Placement of electrodes so as to generate killing heat mainly in cancerous tissue while holding heat to tolerable levels in surrounding healthy tissue requires a basic, but not necessarily advanced, knowledge of electric fields by the physician. Because the needs for electrode placement will vary widely according to the particular tumor to be treated, several types of electrodes and methods of application have been devised, and more probably will be, to allow pinpointing of LCF heating in various parts of the body.

One such technique uses pins—literally. Ideally, one might use 2 parallel plates, so that rf current would flow through cancerous tissue between the plates. Current density would be approximately the same at the plates as at points in between them (with proper geometry) and heating would be approximately uniform, assuming uniform resistivity and heat transfer characteristics in the tissue.

However, in clinical application, it would be impossible, or at best, traumatic, to make incisions and place plates on each side of a tumor. Parallel rows of pins in lieu of plates can provide a very close approximation of the plate effect. And, in many locations, the effects of placing pins in surrounding healthy tissue would be negligible to the patient.

For a tumor close to the surface of the body, the therapist could insert 2 parallel rows of pins, one row on each side of the tumor, to a depth approximately equal to the deepest part of the tumor. The pins in each row would be connected to an rf generator output terminal. Hypodermic-mounted thermistors would be inserted at appropriate points to monitor temperature, taking care that such conductors are vertical to the electric field. A thermistor-hypodermic positioned along the field, being a conductor, would distort the current field.

For deeper seated tumors, the same techniques with possible variations would be equally effective. One variation would be to place insulating sheaths around the upper portions of the pins. This would prevent a thermally significant field from being generated in healthy tissue between the skin and the tumor. Another variation would be to incline the rows of pins so that the points would be closer to each other than the shanks of the pins at the surface. Current density would vary inversely with the distance separating the electrodes; the current passing through the tumor would be more dense and generate lethal temperatures while current passing through healthy surface tissue would be less dense and generate lower, nonlethal temperatures.

But pins, versatile as they be, would not be applicable in a number of cases. For instance, a tumor deep within the abdominal cavity in an organ might best be attacked by shaping a metal mesh to fit one side of the organ. The other electrode (with more surface area) would probably be outside the body.

In the case of a tumor in or surrounding the esophagus or the colon, a cylindrical electrode could be inserted in the canal to the affected area and a cloth soaked in saline solution wrapped about all or part of the patient's torso as the external electrode, creating a coaxial geometry. The current density in the immediate vicinity of the probe would be high, creating heat. Current density would diminish rapidly with the distance from the probe, thus heating effects on healthy body tissue throughout the region to the surface would be negligible.

Among the most difficult of tumors to treat are those of the tongue. MP-3 personnel have built a prototype LCF applicator unit that consists of an electrode plate integral with a clamp which is placed over the tongue, and an external electrode fitted under the chin and on the neck. By varying the size and position of both electrodes, current density and thus heat can be concentrated at desired points in the tongue.

Some of the intriguing aspects of hyperthermia under investigation include the response of cancer cells to heat in general. In many tumors a portion of the cancer cells are anoxic, or oxygen deficient, and for reasons not yet clearly understood, this anoxic state makes them more resistant to radiation. On the other hand, recent evidence indicates that anoxic cells may be as sensitive to heat as cells with normal oxygen levels. In clinical practice, this would mean fewer anoxic cancer cells would survive heat therapy to begin growing again at some future date.

And while LCF hyperthermia has been investigated to date only as a single weapon against cancer, it theoretically offers at least as much promise applied in conjunction with other forms of therapy. Some recent experiments suggest that hyperthermia substantially increases the sensitivity of cells to radiation. Heat may also enhance the efficacy of certain drugs in chemotherapy. It's not hard to imagine that with "one-two punches" such as these, therapists will "knock out" a considerably higher percentage of malignancies in the future.

Encouragement from Animals

Doss, McCabe, and others at the LAMPF Biomedical Facility work in close cooperation with the University of New Mexico Medical School. LASL provides the technological development and hardware while the Medical School provides the medical expertise and clinical facilities.

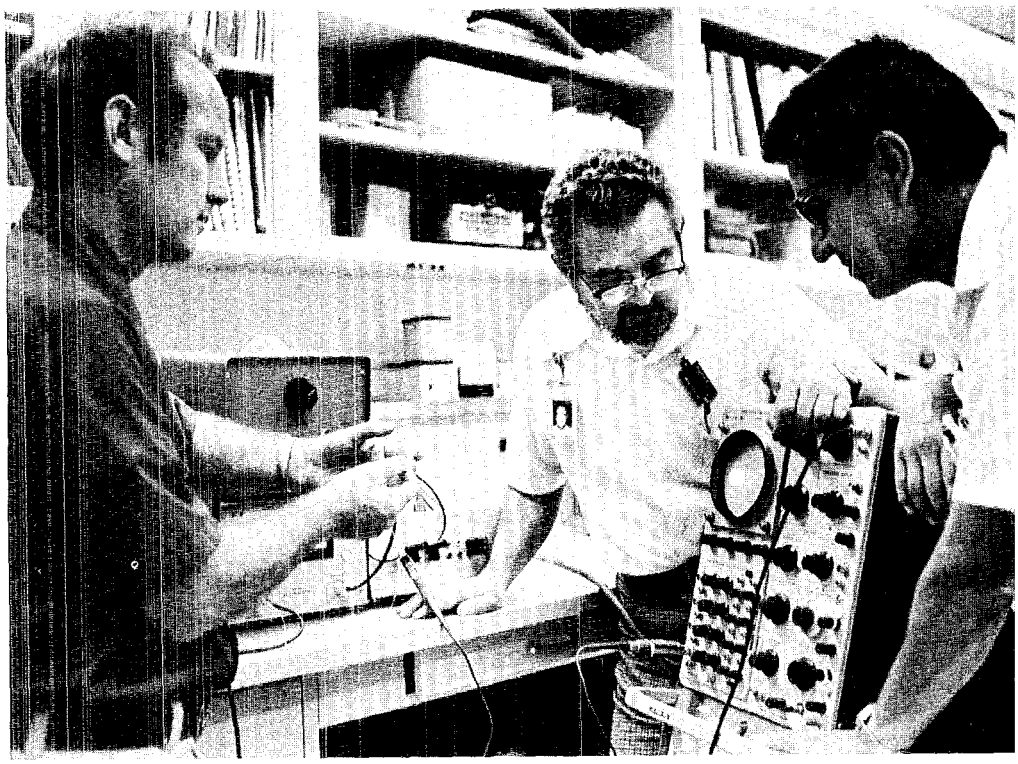
Experiments with animals have been in progress at the Medical School for more than 2 years, conducted in collaboration with veterinarian Phillip Day and physician Sterling Edwards. To date, some 18 cats and dogs, 6 horses, and even an elephant have received LCF hyperthermia therapy.

Of the cats and dogs, 2 have shown no response, 12 have experienced temporary regressions, or diminution of tumors and 4 appear to have complete remissions, or disappearances of the tumors. Among horses, 5 of the 6 treated for benign sarcoid tumors (which do not respond well to conventional therapy) show apparently complete remissions. Investigators are quick to point out that the number of animals treated is far too small to yield statistically meaningful results.

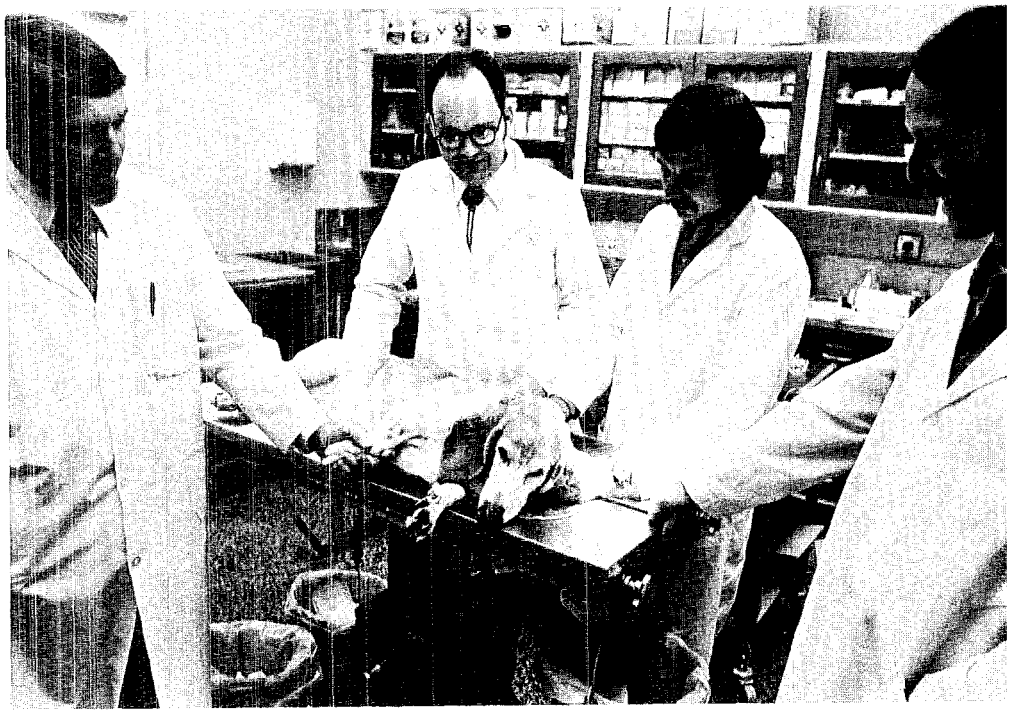
The elephant treated was Toto, a 3-year-old denizen of the Albuquerque Zoo. What was believed to have been a malignancy was discovered at the base of the trunk. LCF was applied. Later, the lump was diagnosed as rapidly proliferating granulation tissue. Nonetheless, the application of LCF eliminated the growth, which probably would have proven fatal since surgery was not considered applicable. The animal survives today in good health.

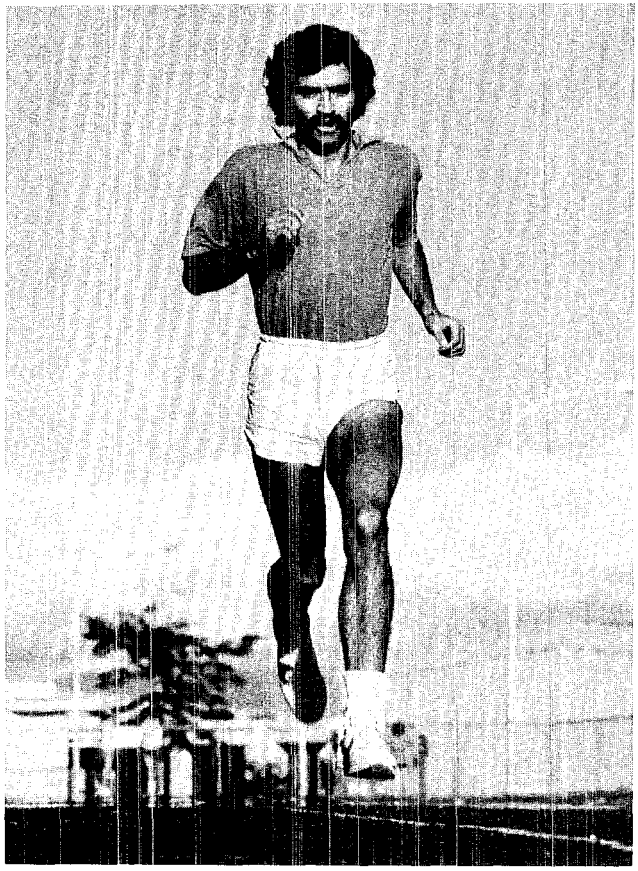
Several lesions treated in dogs were mast-cell tumors, which have no precise counterparts in humans. However, many of the tumors treated in cats were squamous-cell cancers, which do have a counterpart in humans. These are usually not easy to treat, either by radiation or surgery, in humans or cats. So far, of the 5 cats with this type of tumor treated, all have shown significant regressions or apparent remissions. But again, neither a sufficient number of animals nor adequate time has passed to allow drawing conclusions applicable to human treatment.

Nevertheless, the investigators cannot help but feel encouraged by results so far obtained, preliminary and tentative as they may be. If the future holds no unpleasant surprises, it seems entirely likely that some day LCF hyperthermia may take its place among the modern weapons deployed against cancer in humans, both in partnership with radiation and other forms of therapy and as a weapon with some unique capabilities of its own.

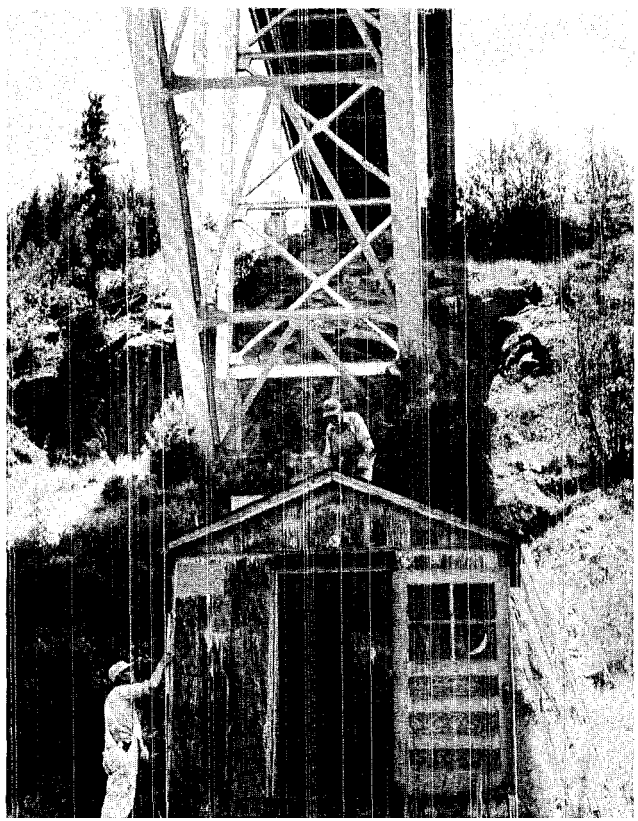


Above, Bill McCabe, MP-3, touches a thermistor probe to his finger, causing it to alter the power output from the radio-frequency source being watched by Charles Pacheco, MP-3, and Joe Albillar, E-2. Temperature can be controlled to 1/10°C. Below, veterinarian Phillip Day, Danny Doss, MP-3, UNM technician Howard Roth, and UNM anesthesiologist Robert Cipoletti, prepare to treat a patient at the Animal Resource Facility of the UNM Medical School.





Ricardo Rojas, MP-7, is flying high in sports and over the streets of Los Alamos as he trains for the 26-mile and 385-yard marathon at the Pan American Games in Mexico City from October 13-26. Rojas beat top-flight national and international competition at a Flagstaff, Ariz., marathon in August to qualify for the Games. Below, the unusual siting of the shack is due to its upcoming use by the Group H-8 Meteorological Section to measure mesa-canyon weather interactions. Instruments will be strung on cables between it and the bridge to measure effects at various heights.



A negative of a photo of Enrico Fermi, prints of which have never been published, was found among LASL Director Harold Agnew's photos made during World War II. A print is being presented to the Fermilab, Batavia, Ill. Fermi would have been 75 in September.

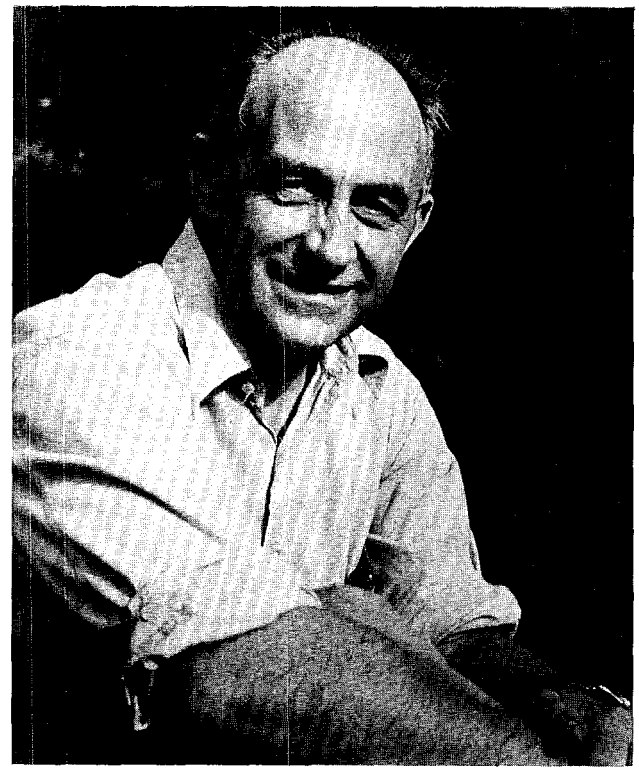
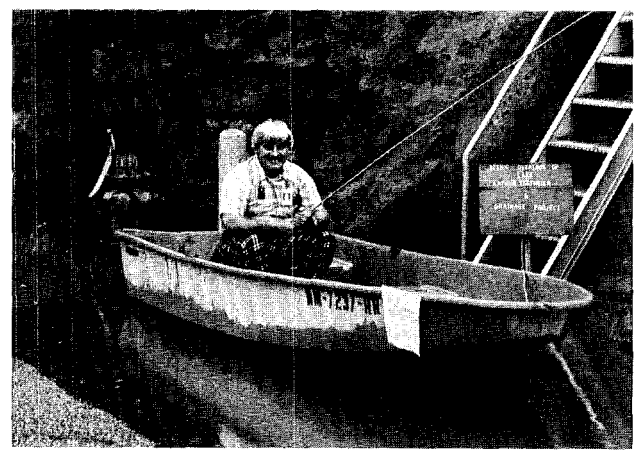


Photo Shorts



Heavy rains early in September saturated Los Alamos soil, resulting in this impressive body of water at TA-46. Pranksters couldn't resist floating a boat on the water and taking a photo of Henry Filip, L-8, fishing. The body of water was unofficially named Lake Arthur Tegtmeier. Tegtmeier, ENG-4, is TA-46 site representative.

short subjects

Honors: **Peter Carruthers,** T-Division leader, was elected to the Board of Trustees and the Executive Committee of the Aspen Center for Physics during the July meeting of the Board.

Haskell Sheinberg, CMB-6, has been elected a Fellow of the American Society for Metals. The honor will be conferred upon Sheinberg at a convocation of Fellows in Cincinnati in November.

Dale Henderson, T-6, has been invited to serve as a member of the National Aeronautics and Space Administration (NASA) Research and Technology Advisory Council Panel on Research for fiscal year 1976.

Xavier (Zeke) Corlis, L-3, received the Presidential Management Improvement Award, the only one given each year, from Secretary of Defense James R. Schlesinger in Washington, D.C. in August. Corlis saved $692,000 in chemical purchases for the High Energy Laser Program.

Gil Ortiz, ISD-5 alternate group leader, was elected president of the New Mexico Chapter of the Association of Records Managers and Administrators for 1975-76.

Formal dedication ceremonies of the University of New Mexico Cancer Research and Treatment Center were held in Albuquerque on August 8. The Center works closely with the Biomedical Facility at the Clinton P. Anderson Los Alamos Meson Physics Facility in pion-radiation research. Among speakers and guests of honor were **Morton Kligerman,** director of the Center and assistant director for radiation therapy at LASL, and **Louis Rosen,** MP-Division leader.

From ERDA: U.S. Air Force Lieutenant General **Edmund F. O'Connor** has been appointed deputy assistant administrator for nuclear energy at the U.S. Energy Research and Development Administration in Washington, D.C. O'Connor will be responsible to **Richard W. Roberts,** assistant administrator for nuclear energy, in assisting in the management of programs which include those for continued development of reactors for the nuclear power industry and for special purposes. O'Connor was previously vice commander, Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio.

At a recent international symposium in the Republic of Gabon, a U.S. delegation headed by **George Cowan,** CNC-Division leader, and **Ray Walton,** project engineer with ERDA's Nuclear Fuel Cycle and Production Division, presented papers on the Oklo Phenomenon, a deposit of uranium ore in Gabon containing remnants of naturally occurring nuclear fission reactions that took place 2 billion years ago. "Because we are concerned with the possible mobility of radioactive elements in geologic formations, the mechanism of formation and the survival of a rich deposit of uranium for 2 billion years at Oklo, although not necessarily representing a unique event, is in itself of considerable interest," says Cowan. "But what is more surprising, in a preliminary analysis, is that nearly all of the heavy elements and most of the fission products from the nuclear chain reactions have remained at the Oklo site over the same period of time." The study of the Oklo Phenomenon may lead to findings relevant to nuclear waste disposal methods.

Robert Reedy, Dennis Perry, and **Donald Barr,** all CNC-11, placed a "Space Environmental Nuclear Dosimetry Activation Package" containing metallic foils aboard the Apollo spacecraft used in the joint U.S.-U.S.S.R. mission in July. The purpose of the test was to measure nuclear particles produced inside the spacecraft by cosmic rays. To capture products with short half-lives, within 23 hours the package was retrieved from the spacecraft upon splashdown, and flown to San Francisco where Reedy hand-carried it to LASL for analysis. The data may prove applicable to the design of future space vehicles and the equipment within them.

Retirements: **Eugene H. Roach,** SD-4, laboratory inspector; **Filberto Martinez,** CMB-AP, storesman; **Patricia Crosby,** ISDO, secretary; **Clyde Reum,** SP-3, assistant department head; **Horace Sanders,** M-4, staff member; **Alfredo L. Martinez,** SD-DO; **Jacob O. Trujillo,** M-4, property representative; **Anna K. Hooser,** PER-1, administrative secretary; **Presciliano Dimas,** WX-2, chemical laboratory technician; **Thomas Land,** AO-3, group leader; **William H. Lane,** C-1, EDP operator; **William E. Braun,** SD-5, development machinist; **James C. Robinson,** SD-5, laboratory machinist; **Arthur R. Sayer,** J-14, staff member; **John Baldridge,** AO-3, accountant.

BOTTLED BOMBS

Even before the world's first atomic device was detonated at Trinity Site on July 16, 1945, scientists at Los Alamos were in the bomb-confinement "business." Jumbo, a 214-ton cylinder, had been built by the Babcock and Wilcox Corporation in Ohio and shipped to the test site with the intention of exploding the world's first atomic device within it. Not even Jumbo's 14-inch thick wall was expected to withstand the force of an atomic explosion, but if the plutonium in the device failed to react, Jumbo was expected to allow the retrieval of precious fissionable material for the building of another device.

Jumbo was never used for this purpose. It was, however, installed on a tower 800 feet from ground zero. It emerged from the test unscathed. By the time of the test, production of weapons-grade uranium and plutonium at Oak Ridge and Hanford was sufficient to provide materials for future bombs. And scientists needed to make a myriad of measurements during the atmospheric shot without the container altering effects of the explosion and without debris from the container "polluting" the products.

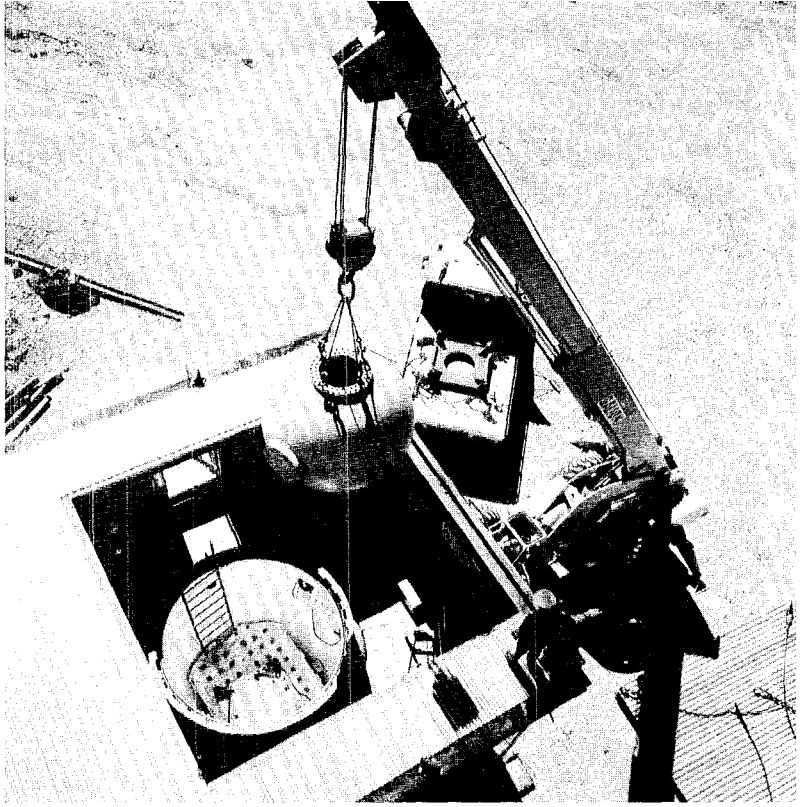
While Jumbo was the most spectacular of the containers, it was by no means the only one. Lesser "jugs" called Jumbinos, similar to those used today, were used to test various components of the early devices.

If the need for these "bottles" was great in 1945, it is even greater today. Environmental and safety requirements, along with the need to test weapon components of increasing sophistication, have placed new emphasis in recent years on testing in containers. While whole nuclear weapons cannot be tested in them, various components can, including components containing fissionable material.

In the case of the latter, an ingenious "bottle within a bottle" method is used. Even though the inner confinement vessel has a large safety factor above the requirements for the tests conducted within them, the whole vessel is nevertheless placed within another larger vessel to preclude the escape of toxic materials in the event of a failure of the inner vessel. The outer vessel is evacuated to form a vacuum between the two vessels; the negative gage pressure reduces shock effects in the event of a failure and acts to contain any waste within the system.

The inner vessel contains the experimental device in a vacuum, or surrounded by air or vermiculite flakes (with or without air). Air is allowed to remain in the container

Below left, the original Jumbo, shown at Trinity in 1945, is still the heavyweight champ of bomb-confinement vessels at 214 tons. A latter-day Jumbo, weighing in at 118 tons, right, is in process of being moved to PHERMEX where it will protect photographic equipment during open explosive tests.



Like a pumpkin being picked from a field, a 6-foot vessel is lifted from a storage area for transporting to the site of a 12-foot vessel in preparation for a test. At right, it is lowered into the larger vessel.

if the interaction between the device and the normal atmosphere needs to be measured. A vacuum is used in other tests; this eliminates the shock wave formed in air and allows larger charges to be detonated. Vermiculite flakes allow the largest shots of all. They act like a cushion to attenuate and "stretch out" the shock pulse from the blast. However, vermiculite is not used in tests where recovery of toxic materials is required. The vermiculite is not amenable to normal recovery schemes used today.

Group M-2, responsible for the construction, testing, and use of the containers, has built 44 of the smaller vessels, each 3 feet in diameter with 1-inch walls and weighing 2½ tons each, and 34 vessels 6 feet in diameter, also with 1-inch walls and weighing 4 tons each. A new 6-foot design with 2-inch walls to contain more than twice as much explosive is on order. Only one of the larger outer containers, used for experiments with fissile materials, exists because it may be reused indefinitely. It is 12 feet in diameter with a 1⅝-inch wall and weighs 30 tons.

The large container has its own "private residence" at R-Site — a metal shed with a removable roof section. In setting up a test, the roof section is removed, a hatch in the large container is opened, and the smaller vessel is lowered into the larger by a crane. After the experiment, if fissionable material was involved, the smaller vessel then goes to Group CMB-11 for removal of waste products and the vessel is not used again. A vessel that has contained only high explosives may be reused a number of times provided no flaws can be detected in the walls and other components.

Not all tests are conducted at the container's "private residence." Sometimes, the 30-ton sphere is moved to PHERMEX (a procedure called "quite an operation' by M-2 personnel) for "double-bottle" flash radiography. One reason that power is in the process of being increased at PHERMEX is to generate x rays of sufficient energy and in sufficient quantities to penetrate the containers with greater resolution.

Surprisingly, no exotic alloys are required for the vessel walls; "ordinary" high-strength steels are used. One little-known problem, however, is that of nil-ductility at low temperatures; at −20°F, many types of steel lose most of their ductility, becoming brittle. During World War II, several ships crossing the North Atlantic in winter inexplicably broke apart. Investigation led to the discovery that minor flaws in the steel hulls had propagated to become major ruptures because of the loss of ductility in the extreme cold.

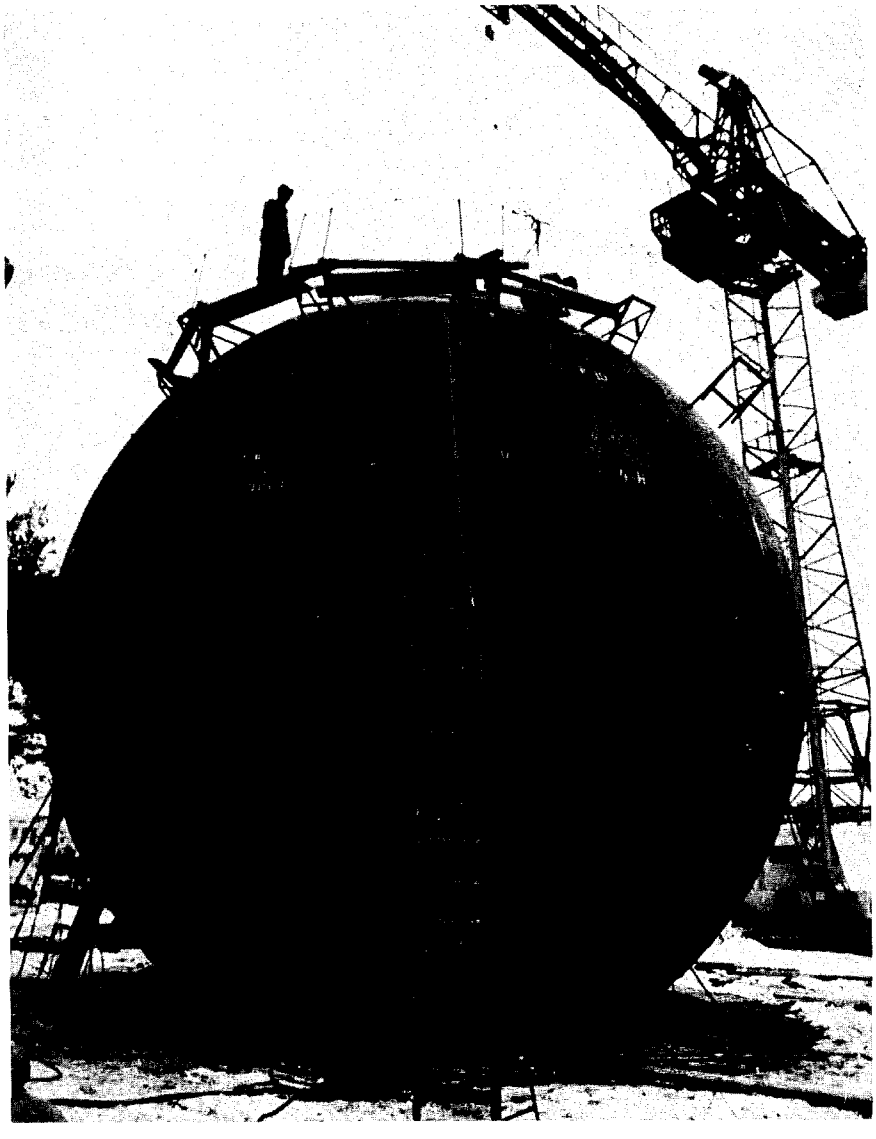
Corrective measures have since been incorporated into post World War II shipbuilding. Group M-2 easily circumvents the problem by heating its vessels to 50°F or higher

during tests.

Recently, memories of World War II's Jumbo were evoked by the sight of another monstrous Jumbo being moved laboriously down a specially built site road. This Jumbo, weighing 118 tons, had been used at Kappa Site by Group M-3 for containing shrapnel effects of certain high-explosive tests, but not the entire explosive energy. Its use for this purpose was recently discontinued, and Group M-2 saw that it could serve another purpose as a camera bunker during open testing at PHERMEX. There the massive cylinder will be mounted on virtually friction-free air bearings so that it may be maneuvered to various camera positions in close proximity to the explosions.

The huge vessel was dragged in on skids. Unfortunately, the latter-day Jumbo's tremendous weight proved too much for even the Pajarito Plateau's hard soil, and the cylinder bogged down. Efforts are now under way to free the vessel and complete its journey to its new home.

The U.S.S.R. also has a well developed explosion-containment technology, judging by this photo taken earlier this year by LASL Director Harold Agnew during his U.S.S.R. visit. This vessel appears to be 20 to 30 feet in diameter.



Baby Bottles

Because of the expertise developed at the Los Alamos Scientific Laboratory in the use of these "big bottles," it was natural that various organizations concerned with bomb disposal, such as law-enforcement agencies, the U.S. Department of Defense, and the Federal Aviation Administration, seek technical assistance from Group M-2 in the face of bombing incidents which in recent years have reached near-epidemic proportions.

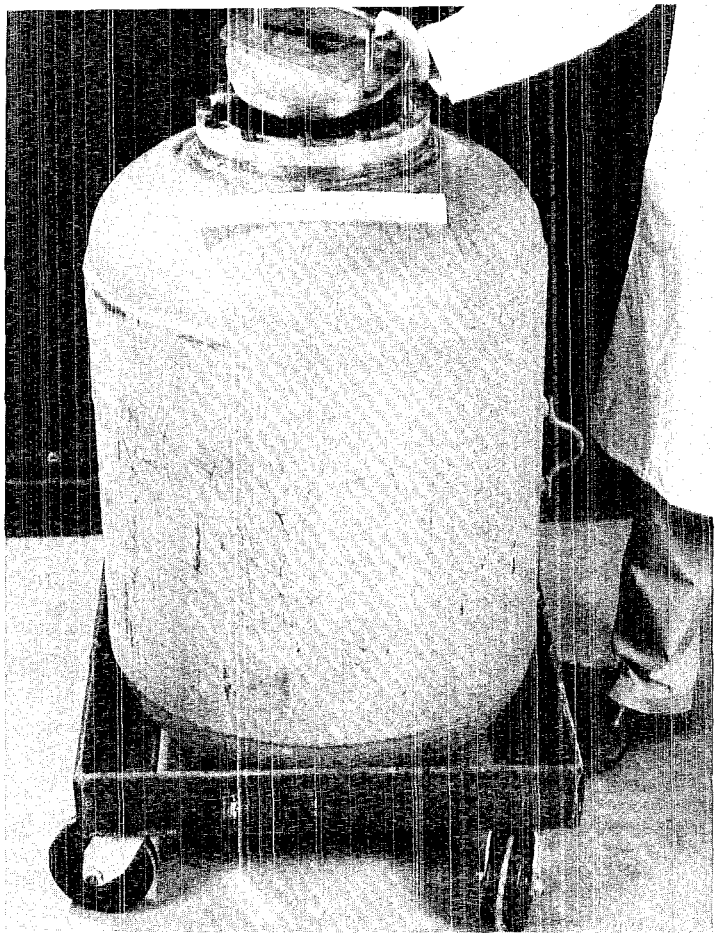
News reports of bombing incidents rarely convey the extent of the problem. Roger Taylor and Roger London, both M-2 and heavily involved in the group's program to assist civil agencies, cite some impressive facts and figures:

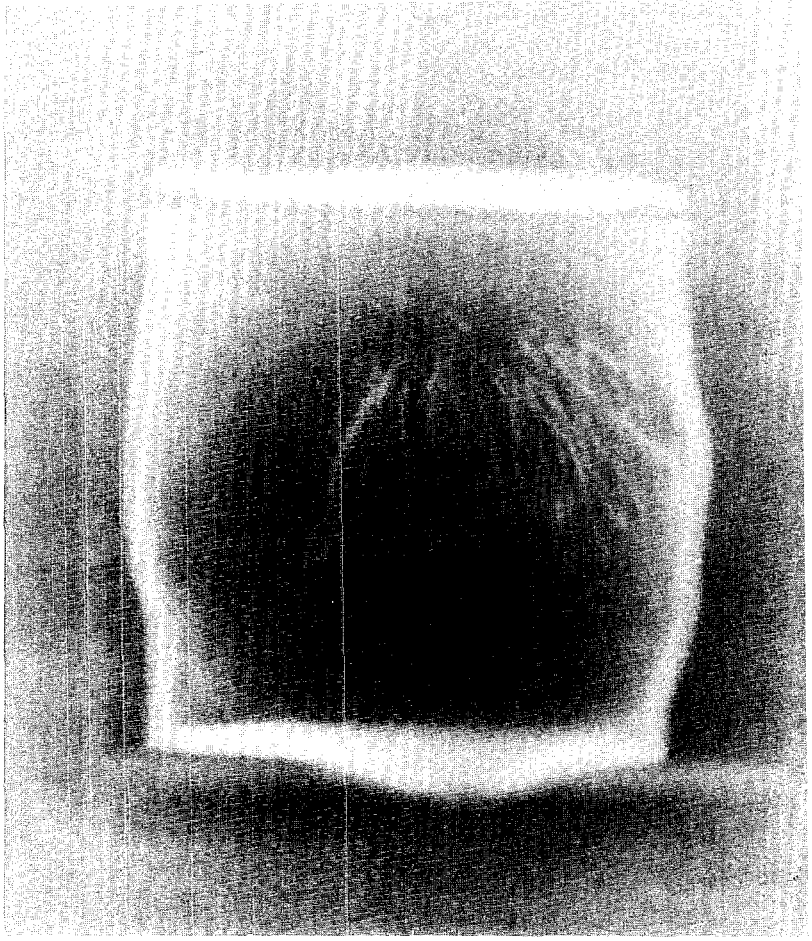
Roughly 2,000 incidents a year (almost 6 per day) take place nationally, of which ¾ are actual bombings while ¼ are attempts that fail or are thwarted. A little more than half of the incidents involve incendiaries, the rest explosives.

About 40% of bombing incidents occur in cities of over 250,000 population, and the states most afflicted are California, with about ¼ of the incidents reported, followed by Ohio, New York, and Colorado. About ¾ of incidents occur at night with about ½ directed at residences and commercial establishments, the balance against schools, vehicles, and others, resulting in $5-10 million in property damage per year.

In recent years, deaths have amounted to "only" 10 to 30 per year with injuries ranging from 100 to 200 annually. However, if these statistics seem small in comparison to the high number of incidents per year, law enforcement personnel are very much aware that the "right" bomb at the "right" place at the "right" time could easily boost these statistics to catastrophic levels.

One of the more interesting devices conceived by Group M-2 for the Federal Aviation Administration (FAA), and which also elic-





Designed for use aboard aircraft is the light-weight, portable vessel above. At right, explosive equivalent to 3 sticks of dynamite, surrounded by nails to simulate a homemade device, is detonated within the vessel. Flash radiography, taken at PHERMEX, shows the vessel walls being distorted by the explosion. The vessel survived the test intact.

ited interest by the Canadian government, is an airborne bomb-containment vessel. Weighing only 300 pounds (light enough to be of little significance in today's large jets), the container could be placed aboard a plane or wheeled fairly rapidly aboard a plane from an airport station by a couple of men. The vessel is narrow enough to roll down aisles in a jetliner. Yet, it will contain an explosive force equivalent to that produced by 3 sticks of dynamite.

Since the inception of the design, the FAA's emphasis on security measures has shifted from the aircraft itself to the airport, and the design is "on the shelf." However, it may well find other applications on the ground because of its portability, or may once again be considered for use aboard aircraft if the nature of bomb threats and incidents involving airports and aircraft changes.

Other designs, somewhat heavier, but capable of containing more energetic explosions, include a larger airborne system (also transportable by helicopter) weighing 425 pounds, a small 3-foot sphere, derived from the present 3-foot sphere used by M-2, which is transportable by a heavy duty pickup or trailer, and a 6-foot sphere, also derived from present models, which is transportable on a heavy duty tandem trailer or a 4-ton rated truck. The latter model is being developed under contract for the U.S. Munitions Command.

All employ mechanical or hydraulic quick-closure devices, and the larger models provide for detonation of a suspected bomb within.

In addition to hardware design and development, Group M-2 provides a wealth of technical information and sometimes instruction to such as the New Mexico Police Academy, the New York City Police Academy, and various units and departments of the U.S. Army. Taylor and Benjamin "Buck" Rogers, now Q-DO but formerly M-2, co-authored an article on bomb containment devices for the FBI Law Enforcement Bulletin magazine in 1973. Robert Pogna, DIR-SEC, is developing liaison with various law enforcement bodies for the more widespread dissemination of information.

It seems appropriate to Taylor, London, and their colleagues at Group M-2 that the "bottles" originally conceived as a means to test weapons have themselves become weapons in the continuing "war" against the clandestine and dangerous bombing incidents that characterize the violent elements in our society.

Homing on the Range

Raising livestock today is a high-stake roulette game where you bet against rustling losses on one side of the table and against disease on the other.

To give an idea of what is meant by "high stakes," good dairy or beef cattle can be worth $500-$1,000 a head. A young, marketable hog can be worth $75-$150. The estimated population and value of America's livestock population are huge. There are about 132 million cattle worth $21 billion; 56 million swine worth $2.5 billion; 14.5 million sheep worth $442 million; and 7 million horses worth $3.5 billion. Even small savings can add up to millions or hundreds of millions of dollars.

The only countermeasures for some deadly livestock diseases, such as hoof and mouth disease in cattle and cholera in hogs, is slaughter of the diseased animals and any animals that may have come in contact with them. In 1969-70, the Dismal Swamp hog cholera epidemic resulted in the death or destruction of 13,000 swine at a loss of $1.3 million.

In many ways, livestock growing is a far cry from the days of the Old West. Animals are no longer raised and grazed in one area and driven to a railroad for shipment to the meatpacking centers of the Midwest. Now, animals may be bought and sold 7 times and transported 3 times for long distances from winter to summer pastures, to feedlots, auctions, and slaughterhouses. Each movement increases the risk of loss through human error or theft. One cattle spread in Arizona spends $300,000 a year to combat rustling.

Yet, methods of identifying stock, keeping track of it, and watching it for signs of disease have changed but little since the days of the Old West. Identification still largely starts with a fire and branding iron, records are "writ by hand," and spotting disease is still dependent upon the more or less watchful eyes of those who run the herd.

Seeking to give the modern livestock industry the means of managing herds and detecting disease somewhat more advanced than those of the Old West is an interdisciplinary group at the Los Alamos Scientific Laboratory. Essentials of the system under development are a portable interrogator-transmitter-receiver and a passive transponder, implanted in an animal for life, which identifies the animal being interrogated by a 15-digit decimal number and reports that animal's temperature to 1/10th of a degree Celsius.

The successful development of such a system would lead to a number of meaningful, even revolutionary, advances in the livestock industry:

—Regional or national registry of all livestock would determine animal ownership in the field or mixed herds. Data banks, computer processing, and data transmittal could ultimately identify any animal anywhere in seconds.

—Computerized record-keeping in transactions would greatly reduce stock loss through human error and make the keeping of inventory and records of animals simpler, more complete, and more accurate.

—Rustling would be deterred by

Dale Holm, H-6, project coordinator, who confers frequently with USDA officials, holds a laboratory model of the "electronic brand" being developed at LASL.

a nationwide identification and information system and in the fact that the implanted device's identification number could not be changed. Attempts to remove the implant from an animal would be obvious.

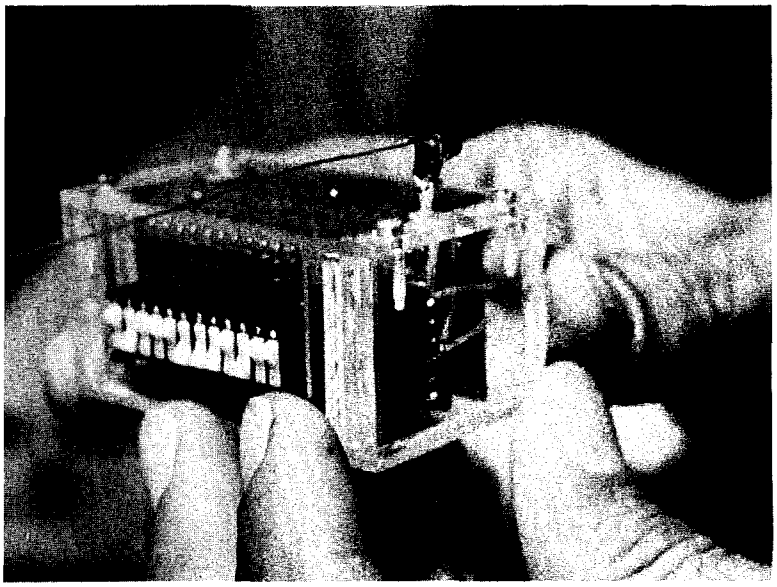
—Disease or stress would be detected early through temperature change. Suspect animals could be isolated and diagnosed before contagion reached epidemic proportions. At packing houses, it would provide a final safeguard to assure that only healthy animals are slaughtered.

—For breeding, the system would provide genetic control, selection of high-food-conversion animals, and determination of ovulation cycles through temperature profiles. Temperature profiles could also provide an effective, low-cost means of testing the efficacy of various vaccines.

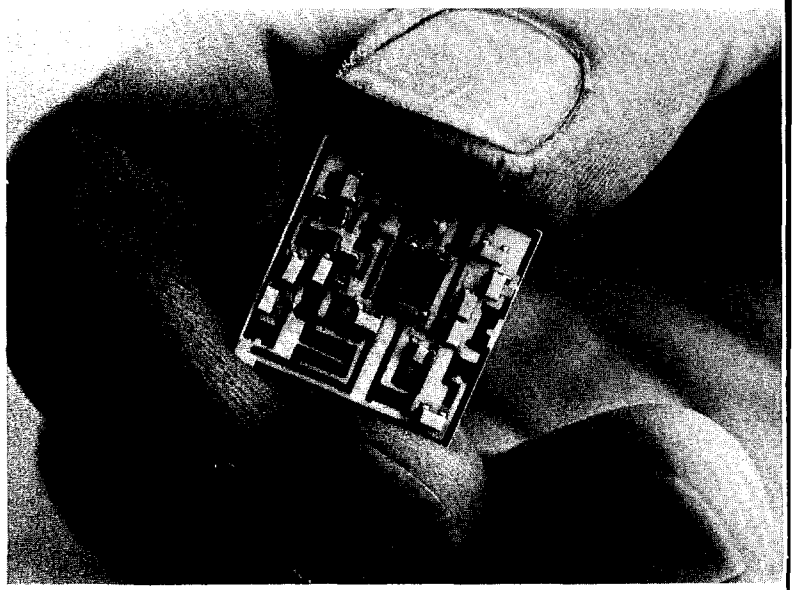
At this point, the veteran stockman could well become dismayed. Wouldn't such sophisticated gadgetry be prohibitively expensive? Not so, answers Dale Holm, H-6 project coordinator. He speculates that the interrogator-transmitter-receiver equipment, which would presumably become "capital equipment" with a lifetime of many years, might cost on the order of $1,000. The passive transponders, incorporating integrated circuits mass-produced by the millions, could cost as little as $5 each. If costs something like these are achieved, that would make the scheme not only feasible, but extremely attractive, to not only large growers, but smaller livestock operations as well.

Vitally interested in the development of such a system is the U.S. Department of Agriculture (USDA) which is responsible for controlling livestock disease epidemics and eradicating diseased and exposed animals. Because the USDA indemnifies growers whose livestock they destroy, even slight reductions in animals destroyed could save millions of taxpayers' dollars. Consequently, the USDA is funding the program and supports it in other

Above, Ron Bobbett, E-3, tests an encapsulated transponder by suspending it in a saline solution in the "cow tank." A signal is sent to the transponder and a return signal received back from it by the antenna assemblage behind the tank. Bobbett's hand is on a temperature read-out device. Below, Paul Salazar, E-2, assembles a radio-frequency mixer for the interrogator.



This transponder transmits both temperature and a 3-digit identification number, which can be set by switches. It successfully demonstrated the principle.



This hybrid circuit transmits temperature only. When it is redesigned as an integrated circuit, it will transmit both temperature and identification.

ways, such as by testing devices in use at various experimental stations. These stations are at Ames, Iowa, the Plum Island Animal Disease Laboratory, New York, and, closer to home, at Los Alamos, where USDA representative Coleman Hensley has done much to generate support for the concept and to provide continuing consultation to LASL investigators.

The USDA is not alone in its interest. The State of California has passed enabling legislation that would require the livestock industry in that state to adopt an electronic system when it becomes available. The International Brand Conference supports it. Numerous state and regional livestock associations have sent delegates to conferences on the subject. Several companies are interested in manufacturing various parts of the system.

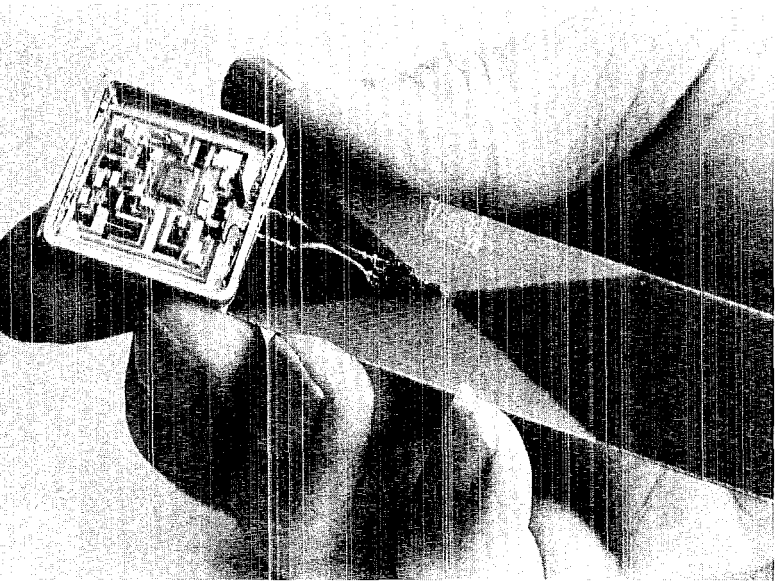
At the start of the program in 1973, it was decided that a passive, rather than a powered, transponder was required for implantation. A power cell would add to size and cost. Unless it were a nuclear power cell, it would run down. Further, toxic materials, such as mercury or plutonium, cannot be implanted in animals lest they inadvertently find their way into food for human consumption.

On the other hand, a passive transponder implanted under the skin would have to be sensitive, indeed. It would receive only 1/50th of the power transmitted to it if the transponder were in air, due to the loss caused by the intervening hide. Neither would it be desirable to attempt to overcome this loss by boosting power, as this could pose problems in safety for both animals and humans.

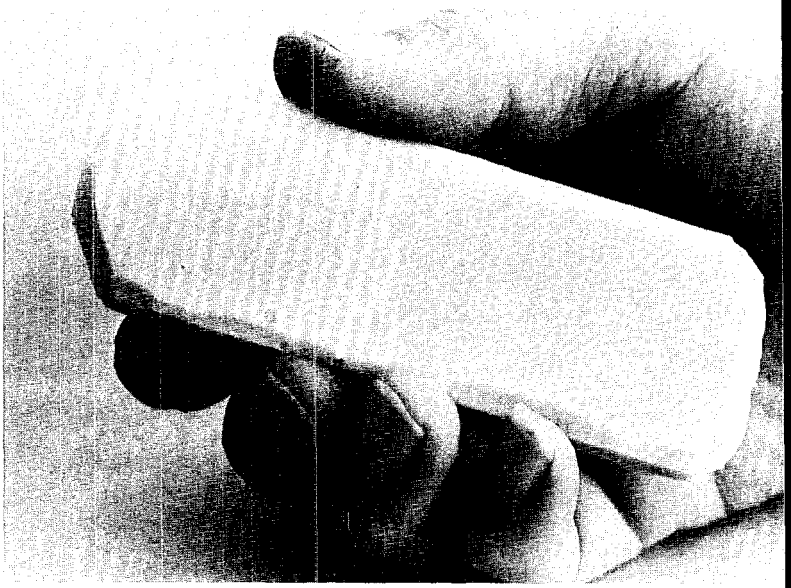
And there were a number of other problems, including finding a low-cost but virtually indestructible and leakproof method of sealing the device.

With problems such as these to deal with, the group decided at the onset of the program in January 1973 to prove the principle itself as a first step. Consequently, Steve Depp, E-DO, Al Koelle, E-3, Bob Freyman, TD-7, Howard Baldwin, H-6, and Paul Salazar, E-2, built a preprototype transponder that would both identify and report temperature in 3 digits. A handwired "breadboard" model, it was not intended for implantation but for demonstration.

It served this purpose well at the U.S. Animal Health Association conference in St. Louis in late 1973. The reaction of the conferees, according to Holm, was enthusiastic. With this kind of encouragement, the unit was next demonstrated at a meeting in Oklahoma City to a cross section of livestock-industry representatives, including feedlot operators and farm bureaus. Did



A hybrid circuit is mounted on an antenna, which must be compatible with the incoming signal so that enough energy is derived to generate a return signal.



Encapsulating the transponder with a tough, leakproof material makes it suitable for implantation. On a cow, the implantation may be made on the neck.

they really feel a need for this type of system? If so, what type of transponder would they prefer?

The response was unanimous for a subdermal, or under-the-skin, passive responder. Industry representatives believed it would be more tamper-resistant and would provide more useful temperature readings.

A 15-digit decimal system for identification was recommended as near-optimum by the National Brand Conference. It allowed sufficient digits not only for a specific serial number for all of America's livestock, but for numbers giving useful information such as state and herd of origin, year of birth, and breed. Theoretically, many billions of combinations are possible.

With these guidelines, the program at LASL was broken down into separate phases: (1) the development of a laboratory-model temperature-only passive transponder; (2) the development of an identification and temperature transponder incorporating a new coding system with 15 decimal digits; and (3) the development of an antenna compatible with the system, yet suitably small and contained with the electronics in a single "package" for animal implantation.

The temperature-only transponder electronics were fairly straightforward. A unit was built for testing. To simulate the resistance of tissue to radio-frequency signals, a saline solution was used, in which the unit was immersed. A styrofoam cooler was purchased for use as a tank and a stand was built. LASL personnel involved couldn't resist adding a few embellishments to the tank, as shown on the front cover and explained on the inside front cover.

A code was devised by Koelle, Depp, Ron Bobbett, E-3, and Jeremy Landt, E-DOR, to meet the requirements of the 15-digit decimal system. In practice, the code will be stored in a PROM (Programmable Read-Only Memory) located on an integrated circuit chip. This code will be permanently programmed into the PROM at the time the transponder is issued to the user.

An innovative method was developed for transmitting this code from the transponder to the interrogator. Its reliability, accuracy, and simplicity suggest other future applications, such as for human identification in security systems or in shipping and storing containers of nuclear waste.

Antenna design is critical. As much of the signal as possible must be captured by the passive transponder to provide enough energy for the electronics to broadcast a usable signal back to the interrogator. LASL researchers had determined that a certain transmit-

ting frequency best met requirements for penetration of animal skin and other technical considerations. To match the radar cross-section of this frequency, a special antenna several inches long was fabricated.

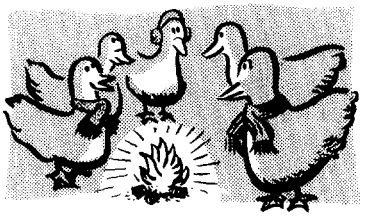
The combination of antenna and electronics in the package utilizes about 5% of the energy received—no mean feat. But the researchers believe that further refinement can boost this to 20%. Achieving this would result in a range of 10 meters, or about 33 feet, for the system. While not sufficient for "reading" animals at distances in pastures, it is more than adequate for the places where animals are most often counted, identified, and observed: being herded through chutes, in pens and barns, or being loaded aboard trucks or trains.

The next step planned is to combine the temperature-reading and identification functions in a single passive transponder and test it. Once demonstrated, the present hybrid circuitry, essentially hand assembled with various types of components, will be redesigned as an integrated circuit amenable to economical mass production. A recently developed silicon glass-like material from a commercial source shows promise of being a very low-cost encapsulating material.

Concurrently with this hardware development, the USDA has been testing and will continue to test the system at its agricultural experiment stations. Temperature profiles of healthy and diseased animals under a variety of conditions will be made, providing data useful for interpreting temperature readings when the system finds application in the field.

Perhaps in some future era, Western artists will paint scenes of cowboy life in which radarlike electronics will be as familiar a part of the picture as chuck wagons, saddles, and ten-gallon hats. If such an era comes about, it will be as the result of research and development by LASL scientists with a lot of support by the USDA and the livestock industry.

10 years ago in los alamos



Culled from the September & October, 1965, files
of The Atom and the Los Alamos Monitor by Robert Y. Porton

Landmarks Go:

The long-pending separation of Laboratory facilities from the Los Alamos Town Site has been completed. Transferred to the new Administration Building annex on South Mesa are the Supply and Property and Personnel Departments, the community relations office and the LASL Science Museum. Writing finis to all LASL operations in TA-1, the AEC has authorized removal of P-Prime and AP Buildings in the old Main Technical area and two other structures dating from the earliest days of the Project. These are a Ranch School log cottage and the rambling Central School. When the site is cleared, construction is to begin on the new Los Alamos County Building.

Who Dun It???

The appearance of five ducks on Ashley Pond poses somewhat of a mystery to county officials, who earlier authorized the lodgement of a dozen of the downy creatures on the local waterway. But these aren't those, says Bob Hughey of the county staff. Apparently some munificent individual noted the publicity on a request from the Izaak Walton League (which was approved with stipulations) and provided five ducks on his own. With winter coming, the question of responsibility for the fowl has been bandied about and so far the county has ducked responsibility for the ducks.

Death Takes The Voice of Trinity:

Samuel King Allison died September 15 following heart surgery in Oxford, England. At his death, Allison was director of the Enrico Fermi Institute for nuclear studies at the University of Chicago. He played a salient role in the Trinity test drama when, at 20 minutes of zero on July 16, 1945, he took over the microphone to deliver the countdown for the world's first atomic explosion.

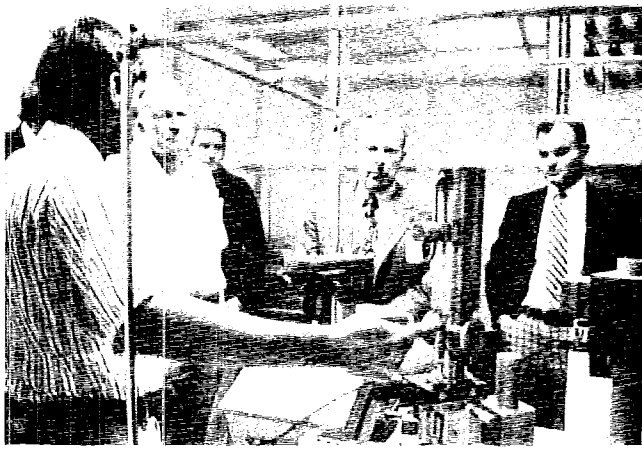
Hill Resident Appraisals:

The appraisals of Los Alamos residential properties that are subject to priorities were released to the public by the Housing and Home Finance Agency this week. Examples picked at random show: 3-BR Western Area original $12,000, 2-BR Group 16 house $9,700, 4-BR Group 17 house $11,600, 5-BR Group 18 house $13,750.

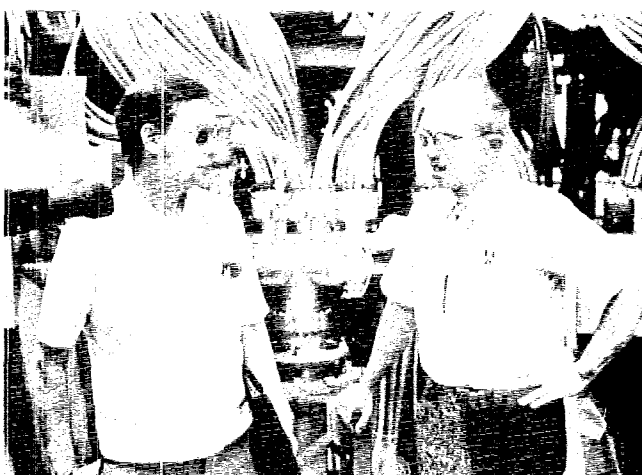
Among Our Guests

Aage Bohr, son of the late Niels Bohr and himself a scientist, visited LASL on July 30. Here Bob Brashier, ISD-2, left, explains exhibits at the Bradbury Hall of Science to Bohr, his daughter Margrethe, and his colleague, Professor Raymond Sheline of Florida State University.

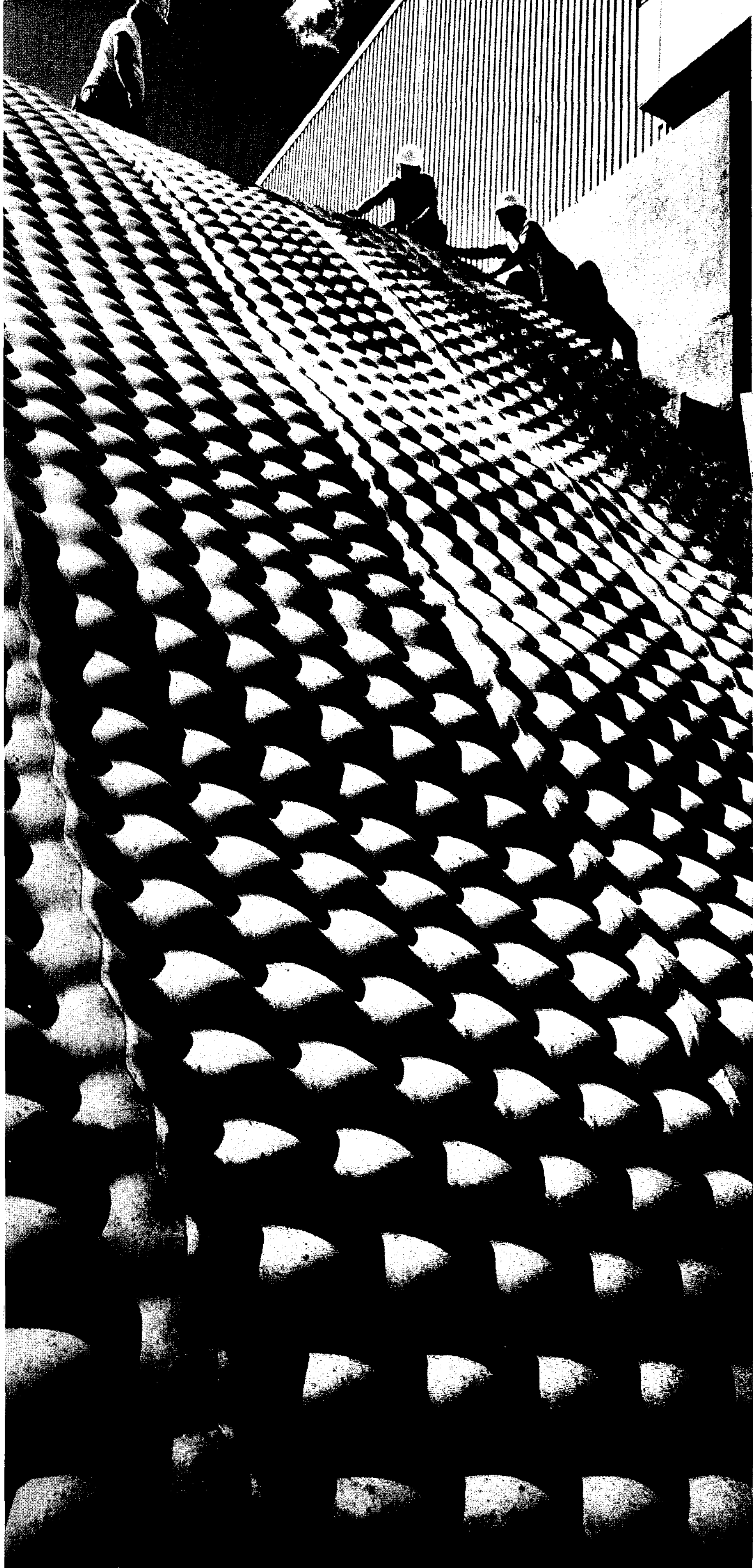
The General Advisory Committee to the U.S. Arms Control and Disarmament Agency, of which Director Harold Agnew is chairman, visited LASL on August 21 and 22. Here Sidney Graybeal, consultative commission member, Dean Rusk, former Secretary of State, Agnew, John McCone, former Chairman of the Atomic Energy Commission, and Gary Seyster, committee staff listen as Bill Heath, WX-3, and Jesse Aragon, WX-3 group leader, explain activities at S-Site.



Major General Joseph K. Bratton, USA, Director of ERDA's Division of Military Application (DMA), came to LASL August 27 for a 2-day inspection of facilities. Here Steve Lockwood, L-8, describes L-Division activities to Duncan MacDougall, associate director for weapons, Harold Agnew, Director, Bratton, and Commander Rudolf Bredderman, USN, of the DMA research and development staff.



Hunter Spillan, senior staff assistant for the U.S. House of Representatives Appropriations Committee, visited LASL on August 26, here talks with George Sawyer, CTR-Division alternate division leader, about fusion power at Scyllac.



A project to control erosion becomes a composition in abstract art for ISD-1 photographer Bill Jack Rodgers. An embankment which is part of a radiation shielding system at Area A of the Clinton P. Anderson Los Alamos Meson Physics Facility (LAMPF) had been eroded from 10 to 12 feet over a 3-year period. Group ENG-4, the Zia Company, and the Fabriform Division of the Intruision Prepakt Corporation, Mesa, Arizona, poured concrete between 2 nylon blankets which are quilted so that the concrete will form the bulges. The bulges slow down and break up flowing water.