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Ten-Color Atlas Map, Poland and Czechoslovakia

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Abundant energy released from the hearts of atoms promises a vastly different and better tomorrow for all mankind

YOU AND THE OBEDIENT Atom

By ALLAN C. FISHER, JR.,
Senior Editorial Staff, National Geographic Magazine

THOUGH man may reach for the moon and the planets, he has found the richest of all new worlds behind the familiar face of his everyday environment. Here, deep in the mysterious cosmos of inner space, lies that world within a world, the powerful, obedient atom.

So small are nature's basic building blocks that you could put 36 billion billion atoms on the head of a pin. Yet these unimaginably tiny particles work like genii at man's bidding. Their peaceful energy is gradually shaping our world into a far better place.

Atom Surveyed Across the Nation

To bring you this story of the atomic revolution, National Geographic representatives have been at work two years in research and industrial installations all over the United States. Editors reviewed thousands of photographs. Artists, advised by distinguished physicists and engineers, illustrated what the camera could not capture—the subatomic dramas, fission and fusion.

Meanwhile, chief photographer B. Anthony Stewart journeyed 12,000 miles with me for a thorough, over-all look at the Atomic Energy Commission's peaceful program. We toured vast research centers, visited nuclear power plants and private industries, and talked to scores of scientists who are pioneers on this new frontier of knowledge.

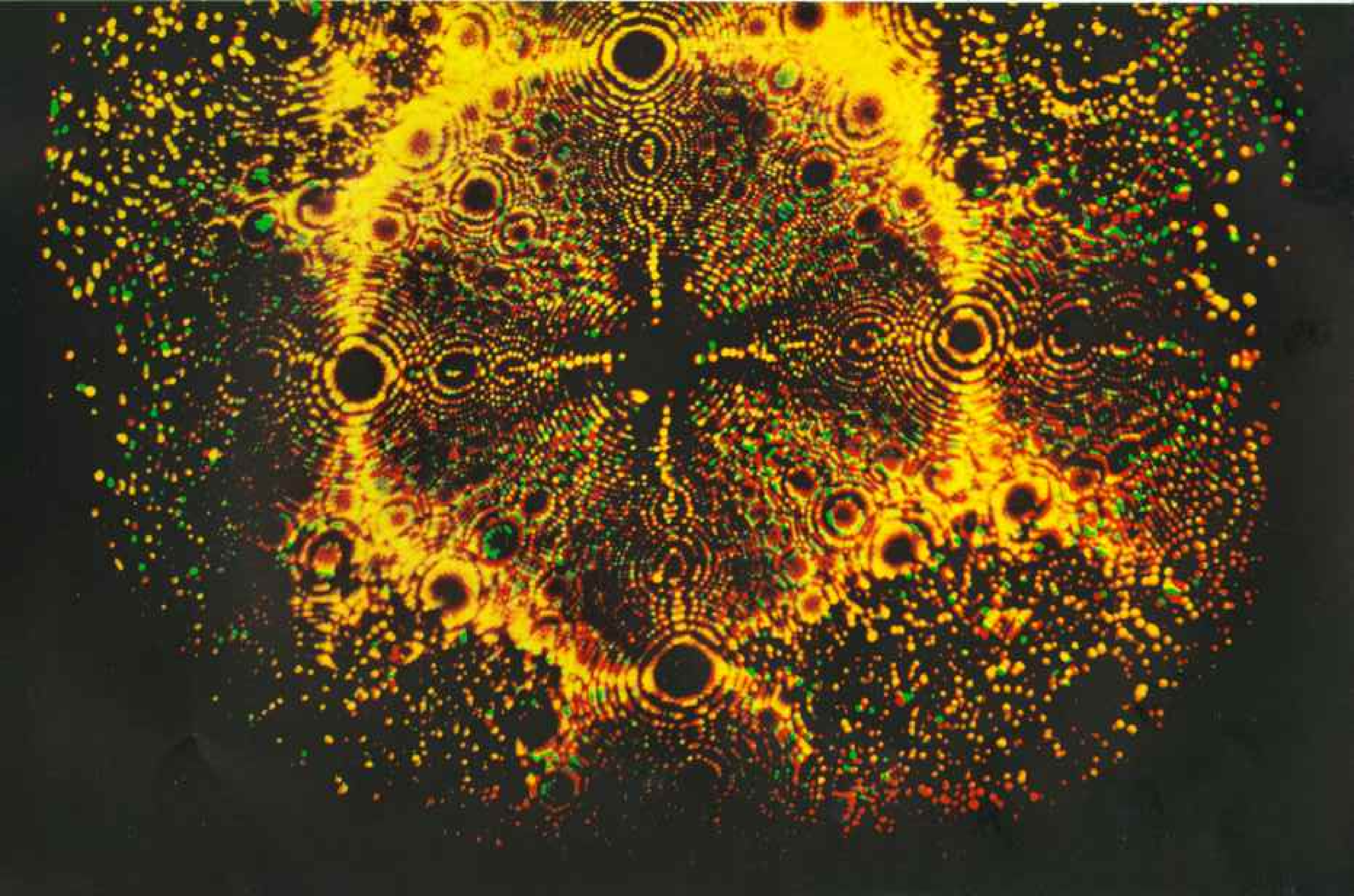
Pioneering within the atom, as in nature's wilderness, seems to be a young man's pursuit. Many nuclear scientists look youthful enough to pass for students. Frequently they show a flair for pithy, colloquial speech, as I discovered at our first stop, Oak Ridge National Laboratory in Tennessee.

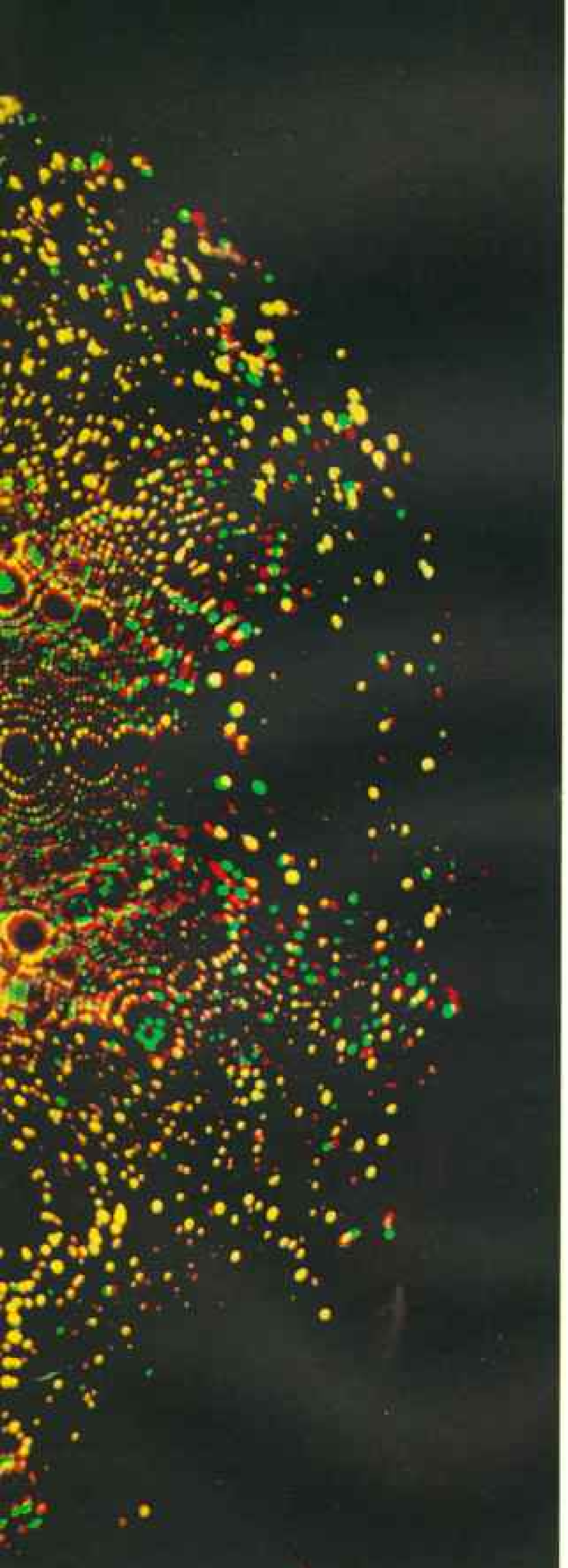
Oak Ridge is one of the Nation's largest atomic centers, a 55,000-acre reservation carved from farmland and oak-covered hillsides during World War II. Here Tony Stewart and I, after obtaining passes from courteous but hard-eyed guards, sat at luncheon with seven physicists and engineers.

They were a clean-cut lot, casually dressed in sport shirts and slacks. I felt like a visitor to a college campus who finds himself surrounded by disturbingly precocious freshmen. My questions, I feared, would be answered in a patois of Greek and mathematical equations. Then a young man on my right spoke.

"Atomic energy uses? Let's tick them off. Electric power: a big effort getting bigger. Ship propulsion: very promising—look at the Navy's submarines. Aircraft propulsion: something for the future. Fusion energy: possibly far off, but extremely important. Last, the real plum of the program: radioisotopes. They have a thousand applications, particularly in agriculture and medicine."

That capsule description, I later found, could stand as a general outline for this story.





Whole Galaxies of Atoms Glitter in a Single Crystal of Metal at the Tip of a Platinum Needle —Magnified 750,000 Times!

As man stands on the threshold of the nuclear age, he looks forward to a day when all life will be altered, made easier and more fruitful by his conquest of the atom. Nuclear fuel, a substitute for earth's dwindling stores of coal, gas, and oil, promises unlimited power for electricity and the propulsion of ocean liners and aircraft. Eventually atomic power may carry man to the other planets. Scientists have already used radioactive atoms to improve crops and livestock, simplify industrial procedures, attack cancer and other diseases, and pioneer in new fields of research.

Yet, until recently, no one had ever seen one of these familiar, basic particles of matter; even the most powerful microscope had failed to bring them within the scope of the human eye.

Now Dr. Erwin W. Müller, a physicist at Pennsylvania State University, has succeeded for the first time in showing us the face of this newest of mankind's servants. Dr. Müller cools a platinum needle almost to absolute zero (minus 459.69° F.), where atoms cease the whirling dance that produces the phenomenon known as heat. Then by a complex process akin to that in which speeding electrons create a picture in a television tube, actual atoms are magnified 750,000 times and revealed as blobs of light on a fluorescent screen. If the two pages on which this picture is printed were enlarged to the same degree, they would reach from New York to Boston!

The particles, being 1,000 times smaller than a wave length of light, have no color of their own. To create this dramatic effect, Dr. Müller photographed the needle tip as it was projected on the screen, and then copied the negative in green light. Then, using electricity, he stripped away some atoms and rearranged others. Another photograph was made and copied in red light, and the two color images were combined. Atoms that were unchanged during both exposures look yellow—the sum of red and green light. The green dots represent atoms present in the first picture but removed before the second; red shows particles rearranged between exposures.

Dark holes do not represent empty space, but tightly packed atoms at lower levels in the crystalline structure of a needle tip fifteen millionths of an inch in diameter.

Ansnelamne by Erwin W. Müller

A GLOSSARY FOR THE ATOMIC AGE

ACCELERATOR. A machine that speeds up electrically charged particles for use as atom-smashing bullets and as research tools.

ALPHA RAYS. Particles constituting the least penetrating form of radiation. Can be stopped by paper.

ATOM. Smallest unit into which an element can be divided without losing its distinguishing characteristics. Electrically neutral, though its parts carry charges.

BETA RAYS. Nuclear particles intermediate in penetrating power between alpha and gamma rays.

CHAIN REACTION. Splitting atoms release neutrons that in turn split other atoms in a self-sustaining process. See fission.

CRITICAL MASS. Amount of nuclear fuel, such as uranium, needed to set up a chain reaction.

DEUTERIUM. Heavy isotope of hydrogen. Mixed with oxygen, it forms heavy water.

DEUTERONS. Nuclei of deuterium atoms.

ELECTRONS. Smallest major constituents of an atom. Negatively charged, they orbit around the nuclei, giving atoms their chemical properties.

ELEMENT. The raw material of all matter. Each of the 92 natural and 10 man-made elements consists of only one type of atom with its related isotopes.

FISSION. Process in which the nucleus of a heavy atom splits when it encounters an extra neutron, releasing energy and other neutrons. If enough fissionable atoms are present to constitute a critical mass, the reaction can become self-sustaining, as in the atom bomb (page 314).

FUSION. Reaction in which energy is released when nuclei of two light atoms are briefly welded together (page 320), as in the hydrogen bomb.

GAMMA RAYS. Most penetrating form of nuclear radiation. Consist not of particles, as alpha and beta rays, but of waves like X rays.

HOT. Dangerously radioactive.

ION. Atom which has gained or lost electrons, thereby acquiring an electrical charge.

ISOTOPES. Forms of the same element having identical numbers of protons and electrons—thus being identical electrically and chemically—but with varying numbers of neutrons, hence differing in weight. U-235 and U-238 are both isotopes of natural uranium, one having three more neutrons than the other.

MOLECULE. Generally, two or more atoms forming a stable compound such as H_2O—two atoms of hydrogen and one of oxygen—a molecule of water.

NEUTRONS. One of two major types of particles making up the atomic nucleus. Electrically neutral.

NUCLEUS. Heart of the atom. Made up of neutrons and protons, its positive charge is neutralized by orbiting electrons.

PARTICLES. Subatomic units of matter: among others, protons, neutrons, electrons.

PROTONS. With neutrons, make up atomic nuclei. Equal neutrons in weight, but are electrically positive.

RADIATION (RADIOACTIVITY). Emission of atomic particles or rays by nuclei of unstable atoms. Rays thus released can penetrate and change matter.

RADIOISOTOPE. Radioactive form of an element.

REACTOR. Nuclear furnace heated by fission.

Another scientist, sporting a crew cut, contributed a breezy general observation.

"New discoveries bring new problems; so this business changes from month to month. We may not always know where we're headed—how could we? But, wherever it is, we seem to be getting there jet propelled."

This exuberant figure of speech is not as extreme as it might appear. Admittedly, a number of observers, including some industrialists and Congressmen, believe the atomic energy program is not moving either fast enough or far enough in some fields. Yet it has been not quite 16 years since the late Enrico Fermi and his colleagues achieved the first sustained nuclear chain reaction. Compared with previous technological revolutions, this is a mere moment in time.

Today only a few nations, principally the United States, Great Britain, and the U. S. S. R., can claim well-advanced programs for harnessing the atom. However, the bright potential for all men is abundantly evident. This September the United Nations sponsors its Second International Conference on the Peaceful Uses of Atomic Energy at Geneva, Switzerland, with more than 2,000 delegates exchanging knowledge and ideas.

Atom Power Plants Now a Reality

In 1954, when The National Geographic published an early survey of the peaceful atom, privately operated power plants using nuclear energy were merely bright dreams on paper.* In the United States three such plants now generate electricity for homes and industries, four additional ones are under construction, and 11 more are planned. All have been licensed by the AEC, which assists in their planning and, usually, their financing. The figures do not include the AEC's own experimental power program, which encompasses a number of prototypes now producing power for Government installations. Their reactors, or atomic furnaces, represent half a dozen different approaches to the problem of economical nuclear power.

An atom-powered merchant vessel, the N. S. (Nuclear Ship) *Savannah*, will cruise the ocean highways by 1960. A tanker, now building, may be converted to nuclear energy, and other projects are in the study stage.

Companies engaged in this peaceful pursuit owe a large debt of know-how to the United States Navy. The nuclear submarine

* See "Man's New Servant, the Friendly Atom," by F. Barrows Colton, National Geographic Magazine, January, 1954.

Rotochrome by National Geographic Photographer Thomas J. Abercrombie © N.G.S.

Metal Fingers Clutch a Deadly Pill; 30 Inches of Liquid Shield the Man

A Bakelite-encased uranium sample undergoes analysis at Argonne National Laboratory, near Chicago. The magnifying glass, held by another mechanical hand, inverts the technician's face. Glass plates 30 inches apart hold a solution of zinc bromide that absorbs gamma radiation. The camera was inside the chamber.

Nautilus cruised Jules Verne's fabled 20,000 leagues on only one loading of uranium, and two other atom subs are now operating. The Navy's atomic program includes 19 additional submarines, an aircraft carrier, and a guided-missile cruiser.

Adm. Arleigh A. Burke, Chief of Naval Operations, has said:

"Perhaps ten to fifteen years from now we will have several hundred ships with nuclear power. We will develop, I am sure, nuclear power plants suitable for small ships."

Aircraft propulsion represents a far more complex problem, and here progress has been spotty and relatively slow. A nuclear-powered plane has yet to be built, although a number of aircraft reactors have been ground tested. As of today, any civilian application seems distant, though I found plenty of optimism for the future utility of atom jets, ramjets, and rockets.

Project Sherwood, the AEC's fusion program, is still in the laboratory experimental stage. But scientists see glittering promise in thermonuclear energy—the joining together of hydrogen atoms at temperatures of millions of degrees, as in the sun, where the process occurs naturally. Fusion represents the antithesis of fission, the splitting of atoms, principally uranium.

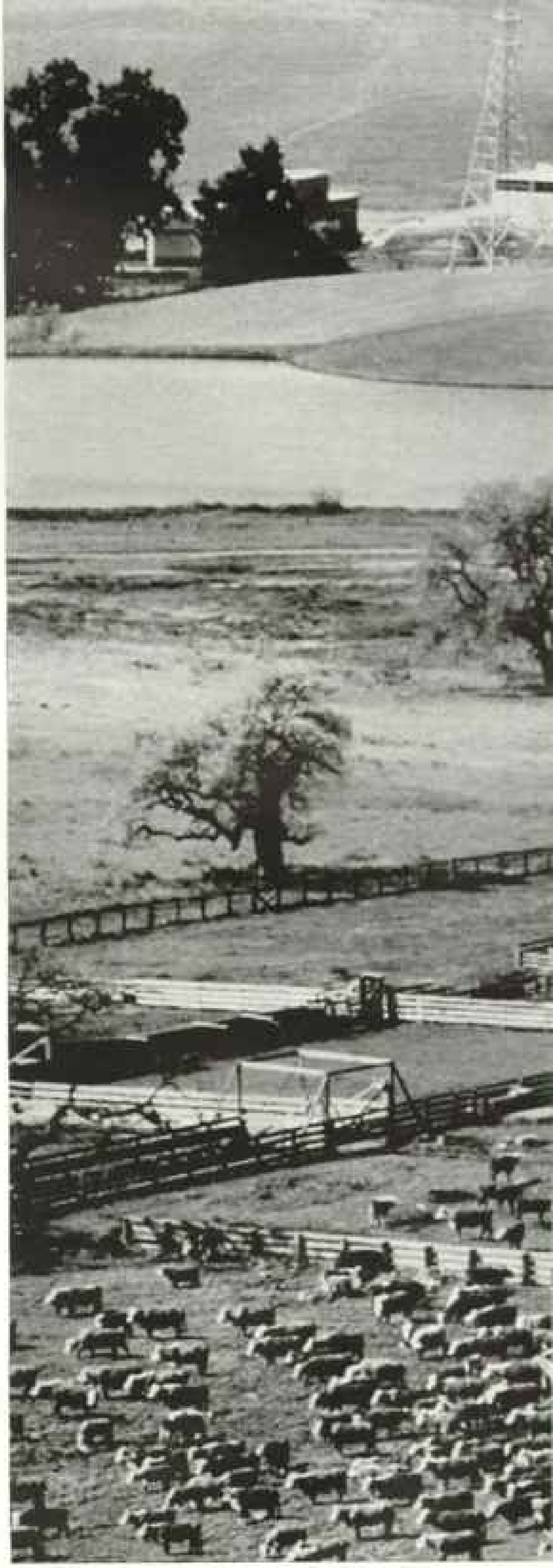
"Hot" Atoms Save Vast Sums

To date, radioisotopes are, indeed, the plum of the program. Dr. Willard F. Libby, an AEC Commissioner, estimates that these tiny bits of "hot" matter saved United States industry $500,000,000 in 1957 by improving various processes. These savings, he believes, will reach $5,000,000,000 annually in 10 years, more than twice the entire yearly cost of the AEC's present program, including defense.

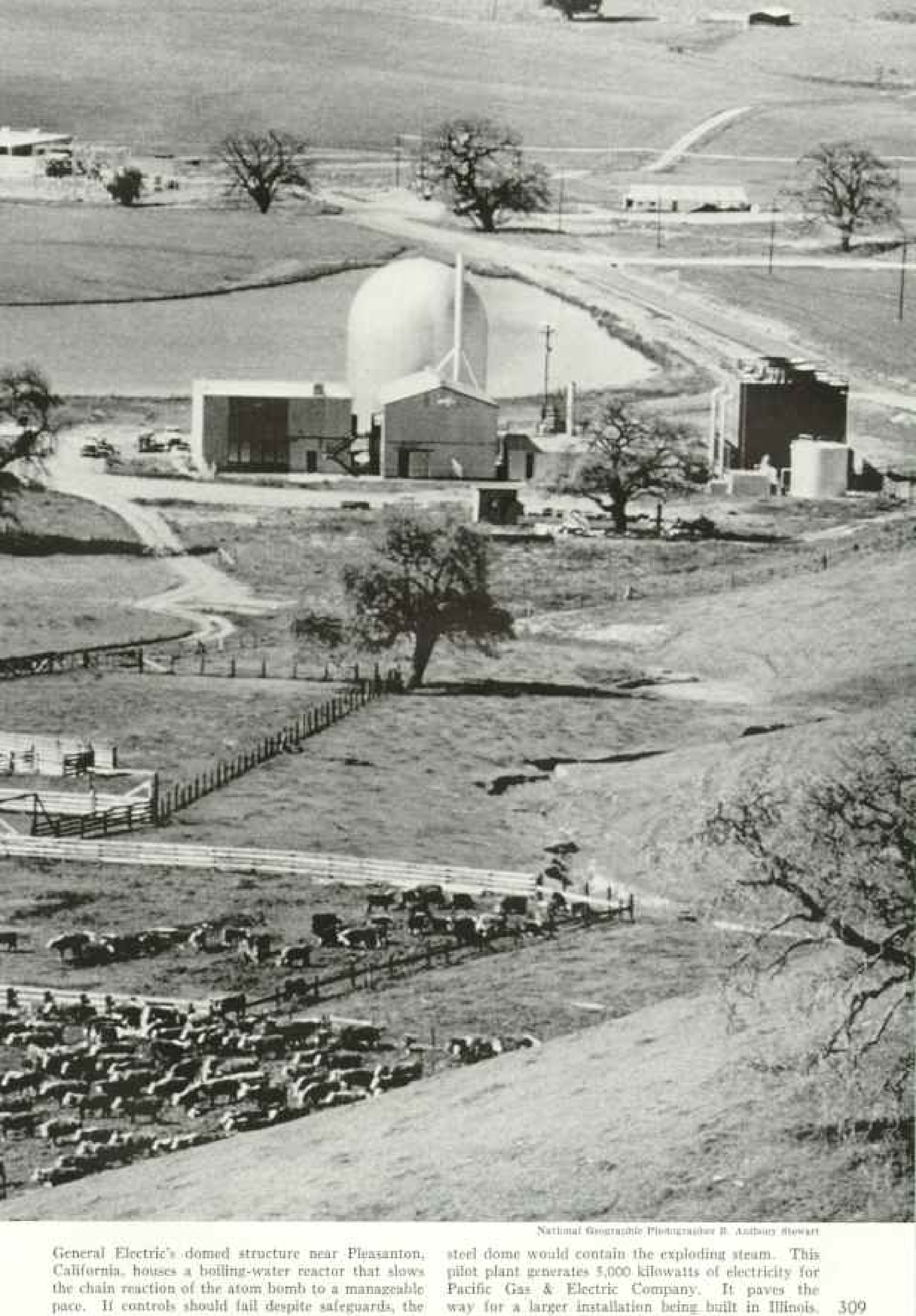
Radioisotopes are atoms that have been made radioactive. They emit unseen but powerful and easily detectable rays; hence their unique value. Physicians and scientists use this radiation for medical therapy (page 334) or to trace the complicated paths of chemicals within living organisms (page 331). Industry harnesses the isotopes in many ways, for example, to control the thickness of materials or to make X-ray pictures revealing structural flaws (page 337).

The very paper on which you read these words was manufactured to a precise thickness of 3/1000 of an inch by using a scanning gauge containing radioactive thallium. The gauge works in this fashion:

Mounted atop a machine, the scanner

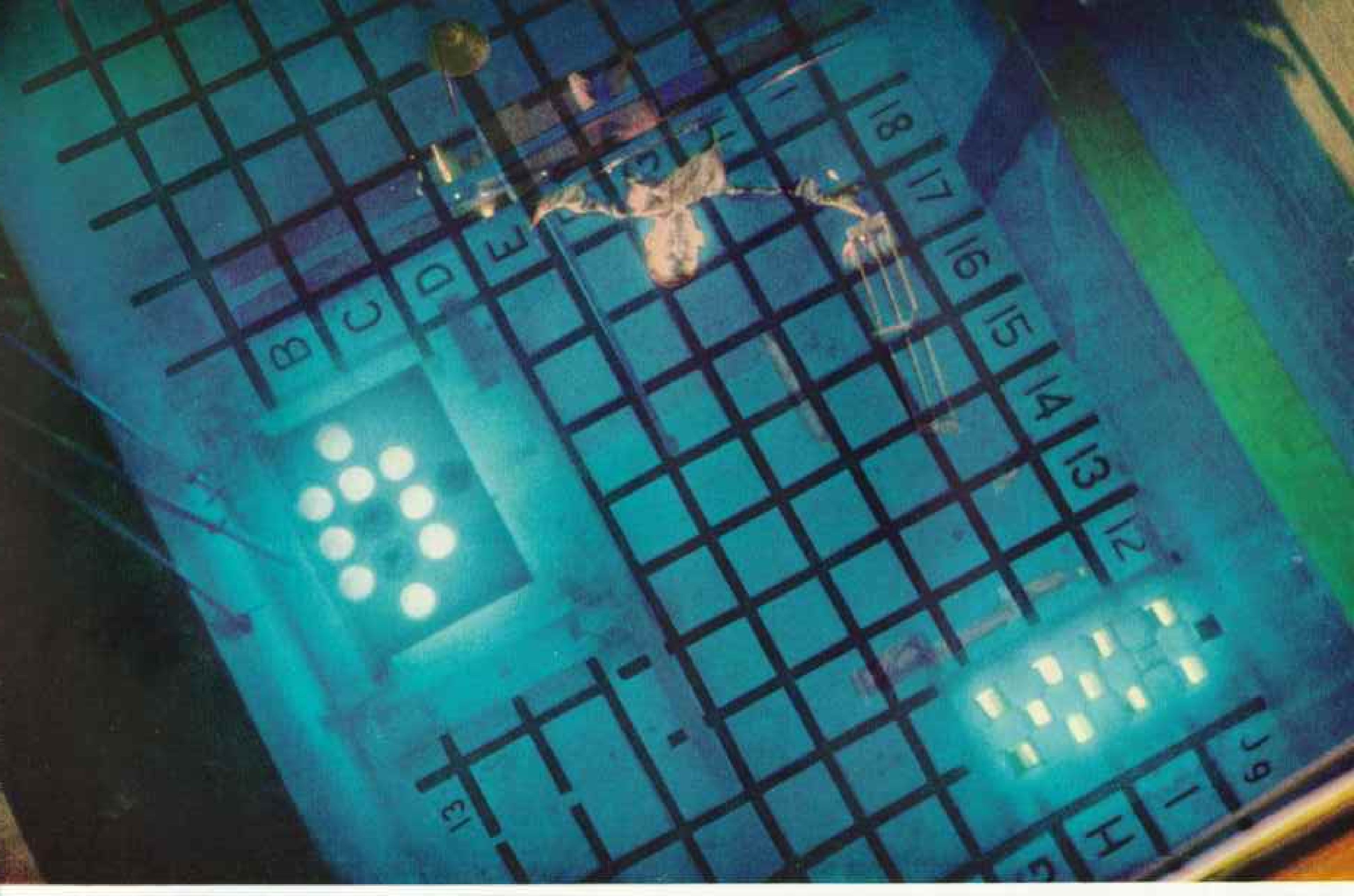


Cattle Graze Beside Vallecitos Laboratory, a Home of the Peaceful Atom



National Geographic Photographer B. Anthony Stewart

General Electric's domed structure near Pleasanton, California, houses a boiling-water reactor that slows the chain reaction of the atom bomb to a manageable pace. If controls should fail despite safeguards, the steel dome would contain the exploding steam. This pilot plant generates 5,000 kilowatts of electricity for Pacific Gas & Electric Company. It paves the way for a larger installation being built in Illinois.



Irradiated Water Glows a Baleful Blue at Argonne Laboratory

The camera looks down into a pool where 17 feet of water covers luminous containers of spent uranium. Dark canisters beside the lower group hold food, oils, plastics, and other materials undergoing radiation tests. For lesser doses, technicians place materials in outlying squares. Scientists have computed the strength of radiation in each of these numbered-and-lettered locations. The water shields personnel from gamma rays. Here it reflects the ghostly operator who stands on a metal bridge.

The blue glow, known as the Cerenkov effect, takes its name from the Russian scientist who discovered it. When gamma rays strike the water, excited electrons emit energy visible as blue light.

Bombarded Foods Stay Germ-free as Others Rot

Using gamma rays to destroy micro-organisms that cause decay, the Army Quartermaster Corps preserves foods for weeks and months at room temperatures. When exposures are light, changes in taste are scarcely noticeable; gamma radiation does not linger.

Foods irradiated in Argonne's pool (left) and elsewhere were first fed to rats, without harmful effect. Later, military volunteers tried samples. Congressmen have eaten entire gamma-sterilized dinners.

Both samples of frankfurters were kept three months in air-tight plastic wrappers. Irradiated meat on right looks as fresh as ever. A potato sprouts six months after harvesting; in its opposite, sprouting is delayed. Treated oranges stay fresh and juicy. Moldy bread contrasts with a two-month-old treated loaf. The Food and Drug Administration has not yet certified gamma-treated foods for the market.

Monochrome (left) by National Geographic Photographer Thomas J. Abercrombie and Ektachromes by Gervase A. Arndt © N.G.S.

National Geographic Photographer Thomas J. Abercrombie (above) and U. S. Department of Commerce

Atom-powered supertanker model goes on display in Chicago. The proposed ship would weigh 30,000 tons and deliver 20,000 horsepower. Atomics International, the designer, intends to use a liquid hydrocarbon, oil-like in appearance, to circulate heat from the reactor. American engineer Edward G. Lowell (left) explains the model to Victor Spitsyn, a Moscow scientist.

Nuclear Ship *Savannah,* under construction for 1960 delivery to the U. S. Maritime Administration, will carry 60 passengers and cruise at 20 knots, refueling only once every two to three years. Pressurized water will distribute the reactor's heat to the ship's boiler. This model has been attracting attention in the U. S. pavilion at the World's Fair in Brussels.

beams beta rays through a fast-moving web of paper emerging from rollers. An electronic radiation detector picks up the beam. If the thickness is too great, the beta signal weakens; if too thin, it grows in strength. Automatic controls then readjust the paper-making machine to the desired thickness.

All of these uses stem from the magic in uranium, a metal unique among nature's elements. When struck by neutrons, the nuclei of some uranium atoms will split, emitting still other neutrons and releasing energy. If enough of this unstable material is brought together in a "critical mass," the fission, or splitting, process will continue in a chain reaction (page 314).

Splitting Atoms Emit Lethal Rays

Despite its utility, fission is often called "a filthy process." Atoms emit lethal rays when they rend one another, and radiation may linger for many years in the nuclear fragments. Featureless walls of concrete, or huge, water-filled tanks, shield that specialized furnace, the reactor.

Protection of personnel is a never-ending problem, but health specialists of the AEC and its contractors maintain an excellent safety record. There have been remarkably few cases of serious radiation exposure in the peaceful program, and none proved fatal.

A cryptic conversation I overheard at Oak Ridge will illustrate how the industry protects its own. I was standing outside a shielded chamber called a "hot cell," used for remote dissection and examination of spent fuel (page 307). Uranium is sometimes pyrophoric—inclined to catch fire spontaneously—and there had been a small but merry blaze in the cell when mechanical hands guided a power saw into the fuel specimen. Now someone had to enter, with protective clothing, and clean up the mess (page 353).

Efrem Schwartz, chief of the cell's crew, managed a wry grin and gestured toward his offending chamber.

"A can opener that cost a quarter of a million dollars—and now, for a while, we can't use it. You know what I am? I'm a physicist by training and a hot janitor by profession."

His boss, Stewart Dismuke, joined us, and the two young scientists began discussing the cleanup problem. Their conversation follows:

Dismuke: "How do you stand on the list?"

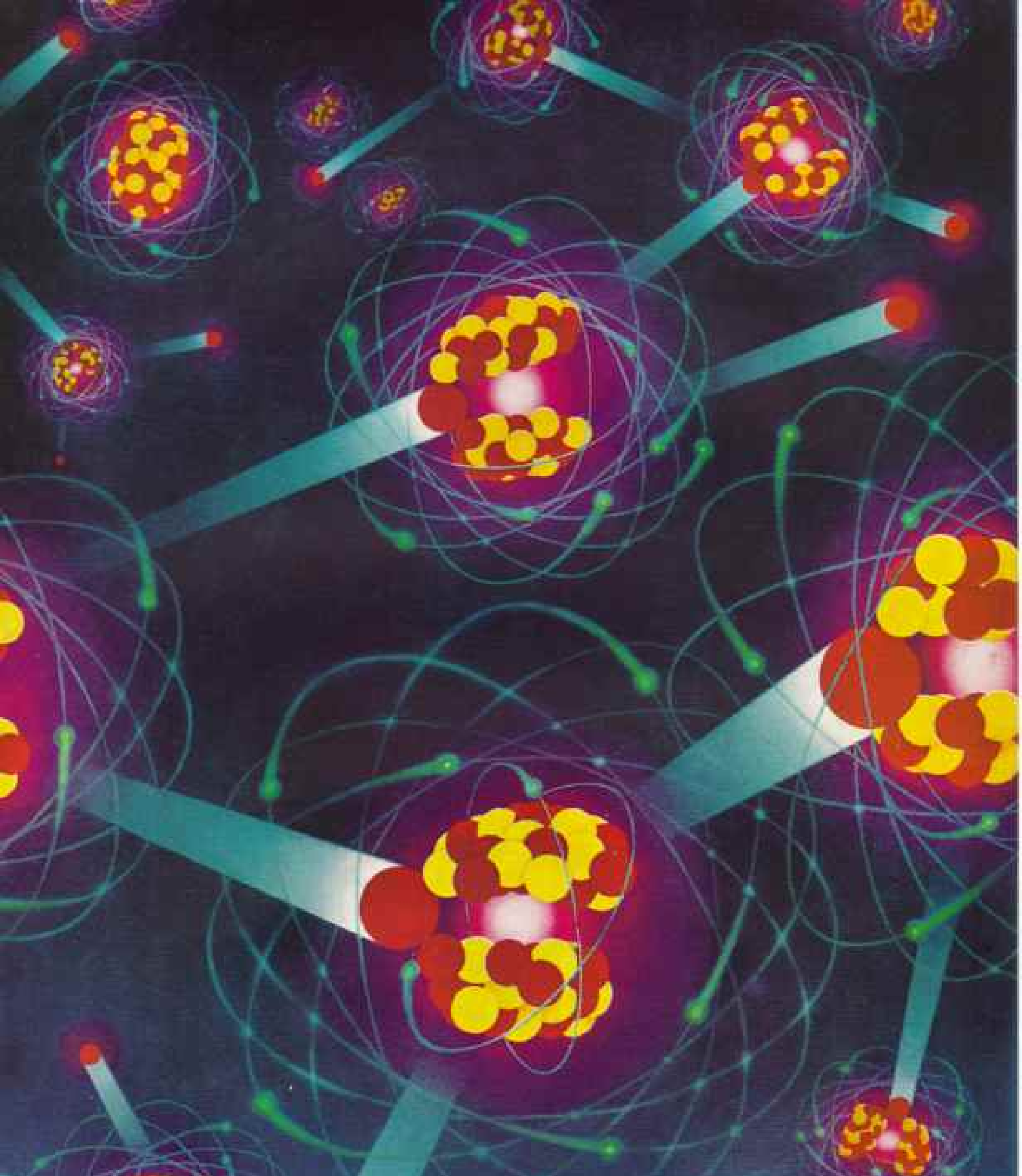
Schwartz (with an eloquent shrug): "I'm burned up."

Dismuke: "Is Sims still high?"

Schwartz: "Yeah, he's high."

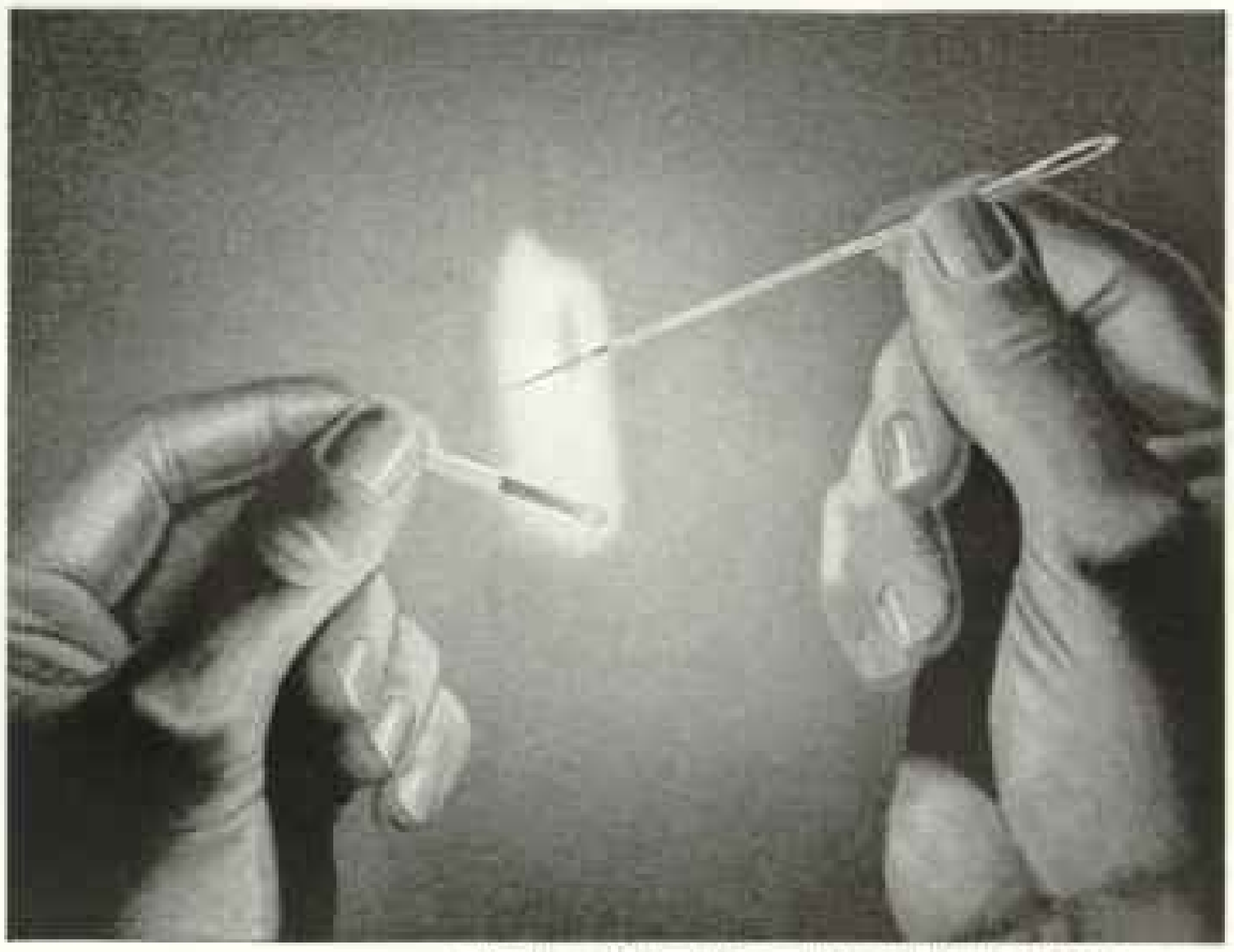
This exchange might have been spoken in Swahili for all it meant to me; so I sought interpretation.

AEC rules require that cumulative records be kept, showing for each worker the amount of exposure to radiation. No employee may exceed in one week's time a certain total dose—far below the level believed dangerous.



Match and Needle Illustrate Heat: Atoms in Continual Motion

Heat's nature mystified man until atomic theory explained it about a century ago. Temperature rises as dancing atoms and molecules collide and transfer energy to one another. In the steel needle, atoms at the cold end move at 800 miles an hour; at the hot end, 1,200 miles. Paper in the match releases energy through chemical reaction, a recombination of elements. Uranium (opposite) frees energy by fission—splitting its atoms into other elements.



Drawing by National Geographic Artist Gilbert H. Emerson

Schwartz's phrase, "burned up," was simply a slang expression meaning that he had reached the maximum permitted him that week. An office listing showed that Sims had very nearly reached the permissible total, and he, too, was unavailable for cleanup duty. But a "low" man volunteered, and the cell soon went back into service.

Two Kinds of Uranium Work for Us

Uranium's unique ability to destroy itself for the benefit of mankind is not difficult to understand.

This heavy metal not only splits itself, it also possesses what might be termed a split personality, since there are two twinlike, yet perversely different, uranium atoms that serve man.

One, uranium-235, binds 143 neutrons and 92 protons in its nucleus. The other, U-238, holds 146 neutrons and 92 protons.

Chemically these atoms are indistinguishable. The same number of negatively charged electrons—92—spin planetlike around their nuclei, and electrons determine the atom's chemical properties.

But the nuclei do not contain the same number of neutrons, so they differ in mass. We call such seeming twins "isotopes," from Greek words meaning same and place. Many other isotopes occur naturally among the other elements. Men make additional ones—some stable, some radioactive—by splitting uranium or by bombarding materials so that they absorb extra neutrons.

The small difference in the mass of the two uranium atoms may not seem important—but that's where their perversity asserts itself. Only U-235 will split readily.

Unfortunately, U-238 is 140 times more plentiful in nature than U-235. The AEC separates them by gaseous diffusion, a process based upon their slight dissimilarity in weight.

One might assume that U-238 ends up on a dump heap. However, it boasts a magic of its own. If one of its atoms absorbs a neutron, two electrons fly out; then the atom becomes the new element, man-made plutonium. In similar manner thorium changes to U-233, also nonexistent in nature.

Both these new elements, bred in reactors, will split. Both seem promising as peacetime fuels, though plutonium today is used chiefly for bombs.

If the bomb's symbol is a malignant mushroom cloud, the symbol of peaceful use of the atom in this country might well be an unpretentious-looking structure beside the Ohio River near Shippingport, Pennsylvania. This building houses the Nation's first full-scale nuclear power plant for civilian use. There I saw the atom controlled and harnessed.

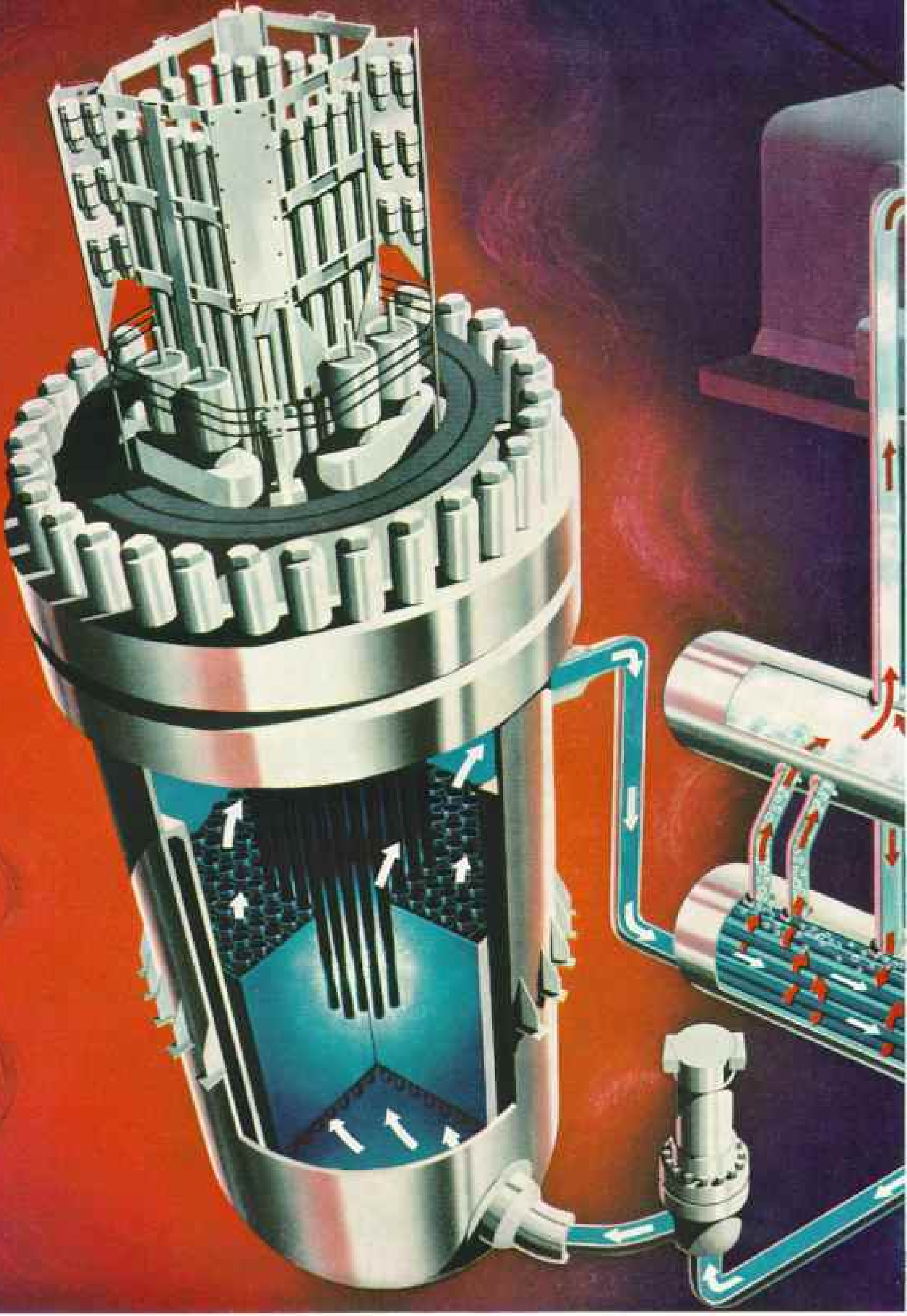
Shippingport itself is a quiet town appar-

(*Continued on page 327*)

Neutrons, Flying out of Atoms, Start a Fission Chain Reaction in U-235

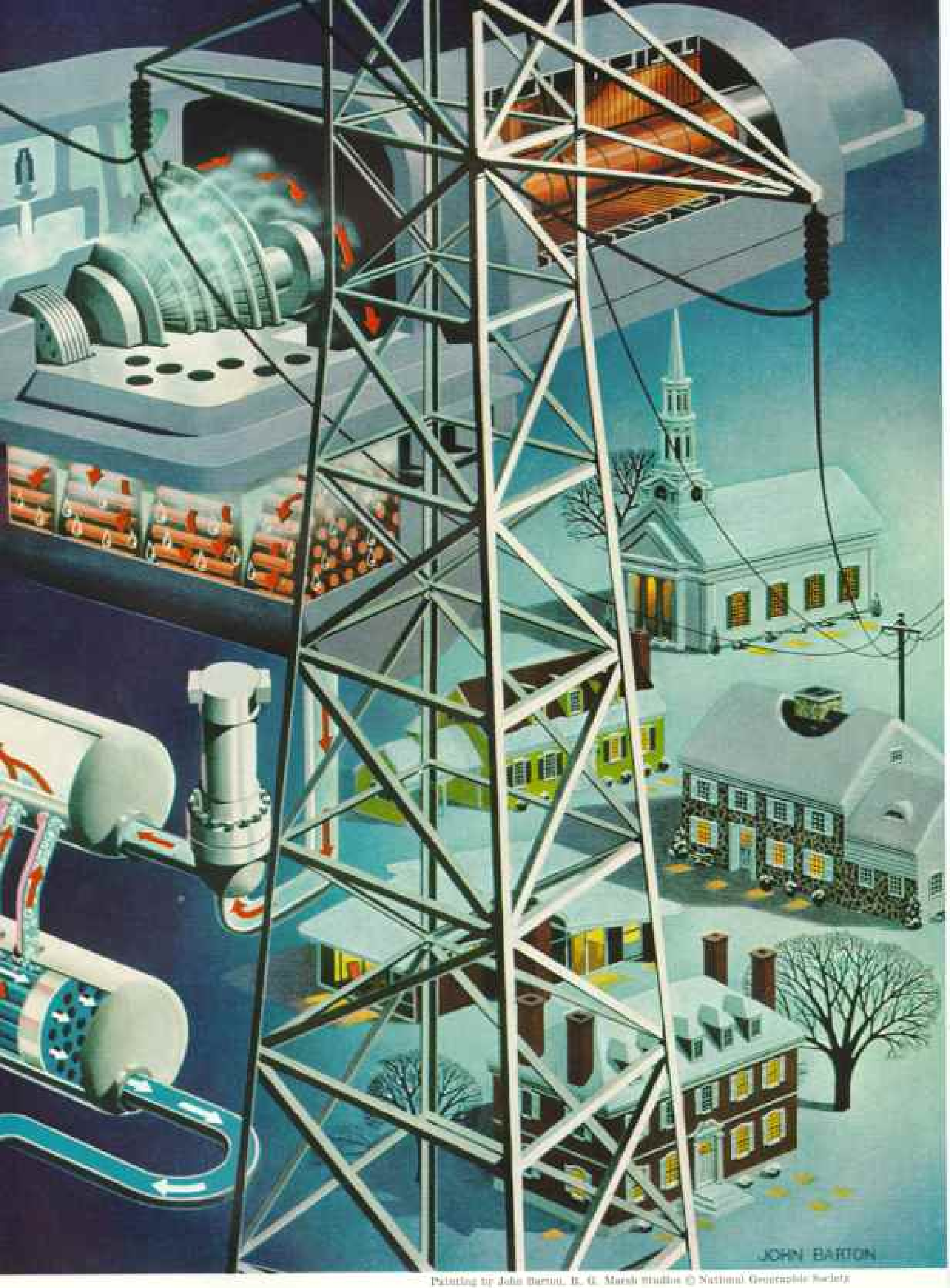
Here planetlike electrons (green) orbit around nuclei composed of 143 neutrons (red) and 92 protons (yellow). A critical mass of fissionable uranium having been assembled, neutrons leave the unstable nuclei at speeds up to 18,000 miles a second and split neighboring atoms, whose neutrons in turn break up others. Reactors control the process; bombs let it rage.

Painting by John Barton, R. G. Marsh Studios © National Geographic Society



Pressurized-water Reactor Generates Electric Power, Lighting a Village

The artist cuts open a simplified atomic power reactor (left) to show its fuel elements and controls. Cylinders contain plates of enriched uranium and pellets of natural uranium. Long black control rods of hafnium,



Painting by John Barton, R. G. Marsh studios © National Geographic Society

a metal with a voracious appetite for neutrons, dip into the core to slow the chain reaction, or pull out to speed it. Pressurized water heated to 525° F. by the fuel follows arrows from reactor to pipes in the heat exchanger (lower center). There water in a secondary system picks up heat and rises as steam to drum (above). Steam then turns the generator's turbine and, condensing, returns to the drum.

ACTOR PIT

Men in Surgical Whites Take Geiger Readings Above a Domed Reactor

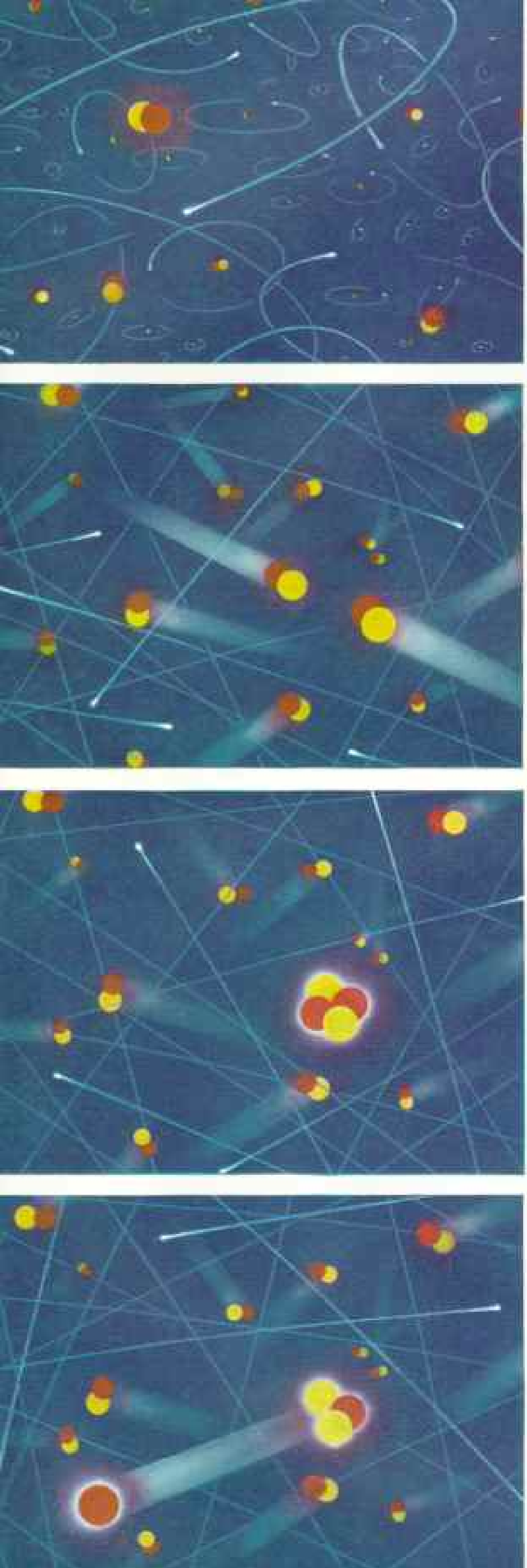
Fueled last December at Shippingport, Pennsylvania, the reactor's natural uranium will last through 1960; its enriched uranium elements will be replaced as they become exhausted. When a fuel element is removed, technicians unbolt the reactor's steel dome, and the crane hauls away the deadly element for a safety bath in pool behind men. The plant feeds 60,000 kilowatts into the Pittsburgh area.

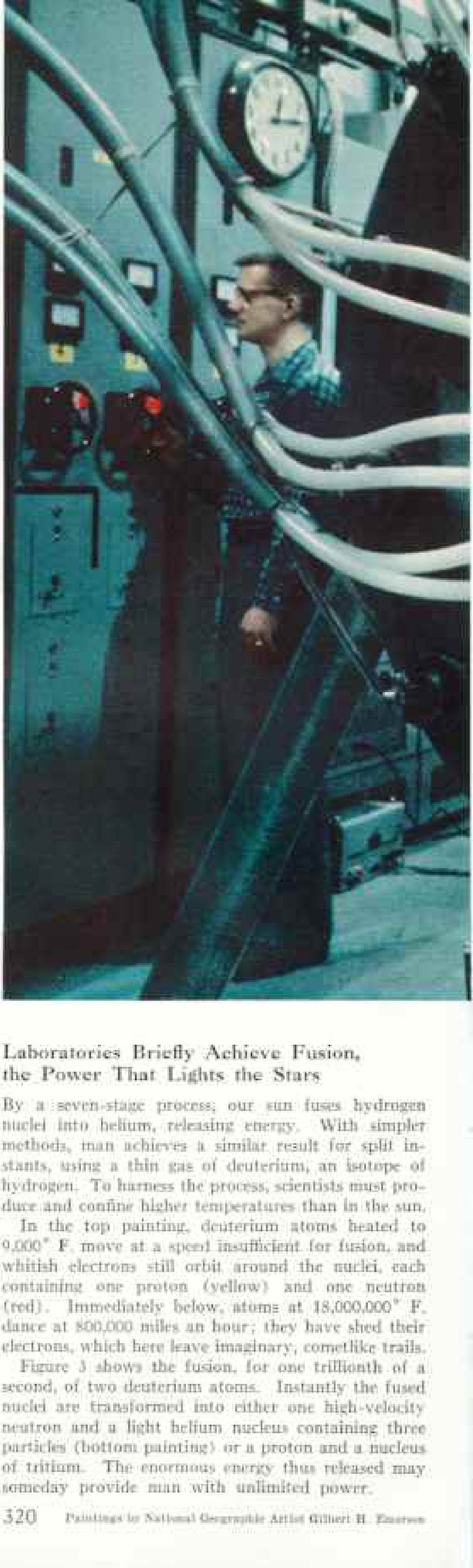
A Beaker of Liquid Equals a Thousand Tons of Coal

To power an experimental installation generating 300 kilowatts of electricity, Oak Ridge National Laboratory uses uranyl sulfate dissolved in heavy water, replacing costly solid fuel. Here engineer Richard Engel pours 500 cubic centimeters of fuel, containing 300 grams of uranium, into a reactor. Enough to replenish the system for two months, it does the work of 1,000 tons of coal. Before it fissions, uranium is only mildly radioactive. Gloves protect Mr. Engel's skin from toxic contact.

Pittsburgh's Golden Triangle glows with peaceful atomic energy. Electricity from the Shippingport reactor flows into a grid of coal-generated power; so it alone lights no single building. On a shopping night the triangle requires 90,000 kilowatts; Shippingport could supply two-thirds of that load.

National Geographic Photographer B. Anthony Stewart © N.G.S.





Laboratories Briefly Achieve Fusion, the Power That Lights the Stars

By a seven-stage process, our sun fuses hydrogen nuclei into helium, releasing energy. With simpler methods, man achieves a similar result for split instants, using a thin gas of deuterium, an isotope of hydrogen. To harness the process, scientists must produce and confine higher temperatures than in the sun.

In the top painting, deuterium atoms heated to 9,000° F. move at a speed insufficient for fusion, and whitish electrons still orbit around the nuclei, each containing one proton (yellow) and one neutron (red). Immediately below, atoms at 18,000,000° F. dance at 800,000 miles an hour; they have shed their electrons, which here leave imaginary, cometlike trails.

Figure 3 shows the fusion, for one trillionth of a second, of two deuterium atoms. Instantly the fused nuclei are transformed into either one high-velocity neutron and a light helium nucleus containing three particles (bottom painting) or a proton and a nucleus of tritium. The enormous energy thus released may someday provide man with unlimited power.

Super Anscochrome by National Geographic Photographer B. Anthony Stewart © N.G.S.

Octopuslike lead-in wires converge in this "pinch-effect" fusion chamber used by scientists at Los Alamos Scientific Laboratory, New Mexico, to study the behavior of deuterium. Physicist at switchboard applies high voltages through the wires; discharges in the chamber create astronomical temperatures and set up a magnetic field that pinches the rarefied gas into the center of the windowed tube. If gas touched the tube's cool walls, the reaction would stop instantly.

Electric coil of a similar apparatus (below) entwines a quartz fusion chamber, helping to control the pinch. Gas used in the tube must be rarefied to a near vacuum; fuel of greater density would be unmanageable at high temperatures.

The object of such experiments is to harness nuclear fusion, the power of the H-bomb.

Los Alamos Scientific Laboratory

Ultraviolet Light Bathes a Scientist Studying the Plastic Model of a Crystal

Dr. Douglas S. Billington, of Oak Ridge, seeks new materials to withstand heat and radiation damage. Here he examines the crystal lattice of sodium chloride, or table salt. Circles of fluorescent paint, glowing in ultraviolet light, represent atoms of sodium (red) and chlorine (yellow).

Ground and polished, a uranium-carbon alloy reveals its structure in a photomicrograph. An acid bath brings out the colors: UC_2, dark; UC, light. Oak Ridge tests the material as a fuel.

Cheerfully Glowing Flasks at Oak Ridge Subject Stainless Steels to Corrosion

These experiments determine the alloys that can best withstand liquid fuels fed to some reactors.

Migrating electrons in calcite cast a red glow on Dr. Charles D. Wagner, a chemist with Shell Development Company in Emeryville, California. Studying radiation effects, Dr. Wagner bombards crystals with a particle accelerator, whose X rays knock electrons out of orbit. As the electrons fall back into place, the calcite emits visible rays; the effect fades away after a few minutes.

Kodachromes (above) and Super Anscochrome by National Geographic Photographer B. Anthony Stewart; Photomicrograph by C. K. H. Dufford and R. J. Gray © N.G.S.

Rats and Mice Serve Humanity in Radiation and Cancer Studies

Man still has gaps in his knowledge of how radiation affects humans. Seeking new clues and leads, he experiments with rats and mice, whose reactions in many respects approximate his own.

Since excessive radiation can induce cancer, scientists use rodents to study tumor formation and growth. The animals also aid our understanding of how tissue is damaged by powerful rays.

Anesthetized rats at Argonne National Laboratory ride a toy train to get a dose of electron rays. Legs taped to flat cars, they pass under a particle accelerator. Electrons, streaming through holes in the metal bars, bombard a small area on the back of each animal. To determine radiation sensitivity, biologists measure the time the exposed skin requires to recover.

The train takes each rat under the beam at scheduled intervals. Tray contains gentian violet dye used to outline target areas.

X-rayed mouse shows a tumor induced by strontium-90, which has chemical similarity to calcium and so tends to lodge in the bones, where it emits beta rays.

The mouse received a strontium injection at Argonne Laboratory. It developed bone damage; later a large cancerous mass appeared, grossly distending the animal's right leg.

Three X-ray negatives, each printed in a different color, were combined and enlarged two diameters to create this unusual effect.

Hair of one mouse turned gray after radiation exposure. Its brown brother, spared from experimentation, shows normal pigmentation. Argonne Laboratory subjected the test animal to gamma rays from radioactive cobalt (page 335). Some treated mice appear to age prematurely; others go blind.

Kodachromes and X-ray print by National Geographic Photographer Thomas J. Abercrombie © N.G.S.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ently little affected by the presence of a famous neighbor—possibly because that neighbor has settled in the near-by hills behind a high wire fence, well protected by guards who discourage casual visitors.

My initial reaction to the plant was one of vague disappointment. At first glance it seemed conventional. Outdoor pipes and tanks suggested a refinery. Nothing visible even looked expensive. I could see but one curious feature: the metal-clad main building lacked windows.

But the uniqueness of Shippingport Atomic Power Station lies inside the blind building. There, since last December, fissioning atoms have been producing as much as 60,000 kilowatts of electricity for the Pittsburgh area.

The plant's price tag has been estimated as high as $110,000,000, including development charges. Its joint builders—the AEC, Duquesne Light Company, and Westinghouse Electric Corporation—consider every penny a prudent investment. From Shippingport they expect to learn many things that will cut costs in later plants.

TV Cameras View Spent Fuel

Before entering the reactor area, I slipped my feet into plastic covers resembling overshoes and put on a spotless white coat similar to those worn by hospital attendants. Superintendent Malcolm Oldham inspected my sterile-looking garb.

"It serves two purposes," he said, "to protect your clothing from possible radiological contamination, and to prevent you from bringing any dirt into the reactor room. The water we use is demineralized and purified, and it runs through a maze of pipes and valves. The chance of dirt getting into the system is remote, but we don't take chances."

Entering the plant's inner sanctum, I surveyed a rectangular room as large as an aircraft hangar, with a series of 30-foot-deep pools at its center (page 318).

"There's no water in them now," Mr. Oldham explained, "but we can flood them at will. Later we will store spent fuel in the pools until its radiation cools off a bit. Water is a good shield, and we can study the fuel close-up with periscopes or television."

Looking into one of the empty canals, I saw the dome of a massive metal tank housing the reactor. Like an iceberg, Shippingport's heart lay concealed from view, but my guide's knowing words stripped away the surface.

"The tank you see is a protective outer shell," said Mr. Oldham. "Inside is another vessel, and it contains the reactor. We pressurize water so that it won't boil, then pump it through the core. It picks up heat, flows into four heat-exchange units and generates steam in a separate water system. This system powers the turbine.

"That's a simplified explanation," he added. "It's too intricate to describe in detail. All the major components lie beneath the floor, and they're enclosed in metal shells. Each container has an air lock and connecting passageway, and we can get in for repairs—but not while the plant is operating."

Seed and Blanket Heat Reactor

Engineers stoked the reactor's core with both kinds of uranium—a wedding of convenience, since it assures longer life for the fuel. An inner assembly, called the seed, contains enriched fuel—uranium with a large amount of isotope 235. Metallurgists combine it with zirconium, an element that possesses extreme resistance to heat, corrosion, and radiation damage. They roll the alloy into thin plates, and stack the plates, sandwich fashion, within long tubes—32 tubes to the core. A second assembly, the blanket, holds 14 tons of natural, unenriched uranium in the form of pellets loaded in tubes. Neutrons fly out from the U-235 and transmute the U-238 to plutonium; it, too, feeds the chain reaction.

Water not only carries off heat from splitting atoms, it helps them do an efficient job. Neutrons travel at enormous speed, but U-235 reacts better if the neutrons have been slowed. These particles are moderated, or lose speed, in collisions with hydrogen atoms in water.

Without control, the reactor would destroy itself; so the system includes 32 neutron-absorbing control rods. Fully inserted, they shut down the reaction; partially withdrawn, they permit it to continue noiselessly at any desired power level (page 316).

Oak Ridge High School Seniors See the World's Oldest Working Reactor

Controlled by dials in the operator's booth, this graphite-moderated pile, or reactor, started up in 1943, a year after Enrico Fermi built the first atomic pile (since dismantled) in Chicago. Scientists use the reactor for research and production of radioisotopes for industry, agriculture, medicine, and laboratory experiments. Holes in the loading face contain uranium fuel.

Kodachrome by National Geographic Photographer B. Anthony Stewart © N.G.S.

National Geographic Photographer Thomas J. Abercrombie

Radiation-induced freak: "Schizophrenic" carnation grows half its petals red, half white after exposure to powerful rays (above). Pale flower in photograph on right is a mutation of crimson blossoms surrounding it.

Kodachromes by Willard R. Culver (below, left) and National Geographic Photographer B. Anthony Stewart

Tortured Plants in an Eerie Mist Haunt a "Gamma Garden"

Brookhaven National Laboratory, at Upton, Long Island, bombards vegetation with cobalt-60 gamma radiation to alter the chromosomes and genes of heredity and thereby cause mutations. Man accomplishes in a twinkling the evolutionary changes that might take ages in nature.

Flowers of evil and flowers of good emerge from the irradiated plants. Monstrous, ugly distortions balance such beneficial changes as rust-resistant oats and early-maturing peaches.

In this view, a white fog of radiation invisible except on film spews from cobalt-60 housed in the pipe at left; a metal collar diffuses it.

To resist rays that would otherwise streak the film, General Electric Company developed a 29-pound camera shielded with lead and uranium. Instead of a lens, which could not focus the radiation, the camera used a glassless pinhole .0135 inch in diameter.

X-ray film recorded radiation; negative color film captured visible light. Both films were exposed simultaneously and printed as a unit.

Cobalt-60 Removed, a Sunlit Greenhouse Appears

Cacti, African violets, columbines, and orchids surround biologist Lloyd A. Schairer and technician Brenda Robinson. They work in safety, for gamma rays leave no contamination. Mr. Schairer holds peach embryos in a nutrient solution.

As Mr. Oldham concluded his explanation, I noticed a trio of white-garbed figures wet-mopping the area around us. We turned to leave, and the men followed our footsteps, swabbing vigorously. I felt as guilty as a child who tracks up the family kitchen.

"Just routine," Mr. Oldham assured me. "Our standards for cleanliness rival those of a hospital."

Cold Feet and Hands, Fortunately!

Tony Stewart, who had been prowling the room in search of camera angles, joined me at the exit. After we had stripped off our protective shoe covers and coats, the inevitable radiation safety check of our hands, feet, and clothing began.

"You first," a technician said to Tony. He led him to the hand and foot counter, an ingenious gadget resembling a weighing machine.

"Is your watch off?" the technician asked. "A radium-coated dial will disturb the radiation count."

"It's off," said Tony. He stepped on the machine's pedestal and thrust his hands into holes in its face. A panel light flashed on, spelling out the laconic command, "Wait."

Electronic eyes scanned his hands and feet for radiological contamination. The machine voiced a series of soft clicks, indicating only harmless background radiation, present everywhere on earth. Then a second panel lit up with a cheerful "O.K."

We passed the inspection of many such machines during our three-month tour. In addition, completely automatic detectors, strategically placed in doorways leading from hot areas, double-checked us as we left. If anything had looked amiss to these electronic snoopers, alarm bells would have clamored.

Health technicians, after watching Tony climb a ladder or crouch on the floor to get pictures, often went over him head-to-toe with a portable Geiger counter, familiarly known as a "cutie pie." World War II gave birth to this whimsical name, originally a code designation to conceal the machine's real purpose.

To date, the high cost of nuclear power has tempered enthusiasm. Some industrialists, while not disclaiming the atom's potential, believe it may be two or more generations before nuclear energy supplies most of our electricity.

Using conventional fuel, United States utilities produce electricity at an average cost of seven to eight mills per kilowatt hour. Comparable costs at Shippingport have been reliably estimated at about 64 mills.

This seems paradoxical, since a pound of fissionable material contains as much energy as 1,500 tons of coal or 250,000 gallons of diesel oil, and a single fueling lasts two to three years. But costs skyrocket in the fabrication of fuel elements, in the development of metals resistant to radiation damage, and in the elaborate safety precautions.

Unlike many nations, this country is blessed with enough fossil fuel—coal, natural gas, and oil—for several more generations, even assuming that the demand for electricity will continue to double each decade. Why, then, should the utility companies invest so heavily in nuclear power?

Philip A. Fleger, Chairman of the Board of Duquesne Light Company, answered this question. Under his leadership, Duquesne provided the site for the Shippingport plant, built its conventional portion, and contributed toward the nuclear facilities—a private investment of more than $20,000,000.

"Previously the electric utilities have offset the general rise in price level by certain basic technological improvements," Mr. Fleger told me. "Now we are experiencing a decrease in the rate of improvement.

"We believe we cannot continue to hold down the price of electricity over the long term unless we develop some new major sources of economies. As of the present time, the only new development that offers a chance of large-scale savings is nuclear fuel."

Pilot Plants Yield Information

Any saving is hard to see at present, I suggested.

"That involves not only what the costs are today, but what they will be over the life of the plant, perhaps 30 to 50 years," Mr. Fleger replied. "Conventional costs are sure to go up, but the others are sure to go down."

And when might nuclear plants become competitive with conventional ones?

"There is not enough information for a reliable estimate. But we feel the industry has no alternative but to explore the full potential of this new fuel. The costs of first-generation plants are meaningless because you cannot estimate the developmental charges accurately. Only the mass-production techniques that will be used in second-generation plants will provide a significant set

Carbon-14 Helps Man Follow the Paths of Photosynthesis

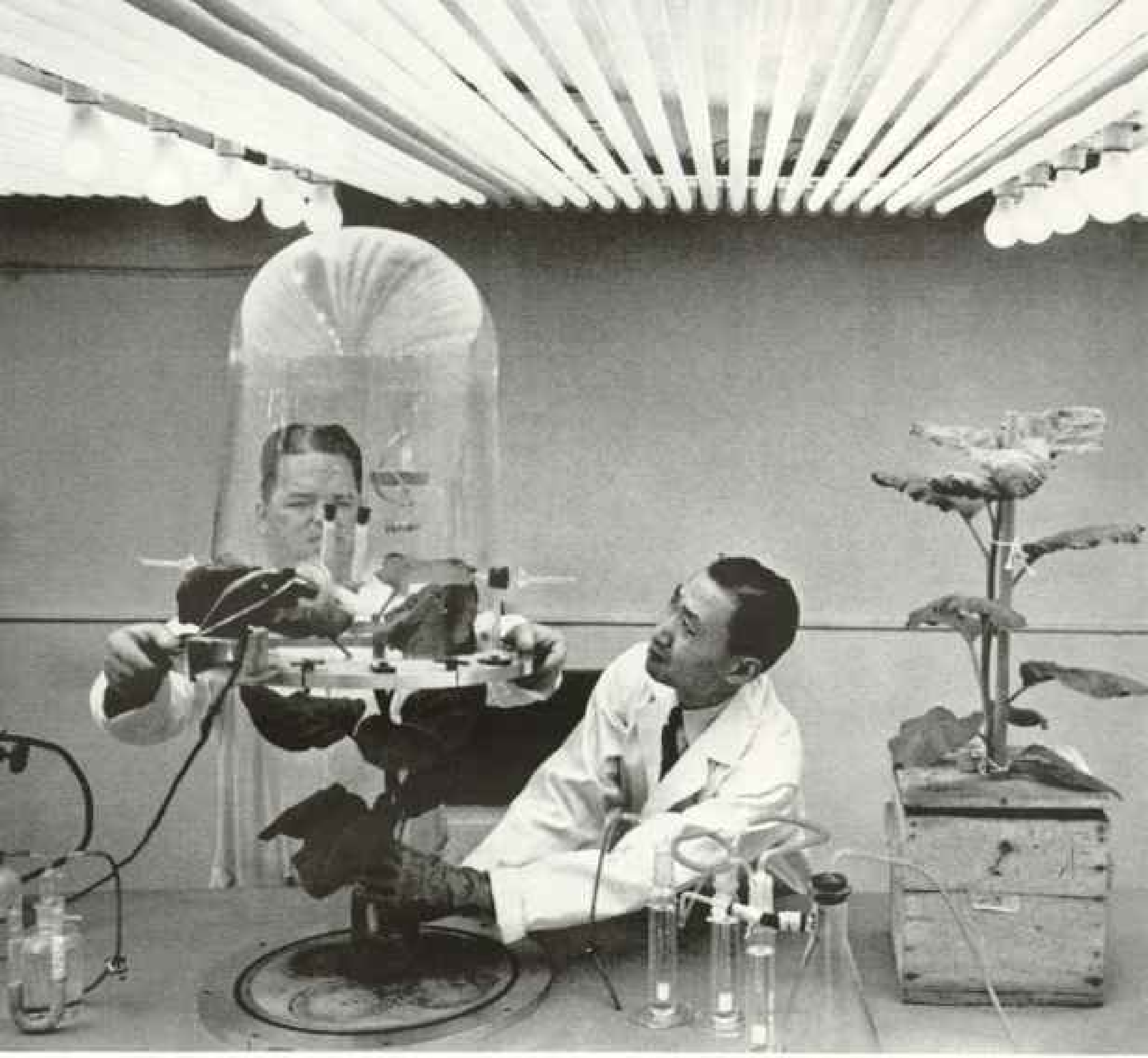
Radiocarbon's telltale atoms have helped unravel one of science's most baffling enigmas: the process by which plants use the energy of sunlight to turn water and carbon dioxide into life's building blocks: sugar, fats, starches, and protein. Without photosynthesis, nature's most important biological process, life would not be possible.

On the right, Dr. N. Edward Tolbert, a senior biochemist at Oak Ridge, withdraws a culture of algae from a tube. Fluorescent lights do the work of the sun.

Below, Dr. Tolbert injects carbon-14 into the algae and prepares to drain the solution into a beaker of plant-killing acid.

Analysis reveals that in six seconds the algae use carbon dioxide in creating more than twenty compounds. The presence of radiocarbon identifies those formed during the experiment.

Super Associations by National Geographic Photographer B. Anthony Stewart © N.G.S.



National Geographic Photographer B. Anthony Stewart

Scientists Adjust a Bell Jar to Feed Radiocarbon to a Tobacco Plant

Drs. John C. Brown and T. C. Tso, working in the U. S. Department of Agriculture research center at Beltsville, Maryland, use C-14 to trace formation of compounds, including nicotine.

of figures. Plants such as ours will yield information that will settle a lot of questions and simplify design."

Many experts pin their hopes for economical power on reactors that differ markedly from the Shippingport type. Two of these experimental systems now produce commercial electricity on a small scale.

One, built by General Electric near Pleasanton, California, permits water to boil in the reactor core (page 308). Steam, slightly radioactive, then passes directly to the turbine. Atomics International, a division of North American Aviation, operates the second power producer near Los Angeles. Its reactor uses liquid sodium as a coolant. The silver-white metallic fluid flows through the core and transfers heat to a water system.

Less advanced, but highly promising, is the "breeder" power reactor.

Shippingport converts some uranium to plutonium, so it is called a converter plant. In this case the new element is merely a by-product, though it contributes to the reaction. It is possible, however, for a plant to produce more fissionable material than it uses as fuel.

Several years ago a small AEC installation successfully demonstrated the alchemy of breeding at the National Reactor Testing Station in Idaho. Earlier, on December 20, 1951, the plant generated the world's first electricity from nuclear power.

Having one's cake while eating it, too, is wonderfully attractive, but the system is difficult to harness. For example, a converter relies primarily upon slow neutrons, but a breeder must employ the fast kind, unmoderated by water or other substances.

Other approaches include the homogeneous and organic-moderated reactors—big words involving simple principles. In the former, uranium is dissolved in heavy water—water with a large proportion of the hydrogen isotope deuterium—to form a liquid fuel, eliminating the costly fabrication of fuel plates (page 319). An organic reactor employs oil-like liquid hydrocarbons, such as the polyphenyls, to remove heat and slow neutrons.

I visited all the reactor experiments in rounding out our survey. Without exception they are small and unglamorous looking, but each type will be represented, full scale, in the private power program.

Experiments Await Time's Verdict

You may be wondering, "Which approach seems the most promising?"

John F. Floberg, an AEC Commissioner, replied to this question with an amusing query of his own.

"You appear too young to have grandchildren," he observed. "Therefore, you certainly can't tell me what is the best suit for your grandson to wear to his wedding, can you? Similarly, we need second and third generations of power plants to supply answers. This is too new an art to determine now if all approaches are right, if just one is right, or if none is right."

This uncertainty is one reason why some experts predict slow development of the power program. They point out that atomic plants will be generating only some 700,000 kilowatts of electricity by 1960; this represents a fraction of one percent of the Nation's installed generating capacity—135,000,000 kilowatts.

Other observers express doubts that atomic power plants can be made economical in the near future. Though such installations offer a new fuel, utility companies have found that fuel represents only 15 to 20 percent of the costs in producing electricity. This is not a large area for savings.

Our own Nation has substantial reserves of coal, gas, and oil, but most of the world does not. Many countries want atomic power soon, and they have turned to us for training and help. The AEC is cooperating in four regional programs, two in Europe, one in Asia, and one for Central and South America. By June, 1958, United States manufacturers had built or contracted to build more than 25 reactors for use abroad.

However, several members of the Joint Congressional Committee on Atomic Energy doubt that we can provide effective foreign help unless we speed up our power program, as has Great Britain.

Great Britain's supplies of coal are running short, and the nation must import all of its oil, mostly from the unsettled Near East. Spurred by necessity, the British have launched an ambitious atomic power program. Calder Hall, a nuclear plant on England's west coast, has been generating power—now up to 70,000 kilowatts—for the past two years. Four larger plants are building, and a network of others is planned.

Sir John Cockcroft, a member of the United Kingdom Atomic Energy Authority, has said that by 1963 nuclear power will be no more expensive in his country than conventional power.

But spokesmen for both Great Britain and the United States deplore the tendency to compare national programs. What is economical in the British Isles, they say, is very uneconomical over here.

AEC officials have explained this repeatedly. From our country's standpoint, there is a major objection to following the British approach: their gas-cooled reactors use natural uranium, rather than enriched fuel.

British Approach Too Expensive Here

Natural uranium, even though it contains little of the fissionable isotope, will chain-react, but, to make it do so, very large amounts must be used. This, in turn, requires huge power plants, which are impracticable to build in the United States because of higher capital costs.

The British approach, however, may look attractive to many nations. Any country dislikes being completely dependent upon another for its fuel, but Free World nations using enriched uranium would have to get it from us or build costly gaseous-diffusion plants of their own.

The Navy's dramatic success with nuclear submarines has shown that the atom brings a revolution in over-all ship design, as well as propulsion. Aboard the nuclear submarine

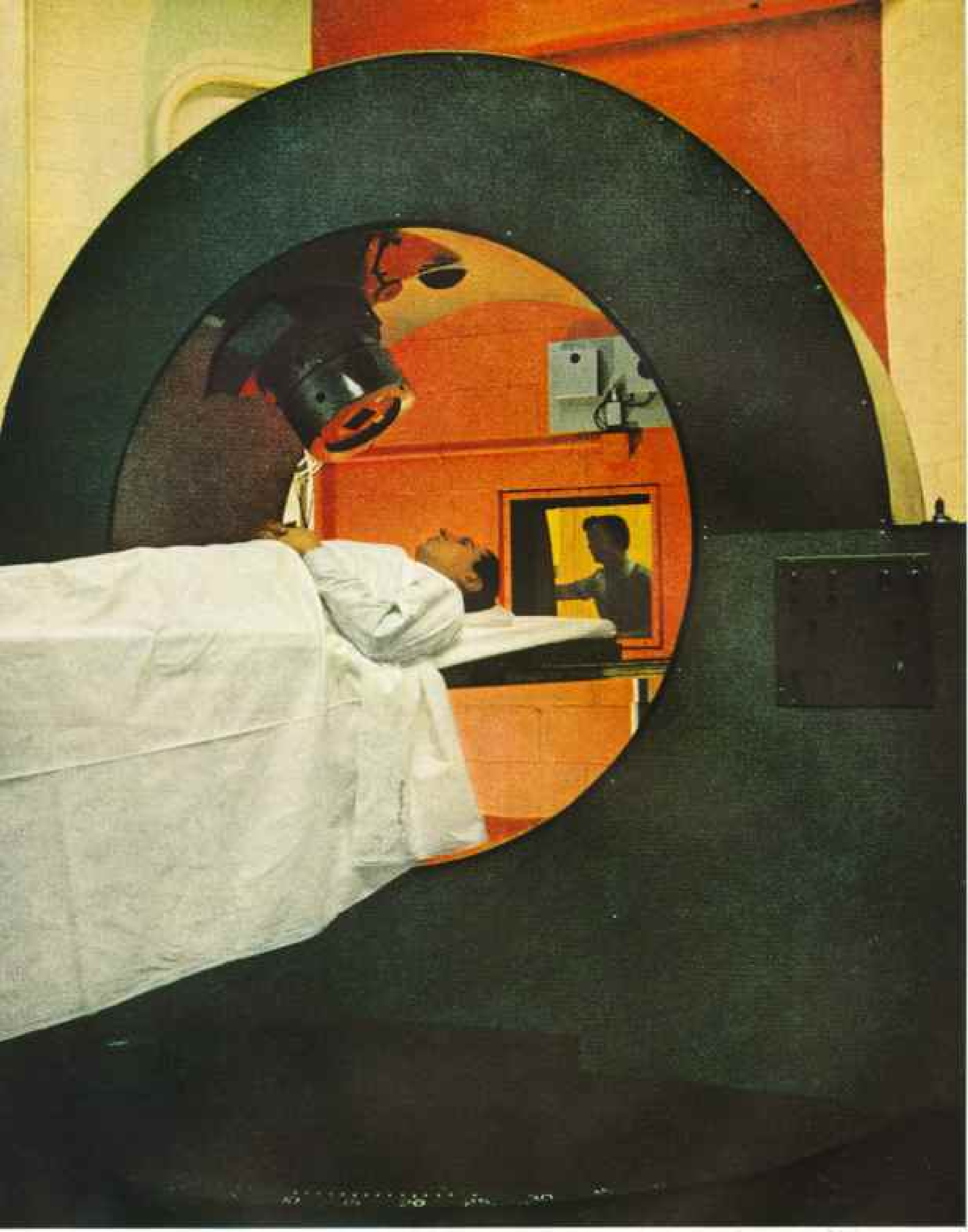
Kodachrome by Willard R. Culver © N.G.S.

Oak Ridge Stores Medicinal Isotopes in an Earth-banked Concrete Vault

With his tongs, a technician from the cancer research center removes a vial of radioactive *iodine*. He deposits it in a "pig," the lead cask in which he will wheel it to the bedside of a thyroid patient. Because the thyroid attracts the body's intake of iodine, physicians use the irradiated variety for concentrated bombardment of the gland.

Super Anscochrome by National Geographic Photographer B. Anthony Stewart © N.G.S.

Radio-iodine capsules are filled at Abbott Laboratories, Oak Ridge. Too light for radiation therapy, these doses merely determine a patient's ability to absorb iodine. Abnormal absorption may indicate a thyroid disorder.



Kodachrome by National Geographic Photographer Thomas J. Abercrombie © N.G.S.

Cobalt-60 in a Rotating, Doughnutlike Wheel Bombards a Cancer Patient

Behind her windowed shield at Argonne Cancer Research Hospital, Chicago, the operator tilts the ring at any angle and spins it through 360 degrees; X-ray machines lack such versatility. Cobalt-60, in a concentration 400 times as powerful as radium, emits gamma rays from the lenslike eye above the man. Rays focus on tumor, minimizing damage to healthy tissue.

Seawolf, on a one-day cruise out of New London, Connecticut, I saw how atomic energy conserves space as well as fuel.

Seawolf is the second of our atom subs, a 330-foot steel shark that travels faster beneath the ocean than on its surface. Her exterior, though ultrastreamlined, held few surprises for me, but her interior proved a revelation. Six years earlier, I had cruised aboard various World War II type submarines; *Seawolf's* compartments, by contrast, seemed like ballrooms.*

The officers' wardroom was indeed a room, not a cramped cubicle. Aft, in the enlisted men's quarters, I strolled past neat staterooms instead of squeezing between bunks slung from the hull. Some compartments were on split levels, like rooms in a modern home, and everywhere pleasing pastel colors met my eyes.

The spaciousness puzzled me, until a memory stirred. If this had been a conventional submarine, I would have passed through compartments holding four big diesel engines.

"Their elimination saves space," agreed my escort, Lt. Comdr. John H. Ebersole, ship's medical officer. "Also the big fuel tanks are gone, along with the heavy batteries subs formerly used for underwater propulsion."

Buddha Brings Luck to *Seawolf*

Continuing aft, we entered the reactor compartment, as big as a living room, and threaded our way among instrument panels to the compartment's center. A stainless-steel cap, knobby and shaped like a crown, jutted up from the floor. Beneath this cap lay the reactor.

I had been briefed on the *Seawolf's* reactor at various atomic installations. Liquid sodium extracts the heat and transfers it to water, generating steam. The steam spins turbines which drive the propellers. Early in its career, the prototype of the *Seawolf* reactor plant developed a leak in the superheater.

"There was some early trouble," said Comdr. Richard B. Laning, *Seawolf's* captain, "and the Navy has decided to change to a pressurized-water reactor. Our power plant will be replaced later on.

"But we have been in commission more than a year and have traveled more than 38,000 miles, 60 percent of it submerged. During this period no maintenance has been required by the reactor system."

I noticed a small bronze statuette in the middle of the reactor cap.

"A little Buddha, put there by a retired Navy captain," explained Commander Laning. "He predicted it would bring us good luck."

When the *Nautilus* finally refueled after sailing 60,000 nautical miles, it was announced that she had consumed an amount of uranium smaller than a light bulb. The actual fuel assembly would have been much larger, since the uranium must be alloyed and made into fuel elements. But the power packages in both *Nautilus* and *Seawolf* obviously are compact.

Fuel a Problem for Polar Stations

Similarly compact reactors may be used by the Army, Navy, and Air Force at isolated outposts, such as polar stations, for heat and electricity. Fuel oil now comprises 75 percent of cargoes flown to the United States scientific station at the South Pole.†

Nuclear power enables the *Seawolf* and her sister subs to cruise underwater indefinitely, since reactors, unlike diesel engines, do not require air. Surface ships cannot trade upon this advantage, but they do reap the other benefits—unlimited range and increased space. The latter may prove particularly important in merchant ships, since it promises bigger payloads.

The Russians have launched at least one atomic surface ship, an icebreaker. But, so far as is known, N.S. *Savannah* will be the world's first atom-powered merchantman (page 312). Workmen of the New York Shipbuilding Corporation laid her keel last May 22—National Maritime Day—at Camden, New Jersey.

Savannah Named for Early Steamer

This rakish-looking ship bears a time-honored name. The old S.S. *Savannah* made the first steamship crossing of the North Atlantic, a voyage that began May 22, 1819, and continued 29½ days. Much of the time she traveled under sail, since she could carry only a 90-hour supply of coal and wood for her wheezy one-cylinder engine.

Babcock & Wilcox is building the new *Savannah's* power plant at Lynchburg, Virginia. It will be a pressurized-water reactor similar to those used by the Navy.

As partners in the program, the AEC and

* See "Our Navy's Long Submarine Arm," by Allan C. Fisher, Jr., National Geographic Magazine, November, 1952.

† See "Man's First Winter at the South Pole," by Paul A. Siple, National Geographic Magazine, April, 1958.

Portable Isotope Camera Scans a Submarine's Hull

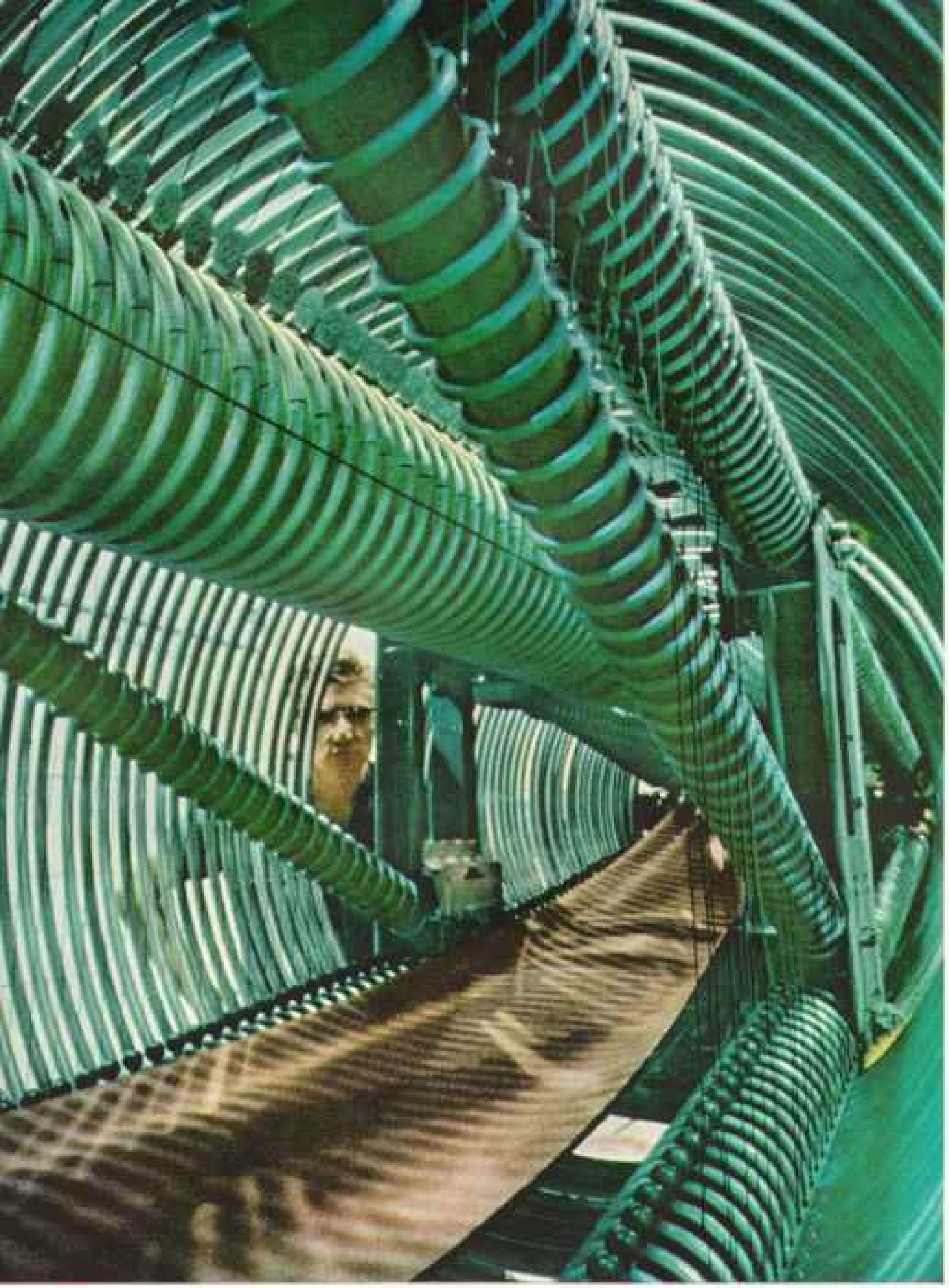
Industry makes extensive use of radioisotopes as a substitute for cumbersome X-ray machines in photographing structural materials. The shadowy pictures reveal flaws that might otherwise go undetected.

Oak Ridge Laboratory supplies most of the Nation's radioisotopes. In 1957 it made 14,126 shipments, 383 to foreign countries. Oak Ridge packages the hot atoms in tiny cylinders, which it sheathes in lead casks weighing hundreds of pounds.

Here, radioactive iridium, sealed within a camera, tests a patch weld on the ballast tanks of the submarine *Sea Lion* in Philadelphia. Powerful gamma beams from the iridium penetrate the hull like X rays, but require no electricity.

Within the submarine, a strip of X-ray film, here being attached to the bulkhead, receives an impression of the weld and tells whether it is strong or weak.

National Geographic Photographer J. Baylor Roberts



Maritime Administration have issued study contracts for a number of other merchant ship reactor designs, including three which would use gas as a coolant. General Atomic, a division of General Dynamics Corporation, has made one of these feasibility studies for the gas-cooled approach.

Dr. William Thompson, in charge of developing a maritime reactor for General Atomic, told me that "any kind of system with which we are familiar today, if put in a ship, would not compete in cost with conventional fuel systems." The same expenses that plague the power industry also affect ship propulsion.

He predicted that maritime reactors, at least in the near future, would find their most economical use in "small, very fast ships where weight saving is important."

Atom Jets and Rockets Sought

Secrecy shrouds details of the work in aircraft propulsion, but the basic approaches are known.

Conventional jet engines compress air and force it into a combustion chamber, where it mixes with fuel and is ignited. Hot gases are then expelled to exert thrust, or the gases can drive turbines that turn propellers.* In the nuclear concept, a reactor would take the place of chemical fuel and heat air for propulsion (page 345).

Ramjets work on essentially the same principle as jets, except that they compress air by the speed of their flight through the atmosphere, rather than by compressors. A ramjet will not work until it has been boosted to high speed by another engine. In the ramjet a reactor could also be used to heat air and eliminate chemical fuel.

The nuclear rocket principle is somewhat different. Conventional rockets, since they reach airless space, must carry tons of oxidizer —usually liquid oxygen—for combustion. A reactor does not provide heat by combustion, so there is no need for an oxidizer, thus eliminating much weight. However, the nuclear rocket would require a light gas, such as hydrogen. This gas would be heated and expelled, giving thrust.

All these nuclear systems promise one great advantage: unlimited range and duration of flight. Conversely, atom jets and ramjets, and to a lesser extent the atom rocket, share one formidable disadvantage: weighty shielding to protect crews from radiation.

Aircraft designers regard weight with the same distaste with which clergymen regard sin. Weight subtracts from aircraft performance. Yet technical discussions, for years, have centered upon the necessity for thick, bulky shielding in atomic planes.

I was not so sure that these objections still held true after talking with Hall L. Hibbard, Senior Vice President of Lockheed Aircraft, whose company holds a study contract for an airframe that would utilize nuclear power.

"We are trying to develop a method of deflecting radiation," Mr. Hibbard said. "We have actually tried 21 different approaches. More than that I can't say. But I will volunteer this: If man is smart enough to use nuclear power in peaceful pursuits—and he is—we believe he is smart enough to solve the radiation-shielding problem."

With Air Force or AEC permission, Tony Stewart and I toured areas in several atomic aircraft research facilities. In the Idaho desert, at the National Reactor Testing Station, General Electric officials showed us a huge hot cell where radioactive components can be examined by television; an underground control room for reactor power runs; and a bizarre shielded locomotive used to transport hot reactor parts (page 343).

In New Mexico, within the sheltering con-

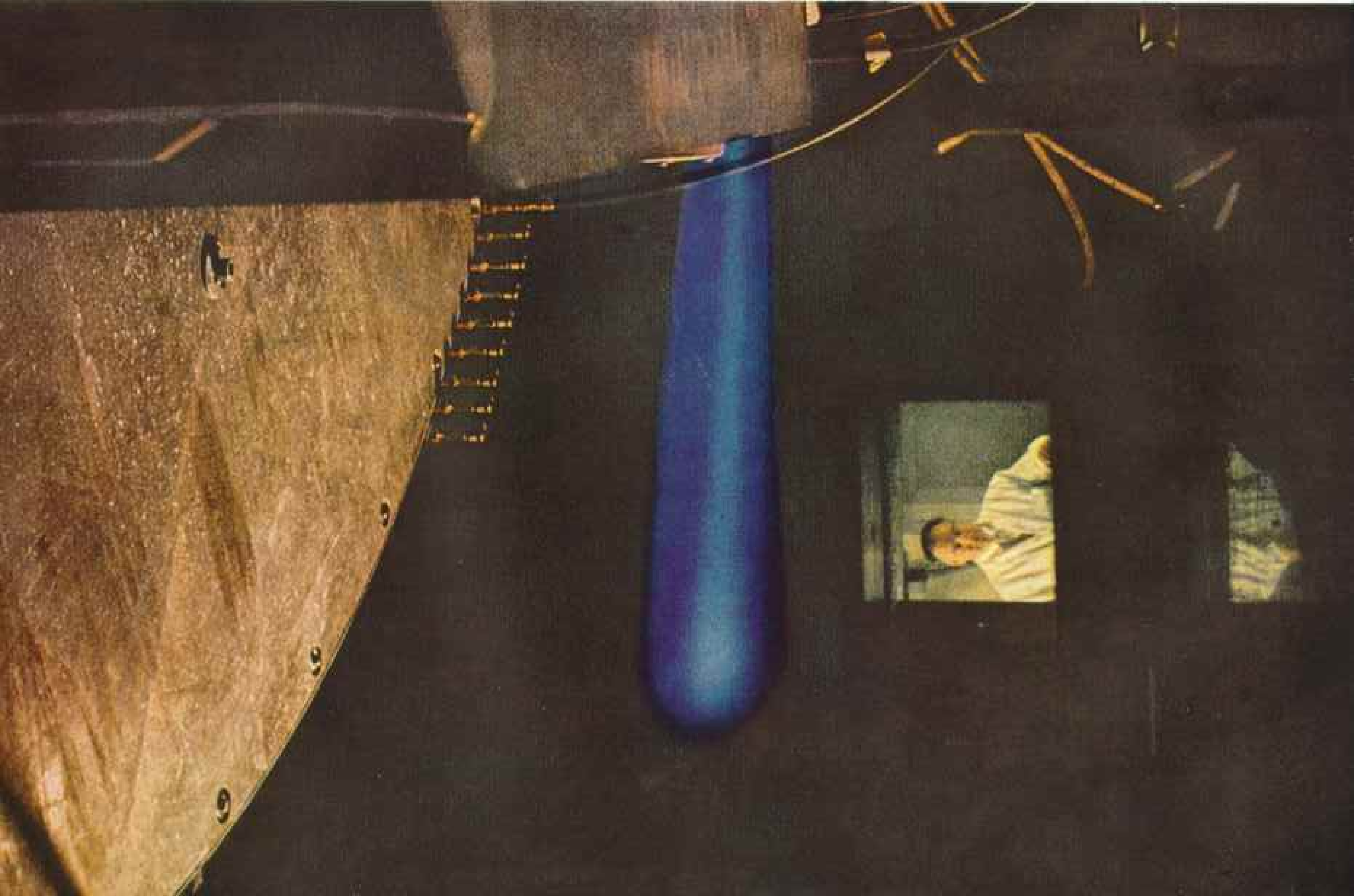
*See, in the National Geographic Magazine: "Aviation Looks Ahead on Its 50th Birthday," by Vice Adm. Emory S. Land; and "Fact Finding for Tomorrow's Planes," by Hugh L. Dryden, both December, 1953; and "Flying in the 'Blowtorch' Era," by Frederick G. Vosburgh, September, 1950.

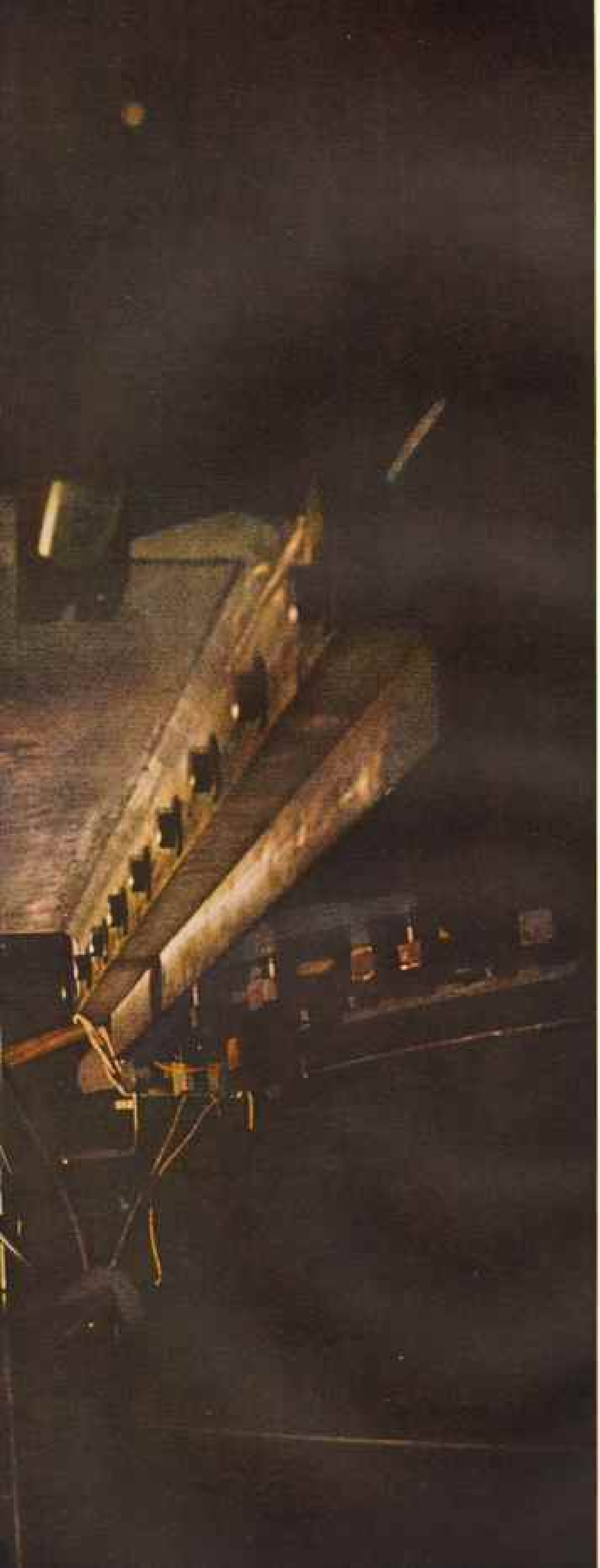
Looking into the Van de Graaff Accelerator's Complex Entrails

Argonne Laboratory uses this 4,250,000-volt atom smasher to study the mysteries of subatomic physics: what happens to nuclei when they break into bits or fuse with other particles. Scientists employ a powerful electric charge to propel protons down the large central tube at 18,000 miles a second. At the tube's end the protons smash into target materials, leaving a debris of short-lived particles and transmuted atoms—elements forged in this atomic shooting gallery by altering the structure of nuclei.

Energetic deuterium ions create shimmering lights within this Cockcroft-Walton accelerator.

Ansochrome (above) and Kodachrome by National Geographic Photographer Thomas J. Abercrombie © N.G.S.





Speeding Particles Create a Blue Glow as They Ionize Air in a Cyclotron Room

Argonne Laboratory's cyclotron, a powerful accelerator, uses magnets to guide ions as atom-smashing bullets. During operation the accelerator can be viewed safely through a glass-and-liquid window (left) piercing seven-foot concrete walls.

Several nights of experimentation resulted in this remarkable view of the machine's lethal beam in action. National Geographic photographer Thomas J. Abercrombie placed his plastic-sheathed camera within the chamber, stood outside, and worked the shutter by remote control. Each time he took a shot, a scientist in protective clothing shut off the power, entered the room, and advanced the film. Abercrombie's film escaped radioactivity's customary fogging, but magnetization ruined his $400 camera.

Using a cyclotron, University of California chemists have created seven of the ten artificial elements heavier than uranium, the weightiest in nature. They have used the bevatron, a still more potent atom smasher, to fabricate "antimatter," whose characteristics, still obscure to scientists, seem diametrically opposite those of all terrestrial matter. When anti-proton or anti-neutron encounters its opposite, the particles annihilate one another, releasing several hundred times more energy than nuclei emit when they fuse, as in the hydrogen bomb.

fines of a rugged canyon, physicists from the Los Alamos Scientific Laboratory permitted us to see several critical assemblies, forerunners of possible full-scale power packages for nuclear rockets. Such assemblies are mock-ups which bring together small amounts of fissionable material in a critical, or chain-reacting, mass, thus proving the physics and design of more refined reactor systems.

Los Alamos scientists show a flair for the whimsical. One of their experimental reactors can be technically classified as an unshielded, bare assembly, so they call it Godiva. Another, with wicked characteristics, is called Jezebel. Still a third is used in developing a ground-test reactor known as Kiwi, the New Zealand bird that cannot fly.

Lockheed, at Marietta, Georgia, is looking to the future by testing the reactions of crewmen during long confinement in a simulated nuclear aircraft cockpit (page 345). Here, too, as an intriguing sideline, the company experiments with nuclear reactors as a possible source of industrial space heating. One AEC contractor warms a few buildings with surplus reactor heat transferred to water lines. Lockheed believes this application shows commercial promise and has set up a new department to exploit it.

Taming the Energy of the Stars

All uses we have considered thus far are based upon the splitting of atoms. But there is another method of obtaining nuclear energy which man may one day harness; this process is fusion, the once-puzzling secret of the stars (page 320).

In fusion, two nuclei of a light element such as deuterium, an isotope of hydrogen, join together, releasing energy. A nucleus of common hydrogen consists of a single proton, but the deuterium nucleus contains both a proton and a neutron. Thus, in deuterium fusion, four particles merge. The combination is unstable and one particle, either a proton or neutron, is immediately ejected.

Unfortunately, deuterium nuclei find one another repulsive—literally. They bear positive charges of electricity, as do all nuclei. Like charges repel, and opposites attract. However, deuterium's aversion for itself can be overcome by tremendous heat, which makes the nuclei dash about furiously, collide, and fuse.

In the H-bomb, an A-bomb wrapping, or "trigger," supplies the heat. No such drastic solution is possible, of course, in taming the process for power. The scientist follows several ingenious approaches to the heat problem, all based on the use of magnetic fields.

He may fire a discharge of electricity through tubes containing deuterium gas. This laboratory lightning bolt heats the gas and squeezes it into the tube's center, making the deuterium even hotter, and stripping its atoms of their orbiting electrons. Some machines employ an auxiliary electric coil, or winding, about the tube to prolong the "pinch" (page 321).

Other machines forego an electrical discharge; instead they constrict the deuterium with an external magnetic field. Such a field induces great pressure on the confined gas, and the pressure increases its temperature millions of degrees.

Columbus Fires a Thunderbolt

A group of Los Alamos physicists—the youngest I encountered anywhere—showed me a number of their machines and "fired" one of the largest, the Columbus II. A bank of 10 huge capacitors, which store electricity, surrounded Columbus's tube. We retreated from the room while, for several minutes, the machine built up its dangerous charge.

Ten seconds before firing, one man began intoning a countdown. At zero second another scientist threw a switch, and a noise like a rifle shot whiplashed our ears.

Last January the British announced their machines had achieved 9,000,000° F. for periods of 2 to 5/1000 of a second. United States spokesmen said they had attained a maximum of 10,800,000° F., but for briefer periods. Temperatures of about 180,000,000° F. are needed to make the reaction self-sustaining. Power pulses must last several seconds, not several milliseconds.

One may confidently predict that by now the published figures have been exceeded and that new techniques have been introduced. The Geneva conference will hear many scientific papers on the subject.

Most experts feel that useful thermonuclear power is years in the future. Once fusion has been tamed, some means must be found of tapping the energy on a major scale. No one knows how to do this at present.

Controlled H-bomb power, however, promises almost inconceivable advantages.

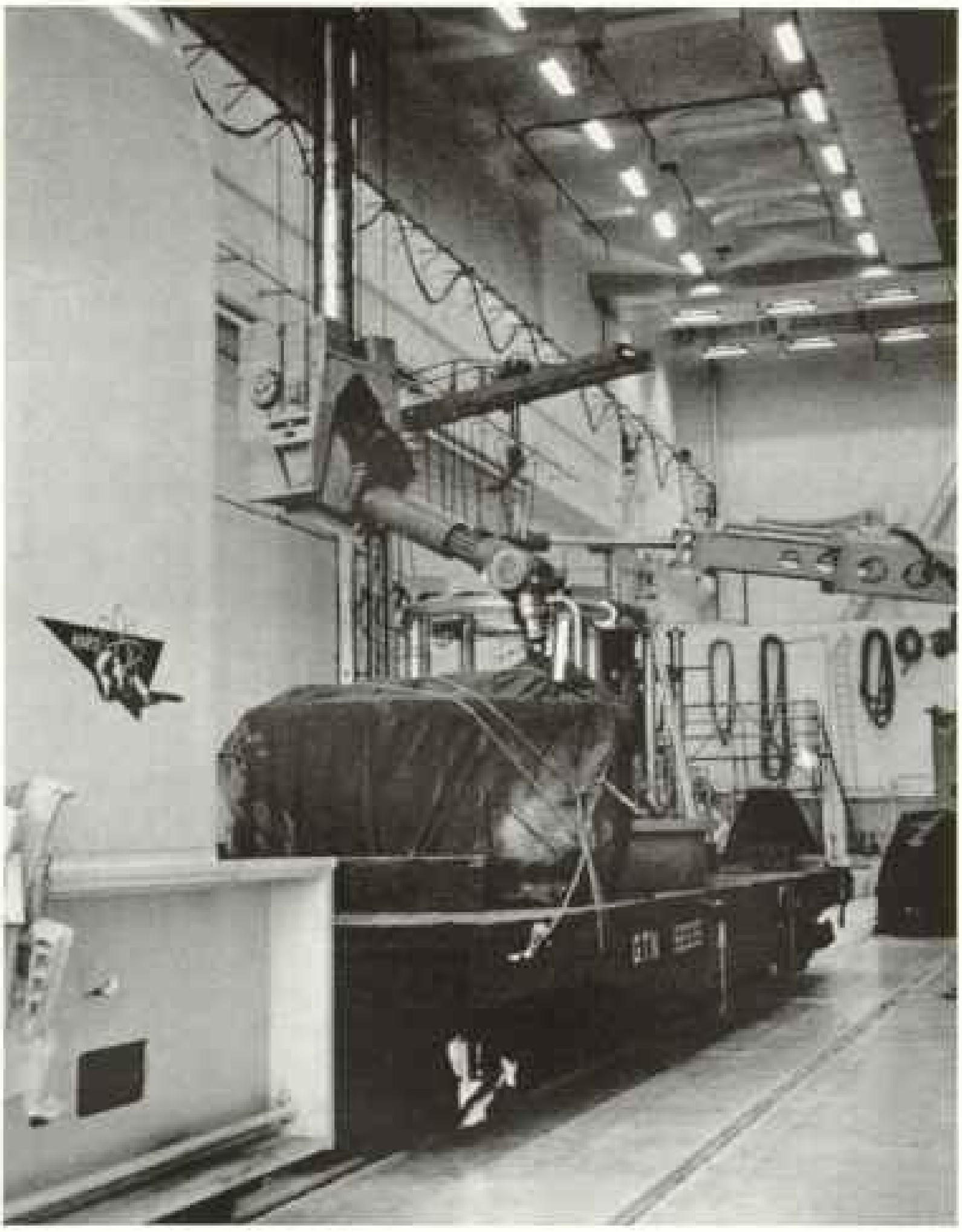
The oceans contain enough deuterium to supply the world's energy needs for billions of

Locomotive in Hot Cell Pushes a Lethal Load

General Electric, under contract to the U. S. Air Force and AEC, is testing reactors for jet aircraft in the Idaho desert. Here a diesel locomotive (left), with lead-and-water-shielded cab, pushes a flatcar into a cell as big as a basketball court. A virulently "hot" lid from a reactor rides the car. Huge metal claws remove the lid's canvas cover.

Robert R. Jones, the engineer, dares not leave his cab. Fellow workers call him Casey.

Numerous reactors have undergone ground tests in the United States, but no nuclear craft was known to have flown here or in other countries at the time this issue went to press.



Television guides panel operator A. G. Stoneberg, who switches the train by remote control. His screens show the turntable (left) and the testing site, a mile distant.

National Geographic Photographer
B. Anthony Stewart

years. Extraction is not expensive; deuterium may cost less than one percent the price of coal. One bucketful of sea water, it has been computed, holds the energy content of more than three tons of coal.

Someday thermonuclear energy may be converted directly to electricity, since electric and magnetic forces, as well as charged particles, play integral roles in fusion. Scientists envision a distinct chance of eliminating heat-transfer systems and bulky generators.

Fusion offers yet another advantage—comparative cleanliness. Its ash, so to speak, is primarily helium, a harmless, inert gas. Fission, on the other hand, creates huge amounts of dangerous radioactive waste, mostly a debris of intermediate-weight elements born when the heavy uranium atoms split.

Shippingport alone, in its first year of operation, will accumulate almost four times as much radioactive material as a very large atomic bomb could spew out into the atmosphere. A processing plant at the site removes dangerous impurities from liquids and gases. If sufficiently clean, plant water is pumped into the Ohio River, and gases are released into the atmosphere. Underground tanks hold the more virulent waste, including some solids.

Atomic Wastes Pose a Problem

Deadly spent fuel elements go back to an isolated chemical plant in the Idaho desert. There, behind sheltering walls of concrete, acid baths dissolve the fuel elements, and chemical processes reclaim unfissioned uranium. Technicians brew the complex mixtures by opening and shutting valves outside shielded vats.

Don Reid, the superintendent, led me through this plant and explained that the residue drained off into massive steel tanks buried deep in the earth. Water pipes surround some of the tanks and carry off heat generated by highly radioactive waste; otherwise the waste would form gases difficult to contain.

Some persons fear that, as vast stores of waste build up, their safe disposal may prove a limiting factor in atomic development. This view, however, presumes that nothing can be done about the problem. The AEC continually studies new disposal techniques, including a promising method of solidifying liquid waste, thus reducing it in bulk and containing much of the radiation.

Only a small amount of these fission by-products can be used, at present, in the radioisotope program. No service has been found for most of them.

But, as Mr. Reid observed to me:

"The meat packers learned to use all of the pig but the squeal. We'll learn to use the waste, too, and we'll sell it profitably."

Fleeing from a Radiation Beam

Tony Stewart and I had but one chance exposure to radiation. We had left the chemical plant and had driven across the desert to the big Materials Testing Reactor. Discussing a picture possibility, we gazed up at the reactor's bulky shield and awaited our escort, who had excused himself to make a telephone call.

A test reactor contains numerous openings where scientists insert alloys, plastics, or other samples. Pushed deep into the atomic furnace, the samples undergo a barrage that determines their ability to withstand radiation. We could see outlines of several such beam holes, as they are called, but all wore protective metal plugs.

Suddenly I felt a hand tapping my back. "Pardon me," said a quiet voice, "but you gentlemen are standing in a radiation beam."

Tony and I exchanged a startled look, then bolted toward a corner of the room. He showed "early foot," as the turf reporters say, but I beat him by a stride.

The man who had spoken strolled over—and I was glad to see he was smiling.

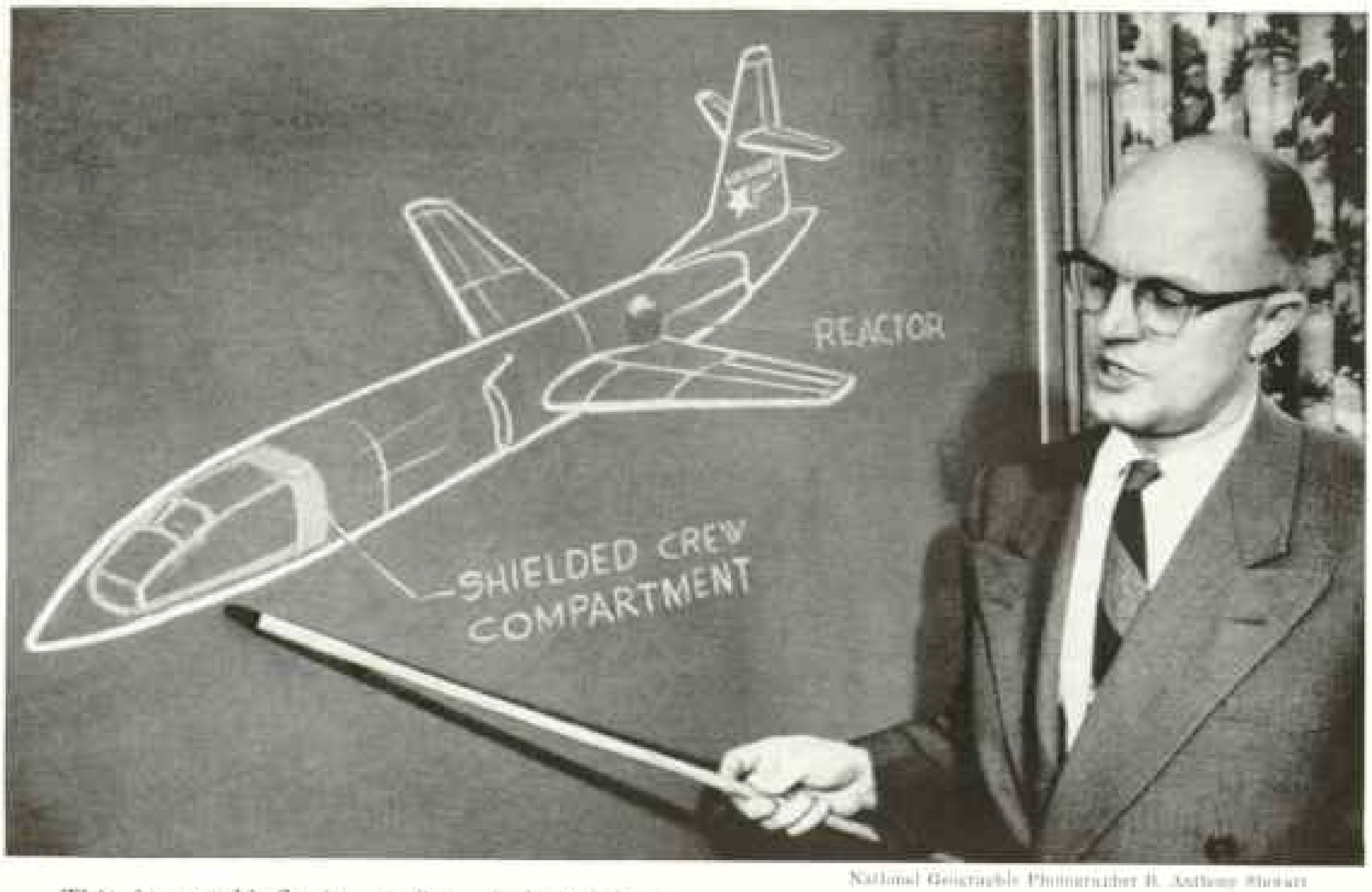
"It's a weak beam, just a little radiation escaping from a hole," said the technician. "We know it's there and avoid it, duck under it, or hurry through. I don't think you stood long enough to get much exposure. But, if you did, you'll hear about it."

Health Experts Guard the Public

His last remark referred to our film badges. These badges, worn by all workers and visitors, record radiation (page 348). The film would be developed at the end of our week's stay in Idaho. If it showed overexposure, we would be notified.

A few anxious days passed, but the feared notice never came. Our exposure had been within permissible limits.

The AEC is circumspect in protecting the general public from radioactivity born at atomic centers. Scientists collect many plants and animals from areas around installations.



National Geographic Photographer B. Anthony Stewart

This jet would fly by expelling air heated in a nuclear reactor. Engineer F. A. Cleveland points to the crew's shielded cabin in a design undergoing development at Lockheed Aircraft's new nuclear laboratory at Marietta, Georgia. The machine would depend on gas scooped from the atmosphere; it would remain airborne indefinitely, but could not penetrate space.

Flies in the grounded cabin test man's endurance for 120 hours in the air. Teams work, sleep, and relax as they would in Lockheed's first nuclear-powered aircraft. Using the mock-up's dummy controls, they simulate take-offs, days-long flights, and landings. Psychologists controlling the Marietta experiment set up emergency flight problems.

and then examine the specimens for radioactivity (page 351). By such regular check-ups they make sure there is never enough radiation to endanger animals or humans, either by direct exposure or by eating slightly contaminated crops and other food.

Safety specialists feel their responsibility so strongly that they go to extreme lengths to check an area. Take the case of the nocturnal spider.

Scientists from the University of Georgia, working on a research project at the huge Savannah River Plant, near Aiken, South Carolina, felt there was a gap in their knowledge of radiation levels among local flora and fauna. Within the near-by woods lived a certain species of spider which, like the owl, preferred night life. Birds, and perhaps a few animals, fed on this spider, so it went on the agenda for a radiation check.

A biologist volunteered to kidnap several specimens. That night, with a flashlight, he crept about the woods on hands and knees. Before he had been 10 minutes at the task, a vigilant plant guard collared him.

"What are you doing here?" snapped the guard.

"Just looking for spiders."

"Sure you are!" the guard hooted, and led him away for interrogation.

Contractors Operate AEC Facilities

The hapless biologist was merely conforming to AEC philosophy, which emphasizes basic research. Unlike most Government agencies, the AEC does not operate the facilities it pays for and builds. Instead the commission hires contractors to do the job, knowing they will offer attractive wages and get the best men. Contractors are not only permitted to engage in basic research, they are required to do so.

Their research embraces many fields of science and is amazingly diversified. The main emphasis, however, is directed toward two major areas: understanding the nature and effect of radiation, and finding ways of using that radiation for mankind.

In the first area, giant atom-smashing machines are a vital research tool (pages 338 and 341). Scientists have used them to discover many new subatomic particles whose functions are as yet little understood.

We also have gaps in our knowledge of how the atom's rays may affect living things. For example, why does radiation, in certain amounts, seem to cause premature aging? No one yet knows much about this problem. But, using mice, both Brookhaven National Laboratory at Upton, Long Island, and Argonne National Laboratory at Lemont, Illinois, study it (page 325).

We know that radiation may damage the genes governing heredity, thus affecting unborn generations. But how much exposure is harmful? To what degree?

Radiation Damage Studied with Mice

A gifted couple, Dr. William L. Russell and his wife, Dr. Liane B. Russell, seek the answers at Oak Ridge (opposite). Their research requires a population of 100,000 mice, which lead pampered, playful lives in cages that are washed and sterilized each week.

Radiation doses injurious to body tissue have been fairly well established. Scientists know most of the "thresholds," or exposures where damage can be expected. But for genetic effects evidence long has indicated that there is no threshold dose. Even a small amount of radiation may cause mutations.

"When we began our work about 10 years ago," said Dr. William Russell, "the amount of genetic damage expected from a given dose of radiation had to be estimated mainly from studies of fruit flies. Our work showed that mice were about 15 times as sensitive to mutation as the flies. Humans are, of course, much more closely related to mice than they are to the fruit fly.

"We have also shown that mutated cells are not gradually eliminated from the reproductive glands during the life span. Thus there is no recovery with time.

"Another important discovery is that by no means all genetic damage is delayed for many generations in its expression. A considerable amount of it appears in first-generation offspring."

The AEC, in its exposure regulations, makes due allowance for the Russells' findings.

Sometimes the research in radiation effects might be termed, not merely basic, but "basic basic."

For example, one day a Brookhaven scientist asked me: "Would you like to see my goldfish?" He showed me several large tanks containing dozens of the familiar fish. Preliminary findings, he explained, indicate that goldfish have a reaction to X rays not at all typical of the animal kingdom. If one group gets a single large dose of radiation, most of

National Geographic Photographer B. Anthony Stewart

Husband and Wife Test Gamma Rays' Genetic Effect on Caged Mice

Though the human body can recover from considerable radiation, genes in reproductive cells show less tolerance. A light exposure may produce mutations damaging unborn generations. Drs. William L. and Liane B. Russell, working at Oak Ridge, found that mice have extreme genetic sensitivity. Partly as a result of these experiments, national regulations governing human radiation exposure were tightened. These animals will absorb cesium-137 rays. Mrs. Russell holds a mouse by the tail, a handling technique that causes no pain.

its members soon die. But if a second group takes that same large dose, preceded by a smaller one, most of its members live longer than those in the first group. Why?

I hope he finds the answer, because it may prove important. Great discoveries have been made by permitting scientists to gratify their intellectual curiosity. A leading industrialist once told me, "Basic research is simply research without an auditor." Within sympathetic limits, the AEC wisely follows that philosophy.

Isotope Use Blankets the Nation

In putting radiation to work, the AEC probably has scored its most conspicuous success with the radioisotope program.

Today nearly 1,700 industrial organizations, including 250 of the 500 largest corporations in the Nation, hold AEC licenses for the use of radioisotopes. Approximately 2,000 medical institutions and physicians with similar licenses use the new tool in treating more than a million patients each year.

Universities and Government laboratories employ isotopes in research. Here the applications seem as innumerable as the stars; and new ones are being found each day.

The 92 natural elements have more than 900 radioactive forms. Reactors produce most of them, but in two different ways. When the uranium atom splits, its parts become radioisotopes of elements from atomic numbers 30 to 64, and they can be separated chemically. Others take form under neutron bombardment of materials inserted in reactors.

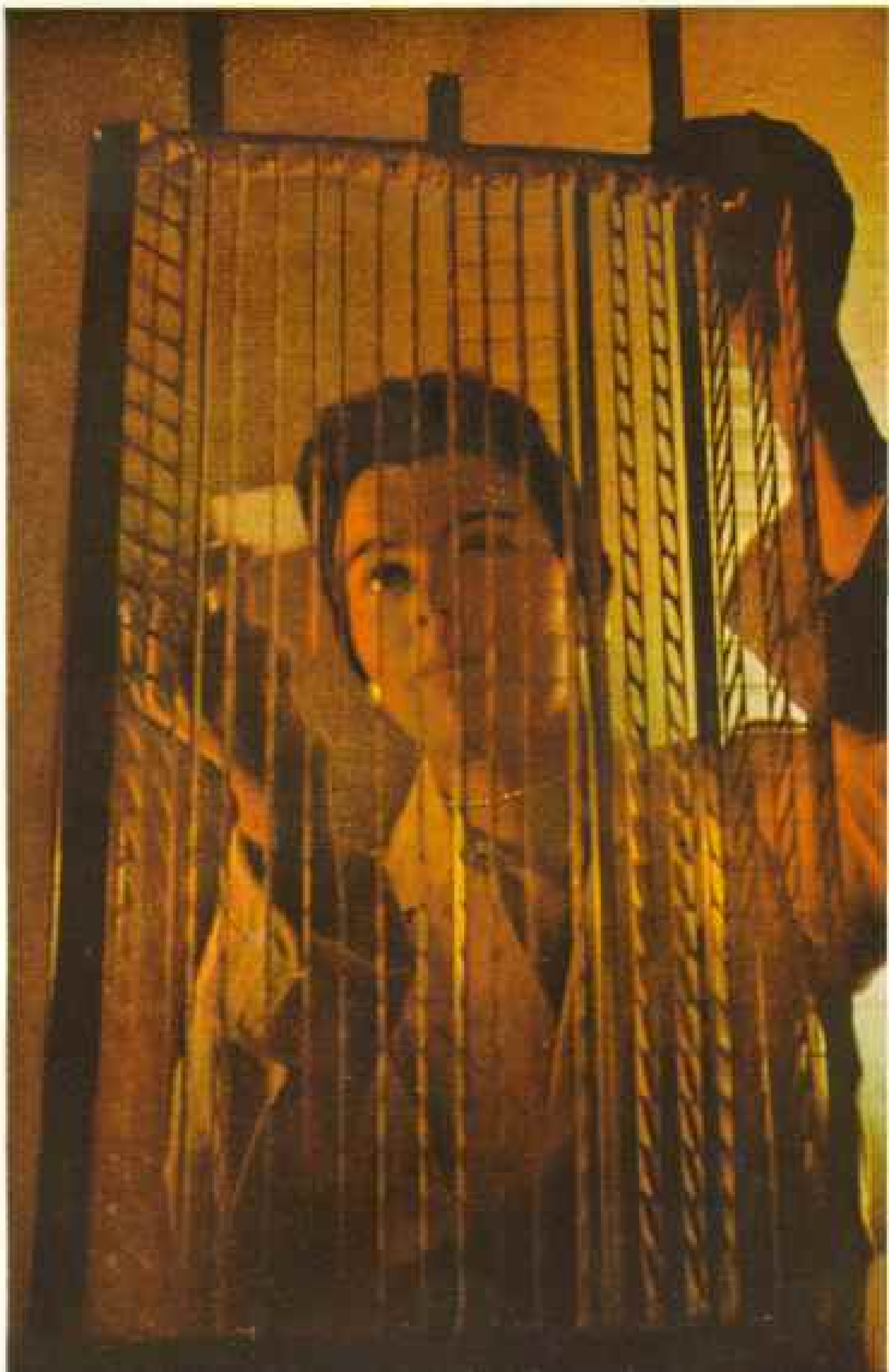
Rays from various elements differ in strength. Human skin stops alpha rays; thin

Super Anscochromes by National Geographic Photographer Thomas J. Abercrombie © N.G.S.

Safety-film Badges Reveal the Exposure of Each Worker

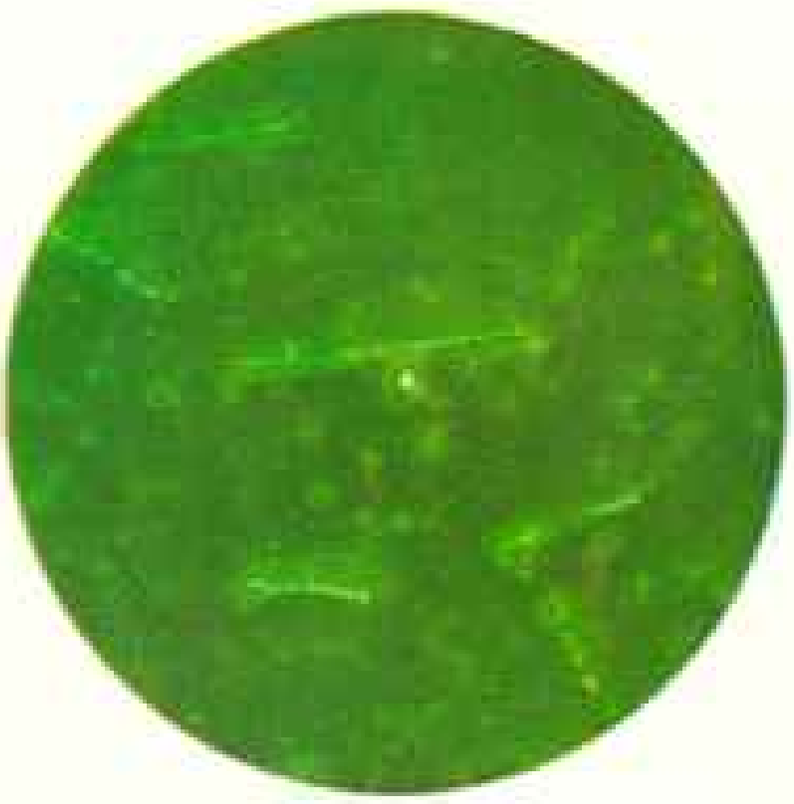
AEC standards permit only radiation doses far below the level believed dangerous. Each employee wears a ray-sensitive film pack and turns it in at the end of the week.

This "exposure historian" at Argonne National Laboratory counts monitoring film badges to make certain that all have been turned in.



Working in a darkroom, the technician examines a rack of developed film. She holds an undeveloped badge. A densitometer, scanning each frame, will measure the fogging effect of radiation.

Photomicrograph, enlarged 450 diameters, shows the long tracks of flying neutrons. Argonne deliberately exposed the film to radiation beyond the safety point.



sheets of metal or plastic block beta rays. Gamma rays, akin to X rays, readily penetrate the human body.

Radioactive materials also differ greatly in their half life, the amount of time required for half the atoms to dissipate their radiation. Some substances have a half life of seconds, others of hours, days, weeks, or hundreds of years.*

Oak Ridge, which pioneered the manufacture of radioisotopes, is still the Nation's major source of supply. Its laboratory has elaborate facilities for separating the elements and packaging them on an assembly-line basis. In 1957 Oak Ridge's "atomic drugstore" made 14,126 shipments, including 583 direct to foreign countries.

Atoms Select Construction Sites

Industry bases most of its radioisotope uses upon radiation's ability to penetrate matter. The gauge that measured the thickness of this paper is an example. Radiography, or making X-ray pictures of materials, is yet another. It eliminates the need for expensive, conventional electric-powered X-ray equipment.

Hot atoms measure the density of materials, as well as their thickness, and in much the same manner. This has many applications; among the most recent is the use of radiation to determine the density—and so the firmness—of sites for aircraft runways, roadbeds, and dams.

When atomic rays strike phosphorescent materials, they cause emission of light, as in radium-coated watch dials. Numerous businessmen foresee a bonanza for radioisotopes in this application. Self-luminous ship and aircraft markers, runway lights, railway signals, and similar devices have been built.

AEC installations did the spadework for almost all the commercial uses and are evolving many more. Let's look at several of tomorrow's promising applications.

At Brookhaven I saw the world's most unusual gardens—indoor and outdoor facilities where gamma rays from cobalt batter various plants (pages 328-9). As days or weeks pass, the powerful radiation affects some of the plant's chromosomes, which contain the genes of heredity. Irradiated seedlings often show bizarre changes when they grow to maturity. Similarly, the offspring of bombarded plants frequently differ in unpredictable fashion from normal species.

"Exposing plants to radiation is like beating their cells with a sledge hammer," said Dr. James L. Brewbaker, a Brookhaven geneticist. "It produces some weird changes. Take a look at these petunias."

We bent over a sickly looking plant and inspected its reddish-purple flowers.

"See? They have eight petals instead of five," Dr. Brewbaker beamed. "We call that effect fasciation. Two broken chromosomes grew together, and eventually they produced double flowers."

The flowers, however, drooped as if suffering from some blight, and many of the leaves were undersized and misshapen.

"We gave the plant a 500-roentgen exposure when it was quite small," the young scientist said. "If you examined its cells closely under a microscope, you would find that they had divided in wild disorder, like cancerous growth."

Most mutations prove undesirable, but some are highly beneficial. Radiation-induced changes have yielded such prizes as rust-resistant oats and wheat and early-yield fruit. Meanwhile, scientists hope they may be able to produce radically different species of plants; and research institutions from many parts of the United States and numerous foreign countries send specimens to Brookhaven for an atomic barrage.

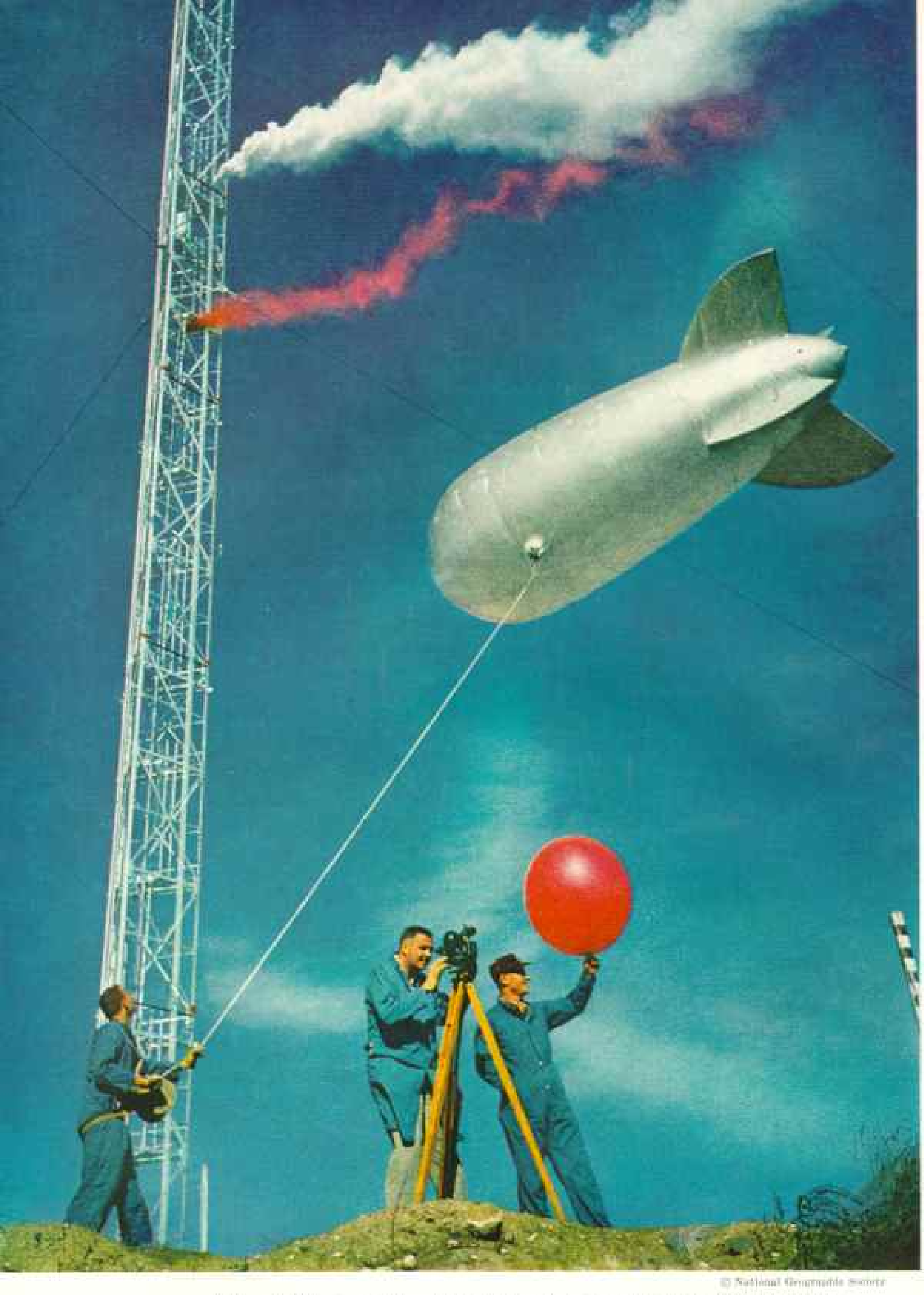
Rays Show Phosphorus Use in Sheep

Agriculturists commonly use radioactive phosphorus, calcium, and other isotopes to determine how plants utilize elements contained in fertilizers. Their findings have changed previous concepts about plant feeding. An Oak Ridge farm operated by the University of Tennessee adapts the technique to animal studies. There I watched veterinarians skillfully inject radiophosphorus into the jugular veins of sheep. Measurement of radioactivity in the animals' excrement would indicate how much phosphorus they had retained in their bodies for bone-building and other vital functions.

AEC's experimental medical program takes as its principal target that most enigmatic of scourges, cancer.

We have long known that some cancers succumb to radiation. Scientists theorize that the cancerous cell, being primitive in structure, is more susceptible to radiation damage

* See "How Old Is It?" by Lyman J. Briggs and Kenneth F. Weaver, NATIONAL GEOGRAPHIC MAGAZINE, August, 1958.



Blimp, Balloon, and Smoking Tower Test the Wind for Fallout Effects

Weather information gathered by this crew tells near-by plants of Hanford Atomic Products in Washington State when they can safely dispose of mildly radioactive waste gases. Meteorological tower emits oily logs, color coded for identification, at different levels. Instruments in the blimp, sent aloft downwind, determine how radioactive material will disperse in the air.

Jack Rabbit Wears a Ray-counting Collar

To double-check on exhaust gases, health teams at the National Reactor Testing Station in Idaho go as far as 20 miles downwind, shoot rabbits, and analyze their thyroid glands for radio-iodine, a fallout product. They also trap live rabbits and give them measured doses of the iodine. The machine's count on these laboratory animals tells technicians exactly how much iodine is required to produce a particular level of thyroid radioactivity.

This animal's red neckwear transmits the gamma-ray count to the electronic machine at right.

To Keep the Columbia River Safe, Hanford Men Fish for Radioisotopes

General Electric Company, operator of the plutonium plant, uses Columbia water to cool reactors and returns it—slightly radioactive—to the river. Ensuring against damage to fish and to the people who eat them, employees net specimens and subject them to analysis for radioactive phosphorus, cesium, strontium, zinc, copper, iron, chromium, and sodium. Activity runs far below the danger level.

Super Ansco/Ironne (above) and Kodachromes by National Geographic Photographer B. Anthony Stewart © N.G.S.

than normal tissue. A few years ago, radioactive elements seemed the answer to a cancer crusader's prayer. AEC literature, however, states frankly that their present usefulness in therapy is limited.

True, gamma sources have been highly effective as substitutes for X-ray machines (page 335). Radiophosphorus controls polycythemia vera, an excess of red blood cells, and radio-iodine has benefited thousands suffering from hyperthyroidism and cancer of the thyroid gland. Generally speaking, however, isotope therapy has not been conspicuously successful.

"We haven't made any real inroads into the cancer problem, because in most cases we haven't been able to localize the isotopes in cancerous tissue," explained Dr. John H. Lawrence. Dr. Lawrence heads the Donner Laboratory and Donner Pavilion, medical research facilities at the University of California. The AEC supports these facilities and similar ones at Oak Ridge, Brookhaven, and the University of Chicago.

The isotopes-vs-cancer story is not one of unrelieved pessimism; it has its promising aspects.

Atom tracers have been used in many ways to follow complicated chemical reactions in blood and body cells, and even to study the manner in which cells divide and multiply. These techniques arm researchers with knowledge essential to an ultimate understanding of how malignancies occur and spread.

Hormones Influence Cancer Growth

With unflagging determination, scientists strive for break-throughs in radioisotope therapy. The record may have been disappointing, but bold new measures are being tried.

Scientists have demonstrated that hormones secreted by the pituitary gland—located in the head—contribute to the growth of breast cancer. Since the gland is not essential to life, the University of California destroys it precisely with a cyclotron beam. The University of Chicago accomplishes similar results by implanting irradiated yttrium pellets in patients.

At Brookhaven persons with brain tumors have been treated by neutron beams from a reactor. Doctors first give each patient an injection of boron salts, which concentrate briefly in the tumor. Boron captures neutrons and discharges powerful alpha rays through the tumor. This technique is expected to be more effective with completion of Brookhaven's new medical reactor, which will have special facilities for tumor irradiation and other experiments in nuclear medicine.

A New Approach to Leukemia

Doctors at Oak Ridge use a radical new treatment for leukemia, the blood cancer. It has always been difficult to treat this disease by irradiation because the rays destroy vital bone marrow needed to produce new blood cells. But some patients have been exposed to gamma rays from a cobalt source, and then have received bone injections of marrow withdrawn from relatives. The injections act as transplants, replacing irradiated marrow.

Patients at the various research centers volunteer, of course, for experimental treatment, and all must be referred to the hospitals by other institutions. I saw a number of these patients, and well do I remember the poignant resignation on their faces. There was a single, smiling exception: a small boy, the victim of leukemia.

He sat in a wheel chair while a nurse rolled him down a corridor. Though the boy's face was wan, it wore a pleased grin, and he scanned with eager attention a booklet telling in comic-strip form the story of peaceful atomic energy. As he turned a page, I glimpsed the title, "Dagwood Splits the Atom."

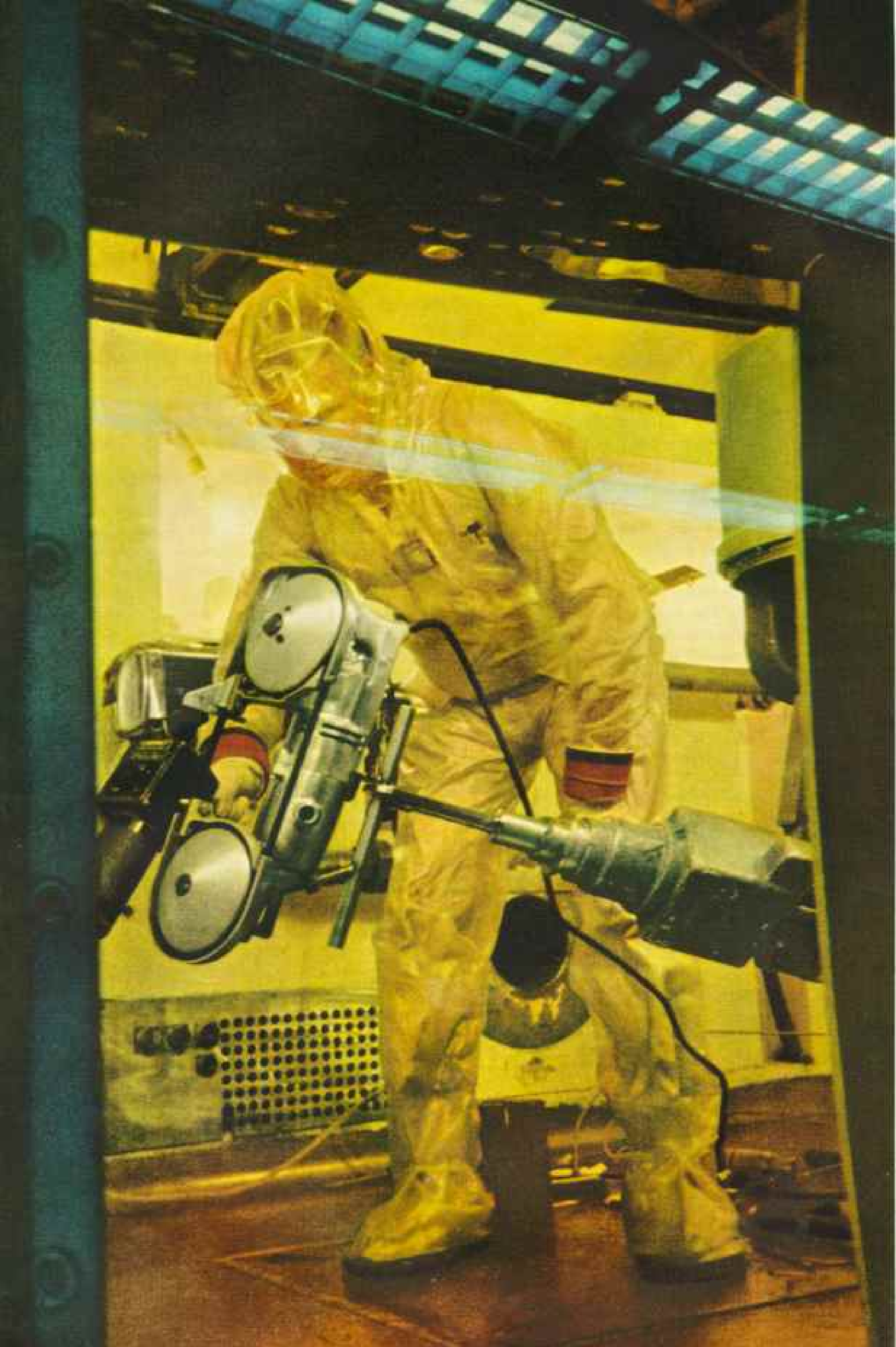
I do not know to what ultimate fate that boy was being wheeled. But he realized the atom might hold hope and renewed health for him, and he was trying to understand its strange forces.

Each of us, too, has a stake in the atomic revolution, even though it may not be so direct and vital as that of the little boy. We have crossed the threshold into a new era, as yet dimly perceived. But we know it will shape and change our lives in ways undreamed of today—and there can be no turning back.

Swathed in Plastic, Breathing Piped-in Air, a Worker Checks a Hot Cell

Before cleanup crews at Oak Ridge National Laboratory can enter, someone has to make sure the room is reasonably safe. This man, seen through three feet of liquid and plate glass, takes a Geiger counter reading. Leaving, he will change clothes and take a shower. Large metal arm in front of him polishes irradiated metal for photomicrographs (page 322).

Kodachrome by National Geographic Photographer B. Anthony Stewart © N.G.S.



What is it like in Europe's largest satellite after a decade of Communist rule? Here a distinguished husband-and-wife team of American journalists provides an answer

Poland Opens Her Doors

By DELIA and FERDINAND KUHN

With Photographs by Erich Lessing, Magnum

OVER the loudspeaker came the words: "Ladies and gentlemen, we have just landed at Warsaw airport."

How easy it had been, flying nonstop from Brussels, to pierce the Iron Curtain at 18,000 feet. For almost 10 years Communist-ruled Poland had been virtually sealed from the Western World. Now the door had been opened—part way. Westerners could come in, and a limited number of Poles could get out.

What kind of welcome, we wondered, awaited two American reporters? What kind of country had Poland become?

The customs inspector, a smiling young woman, waved us through without opening our baggage. A crowd shivered outside the customs shed. Some passengers were being met by friends or relatives. A familiar figure shouldered his way through the throng—a Polish friend we had not seen for 10 years.

Lost Liberties Regained in '56

We had written our friend, with some hesitation, to tell him we were coming. Perhaps it would not be "healthy" for him to resume contact with Americans. Yet here he was, and he showed every sign of being delighted to see us.

His greeting was only the first of many evidences that Americans were welcome in Poland. Before "October," the name Poles give their bloodless revolution in the autumn of 1956, this would not have been so. For then the Polish people regained some of their long-lost liberties, among them freedom to meet and talk to foreigners without fear.

Traveling through the country for five weeks, we made scores of new acquaintances and even a few firm friends. We were never shadowed by the police, as far as we knew. We met no interference as we observed Polish life. Everywhere we found signs of friendliness, courtesy, and interest in our country.

Poles Eager to Talk to Foreigners

Each time we rode a crowded train, a Pole got up to offer a seat. Or else people squeezed together on the wooden benches to make room for us. Then the conversation began.

"You are German, perhaps? English?"

The truth was greeted with excitement.

"Ah, Americans! You have come very far—to visit relatives, no doubt?"

The word would be passed along. "Americans!" Heads would turn, and people would gravitate toward the two strangers. Then came the personal histories:

"I lost two brothers in the first war, two sons in the second." Or, "My home in Warsaw was bombed, and I lost everything." Sometimes, "I was in England for six years. Once my English was good, but when one has no chance to practice. . . ."

Inevitably someone said, "Poland is a poor country, but we are working hard to rebuild. You must have it much better in America."

There was a teacher on an excursion with her class of 35 fresh-faced, teen-age girls.

"Please lend me your camera," she begged. "I want to take your picture. Then if you send it to me, I can show that I've seen Americans."

There were many who said, "I have relatives in America." One man confessed: "I have forgotten where my uncle lives. Is there a place called Chicago?"

Grim Faces of Poland: Steelworkers Rest Beside Their Blast Furnace

For centuries a granary of Central Europe, Poland underwent an industrial revolution after World War II. The acquisition of mines and factories in former German territory triggered a migration from farm to city like that experienced by the United States at the turn of the century. These men labor in the nation's largest steel mill at Nowa Huta, near Kraków.

A Nation Reborn Dances Welcome to the Harvest

Crisscrossing Poland for more than a month, the authors met a heart-warming welcome among a people living under a Communist regime but eager to renew their traditional friendship with the United States.

Here some 2,000 performers in native costumes gather at Warsaw to symbolize the nation's exuberance at harvest time. A crowd of 70,000 fills the Tenth Anniversary Stadium, completed in 1955 to commemorate a decade of freedom from Nazi rule. Poland's red-and-white colors fly between Communist banners above the stands.

Three-headed grain demon with beribboned hair and beards of straw represents a threat to plentiful crops. Tradition required harvesters to chase away evil spirits or bribe them with the crop's first handfuls of grain.

All Kodachromes by Erich Lessing, Magnum © National Geographic Society

The Authors

Ferdinand Kuhn joined the staff of the *New York Times* in 1925. Six years later he married Delia Wolf, an associate editor of *Current History*. Since then the Kuhns have become one of the Nation's most respected husband-and-wife teams of journalists.

During and after World War II Mrs. Kuhn wrote for various Government agencies; her husband, after 12 years as a London correspondent, served as Chief of the British Division, Office of War Information and, later, as Deputy Director of the OWI. From 1945 to 1953 Mr. Kuhn was international affairs reporter for the *Washington Post*. Keenly interested in world politics, the Kuhns have reported from the Far East, India, North Africa, and much of Europe.

A handsome old woman, wedged beside us in a train compartment with her granddaughter on her knee, declared firmly:

"I knew right away you were Americans. Only Americans have good teeth."

Considering their long years of isolation from the West and of listening to propaganda, it was not surprising that some Poles had odd ideas about Americans.

"Don't you all do rock-and-roll in the streets?" one woman asked. But the interest in rock-and-roll, especially among Polish students, was more than offset by the thirst for American books, plays, and films, and for news of the scientific and technical progress of the past 20 years.

"We've been cut off from all this, and we must catch up," was the way one high-school teacher put it.

Most of these conversations with Poles were conducted in a mixture of bad English (theirs), worse Polish (ours), and indifferent German (almost everybody's). Sometimes a little French helped things along. Always the talk was spiced with expressive gestures. Eagerness to communicate gets you over many barriers. In Poland the language barrier is serious, for the roots of English and Polish are different, and Polish pronunciation comes hard to English-speaking people.

Poles rightly complain that English is illogical, if not idiotic, what with *bough, cough, dough, rough, through*, all pronounced differently. But they are the first to sympathize with any foreigner who struggles to cut his way through the thickets of Polish consonants.

For example, there is nothing to stop your walking into a high-tension wire in Poland except the sign *Niebezpieczeństwo!*—which simply means "Danger!" If you want to express polite surprise, you must learn to say *Rzeczywiście!*—which is the way Poles say "Really!"

Luckily, Polish people are ready to laugh with you, and they delight in teaching you some of their favorite tongue twisters.

You will be asked to wrestle with *chrząszcz brzmi w trzcinie*—which, roughly translated, means "the cricket is singing in the reeds." Anyone who can master that is ready for the ultimate. It is all about Peter, who is in danger of putting too much pepper in the pork, and it goes like this:

Nie pieprz Pietrze wieprza pieprzem, bo przepieprzysz Pietrze wieprza pieprzem.

Really! Or, rather, rzeczywiście!

Now that traffic both in and out of Poland has increased, many Poles are making an effort to learn a Western language, and English is the most popular.

This is true not only of youngsters, who have had to study Russian as a second language in schools, but also of their parents. In the provinces English-speaking Poles are still a rarity, but in Warsaw we found friends and chance acquaintances eager to guide us around the city in our own language.

A Reborn Warsaw Rests on Rubble

Although Poland's capital has a recorded history going back to the 13th century, it is one of Europe's newest cities: 85 percent of it was destroyed in World War II.

The rebuilding of a city of more than a million people is an epic. We cannot begin to do justice to it here. The first chapter would describe the colossal task of clearing miles of ruins. It would tell how thousands of men and women, boys and girls set to work with picks and shovels, opening paths through the debris. Another chapter would recount the mobilizing of architects and artists to draw plans for the new city.

Stalin's Gift to the People of Poland: a 30-story Skyscraper

Some 5,000 Russian technicians and workers erected the needle-spired Palace of Culture and Science, which dominates Warsaw. It contains 2,500 rooms, three theaters, two motion-picture halls, museums, and a swimming pool. Warsavians call this architecture "Stalinist Gothic"; lavishing mock praise on the skyscraper, they describe it as "tiny, but so beautiful."

U. S. W. Press

Army General Inspects Warsaw's Ruins in 1945

Accustomed to German rubble, Dwight D. Eisenhower described Polish devastation as the worst he had seen.

Gen. Marian Spychalski (right) became Poland's Minister of Defense in 1956.

High-wire rides thrill customers at a fair in Nowa Huta. Children pay a few pennies for a flight on the cable, ride on the Ferris wheel, or spin on the carrousel. Unfinished apartments rise beyond the safety net.

We saw the giant enterprise at an interesting moment. About 60 percent of the plan had been realized. Broad new arteries had been cut through the rubble and paved. Solid blocks of new office and apartment buildings lined them for miles.

Some were finished even to the statuary and decorative iron grillwork. Others were still raw faces of brick framed in wooden scaffolding. Still others were in the foundation-digging stage, with cranes and earth movers towering over vast holes.

In some parts of the destroyed city the rubble was too thick to be carted away. So it was simply leveled and used as a foundation. This explained why many of the new buildings perched as much as 10 feet above the level of the pavements. Archeologists of some far-off time will find traces of successive Warsaws at different levels, as they found the nine cities of ancient Troy.

New Architecture: Stalinist Gothic

Many untouched ruins still lifted their crazy shapes skyward, exposing jagged walls, empty archways, and staircases that led nowhere. Nature had charitably softened some of their outlines with weeds and vines.

Rebuilding went into high gear in 1952. Five years later we found a new city, big enough to house Poland's government and more than 1,000,000 people. The character of modern Warsaw had taken form.

We asked a Polish economist: "What would you call this new architectural style?" He answered dryly: "Stalinist Gothic—vintage of 1925." And he added:

"Expensive and pretentious, but we didn't have much choice. We were cut off from the best in up-to-date design and town planning."

In all Warsaw we met no one who had a kind word to say for the postwar style, or for its most conspicuous expression, the Palace of Culture and Science. This is the 30-story gift of Josef Stalin to the people of Poland. He not only gave the building; his architects designed it, and he sent 5,000 Russian workmen to Warsaw to build it (page 359).

The Palace cost an estimated $34,000,000 and houses three theaters, two cinemas, and an elaborate Congress Hall of red and gold and marble that seats 3,000 people.

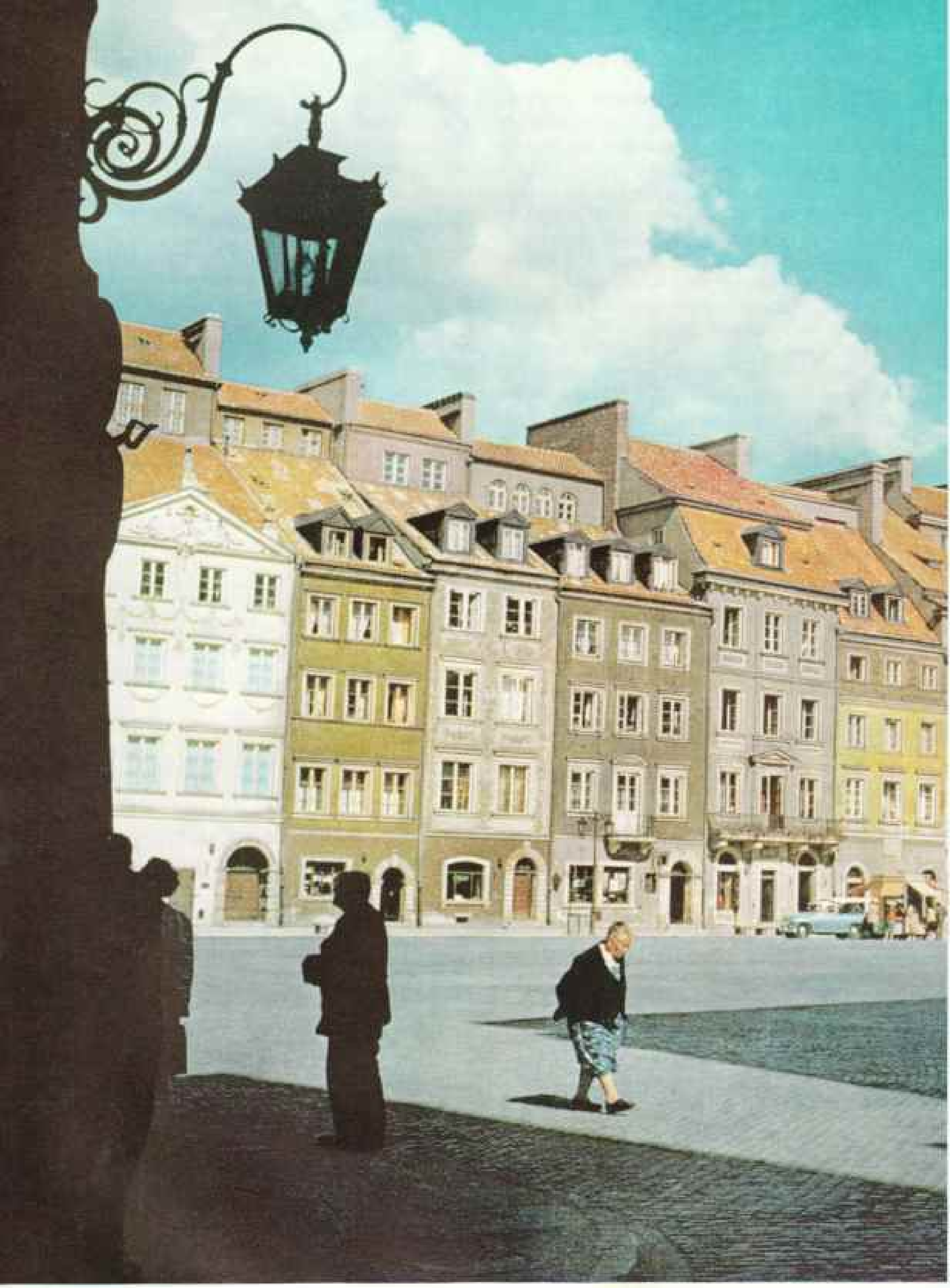
Wherever you go in Warsaw, the Palace is visible on the horizon. For the stranger, the landmark is useful. To some Poles, however, the ever-present tower is an irritant.

"The best place to take a picture of Warsaw," we were told, "is from the Palace. It's the only place you can't see the Palace!"

Warsaw's Old Town Lovingly Restored

With Stalinist Gothic as a background to their daily lives, Warsaw people needed and craved some visible link with their historic Polish past. The Old Town of Warsaw, the Stare Miasto, in particular, had been one of their national treasures. Scholars, artists, and patriots had lived on or near the old market square. Marie Curie, co-discoverer of radium, had been born near by. The 17th- and 18th-century buildings had stood intact until 1939.

Then war swept Poland, and by the end of 1944 hardly a single structure in the Old Town was standing. In September, 1945, a



Stare Miasto, Warsaw's New "Old Town," Rises Phoenixlike from Its Ashes

Poles long venerated the spacious square as a national treasure. Then bombs and shells smashed all but two houses. As Józef Sigalin, the chief architect of the reborn city, observed, "Our people felt they had no

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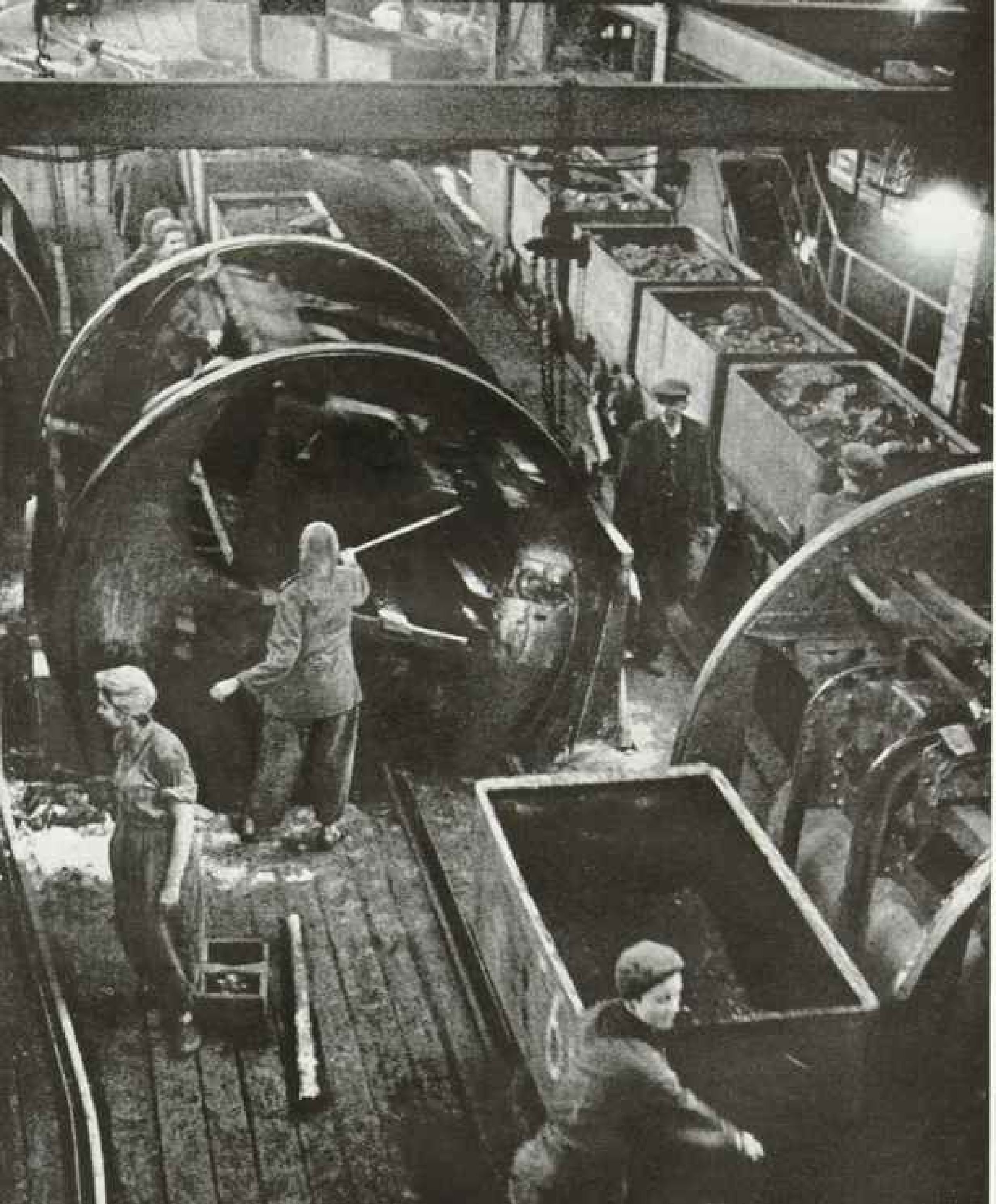
birth certificate until Warsaw lived again." He and others painstakingly restored the old market district from paintings by an 18th-century Venetian artist and from plans drawn up before the war. Today the square, with its wrought-iron lanterns, pastel house fronts, and cobblestone pavements, serves as a shrine to Poland's past. Apartment dwellers live above ground-floor souvenir shops and restaurants.



smiling visitor in an American five-star general's uniform flew to Warsaw from Berlin. He came to receive one of Poland's highest decorations, the Cross of Grunwald. As Supreme Commander of the Western Allies Gen. Dwight D. Eisenhower trudged through the ruins, the smile left his face, and he looked somber and thoughtful (page 360).

"Warsaw," he said, "is far more tragic than anything I have seen."

From a man who had seen Berlin, Cologne, and many other shattered cities, this was a grim superlative.

If he should go back to the Old Town of Warsaw now, he would not believe his eyes. The market square has been restored as it was in Warsaw's most splendid period in the 18th century. The gilded frescoes, the blue, pink, buff, and green of the plaster, the sculpture and wrought iron of lamps and doors, all have been reproduced with a loving faithfulness. This is a Williamsburg on the Vistula: a meticulous re-creation of an earlier time (page 362).

But it is little more than a stage set. The traffic of modern Warsaw passes it by. Day after day we wandered to the square to catch something going on. The place was lifeless except for occasional groups of school children with their teachers, touring the small museums around the square. A few government shops sold souvenirs, rare postage stamps, costly china, but nothing that Warsaw needed at prices Warsaw could pay.

The old-style section of the city now stretches for two and a half miles on the bluff above the Vistula. If Poles criticize it today —and many do—it is because the money and materials might better have been used for more apartments, hospitals, and schools.

When you walk into one of the city's massive new apartment buildings, you find that the average family of four or five occupies two small rooms. Each citizen is officially entitled to 75 square feet of living space, though he seldom gets it.

The average Pole faces shortages not only of living space but also of money and almost everything money can buy. Warsaw's giant new department stores—one of them is entirely dedicated to children—have the air of museums. Goods are few and most of them are inside glass cases.

They are out of reach in another sense. The prices are staggering for Polish purses. A set of china would be an unheard-of luxury; each plate represents almost a day's wages. A little rubber doll or a celluloid rattle would cost a dollar, half a day's pay for a Pole. We combed Warsaw for a couple of flashlight batteries and felt triumphant when we finally found some.

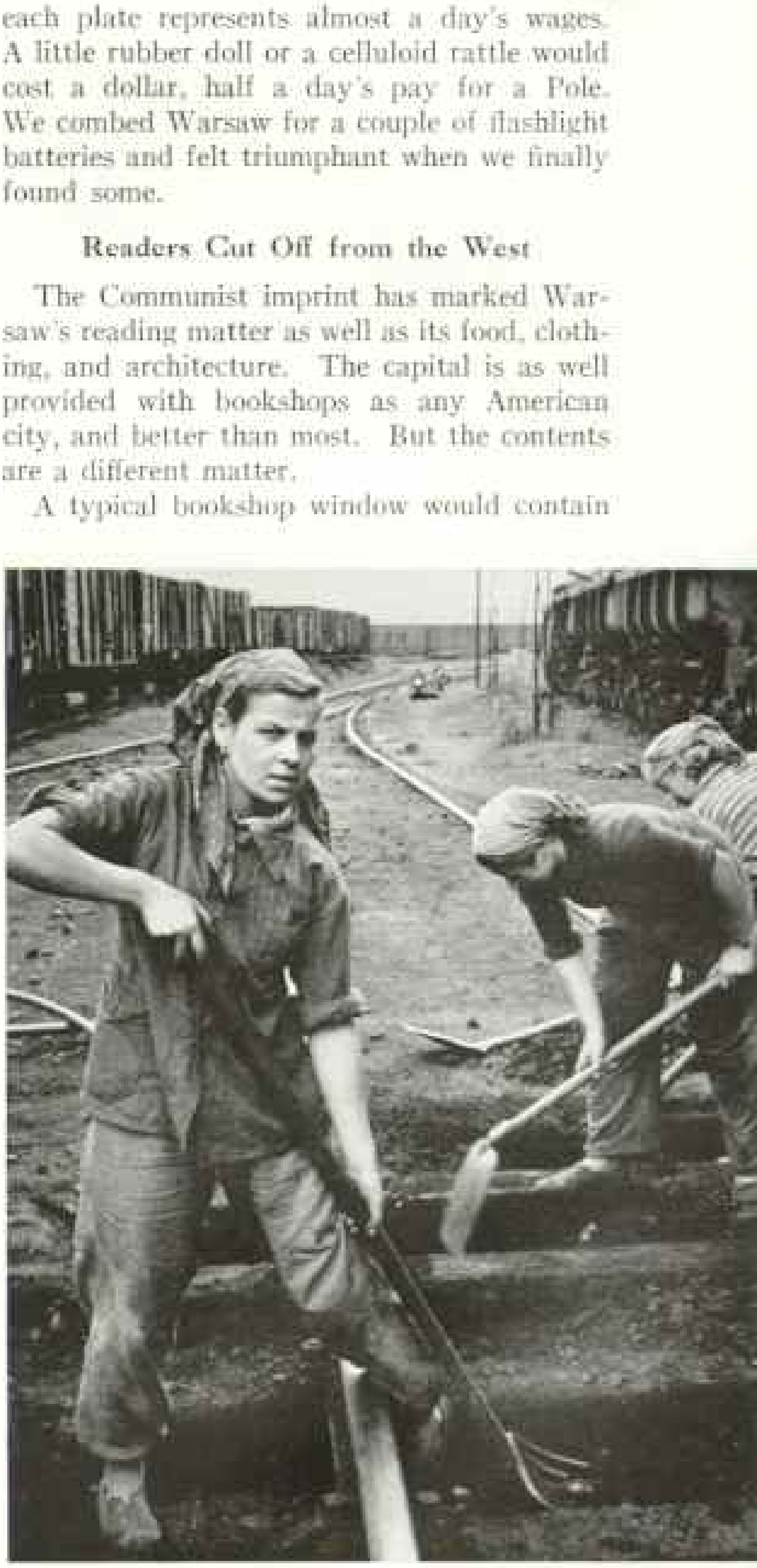
Readers Cut Off from the West

The Communist imprint has marked Warsaw's reading matter as well as its food, clothing, and architecture. The capital is as well provided with bookshops as any American city, and better than most. But the contents are a different matter.

A typical bookshop window would contain

Women Do a Man-size Job in Silesian Mines

Thousands of women and teen-age children fill jobs in heavy industry to bolster family income. Under the watchful eye of their foreman, these women load coal cars at Bytom, using revolving hoppers. Once permitted to work underground, they are now restricted to the surface.



Clearing railroad ties, young workers restore track at the Bytom mine. Despite the payment of comparatively high wages, Polish mines suffer heavily from absenteeism.

Nylon Stockings Sell for Small Fortunes

In quest of luxuries, Warsaw housewives visit the Ciuchy, a market known affectionately as "the Polish-American Friendship Society" for its preponderance of U. S. goods. Most strollers can only gaze longingly at champagne, French scarves, and American coffee, clothing, and cosmetics.

Sidewalk supermarket tempts goods-hungry consumers—but at breath-stopping prices. At the official tourist rate of 24 zlotys to the dollar, this woman's Hershey bars bring $2. Nylons sell for $8 a pair, and cigarettes for more than $1 a pack. Here roasted peanuts, tooth paste, and powdered milk, tea, soft drinks, and canned pineapple —all from the United States —compete for the attention of passers-by.

19th-century Polish classics, the works of Marx and Lenin, translations of novels by Jack London and James Oliver Curwood, and, in English, irrelevant odds and ends like *Lilies for American Gardens, Principles of Bacteriology and Immunity*, and a two-year-old copy of *House Beautiful*.

Today the children, not adults, have the advantage in Polish bookshops. Perhaps out of economic necessity, the most renowned poets and artists of modern Poland are willing to write and paint for children. The results are the most charming books we have seen anywhere.

Prices range from 25 cents for paperbacks to about two dollars for exquisitely illustrated color-printed volumes in hard covers. Not since Beatrix Potter, Lewis Carroll, Sir John Tenniel, and Arthur Rackham have such talents been put to work for a younger generation. Or so it seemed to us.

Queues Form for New Goods

Only one Warsaw luxury is really cheap: window-gazing. Along a main street called Nowy Swiat—New World—knots of people cluster around shopwindows. Often it means that something new has arrived—raincoats from Czechoslovakia, perhaps, or bright-colored woolen sweaters from the Polish mills at Łódź, or a bolt of silk from China. If the new article is within the range of the pocketbook, a queue forms. The long lines of drably dressed people—men reading newspapers, women with patient faces—are Warsaw institutions. And the same was true in every other Polish city we saw.

Queuing up can teach one a great deal about life in Poland. One line led us to lemons, the first seen there in six months; another, to tiny sugar angels to decorate the Easter feast and delight the children. But many queues form only for the purpose of filling the family's daily needs: a loaf of brown or white bread, or *czarny chleb*, the delicious coarse, dark rye bread; or a few carrots and beets for making *barszcz*, the favorite Polish soup; and perhaps a salt herring fished up from a big barrel.

While the housewife waits her turn for daily fare, she can admire shelves of luxury foods: jars of *dżem*, plum or strawberry; cans of pineapple preserve from China; hams and tongues; and American fruit juice in small tins. But rarely can she buy them.

One day we joined a queue with the greedy purpose of getting a two-ounce tin of powdered coffee we had spied in the window of a state emporium. We coveted that coffee. For days we had not tasted anything but coffee substitute, made from grain. When our turn finally came, the salesgirl met our request with a flat "*Niema!*" She said it three times, shook her head, and waved her arm negatively. The tin in the window apparently was a dummy.

The people waiting behind us craned their necks and showed impatience. Then a tall man of about 65 stepped out of line and joined us.

"Do you wish to buy coffee?" he asked in English. We told him we had seen a tin in the window.

"If it is in the window, then there must be some for sale," he said firmly. "That is the rule."

He argued with the salesgirl, who shrugged her shoulders. He called the manager. After a heated discussion, the manager disappeared. The queue lengthened.

"It doesn't matter," we assured our courtly helper.

"It does matter," he answered. "You shall have your coffee. The manager is searching the basement. Are you English, by the way? I was in England before the war."

The manager reappeared, bearing a tin of coffee like the one in the window. The tall man presented it to us with a flourish. At this point, we did not dare ask the price. Our bill was 95 zlotys for two ounces of coffee, or nearly $4 at the official tourist rate of exchange. We paid it, the wildest extravagance of all our time in Poland.

Visit to Ciuchy Full of Surprises

The Polish idea of extravagance is the Ciuchy. This is the name for open-air markets in Warsaw (and other Polish cities) where goods from abroad are bought and sold.

For Americans, a visit to Warsaw's biggest Ciuchy is full of surprises and not a little pathos (opposite). To reach the market, you squeeze aboard a red trolley car opposite the forbidding Communist Party building. After buying a ticket for 50 groszy (two cents), you hang onto a strap as the trolley rocks across the Vistula River by one of the city's two main bridges. The first stop across the river is Washington Rondo, surprise No. 1. Here, ironically, stands a Russian war memorial, a heroic profile carved in stone.

The trolley continues down a broad thor-

Weeds and Jumbled Cobbles Litter Gdańsk, the Danzig of the Teutonic Knights

One visitor flying over postwar Poland likened its roofless buildings to "rows of decayed teeth with their fillings missing." Such devastation characterizes

Gdańsk. Hitler's demands for this thousand-year-old port on the Baltic precipitated World War II. His artillery and bombs made a shambles of the Old Town, shown here with reconstructed gabled fronts. Ruins in foreground have lain bare 13 years. St. Mary's tower and Town Hall spire overlook the desolation.

oughfare—Washington Avenue! The name of the first United States President has survived all through the Communist years.

A short ride down Washington Avenue and a short walk bring you to the market. Before you have time to look around, you are spotted as a foreigner and asked whether you have something to sell. The merchandise, on tough wooden benches, looks familiar.

Here are scores of cheap shoes, all worn, all stamped with the names of American makers. Across the aisle are piles of bright flowered skirts, products of American factories. One shopper is trying on an old muskrat coat. The label inside (you discover later) bears the name of a furrier in Passaic, New Jersey. The asking price is 7,500 zlotys, more than $300 at the tourist rate of exchange, or $75 at the current black-market rate.

"How can people afford to pay such prices?" we asked a girl from Warsaw University who had come with us.

"Most of the time they can't," she replied. "But it costs only a trolley fare to come and look. The Ciuchy is one of our best shows." Then, with a laugh, she added: "We call it the Polish-American Friendship Society!"

It was not until we had left the market and were straphanging homeward again that we realized a striking fact about the Ciuchy. Unlike the Paris Flea Market, the Rag Market in Rome, and the Caledonian in London,

A breakfast of cabbage and potatoes starts the day for this farm family near Gdańsk. Postwar reforms broke up large estates in the area, giving many farmers their first individually owned land. This family received 17 acres, enough to support father, mother, and four children. Further reforms in 1956-7 modified the government's compulsory delivery program, permitting farmers to sell milk and more of their grain at higher prices on the free market. Here the family gathers in the combination dining room-bedroom.

Sharpening his scythe to cut wheat, the father pauses to talk to his daughter. The government does comparatively little to help small farmers, but has relaxed its efforts to force them into collectives.

antiques were not on sale. Almost everything was secondhand, yet nothing was really old.

Had the war destroyed every treasure of the past, every vestige of old Poland? We discovered the answer when we traveled to Kraków (pronounced Krahkoof), from 1138 to 1596 the capital of Polish kings.

Kraków is the heart of traditional Poland. The city survives intact. The Germans evacuated it in such a hurry in 1945 that they did not have time for demolition or a last-ditch fight. After a surfeit of ruins and raw new buildings in Warsaw, we felt

Robed and Mitered Bishop Blesses Pilgrims Massed Before the Black Madonna's Shrine

Despite Communist teachings, Poland remains 95 percent Roman Catholic. Each year thousands of the faithful journey to Częstochowa to honor a portrait of the Virgin and Child said to have been painted by St. Luke and owned by Charlemagne.

Legend credits the painting with supernatural powers. Defense of the shrine against Swedish invaders in the 17th century rallied Poles and saved the country.

This record crowd gathered in 1956 to hear Mass. Portrait on the bishop's vestment copies the Black Madonna.

Outdoor confessional, a plain wooden chair beside the cathedral, serves priest and worshipers at Częstochowa. As many as a million pilgrims crowd the town. Residents throw open their homes, sometimes putting 20 guests in a single room.

Women kneel outside the chapel where the Madonna is exhibited throughout the day.

refreshed by Kraków's castles and churches, its towers and archways mellowed by time.

On our first walk through the town, a boy of about 12 in a student cap attached himself to us. He seemed to want to walk with us, although we knew only a few phrases of Polish, and he could speak nothing else. His first question was:

"English?"

"American," we answered.

"New York?"

"No, Washington."

A big smile lit up his face.

"Washington—Kościuszko!" he shouted. We stopped and shook hands all around. To him, "Washington" meant George Washington. And Kościuszko, of course, was the young Polish engineer who fortified West Point and Saratoga, and helped Washington win the American Revolution.

Having established this bond between us, our young friend said no more until we came to Kraków's huge main square. There women in bright shawls were selling shriveled apples and scrawny chickens outside the arcaded 14th-century Cloth Hall (page 378). A toy salesman struggled to avoid being dragged off his feet by a cloud of rubber balloons that billowed above him. A dozen young men stood gaping at a 1950 Chevrolet.

Kościuszko: Glorious Failure

The boy led us to a tablet in the pavement.

"Kościuszko!" he announced again.

This was the spot where the young veteran of the American campaigns had taken command of Poland's uprising against the Russians in 1794. Our guide, his mission accomplished, left us with fervent handshakes.

Kościuszko's insurrection failed, and its leader, badly wounded, was carted off to St. Petersburg a prisoner. But in the eyes of every Pole, his was a glorious failure. On a hill outside Kraków his countrymen built a memorial to him in the form of a huge mound, 100 feet high. Dust from Saratoga was brought there and entombed with earth from Kościuszko's battlefields in Poland. A future President of the United States, Herbert Hoover, spoke from this mound to 30,000 grateful Poles in 1919, when he had charge of American relief.

One other spot in Kraków is a place of pilgrimage for every Pole who venerates the memory of Kościuszko. This is the Wawel, the "Acropolis of Poland," a wall-enclosed hill on which a citadel, cathedral, and royal castle tower above the Vistula and the old city (page 376).

In the much-restored cathedral, a verger led us to the royal crypt. There, among the tombs of kings and other national heroes, he pointed to a marble sarcophagus bearing the name Tadeusz Kościuszko.

A Wartime Treasure Hunt

Next to the cathedral, in the royal castle, we had the most overwhelming surprise of our entire stay in Poland. This was our first sight of the Kraków Altar, carved in wood and painted between 1477 and 1489 by the genius whom the Poles call Wit Stwosz and the Germans Veit Stoss. The moment we saw it we knew we were in the presence of a supreme work of art (page 384).

The altar had been dismantled and was being restored in a wing of the Wawel Castle. Each of its 18 sculptured panels, representing scenes in the lives of Christ and the Virgin, was standing on a giant easel at eye level. It was as if the Sistine Chapel frescoes had somehow been brought down from their ceiling and put where you could see them at close range.

"You Americans are responsible for bringing this altar back to our city," Prof. Karol Estreicher of the University of Kraków told us. When the Germans invaded Poland in 1939, they took the altar to Germany and hid it. After the war, Professor Estreicher worked with United States authorities to locate it.

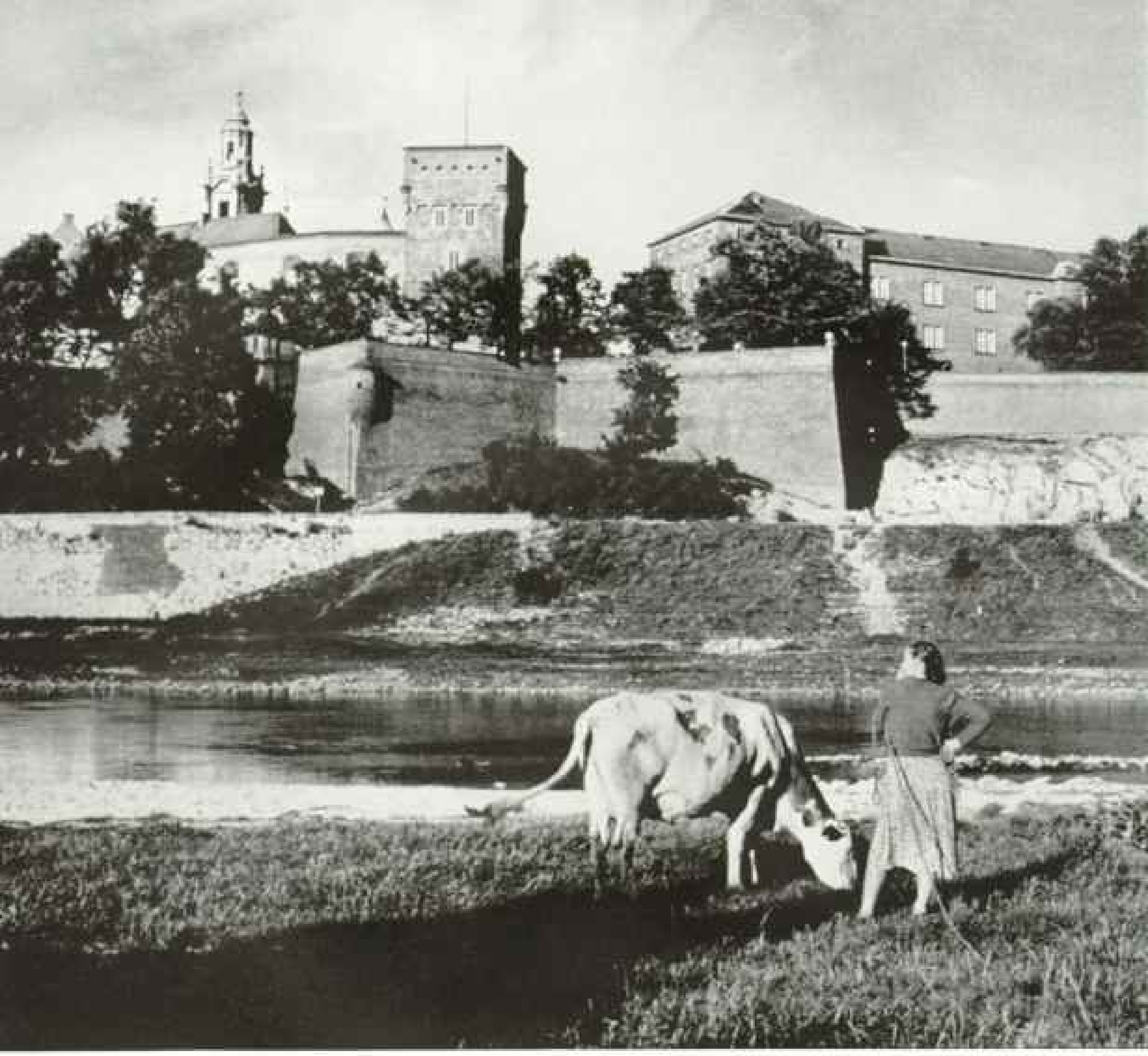
"It was like a detective story," he recalled. "In 1942 the Polish underground in Switzerland learned that our precious altar was in or near Nürnberg. When your American soldiers took Nürnberg in 1945, officers began searching for it under the rubble of the city's medieval castle.

"They found that what looked like a small cellar was really the entrance to a huge underground vault. Your men had to open three 10-foot-high pairs of steel doors, set in concrete, to get into the vault. That's where they found the altar.

"They packed it carefully and sent it back

Children Near Gdańsk Use a Russian Tank in Place of Swings and Seesaws

Poland, like Europe's other Communist lands, has many memorials to Russian arms, but the authors saw only one statue of Stalin, a commonplace elsewhere in the Soviet bloc.



to us in 1946 in a special train. I was aboard the train, and I'll never forget the excitement when it pulled into Kraków."

For more than 11 years the altar was under careful restoration. The Polish Government has given it back to the Roman Catholic Church, and it is now in its original position under the soaring Gothic arches of the Church of Our Lady, on Kraków's main square.

In the 14th-century church we saw scaffolding in place for the work of installation. An unending procession of worshipers moved slowly down the nave, and we found ourselves swept along with them. For this was the day before Easter, and all of Kraków's 465,000 people, it seemed, were visiting the flower-banked churches to see the effigy of Christ.

Though Poland is Communist-ruled, its people are 95 percent Roman Catholic. Its Cardinal was released from three years' detention late in 1956. Religion is being taught again in the public schools, and the church is flourishing.

Not even in Rome can you hear such a clangor of church bells as in Kraków early on Easter Sunday. It sounded as if all the bell ringers in all the city's 56 churches were competing to summon Krakovians to prayer.

Easter a Time for Christenings

Easter is not only a day of worship in Poland; it is also a time for family feasting, for weddings, and for christenings. We had asked a Polish journalist whether we might attend a christening.

"Why not come with us?" he offered. "Our daughter is being christened on Easter."

So, at St. Stephen's Church, we were guests of the proud family as they gathered for the christening. The baby found the candles more fascinating than the big, good-natured priest in his white-and-gold vestments. Three

The Wawel, Shrine of Saints and Patriots, Endures Beside the Quiet Vistula

Medieval kings built the walled town, complete with palace and cathedral, to guard Krakow, for almost five centuries the royal capital. Austrian conquerors in the 19th century turned the castle into barracks; Poles restored it before and after World War I. Today the riverside Wawel serves as a national shrine. The cathedral contains the tombs of St. Stanislas, patron of Poland, and Tadeusz Kosciuszko, Polish patriot and volunteer in the American Revolution.

ceremonies were going on at once—a wedding at the high altar, and two christenings in the side chapels.

After the ceremony the family took us to their home in what had been a spacious six-room apartment. Today four families occupy the flat, sharing bathroom and kitchen. Our hosts considered themselves fortunate, for they have two good-sized rooms, plenty of old family furniture, and a grand piano.

The christening feast, spread out on a white cloth, consisted of cold meats, including Polish ham, liver paste, white bread, and two kinds of cake. With the meal we were offered three kinds of vodka; straight and fiery for the men, mixed with cherry sirup or honey for the ladies. After dinner the hostess served real coffee in small china cups.

By such family feasts as this one, by unswerving devotion to the Catholic Church, and by remembrance of saints and heroes and historic places, the Polish people keep their past close to their daily lives.

They keep it alive, too, by carefully preserving folk songs, dances, and costumes (page 356). A Pole goes as wild about a troupe of folk dancers and singers as an American does about a winning baseball team. The peasant costumes seem to recall something he saw packed away in a family chest, in childhood. The songs, adapted from old tunes, may be those he heard his grandmother sing. The whirling peasant dances stir his blood.

Audience Demands Five Encores

We were lucky to get tickets for a performance by one of the best of the song-and-dance troupes, the Mazowsze. The company was a semiprofessional one, recruited from farm villages. The program was a mixture of choral singing with solos and dances from a dozen parts of Poland.

One singer impersonated a farmer driving a team of horses. He brought down the house, and we couldn't understand why. Our Polish companion whispered the explanation:

"The farmer is saying, 'Don't beat your horse, or make him pull a load that's too heavy for him. Even if you feed the horse a lump of sugar, he won't like you. The farmer's horse never forgets.'"

The audience, remembering the long years of being beaten by Nazi and Communist drivers, saw a political implication in the song as well as exciting showmanship. The farmer-singer had to give five encores before the crowd would let the show go on.

The Mazowsze troupe has traveled as far as Peiping and London. In England they had learned "My Bonnie Lies Over the Ocean," and they sang it with great charm.

When the song ended, the Poles sitting around us turned, smiling and eager, to see whether we, the English-speaking visitors, had liked the effort. We had—and clapped long and hard to show our appreciation.

Later we went backstage and met Mira Zaminska, the troupe manager. She told us that her young men and women hoped to

Kraków's Six-century-old Cloth Hall Wears the Scaffolding of Renovators

Cradle of the nation, Kraków crowned Poland's kings and rallied resistance against invaders. After Mongols destroyed Kraków a new, planned city arose on the

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ruins in 1257. Amid other stately structures, the Cloth Hall took shape in 1391. Medieval merchants sold fabrics and other goods in booths behind vaulted arches. Here the hall undergoes the latest of several restorations. On the right, poet-patriot Adam Mickiewicz stands in bronze amid visitors and pigeons.

Teen-agers Cheer a Beauty as Photographers Record Her Victory

Sopot scandalized the Communist press in 1956 when some 10,000 unruly spectators flocked to the beach resort for a bathing-beauty contest and jazz festival. Enthusiastic supporters of Elzbieta Sosinska (above), a 19-year-old drama student, celebrated her selection as Miss Sopot by overturning a Radio Warsaw mobile unit broadcasting the contest.

go to America soon. They wanted to sing at least one American song. We came up with a suggestion: "Clementine." We could hear these sturdy peasant artists singing:

"Oh, my darlin', Oh, my darlin',
Oh, my da-a-a-arlin' Clementine. . . ."

The words should not be too hard for them —and anyway, "Clementine" is a song of lusty young pioneers who were not unlike these singers and dancers from rural Poland.

The serious theater, too, has its enthusiasts in every important city of Poland.

In a dressing room in Warsaw's vast Palace of Culture and Science, we talked about the legitimate theater with Eva Krasnodemska, one of the outstanding actresses of the post-war generation in Poland.

"We have 13 companies in Warsaw alone," she told us. "They are all subsidized by the state. Then we have five or six others that you would call 'off-Broadway' companies."

Miss Krasnodemska was appearing in a Polish version of *The Diary of Anne Frank*, which had been phenomenally popular. We guessed that it was popular because it echoed experiences that had come to so many Poles during the war.

Patriotism in Chopin's Music

The Poles also have an insatiable appetite for translations of Molière and Shaw and for their own 19th-century dramatists who wrote from exile, when their country was partitioned among three neighboring empires.

The plays, novels, and music of this period helped keep the Poles' sense of nationhood alive. One composer, in particular, has stirred Polish pride through the dark years. He, of course, is Chopin, whose birthplace at Żelazowa Wola, 28 miles west of Warsaw, is a national shrine. Here, every Sunday in the


ADAMOWI
MICKIEWICZOWI
NARÓ

spring and summer, the public is invited to a Chopin concert.

With a crowd of Polish tourists, we stood in the Chopin family living room while a blind pianist, Edwin Kovalik, played the "Ballade in A-Flat Major" and other Chopin pieces.

"He learned all his music in Braille," Kovalik's sister told us. Chopin himself would have liked the achievement. As a boy he was delighted by the skill of a blind bass-viol player in a near-by village.

Although Chopin left Poland forever at the age of 20, he never forgot the melodies he heard in the villages near Żelazowa Wola. His polonaises and mazurkas, by their very names, sing of Poland. A polonaise is a slow dance of Polish origin; a mazurka is a lively dance in triple time which originated in Mazovia, the region where Chopin was born.

Side Roads Lead into the Past

Traditional Poland lives in Chopin's music, and also in the farm villages around his birthplace. Here, on the great north European plain, is the Poland we had imagined: a wide expanse of flat or gently rolling fields, with a high sky and far horizons like those of the Dakotas. Icy winter winds blow snowdrifts high against the houses. In the long, slow spring, which lasts until mid-May, and in the relatively short summer, every pair of hands is needed to sow or harvest the wheat, rye, potatoes, or sugar beets.

Well-paved main highways streak across this landscape like shiny ribbons. Tall poplars line the roads. Even without traffic, these hard-topped roads have a modern look. But old-fashioned Poland begins as soon as you take a side road to any farm village.

Geese waddle across the roads, and hogs grunt in their sties as they do on farms everywhere. But Polish hogs are special, for they produce the Polish ham that rivals the Danish as the best in Europe.

For the farmers, life is very much as it was 100 years ago. Mechanized equipment is scarce. A farmer relies on a team of sturdy horses to pull his battered harrow. His Communist government gives him relatively little help. Until late in 1956 its chief concern with agriculture was to force the farmers into collectives, on the Soviet model.

The effort failed, chiefly for two reasons. The Polish farmer, like many others, needs the incentive of private property and profit. And he is a conservative fellow, deeply religious, deeply attached to his piece of earth, and stubborn in keeping to his old ways.

His wife still bakes her own dark rye or whole wheat bread. She smokes her own ham and bacon, grinds her own buckwheat for cereal, and makes her own sour cream. To sample the best food in Poland today, one has to go to the farm and market towns.

Country Lunch Overwhelming

One day we stopped for lunch at a market-town restaurant near Poznań.

"You won't find anything better around here," our driver said apologetically.

On the door was a sign saying "KAT. 3." This means third category, or lowest class. A dozen bicycles were parked against the wall. Inside, all but one of the 10 square tables were crowded with men in boots and rough work clothes. Obviously they were farmers, in town for the day. They cast curious but not unfriendly looks at us as we sat down.

The waitress, a buxom farm girl, took our order: split-pea soup, sausage, cabbage and potatoes, and dark rye bread with a stein of beer to wash it down. The quart bowl of soup, with chunks of pork in it, was delicious. But we were unequal to the challenge. We could only sample the mammoth sausage and mounds of vegetables that followed.

Nothing in Warsaw's best hotel had tasted half so good. The whole meal cost the equivalent of 50 cents per person.

Rural Color Survives in Zakopane

Although Polish farmers eat better than most cityfolk, their lives are still hard and drab. The color and gaiety usually associated with countryfolk can still be found, but in only a few places. One is Łowicz, 50 miles west of Warsaw. On Sundays the women put on their striped skirts of green, orange, and black wool and trudge across the fields to church. In summer, especially, the costumes make Łowicz a garden of flashing colors.

We spent two Sundays at Łowicz, which pleased but did not satisfy our Polish friends.

"You must go to Zakopane!" they urged. They said it so often and so insistently that we would hardly have dared to disobey.

When we first heard of Zakopane, we made the mistake of asking, "What is it?" Ap-

Balloons in Peppermint-candy Hues Capture the Hearts of Kraków Children

Kodachrome by Dalia and Ferdinand Kuhn, © National Geographic Society

Museum Technician Inspects Kraków's Priceless Altar

For colossal design and skill of workmanship, few religious masterpieces rival the great altar of the Church of Our Lady, a 12-year work of the sculptor Wit Stwosz, known also by his German name, Veit Stoss. His panels contain 446 carved wood pieces representing the life of the Virgin.

Germans seized the altarpiece in 1939; Americans found it in an underground vault in Nürnberg and returned it.

Bereaved St. John witnesses the death of the Virgin Mary.

Trumpeter hails the hour atop the church. Thirteenth-century tradition memorializes a sentry who warned Krakovians of a Mongol invasion. Trumpeters today end their call precisely where a Tatar arrow in the lookout's throat stopped the original.

Wawel Castle rises in the distance.

parently it was like asking a Frenchman "What is Cannes?" or a German "What is Garmisch?"

For Zakopane is the resort that many Poles regard as the closest thing to heaven on earth. To reach it, you must travel to the extreme south of the country, to the Tatry Mountains along the Polish-Czech border. Around the town, a few of the peaks soar above 8,000 feet. They are snow capped most of the year, and some of their high slopes are good for skiing until mid-May.

Polish love of the Tatrys is understandable, but pride in Zakopane itself is puzzling. To Western eyes, the town cries out for paint and plaster and for the flower boxes and other cheerful touches that make Swiss and Austrian mountain resorts so attractive.

But if Zakopane lacks color and charm, the mountain folk of the Tatrys have both in ample measure. The *górale*, or highlanders, are not only shepherds and farmers, but also poets, singers, wood carvers, and weavers of uncommon skill. Any day you will see the men wearing their distinctive górale dress: tight trousers of heavy white homespun wool, richly embroidered from waist to knee; loose jackets, also embroidered, slung across their shoulders; and black felt hats with smooth crowns and narrow brims (pages 391-98).

A Poet Tends Hillside Sheep

On a hill above Zakopane we met the góral family of Stanislaw Byrcyn. Stanislaw, a smiling, weather-beaten man of 46, owns about five acres of steep hillside and 25 sheep. But from these you cannot guess his main occupation. "I am a poet," he told us.

The three younger children—out of seven—tend the sheep while father tends his art. His wife, Agnieszka, and their 18-year-old daughter of the same name are the family business managers. They spin and weave the wool into the brightly patterned rugs that are a well-known product of the Tatrys.

Would we come into their 125-year-old house and see them at work? Mother set up the spinning wheel, daughter pulled out the loom. Father had a caller, a fellow poet named Adam Pach. They sat down together.

The father called his nine-year-old son. "Wojciech, bring the *dudy*!" This is the highlander's bagpipe, with a sheepskin bag. Father puffed out his cheeks and blew a lilting tune. Then the two poets sang an old shepherd's song together.

Bagpipe, song, loom, and spinning wheel are just as they have been for generations. As we rode a crowded bus down from the mountains to the plains, we felt that the Tatrys were one of the last refuges of the old, traditional Poland.

Little more than 100 miles to the northwest, we were to find an area where the people and their lives had changed suddenly, profoundly, almost beyond recognition. This was in what the Poles call their "Western Territories."

The maps of Poland on the opposite page illustrate how the country has literally moved westward. At the war's end, Poland lost a Missouri-sized piece of territory to Russia in the east; subject to eventual ratification by a treaty, it gained a smaller piece, the size of Kentucky, from Germany in the north and west. This shift in geography is one of the most drastic of all the changes that have come to Poland in the past dozen years.

An Exodus Transforms a Nation

With the shift of territory came a shift of people the like of which modern Europe has never seen. No fewer than 8,000,000 Germans fled or were expelled from what became western Poland. And more than 5,000,000 Poles, most of them from territory seized by Russia, moved in to take their places.

To find out what had happened in the area formerly German but now Polish, we hired a car at Katowice and set out on a 300-mile exploration. We chose the most valuable of Poland's newly acquired lands: Upper Silesia, with its rich coal deposits and its powerhouse of steel and chemical industries, and Lower Silesia, with its fertile land and the great industrial city of Breslau, renamed Wrocław.

The only car to be hired in Poland today is the Warszawa. It is Polish-made but has an oddly American look. The reason is that it is a virtual copy of a 1946 American car, made with jigs and dies supplied to Poland by Russia. The model does not change from year to year. It is a tough little car, and it stood us in good stead as we rolled through the factory towns of Upper Silesia.

The smoking chimneys and the slag heaps of Upper Silesia could be duplicated in any coal-mining area of Europe. But once outside the cities, we knew we were in former German territory. The high-roofed village houses were as German as sauerkraut. The countryside had the neat, well-tended look of German farmland. The empty road was one of Hitler's *Autobahnen*, an express highway that connected the factories of Upper Silesia with the interior of Germany.

At Opole (Oppeln), a city of 52,000 before the war, we asked how many Germans were left.

"They're gone—all gone," was the answer.

The shopping crowds on the sidewalks were Poles from Lwów or Wilno or other former Polish towns now inside the Soviet Union.

At Olawa, formerly Ohlau, the answer about the Germans was the same. Here Russian officers clumped the sidewalks in heavy boots. Nobody paid attention to them, or to passing truckloads of Russian troops. The Russians are believed to have at least 30,000 troops in Poland, by agreement with the Communist government in Warsaw.

On our journey northward through the wide valley of the Oder, we saw occasional big houses set in groves of trees. These had belonged to the great German landowners. Who was living in them now? We stopped at one stately house to find out.

A woman hurried down the grand staircase to greet us. Three children followed her and stood watching, shyly. Then another woman and another brood of children; then another and still another. Soon we were standing in the middle of a friendly circle of 30 men, women, and children.

One of the men answered our unspoken question.

"Six families live in this house," he explained. "Seven more families, 40 people in all, live in farm buildings near by. Most of us have come from eastern Poland."

A wealthy German had owned

Poland, Reborn at Versailles, Moved West After World War II

For more than a century Poland existed only in the hearts of her people. Swallowed up by Russia, Prussia, and Austria by 1795, she became a nation again after World War I. Hitler's invasion in 1939 started the second great war.

When peace came, Poland gained large areas in the west from Germany and lost even more to Russia in the east. Millions of Poles migrated westward with their country's boundaries.

the 642-acre estate. Now it was a state farm on which the workers were employees of the Polish Government. In the big house all traces of the German owner had been wiped out. Not a stick of his furniture was left.

With the women and children trailing behind, our interpreter led us down a long corridor to what had once been a grand salon. The ornate ceiling was cracked, the paint on the walls was flaking off. The room was bare except for a ping-pong table in the middle.

Two boys picked up paddles and showed that they were good at the game. Across one end of the room where, no doubt, the German owner had hung his tapestries and placed his grand piano, the Polish families had built a stage for amateur theatricals. The new tenants agreed that they "never had it so good."

What, we wondered, would the German owner think if he could see his ancestral halls now? His house, at least, was still intact. Many of the great houses in the former battle zone have been destroyed.

Ghostly Castle Rises on Dragon Hill

Anyone who explores a recent battlefield is bound to become accustomed to the sight of ruins. But nothing prepared us for what we found in a village which the Poles now call Żmigród—Viper Town—and which the Germans, for centuries, had known as Trachenberg—Dragon Hill.

Among great oak and chestnut trees stood the remains of what had been a castle in fairly recent times. It was ghostly in its emptiness. Blue sky showed through every window.

"Hello!" our driver called. Then he whistled, but no living thing stirred.

We picked our way up the ruined stone steps into what had been the entrance hall, now open to the sky. Roofless corridors led off into the wings. How had the house been destroyed? Why? Who had lived there?

We found just one clue. Carved above the front entrance were the initials F. H.

"I think the name was Hatzfeldt," our driver volunteered.

This rang a bell. Count Paul von Hatzfeldt had been one of Kaiser Wilhelm I's ambassadors in London. The name was that of a famous landowning family. We resolved to find out what had happened to the family and to the castle.

Weeks later, in West Germany, a young man met us, by appointment, outside the Cologne Cathedral.

"I am Edmund von Hatzfeldt," he said.

From water to water; the Elbląg Canal boat

He was the son and heir of the family that had owned the castle for generations. One of his ancestors had been the F. H. of the carved initials; his father had been an attaché in the German Embassy in Washington early in World War I.

"My sister was born in Washington," the young man said, "so, in a way, she's American.

"You know," he said, "you are the first people I have met since the war who have seen Trachenberg. Tell me, what does it look like?"

The subject was not too painful for him to want every scrap of information he could get. We sat down in a coffee shop and told him

makes an over-the-hill portage on rails. Passengers enjoy a voyage past dense forest

what we had found. Then it was our turn to ask questions.

He first showed us a book of pictures of the castle as it had looked in his boyhood. The vast reception rooms were museums of Louis XV furniture and chandeliers. Old family paintings adorned the walls.

"We managed to move a few pieces of the art into Germany in 1944," the young man told us. "But all our furniture and personal possessions had to be left behind when we got away from the Russian army. They turned the house into a hospital and a prison. They threw everything out the windows and covered the floors with straw.

"I don't think they meant to burn it. But one night someone must have dropped a lighted cigarette in the straw, and by morning the whole castle was burned out.

"My father owned 42,000 acres and many villages," he went on. "There were a game preserve, sheep and dairy herds, and one of the biggest carp fisheries in Germany. We grew wheat, vegetables, and sugar beets, and we refined the sugar at Trachenberg.

"You ask what I am doing now. I am a clerk in an insurance office here in Cologne."

Old Poland, too, had its landed estates, its great families. Among them, the Radziwiłls, Potockis, and Sapiehas contributed more

than their share to the roster of Polish statesmen, generals, cardinals—and profligates.

Today their great estates are no more. Some are run as state farms; others were divided among former tenants or refugees from the east. The country castles remain as rest homes for artists, writers, and favored officials of the Communist regime.

The families themselves have vanished from Poland, with a few exceptions. One Radziwiłł, we were told, still can be seen in Warsaw, a tall, aristocratic figure who used to march in the Communist May Day parades. One elderly Potocki, still handsome and courtly, holds a clerical job in Kraków.

One chilly spring day we drove to Nieborów, about 40 miles west of Warsaw, where the palace of Prince Janusz Radziwiłł now serves as a retreat for intellectuals. The stately 17th-century mansion stands in a park of lawns, tall trees, and clipped hedges.

We had planned to picnic in a field, but cold wind drove us to ask whether we might bring our lunch into the palace. An elderly caretaker politely showed us into a room with a big polished table. As we picked chicken bones in our fingers, the portraits of the Radziwiłłs looked down at us from the walls. Their pale, aristocratic faces regarded us coldly. Their eyes seemed to say:

"Who are these intruders? And what table manners!"

We raised paper cups of wine in a toast to our silent hosts.

Minority Groups Are Gone or Going

The disappearance of such landed families and their holdings is another of the profound changes in Poland. Still another is the virtual disappearance of the minorities. In prewar Poland at least 30 percent of the people were Poles only by citizenship. The polyglot population included 6,000,000 Ukrainians, White Russians, and Ruthenians, and 750,000 Germans. There were also 3,000,000 Jews.

Most of the Ukrainians have been swallowed up by the Soviet Union; all but a few of the Germans fled, were deported, or have left within the past year to rejoin relatives in Germany. As for the Jews, only about 50,000 are left, and these are emigrating as fast as they can get permits and visas, most of them to Israel. The vast majority died in concentration camps or in the savage fighting in the Warsaw Ghetto in 1943.

The textile city of Łódź, for example, harbored almost 200,000 Jews before the war. On working days the streets of the Jewish section used to swarm with pushcarts and traders, and with bargain hunters from other parts of the town. On the Sabbath and on feast days, in every crowded home, ancient prayers were repeated and traditions kept alive. Today all this pulsing life is silenced.

Some of the crowded tenements were blown up by the Germans, others have collapsed in recent years from sheer decrepitude. The houses that remain are bulging with Polish refugees from the former eastern provinces.

Poland Today a Homogeneous Country

"I wouldn't have believed it," a Jewish acquaintance told us as we walked through one of these districts. "When I came back from a Russian labor camp after the war, I searched these streets for someone—just anyone—I knew. I didn't find a single one. All my relatives and friends had disappeared. Strangers had moved in where they lived."

Through the disappearance of her minorities, Poland lost the farming skill of the Ukrainians, the technical and managerial talents of the Germans, the commercial enterprise of the Jews. But Poles will point to the other side of the ledger. The frictions, and sometimes the killings, that resulted from Poles and minorities living side by side—these, too, are virtually ended.

Today Poland is a homogeneous country. About 95 percent of its people now speak the same language, profess the same faith, treasure the same customs, and face the same prospects together.

If Poland were on another continent, what bright prospects it would have! The country has plenty of resources, and 1,000 years of struggle have toughened its people for survival. But living where they do, can the Poles keep their doors to the Free World open? This question was always on our minds, and still is. Who can tell? One thing is sure: Poles have long dreamed of freedom and they still do.

In the years when foreign conquerors occupied their land, Polish exiles used to sing:

"Poland has not perished yet
While we are still alive. . . ."

Like the Japanese who rebuilds after every earthquake, like the Italian on the slopes of Vesuvius who replants his vines after each eruption, the Pole is indestructible.

Raftsmen shoot a gorge of the Dunajec River beneath 14th-century Niedzica Castle in the scenic Zakopane region. Visitors ride this spectacular seven-mile stretch on homemade log floats.

Crewmen relax after a run. Felt hats and richly embroidered vests present variations of the regional costume (following pages).

Pigs Scrubbed Pink Ride Shaded Carts in Nowy Targ Market

Dealers, once an integral part of the farm-market system, have vanished under the Communists; farmers sell to one another or to government buyers.

Resplendent farmer wears white wool trousers with intricate embroidery and flaring trouser bottoms.

The *górale*—Poland's mountaineers—use part or all of their traditional costume on workdays as well as holidays.

"What am I bid?" asks the owner of a pig. Prices, fixed in government stores, vary elsewhere according to supply, demand, and bargaining skill.

Hikers Tread a Path Between Nations, Poland (Left) and Czechoslovakia

This section of the Tatry Mountains, once tightly closed by patrols, now welcomes sightseers and hikers from the United States and Western Europe. Commercial traffic funnels through distant check points. Many Poles, escaping to West Germany at war's end, fled by this roundabout route through Czechoslovakia.

Here a Czech family strolls a ridge near Kasprowy Peak.

Sunday Churchgoer Stops for Repairs to Her Hairdo

Bright blue eyes and blond hair predominate among the mountaineers. Fiercely independent, the górale never experienced serfdom. Secure on the heights of the wild Tatrys, they escaped the tides of war and conquest that swept Poland's plains for a thousand years.

Surfaced roads and railways succeeded where medieval armies failed; skiers and excursionists now make the Tatrys a popular resort area.

Mother and daughter live near Zakopane.

Convertible carriage, its team gaily harnessed, takes a mountain family on an outing in Dolina Chocholowska, a valley in the Zakopane region. Wood carvers raised the wayside shrine.

Dazzling górale finery enriches a wedding portrait. Some of the men's jackets, marvels of unbleached wool encrusted with needlework, pass from generation to generation. Women's dresses, less elaborate, are embroidered with dyed silk. Husband and photographer wear moccasinlike shoes laced tight to trouser bottoms.

Serious moments are few in a mountain wedding, a celebration that may begin one day and spill over to the next. On the way home from church, guests capture the bride and groom. Here the bride's mother, surrounded by jailers, laughingly agrees to a proper ransom—in this case, vodka for all.

Bride and Bridegroom Kneel for a Blessing

Costumed friends (opposite) witness a traditional ceremony: the couple's dutiful farewell to parents before they go to the church to exchange vows. The bridegroom stares gravely ahead as his fiancée, overcome by the solemnity of the moment, kisses her father's hand.

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Wedding Cake and Salt Greet the Returning Man and Wife

Freed by merrymakers, the couple pause on the threshold of the bride's home for a reception by her father. He bestows a gift of bread and salt and reads a second blessing. Here the bride, prayer book in hand, bows for the benediction. The newlyweds will move in with the bride's family until they acquire a house of their own.

New Polish-Czech Map Charts a Political Divide

MORE than 125,000 National Geographic member-families now have The Society's Atlas Folio in their homes. This month they will mount in it the fifth map in the Atlas Series, covering **Poland and Czechoslovakia.**

Here, in a 10-color chart of unique and timely interest, they will find the answers to myriad questions on Europe's recent history and timeless geography. The map, mailed with this issue to 2,250,000 members around the world, brings into immediate focus the triumph and the tragedy of our time.

Map Records Europe's Shifting Frontiers

As Plate 38, the new Atlas Map will be mounted with a single center fold—a crease that almost touches the old "Centrum Europae" once claimed by Bohemia as the geographical center of the Continent. Families might want to debate whether Bismarck was right when he asserted, "Who is master of Bohemia is master of Europe."

Twice in the past four decades world wars have recast the face of middle Europe. The changes show clearly. Today's international boundaries stand out in wide bands of various colors; yesterday's, drawn in 1919 and preserved only until 1938, are marked by a distinctive red symbol.

A scale of 34 miles to the inch—the most detailed ever used for a National Geographic map of this area—permits readers to appraise postwar changes. Here is clearly visible the westward shift of Poland, which brought hundreds of German communities like Stettin and Breslau under Polish dominion (see maps, page 387).

The advance of the U. S. S. R. is also measurable: as much as 300 miles westward, making Lithuania again a part of Russia. Also annexed were chunks of East Prussia and prewar Poland. In bobbing the tail of Czechoslovakia, Russia acquired a short common frontier with Hungary—an area of fateful importance in the Hungarian uprising of 1956.

Germany remains divided. But the map reveals how Berlin, no longer joined to the West by a single corridor, stands like an island only 30 miles from the new Polish border. Military traffic still approaches the onetime German capital through the old corridor, but tourists may enter by several other roads. Five high-speed *Autobahnen*, double-lined in red on the Atlas Map, converge on the partitioned city.

Behind the Iron Curtain readers will find revealing changes. In East Germany, for example, the city of Chemnitz is now Karl Marx Stadt. And Czechoslovakia's highest mountain, formerly called Gerlach, now appears under its postwar name of Stalinov Štit, a 1949 birthday honor for Josef Stalin.

Some 6,000 place names appear on the map—cities, villages, and natural features that have molded recent history and could make tomorrow's headlines.

Mineral deposits spot this area. On the Czech-East German line, the Erz Gebirge—literally, Ore Mountains—have long been worked for silver, tin, zinc, and lead. From the ore of Jáchymov the Curies extracted the world's first radium. Today the region supplies much of the Communist bloc's uranium.

Despite current politics, the map records the landmarks of liberty-loving peoples. Lidice, the village whose planned obliteration aroused the world, stands rebuilt on a new site west of Prague. And the venerable city of Kraków guards the tomb of the Polish patriot, Tadeusz Kościuszko, who aided a fledgling America in the cause of freedom.

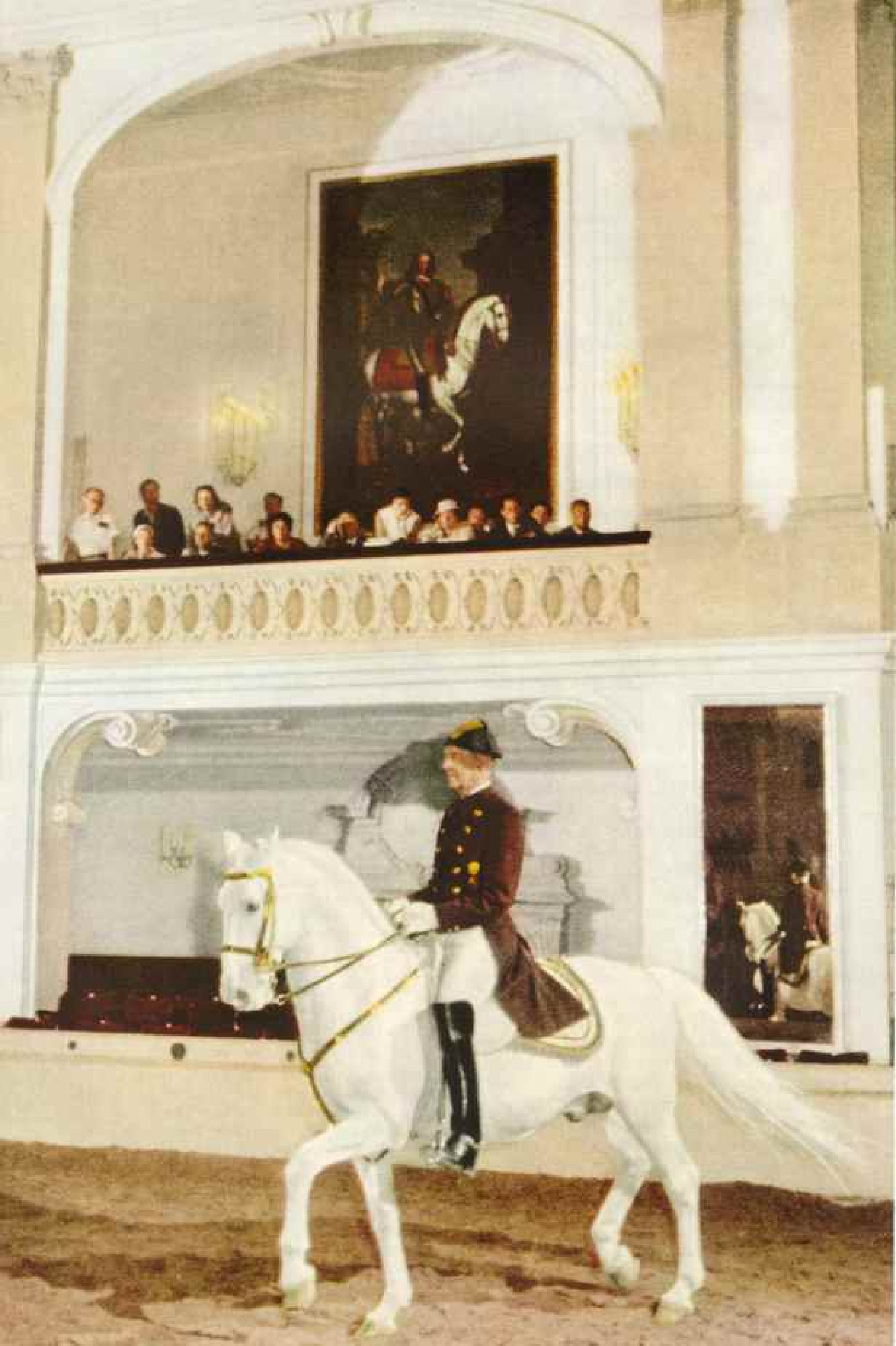
Members may obtain additional copies of the new **Poland and Czechoslovakia** map, and previous Atlas Maps, postpaid to all countries, 50¢ each. The **Atlas Folio** is priced at $4.85, including postage. Five Atlas Maps have been published: Southeastern United States, Southern South America, National Parks, British Isles, and Poland-Czechoslovakia.

Available only from the National Geographic Society, Washington 6, D. C.

Near East Wall Map

now available to members

With the world's eyes focused on the Near East, Society members can follow events in these turbulent lands on their 41-by-29-inch wall map, **Lands of the Bible Today.** New members desiring copies of this detailed 10-color map, covering countries of the eastern Mediterranean, may order them from the National Geographic Society, Department 86, Washington 6, D. C. Prices: $1 each on paper; $3 on fabric, postpaid. Index to place names, 50¢. All remittances payable in U. S. funds.



The White Horses of Vienna

By BEVERLEY M. BOWIE, Assistant Editor, National Geographic Magazine

Illustrations by National Geographic Photographer VOLKMAR WENTZEL

THE great double doors at the end of the riding hall swing slowly, slowly open, moved by invisible hands. The violins of Bizet's "Arlésienne Suite" breathe a gentle invitation, and from the gloom of the passageway the first horse and rider, an apparition in brown and white, move gravely forward into the hushed arena.

A tall, iron-gray man with lean, ascetic cheeks and grieving mouth, the rider sits his snowy stallion in complete composure, hands as still as marble, back firm, boots straight and tranquil, eyes fixed ahead. Under him his horse moves with quiet pride. Its neck is arched, its hoofs spurn the smooth-raked sand.

Seven other riders in file follow the leader. Soberly uniformed in the cinnamon livery of a bygone era, they exhibit the same impassive, taut control of themselves and their mounts. Beneath the many-faceted chandeliers—Christmas trees of dripping ice—they parade the length of the gold-and-ivory hall until, approaching the lofty portrait of Charles VI, they doff their two-cornered hats in wide-sweeping salute (next page).

Austria Preserves a Greek Legacy

The deliberate, majestic gesture wrings a spurt of applause from the audience packing the double balconies. For the spectators instinctively recognize in this homage more than a formal tribute to an imperial patron of the Spanish Riding School. They sense here a willing acknowledgment by today's riders that they are the trustees of a fragile but precious tradition of horsemanship that has been passed along, by word and example, from one generation to another through the centuries.

This high and exacting technique of *dressage*, once common to the Greek world of Xenophon, sank out of sight in Roman and medieval times, emerged again in the Renaissance, and came to full flower in the imperial courts of the 18th century. Today it survives in its purest form only in Vienna, home of the Lipizzaner stallions.

Art of the Disappearing Rider

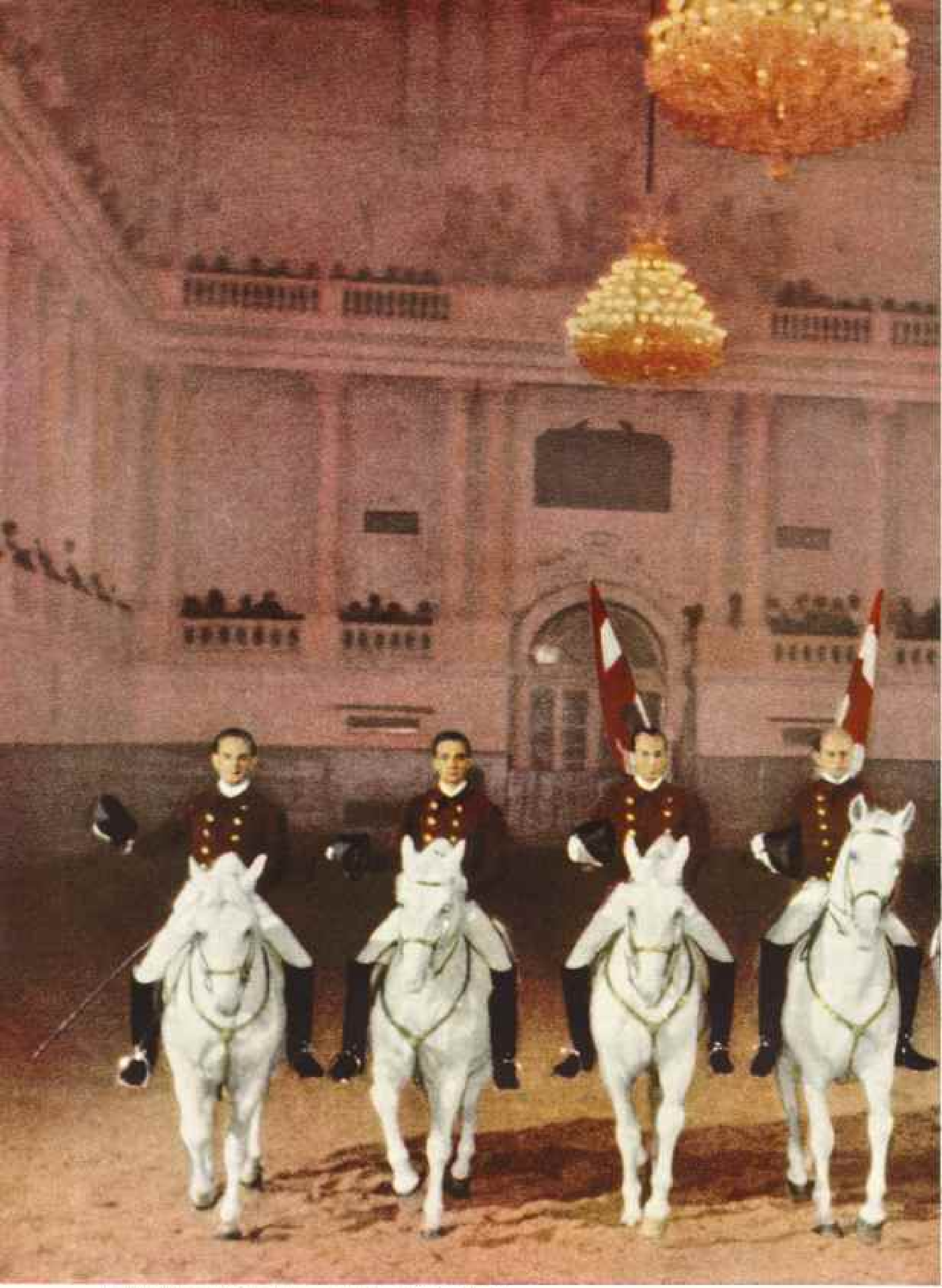
Should anything happen to the school and the thin line of continuity with the past be snapped, more would be lost than the livelihood of a few score horses and riders. An art form of great subtlety and power, as abstract and as moving as the ballet, would vanish from the world's cultural heritage.

Horses walking. That is all that the stallions of the school troupe are doing when Col. Alois Podhajsky leads them into the hall to begin the quadrille. Is there anything exciting about a walk?

One might not think so. Yet the spectators hunched over the red-velvet balustrades seem almost hypnotized, drawn into this tense spell in which horse and rider appear to move as in a dream. Some of them may know, others merely surmise, that it takes two years to teach a Lipizzaner to walk. But all of them respond to the achievement: the high knee action, the stately vertical carriage of the head, the slight downward thrust of the haunches, the precise and delicate placing of the feet—in sum, the indefinable impression of great vitality under the most sensitive and unobtrusive control.

Proud, Poised, and Precise, a Lipizzaner Floats in the Spanish Step

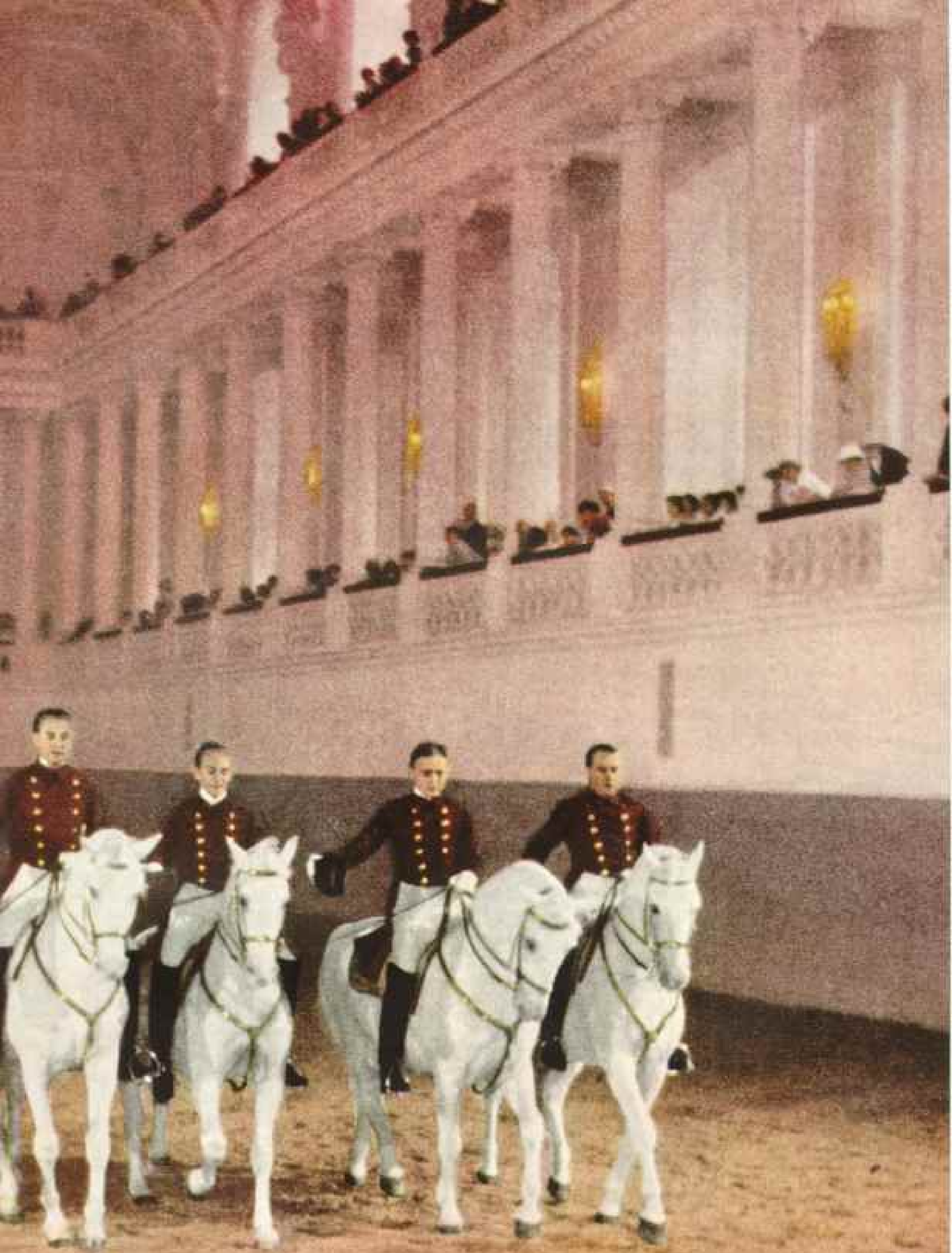
For four centuries the Spanish Riding School, a troupe of superbly trained stallions and their dedicated riders, has brought equestrian glory to Vienna. Lipizzaners take their name from a stud farm in Equile Lipizzano, Yugoslavia, and their ancestry from Spanish and Arab strains. Here Col. Alois Podhajsky, the troupe's leader, practices the same classic gait pictured above the gallery in the portrait of Emperor Charles VI, an early benefactor of the school. When Podhajsky quit the bomb-torn Austrian capital with his horses in 1945, he rolled up the royal portrait and carried it to safety in a cattle car.



Super Auvergnes by National Geographic Photographer Volkmar Wentzel

Elegant in Ivory and Gold, the Riding Hall Has Housed the School for 223 Years

The world's foremost equestrian academy might have disappeared forever in the rubble of World War II had not a U. S. general taken an interest in it.



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Intervention in 1945 by George S. Patton, Jr., commander of the Third Army, enabled Col. Alois Podhajsky to round up and reorganize his scattered troupe. The breeding herd was rescued from Czechoslovakia. Here riders salute the memory of Charles VI, the school's most enthusiastic royal patron. 403

Here, indeed, we come near the heart of the *haute école*. For the objective of this demanding discipline is not so much the hackneyed goal of "making the man and his mount seem like one," as it is that of causing the man himself virtually to disappear. So serene must be the rider in his seat, so disguised or invisible his guidance by the pressure of thigh or heel, rein or body weight, that the audience's attention slips away from him altogether and becomes focused wholly on the fluid movements of his horse.

Names Link Horsemanship and Ballet

Those movements range from the exact performance of walk and canter to the *piaffe*, a sophisticated "trotting on the spot," and the *passage*, or Spanish step, which Colonel Podhajsky describes thus: "The horse throws the diagonal pair of feet upward with the greatest of energy and pauses a moment longer than when trotting. This awakens the impression that he sways free of all earthly weight."

The feats also include pirouettes and half pirouettes, the mincing cross-steps of the *plié*, the intricate weaving and shuttling of the quadrille and *pas de trois*—and much more. Most dramatic, of course, is the "work above the ground"—the *courbette*, *levade*, and *capriole* (opposite and pages 413 and 416).

Stylized these various exercises certainly are. Yet, paradoxically, they are all based upon the spontaneous action of the horse in nature, a formalization of the leaps and kicks, curvetting and prancing that can be observed in any pasture. Nothing artificial or grotesque enters the curriculum of the school—none of the three-legged gallops, the backward canters, the waltz steps of the circus and the trick-riding ring. Each movement simply develops to its ultimate refinement a natural pace or position.

An antique art, if you will, but one with a curiously timeless and universal appeal. Emperors and archdukes, kings and queens once graced the galleries of the riding school; so concerned with its work was Emperor Joseph II that he requested weekly reports on the progress of each pupil. Today in republican Austria royal visitors are rare, and the school falls officially under the aegis of the Minister of Agriculture. But each performance finds the hall crowded with commoners no less entranced than were the aristocratic spectators, and cherishing quite as possessively this unique national legacy.

Perhaps they value it the more because it was so nearly lost. In the closing days of World War II, as the guns of the Red army were thundering at the gates of Vienna, Colonel Podhajsky confronted a desperate situation. He had managed unobtrusively to smuggle many of his stallions out of the city to a refuge at St. Martin im Innkreis in Upper Austria. But the Nazis balked at dissolving the school altogether; the people, they argued, would take it as a sign that the jig was up.

The colonel was left, then, with ten horses and two riders to survive the approaching cataclysm as best he might. Bombs probed at the vitals of the capital with fingers of fire; buildings to right and left of the riding hall flowered suddenly into flame and collapsed in smoking rubble.

Lipizzaners Gallant Under Fire

"The horses—they behaved like veterans," the colonel told me. "Magnificent! The air-raid signal would sound, and, without even being called, they would calmly file out of their stalls, ready to take shelter in the passageway alongside the riding hall. A bomb would come down—crash!—in the Michaelerplatz, the glass would fall around us like hail, and the Lipizzaners would crouch down, down, down, like this"—and he held his palm out flat—"until the attack was over, and then they would just get up. They shivered. But they never panicked."

Nevertheless, by early March of 1945 Colonel Podhajsky knew that Vienna might soon be without heat, light, water. Somehow, he must get his horses away.

"I went to an officer I knew in the Transport Section and demanded boxcars for my stallions and fodder and gear. He threw up his hands. 'I don't have enough even for munitions, much less your precious horses,' he said. But I knocked upon his Austrian heart, and in the end he produced them."

With an Electrifying Leap, a Stallion Begins the *Courbette*

Though the school's Lipizzaners are uncommonly supple and strong, only a few among the select troupe can master the arduous courbette. From the crouching levade position (page 415), the horse springs into the air and executes three or more leaps, forelegs never touching the earth. Riders in this school "above the ground" use no stirrups.

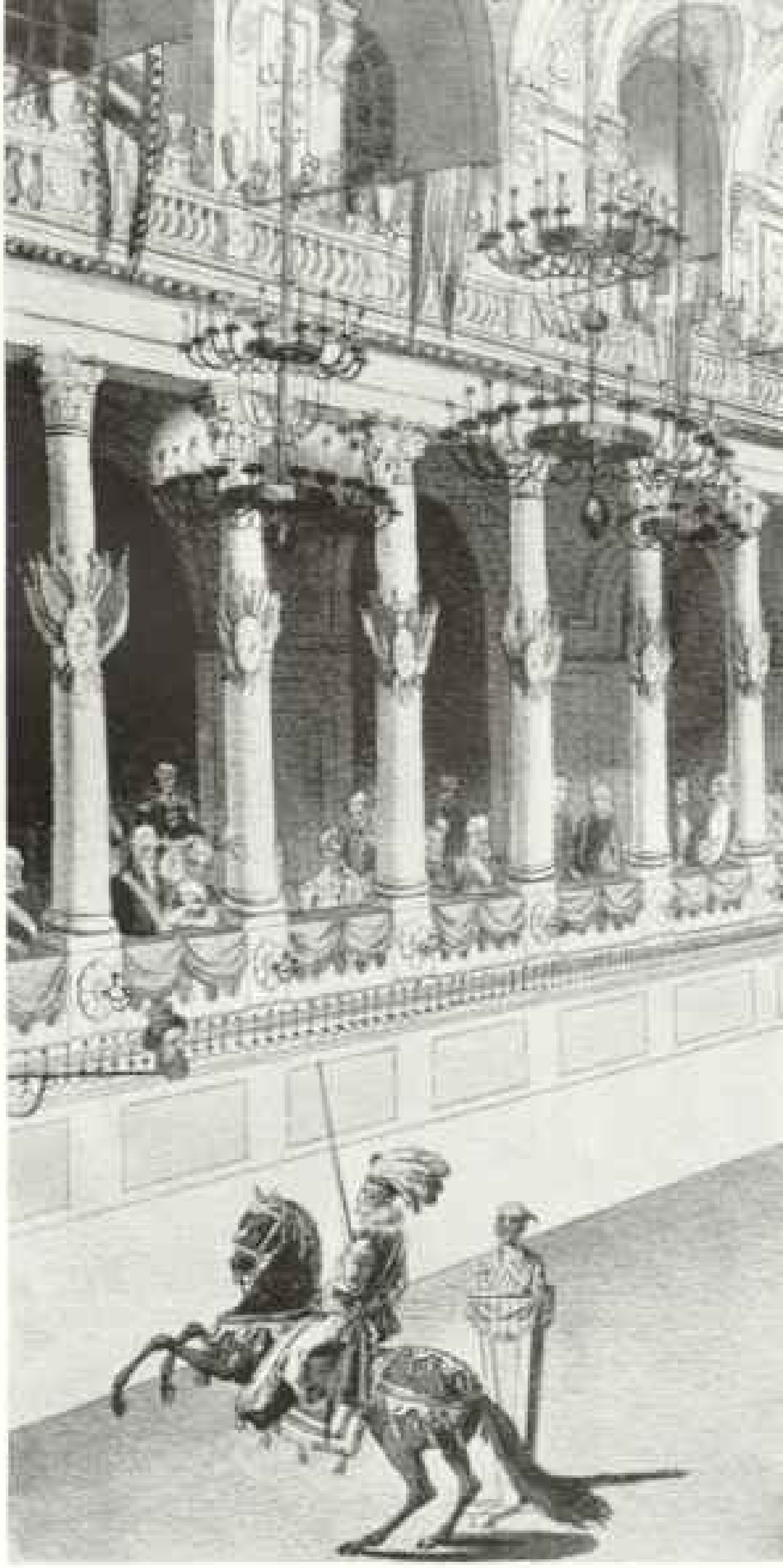
Quickly the colonel packed the school's trophies, hid the great chandeliers, rolled up the huge portrait of Charles VI, and put his charges aboard a westbound freight. Strafed and bombed, the train crawled haltingly through the night like a wounded animal, zigzagging, hiding in tunnels, waiting for blown rails to be replaced. The 250-mile journey to St. Martin im Innkreis took six days.

Relatively safe in a castle once used as a stage on the old coach route, the white horses waited patiently while the broken Nazi divisions reeled back upon Germany and the American XX Corps took over. On the last day of the war in Europe, Gen. George S. Patton, Jr., and Under Secretary of War Robert Patterson attended a special performance of the school troupe in their honor.

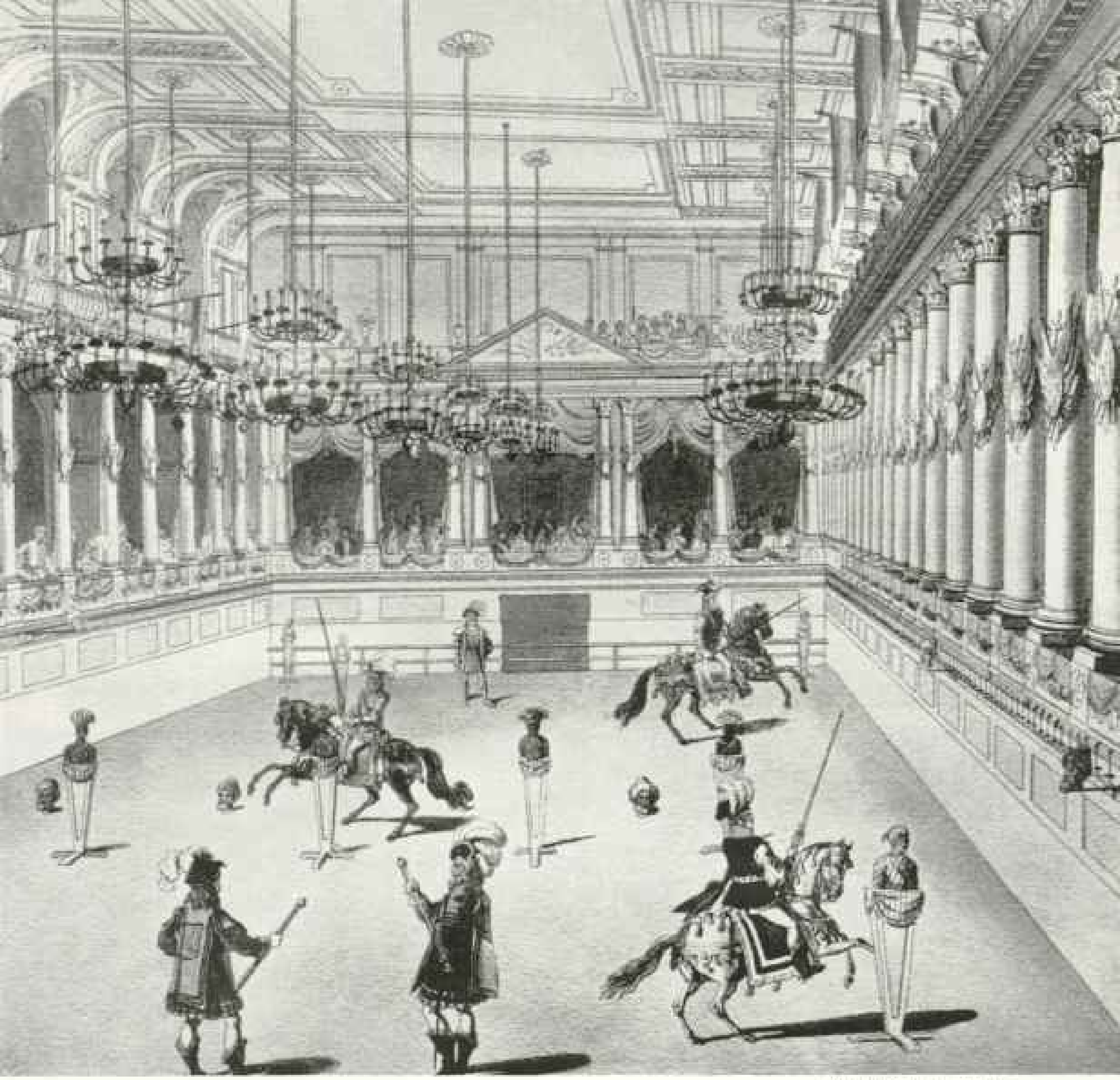
At its conclusion the colonel, mounted on his favorite stallion, rode alone to the general's box, saluted with a wave of his gold-cockaded hat, and formally requested Patton to place the school under American military

Kings at the Congress of Vienna Look Down on an Equine Carrousel

In the same magnificent hall used by today's Spanish Riding School, notables of 1814 watched Austria's foremost equestrians tilt at turbaned heads, prance in the quadrille, and practice leaps. At other periods the hall housed the Stock Exchange and the Parliament.



Sound and fury but no blood issued from the tournament of 1843 in honor of Archduke Charles. Costumed "Roman" knights flailed ceremoniously but harmlessly at one another in stylized maneuvers. Stirrups—never used by Romans—provided an unauthentic touch.



Historical Museum of Vienna

protection. Patton, who like Podhajsky had been an Olympic Games equestrian, consulted with Patterson and agreed.

He went further. He flew Podhajsky to Hostoun in Czechoslovakia, where one of General Patton's advance units, while rescuing a group of Allied prisoners, had captured a string of Lipizzaner brood mares, foals, and breeding stallions. This herd, driven north by the Nazis early in the war, was made up of horses from the Austrian stud farm at Piber, from the Yugoslavian stud at Demir-Kapija, and from the Yugoslavian village of Equile Lipizzano, from which the whole great strain of Spanish horses takes its name.

Col. Charles H. Reed, informed by a congenial German general of the existence of this equine treasure-trove, had sent a German prisoner on a bicycle through the lines to contact the herd's supervisor, Capt. Rudolph Lessing. Mounting a Lipizzaner stallion and leading another, Lessing had returned by night to confer with Reed.

Plans were hurriedly drawn for an attack. Lessing felt confident he could handle his own herdsmen, but the SS troops guarding the border would be another matter. Nevertheless, he and an American officer slipped back to Hostoun to organize the coup, and two days later the Americans went into action.

After a sharp fight, Reed's troops broke through the German defenses, leaving 100 enemy dead, and swept into Hostoun. The prisoners were freed and, within a few weeks, all the school's breeding stock had been convoyed across the frontier to safety.

The nucleus for the rebuilding of the school troupe and its stud was now assured.

Portrait of a Patriarch: Conversano Montebella

The Lipizzaner's large expressive eyes and nobly arched neck characterize this stallion at stud in Piber, site of the school's breeding farm.

Pied piper on the mountain meadows above Piber summons his Lipizzaner charges. Inquisitive colts often nibble the guard's bugle in an attempt to uncover the noise.

For 10 postwar years the Lipizzaners wandered in the wilderness, exiled from their handsome hall in Vienna. Neither bombs nor shells had destroyed the lovely creation of baroque architect Joseph Emmanuel Fischer von Erlach, but it stood in need of more repairs and refurbishing than the busy capital of an occupied country could immediately afford. Among other projects, the rebuilding of the Opera came first, and while that was being accomplished, the Opera's scenery was stacked upon the floor of the riding arena.

Colonel Podhajsky, stumbling upon the old cavalry barracks at Wels, where he had first learned to ride, made it the school's interim headquarters. From here he took the "first team" on repeated tours of the Western World —Switzerland, Italy, West Germany, Scandinavia, England, Spain, Portugal, France, the Netherlands, Belgium, the United States.*

Then, in the autumn of 1955, the Lipizzaners came home.

"It was the greatest moment of my life," the colonel confessed. "When I had left the school in '45, with Vienna coming down around my ears, I had thought I would never see it again. Yet here we were, putting on a gala performance for members of the cabinet, for Parliament, for the diplomatic corps—everyone—and do you know, it was exactly 220 years since the opening of the riding hall! I wrote the dates into the sand of the arena for all to see: 1735-1955."

School Dates from 1565

The beginnings of the school itself, of course, go even further back: in 1565 a state document noted that money was allocated for a riding ground in the Hofburg gardens. And in 1572 there cropped up the first reference to the "Spanish Riding Hall"—then a wooden building on what is now the Josefsplatz.

Why Spanish? The term had nothing to do with a "Spanish" mode of riding, or with any court school ever established in Spain. It referred simply to the Spanish ancestry of the Lipizzaners.

Basically, the Lipizzaner derives from a fusing of three bloodlines—Andalusian, Arab, and, to a lesser extent, Vilanos. The Andalusian had been famous even in Caesar's time as a swift, courageous, high-spirited horse. When the Moors took over Spain, they crossed the native mares with their own fine desert steeds, and, in the centuries that followed, they refused to permit adulteration of this stock by mixture with the gross, heavy-gaited war horses of Western Europe.

With the fall of Spain to the Christian knights, however, the Arab-Andalusian was bred to the Vilanos of the Pyrenees, a taller and stronger horse. The objective was to attain a mount powerful enough to bear an armored rider, yet still agile and fleet.

The experiment proved a distinct success, and the new strain soon dominated the royal studs established in Italy, Denmark, and the Hapsburg Empire. Of all the breeding farms, the one set up in the obscure village of Equile Lipizzano, near Trieste, by Archduke Charles of Austria, proved over the years the most satisfactory. Its rugged, limestone terrain served to keep the Lipizzaners in excellent fettle, sinews toughened, gait elastic, bones strengthened by the minerals in the sparse, sun-baked grass. Before long, the term "Lipizzaner" came to be the very definition of the Spanish horse at its noblest.

Mares and Foals Frolic Like Puppies

With the dissolution of the Austro-Hungarian Empire and the loss of Trieste to Italy at World War I's end, the stud moved to Piber, a 900-year-old village 15 miles from Graz. I went down to visit it one day in June.

Some 150 Lipizzaners are quartered here now, under a staff headed by Dr. Heinz Lehrner. A slender young man in jodhpurs and dark glasses, a riding crop tucked under his armpit, Lehrner strolled with me to a pasture where a group of mares browsed with their foals. No sooner had they caught wind of us than they ambled over and crowded around us like a batch of inquisitive puppies, nuzzling our pockets in search of a possible carrot or lump of sugar, the mothers no less curious and insistent than their offspring.

Turning to Lehrner as a foal tentatively nibbled my shirtsleeve, I said: "Are those really Lipizzaners? Somehow, after seeing them in the ring, these mares look, well—ordinary."

"Not to me. But I can understand your surprise, perhaps, at their difference from the Thoroughbred. The Lipizzaner, you might say, is a baroque horse—compact, somewhat thickset, with occasionally a rather heavy neck. But you mustn't judge him as he browses in a pasture.

* See "New York Again Hails the Horse," by Walter B. Devereux, National Geographic Magazine, November, 1954.

Mares and Foals Lope Home to Lunch

Children of the 900-year-old village of Piber line fence rails each day to watch their cherished Lipizzaners return from pasture.

Foals live with their dams the first five or six months, then graduate to a herd of their contemporaries.

For young stallions, education begins at 3½ to 4 years, when they leave Piber for the riding school in Vienna.

Mares and fillies get basic training as saddle and carriage horses in a near-by riding hall. Many attain the strength to perform the exacting routines of the school, but to mix them with the mettlesome stallions would only invite trouble.

Carefree and Unconfined, Colts Enjoy Their Fling

Still at liberty at an age when Thoroughbreds would long have knuckled under to the regimen of the race track, slowly maturing Lipizzaners build up stamina on the 5,000-foot Alpine slopes above Piber.

Here, as in Kentucky's Bluegrass, vitamin- and calcium-rich grasses growing above limestone subsoil impart superior strength to bones and hoofs.

Haflingers; Austrian draft horses with dark coats and palomino manes, cavort with these colts.

"When you see him with a good rider up, he's an entirely different animal—taut and proud and full of grace. The grace is always there, implicit in the horse and his basic conformation. But you may miss it in the meadow, just as you might not recognize a ballerina wearing her overcoat and sitting in a tramcar."

Resting my notebook on the velvety rump of a near-by foal, I scribbled steadily for some minutes as Lehrner talked on about the characteristics of a Lipizzaner—thick chest, large, limpid eyes, long and broad back, low withers, muscular legs, well-shaped hoofs, height of about 14 to 15 hands, great docility and intelligence.

Superstition Smiled at—but Not Ignored

"What about the head?" I asked. "In the old paintings at the school, the Lipizzaners generally have a somewhat ramlike nose. But most of these mares seem quite straight nosed. Has more Arab blood been introduced over the years?"

"There was quite a strong infusion of Arab blood in the early 19th century, through the Siglavy line, at Equile Lipizzano. But the more important fact is that we've been deliberately breeding away from the ram heads—a selection within the race, you might say."

"And you're concentrating on white?"

"Technically, we call them grays. But fortunately, we produce an occasional bay or black or cream-colored stallion, too." He grinned. "I say 'fortunately,' because there's a superstition which holds that Austria has fallen on bad times in the years when we didn't have a non-gray among the school troupe. There was 1809, for instance, when Napoleon invaded our country; 1934, when Dollfuss set up his dictatorship; 1938, when the Nazis swallowed up Austria altogether.

"See that little bay foal over there by his dam? We smile at the superstition, of course, but all the same we take very good care of him!"

The bay foal was not particularly conspicuous. All Lipizzaners are born dark, reminiscent of their heritage from six great Andalusian sires—Pluto, a dappled gray from the Denmark stud, born in 1765; Conversano, a Neapolitan black, 1767; Neapolitano, a brown from Naples, 1790; Favory, a dun-hued stallion, 1779; Maestoso, a gray, 1773; and Siglavy, an Arabian gray, born in 1810. The young Lipizzaner doesn't acquire its handsome milk-white coat until it is from three to seven years old.

High spirited, often fiery in its bearing, the Lipizzaner is yet fantastically gentle—largely because from birth it meets nothing but kindness. Its mildness comes not from being cowed, but, on the contrary, from being free of fear. Slow to mature, the young stallion does not enter the school until he is nearly four and will not be fully trained until he is eight. At the age of two, when a Thoroughbred is earning his oats on the race track, a Lipizzaner is still spending long, carefree days on Piber's Alpine meadows, unfamiliar even with a snaffle. On the other hand, at 25 the Lipizzaner may still be a star performer in the riding hall, and the Thoroughbred be long since dead or retired to pasture.

At three years and a half the young stallion finally joins the school troupe. His life of freedom is now behind him: henceforth his world will consist of the stables along the Reitschulgasse and the riding hall across the street.

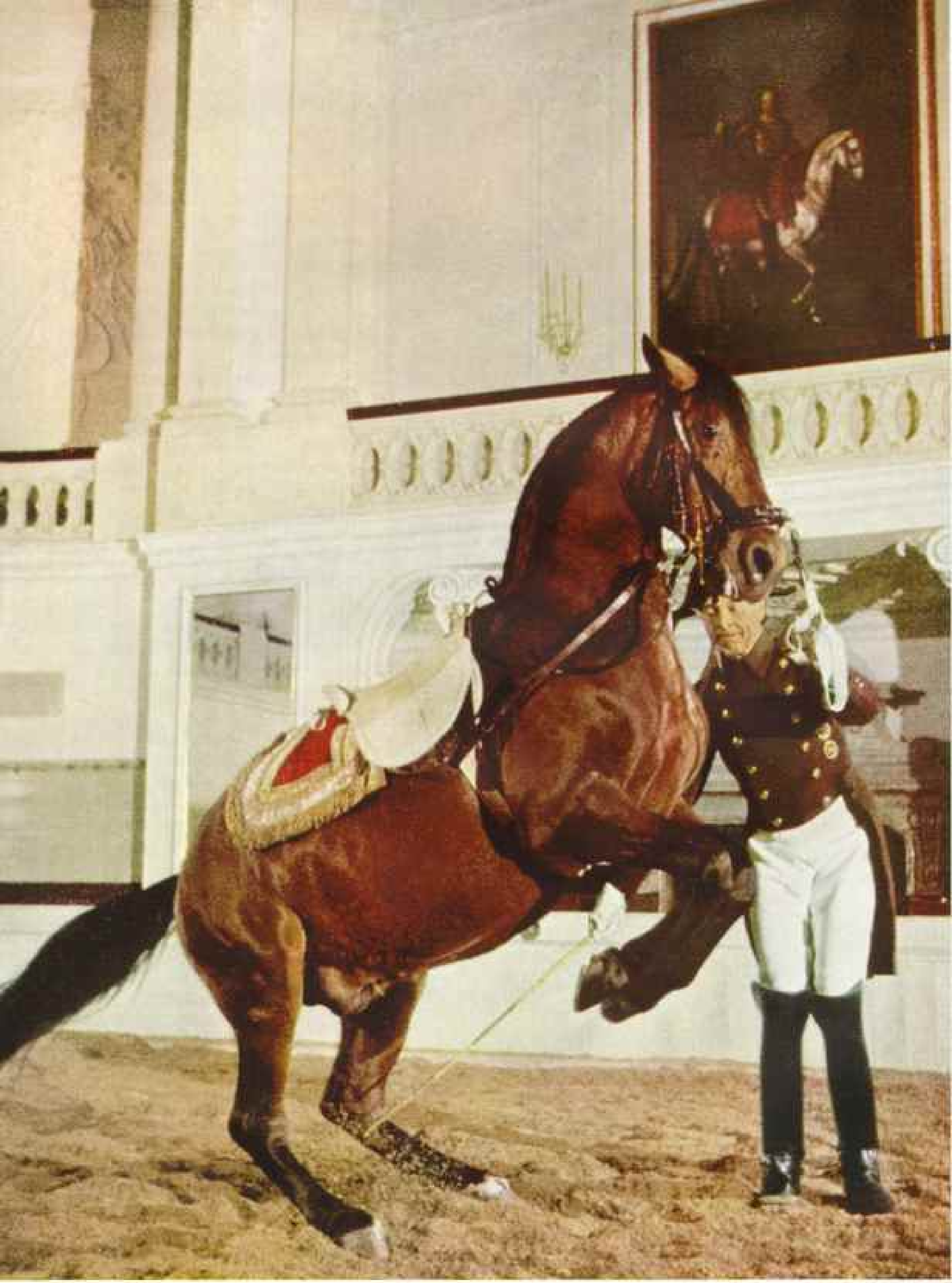
It is a world compounded of affection and formality, great demands and great respect. Morning after morning I have sat in the quiet sunlit hall and watched the novice stallions brought in, one by one, for their intensive individual schooling. Bright eyed, eager, nervous footed, they dance forward as if made of tight-coiled springs, vibrant with a kind of adolescent passion to perform.

An Exercise in Understanding

Their anxiety is underscored by the atmosphere of the arena; the solemn silence is broken only by the occasional bark of an instructor giving a command to some apprentice or berating him briefly in stinging Viennese for a particularly horrendous blunder. For the rest, riders and their mounts pace and pirouette, leap and turn in profound concentration, like figures in a trance.

Part of this ritual and yet unmistakably dominating it, too, is Colonel Podhajsky, schooling his own string of stallions or appraising the work of other riders. At 59, hard and spare as a leather crop, relentless in his quest for perfection in himself and others, he seems telepathically aware of every movement in the ring, every slight mistake.

Pausing between a change of horses one day, he talked to me of the school's philosophy. "This drill," he said, "you must not think of it simply as discipline, as mechanical



Neck Curved, Haunches Tensed, a Stallion Performs the Statuesque *Levade*

Only daily practice and careful muscular development permit the horse to balance its weight on hindquarters. Here a rare Lipizzaner bay responds eagerly to Colonel Podhajsky's urging.

repetition. *Nein!* It is an exercise in understanding. The horse must understand what we want him to do, and we must understand precisely what he is capable of doing."

The colonel shook his head sternly. "The rider must be firm, he must be in command, but he must not be cruel. That is stupid. We do not indulge in great whips and special spurs and devilish bits. We remember the words of old Guérinière, the 18th-century riding master, who said, 'The more iron in the mouth of the horse the less the knowledge of the rider.'"

He interrupted himself to stare reprovingly at an instructor attempting a third and fourth levade. The horse, sinking back on its haunches, was trembling violently, its breath came in snorts, its flanks were slick with sweat. "*Ach so*," said the colonel gently, "he has had enough, eh? Have him do some other movement and do it well and then let him go, with some sugar."

He turned to me again. "That is the important thing: never let a horse stop with a sense of defeat. If he is going well, release him early, in the flush of achievement. If he is misbehaving, continue until he has done something to please himself and you. In that way, he

Lipizzaner Learns to Trot Without Going Anywhere

Antoine Pluvinel, 17th-century French riding master, invented the technique of training a horse "between the posts." Secured by a padded halter, the stallion performs exercises that strengthen his muscles for the advanced leaps. A favorite drill is the high-stepping *piaffe*, or trot in place.

Piber's White Mares Take Black Shadows on a Stroll

Lipizzaners invariably are born dark and do not acquire their white coats until they are between three and seven years old. Gentled from birth, they remain as unafraid, as curious, and sometimes as mischievous as puppies.

will come back to the ring the next morning eagerly, with a fresh heart."

"How many hours a day do you train each horse?" I asked.

"Not hours," he said. "Minutes. Forty-five minutes a day. You must realize: a courbette, a capriole, even the passage, the Spanish step, demands the utmost from the horse. The Lipizzaner is strong; he is willing. But I assure you—three-quarters of an hour is quite enough."

Fan Mail for Pluto Theodorosta

A stable boy came up with another mount for the colonel. Podhajsky looked at the horse for a moment with the fond, slightly bemused air of a parent whose child has won every conceivable school prize. The stallion gazed back at him serenely, an artist quite inured to the world's adulation. His translucent skin, the texture of old soft silk, clothed muscle and sinew so tautly as to bring up a faint rose-tinted blush from the flesh beneath.

"This is Pluto Theodorosta," said the colonel. "He has traveled much of the Western World. Queen Elizabeth of England rode him when he visited the royal stable.

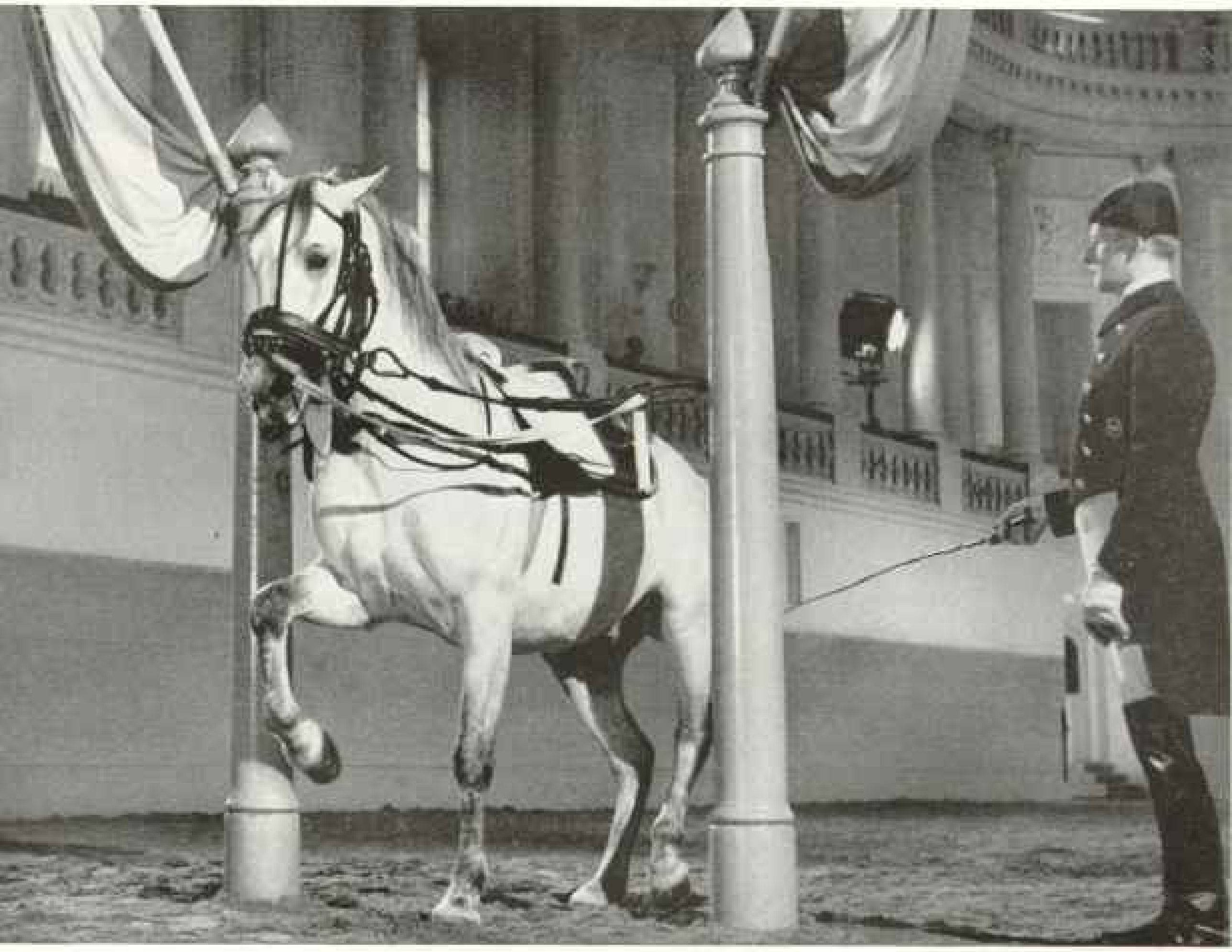
"One day, before we returned to Vienna, a letter came to Wels, Austria, addressed to Mr. Pluto Theodorosta. He received it, all right, though I had to read it for him."

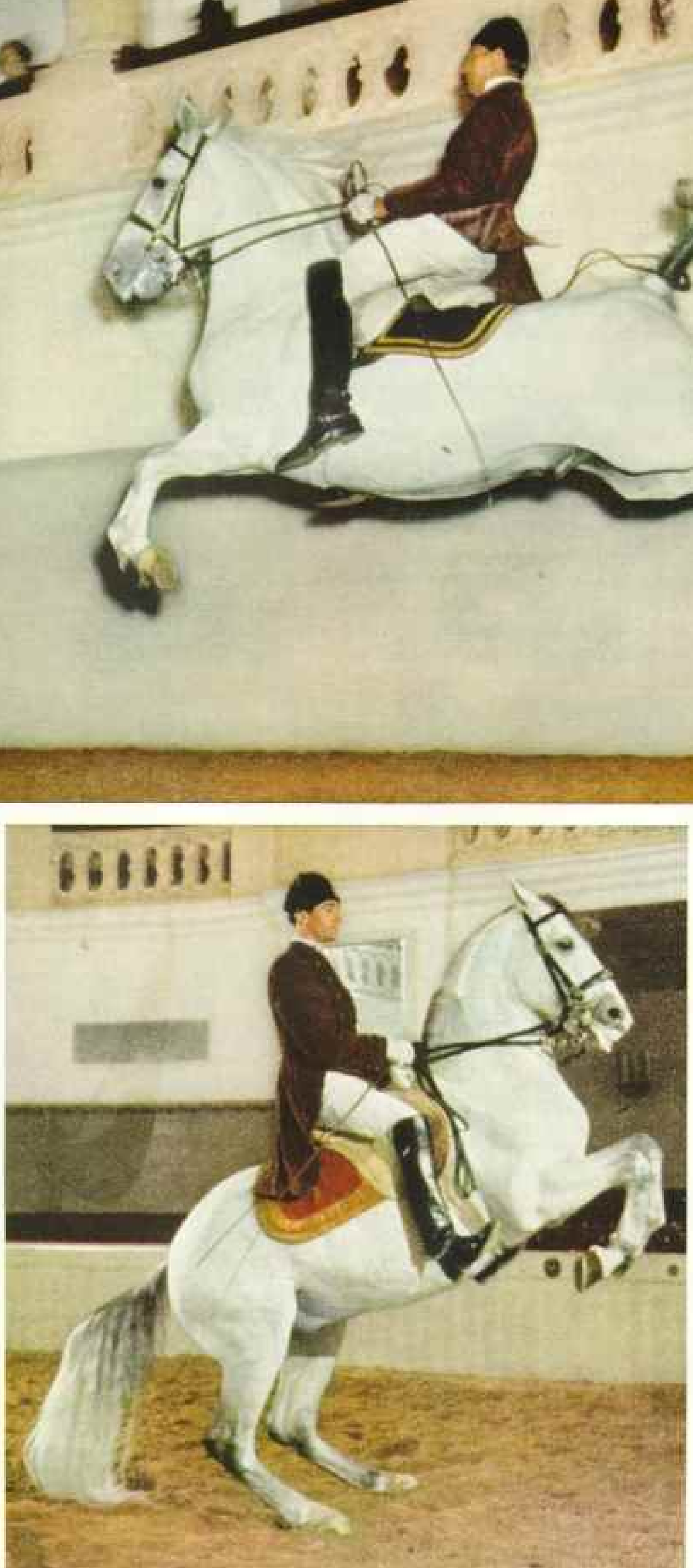
Podhajsky swung up into the saddle in one easy motion. Pluto Theodorosta moved not an inch until the colonel, gathering three reins in his left hand, one in his right, unobtrusively shifted his weight forward, and the stallion moved away in a stately walk.

They passed a slip of a boy in gray-green uniform astride a Lipizzaner on a longe, or guide rein, held by an instructor on foot. The stallion trotted in an endless circle while the apprentice, with neither stirrups nor reins, sat him as lightly as a leaf.

Sometimes, at the command of his sharp-eyed tutor, the boy would rotate his arms in paddle-wheel fashion, fold them across his

Classic Faxbir from Pix (opposite) and Austrian National Library





A Mounted Pegasus Defies Gravity in a Soaring *Capriole*

Stallions perform after three to four years of schooling. But it takes a rider six to seven to gain a place in the troupe.

Once the academy drew largely on cavalry for its personnel; now it trains its own boys from 16 years onward. Often an apprentice's mount is older and wiser than he.

In perfect balance, horse and rider maintain for seconds the classic pose of the levade, the model for countless equestrian statues of generals.

The rider holds three reins in his left hand, one rein and a birch switch in his right, maintaining a balanced control of the horse from a central position. Blunt spurs and a mild curb bit serve as aids. Infinite patience, not heavy-handed cruelty, assures the stallion's sensitive response.

Super Annotations by National Geographic Photographer Volkmar Wentzel © N.G.S.

chest, wave them from side to side, or hold them straight down like sticks. No matter what his position, his balance never wavered nor did his back slump.

In the middle of the arena an older member of the troupe was schooling a young horse "between the posts." From a padded halter, two short straps ran to the wooden pillars; the horse, urged on by his instructor, performed his exercises in place (page 415). By practicing such movements as the piaffe and the levade under this kind of control, the stallion strengthens and lowers his haunches, renders all his muscles more supple, and unconsciously provides his trainer with clues as to where his specific talents may lie.

For while all the Lipizzaners take part in the "school on the ground"—that is, the stylized walks, trots, canters, pirouettes, the piaffe and passage, and lateral movements—only a few especially gifted stallions can go on to master the great leaps of the "school above the ground." And of these, each will concentrate upon one particular exercise: ballotade or capriole, courbette or croupade. No one Lipizzaner has ever learned to do them all, and Colonel Podhajsky is quite certain none ever will.

Old Horses Teach Fledgling Riders

The process of learning in the school is curiously reciprocal: the old horses teach the fledgling riders, and the veteran instructors school the young stallions. A wise and learned Lipizzaner can provide a rich education for a novice rider, but he also can and sometimes does make a fool of his master. Many a tale is told in the stables, with a slap of the thigh and a rich guffaw, of pretentious pupils who took their mount's effortless performance as a tribute to their own equestrian skill—and then were dumped onto the sand by an unscheduled capriole or courbette.

The bond between rider and horse, however, is more apt to be close and even uncanny. Each man has four horses which he alone may ride and educate, or be educated by. He lives and works with them, day in and day out, until he knows their moods and idiosyncrasies better than those of his wife.

In the riding hall this rapport can be sensed in oneness of action. In the stables it bubbles out in more overt expression. The colonel, rigidly correct in the ring, sheds his formality at the door, gladly, like a stiff collar.

I was with him one morning when he paused before a gleaming mahogany stall, rubbed his cheek against the stallion's outthrust nose, and explained to me: "This one, he is a great straw eater. He would eat his whole stall if I let him and, by morning, there would be no straw and he would be fat, ach, like this. . . ."

At another stall Podhajsky entered and tried to protect his coat pocket from a forthright attack. "*Ja, ja,*" he murmured, "sugar. But not only sugar. A little love, too, eh? That is what a horse wants. However, in the end, yes, some sugar. Of course." And he parted with a handful poured from a small leather pouch.

He turned to me. "They like the talk. They are important then, and they know it."

The Sum of One Man's Life

Later, in his handsomely appointed office, the colonel moved a yawning dachshund aside so that I could sit down on the sofa near his desk, and folded his own lank frame into a dangerously fragile gilt armchair. The dog burrowed down beneath Podhajsky's discarded overcoat and disappeared.

"In my next life I shall be a dachshund," declared the colonel. "Now, as the director of the school, I must begin every day at seven, and work six full days a week. If I were just supervising, and not a trainer and a rider, too. . . . But I think it is better this way. Otherwise, the men start saying to themselves—'Ja, you talk it very well, but—can you do it yourself?'"

With a sigh Podhajsky ran his fingers through his hair. "Before World War I, you could have gone to almost any court in Europe and found an excellent school of classical riding. Now? Now, there is only one."

He stared through the tall windows which gave on the Michaelerplatz. "We must live for the school. Offer our lives to it! Then, perhaps, little by little, the light will grow from the tiny candle we keep lit here, and the great art—the art of the haute école—will not be snuffed out."

Later, as I rose to go and we were shaking hands by the door, he returned to this theme. Talking partly to me but possibly more to himself, he said:

"These are drab materialist times. Drab! Surely, if we can let into them one beam of elegance, of splendor, of glory, from the ancient classical world . . . that would be worth a man's life, no? When I am tired, I tell myself, yes, it would."

Matched Pairs in a School Quadrille
Advance and Retreat to Stately Cadences

Cued neither by gesture nor command, the eight quiet horsemen weave an antique, complex pattern of the dance across the arena's sands, keyed to the music of

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Chopin or Bizet. Their cinnamon livery and two-cornered hats come down from Napoleonic times. Austria's red-white-red banners hang from the training posts. The quadrille represents the last vestige of the brilliant equestrian balls and carrousels once held by royalty in this graceful hall.

After six years of experimentation, a Utah woman has learned how to preserve flowers indefinitely

Blossoms That Defy the Seasons

By GENEAL CONDON

With Photographs by David S. Boyer, National Geographic Staff

IT was a snowy, blustery day, and the passer-by who rang the bell of my front door said:

"Ma'am, I want to ask you just one question—are they real?"

"Are what real?"

"Those flowers in your window!"

I smiled. He had been staring at a bouquet of roses, bridal wreath, yellow marigolds, and white daisies I had arranged in our north window. "See for yourself," I said.

He walked in, and when he caught sight of a score of other floral displays around the room, composed of nearly 40 varieties of blooms, he grew really excited. Bending over a spray, he turned suddenly and said:

"Oh. They're dried, aren't they?"

I set him straight at once. In as authoritative a voice as I could muster, I said: "No. They're not dried. They're preserved."

And there's a world of difference, a gulf as broad as that between a mail-order smock and the creation of a Parisian couturier. To me, "dried flowers" suggests those conglomerations of desiccated weeds, pods, and everlastings that grandmother used to gather, hang upside down in the attic for a while, and then stuff into a vase. If they looked a bit dull, she could always splash them with a little gold or silver paint.

No Two Flowers React the Same

That isn't for me. My objective is to take a fresh garden flower and preserve it so perfectly that every graceful petal and stamen and leaf retains its natural tint and shading, aglow with its original splendor. I want to create a flower that I can't tell from a fresh one except by touching it.

Impossible? No. But difficult—yes. I've put in six years of painstaking study and experimentation, twelve to fifteen hours a day, seven days a week during blooming time. And I'm still discovering how temperamental a flower can be. No two blooms, even though cut from the same branch, react to treatment in the same way; like children, one will respond like an angel, another like a brat.

Idea Came from an Old Cookbook

I found my clue to flower preservation in—of all things—an old cookbook that belonged to my mother. Somewhere between a formula for removing warts and some advice on how to take stains out of linen, I came upon the declaration that "Fresh flowers buried in sand for two weeks will become permanent and retain their color and form."

That was all. Busy with two small children, I had no time for further investigation. But I tucked the information away in my mind, and 10 years later, in Greece, I pulled it out again and started to work.

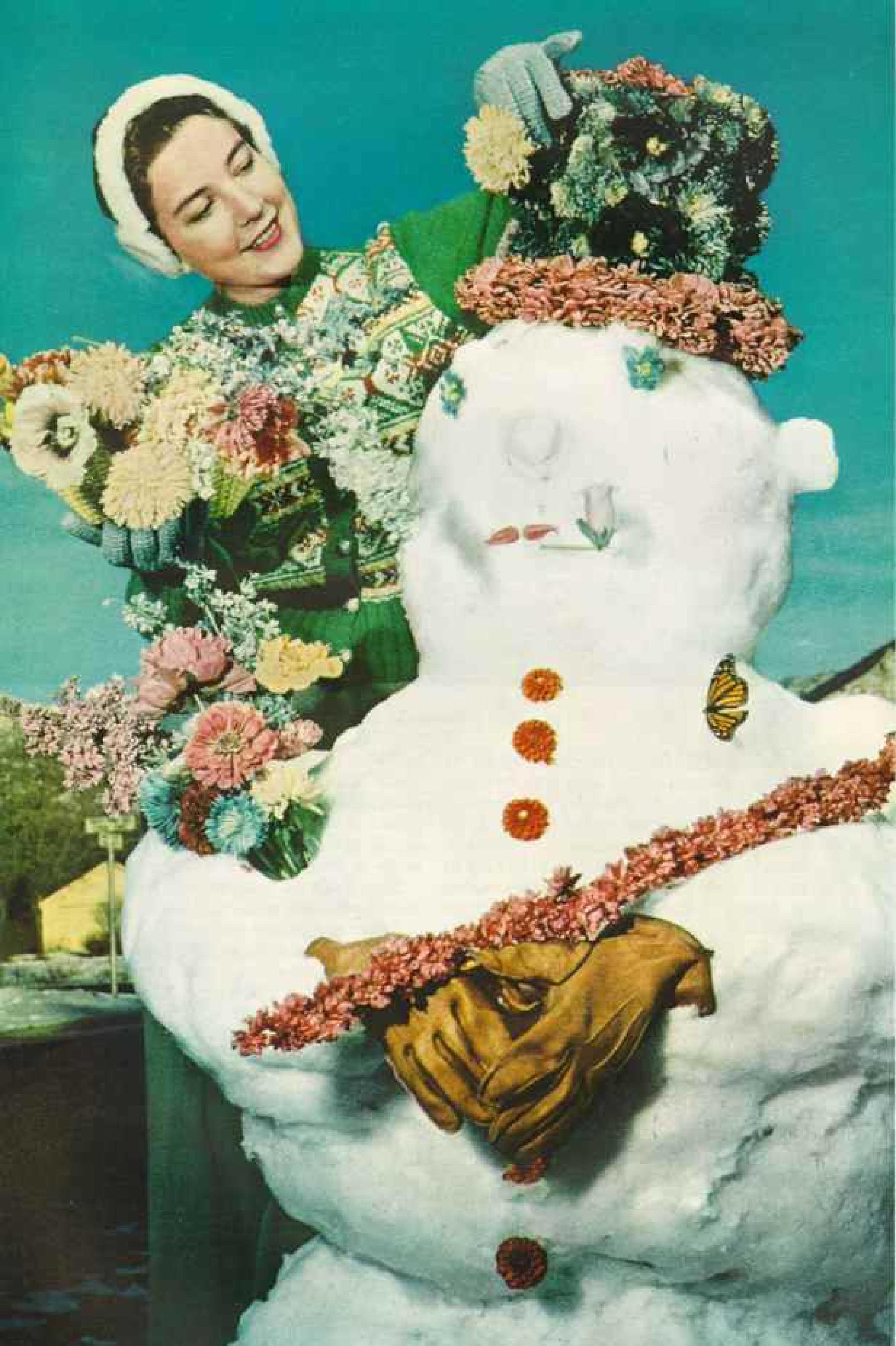
My husband was stationed in Athens in the United States Foreign Service, and the wife of our ambassador was organizing a Cavalcade of Greek Fashions to gain international recognition for native talents. She asked me to create some flower jewelry to be worn with the Greek gowns.

I accepted the assignment, using seeds at first and then turning boldly to buds of the pink almond, the bachelor button, and the daisy. Later, remembering the cookbook recipe, I tried, with varying degrees of success, a few full-blown flowers.

A few years later, in Karachi, I returned to the experiment. A Pakistani winter and spring meant warm, relatively dry weather, and there was, heaven knows, no shortage of sand. The chief problem was to find flowers. Fortunately, our hotel maintained luxurious

Blooms of Bygone Summers Glorify a Salt Lake City Snowman

As bright and full bodied as on the day they were picked, these flowers are as much as three years old. Their secret: burial in sand. Here a friend of the author fashions a hat of asters, hollyhocks, and zinnias. Delphiniums make the eyes; miniature dahlias, the buttons; flowering peach, the walking stick. Peonies, lilacs, and others compose the bouquet.



To preserve flowers, the author uses the soft, gentle sands formed

gardens, and I finally persuaded myself to filch an occasional bloom, carry it to my room, and bury it in sand. Anything for science.

Not until I returned to the United States, however, did I settle down to the project in earnest. Re-established in Salt Lake City in 1953, I found an ideal climate, an abundance of flowers, and—best of all—the sand of Great Salt Lake.

Sand Washed, Then Rinsed 40 Times

Ordinary quartz sand, when you see it under the microscope, is often sharp and jagged. But Salt Lake sand consists for the most part of limestone built around pellets of waste matter cast off by salt-water shrimp. Rubbed smooth and round, the grains are soft and absorbent. Applied to flowers, they hasten dehydration, bring more weight to bear on the petals, and are kind to the delicate surfaces.

Even so, I found that I couldn't use the "raw" sand just as it came from the beach. Now I wash every bucketful in hot soapy water, stirring constantly, pour off the suds, and rinse no less than forty times in clear water. Then I empty the sand into a large container and either set it in the oven or spread it on clean muslin in the sun. Sun-drying is quicker, but the oven-dried sand seems to produce better results.

Next, I sift the sand through fine mesh, to remove all coarse grains and foreign particles, and pour enough of it into a container to form a cushion for the flower. Almost any kind of container will do—a teacup, a milk carton, a mixing bowl, a coffee can. The important rule is: only one flower to a container.

Most flowers should be placed face up on the sand cushion, with the calyx covered and the petals deftly supported so that they maintain a natural position. Then gently bury one layer of petals at a time.

Fill the box to the top for added pressure, tap it on all sides to eliminate any air pockets and to settle the flower solidly, affix a label bearing the date and the type of flower, and set the container in a warm, dry place for about two weeks.

A basement is a good spot in Utah, except

in the early spring or late autumn. Then my collection invades nearly every room in the house.

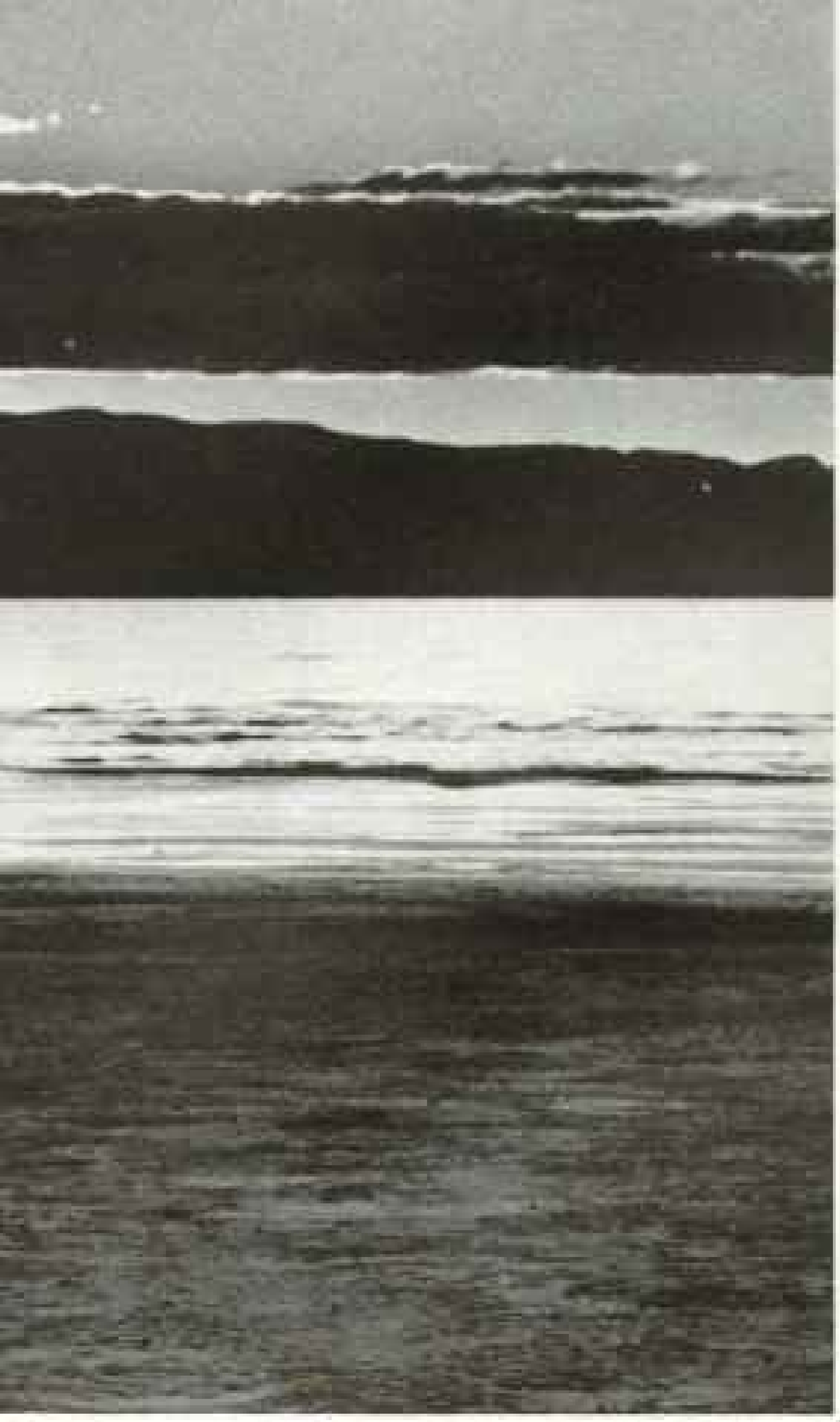
Patience is the prime virtue in a flower preserver. I once spent three months wrestling with some stubborn blue bachelor buttons which insisted on fading. They turned white, and I thought my hair would do the same thing before I conquered them.

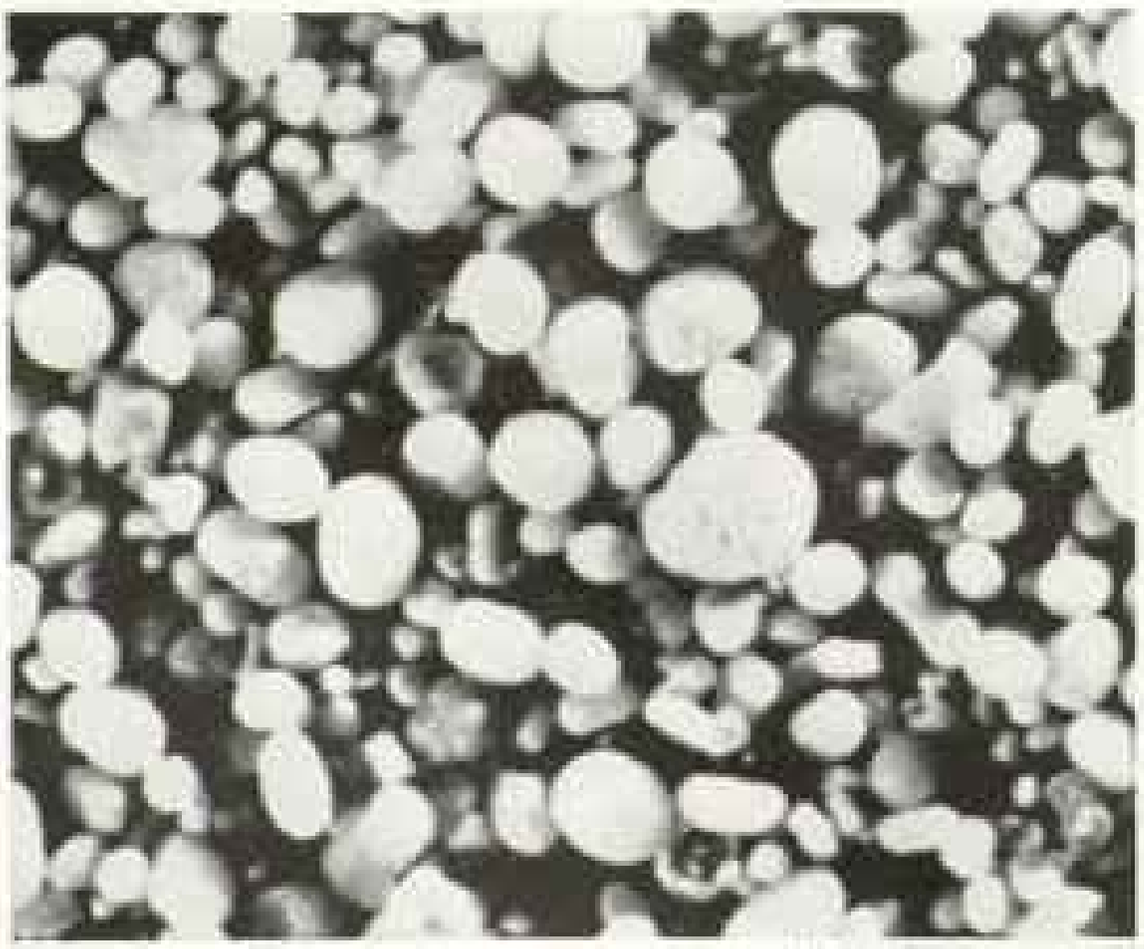
Bachelor Buttons Oven-cured

The trick, I discovered, is to sneak up on the flower before it knows what is happening and pop it right in the oven—but only for two hours.

This is the only flower that I have regularly preserved in the oven. When it emerges, it will keep its lovely blueness even under a full summer sun—which is more than I can say for many a curtain and slipcover!

A word of caution. Enthusiasm must be tempered with an eye to the available floor space. I have come to dread the





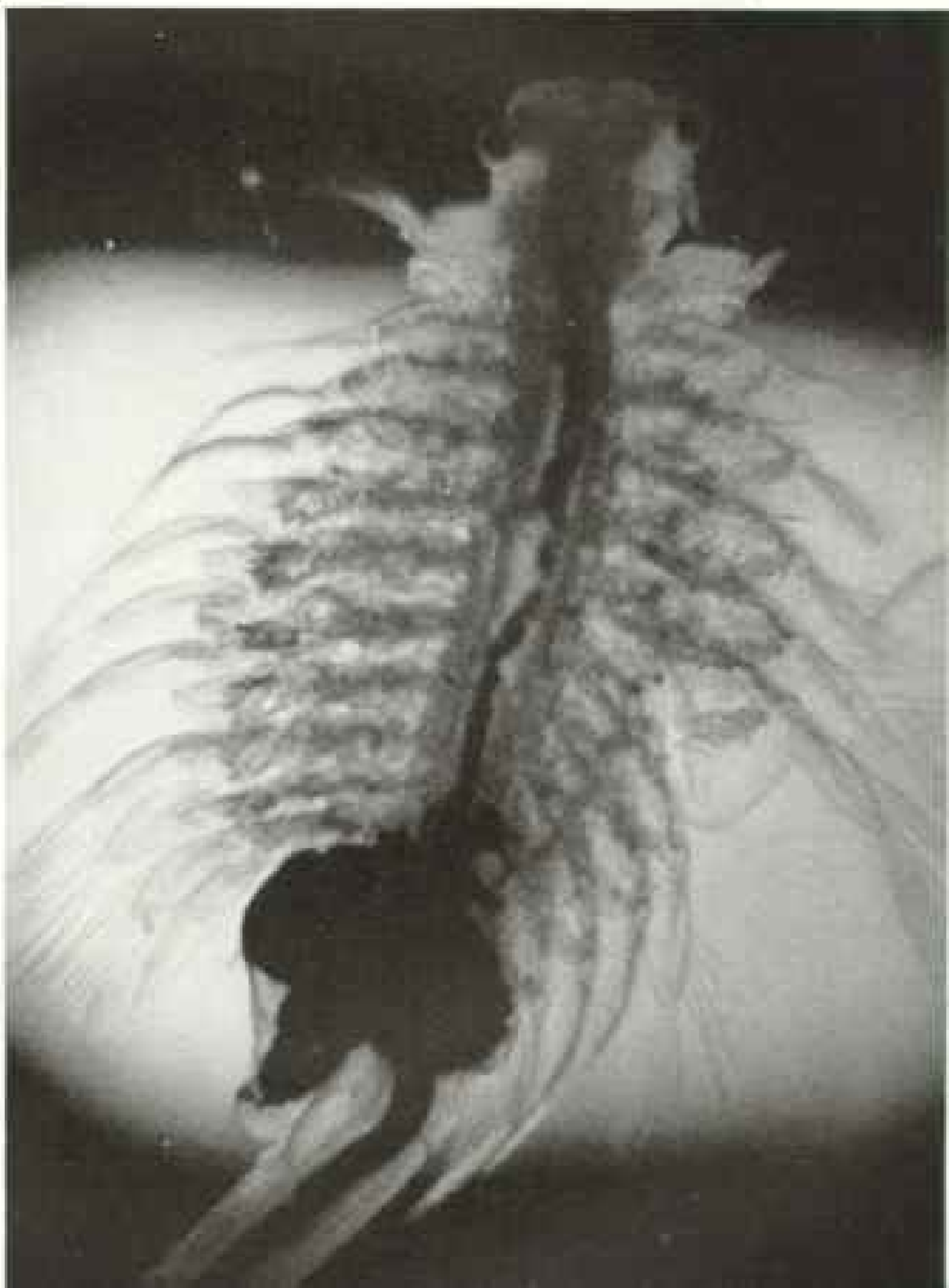
Walter P. Cottam

Chalky sand, formed around waste products of microscopic shrimp, consists of smooth, rounded particles, here shown greatly magnified. Unlike jagged quartz sand, it does not scratch delicate petals.

Each summer Mrs. Condon soaps some 1,500 pounds of sand, rinses it 40 times, and dries it. Finally she sifts it through mesh. Re-use of the material each year appears to bring out brighter colors.

A brine shrimp magnified 20 times. Shrimp, inhabiting the Great Salt Lake in countless numbers, deposit chalklike pellets of excrement. Waves coat the pellets with limestone in a process not unlike that by which an oyster produces a pearl. Grains of gleaming sand result.

Edwin V. Hawley



Fresh from Beds of Sand, Blossoms Undergo Grooming for a Year-round Display

Mrs. Condon carefully brushes sand from a zinnia; toothpicks lie handy for removing stubborn grains. She dries the stems separately and cements them to heads. Water lily at left, obtained from a distance, had to be revived in ice water and stripped of moisture before it was interred in sand.

Buried Rose Preserves the Peak of Its Beauty

The author plants the bloom in the separate container required for each flower. She dribbles sand around and between the petals, using a rounded stick to ensure that the grains touch every surface and the flower maintains shape. Two weeks in sand will complete the treatment.

Better than borax, a medium used by some preservers, the oölitic sand smooths the petals, allows less shrinkage, and protects the sheen. Borax leaves a powdery white film difficult to clean.

tenth of the month, when the gasman arrives to read the meter. As his glance takes in the maze of cans and bowls and boxes and strings of preserved flowers extending from wall to wall, he looks pitifully at me for guidance. I conduct him as best I can through the labyrinth, telling him when to jump or duck, as the situation may demand.

My son has had his troubles, too. Once he came home from college for the holidays and, since we were somewhat crowded, had to sleep in the basement. Across his bed stretched ropes of sand-dried blooms—a canopy of lilacs, in fact. I thought they were lovely, but he complained that when he first opened his eyes in the morning he thought he was underground "pushing up the daisies."

Another warning: don't peek too soon at your buried blooms. When I'm experimenting with a new variety for the first time, I have a particularly hard time waiting for the drying period to pass. I tell myself: this type may not contain quite as much moisture as the others. Surely, just one little look. . . .

The result is always the same: the flower flops.

Suppose, however, that you've been a model of self-control. The flower is ready, and it's time to uncover it. Hold the box in your left hand and use the fingers of your right as a sieve as you slowly pour out the sand.

Pick up the flower by its stem, never by its petals. Set it upright in another container of sand and clean it with a soft camel's-hair brush and a wisp of cotton. Some flowers, with rather waxy surfaces, may retain a few stubborn grains; use a flat toothpick, very gingerly, to remove these, and follow with a light brushing.

Butterfly Adds a Final Touch

Your flower, cut short to fit into its drying box, will need an extra stem and more foliage. You can dry all the stems you want simply by exposing them to the air, but the foliage should be sand-treated. To attach the leaves, slice the dried stem with a toothpick, apply a dab of glue, and then insert the bit of foliage. Stems, since they turn white, must be stained the proper shade of green.

You may want to add a butterfly, as I often do; for a winter display it is, I think, the final touch. To do this, start the previous summer, net in hand, and never mind if the neighbors think you're a bit daft. Hold your quarry by the wings and touch its nose (I guess butterflies have noses) with a plug of cotton saturated in ether or cleaning fluid. The butterfly goes to sleep like a baby. Later, when you're ready to complete your floral arrangement, attach it to a petal with a drop of glue (page 427).

How do you display preserved flowers? Just as you would fresh ones, but with this difference: they're light as feathers and must be well anchored. For shallow bowls, use floral clay; for tall vases, sand.

Everything Saved but the Scent

And here are a few "don'ts." Don't let visitors pinch the flowers. "Admire, but don't touch," is the rule. Again, don't lay a preserved flower down on a table or hard surface; keep a container of sand near by in which you can stand it upright.

Third, don't process a flower unless it's absolutely dry; with even a minute tinge of surface moisture, it will turn brown. Fourth, don't cut more flowers than you can process before they wilt; three at a time is plenty. Fifth, don't waste time on imperfect blooms; every defect will be magnified in the finished product.

And one last admonition. Watch out for certain hard characters, such as the iris; mine have all turned as transparent as glass. Lilies of the valley are apt to become quite yellow, while most red flowers tend to darken. Coral and pink hybrid petunias fade to a grayish lavender, and poppies drop their petals.

But don't be discouraged—nature is a spendthrift. Neither you nor I will ever get around to preserving all the flowers that can come from just one packet of seeds. Begin with the simpler forms first: a daisy, a hollyhock, a tulip. Then, when you've acquired the feel of the process, go on to more complicated varieties.

It means work, a great deal of work. But there is an incomparable thrill in being able at last to achieve a flower with no single flaw, except the inescapable one: its lack of scent.

And even this can be subtly overcome by the very perfection of preservation. My greatest accolade, I think, came last winter when a woman census taker appeared at my home. It was bitterly cold, and as she stepped into my living room and looked around at the hundreds of vivid blooms on display, she cried out in pleasure:

"My, your house certainly does smell lovely with all these flowers in here!"

Anchored in sand, tree peonies fill a vase.

Festooned Clotheslines Promise Eternal Summer

The author strings peonies for a Bouquet Geneal, trade name for her product. Desiccated jonquils, larkspurs, lilies, and zinnias bloom in her basement garden. Red carton holds butterfly bush.

Monarch butterfly appears to sip nectar from preserved hollyhock, larkspur, and feverfew. Mrs. Condon's arrangements won honors at this year's International Flower Show in New York.

Color cameras record for the first time a fabulous courtship ritual, acted out by Greater Birds of Paradise transplanted halfway around the world to a remote West Indian islet

Feathered Dancers of Little Tobago

By E. THOMAS GILLIARD, Associate Curator of Birds, American Museum of Natural History, and Leader, National Geographic Society-American Museum of Natural History Little Tobago Expedition

With photographs by Frederick Kent Truslow

NOBODY, as a rule, expects to find elephants in the Adirondacks.

Yet here we were, crouched in a steaming blind on a tiny West Indian island, hoping to sneak up on a quarry no less out of place: the Greater Bird of Paradise.

These extraordinary creatures, native to the Aru Islands off distant New Guinea, had been brought to mile-long Little Tobago half a century ago by Sir William Ingram. But how many had survived? And could we capture on film the fantastic mating dance that I had three times gone halfway around the world to see—and each time had failed to photograph?

Explorer's Report Never Verified

We waited in our canvas blind—Fred Truslow with his wires and batteries and telephoto lenses, I with an electrically driven movie camera—choking off our coughs, whispering occasionally, but scarcely daring to move.

I thought back glumly to the story that had brought me to Little Tobago. Could Alfred Russel Wallace have been wrong?

Almost exactly a century ago the great naturalist and explorer reported an amazing performance of Greater Birds of Paradise (*Paradisaea apoda*), a report that had not been confirmed, except through secondhand accounts of natives, from that day to this.

In May, wrote Wallace, the birds congregate deep in the forests of the Aru Islands, in trees with immense, spreading branches. "On one of these trees a dozen or twenty full-plumaged male birds assemble together, raise up their wings, stretch out their necks, and elevate their exquisite plumes, keeping them in a continual vibration. Between whiles they fly across from branch to branch in great excitement, so that the whole tree is filled with waving plumes in every variety of attitude and motion."

Wallace illustrated his story with a woodcut showing dance trees full of males whose plumes cascaded like golden waterfalls. Two bowmen lurked amid the branches; a third retrieved a bird from the ground (page 438).

Well, that was vivid and detailed enough. But when I went to eastern New Guinea and studied the birds of paradise there, I found that they behaved quite differently.* Each male not only defended a solitary display limb, but rarely tolerated another male near it. It would have been impossible for natives to have hunted these birds as Wallace said they did in the Aru Islands.

Different Species Sometimes Look Alike

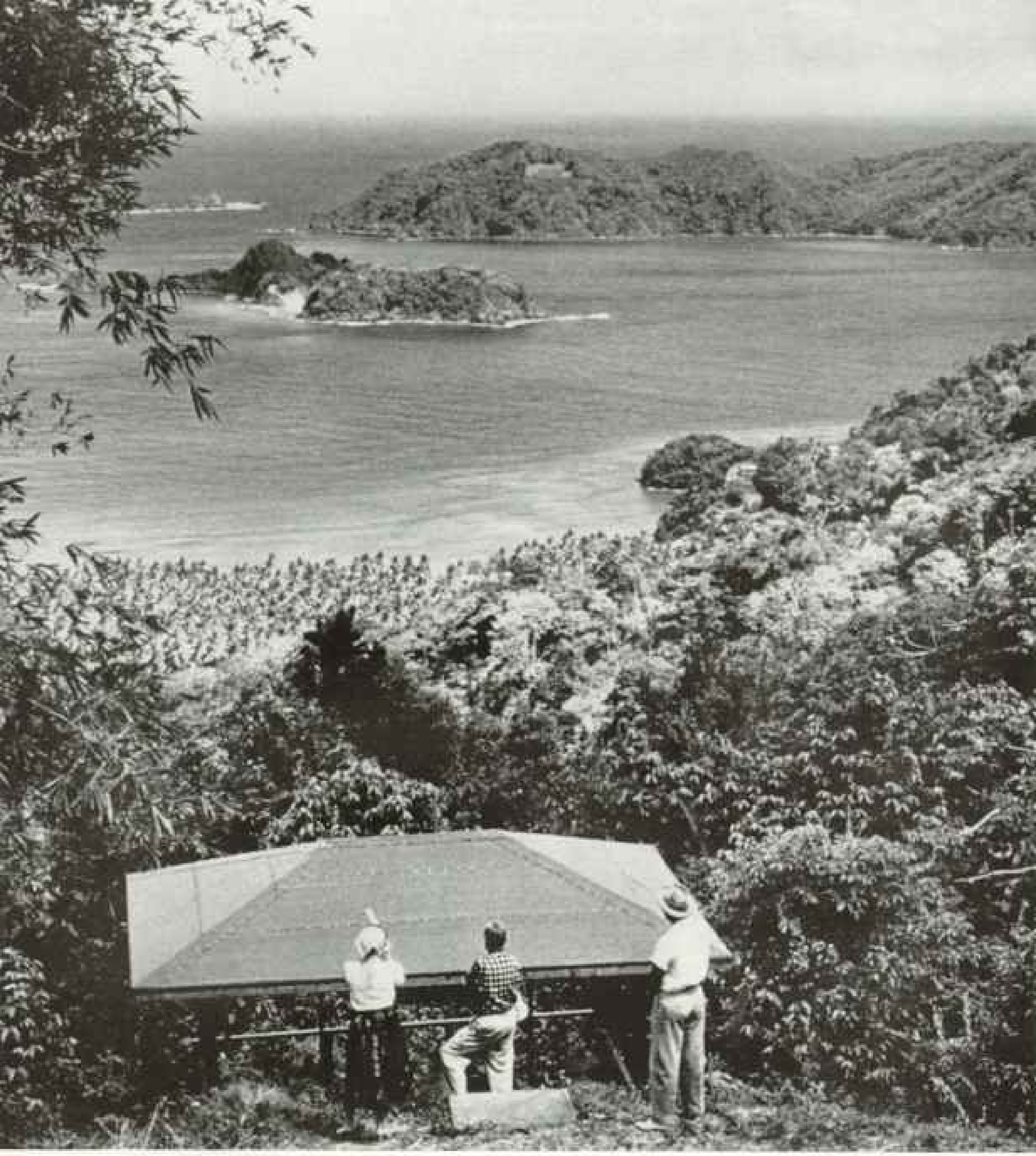
Had the explorer, sick during much of his stay in the Arus, trusted stories told him by the natives? Or had Wallace and I been watching the courtship displays of two quite different species of birds, each with its own unique manner of attracting a mate, that happened to look rather alike?

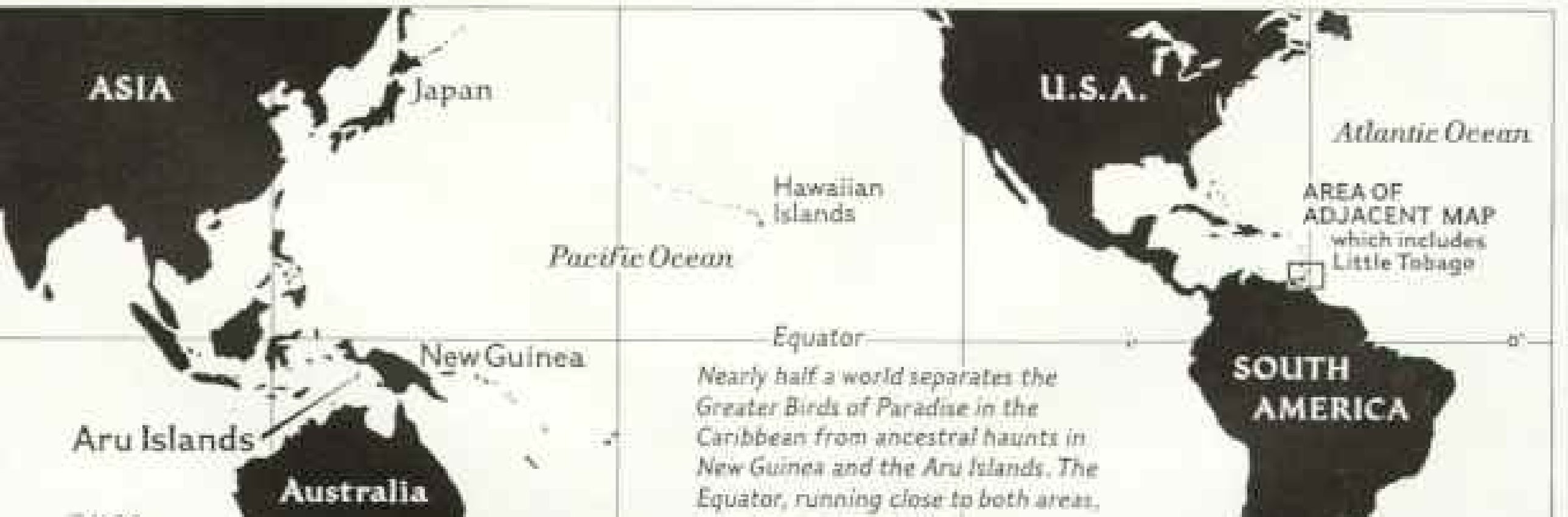
Scientists distinguish between species not primarily by appearance but by differences in courtship and reproductive behavior. Was

* See, in the NATIONAL GEOGRAPHIC MAGAZINE: "New Guinea's Paradise of Birds," November, 1951; "New Guinea's Rare Birds and Stone Age Men," April, 1953; "To the Land of the Head-hunters," October, 1955, all by E. Thomas Gilliard.

Trailing Plumes of Gold, a Bird of Paradise Bugles His Call to Dance

The setting: a theater of bare branches deep in a tropical forest. The players: magnificently costumed males of the **Greater Bird of Paradise.** Here at dawn the curtain goes up on the first complete courtship ritual ever photographed in the wild. After summoning the troupe, the master of ceremonies spreads coffee-colored wings and listens for the answering cries of his rivals. The show goes on even though females often fail to attend.





Nearly half a world separates the Greater Birds of Paradise in the Caribbean from ancestral haunts in New Guinea and the Aru Islands. The Equator, running close to both areas, links them climatically.

Little Tobago Island: the New World's Only Home of Wild Birds of Paradise

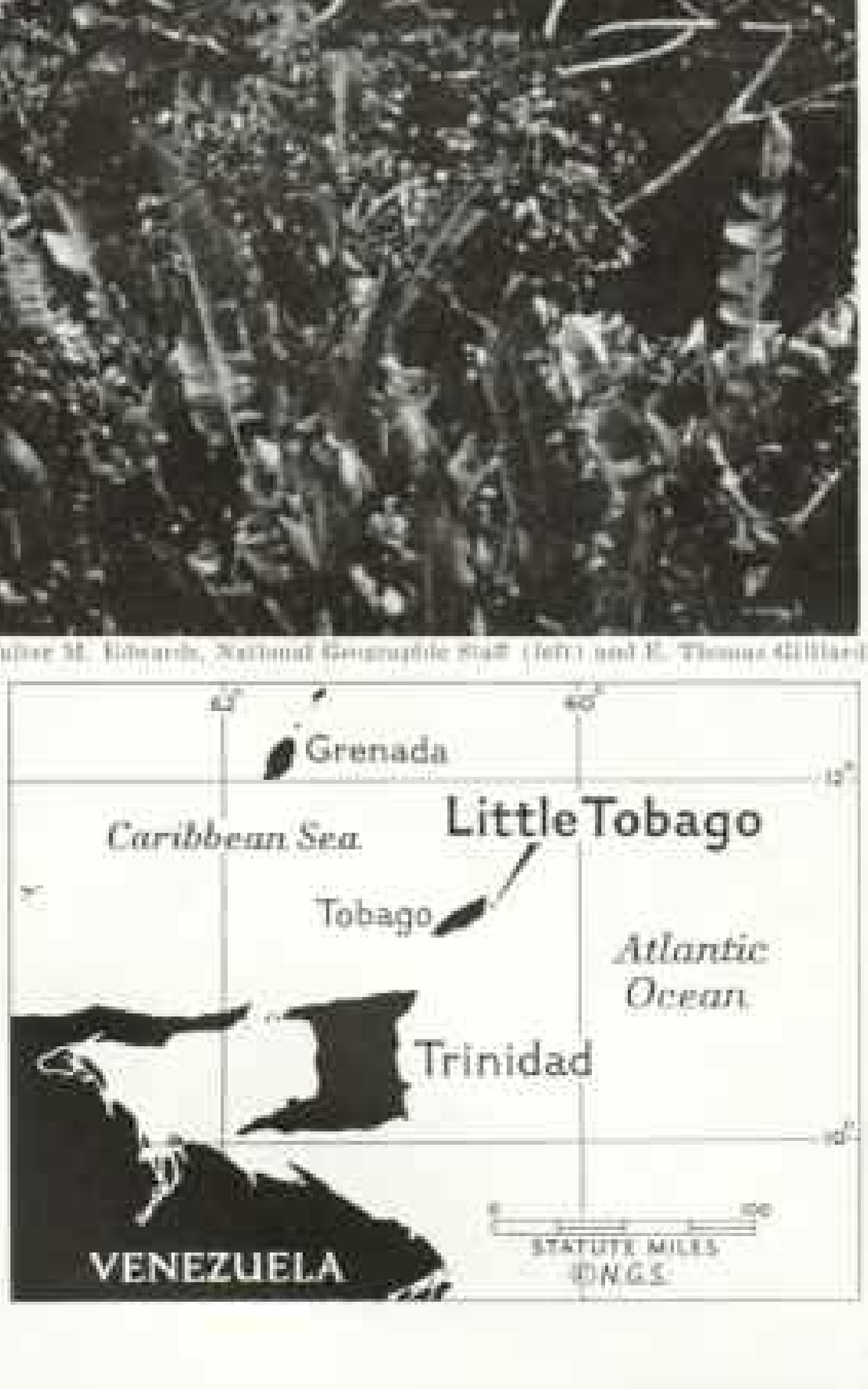
The gaudy plume bearers must be ranked among "the most beautiful and most wonderful of living things," wrote British naturalist Alfred Russel Wallace after visiting the Aru Islands off New Guinea in 1857. But man's admiration proved a curse, not a blessing.

Brilliant, silky flank plumes, long used as ornaments by New Guinea tribesmen and Eastern potentates, became the rage of European fashion in the late 1800's. To meet the millinery demand, hunters slaughtered thousands of the birds annually.

Although legislation to outlaw the traffic was pending, London publisher Sir William Ingram decided immediate action was necessary to save golden-feathered *Paradisaea apoda*, the Greater Bird of Paradise. He purchased Little Tobago in the British West Indies (map, below) for use as a sanctuary and sent to the Aru Islands for immigrants. By 1912, 47 birds had been set free. Today their descendants number about 35, possibly the maximum number the mile-long island can support.

Now part of the new West Indies federation, this Caribbean preserve is the only spot in the world where sightseers can watch birds of paradise displaying in the wild. Here the Speyside area of Tobago looks out across Goat Island to jungle-clad Little Tobago. White clearing on the hill at left is Doublegate Garden, one of eight planted in fruit trees to support the feathered colonists. Over the years an occasional bird has hopped the channel to Tobago.

Island superintendent Jeremiah George serves visiting ornithologists as a knowledgeable guide.



Walter M. Edwards, National Geographic Staff (left) and E. Thomas Gilliard

it possible that Wallace's yellow-plumed Aru Islands birds and the red-plumed ones I had seen in New Guinea were separate species, and not merely varieties of the same species, as science had so long assumed?

This was the puzzle. Now, hoping to solve it—thanks to a liberal grant from the Research Committee of the National Geographic Society and the cooperation of the American Museum of Natural History—Fred Truslow and I perspired and grumbled in our blind on Little Tobago, waiting not very hopefully for the descendants of Sir William's birds of paradise to show up.

Actors Preen Before the Dance

Lying there in the forest hour after hour, Fred and I lived in a state of perpetual frustration. The days dragged by fruitlessly. We were coming to the hottest part of the year. Trees stood stripped, lifeless, stark and strangely out of place among bamboos and chaffering fan palms. Rafts of stony clouds sailed the brazen sky, scarcely casting a shadow and yielding no drop of rain.

Then, one morning, our luck turned.

We were slumped behind the blind as dawn filtered through the forest. Several male birds of paradise began calling from near the top of the island, and were answered presently by bugling far down the slope. Soon a male called out distinctly a few yards from us.

Shortly after six o'clock he flew directly in front of us and perched on a horizontal limb. Wiping his bill several times on the branch, he preened actively for a minute or two, then called out in a rich tone that must have carried a good quarter of a mile. Somewhere in the woods a bird replied.

The male in front of us shook his chest like a wet dog drying himself and resumed his preening, running his long tail wires methodically through his bill with a roundhouse sweep of his head. More interested now in displaying, he stretched each wing separately, tightened his body feathers, and emitted four or five deep "awk-awk-awk's" in rapid succession, squeezing his wings against his sides as if to press out the sound (opposite).

A bird bugled in response, and he renewed his invitation in quickened cadence. Between calls he fanned his wings and held them stiffly open in a sort of beckoning gesture for twenty seconds or more, his head either hidden beneath his wings or raised and twisted over his shoulder in a curiously fixed manner. Frequently he reared up as if to dive, his flank plumes cascading up and down.

His excitement grew as a long-plumed bird displayed at first in a near-by tree and then sailed directly onto the main stage—a series of three or four sloping limbs.

The calling back and forth stepped up in tempo. Suddenly, both birds broke into an amazing dance, charging along the tops of the main display limbs in nearly perfect time, starting and stopping as one. They reminded me of two golden circus poodles performing to the same tune. Most unexpected of all, both gave vent to a series of synchronized calls that provoked a new spate of charges.

Brought to an apparently unbearable pitch of emotion, the males broke off their synchronized pattern and seemed to lose partial control of their movements. As if crippled, they dragged a leg along the perch, shuffling sideways, but still scurrying, head downward.

Displaying Suitors Resemble Flowers

The dance that day ended here, but on a subsequent day we were privileged to see it progress, thanks presumably to the presence of females in the vicinity, to a new phase of fantasy. A good attendance was on hand, two adult males, three subadult males, and three other birds whose plumage indicated that they were either very young males or adult females.

The displaying males crouched on their branches, heads drooping below the perches, legs tucked under chests or necks. Mouths open, eyes glassy, the expiring suitors made a few short, spasmodic movements and then, magically, ceased to resemble birds (page 437).

Frozen, their wings hanging down, their tail wires pointing earthward, the birds flaunted their flank plumes like gorgeous sheafs of sun-ripened wheat. In the slight breeze of the

A Shimmering Banner of Feathers Billows Above a Charging Dancer

Actors attend first to make-up. Each vigorously preens body, wings, and long, trailing tail wires (left). Warming up, the male Greater Bird of Paradise stretches his wings, then tightens them against his body while giving voice to quick "awks." Feature performance begins as two or more birds burst into intricate dance steps, sometimes synchronizing their bugling and running and jumping in perfect cadence on different limbs of a display tree.

All Kodachromes by Frederick Kent Truslow © National Geographic Society

Excitement Mounts as a Suitor Freezes, Whirls, and Struts

Star billing goes to Greater Bird of Paradise males with the longest, finest plumage; they hold the center of the stage on main display limbs. Youngsters in short plumes, such as this one, cavort on side branches. Rank appears the result of instinct rather than of fighting. Cocks dance only within sight or sound of other males, but hens inspire more prolonged posing (left) and more agitated contortions (below).

forest, the lacelike filaments nodded back and forth like grasses in currents undersea. Exotic great flowers now, the males posed for minutes on end, as the females climbed about in the periphery of the display area awaiting the next phase of this bizarre and not yet completely understood courtship ritual.

Here, certainly, was Wallace's "whole tree . . . filled with waving plumes." Enlargements from my movie film, made during this display, look remarkably like some of the birds in T. W. Wood's century-old engraving (page 438). We may never know whether or not Wallace saw this extraordinary sight with his own eyes, but I could have no doubt now that his observations, even if secondhand, had been characteristically reliable.

Once the display had concluded, some of the males settled down in the display tree, but never on the peculiarly bent limbs where they had just performed their climactic dance. A favorite, if odd, position was to squat for as long as a minute with the head crooked over the shoulder and the neck pulled back.

Then the bill would open a little, and in a shallow arc the bird would squirt out, with no jerk of his head, a cherry seed from some long-since swallowed fruit. Sometimes he would spit out as many as three, one at a time, the pits pattering on the drumlike surfaces of the forest's big leaves or bouncing softly into spider webs, where I later collected them.

Often males, particularly the young ones, would then revive, begin to flip their wings, and commence a new cycle of display, culminating in the state of flowerlike demise. One youngster I watched completed four such rounds in one afternoon, while an older bird some five feet above him called enthusiastically, but apparently was too spent to display more than feebly.

Courtship Puzzle Still Unsolved

Well, why do they do it? We ornithologists aren't at all sure. It's perplexing to find males displaying together, not fighting and, one assumes, depending on one another's presence for stimulation. Adding to the mystery is the fact that this highly developed social dance may be and usually is performed in the total absence of the female.

True, the ruff of Eurasia, a relative of the snipe and woodcock, puts on a somewhat similar group performance. The cocks congregate annually at a little spot on a grass-covered display mound, so that the group resembles a weird flower bed. And when a female appears to select a mate, the males fall into a kind of trance, their bodies prostrate and their bills driven into the grass.

But why? The answer seems to be that in species such as these, in which there is virtually no time for selection of a partner prior to mating, the males use these displays among themselves to establish a breeding hierarchy. In this way, even in the absence of the females, the dominant males are selected from the stock and enabled to occupy preferential spots on the display grounds, thereby winning more mates.

Longest Plumes Rate the Best Limbs

Apparently, the social and nonaggressive courtship dances of groups of males that we found in the Greater Bird of Paradise—as well as among the ruff and several species of grouse—serve the same function as the courtship fighting found among pheasants and chickens, in which each male has to fight every other male to find his place in the "peck order."

I noticed, for instance, among Greater Birds of Paradise that the male with the longest ornamental plumes generally sat in the center of the community bower; shorter-plumed males relinquished these central perches when longer-plumed birds arrived.

I think we must take it that the flowerlike display on the bent limbs is a form of symbolic mating. The males, indeed, are very masculine, despite their delicate plumage. Their bugling and dancing are violent and strong, and their association with other males occurs only during these displays. Where and when they mate with the females, we were never able to discover. But, in any event, the Greater Bird of Paradise belongs to that relatively small group of birds that practices promiscuous polygamy; they form no pairs, protect no harems, but meet, mate, and part in a matter of minutes.

If these displays were exhausting to the birds, they were at least as trying for us. "Bird watching" is a term that summons up an image, perhaps, of energetic ladies and frail professors off on a Sunday ramble. I am afraid it would have taken a most resolute amateur bird watcher to have survived our daily harassments on Little Tobago.

Each morning before sunrise, after stumbling a quarter of a mile over a dripping forest trail, we would reconnoiter the blind for

Plumes Fan Out Like Flower Petals: the Finale of an Ecstatic Dance

In the courtship ritual, dancing serves as a prelude to this climactic act. The suitor's wings are rigid; his tail hugs the limb; eyes go glassy, and mouth gapes wide. When a female joins the audience, he holds this pose for minutes at a time.


Wood

Aru Islanders Shoot Down Guests at an Avian Ball

A century ago this woodcut appeared with Alfred Wallace's colorful description of the social courtship of the Aru Islands' Greater Bird of Paradise. Although illness may have prevented the naturalist from actually seeing the birds' communal dancing, his report and T. W. Wood's illustration have stood through the years as the classic source of information on the phenomenon.

The Little Tobago expedition, led by E. Thomas Gilliard, associate curator of birds, American Museum of Natural History, and sponsored by the National Geographic Society, confirmed at first-hand Wallace's remarkable report.

Plume hunters, Wallace wrote, used knob-tipped arrows. "When the birds come at sunrise . . . and have begun to dance, the hunter shoots with his blunt arrow so strongly as to stun the bird, which drops down, and is secured and killed by the boy without its plumage being injured by a drop of blood."

Little Tobago's Fan Dancers Lift Plumes in Unison

Group courtship rituals sometimes last for more than an hour, but individual birds usually perform for only a few minutes at a time.

Having failed to attract a mate during h's first dance, the avid suitor above gives an encore following an intermission. Birds in the lower picture provide dramatic confirmation of the details in the old woodcut. Both photographs are enlarged from single frames of Dr. Gilliard's 16-mm. motion pictures.

The spectacle frequently attracts other birds. Excited tanagers and thrushes in the audience reminded the author of "devotees at a burlesque theater."

whatever wildlife had crept in during the night. Since there was a fair chance that the first one across the threshold might have to dispute possession of the tent with a lizard, a scorpion, or a soldier crab, we indulged in a rather courtly contest.

"After you, sir," I would say politely.

"No, no," Fred would reply. "Be my guest!"

And there were the snakes. The slender, yard-long creatures rustled through the papery leaves around us and sometimes amazed us by climbing the scaly trunks of near-by trees, twisting their bodies back and forth adhesively across vertical surfaces that seemed to offer practically no holds.

Snakes sometimes proved downright impertinent. Once one of them made a beeline for my feet. I grabbed a handful of pebbles and, when the snake was within a foot of my exposed hand, tossed them in its face. To my consternation, the snake reared up like a little cobra, struck at the spot where my hand had been, and then darted into the blind itself. I left—straight up through the roof.

But the real trial was neither the scorpions nor the snakes. Looking back, I remember even more vividly the accumulated tension, the fatigue, the anxiety—and, occasionally, the exhilaration—we knew in the forests of Little Tobago.

Fred Truslow has shot big game, competed in championship rifle matches, raced automobiles, and helped direct the complex affairs of a giant corporation. I feel sure he would face the charge of a Kodiak bear with ice in his

Boatmen wade ashore at Little Tobago to take off expedition members. Two miles of dangerous currents isolate the sanctuary from Tobago (background).

veins. Yet I have heard him in his blind undergoing all the symptoms of buck fever as our birds went into their act.

Sometimes he had an agonizing suspicion that his batteries had run down during the long wait. Sometimes he was sure the wonderfully plumed birds would break off their dance and vanish during the interminable 18 seconds it took to recharge his strobe-light condensers. He groaned, he sighed, he mumbled in language unparadisean.

The important thing is that he brought home the bacon, as his magnificent photographs proclaim. And his still pictures, my films, and our joint observations served to answer resoundingly the questions we had brought with us.

The birds of the Aru Islands have successfully adapted themselves to life in the New World, and their behavior bears out to the hilt everything that Wallace wrote about them. Even more noteworthy, our studies prove conclusively that the Aru and Little Tobago birds—still identical in habits and color, of course, after half a century of isolation from one another—form a distinct and separate species in the fabulous company of the birds of paradise.

It is a shame that Sir William Ingram could not have lived to know that his campaign to save the Greater Bird of Paradise is succeeding. In this light, Little Tobago assumes a unique importance as a haven for one of nature's most remarkable—and certainly one of her most beautiful—creations. How fortunate that West Indies federation authorities have seen fit to leave this handful of birds in their natural state, unharmed and safe from the plume hunter who still threatens their survival in the Aru Islands.

INDEX FOR JANUARY-JUNE, 1958, VOLUME READY

Index for Volume CXIII (January-June, 1958) of the NATIONAL GEOGRAPHIC MAGAZINE will be mailed upon request to members who bind their copies as works of reference.

The Book of Dogs

NATIONAL GEOGRAPHIC'S NEWEST ACHIEVEMENT

By MERLE SEVERY, Chief, National Geographic Book Service

IN UPPER EGYPT 3,400 years ago, an artist watched a barefoot hunter return laden with game from the chase. With the hunter was his loyal hound, tired, panting, but proudly leading the victory march.

The Theban artist was impressed; he used this scene for a fresco in a royal tomb, catching in color a timeless image of man and dog in affectionate alliance. Then the tomb was sealed and the centuries slipped by.

No living man has seen that original fresco. Next month, however, the world at large will have the first chance to see this extraordinary design in color. It appears as one of 342 illustrations in The Society's new *BOOK OF DOGS*, available in October.

Egyptologists Provide a Clue

Tracking down this work of Egyptian art involved a suspense story worthy of fiction. Our Book Service staff in Washington had heard that the mural existed, but where could it be found? We asked Egyptologists in New York and London, then rushed a query to a group of archeologists on expedition in Luxor.

Back came a cable: "Theban tomb hunting scene destroyed. . . ." The situation looked hopeless; the tomb had been ravaged by vandals more than a century ago.

But the archeologists had one suggestion. A French artist, in 1836, had toured Egypt, faithfully copying ancient wall designs. He had published his color lithographs in a limited Paris edition. A copy might still exist.

The staff promptly consulted the Library of Congress; a quick search was made among rare volumes. And after seeking it on three continents, we were able to photograph this rare hunting scene in Washington, right where the search had begun. In full color, it forms a dramatic frontispiece for the chapter "The Dog Through the Ages."

The *BOOK OF DOGS* is unlike any other work in its field. In 432 pages this reference book organizes a treasury of fact and anecdote—from the parlor capers of the tiny Chihuahua to the heroic Alpine labors of the St. Bernard. Here, too, you will find practical instruction on dog care, written simply enough for the youngster who even now is giving his parents that well-known campaign promise: "If you'll just let me have a puppy, you won't have to take care of him at all."

Arthur Frederick Jones, of the American Kennel Club, draws from decades of experience as he explains "How to Choose, Care for, and Train Your Dog." Mr. Jones ventures advice in matching breeds to owners: "In the main, you will find quieter temperaments among the gun dogs, most of the hounds, and the larger working dogs." Terriers may not be "in tune with people who like to relax."

An illustrated check list shows how to choose a healthy dog. Puppyhood gets special attention: when to stop formula feeding, when to increase the dosage of cod-liver oil. The author tells how to travel with a dog by plane, ship, train, or family motorcar. He gives hints on diet ("cottage cheese . . . for overweight dogs"), health rules, commands.

In nine sections other authors tell the dog's exciting story from the days of chariots to the airborne "paradogs" of today. Here readers can visit the aristocratic Westminster Kennel Club Dog Show, where Queen Victoria once entered two deerhounds worth $50,000 apiece, and the Dog Mart in Fredericksburg, Virginia, where animals of doubtful ancestry have had their day since 1698. The unpedigreed pooch, in fact, merits a full section of his own.

112 Breeds Portrayed in Color

Detailed biographies describe separately all 112 breeds recognized by the American Kennel Club, their origin, unusual deeds, special habits and abilities, size, and markings. Each breed is shown in a full-color portrait painted by a leading natural history artist especially for the National Geographic Society.

"Likely the most varied collection of dog paintings and photographs ever assembled between covers"—so commented a curator at the National Gallery of Art as he leafed through proofs.

Together, word and picture tell the dog's heroic exploits. Readers share the drama of explorer Robert E. Peary pushing toward the North Pole. To attempt "the Great Ice"

National Geographic Photographer Thomas J. Abercrombie

A Proud Great Dane Helps Dog Book Editors Check Proof on Her Breed

without his huskies, he says, "would be folly."

A Pompeian pet struggles at his chain to escape the fatal ash of Vesuvius. A photograph shows the dog's own cast, an action detail preserved perfectly since A.D. 79.

Sharp details bring into human focus history's illustrious personalities in the company of dogs. The reader learns Socrates's favorite oath, to swear by the dog. Julius Caesar complains about the lap dogs of Roman ladies. Theodore Roosevelt marvels at the conflict of an African hyena with an Airedale terrier "not a third its weight."

Beautifully printed and bound, the *BOOK OF DOGS* will have lasting library value. "A most valuable source . . . skillfully authenticated," affirms a member of the American Kennel Club staff.

Member-families, whatever dog they own or love, will find in the *BOOK OF DOGS* a warmth and understanding which will help young masters learn the art of responsibility. Here is the whole noble scope of man's best friend, arranged in his great variety, as Shakespeare said, "According to the gift which bounteous nature hath in him closed."

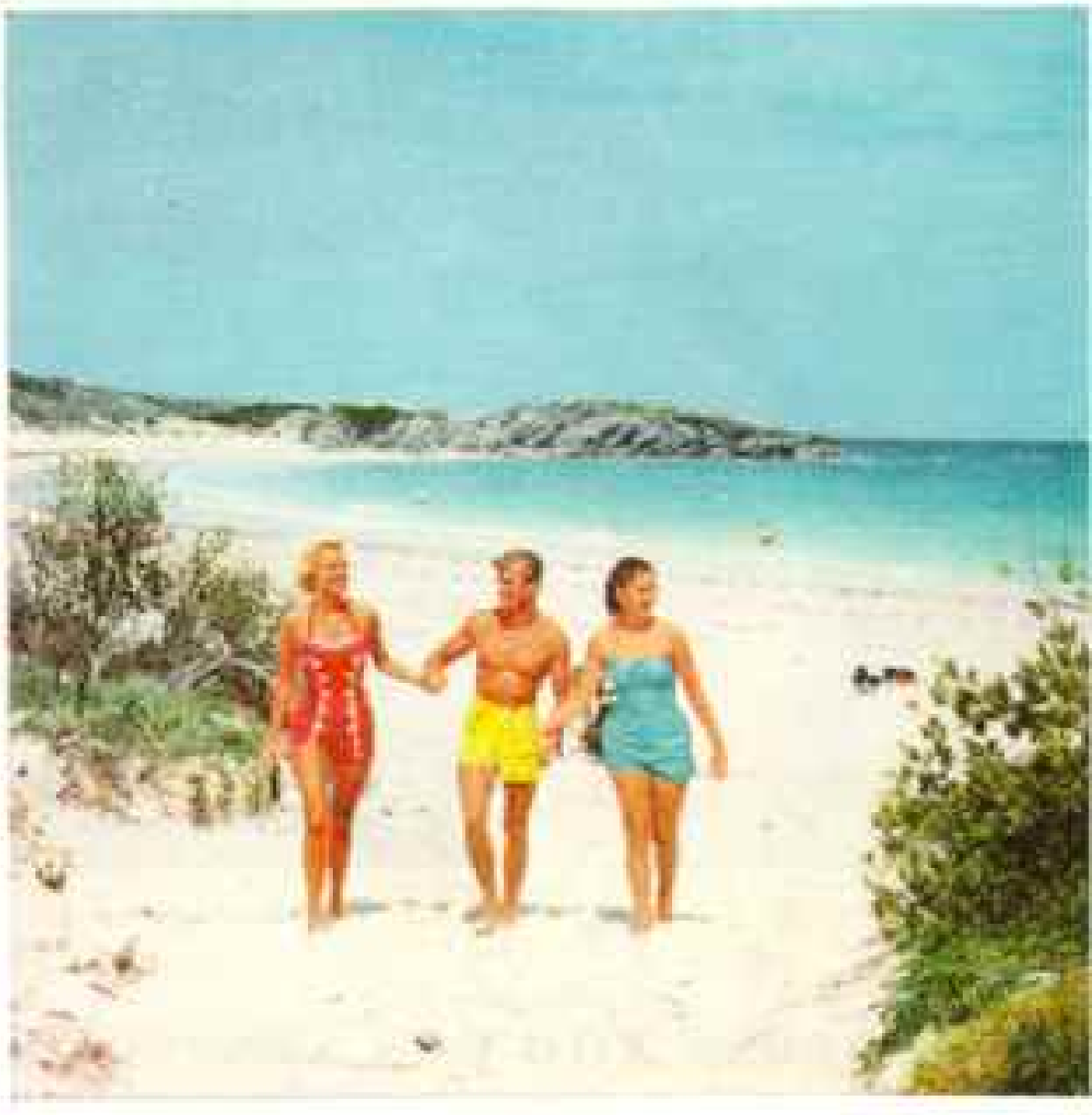
NATIONAL GEOGRAPHIC Society

16th & M Streets N.W. Washington 6, D. C.

National Geographic Magazine

ORGANIZED IN 1888 "FOR THE INCREASE AND DIFFUSION OF GEOGRAPHIC KNOWLEDG

To increase knowledge, the National Geographic Society has conducted 150 scientific projects and exploring expeditions literally to the ends of the earth. The Society diffuses knowledge through its monthly National Geographic Magazine and its books; 16 million large color maps a year, bulletins for schools, and news releases on world events for press, radio, and television.



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Her charm and grace are made of many things

There's a world of sports, a wealth of holiday fun awaiting you in Bermuda. Lovely pastel homes and vivid flowers delight the eye. Beaches of soft pink sand invite loafing, a swim in clear waters. There are five beautiful golf courses, en-tout-cas tennis courts . . . sailing, water-skiing, skin-diving, fishing. Taxis, cycles, buses and ferries make it easy to shop and sightsee. You can dance nightly at Bermuda's famous hotels, and enjoy her friendly guest houses and cottage colonies.

Bermuda is 700 miles from the mainland—easy to reach by trans-Atlantic airlines; and there are weekly sailings on luxury ocean liners. To plan wisely, see your travel agent. For free Vacation Kit, write The Bermuda Trade Development Board, 620 Fifth Avenue, New York 20, New York.

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* See subscription form in back advertising pages of this issue.

RECOMMENDATION FOR ... AND INQUIRY ABOUT *Membership* CHECK ONE

Members of The Society roam the world through the pages of their official journal, the NATIONAL GEOGRAPHIC MAGAZINE. Annual dues of **$6.50** include subscription to the Magazine, and bring frequent 10-color map supplements. Members' enthusiastic nomination of friends for membership explains The Society's phenomenal growth.

Nonmembers interested in joining The Society—but who do not know a member—should inquire (right).

Members and others may make gifts or bequests of money, securities, or other property to The Society for "the increase and diffusion of geographic knowledge." Such gifts are deductible for tax purposes.

Please print form & mail to

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NATIONAL GEOGRAPHIC SOCIETY
WASHINGTON 6, D. C.

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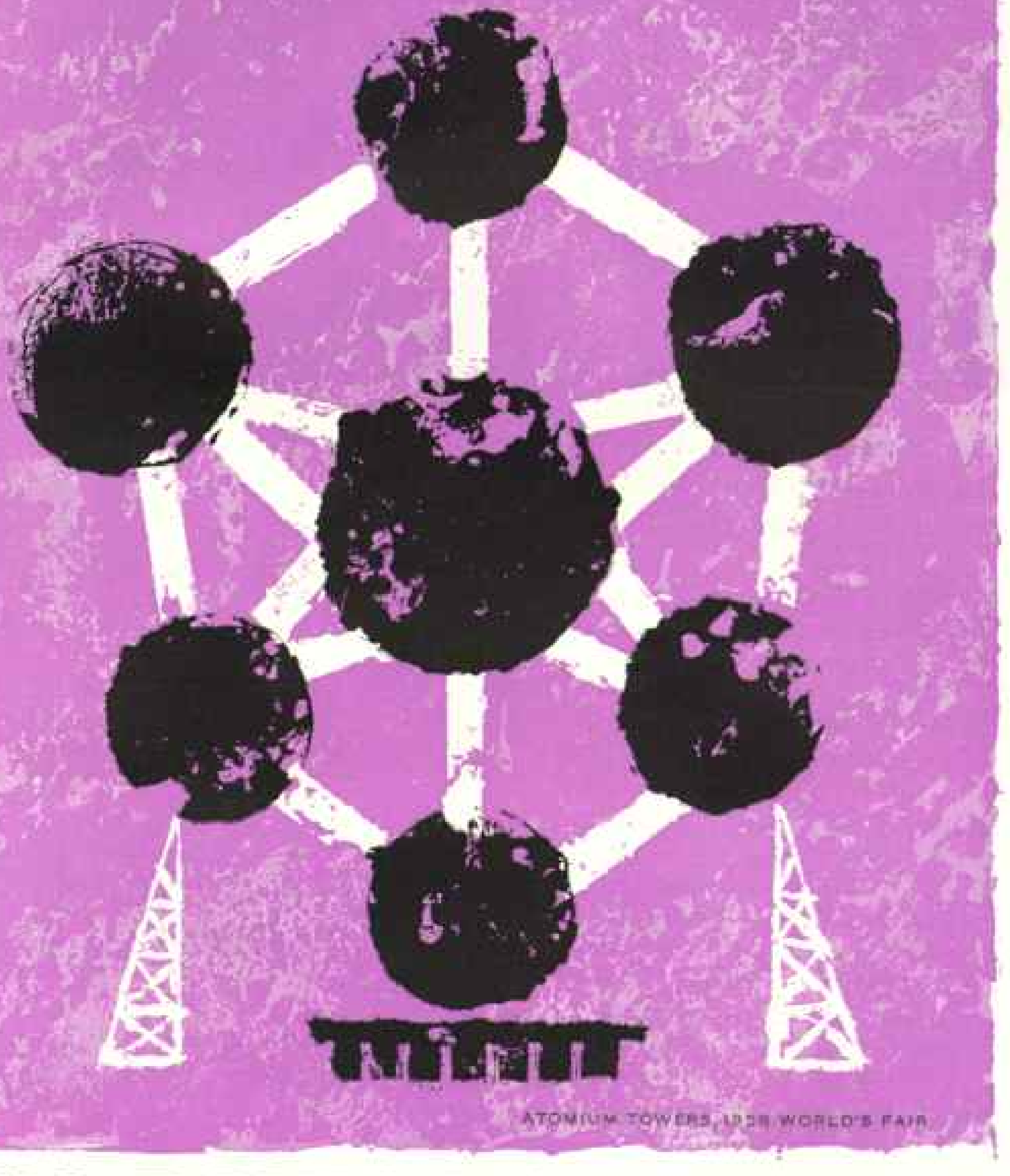

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New Kodak Cavalcade Projector: you turn it on... it does the rest!

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Now you can be a guest at your own slide shows!

With the Kodak Cavalcade Projector, you keep an eye only on the screen. You can come and go—and still the show goes on.

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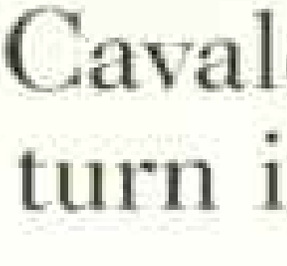

Remote-control changing, up to 12 feet. You control the show from anywhere in the room.

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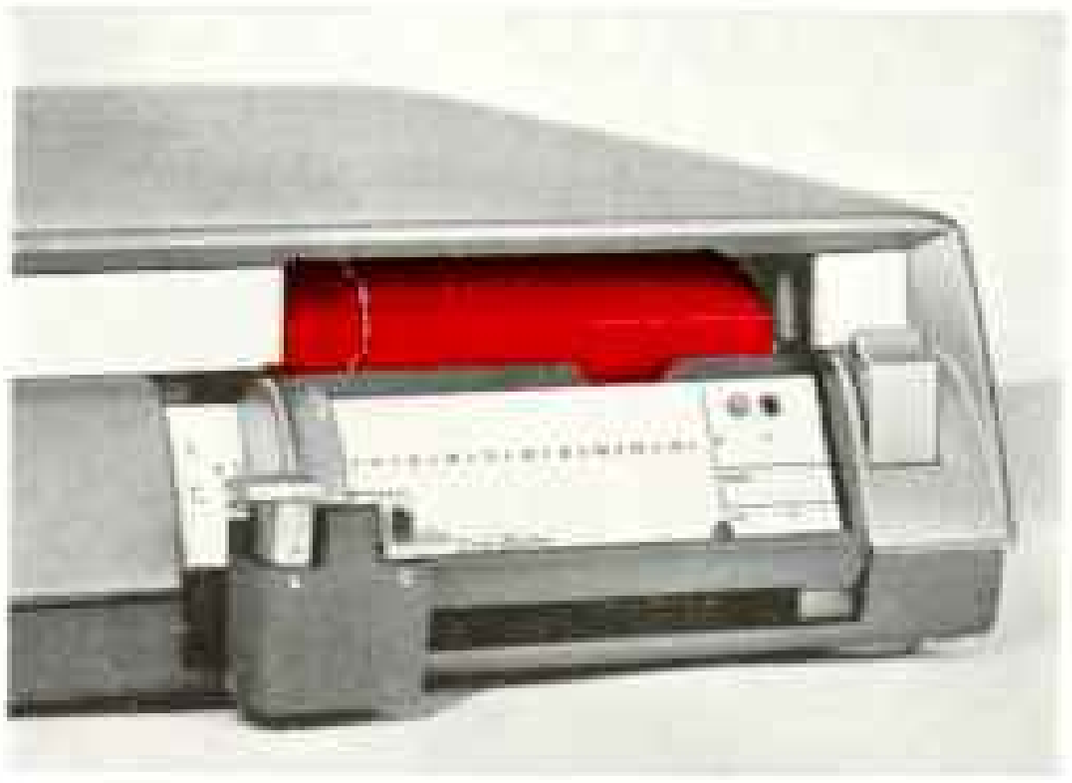

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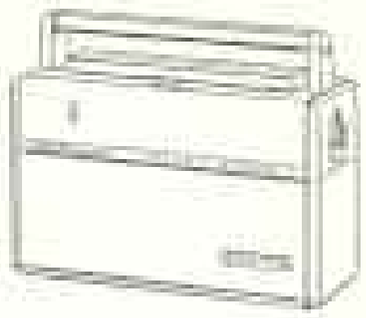

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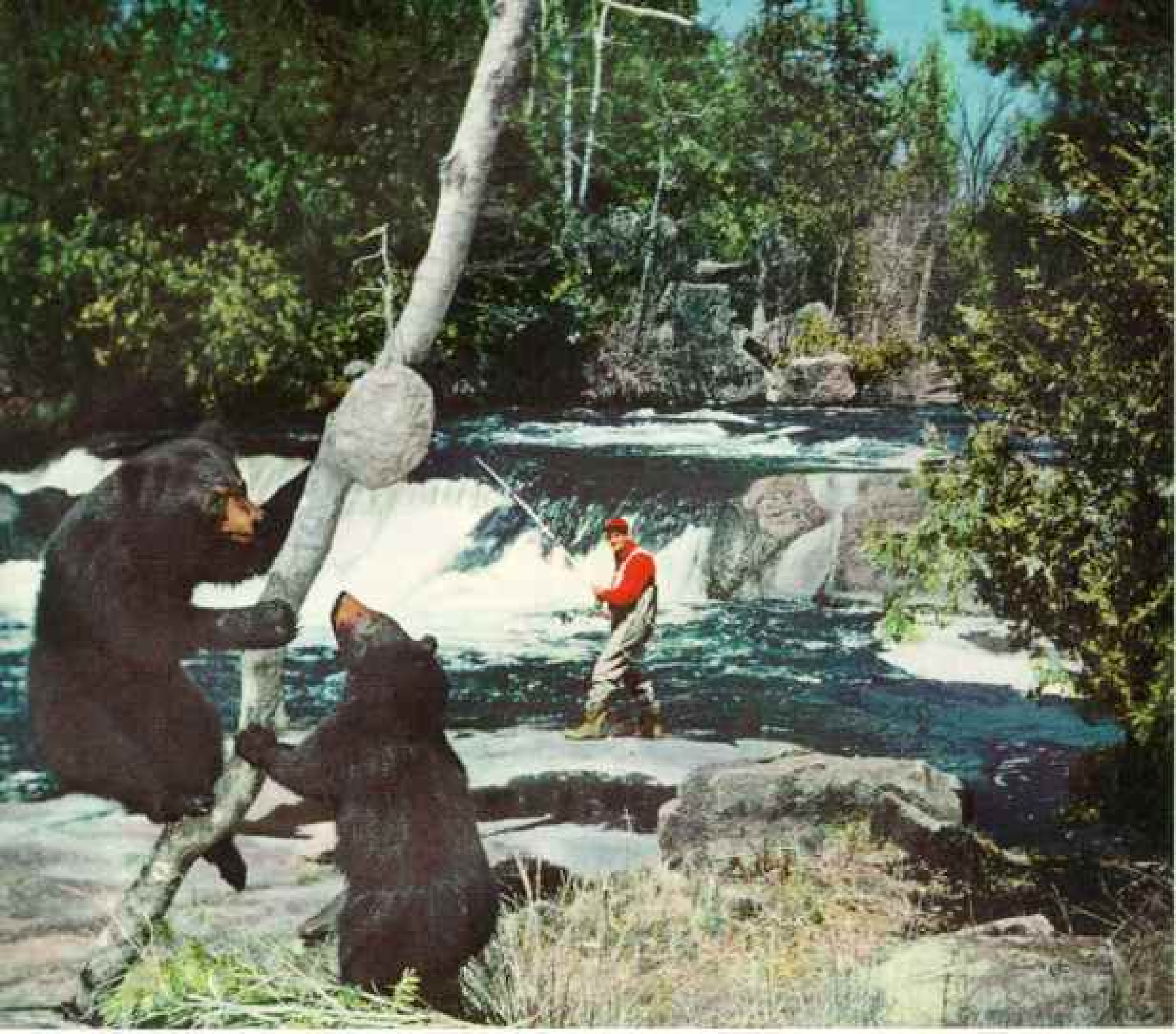

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Nature—man's first and finest playground

Man has always loved the glories of Nature, for here is home-base; touching it, he feels safe. Standing in forested mountains, near tumbling waters, close to the wonder of living things, his heart is lifted and his hopes nurtured.

Thoreau, who found all life's meanings beside Walden Pond, would have loved Wisconsin's wonderful parks and forests. *And your will, too,* for wise conservation has kept the sylvan beauty that entranced Joliet and Marquette in 1673. You can study ancient Indian rock-carvings, or watch exciting Indian ceremonials, or perhaps find arrowheads to bring back home. *There are eight thousand lakes for you to swim in,* bass, pike and muskie to catch, and wild life to watch. There's camping, and hiking, and a million trees to sit under and watch the grass grow.

All men hunger for peace. It is still to be found in Nature. In the inspiration of cloud and forest, blossom and star, you will find testimony to the essential goodness of life — and the dignity of man.

★ ★ ★

FREE TOUR INFORMATION If you would like to visit Wisconsin's parks and forests, or drive anywhere in the U.S.A., let us help plan your trip. Write: Tour Bureau, Sinclair Oil Corporation, 600 Fifth Ave., New York 20, N. Y.

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for *leading drives* throughout the nation to provide parks and playgrounds to help citizens of all ages make wise use of leisure time. As the foremost source of recreation information and guidance, the Association *has enriched the nation* by showing the community how to conserve mental and physical health, win the rewards of worth-while recreation indoors and out, and gain the values of creative living that *uplift the spiritual well-being of all Americans.*

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This delightful Domeliner is the finest and fastest between Chicago and Portland, with through Pullman to Tacoma-Seattle.

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Pullman and Coach equipment is the very latest in design, providing both relaxing comfort and convenience. And, of course, the money-saving Family Plan Fares apply on *all* Union Pacific trains.

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Fall foliage forms a fascinating foreground for regal Mount Hood.

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A good school year often starts in the doctor's office

Your child will soon be off to school—with thirty-nine and one-half million other children—the largest enrollment in our country's history.

Naturally, you hope your child will stay well and do well throughout the school year. To help him do so, why not take him to your doctor now—*before school opens*—for a thorough health examination?

This is important for all children, but doubly so for the "beginner" who may be exposed for the first time to the communicable diseases. The child should be protected against whooping cough, polio, diphtheria, smallpox and tetanus.

If he has already had "shots" for these diseases, it may be time for "booster doses." These increase protection or hold it at such a level that the child is more able to resist the disease to which he is exposed.

A pre-school check-up may reveal unsuspected defects of the eyes or ears. A child who has impaired hearing or vision cannot do his best work at school. Besides getting low marks, he may become discouraged or at best have difficulty in making adjustments.

Your doctor can also advise you about improving your child's health habits to increase resistance to colds and other respiratory infections that keep so many children away from their classrooms.

What about older children—teen-agers especially? They, too, should have health examinations. The doctor's advice on physical development, emotional problems, and other "troubles of the teens" can ease many worries that beset this age group.

Metropolitan offers two free booklets on the health of both younger and older school-age groups. Check below the booklet or booklets you want.

Metropolitan Life Insurance Company
1 Madison Avenue, New York 10, N. Y.

Please send me the free booklets:
☐ "*ABC's of Childhood Diseases*," 8-58-N.
☐ "*Understanding Your Teen-Agers*," 8-55-N.

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One of a series of posters displayed during the Second International Conference on the Peaceful Uses of Atomic Energy in Geneva, September, 1958. Triga is an inherently safe training, research, isotope-production reactor designed and manufactured by the General Atomic Division of General Dynamics Corporation.

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Ever wonder what
Jack Dempsey carries
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