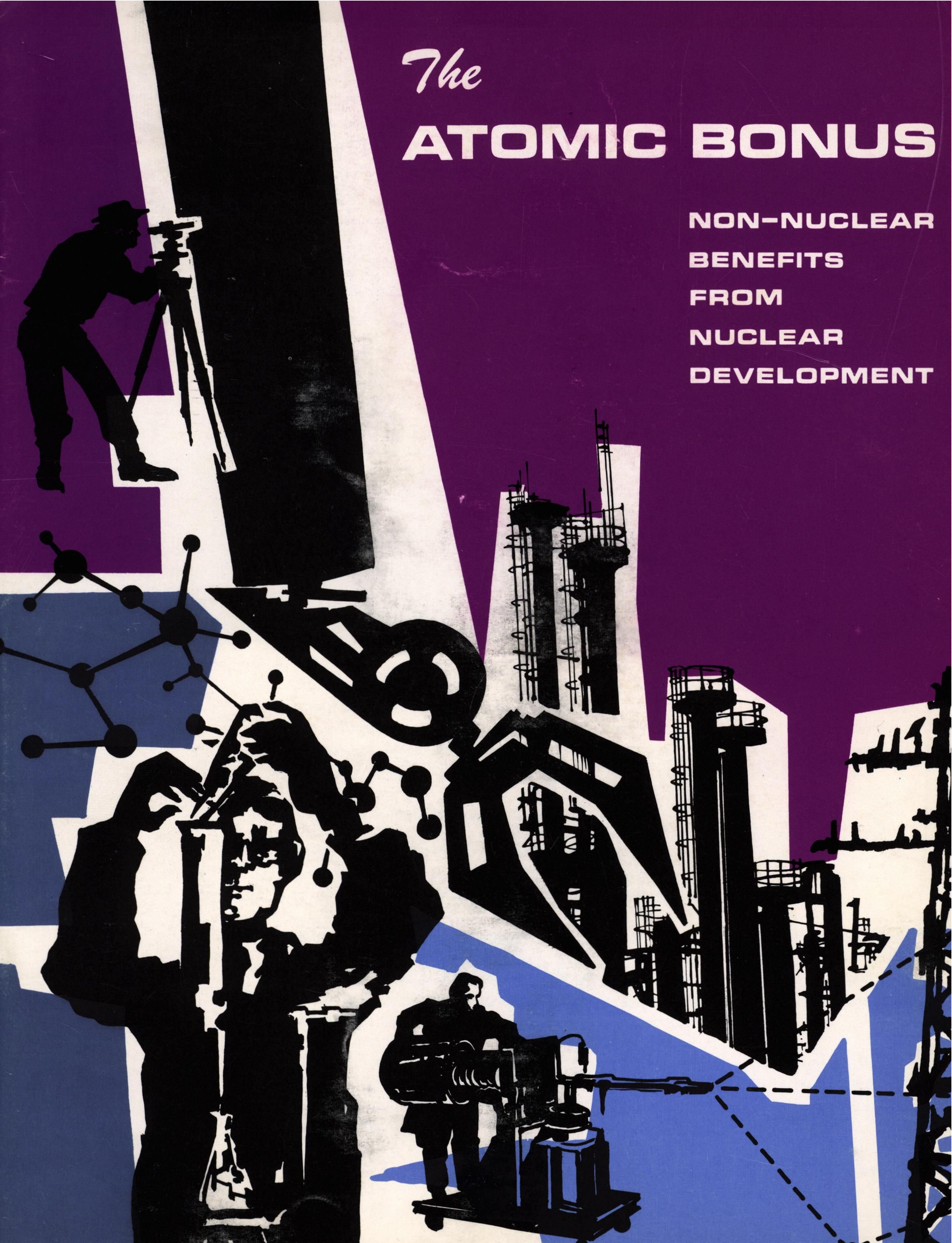
The ATOMIC BONUS

NON-NUCLEAR BENEFITS FROM NUCLEAR DEVELOPMENT



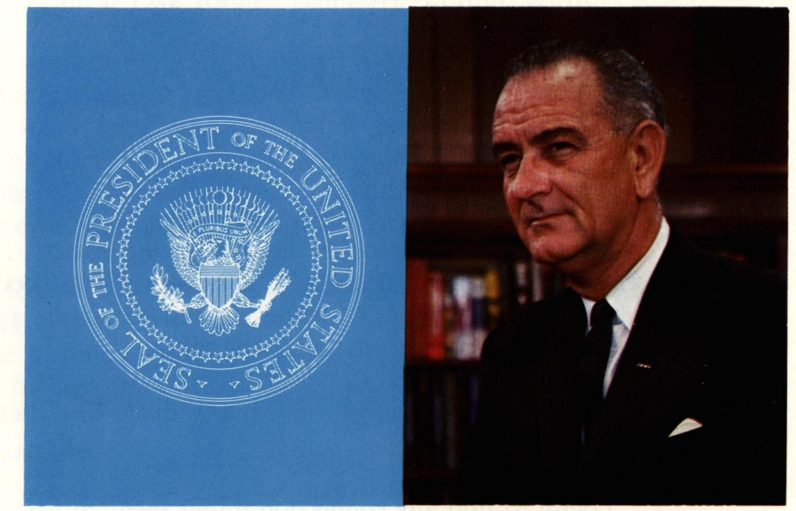
Booklet by:
U. S. Atomic Energy Commission

Photographic Credits:

Oak Ridge Operations Office
General Telephone & Electronics Corp.
Sandia Corporation
Pacific Northwest Laboratory
Brookhaven National Laboratory
Loffland Brothers Co.
Reynolds Electrical & Engineering Co.
Monsanto Research Corp.
Lawrence Radiation Laboratory
Brookhaven National Laboratory
Los Alamos Scientific Laboratory

TABLE OF CONTENTS

FOREWORD



Atomic research and development, which began in the darkness of war, are today contributing to the peaceful progress of all mankind. Nuclear power plants are generating electricity. Radioisotopes are leading us to new and revolutionary discoveries in basic research. The atom is at work in medicine, in agriculture, and in industry.

But in addition to these well-known benefits, there are many other indirect benefits. "Spin-off" from atomic development already has brought about a number of useful—and sometimes surprising and unexpected—advances in such diverse fields as virus research, improved color television reception, and ways of improving the cleanliness of hospital operating rooms.

Spin-off is a bonus to the taxpayer, since it represents an extra return on money originally invested for a different purpose. It is a bonus to industry and to the consumer because it leads to improved, or more economical, processes and products. And because we are sharing our non-military nuclear technology with other countries, the bonus is shared by people everywhere.

We must continue our efforts to expand these peaceful applications of atomic energy. By so doing, we will be fulfilling a major and basic American commitment: to harness the awesome power of the atom for the purposes of peace and the improvement of human life.

President Lyndon B. Johnson.

THE ATOMIC BONUS

NON-NUCLEAR BENEFITS
FROM NUCLEAR DEVELOPMENT

THE STORY OF SPIN-OFF

Better color TV pictures in your living room . . . a new way to attack the common cold . . . cleaner hospital operating rooms . . . cleaner and cheaper water purification . . . better control of stream pollution . . . a new kind of pig . . . the modern electronic computer.

What do these things—and many more like them—have to do with atomic energy?

Trying to find any connection might seem, at first, to be stretching things a bit.

But the fact is that numerous and important non-nuclear civilian advances are arising from basic research into the atom and from development of its many uses.

These new civilian products and techniques are known as "spin-off," indicating that they are beneficial side developments stemming from work originally and primarily related to the Nation's atomic energy program.

"In a way," says Dr. Glenn T. Seaborg, Chairman of the AEC, "the whole vast and growing program of peaceful uses of the atom is spin-off from original nuclear research and development which had military and national defense purposes as their objectives.

"These peaceful applications now include the growing use of nuclear-generated electrical power for homes, businesses and industries; our plans to harness nuclear explosives for large earth-moving projects such as canal, highway and harbor construction and underground blasting and mining operations; and the use of long-lasting sources of radiation to operate ship channel buoys, lighthouses, remote automatic weather data stations and signal transmitting equipment from earth-circling satellites.

"Other uses include the employment of radiation sources in many industrial measuring, control, photographic and processing operations; their use in new and important food preservation processes and in medical, biological and agricultural research and applications, and in a host of other ways.

"In addition to outstanding achievements in these areas, there are many advances which generally are not the main goal or end product of atomic research and development but which—while useful in the nuclear field—also have important beneficial non-nuclear applications.

"These are what we mean by atomic energy 'spin-off.' "

EARLIEST EXAMPLES

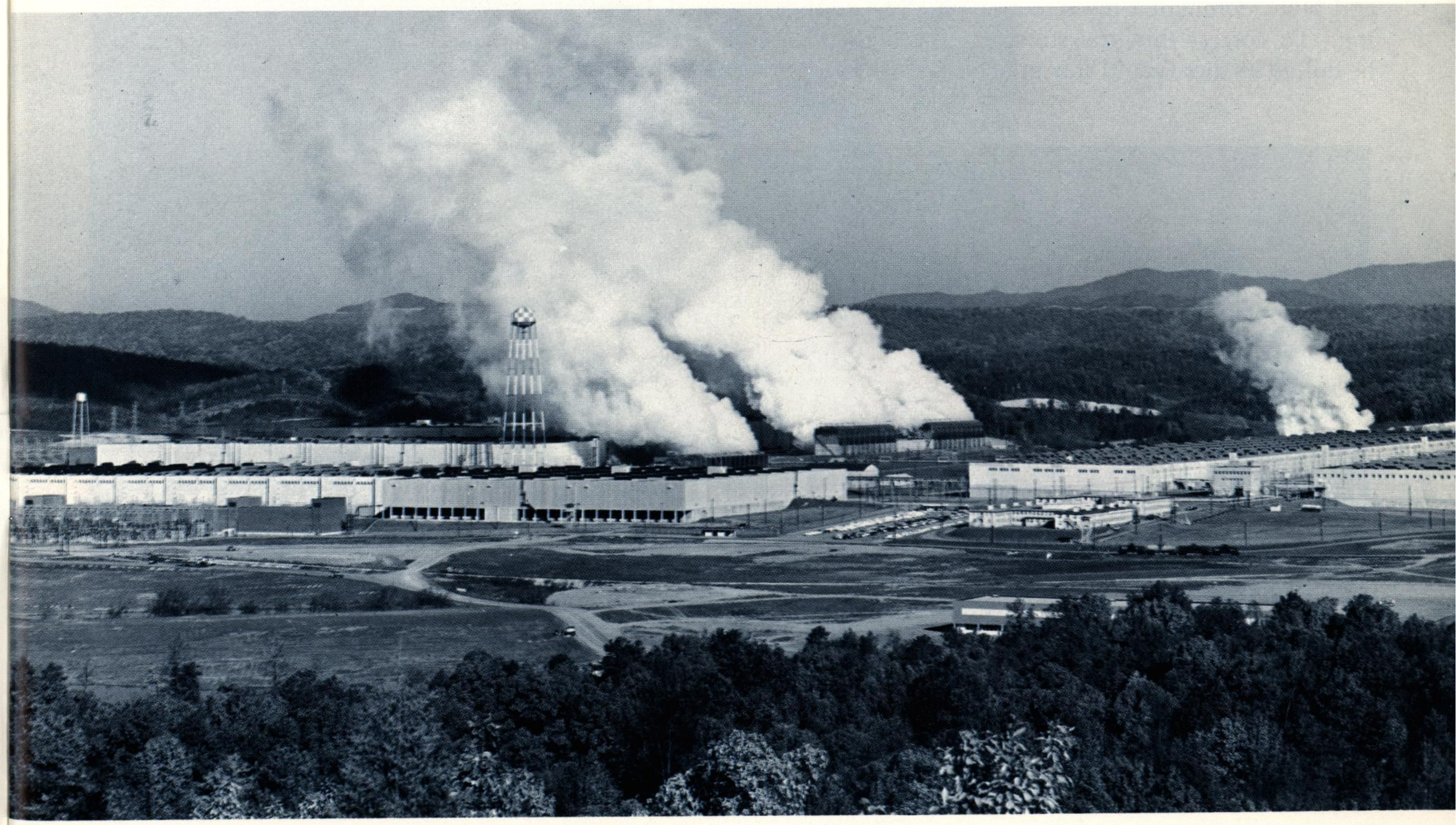
Some of the earliest examples of AEC spin-off resulted from the construction of the huge gaseous diffusion plant at Oak Ridge, Tennessee, during World War II.

The plant, unlike anything ever previously built, was created for volume production of highly-fissionable uranium-235 for the atomic bomb. It was described as a "totally new type of plant built to employ totally new processes for the production of a totally new product" and it employed more power, pumps and instruments than anything ever heard of before.

To solve unprecedented problems of construction and operation, some of the most concentrated research ever devoted to a single industrial project was focused upon the plant. The technical lessons learned proved to be of immediate interest to a number of important non-nuclear industries.

The case of pumps is a good example.

Vast Oak Ridge diffusion plant was one of early sources of spin-off.



Thousands of pumps were needed to push uranium gas through miles of pipes and through the diffusion chambers where the uranium could be properly separated. None could leak. None could corrode. All had to exceed normal efficiency. Top flight pump designers were called in from leading manufacturers to tackle the job.

The pumps they came up with not only met the stringent diffusion plant requirements; they added substantially to known pumping techniques and were at once of importance to the petroleum refining, general chemical and processing industries. These are industries having large volumes of liquids and gases to move.

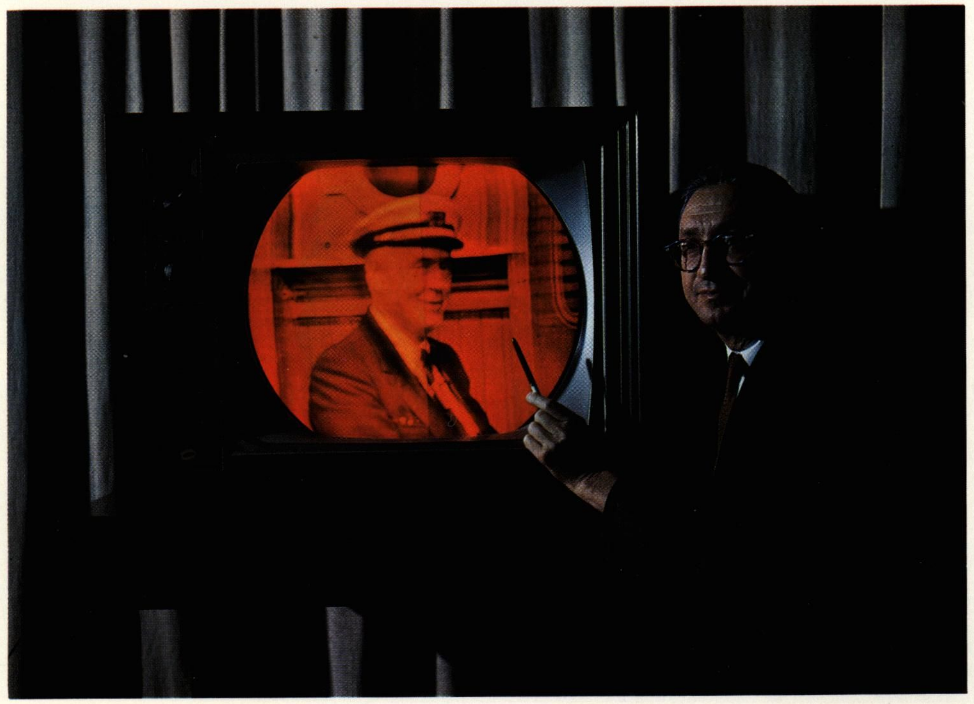
LIFELIKE COLOR IN TV

What about more recent and more clearly consumer-linked spin-off from atomic energy?

Vastly improved color television is one of the most recent examples.

Color in television reception is produced by some 900,000 tiny phosphor dots on the inside of a typical TV tube. Depending on their composition, these dots give off red, green or blue light when excited by cathode rays generated by electron guns within the tube.

But the phosphor hitherto used to produce red—silver-activated cadmium zinc sulphide—was able to produce only an inferior shade, actually more orange than red in color. Furthermore, the reds in TV pictures were too weak. Greens and blues dominated the screen, with some strange shadings frequently resulting. To correct this, the stronger blue and green emitting phosphors had to be dulled so they would stay in balance with the weaker red-emitting phosphors.



Rare earth red phosphor has greatly improved quality of color television reception.

Now the color TV picture has been changed—literally—by little known elements called rare earths.

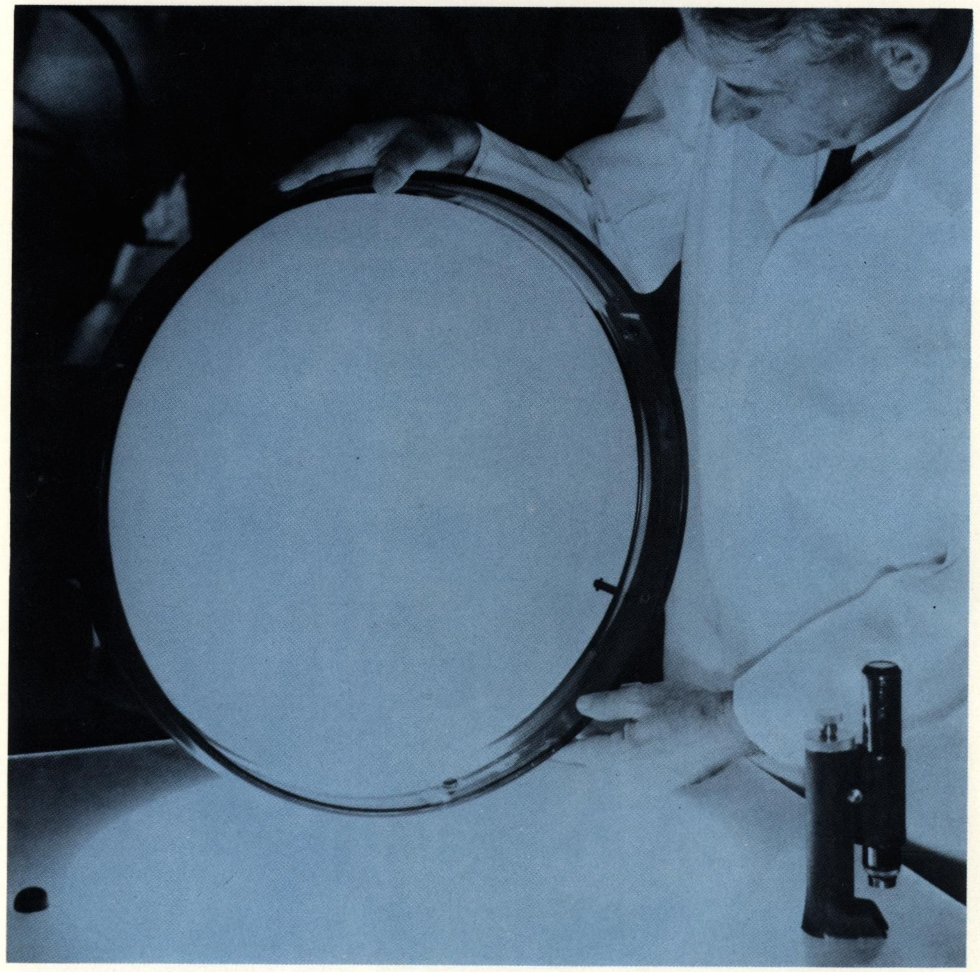
The use of rare earths in the red-emitting phosphors, it was discovered, would result in redder and more lifelike reds on TV screens. This, in turn, permitted the use of stronger greens and blues. An added bonus proved to be the appearance of additional colors, particularly purples and magentas, that could not be obtained in TV tubes before.

The result has been far brighter and more realistic colored pictures on viewers' screens from tubes using these new rare earth phosphors.

Rare earths, which really are closely related metals, had been known for many years, but their use was limited because of the great difficulty of separating one from another.

Their value in the Nation's nuclear weapons program led to work at the AEC's Ames Laboratory on the campus of Iowa State University that resulted in practical and efficient methods of rare earth separation.

Improved color television sets using rare earth phosphors began reaching the market in volume in 1965.



New television tubes using rare earth phosphors are 40% brighter in black and white.

COLD VACCINES FROM SPIN-OFF

A new attack on the common cold has been made possible by atomic energy spin-off from a method of separating uranium isotopes that employs a high-speed rotating machine called a centrifuge.

The centrifuge, developed at the AEC's Oak Ridge gaseous diffusion plant, was used to whirl gaseous uranium at high speeds so that uranium isotopes would separate according to their weight, much as cream is separated from milk in a cream separator.

Scientists at Oak Ridge, using skills available from their gas centrifuge work, now have developed a liquid centrifuge to aid in preparing vaccines against colds and other upper respiratory ailments.

When virus culture fluids are spun at high speeds, several kinds of human respiratory viruses are isolated in pure form and in concentrations previously unattainable. The isolated virus materials then are collected and used to develop the vaccines.

About 40 of these machines—called zonal liquid ultracentrifuges—now are in existence.

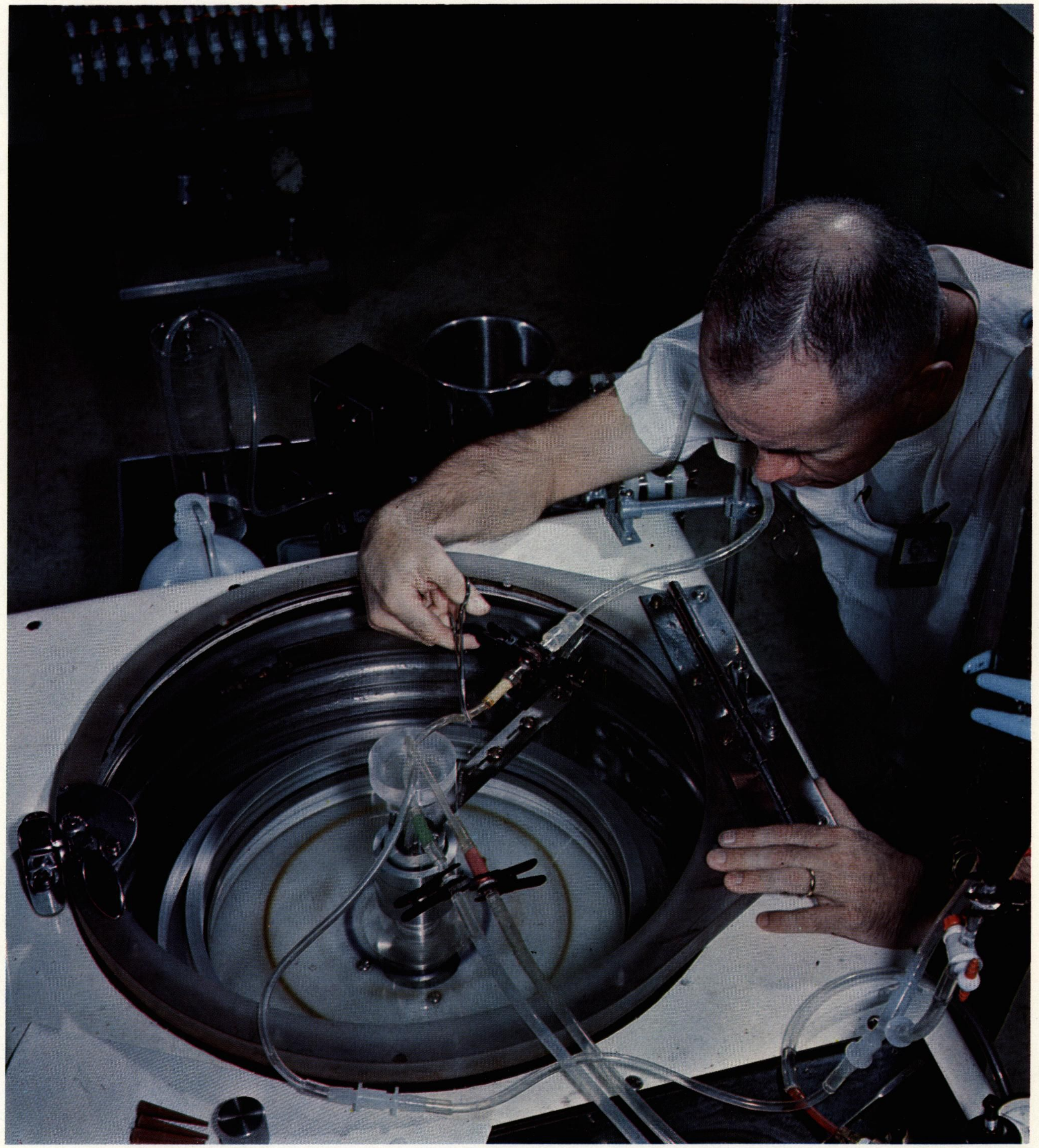
Some are used to separate whole cells, cell nuclei, viruses and a whole series of cell particles and large molecules in both quantity and a high state of purity.

Scientists say our understanding of the nature and function of cell constituents will advance more rapidly because of these new tools of medicine.

Work of virus separation by means of centrifuge devices is done in the Oak Ridge Laboratory.

Other machines are available for the separation of virus-like particles from the blood of leukemia patients and are expected to aid in research and possible vaccine development for the treatment of leukemia and cancer.

Developed from uranium separation work, this centrifuge now aids in fighting colds.



CLEANER HOSPITAL OPERATING ROOMS

Cleaner hospital operating rooms are possible through a spin-off development called the "laminar air flow clean room."

Developed at the AEC's Sandia Laboratory in Albuquerque, New Mexico, in 1961, the laminar air flow clean room has revolutionized the design of industrial clean rooms throughout the country and shows considerable promise as a means of controlling the dispersion of bacteria.

The process uses a continuous, uniform flow of filtered air—from ceiling to floor or from wall to wall—to remove contamination from a room. "Laminar flow", incidentally, means a uniform flow of a layer of air or liquid. The laminar flow clean room concept was developed at Sandia as part of a program to provide the cleanest possible conditions for assembly of nuclear weapon components and systems.

Bacteria shed by people in a laminar down-flow clean room are confined to a sheath of air closely surrounding each person and are gently but inescapably swept down to the floor and out of the room. The number of dust particles one-third micron or larger left in such a room is less than 1,000 per cubic foot of air. A conventional clean room contains at least a million such small particles per cubic foot.

Thus, the working environment produced by laminar flow may be 500 or more times cleaner than that in the typical hospital surgery room, even though persons dressed in ordinary street clothing are working in the room.

A recent Sandia study indicates that laminar flow may be widely useful in controlling bacteria in surgery rooms, autopsy rooms, rooms for vaccine preparation and rooms for raising germ-free animals for research. It also promises to be helpful in treating allergies and second and third degree burns.

The first operating room to use the laminar flow principle has now been constructed in an Albuquerque, N. M., hospital.

Ceiling-to-floor air downflow removes contamination in clean room originally designed for nuclear weapons parts assembly. Principle now has revolutionized industrial clean room techniques and promises better control of bacteria in hospital operating rooms.

IMPROVED WATER PURIFICATION

One outgrowth of research and development work carried on at the Atomic Energy Commission's Hanford, Washington, plant is water-treatment improvement that permits water processing at twice the former rate.

Hanford's plutonium production reactors have a tremendous appetite for very pure water and each has its own water treatment plant. One of the newer plants has a capacity of 335 million gallons a day—enough to supply a city of about 350,000 with its daily water needs.

After development and pilot-plant tests, the water-treatment plants were converted to an improved process that doubled and, in some cases, tripled water flow and saved some $20 million that would have been needed for new treatment facilities under the former process.

The basic difference in the new process is the elimination of one of two chemicals which are normally added to the water to assist in the coagulation of solids, and the addition of a new chemical which helps the water filter collect and hold the solids. The new system not only is faster; it removes half again as many solids as previous methods of purification.

The municipal water plant of Pasco, Washington, was modified in 1960 to this new process. The plant's capacity was doubled at only minor cost and the cost for chemicals per million gallons of water treated was cut by as much as 88%.

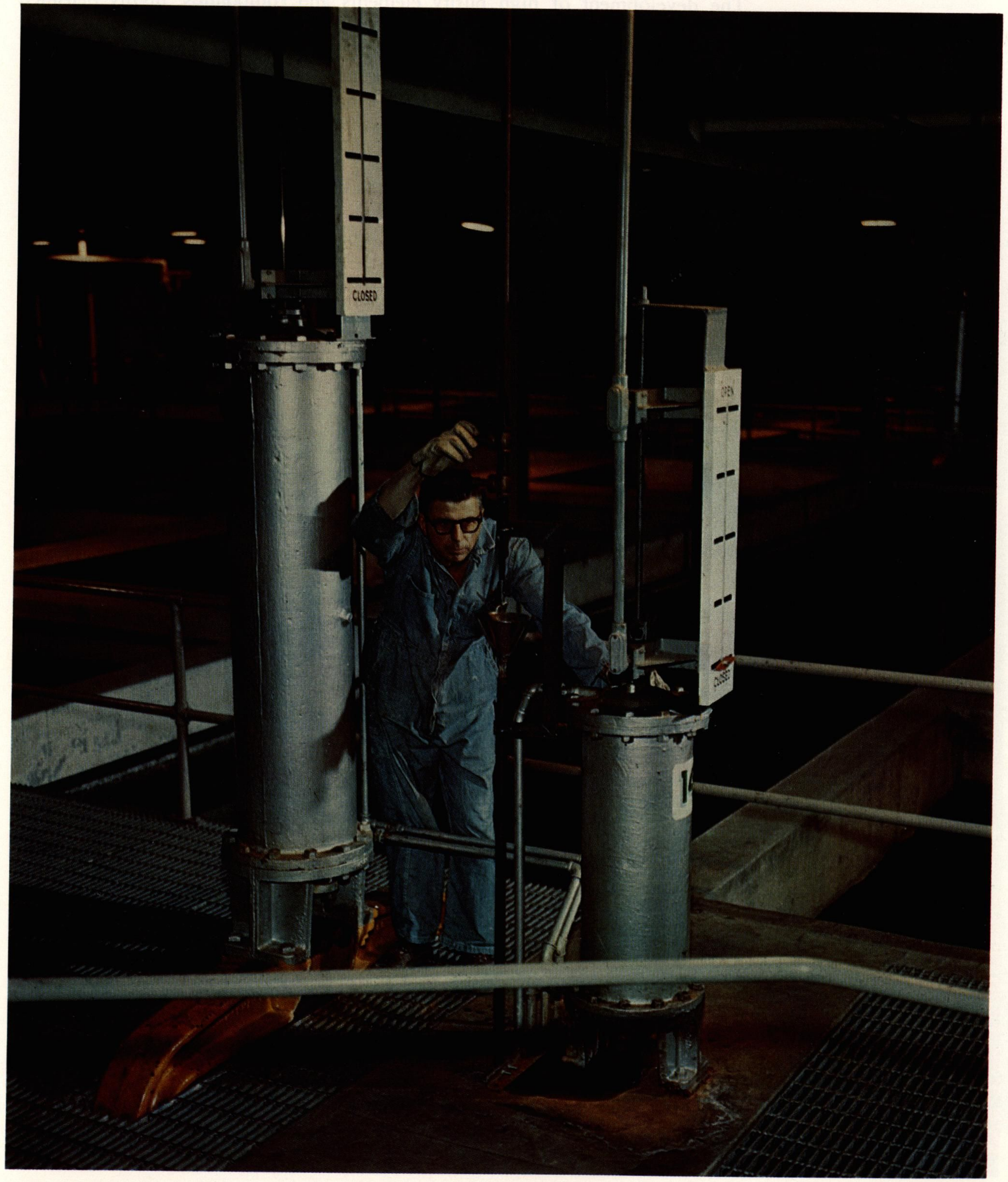
Approximately 40 municipalities from Delaware and North Carolina on the East Coast to Oregon and Idaho in the West now have adopted the new process and communities from New Brunswick, Quebec and British Columbia to the north to Caracas, Venezuela, to the south have installed or are installing this process.

More knowledge of how stream pollution works has been gained because of AEC interest in how readily low-level radioactivity mixes and disperses in streams and estuaries.

AEC studies with radioactive isotopes added as tracers in water, even though in very minute quantities, have produced the first precise data on the rates of dilution in rivers when pollution occurs. The method already has been borrowed by the utility industry for use in forecasting the effect of building a conventional power plant on a river site.

AEC-developed methods of taking core samples from ocean and river bottoms also have been borrowed for work in oceanography.

Pure water requirements for Hanford reactors have led to improved and faster methods of treatment.

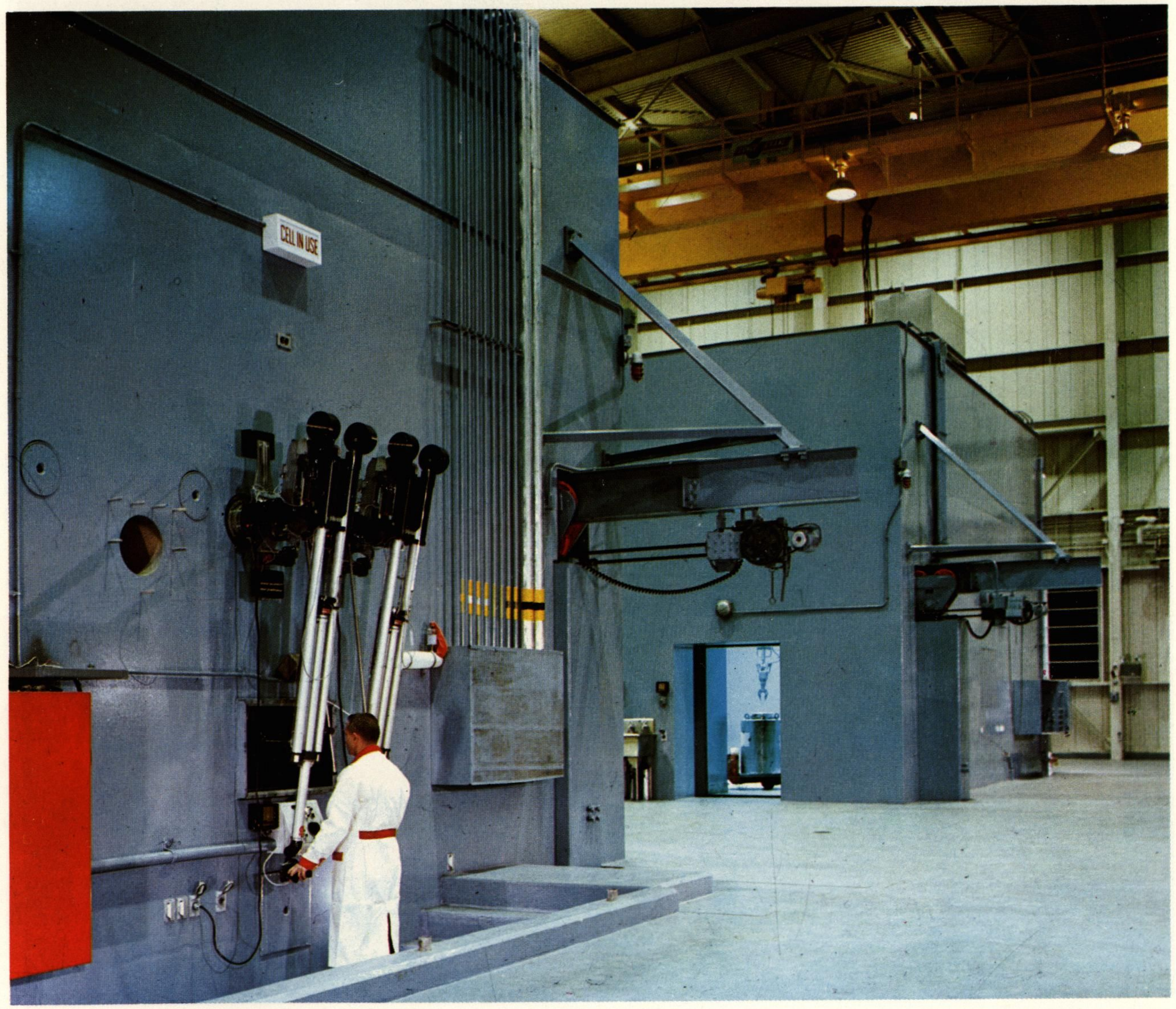


OTHER NEW HELPS TO INDUSTRY FROM ATOMIC ENERGY SPIN-OFF

The development of high purity elements and compounds, highly densified ceramics, a method for testing the strength of metals at high temperatures, advances in high precision measurement, methods for remote handling of dangerous materials, high speed photographic techniques, and new advances in large hole earth drilling are among many significant instances of recent atomic spin-off which have been of direct benefit to non-nuclear industries.

Let us consider the case of improved drilling techniques as an example of these industrial spin-off benefits.

Remote control methods for moving and using highly radioactive sources have been adopted by industries having dangerous materials to handle.



BETTER WELL DRILLING TECHNIQUES

Large hole drilling technology devised for the conduct of the AEC's underground nuclear weapons test program in Nevada has proved to be of major interest to commercial drilling and mining.

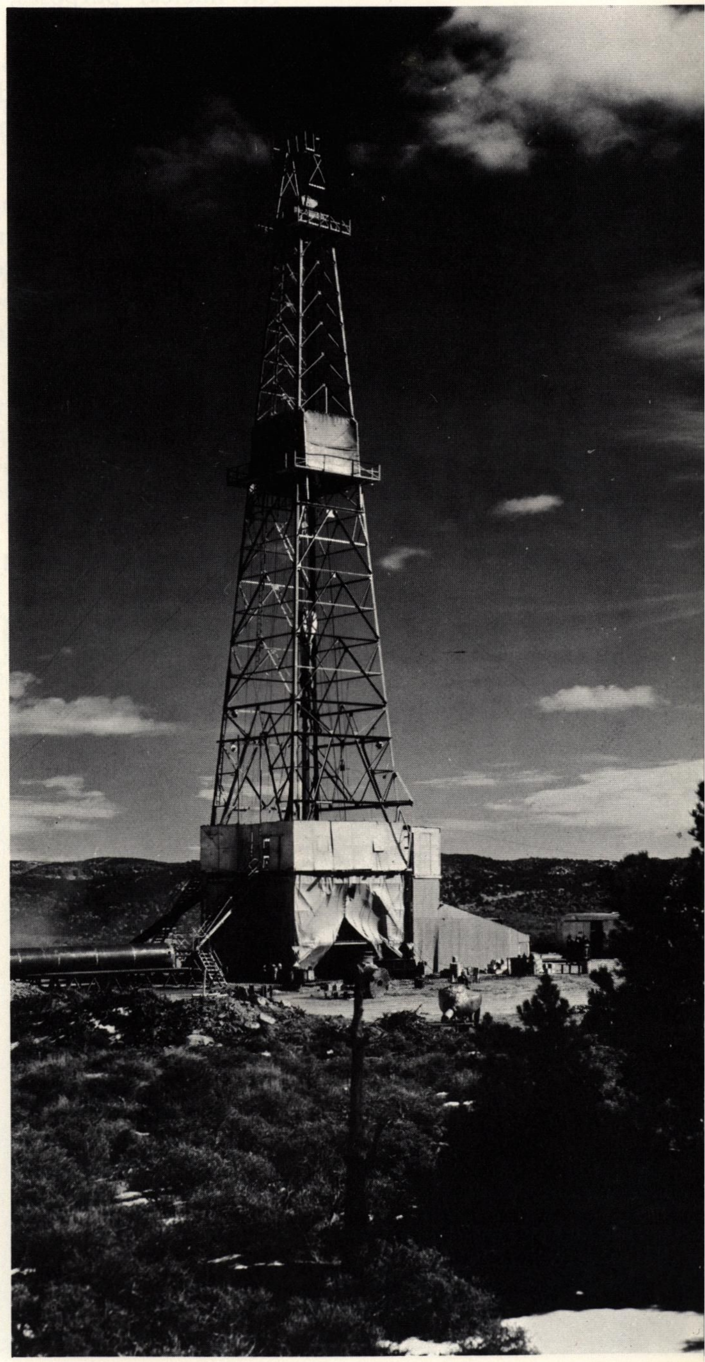
Rigs previously used only for off-shore oil drilling were brought to the Pahute Mesa area of the Nevada Test Site and adapted and used for drilling holes six feet in diameter and nearly a mile deep—the deepest large diameter holes ever drilled.

Holes as large as 13½ feet in diameter and as deep as two thousand feet have been drilled by other equipment at the test site.

Oil and drilling industry leaders have been impressed by the equipment developed on Nevada rigs for handling weights far in excess of what had been considered possible before. One oil company, after studying AEC operations, opened a new field in West Texas where the oil bearing formations are so deep that drilling for oil had not been economically feasible in the past.

Other unique test site developments include a new closed circuit television method of locating and recovering lost bits, piping and other equipment and materials dropped into drill holes; the proposed use of smoother lighter and cheaper plastic drill casing instead of steel casing for deep hole drillings; and the perfection of dual string drilling—i.e., the use of one string of drill pipe inside another for drilling below the water table or in water-filled holes.

Drilling experts from all over the world have watched these advances with particular interest and inquiries have been received from as far away as West Germany and Australia.



Off-shore drilling rigs adapted for land use at AEC's Nevada Test Site have made possible commercial drilling to record depths.

IN THE FIELD OF METALS

Here are some random samples of additional technical spin-off which have proved to be of real interest to industry and, thus, to the civilian economy:

Electron beam welding. It is difficult to weld many metals such as aluminum and zirconium alloys, titanium and columbium. To do so requires the absence of both oxygen and nitrogen.

For nuclear purposes, the AEC's Pacific Northwest Laboratory developed a new method of fusion welding in a high vacuum by the use of high-velocity electrons. The process is now widely used by industry throughout the world for both common and rare metals. Welds are better and, frequently, less costly than with conventional processes.

Metal identifier. During 1958 and 1959, AEC's Oak Ridge National Laboratory was engaged in building a nuclear reactor which required large amounts of Inconel, a corrosion-resistant alloy. Since Inconel is almost identical in appearance to a number of other metals, welders had to have some simple but accurate means of making sure that tubes and pieces of piping they joined were both of Inconel.

Electron beam welding, developed primarily for fabricating nuclear fuel elements, has been adapted for use in all areas of industrial welding.

ORNL staff members thereupon produced a "Metal Identification Meter." The meter at first could identify only metals in the Inconel range, but later was improved so it could identify all metals. In operation, the meter induces electrical currents into the metals to be identified and then sorts metals and alloys according to their electrical conductivity and permeability.

Three new and modified instruments now have been developed after a survey disclosed wide industrial interest in the device. One will identify the alloys of aluminum, another will distinguish from among the alloys of stainless steel, and the third is an advanced model of the "mother instrument" which will identify all metals.

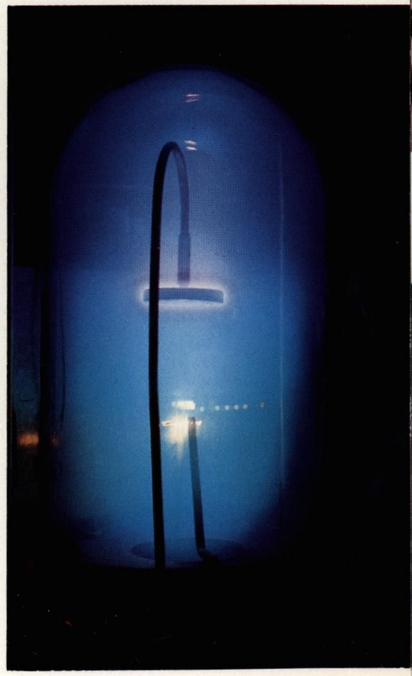
Ion Plating. One difficulty with metal plating is that the metal to be plated frequently gets covered with a gas or oxide that prevents plating material from sticking firmly to it. The AEC's Sandia Laboratory, Albuquerque, New Mexico, found that by bombarding a metal with ions, or electrically-charged particles, it could keep a metal clean and plate it at the same time.

The method makes a stronger-than-ever bond and permits superior plating with such previously incompatible combinations as aluminum on steel or uranium; gold or copper on aluminum; and gold or copper on molybdenum.

This improvement is of special importance to the economy in view of the fact that more metals are being plated these days for a great variety of civilian applications and uses.

What kind of metal is it? A new gadget created for atomic energy needs can identify any type of metal instantly.

Ion plating process developed at AEC lab permits improved metal plating in many industrial processes.



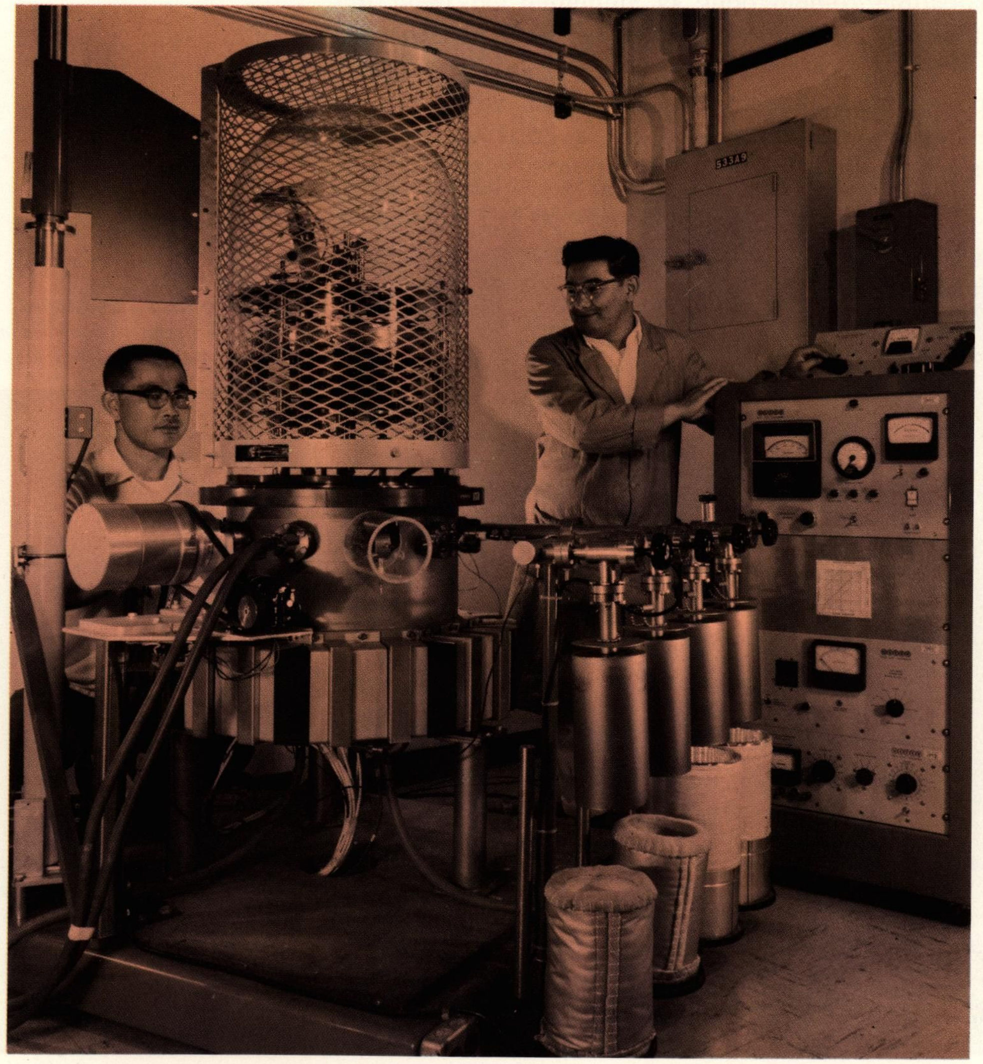
THREE VARIED DEVELOPMENTS

Higher vacuums. Vacuums higher than man had ever been able to achieve were needed in two important AEC programs: construction and operation of accelerators, or "atom smashers" (which scientists use to learn more about the fundamental nature of matter); and work on nuclear fusion (the process by which scientists hope to develop electrical power from the merging of nuclei of light atoms).

Vacuum techniques for accelerators were developed at the Lawrence Radiation Laboratory—operated for the AEC by the University of California—by pushing known vacuum principles to limits technicians had not thought possible. Ultra-high vacuum levels for fusion then were built upon those achieved in the accelerator field.

Now, space scientists have borrowed and advanced these super-advanced vacuum techniques still further—with beneficial "feedbacks" to the accelerator and fusion programs!

AEC high vacuum technology broke the limits set by previous vacuum producing methods.

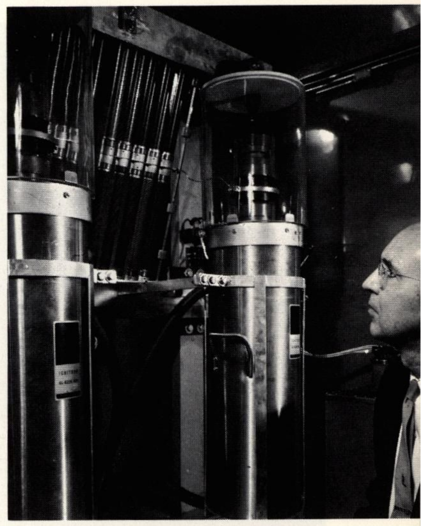


New Electronics Parts. Whenever a new accelerator is developed it invariably is impossible to buy some of the needed radio frequency and other electronic parts. So laboratory engineers or industrial companies working for them must design and build these parts.

As a result, a new accelerator has a large assortment of radio-frequency and electronic components that simply do not exist elsewhere, and these frequently are borrowed for uses unrelated to accelerators.

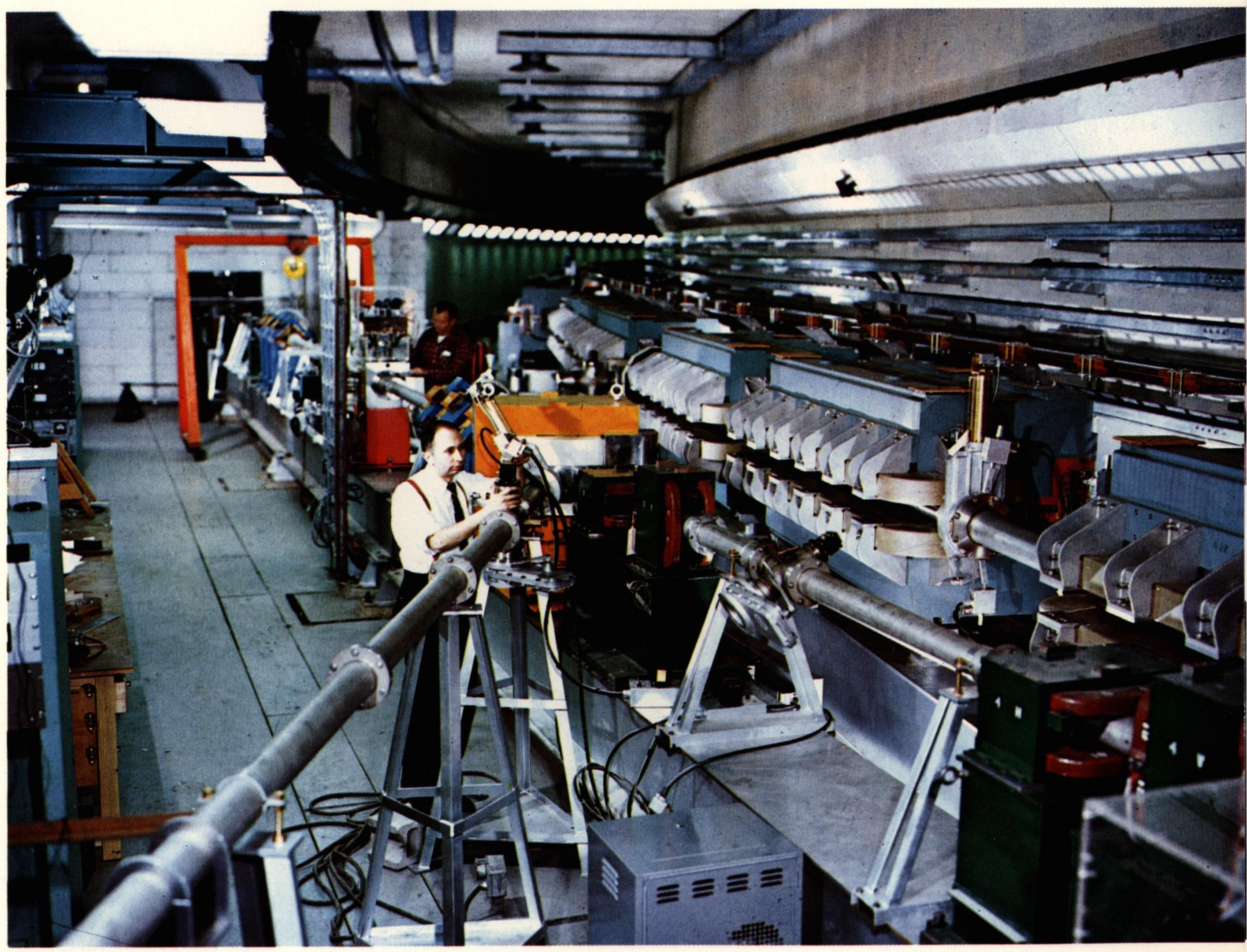
Such a development at the Lawrence Radiation Laboratory, for example, is the "crowbar"—an electrical shunt designed to divert high-power electrical loads in very expensive tubes and thus prevent their accidental destruction. The idea originally was put into practice to protect tubes used in the Lawrence Radiation Laboratory accelerators.

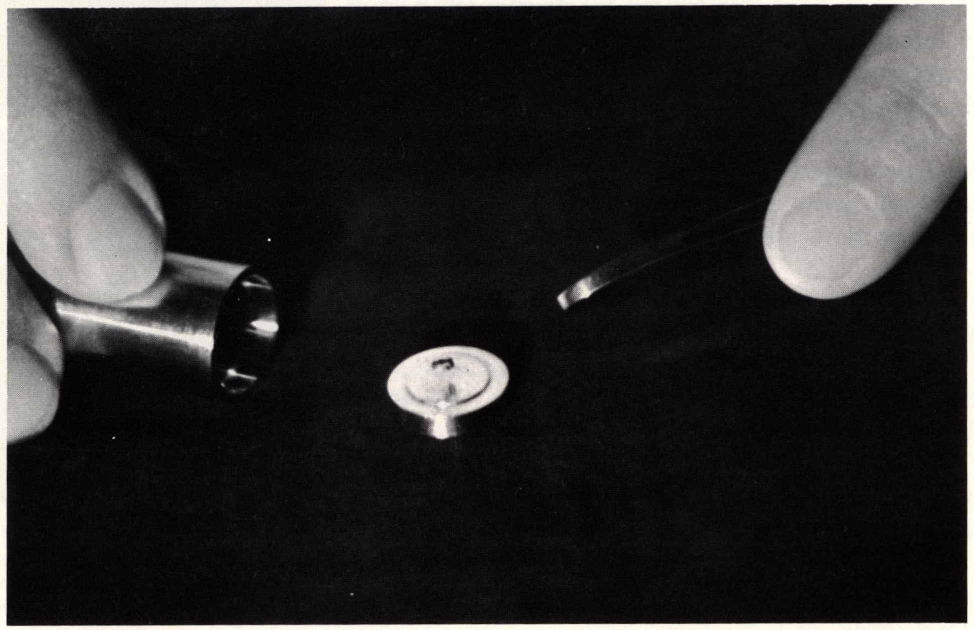
Today, the crowbar is used widely in TV and radio transmission to prevent the destruction of tubes costing many thousands of dollars.



This electrical shunt, capable of diverting power overloads in less than 10 microseconds, now protects expensive TV transmission tubes.

Large accelerators such as Brookhaven National Laboratory's have led to important advances in the electronics field.





An ant is coaxed into the capsule of an atomic energy-developed calorimeter so sensitive it can measure the insect's slightest movement.

Heat measurement. Ordinary thermometers are far too insensitive to measure the heat from some radioactive materials, so super-measuring devices called precision calorimeters were developed at the AEC's Mound Laboratory at Miamisburg, Ohio.

In a test of the heat output of an insect, the calorimeter proved so sensitive that it recorded the heat generated when the insect moved its antennae!

Non-nuclear uses foreseen for these devices are for measuring reaction heats and other properties of materials and metabolism studies in biological research.

The mature Palouse sow at the left weighs 800 pounds. The young Hanford miniatures weigh 110 pounds each.

A NEW BREED OF PIGS FOR MEDICAL RESEARCH

One interesting thing about pigs is that they are similar in many ways to man. Because they eat almost anything, as man does, their gastro-intestinal tracts are about the same as man's. So is their dental structure. Their bone and body mass approximate that of man, allowing for their shorter limbs. Their skin is about the same, being just slightly thicker, but having the same general composition and renewing itself at about the same rate—every four weeks.

Thus, pigs are ideal animals for medical research. Pigs at six months weigh between 160 and 180 pounds—about the weight of an average man. This would make them even more ideal for medical studies except for the fact that they then get bigger—rapidly. At maturity, pigs become hogs weighing 600 pounds or more.

The new smaller breed of Hanford miniatures, similar in size to man, is being used in many beneficial experiments and health studies.

Dental studies are useful since tooth structure resembles man's.

Metabolism experiments add to knowledge of the process in people.

Handling such large animals in medical research obviously would be too much of a chore. Too, a 600-pound hog has lost much of the similarity of mass that makes him so valuable for this kind of study.

So, about five years ago, the AEC's Hanford Laboratory, (now the Pacific Northwest Laboratory) at Richland, Washington, set out to develop a breed of pigs that would reach—and stay at—the average man size of 160 to 180 pounds. Reason for the lab's interest: Such pigs would be invaluable in the study of radiation effects because it could be assumed that the distribution of a dose of radiation in them would be similar to that in man.

By crossing a Palouse sow with a light-colored Pitman-Moore boar, the laboratory succeeded in starting a new strain of pigs—called Hanford Miniatures—that weigh between 160 and 180 pounds at maturity. They have been used at Richland for long-term skin irradiation studies, for external radiation studies where high radiation dosages, body mass and the formation of blood cells were important considerations, and other research. A breeding herd of 100 has been kept at the laboratory to supply increasing demand for the animals—a demand, incidentally, that is threatening to get out of hand!

Now the University of Oregon Dental School is using the pigs in three studies: on braces (pigs have a grinding dental motion as humans do); on studies of cancer of the gum; and on studies of tartar formation.

The University of Colorado and Colorado State University are using the animals in a joint study of heart failures and consequent lung and respiratory changes.

Others using the pigs for research include the U.S. Department of Health, Education and Welfare; Hammersmith Hospital, London, England; Texas A. & M. University; Veterans' Administration Hospital, Salt Lake City, Utah; U.S. Air Force School of Aerospace Medicine, Brooks AFB, Texas; Washington State University; University of Washington Medical School, and Oregon State University.

ELECTRONIC COMPUTERS GREW UP BECAUSE OF NUCLEAR RESEARCH

Electronic computers not only are used today to forecast results on the night of Presidential elections—the use probably most familiar to the greatest number of people—but are being applied in almost every field of human endeavor.

Computers are called upon to predict weather, to compose music, to control complex industrial processes and to direct traffic in large cities.

They are employed for mass processing of scientific data, for all sorts of design calculations in science and industry and for things like customer billing and inventory control in industry and business.

Today's computer industry grew out of needs for the atomic program.

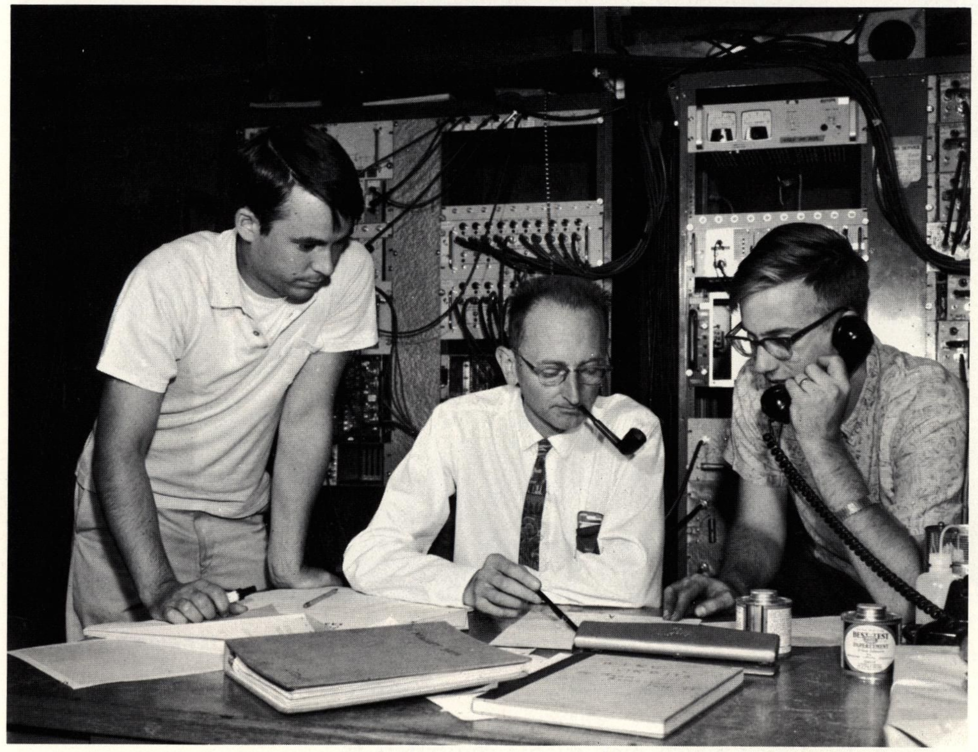
For the future, methods are being developed which may enable computers to carry out many additional functions such as medical diagnoses, translation from one language to another and management of major industrial tasks.

Development of the modern computer began at Harvard University and the University of Pennsylvania during World War II when methods of rapid calculation were needed for artillery firing tables.

But it was the enormous number of calculations needed for the atomic weapons program that spurred the birth of today's highly versatile machine. A key figure in this development was John von Neumann, then a consultant for both artillery work and for the group working on computational problems associated with the bomb.

Von Neumann's basic improvement was his "stored-program" computer in which the sequence of operations can be changed at will without the complicated changes in switch settings and wirings which previously had been necessary.

Von Neumann's principle was developed at the Institute for Advanced Studies at Princeton, New Jersey, with joint AEC, Army Ordnance and Office of Naval Research support. The principle has influenced all subsequent computer designs and become the basis for an industry that now produces equipment at an estimated rate of more than four billion dollars a year. Von Neumann, later an AEC Commissioner, won the first Fermi award—established under the Atomic Energy Act for outstanding contributions to atomic energy—for his achievement.



Young scientists trained in the exacting art of the atom are one of the Nation's great resources for the future.

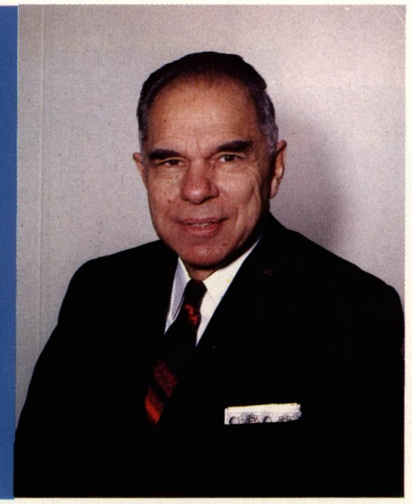
PEOPLE AND JOBS FROM SPIN-OFF

One of the most important technological by-products of basic atomic research is the development of people with highly advanced scientific training. Some of the nation's best minds have been honed and sharpened in tough, fundamental research disciplines in the university graduate studies necessary for careers in atomic energy.

A study at the University of California, for example, has shown that university graduates who earn the Ph.D. degree for work in atomic sciences are highly regarded in government, industry and in academic circles and go on to positions of highest responsibility in these areas.

Other atomic spin-off contributions include the emergence of businesses and industries that never existed before and the employment of people in jobs in these new fields. Examples of these new occupations are the design, construction and operation of nuclear reactors, fabrication and handling of nuclear fuel, design, manufacture and use of nuclear instruments, and basic scientific research. Approximately 185,000 people now have found jobs in such direct and related atomic activities.

Jobs in the nuclear energy industry that never existed before are a prime example of atomic spin-off.



The research and development program of the Atomic Energy Commission continues to advance the practical application of the atom, particularly in the growing number of nuclear energy uses of benefit to mankind. As this booklet has shown, achievements in the nuclear field not only have been of genuine significance to the Nation and to society in and of themselves, but also have resulted in those extra benefits from basic nuclear research and development known as spin-off. Now, as we continue to look for new and useful applications of the atom, I think we can also expect to see new and useful examples of spin-off steadily arising from our nuclear program for the continued enrichment and advancement of our civilian life.

GLENN T. SEABORG
Chairman
U. S. Atomic Energy Commission

☆ U.S. GOVERNMENT PRINTING OFFICE : 1966 O—214-715

SUMMING UP

Whether of direct benefit to the consumer, as in the case of improved color television reception, or of indirect benefit to him through help to business and industry, spin-off from atomic energy already has made substantial contributions to civilian life.

One happy side result has been that the taxpayer has gotten added value for each of his dollars spent for atomic energy research and development. It's a kind of spin-off from spin-off, so to speak, an Atomic Bonus.

Now the Atomic Energy Commission, working in cooperation with U.S. industry and with other government agencies, is attempting to find still better ways to accelerate application of its technologies to the civilian economy. Here are some recent steps in this direction:

1. The AEC and the Small Business Administration have begun a cooperative effort to explore ways to transfer technology to small business more effectively.

2. The AEC is cooperating with the National Aeronautics and Space Administration in a program to bring useful innovations to the attention of industry.

3. The AEC has begun a cooperative program with the Clearing House for Federal Scientific and Technical Information of the U.S. Department of Commerce for more effective announcement of AEC reports to industry and for preparation of selected reviews and bibliographies of industrial significance.

The goal is to make sure that no basic advances that have potential benefit to the over-all civilian economy will be overlooked.